

# SCIENTIFIC AMERICAN



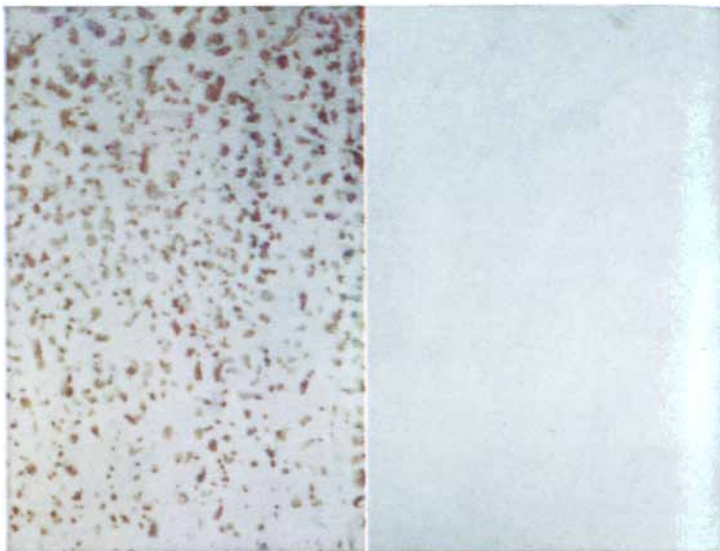
NOCTILUCENT CLOUDS

*FIFTY CENTS*

*June 1963*



**Foamed plastisol protects highly finished parts:** Our new flame-resistant foamed plastisol is an ideal "wrapper" for plated and machined parts—partly because it is so easy to peel off, mostly because it costs less and protects better than a paper wrap. This vinyl material doesn't develop its economical, cellular structure until heated. It is easily applied by spraying, which means less waste, with more accurate control of its thickness.



**How microscopic cracks retard corrosion of plated metal:** Plate more than 20 millionths of an inch of ordinary chromium on auto brightwork and it soon develops relatively gross cracks, some extending right to base metal, inviting corrosive action (*left*).

A new M&T plating process can plate 50 millionths or more, controlling fissures to micro-cracks that reduce galvanic action, retard corrosion of the nickel undercoat and basis metal (*right*).



**Fast cure for bubbles in fine glass:** Molten glass that includes M&T Sodium Antimonate is free from objectionable bubbles or "seeds." Sodium antimonate contributes an oxygen pressure, forming large scavenging bubbles that sweep small bubbles from

the glass. This "fining" cuts rejects—in T.V. tubes, for example.

An added advantage is that M&T Sodium Antimonate prevents glass from darkening due to ultra-violet light. The same M&T chemical works particularly well with photosensitive glasses.

*Uniting imagination in chemicals with know-how in metals...M&T research and technical service engineers can help with problems in chemistry, ceramics, plating, organic coatings, minerals and welding. Write M&T Chemicals Inc., General Offices, Rahway, N. J.*

**M&T Chemicals Inc.**

FORMERLY METAL & THERMIT CORPORATION

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# ANNULAR - A New Motorola Breakthrough in Silicon Transistor Design

*The high-voltage barrier to passivated PNP transistors has finally been broken  
—but it took a new manufacturing process to overcome the obstacles.*

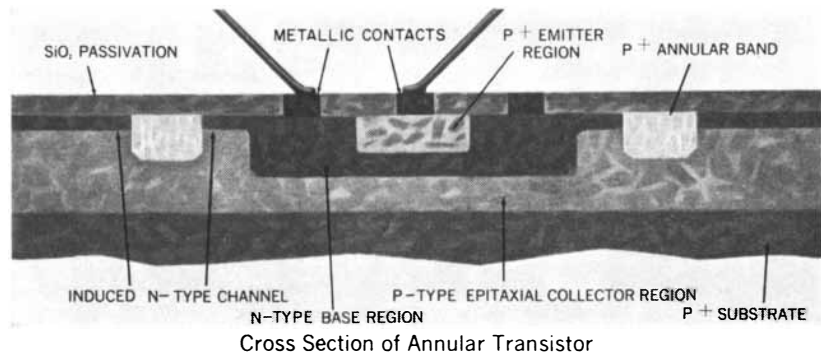
Some new words are being added to the dictionary of semiconductor terms — words like Annular\* and Band-Guard†, words that relate to a new manufacturing process which will have a strong influence on transistor design and promises to open new areas for transistor applications; a manufacturing process that provides a new degree of freedom from surface effects for semiconductor devices.

For years, the industry had been working to design high voltage silicon PNP transistors with the low leakage currents normally associated with NPN types, surface passivated by the planar process. For PNP devices, planar techniques proved inadequate since any attempt to increase voltage ratings beyond approximately 20 volts (through increasing collector material resistivity) induced a phenomenon, called channeling, which actually increased leakage current far beyond tolerable levels.

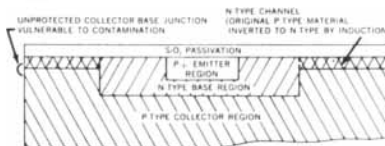
*Channeling is a condition whereby the surface portion of a transistor collector region actually changes polarity and becomes an extension of the base region. The base-collector junction, therefore, rather than coming to the top surface where it is protected from the environment by a silicon oxide coating, extends to the unprotected edges of the transistor where it is subject to contamination and surface damage. This phenomenon circumvents the passivation advantages of planar designs and results in excessive leakage currents.*

*The formation of channels has been traced to effects of ionized or polarized particles on or within the passivating oxide coating which create an electrical environment that tends to alter the apparent polarity of the material directly beneath the oxide—an effect which is particularly pronounced in lightly doped P-type material. The channels are random in nature and erratic in characteristics, and can be highly sensitive to radiation bombardment.*

As a result of channeling, some manufacturers have reverted to earlier sili-



con mesa structures or have deliberately circumvented the oxide passivation in planar transistors in order to produce high-voltage devices. These methods have yielded high voltage ratings but other characteristics of the resulting transistors do not compare favorably with those of surface passivated devices.



Cross Section of Planar Transistor

Now, Motorola has overcome these obstacles—but it has taken a new manufacturing process to do so. Rather than trying to eliminate the channel, Motorola, in a new series of “Band-Guard” transistors, has deliberately introduced a channel whose controlled characteristics completely overshadow the variable effects of any randomly induced channel, thus providing a high degree of performance stability. Moreover the controlled channel is terminated close to the base region by a diffused annular band of the same polarity as the collector region but with a resistivity level impervious to channeling. The collector-base junction, therefore, is properly terminated underneath the oxide coating where it is protected against environmentally induced leakage currents. The resultant “Band-Guard” PNP silicon devices, for

the first time, combine the low-leakage characteristics of passivated junctions with the high-voltage characteristics of non-passivated, or mesa structures.

And, if theoretical analysis of this process is confirmed by tests now in progress, they will prove to be more resistant to radiation, thus heralding improved performance and greater reliability of space equipment.

Though initially devised for the production of high voltage silicon PNP transistors, there are strong indications that the Annular process yields major benefits for NPN and field effect transistors and other semiconductor devices as well.

In view of these considerations, there is little doubt that the new, Motorola developed Annular process will take its place among the major milestones in the advancement of the semiconductor art.

The new “Band-Guard” devices are in full-scale production and are available through Motorola Semiconductor district offices and authorized distributors. For further information write: Motorola Semiconductor Products Inc., Technical Information Center, Box 955, Phoenix 1, Arizona.

\*Patent Pending †Trademark of Motorola Inc.



## TIME IS SOMETHING YOU CAN PUSH AROUND

Until now, man has never believed he could win his war against the clock. You can hardly blame him. The moment he developed anything new or wonderful, time in its remorseless way began to destroy it. Da Vinci's rueful comment seemed right, "Oh Time, Thou that consumest all Things!" And yet, Da Vinci was wrong—refuted by his own Mona Lisa, still around nearly five centuries later.

In those five centuries, man—stubbornly determined to re-make his universe instead of re-making himself to fit—has evolved a new view of our ancient foe. Far from being the eternal tyrant, time is actually something you can push around. Only a little, so far. But camera, printing press and sound recording prove that time cannot wipe out the past. And the present lasts far longer than it used to. For we've made time slow down... curbed the old despot's destructive disposition by learning to postpone, almost indefinitely, the damage he can do. The things we use and enjoy most—cars, clothes, furniture, home—now change far less in a year than they used to change in a day.

Many of our triumphs over time... and his tag-along troops of fungi, fumes, ozone, water and ultra-violet rays... are being won by Cyanamid research. And being worn by you. Today, a fabric that's born beautiful stays that way, protected and pampered by one of Cyanamid's many

textile finishes. Wear your new golf jacket long and hard; the efficient PERMEL PLUS® finish lasts as long as the jacket, fights off rain, dirt and stains. Carry your clubs to the tropics, in a canvas or leather bag; resins and fungi-fighters ward off rot and mildew. And just relax when your wife walks in with a new print dress that looks gossamer-frail. Time will have little effect on it; only a shift in style can make it out of date.

Cyanamid science is fighting time on a lot of fronts. Even money lasts longer; a buck may be hard to hang on to—but it's much harder to tear. The resins that reinforce our greenbacks make other kinds of paper last longer, too. Paper napkins used to fall apart before the picnic started. When a paper towel got wet, you threw it away. Not any more—thanks to resins.

Metal becomes practically impervious to time with CYMEL® resins which put a mar-resistant finish on metal furniture strong enough to take a kick from a spike-heel shoe without showing a scratch. On an automobile it can deliver 100,000 miles of roadwork and still stay fresh and glossy. And ultra-violet rays—time's secret weapon to make plastics dark and brittle—get tamed by CYASORB® light absorber now used to preserve—among other things—the plastic windows in convertibles.

The same Cyanamid science that has slowed down time has managed to speed it up, as well. Instead of

waiting for a cotton plant to lose its leaves when time and nature dictate, calcium cyanamide makes it possible to shed the leaves speedily and then harvest mechanically. In giving Americans their healthy, high protein diet, AUREOMYCIN® chlortetracycline has dramatically shortened the time it takes to put high grade meat on your table. The traditional "chicken every Sunday" has become chicken any time you want it; plump, tender broilers are readied for market in about half the time it once took. Some plants, too, are getting their internal clocks re-set. The red poinsettia is a case in point. The plant you get next Christmas will probably be a perfectly matured beauty, its size controlled quite independent of normal growing time by a new Cyanamid plant growth regulant.

In many big and little ways, time isn't pushing us around quite as much as he used to. We're giving the "bald old cheat" a pinch here, a pull there. We may never be able to turn time off and on like a water tap, but sure as spaceships, we *can* make him change his ways.

*A 24-MINUTE COMMERCIAL? Yes, we have one—and in color too. It's a brand-new film all about Cyanamid entitled "What Can the Matter Be?" We think it covers the ground in an entertaining way. If you or your group are really interested to know that much about what we're up to, drop us a line. Print quantity is limited, but we'll do our best.*





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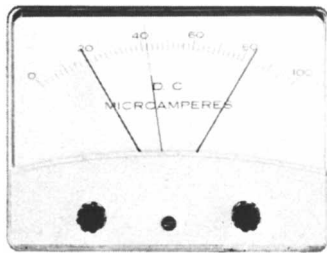
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# NEW!

## THE API OPTICAL METER-RELAY



**Continuous indication  
and control  
—without contacts**

API's new optical meter-relay is a truly remarkable instrument . . . the first to combine fiber optics, the d'Arsonval movement, and solid-state electronics in a sensitive and reliable indicating and control device. Operating without contacts, it requires no amplification and will respond to signal changes as small as 0.0125 ua or mv (or 0.750°F. as a pyrometer).

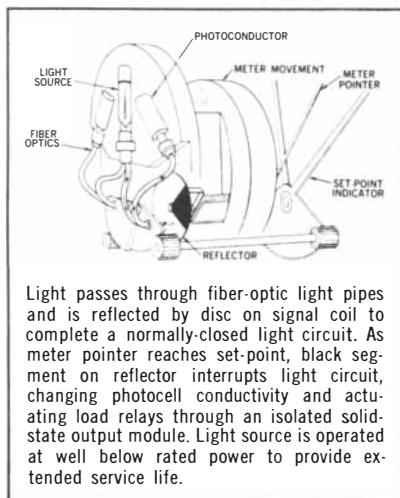
Set-points are fiber-optic light pipes; there are no other movable parts in the control phase. The measuring element is unrestricted at all times.

The optical meter-relay can monitor and control any variable that is electrically measurable. Control action is produced by the interruption of a beam of light (see below). Through a solid-state output module, the meter-relay can provide on-off, time-proportioning, or modulating (SCR) control. All are fail-safe. Full-scale sensitivity is as low as 5 ua or mv in taut-band models. Seven sizes are available from 3 1/4" to 6" in API's new Stylist/Panelist line.

**For more information on the most talked about control instrument today, request Bulletin 33.**



**ASSEMBLY PRODUCTS, INC.**  
Chesterland 5, Ohio



Light passes through fiber-optic light pipes and is reflected by disc on signal coil to complete a normally-closed light circuit. As meter pointer reaches set-point, black segment on reflector interrupts light circuit, changing photocell conductivity and actuating load relays through an isolated solid-state output module. Light source is operated at well below rated power to provide extended service life.

SA 2792



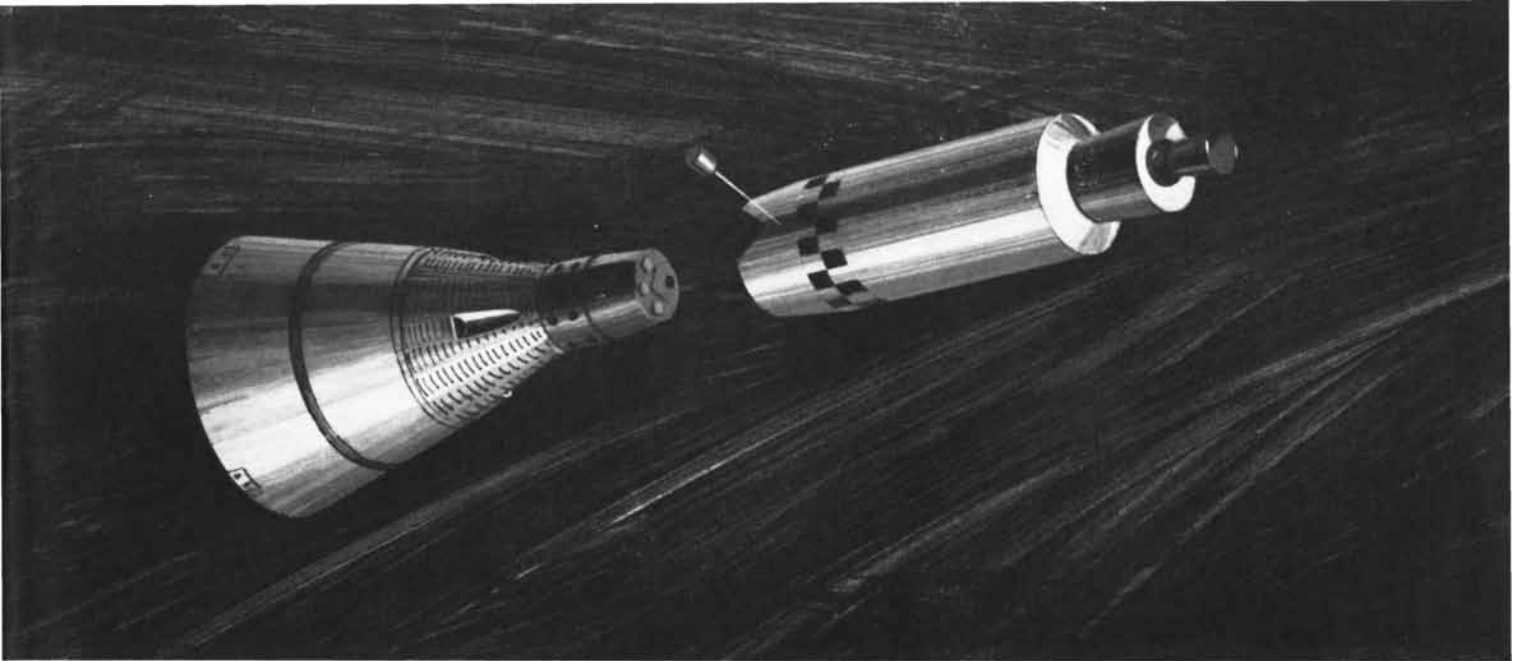
**THE COVER**

The photograph on the cover records a display of noctilucent, or "night-shining," clouds over Stockholm, Sweden, in July, 1959. The clouds appear in summer at high latitudes at an altitude of about 50 miles (see "Noctilucent Clouds," page 50). They are the highest clouds known. The photograph was made near midnight from the roof of the Institute of Meteorology at the University of Stockholm. The reddish-orange glow outlines the so-called twilight arch. The clouds shine by reflecting light from the sun when it is six to 12 degrees below the horizon. Some travel at 400 miles per hour.

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Cover photograph by Georg Witt

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## Westinghouse radar will guide the first orbital rendezvous



## Westinghouse is working on advanced radar systems for deep space missions

When the Gemini two-man spacecraft first performs rendezvous and docking maneuvers in earth orbit, a new Westinghouse radar system will help assure the success of the mission.

The Gemini spacecraft itself, one important mission of which is the perfection of rendezvous techniques, is being built by McDonnell, prime contractor for the Gemini project, under the technical direction of

NASA's Manned Spacecraft Center.

Using a unique interferometer system developed by Westinghouse's Air Arm Division, the spacecraft interrogator will transmit a series of pulses to the target transponder. Reply pulses received by the spacecraft will be used to measure range and azimuth and elevation angles.

The first of its kind in space, the Westinghouse radar system for Gemini is the be-

ginning of a new generation of advanced radars for deep space missions, lunar landings, planet exploration and space station logistic support.

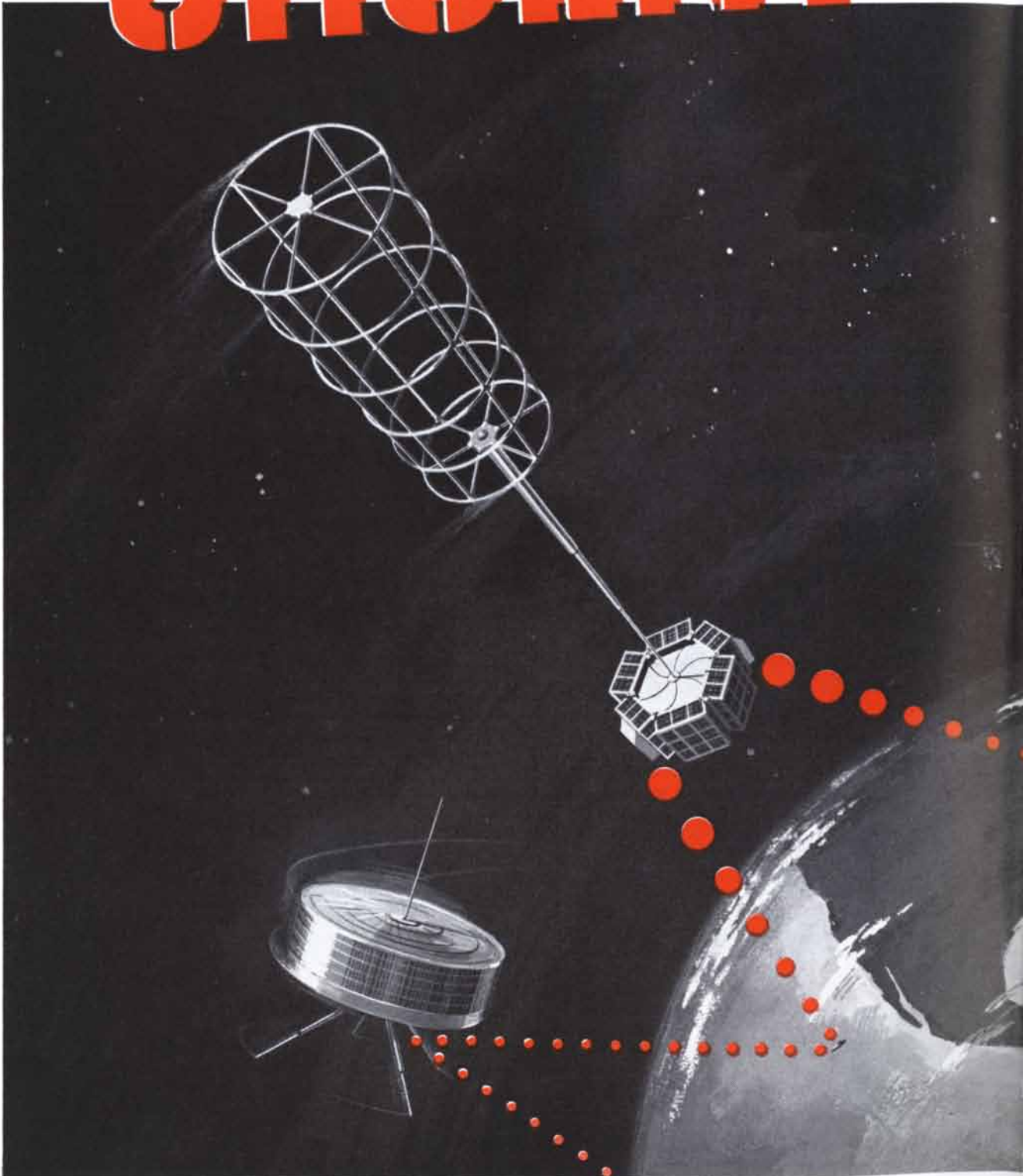
For more information on Westinghouse Air Arm Division space programs, write for new brochure, "Into Space," to Westinghouse Electric Corporation, P.O. Box 868, Three Gateway Center, Pittsburgh 30, Pa. You can be sure...if it's Westinghouse.

J-02348

**We never forget how much you rely on Westinghouse**

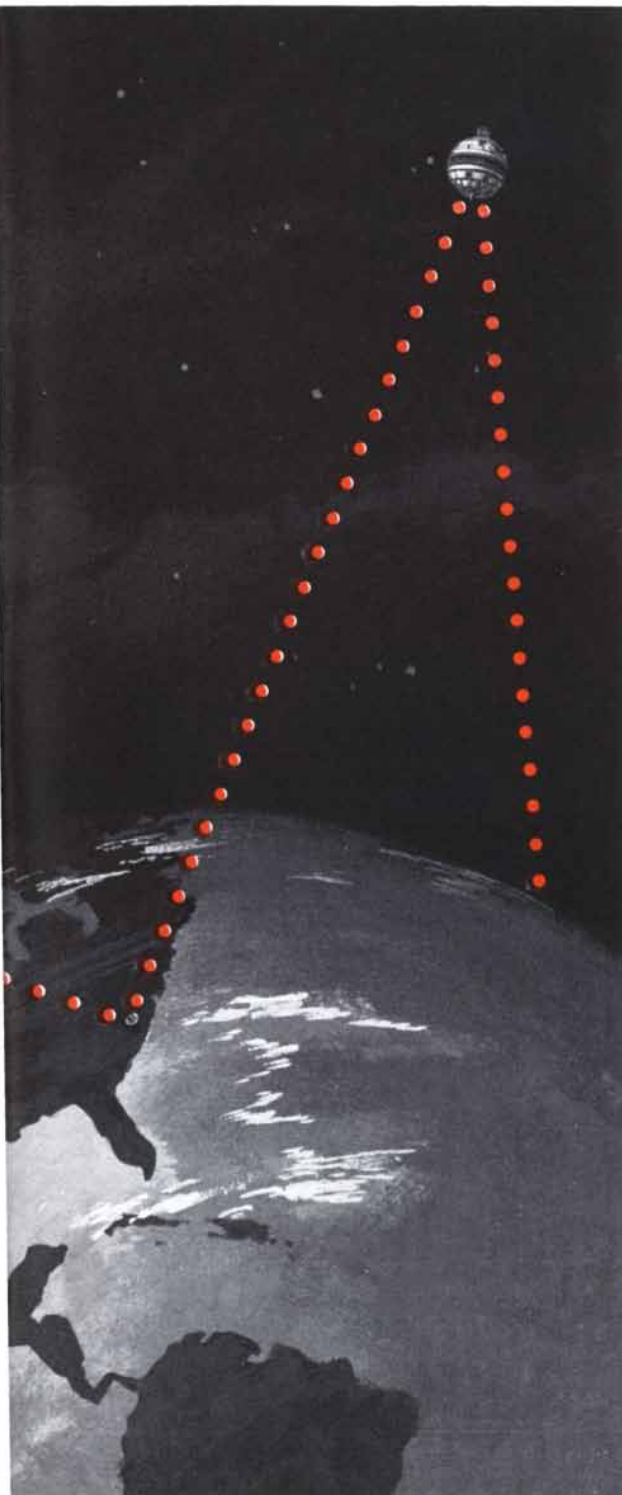


# URGENT:





# CLOSE THE GAP IN KEY DEFENSE COMMUNICATIONS!



Today, with the security of the free world so heavily dependent on unbroken communications, the scientists and engineers of General Telephone & Electronics continually work to strengthen military communications. In so doing, they have developed a capability for providing a worldwide communications network that would be free of blind spots, blackout zones, or fading.

**Such a network** would involve satellite and ground communications installations, and would require traffic control of such communications, tracking of satellites, data handling, switching, and a variety of display techniques.

**GT&E brings a wealth of experience** to all types of communications. For example, Lenkurt Electric, one of the subsidiaries, is a world leader in multichannel telecommunications systems and in microwave communications at common-carrier frequencies. Sylvania has produced many secure and low vulnerability communications systems using ultra-reliable, solid-state techniques. GT&E Laboratories with Lenkurt produced the echo suppression equipment that makes space communications practical.

**Controlling communications traffic** is an everyday function at the General Telephone operating companies. Providing near-instantaneous control for this traffic is a job performed by electronic switching systems of Automatic Electric. Space vehicle tracking, data handling and display systems, as well as the design and construction of the ADVENT antenna system, have been provided by Sylvania.

**Supporting so vital a system** with so many techniques simultaneously is one of the many ways the scientists and engineers of the General Telephone & Electronics corporate family bolster the nation's defenses. The vast communications and electronics capabilities of GT&E, directed through Sylvania Electronic Systems, can research, design, produce, install and service complete electronic systems. These systems include detection and tracking, electronic warfare, intelligence and reconnaissance, communications, data processing and display.

**That is why we say the many worlds of defense electronics meet at Sylvania Electronic Systems, Division of Sylvania Electric Products Inc., 40 Sylvan Road, Waltham 54, Mass.**

**GENERAL TELEPHONE  
& ELECTRONICS** 

Total Communications from a single source through

**SYLVANIA ELECTRONIC SYSTEMS**

Including Automatic Electric • General Telephone & Electronics International • General Telephone & Electronics Laboratories Lenkurt Electric • Sylvania Electric Products

# ingots

## reduced to

*It says  
"ultra-thin foil  
or wire"*

We have probably reduced more alloys to ultra-thin foil than any other company in the world and are experts with ultra-thin wire.

When we speak of "ultra-thin" metals, we're referring to our unique ability at Hamilton to roll foil as thin as 80-millionths of an inch. Experimentally, we've done it with just about every alloy imaginable. And some 30 different types are worked on a regular production basis, starting with ingots, bars or strip and proceeding through every operation necessary until we turn out the finished foil or strip, rod or wire.

While we're patting ourselves on the back, here's one more interesting fact our present customers appreciate: at Hamilton, our rejection rate for ultra-thin precision metals—rolled or drawn to your particular specifications—is less than 2% of gross volume!

Control at the basic stages is one key.

Trained manpower is another. Men with precise watchmaker skills have spent the better parts of their working lives as members of the Hamilton family of fine craftsmen. We've had companies come to us to do their precision work

who have the same machinery we have, yet they couldn't attain the close tolerance, the superior mechanical properties nor the faithful reproduction to specifications from lot-to-lot our men accomplish on a daily basis.

How important are our unique melt-to-finished-product capabilities? As important as the increasing demands for precision metal parts to be incorporated into today's sophisticated electronic and other equipment (diaphragms, bellows, vibration reeds, spacers, wear strips, delay lines, strain gages, et al). We're geared to deliver. Our facilities are such that we're perfectly willing to take the total responsibility . . . handling short-order prototypes or long production runs in any alloy.

A brush statement?

Frankly, a few years ago it would have been. We wouldn't have dared stick our necks out like this. Let's face it . . . unless you're sure you can handle costly ingots properly, a great deal of money can disappear into the melting furnace. Our days of doubt have been over for some time.

We think we offer industry the world's

finest reducing plan for precious metals alloys.

We'd be the first to admit that any company executive, design engineer or metallurgist in his right mind would insist that we prove what we say here is true. We want to do just that. The best way we can prove our point is to have you visit us in Lancaster and receive a personal tour of our Precision Metals facilities . . . without obligating yourself in any way. Consider this an open invitation. Meanwhile, the booklet you see below will give you a quick picture-tour and some pertinent facts. It's yours for the asking.

Then again, why not challenge us to solve your immediate problem?



**PRECISION METALS DIVISION**

**HAMILTON WATCH COMPANY**

DEPT. 3706, LANCASTER, PENNSYLVANIA • PRECISION METALS, COMPONENTS AND INSTRUMENTS FOR INDUSTRY



**on target with liquid metal technology.** Basic effort to increase our knowledge of critical technologies is fundamental to our research. Liquid metal laboratory studies have now led to product applications. Our liquid metal cell has produced electric power continuously for 24 hours. Liquid metal cools the Military Compact Reactor Allison is developing for the AEC, and is the key to an Energy Dept concept. This new technology is one more reason why our aerospace and nuclear programs are on target.

**Allison**   
THE ENERGY CONVERSION DIVISION OF  
GENERAL MOTORS, INDIANAPOLIS, IND.

## NEW APPROACH TO SPECIAL ALLOY PRODUCTION

Have you experienced the difficulty of getting small quantities of your research alloys produced with exact composition... or of tailoring an alloy more precisely to your needs?

Magnetic Metals Company's metallurgical facility can supply R & D quantities of specified alloys in a wide range of forms. Melting and alloying conditions are carefully selected to maintain close control of composition and to eliminate the usual residual and marginal impurities. Refractory and gaseous inclusions are reduced far below the normal commercial limits.

In addition to producing alloys in pilot quantities, we offer expert assistance in modifying your alloys to provide optimum performance in specific applications. We can also work with you in bridging the gap between laboratory and full-scale production—determine methods of converting the alloy into a finished component; establish procedures to grade pilot production items; arrange capable large-scale alloy production when you are ready.

These services are now available for a broad range of special-purpose alloys, including both magnetic and non-magnetic types. Our metallurgical and engineering staffs are ready to discuss your specifications and recommend appropriate procedures. Write or call Metallurgical Services Department, Magnetic Metals Company, Hayes Avenue at 21st Street, Camden 1, New Jersey. Phone: 609-964-7842.

**M**MAGNETIC  
**M**METALS

# LETTERS

Sirs:

I was fortunate enough to have read the article "Problem-solving" before turning to the "Mathematical Games" section in the April issue of *Scientific American*. Hence I could not read any of the problems proposed without first examining my attitude to see what particular psychological "set" I had assumed. Thus upon reading the problem of rearranging the letters of NEW DOOR to form one word I immediately hit on this unique "true" solution: DOORMEN!

WILLIAM T. WALSH

Brookhaven National Laboratory  
Upton, N.Y.

Sirs:

I was particularly interested in the excellent article "Ball Lightning," by Harold W. Lewis [*SCIENTIFIC AMERICAN*, March], because I performed an interesting but negative experiment on the phenomenon last year after one of our neighbors saw a kugelblitz in a thunderstorm.

Before describing my experiment I should like to make a correction to Dr. Lewis' argument that increases its force tenfold. It is stated that a cubic centimeter of air at atmospheric pressure requires 100 joules to ionize it. That is true, except that the ionized gas would reach thermal equilibrium and a temperature of 20,000 degrees Kelvin in a few microseconds, so that the original cubic centimeter would expand 240 times—60 times owing to heat and four times owing to dissociation and ionization of the air to ions and electrons. Thus the 100 joules would be distributed over 240 c.c. at atmospheric pressure, giving .4 joule per c.c., and we should be even more surprised at the water-butt phenomenon.

We regularly generate gases of this energy density at atmospheric pressure by using the induction-plasma torch at the Lincoln Laboratory of the Massachusetts Institute of Technology. Since a plasma is a good conductor, it can be heated inductively without any electrodes contacting the plasma. The plasmas we generate are spheres a few centimeters in diameter, contained in a quartz cylinder surrounded by the induction coil. After a neighbor down the street had seen a kugelblitz in a thunderstorm

and I had finally convinced myself that they were seen not just by old wives, I wondered if it would be possible to make a plasma vortex in the same fashion that the smoke rings in Times Square are generated. These rings are created by suddenly forcing air from a large chamber through a small hole. The resulting ring travels at a few feet per second, much as the kugelblitz is said to move. I put a piston upstream from the plasma in our induction-plasma torch and convinced myself that it was functioning properly by blowing smoke rings that traveled across the room. I started the plasma and pushed the piston many times, but I succeeded only in extinguishing the plasma, never propelling it from the tube. I was not surprised since I realized the low-energy density of plasmas.

This experiment only proves that kugelblitzes cannot be made in this manner under these conditions; however, even negative experiments are often suggestive to others, and I hope this description will stimulate someone to run a positive experiment that will remove the kugelblitz from the realm of witchcraft and place it securely in the domain of science.

THOMAS B. REED

Lincoln Laboratory  
Massachusetts Institute of Technology  
Lexington, Mass.

Sirs:

We should like to suggest possible identifications of some of the "organized elements" in Brian Mason's article "Organic Matter from Space" [*SCIENTIFIC AMERICAN*, March]. The hexagonal orange particle on page 45 resembles ragweed pollen grains stained by the Gridley method (illustration on page 49). It is perhaps significant that the original meteorite preparation of George Claus and Bartholomew S. Nagy, in which they found this particle, had also been stained by the Gridley method. The chromic acid used in the Gridley stain distorts the spheroidal pollen grains to a pseudo-hexagonal shape.

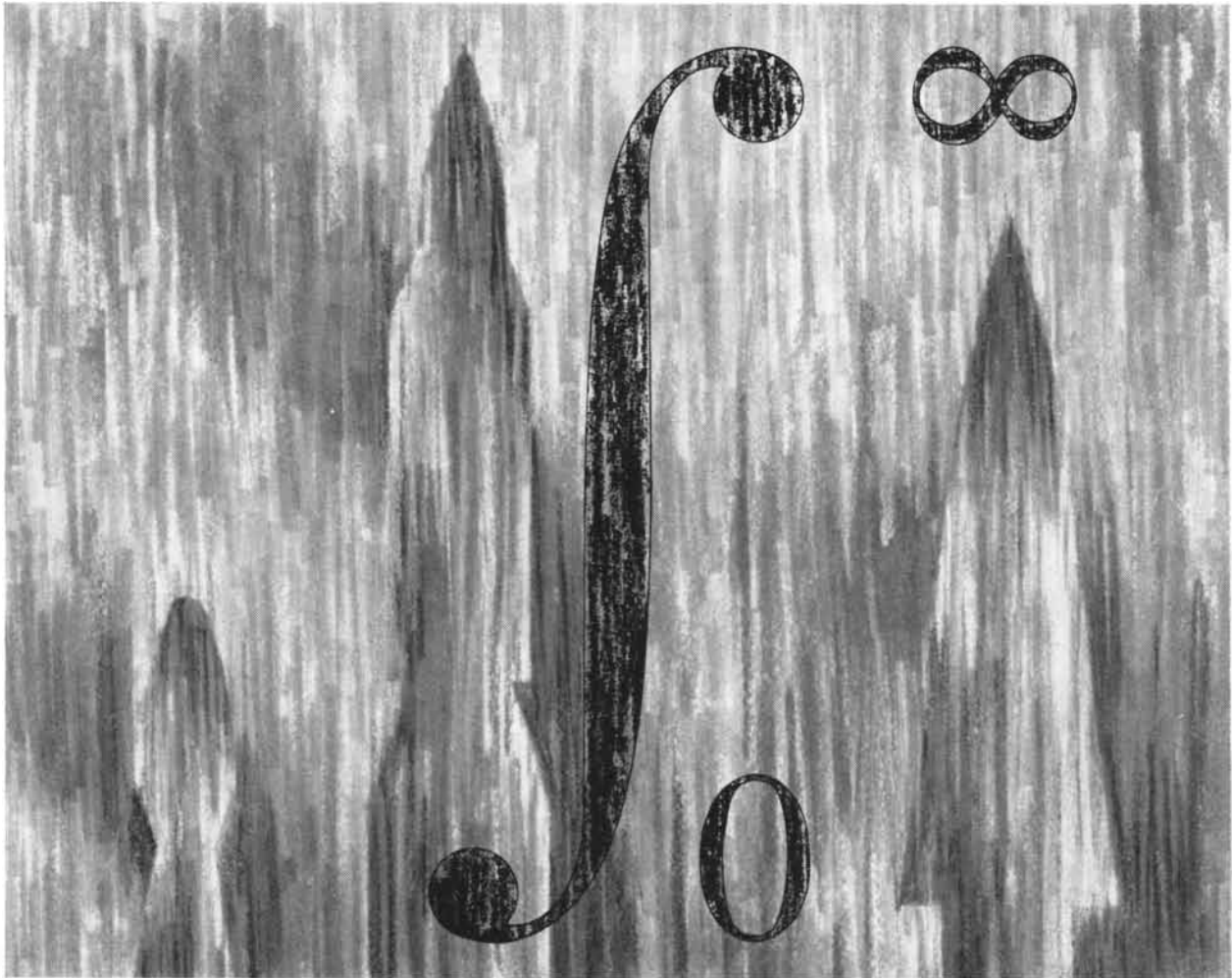
During the hay-fever season literally thousands of ragweed pollen grains can be collected on a single microscope slide in 24 hours. Unless the most stringent precautions are taken, a few pollen grains, mold spores and other air-borne contaminants are bound to find their way into meteorite preparations during the few minutes it takes to prepare a slide. Particles occurring at levels of less



Aerospace planners find themselves with a number of potential vehicle designs for any given mission. To avoid the multimillion dollar expenditures testing even a few of these would entail, industry has devised mathematical procedures that do the big job of weeding out the poorer designs. □ Douglas missile and space system mathematical simulation programs are among the most advanced and comprehensive in operation today. The company's researchers have developed a variety of procedures that "flight test" hyper-

## **MATHEMATICAL MISSILES** **...AND WHAT DOUGLAS IS DOING WITH THEM**

sonic vehicles in the laboratory... "expose" configurations to intense heating and loading environments... even conduct "battles" between missiles. Another aid is a unique Douglas viewing system which allows relationships between various parameters (trajectories, et cetera) to be observed in three dimensions.

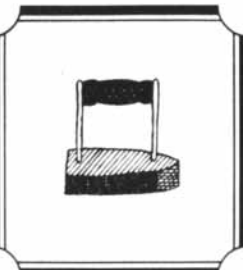


Advanced mathematical short-cuts to better aerospace systems are among the numerous research programs in 23 broad technological areas now under way at Douglas. Major Douglas Divisions are located in Santa Monica and Long Beach, California, **DOUGLAS** Tulsa, Oklahoma, and Charlotte, North Carolina.





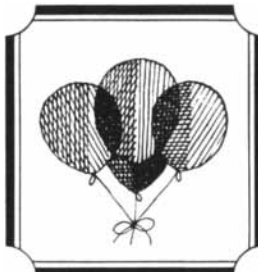
Meet "Therma-Snap" switches



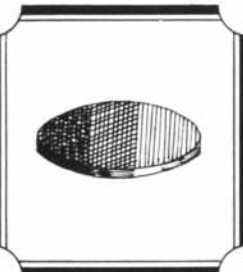
for heated surfaces . . .



a variety of liquids . . .



and aeroform environments.



With a precise bimetallic disc



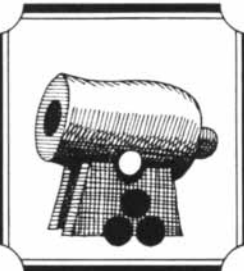
for long life, low drift



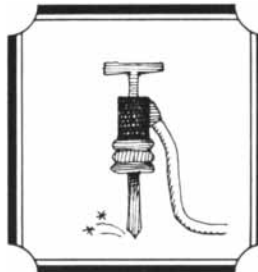
and fast "snap" action.



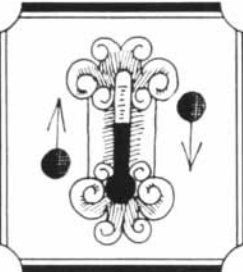
Therma-Snaps are light



can withstand a 60g shock



50g's vibration to 2,000 cps



ambients -65° to +600° F



in small, smaller and smallest.



Need accurate thermal switches?



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than 10 per slide are a priori suspect of being contaminants.

The two "organized elements" at the top of page 48 have never been seen in our preparations from the Orgueil meteorite, and they definitely do not deserve the adjective "typical." We think that the one on the left is an air-borne mold or fungus spore and the one on the right an artifact. We have not seen Frank L. Staplin's *Clausisphaera fissu* and have no opinion on it. His *Caelestites sexangulatus* appears to be an iron sulfide crystal partly oxidized to hydrated iron oxide, as suggested by Henry P. Schwarcz and George C. Mueller.

We have pointed out previously that all organized elements so far described fall into two distinct categories: complex but rare particles and simple but abundant particles. The complex particles look biological, but we think that most or all of them are earthly contaminants. The simple particles generally look like mineral grains; they have the chemical composition of mineral grains, and apart from their rather featureless morphology there is no evidence that they are not in fact mineral grains of purely inorganic origin. It would seem that further, independent criteria must be developed before an extraterrestrial biological origin of any class of organized elements can be safely postulated.

FRANK W. FITCH  
EDWARD ANDERS

University of Chicago  
Chicago, Ill.

*Scientific American*, June, 1963; Vol. 208, No. 6. Published monthly by Scientific American, Inc., 415 Madison Avenue, New York 17, N.Y.; Gerard Piel, president; Dennis Flanagan, vice-president; Donald H. Miller, Jr., vice-president and treasurer.

Editorial correspondence should be addressed to The Editors, *SCIENTIFIC AMERICAN*, 415 Madison Avenue, New York 17, N.Y. Manuscripts are submitted at the author's risk and will not be returned unless accompanied by postage.

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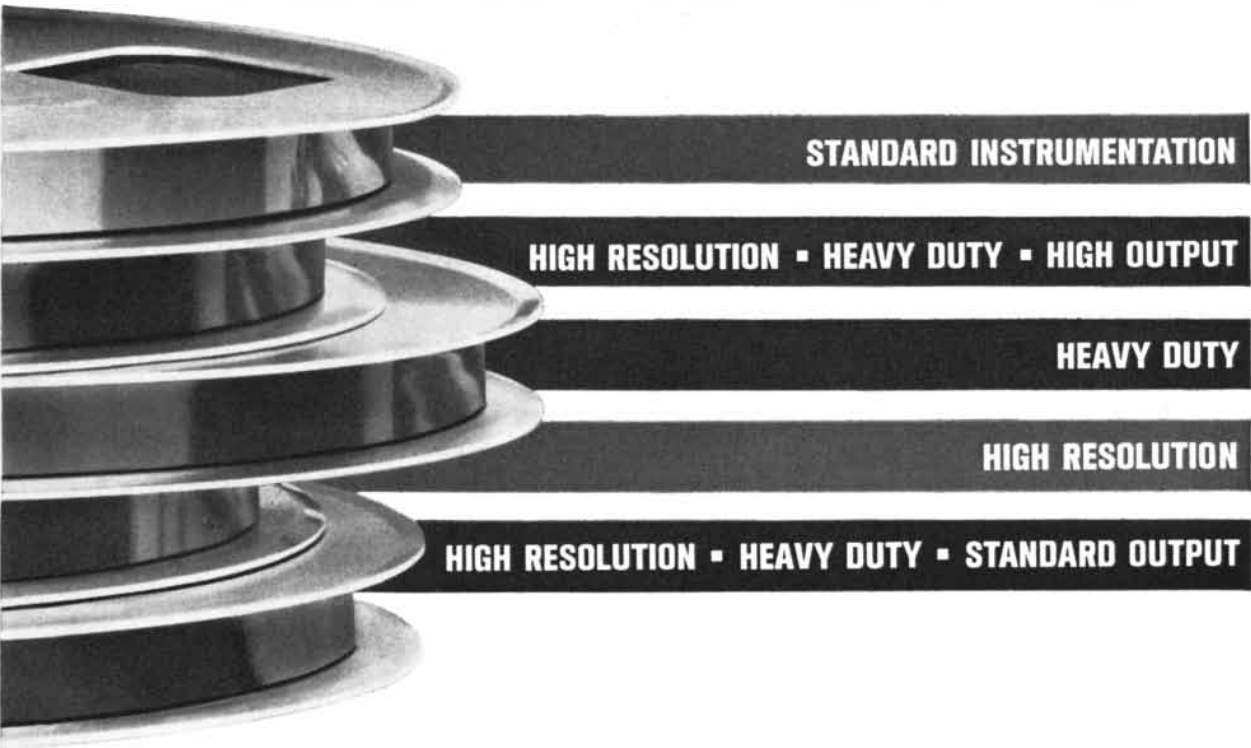
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**How do you turn out loads of laundry without**





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## loads of trouble? Borg-Warner knows how!

Doing the laundry may be woman's work, but fixing a washer when it breaks down is a man's job. And automatic washers just weren't up to the grind of daily family use before the people at Norge Division of Borg-Warner decided to change things.

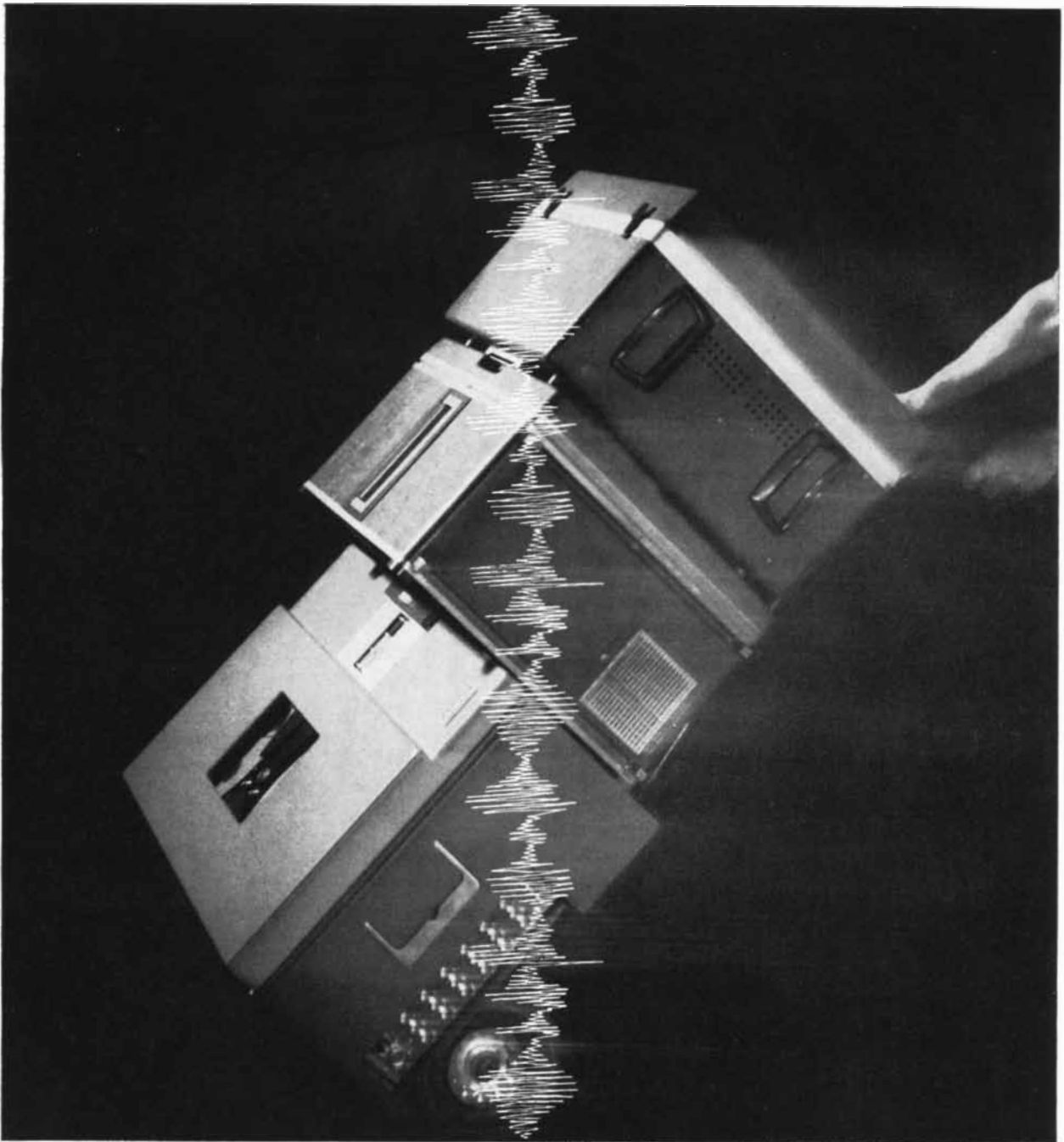
First, they tackled the problem of making automatic washers easier to service. All parts that might ever need servicing were moved *up front*, behind two easily-removed panels. Next, they devised a unique motor mount that absorbs the shock of big laundry loads so that belts, pumps and motors now last far longer.

Result: After a year's experience, the re-designed Norge automatic washer needed *half* as many service calls as the national average of all makes. And thanks to front service, repairs took *one-third* the time needed to fix other automatics.

From space-age marvels to the design and production of more trouble-free appliances, you'll find Borg-Warner research and engineering working for you. Borg-Warner Corporation, 200 South Michigan Avenue, Chicago 4, Illinois.



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Who can deliver the most complete line of portable instrumentation recorders?

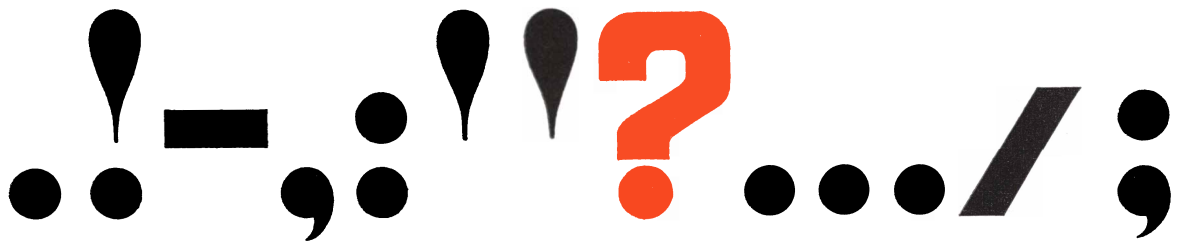
**AMPEX**

And what a line it is. There's a portable for medical, for industrial, for research applications, for rugged applications — for almost every data acquisition need. And there's a price to fit almost every budget. Behind each recorder stands the name of Ampex — to assure you true instrumentation performance all the time. On the top, above: the low-cost SP-300. It has four speeds, four tracks, push-button selection for FM or Direct recording, plus built-in attenuation, monitoring, calibration and erase. In the middle is the FR-1300. It offers 14 tracks, 300 cps to 300 KC capability on Direct, DC to 20 KC on FM and six speeds precisely controlled by a unique servo-driven capstan. On the



bottom: the rugged CP-100. It records Direct, FM-Carrier and PDM. Has a closed loop drive, six standard speeds, 14 tracks, a frequency response of up to 250 KC on Direct, down to DC on FM. And it operates on almost any source of power—including batteries. In other words, Ampex has a portable line so complete you can pick a recorder to fit your needs instead of having to modify your requirements to fit the recorder. For more information write the only company providing recorders, tapes and core memory devices for every application: Ampex Corp., 934 Charter St., Redwood City, Calif. Term financing and leasing available. Worldwide sales and service.

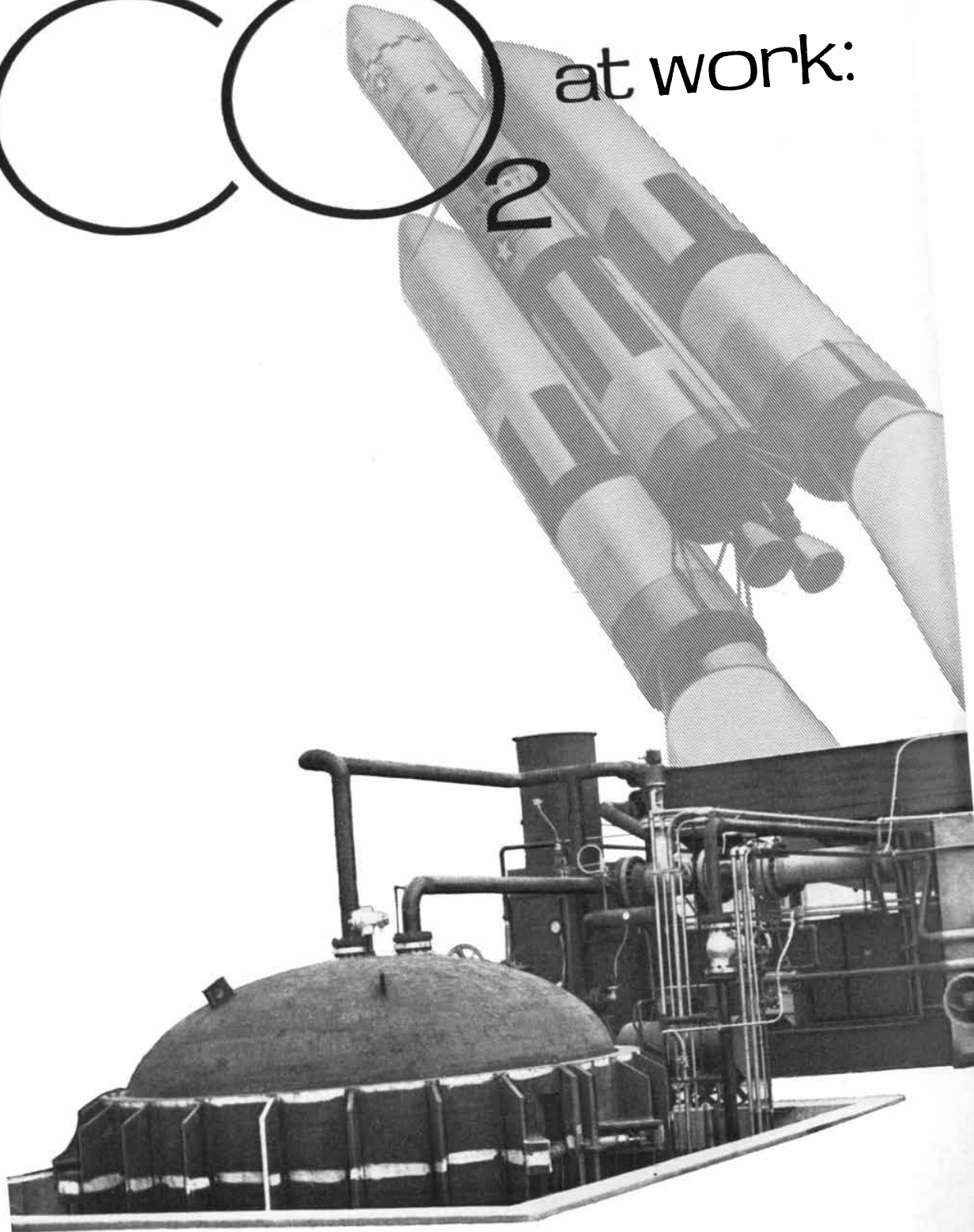




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CO<sub>2</sub> at work:





# HITCO solves a critical problem for Titan III

The TITAN III-C, one part of the Air Force's complete standard space launch system, will lift off from Cape Canaveral in mid-1965 with 2,000,000 pounds of thrust. The volcanic forces of United Technology Center's two first-stage, solid propellant boosters will be exhausted through 120-inch nozzles fabricated by H. I. Thompson Fiber Glass Company (HITCO), Gardena, California—with an assist from Liquid Carbonic.

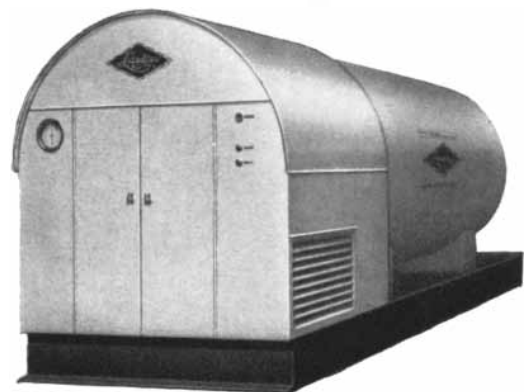
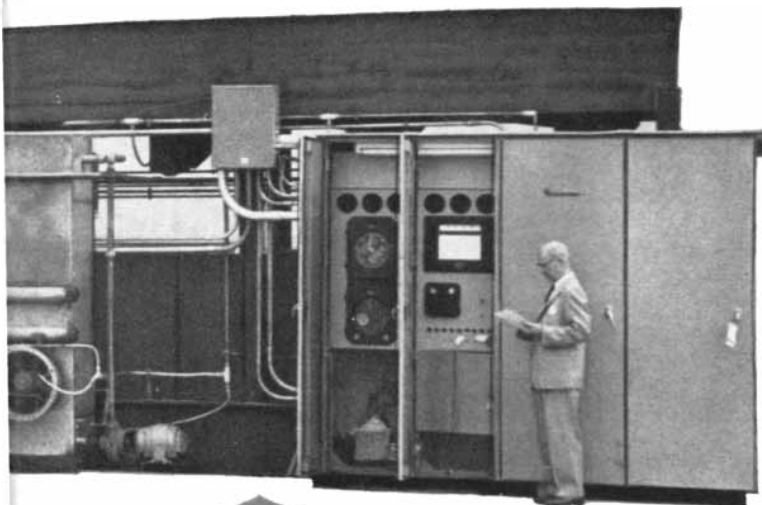
One stage of production for the mammoth rocket motors required construction of one of the nation's largest hydroclave-autoclave combinations to mold and cure ultra-high temperature resistant plastic linings for the nozzles, according to design requirements of 1000 psi (hydroclave) and 300 psi (autoclave). Liquid engineers installed the Liquiflow\* system to provide a carbon dioxide inerting atmosphere during the curing process, at the exact pressure and to completely eliminate the danger of flash fires.

The Liquiflow system, providing precisely controlled nonvolatile pressurizing gas for a most critical part of the HITCO process, has also opened the door to successful use of new, more efficient materials which had previously been considered impractical from the standpoint of volatility.

HITCO has come to rely on the advantages of carbon dioxide applications by Liquid Carbonic. In the words of Program Manager Don Slocum, "HITCO's confidence is certainly demonstrated in this latest installation of the 132-inch hydroclave-autoclave combination at Gardena. This unit, which will be used to cure some of the largest nozzles ever made, will utilize Liquid Carbonic CO<sub>2</sub>."

Look to Liquid for professional assistance on any problem requiring controlled applications of carbon dioxide, oxygen, nitrogen, argon, helium. Your Liquid District Sales Engineer is at your service.

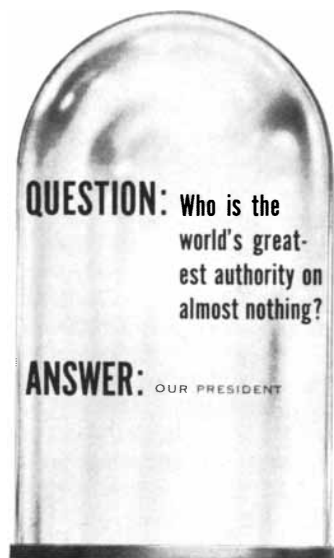
\*Registered trademark of Liquid Carbonic's low-pressure CO<sub>2</sub> system



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You can take that either of two ways, but we would prefer you interpret it in the way most favorable to Dr. X, our president, whose desire to disseminate knowledge about ion pumping transcends even the commercial instincts which impel him to visualize Ultek ion pumps on every conceivable application of high vacuum — including thin-film deposition, space simulation, surface physics studies, and vacuum tube processing.

Anyway, Dr. X did invent the ion pump (to which fact the U.S. Patent Office will attest upon receipt of 25¢ and a request for a copy of patent #2993638), but he modestly gives credit to an assist from F. M. Penning, who first made reference to the use of sputtered metal films in producing high vacuum. Penning developed a gauge which measured high vacuum, but because it had a pronounced tendency to trap gas particles, it made almost as good a pump as it did a gauge. Dr. X's ion pump, on the other hand, makes a very fine gauge!

So that you, too, can become an authority — and on quite a bit more than almost nothing — Dr. X has written a 52-page compendium of vacuous information entitled "A little bit about almost nothing," and will mail it to you upon the slightest provocation. Ask for our booklet #73.

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## 50 AND 100 YEARS AGO

### SCIENTIFIC AMERICAN

JUNE, 1913: "It is a matter of particular importance at the present juncture, in view of the recent crisis, that the people of America should take serious stock of Japanese naval development. The navy of the United States is still incomparably superior to that of Japan; but its superiority is very largely dependent upon ships built during what is known as the 'pre-dreadnought' era, and which are therefore in a state of ever-increasing obsolescence. The Panama Canal, while it will add to the mobility of the American fleet, increases its responsibilities. Four years ago M. Sartori Kato, one of the best-informed of Japanese publicists, wrote in an English naval periodical: 'Whether allowed or disallowed, Japan's insistent aspiration is to be mistress of the Pacific.'"

"Until recently leprosy had not been produced in animals for purposes of experimental study, and it is barely four years since the germ was first isolated at the Louisiana Leper House. The work of Duval and Couret in the laboratories of pathology and bacteriology at Tulane University has given a new and sure foundation for future investigation of this disease. Duval says that 'to produce the disease experimentally it seems necessary to give the animal repeated injections of large numbers of leprosy bacilli at given intervals for a period of months.' His research shows that an injection of first four million and later of four billion bacilli were given before the disease 'took.' Even after the first injection and for nearly two weeks after the injection of four billion 'there was no evidence of either localized or general infection.' The animal first infected with leprosy was a monkey (*Macaca rhesus*), the initial injection being given October, 1910. It was not until the following March that he was recognized as afflicted with a disease having all the characteristics of 'human leprosy.'"

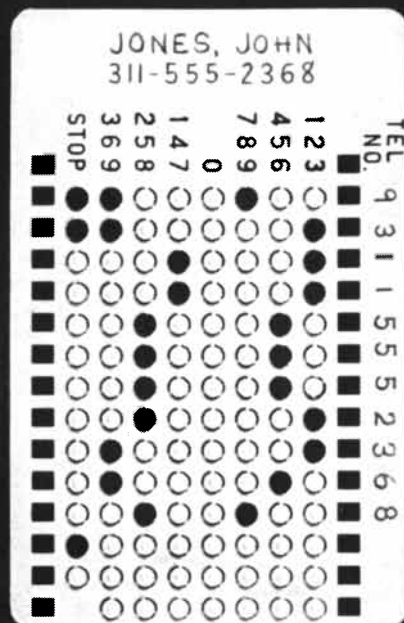
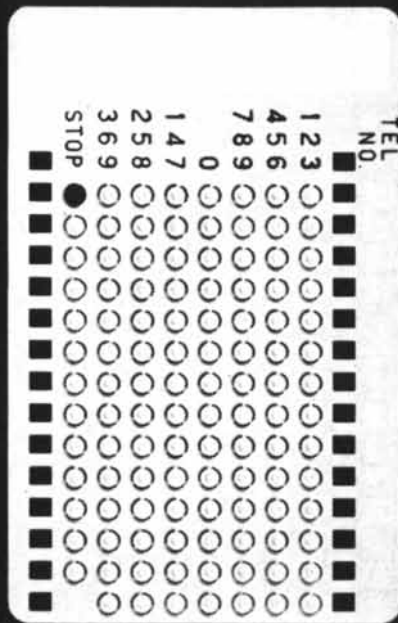
"According to Prof. T. W. Edgeworth David of the University of Sydney, Australia, the deposits of coal discovered by

the Shackleton and Scott expeditions in the Antarctic will perhaps prove to be one of the largest unworked coal fields in the world. Wild, of the Shackleton expedition, discovered seven seams of coal outcropping in a great cliff face of sandstone and shale. The thickness of these seams, inclusive of a few clay bands, was seven feet. Specimens chopped out by Wild with his ice ax have been analyzed at Sydney and show the coal to be of workable quality. Scott's geologists traced this field for a distance of 650 miles, extending northward from the head of the Beardmore Glacier."

### Scientific American.

JUNE, 1863: "It is one of the anomalies of our condition of civil war that our foreign commerce is unusually prosperous, even with the draw-back of the depredations of the rebel steamers. The exports from New York to foreign ports, during 10 months of the current fiscal year, amounted in value to \$206,317,200, against about \$126,000,000 in the corresponding period of the two preceding years. The imports thus far this year amount to \$155,613,100, against \$117,385,400 in 1862 and \$196,795,200 in 1861. The revenue from customs at New York has been \$43,421,008, against \$26,814,182 in 1862 and \$26,358,740 in 1861. In Philadelphia, Boston and other ports a corresponding improvement is noticed."

"The magnetic needle is like a wind vane, as it serves to render visible the direction and intensity of that mysterious force which operates through the earth. Observations upon the magnetic needle reveal the fact that it will sometimes start and oscillate with great activity without any apparent cause, and it has been noticed that magnets in various parts of the world are always thus agitated at the same moment. It is believed that these phenomena have a connection with movements in the sun. Prof. Schuabe of Dessau has been watching the disc of the sun for nearly 40 years, and he has recorded the groups of spots which have appeared upon it. He has found that these occur in greater number in periods of about 10 years. They were noticed in 1848 and 1859, and in these two years great disturbances of the magnetic needle were observed. Magnetic storms are always accompanied by auroræ and earth magnetic currents. It appears that magnetic disturbances oc-



a card that remembers telephone numbers and dials them for you

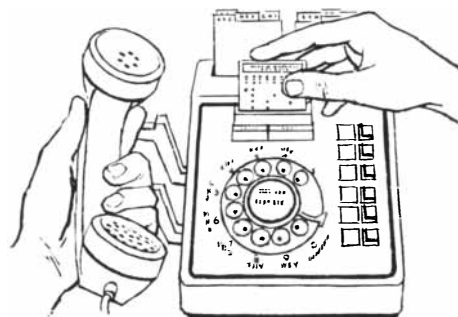
How can you make a telephone remember numbers you often call and then dial them for you?

Engineers at Bell Telephone Laboratories are solving this problem in more than one way. One solution is the Card-Dialer telephone shown at the right. Here the required memory is in the form of economical plastic cards which fit into a slot in the telephone.

Each card contains a complete telephone number punched out in a simple pattern (see upper right). When a card is inserted in a Card-Dialer telephone, the recorded number is automatically dialed. To do this, the telephone senses the code on the card and generates a corresponding train of dial pulses. These pulses are then detected by central office equipment in the same way as those generated by a regular telephone dial. Simply by punching out the necessary holes with a pencil, you can prepare as many cards as you wish for both local or Direct Distance Dialing.

The new Card-Dialer telephone is now being manufactured for the Bell System by the Western Electric Company.

*As the card is pushed down, the square holes engage sprockets which wind a spring. Then, as the card emerges, it contacts plastic rollers which detect the round holes and appropriately actuate a pulse generator. The 2-out-of-7 code is easy to use and does not require a costly sensing mechanism.*



**Bell Telephone Laboratories**

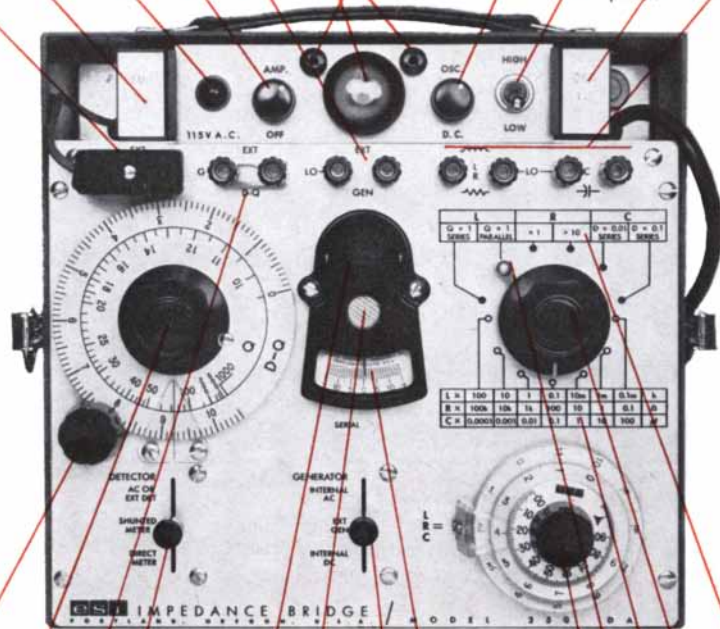
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Detector output terminals for meter or oscilloscope display.  
 AC/DC generator switch and AC generator voltage control.  
 Switch for setting the DC level for maximum sensitivity resistance measurements.  
 Resistive tuning network for setting oscillator frequency.  
 Terminals for connecting unknown component and for making special connections for unusual measurements. All bridge corners available on front panel.



D-Q Vernier control makes bridge balance easier.  
 D-Q dial balances the bridge and indicates value of dissipation factor D or quality factor Q as indicated by circuit selector switch.  
 Terminals permit extension of D and Q ranges by connection of external resistance.  
 Switch chooses between external detector terminals which normally have the bridge AC detector connected to them and the shunted or direct galvanometer connection.  
 The zero position of the galvanometer can be set.  
 Galvanometer can be locked when the bridge is moved.

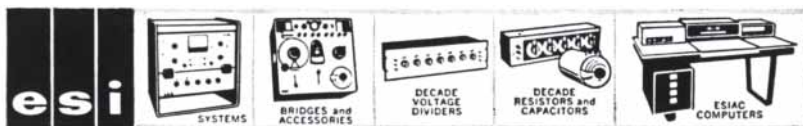
D-Q range values multiplied by D-Q dial setting give value of dissipation factor D or quality factor Q. Two Resistance Multipliers Range dial chooses value and units  
 Circuit selector switch chooses bridge circuit.  
 Range value and units multiplied by LRC dial reading give value of unknown.  
 LRC dial balances the bridge. 12,005 dial divisions of resolution for finding resistance, capacitance or inductance value.  
 Resistance bridge null is read on galvanometer.  
 Switch chooses between generator connected to external generator terminals and internal AC and DC generators.

## MODEL 250DA UNIVERSAL IMPEDANCE BRIDGE

Resistance to 0.1%, eight ranges; Capacitance to 0.2%, seven ranges; Inductance to 0.3%, seven ranges. Simple in-line readout—12,005 dial divisions of resolution. This is the bridge that has been the industry pacesetter since its introduction—the bridge that dollar for dollar offers the most in bonus advantages. For detailed information, send for Catalog Sheet C-16

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cur in the sun, in the earth's atmosphere and in the earth itself, at the same time and at regular periods. The mysterious force, 'magnetism,' seems to pervade the entire solar system, and perhaps the whole universe."

"We lately noticed that during a balloon ascent in England Mr. Glaisher found that it required a much longer period of exposure to light to take photographic pictures at high elevations than upon the ground. From this statement many persons have concluded that the actinism of the solar ray decreases with altitude above the surface of the earth. This is not the case, as Prof. Piazz Smith of Edinburgh obtained results the very opposite of those of Mr. Glaisher when the former made his astronomical observations at Teneriff in 1857. At an elevation of three miles the actinic intensity in Teneriff was as seven to three at the level of the sea. Some other cause than mere elevation must have affected the photographic action during the balloon ascent of Mr. Glaisher."

"Mr. William Bullock of Pittsburgh, Pa., has recently produced a press capable of printing a newspaper complete before it issues from it! Most persons are aware that a newspaper is ordinarily printed on but one side at a time, and that it has to be put through the press twice in order to finish it. This duplicating is avoided in Bullock's press; the paper is fed from a large roll, and cut off at the proper time by a suitable apparatus, thus avoiding all unnecessary handling, both in the sheet and in transferring the paper from one press to another, also doing away with feeding by hand. We saw this press in operation a short time since, and it then worked very well indeed, at the rate of 9,000 finished sheets per hour!"

"An unique barometer for measuring small atmospheric disturbances has recently been devised by Dr. Joule of Manchester, England. It consists of a large glass carboy connected by a glass tube with a miniature gasometer, formed by inserting a small platinum crucible over a small vessel of water. The crucible is attached to the short end of a finely-suspended lever, multiplying its motion six times. When the apparatus was raised two feet, the index moved through one inch; hence he was able in serene weather to observe the effect corresponding to the elevation of less than one inch. The barometer is undoubtedly very sensitive and is highly spoken of amongst scientific circles in Manchester."

## It almost ties itself!

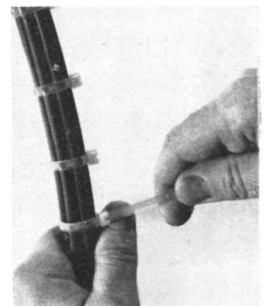
"Self-Tying TY-RAP™" is its name. We would like to send you a sample.

Not a "sophisticated device" — but rather a practical, new concept for fastening. Wherever the bundling of wire, cable or tubing is made with string, tape or miscellaneous clamps, TY-RAP offers economies. Our customers have recorded cost reductions from 40% to 60%. An engineer on the West Coast reported \$155,000.00 in cost reductions for a 12-month period.

TY-RAP products provide a complete cabling system which enhances the appearance of all equipment wiring. It consists of color-coded ties, clamps and identification plates. Hand and air tools are available for high-speed production. The fabrication of harnesses and tying cable bundles can be put on a measurable basis. Appearance, workmanship, reliability and cost can now be evaluated in engineering terms. Training time is cut by 70%, 46 sizes of clamps eliminated from inventory and harnessing time improved 40% to 60%.

If your firm uses wiring or tubing, there are uses for TY-RAP cable ties and straps. The TY-RAP cable tie is a nylon strip, engineered to securely lock around anything from  $\frac{3}{16}$ " to 4" in diameter — quickly, neatly and more economically than *anything* presently available. Remember it almost ties itself — and also meets MIL specs (no matter who does the tying). MIL-S-23190 (WEP) specifically covers TY-RAP cable ties and identification ties. Other applicable MILS specs are also met.

Write to the Thomas & Betts Co., TY-RAP Section, Elizabeth, New Jersey for your sample and evaluate this new cost reduction method.



PATENT PENDING

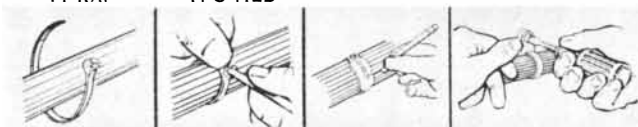
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SLIP ON  
TY-RAP

PULL TIGHT  
IT'S TIED

IDENTIFYING

CLAMPING

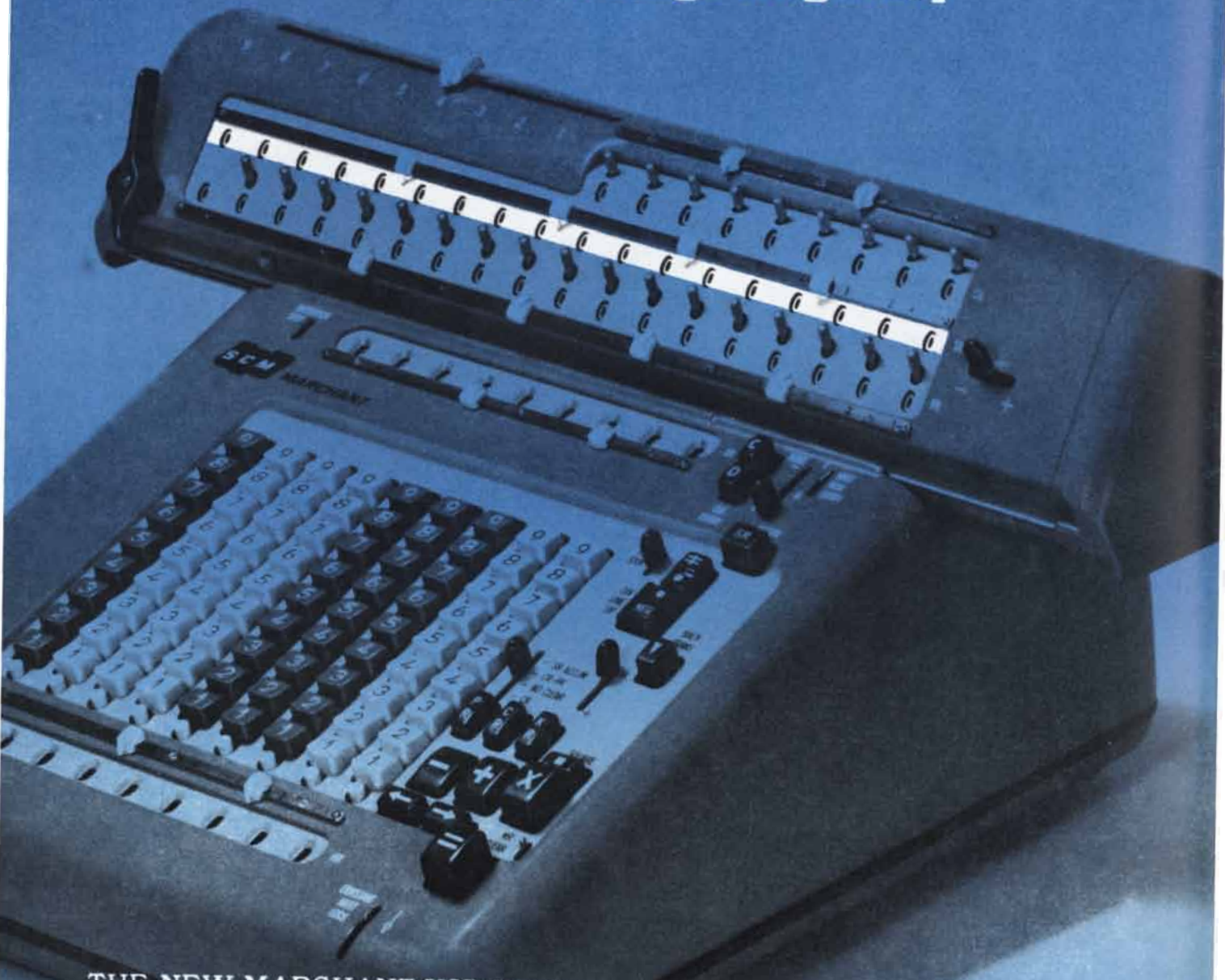


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# Why you should wear ACCUTRON® instead of a watch

ONLY THE ACCUTRON TIME-PIECE is guaranteed 99.9977% accurate on your wrist (not just in a test laboratory).

ONLY THE ACCUTRON TIME-PIECE does away with the hair-spring and balance wheel, the parts which limit the accuracy of all watches.

ONLY THE ACCUTRON TIME-PIECE—with just 12 moving parts—is so rugged, so trouble-free you can forget about usual watch maintenance and repair.



ONLY THE ACCUTRON TIME-PIECE keeps time by the constant vibrations of a tuning fork activated electronically. It doesn't tick. It hums.

THE ACCUTRON TIMEPIECE never, never needs winding—even off your wrist. Power cell lasts a full year. Second year's cell free. Additional cell only \$1.50.

ACCUTRON has been selected as a timing device in U. S. space satellites and Telstar 1.

Above: Revolutionary electronic tuning fork mechanism of ACCUTRON seen through transparent dial of "Spaceview" model. 14-KT gold case. \$200\*

ACCUTRON is the only timepiece guaranteed 99.9977% accurate on your wrist. It makes the finest watches—even electric watches—obsolete.



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The ACCUTRON timepiece already has become the new world standard of accuracy. It was purchased by the U.S. Air Force for every X-15 pilot. It's approved for use by all major railroads. And it's the timepiece of leaders in science, industry and government.

See ACCUTRON—the most distinctive timepiece you can own, the most unique gift you can give. Your choice of many distinguished waterproof\* and shock-resistant styles, from \$125 to \$2500\*.

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**Read the ACCUTRON guarantee of accuracy!** ACCUTRON is guaranteed by Bulova not to gain or lose more than one minute a month in actual daily use on your wrist. For one full year from date of purchase, the authorized jeweler from whom you purchased your ACCUTRON timepiece will adjust it to this tolerance, if necessary, without charge.



ACCUTRON "214" Brilliant stainless steel case, raised dial markers. \$125\*

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of Laser crystals—at temperatures above 1700°C!**

Growing high-purity calcium tungstate Laser crystals involves intense heat and continued high temperature cycling. Temperatures often go far above 1700°C and contamination must be avoided.

That's why the Solid State Materials Corporation—a leading producer of Laser crystals and a subsidiary of the Perkin-Elmer Corporation—specifies iridium crucibles for growing these crystals. They find that crucibles of iridium are the only containers which perform satisfactorily under these severe high temperature conditions.

Most experts consider iridium crucibles absolutely essential in growing refractory crystals at temperatures ranging to 2000°C. (Rhodium and platinum crucibles are considered equally satisfactory for growing crystals at lower temperatures.)

#### **It could pay you to use a Platinum Metal**

Your problem might be readily and economically solved with a Platinum Metal—where freedom from product contamination at high temperatures is required, such as in the growing of Laser crystals...where superior electrical properties are required, such as in grid wires...where high temperature corrosion and spark erosion are involved, such as in aircraft sparkplugs...where wear-resisting, non-tarnishing surfaces are required, such as for printed electrical circuits...where a combination of severe corrosion and erosion must be met, as in the case of spinnerettes for rayon production...where peak catalytic efficiency is required, as in the refining of high octane gas-

oline...or where product purity must be retained despite high temperatures, as in the case of lens glasses...the Platinum Metals have proved to be the most economical for certain critical equipment.

Industry is going to higher temperatures and higher pressures. Perhaps your own progress has been blocked by the limitations of materials to withstand such severe conditions. The Platinum Metals have removed many barriers. Have you considered them for your problems?

Platinum, palladium, rhodium, ruthenium and iridium have unique potentials, well worth your attention. Specialists are prepared to work closely with you in evaluating these metals for new commercial and scientific uses.

As a first step, write us for additional data on the outstanding characteristics and successful applications of the six Platinum Metals and their alloys—indicating your field of interest or how we might be of assistance.

<b>CAN THESE PROPERTIES OF THE PLATINUM METALS HELP YOU?</b>
High Temperature Stability Exceptional Chemical Inertness Superior Wear Resistance Peak Catalytic Activity Low Vapor Pressure

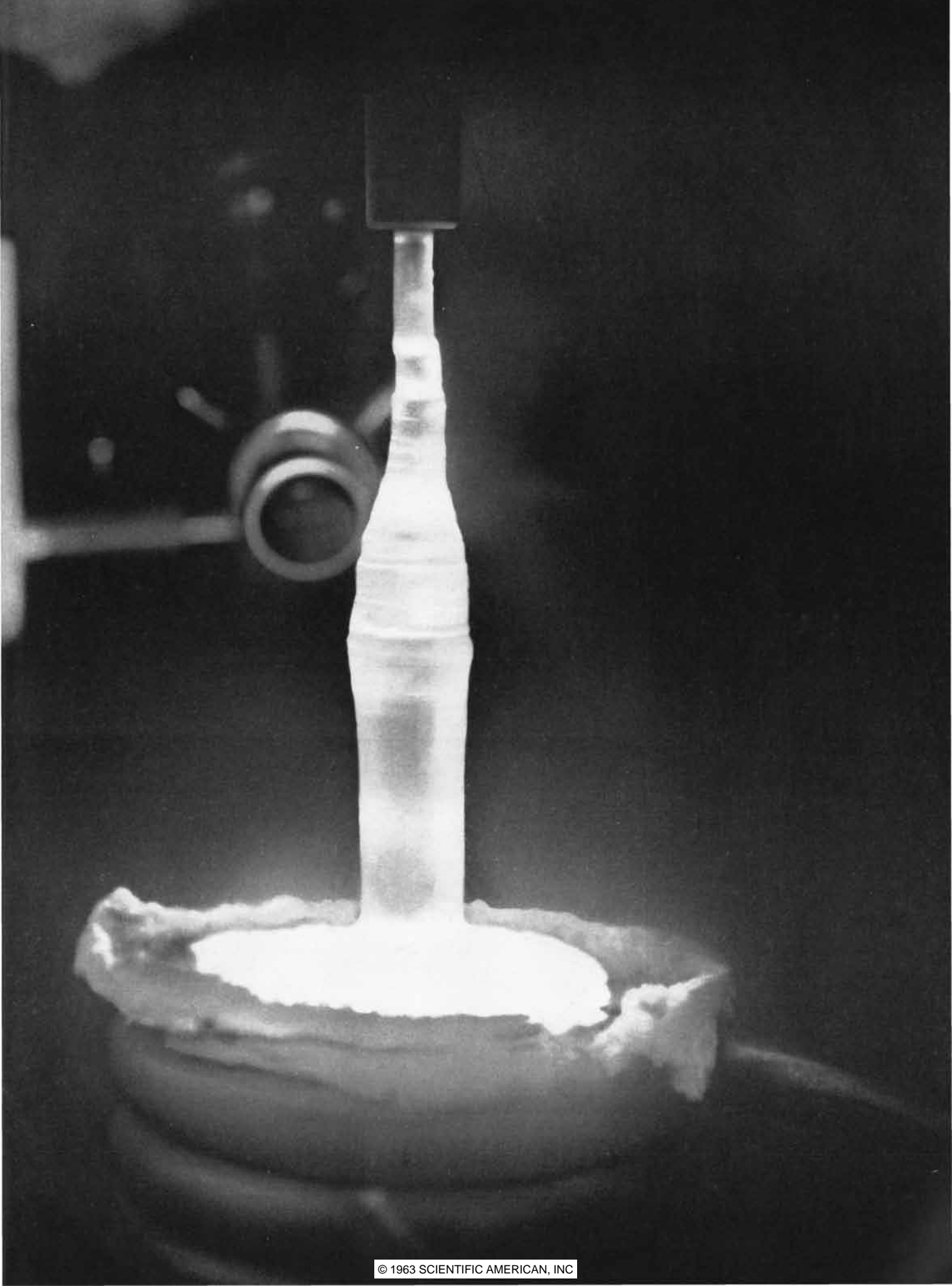
*The six Platinum Metals are:*

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**PLATINUM METALS DIVISION**

The International Nickel Company, Inc., 67 Wall Street, New York 5, New York





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Can you use such a material that is also low in cost, light in weight, structurally strong, corrosion resistant, impervious to moisture, has color clear through, won't warp or rust, is easy to fabricate and consistently uniform in quality? If so, write for data plus a set of color chips as illustrated above: B.F. Goodrich Chemical Company, Dept. CA-6, 3135 Euclid Avenue, Cleveland 15, Ohio. In Canada: Kitchener, Ontario.

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## THE AUTHORS

GEORGE M. WOODWELL ("The Ecological Effects of Radiation") is assistant ecologist in the department of biology at the Brookhaven National Laboratory in Upton, N.Y. Woodwell went to Brookhaven in 1961 to initiate and direct a research project on the effects of radiation on ecological systems. He points out, however, that this project is the product of the efforts of a large number of colleagues and collaborators at Brookhaven and elsewhere. Woodwell originally studied botany at Dartmouth College, receiving an A.B. in 1950. After three years at sea with the Navy (which included service on two oceanographic survey ships), Woodwell studied botany at Duke University, where he acquired an A.M. and a Ph.D. in 1956 and 1958. He became a member of the faculty at the University of Maine in 1957 and formally joined the Brookhaven staff in his present post in 1962.

ROBERT K. SOBERMAN ("Noctilucent Clouds") is chief of the Meteor Physics Branch at the Air Force Cambridge Research Laboratories in Massachusetts and associate professor of physics at Northeastern University. Soberman obtained a B.S. from the College of the City of New York in 1950. He then did graduate work at New York University, receiving a Ph.D. in 1956 with a doctoral thesis on cosmic rays. Soberman spent a year at the General Electric Vallecitos Atomic Laboratory and three years with the Avco Research and Advanced Development Division before joining the faculty of Northeastern University. In 1960 Soberman went on indefinite leave from Northeastern to head a meteor-physics research program for the Air Force, part of which has involved the studies discussed in his article.

KLAUS DRANSFELD ("Kilomegacycle Ultrasonics") is associate professor of physics at the University of California at Berkeley. Dransfeld was born in Germany and studied philosophy and physics at the University of Cologne. At first attracted by the philosophical implications of quantum theory, he later discovered great enjoyment in preparing experimental demonstrations for the lectures of Clemens Schaefer, with whom he did his doctoral thesis on ultrasonics. After receiving a Ph.D. in 1952, Dransfeld remained at Cologne until 1954, when he went to the laboratory of the

late Sir Francis Simon at the University of Oxford. His two years there, spent in doing research on several aspects of superfluid helium, introduced him to the general field of low-temperature physics. In 1956 he joined the Bell Telephone Laboratories, where much of the work he describes in the present article originated. Dransfeld joined the faculty at Berkeley in 1960.

H. S. MAYERSON ("The Lymphatic System") is professor and chairman of the department of physiology at Tulane University. Mayerson obtained an A.B. from Brown University in 1922 and a Ph.D. in physiology from Yale University in 1925. He went to Tulane in 1926, becoming professor of physiology and chairman of the department in 1945. He was president of the American Physiological Society in 1962 and served on the board of directors of the American Heart Association from 1954 to 1960. Mayerson's numerous other activities have included his association with the National Research Council in various capacities: as a representative of the Biology and Agriculture Review Committee on the International Exchange of Persons, from 1955 to 1957; as a member of the Committee on Shock, from 1954 to 1961; and, since 1961, as a member of the National Committee for the International Union of Physiological Sciences.

MORTON S. ROBERTS ("Hydrogen in Galaxies") is lecturer in astronomy and research associate at the Harvard College Observatory. Roberts received a B.A. in 1948 from Pomona College, where a job at the college observatory eventually led him to do graduate work in astronomy. From 1949 to 1952 Roberts taught physics at Occidental College (acquiring an M.Sc. from the California Institute of Technology in 1950). He worked for a year as a physicist in underwater ordnance for the Navy Department and then went to the University of California, which awarded him a Ph.D. in 1958. Roberts joined the Harvard Observatory in 1960.

JOHN PAPADIMITRIOU ("The Sanctuary of Artemis at Brauron") was General Director of Antiquities and Historical Monuments of Greece. He died in April of this year, shortly after completing the present article. Papadimitriou's career as an archaeologist spanned a period of 37 years, beginning in 1926, when he was graduated from the faculty of philosophy at the University of Athens. From 1930 to 1958 Papadimitriou was successively curator



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In the beginning, LAND-ROVERS were used by the world's armies (26 of them), police forces (37 of them), border patrols, big game hunters, archeologists, titled persons (mostly for country use), oil companies, farmers, lumbermen, explorers, foresters, and so on. Now, lots of other people are buying them too: commuters, doctors, skiers, gentlemen farmers and members of hunt clubs, antiquers, rock hounds, dog trainers. Even racing drivers buy them (all aluminum alloy body and eight speeds forward). The LAND-ROVER's a lot of fun--you're never frustrated--you can do anything--go anywhere--see everything--in short, it's GRAND SPORT!

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This is the Heat-Shield Roof, one of a whole battalion of unique features.





*For want of a nail . . .  
 . . . the kingdom was lost . . .*

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The problem is not a new one . . . we can trace the source of our nursery rhyme to one John Gower, circa 1390 AD. Be that as it may, reliability *is* a problem today . . . a very real one!

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of antiquities and director of the museum on the island of Corfu, ephor (superintendent) of antiquities at Argolid and ephor of antiquities in Attica. He became General Director of Antiquities of Greece in 1961. Of his many excavations, the most important were at Mycenae and Brauron.

GILBERT W. KING and HSIEN-WU CHANG ("Machine Translation of Chinese") are respectively vice-president and director of research of the Itek Corporation and manager of systems organization and logic in the Experimental Systems Department of the International Business Machines Corporation. King received his B.S. and Ph.D. degrees in 1933 and 1935 from the Massachusetts Institute of Technology and then was a National Research Fellow at the California Institute of Technology, Harvard University and Princeton University. He went to IBM as a senior scientist in 1958, having previously been a research chemist for Arthur D. Little, Inc., and chief engineer for the International Telemetering Corporation. Prior to his subsequent appointment as director of research for IBM, he was directly responsible for all programs concerning information retrieval and the automatic translation of languages by computer. King, who joined Itek this year, is a member of the President's Science Advisory Committee Panel on Problems of Scientific Information and head of the Library of Congress' study group for information retrieval. Chang holds B.S. degrees in electrical engineering and mathematics and an M.S. in electrical engineering from the University of Michigan. After obtaining the last in 1957, Chang joined IBM, where during the past several years he collaborated with King in the research they discuss in the present article.

VICTOR H. DENENBERG ("Early Experience and Emotional Development") is professor of psychology at Purdue University. Denenberg acquired a B.A. at Bucknell University in 1949 and an M.S. and a Ph.D. at Purdue in 1951 and 1953. From 1952 to 1954 he did research at George Washington University on problems and methods of training military personnel. He joined the Purdue faculty in 1954.

J. BRONOWSKI, who in this issue reviews Ivor B. Hart's *The World of Leonardo da Vinci: Man of Science, Engineer, and Dreamer of Flight*, is the author of books on mathematics, poetry, science and the history of ideas.



## New brilliance for records...

Have you ever had trouble with dust clinging to your phonograph records—clogging the grooves, collecting on the needle, and spoiling the most carefully reproduced sound? That happens when a record builds up static electricity and becomes a magnet for dust every time it's played. ▶ But Union Carbide scientists have found a way to end this nuisance. Into the vinyl plastic developed for records, they have built a special anti-static agent. Already more than 50 million stereo records have been produced from this improved plastic. ▶ Ever since the creation of the first vinyl phonograph record, Union Carbide has worked closely with the leaders in the record industry to achieve the brilliant high-fidelity available to you today. Vinyl is one of the important family of BAKELITE brand plastics, which includes phenolics, styrenes, epoxies, polyethylenes, and polypropylenes. Pioneers in plastics for more than 50 years, the people of Union Carbide are continuing their research in these useful materials.

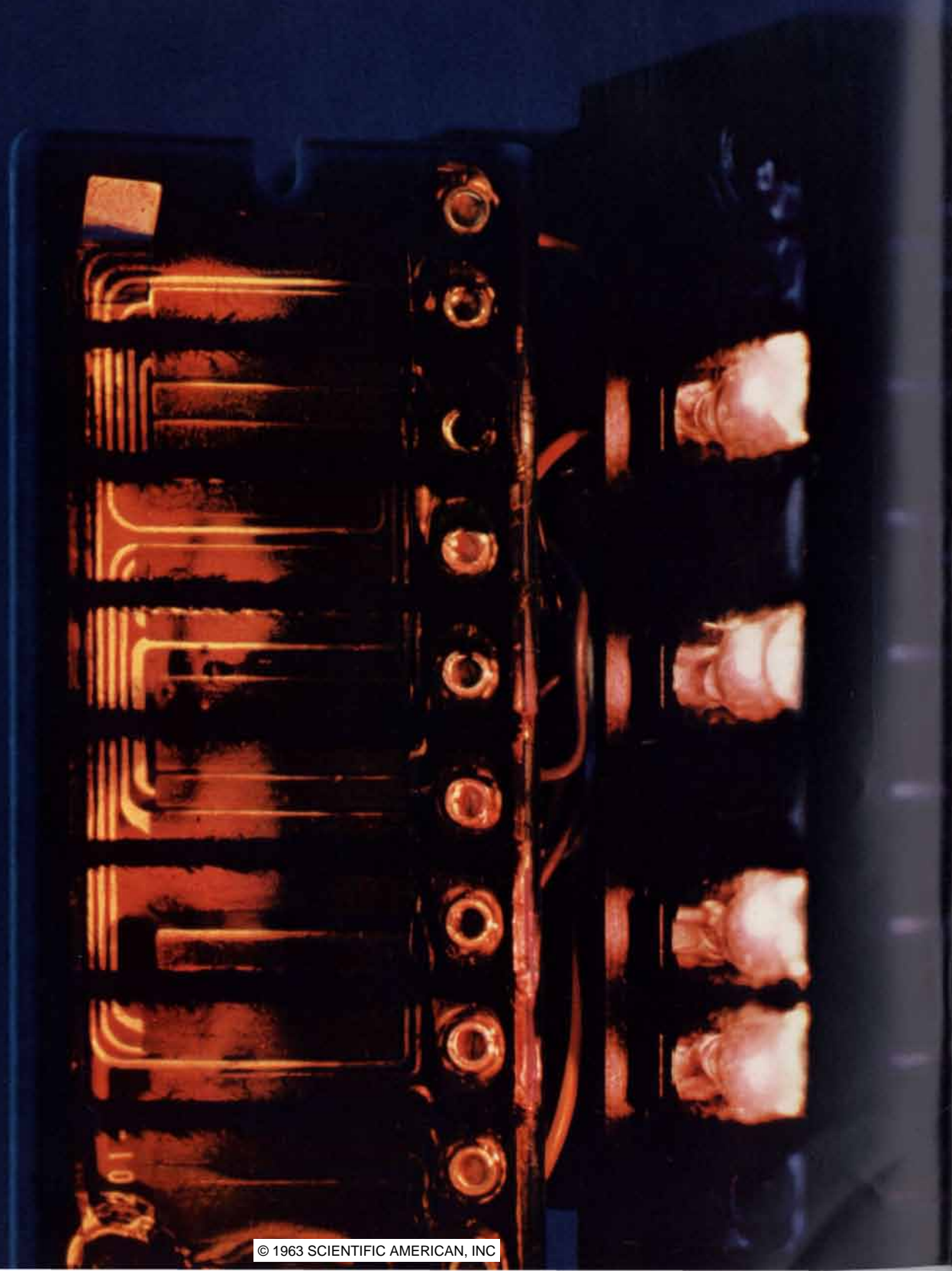
A HAND IN THINGS TO COME

LOOK for these famous Union Carbide consumer products—EVEREADY batteries,  
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**This is how electronic counters  
got where they are today**





# PROGRESS

Frequency and time measurement demand continuing improvement in the operation, readability and reliability of electronic counters. These instruments are used in all scientific disciplines for making measurements involving time and frequency. The electronic counter is capable of measuring frequencies with extreme accuracy, measuring the period of unknown frequencies directly, making time interval measurements, counting random events, and determining the ratio of one frequency to another. This is accomplished by the use of a precision time base and high speed binary electronic circuits that perform mathematical functions. The measurement is displayed directly and accurately in an in-line display of numerals.

Solid state electronic counters usually require complex circuitry to drive these numerals. This circuitry must take binary information and convert it to decimal data before it can be displayed and read. Many counters employ networks of 10 high voltage transistors, 10 diodes and many resistors for each numeral. Some use space consuming relay networks. Hewlett-Packard has pioneered a totally new technique which simplifies circuitry and provides the needed amplification for readout signals while still retaining the rapid speed of operation. This technique incorporates a photoconductor—a device that changes its electrical conductivity by a factor of several thousand under varying degrees of illumination.

The high speed photoconductor developed by Hewlett-Packard and manufactured by its affiliate, HP Associates, translates the binary information to decimal data. Eight neon bulbs that are part of the binary counting circuits are lighted according to the count. These illuminate the photoconductor matrix, cause it to conduct, and light the correct readout numeral on the instrument's front panel. No other switching or amplification is required.

In addition to translation and switching, the photoconductor matrix allows the last reading of the counter to remain while the next count is being made. Because the display does not continually change, it is easier to read and faster measurements may be made.

Photoconductor research is but one way that Hewlett-Packard seeks constantly to produce definable advances in the state of the art of measurement. Electronic counters are but one example of progress from the world's largest manufacturer of precision electronic test equipment.



**hp 5245L 50 MC Solid State Counter** This counter employs the hp photoconductor matrix for driving its 8-digit in-line display. The instrument measures directly to 50 mc and also measures period, period average of up to  $10^5$  periods, ratio between two frequencies, and, with the addition of plug-ins, will count frequencies, up to 512 mc and will measure time interval of 1  $\mu$ sec to  $10^9$  sec. \$3,250. Frequency-extending and time interval plug-ins optional at extra cost.

## HEWLETT-PACKARD COMPANY

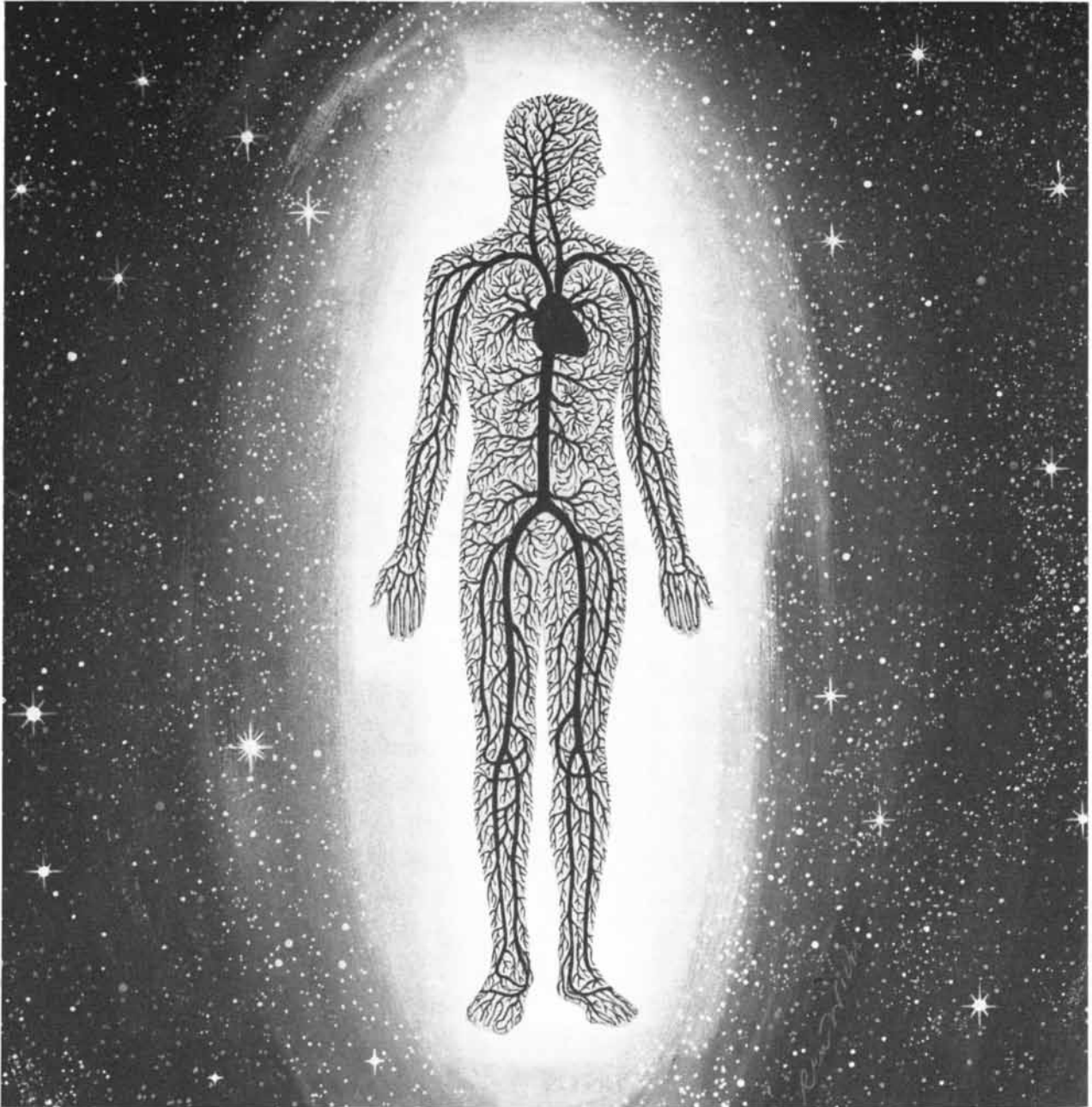
1501 Page Mill Road, Palo Alto, California

Hewlett-Packard S. A., Geneva; Hewlett-Packard (Canada) Ltd., Montreal; Boonton Radio Company, Dymec Division, Harrison Laboratories Division, HP Associates, F. L. Moseley Co., PAECO, Sanborn Company. Plants: California (4), Colorado (2), Massachusetts, New Jersey (2), England, Germany.



*Shown three times actual size, this Hewlett-Packard developed photoconductor matrix (a network of light operated switches), eliminates many components formerly crowded into a bulky assembly, saves cost and increases reliability on Hewlett-Packard solid state electronic counters.*





## Life sciences explore the anatomy of space

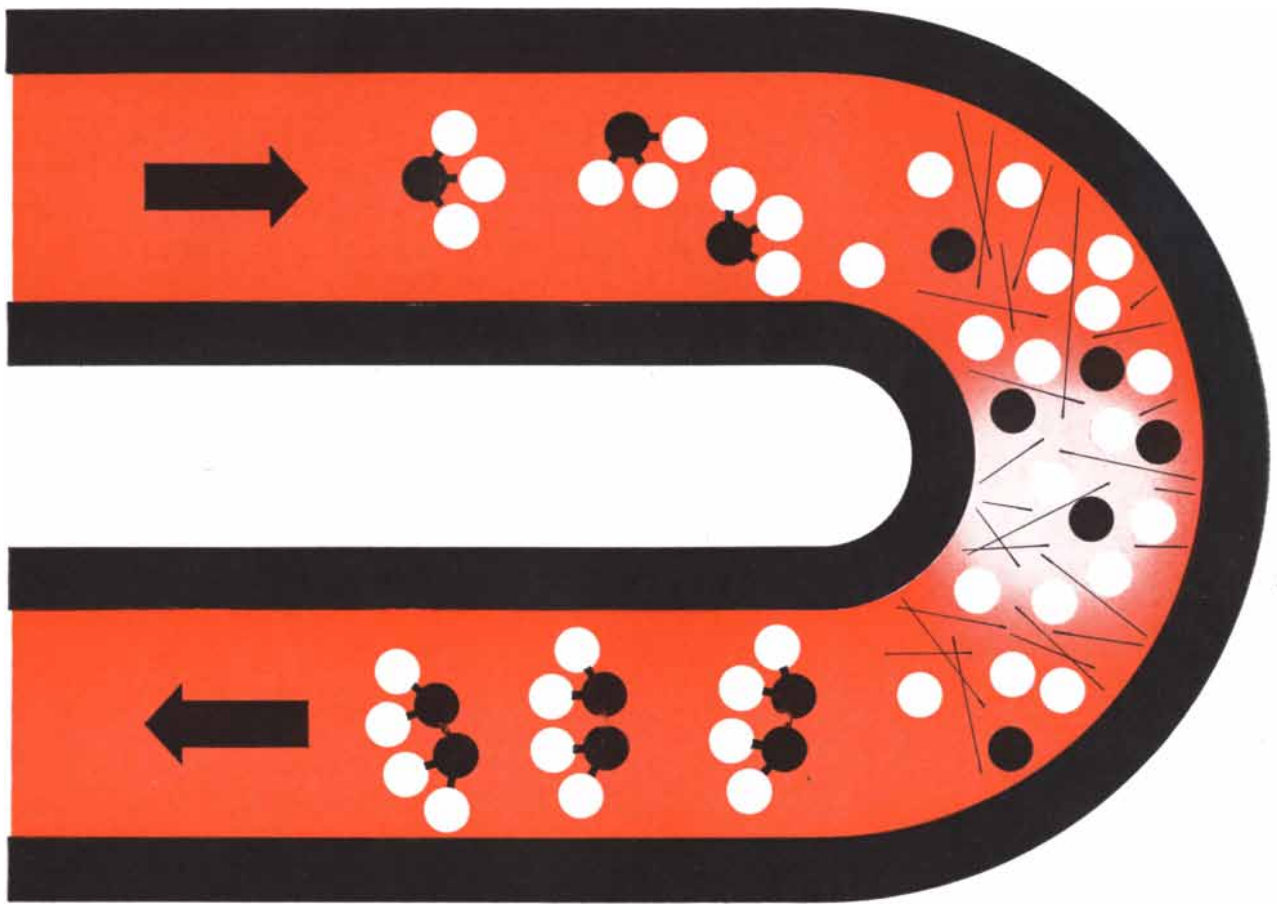
The life sciences group at The Garrett Corporation is concerned with the reaction of living organisms to their environment, and the development of environmental systems to support such organisms. Intensive investigation is now being conducted at Garrett in all major areas of the life sciences—microbiology, neurophysiology, psychology, biochemistry, biophysics and related areas—to study the relationship of man to his environment in extended space travel.

These studies vary in scope from determining the effects of near vacuum conditions on laboratory subjects over long periods of time, to definitively evaluating the effects of re-entry acceleration on human beings.

The only product of this extensive life sciences program is knowledge—knowledge which will support the important contributions continually being made by The Garrett Corporation to this nation's manned spaceflight programs.



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## FISSIO-CHEMISTRY FOR CHEMICAL MANUFACTURING

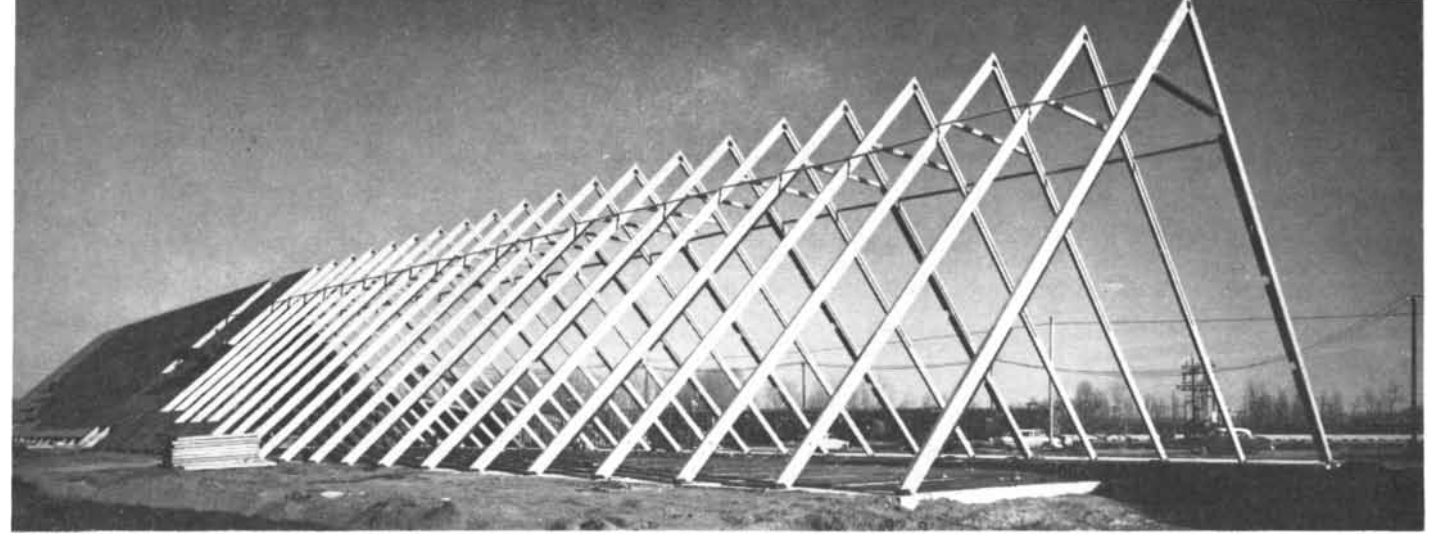
A process that may represent a truly economical use of atomic power has recently been developed at Aerojet-General Nucleonics. ■ We call it fission-chemistry. ■ We think it has great potential for the manufacture of high-energy compounds that now can be produced only by relatively inefficient and expensive means—and for the production of entirely new compounds, too. ■ Under Air Force sponsorship, AGN has already used fission-chemistry to convert ammonia into hydrazine, the storable rocket fuel, at a rate projected to be just a fraction of the present cost. In the process, uranium fission fragments break up  $\text{NH}_3$  molecules, which then reform into  $\text{N}_2\text{H}_4$ . ■ For the Atomic Energy Commission, AGN has also demonstrated the feasibility of fission-chemical synthesis of  $\text{NO}_2$  from air, suggesting the economical production of nitric acid and nitrogen fertilizers. This application may be of particular interest to emerging nations having limited domestic raw material sources. ■ AGN's continuing research in the field of fission-chemistry is aimed at development of a production reactor in which the fissionable material is suspended directly in the reactants. This will make it possible to take full advantage of the high linear energy transfer and rapid quench inherent in a process that utilizes the recoil energy of fission fragments. ■ For additional information about fission-chemical processing, write for AGN Active File No. 4.

# AGN

**AEROJET-GENERAL NUCLEONICS** / San Ramon, California



T.M.



## 60,480 square feet of new warehouse in less than three months

Last fall, CARGO CARRIERS, INC., transportation affiliate of CARGILL, INC., Minneapolis, Minnesota, wanted a bulk storage fertilizer warehouse *fast*. It had to be ready to receive river barge shipments that were being rushed to beat the winter closing of the Minnesota River. Add another complication: bulk fertilizer corrodes metal.

They got their warehouse, and at low cost, with corrosion-proof laminated wood "A" frame construction. UNIT STRUCTURES, a department of Koppers

Wood Preserving Division, worked with engineers of the T. E. Ibberson Company, Minneapolis, in the design of the 28,000-ton capacity building. Engineering plans for the 43 "A" frames were approved on August 28, 1962. Twenty days later, two truckloads of the laminated frames were delivered to the job site, and all frames were delivered by the 20th of September. CARGILL started to fill the warehouse on November 10, less than three months from the day the laminated "A" frames were ordered.

The bulk fertilizer can't corrode wood, and the beams are protected from rot, termites and decay because all exposed portions were pressure treated with WOLMAN® salts, a Koppers wood preservative. The building is strong; pound for pound the laminated wood beams are actually stronger than carbon steel. Permanent, low cost construction with laminated arches and beams or WOLMANIZED® lumber can answer many of your building problems. Check the coupon for details on laminated wood construction.



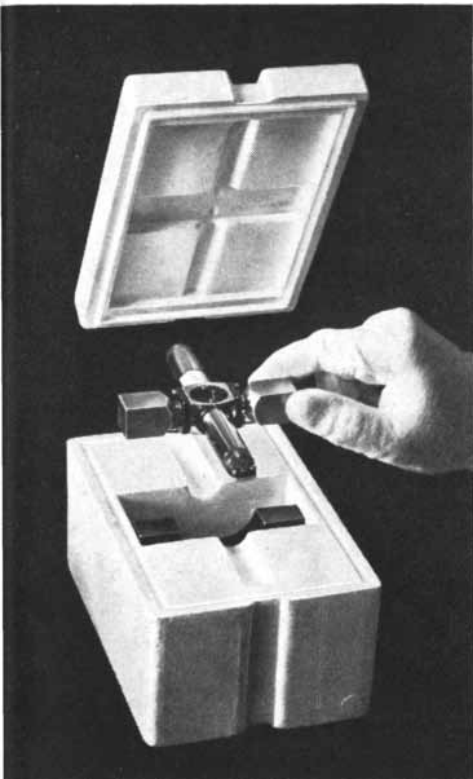
## Five years on the river and still no maintenance on HOLSET couplings



When the *Eastern* and its sister ship, the *Western*, were built for the UNION BARGE LINE in 1956, the couplings linking each ship's two engines to the gear boxes required lubrication and maintenance every few months, which resulted in considerable downtime. In 1958, they were replaced with HOLSET resilient couplings made by Koppers. The new couplings have been on the go for five years now, with no lubrication, and no maintenance. Because of this exceptional record (river towboat work is one

of the most punishing jobs for couplings), UBL again selected HOLSET couplings when they made replacements on a similar boat last year.

Koppers produces HOLSET and FAST's couplings for virtually all applications where mechanical power must be transmitted from a driving to a driven shaft. Their records for low maintenance and long life are a result of the simplified design of the couplings, and careful attention to the design and manufacture of each part. Check the coupon.



## DYLITE® foam plastic saves \$1.37 per package

The product is a seismic galvanometer, made by THE GEOTECHNICAL CORPORATION, Garland, Texas, for equipment that monitors earthquakes and explosions. It's a delicate instrument that must have the best possible protection during shipment. It has it: a two-piece container made of DYLITE expandable polystyrene, a Koppers foam plastic.

The new pack weighs 21 ounces less than the wood box and filler it replaced. It costs \$1.37 less than the old box, and a shipper can pack ten of them in the time it used to take to pack one. The instrument is placed in a molded recess, then the top is strapped on. It's ready to ship with no additional labor.

This rigid, impact-resistant foam plastic can be molded in virtually any size or shape to fit any product. DYLITE probably can lower your packaging costs, too. Check the coupon.

Package molded by CROWN MACHINE AND TOOL COMPANY, Fort Worth, Texas.

# KOPPERS

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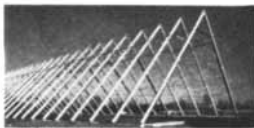


## This roof just survived its 33rd winter . . . with no maintenance

Most roofs carry only a twenty-year bond. The Koppers bond is for *twenty-five* years of trouble-free service. We upped the bond when our records showed that so many of the roofs had outlived the twenty-year mark. For example, the 33-year-old coal tar pitch roof on the Milwaukee County Court House has *never* needed contractual maintenance of any kind. Fred A. Melms, Building Maintenance Superintendent, says this 65,900-square-foot roof won't need any touching up for at least another ten years.

This Koppers roof isn't a rarity. There

are others as old and older in every section of the country. They get their long life and watertightness from coal tar pitch, the most waterproof material known to construction. Alternate layers of coal tar pitch and tar-saturated felt, topped with slag or gravel, form a continuous membrane that water can't penetrate. And coal tar's remarkable "cold flow" characteristic actually heals hairline cracks if they develop, and stops trouble before it starts. Check the coupon for complete information about Koppers built-up roofs.



- Laminated Arches and Beams — For low cost construction
- WOLMANIZED® LUMBER — For permanent protection of wood



- HOLSET RESILIENT COUPLINGS — To absorb and dampen heavy torque fluctuations



- DYLITE® EXPANDABLE POLYSTYRENE — Light, shock-resistant plastic for packaging



- COAL TAR PITCH BUILT-UP ROOFING — Guaranteed for twenty-five years

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One of a series briefly describing GM's research in depth

## How Do lubricants affect fatigue?

Everyone knows what a lubricant does. Or do we?

Besides reducing wear and friction, there is growing evidence that a lubricant profoundly affects the fatigue life of the component being lubricated. Members of our staff, for example, have observed 30-to-1 differences in the fatigue life of bearing balls due to lubricant variation. The study covered some sixty base oils from eleven chemical classes.

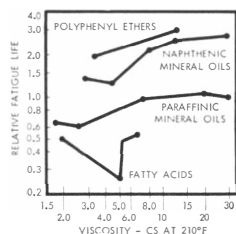
True, the evidence comes from bench tests. Its exact prediction of service experience is open to question, since tests were run at greatly elevated loads to shorten fatigue times to minutes.

But it offers some highly intriguing leads . . . leads we're following up by evaluating the many possible lubricant properties that may control the fatigue process. Viscosity is one. Antiwear characteristics, reactivity, and polarity are others. More rings in the lubricant molecule, for instance, usually result in longer life. And apparently there's an optimum wear rate for maximum life. Additives and precoatings play significant roles.

Research such as this is adding to our knowledge of the chemical and physical processes going on at contacting surfaces. It may well lead to improved performance of tomorrow's mechanical systems through controlled friction, reduced wear and fatigue. It's another illustration of how General Motors research people are working to find a better way.

### General Motors Research Laboratories

Warren, Michigan



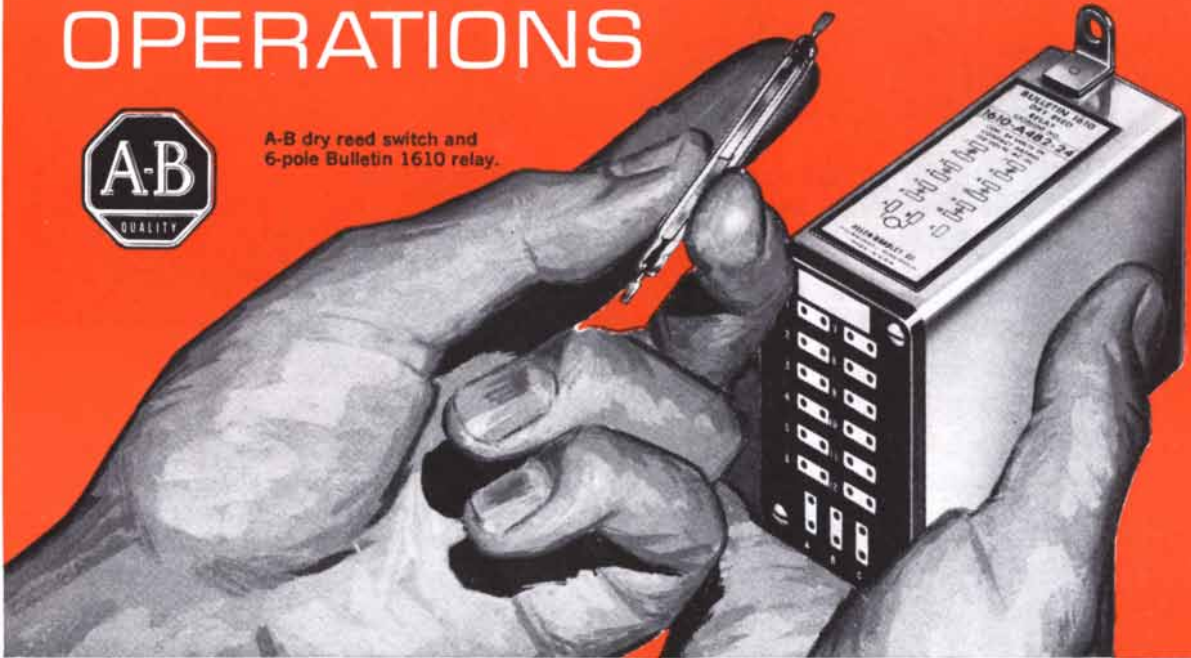
Effect of lubricant composition on fatigue.



# NEW Allen-Bradley Bulletin 1610 Dry Reed Relay good for HUNDREDS OF MILLIONS OF "PERFECT CONTACT" OPERATIONS



A-B dry reed switch and  
6-pole Bulletin 1610 relay.



■ Here's the new line of Allen-Bradley Bulletin 1610 dry reed relays that gives you a very high operating speed and complete freedom from contact failure. These relays are DC operated and are of small and uniform size.

The modular-type steel enclosures have uniform height and depth—only the width varies with the number of poles. The enclosure serves also to shield the dry reed switches from external magnetic fields. Its rugged construction, as well as the ruggedness of the entire assembly, makes these Bulletin 1610 relays virtually shock and vibration proof.

All wiring is from the front, although by inverting the enclosure, thus bringing the mounting feet to the front, the wiring can be made from the rear of the relay. Each terminal accepts two taper pins to simplify interconnections. Numbered terminals show the contact arrangement.

The Allen-Bradley dry reed switches used in the Bulletin 1610 relays are produced under "white room" conditions to eliminate contamination. Each switch is tested individually by radioactive methods to assure a perfect hermetic seal. The switches are provided with precisely controlled, metallurgically uniform, sintered gold contacts, to guarantee low and uniform contact resistance. The operating speed of the 12-pole relay is on

the order of 5 milliseconds; less for relays having fewer poles. The power required to operate the 12-pole relay is 1.9 watts; less for the relays of fewer poles.

The Bulletin 1610 dry reed relay contacts carry a nominal overall rating for make-and-break service of 0.5 amps. max., 150 v. max., AC or DC, and a continuous current of 2 amps. max. when closed. Bulletin 1610 relays are available in 3, 6, 9, and 12-pole constructions and can be furnished with various combinations of N.O. and N.C. contacts. They can be supplied magnetically latched as 2, 4, 6, and 8-pole relays. For details, please write for Bulletin 1610: Allen-Bradley Co., 1204 S. Third St., Milwaukee 4, Wis. In Canada: Allen-Bradley Canada Ltd., Galt, Ontario.



3-Pole Relay



9-Pole Relay



12-Pole Relay

# ALLEN - BRADLEY

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**QUALITY  
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# The Ecological Effects of Radiation

*Ecosystems, the basic biological units of man's environment, are altered significantly by ionizing radiation. Forests appear to be among the most sensitive systems; weed fields are more resistant*

by George M. Woodwell

It is understandable that concern about the effects of radioactive fallout and radioactive wastes should center on their direct hazard to man. The fallout from nuclear explosions and the wastes of nuclear reactors both emit ionizing radiation, the term given to the energetic photons (gamma rays) and various subatomic particles emitted when radioactive elements decay. Ionizing radiation is also produced by X-ray machines and particle accelerators. The radiation is so named because it can knock electrons out of stable atomic or molecular structures, leaving behind a trail of electrically charged particles, or ions.

Low levels of ionizing radiation have been part of the terrestrial environment during the entire period in which life has evolved. Since the first nuclear explosion at Alamogordo in 1945, however, man has had the capacity to greatly increase radiation levels, either generally by a nuclear war or locally by accident. It has generally been assumed that if man could be protected from the harmful effects of ionizing radiation, the other living things around him, particularly plants, would be safe by a wide margin.

This comforting view has now been challenged by several recent studies. They show that ionizing radiation of sufficient intensity to harm the human organism would also have direct and damaging effects on some of the large-scale biological units, called ecosystems, that

are part and parcel of man's environment and essential to his well-being.

Ecosystems are terrestrial or aquatic units of the biosphere that embrace one or several plant communities, animal communities and all the physical and biological factors that influence them. For purposes of this discussion I shall insert the qualification "naturally occurring," thereby excluding cities, self-sufficient manned space capsules and such political units as national states.

This article will describe changes that ionizing radiation has produced in several terrestrial ecosystems. It is based on recent experiments showing that typical North American forests are damaged by exposures in the same range as those that approach lethal exposures in human beings. Pine trees are particularly sensitive. In irradiated forest ecosystems pines have been killed by six months' exposure to 20 or 30 roentgens per day, and deleterious effects were produced by exposures of only one or two roentgens per day. (A roentgen is a unit of radiation dosage, an amount of energy deposited in a region through which ionizing radiation has passed. A typical dental X ray delivers a local dose of one to five roentgens; a whole-body dose of 500 to 1,000 roentgens is generally fatal to man.) In contrast to forests, fields of weeds are remarkably resistant, surviving exposures of 100 to 200 roentgens per day without major short-term damage. It is becoming apparent that there are patterns of radiation

sensitivity among major ecosystems, forests being among the most sensitive, tundra and grassland among the most resistant.

Even one or two roentgens per day is a substantial dose of radiation. It is at least 4,000 to 8,000 times more radiation than New Yorkers received from nuclear-test fallout in 1958, the record high year to date. (According to present indications, 1963 levels will be substantially higher.) More to the point was the experience during the 1954 tests at Bikini, where capricious winds exposed islands 100 miles away to radiation levels comparable to those we have found clearly harmful to forests.

Naturally occurring ecosystems can be named from their most conspicuous component—the plants—and can be characterized by three distinct types of pattern. These are the geographical pattern, the temporal pattern and the pattern of internal structure. The illustration on page 42 shows the geographical patterns of the principal ecosystems of North America as they would appear if they were left undisturbed for 100 years or so and allowed to develop into stable systems. Six systems, named after plant communities, are represented: Eastern deciduous forest, coniferous forest (mainly in the western U.S. and Canada), grassland, desert, tundra and tropical forest. These geographical patterns are greatly influenced by climate, and the stable ecosystems that develop





**DEVASTATED REGION OF FOREST**, produced by six months' exposure to gamma radiation, shows up as a circular bare patch

near the center of this aerial photograph. The forest is on the property of the Brookhaven National Laboratory on Long Island.



**CLOSE-UP OF RADIATION DAMAGE** reveals that trees have been destroyed within a radius of 40 meters from the source of radi-

ation. Such experiments have shown that radiation levels harmful to man would also damage vital components of his environment.





- |  |   |
|--|---|
|  TUNDRA                   |  GRASSLAND       |
|  CONIFEROUS FOREST        |  DESERT          |
|  EASTERN DECIDUOUS FOREST |  TROPICAL FOREST |

**MAJOR ECOSYSTEMS OF NORTH AMERICA** reflect patterns of climate and topography. Experiments indicate that coniferous forest is the most sensitive to radiation of the six ecosystems shown. Tundra, grassland and desert are probably most resistant.

have their counterparts in similar climates throughout the world. Although similar in structure and function, the counterparts will often contain different species of plants and animals.

Leading to the development of these "climax," or stable, ecosystems is a regular succession of systems that constitute the temporal pattern. The sequence starts with simple systems of rock ledges, gravel banks and open fields. In large upland areas of eastern North America these simple systems include a stage characterized by a thick cover of broom sedge (*Andropogon*), which is normally followed by pine forest and later by the climax deciduous forest. Such temporal patterns result in the accumulation of energy within the plant community until a high stable equilibrium is reached. The curve at the top of the next page, based on the work of several investigators, shows the approximate rate of accumulation of energy in abandoned fields in eastern North America. Both the time involved in such successions and the degree of stability achieved vary with geography and even with locale. An extreme example occurs in the arctic tundra, where frost action annually churns the soil over large areas. These unstable tundra soils support plant communities that would be early successional stages elsewhere. Even here, however, clear long-term patterns exist; they are stable and therefore predictable.

Energy flow also serves as a useful criterion for comparing ecosystems of diverse types [see bottom illustration on next page]. Solar energy is trapped by growing plants and is stored in their chemical structure. In an ecosystem that is part of a successional sequence, energy fixation by the plant community exceeds losses from the system and energy accumulates. Most of the energy is stored in plants, but part of it accumulates in the animal populations. The ecosystem loses energy in the form of heat carried off by the respiration of both plants and animals, and in death and decay. If such a system is disturbed by a devastating storm, for example, losses exceed energy fixation for a few years until the succession is restored and development toward climax continues.

The climax provides a most useful reference when one is considering ecological problems. As a system develops toward climax it provides an increasing diversity of microenvironments and a progressively milder total environment. As a result ecosystems approaching

climax usually contain many different species and a complex internal structure. These changes are particularly well illustrated in eastern North America, where the simple weed-dominated ecosystems, typical of abandoned fields, are gradually converted into the complex deciduous-forest ecosystem, with its tempered internal environment.

In general, disturbance of the climax tends initially to simplify the ecosystem, to reduce the diversity of species and to introduce the possibility of large oscillations in populations of plants and animals. Usually within a year or so the disturbance is resolved into some stage of the normal succession, or a modification of it. This stage may well involve a greater diversity of species than the climax stage because of an admixture of successional and climax species. Such a pattern characteristically follows many types of disturbance, whether caused by fire, ionizing radiation or some other factor. In making an analysis of such disturbances one usually finds that the direct effects are obvious enough; the secondary effects are often harder to discern because they involve the whole complex of biological interactions that are an integral part of the ecosystem environment.

Both the direct and secondary effects of ionizing radiation on plant populations have been observed at the sites of atomic bomb tests since 1945. For various reasons, however, it has usually been difficult to say that the observed changes were due entirely to ionizing radiation and not to some other unknown factor.

For example, in 1956 F. Raymond Fosberg of the U.S. Geological Survey observed a range of damage to vegetation on islands of Rongelap Atoll, which had been heavily exposed to radioactive fallout from atomic tests two years before. On Gegen Islet, which had received some 3,360 roentgens of ionizing radiation, there was widespread death of the terminal shoots of several plant species. This is a characteristic effect of radiation, but for lack of controls Fosberg could not conclusively attribute the damage to radioactive fallout.

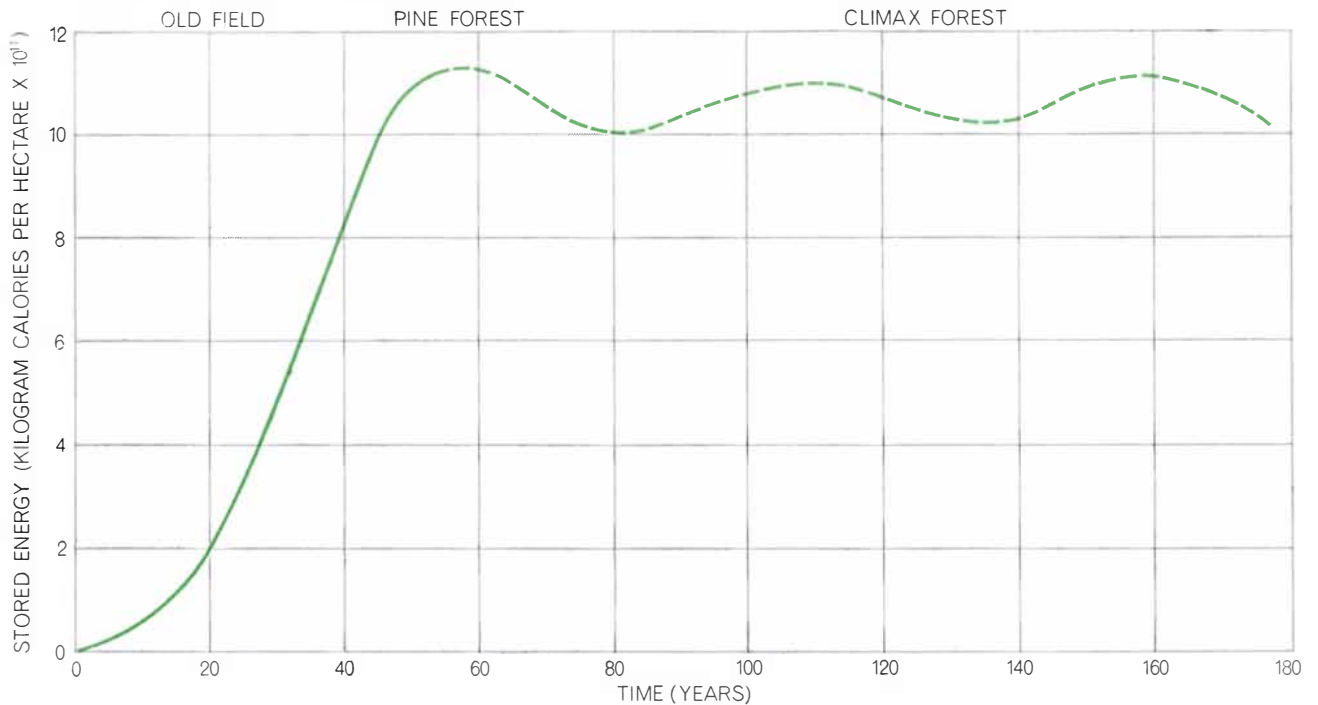
The completion in 1958 of an unshielded nuclear reactor in a forested valley outside Atlanta, Ga., has provided another and better opportunity to observe the effects of radiation on complex ecosystems. Here it has been possible to measure radiation exposures and to revisit particular sites. A group under Robert B. Platt of Emory University has

followed the changes in the surrounding ecosystems since the reactor went into operation. The ionizing radiation, consisting of a mixture of gamma rays and neutrons, has devastated the surrounding vegetation, selectively killing pine trees several hundred feet from the reactor. Farther away the growth and reproductive capacity of pines have been inhibited, and the normal successional pattern of the forest has been distinctly altered. The experiment has clearly



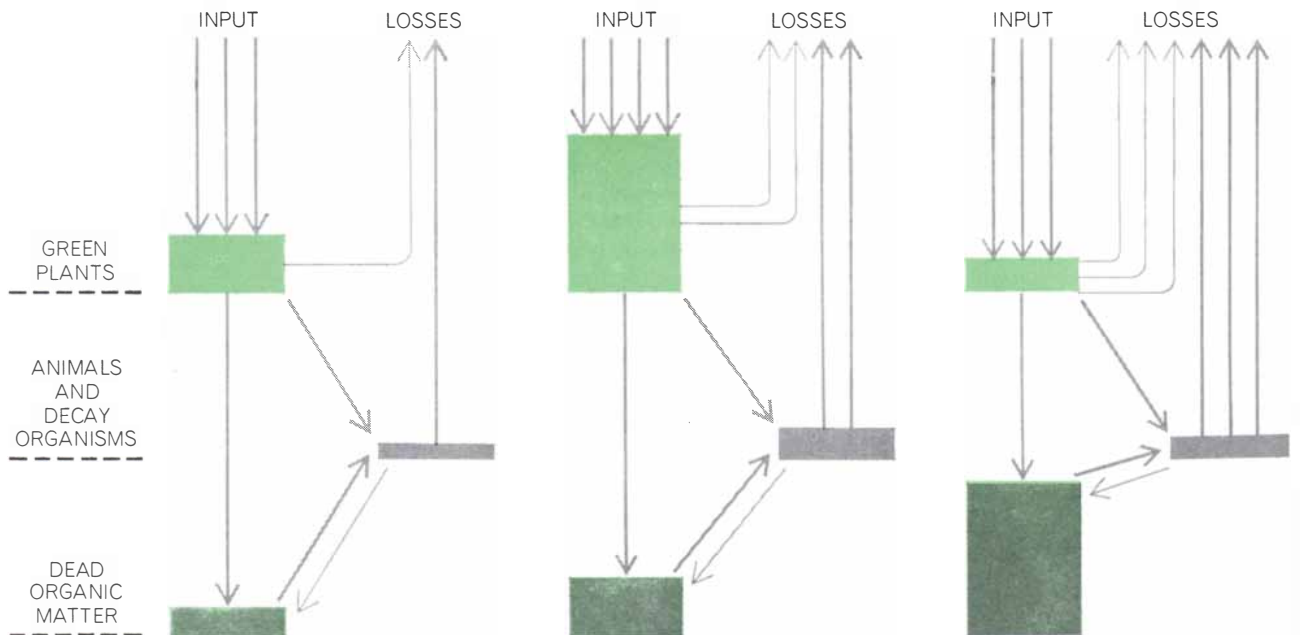
"OLD FIELD" covered by a year's growth of weeds was exposed for six months to several hundred roentgens per day. Weeds were seriously affected but withstood exposure much better than forest plants did.





**TEMPORAL PATTERN** of terrestrial ecosystems involves a succession of plant and animal communities. The plant succession il-

lustrated here is typical of much of eastern North America. Energy accumulates in such developing systems until stability is reached.



**ENERGY FLOW** in an ecosystem varies with its stage of development. The input is solar energy fixed by photosynthesis; losses are by respiration, death and decay and "export." As long as input ex-

ceeds losses, the system develops through successional stages. Input is equal to losses in the "climax," or stable, stage. A disturbance such as a flood or a severe storm makes losses exceed input.

shown how differences in radiation sensitivity can upset the normal patterns of a natural ecosystem.

In a series of ingenious experiments at another site Platt and J. F. McCormick studied the effects of ionizing radiation on a community of annual plants characteristic of rock outcroppings in the southeastern U.S. They observed that the radiation quickly produced a simplification in the community and within two years led to large changes in the relative abundance of surviving species. They also found that in general the tolerance of plants to environmental stresses such as drought decreases with increasing exposure to ionizing radiation. This underscores the importance of physiological responses in determining radiation effects.

In our own experiments at the Brookhaven National Laboratory on Long Island we have studied the effects of chronic exposure to ionizing radiation on two ecosystems at opposite extremes of the temporal sequence characteristic of Eastern deciduous forest. One system was a near-climax forest: a stand of white oak, scarlet oak and pitch pine [see top illustration on page 41]. The stand was characteristic of those found on glacial-outwash sands in many parts of northeastern North America. The second system chosen was a field of weeds, which we refer to as an old field. The field had been under cultivation until a year before the radiation experiment and was typical of abandoned agricultural land on Long Island. Within the year it had developed a dense stand of pigweed (*Chenopodium*), various grasses and other herbs.

The two ecosystems were irradiated according to the same general plan. A source of gamma radiation was suspended in a tower in such a way that it could be raised or lowered from a safe distance by a winch. When the source was lowered into a lead container, it was completely shielded and people could safely enter the area. The radioactive source used for the forest was cesium 137; for the old field it was cobalt 60. Both emit gamma rays and both produced exposure rates ranging from several thousand roentgens per day at a distance of a few meters to about two roentgens per day at 130 meters.

The highest exposures, continued daily throughout the winter and spring of 1961 and 1962, devastated both ecosystems [see bottom illustration on page 41 and illustration on page 43]. There were, however, substantial differences in the resistance of the two systems to lower radiation exposures. These dif-

ferences are shown in the two illustrations on the next two pages. No higher plant of the forest survived exposure beyond 360 roentgens per day, whereas in the old field the common groundsel (a hardy species of the genus *Senecio*) survived exposures up to several thousand roentgens per day. In the forest most trees of all species were killed by exposures above 60 roentgens per day. Comparable destruction of plants in the old field did not occur until the radiation reached 300 roentgens per day, although growth, form and reproductive capacity were markedly affected by exposures of 100 to 300 roentgens per day.

Pine trees were the most sensitive plants. They were killed by exposures of between 20 and 30 roentgens per day and growth was inhibited by exposures of one or two roentgens per day. This was about half the exposure that caused comparable damage in the oak trees. The forest ecosystem, considered as a unit, suffered an important change in structure at 60 roentgens per day, an exposure rate that was about a fifth the amount needed to eliminate a single important species from the old field.

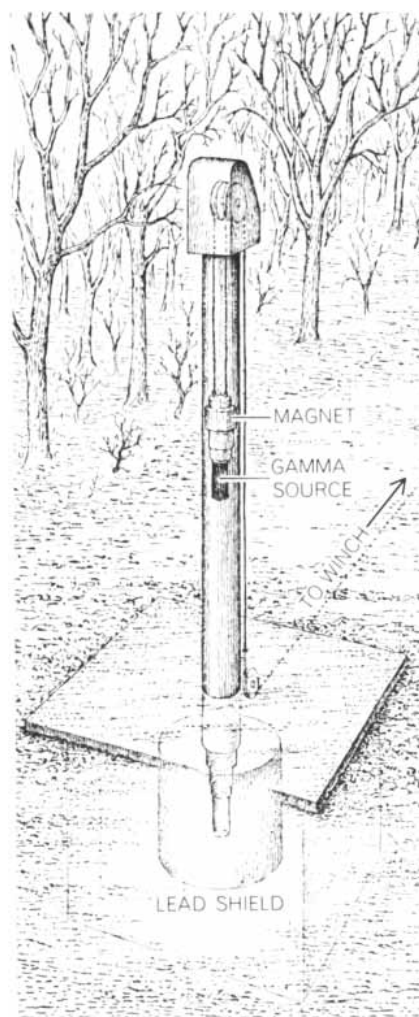
Although it is risky to generalize on the basis of only two experiments, the sharp difference in the response of the forest and the old field suggests that there may be a significant parallel between radiation sensitivity and the structural complexity of an ecosystem. The factors known to influence radiation sensitivity tend to support this generalization.

At the organism level Arnold H. Sparrow and his colleagues at Brookhaven have shown that the severity of radiation damage to plants is closely correlated with the amount of energy absorbed by the chromosomes, the threadlike structures in the cell that bear the genes of the organism. Plants that have many small chromosomes are in general more resistant to ionizing radiation than plants with a few large chromosomes.

There are difficulties, however, in extending this apparently simple rule to predict the effects of ionizing radiation on ecosystems. First, chromosome size and number vary not only among organisms but also within organisms and at various stages in their life cycles. Second, the total amount of energy absorbed by an irradiated cell varies with the period of exposure. Therefore when a cell that is dividing slowly is irradiated over an extended period, it receives a greater total exposure before its next division than a cell that is dividing rapidly. Furthermore, in a tissue that contains

rapidly dividing cells, damaged cells may be replaced by undamaged cells nearby, thereby increasing the apparent resistance of the tissue. If we consider two extreme conditions, dormancy and rapid growth, it is clear that with equal chronic exposure individual cells in the dormant bud would accumulate greater total damage per cell than rapidly dividing cells in an expanding shoot.

One would expect a seed to be even more vulnerable to radiation damage than a dormant bud, but this does not seem to be the case. Dormant seeds actually show a surprising resistance to radiation. For example, François Mergeron of Yale University collected cones from Brookhaven pine trees that had been exposed to 27 roentgens per day and found that 95 per cent of the seeds within the cones were alive after a total exposure of 12,000 roentgens. Yet more than 90 per cent of the pine trees exposed to 27 roentgens per day were dead before they had received 12,000 roent-



**RADIATION SOURCE** for Brookhaven experiments is raised and lowered by a winch. Electromagnet drops source in emergency.

gens. The high radiation resistance of pine seeds may be attributable to their dehydration, low oxygen content and small chromosome size.

Before exposing the two Brookhaven ecosystems to ionizing radiation we tried to predict the outcome for the forest on the basis of Sparrow's finding that radiation damage is proportional to the energy absorbed by the chromosomes. We predicted that the hardiest species would be able to endure about 30 times more exposure to radiation than the most sensitive species. Instead the experiment showed that the hardiest species were only about five times more resistant, and all species were more sensitive than predicted. The greatest departure from the prediction was in the forest ground cover, which suffered a severe change of environment when the trees died, leaving the ground cover exposed.

This observation suggests that in a complex ecosystem such as a forest the direct changes produced by ionizing radiation set in motion a chain of deleterious secondary effects. It means further that the sensitivity of a complex system to short-term damage is determined primarily by the sensitivity of a species that provides the primary ecological structure. In forests, where ecological structure is important, the number of species involved may range from one for pine forests to several score for tropical forests. Because of the importance of structure, complex systems are more vulnerable to disturbance than simpler systems such as the old field, which has little ecological structure and little dependence on it. There the elimination of one or several species causes a relatively minor change in the environment of the surviving species.

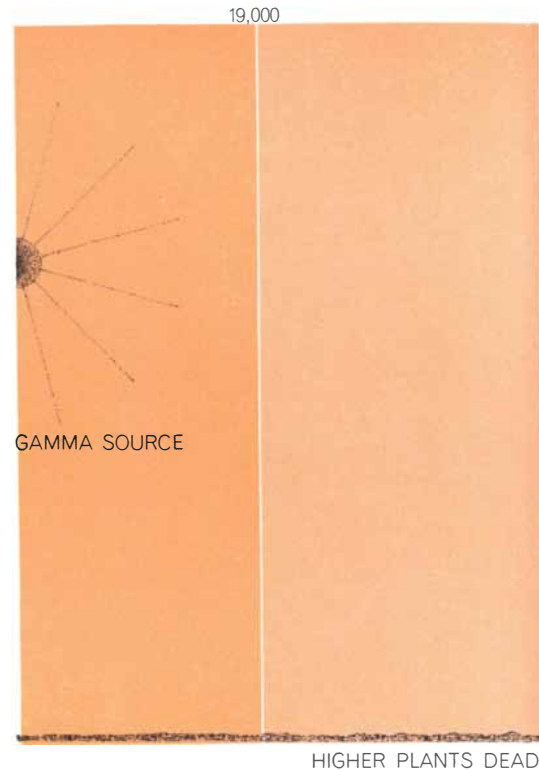
Several additional factors tend to increase the radiation sensitivity of forest ecosystems. The plant communities of the forest are made up of perennials, most of which have buds that are well above the ground and therefore directly exposed to radiation. Old-field plants are principally annuals, which survive the winter as comparatively radiation-resistant seeds. After germination, growth is fairly rapid until new seeds have been set. The grasses and other monocotyledonous plants enjoy still a further advantage under chronic irradiation: the dividing cells that produce new tissues are at the bases of leaves and may be at ground level or slightly below it, thereby receiving a certain amount of shielding not enjoyed by the buds of woody perennials.

Such characteristics as these, which

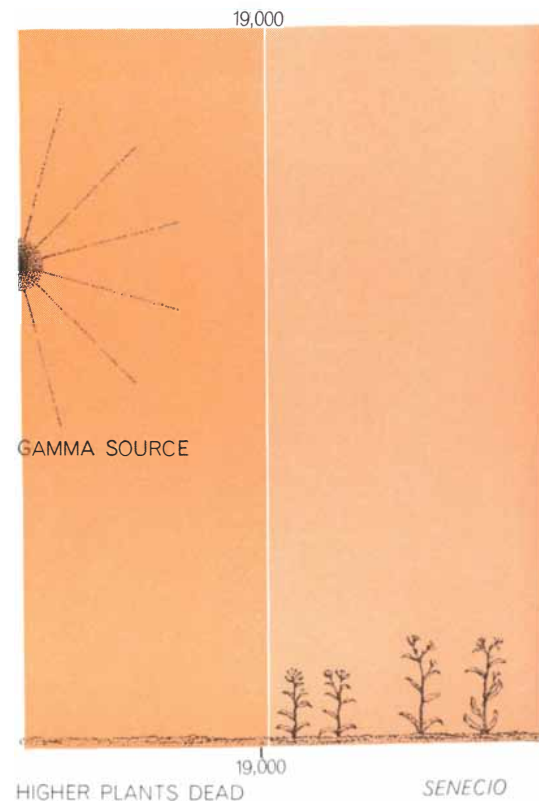
contribute to radiation resistance, contribute also to the ability to survive various types of environmental extreme. The seed, for instance, not only acts as an agent of dispersal but also enables the plant to survive severe environmental conditions that would be lethal to vegetative structures. Desert annuals may survive years of drought as seeds, completing their life cycle in a matter of days after a sudden rain. Other organisms such as grasses and sedges, which have their perennating structures at ground level or below it, are particularly well adapted to certain types of harsh environment, such as the tundra.

Still another adaptation that seems to confer resistance to radiation as well as to stresses encountered in the natural environment is an increase in the number of chromosomes. Sparrow and his co-workers have shown conclusively, for instance, that polyploidy—the occurrence of extra sets of chromosomes in the nucleus—confers additional resistance to damage from radiation. Biologists have recognized for many years that the incidence of polyploidy among plants increases with latitude, rising from a low of about 30 per cent in the Temperate Zone to as high as 80 per cent in certain arctic regions. The incidence of polyploidy increases near the periphery of the range of the plant and is usually more frequent among organisms that are characteristic of harsh environments. Among the genera of old fields, for example, polyploidy is common; the number of chromosomes in some species runs as high as 200. Most trees, on the other hand, have fewer than 40 chromosomes.

Such relations as these provide a reasonable basis for appraising the potential direct effects of various radiation exposures on the three types of ecosystem pattern discussed earlier. First, in the temporal sequence, the early successional stages appear to be substantially more resistant than the more complex stages later in the succession. The mosses and lichens, for instance, which are important components of the early successional plant communities of bare rock surfaces, have survived total exposures of more than 200,000 roentgens in the irradiated forest at Brookhaven. In Georgia, McCormick and Platt have found that an early successional plant community characteristic of rock outcrops suffered large changes in structure only at total chronic exposures in the range of 20,000 to 40,000 roentgens, administered over nearly four

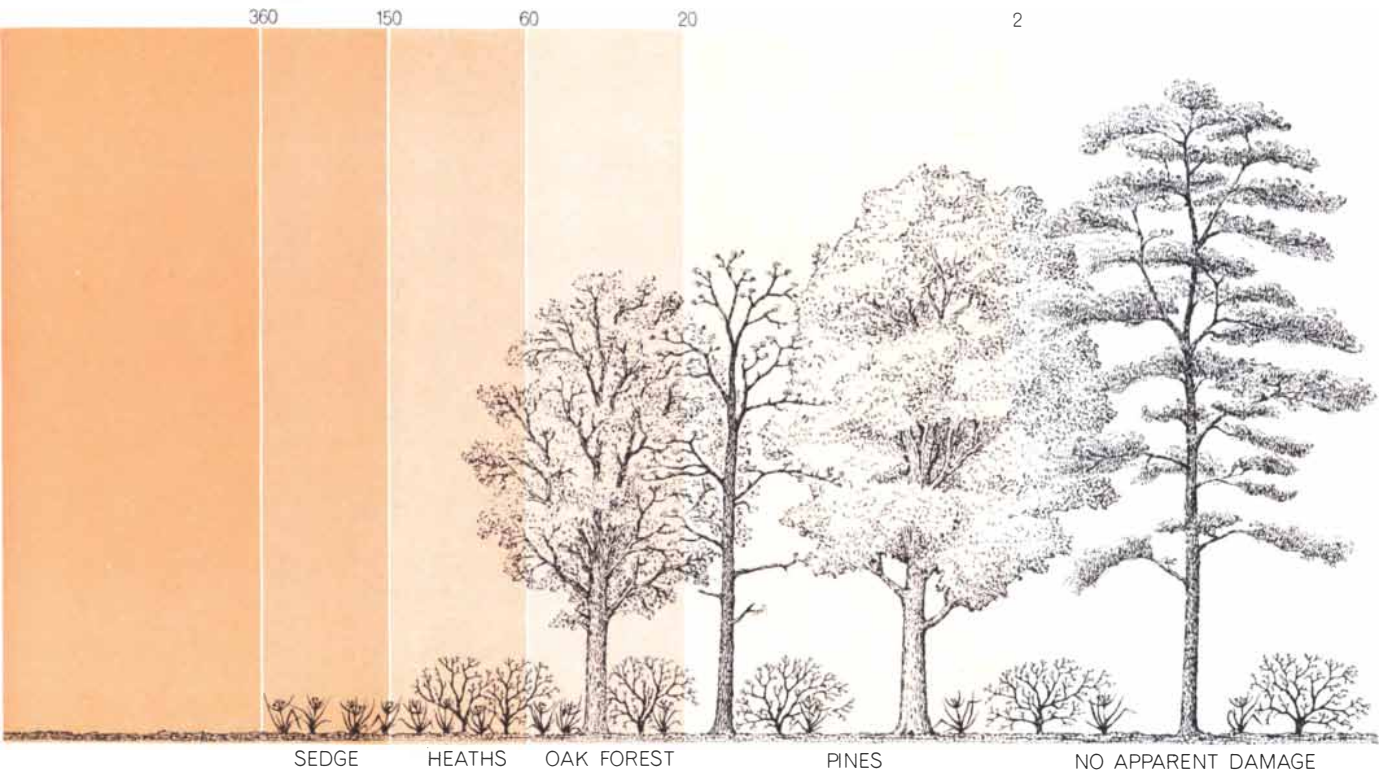


**FOREST** of pine and oak was severely affected by six months' exposure to gamma radiation. The exposure varies with dis-



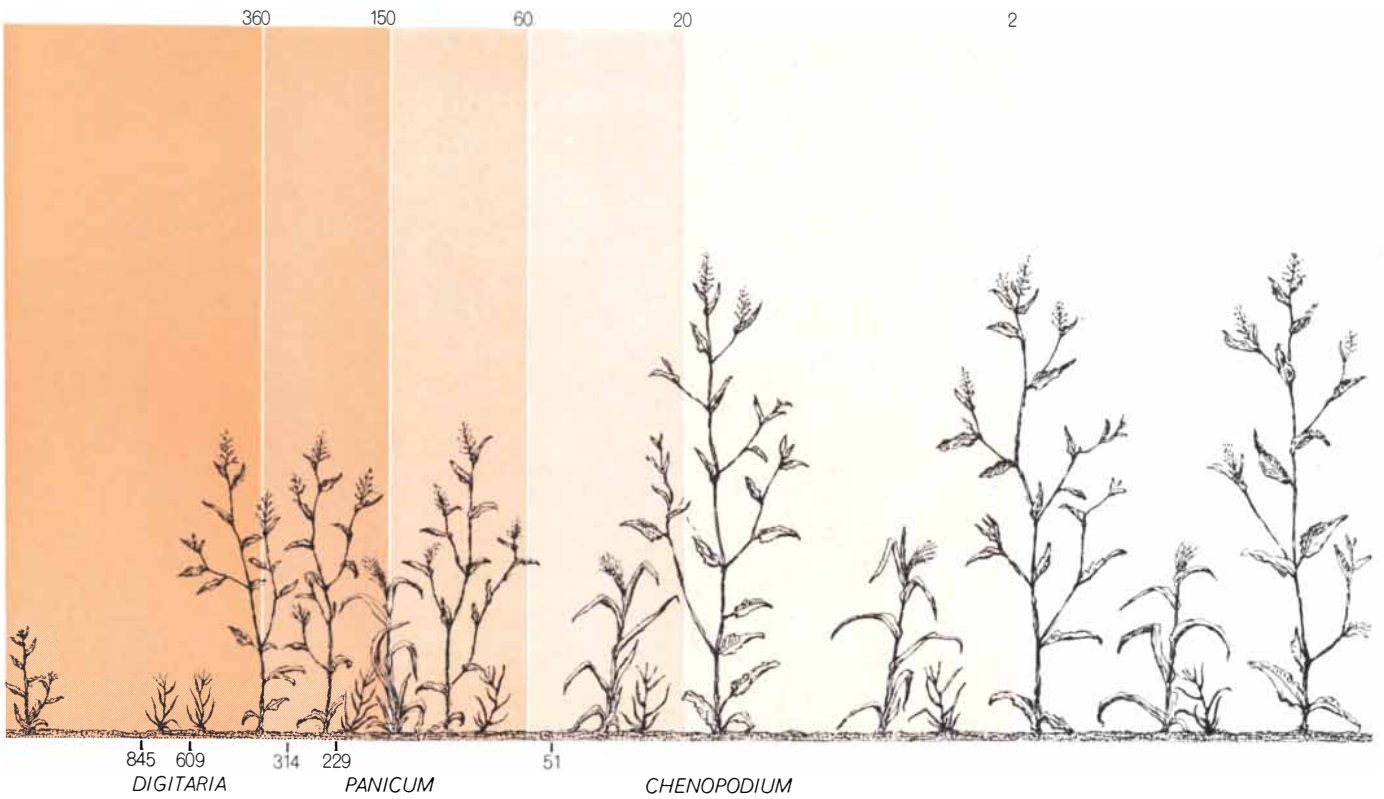
**WEED FIELD** exposed to the same amount of radiation was about five times hardier. The basic plant population, primarily pig-





tance from the source (*left*), as indicated by the various shades of color. The numbers at the top of the chart give the radiation exposures in roentgens per 20-hour day. Pine trees were most suscep-

tible: their growth was inhibited by one or two roentgens and trees were killed by 20 to 30. All trees exposed to more than 60 roentgens died. Only the mosses and lichens survived more than 360.



weed (*Chenopodium*) and crabgrass (*Digitaria*), was essentially unaltered at exposures of less than 300 roentgens per day, although there were deleterious effects on growth above 100 roentgens. The

common groundsel (genus *Senecio*) proved most resistant, surviving exposures of more than 10,000 roentgens. Most weeds are annuals; their seeds are considerably harder than perennials' buds.





LEAVES OF WHITE OAK (*Quercus alba*) are from trees subjected to the gamma-radiation exposures indicated (in roentgens per

day) below each leaf. Even low exposures changed the form of the leaves, long before there was enough radiation to kill the trees.

months at rates between 170 and 310 roentgens per day. Charles Daniel, a colleague of Platt's, has shown that the species composition of old-field plant communities in the vicinity of the unshielded nuclear reactor in Georgia was altered but that the community persisted

after acute exposures of between 28,000 and 44,000 roentgens. Such ecosystems, characterized by plant communities containing annual and perennial herbs—"weeds" when they are encountered in gardens, on roadsides and in wastelands—would survive months of exposure to

between 100 and 300 roentgens per day and acute exposures in the range of 20,000 to 40,000 roentgens without significant and immediate direct effects. Such exposures, however, would have harmful effects on the growth rate, form and reproductive capacity of the plants ex-



IRRADIATED FOREST has a ghostly appearance in this infrared photograph made looking down the path from the winchhouse

to the gamma ray source (center). Green leaves and ground cover register white on infrared film. Placards give radiation exposures.

posed. These exposure rates are very high indeed and would be produced over large areas only by a nuclear war or other catastrophe.

Near the other end of the temporal sequence of ecosystems, at least in eastern North America, the forest ecosystems have quite a different range of sensitivity. Chronic exposures between 20 and 60 roentgens per day, continued through a period of several weeks or longer, would cause major damage to trees, which are the chief structural units of forest ecosystems. Sparrow and his colleagues have shown that coniferous forests, for example, would probably suffer severe damage at 20 to 30 roentgens per day continued over a six-month period. A total exposure of 1,000 to 2,000 roentgens in one day would cause equivalent damage.

Deciduous-forest ecosystems are somewhat more resistant but would suffer grave damage, including death of the principal trees, at exposures in excess of 30 to 60 roentgens per day or from acute exposures in excess of 5,000 to 10,000 roentgens. To sum up, one would expect the coniferous-forest ecosystems to be among the most sensitive and the tundra, grassland and probably the desert ecosystems to be among the most resistant.

In all these ecosystems, however, the radiation exposures necessary to cause direct effects of the magnitude I have been discussing are far greater than exposures from naturally occurring sources and present levels from fallout. Nonetheless, these high levels are well within the ranges possible over large areas following nuclear explosions, as was demonstrated by the fallout pattern from the "Bravo" test explosion in 1954 at Bikini [see illustration on this page]. Radiation exposures in the range of thousands of roentgens occurred as much as 100 miles from the bomb burst. It is now clear that such exposures would not only affect man, who succumbs to exposures in the range of 500 to 1,000 roentgens, but would also have important deleterious direct effects on the dominant plant populations of natural ecosystems.

The lowest exposure necessary to modify the internal structure and function of ecosystems is a vital but elusive question. Since there is no threshold for the production of mutations, one can assume that any increase in levels of radiation exposure will increase mutation rates, thereby increasing the probability of altering the genetic make-up of the plants and animals popu-

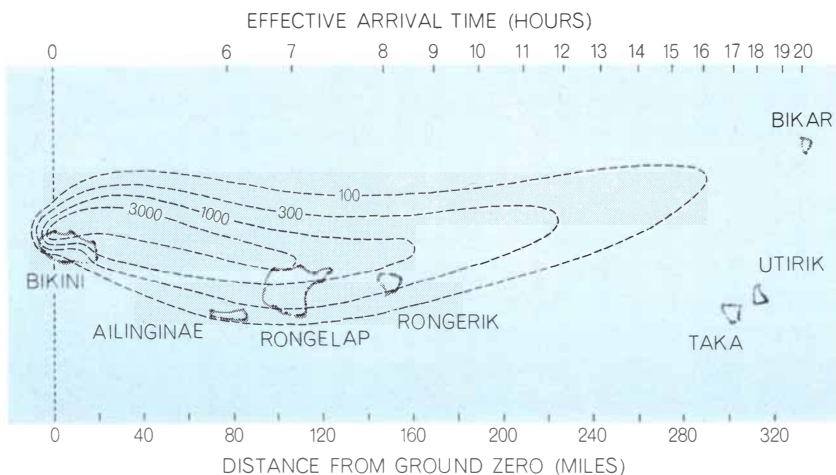
lating the ecosystem. The effects of mutations or new gene combinations would be important at the ecosystem level only after several generations and are quite unpredictable.

It is still harder to measure the small, immediate somatic (nongenetic) changes that radiation produces in the exposed populations. As a result it is not known whether or not a certain threshold of exposure must be exceeded before somatic changes occur. Our work shows that exposures of one or two roentgens per day continued during more than six months cause minor morphological changes in pines, one of the most radiation-sensitive plants known. Such exposures, however, are still well above general levels from fallout. If exposure rates of one or two roentgens per day, or even less, prove to have important ecological effects, they will probably be the result of genetic or physiological mechanisms. Such effects become apparent only after months, possibly years, and they may be totally obscured under natural field conditions by a host of secondary effects.

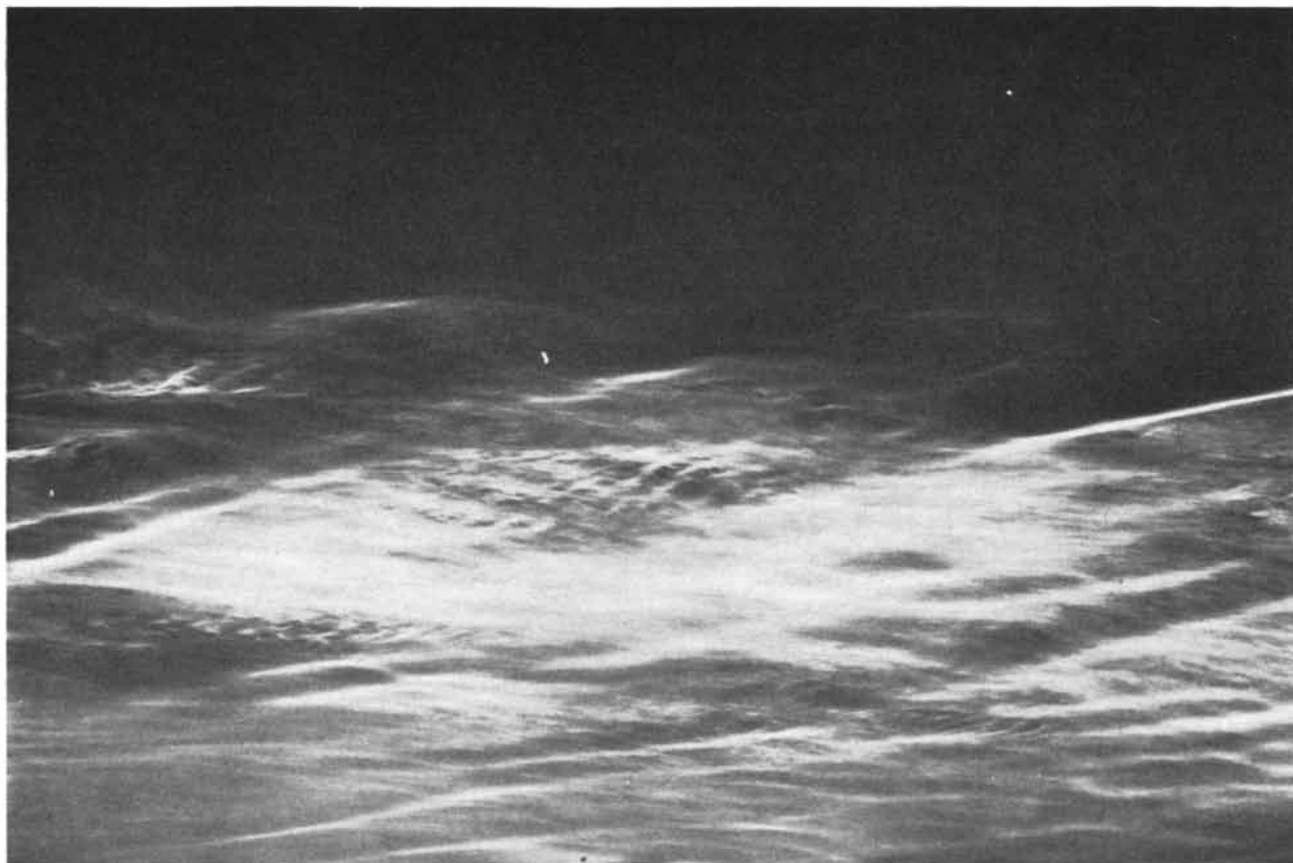
It is these subtle, usually complex and always possible secondary effects that generate some of the large, difficult and frequently open-ended questions of ecology. The effects are attributable to alterations of the "normal" behavior of the various interacting components of the ecosystem and are frequently difficult to verify except by experimentation. With present knowledge one cannot yet make detailed predictions; one can only generalize. We know in general that the disturbance of complex ecosystems produces simplification of internal structure, reduction of the number of species present and some form of in-

stability. Severe or long-continued disturbance favors vigorous organisms that reproduce rapidly and even asexually. Among animals, those whose food chains are short, such as the herbivores and especially the herbivorous insects, are particularly well adapted to survive any sort of widespread disturbance. But the very survival of these hardy groups can only accentuate the direct effects of radiation damage on the primary producers: the plants. The Brookhaven work has shown that populations of the insects known as leaf tiers and leaf rollers in the irradiated forest were more resistant than their hosts, the white oak trees, and, apparently without increasing in absolute numbers, the insects ate much of the foliage remaining on radiation-damaged trees. A simultaneous increase was observed in populations of bark lice and pine wood borers. Other insect populations were depressed. Such changes in the relation between parasite and host can sharply amplify the disturbance caused by the direct effects of irradiation.

Research at these ecological levels of organization is complex and slow because the natural units are large and replication of an experiment is difficult. Large-scale field studies, such as those I have described, represent in vivo experiments of radiation effects on ecosystems. Supplementary laboratory and greenhouse studies with isolated components correspond to the in vitro experiments of the biochemist. Such studies not only provide greater confidence in predicting the effects of various environmental contaminants, including radioactive fallout and wastes, but will also clarify the principles governing the behavior of ecosystems.



**FALLOUT PATTERN** from a thermonuclear test explosion at Bikini in 1954 shows the magnitude of radiation exposures to be expected downwind from a hydrogen bomb burst. Contour lines indicate the total dose in roentgens per hour 96 hours after the explosion.



**NOCTILUCENT CLOUDS** were photographed near Östersund, Sweden, on the night of August 10-11, 1958, by Georg Witt, who also made the photograph on the cover. The upper photograph was

made at 11:45 p.m., the lower at 12:10 a.m. The display moved higher in the sky and the clouds changed considerably between exposures. The waves average about 15 miles from crest to crest.

# NOCTILUCENT CLOUDS

These mysterious “night-shining clouds” that occur 50 miles up are seen occasionally in summer at high latitudes. Last August rocket-borne collectors brought back samples of their substance

by Robert K. Soberman

**D**uring the summer months in far northern and southern latitudes an alert observer will occasionally see tenuous clouds glowing faintly in the sky at twilight. Tinged a silvery blue, the clouds usually form billows resembling the waves of a ghostly ocean. Such clouds have been given the name noctilucent clouds, meaning “luminous night clouds.” Although they must have aroused the wonder of the inhabitants of high latitudes for centuries, it is only recently that the real mysteries they present have come to be appreciated.

In 1896 the German astronomer O. Jesse measured the altitude of a display of noctilucent clouds over northern Germany from the parallax apparent in simultaneous photographs made with cameras 22 miles apart. He arrived at the startling figure of 250,000 feet (50 miles). Measurements made since have invariably come within a few thousand feet of this altitude. This explains the luminosity of the clouds: it is the reflection of sunlight reaching them from far below the horizon of the observer. The noctilucent clouds are the highest clouds of the planet. They ride in the sky above more than 99.9 per cent of the atmosphere and 40 miles higher than the realm of the weather.

At such high altitude what substance and what process can form clouds? Various investigators have argued that noctilucent clouds consist of tiny crystals of pure ice; that they are clouds of dust of terrestrial or meteoritic origin; that they are clouds of dust particles covered with ice. The third hypothesis has attracted the most support, but the issue could be settled only by examination of an actual sample of a noctilucent cloud.

Last August a rocket-borne collector trapped some of the substance of one of these clouds over Sweden and brought

it safely back to earth. Analyses now being conducted in several laboratories in Sweden and the U.S., including my own in the Air Force Cambridge Research Laboratories, seem to have set aside the first two hypotheses without, so far, completely confirming the third. The evidence that the clouds contain ice-covered particles of meteoritic dust has now opened a series of new questions.

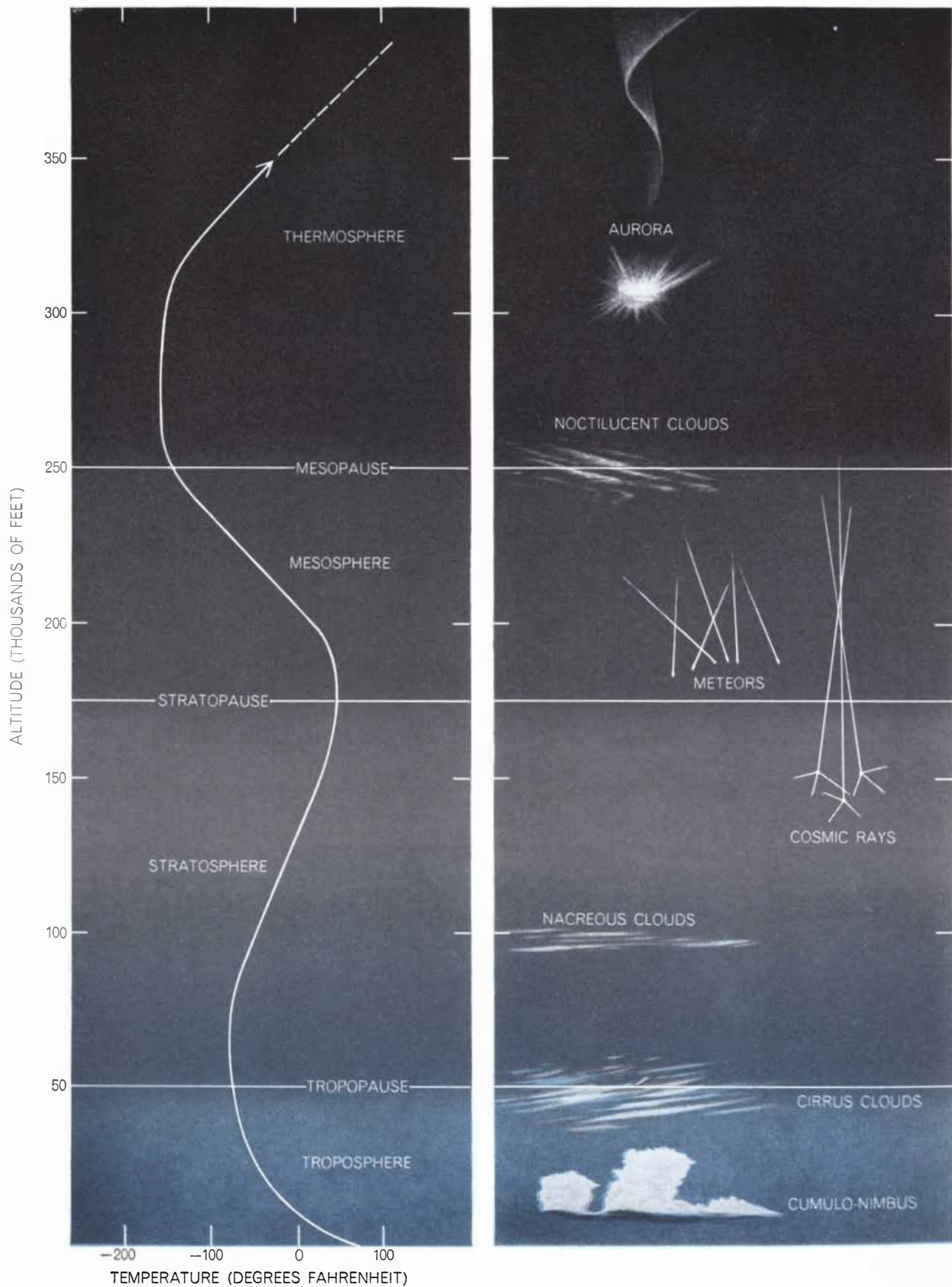
It is not at all clear, for example, why the clouds are seen only at high latitudes and almost exclusively in summer. On the one hand, conditions may be more favorable for seeing them at these latitudes in this season and they may be more widely distributed but unseen in the sky over the rest of the planet; on the other, the formation of the clouds may actually be confined, for reasons yet to be discovered, to the regions of the sky where they are seen and to the summer season. Why they always occur within a few thousand feet of an altitude of 50 miles presents still another question. The noctilucent clouds also invite investigation because the speed with which they move across the sky, sometimes exceeding 400 miles an hour, provides a measure of the wind velocity in the extremely thin atmosphere at such high altitude. Finally, in the mechanism that drives the winds there may be an explanation for the undulations of the clouds, which can extend dozens of miles from crest to crest and several miles in depth, sometimes standing still and sometimes even traveling in the opposite direction to the motion of the cloud as a whole.

**N**octilucent clouds almost always make their appearance in the same well-defined region of the sky between the twilight arch at the horizon and the

darkening vault of the night sky overhead. This is because they scatter the sunlight best in the forward direction and the optimum illumination and contrast exists when the sun is between six and 12 degrees below the horizon [*see upper illustration on page 54*]. A large part of the sky behind and partly above the observer is then in the shadow of the earth; there the sky is dark and stars are plainly visible. From the horizon to about 10 degrees above it, however, the dense lower atmosphere and the haze of dust and moisture in it catch and scatter the sunlight, outshining stars and noctilucent clouds. It is therefore in the region 10 to 20 degrees above the horizon, between the twilight arch and the night sky, that the clouds usually appear.

The clouds visible to the observer may be part of a system covering much larger regions of the sky. Although occasional bright displays have been seen even up to the zenith in the clear atmosphere of northern Scandinavia, the clouds that are overhead at one place are usually visible only to observers elsewhere who can see them at a lower angle. Noctilucent clouds are so thin that bright stars shine through them. Binoculars or a telescope can be used to exclude the light of the twilight arch from the eyes and increase the apparent contrast in the wave structure of the clouds. For some unknown psychological reason it is also helpful to observe the clouds inverted by a mirror, prism or lens or simply by bending over or lying down to get the inverted view. The illusion of depth and distance and the brightness of the clouds can be enhanced even in a photograph if one looks at the photograph upside down; the reader can verify this with the cloud photographs illustrating this article, allowing 30 seconds or so for the illusion to take effect.





**TEMPERATURE CHANGES** define various regions of the atmosphere (*left*). Troposphere contains the weather clouds. At the tropopause the temperature ceases to drop. It starts to decline again

at the stratopause, and at mesopause it reaches a second minimum. Noctilucent clouds occur only in the region of the mesopause. The lower nacreous clouds are also rare and poorly understood.

From the record of observations one might conclude that noctilucent clouds are rare and that they appear mostly during the summer and only between the latitudes of about 45 and 80 degrees in the Northern Hemisphere. The record becomes suspect when one notes that most sightings have been recorded in northwestern Europe and the U.S.S.R. above 58 degrees. According to Benson Fogle of the University of Alaska, only two sightings from Canada and one from Alaska had been recorded before 1962. Obviously the paucity of observations in the high latitudes of North America and the Southern Hemisphere must be more closely related to the lower density of population and hence to the smaller number of potential observers in these regions than to the physics of the upper atmosphere. At the suggestion of Sydney Chapman of the University of Alaska observers kept a cloud watch at College, Alaska (near Fairbanks) last August. The record for North America was immediately doubled by the recording of three new displays. The stir of interest in the subject has since brought a report from the U.S. Weather Bureau at Anchorage, Alaska, to the effect that noctilucent clouds are observed there at least once a year and that the bureau's record for 1962 showed a sighting in May and another in August. Arnold Hanson of the University of Washington has recently told of seeing noctilucent clouds on September 13, 1961, from a floating ice island, Arliss II, off the northern coast of Alaska at a latitude of 76 degrees, the second northernmost sighting ever reported. The sparse record of the Southern Hemisphere has been fleshed out by a report from the U.S. oceanographic vessel *Eltanin* of a sighting last December over the South Atlantic east of Tierra del Fuego.

The question still remains whether or not the clouds as well as the observations are restricted to the high latitudes during the summer. Without doubt the chances for sighting the clouds are best in those regions at that time because the sun does not dip far below the horizon before starting to rise again. Twilight and ideal seeing conditions can therefore last for hours [see lower illustration on next page]. On the other hand, since the twilight centers around midnight at these latitudes, low temperatures and frost may deter all but the most dedicated cloud-hunters. The clouds have been sought at lower latitudes but without success. It is true that the twilight is shorter; it lasts for only 20 minutes at 30 degrees from the Equator.

In addition, an untrained person can easily mistake noctilucent clouds for the familiar cirrus and cirro-stratus clouds. Offsetting these considerations is the fact that the observing time comes at a more reasonable hour. There are also many more qualified observers living in these latitudes, some of whom should have seen noctilucent clouds if any had occurred.

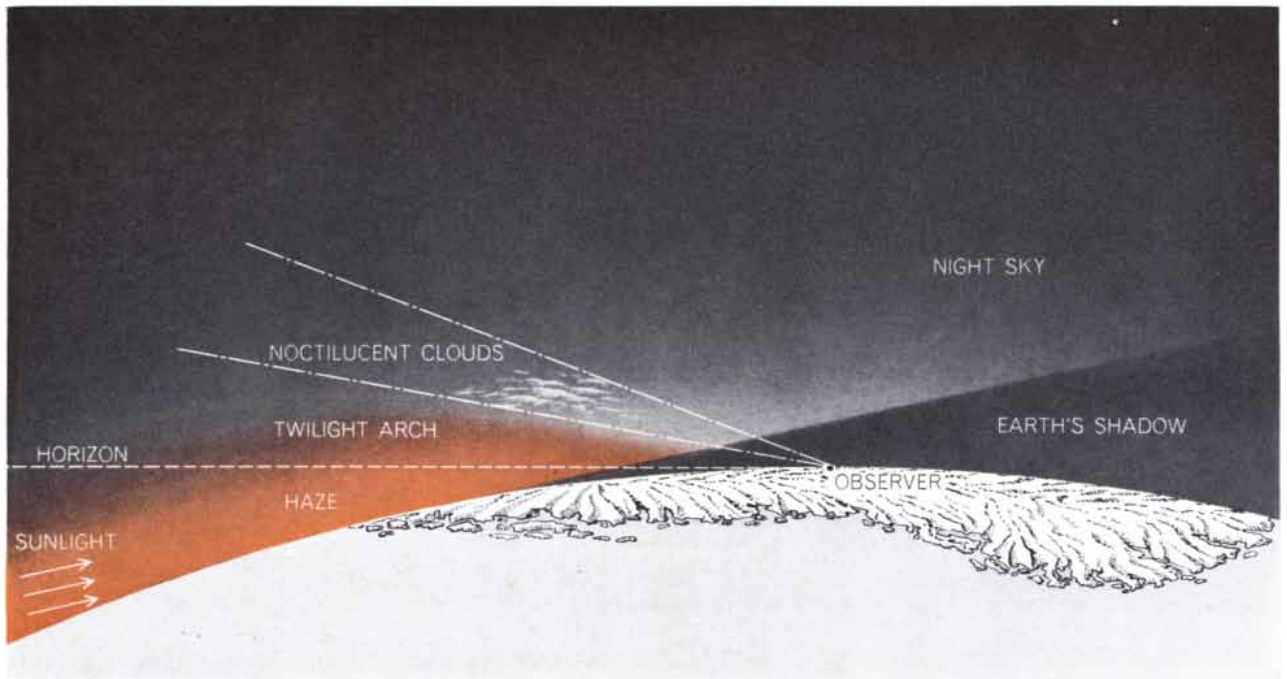
Two of the three hypotheses about the nature of the clouds offer some explanation for the apparent localization of the phenomenon in time and space. According to the first hypothesis, noctilucent clouds are true ice clouds formed by the spontaneous condensation of water vapor. This can occur when the moisture content of the air becomes so great in relation to the temperature that the air is supersaturated (a relative humidity of more than 100 per cent), a common condition in the atmosphere from sea level to 30,000 or 40,000 feet. Higher in the stratosphere, up to about 175,000 feet, the relatively high temperature and low moisture keep atmospheric moisture in the vapor state. At still

higher altitudes the temperature drops until it reaches a second minimum at about 250,000 feet [see illustration on opposite page] in a region known as the mesopause. Here, given sufficiently high humidity along with sufficiently low temperature, condensation of the atmospheric moisture could occur. Rocket studies over Fort Churchill in northern Canada have established that the mesopause temperature at that latitude reaches its lowest value, about 160 degrees below zero Fahrenheit, during the summer months. This may explain why the clouds appear only in summer, and only in the mesopause.

The second hypothesis, which holds that noctilucent clouds consist of non-volatile solid particles, has drawn some support from weak correlations between meteoritic showers and observations of the clouds. An unusually brilliant display over Russia, Sweden, Denmark, Germany and England appeared hours after the great Tunguska meteorite fell in Siberia in 1908. The lowest-latitude sighting, at 45 degrees, was reported on this occasion. Meteorites typically vaporize below 300,000 feet. Many are seen

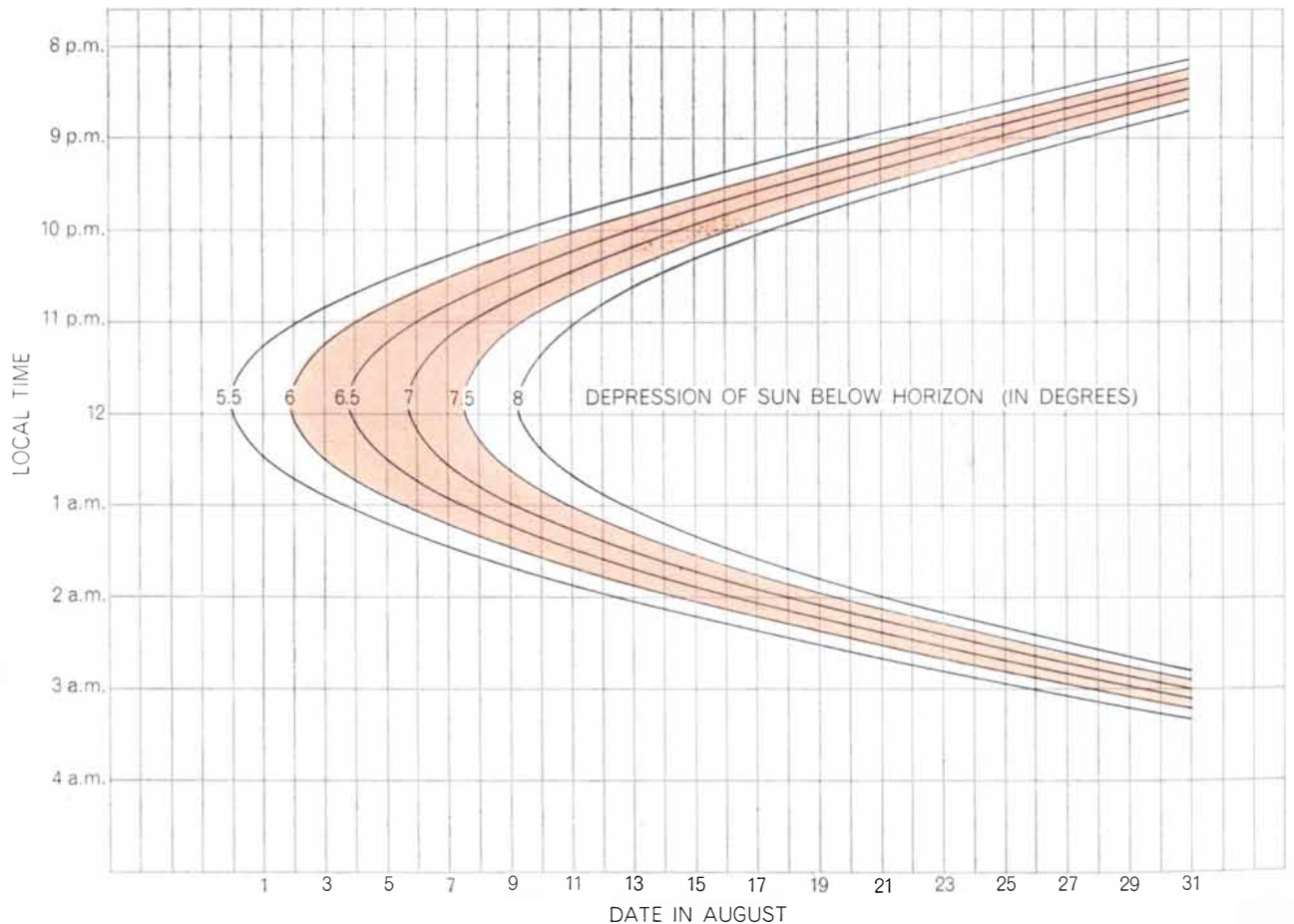


**SITE OF ROCKET EXPERIMENT** was Kronogård, a farm near the Arctic Circle. Observers at Kristineberg could see noctilucent clouds that were directly overhead at Kronogård, although invisible there. Airplane pilots also kept watch between Stockholm and Kiruna.



**TWILIGHT CONDITIONS** associated with observation of noctilucent clouds are illustrated in this diagram. Sunlight comes from below horizon; observer is in semidarkness. Haze layer absorbs sunlight and scatters red wavelengths toward observer, producing

twilight arch (*color*) that blots out faint sources of light. The noctilucent clouds can be seen only above the arch. Occasional bright cloud displays are visible directly above the observer. Conditions shown here last for hours in summer in far north and south.



**OPTIMUM OBSERVING TIME** (*color*) during August at Kristineberg can be found on this chart devised by Witt. Clouds seen

from Kristineberg at normal angle are directly overhead at Kronogård. Continuous observing time is longest early in the month.



to break up in their flight through the atmosphere. In addition, particles too small to leave a visible meteor trail—micrometeorites—constantly rain on the earth. They can be recovered from the air and from deep-sea sediments [see "Cosmic Spherules and Meteoritic Dust," by Hans Pettersson; *SCIENTIFIC AMERICAN*, February, 1960]. The idea that meteoritic dust alone makes up the clouds, however, leaves a number of aspects unexplained. Since the meteoritic dust particles are a permanent feature of the upper atmosphere and presumably distributed evenly around the world, there is no immediately apparent reason why the clouds should make such infrequent appearances, during the summer only, at high latitudes and at the 250,000-foot altitude.

Only a few investigators have suggested that the clouds could be composed of solid particles from the earth. Measurements of the intensity and polarization of the light from the clouds have indicated that the mean diameter of the cloud particles ranges from .1 to .4 micron. (A micron is a thousandth of a millimeter.) There is no evidence for vertical winds strong enough to lift particles of this size to 250,000 feet. Without the aid of cataclysms such as volcanic eruptions (rarer than noctilucent clouds) or the explosion of nuclear bombs (unknown before 1945) such particles could not reach the required altitude.

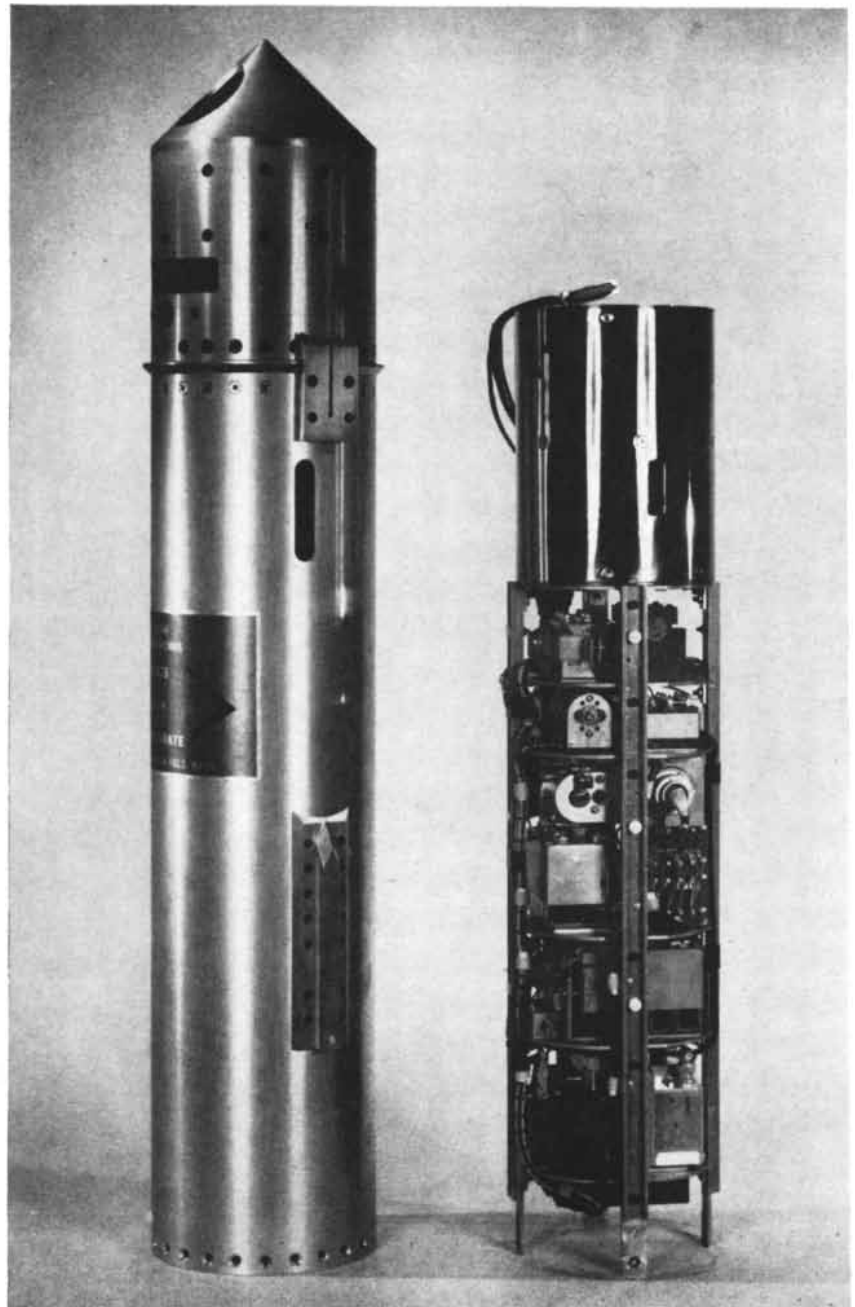
The idea that clouds consist of crystals of ice condensed around non-volatile solid particles agrees with what is known about the formation of ordinary clouds in the troposphere. Solid particles of microscopic size form condensation nuclei that promote the translation of the water in the atmosphere from the vapor to the liquid and solid state. In line with this idea it could be shown that the condensation nuclei of the noctilucent clouds may have a terrestrial origin; they are presumably small enough to be raised by the same circulation mechanism that brings the water-vapor molecules to high altitude. Dust of meteoritic origin, however, could supply the condensation nuclei equally well. In either case the ice coating would cause the particles to "grow" to the postulated diameter of .1 to .4 micron, at which time they would become visible as clouds. The rarity and the peculiar distribution of the clouds could be explained in terms of the special meteorological conditions necessary to wring the water vapor out of the thin

upper atmosphere. Some investigators have even suggested that variation in the delicate balance of condensation and evaporation at slightly different heights causes the wave formations so characteristic of the clouds.

In 1960 the Meteor Physics Branch under my direction at the Air Force Cambridge Research Laboratories started looking into the possibility of direct rocket investigation of noctilucent clouds. We were then working with groups at Union College in Schenectady, N.Y., and Northeastern University in

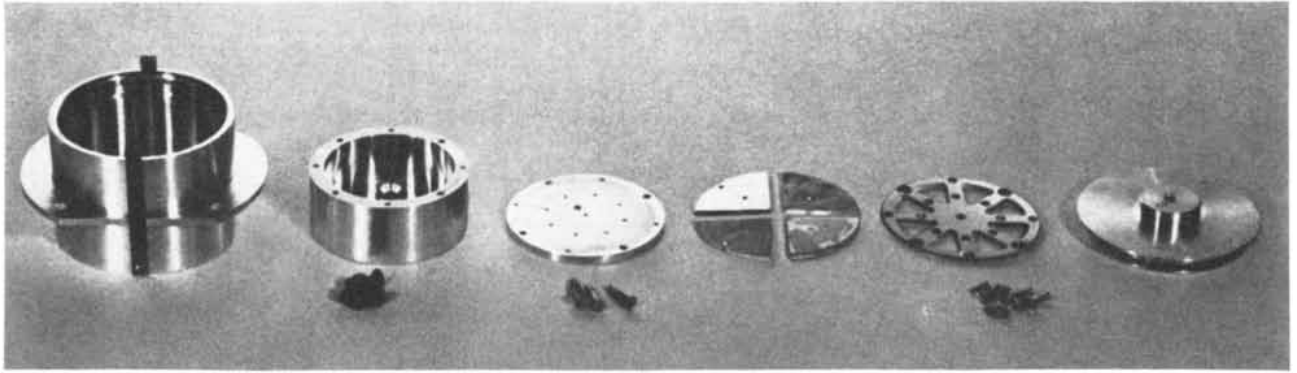
Boston on a project employing rockets to sample meteoritic dust in the upper atmosphere. In June, 1961, the first successful flight of the "Venus Flytrap" rocket brought back particles of this material from 102 miles above its launching site at White Sands, N.M. We decided that direct sampling of noctilucent clouds offered an equally interesting challenge.

Since the project would entail waiting at the launching pad with a "hot" rocket until the clouds appeared, we needed a location where noctilucent



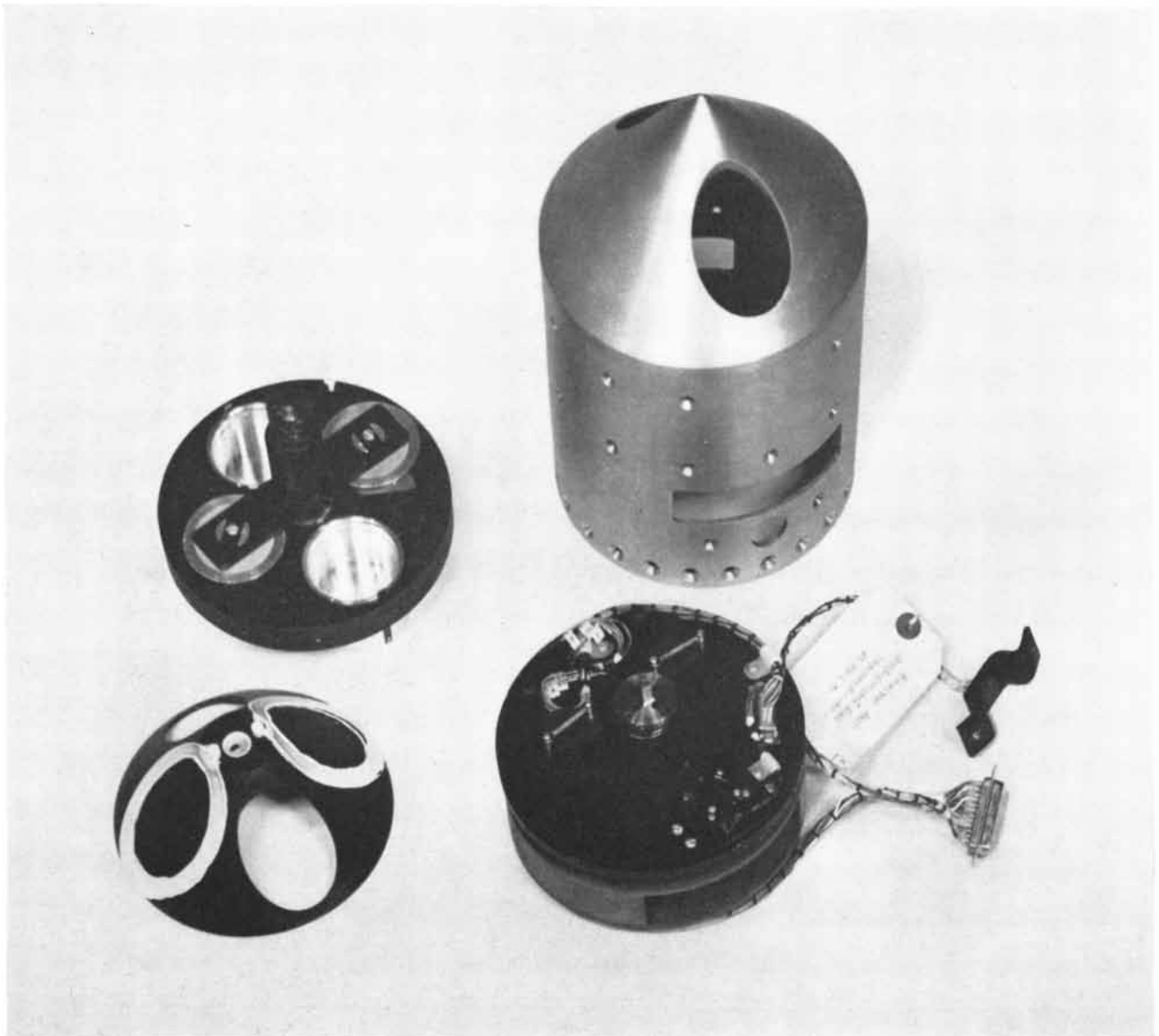
**ROCKET PAYLOAD PACKAGE** included electronic controls, radio transmitters and other equipment seen here. The nose cone, empty here, carried experiments shown on next page.





**PARTICLE COLLECTOR** carried by rocket into noctilucent cloud consisted of (*from left*) can, two spacers, four coated surfaces to catch particles, spoked hold-down plate and a cover for can. Alternate spokes of hold-down plate crossed but did not touch center of

each surface, enabling particles from air to settle there but keeping upper-atmosphere particles away from this area. This arrangement provided one of the controls that allowed the investigators to differentiate between matter from the lower and the upper atmosphere.



**INNER NOSE CONE** of rocket (*upper right*) had two oval holes to expose cans (*upper left*) for collecting particles from mesopause region of atmosphere. Slot in cone was port for nuclear-emulsion pack (*lower right*) of cosmic ray experiment. Interior cone (*lower*

*left*) rotated 90 degrees at 275,000-foot altitude to close ports, and rod holding the can covers also turned 90 degrees to seal the cans. The nuclear emulsion was also turned away from slot. All the parts are arranged here in the "open" position in relation to each other.

clouds had been reported with reasonable frequency. We decided on northern Sweden, which has regions of flat terrain that would make possible overland firing of the rocket and subsequent recovery of the payload. We learned from Bert R. J. Bolin, director of the Institute of Meteorology at the University of Stockholm, that some of the workers at the institute had for several years been conducting an extensive program of ground-based observations of noctilucent clouds (known in Swedish as *nattlysende moln*). With the ready co-operation of the Swedish workers and with equipment supplied by the U.S. National Aeronautics and Space Administration, we set out to take the first samplings of noctilucent cloud particles in the summer of 1962. My principal colleagues on the project were Georg Witt of the University of Stockholm, Curtis L. Hemenway of Union College and William Nordberg of NASA.

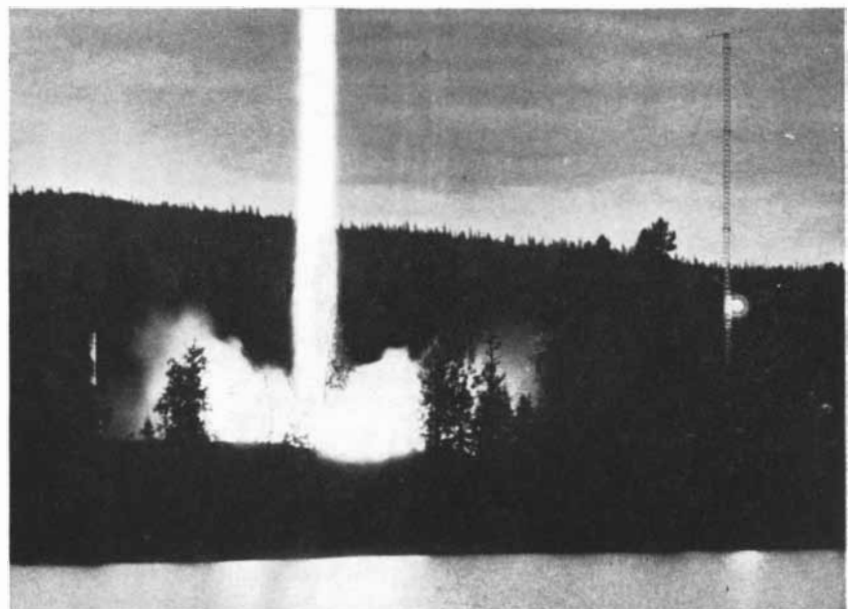
Our scheme was to sample the particles from an observed cloud and also to sample the atmosphere at the same altitude at a time when no cloud was observed. For this purpose NASA supplied us with four Nike-Cajun solid-fuel rockets, capable of carrying a 90-pound payload to an altitude of 75 miles. Into the rocket we packed not only our own cloud-sampling gear but also the instrumentation for two other experiments. These were joint undertakings of the Kiruna Geophysical Observatory and the University of Lund, both in Sweden, and the Cosmic Ray Group at the Air Force Cambridge Research Laboratories. The payload in addition had to include the power supply and electronics for control functions and for the transmission of information to the ground. The package also included dive brakes, a parachute and a radio beacon to bring the payload safely to earth and direct us to the landing spot.

The cloud-sampling gear, carried in the nose of the rocket, consisted of two cans for collecting particles or evidence of particles. To expose the specially prepared collecting surfaces in the cans, the payload ejected its outer nose cone at 225,000 feet. At 275,000 feet the remaining inner nose cone rotated a quarter turn to close the collecting ports and place covers on the cans. The closing of the cans sealed in a sample of the high vacuum of this altitude as well.

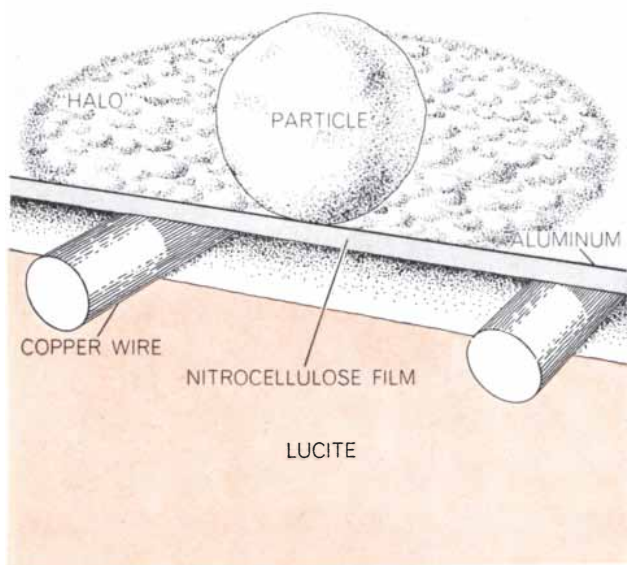
At each point we took extreme precautions to prevent contamination of the collecting surface by terrestrial particles, which could have ruined the ex-



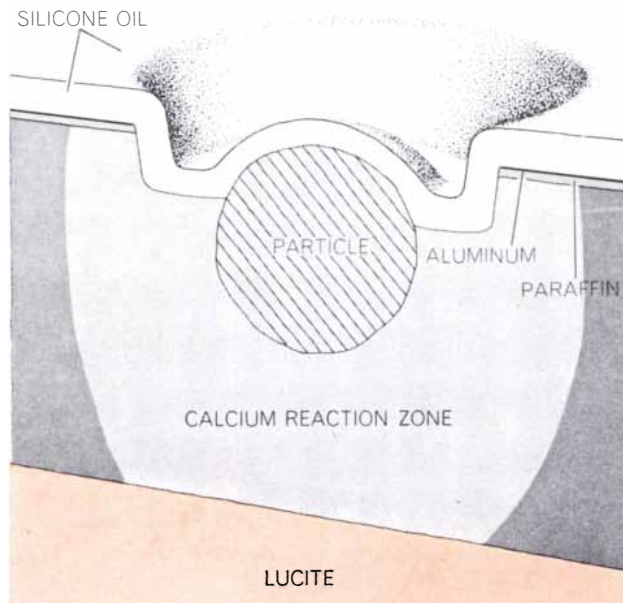
**NIKE-CAJUN ROCKET** is shown being prepared for launching last August at Kronogård. Four of these rockets were flown and two nose cones descended successfully from mesopause.



**MOMENT OF LAUNCHING** of the second rocket took place on August 11 at 2:40 in the morning. The two photographs on this page were supplied by the Swedish Space Committee.



ONE NITROCELLULOSE SURFACE had coating of aluminum, as diagramed here. Another was coated with fuchsin dye. The nitrocellulose film rested on copper-wire mesh. Drawing shows only the arrangement, not the relative scale of the various components.



CALCIUM COLLECTING SURFACE was expected to react chemically with any ice surrounding particles. The silicone oil sealed the hole against atmospheric moisture after penetration by particles. The various parts of this diagram are also not drawn to scale.

periment. The surfaces were prepared and loaded into the cans in a dust-free laboratory. The payload tip was cleaned and the cans were placed inside in a portable dust-free chamber. Before launching we kept the cone in a plastic bag through which filtered air was circulated under positive pressure. Atmospheric friction on the ascent completed the rocket "scrubdown." We knew that, in spite of such precautions, we could not exclude all terrestrial contamination; therefore we built several controls into the experiment to enable us to recognize the contaminants. For example, we mounted a shield over a small area of each of the collecting surfaces, close to but not touching the surface. In the lower atmosphere particles of the size we expected to collect in the mesopause move by Brownian movement and essentially "float" in the air, so that any surface over which air passes will collect some of the particles. At the extremely low pressure of the upper atmosphere, particles of this size travel in ballistic trajectories and cannot strike a shielded surface. Hence we could discount as contaminants any particles found on the unshielded areas that looked like those on the shielded areas.

We prepared four different kinds of collecting surface. One was designed to collect solid particles that did not evaporate; it consisted of a nitrocellulose film with a thin coating of aluminum, resting on a copper-wire grid [see illustration at left above]. To record the pres-

ence of ice, which would have melted and evaporated before we could recover the nose cone, we coated another such film with a fuchsin dye that would show spots where particles or parts of them had melted. We made one surface out of the soft metal indium in the hope that it would show the impact craters of particles, whether or not they were still present. (Unfortunately the craters, if any, are so small we cannot as yet pick them out from the roughness of the surface attributable simply to the grain structure of indium.) The fourth collecting surface consisted of calcium coated with paraffin, aluminum and silicone oil. This surface too was designed to detect the presence of ice particles or ice-coated particles. The particles would have sufficient momentum to penetrate the protective coatings, and the water would react with the calcium to produce calcium hydroxide. Any solid particle or solid core of a particle would be sealed in the calcium by the oil, which would protect the calcium from reaction with water vapor in the atmosphere.

The launching site, prepared under the direction of Lars Rey and the Swedish Space Committee, was an old farm called Kronogård near the Arctic Circle. All the equipment was set up and made ready early in August, and we began our nightly vigil. Experienced observers searched the sky from ground stations throughout Scandinavia while Swedish aircraft carried trained men

above the low clouds to watch for noctilucent clouds. On their nightly run from Stockholm to Kiruna commercial airline pilots were to report by radio if they saw what they thought were clouds of this type. Trained observers stationed at Kristineberg, about 90 miles south of our station, provided particularly valuable information. They looked for clouds 20 degrees or so above their northern horizon; these clouds would be directly over our heads at Kronogård. We probably would not be able to see them, although we might see extensions of the same display above our northern horizon. After a week of expectancy, shared by all of Sweden through the newspapers, we fired the first rocket. Before the month was over we had fired all four. Two of the flights were successful. We recovered cans from one flight into a noctilucent cloud and from one when no clouds were visible.

The rocket that penetrated the cloud collected some 10 million particles per square inch of collecting surface. This was between 100 and 1,000 times more than the number of particles collected by the rocket that traversed the same upper regions of the atmosphere on a cloudless night. From the solid particles or nuclei of particles [see illustrations on opposite page], we have learned that part, at least, of the cloud substance is solid and not volatile. About 20 per cent of the particles, however, are surrounded by a halo, or ring, on the collecting surface, indicating that these particles

had a coating of some substance that later evaporated. From studies of the calcium surface it appears that the coating was indeed ice. Significantly, the particles collected by the control rocket from a cloudless sky show no evidence of having had a coating of ice. Further detailed studies of the particles are now being conducted under at least seven different electron microscopes on both sides of the Atlantic.

In our laboratory we have turned to the determination of the chemical composition of the particles, an extremely difficult task because the total mass of the particles collected comes to only a ten-millionth of a gram. For chemical analysis we have to employ neutron activation in a reactor or bombardment with electrons to obtain an X-ray spectrum. These techniques are sensitive only to certain elements and at best yield limited information. The solid particles do seem to contain nickel, an element quite rare in terrestrial particles but common in those of meteoritic origin. The size of the solid particles, which mostly range from .05 to .5 micron in diameter, also indicates an extraterrestrial origin; this is in agreement with the size of the particles as estimated from optical studies and is considerably larger than the maximum size of terrestrial particles that could be carried upward in the atmosphere.

**I**t would appear, therefore, that the noctilucent clouds consist of extraterrestrial dust particles coated with ice. This finding as to the substance of the clouds by no means explains their origin. The meteoritic particles are supposed to be uniformly distributed in the upper atmosphere, and there is no good reason why they should be distributed in any other way. Yet our flight into a cloudless sky yielded a particle count like that from the Venus Flytrap rocket over New Mexico, or between 100 and 1,000 times fewer particles than the flight into a cloud. No one has yet proposed an explanation for such a large local fluctuation in the concentration of extraterrestrial particles in the high atmosphere. It is also an open question whether the higher concentration of these particles, serving as condensation nuclei, initiates the formation of the clouds or whether the condensation of the clouds is more purely a matter of local temperature, air pressure and vapor pressure. We hope the rocket flights now being planned for 1964 will begin to answer these and the other questions that surround the rare and beautiful spectacle of the noctilucent clouds.



**NOCTILUCENT CLOUD PARTICLES** were captured on an aluminum-nitrocellulose surface during rocket flight. Particles are nonvolatile, but many are surrounded by halos presumably made by volatile material. The particles are enlarged about 30,000 diameters in this electron micrograph, which was made at Air Force Cambridge Research Laboratories.



**MESOPAUSE PARTICLES** such as this one, collected during rocket flight into sky empty of noctilucent clouds, produced no halo on aluminum or dye surfaces. Collecting surfaces from cloudless mesopause contained 100 to 1,000 fewer particles than those flown into cloud.



# Kilomegacycle Ultrasonics

*“Ultrasonics” usually means acoustic frequencies up to a billion cycles per second: one kilomegacycle. Waves of higher frequency interact with matter and other forms of energy in intriguing ways*

by Klaus Dransfeld

Experiments in ultrasonics have recently entered a new realm. The word “ultrasonics” customarily refers to acoustic waves with frequencies from 20,000 cycles per second—the upper limit of human hearing—to a billion cycles per second. The new experiments deal with acoustic waves with frequencies up to 20 billion cycles per second: 20 kilomegacycles.

These frequencies are the same as those of the electromagnetic waves of microwave radar. Because acoustic waves do not move so fast as electromagnetic waves their wavelengths are shorter; this is a consequence of the law that wavelength times frequency equals velocity. Kilomegacycle acoustic waves have a velocity of about 400,000 centimeters per second and a wavelength roughly equal to that of visible light.

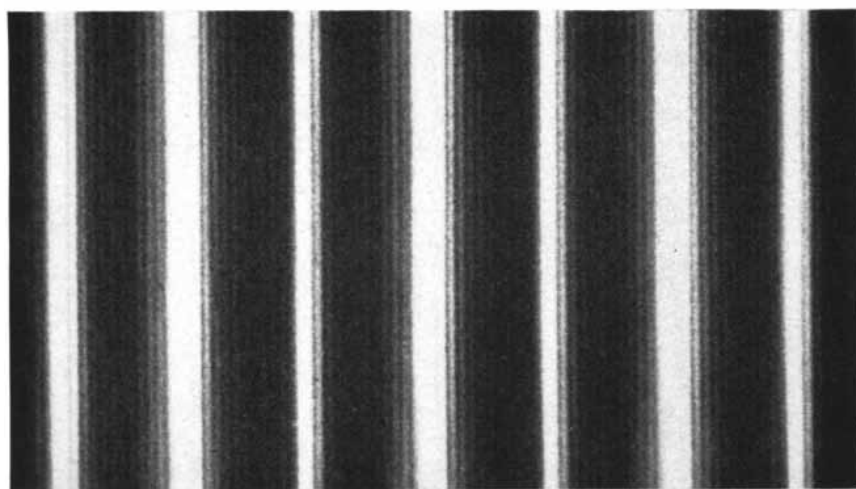
This very short wavelength allows the waves to interact with matter and with other forms of energy in a number of interesting and informative ways.

For example, kilomegacycle acoustic waves can be made to interact with light waves. As a matter of fact, light waves will also interact with ultrasonic waves of lower frequency. If a piece of transparent material is set up so that such waves travel through it in one direction, and if light waves are then sent through it at right angles to this direction, the light waves behave as though they were passing through a diffraction grating. The index of refraction of the material is changed at regular intervals corresponding to the length of the ultrasonic waves, and the straight fronts of the much shorter light waves are diffracted into a corrugated pattern accord-

ing to the laws of geometric optics. If the diffracted waves fall on a screen, they reinforce and cancel one another to produce the light and dark “fringes” characteristic of diffraction from a flat grating [see illustration on this page].

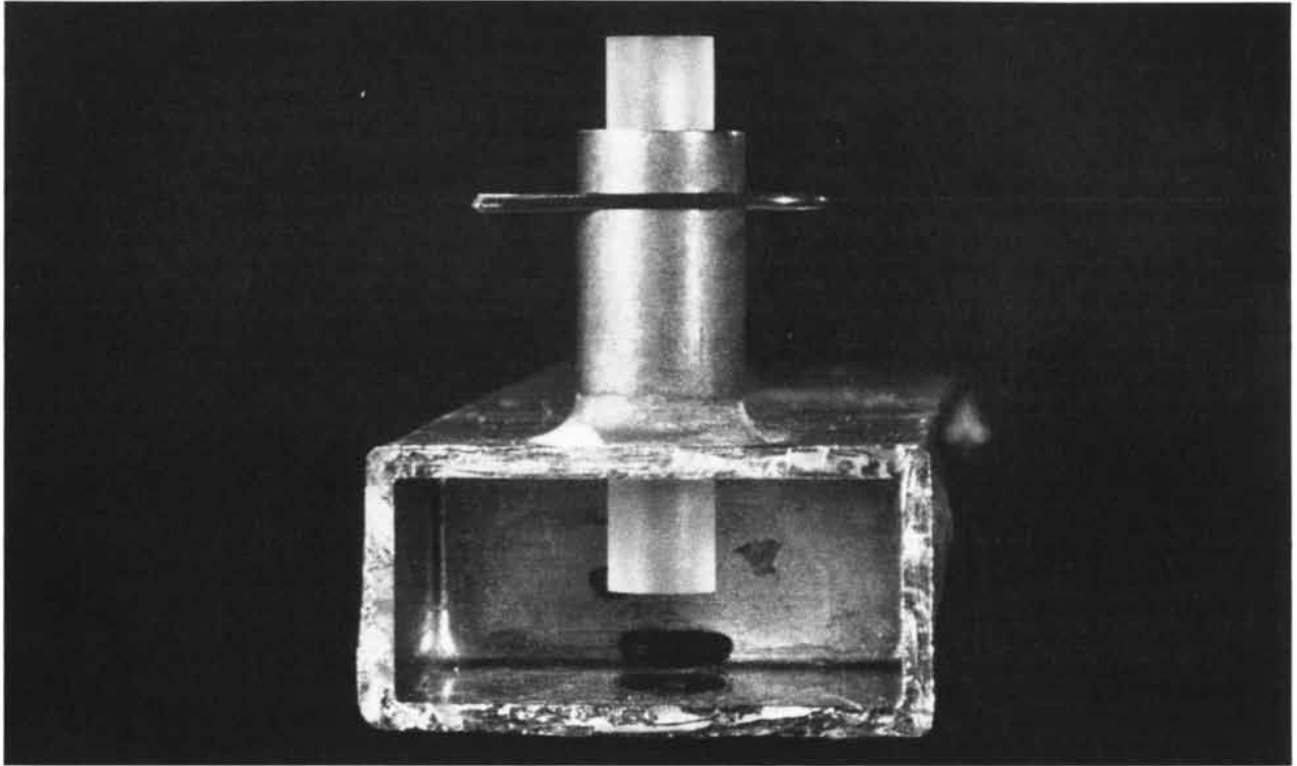
When the ultrasonic waves passing through the crystal are in the kilomegacycle range, the light waves behave in a somewhat different way. The acoustic waves and light waves are now of similar length, and light waves sent through the material at right angles to the direction of the acoustic waves simply pass through the material without being bent. If, on the other hand, the light waves are sent through the material at certain other angles to the direction of the acoustic waves, the light waves are reflected [see bottom illustration on page 62]. This reflection obeys the laws that apply to the diffraction of X rays by planes of atoms in a crystal: the phenomenon named Bragg reflection after its discoverer, the British physicist Sir William Bragg.

In Bragg reflection by planes of atoms the reflecting system is stationary; in Bragg reflection by ultrasonic waves the reflecting surface is moving at the speed of sound. The surface thus acts like a moving mirror and shifts the frequency of the reflected light. If, for example, the ultrasonic wave is moving away from the light source, the frequency of the reflected light wave is reduced exactly by the frequency of the ultrasonic wave. In quantum-mechanical terms this means that part of the energy of the light wave is added to the energy of the acoustic wave; indeed, a kilomegacycle acoustic wave can be amplified by the waves in a strong beam of light.



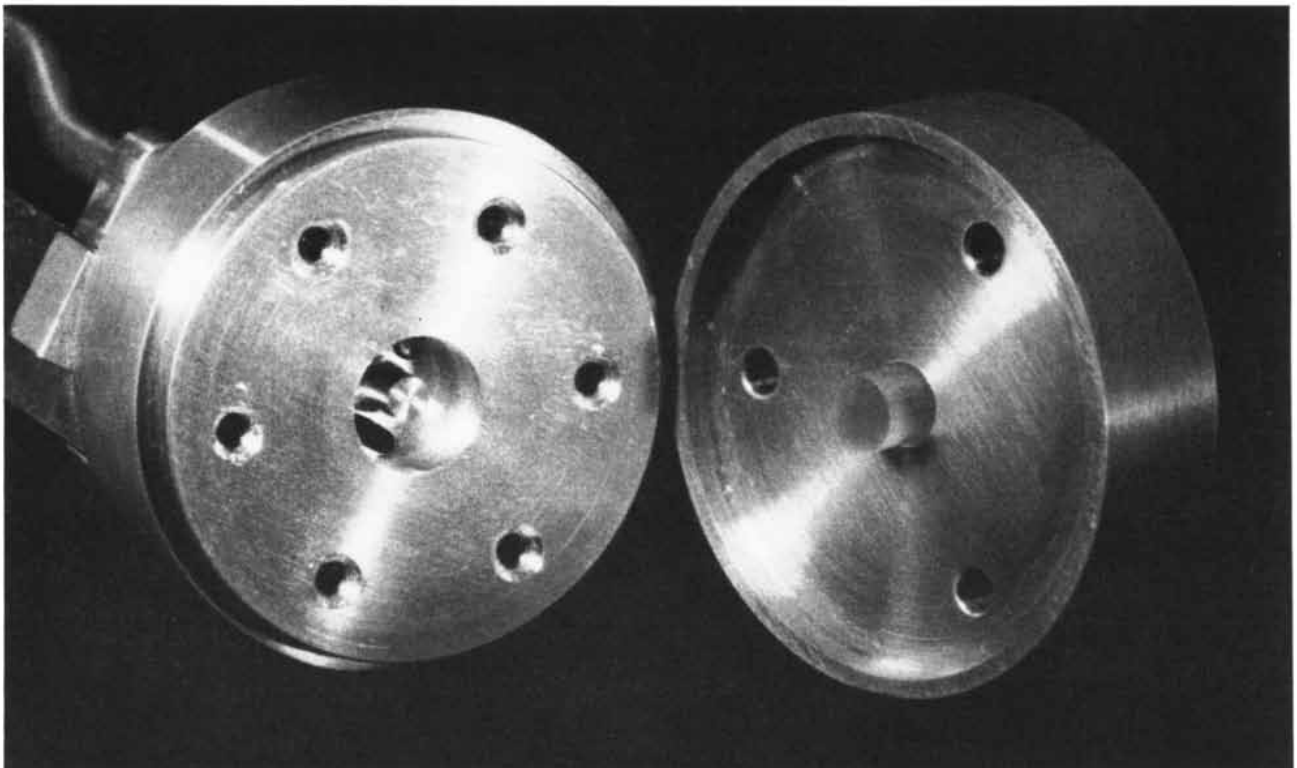
LIGHT IS DIFFRACTED by ultrasonic waves having a frequency of less than one kilomegacycle. The pattern of fringes in this photograph by Walter G. Mayer of Michigan State University was produced by shining a beam of light through water that was subjected to ultrasonic waves with a frequency of 5.2 megacycles. The beam was perpendicular to the direction of ultrasonic wave travel. Where the light waves reinforced one another they appear as light bands; where they canceled, as dark areas. The band at center is undiffracted light.

At this point the reader may be asking: How are kilomegacycle acoustic waves made? Like ultrasonic waves of



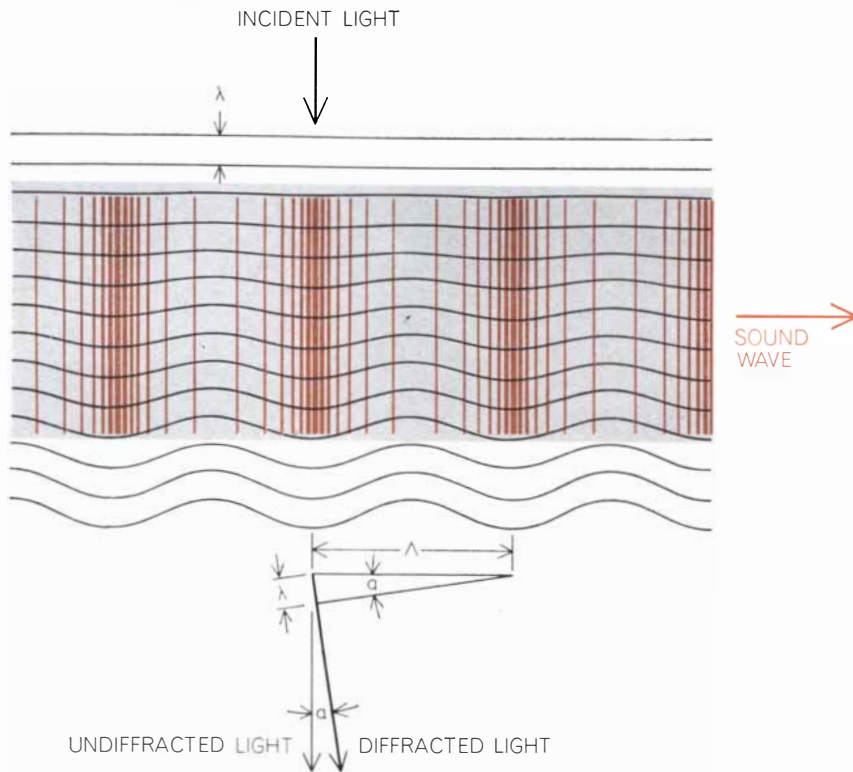
**KILOMEGACYCLE ULTRASONIC WAVES** can be generated in a quartz rod by microwave energy. Here the rod protrudes into a rectangular microwave cavity made by inserting a small metal partition several centimeters from the end of a wave guide. The oblong

hole at the bottom of the partition allows the passage of the microwaves that excite ultrasonic waves in the quartz. The lid of the cavity has been removed to show the rod. The diameter of the rod in this photograph and in the one below is about five millimeters.

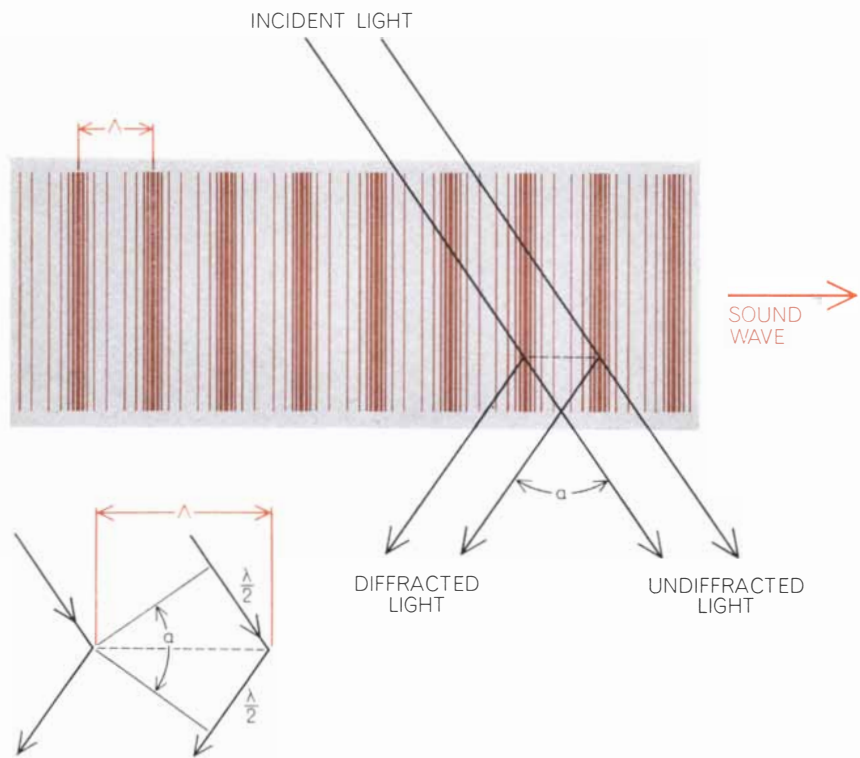


**RE-ENTRANT MICROWAVE CAVITY** is used to generate and detect acoustic waves of kilomegacycle frequencies. In use the two halves shown here are screwed together. The quartz rod at right rests against the center post of the cavity at left. Microwave energy

applied through the post generates ultrasonic waves in the rod. Echoes of waves from the external end of the rod (*not visible*) are reconverted into electromagnetic signals (in the cavity), which pass through the hole next to the post to a sensitive receiver.



**LOW-FREQUENCY ACOUSTIC WAVES** in a transparent material diffract light as shown in this diagram. The relation governing this effect states that the sine of the angle of diffraction ( $\alpha$ ) equals the wavelength of the light ( $\lambda$ ) divided by the wavelength of the sound ( $\Lambda$ ). Diffraction is greatest when the incident light is parallel to the acoustic wavefronts.



**HIGH-FREQUENCY ACOUSTIC WAVES** diffract light according to the laws of Bragg reflection; that is, twice the sine of one-half the diffraction angle ( $\alpha$ ) equals the light wavelength ( $\lambda$ ) divided by the acoustic wavelength ( $\Lambda$ ). If, however, the incident light is perpendicular to the direction of the acoustic waves, it passes through without being diffracted.

lower frequency, they can be generated by piezoelectric crystals: crystals that change their shape when they are subjected to an electric field and that conversely create an electric field when their shape is changed. In conventional ultrasonics the crystal is cut in such a way as to resonate at the desired frequency; this could also be done to generate kilomegacycle waves, but a simpler method is available. It calls for a fairly large quartz crystal that has flat, parallel ends; the planes of atoms in the crystal must be suitably oriented, but the crystal is not cut for resonance. If one end of the crystal is subjected to an alternating electric field of high frequency, the alternating mechanical strain that results is transmitted through the length of the crystal as an ultrasonic wave. At the other end of the crystal the acoustic energy of the wave is partly reconverted into electrical energy.

In practice the quartz rod is set up so that each end is inside a resonant cavity [see top illustration on opposite page]. Pulses of microwaves are fed into one cavity; the other cavity is connected to a sensitive receiver and perhaps to an oscilloscope. The microwave pulses produce ultrasonic pulses that echo back and forth between the ends of the rod. On the oscilloscope the amplitude of the echoing pulses can be observed to decay as they are absorbed [see bottom illustration on opposite page].

Kilomegacycle waves are strongly absorbed in a quartz crystal at room temperature. When the behavior of such waves in quartz was first investigated, however, it was soon discovered that the absorption almost disappeared in a crystal that had been cooled to the temperature of liquid hydrogen (20 degrees Kelvin, or 20 degrees centigrade above absolute zero). It turned out that above about 40 degrees Kelvin the absorption is almost independent of temperature; it simply increases with the square of the frequency, reaching very high values in the microwave region. Below 40 degrees K. the absorption rapidly disappears, even for the highest frequencies.

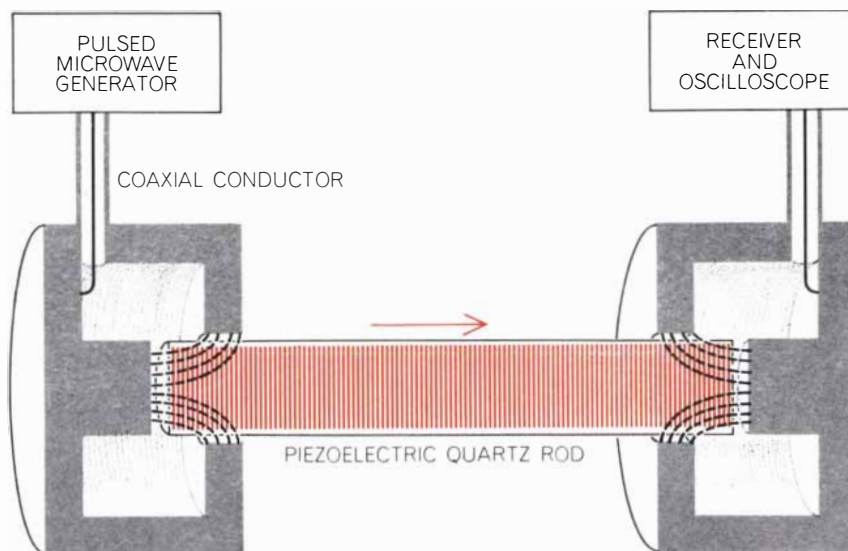
Why is this so? The best explanation is provided by a theory put forward by the Soviet physicist A. I. Akhiezer even before the kilomegacycle experiments were undertaken. At ordinary temperatures the atoms in a crystal are in ceaseless vibration around their positions in the crystal lattice; the thermal energy that excites the vibration is transmitted through the crystal in tiny pulses, or quanta, of sound that are called phonons. According to Akhiezer's theory, when an

ultrasonic wave passes through a crystal, it puts a strain on the crystal lattice and disturbs the equilibrium distribution of the thermal phonons. The equilibrium distribution is then restored by the random collision of phonons. This "relaxation" takes a measurable time, during which the entropy of the system is increased at the expense of the ultrasonic wave; in other words, ultrasonic waves are absorbed and converted into heat.

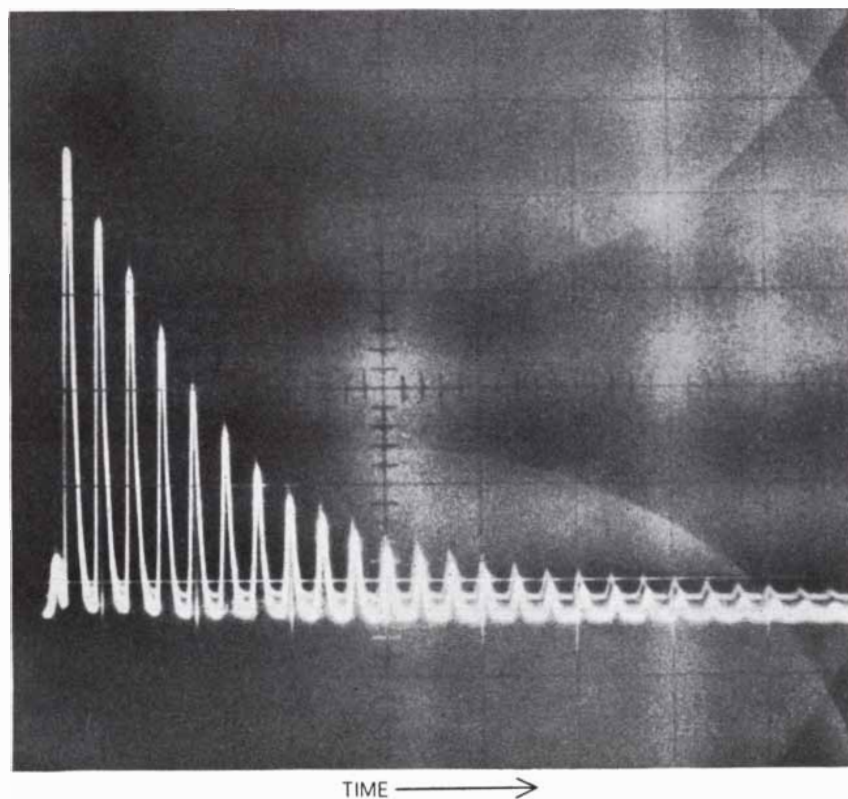
On this basis the absorption of the ultrasonic waves is dependent on the frequency of collisions between thermal phonons. When a crystal is cooled, it contains fewer thermal phonons and therefore fewer phonons are available for collision. As the crystal is cooled to the point at which the frequency of phonon collision approaches the frequency of the ultrasonic waves, the absorption of the waves diminishes sharply. This occurs at about 40 degrees K. The same general phenomenon has now been observed not only in quartz but also in germanium, silicon and sapphire; it probably holds true for all perfect single crystals of substances that do not conduct electricity.

In a semiconducting crystal—a crystal that contains a few free electrons for the conduction of electricity—ultrasonic waves can also interact with electrons. This interaction is particularly strong in piezoelectric semiconductors such as cadmium sulfide and zinc oxide, because the strain imposed on the crystal lattice by the ultrasonic wave gives rise to an alternating electric field within the crystal. The interaction is strongest of all when the electrons stay in the same region of the ultrasonic wave; for example, when they are moving in the same direction and at the same speed as the wave.

A. R. Hutson, J. H. McFee and D. L. White of the Bell Telephone Laboratories have demonstrated that this interaction can be harnessed to amplify ultrasonic waves. If a semiconductor is subjected to a direct-current voltage of sufficient magnitude to make the conduction electrons drift through the crystal at the same speed as an ultrasonic wave, the electric fields associated with the wave will bunch the electrons in the wave troughs [see illustration on page 65]. If the voltage is increased, the bunches of electrons will tend to overtake the acoustic wave. As they do so, however, they must work against the electric field associated with the wave. The energy lost by the electrons is now contributed to the acoustic wave; that is, the wave is amplified. The method works

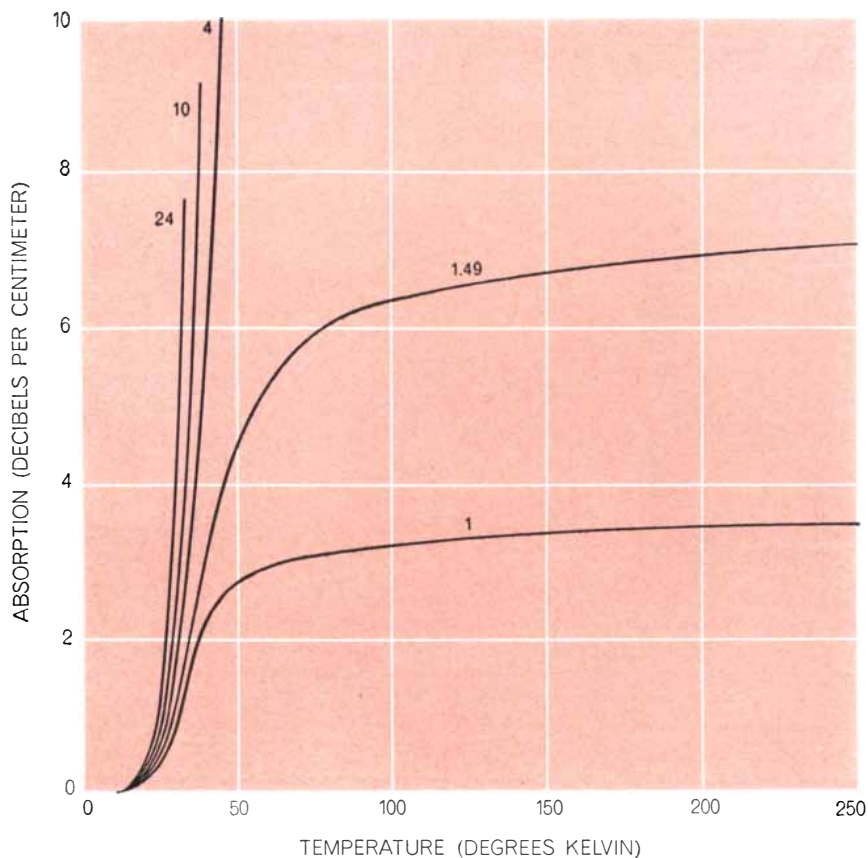


GENERATION AND DETECTION of kilomegacycle ultrasonic waves are depicted schematically. A microwave generator feeds pulses of microwaves into cavity containing one end of a special quartz crystal (left). The microwaves produce ultrasonic vibrations in the crystal; these ultrasonic waves echo back and forth between the ends of the crystal. In the resonant cavity at the other end a small fraction of the waves are reconverted into electrical energy, which is "picked up" by a sensitive receiver and recorded on an oscilloscope.

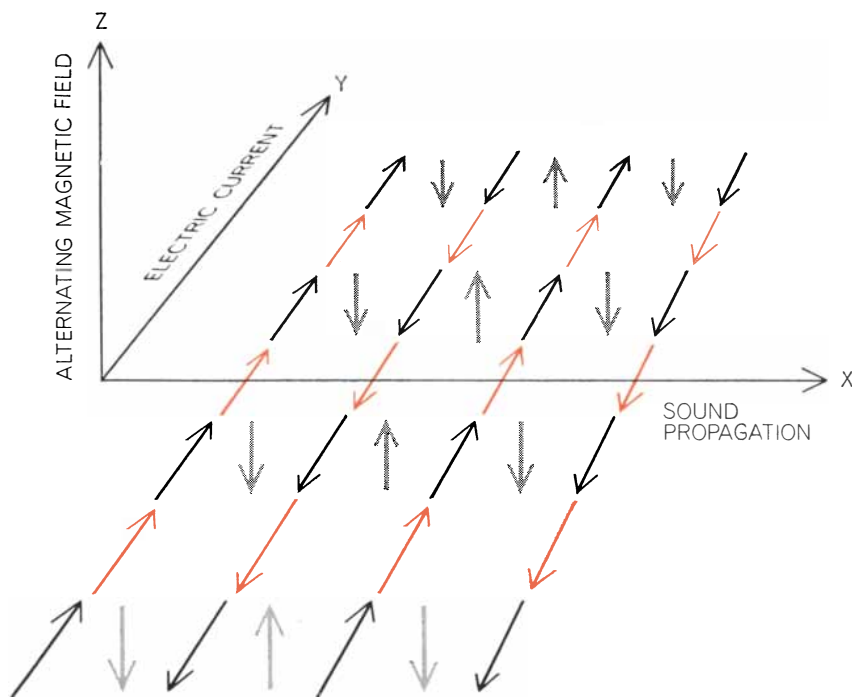


ECHOING ULTRASONIC WAVES were recorded in this oscilloscope trace produced in the author's laboratory at the University of California. The small peak at bottom left marks the time at which the first ultrasonic wave was generated. The tallest peak represents this initial wave, transmitted through a quartz crystal one inch long to the receiver cavity (see illustration above). The next pulse records a wave that has made, in addition, one round trip between the end faces of the crystal; that is, it was reflected at the receiver and then at the generator end before being recorded. Each succeeding pulse thus represents a wave that has made one additional circuit more than the wave that preceded it. The time between pulses is 10 millionths of a second. The decreasing height of the peaks results from acoustic absorption by the quartz crystal. The frequency of the waves was one kilomegacycle.





**ABSORPTION OF LONGITUDINAL ACOUSTIC WAVES** (compressions and rarefactions) in quartz is independent of temperature above 75 degrees Kelvin; below 20 degrees, quartz is transparent at all frequencies. Numbers on the curves indicate kilomegacycles.



**ABSORPTION OF TRANSVERSE ACOUSTIC WAVES** (motion perpendicular to wave travel) at kilomegacycle frequencies may differ from that of longitudinal waves. A transverse wave in metal would cause the positive ions to move (black arrows) perpendicularly to wave travel, generating an alternating magnetic field (vertical arrows), which in turn induces an electric field (colored arrows) acting on the conduction electrons in the metal.

well at frequencies below one kilomegacycle and is most promising for the amplification of higher frequencies. It is predicted that in certain materials a 10-kilomegacycle acoustic wave will be amplified by a factor of a million after traveling only half a millimeter.

If ultrasonic waves interact with the conduction electrons in a semiconductor, they will obviously interact with the far more numerous conduction electrons in a metal. Some years ago at the Bell Laboratories Hans E. Bömmel showed that even at lower frequencies ultrasonic waves are absorbed by the conduction electrons in various metals. That this absorption is really due to interaction with electrons is demonstrated by the fact that it disappears when the metals are cooled to the point where they become superconducting; in the superconducting state, in which a metal has no electrical resistance, there are hardly any conduction electrons available to interact with the acoustic waves. At temperatures above those at which a metal is a superconductor, the absorption of low-frequency ultrasonic waves increases with frequency.

Only a few experiments on the absorption of waves in the kilomegacycle range have been performed, but one can predict that the absorption may differ strikingly for two aspects of the same wave. Like all acoustic waves, ultrasonic waves can be represented by two kinds of particle motion: in the case of longitudinal waves the particles move back and forth in the direction of the propagation of the wave, giving rise to compression and rarefaction; in the case of a transverse wave the particles move at right angles to the direction of propagation, and there is no compression and rarefaction. The crystal lattice of a metal is made up of positively charged ions, and when an ultrasonic wave passes through the crystal, its longitudinal component moves the ions back and forth around their positions in the lattice; in other words, the ions are alternately compressed and rarefied. Up to very high frequencies the free electrons in the crystal, being negatively charged, then move back and forth in almost immediate response: they too are alternately compressed and rarefied. Now, the behavior of electrons in a metal follows the rules of Fermi statistics, according to which the energy of electrons is always related to their density. Thus when the density of the electrons in a metal is disturbed, the distribution of their energies is also disturbed. To re-establish the

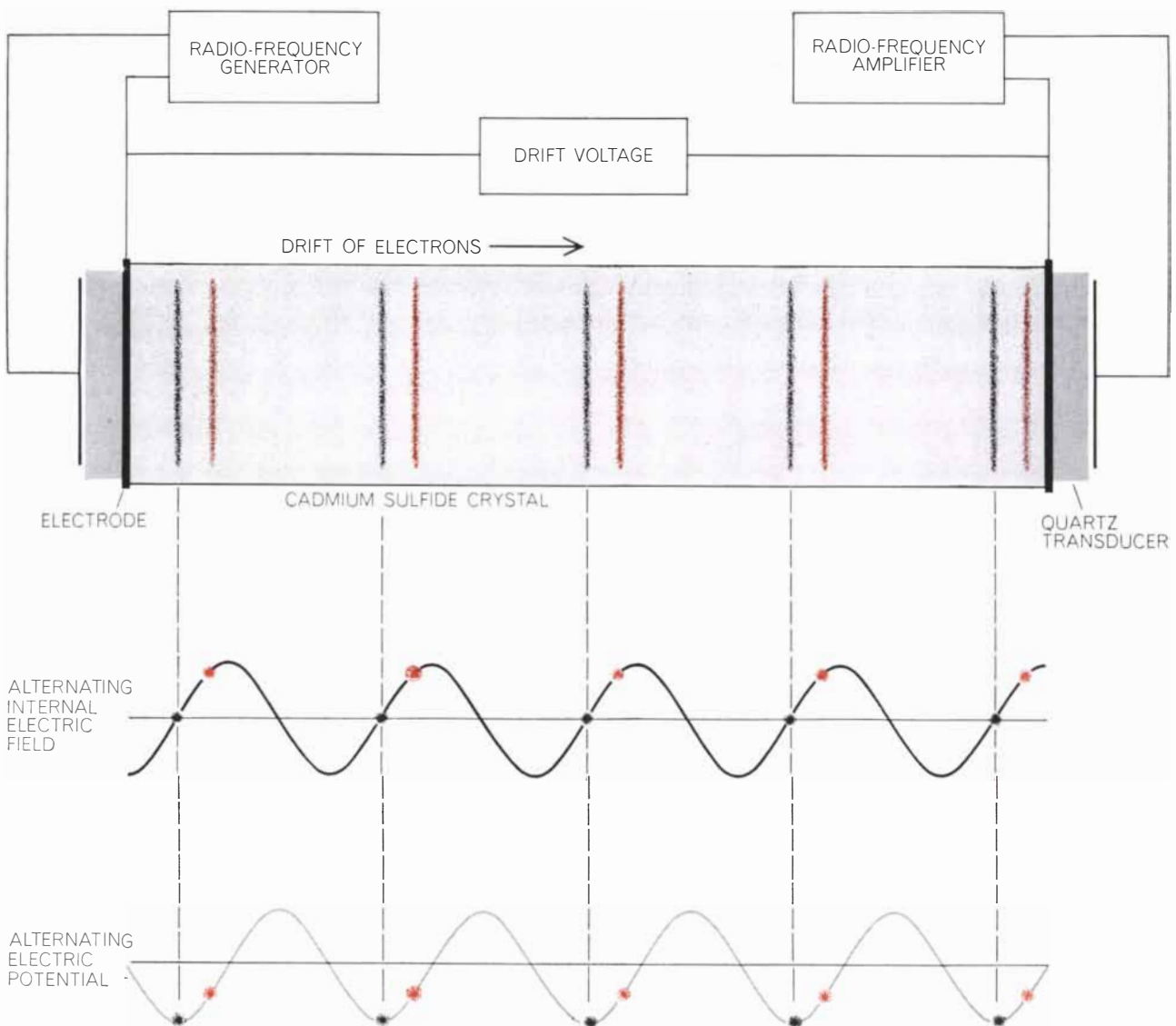
equilibrium distribution—as to re-establish the distribution of the thermal phonons—a certain relaxation time is required, and again some of the energy of an acoustic wave passing through the system is absorbed and dissipated as heat. In fact, in a typical metal a longitudinal wave that has a frequency of 10 kilomegacycles may be expected to lose half of its energy in only .1 millimeter.

What is striking is that the fate of a kilomegacycle transverse wave may be quite different. Since the transverse wave does not compress and rarefy the positive ions and electrons, it cannot

lose energy in this way. The transverse motion of the ions induced by the transverse wave nonetheless represents an electric current; this current generates a magnetic field, which in turn generates an electric field parallel to the current. The electric field does interact with the electrons in the metal and lead to the absorption of acoustic waves. It can be shown, however, that for acoustic waves of very high frequency the strength of the induced electric field decreases. It may therefore turn out, when the experiments are performed, that at kilomegacycle frequencies metals are con-

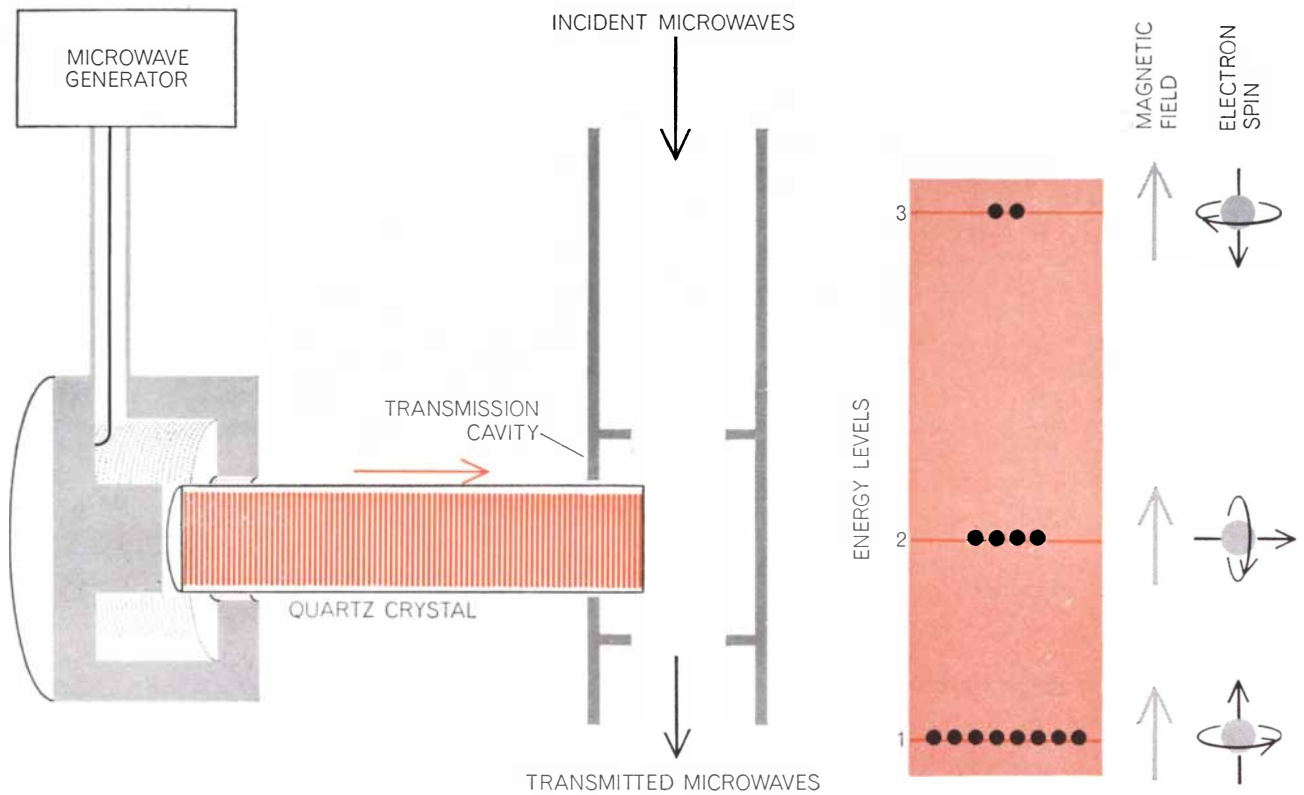
siderably more transparent to transverse acoustic waves than to longitudinal ones.

So far in the discussion no account has been taken of the fact that the electron is not only an electrically charged particle but also a magnetic dipole: it has “north” and “south” magnetic poles. This property of the electron, which arises from its spin, underlies the large-scale magnetism of magnetic materials. In an iron atom most of the electrons are “paired”: their spin and their magnetism are canceled by the opposite spin of another electron. Some of the electrons,



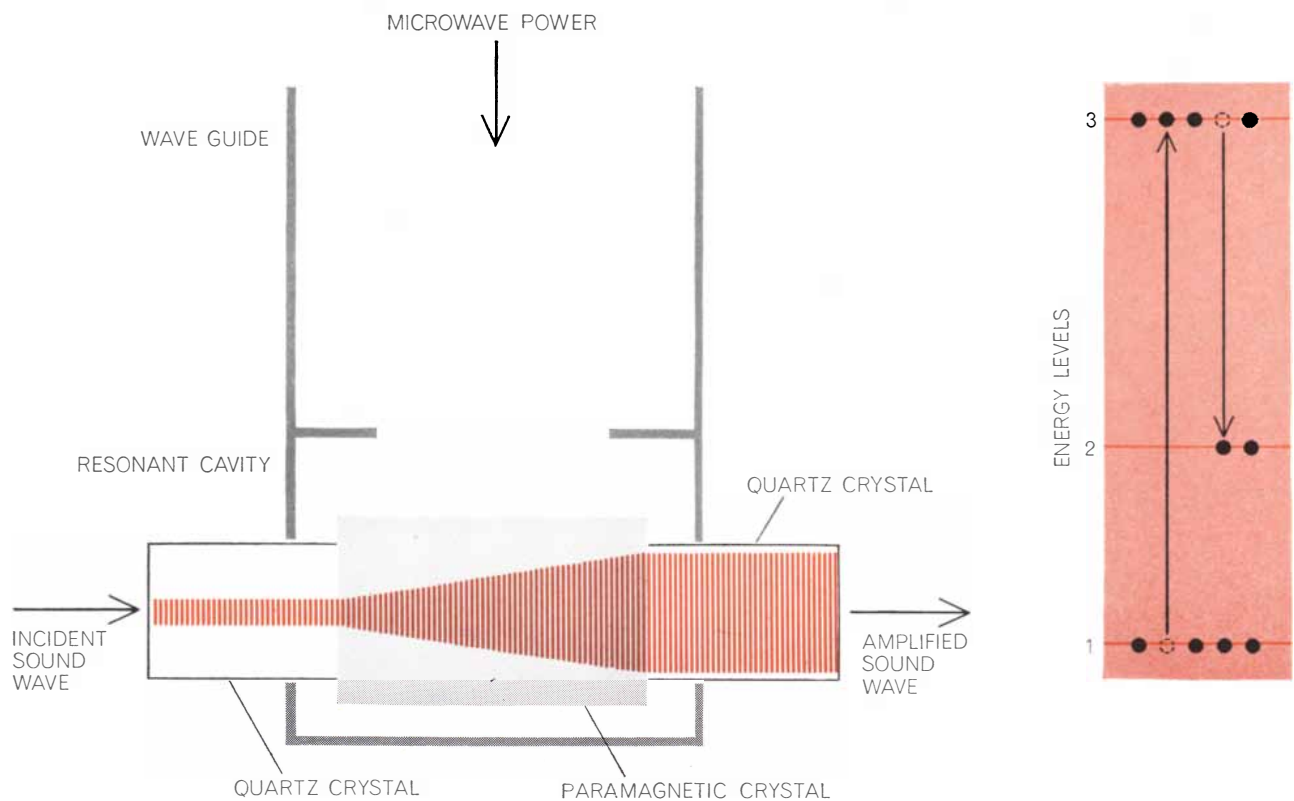
**ULTRASONIC WAVES ARE AMPLIFIED** by conduction electrons in a piezoelectric semiconductor. The passage of an ultrasonic wave (*not shown*) through the cadmium sulfide semiconductor induces an alternating electric field (*black curve*) within the crystal. When a given drift voltage is applied, the conduction electrons (*black stippled areas in the crystal and on both curves*) move

through the crystal at the same speed as the ultrasonic wave and tend to become bunched in the troughs of the wave. If the drift voltage is increased, the electron bunches begin to overtake the wave (*colored stippled areas*). They are slowed down, however, by the electric field associated with the wave; the energy lost by the electrons as a result of this interaction amplifies the ultrasonic wave.



**ELECTRON SPINS** of paramagnetic impurities in a quartz crystal can be used to detect ultrasonic waves. Electron spins can assume three orientations with respect to a magnetic field (*right*). At low temperatures most electrons occupy lower energy levels. They are

raised to higher energy levels by the absorption of either microwave or acoustic energy. Thus a paramagnetic crystal that normally absorbs a given amount of microwave energy in the presence of a magnetic field will absorb less when an ultrasonic wave is applied.



**“MASER” ACTION** amplifies acoustic waves in a paramagnetic crystal. Microwave power of a particular frequency inverts the electron populations of levels 2 and 3 (*right*). An incident acoustic

wave of the proper frequency stimulates the level-3 electrons to emit this excess energy, amplifying the wave. (The direct-current magnetic field acting on the paramagnetic crystal is not shown.)

however, are unpaired; it is the spin of these electrons and their motion around the nucleus that endow the iron atom with its magnetism.

If magnetic atoms are subjected to a magnetic field that changes direction at the appropriate frequency, the spin axes of the electrons are made to precess, or rotate around their normal orientation. This "magnetic resonance" has been applied in a wide variety of useful ways [see "Magnetic Resonance," by George E. Pake; *SCIENTIFIC AMERICAN*, August, 1958]. It now seems possible that magnetic resonance can be excited not only by alternating magnetic fields but also by ultrasonic waves.

Consider, for example, a crystal in which iron atoms occupy some positions in the lattice of the nonmagnetic material magnesium oxide; such a crystal is paramagnetic, or weakly magnetic. Here one must recall that the magnetism of the iron atom is due both to the spin of unpaired electrons and to their orbital motion. The magnetic moment of the spin and the magnetic field due to orbital motion interact in what is known as "spin-orbit coupling." If an ultrasonic wave of the appropriate frequency and polarization is sent through the crystal, the displacement of the atoms in the crystal lattice will slightly distort the electron orbits. Because of spin-orbit coupling, this will in turn cause a periodic disturbance in the spin of the electrons: they will be made to precess.

This possibility was first suggested by an experiment performed by E. H. Jacobsen, Norman S. Shiren and E. B. Tucker of the General Electric Research Laboratory. To understand the experiment, which has other interesting implications, one must view magnetic resonance more in quantum-mechanical terms. In this view the spin of an electron in a magnetic atom that has been subjected to a magnetic field can only be oriented in certain ways with respect to the direction of the field. These orientations correspond to energy levels.

Let us assume for purposes of discussion that there are only two spin orientations and two energy levels. In a crystal at low temperature most of the spins will be pointed into the direction of lower energy; that is, the lower energy level will be more heavily populated than the higher. If a quantum of electromagnetic or acoustic energy with the right frequency comes along, it can enter into one of two processes: it can be absorbed by raising an electron from the lower level to the higher, or it can induce the emission of another quantum by

causing an electron to drop from the higher level to the lower.

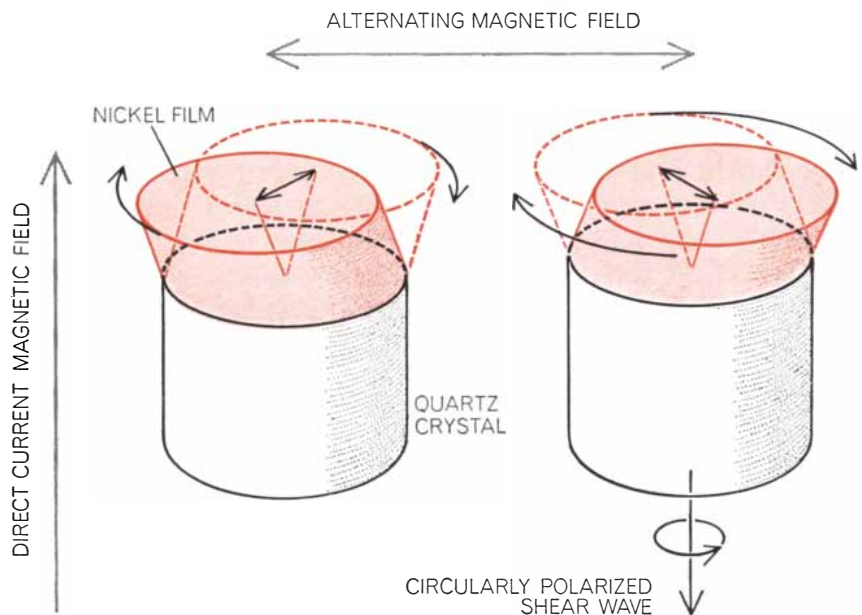
In their experiment Jacobsen, Shiren and Tucker used a quartz crystal that contained a small number of magnetic atoms. One end of this paramagnetic crystal was inserted into a microwave cavity so that the absorption of microwave energy by the electron-spin system inside the cavity could be observed [see top illustration on opposite page]. At a frequency of 10 kilomegacycles the microwaves impinging on the crystal induced the transition of electrons from the lower level to the higher and from the higher level to the lower. The net amount of microwave energy absorbed by the crystal was a measure of how many more electrons were in the lower energy state than were in the higher.

In order to generate ultrasonic waves in the crystal the other end was placed in a second microwave cavity. Into this cavity were also fed 10-kilomegacycle microwaves, which gave rise in the crystal to ultrasonic waves of the same frequency. If the ultrasonic waves interacted with the electron spins, one would expect that the waves would raise some of the electrons from the lower energy level to the higher. And if the ultrasonic power were sufficiently strong to compensate for those electrons that fell back into the lower level, both levels would

soon be equally filled. In that case the microwaves impinging on the crystal in the first cavity would no longer be absorbed. This is exactly what was observed. The experiment not only demonstrates that ultrasonic waves do interact with electron spins but also provides a new method for the detection of very-high-frequency acoustic waves.

The interaction can also be used to generate and amplify acoustic waves in much the same way that electromagnetic waves are amplified by a "maser." Indeed, Tucker has already operated such an acoustic maser. The device consists of a paramagnetic crystal that is bonded to two quartz crystals for the transmission of ultrasonic waves [see bottom illustration on opposite page]. Here one thinks not of two energy levels but of three. The frequency of the ultrasonic wave can be chosen to match the difference between the middle energy level in the crystal and the highest energy level. An electromagnetic frequency is then chosen to match the difference between the lowest energy level and the highest. The electromagnetic wave is also more powerful than the ultrasonic wave.

When both waves are fed into the paramagnetic crystal, the ultrasonic wave will seek to equalize the popula-



**FERROMAGNETIC RESONANCE** of a nickel film (color) evaporated onto the end of a quartz rod can be used to generate ultrasonic waves. The film is first subjected to a direct-current magnetic field perpendicular to the film surface. As discussed in the text, the application of an alternating magnetic field parallel to the film surface will then cause all the electrons to precess around the first field, generating a circularly polarized shear, or transverse, wave (i.e., a wave whose plane of polarization rotates around the direction of travel).



tion of electrons in the middle level and the highest level, and the electromagnetic wave will equalize the number of electrons in the lowest level and the highest level. The ultrasonic wave then "sees" more electrons in the highest level than in the middle one. It stimulates electrons to drop to the middle level, with the emission of a quantum of acoustic energy. In this way the acoustic signal is amplified. Tucker also observed that if the magnetic crystal is provided with reflecting surfaces, the acoustic wave being amplified will bounce back and forth within the crystal; the system is thus an acoustic oscillator. Such an oscillator may lend itself to the generation of waves in the very-high-frequency region, where piezoelectric methods become less efficient.

Up to this point it has not been necessary to take into account the fact that the spinning electron in a magnetic atom interacts with spinning electrons in neighboring atoms. In paramagnetic crystals this interaction is weak and can be disregarded, but in more concentrated magnetic substances it is strong. Such substances are either ferromagnetic (e.g., iron) or ferrimagnetic (e.g., yttrium iron garnet). In ferromagnetic and ferrimagnetic substances interaction of the electrons causes them to precess in unison. This "coherent" precession gives rise to new acoustic interactions.

Here let us consider a thin film of nickel that has been evaporated onto the polished end of a quartz rod. The film is subjected to a steady magnetic field in which the lines of force are perpendicular to the surface. If an alternating magnetic field of the right frequency is now applied at right angles to the

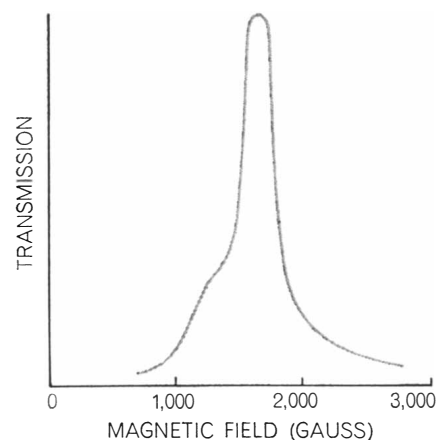
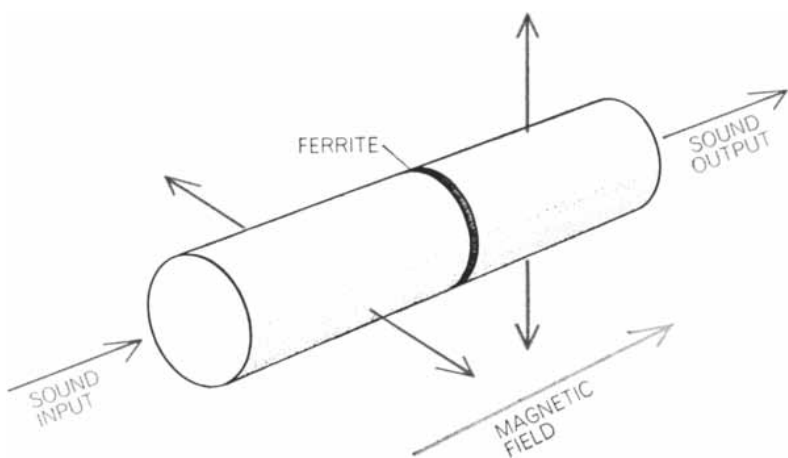
steady field, the electron in the nickel atoms will precess around the lines of force in unison: one has induced a motion known as ferromagnetic resonance. What is of interest is that associated with ferromagnetic resonance is the phenomenon of magnetostriction.

Magnetostriction can readily be visualized in terms of a sphere of initially unmagnetized iron. If the sphere is now magnetized, it will expand slightly in the direction of the lines of magnetic force and contract slightly at right angles to them; the sphere becomes an ellipsoid. If one could rotate the direction of the magnetic field, the long axis of the ellipsoid would follow the field simply by changing its shape. This will suggest what happens to the nickel film. When the film is in ferromagnetic resonance, the coherent precession of the electron spins around the lines of force in the steady magnetic field subjects the film to a rotatory shear motion. If the film is no thicker than about half an acoustic wavelength, the motion generates an ultrasonic wave. The wave, which has the same frequency as that with which the electrons precess around the steady magnetic field, is carried away by the quartz rod. Although this method of generating an ultrasonic wave, unlike the other methods described, requires the addition of a steady magnetic field, it has certain advantages. For one, it is a more efficient means of converting electromagnetic energy into acoustic energy. For another, it makes possible the transmission of ultrasonic waves into any solid by the simple expedient of evaporating a ferromagnetic film onto it, thereby avoiding the difficult problem

of making acoustic bonds between different crystals.

Like other waves, ultrasonic waves can be linearly polarized; that is, the particle motion in the transverse wave can be restricted to one plane. When a linearly polarized electromagnetic wave passes through a magnetized medium, the plane of polarization is rotated; the rotation is called the Faraday effect. An analogous effect occurs when a linearly polarized acoustic wave passes through a ferromagnetic or ferrimagnetic crystal. In the experiments that demonstrated this effect a ferrimagnetic crystal was placed between two quartz rods [see illustration below]. Polarized ultrasonic waves were generated in one quartz rod; the plane of polarization of the second quartz rod was rotated at 90 degrees to that of the first. Thus only those waves that had been rotated through about 90 degrees would be detected by the second rod.

The ferrimagnetic crystal between the two rods was then subjected to a steady magnetic field. Ultrasonic waves were detected by the second rod only when the strength of the field was near the value at which the electrons in the crystal were in ferrimagnetic resonance. At this value, however, the plane of polarization is rotated quite strongly. The first experiments at a frequency of one kilomegacycle showed that in yttrium iron garnet the plane rotates 90 degrees in less than .1 millimeter. This is the first instance of the rotation of the plane of polarization in acoustic waves. The effect is presumably due to the interaction of ultrasonic waves and waves associated with the spin system of the crystal, but the matter is still under study.



ACOUSTIC PLANE OF POLARIZATION of ultrasonic waves can be rotated by transmitting the waves through a ferrite crystal in the presence of a steady magnetic field. Each of the two quartz rods between which the ferrite is placed transmits only waves polarized

in a particular plane (unlabeled arrows). Waves generated in the first crystal must be rotated 90 degrees to be detected in the second. The degree of rotation caused by the ferrite (and hence transmission) depends on the magnetic-field strength (curve at right).

## Kodak reports on:

applesauce . . . Kelly's references . . . microfilming computer printout . . . a nice way to look down

### Food physics



Meet Noel H. Kuhrt and Russell A. Broxholm. They hold U. S. Patent No. 3,034,898 which, as loyal employees, they have assigned to us. In that document they disclose to humanity the concept of "conjoined crystals." This concerns applesauce, among other matters. The attractive concoction filling the bowl is 8 ounces of applesauce—good, wholesome applesauce, enough to top the fresh-sliced fruit dessert that might be served at an afternoon of bridge to all the ladies in a large and prosperous subdivision, with the approval of their modistes, to say nothing of their physicians.

Alas, we plan no such party with no such dessert, no sale or giveaway of household samples, no entry in the wild race for space on the supermarket aisles. The very thought scares us. Companies that do understand the game may well wind up using the conjoined crystals in foods little resembling our cream-puffy visions, nor would they have reason or advantage to let on that their miracles stem from MYVATEX Food Emulsifier, Type 3-50, purchased from Eastman Kodak Company, which takes prime food fats and reacts, distills, and blends them into an interlaced mixture of glycerol monostearate crystals and propylene glycol monostearate crystals.

Kuhrt and Broxholm show how this combination of crystals (which, despite their unattractive chemical names, are generally recognized to be as safe in food as crystals of NaCl) holds fast against a change in crystal habit that formerly could be reversed only by a precise and economically inconvenient heating cycle. The change is purely physical, not chemical. The  $\alpha$  polymorph traps air bubbles quickly and holds them. The  $\beta$  polymorph doesn't very well. At room temperature, unless you do as Kuhrt and Broxholm say,  $\alpha$  soon becomes  $\beta$ .

This odd little bit of physics should also help the cake-mix and baking businesses, with whom we have enjoyed the friendliest tonnage relations for years.

*Men who can take care of the food brokers and the women's page editors while we take care of the polymorphism should get in touch with Distillation Products Industries, Rochester 3, N. Y. (Division of Eastman Kodak Company).*

### Roentgen movies



Meet Miss Lina-Lou Kellogg. Working anonymously as "X-ray Sales Division, Eastman Kodak Company, Rochester 4, N. Y.," she has brought her bibliography of x-ray cinematography up to 750 references. It's a live subject. "Kelly" has the impression that interest is shifting from technique to medical interpretation. She also has the feeling that she is barely scratching the surface. Still, whoever wants a copy has only to ask and he shall receive.

### The 29-minute mile

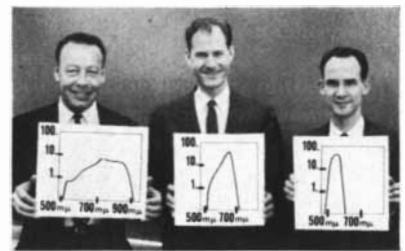
The new RECORDAK ROTOMATIC Microfilmer we believe to be the world's fastest off-the-shelf microfilmer. To keep the shelf stocked we find it necessary to scramble. The customers are in desperate need. Their computers keep pouring out computations. They signed up for the computer when impressed with how fast a mile of computation could be pushed out. When the mile shoots out as promised, the question arises of what to do with it. To feed the printout through a chute directly to the paper shredder and baler in the basement would represent ingenuity masking a pathetic failure to understand.

Between generation and shredding, the computations should be microfilmed for possible future reference. An interposed RECORDAK ROTOMATIC Microfilmer photographs the mile in 29 minutes on 220 feet of 16mm film. Acreage from paper to film shrinks by a 500 factor, which is desirable in the high-rent district. The paper can then safely move to the shredder, which usually returns a small but steady cash income.

You ask: why, with the electronic art in its present sophisticated state, bother with the paper at all instead of impressing the output signal from the computer directly on microfilm? We have been over *that* route before. We know exactly how to do it. The only trouble is that we also know how to build this little microfilmer for a tiny fraction of the price that a decently sophisticated device to accomplish the same end-result has to cost!

*In case interested, address is Recordak Corporation (Subsidiary of Eastman Kodak Company), 770 Broadway, New York 3.*

### Under false colors



Meet Raife Tarkington, Allan L. Sorem, and Norman L. Fritz, the latter two of the Military Photography Department of the Kodak Research Laboratories. As a by-product of work of theirs that need not be discussed here, they offer ecologists, geologists, and any others interested the opportunity to look down on the earth with new eyes. The left-hand spectral distribution of reflected radiation can appear red (when it's actually mostly infrared), the middle one as green (when it's actually red), and the third as blue (when it's actually green). This might give the world a crazy aspect but heighten sensitivity, among other possible benefits, to the way various carotenoids and xanthophylls mark the members of the association of a rain forest.

Color vision can be exploited for scientific purposes. The brain's response to the spectral distribution of energy falling directly on the cones of the retina is measurable but not truly describable and certainly immutable. Color film lacks such mystical character. If we want to make it see well at 850m $\mu$ , we do so without waiting for eons of evolution. We can then use it to adapt the mystical properties of the central nervous system to man's needs in 1963 A.D., as distinguished from his needs in 200,000 B.C.

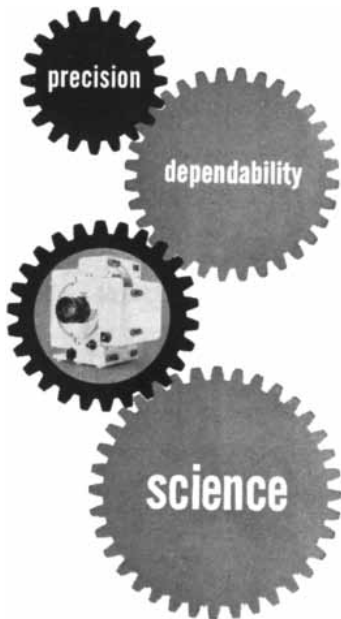
*Tarkington, Sorem, and Fritz take no more of an interest in ecology, geology, and anthropology than the ordinary alert citizen. They merely offer the three spectral responses in the three layers of a new film devised with their guidance and available in aerial-film widths and lengths (only) as KODAK EKTACHROME Infrared Aero Film. A KODAK WRATTEN No. 12 Filter is assumed. If you don't know any aerial photographers, ask Eastman Kodak Company, Professional Photographic Division, Rochester 4, N. Y.*

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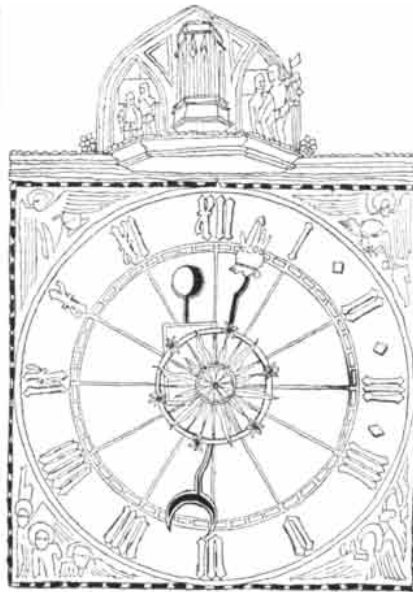
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## *Resurgent Antivivisectionists*

**T**here is a good chance that the 88th Congress, now in its first session, will pass legislation restricting the use of animals in scientific investigation. Five different bills have been introduced. The most stringent (H.R. 4856) would establish in the Department of Justice an enforcement agency headed by a special attorney.

Among other things the bill would require that laboratories operated by or receiving grants from the Federal Gov-

ernment, or selling drugs or any other products to the Government, obtain a license to work with live vertebrates or "any other species having a central nervous system." The laboratories would have to agree to allow inspection of their facilities and books at any time by the new Federal agency or by law-enforcement officers of their state. Laboratory workers would have to obtain approval for the complete plan of any investigation involving live animals. A minimum number of animals would have to be used; wherever possible lower species would be substituted for higher (apparently according to the judgment of the enforcement agency). One provision would require the killing of an animal immediately after any procedure causing pain or stress, "whether or not the objective of the experiment or procedure has been attained." If any state law-enforcement agency or "any incorporated humane society" charged a laboratory with violating the law, the enforcement agency would have to hold a hearing, using the power of subpoena, and publish a formal finding.

This bill and those less restrictive have drawn opposition from the American Veterinary Medical Association, the

### E. P. ROSENBAUM

E. P. Rosenbaum, the Executive Editor of *SCIENTIFIC AMERICAN*, died in April of cancer. He was 47.

Rosenbaum was a central figure in the development of this magazine since its reorganization in 1948. He was a tremendously able man with a solid grounding in mathematics and physics, and his colleagues relied on him to solve the most difficult problems of writing and editing. One measure of his contribution is that some of the articles of which his colleagues were proudest were jointly signed by him and the investigator who had done the work under discussion; a good example is the article "Elementary Particles," by Murray Gell-Mann and E. P. Rosenbaum [*SCIENTIFIC AMERICAN*, July, 1957].

He was a tall, elegant, booming, profane, irrepressible man who was at the same time grave and introspective. He grew up in New Haven, Conn., did well at Harvard for three years but graduated from Yale, worked on radar and glide bombs in the Air Force during the war, taught mathematics and physics in preparatory school, worked as an accountant, a free-lance writer and a television producer. In 1952, as he put it in his 25th anniversary college yearbook, "this diffuse background came into focus when I joined the staff of *Scientific American* [and became] engaged in the endlessly fascinating job of helping scientists explain their work and their ideas to laymen." He became seriously ill five years ago and had several periods of great suffering, but he continued to work prodigiously; in fact, some of his writing appears in this issue.

# THE CITIZEN

American Medical Association and other groups, faculties and individuals in all fields of the biological sciences and psychology. The National Society for Medical Research, made up of nearly 700 organizations and institutions conducting biological investigations, has summarized the objections.

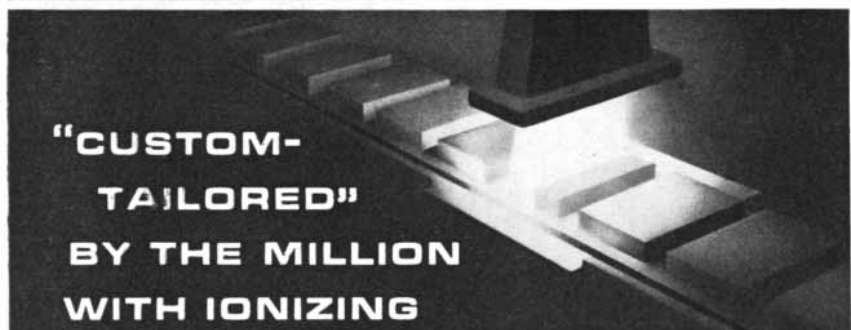
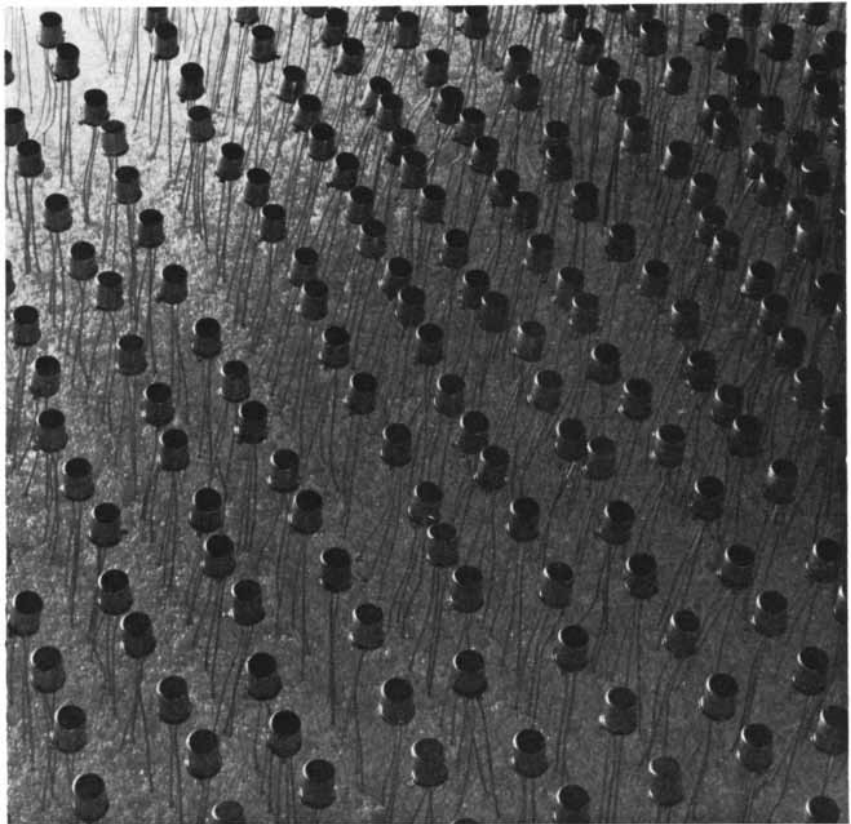
Most of the bills, the society says, assume quite wrongly that cruelty to animals is common in laboratories. The bills also assume that police inspectors would be wiser, kinder and technically better qualified to supervise scientific investigation than the investigator. The more restrictive bills, if enforced, "would stop all medical and biological research except on animals lower than fishes for many years until scientists could be sure that every possibility for the use of such lower forms of life... has been exhausted." Having to follow a plan, the society observes, would greatly hamper research; an investigator cannot know in advance every step he will take, and often he drastically revises his original plan in the midst of a study. The maintenance of the required records would be expensive and would serve no scientific purpose. The society points out that in all 50 states the statutes prohibiting cruelty to animals apply to scientists as well as to others.

Medical and biological organizations have suggested that Congress pass a law providing for more research in animal care, for training people to care for animals, for distributing information about animal husbandry and to help finance the construction of better animal-care facilities in laboratories.

Congressional mail is said to be running heavily in favor of the restrictive bills.

## *Tolerance by Injection*

Adult mice have been conditioned to accept skin grafts from mice of another strain by repeated injections of nonliving cell material from animals of the donor strain. This accomplishment, the work of Carlos Martinez and his colleagues at the University of Minnesota, represents a double gain for research aimed at making possible the transplantation of organs from one human being to another. Until now most procedures for inducing tolerance to tissue grafts



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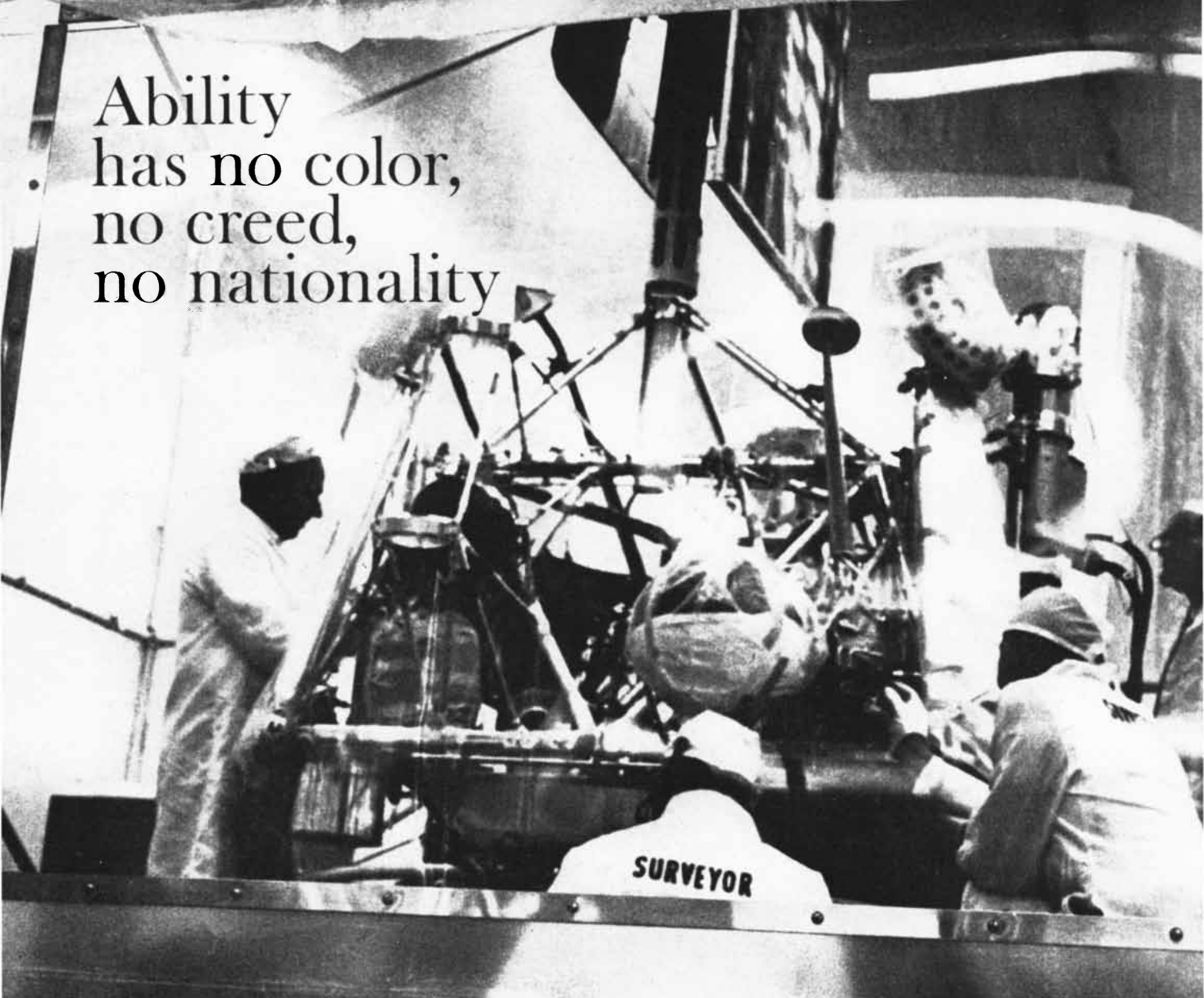
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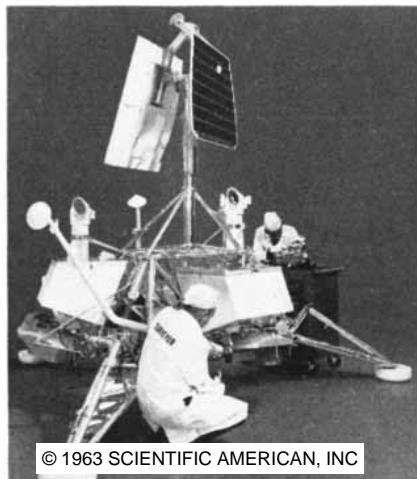
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have been effective in newborn animals but only to a limited degree in adult animals, and have required the use of living cells from the donor. Such cells can themselves manufacture antibodies that destroy host tissue and cause the severe wasting illness known as homologous disease.

The starting point for the Minnesota work, which was reported at the April meeting of the Federation of American Societies for Experimental Biology in Atlantic City, N.J., was an observation dating back more than 20 years. This was that if animals are repeatedly injected with an antigenic substance to which they ordinarily react strongly, they ultimately tolerate the antigen. Martinez and his associates undertook to learn whether or not graft tolerance could be similarly induced by repeated injections of nonliving donor-cell material.

The injection material was obtained by subjecting spleen cells from donor-strain mice to the disruptive action of alternate freezing and thawing. Up to 40 injections were administered, spread over 12 weeks. Graft tolerance was successfully induced in many animals even when there was a strong genetic difference between the grafted and donor animals. Experiments are now under way to determine if the procedure can be applied to other animals and if easily obtained cells such as white blood cells can be employed as the source of the injection material. If such experiments succeed, they may open the way to relatively simple methods of carrying out tissue and organ transplantation in man.

### *Another Solar System*

A planet-sized "dark companion" has been discovered revolving around a dim star some six light-years distant in the direction of the constellation of Ophiuchus. The "sun" of this solar system is Barnard's star, otherwise known chiefly for having the largest motion across the sky of any star. The planet is 50 per cent more massive than Jupiter; it has been named Barnard's star B by its discoverer, Peter van de Kamp of the Sproul Observatory of Swarthmore College.

In a recent report to an American Astronomical Society meeting in Tucson, Ariz., van de Kamp pointed out that although Barnard's star and its companion are the third known "solar system" outside our own, they constitute the first such pair in which the companion is small enough to be classified confidently as a planet. Accompanying two other stars—61 Cygni and Lalande

21185—are bodies with masses about a hundredth that of our sun; these can be considered either as being very large planets or very small stars. Barnard's star B has a mass a seven-hundredth that of the sun and a hundredth that of its parent star, which makes it the smallest body ever detected outside our solar system.

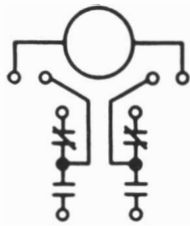
The discovery of the new planet—invisible to the most powerful telescopes—was made by measuring minute "wobbles" in the trajectory of Barnard's star on thousands of photographic plates, some made as long ago as 1916. These deviations from uniform rectilinear motion are caused by the gravitational interaction of Barnard's star and its planet, which describes a complete orbit every 24 years.

### *Drifting Continent*

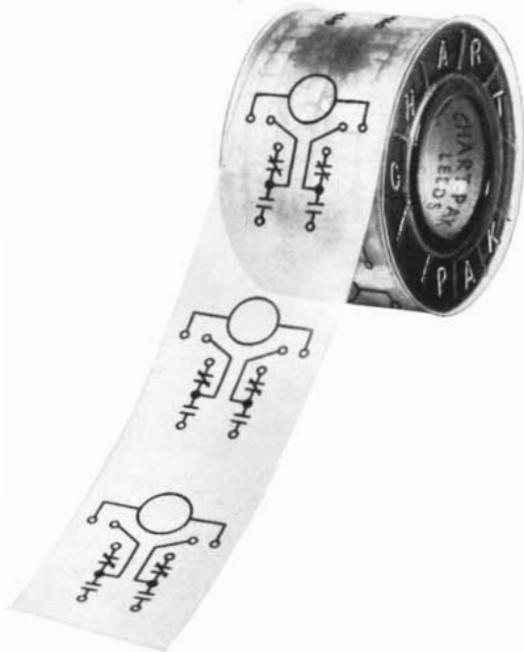
Fossil-magnetization and radioactive-dating studies of rocks from eastern Australia and Tasmania have added new evidence that Australia was once much nearer the South Pole than it is today and has arrived at its present location only within the past 100 million years. In that short geological span the southern continent may have drifted as much as 3,000 miles with respect to North America and Europe at a rate approaching two inches a year.

The studies, which are described in the *Journal of Geophysical Research* and the *Journal of the Geological Society of Australia*, were carried out chiefly at the Australian National University under E. Irving, with the participation of J. F. Evernden, a specialist in potassium-argon radioactive dating, from the University of California at Berkeley. Altogether several hundred specimens from more than a score of sites in four areas of eastern Australia and one site in Tasmania were investigated. The samples included sedimentary, igneous and volcanic rocks ranging in age from 93 million years to well over 200 million years. All were tested for "remanent" magnetization: magnetization that was imposed on them by the earth's magnetic field at the time they were formed and that was "frozen" as to direction and dip once the rocks were in the solid state. Where possible, samples from each area were also dated by the potassium-argon method.

The specimens from all five areas point to a location for the South Pole much closer to Australia than now. This location, however, differs by nearly 50 degrees from positions for the Pole derived from similar studies of



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Irving and his colleagues conclude that their observations can be explained only by assuming either that the earth's magnetic field then had some unusual configuration (with more than the present two poles) or that Australia has since moved. They note that other paleomagnetic studies, involving younger rocks, suggest that Australia began to move about 100 million years ago, not long after the postulated date for the breakup of the supercontinent of which advocates of continental drift believe Australia was once a part [see "Continental Drift," by J. Tuzo Wilson; SCIENTIFIC AMERICAN, April].

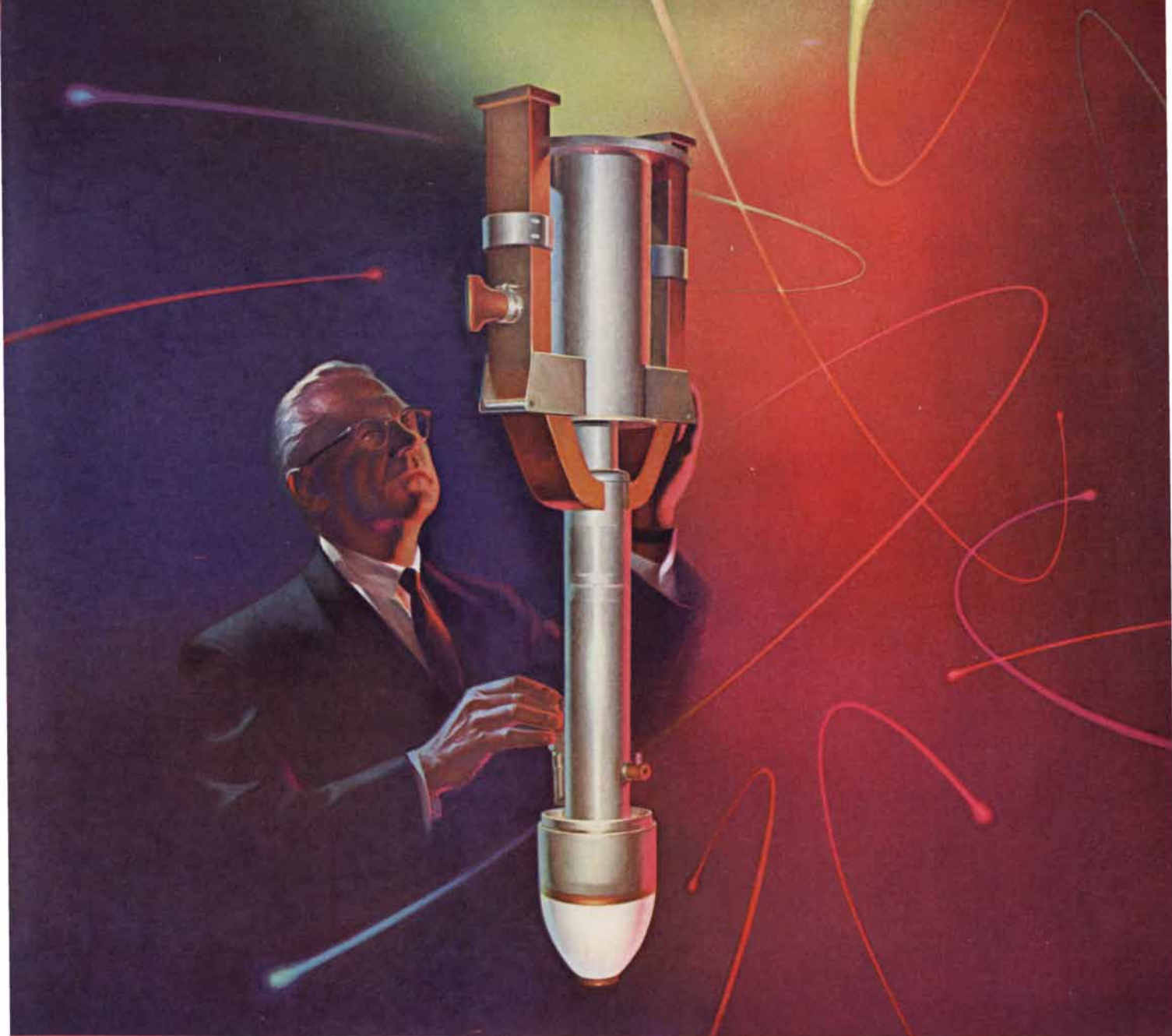
### Defective Virus

A new approach to the search for human cancer viruses has been opened up by the discovery that one of the best-known tumor viruses—the Rous sarcoma virus of chickens—is "defective" and is unable to reproduce without the assistance of a second virus. The discovery was reported in *Proceedings of the National Academy of Sciences* by Hidesaburo Hanafusa, Teruko Hanafusa and Harry Rubin of the University of California Virus Laboratory.

Investigators have been aware for more than a dozen years that bacterial viruses sometimes occur in the defective form. Such viruses lack one or more genes required for virus multiplication, such as a gene for the production of a needed enzyme. Defective viruses can multiply only in the presence of another virus that produces the needed enzyme. Hitherto defectiveness has been known only among bacterial viruses.

Rubin and his associates were led to the discovery of defectiveness in the Rous virus by the behavior of a strain of the virus in tissue culture. When the culture was diluted so that spots of tumor cells were no longer produced, another virus, present in even higher concentration than the Rous virus, appeared. Upon isolation the new virus proved indistinguishable from the Rous virus except for its inability to cause tumors in chickens or tumor cells in tissue culture. The new virus, which has been named the Rous-associated virus (RAV), does, however, cause leukemia in chickens.

In a variety of experiments the two viruses were successfully separated. Whether the experiments involved entire colonies of Rous tumor cells or single cells, it was found that the production of infectious Rous particles



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work. And protective measures for mechanical components.

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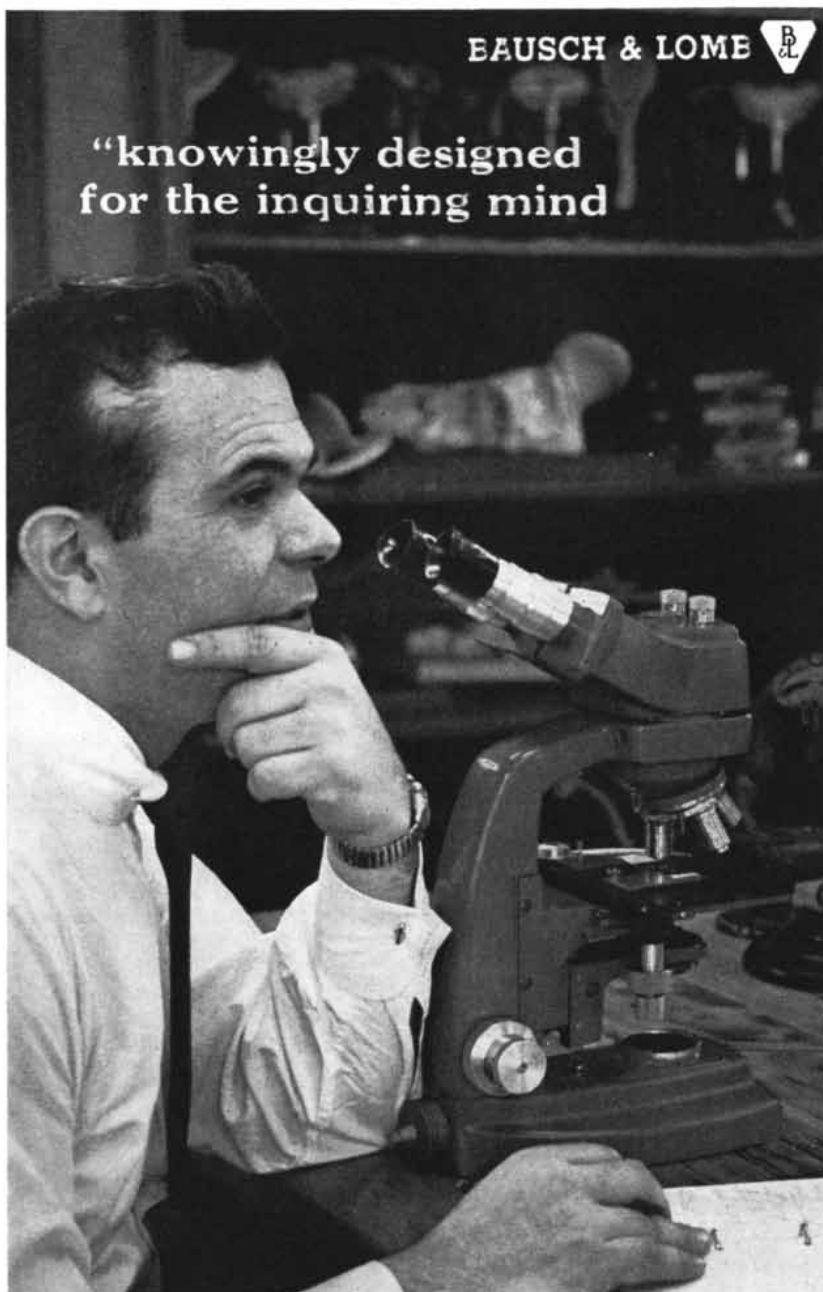
occurred only when RAV was present. RAV-free tumor cells grew normally and produced new tumor cells by cell division, but they yielded no tumor virus that could infect new cultures. On the other hand, Rous virus appeared freely as soon as RAV was added to tumor-cell cultures.

The California virologists believe that the Rous virus requires something made by RAV in order to reproduce itself. A similar situation, Rubin suggests, may obtain in the reproduction of other cancer viruses, including the still undiscovered viruses held by many investigators to be involved in human cancers. In that case it might be necessary to find the associated viruses first and then use the associated viruses to uncover the tumor viruses.

### *Respiratory Particle*

The highly structured little bodies called mitochondria have been known for 25 years to be the powerhouses of the living cell, where the energy of food is converted into energy available to do the work of the organism. Now investigators at two universities have collaborated to identify and isolate the individual turbines within the power plant: "elementary particles" that accomplish the final steps in the oxidation of foodstuffs. The particles include four complexes of proteins and lipids that constitute the "respiratory chain." Electrons extracted from the intermediate products of metabolism are passed along this chain, ultimately to combine with oxygen to form water. The energy of the electrons is tapped at three points along the chain to manufacture adenosine triphosphate (ATP), the universal intracellular fuel.

The work was reported at the April meeting of the National Academy of Sciences in papers by Humberto Fernandez-Moran of the University of Chicago and by David E. Green, Paul V. Blair and Takuzo Oda of the University of Wisconsin. In 1960 Fernandez-Moran, then at the Massachusetts General Hospital, detected a repeating substructure in the membranes of mitochondria examined with the electron microscope. Large numbers of polyhedral particles about 100 angstrom units in diameter (an angstrom unit is a hundred-millionth of a centimeter) were arrayed along the membrane and attached to it by short stems. Green and his colleagues at Wisconsin's Institute for Enzyme Research managed to separate these particles from the structural membrane. The resulting preparation of



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**By Jerry Slocum, Manager, Electronic Engineering Section, SATURN Systems, Packard Bell Electronics, Los Angeles, California**

"The SATURN Automatic Checkout System built by Packard Bell Electronics is a computer controlled system used for factory checkout of the SATURN I booster. The first system has been delivered to NASA's Quality Assurance Division at Marshall Space Flight Center, Huntsville, Alabama.

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"The Satellite Test Station Flexowriters and the buffered Flexowriter at the Master Console participate in all three modes of operation of the Automatic Checkout System.

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"In the automatic mode, under computer control, the Flexowriters provide such things as hard copy outputs of test results; tabulation of GO and NO-GO measurements with their identification points; type out of test progress and type out of the actual test steps being executed; and type in and type out of operator instructions where manual intervention is required.

"In the manual mode, the test stations are off line from the computer complex and the Flexowriters are the sole means of command communication with the test station. They provide means for manual data entry via the keyboard or the Flexowriter Tape Reader, and allow such operations as manually single stepping through a program routine; continuous cycling for maintenance purposes; and the manual exercising of various system devices for confidence check of hardware and programming.

"In the single step mode, the Flexowriters aid in the detailed de-bugging of either programs or hardware by allowing manual data entry in combination with the single step sequencing provided by the test station.

"In addition to their function as integral test station devices, means are provided for easily switching the Flexowriters to off-line operation for the more conventional usages such as typing, preparing program tapes, and regenerating existing tapes."



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elementary particles was capable of carrying on the electron-transfer process. The particles were broken down further into the four component segments of the respiratory chain and then reconstituted, and again they exhibited the proper activity. Both the isolated and the reconstituted particles, when examined by Fernandez-Moran, appeared to be "essentially identical" with the repeating units of intact mitochondria.

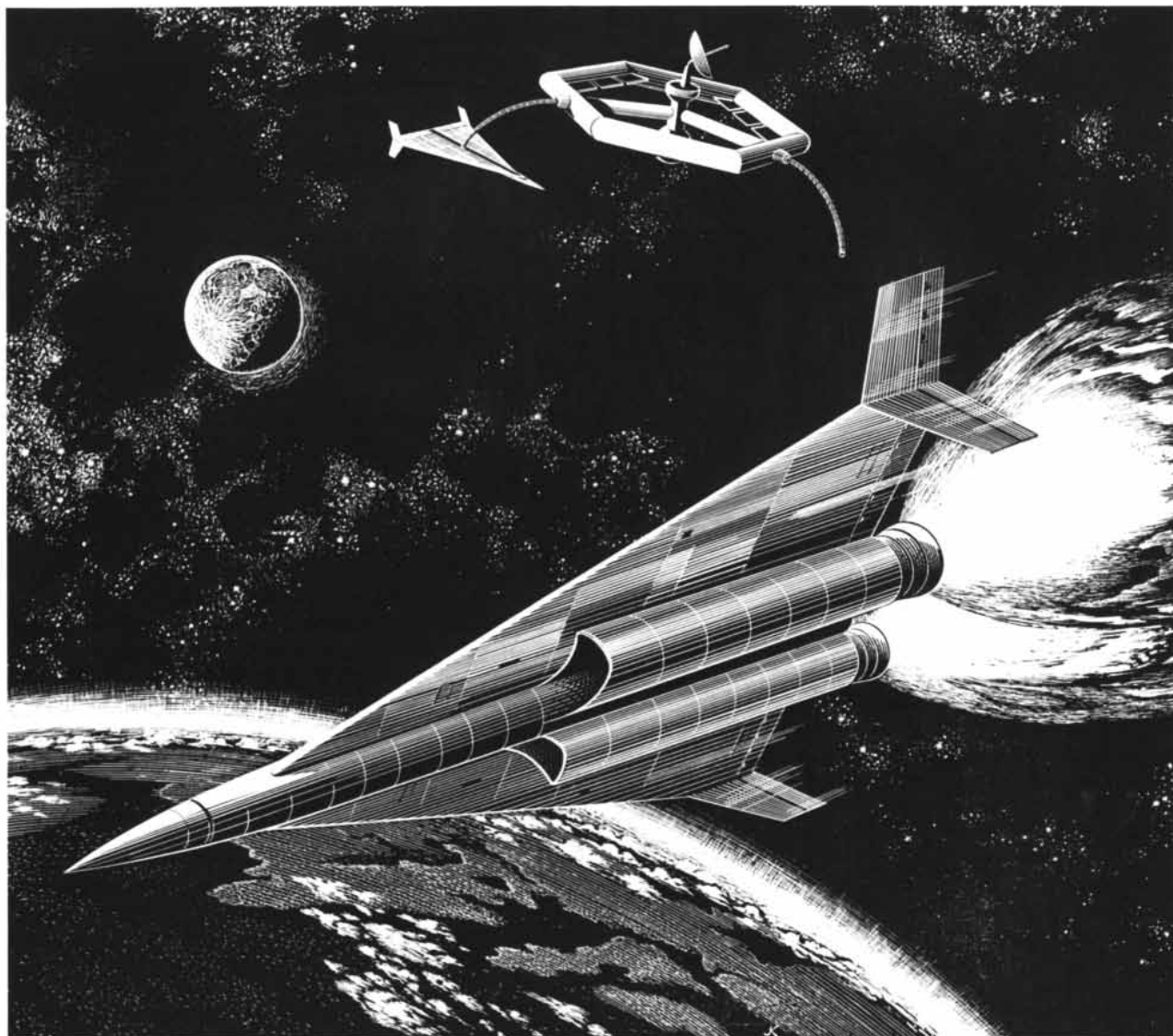
The isolated elementary particles do not accomplish oxidative phosphorylation: the synthesis of ATP that in the intact mitochondrion is implicit in the process of electron transfer. Apparently the rough treatment to which the particles are subjected in the course of isolation somehow throws this "coupled" process out of gear. But the Wisconsin workers are confident that the particles are in fact the sites of phosphorylation, and they expect to find ways of isolating particles that retain this capacity.

### Cool Fuel Cell

Fuel cells able to oxidize pure hydrogen and produce a modest output of electricity have been available for several years. A large hydrogen fuel cell built by the General Electric Company will provide nearly two kilowatts of electric power for the Gemini spacecraft, which will be able to sustain two astronauts in orbit for several weeks. The Gemini unit, weighing less than 175 pounds, will provide the energy of about a ton of batteries.

Now General Electric has announced a more advanced fuel cell able to dispense with costly hydrogen and operate on a wide variety of ordinary hydrocarbons, from methane to diesel fuel. Moreover, the new cell operates at temperatures between 150 and 200 degrees centigrade instead of the 600 to 1,000 degrees needed to sustain the reaction in most previous cells. Operating efficiencies of 40 to 50 per cent have already been achieved with the new cell (compared to 20 to 25 per cent for ordinary internal-combustion engines), and practical efficiencies as high as 70 per cent seem attainable.

The chief limitation to widespread use of the new cell is the high cost of its platinum-containing catalyst. It is hoped that eventually cheaper catalysts will be found and that the fuel cell will begin to take on a wide range of familiar jobs, perhaps including automobile propulsion. The workers credited with development of the new cell are Thomas Crubb and Leonard W. Niedrach of the General Electric Research Laboratory.



## Marquardt needs advanced propulsion engineers

Propulsion for the Aerospaceplane concept is one of a number of major contributions to advanced technology by engineers and scientists at Marquardt. This revolutionary system requires a propulsion system capable of take-off from conventional runways, acceleration through the atmosphere, orbital cruise in space, and return for an earth landing.

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At ASTRO, Marquardt's aerospace research group, engineers are needed for company-sponsored and government-contract activity in chemical and electric propulsion research and in such support areas as high temperature materials research,

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# THE LYMPHATIC SYSTEM

This second circulation plays an essential role in maintaining the body's steady state, draining from the spaces between cells fluid, protein and other substances that leak out of the blood

by H. S. Mayerson

Living tissue is for the most part a collection of cells bathed in a fluid medium. This interstitial fluid constitutes what the French physiologist Claude Bernard named the *milieu intérieur*: the internal environment of the organism that is the true environment of its cells. The interstitial fluid brings nutrients to the cells and carries away waste products; its composition varies in space and time under the control of the co-ordinated physiological processes that maintain homeostasis, the remarkably steady state that characterizes the internal environment of a healthy organism. In the maintenance of the homeostasis of the interstitial fluid the circulation of the blood is obviously of fundamental importance. In the higher vertebrates there is a second circulation that is equally essential: the lymphatic system. Its primary function is to recirculate the interstitial fluid to the bloodstream, thereby helping to create a proper cellular environment and to maintain the constancy of the blood itself. It also serves as a transport system, conducting specialized substances from the cells that make them into the bloodstream. In recent years physiologists, biochemists, physicians and surgeons have been studying the lymphatic system intensively, in health and in disease. Their investigations are providing much new information on how the body functions, explaining some heretofore poorly understood clinical observations and even suggesting new forms of treatment.

The fact that the lymphatic system is an evolutionary newcomer encountered only in the higher vertebrates is significant. In lower animals there is no separation between the internal and external environments; all the cells of a jellyfish, for example, are bathed in sea water. With progression up the evolutionary

scale the cells become separated from the external environment, "inside" is no longer identical with "outside" and rudimentary blood circulatory systems make their appearance to conduct the exchange of nutrients and waste products. As the organism becomes more complex the blood system becomes more specialized. The system develops increasing hydrostatic pressure until, in mammals, there is a closed, high-pressure system with conduits of diminishing thickness carrying blood to an extensive, branching bed of tiny capillaries.

At this point in evolution a snag was encountered: the high pressures made the capillaries leaky, with the result that fluid and other substances seeped out of the bloodstream. A drainage system was required and lymphatic vessels evolved (from the veins, judging by embryological evidence) to meet this need.

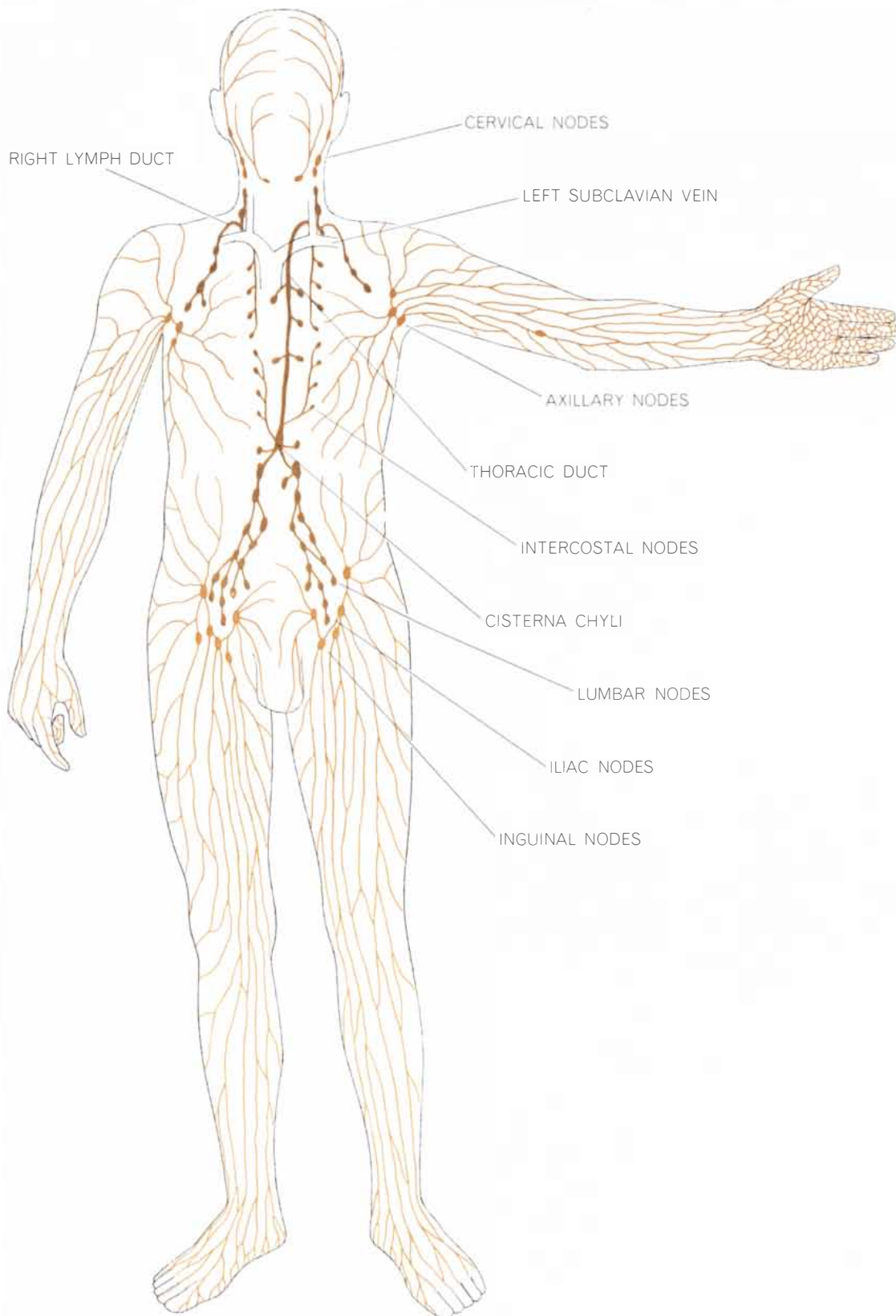
In man the lymphatic system is an extensive network of distensible vessels resembling the veins. It arises from a fine mesh of small, thin-walled lymph capillaries that branch through most of the soft tissue of the body. Through the walls of these blind-end capillaries the interstitial fluid diffuses to become lymph, a colorless or pale yellow liquid very similar in composition to the interstitial fluid and to plasma, the liquid component of the blood. The lymphatic capillaries converge to form larger vessels that receive tributaries along their length and join to become terminal ducts emptying into large veins in the lower part of the neck. The largest of these great lymphatics, the thoracic duct, drains the lower extremities and all the organs except the heart, the lungs and the upper part of the diaphragm; these are drained by the right lymphatic duct. Smaller cervical ducts collect fluid from each side of the head and neck. All but the

largest lymph vessels are fragile and difficult to trace, following different courses in different individuals and even, over a period of time, in the same individual. The larger lymphatics, like large veins, are equipped with valves to prevent backflow.

Along the larger lymphatics are numerous lymph nodes, which are of fundamental importance in protecting the body against disease and the invasion of foreign matter. The lymph nodes serve, first of all, as filtering beds that remove particulate matter from the lymph before it enters the bloodstream; they contain white cells that can ingest and destroy foreign particles, bacteria and dead tissue cells. The nodes are, moreover, centers for the proliferation and storage of lymphocytes and other antibody-manufacturing cells produced in the thymus gland; when bacteria, viruses or antigenic molecules arrive at a lymph node, they stimulate such cells to make antibodies [see "The Thymus Gland," by Sir Macfarlane Burnet; SCIENTIFIC AMERICAN, November, 1962].

## Starling's Hypothesis

The present view of the lymphatic circulation as a partner of the blood system in maintaining the fluid dynamics of the body stems from the investigations early in this century by the British physiologist Ernest H. Starling. "Starling's hypothesis" stated that the exchange of fluid between the capillaries and the interstitial space is governed by the relation between hydrostatic pressure and osmotic pressure. Blood at the arterial end of a capillary is still under a driving pressure equivalent to some 40 millimeters of mercury; this constitutes a "filtration pressure" that tends to make plasma seep out of the capillary. Starling



**LYMPHATIC VESSELS** drain the entire body, penetrating most of the tissues and carrying back to the bloodstream excess fluid from the intercellular spaces. This diagram shows only some of the larger superficial vessels (*light color*), which run near the surface of the body, and deep vessels (*dark color*), which drain the interior of the body and collect from the superficial vessels. The thoracic

duct, which arises at the cisterna chyli in the abdomen, drains most of the body and empties into the left subclavian vein. The right lymph duct drains the heart, lungs, part of the diaphragm, the right upper part of the body and the right side of the head and neck, emptying into the right subclavian vein. Lymph nodes interspersed along the vessels trap foreign matter, including bacteria.

visualized the wall of the capillary as being freely permeable to plasma and all its constituents except the plasma proteins albumin, globulin and fibrinogen, which could leak through only in very small amounts. The proteins remaining in the capillary exert an osmotic

pressure that tends to keep fluid in the capillary, countering the filtration pressure. Similar forces are operative in the tissue spaces outside the capillary. At the arterial end of the capillary the resultant of all these forces is ordinarily a positive filtration pressure: water and

salts leave the capillary. At the venous end, however, the blood pressure is decreased, energy having been dissipated in pushing the blood through the capillary. Now the osmotic force exerted by the proteins is dominant. The pressure gradient is reversed: fluid, salts and the waste products of cell metabolism flow into the bloodstream [see top illustration on page 84].

It follows, Starling observed, that if the concentration of plasma proteins is decreased (as it would be in starvation), the return of fluid to the bloodstream will be diminished and edema, an excessive accumulation of fluid in the tissue spaces, will result. Similarly, if the capillaries become too permeable to protein, the osmotic pressure of the plasma decreases and that of the tissue fluid increases, again causing edema. Capillary poisons such as snake venoms have this effect. Abnormally high venous pressures also promote edema, by making it difficult for fluid to return to the capillaries; this is often one of the factors operating in congestive heart disease.

A fundamental tenet of Starling's hypothesis was that not much protein leaves the blood capillary. In the 1930's the late Cecil K. Drinker of the Harvard Medical School challenged this idea. Numerous experiments led him to conclude "that the capillaries practically universally leak protein; that this protein does not re-enter the blood vessels unless delivered by the lymphatic system; that the filtrate from the blood capillaries to the tissue spaces contains water, salts and sugars in concentrations found in blood, together with serum globulin, serum albumin and fibrinogen in low concentrations, lower probably than that of tissue fluid or lymph; that water and salts are reabsorbed by blood vessels and protein enters the lymphatics together with water and salts in the concentrations existing in the tissue fluid at the moment of lymphatic entrance." In other words, Drinker believed that protein is continuously filtering out of the blood; the plasma-protein level is maintained only because the lymphatic system picks up protein and returns it to the bloodstream.

Unfortunately Drinker had no definitive method by which to prove that the protein in lymph had leaked out of the blood and was not somehow originating in the cells. Perhaps for this reason his conclusions were not generally accepted. Teachers and the writers of textbooks continued to maintain that "healthy" blood capillaries did not leak protein. It was in an effort to clarify this point that I undertook an investigation of lymph



**TWO CIRCULATORY SYSTEMS**, the blood and the lymphatic (color), are related in this schematic diagram. Oxygenated blood (light gray) is pumped by the heart through a network of capillaries, bringing oxygen and nutrients to the tissue cells. Venous blood (dark gray) returns to the heart and is oxygenated in the course of the pulmonary (lung) circulation. Fluid and other substances seep out of the blood capillaries into the tissue spaces and are returned to the bloodstream by the lymph capillaries and larger lymphatic vessels.



and the lymphatics some 15 years ago. At that time I was working with a clinical group measuring the retention of blood by patients given large infusions. We saw that the patients were retaining the cellular components of the blood quite well but were "losing" the plasma. The loss was clearly into the tissue spaces, not by way of excretion from the kidneys.

If blood capillaries did indeed leak plasma, together with its proteins and other large molecules, then Drinker was correct. If the proteins entered the interstitial fluid, they would stay there, since Starling's measurements and Drinker's findings made it clear that large molecules could not get back into the blood capillaries—unless they were picked up by the lymphatic system. If they leaked from the blood vessels and were in fact returned by the lymphatic vessels, the evolutionary reason for the development of the lymphatic system would be established beyond question. I decided to return to my laboratory at

the Tulane University School of Medicine and investigate the problem.

Over the years I have had the enthusiastic assistance of several colleagues—notably Karlman Wasserman, now at the Stanford University Medical School, and Stephen J. LeBrie—and of many students. Time had provided us with two tools not available to Drinker. One was flexible plastic tubing of small diameter, which we could insert into lymphatic vessels much more effectively than had been possible with the glass tubing available earlier. And we now had radioactive isotopes with which to label proteins and follow their course.

#### Experiments with Proteins

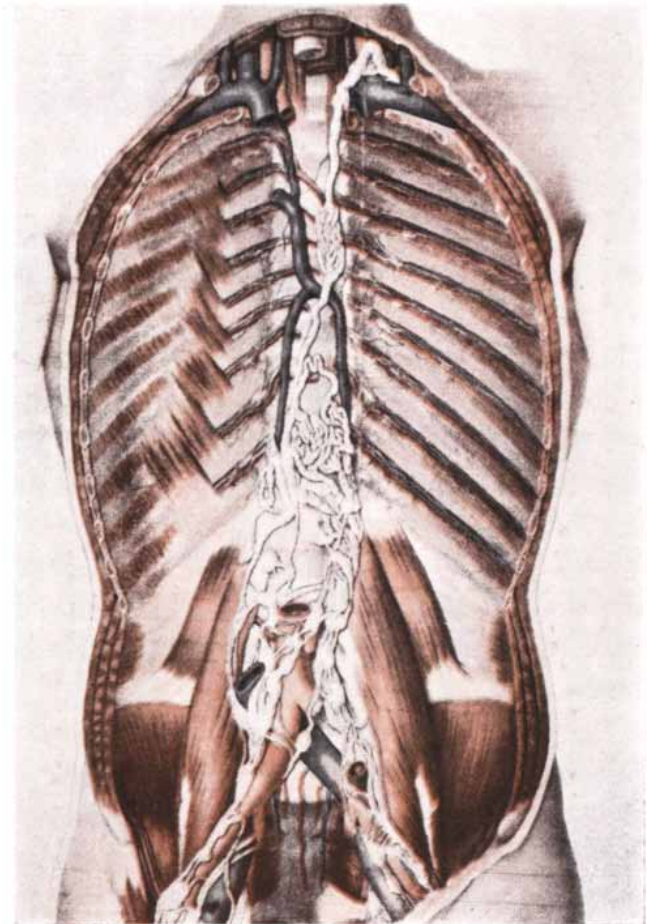
We injected the blood proteins albumin and globulin, to which we had coupled radioactive iodine atoms, into the femoral veins of anesthetized dogs. The proteins immediately began to leave the bloodstream. By calculating the slope of the disappearance curve in each ex-

periment we could arrive at a number expressing the rate of disappearance [see top illustration on page 85]. The average rate of disappearance of albumin, for example, turned out to be about .001; in other words, a thousandth of the total amount of labeled albumin present at any given time was leaking out of the capillaries each minute. If we infused large amounts of salt solution, plasma or whole blood into our dogs, the disappearance rate increased significantly. The same thing happened in animals subjected to severe hemorrhage. In some experiments we simultaneously collected and analyzed lymph from the thoracic duct [see bottom illustration on page 85]. As before, labeled protein left the blood; within a few minutes after injection it appeared in the lymph, at first in small quantities and then at a faster rate. It leveled off, in equilibrium with the blood's protein, seven to 13 hours after injection.

We were able to calculate from our data that in dogs the thoracic duct alone

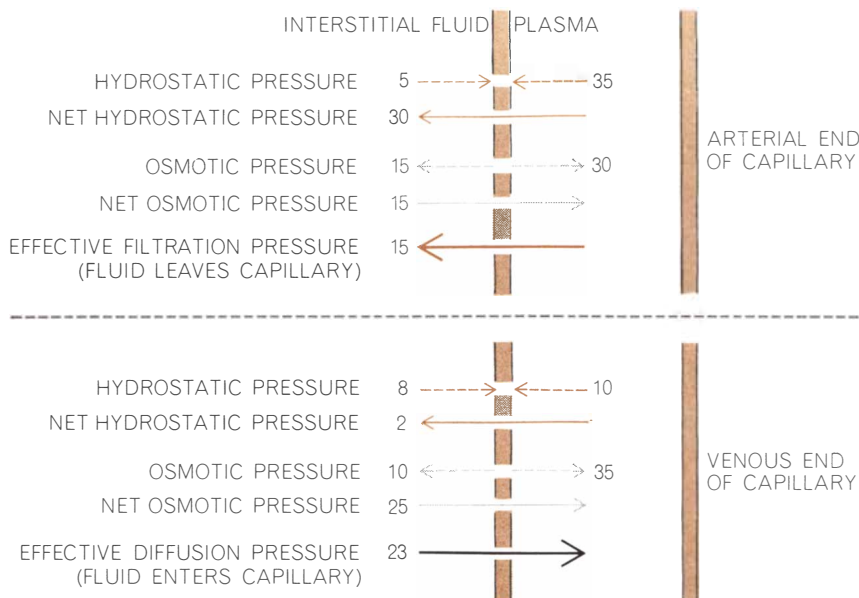


LACTEALS, the lymphatics of the intestine, were first described by the Italian anatomist Gasparo Aselli in 1622. They were pictured in his *De Lactibus*, the first anatomical work with color plates. This plate shows veins (A), lacteals (B), mesentery (C), stomach (D), small intestine (F, G, H) and a lymph node (L).

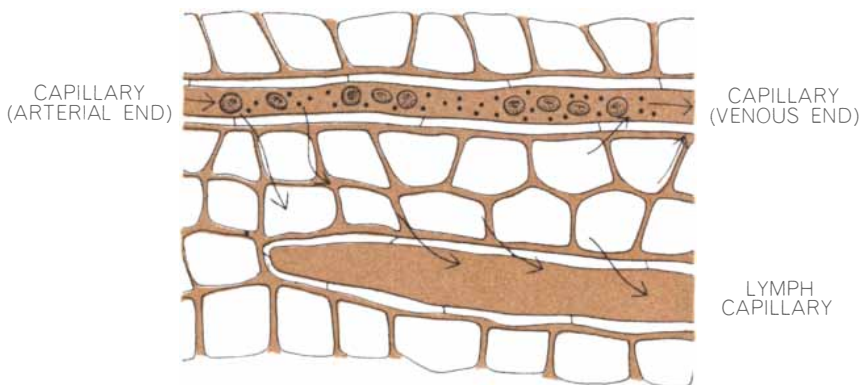


THORACIC DUCT and the major lymph vessels of the lower extremities and trunk that contribute to it are seen in this plate from a French book of 1847, *Atlas d'Anatomie Descriptive du Corps Humain*. The duct arises from a plexus of abdominal vessels and arches up into the lower neck before entering the subclavian vein.

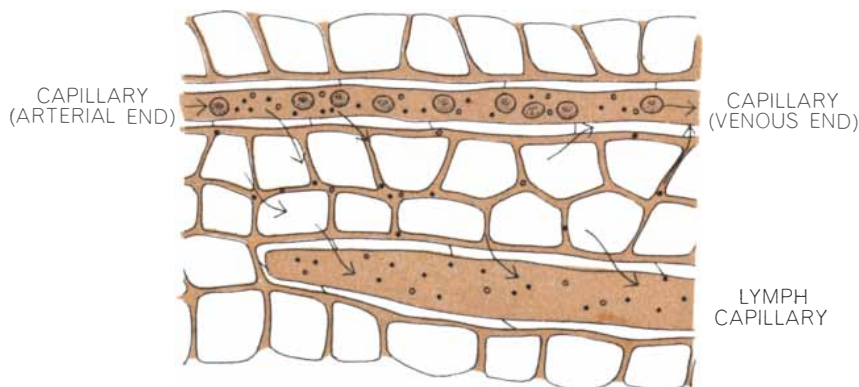




**STARLING'S HYPOTHESIS** explained the exchange of fluid through the capillary wall. At the arterial end of the capillary the hydrostatic pressure (*given here in centimeters of water*) delivered by the heart is dominant, and fluid leaves the capillary. At the venous end the osmotic pressure of the proteins in the plasma dominates; fluid enters the capillary.



**FLUID EXCHANGE** is diagramed as postulated by Starling. He believed that fluid and salts (*arrows*) left the blood capillaries, mixed with the interstitial fluid and for the most part were reabsorbed by the capillaries. Excess fluid was drained by the lymph vessels. He took it for granted that most of the protein in the blood stayed inside the blood capillaries.



**PRESENT VIEW** of fluid exchange is diagramed. It appears that such large molecules as proteins (*black dots*) and lipids (*open circles*) leave the blood capillaries along with the fluid and salts. Some of the fluid and salts are reabsorbed; the excess, along with large molecules that cannot re-enter the blood capillaries, is returned via the lymphatic system.

returned about 65 per cent of the protein that leaked out of the capillaries. Extension of this kind of experiment to man showed similar rates of leakage. In the course of a day 50 per cent or more of the total amount of protein circulating in the blood is lost from the capillaries and is returned to the bloodstream by the lymphatic system.

The importance of lymphatic drainage of protein becomes clear if one considers its role in lung function, which was elucidated by Drinker. The pulmonary circulation, in contrast to the general circulation, is a low-pressure system. The pulmonary capillary pressure is about a quarter as high as the systemic capillary pressure and the filtration pressure in the pulmonary capillaries is therefore considerably below the osmotic pressure of the blood proteins. As a result fluid is retained in the bloodstream and the lung tissue remains properly "dry."

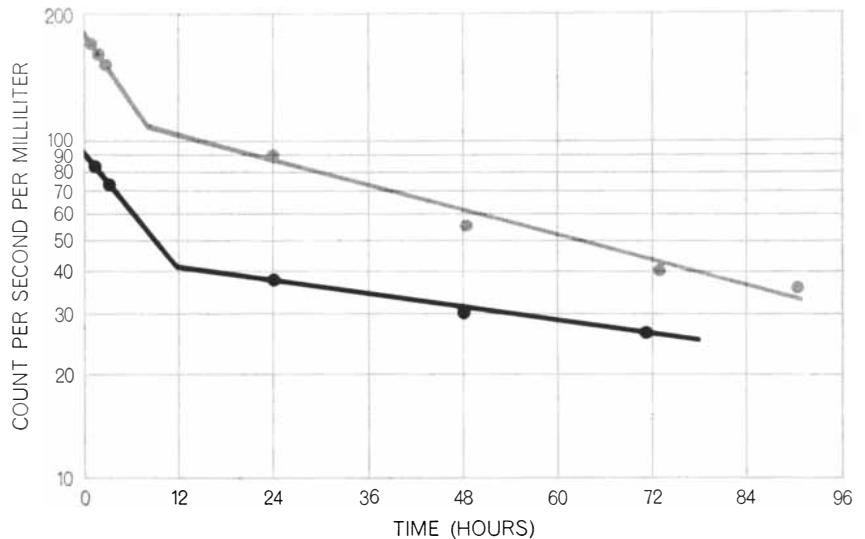
When pulmonary capillary pressure rises significantly, there is increased fluid and protein leakage and therefore increased lymph flow. For a time the lymph drainage is adequate and the lungs remain relatively dry. But when the leakage exceeds the capacity of the lymphatics to drain away excess fluid and protein, the insidious condition pulmonary edema develops. The excessive accumulation of fluid makes it more difficult for the blood to take up oxygen. The lack of oxygen increases the permeability of the pulmonary capillaries, and this leads to greater loss of protein in a vicious circle. Some recent findings by John J. Sampson and his colleagues at the San Francisco Medical Center of the University of California support this concept. They found that a gradual increase in lymphatic drainage occurs in dogs in which high pulmonary blood pressure is produced and maintained experimentally. This suggests that the lymphatic system attempts to cope with the abnormal situation by proliferating, much as blood capillaries do when coronary circulation is impaired.

Leakage from blood capillaries and recirculation by the lymphatic system is, as I indicated earlier, not limited to protein. Any large molecule can leak out of the capillaries, and it cannot get back to the bloodstream except via the lymphatics. All the plasma lipids, or fatty substances, have been identified in thoracic-duct lymph. Even chylomicrons, particles of emulsified fat as large as a micron (a thousandth of a millimeter) in diameter that are found in blood during the digestion of fat, leak out of the bloodstream and are picked

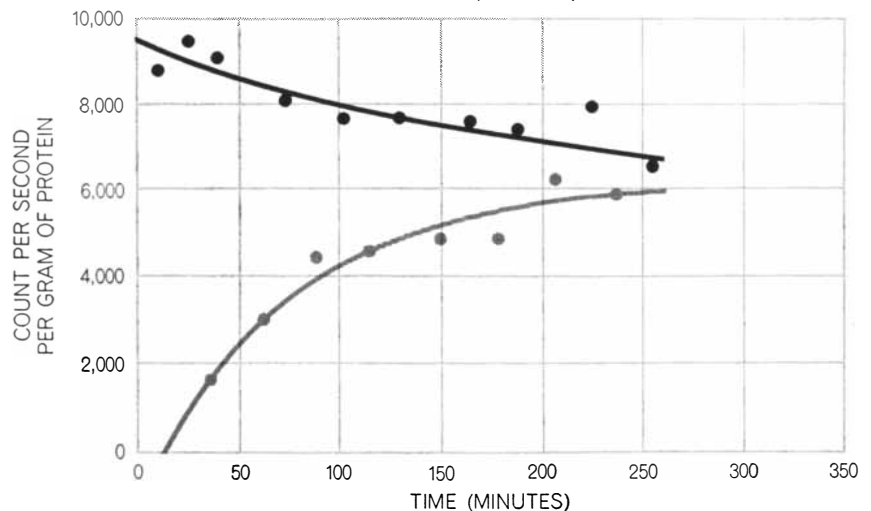
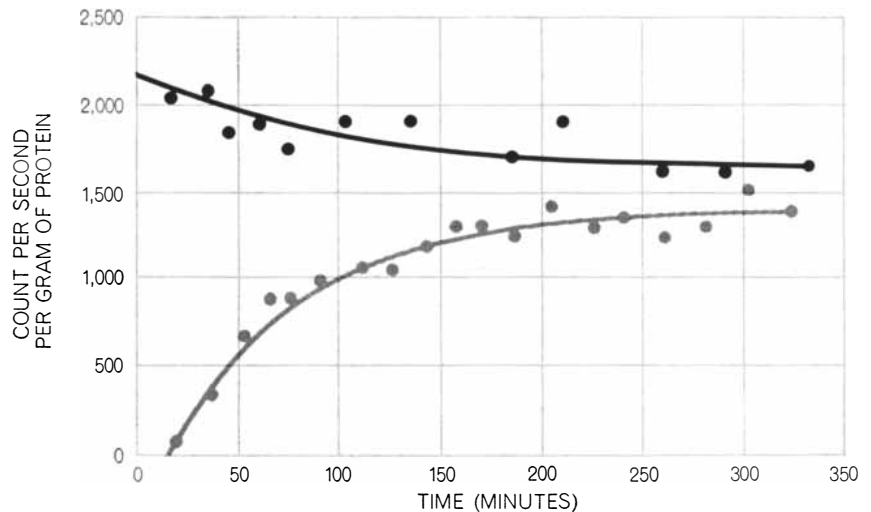
up and recirculated to the vascular system by the lymphatics. As a matter of fact, there is evidence that they may leak out even faster than proteins. The significance of these findings remains to be explained. Aaron Kellner of the Cornell University Medical College has suggested that atherosclerosis, a form of hardening of the arteries in which there is infiltration of the walls of the arteries by lipids, may have its origin in the fact that under normal conditions there is a constant flow of fluid containing lipids and proteins across the blood-vessel lining into the vessel wall. Ordinarily this fluid is removed by the small blood vessels of the wall itself and by the lymphatics. It is conceivable that something may interfere with the removal of lipids and cause them to accumulate in the blood-vessel wall. It is even conceivable that the high capillary filtration that accompanies hypertension may increase the leakage of lipids from capillaries to a level exceeding their rate of removal from the interstitial fluid, which would then bathe even the outer surfaces of the arteries in lipids.

In addition to demonstrating that the lymph returns large molecules from the tissue spaces to the bloodstream, recent investigation has confirmed the importance of lymphatic drainage of excess fluid filtered out of the capillaries but not reabsorbed. Experiments with heavy water show that blood is unquestionably the chief source of the water of lymph. In dogs the amount of lymph returned to the bloodstream via the thoracic duct alone in 24 hours is roughly equivalent to the volume of the blood plasma. Most of this fluid apparently comes from the blood. In some of our experiments we drained the thoracic-duct lymph outside the dog's body and found that the plasma volume dropped about 20 per cent in eight hours and the plasma-protein level some 16 per cent. Translated to a 24-hour basis, the loss would be equivalent to about 60 per cent of the plasma volume and almost half of the total plasma proteins circulating in the blood. Thus the return of lymph plays an essential role in maintaining the blood volume.

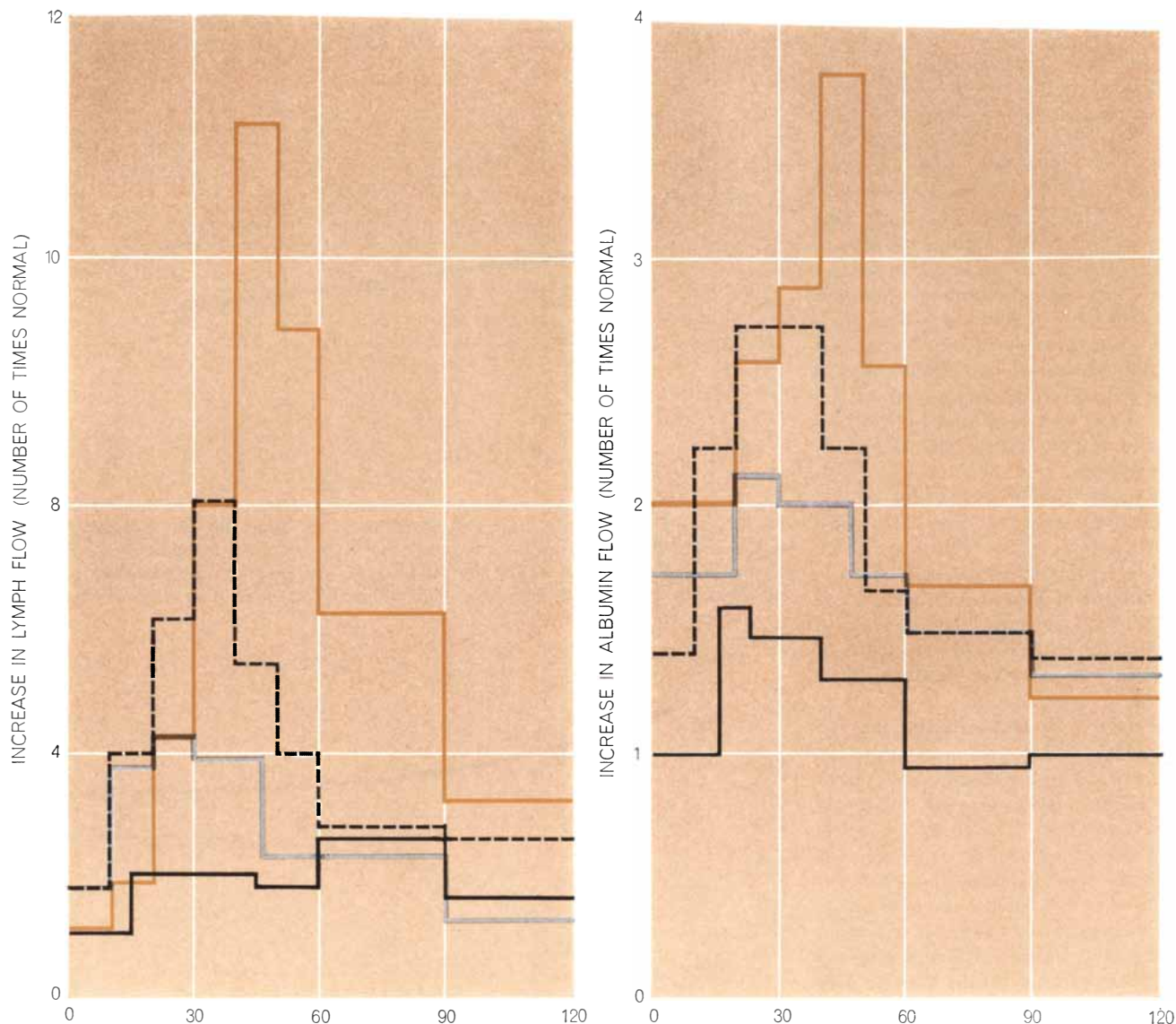
One situation in which this function can be observed is the "lymphagogue" effect: the tendency of large infusions into the vascular system to increase the flow of lymph. As we increased the size of infusions in dogs, lymph flow increased proportionately; with large infusions (2,000 milliliters, about the normal blood volume of a large dog) the thoracic-duct lymph flow reached a peak value about 14 times greater than that



**LABELLED PROTEINS** were injected into dogs' veins. Measuring the radioactivity per milliliter of blood withdrawn from an artery showed how quickly the globulin (*gray*) and albumin (*black*) disappeared. The steep slopes represent disappearance, the shallow slopes subsequent metabolism of the proteins. The radioactivity is plotted on a logarithmic scale.



**PROTEIN** appeared in thoracic-duct lymph (*gray curves*) and increased in the lymph as it disappeared from the blood (*black curves*). The upper graph is for albumin, the lower one for globulin. In time the labeled protein in blood and lymph reached equilibrium.



EFFECT OF INFUSIONS on lymph flow (graph at left) and on albumin flow in lymph (graph at right) in dogs is illustrated. Each curve shows the ratio of the flow after an infusion of a given size

to the flow before the infusion. The curves are for infusions of 250 (solid black), 500 (gray), 1,000 (broken black) and 2,000 (colored) milliliters. The larger the infusion, the more leakage.

of the preinfusion level [see illustration above]. Most of the excess fluid is excreted by the kidneys in increased urine flow. But the displacement of fluid from the blood circulation into the lymph "saves" some of the fluid. In other words, it can be considered as being a fine adjustment of the blood volume so that not all the fluid is irrevocably lost from the body. Large infusions also increase protein leakage, but again the fact that the protein goes to the lymph and slowly returns to the bloodstream minimizes changes in total circulating protein and the loss of its osmotic effect.

#### The Mechanism of Filtration

The exact processes or sites of the filtration of large molecules through the

capillary wall, and through cell membranes in general, are still unclear. As Arthur K. Solomon has pointed out in these pages [see "Pores in the Cell Membrane," by Arthur K. Solomon; SCIENTIFIC AMERICAN, December, 1960], "some materials pass directly through the fabric of the membrane, either by dissolving in the membrane or by interacting chemically with its substance. But it seems equally certain that a large part of the traffic travels via holes in the wall. These are not necessarily fixed canals; as the living membrane responds to changing conditions inside or outside the cell, some pores may open and others may seal up."

This last point appears to explain our results with infusions in dogs. The massive infusions overflow the closed blood

system, raise filtration pressure in the capillaries and result in increased leakage through the capillary walls; lymph flow is copious and the lymph contains more large molecules. Small infusions do not do this. The reason, then, that patients did not do as well as expected after receiving large infusions or transfusions was that the plasma and proteins leaked out through stretched capillary pores. A similar effect accounted for the case of animals subjected to severe hemorrhage: there was not enough blood to oxygenate the capillary walls adequately, the walls became more permeable and the protein molecules passed through.

We found that the rate of leakage for any molecule depends on its size. Globulin, which has a molecular weight of

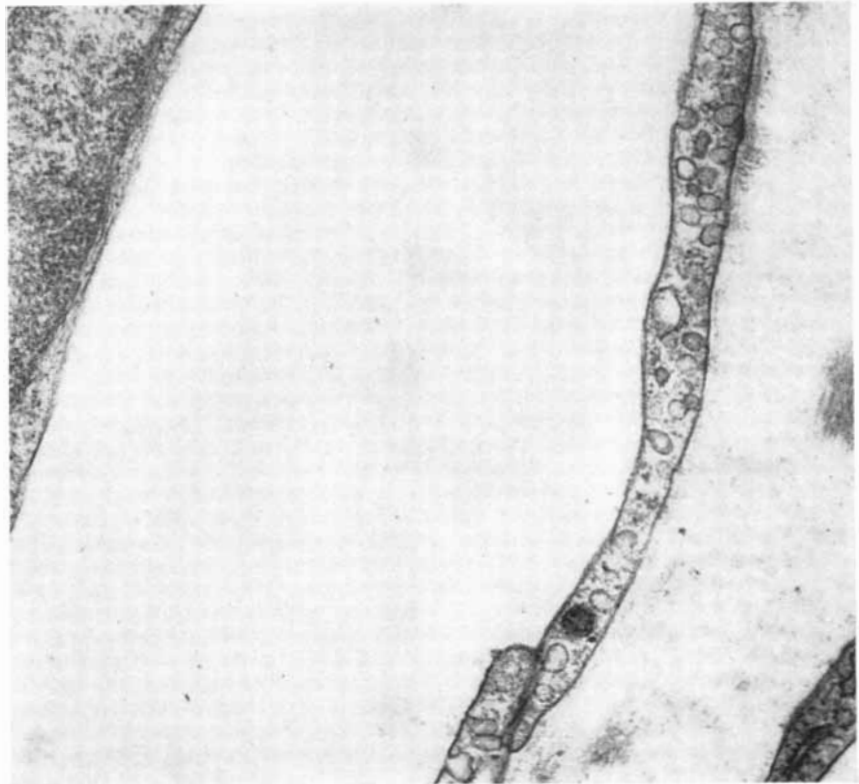
250,000, leaked more slowly than albumin, which has a weight of 70,000. The third plasma protein, fibrinogen, has a molecular weight of about 450,000 and leaves the blood still more slowly. By introducing into the blood various carbohydrate molecules, which unlike protein molecules do not carry a charge, we were able to demonstrate that it is size and not electrical charge that determines a molecule's rate of movement through the wall.

When, after infusing the carbohydrates, we collected lymph from different parts of the body, we found larger molecules in intestinal lymph than in leg lymph, and still larger molecules in lymph from the liver. This indicated that capillaries in the liver have substantially larger openings than leg capillaries do, and that the vessels of the intestine probably have both large and small openings. There are other indications that liver capillaries are the most permeable of all; for example, apparently both red cells and lymphocytes pass between the blood and the lymph in the liver. Recent studies with the electron microscope confirm the indirect evidence for variations in the size of capillary openings; the structure of the capillaries seems to vary with the organ, and these differences may be related to differences in function.

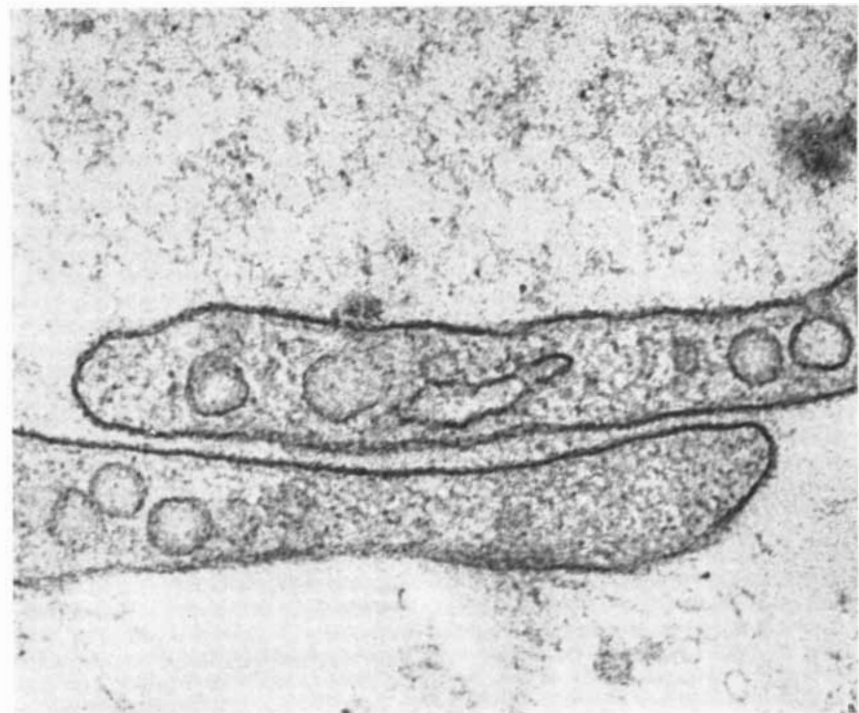
### Transport by the Lymph

When Gasparo Aselli first described lymphatic vessels in 1622, the ones he noted were the lacteals: small vessels that drain the intestinal wall. The dog Aselli was dissecting had eaten recently; the lacteals had absorbed fat from the intestine, which gave them a milky-white appearance and made them far more visible than other lymphatics. The transport of certain fats from the intestine to the bloodstream by way of the thoracic duct is one of the lymphatic system's major functions. Studies in which fatty acids have been labeled with radioactive carbon show that the blood capillaries of the intestine absorb short-chain fatty acid molecules directly, together with most other digested substances, and pass them on to the liver for metabolism. But the lacteal vessels absorb the long-chain fats, such as stearic and palmitic acids, and carry them to the bloodstream via the thoracic duct. The lymphatic system is also the main route by which cholesterol, the principal steroid found in tissues, makes its way into the blood.

Since the lymphatics are interposed between tissue cells and the blood sys-

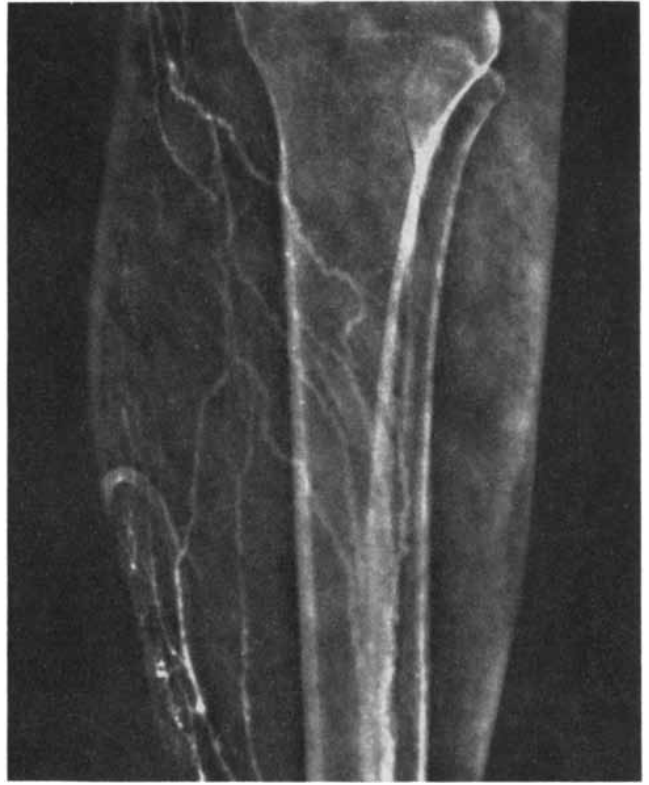


LYMPH CAPILLARY (*lightest area*) of mouse arterial tissue is enlarged 30,000 diameters in this electron micrograph made by Johannes A. G. Rhodin of the New York University School of Medicine. At upper left is part of the nucleus of an endothelial cell of the vessel wall. The thin ends of two other cells overlap near the bottom. The faint shadow in the connective tissue outside the wall is a slight indication of a basement membrane.



"LOOSE JUNCTION" between the overlapping ends of two endothelial cells of a vessel wall is seen in this electron micrograph, also made by Rhodin, of a lymphatic in mouse intestinal tissue. The lymph vessel is at the top, connective tissue at the bottom. In this case there is no sign of a basement membrane outside the wall. The enlargement is 90,000 diameters.





**LYMPHANGIOGRAM** is an X-ray photograph in which the lymphatic vessels are made visible by injecting into them a radiopaque dye. In the normal leg (*left*) the vessels are straight and well defined. In lymphedema (*right*) there is insufficient drainage of fluid

and proteins, in this case because there were too few vessels in the thigh. The extra pressure on the lower-leg vessels increased their number and made them tortuous. These pictures were made by Carl A. Smith of the New York University School of Medicine.

tem it is not surprising to find that they serve as the channel for transport to the bloodstream of substances that originate in tissue cells. The lymph is probably the route by which at least some hormones, many of which are very large molecules, are carried to the blood from the endocrine glands where they are synthesized. Some enzymes, found in lymph in small concentrations, may merely have leaked out of the capillaries. But others are apparently picked up from their cells of origin and carried to the blood by the lymph. Certain enzymes, including histaminase and renin, are present in greater concentrations in lymph than in the blood. The finding of renin, reported by A. F. Lever and W. S. Peart of St. Mary's Hospital Medical School in London, is of particular interest to investigators working on the problem of hypertension. One concept ascribes high blood pressure in some individuals to the production of renin by a kidney suffering from inadequate blood circulation; the renin is thought to combine with a globulin in the plasma to form hypertensin, an enzyme that narrows the arterioles and results in high blood pressure. It has been difficult to establish this concept because no one has been able consistent-

ly to demonstrate the presence of renin in the blood of hypertensive patients. Now that it has been discovered in lymph coming from the kidney it is clear that renin is indeed being formed in these patients, although in amounts so small that it usually escapes detection after being diluted in the blood.

Recently Samuel N. Kolmen of the University of Texas Medical Branch in Galveston has provided what may be a confirmation of the renin concept. He produced hypertension in dogs by removing one kidney and partially constricting the artery supplying the other one. When he shunted the thoracic-duct flow into the dog's gullet or allowed it to escape, the hypertension diminished. The implication is that renin was being kept out of the bloodstream. When Kolmen stopped lymph flow in the shunt, presumably inhibiting the diversion of the renin, the hypertension returned.

#### The Lymphatic Circulation

To the investigators of the 19th century the lymphatic system was "open-mouthed": its capillaries were assumed to be open to the tissue spaces. More recent evidence has shown that the

lymphatics form a closed system, that fluid enters not through the open ends of vessels but through their walls. The walls of the terminal lymph capillaries, like those of blood capillaries, consist of a single layer of platelike endothelial cells. This layer continues into the larger vessels as a lining but acquires outer layers of connective tissue, elastic fibers and muscle. Although the capillaries of the blood and lymphatic systems are structurally very similar, recent electron micrographs show differences in detail that may help to explain the ease with which the lymph vessels take up large molecules. Sir Howard Florey of the University of Oxford and J. R. Casley-Smith of the University of Adelaide in Australia believe that the most important difference is the poor development or absence in lymph capillaries of "adhesion plates," structures that hold together the endothelial cells of the blood capillaries. They suggest that as a result there are open junctions between adjacent cells in lymph capillaries that allow large molecules to pass through the walls. Johannes A. G. Rhodin of the New York University School of Medicine puts more emphasis on the apparent absence or poor development in lymph

capillaries of the "basement membrane" that surrounds blood capillaries.

Certainly it is clear that very large particles do enter the lymphatic vessels: proteins, chylomicrons, lymphocytes and red cells—the last of which can be as much as nine microns in diameter. Bacteria, plastic spheres, graphite particles and other objects have been shown to penetrate the lymphatics with no apparent difficulty. Yet we have found that when we introduce substances directly into the lymphatic system, anything with a molecular weight greater than 2,000 is retained almost completely within the lymphatics, reaching the blood only by way of the thoracic duct. If large particles can get into the lymphatic vessels, why do substances with a molecular weight of 2,000 not get out by the same channels?

I have spent many hours trying to formulate an answer to this question without arriving at a sophisticated concept, and have had to be content with a simple explanation that is at least consistent with the current evidence. Assume that the smallest terminal lymphatics are freely permeable to small and large molecules and particles moving in either direction through intercellular gaps. Compression of these vessels in any way would tend to force their contents in all directions. At least some of the contents would be forced along into the larger lymph vessels, where the presence of valves would prevent back-flow. And once the lymph reaches a larger vessel it can no longer lose its large particles through the thick and relatively impermeable wall of the lymphatic.

One can argue that this seems to be a rather inefficient and even casual way of getting the job done. Indeed it is, and this physiological casualness is a characteristic of the lymphatic system as a whole. There is no heart to push the lymph, and although lymphatic vessels do contract and dilate like veins and arteries this activity does not seem to be an important factor in lymph movement. The flow of lymph depends almost entirely on forces external to the system: rhythmic contraction of the intestines, changes in pressure in the chest in the course of breathing and particularly the mechanical squeezing of the lymphatics by contraction of the muscles through which they course.

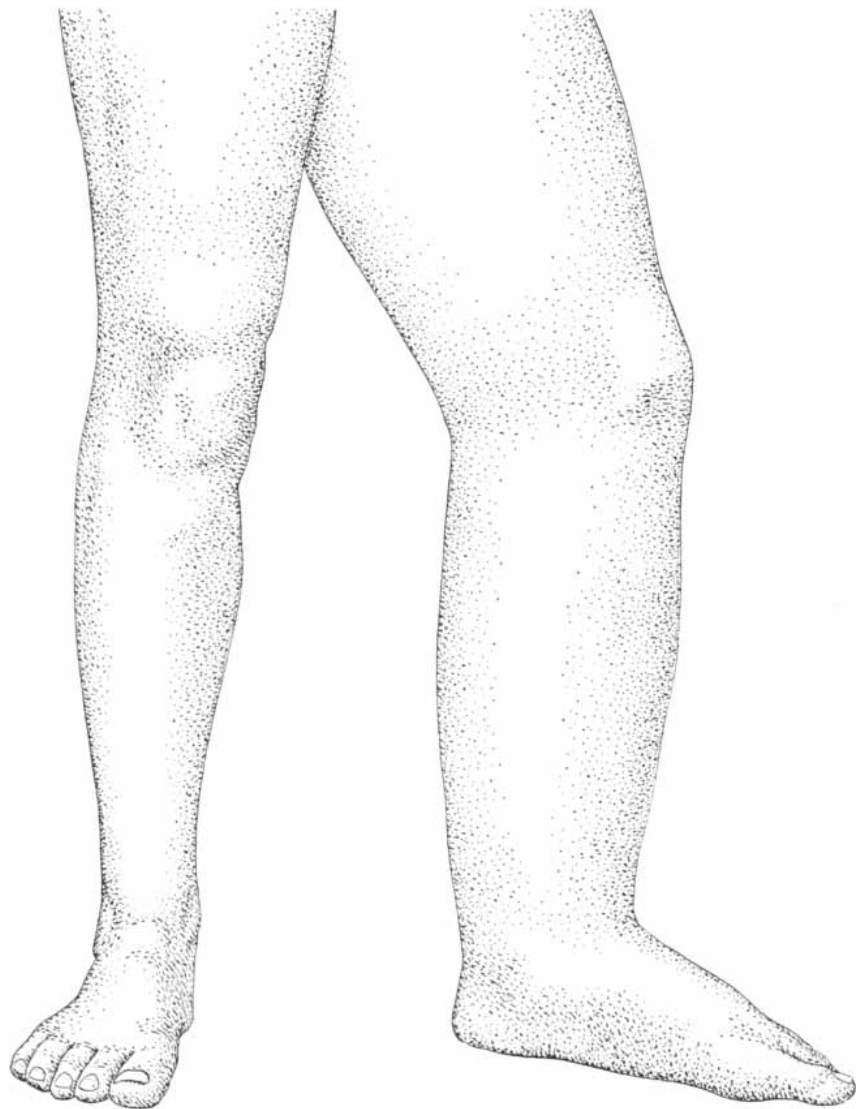
### Lymphatic Malfunction

In spite of the casualness of the lymphatic system, its development, as I have tried to show, was an absolute

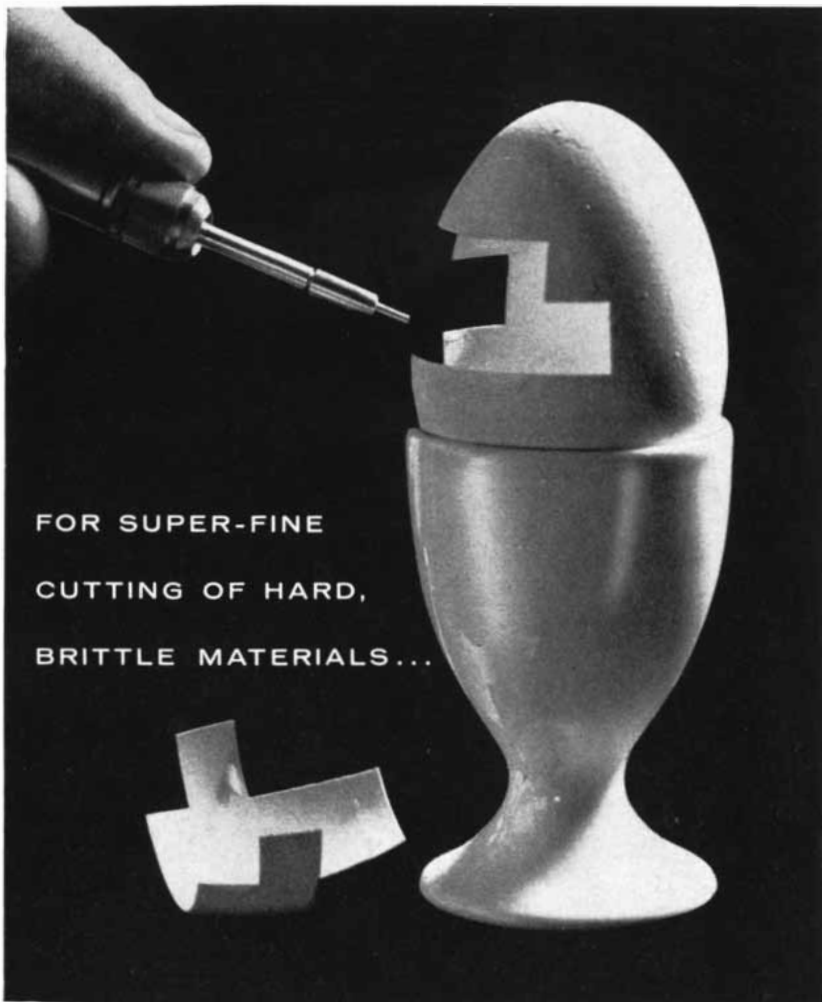
necessity for highly organized animals. Its importance is most visibly demonstrated in various forms of lymphedema, a swelling of one or more of the extremities due to the lack of lymphatic vessels or to their malfunction. In some individuals the lymphatic system fails to develop normally at birth, causing gradual swelling of the affected part. Lymphangiographic studies, in which the vessels are injected with radiopaque dyes to make them visible in X-ray photographs, show that the lymphatics are scarce, malformed or dilated. Insufficient drainage causes water and protein to accumulate in the tissues and accounts for the severe and often disabling edema. There is evidence that genetic factors may play a role in this

condition. Surgical procedures that destroy lymph vessels may have a similar effect in a local area. Elephantiasis is a specific form of lymphedema resulting from the obstruction of the vessels. It can be caused by infection of the lymphatics or by infestation with a parasitic worm that invades and blocks the vessels.

The lymphedemas have been recognized as such for many years. Recently the view that the lymphatic system is essential to homeostasis—which is to say "good health"—has led to a number of investigations of its role in conditions in which no lymphatic involvement was previously suspected. Our group at Tulane has found that lymphatic drainage of the kidneys is essential in order to maintain the precise osmotic relations



**LYMPHEDEMA** can cause gross deformity of a limb and even disability. The drawing is based on a photograph of an 11-year-old girl whose leg began to swell at the age of seven, probably because of an insufficiency of lymphatic vessels. The patient's condition was greatly improved by an operation in which the tissue between skin and muscles was removed.



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on which proper kidney function depends. This may explain the dilution of the urine observed in some patients after kidney operations: the lymph vessels may have been damaged, decreasing their capacity for draining proteins and interfering with the reabsorption of water by the kidney tubules.

At the New York University School of Medicine, John H. Mulholland and Allan E. Dumont have been investigating the relation between thoracic-duct flow and cirrhosis of the liver. Their results suggest that the cirrhosis may be associated with increased lymph flow in the liver and that the inability of the thoracic duct to handle the flow may bring on the accumulation of fluid, local high blood pressure and venous bleeding that are frequently seen in cirrhosis patients; drainage of the duct outside the body temporarily relieves the symptoms.

These and other clinical observations are consistent with my feeling that the lymphatic system does a capable job when all is going well but that its capacity for dealing with disturbances is limited. As a phylogenetic late-comer it may simply not have evolved to the point of being able to cope with abnormal stresses and strains. The role of the second circulation in disease states is currently under intensive investigation. As more and more is learned about its primary functions and its reactions to stress, the new knowledge should be helpful in diagnosis and perhaps eventually in the treatment of patients.



**DILATED THORACIC DUCT** of a patient with cirrhosis is seen in this photograph made by Allan E. Dumont and John H. Mulholland of the New York University School of Medicine and reprinted from *Annals of Surgery*. The plastic tube just below the duct is a tenth of an inch in diameter. A normal duct would be smaller than the tube.



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# HYDROGEN IN GALAXIES

Recent studies with radio telescopes indicate that the amount of interstellar hydrogen in a galaxy is correlated with its structural type and holds clues to its origin and evolution

by Morton S. Roberts

In 1944 H. C. van de Hulst, a young astronomy student at the University of Leiden, proposed that it might be possible to detect radio emission from hydrogen atoms spread thinly through interstellar space. Because the Netherlands was then occupied by German troops van de Hulst's proposal did not become generally known until the war had ended. Even then few astronomers took it seriously, because it seemed likely that the hydrogen signal would be extremely faint. Finally, in 1951, the hydrogen emission was detected with a crude-looking but sensitive apparatus by Harold I. Ewen, a Harvard University graduate student, and his professor, E. M. Purcell. Almost simultaneously a radio telescope was completed at Leiden and van de Hulst confirmed the Harvard discovery and his own prediction.

Since 1951 radio astronomers at Leiden, Sydney in Australia, Harvard and elsewhere have spent thousands of hours recording the hydrogen emission from within our own galaxy and from some 35 or 40 other galaxies near enough to yield a detectable hydrogen signal. The recordings from within our galaxy have shown that the hydrogen is concentrated in the spiral arms of the galactic structure. What is more significant, the location of the hydrogen and its relative motion in space can be mapped even in distant regions of the galaxy where stars are obscured by dense veils of interstellar dust. The dust blocks visible light but not the radio waves from hydrogen. Much of the mapping of hydrogen concentrations within our galaxy has been done at Leiden and at Sydney. At Harvard my colleagues and I have spent several years measuring the hydrogen content of other galaxies, using a radio telescope with a 60-foot dish completed in 1956. Although it is not large as modern radio telescopes go, the

Harvard instrument has been equipped with a very sensitive maser detector.

Our findings, in brief, are that the amount of hydrogen in a galaxy can be correlated with its appearance and structure. In spiral galaxies such as our own about 1 per cent of the total galactic mass is in the form of interstellar hydrogen. In galaxies with more open spirals the hydrogen content runs as high as 14 per cent. Some galaxies with an irregular structure contain as much as 30 per cent. In certain other galaxies, in general those with little flattening or spiral structure, we have been unable to detect any hydrogen at all. These findings are consistent with a recent hypothesis that questions the assumption that galaxies of different appearances represent different stages in galactic evolution. For example, some astronomers have thought that galaxies begin their life as spherical gaseous systems, which become flattened by rotation and later undergo other structural changes. The new view is that galaxies are endowed with different structures from the time of formation and change little with the passage of time. On this view it is reasonable to expect that galaxies may also vary widely in hydrogen content from the outset. The case, however, is far from closed.

Some idea of the difficulty of measuring the hydrogen emission from space can be gained from the following statistics. The amount of radiation from interstellar hydrogen falling on the entire surface of the earth is less than 10 watts. The amount of this energy that can be collected by a radio telescope is an extremely small fraction in which the numerator is the area of the telescope's collecting surface and the denominator is the area of the earth: about  $5 \times 10^{15}$  square feet. Of the total energy of less than 10 watts of hydrogen signal reach-

ing the earth, only about a millionth of a watt is contributed by a galaxy typical of those detectable by the 60-foot Harvard radio telescope. This means that the maser mounted on the telescope is able to detect a signal whose strength is typically  $10^{-18}$ , or a billion-billionth, watt.

What is the source of the hydrogen signal? As van de Hulst recognized, a hydrogen atom floating in the cold void of space can exist in only one of two energy states. In the lower energy state its single electron and proton are spinning in opposite directions; in the slightly higher state the two particles are spinning in the same direction. Every few million years, on the average, the spin axis of the electron will flip over and a hydrogen atom in the higher state will pass to the lower energy state. Simultaneously a photon is emitted and carries off the energy lost in the transition. The emitted photon has a wavelength of 21 centimeters, which is equivalent to a frequency of 1,420 megacycles. This is the 21-centimeter spectral line that Ewen and Purcell were the first to detect. A final point is that hydrogen atoms that have flipped to the lower state will occasionally acquire the energy needed—usually through collision with another atom—to revert to the higher energy state.

The discovery of 21-centimeter radiation has made it possible to carry forward a study of galactic structure that began with the work of Sir William Herschel in the 18th century. A brief account of this quest for knowledge may help to set the stage for a discussion of our own investigations.

It was apparent to Herschel, as to stargazers before him, that the sky is not uniformly populated with stars. Many men must have wondered if the Milky Way, which appears as an irregular band

of light across the night sky, is actually made up of stars so densely packed that the eye cannot resolve them. Using a succession of magnificent telescopes, Herschel was able not only to resolve the stars in the Milky Way but also to make a systematic count of the stars in different directions. He assumed that the extent of our stellar system must be greatest in the direction in which the apparent density of stars is highest.

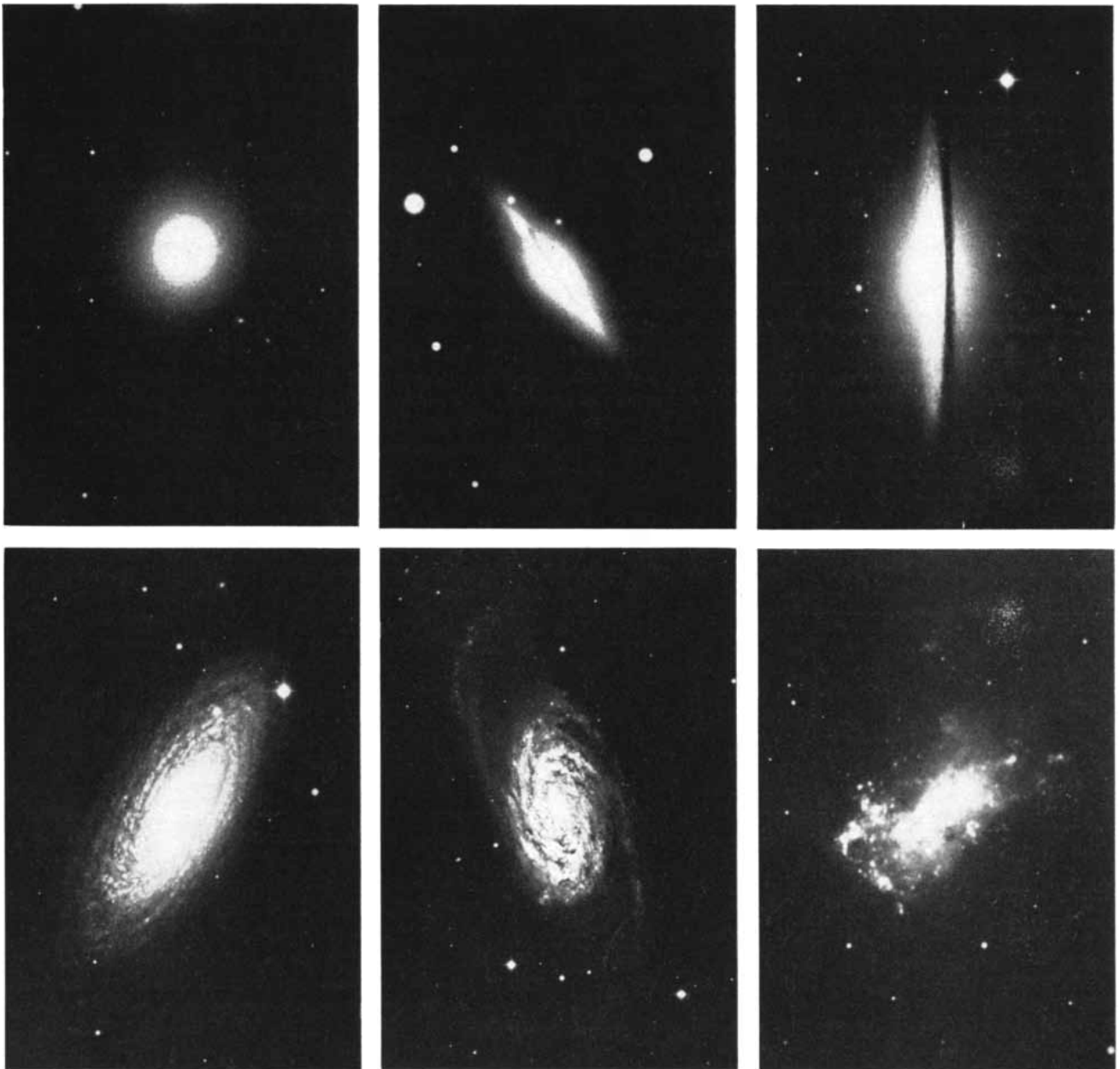
Herschel's method was extended by other observers and finally led, early in this century, to a model known as the Kapteyn universe, named for J. C.

Kapteyn, who began his career at the Leiden observatory. On the basis of photographic star counts Kapteyn concluded that the sun is located almost at the center of the Milky Way, which was thought to define the whole universe. The existence of other galaxies was still unrecognized.

Around 1917, using a completely different approach, Harlow Shapley reached the quite different conclusion that the sun must be located some 50,000 light-years from the center of our stellar system. Studying the distribution of globular clusters of stars, Shapley noted that

most of them are concentrated in one hemisphere of the sky. He guessed that they are in all probability symmetrically located about the center of our galaxy and that their observed distribution means that the solar system is displaced toward the edge of the galaxy. It turned out that Shapley was basically right but that he had overestimated the distance from the sun to the center of the galaxy. The best current estimate places the distance at about 33,000 light-years, not 50,000.

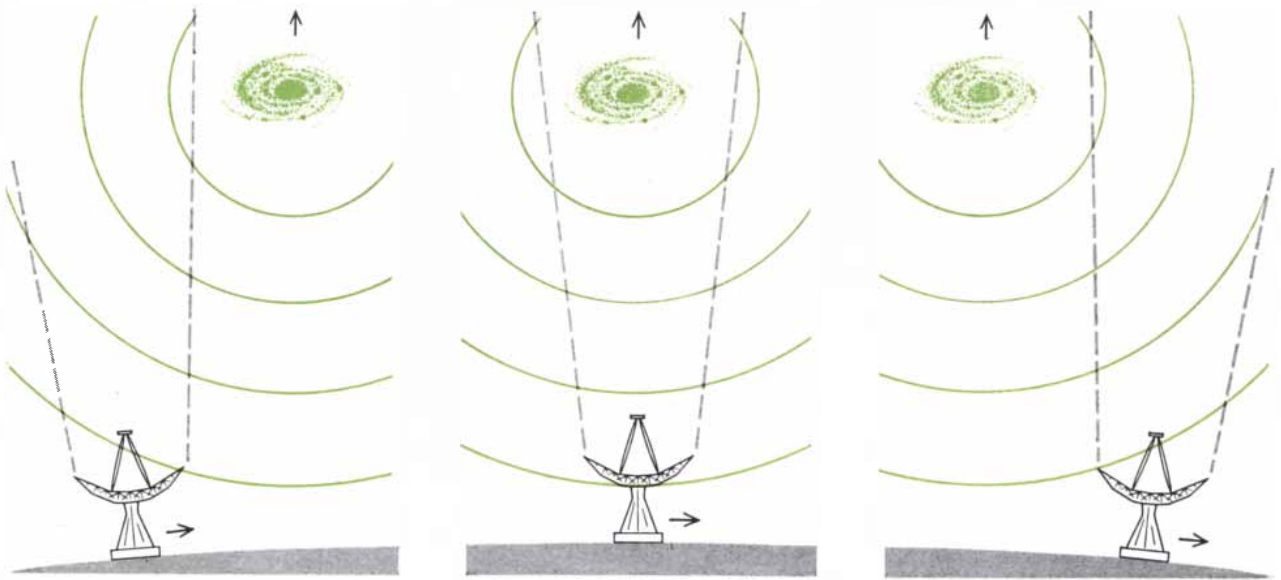
How could Shapley's observation be reconciled with Kapteyn's star counts,



DIFFERENT TYPES OF GALAXIES include (left to right, from upper left) NGC 4486, an elliptical galaxy 40 million light-years distant; NGC 5866, an S0 spiral 33 million light-years away; NGC 4594, an Sa spiral at 37 million light-years;

at 30 million light-years; NGC 2903, an Sc spiral at 23 million light-years; and NGC 4449, an irregular galaxy 11 million light-years away. Amount of hydrogen in galaxies seems to be correlated with structural type. Ellipticals have the least; irregulars the most.





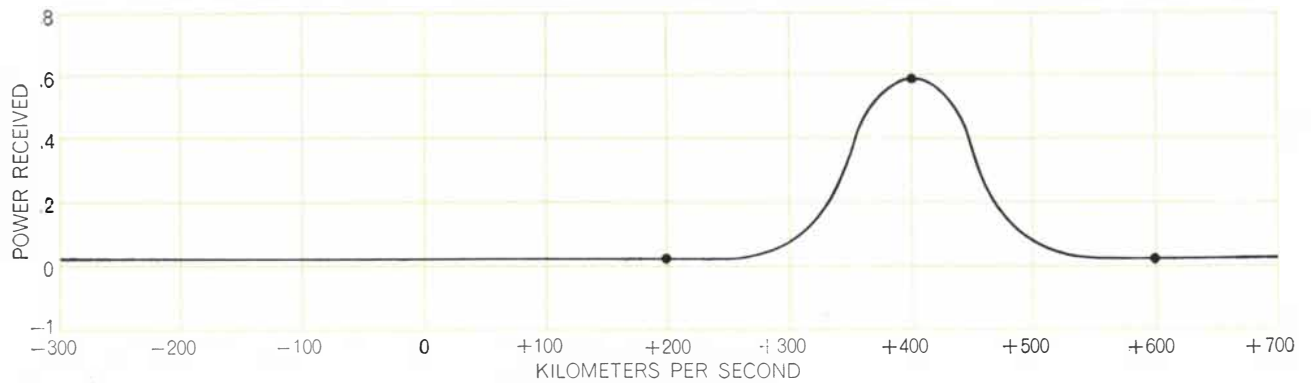
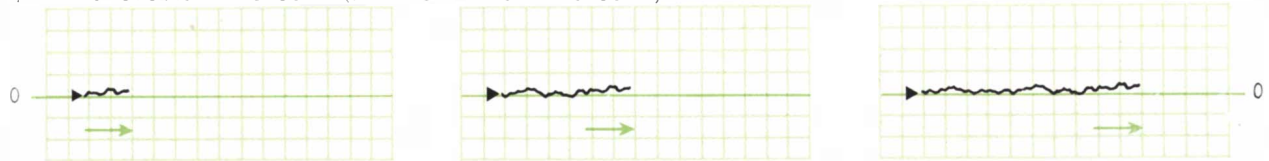
1,419 MEGACYCLES PER SECOND (200 KILOMETERS PER SECOND)



1,418 MEGACYCLES PER SECOND (400 KILOMETERS PER SECOND)



1,417 MEGACYCLES PER SECOND (600 KILOMETERS PER SECOND)



**“DRIFT CURVE” METHOD** of studying hydrogen in galaxies involves aiming radio telescope directly west of galaxy (*top left*) and letting rotation of earth carry it past the galaxy. Idealized recordings on three channels one megacycle apart are shown. Interstellar hydrogen emits radiation at 1,420 megacycles per second.

If the galaxy happens to be receding at 400 kilometers per second, the wavelength is shifted to 1,418 megacycles (*center row of panels*). In this case no emission is recorded at 1,419 or 1,417 megacycles. The curve at the bottom, which plots the power received at various wavelengths, is known as the velocity profile of the galaxy.

which showed roughly equal numbers of stars in all directions? The answer to the riddle was supplied in 1930 by Robert J. Trumpler of the Lick Observatory, and in the process he corrected Shapley's distance scale. Trumpler compared the diameters of several hundred open, or galactic, clusters and reasoned that they should have about the same average size regardless of distance. When he applied the prevailing distance scale, however, he found that the predicted diameters increased with distance. The obvious way to correct this discrepancy was to assume that the distant clusters were actually nearer than the prevailing scale implied. But if they were nearer, why were they not brighter? Trumpler's answer: They were dimmed by interstellar dust.

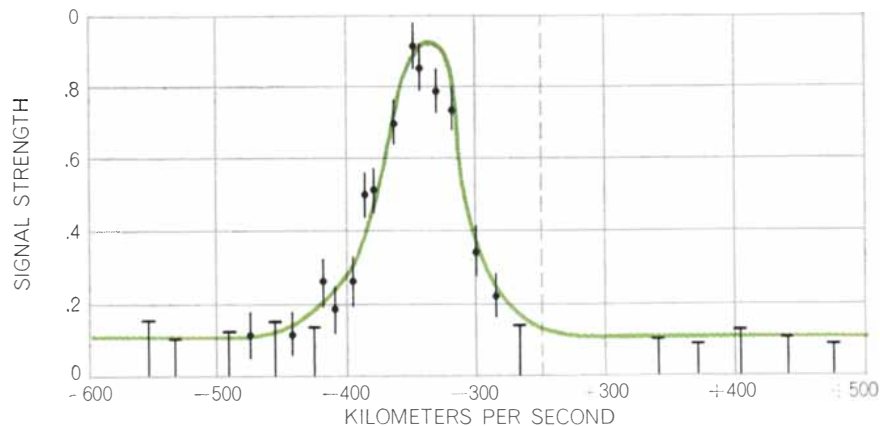
This also explained why Herschel, Kapteyn and others were misled. In the plane of the Milky Way there is so much dust that they could never see the blaze of stars in the galactic center. By 1930, however, Trumpler's brilliant deduction was overshadowed by the somewhat earlier discovery, due chiefly to Edwin P. Hubble of the Mount Wilson Observatory, that our galaxy is only one in a vast universe of millions of galaxies extending for millions and, as we now know, billions of light-years in all directions.

Although Trumpler's discovery seemed to place an impenetrable veil over large regions of the Milky Way, the veil was simultaneously being lifted—although no one realized it at the time—by a young radio engineer, Karl G. Jansky. An employee of the Bell Telephone Laboratories, Jansky was asked to investigate unexplained radio noises that were plaguing transatlantic radiophone communications. In 1932 Jansky reported that at least some of the noise was “cosmic,” originating outside the solar system. This was the accidental beginning of radio astronomy, and for the next 10 years optical astronomers virtually ignored it. Because of poor resolution early radio telescopes had trouble pinpointing the sources of cosmic noise. As a result the first radio maps of the sky resembled topographical contour maps. Closely spaced and roughly parallel lines delineated the plane of the Milky Way. Here and there, like hills on a contour map, a few cosmic hot spots were identified by a series of tightly spaced whorls.

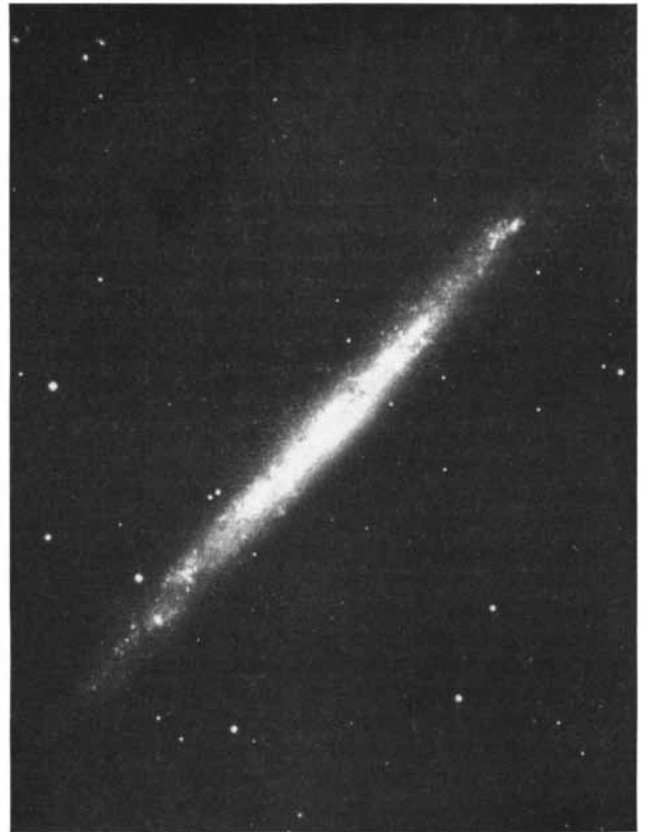
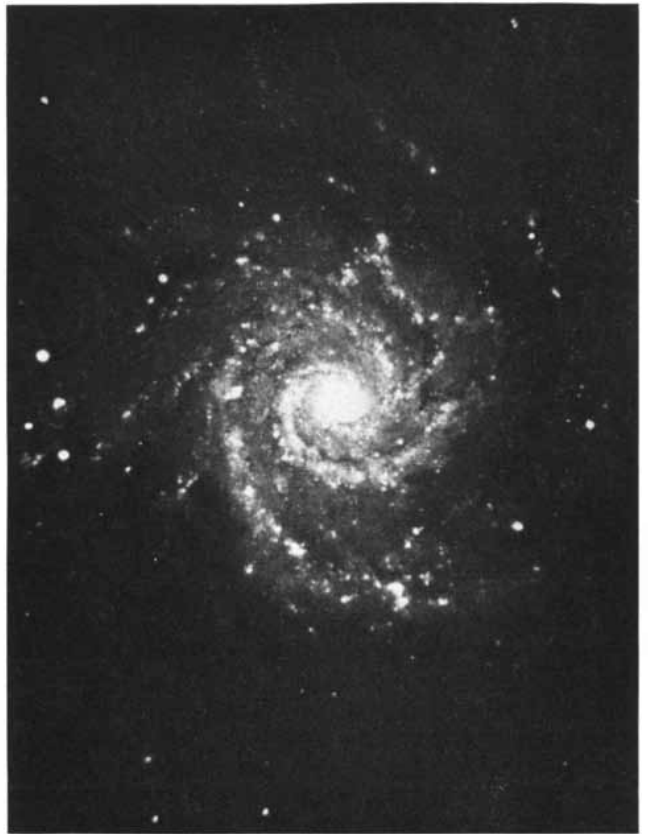
The radio telescopes built before World War II could not possibly have detected the 21-centimeter radiation of hydrogen. They did not operate at such short wavelengths and they were far too



**MULTICHANNEL DRIFT CURVES** of irregular galaxy IC 10 were obtained in one sweep with maser mounted on the 60-foot telescope of Harvard College Observatory. Different frequencies recorded represent velocity differences of about 30 kilometers per second. Responses here show that this galaxy is receding at approximately 347 kilometers per second.



**VELOCITY PROFILE** of galaxy IC 10 comes from several multichannel sweeps. Dots mark specific observations. Thin vertical bars indicate range of error. Short dashes at top of lowest bars mark maximum strength of signal there. Dashed vertical line indicates break in scale.



ANGLE OF GALAXY affects velocity profile. All these are Sc spirals. NGC 5457 (*top left*), 12 million light-years away, is seen full face or along axis of rotation. Its angle is thus zero. NGC 628 (*top right*), 25 million light-years away, tilts at an angle

of 35 degrees. NGC 2403 (*bottom left*), 11 million light-years away, is inclined at 54 degrees as seen from earth, and NGC 4244, 11 million light-years distant, at 86 degrees. These photographs and those on page 95 were made at Mount Wilson and Palomar Observatories.



insensitive. The required sensitivity at short wavelengths was largely an inheritance from wartime radar.

An important virtue of 21-centimeter radiation in astronomy—its ability to penetrate interstellar dust—arises from the fact that its waves are about a million times longer than the dimensions of a dust particle. Light waves, having about the same length as the dimensions of a dust particle, tend to be scattered. Otherwise the two kinds of radiation behave in the same way. Like light waves, the 21-centimeter waves are shifted in frequency if their source has a radial component of velocity—that is, if the source is moving in the observer's line of sight. This Doppler shift is toward a higher frequency if the source is approaching and toward a lower frequency if the source is receding.

A rather complete picture of the central plane of our galaxy, as seen in the "light" of hydrogen radiation, has now been assembled from radio observations made primarily at Leiden and Sydney. The map shows not only the location but also the amount of hydrogen in various parts of the galaxy. Astronomers have been surprised to learn that interstellar hydrogen represents only about 1 per cent of the total mass of the entire galaxy. They had thought the figure would be several times larger.

In 1953 Australian observers recorded the first 21-centimeter radiation from a galaxy outside our own. The faint signal originated from the two small galaxies known as the Clouds of Magellan—our nearest extragalactic neighbors. Before long hydrogen radiation was detected from the Great Nebula in Andromeda, a spiral galaxy only about two million light-years away. It was apparent that to record hydrogen emission from any sizable sample of galaxies one would have to build larger radio telescopes or design more sensitive receivers. Ideally, of course, one should do both.

About five years ago the Harvard radio astronomy group set out to obtain a more sensitive receiver in the form of a maser. The actual design and building was done by two visitors at Harvard, B. Cooper of the Australian Commonwealth Scientific and Industrial Research Organization and J. Jelley of the British Atomic Energy Research Establishment at Harwell. The design followed suggestions made by N. Bloembergen of Harvard and Thomas Gold, now at Cornell University. The maser has been in continual operation since early 1960 and represents one of the major research

tools of the Harvard Radio Astronomy Project.

Since the maser had to be located close to the feed horn at the focus of the 60-foot parabolic reflector, a compact, light design was required. The heart of the device is a ruby crystal located between the poles of a powerful electromagnet. Because the maser operates in a vessel of liquid helium, a convenient way to replenish the helium as it evaporated had to be found. The entire system weighs 200 pounds. It is at least five times more sensitive than conventional receivers and has tripled the number of galaxies that can be detected with the 60-foot dish.

In our study of 21-centimeter radiation from galaxies we have looked for correlations with the galactic structure as deduced from photographs. In the classification scheme originally proposed by Hubble galaxies are of three basic types: elliptical, spiral and irregular.

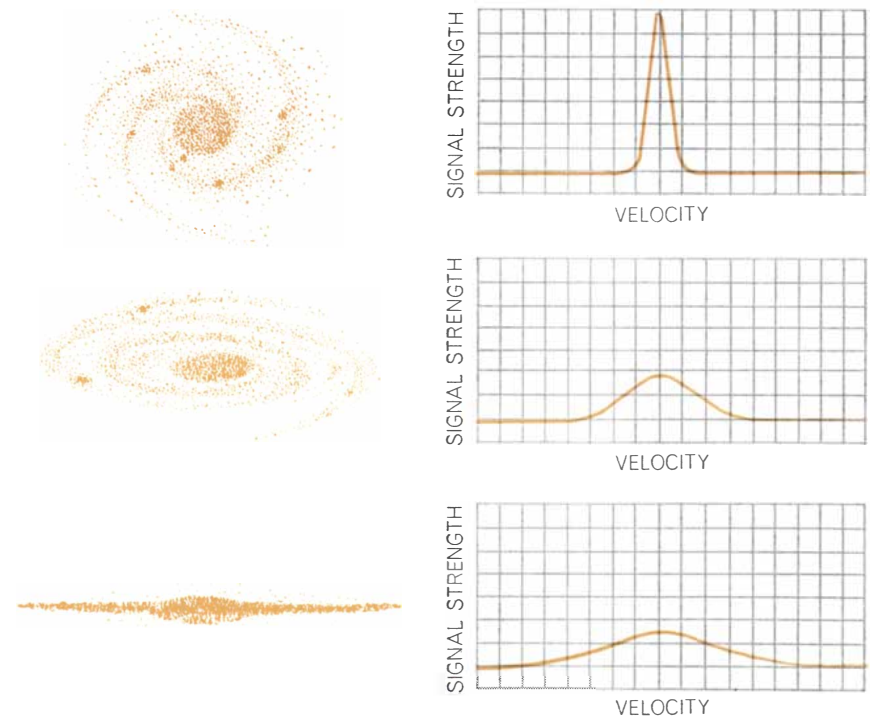
The ellipticals, which are essentially featureless, are classified according to their apparent ellipticity. The spirals are divided into two general categories: "normal" and "barred." In the former the spiral arms appear attached to the nucleus, or central region, of the galaxy; in the latter the arms extend from the ends of a bar that passes through the galactic nucleus. For the sake of simplicity I shall

make no distinction between normal and barred spirals.

The spirals are further classified according to the relative size of the nucleus, the degree of openness of the arms and the resolution of the arms. A spiral with a large nucleus and smooth, tightly wound arms is classified Sa. An Sc galaxy has a small nucleus and large, open arms displaying a great deal of structure. Our own galaxy is an Sb type, intermediate between Sa and Sc in plan. A fourth type of spiral, S0, appears at first sight to be an elliptical, but actually it has a quite different profile of luminosity and contains very little dust.

The irregular galaxies exhibit no features by which they can be further classified; their appearance is chaotic and they show little or no evidence of a nucleus. They are not so highly flattened as spirals seen edge on, but they probably do possess a central plane.

The optically determined colors and spectral features of galaxies are known to vary in a systematic fashion with galaxy type; both sets of properties provide information about the stellar content of a galaxy. From 21-centimeter observations we have tried to determine how the hydrogen content varies in galaxies of different types. Evidence for some sort of correlation was suggested by earlier work, primarily that of Dutch



**EFFECT OF TILT** is illustrated with a single schematic Sc galaxy seen from three different angles. In all three views distance to galaxy, its radial velocity, rate of rotation and hydrogen content do not change. Differences in velocity curves (*right*) are due only to the angle of view. Because other factors are the same the area beneath all three curves is equal.





Model 115 Continuous-Wave Gas Laser

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**Precision** in construction and alignment—A good test is whether it is possible to operate the laser in the plane-parallel resonator configuration. This is also a revealing index of the laser's stability.

**Exciter** Is it designed specifically for laser use? If it is, as in the Model 115, control will be simpler and you'll avoid problems arising from misadjustment of needless controls.

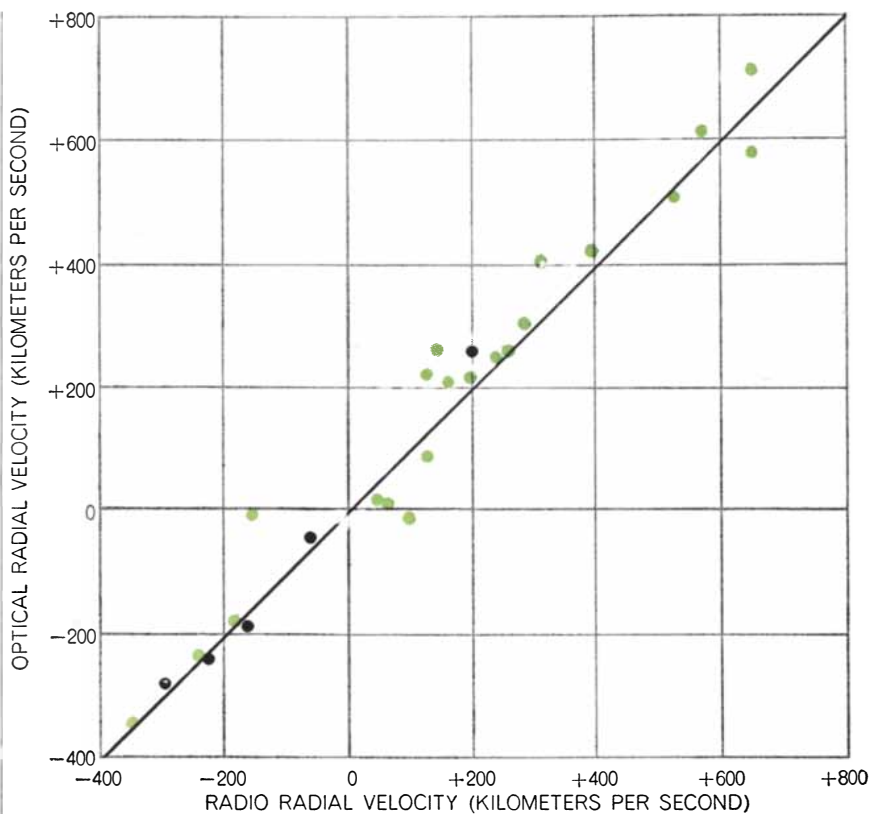
**Warranty** Is the laser guaranteed? Who made it? How many has he made? Who's now using them? Over 70% of all commercial CW gas lasers in use today were developed and produced by Spectra-Physics. The Model 115, backed by an unmatched continuity of experience and user-proved performance, carries a complete warranty (including plasma tube).

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**RADIAL VELOCITIES** of galaxies as measured with radio telescope are plotted against those calculated from optical study of same galaxies. Colored dots indicate radio observation at Harvard; black dots, at Leiden. Diagonal line shows mathematical fit to the points.

observers. We needed a large sample so that meaningful averages could be obtained.

Our observations are made by the "drift curve" method. The radio telescope is aimed directly west of the galaxy under study and the rotation of the earth carries the telescope past the galaxy. In this manner a base line as well as the signal is obtained with one setting of the telescope. Unlike an optical telescope, which has a precisely defined field, a radio telescope accepts a certain amount of radiation from all directions through its "side lobes." The drift-curve method minimizes any changes that occur in side-lobe reception during the observation. The receiver output, recorded on paper tape, shows how the signal strength varies as the telescope "drifts" across the sky.

In making the observations allowance must be made for the radial velocity of the galaxy. For each increment of one kilometer per second in radial velocity, the "pitch" of the 1,420-megacycle hydrogen signal is shifted by five kilocycles. Because such Doppler shifts can often be determined with an accuracy of plus or minus 25 kilocycles, radial velocities determined by radio methods are inherently more accurate than those de-

termined by optical means. Nevertheless, optically determined velocities are a great aid to the radio astronomer in selecting the frequency range needed to observe a given galaxy.

Because the hydrogen within the galaxy being observed is also in motion, the radiation will be further shifted, this time around the average velocity of the entire system. Observations must therefore be made over a range of velocities. In order to reduce the observing time we usually record simultaneously on five different channels, spaced 150 kilocycles apart. This is equivalent to measuring hydrogen radial velocities in five ranges spaced at intervals of 30 kilometers per second. The total recording range is thus 150 kilometers per second, but even this range is not great enough to encompass the random and systematic motions of hydrogen within some galaxies. In such cases the recording frequencies must be shifted and the galaxy may have to be scanned several times.

The multichannel recordings are converted into a velocity profile, which indicates the amount of radiation received at each velocity and therefore the total radiation falling on the antenna. If one knows the distance of the galaxy from optical measurements, one can re-

TELEMETRY DOWN TO EARTH!

# THE HONEYWELL VISICORDER MEASURES STRAIN! ON A ROTATING SCRUBBER MILL

\*\*\*\*\*

Telemetry is usually thought of as signal transmission across tremendous voids. Allis-Chalmers uses the Honeywell Visicorder oscillograph to bring telemetry down to earth.

At the Allis-Chalmers processing machinery department in Milwaukee, design engineers wanted to measure grinding mill stresses while the huge machines process metal ore, taconite, cement, and other materials. Large, costly slip rings and dismantling of the machinery had to be avoided, and if possible, all tests were to be made under actual operating conditions in the user's plant.

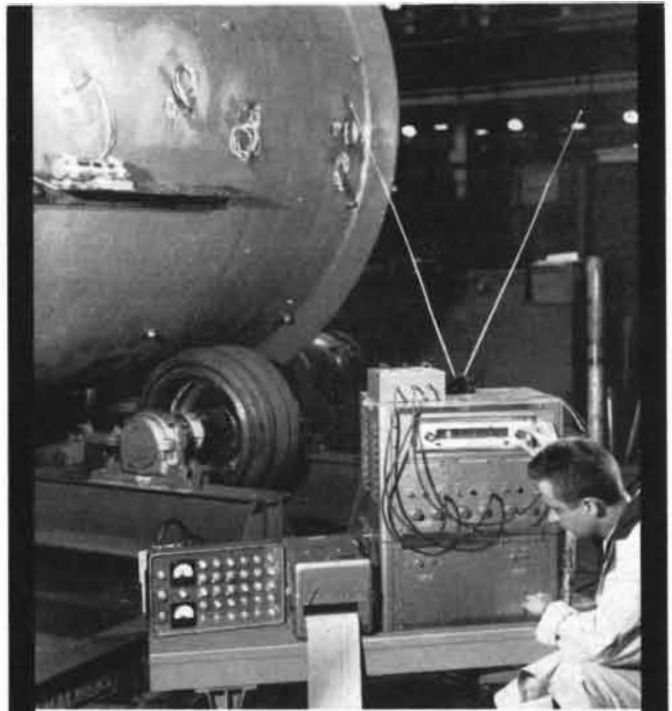
The problem was neatly solved with a telemetry system built around a Honeywell 906 Visicorder oscillograph and a Honeywell Bridge Balance Unit. With this system, stresses on the shell of the mill, torque on the shaft, and strain on the entire mill can be measured with the mill in operation, and with a minimum of inconvenience to the customer.

Strain gages are placed on the mill at points where stresses are to be measured. Multiplexed data from the gages are broadcast by an FM transmitter attached to the rotating mill, and are picked up by an FM receiving unit. The multiplexed signal is 'sorted out' by audio filters and discriminators, and sub-frequencies and frequency variations are changed to a varying DC voltage.

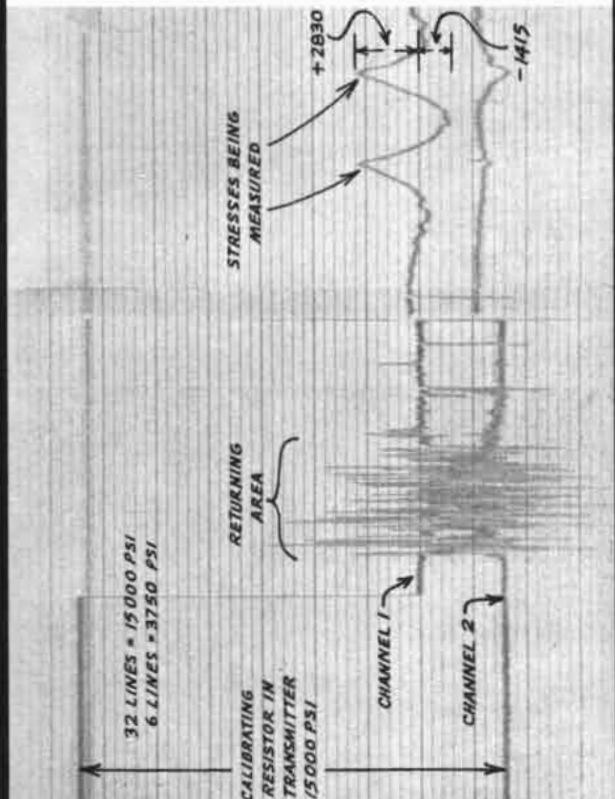
The Honeywell Visicorder was selected to record the data because Allis-Chalmers engineers wanted to measure even the slightest variation at high frequencies (in this case, as high as 1800 cps), and to measure and record all three data channels simultaneously. In addition, the immediately-readable record produced by the Visicorder gave the engineers an on-the-spot reading of stress variations as well as a permanent record for later use.

There is a Honeywell Visicorder to fit your test requirements. Six models offer frequency response from DC to 5000 cps, with paper speeds from .1 inch per hour to 160 inches per second. For complete specifications on all Visicorder oscillographs, call your nearest Honeywell Industrial Products Group office, or write: Honeywell, Denver Division, Denver 10, Colorado, where our number is: 303-794-4311. In Canada, contact Honeywell Controls, Ltd., Toronto 17.

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The Honeywell Model 906 Visicorder oscillograph and Honeywell Bridge Balance Unit used in a telemetry system for measuring stresses on a rotary scrubber mill manufactured by Allis-Chalmers, Milwaukee.



This Visicorder record of telemetered scrubber mill stress data is shown one-half actual size. Records of this type enable A-C to make necessary changes in their formulae for stresses on mill shells and heads.

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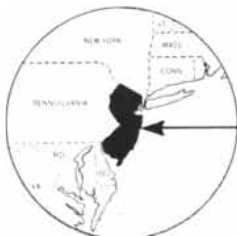
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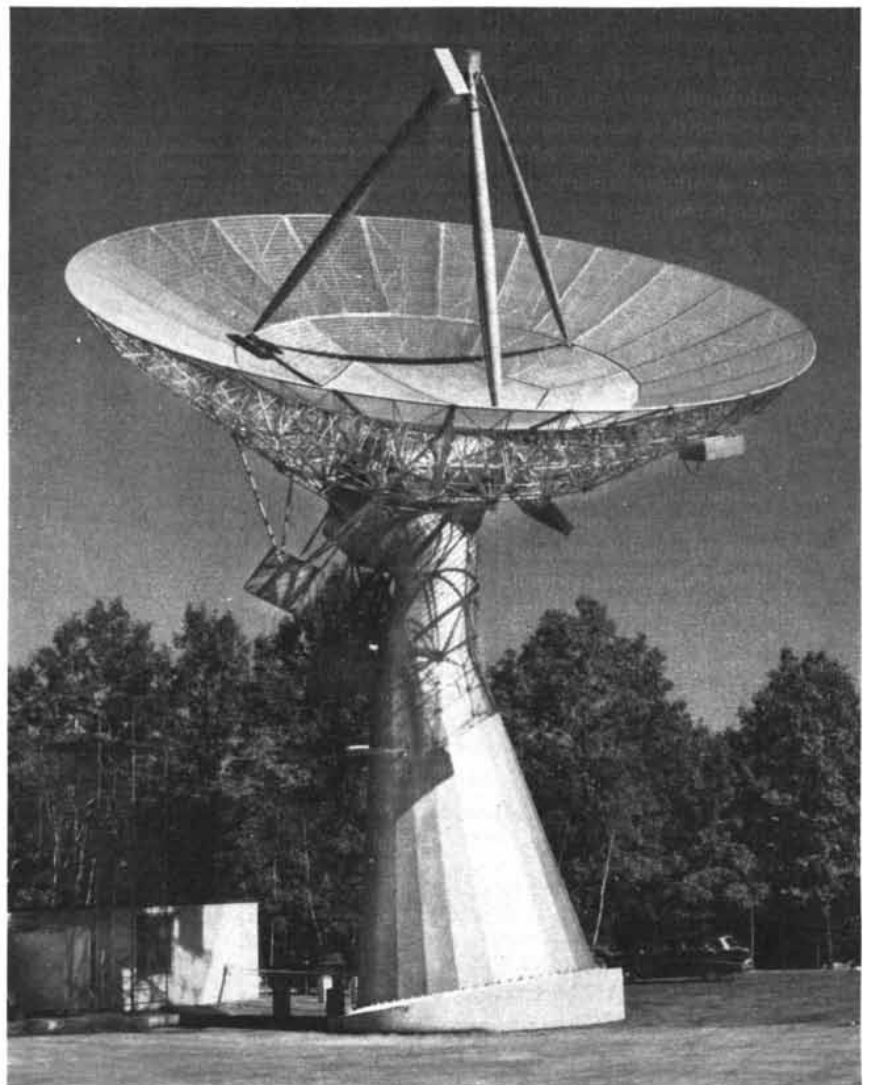
late the measured radiation to the total energy emitted at the galaxy. From this one can compute the total mass of interstellar hydrogen within the galaxy.

The velocity profile also supplies all the information needed to compute the total mass of the galaxy. For this computation one must first take into account how the galaxy is tipped with respect to our line of sight. If a galaxy is viewed edge on, it is evident that galactic rotation will carry the hydrogen in one half of the system toward the observer and that in the other half away from him. This differential motion broadens the velocity profile. If, on the other hand, a galaxy is viewed full face, or along the axis of rotation, all the hydrogen, except for random motion, will have the same relative motion along the observer's line of sight. In this case the velocity profile will be high and narrow. If the same gal-

axy could be viewed at different inclinations, the area under the profile, which measures the total power received, would remain constant [see illustration on page 99].

When we analyze a velocity profile to estimate the total mass of a galaxy, we begin by estimating its inclination as revealed in photographs. For a given inclination two galaxies of different mass will produce velocity profiles of different width. The reason for this is that the total mass of a system determines the strength of its gravitational field, and this in turn determines the motions of particles within the system. In general hydrogen atoms in a low-mass system will not have to travel as fast to maintain a given orbit as hydrogen atoms in a system of high mass.

The largest variation in hydrogen content has been found in Sc galaxies—high-



RADIO TELESCOPE of Harvard College Observatory has parabolic antenna 60 feet in diameter. The 200-pound maser unit is held at the prime focus where the three legs meet.



**TWIN-TURBINE CHINOOK** is new Boeing Vertol tactical transport helicopter now in operation with U. S. Army. Capable of carrying 33 fully equipped troops plus troop commander, or 24 litter patients and attendants, Chinooks have cruise speed of 150 mph. Cabin is 30 feet long, has rear-loading ramp which can be

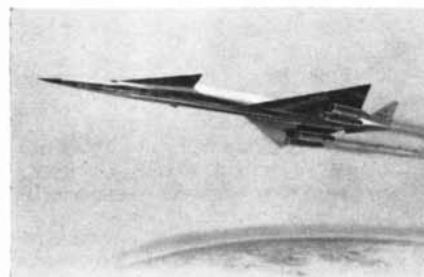
left open in flight for carrying longer loads, or air-dropping troops or supplies. Maximum payload is more than seven tons. The helicopter's sealed fuselage makes water landings possible. Chinooks can also serve as "flying cranes" carrying external loads by means of cargo-hook installed in the bottom of the fuselage.

## *Capability has many faces at Boeing*



**HYDROFOIL** test craft, designed and built by Boeing for U. S. Navy, is jet-propelled, twin-hull boat designed to test hydrofoil systems at speeds to 115 mph.

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**SUPERSONIC** jetliner design, under study at Boeing, where continuing substantial investment in supersonic jet transport research is being made. Supersonic jets would fly two to three times speed of sound, make flight from New York to London in under three hours.

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## RETURN PASSAGE ASSURED! Cable corrosion problem solved creatively with clad metal

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ly developed spirals. Their hydrogen content varies from 2 to 14 per cent, with an average of about 8 per cent. Although the range seems rather large, we are reasonably confident of our measurements. The range might be reduced, however, if it were found that the galactic distances, which enter into the hydrogen calculations, were in serious error. Irregular galaxies show the highest hydrogen content: the average for 11 systems is about 16 per cent. The results for Sc galaxies and irregular systems are based primarily on observations made by Nannielou Dieter, E. Epstein and the author.

Two spiral galaxies of the Sb classification have been examined for hydrogen and found to contain about 1 per cent. This is the same value established for our own galaxy. The two Sb measurements were made by Leiden observers.

No 21-centimeter radiation has been detected in other types of galaxies studied. These include a number of elliptical systems. In general these systems have been fairly distant ones and their hydrogen radiation, if present, would at best be faint. It seems safe to say that their content of interstellar hydrogen is well below 1 per cent.

Before commenting on these results, I should like to mention that for all galaxies we have studied, the Doppler shifts obtained with 21-centimeter radiation have agreed in every case with shifts found by optical methods. This was not really unexpected, but there was always an outside chance that it might have been otherwise. A comparison of radial velocities obtained by optical and radio methods is shown in the illustration on page 100. The most distant galaxy represented is about 23 million light-years away—a rather short distance by extragalactic standards.

The systematic correlation of hydrogen content with galaxy type offers an important clue in the understanding of the life history of galaxies. The largest amount of hydrogen is found in the galaxies that also contain the highest percentage of very luminous stars. Such stars must have formed recently (within the past few million years), since their energy output is so great that they must exhaust their supply of nuclear fuel in a short period.

The relative number of such luminous stars decreases as one goes along the structural sequence of galaxies: irregular, Sc, Sb, Sa, S0, elliptical. This sequence is just the one in which the hydrogen content decreases, at least in so far as it has been measured. The correlation

## Decision-Making: Deploy or not?...When and where?

The costly, complex weapons systems of today make such a decision far more difficult than in the past. World-wide forces and events are frequently involved. The time for decision has been compressed, the information on which it must be based has been multiplied in volume, variables, interrelationships. This new era of decision-making has led commanders and governmental leaders to make use of man-machine systems which provide information processing assistance. SDC's staff of scientists, engineers and computer programmers have been developing these huge systems for more than eight years.

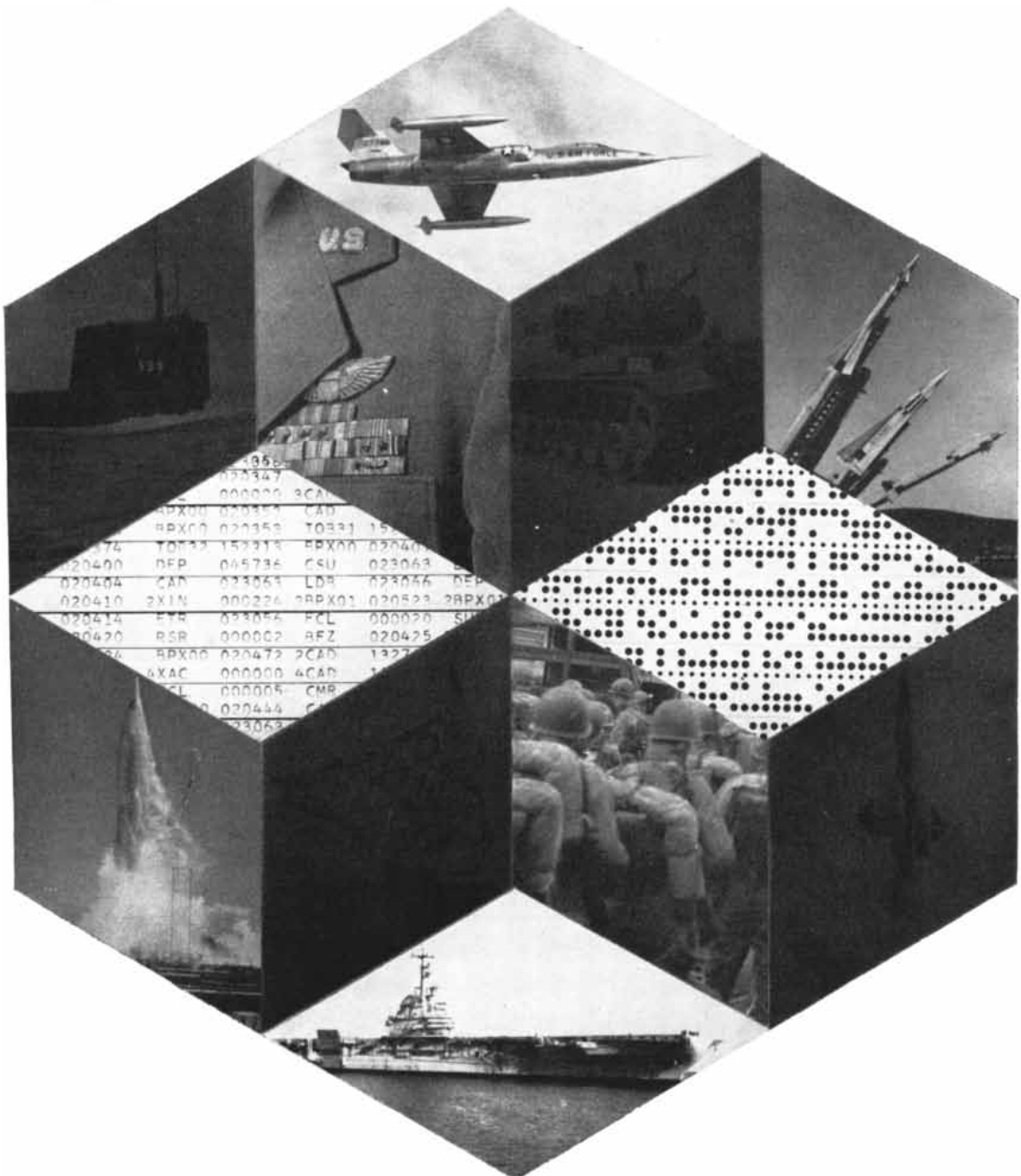
They help develop the system itself, not the hardware within the system. Specifically, they analyze system requirements, synthesize the system, instruct computers which are the core of the system, train the system, evaluate the system, adapt it to the changing needs of its users. And in so doing, they consider the interaction and effect of men, doctrine, tradition, training; of organizations, chains-of-command and chains-of-succession; of communications, traffic centers, command posts, computers and displays. Human factors scientists, operations research scientists, systems-oriented engineers, and computer pro-

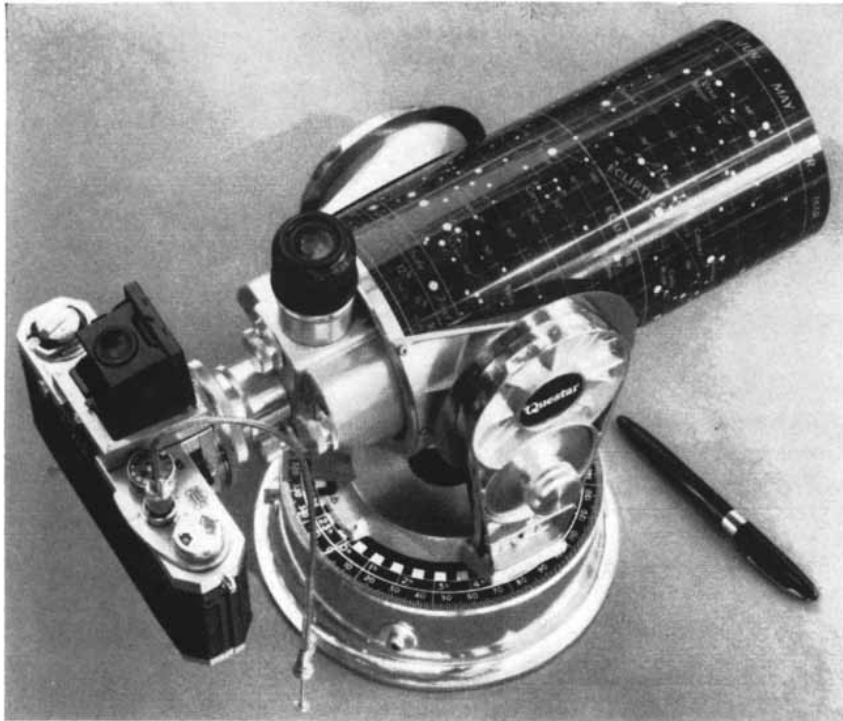
grammers interested in joining this rapidly expanding field and working in a close interdisciplinary effort are invited to write Dr. H. E. Best, SDC, 2430 Colorado Ave., Santa Monica, California. Positions are open at SDC facilities in Santa Monica; Washington, D. C.; Lexington, Massachusetts; Paramus, New Jersey; and Dayton, Ohio. "An equal opportunity employer."



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The problem of taking high resolution pictures through the superfine high-power Questar telescope on 35-mm. film can be reduced to three principal factors: lack of vibration, sharp focus, and correctly thin negatives. The last critical factor, exposure time, can now be measured at the image itself with a CdS lightmeter at Questar's 40x eyepiece.

Vibration during exposure is our chief enemy. Images of perfect optics are formed by an infinite number of overlapping perfect diffraction images. The tiny round dot of Questar's diffraction image, the Airy disk, is only about .0002 inch across. When a reflex mirror slams up a fraction of a second before the roller-blind curtain slit sweeps across the film, a vibration is usually set up of some .001 inch amplitude. Pictures taken before these oscillations are damped out give a fuzzy picture when enlarged. Standard Nikon F bodies can lock the mirror up, allowing the featherweight ball-bearing titanium foil focal plane shutter to work alone with a visible shock of only the dot's width, most of which is post facto effect, after exposure. This gives us negatives so sharp we could not tell them from those taken by waving a black card. But being blind between exposures is most annoying. The arrow points to the Questar

modification, a tiny button which releases the mirror any time after you have checked everything and are ready to expose. Price of Questar-modified standard Nikon F body, as shown, is \$259.60 with bakelite cap. (We regret that we cannot have your own Nikon body modified.) Cable release, \$3.95. Photomic finder, \$99.50. 50-mm. f/2 Auto-Nikkor Lens, \$90.00. Auto-Nikkor f/1.4 50-mm. Lens, \$155.00.

Sharp focus has always been a problem with long-focus telescopes. With camera close-coupled, Questar works at f/16 at 56 inches. With 2-inch extension tubes to reduce vignetting, f/18 at 64 inches. These focal ratios give such dim views that the image is hard to see. The standard split-prism rangefinder works only with fast, low f numbers. But Nikon's Type C interchangeable groundglass, with clear center and hairline cross, at \$17.50, gives brilliant images with a mark to keep the eye from accommodating in front or behind the focal plane. At right is the waist level finder, \$22.50, which permits best view of the Type C cross with eye up close to its lens.

The new cadmium sulphide light meters, with their small openings, have been used by Questar owners to apply directly to visual eyepiece or camera views of the image, to get an actual reading of what the image unit brightness is regardless of magnification of all nature's variables. We have little data on this at present. Recalibration is necessary, but we hear it is simple. At long last we can completely ignore the variables of nature, due to geographical location, sun's intensity, water vapor, time of year and day—all the guesswork which makes exposure tables impossible. The able photographer may locate the subject with Questar's 40-80x eyepiece, then pop the CdS cell over exit pupil of ocular and take a reading to determine speed.

At upper left is a new, more compact ring adapter, \$10.00, to secure Nikon F bodies to Questar's \$23.50 basic camera coupling outfit, a multi-purpose device described in detail on page 26 of the Questar booklet. Questars still cost only \$995, or \$1100 with quartz mirror for best thermal stability. Each is a gem of superfine optics, whose sharpness might eventually be equalled, but can never be surpassed.

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between hydrogen content and numbers of young stars is not surprising. Stars consist primarily of hydrogen, therefore a plentiful supply of hydrogen is necessary if many stars are to form. In galaxies containing little hydrogen one would expect to find relatively few young stars.

Some astronomers have suggested that this correlation indicates an age sequence, that galaxies with the highest hydrogen content and many young stars are the most recently formed. From exactly the same data, however, one can conclude that these galaxies need not be young; with their high hydrogen content they could support the formation of many fast-burning stars for a long period, with only slight depletion of their hydrogen supply.

Three general theories attempt to account for the various galactic structures. One holds that galaxies are continuously forming and implies that as they age they also change from one type to another. The other two theories assume a common age for all galaxies. The different galactic types are attributed either to evolution along the Hubble sequence or to their initial conditions of formation. This last proposal presumes that no significant structural changes have occurred since the formation of the galaxies. Halton C. Arp of the Mount Wilson and Palomar Observatories is a leading proponent of this viewpoint [see "The Evolution of Galaxies," by Halton C. Arp; SCIENTIFIC AMERICAN, January].

Calculations based on the new 21-centimeter measurements indicate that there is ample hydrogen in irregular and spiral galaxies to support the formation of bright stars at the present observed rate for at least 10 billion years, which happens to coincide with the most recent estimate for the age of our own galaxy. During this time the interstellar gas content would have dropped only slightly. These results do not allow us to decide which of the several galactic theories may be correct but they do tell us that the high percentage of bright stars in the irregular and Sc galaxies need not imply that they are young systems. The existing information on the stellar and gaseous content of galaxies is consistent with the view that all galaxies formed at the same epoch and have not evolved from one type to another. Depending on conditions surrounding their formation, different types of galaxies were left with different amounts of interstellar gas. It is this gas that has determined the subsequent rate of star formation, thereby maintaining the structural identity of the galaxy.



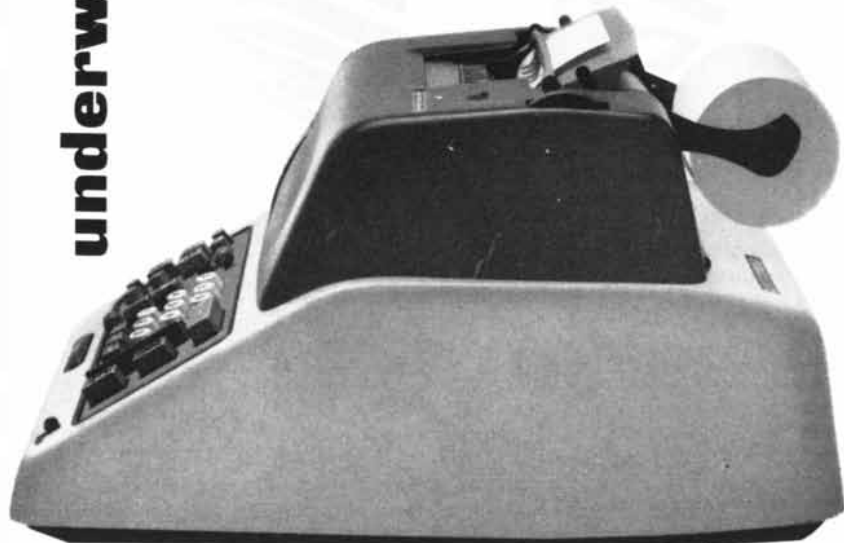
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Not so with the Amphenol Wire-Form Group.

## NO COMPROMISE

The Wire-Form Contact is an interconnection device that combines small size with easy handling in assembly . . . high reliability with low cost. Most important of all, though, is the application versatility of the Wire-Form.

The Wire-Form Group conforms effortlessly to your packaging requirements, whatever they may be. From single contacts on component leads through Strip Connectors or Tiny Tim® Connectors on modules to Micro-Rac® or Mighty-Mite® Connectors for system input-output lines . . . the Wire-Form family can provide the best answer to your design needs. No more "round hole-square peg" problems!

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The Wire-Form Contact is extremely small, permitting high-density packaging. Depending on the connector insert used, you can have contact centers on 0.100", 0.085", or even down to 0.075". Yet connectors are easy to assemble . . . because you terminate *before* contacts are inserted, while there's still room to maneuver. Later, if you want to change circuitry or replace a component, contacts can be removed, repositioned, or replaced without discarding the connector.

Wire-Form Contacts can be termi-

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The Wire-Form family will help keep costs down. High volume manufacturing methods let Amphenol market Wire-Forms at unusually low purchase prices. For example, our circular Wire-Form Connector (the Mighty-Mite) meets or exceeds the performance characteristics of other micro-miniature connectors selling for ten times its price. But initial cost is only half the battle . . . What about installed cost? Well, it's rock-bottom too. The Poke-Home feature means that most all of the assembly can be done out in the open, with plenty of room, and no fiddling with tweezers or magnifying glass. In short, it can be done quickly. And quickly means inexpensively, as labor costs go.

Wire-Forms give top reliability. Equalized, multi-point contact pressure results in exceptionally stable and low contact resistance. Contact resistance

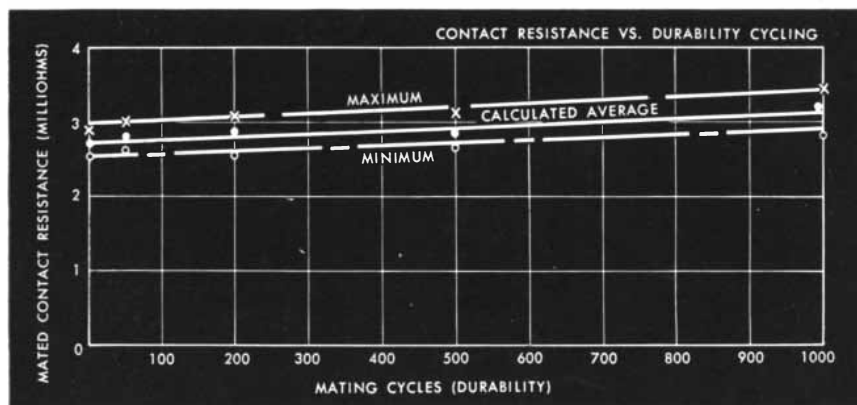
varies less than half a milliohm through a thousand cycles of engagement-disengagement. (See chart below.)

## FAMILY PLAN

One of the more important things to remember about the Wire-Form Group is the way it works as a team. No matter what kind of challenge comes up, at least one member of the Wire-Form team can handle it. This means you only need to stock one basic component, the Wire-Form Contact, to meet virtually all your micro-miniature connection needs. The savings in inventory investment, in stock control, and in uniform manufacturing methods can be substantial.

## FACTS AND FIGURES

The new 24-page catalog on Amphenol Micro-Miniature Connectors (Catalog MM-1) has the facts, figures, drawings, and detailed performance characteristics you'll need to "help yourself." You can get a copy by contacting your local Amphenol Sales Engineer or by writing to Dick Hall, Vice President, Marketing, Amphenol Connector Division, 1830 S. 54th Avenue, Chicago 50, Illinois.



Tested male contacts were Amphenol cat. number 22-692, formed from gold-clad, nickel-interlined beryllium copper wire. The females (cat. number 220-502 short) are copper bodies with electroless gold over nickel plating. Each pair was subjected to 1000 mating cycles.

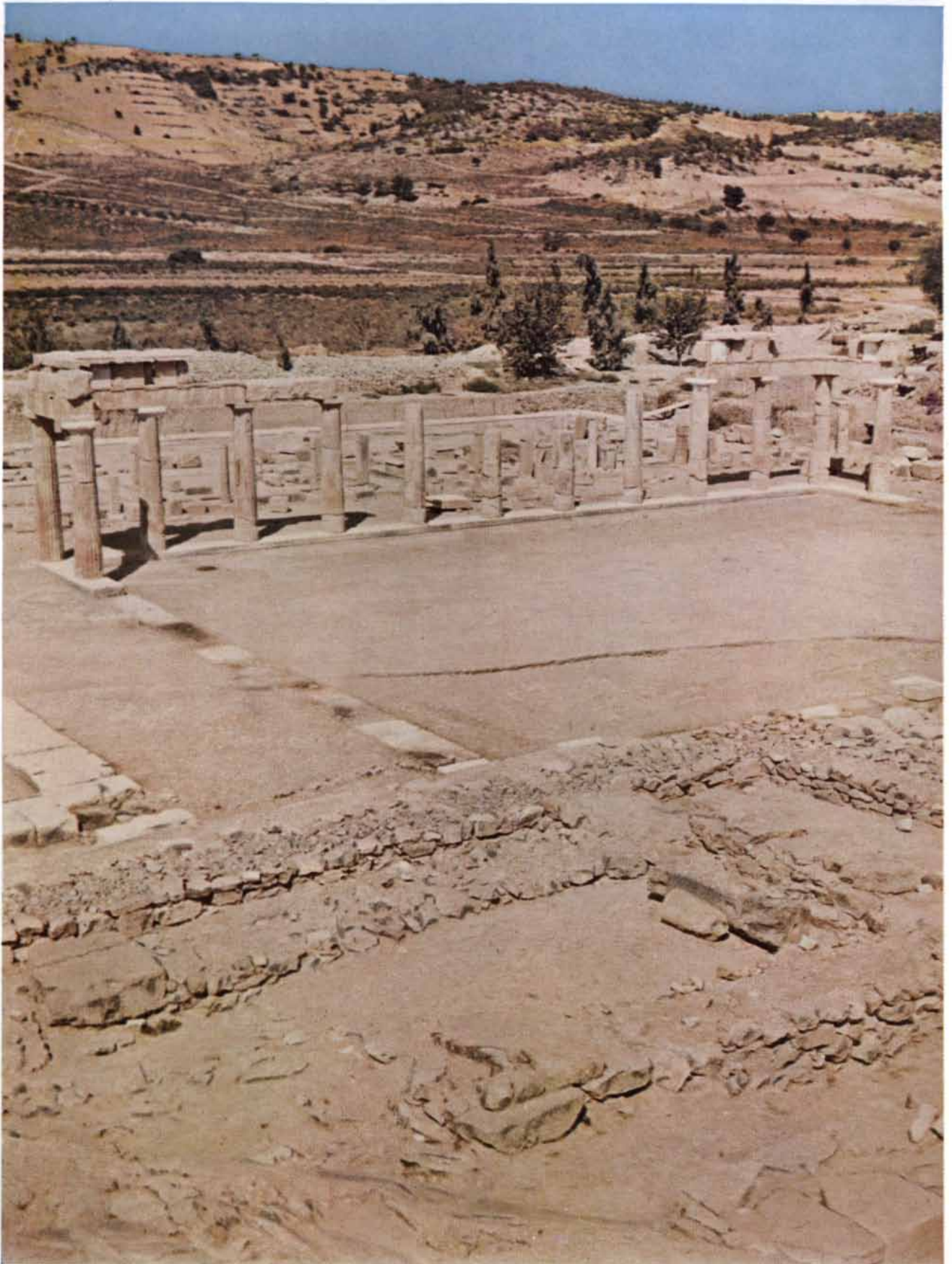


Connector Division / Amphenol-Borg Electronics Corporation









RECONSTRUCTED COLONNADE of the great Doric stoa (a walled portico) at Brauron consists of 13 columns. The colonnade and the remains behind it (including several rooms and a second

portico) once formed the north side of the stoa, which was constructed about 420 B.C. In the foreground appear the ruins of the temple of Artemis Brauronia, constructed shortly before 500 B.C.

# The Sanctuary of Artemis at Brauron

Recent excavations have uncovered the holy place where the women of Greece sought the favor of the goddess in childbirth. The site has also provided evidence on the early political history of Greece

by John Papadimitriou

In his play *Iphigenia in Tauris* Euripides relates the myth of how Orestes, the son of the Greek King Agamemnon, went to Scythian Tauris, in what is now the southern U.S.S.R., to steal a wooden statue of Artemis, whom the Scythians worshiped. He was captured and brought to the temple of Artemis to be sacrificed, after the custom of the country. In the temple Orestes met his sister Iphigenia, who, as the priestess of Artemis, was to make the sacrifice. Once brother and sister recognized each other, they decided to steal the statue together and escape to Greece. They were stopped by the Scythians but were finally rescued by the goddess Athena, who then foretold their destiny and ordained that the Greeks worship Artemis in two personifications, later known as Artemis Tauropolos and Artemis Brauronia.

The legend is preserved not only in the writings of Euripides and other classical Greek authors but also in the soil of Greece. The shrine of Artemis Tauropolos has been found at the site of Halae Araphinides, on the coast of Attica 23 miles east of Athens. The sanctuary of Artemis Brauronia has similarly been uncovered at the site of the prehistoric town of Brauron, four miles south of Halae Araphinides. Over the past 15 years my colleagues and I have worked intensively at Brauron. Our excavations have brought to light a number of significant structures and a treasure of objects of the highest artistic quality. These finds confirm and enrich ancient literary accounts such as *Iphigenia in Tauris*. Moreover, they provide interesting information on the early political history of Greece.

Today one travels to Brauron over the road from Athens to the picturesque little harbor of Porto-Raphthi. About five miles before one comes to the sea one

turns north on a rough road that leads through hills planted with grapevines to the fertile plain of Livadi. At the south edge of this plain rises the rocky hill that was the acropolis of Brauron. The local people call the place Vraona.

The acropolis is about a quarter of a mile from the sea, but in ancient times

the water came to its foot; the plain has been extended by the alluvial deposits of the river Erasinos. When we first sounded the top of the acropolis, we found a large number of vases and figurines that clearly indicate the town of Brauron flourished from Neolithic times to the late Mycenaean period, that is,



SACRED SPRING in lower right foreground lies at the northwest corner of the temple of Artemis Brauronia. It was in this place that thousands of offerings to Artemis were discovered. Farther up the hill behind the temple is the post-Byzantine church of St. George.



from about 3500 to 1300 B.C. We also excavated Mycenaean chamber tombs to the east of the acropolis; they were filled with rich grave offerings such as bronze swords and gold jewelry. In one tomb we found a skeleton interspersed with nearly 100 lead weights from a fishing net that was probably thrown over the dead man; these testify to the maritime character of the town.

From these finds one can conclude that Brauron was most prosperous between 2000 and 1600 B.C. Around 1300 B.C. this prosperity declined, and there is no trace of human occupation

at the site from that time on. It seems, therefore, that the town was abandoned. In my opinion there is a clear historical reason for its abandonment.

According to Thucydides and other literary sources, the ancient Greek state of Attica originally consisted of several towns, each with its own council. When Theseus became king of Athens, he abolished the councils of the other towns of Attica and compelled the aristocratic families of the towns to live in Athens. It was through the support and influence of these families that Athens

became the powerful city of historic times. In memory of this political event the Athenians instituted the festival of Synoikia (Union).

Our excavations would seem to confirm this literary tradition. When the aristocratic families of Brauron were moved to Athens, the rest of the population was settled in nearby villages. Brauron, however, was by no means forgotten. In classical Greek times it was famous as the sanctuary of Artemis Brauronia and the headquarters of her cult.

Artemis is familiarly regarded as the



PREHISTORIC TOWN OF BRAURON on the east coast of the Attic peninsula in Greece lies on a branch of the main road from Athens to Porto-Raphti; the section of this road from Markopoulo to Porto-Raphti is not shown. Halae Araphinides is the site of the

recently discovered temple of Artemis Tauropolos. Paeania, Markopoulo and Porto-Raphti are modern settlements; Paeania was also known in classical Greek times, as were the other towns shown. The plans of Athens and Piraeus are those of about 450 B.C.

goddess of the hunt, but like other Greek divinities she was worshiped for a variety of reasons. As Artemis Brauronia she was the goddess of procreation and fertility, and at Brauron she was identified with her priestess Iphigenia. It now seems that Iphigenia was a personification of the great mother goddess worshiped by the inhabitants of prehistoric Brauron and that her cult survived the desertion of the town around 1300 B.C. It was only later that Iphigenia was associated with Artemis and also identified as the daughter of Agamemnon and the sister of Orestes.

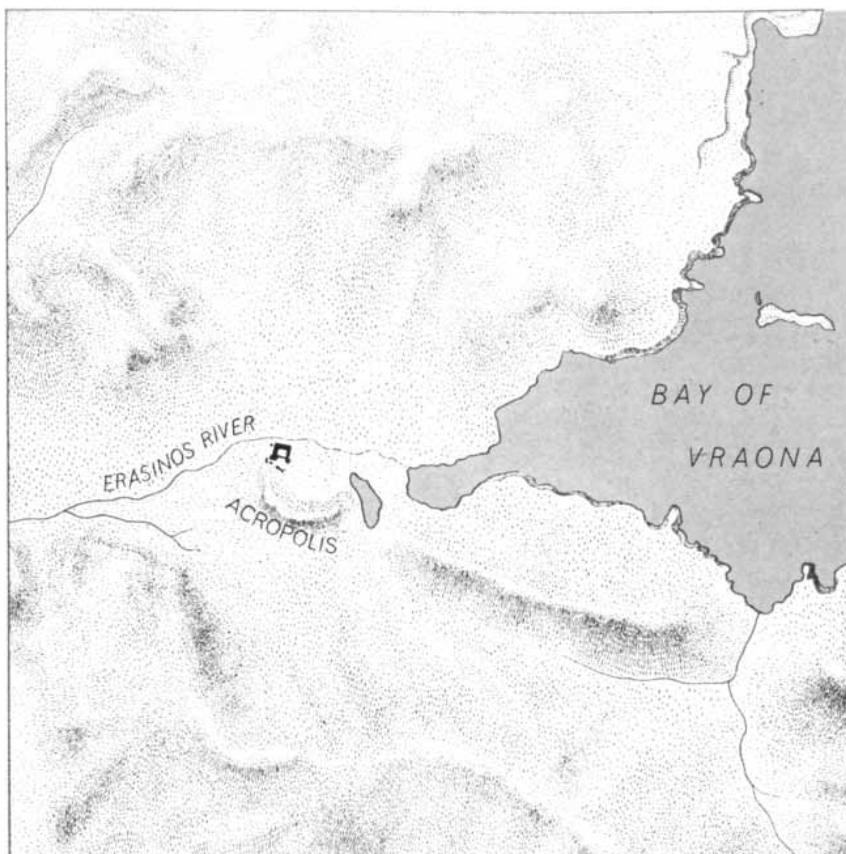
*Iphigenia in Tauris* not only relates the legend of Orestes and Iphigenia but also makes specific reference to the sanctuaries of Artemis Tauropolos and Artemis Brauronia. In the play Athena says to Orestes:

*And thou, Orestes, to mine hests  
give heed—  
For, though afar, thou hear'st  
the voice divine:—  
Taking the image and thy sister, go;  
And when thou com'st to Athens'  
god-built towers,  
A place there is upon  
the utmost bounds  
Of Attica, hard by Karystus' ridge,  
A holy place, named Halae of my folk.  
Build there a shrine, and set  
that image up,  
Named from the Taurian land  
and from thy toils,  
The travail of thy wandering  
through Greece  
Erinyes-goaded. Men through days  
to come  
Shall chant her—Artemis  
the Taurian Queen.*

Then Athena says to Iphigenia:

*Thou, Iphigenia, by the holy stairs  
of Brauron must this Goddess'  
warden be.  
There shalt thou die, and be entombed,  
and webs,  
Of all fair vesture shall they  
offer thee  
Which wives who suffer terribly  
in their travail-tide  
Leave in their homes...*

These lines from Euripides are the most authentic source both for the sites of the two cults and for the location of the two sanctuaries. Some scholars confuse the cults and the places, but Euripides clearly separates them. "Karystus ridge" refers to Karystus on the island of Euboea, a site directly opposite Halae Araphinides. A clue to the location of the



DETAIL MAP locates the prehistoric acropolis of Brauron with respect to the sanctuary of Artemis at the northwest foot of the hill. At one time the inlet of the Bay of Vraona extended to the foot of the hill, which now stands about a quarter of a mile from the sea.

Brauron is provided by the words "the holy stairs of Brauron."

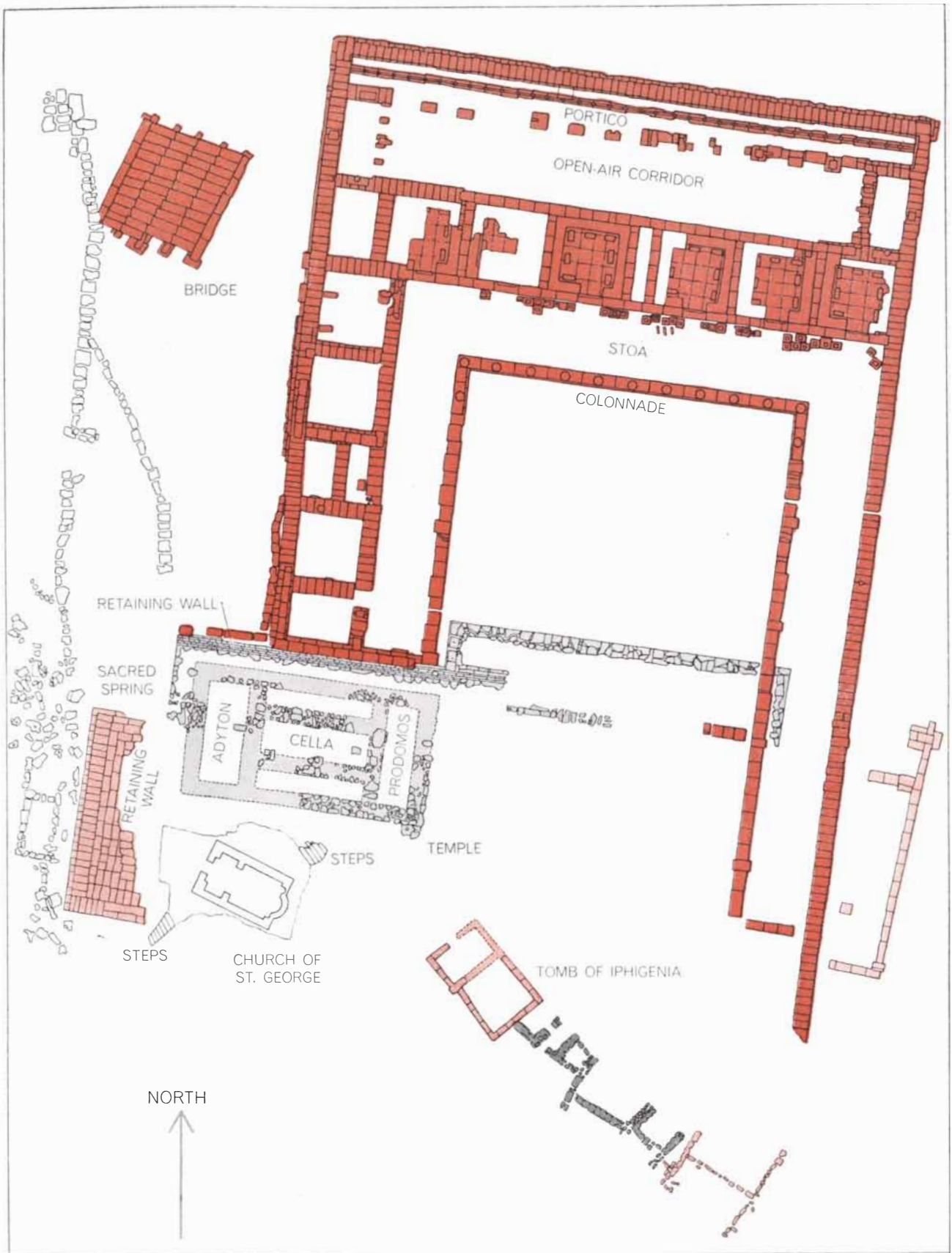
Near the foot of the acropolis of Brauron there stands today a little church: the church of St. George, built in post-Byzantine times. A few feet down the slope, to the north of the church, we discovered and excavated the temple of Artemis Brauronia. Only the south and east walls of the temple survive; on these sides the rock of the hill had been cut and leveled. On the north and west sides, downhill from the temple site, we found the well-preserved remains of a retaining wall. A series of steps leads up over the retaining wall to the level of the temple, and these continue beyond the temple to the site of the church. It seems likely that in antiquity there was an altar on the site of the church; indeed, even now one can see in the interior of the church the traces of the foundation of an earlier structure. The steps are therefore almost certainly the ones to which Euripides refers.

The temple was 66 feet long and 33½ feet wide. It consisted of a *prodomos* (open, pillared portico), a *cella* (closed interior) and an *adyton* (inner sanc-

tum). The interior of the temple was divided into three naves by two rows of columns.

Near the retaining wall we uncovered a number of fallen steles: big marble slabs covered with inscriptions. The inscriptions are mainly lists of offerings, consisting of jewels, rings, mirrors and women's clothing. They also mention the names of the women who, when they were delivered of children, offered their most precious belongings to Artemis-Iphigenia. During the Peloponnesian War the offerings were taken, on the pretext of keeping them safe, to the Acropolis of Athens. There similar lists have been found, and it is now established that they are copies of the lists at Brauron. It seems that when the offerings were made, two lists were inscribed: the original was kept at Brauron and the copy was placed with the offerings themselves in Athens.

On the hillside just below the northwest corner of the temple a spring issues from the rock and forms a pool. In this area we found during our last campaign literally thousands of objects associated with the private lives of women—bronze mirrors, rings, gems, scarabs, statuettes, vases. Particularly precious among them



- ABOUT 430-420 B.C.
- END OF SIXTH CENTURY B.C.
- MIDDLE OF FIFTH CENTURY B.C.
- SEVENTH AND SIXTH CENTURIES B.C.

**GROUND PLAN OF SANCTUARY** shows the temple of Artemis Brauronia, the shrine of Iphigenia and the three-sided Doric stoa that was apparently the residence of young girls who took part in one of the festivals at Brauron. The seven rooms in the north wing of the stoa and three in the west wing contained beds. The dates of these and other structures are keyed to the index at bottom left.

were perishable wooden objects, which by extraordinary good fortune had been preserved in the mud. The bronze mirrors are outstandingly beautiful; on the margin of one is written in archaic Greek: "Hippylla the daughter of Onetor has dedicated it to Artemis in Brauron."

The spring would appear to have been the holiest place in the sanctuary. Almost all the objects from the spot can be dated before 480 B.C.; in that year, according to Herodotus, all Attica was devastated by the Persian conqueror Xerxes, and the sanctuary of Brauron was not spared. Some of the objects date back beyond 700 B.C.; between these dates, in my opinion, the spring received all the offerings made at the sanctuary. The temple itself was probably built only a short time before 500 B.C. Part of its interior pavement and fragments of pottery indicate, however, that it was preceded by an older shrine.

A few yards uphill from the southeast corner of the temple we uncovered the foundations of a most interesting structure: a little shrine 24½ feet long and 14½ feet wide. Beside the shrine a few rooms had been rather casually built of stones and mortar. The rooms were buried under large boulders that had crashed down from the surrounding rocks. From the position of the boulders it has been possible to deduce that the rooms were once situated in a cave.

Now, the tombs of Greek heroes and heroines were usually located in caves. At this site, moreover, we found numerous precious objects: bronze mirrors, gold ornaments, gems and so on. It would seem that the structures in the cave were regarded as being the tomb of Iphigenia, and that when the vault of the cave collapsed the little shrine was built next to it as a monument to the priestess. This is borne out by Athena's prophecy in Euripides' play: "There shalt thou die, and be entombed..." Euripides, a poet and philosopher writing in an age of vigorous rationalism around 400 B.C., would almost certainly not have used information that could easily be checked and contradicted.

The cult of Artemis Brauronia called for an annual festival known as the Brauronia. Allusions in Aristophanes' *Lysistrata* and *The Peace* indicate that the Brauronia was a festival of women, during which the men got drunk and behaved in a licentious manner. Herodotus also speaks of an occasion when the women of Athens celebrating the Brauronia were ambushed and ravished by the men of the island of Lemnos. The Lemnians then took the women to



BRONZE MIRROR with a wooden handle was found near the sacred spring. The handle had been unusually well preserved in mud. The object dates from between 500 and 480 B.C.



Lemnos; there the women gave birth to children who were so much cleverer than the Lemnians that the Lemnians killed the children. The story is said to have been used by the Athenian general Miltiades as a pretext to conquer Lemnos.

Associated with the Brauronia was

the festival of Arkteia, derived from the Greek word *arktos*, meaning "bear." The reason Iphigenia was in Tauris, relates the myth, was that when her father Agamemnon ordered that she be sacrificed, she was rescued by Artemis, who left on the altar in place of Iphigenia a deer. According to a later Attic tradition

Iphigenia was to be sacrificed not in her homeland but at Brauron, and Artemis substituted for her not a deer but a bear. (Both animals were sacred to the goddess.) The legend has it that a bear happened to scratch an Athenian girl, whose brother slew the bear on the spot. In order to appease the wrath of the god-

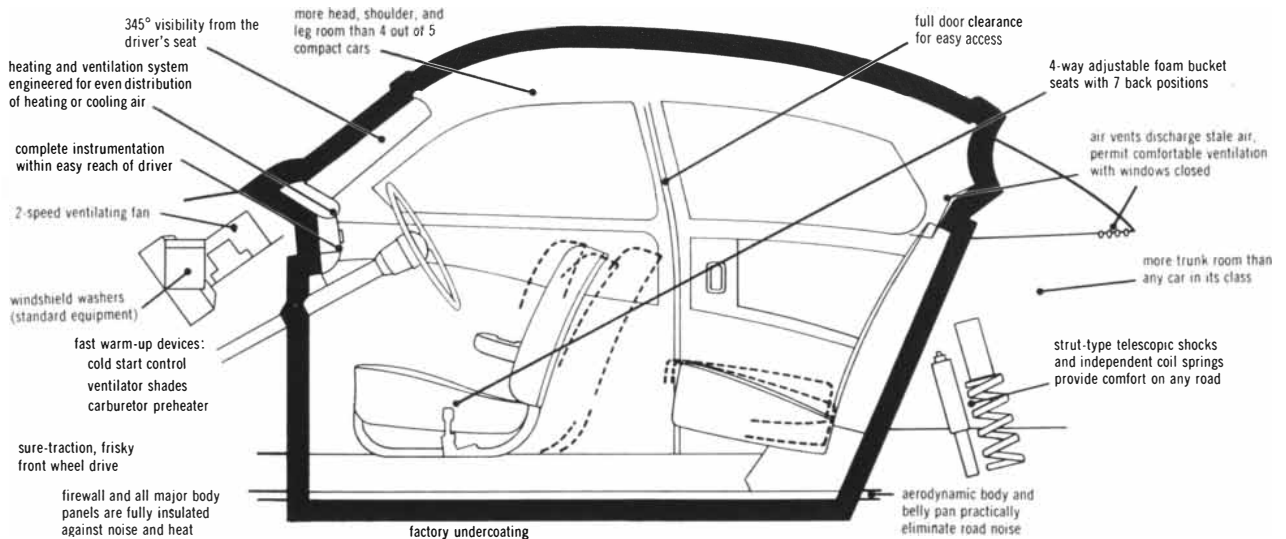


STATUETTE OF YOUNG GIRL, in marble, represents one of the "bears," or priestesses, associated with worship of Artemis Brauronia. She holds a hare, symbolic of her connection with Artemis.



STATUETTE OF YOUNG BOY, also in marble, may have been an offering of thanks to Artemis by a mother who gave birth to a male child. Both of these figures date from the period 400 to 300 B.C.

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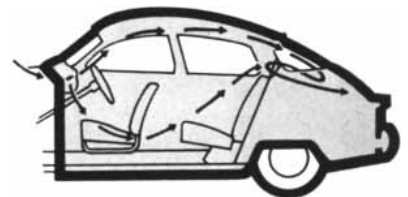
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dess the rites of the Arkteia were instituted. Every five years at the festival of the Brauronia a number of the young daughters of noble families, clothed in saffron-colored robes, were brought to the sanctuary at Brauron. The girls, who were called *arktoi*, imitated bears, took part in the Brauronian procession as *caniphores* (basket-carriers) and as little priestesses sacrificed animals to Artemis. Near the retaining wall of the temple at Brauron we found many statuettes of the *arktoi*.

On the north side of the temple we uncovered the remains of the most impressive structure built at Brauron: a great Doric stoa, or partly walled portico, 96 feet long with columns 12 feet high. Along the north side of the stoa there were seven rooms; along the west side there were three rooms. Along the walls of each room were 11 beds, the

wooden feet of which were fixed with lead into holes in the floor. In front of the row of beds there were sandstone tables covered with marble plaques. An open-air corridor and a second portico ran parallel to the rooms on the north side.

I believe that this great portico and its rooms was the residence of the little "bears." This is strongly suggested by the fact that outside the rooms we found the statuettes of young girls. Most of these statuettes are portraits, and usually the figures hold symbolic objects such as birds and fruit.

It is possible that this sacred stoa was called *parthenon*, which can mean "house of the virgin-goddess" or "house of the virgins," that is, the girls of Brauron. Inscriptions found in the area mention the word *parthenon* as a place where offerings were deposited. In my



**ATHENIAN DECREE** inscribed on a marble stele concerns the proposed repair of various buildings of the sanctuary at Brauron. Of the several buildings mentioned in it, only the temple and the stoa have been found so far. The decree dates from between 300 and 200 B.C.

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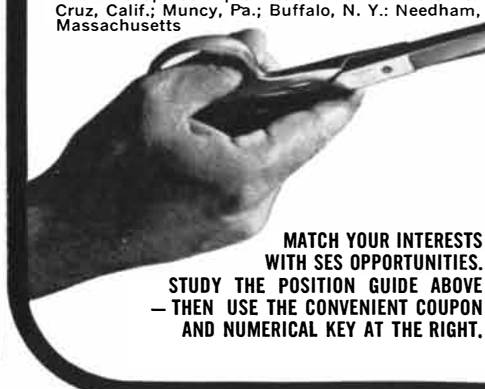
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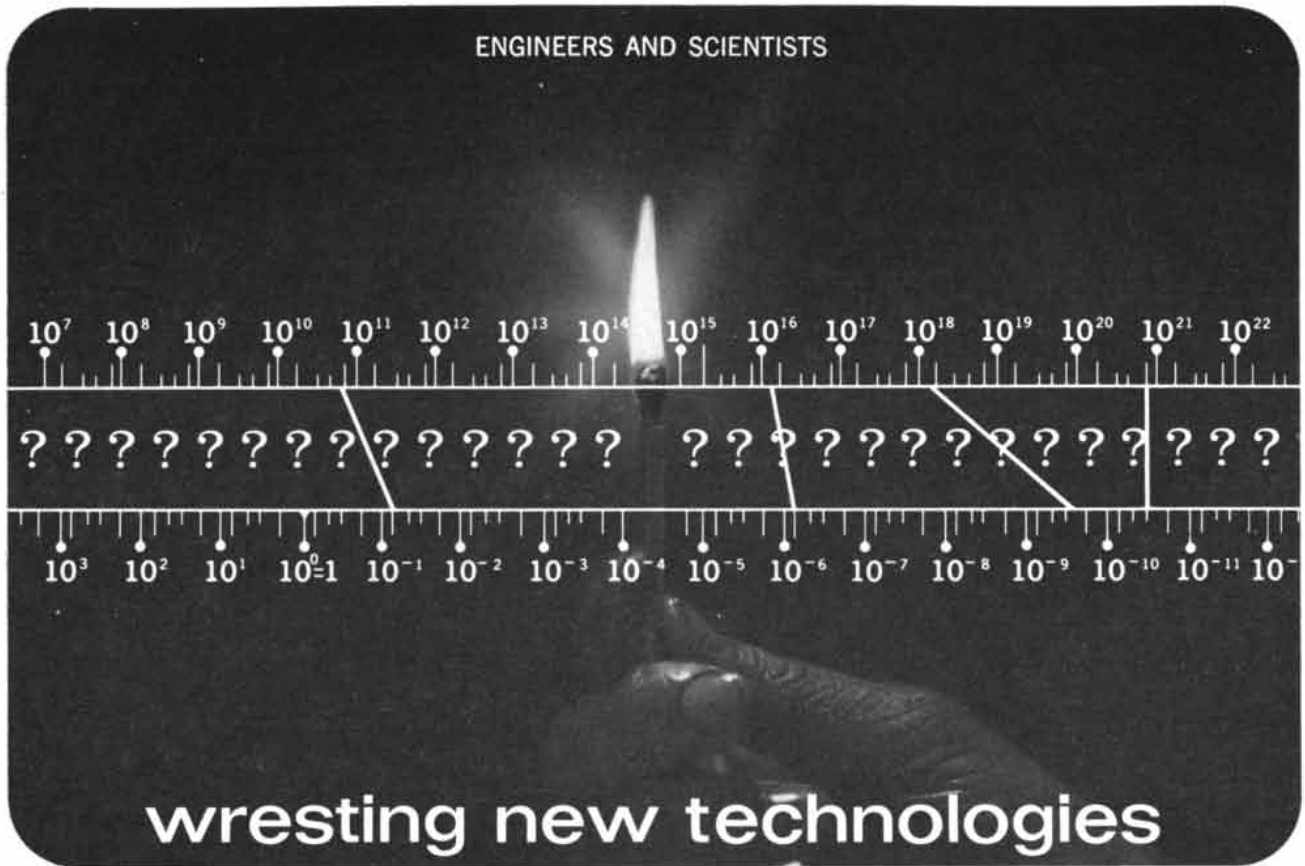
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opinion this does not refer to the Parthenon of Athens but to a *parthenon* in Brauron.

This is confirmed by an inscription discovered only recently. Dating from between 300 and 200 B.C., perhaps two centuries after Brauron was destroyed by the Persians, it is an Athenian decree that instructs certain officials to examine the various buildings at Brauron and to ask the responsible architect for a budget of repairs. The decree mentions the following buildings: the temple, the *parthenon*, the *amphipoleion*, the *gymnasium* (athletic field), the *palaestra* (wrestling school), stables and other buildings. Obviously we have located some of these buildings, notably the temple and the stoa, which is probably the *parthenon*. Someday we hope to find the others.

We have, in fact, recently uncovered near the west side of the stoa an additional structure of considerable interest. It is a bridge that crossed the stream flowing down from the sacred spring. Thirty feet long and 30 feet wide, it is

the only bridge of the fifth century B.C. that has been found on the Greek mainland. Many older Mycenaean bridges are known; they are characterized by corbeled construction, in which each block of a span is stepped outward from the one below it. The bridges of Roman times rest on true arches. The bridge at Brauron introduces a new type of construction in which horizontal stone slabs are supported by a series of walls parallel to the stream, which flows through narrow channels between the walls.

The Athenian decree indicates that almost all the buildings at Brauron were in need of reconstruction. This is confirmed by the fact that we found the architectural members of the stoa embedded in old mud. The damage was apparently done by a flood of the Erasinos that probably occurred between 400 and 300 B.C. Since the mud had not been removed, one can conclude that the reconstruction was never undertaken.

This circumstance has of course been fortunate for the modern excavators of

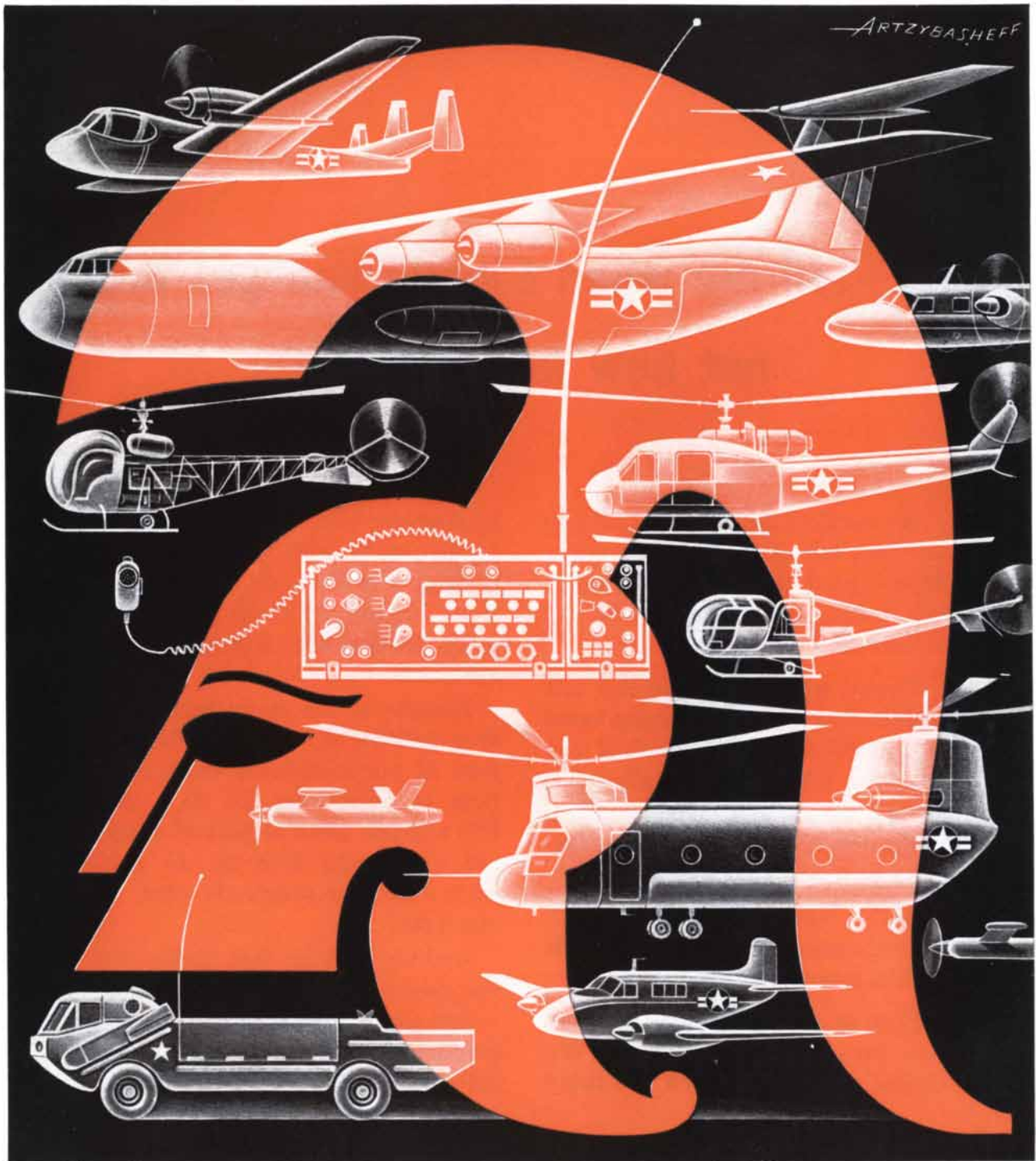
Brauron. Because the members of the stoa were preserved in mud, it has been possible for us to restore the structure with its original materials. From an inscription and the technique of architecture we have decided that it was first put up in 420 B.C.

The mud has also preserved some magnificent examples of Greek art of the classical period. Notable among these are a number of fine bas-reliefs and a great many statues not only of *arktoi* but also of small boys; the statues of boys are associated with Artemis as the goddess of procreation. One of the bas-reliefs is a masterpiece. Known as the "Relief of the Gods," it portrays four Greek divinities. One is seated and almost certainly represents Zeus. The others are probably Leto, Apollo and Artemis. The careful workmanship, the minute attention to detail and the noble expressions of the figures point to the successors of the great sculptor Phidias. The figures are the patron divinities of Brauron, the gods and goddesses who have befriended our excavations.



"RELIEF OF THE GODS" depicts four Greek divinities. It dates from about 400 B.C. The seated figure at left probably represents

Zeus. The other three figures, from left to right, are probably Leto, Apollo and Artemis. The right-hand part of the relief is missing.



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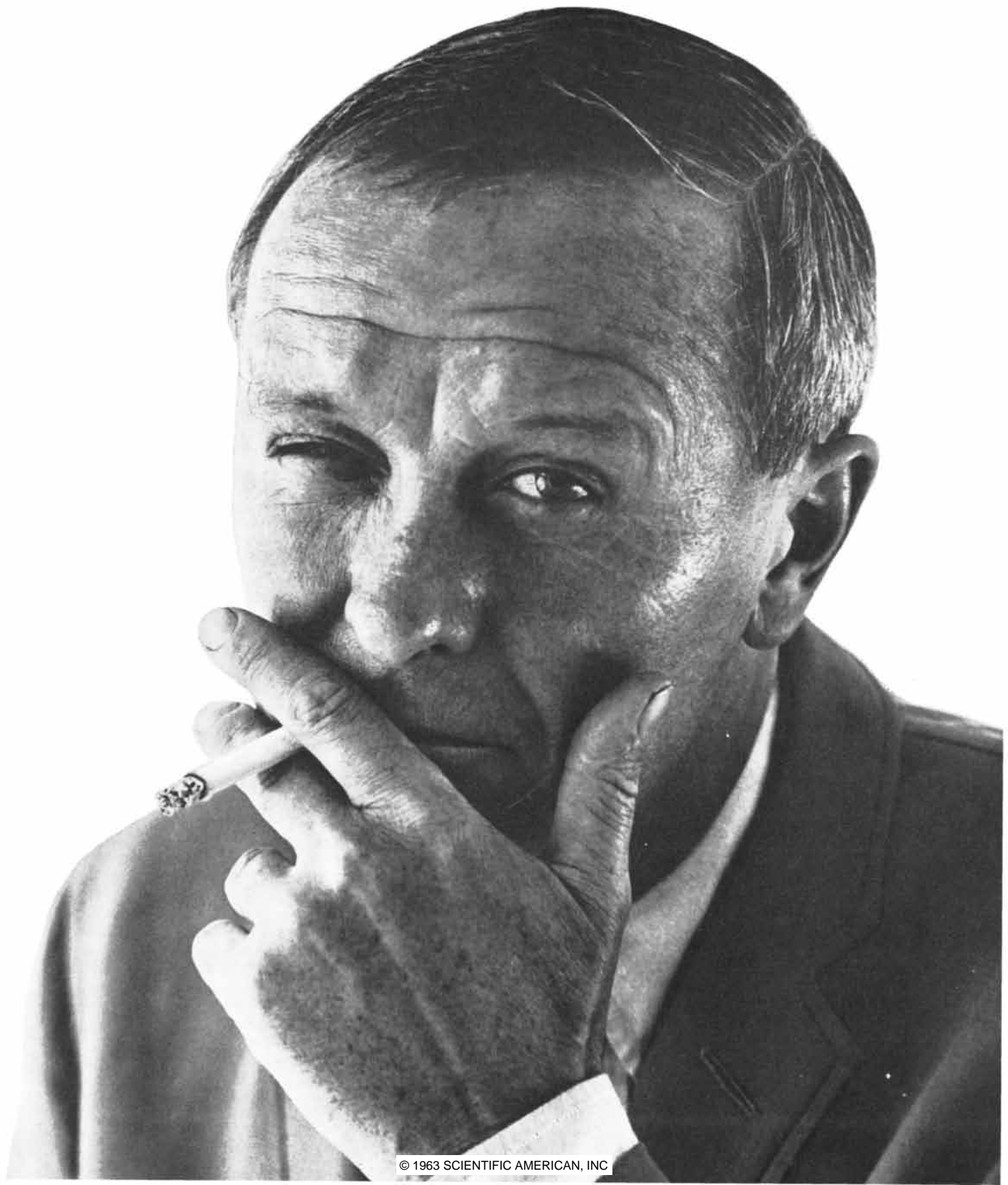
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# Machine Translation of Chinese

*Although perfect translation is known to be unattainable, good progress has been made in translating Chinese with a machine that has high-speed access to a linguistic "library"*

by Gilbert W. King and Hsien-Wu Chang

To the Western mind the Chinese language, particularly the written language, has long been a source of wonder. Because the Westerner has known an alphabet from childhood he can scarcely believe that the strange ideographic characters of Chinese can convey the whole gamut of human thought, from philosophy to platitudes. Even without the added complication of ideographic writing, the Chinese language is so difficult that it seems most unlikely that many Americans or Europeans will ever learn it well.

Machine translation of Chinese would seem to offer the only realistic hope of giving the West ready access to the manners, achievements and aspirations of a fourth of the human race. The Indo-Chinese group of nations, with a population of about 750 million, is currently publishing in newspapers, journals and books about three billion words a year. Much less than 1 per cent of this vast output is now being translated and re-published in English, French or German (undoubtedly a larger percentage is being translated into Russian), yet nearly all of it would be of great interest to one Western group or another. Automatic translation is needed because human translators cannot handle the volume or hope to acquire the special vocabulary needed to make good translations in a wide variety of technical fields.

Almost as soon as the electronic computer was developed some 20 years ago, its potential usefulness for language translation was recognized. Before this potential could be exploited, however, the entire technology of information processing had to be raised to its present high level. The basic problem is to find a match between natural languages and computer languages. The term "computer languages" means formal, coded instruction to a machine capable of making precisely formulated decisions. This need for stringent formalization goes far beyond the description of languages traditionally provided by linguistic scholars. As a result languages have had to be analyzed afresh by linguists willing to recognize the necessity of precise statements for a machine. In return the computer, with its capacity for subjecting an enormous amount of data to formal treatment, has served the linguist as a powerful tool for experimentation. Thus, aside from practical results, the attempt at automatic translation can hardly fail to yield new insights into the general properties of languages.

Several years ago a number of groups in the U.S. began a major effort aimed at machine translation of Russian into English. The work ranged from the highly theoretical to immediate practical efforts at computer programming. Today, under Government auspices, scientific

and technical journals published in Russian are routinely translated by machine. The results, although far from perfect, have demonstrated that understandable and useful translations can be made automatically.

Work on the machine translation of Chinese was undertaken in 1960 at the University of Washington. Research programs have also been initiated at the University of California at Berkeley, Ohio State University and elsewhere. Over this same period Soviet linguists have been hard at work on machine translation of Chinese into Russian.

This article will describe the work of the Chinese-to-English machine translation program that the International Business Machines Corporation undertook in 1960 under a contract with the Air Force. The Chinese program has benefited greatly from ideas and machine techniques developed for an earlier Russian-to-English program. Perhaps the most important feature of that system is a photographic "memory" containing hundreds of thousands of dictionary-like entries, any one of which can be found in a twenty-thousandth of a second [see top illustration on opposite page].

The need for such a large memory arose from an early recognition that a translation program could not be constructed simply by mechanizing existing grammars. It proved impossible to find any fabric of grammatical and syntactical rules that could be reduced to a manageable set of machine instructions. All spoken languages consist of a very large—in fact an infinite—set of conventions. In contrast, the operation of even the most complex machine can be expressed in terms of a relatively small set. In mechanical translation an order must be found in the larger set that makes it amenable to processing by

現在的導彈已能帶上原子彈和氫彈的彈頭，因而它是一種破壞力很大的兵器。

MODERN GUIDED-MISSILE ALREADY POSSIBLE CARRY WITH WAR HEAD OF HYDROGEN BOMB AND ATOMIC BOMB, THEREFORE IT IS ONE KIND WEAPON WITH VERY BIG POWER OF DESTRUCTION.

SAMPLE TRANSLATION of Chinese shows the present state of the machine-translation art. It was produced by methods devised by International Business Machines Corporation.



日

SUN

一

1

二

2

三

3

信

HONEST

水

WATER

羊

SHEEP

鯊

SHARK

魚

FISH

沙

SAND

火箭

ROCKET

火

FIRE

箭

ARROW

多級彈道

MULTISTAGE BALLISTIC

的

"DE"

在...上

ON TOP OF...

在

AT

上

ABOVE

在

AT

后

AFTER

期

PERIOD

像...一样

SIMILAR TO...

因為...的緣故

DUE TO THE REASON...

因

BECAUSE

為

TO BE/FOR

本

PIECE

隻

PIECE

一本書

ONE PIECE BOOK

一隻牛

ONE PIECE COW

美國的

OF AMERICA

太空人回来了

ASTRONAUT HAS RETURNED

太

EXCESSIVE

以...為

BY/THROUGH...IS

發射

LAUNCH/LAUNCHING

GLOSSARY contains a list of Chinese characters in the order of their appearance in the accompanying text. Each Chinese character represents a monosyllable to which one or more English

meanings can usually be assigned. Exceptions are certain characters such as auxiliary words and "functionives" that have no exact English counterpart. Many Chinese words are formed by combining two or

人

MAN

言

WORD

洋

OCEAN

水

WATER  
(VARIANT)

美國

AMERICA

美

BEAUTIFUL

國

KINGDOM

多

MANY/MUCH

級

GRADE

彈

BULLET

道

PATH

在...后期

TOWARD THE END OF...

像

TO RESEMBLE

一

ONE

样

TYPE

的

"DE"

緣

DESTINY

故

REASON

的

"DE"

了

"LE"

我

I  
(PRONOUN)

我的

MY/MINE

空

VOID

人

HUMAN

回

TO RETURN

来

TO COME

了

"LE"

發

TO SEND FORTH

射

TO SHOOT

向

TOWARD

the smaller. To the extent that one cannot regularize aspects of the larger set one must have a way of mechanically storing them. This is the function of the large photographic memory.

This memory contains exhaustive lists covering the many ways in which specific words can function in a sentence. It covers all the common ambiguities, transpositions and hiatuses in word order, idiomatic expressions and hundreds of special cases of the sort that make life so difficult for students learning a foreign language. In its analysis of a typical Russian sentence the machine may refer to this combination dictionary-grammar several hundred times. The analysis is not performed on the raw input sentence but on an intermediate process sentence in which each process word contains, in an appended code, the grammatical and semantic equivalents of the corresponding input word of the sentence. In the automatic analysis grammatical relations among words are established, words are reordered and translation decisions are made. On completion of this analysis the machine has the information needed to fabricate an output sentence that represents a translation of the input.

For Russian, at least, this system proved to be quite successful. Whether or not it would be of more general value in machine translation remained to be seen. Chinese, being so different from both Russian and English in its language type and family, provided an excellent test.

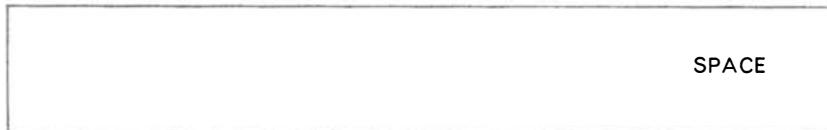
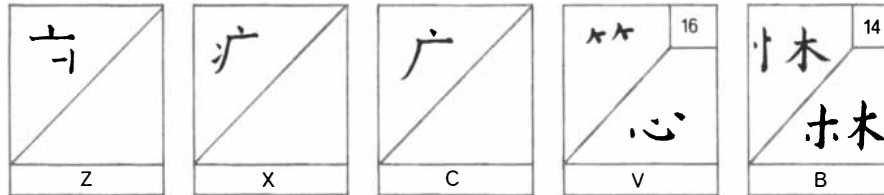
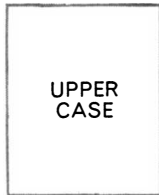
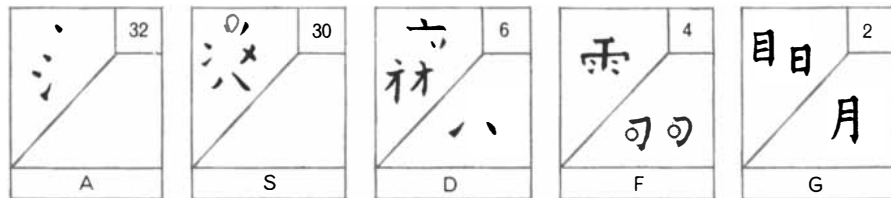
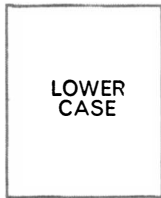
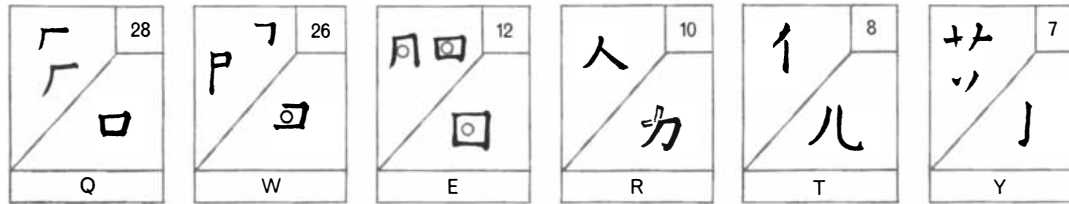
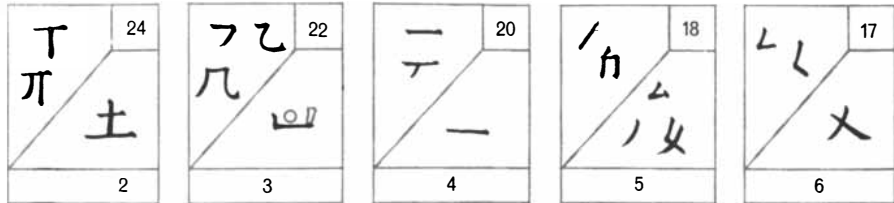
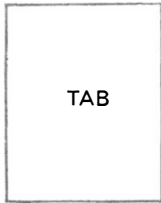
From the outset Chinese presents a problem not found in Russian or other alphabetic languages: the written Chinese character. The machine must be provided with a description, in code, of every character in the sentence to be translated. Moreover, to achieve speed and efficiency the code assignment must be made by a human operator at a keyboard. Machines to "read" Roman or Cyrillic characters have not yet been perfected, and a machine to read Chinese characters is nowhere in sight.

The number of characters used in the average Chinese newspaper is about 4,000. Literary and technical writing may contain 8,000 to 12,000 different characters. Chinese characters originated as stylized pictures, or hieroglyphs. As they evolved, the pictorial aspects became less pronounced, but they did not entirely disappear. They reached approximately their present form more than 2,000 years ago.

The scholar who has most recently reviewed their classification, Y. R. Chao

more characters. In that case the glossary usually shows the multicharacter word, or term, first (in gray), with its meaning, and after it the meaning of the individual characters. Frequently the individual meanings provide a clue to the meaning of the compound.

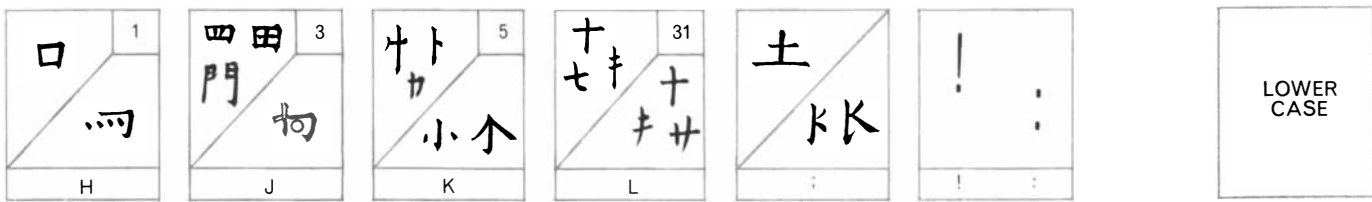
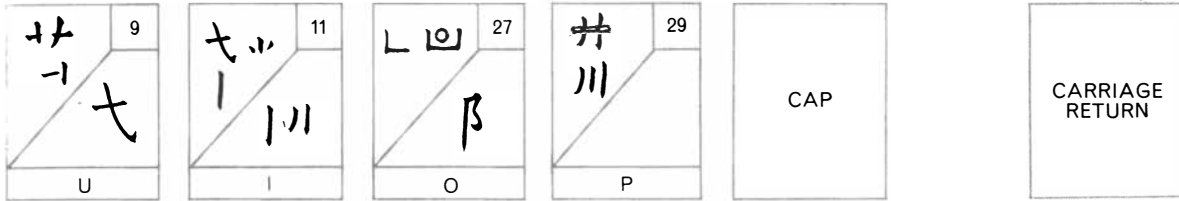
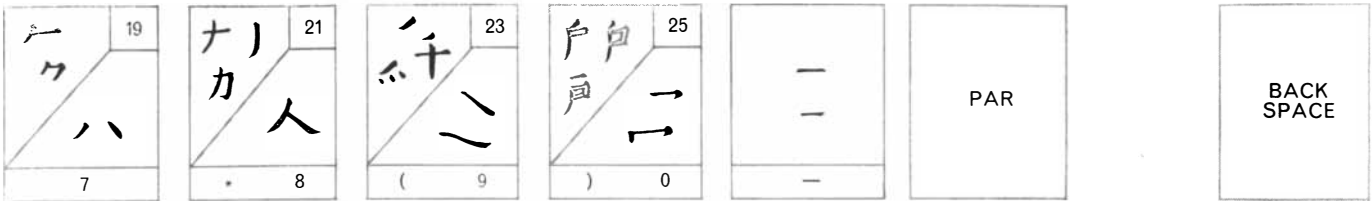




SINOWRITER KEYBOARD provides a means for encoding Chinese characters on standard Flexowriter tape. The designs on the keys represent characteristic features found in the top and bottom of Chinese characters. To encode a character the operator must strike three keys. The first represents a design found in the upper portion of the character. The second represents a design in the lower portion. Together these keys activate a display device that shows the operator a family of characters, all of which incorporate the same upper-half and lower-half features. Such a family of six characters is shown at bottom left on these

of the University of California at Berkeley, describes six categories. The first is made up of pictographs, which in their more ancient form were mere pictures of concrete objects. Thus 日, the symbol for "sun," is derived from an ancient form consisting of a dot in the center of a circle. In the second class are simple ideographs in which concepts are treated schematically; for example, the digits "one," "two," "three" are written 一, 二, 三. The third class contains complicated ideographs whose meaning is the combination of the meaning of their parts. For example, "honest" is written

言, which is derived from 人, "man," and 言, "word." In the fourth class are loan characters, which take on the forms of other characters but have entirely different meanings. The fifth class is made up of derivative characters. The sixth class consists of phonetic compounds, which are generally formed with two component parts; one suggests the true meaning and the other indicates pronunciation. Thus 洋, "ocean," is formed from 水, which is a variant of the character 水, "water," and 羊, which means "sheep." This indicates that 洋 has the same pronunciation as 羊 alone. (En-



two pages. They would appear on the display if the operator struck the "M" key, for upper configuration, and the "5" key, for lower configuration. To designate the first character in the family, the character meaning "peace," the operator would strike the key with "1" in the upper right-hand corner. This is also the "H" key on the conventional Flexowriter keyboard, and the six-digit code for "H" would appear on the punched tape. Thus the complete code

for peace is M5H, which is shown in punched form next to the character. The codes for the other members of the family are M5G (vast), M5J (feast), M5F (honey), M5K (empty) and M5D (death). On some keys color is used to indicate portions of a character that need not appear in the character being sought. A colored circle indicates the position of various alternative strokes. In its present form the Sinowriter contains 6,500 characters.

larged versions of these and other characters in the text can be found either in the glossary on pages 126 and 127 or in the sample sentence on the next page.) Chinese characters have also been classified according to their component parts into radicals. A character is usually made up of two elements: a radical that suggests the meaning and a phonetic that gives a clue to the pronunciation. For example, 鲨 (shark) is made up of the radical 魚 (fish) and the phonetic 沙 (sand). According to the *Kang Hsi* dictionary there are 214 radicals. The problem of encoding Chinese

characters for machine processing could be solved in any number of ways. A straightforward way to provide a code for, say, 10,000 characters would be to build a large keyboard containing 10,000 keys in a 100-by-100 array. Each key, when pressed, would punch a unique sequence of holes in paper tape. If a simple binary code ("hole" or "no hole") were used, a sequence of 14 places would be needed. (A 14-place binary code would actually be long enough to specify 16,384 characters; a 13-place code could specify only half that number.) It is obvious that even a Chinese

scholar would need months to master such a keyboard and that his ultimate coding rate would never be very high. We needed a keyboard that could be learned fairly quickly by people who are not necessarily able to read Chinese. The problem is basically one of devising a scheme for indexing characters so that they can be found readily. The problem had been much studied because it is fundamental to telegraphy, to designing a typewriter and even to selecting the presentation of characters in a Chinese dictionary. Most of the

美 BEAUTIFUL	國 KINGDOM	向 TOWARD	太 EXCESSIVE	平 SMOOTH	洋 OCEAN
發 TO SEND FORTH	射 TO SHOOT	的 "DE"	多 MANY/MUCH	級 GRADE	彈 BULLET
道 PATH	火 FIRE	箭 ARROW	全 ALL	是 TO BE	以 WITH
液 LIQUID	氧 OXYGEN	為 TO BE/FOR	氧 OXYGEN	化 TO TRANSFORM	劑 POTION

CHINESE SENTENCE consists of strings of characters with no intervening spaces. The individual meanings of the 24 characters in this sentence are indicated. By using the "principle of the longest match" the translation machine identifies characters that should be combined to form words or word groups. The result of this processing step is illustrated below.

美國	向	太平洋	發射	的
AMERICA	TOWARD	PACIFIC OCEAN	LAUNCH	"DE"
多級彈道	火箭	全	是	
MULTISTAGE BALLISTIC	ROCKET	ALL	TO BE	
以	液氧	為	氧化劑	
BY	LIQUID OXYGEN	TO BE/FOR	OXIDIZER	

AFTER GROUPING OF CHARACTERS the machine finds that the sample sentence (above) contains 12 words or word groups ("lexical units"). The two characters "by" . . . "to be/for" form a discontinuous constituent that is regarded as one lexical unit for processing.

indexing schemes exploit specific details in the way Chinese characters are drawn.

We have investigated a geometric-recognition scheme that the Chinese author and scholar Lin Yutang had devised for a typewriter. A prototype machine, called the Sinowriter, was developed jointly by IBM and the Mergenthaler Linotype Company for the Air Force. In using the Sinowriter the operator is required to recognize particular shapes in the upper and lower portions of the character.

The present machine has a vocabulary of 6,500 characters, which can be expanded to 16,000. The 6,500 characters are classified into about 1,000 families according to their upper and lower configurations. The task of the operator, in observing a particular character, is to decide which of 36 upper configurations it contains and which of 30 lower configurations. The operator then presses one key to represent the upper and an-

other to represent the lower. The two keys activate a mechanism that projects onto a screen the whole family of characters sharing these particular configurations. The family may contain only one member or as many as 16. Each member of the family is numbered from one to 16, and the operator can easily identify the one that matches the desired character in the Chinese text. He enters the appropriate number by striking a numbered key. For each character, then, the operator strikes three keys: one for upper configuration, one for lower and one for number within a family. Each stroke produces a six-hole (or six-bit) code on paper tape, so that regardless of simplicity or complexity all characters are represented by a group of three six-bit codes. Modifications in the system will undoubtedly be made on the basis of experience.

(It is perhaps obvious that the Sinowriter could be adapted to the job of setting type by machine. Evidently no

typesetting machine yet exists in China, but the Japanese are known to have developed experimental models for their language, which uses characters similar to those of Chinese.)

The punched tape produced by the Sinowriter represents the raw input to the translating machine. Again Chinese presents a special problem. Except for punctuation, the printed Chinese sentence is a stream of characters without spacing. If each Chinese character represented a single word, there would be no problem, but, as we have seen, many words are composed of two characters, and combinations of three and four characters are common in literary and technical Chinese. Each character is a monosyllable to which one or more English meanings can usually be assigned. And the meaning of a combination of characters is often not obvious from its elements.

For example, 美國 is the Chinese word for "America"; taken alone, 美 means "beautiful" and 國 means "kingdom." The two characters 火箭 together stand for "rocket"; individually 火 means "fire" and 箭 means "arrow." The words "multistage ballistic" are expressed in Chinese by four characters, 多級彈道, which individually represent "many," "grade," "bullet," "path."

If the Sinowriter were operated by a Chinese scholar, he could indicate the appropriate character groupings, but in his absence the groupings must be discovered by the translation machine. This is made possible by the "principle of the longest match." The dictionary of characters stored photographically in the translation machine's memory is so ordered that any given character is presented first in groups that have a collective meaning. As the machine searches it finds shorter and shorter groups and finally single characters. The dictionary is so arranged that the machine automatically finds the longest sequence that matches a given input.

To each entry is added a definition, similar to that in a conventional dictionary but much more formal and, in the long run, more definitive. The definitions, in fact, supply the intermediate grammatical and semantic information about the lexical unit, or language unit, that is basic to the whole translation process.

Once the longest lexical units have been identified, the machine's next step is to see how the units are related. A basic feature of modern languages is that lexical units do not necessarily make sense if they are simply translated in the

sequence in which they originally appear. The units have special relations to each other, and frequently the linkage between words or phrases is not between adjacent units but over a span of units. It turns out that all grammatical linkages can be described by a tree structure.

The machine is enabled to create a tree structure by means of "tags" it finds attached to entries in the dictionary and in the tables of grammatical rules. These tags direct the machine from one entry to another and provide, in effect, a dynamic program for processing each input sentence according to its own lexical components. The net result of this sequential look-up process is to assign a label to each lexical unit indicating its position in a tree structure. The fact that a tree has only one trunk, regardless of the number of branches, is equivalent to the recognition of a string of words as a sentence. Although any child, English-speaking or Chinese, can recognize a sentence, machines find the task extremely difficult.

The reason for this difficulty is twofold. First, all words are subtly different in function, even though the differences are often not too important. The traditional classification of English words into the eight parts of speech is a great oversimplification. The possible linkage any given word may have covers a broad spectrum and can vary almost from sentence to sentence. To provide a translation machine with a formal list of just the most common linkages is a formidable job. The second grave obstacle to sentence recognition is the familiar and rather strange fact that virtually every word can be translated in more than one way. The upshot of this twofold difficulty is that ambiguities arise in almost all cases, so that many alternative tree structures are possible on blind application of the "rules of grammar," however elaborate.

One way to handle this problem is to have the machine discover "points of entry" into a sentence. For example, the English word "the" invariably begins a noun phrase and is not linked to a preceding word. In Chinese a useful point of entry is served by the symbol 的, pronounced "de" (or, to be more precise, "duh"), which has no unique meaning of its own but combines freely with other characters to modify their meaning. For this reason linguists call the symbol a functionive.

A tree structure can be built up in an unambiguous way by identifying points of entry and making linkages from these points. For this purpose the memory is supplied with permissible

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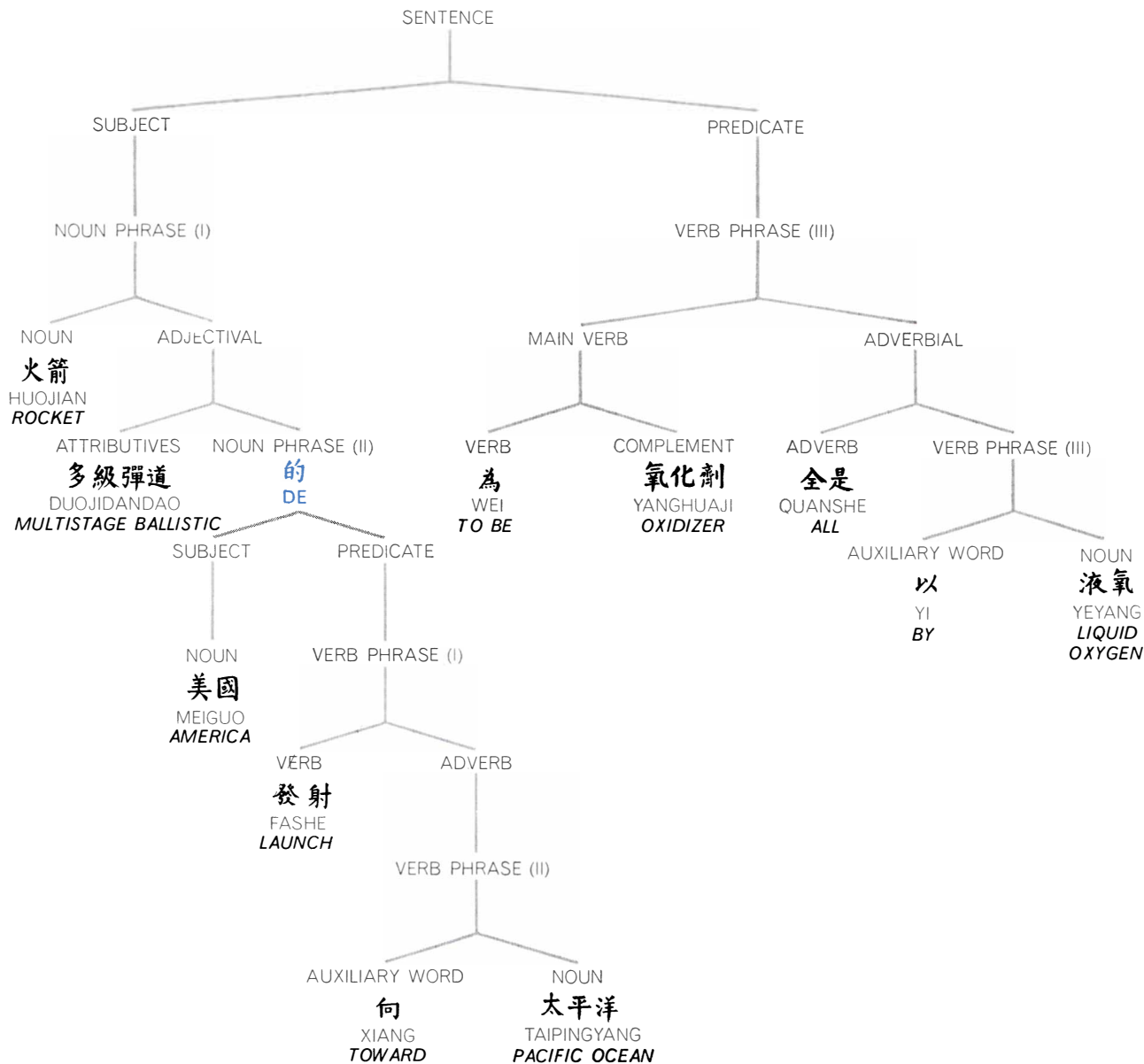
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**TREE STRUCTURE**, showing how various words are related, is a fundamental characteristic of a sentence in any language. The sentence diagrammed is the one shown on page 130. Recognition of a sentence is easy for humans but difficult for a machine. In machine translation sentence recognition can be facilitated by discovering "points of entry" into a sentence. In Chinese a useful

entry point is the auxiliary word pronounced "de" (*color*). "De," which has no exact counterpart in English, is a functive. The pronunciation guide shown under the Chinese characters is based on the Pinyin Romanization System. No attempt has been made, however, to indicate the various tonal inflections (usually four) that can impart different meanings to the same monosyllable.

pairs of words and with a statement of the symbolic properties of these pairs, now considered as a single unit. These complex units are then used to form further pairs until the tree is established. Ambiguities can arise even then, but the procedure must be continued in the hope that a resolving clue will eventually turn up.

Sometimes these clues turn up so late that the procedure is too involved for a machine to unravel. Often clues will reside in preceding sentences in a form the machine cannot retain. Therefore one must accept the fact that real trans-

lation is impossible. The translation can nonetheless be good enough to convey as much information as the original, which itself is not always perfect.

Part of the linkage problem is the problem of the discontinuous constituent. In English familiar examples are "either...or" and "not only...but also." Such constructions are far more common in Chinese than they are in English. In many cases the constituents are nothing more than words whose component characters seldom occur sequentially in a sentence. Examples are 在...上 (on top of...), 在...后期 (toward the end

of...), 像...一样 (similar to...), 因為...的緣故 (due to the reason...). The machine's memory has to be provided with exhaustive lists of all such examples and correct semantic translations of each.

It turns out that the discontinuous constituents, although troublesome, can serve as useful parsing devices; they usually mark phrase or clause boundaries within a sentence. The word order in such phrases or clauses, however, often requires special rearrangement. Translated by simple word-for-word substitution, a Chinese phrase might

read: "As far as atomic energy and rocketry ["de"] computation..." The proper English translation would be: "As far as the computation of atomic energy and rocketry..." A more obscure example, if it is merely translated word for word, might be: "Remove we discuss ["de"] problem in addition..." This should be translated: "In addition to the problems that we discuss..." With proper instructions, and utilizing the discontinuous constituents as parsing boundaries, the machine can unravel such inversions and produce English-sounding sentences.

Another broad class of problems concerns the handling of auxiliary words that have no exact counterpart in English. Such words express relations among other words in sentences and serve as grammatical connections for verbs and their modifying phrases, and for noun phrases. The Chinese auxiliaries can be divided into three broad categories: verbal types, conjunctive types and nominal types. The verbal types, which are the most interesting and important, are used with verbs to express tense, voice and so on. The conjunctive types link clauses, phrases and words. Nominal types indicate such things as whether nouns are plural or singular.

Other auxiliary words are used with nouns and verbs to indicate that a measure is involved. Two such words are 本 and 隻, which can both be translated "piece," as we use the word in "one piece of paper." The first would be used in the phrase 一本書: "one piece book." The second would be used in 一隻牛: "one piece cow."

Perhaps the most versatile word in Chinese is the functive 的 ("de") mentioned earlier. Another important functive is 了 ("le"). The frequency of "de" in Chinese sentences is roughly comparable to the frequency of "the" in English, but there the similarity ends. Several examples of the use of "de" will demonstrate its ubiquity.

When "de" is used with a single noun or pronoun, it frequently imparts a possessive meaning. Thus 我 (I) plus 的 ("de") signifies "my" or "mine." Adding 的 ("de") after 美國 changes "America" to "of America." When used with a group of nouns, "de" can be translated "of," which also connotes the idea of possession. It can be used with words to form adverbs and with adjectives to form nominal modifiers. Sometimes "de" indicates the manner of action of verbs, or it may indicate that an action is completed.

The functive 了 ("le") can be used to indicate a new situation, the comple-

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*Jim Traversano*

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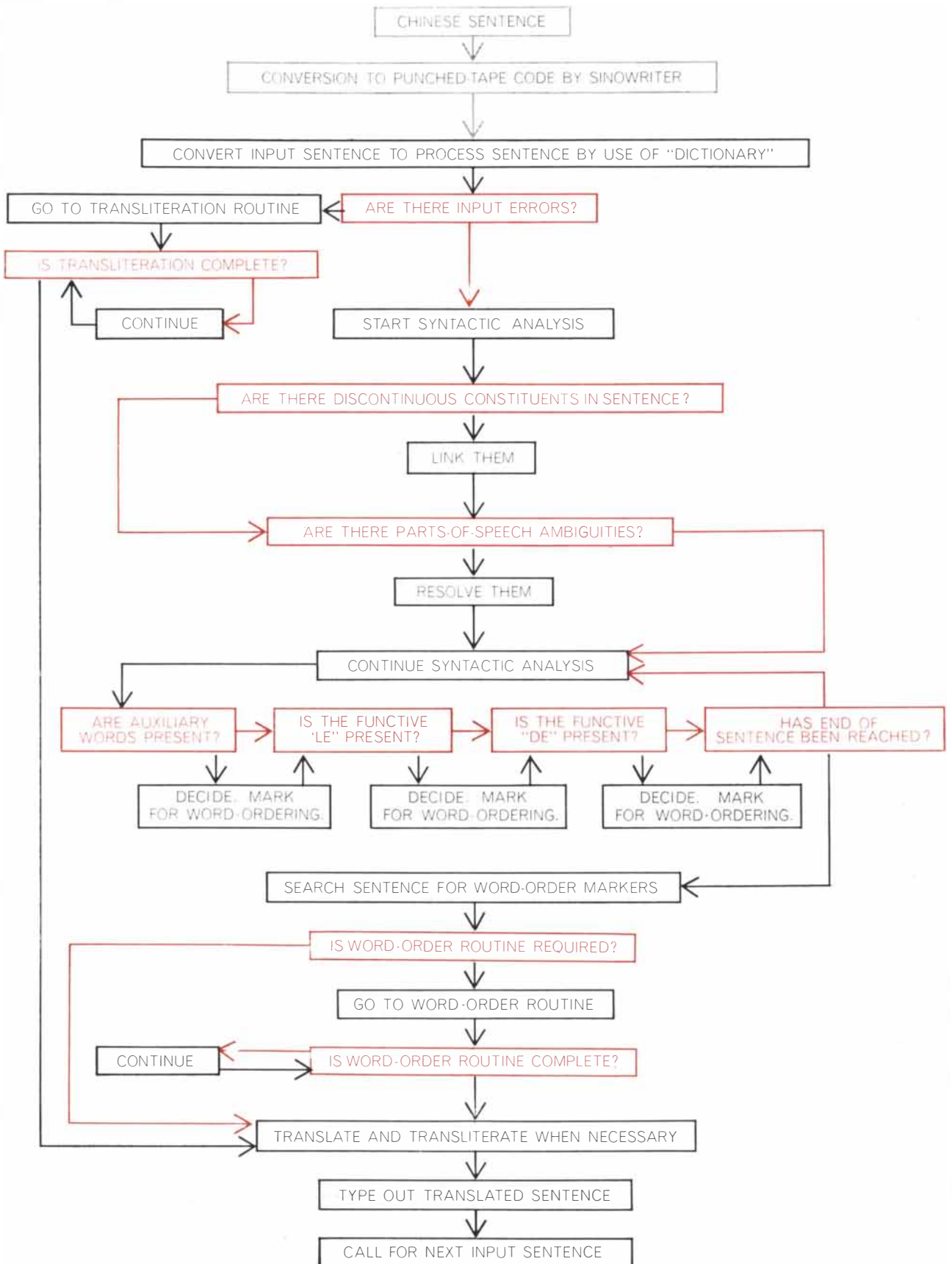
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**FLOW CHART** summarizes steps required in machine translation of a Chinese sentence. The "dictionary" is the diverse linguistic data stored photographically on a disk. A colored arrow means the

answer to a question is "no." A black arrow means "yes," or "proceed." The transliterative routine handles input errors and terms not in the dictionary; such items are simply transliterated.

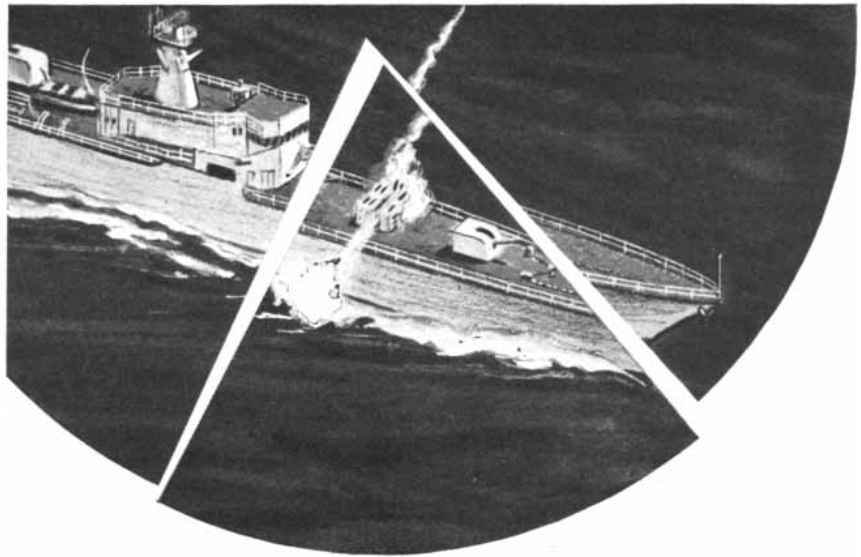
tion of an action or even the continuation of an existing situation. A typical example of the use of 了 is in the sentence 太空人回來了: "Astronaut has returned."

Let us now consider in some detail the steps taken by the machine in translating the following Chinese sentence: 美國向太平洋發射的多級彈道火箭全是以液氧為氧化劑.

Note first of all that the sentence contains 24 characters without spacing. By using the principle of the longest match the machine determines that the sentence actually contains 12 words or word groups, including a discontinuous constituent and the functive "de." (The result of this processing step is shown in the lower illustration on page 130.) A simple word-for-word translation of the sentence would read: "America toward Pacific ocean launch ["de"] multistage ballistic rocket all to be by liquid oxygen to be/for oxidizer."

The machine's next instruction is to link all discontinuous constituents in the sentence. In this case there is one, 以...為 (by/through/with... is/make/cause). Next the machine examines the sentence for ambiguous parts of speech and finds the word 發射, which can mean either the verb "launch" or the noun "launching." It is determined to be a verb. Following this the machine looks for auxiliary words and functives. It finds the auxiliary 向 (toward) and the functive 的 ("de"). The machine determines that "toward" heads the adverbial phrase "toward Pacific ocean." It discovers that "de" is used with the verb "launch" and, in response to a relative-clause subroutine, it inserts the word "which." Word-rearrangement markers are also tagged to all the words that are affected by this subroutine. The last step is word reordering and typing out of the translated sentence: "Multistage ballistic rocket which America launch toward Pacific ocean all use liquid oxygen as oxidizer."

This is a fair example of the results we have been able to obtain by automatic translation, using the methods briefly described in this article. Another sample translation is shown on page 124. We feel that the general usefulness of the linguistic-dictionary approach, first used with Russian, has now been demonstrated with Chinese. This is not to say that all the relevant problems are solved or will soon be solved. The goal, however, is well worth the effort, for we are seeking to remove the serious block that now exists to communications between people of the two largest language groups in the world.



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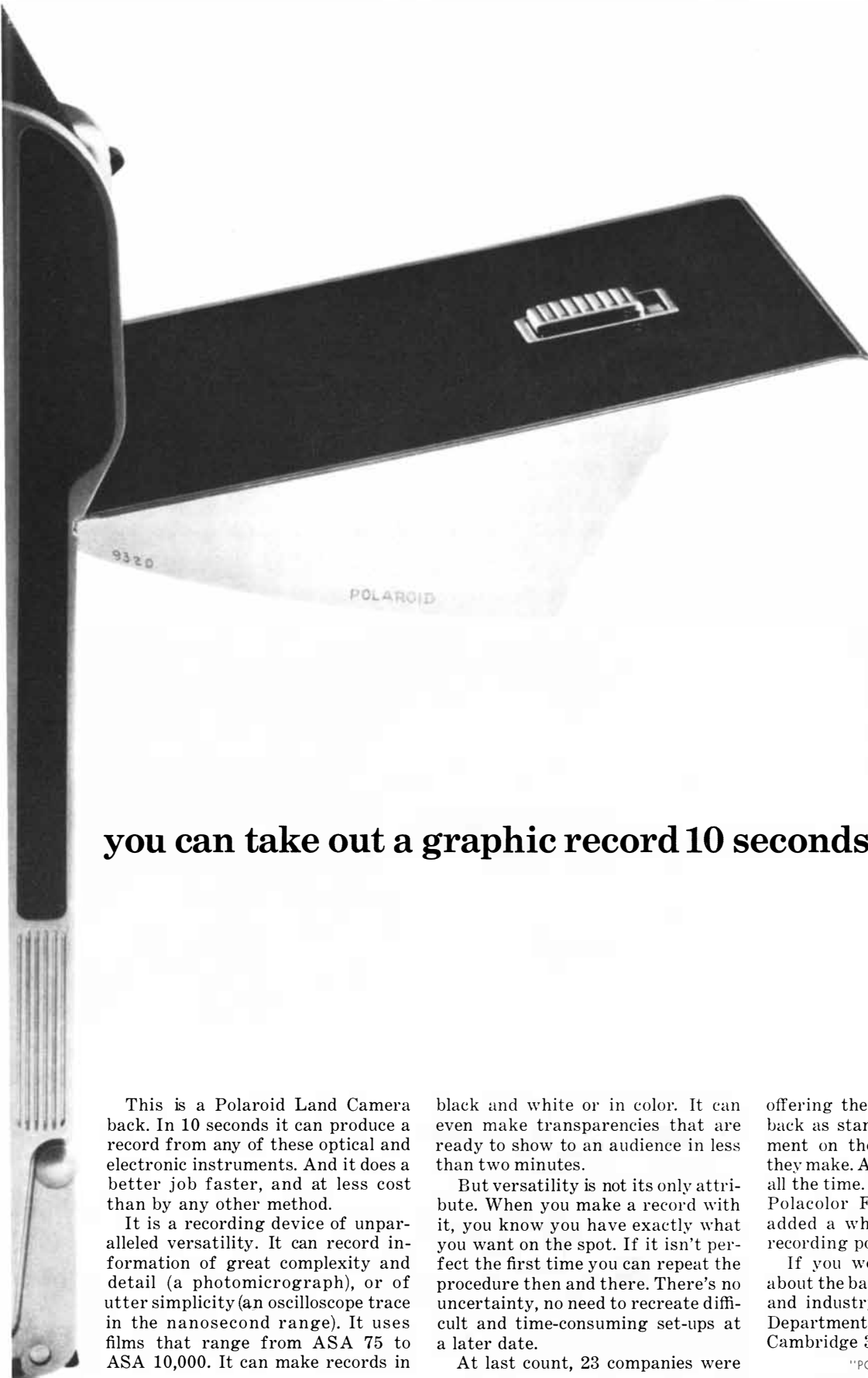
This will give you just a brief insight into a significant situation: **BuShips activities are not limited to ship building alone, but spread over a wide spectrum of technological areas that may, in any way, relate to the development of better ocean-going weapons systems.** The same spread applied to other areas of the Navy as well, especially to weaponry of all kinds and shore installations, where the talents of scientists and engineers of almost all disciplines are required. If you would like to take on wide-ranging responsibilities and tangle with some really tough problems, get in touch with Larry Parachini, Code 500, Room 1000 here in the Main Navy Building, Washington 25, D. C.

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# Early Experience and Emotional Development

*Experiments with infant rats demonstrate the decisive influence of early social experiences on later emotional behavior. Some reciprocal effects of the mother-infant relation are also examined*

by Victor H. Denenberg

A substantial body of clinical evidence supports the general observation that the experiences of early infancy play a paramount role in the growth and development of the individual personality. In particular it has been observed that the emotionality or anxiety of the mother is strongly reflected in the anxiety or lack of it exhibited by the child. With the aim of bringing the process of emotional development under experimental study, investigators in recent years have been observing the relation between early experience and adult behavior in a variety of laboratory animals. They have been gratified to discover that the effects of various modes of treating and handling the infant animal show up consistently and reliably in the adult. To the extent that the analogy with human behavior can be credited, these experiments can be taken as confirmation of what has been observed in the clinic. This work has greater significance, however, because it has shown that the difficult realm of emotional development can be studied in the laboratory on the same terms as, for example, learning or motor development.

During the past few years my colleagues and I at Purdue University have been engaged in work along this line using as our laboratory subjects infant rats of the Purdue Wistar stock. In general we have found that social experiences prior to and immediately after weaning bring about more or less permanent changes in emotional behavior at maturity. As might be expected, our experiments show that the mother-infant relation has decisive effects on the later emotional development of the infant. We have also found—as investigators working with other animals have observed—that early infant-infant relations may have comparably decisive effects.

Our primary method of measuring differences in the emotional behavior of individual rats has been the “open field” test [see illustration on opposite page]. The animal to be tested is placed in a box about four feet square for three minutes. The floor of the box is marked off into nine-inch squares to provide a convenient index for measuring the animal’s activity. A rat that is capable of flexible and adaptive behavior responds to this unfamiliar situation by running about and exploring its new surroundings. Its activity can be scored by counting the number of squares it enters during the period of observation. An emotionally disturbed rat—that is, one with a low or underdeveloped capacity for adapting to unfamiliar situations—responds by cowering in a corner of the box or by creeping about timidly. The disturbed rat also tends to defecate and urinate frequently, a characteristically maladaptive stress response mediated by the autonomic, or involuntary, nervous system. The open-field test thus provides two objective and quantitative indexes for measuring the emotional state of the test animal: the number of squares entered and the number of boluses defecated during the three-minute test period.

In our experiments involving the mother-infant relation we set out first to measure the degree to which the emotional state of a mother rat affects the emotional state of her offspring. With performance in the open-field test as our standard we were able to classify non-pregnant female rats as scoring “high” or “low” on the scale of emotionality or anxiety. All the animals were then mated and put into individual laboratory cages where, about 21 days later, they gave birth to litters of eight or more pups. In order to investigate whether or not the

emotional behavior of the young was influenced by the behavior of the mother, we set up an experiment designed to simulate the effects of inconsistent mothering. Seizing the opportunity presented when two females with the same emotional classification happened to give birth on the same day, we exchanged these mothers every 24 hours until the pups were weaned at 21 days. The differences in the maternal behavior of the mothers in this experiment, we thought, would have effects comparable to the inconsistent maternal care of a single emotionally disturbed mother. In the case of mothers not “rotated” in this fashion, we took care to remove each one from its cage for a short period each day in order to eliminate the possible effects of the handling process itself.

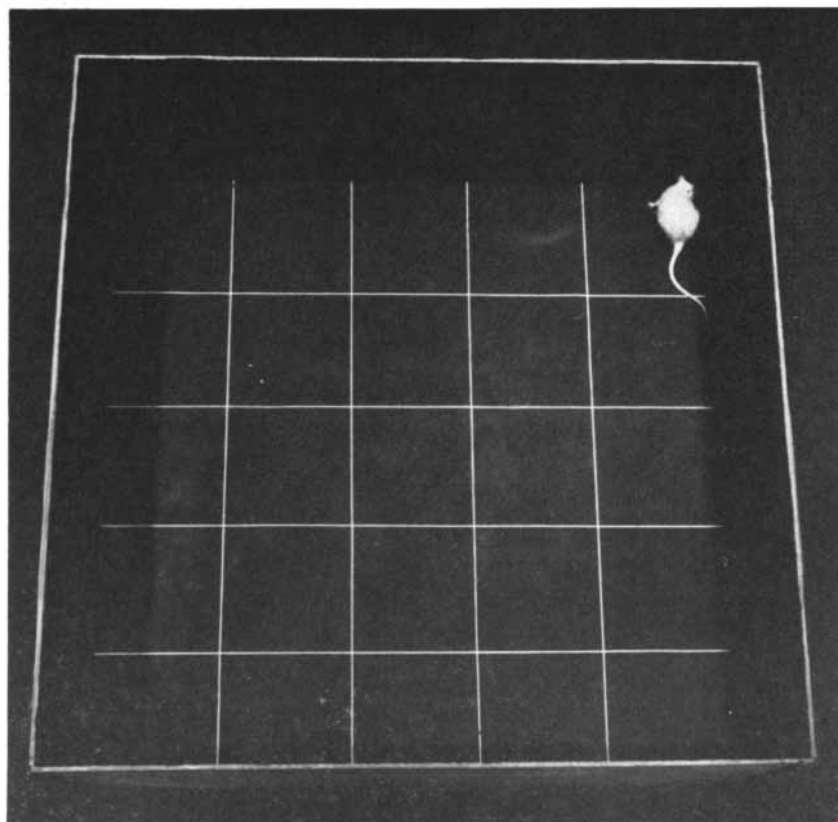
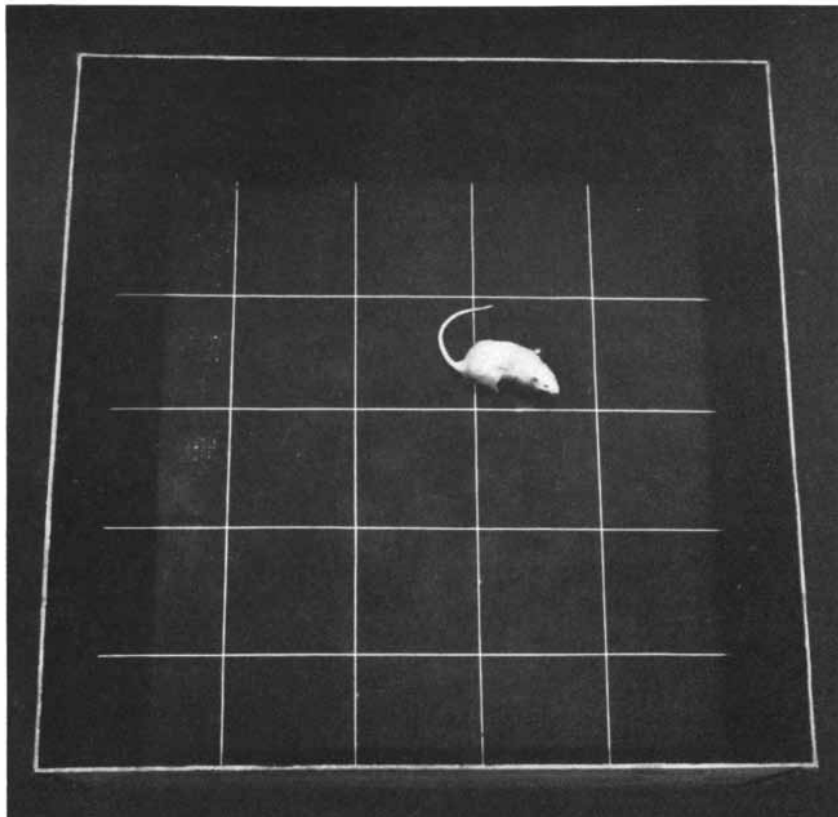
After weaning (at 21 days) the infants were in all cases raised in laboratory cages with littermates of the same sex and were subjected to the open-field test at the age of 50 days. Their performance furnished conclusive evidence that there is a direct relation between the emotional state of a mother and that of her offspring. The offspring of emotionally disturbed mothers showed much lower activity scores and much higher defecation scores than the offspring of normal mothers. The offspring of both classes of mothers that had been subjected to rotated mothering showed a corresponding decrease in activity scores and increase in defecation scores.

Because a direct relation was found between the emotional state of a mother and the emotional state of her offspring, the experiment could be interpreted as demonstrating the effect of hereditary rather than social influences on the emotionality of the offspring. In a control experiment we accordingly exposed the offspring of each class of mother to the maternal care of mothers of both classes

on the same 24-hour rotational schedule. If hereditary factors prevailed, one would expect that the offspring of normal mothers would show higher activity scores than the offspring of disturbed mothers. When infants subjected to this treatment had been allowed to mature and were tested in the open field, however, we discovered that this was not the case. The scores of these offspring were not related in any significant way to the emotional classification of their biological mothers [see top illustration on next page].

The results of this control experiment were so one-sided that we undertook still another, designed to find out whether or not the infant's early social experience is the sole determinant of its later emotional behavior. This time when a normal and a disturbed female gave birth on the same day, we switched mothers so that the mothers of each class were made to foster the offspring of the other. The pups were not touched by the experimenter during this exchange. After this neither the mothers nor the young were handled again until the young were weaned at 21 days. The scores of these offspring, when tested in the open field at the age of 50 days, show that genetic constitution is not without influence on later emotional behavior. Independent of such influence, however, the mother in her interaction with the young between birth and weaning brings about a relatively permanent change in the emotional behavior of the offspring. The ways in which this post-natal maternal influence is communicated to the infants remain to be explored in more detail.

At this point the design and the results of our experiments suggested that we ought to look into another question: How does the behavior of offspring influence the behavior of mothers? In human families it is well known that a cranky infant can arouse anxiety and emotional tension in the mother, whereas a peaceful baby that eats, sleeps and smiles has the capacity to charm and soothe all concerned. In order to investigate this reciprocal relation it was necessary to produce infant rats with emotionality scores as well established as those of the mother rats used in our experiments. Although the open-field test provided a reliable means of classifying normal and disturbed mothers, it was not practicable to differentiate the emotional types of very young pups by this means. Therefore we undertook another experiment, which established that the emotionality of rats can be fixed at will



**EMOTIONAL BEHAVIOR** of a rat can be measured on the "open field": an area four feet square marked off into smaller squares. When a normal rat (*top*) is placed in this unfamiliar environment, it generally responds by running about and exploring its new surroundings. An emotionally disturbed rat (*bottom*) responds to the same situation by covering in a corner and defecating. The principal indices of "emotionality" are the number of squares entered and the number of boluses defecated during three-minute test period.



BIOLOGICAL MOTHER	ROTATED MOTHERS	ACTIVITY SCORE ON OPEN-FIELD TEST (50 DAYS)	BIOLOGICAL MOTHER	FOSTER MOTHER	ACTIVITY SCORE ON OPEN-FIELD TEST (50 DAYS)
EMOTIONALLY DISTURBED	BOTH EMOTIONALLY DISTURBED	48	EMOTIONALLY DISTURBED	EMOTIONALLY DISTURBED	61
EMOTIONALLY DISTURBED	EMOTIONALLY DISTURBED AND NORMAL	74	EMOTIONALLY DISTURBED	NORMAL	88
NORMAL	EMOTIONALLY DISTURBED AND NORMAL	74	NORMAL	EMOTIONALLY DISTURBED	96
NORMAL	BOTH NORMAL	95	NORMAL	NORMAL	106

**MOTHERS WERE EXCHANGED** between litters according to two different schedules. Some were rotated between their own and another's litter every 24 hours from a common birth date until weaning 21 days later (*graph at left*). Other pairs were exchanged at birth and were not handled again until weaning (*graph at right*). When the offspring of four different maternal combinations in the first group were tested in the open field at 50 days, their perform-

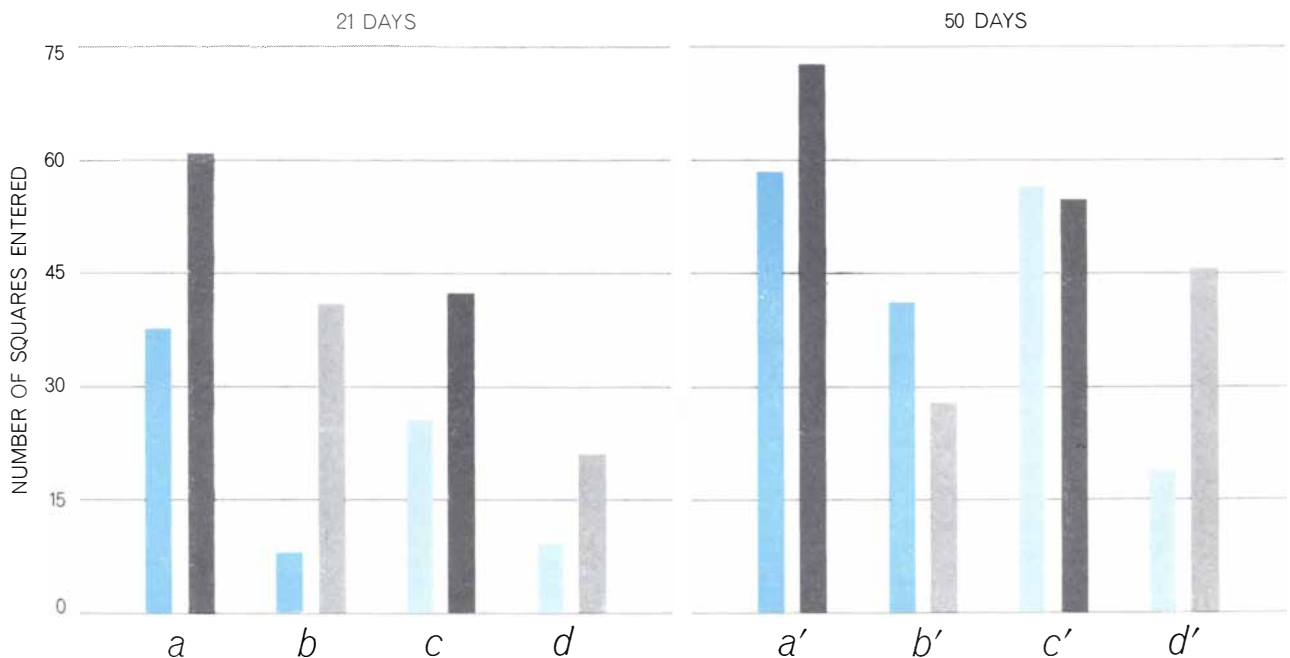
ances reflected the strong residual influence of the mother-infant social relation but did not show any evidence of a comparable hereditary influence. When offspring in the second group were tested, their emotional behavior revealed the influence of their genetic backgrounds as well as of their early social experience. Scores are generally lower in the graph at left because the daily rotation of mothers in itself has a disturbing effect on the infant rats.

by suitable treatment at an early age. We found that rats subjected to electric shock during the first few days of life later showed extremely adaptive and accordingly high activity scores in the open-field test. Seymour Levine, who is now at Stanford University, similarly

found that almost any routine of daily handling in early life is reflected in a higher degree of emotional stability at maturity. Conversely, rats that spend their early life in the comparative isolation of laboratory cages tend to be emotionally disturbed and adapt poorly in

the open-field test [see "Stimulation in Infancy," by Seymour Levine; *SCIENTIFIC AMERICAN*, May, 1960].

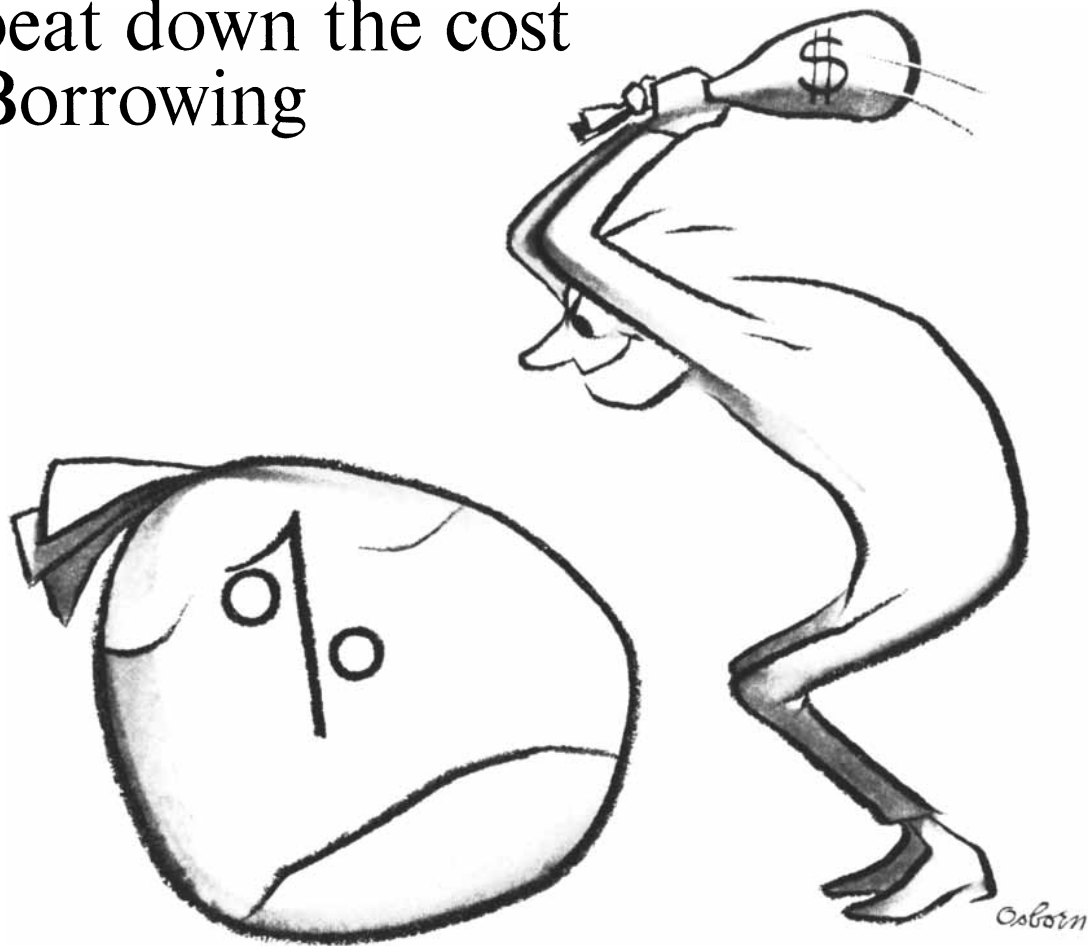
Using our electric-shock techniques, we were able to supply infants of both emotional classifications to mothers of both kinds and thereby set up four dif-



**RECIPROCAL EFFECTS** of four different mother-infant combinations are represented by the paired bars on this graph. Open-field activity scores were recorded for both mothers and infants when the infants were weaned at 21 days (*left*) and again at 50 days (*right*). Normal and emotionally disturbed mothers were initially sorted out according to their prepregnancy open-field test scores. Normal infants were obtained by subjecting them to mild electric shocks in early infancy. Infants that had not received this treatment were classified as emotionally disturbed. The results indicate that the emotional behavior of both the mothers and the infants can be altered significantly as a result of the social interaction inherent in the rearing process.

- NORMAL OFFSPRING
- NORMAL MOTHER
- EMOTIONALLY DISTURBED OFFSPRING
- EMOTIONALLY DISTURBED MOTHER

# How to use your Savings to beat down the cost of Borrowing



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## **What can you do for a Full Service bank?**

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## **In return, what can a Full Service bank do for you?**

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the kids to college. If you've established a good credit reputation with a Full Service commercial bank—chances are good that you can borrow the money there at far less cost than you'd have to pay elsewhere. On a \$2,000 loan, for example, you might save as much as \$100 in interest costs. This is true because interest rates for loans at Full Service banks are usually considerably lower than at most other types of financial institutions.

For another example, take *home loans*. Often, a Full Service bank can save you money because of lower fees, even though the actual interest rate may be the same as quoted by another financial institution.

## **What about the lower interest rate on savings?**

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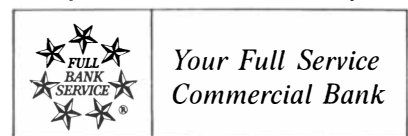
this only cuts you out of \$10 a year. Meanwhile, if you had taken advantage of the low-cost loan we mentioned earlier, you'd already be \$90 ahead—and you'd have a good bank in your corner.

If you're like many people, you'll borrow far more in your lifetime than you'll save. It figures that having to pay even a slightly higher rate on a loan will quickly wipe out any small gain you might make on your savings.

## **How do you get acquainted with a Full Service bank?**

Very simple. Just pick one that's handy to your home or work. (You can be sure it's a Full Service commercial bank if it offers both checking and savings accounts plus all types of loans.)

Then make this bank your financial headquarters. The rest comes easy.



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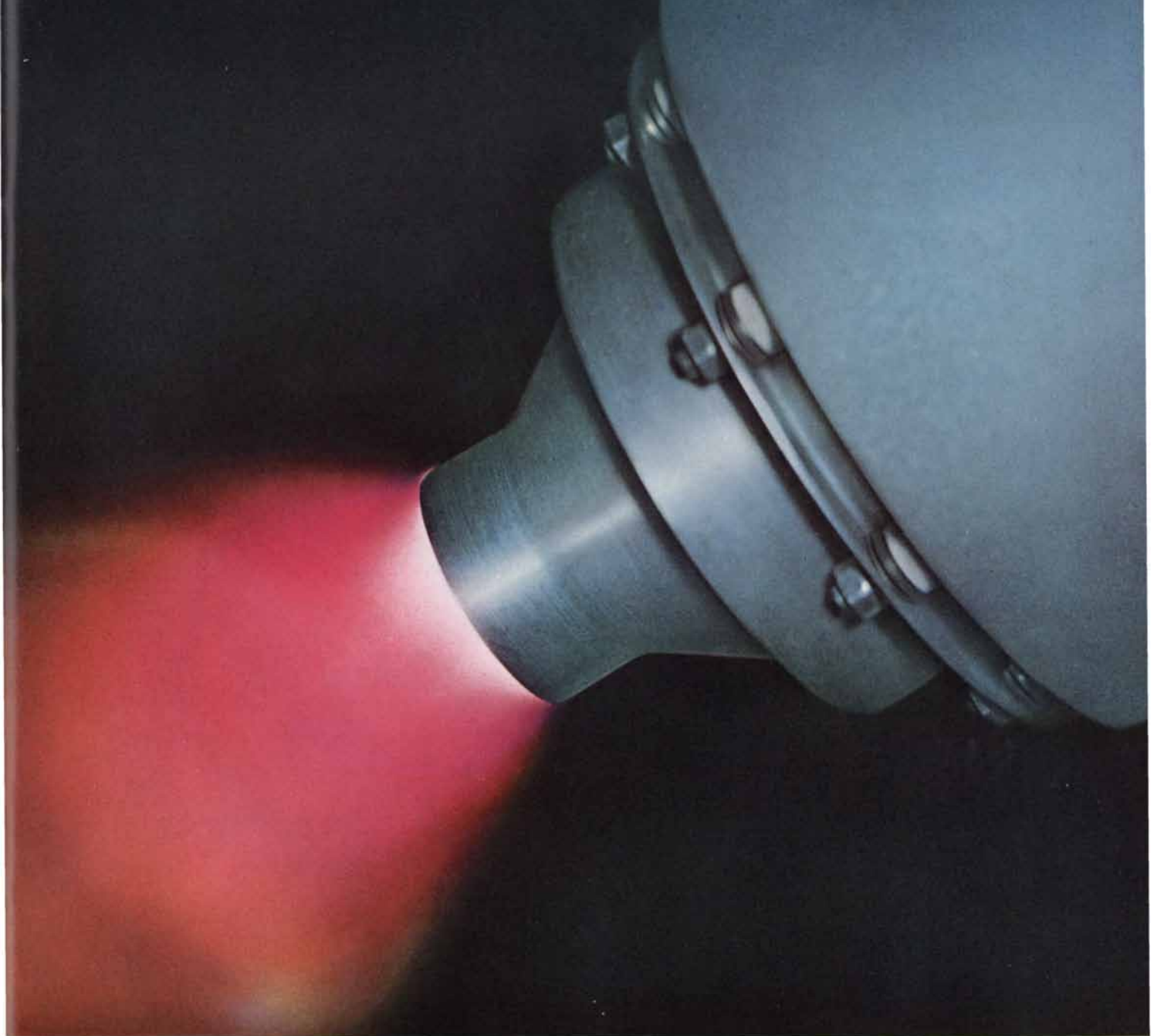


**REARING IN FREE ENVIRONMENT** tended to increase the adult activity scores of both normal (*top*) and emotionally disturbed rats (*bottom*), although the latter continued to show many of the characteristic signs of unstable behavior while in the free-environment box. Play behavior among the normal pups included much wrestling and nipping, whereas disturbed pups generally crowded into the corners of the box. Each box contains eight rats.

ferent mother-infant combinations. At weaning, and again at 50 days, both the mothers and the young of each combination were tested in the open field. In general the results of these tests showed that significant changes in the emotional behavior of both mothers and young occurred as a result of the social interaction inherent in the rearing process. Emotionally stable mothers that had mothered emotionally stable infants scored highest in the open-field tests, as did their infants, whereas emotionally disturbed mothers that had mothered emotionally disturbed infants scored lowest, along with their infants. Scores for the other two combinations ranged between these two extremes [see *bottom illustration on page 140*].

In the course of these experiments we noted that pups from litters of eight or more tended to score significantly lower on their activity tests than pups from smaller litters. This suggested that the effects of interaction with siblings might be as deserving of study as the effects of the mother-infant relation. Experiments with a variety of animals conducted by other investigators had, in fact, indicated that early social relations among infants are decisive in the development of normal peer relations in adult life [see "Social Deprivation in Monkeys," by Harry F. and Margaret Kuenne Harlow; *SCIENTIFIC AMERICAN*, November, 1962]. We proceeded, therefore, to test the effects of association withagemates after weaning on the later emotional behavior of our rats.

For these experiments we divided the infants into two groups, regularly subjecting the members of one group to handling during the first three weeks of life and leaving the other group unhandled, thereby ensuring that the former would later show a low emotionality score and the latter a high one. The usual laboratory procedure is to put the infants into laboratory cages after weaning and keep them there until they are tested in adulthood. It occurred to us, however, that the barren environment of the laboratory cage does little to improve the emotional state of the disturbed rats and probably contributes to their maladaptive stress-response in later life. We suspected that a "richer," or more complex, environment might have a therapeutic effect on some of the emotionally disturbed pups. Accordingly we constructed several large "free environment" boxes about four feet square that contained ramps, tunnels, platforms and plenty of food and water. In one box we placed 16 just-weaned pups that had



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INFANT EXPERIENCE (FIRST 25 DAYS)	POSTWEANING ENVIRONMENT (26 TO 50 DAYS)	DEFECATION SCORE ON OPEN-FIELD TEST (180 DAYS)
HANDLED	CAGE	8.83
UNHANDLED	CAGE	27
HANDLED	FREE ENVIRONMENT	.83
UNHANDLED	FREE ENVIRONMENT	21.38

**THERAPEUTIC EFFECT** of rearing in the free environment compared with rearing in laboratory cages shows up in the lowered defecation scores of both normal and emotionally disturbed rats at maturity. Normal rats were produced by a routine of daily handling in early infancy; unhandled infants tended to be less stable emotionally even as adults.

been handled in infancy; in another we placed 16 pups that had not received this treatment. An equal number of handled and unhandled pups were put into laboratory cages as controls. At 50 days all the animals were placed in laboratory cages and at 180 days they were tested in the open field. As expected, the rats handled during infancy adapted more normally to the unfamiliar test situation, registering higher activity scores and lower defecation scores than the unhandled rats. Within each group, however, the animals that had been reared in the free environment showed lower defecation scores than their controls, which had spent the same 25-day period in laboratory cages [see illustration above]. Apparently the free-environment experience provided an effective form of group psychotherapy in which the opportunity for a broader

range of social interaction had combined with the greater diversity of perceptual and motor experience to stimulate and develop the adaptive capacities of the emotionally disturbed rats.

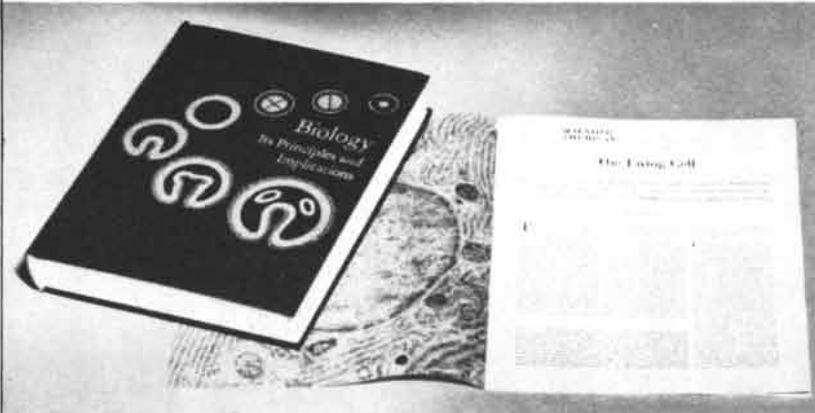
In our next experiment we set out to determine whether or not exposure to emotionally more stable rats in the free-environment situation would have a still greater therapeutic effect on the emotionally disturbed individuals. At weaning we put groups composed of equal numbers of handled and unhandled infants into the boxes; at 50 days we placed all these rats in laboratory cages with littermates of the same sex and at 76 days began open-field testing. To our surprise the effect of mixing the handled and unhandled infants was to make their emotional behavior even more dissimilar at maturity. The activity scores of the unhandled adults were lower and those

INFANT EXPERIENCE (FIRST 25 DAYS)	POSTWEANING FREE-ENVIRONMENT GROUPINGS (26 TO 50 DAYS)	ACTIVITY SCORE ON OPEN-FIELD TEST (76 DAYS)
HANDLED	ALL HANDLED	270
UNHANDLED	ALL UNHANDLED	210
HANDLED	EQUALLY MIXED	382
UNHANDLED		169

**DISPARITY** between the adult activity scores of handled and unhandled infants increased when both were reared together in the free-environment box. The passivity of the unhandled pups during this period apparently stimulated the handled pups to even greater activity, which in turn served to further increase the emotional disturbance of the former.

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of the handled adults were higher than the scores of the rats that had been subjected to the same experience with fellows of like emotional background [see bottom illustration on preceding page].

Our observations of these animals during their stay in the free-environment box indicated that the accentuation of differences was probably influenced by the play behavior of the pups. The handled animals moved about freely and explored the whole box, whereas the unhandled animals huddled in one or two corners. The emotionally freer pups also played more vigorously, wrestling and nipping each other and attempting to engage the emotionally disturbed rats in their activity. This undoubtedly increased the emotional disturbance of the latter. At the same time, the passivity of the unhandled rats apparently served to reduce the inhibitions of the handled rats and to encourage them to even greater activity.

The results of this experiment seem to run counter to the suggestion advanced by several child psychologists that putting an emotionally upset child in with a group of well-adjusted children will improve the emotional development of the upset child. The contrasting situation we observed with our rats was remarkably similar to the results of an experiment conducted by the child psychologist Fritz Redl several years ago. Redl introduced a boy with considerable masochistic tendencies into a group of normal boys who were all friends and members of the same club. In a short time the disturbed boy had stirred up in the others "more sadistic-pleasure temptations than they could cope with" and their violent aggressions disrupted the social relations of the entire group. We have conducted further experiments in which we have varied the ratio of handled to nonhandled rats, thus duplicating more closely the conditions of this analogous human situation. The results are as yet inconclusive.

With considerable confidence, however, we can say that social experience immediately after weaning will bring about relatively permanent changes in the emotional behavior of the adult animal. What is more, such experience can be deliberately designed in experiments to enhance or depress the capacity for adaptive emotional behavior. The combined techniques of stimulation in infancy and open-field testing provide the basis for many more experiments dealing with the function of social variables in the emotional development of individual animals.





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# MATHEMATICAL GAMES

*A discussion of helical structures,  
from corkscrews to DNA molecules*

by Martin Gardner

A straight sword will fit snugly into a straight scabbard. The same is true of a sword that curves in the arc of a circle: it can be plunged smoothly into a scabbard of the same curvature. Mathematicians sometimes describe this property of straight lines and circles by calling them "self-congruent" curves; any segment of such a curve can be slid along the curve, from one end to the other, and it will always "fit."

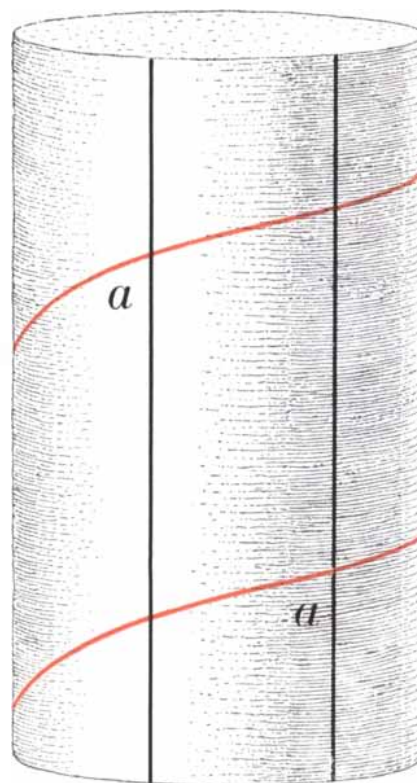
Is it possible to design a sword and its scabbard that are *not* either straight or curved in a circular arc? Most people, after giving this careful consideration, will answer no, but they are wrong. There is a third curve that is self-congruent: the circular helix. This is a curve that coils around a circular cylinder in such a way that it crosses the "elements" of the cylinder at a constant angle. The illustration at the right makes this clear. The elements are the vertical lines that parallel the cylinder's axis;  $a$  is the constant angle with which the helix crosses every element. Because of the constant curvature of the helix a helical sword would screw its way easily in and out of a helical scabbard.

Actually the straight line and the circle can be regarded as limiting cases of the circular helix. Compress the curve until the coils are very close together and you get a tightly wound helix resembling a Slinky toy; if angle  $a$  increases to 90 degrees, the helix collapses into a circle. On the other hand, if you stretch the helix until angle  $a$  becomes zero, the helix is transformed into a straight line. If parallel rays of light shine perpendicularly on a wall, a circular helix held before the wall with its axis parallel to the rays will cast on the wall a shadow that is a single circle. If the helix is held at right angles to the rays, the shadow is a sine curve.

Every helix, circular or otherwise, is an asymmetric space curve that differs from its mirror image. We shall use the

term "right-handed" for the helix that coils clockwise as it "goes away," in the manner of an ordinary wood screw or a corkscrew. Hold such a corkscrew up to a mirror and you will see that its reflection, in the words of Lewis Carroll's Alice, "goes the other way." The reflection is a left-handed corkscrew. Such a corkscrew actually can be bought as a practical joke. So unaccustomed are we to left-handed screw threads that a victim may struggle for several minutes with such a corkscrew before he realizes that he has to turn it counterclockwise to make it work.

Aside from screws, bolts and nuts, which are (except for special purposes) standardized as right-handed helices, most man-made helical structures come in both right and left forms: candy canes, circular staircases, rope and cable made of twisted strands, and so on. The same variations in handedness are found



*Circular helix (colored) on cylinder*



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Helical horns of the Pamir sheep have opposite handedness

in conical helices (curves that spiral around cones), including bedsprings and spiral ramps such as the inverted conical ramp in Frank Lloyd Wright's Guggenheim Museum in New York City.

Not so in nature! Helical structures abound in living forms, from the simplest virus to parts of the human body, and in almost every case the genetic code carries information that tells each helix precisely "which way to go." In fact, the genetic code itself is carried in single giant molecules of nucleic acid that always twist (so most biochemists believe today) in a right-handed helix. Moreover, since Linus Pauling's pioneer work on the helical structure of protein molecules, there has been increasing evidence that every giant protein molecule found in nature has a "backbone" that coils in a right-handed helix. In the case of both nucleic acid and protein, the molecule's backbone is a chain made up of units each one of which is an asymmetric structure of the same handedness. Each unit, so to speak, gives an additional twist to the chain, in the same direction, like the steps of a helical staircase.

Larger helical structures in animals that have bilateral symmetry usually come in mirror-image pairs, one on each side of the body. The horns of rams, goats, antelopes and other mammals are spectacular examples [see illustration above]. The cochlea of the human ear is a conical helix that is left-handed in the left ear and right-handed in the right. A curious exception is the tooth of the narwhal, a small whale that flourishes in arctic waters. This whimsical creature is born with two teeth in its upper jaw. Both teeth remain permanently buried in the jaw of the female narwhal, and so does the right tooth of

the male. But the male's left tooth grows straight forward, like a javelin, to the ridiculous length of eight or nine feet—more than half the animal's length from snout to tail! Around this giant tooth are helical grooves that spiral forward in a counterclockwise direction [see illustration below]. On the rare occasions when both teeth grow into tusks, one would expect the right tooth to spiral clockwise. But no, it too is always left-handed. Zoologists disagree on how this could come about. Sir D'Arcy Thompson, in his book *On Growth and Form*, defends his own theory that the whale swims with a slight screw motion to the right. The inertia of its huge tusk would produce a torque at the base of the tooth that might cause it to rotate counterclockwise as it grows [see "The Horn of the Unicorn," by John Tyler Bonner; *SCIENTIFIC AMERICAN*, March, 1951].

Whenever a single helix is prominent in the structure of any living plant or animal, the species usually confines itself to a helix of a specific handedness. This is true of countless forms of helical bacteria as well as of the spermatozoa of all higher animals. The human umbilical cord is a triple helix of one vein and two arteries that invariably coil to the left. The most striking instances are provided by the conical helices of the shells of snails and other mollusks. Not all spiral shells have a handedness. The chambered nautilus, for instance, coils on one plane; like a spiral nebula, it can be sliced into identical left and right halves. But there are thousands of beautiful molluscan shells that are either left- or right-handed [see top illustration on next page]. Some species are always left-handed and some always right-handed. Some go one way in one locality and



Helical grooves of the narwhal tooth are always left-handed

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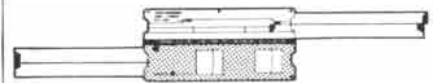
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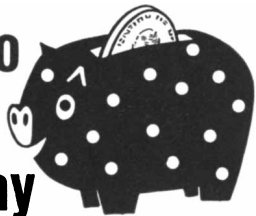


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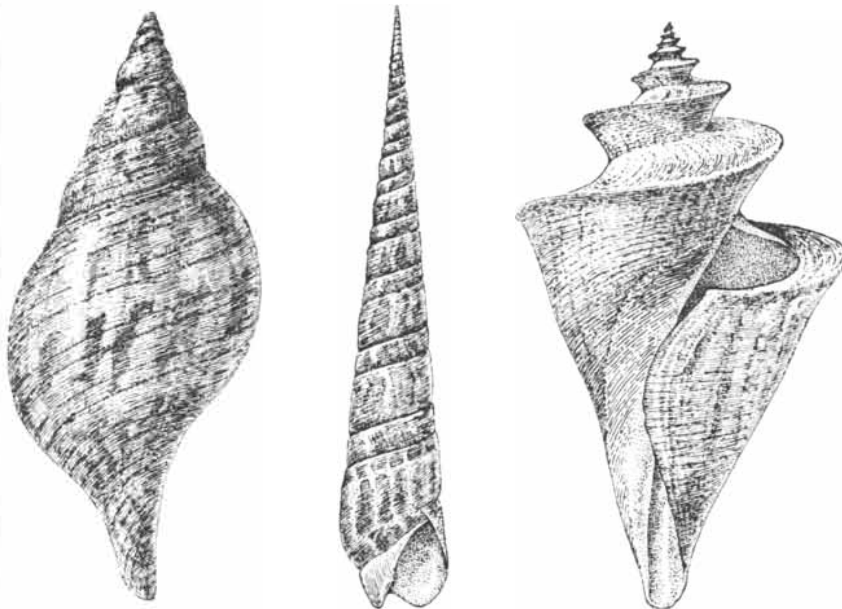
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Three molluscan shells that are right-handed conical helices

the other way in another. Occasional "sports" that twist the wrong way are prized by shell collectors.

A puzzling type of helical fossil known as the devil's corkscrew (*Daemonelix*) is found in Nebraska and Wyoming. These huge spirals, six feet or more in length, are sometimes right-handed and sometimes left-handed. Geologists argued for decades over whether they are fossils of extinct plants or helical burrows made by ancestors of the beaver. The beaver theory finally prevailed after remains of small beavers were found inside some of the corkscrews.

In the plant world helices are common in the structure of stalks, stems, tendrils, seeds, flowers, cones, leaves—even in the spiral arrangement of leaves and branches around a stalk. The number of turns made along a helical path, as you move from one leaf to the leaf directly above it, tends to be a number in the familiar Fibonacci series: 1, 2, 3, 5, 8, 13... (Each number is the sum of the preceding two numbers.) A large literature in the field known as "phyllotaxy" (leaf arrangement) deals with the surprising appearance of the Fibonacci numbers in botanical phenomena of this sort. (Many readers will be interested to know that a new mathematical journal called *The Fibonacci Quarterly* has just been founded. It is concerned entirely with technical and

recreational aspects of the Fibonacci series. The price is \$4 a year. Brother U. Alfred of St. Mary's College in St. Mary's College, Calif., is the managing editor; he will send a prospectus on request. The first issue proposes a new game called Fibonacci Nim.)

The helical stalks of climbing plants are usually right-handed, but thousands of species of twining plants go the other way. The honeysuckle, for instance, is always left-handed; the bindweed (a family that includes the morning glory) is always right-handed. When the two plants tangle with each other, the result is a passionate, violent embrace that has long fascinated English poets. "The blue bindweed," wrote Ben Jonson in 1617, "doth itself enfold with honeysuckle." And Shakespeare, in *A Midsummer Night's Dream*, has Queen Titania speak of her intention to embrace Bottom the Weaver (who has been transformed into a donkey) by saying: "Sleep thou, and I will wind thee in my arms./... So doth the woodbine the sweet honeysuckle/Gently entwist." In Shakespeare's day "woodbine" was a common term for bindweed. Because it later came to be applied exclusively to honeysuckle many commentators reduced the passage to absurdity by supposing that Titania was speaking of honeysuckle twined with honeysuckle. Awareness of the opposite handedness of bindweed and honey-



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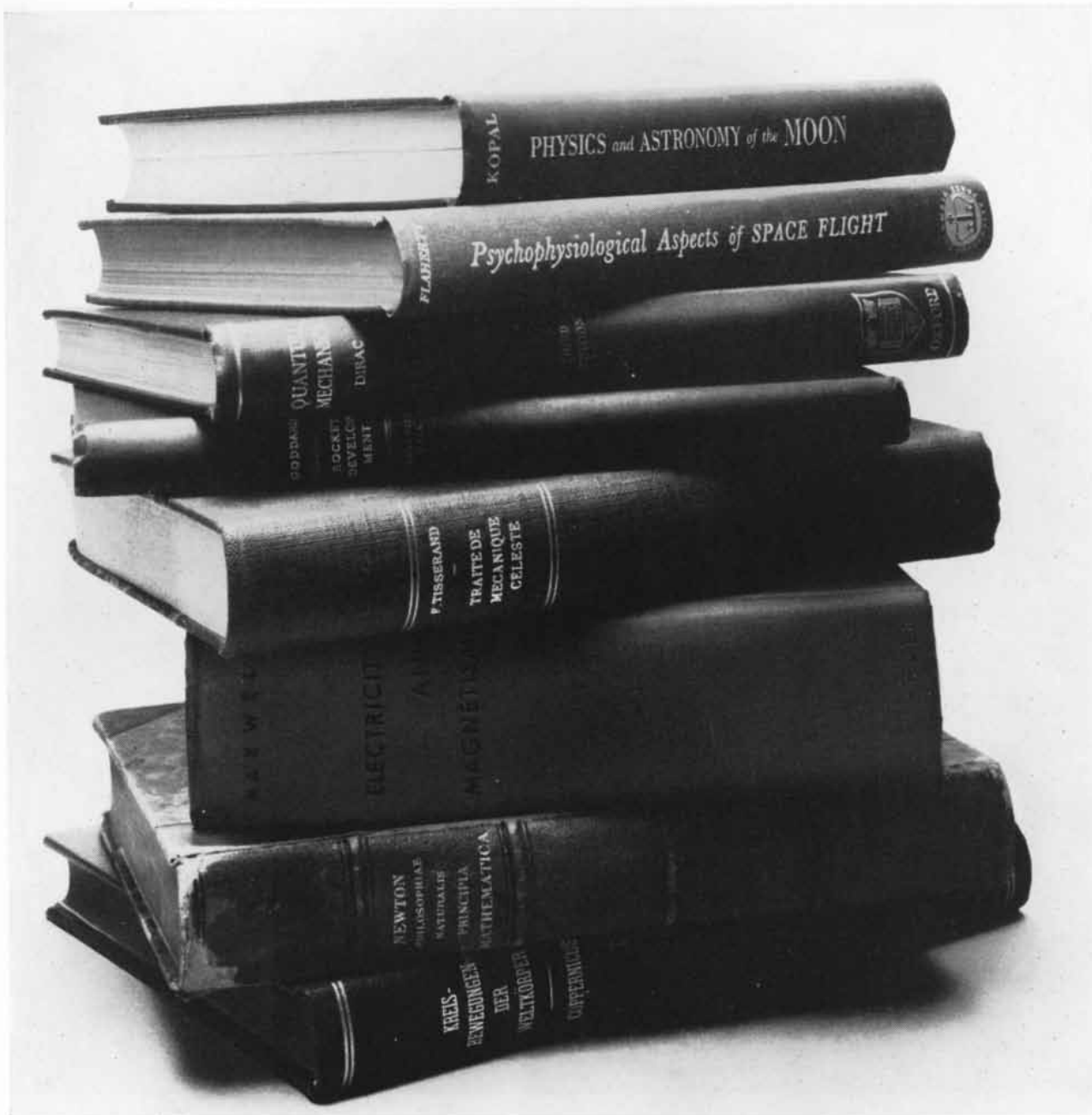
One skeptical auto maker put us through our paces proving that these Enjay Butyl body mounts soak up shock as well in December as they do in May. In the process, Enjay Laboratories set up a series of

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suckle heightens, of course, the meaning of Titania's metaphor.

More recently, a charming song called "Misalliance," celebrating the love of the honeysuckle for the bindweed, has been written by the British poet and entertainer Michael Flanders and set to music by his friend Donald Swann. With

Flanders' kind permission the entire song is reproduced below. (Readers who would like to learn the tune can hear it sung by Flanders and Swann on the Angel recording of *At the Drop of a Hat*, their hilarious two-man revue that made such a hit a few years ago in London and New York.) Note that

## MISALLIANCE

The fragrant Honeysuckle spirals clockwise to the sun  
And many other creepers do the same.  
But some climb counterclockwise, the Bindweed does, for one  
Or *Convolvulus*, to give her proper name.

Rooted on either side a door, one of each species grew,  
And raced toward the window ledge above.  
Each corkscrewed to the lintel in the only way it knew,  
Where they stopped, touched tendrils, smiled and fell in love.

*Said the right-handed Honeysuckle  
To the left-handed Bindweed:  
"Oh, let us get married,  
If our parents don't mind. We'd  
Be loving and inseparable.  
Inextricably entwined, we'd  
Live happily ever after,"*  
Said the Honeysuckle to the Bindweed.

To the Honeysuckle's parents it came as a shock.  
"The Bindweeds," they cried, "are inferior stock.  
They're uncultivated, of breeding bereft.  
We twine to the right and they twine to the left!"

*Said the counterclockwise Bindweed  
To the clockwise Honeysuckle:  
"We'd better start saving—  
Many a mickle makes a muckle—  
Then run away for a honeymoon  
And hope that our luck'll  
Take a turn for the better,"*  
Said the Bindweed to the Honeysuckle.

A bee who was passing remarked to them then:  
"I've said it before, and I'll say it again:  
Consider your offshoots, if offshoots there be.  
They'll never receive any blessing from me."

Poor little sucker, how will it learn  
When it is climbing, which way to turn?  
Right—left—what a disgrace!  
Or it may go straight up and fall flat on its face!

*Said the right-hand-thread Honeysuckle  
To the left-hand-thread Bindweed:  
"It seems that against us all fate has combined.  
Oh my darling, oh my darling,  
Oh my darling Columbine,  
Thou art lost and gone forever,  
We shall never intertwine."*

Together they found them the very next day.  
They had pulled up their roots and just shriveled away,  
Deprived of that freedom for which we must fight,  
To veer to the left or to veer to the right!

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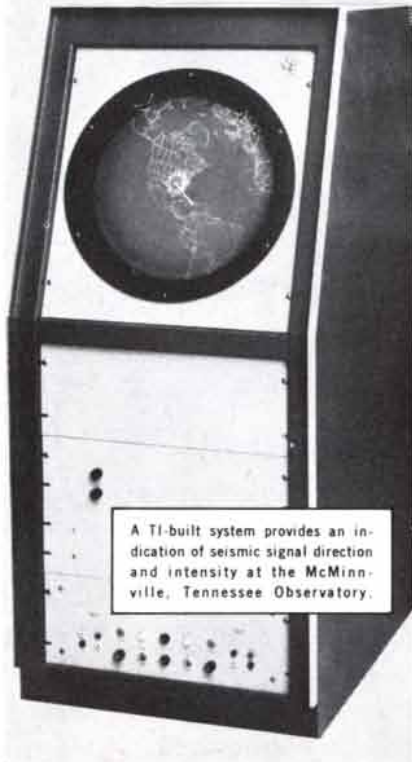


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# TI IS THERE



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Flanders' honeysuckle is right-handed, his bindweed left-handed. It is a matter of convention whether a given helix is called left- or right-handed. If you look at the point of a right-handed wood screw, you will see the helix moving toward you counterclockwise, so that it can just as legitimately be called left-handed. Flanders simply adopts the convention opposite to the one taken here.

The entwining of two circular helices of opposite handedness is also involved in a remarkable optical-illusion toy that was sold in this country about 30 years ago. It is easily made by twisting together a portion of two wire coils of opposite handedness [see bottom illustration on page 152]. The wires must be soldered to each other at several points to make a rigid structure. The illusion is produced by pinching the wire between thumb and forefinger of each hand at the left and right edges of the central overlap. When the hands are moved apart, the fingers and thumbs slide along the wire, causing it to rotate and create a barber's-pole illusion of opposite handedness on each side. This is continuously repeated. The wire seems to be coming miraculously out of the inexhaustible meshed portion. Since the neutrino and antineutrino are now known to travel with screw motions of opposite handedness, I like to think of this toy as demonstrating the endless production of neutrinos and their mirror-image particles.

The helical character of the neutrino's path results from the fusion of its forward motion (at the speed of light) with its "spin." Helical paths of a similar sort are traced by many inanimate objects and living things: a point on the propeller of a moving ship or plane, a squirrel running up or down a tree, Mexican free-tailed bats gyrating counterclockwise when they emerge from caves at Carlsbad, N.M. Conically helical paths are taken by whirlpools, water going down a drain, tornadoes and thousands of other natural phenomena.

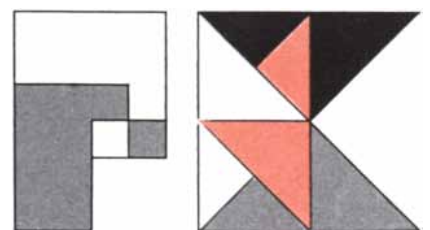
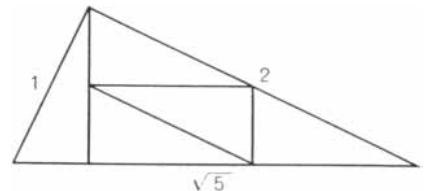
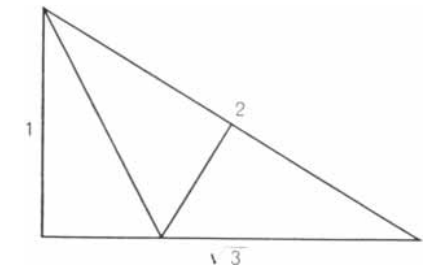
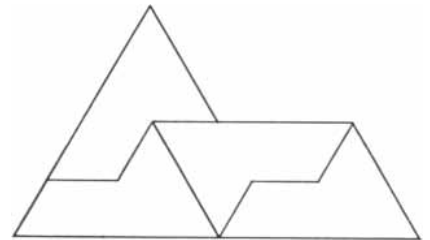
Writers have found helical motions useful on the metaphorical level. The progress of science is often likened to an inverted conical spiral: the circles growing larger and larger as science probes further into the unknown, always building upward on the circles of the past. The same spiral, a dark, bottomless whirlpool into which an individual or humanity is sliding, has also been used as a symbol of pessimism and despair. This is the metaphor that closes Norman Mailer's book *Advertisements for Myself*. "Am I already on the way out?" he asks. Time for Mailer is a conical helix of water flushing him down a cos-

mic drain, spinning him off "into the spiral of star-lit empty waters."

And now for a simple helix puzzle, the answer to which will appear in this department next month: A rotating barber's pole consists of a cylinder on which red, white and blue helices are painted. The cylinder is four feet high. The red stripe cuts the cylinder's elements (vertical lines) with a constant angle of 60 degrees. How long is the red stripe?

The problem may seem to lack sufficient information for determining the stripe's length; actually it is absurdly easy when approached properly.

Last month's problem of dissecting the sphinx is shown in the top illustration below. The next two illustrations show how to construct rep-3 and rep-5 triangles. The bottom illustration gives the solution to the two dissection problems involving stellated polygons. The first of these can be varied in an infinite number of ways; the solution shown here is the simplest.



Solutions to last month's puzzles



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O. C. Carmichael, Jr.  
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The building complex, shown above, is now under construction and will be The Associates new headquarters for nearly 600 branch offices throughout the United States and Canada.

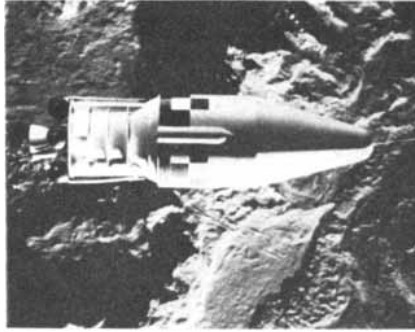
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Here, at Lockheed Missiles & Space Company's Space Communications Laboratory, scientists are re-investigating the possibility of using the moon to facilitate earth communications. Possibilities for the use of the moon as a relay station for earth-to-earth communications have been largely neglected because the moon's shape and rugged surface greatly distorted a return signal. But Lockheed research into the extension of communications on difficult communication channels, using techniques applicable to dispersive time variant channels, is making significant inroads into this problem.

Another area receiving intense study at Lockheed is satellite tracking of deep space probes. Since tracking accuracy



depends greatly on stations being as far from each other as possible, while retaining line-of-sight communications, Lockheed is studying the use of two earth-orbiting satellite tracking stations, 8000 miles apart. Not only would great accuracy be gained by the separation, but it would be further enhanced by the positioning of the stations above the earth's atmosphere, thus eliminating atmospheric distortion.

Examples of other research projects being pursued by Lockheed in the communications area include: Random multiplexing, satellite readout techniques, scatter communications, radar mapping, submarine tracking, modulation of optical energy, communications over multipath channels, and learning systems.

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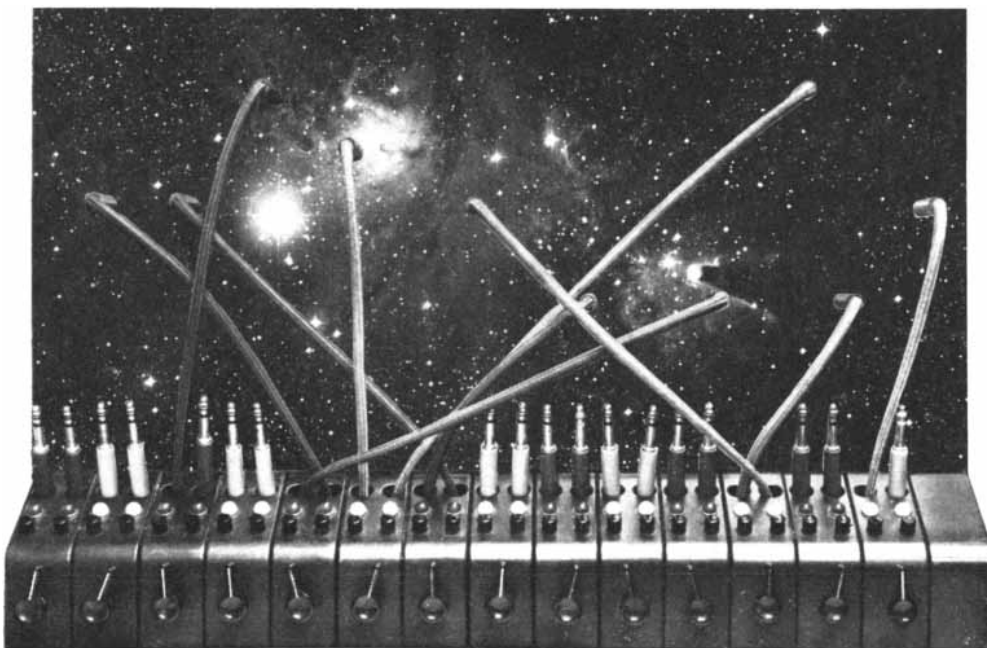
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# THE AMATEUR SCIENTIST

## *A simple analogue computer that simulates Pavlov's dogs*

Conducted by C. L. Stong

The investigation of the conditioned reflex requires formidable preparations if the experimenter wants to follow the methods used by the Russian physiologist I. P. Pavlov, who trained dogs to salivate when they heard a sound associated with food. To protect the dog from distracting sounds, lights, vibrations and odors, Pavlov made the walls of his laboratory eight feet thick and surrounded them with a deep, straw-filled moat. The animal chamber occupied a space near the center of the building and isolated from the adjoining control room [see top illustration on next page]. An instrument panel in the control room enabled Pavlov to manipulate the dog's environment by remote control, to present the animal with stimuli and observe its telemetered responses. He prepared the dog for the experiment by terminating the duct of the parotid gland in a small cheek incision and attaching to the opening a miniature flow meter with which to monitor salivation. Pavlov's laboratory could be duplicated for about \$200,000 by anyone who is reasonably handy with a saw and hammer. Those willing to settle for a close simulation of Pavlov's results can save a lot of time and money by substituting a small analogue computer for the laboratory and dog. The apparatus, which resembles Pavlov's control panel, has been designed by Howard S. Hoffman of Pennsylvania State University primarily as a teaching device in the field of experimental psychology. It is the size of a small table radio and can be constructed in a single evening at a cost of only about \$30.

"The analogue laboratory," Hoffman writes, "gives students some firsthand experience in conditioning research. Under ordinary circumstances students have only limited access to live-animal

experimentation. They read about experiments in conditioning and they may even observe portions of an experiment, but time in the full-scale laboratory is ordinarily scheduled only for qualified research workers.

"Before undertaking the construction of an analogue laboratory it is helpful to examine the problems Pavlov confronted at the beginning of his brilliant experiments. His initial observations were basically simple: when food is introduced into the mouth of a hungry dog, the animal begins to salivate. Pavlov also observed that occasionally the flow of saliva begins prior to the actual insertion of food into the dog's mouth. These 'spontaneous' secretions were exceptions to his previously formulated account of the mechanisms responsible for the digestive activity of dogs. Moreover, they suggested a technique for the experimental analysis of fundamental mechanisms involved in learning.

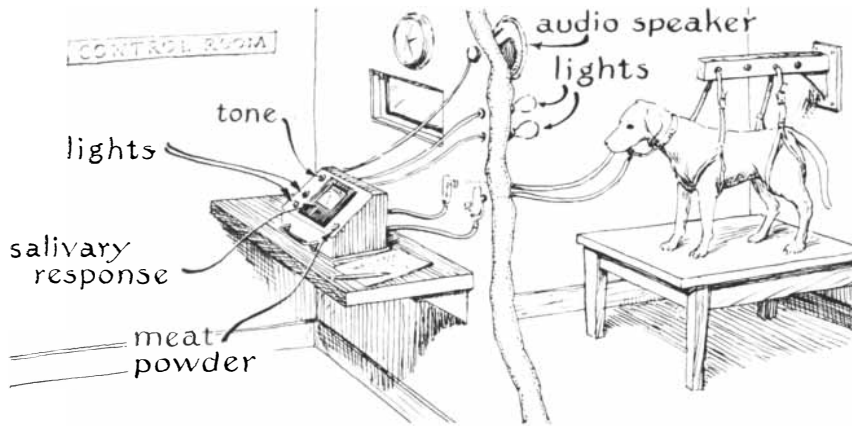
"Pavlov reasoned that certain unspecified stimuli were serving to evoke the salivary reaction. If this was indeed the case, it appeared that such stimuli had gained control over salivation by some process as yet little understood. Perhaps the sight of the experimenter or the sound of his movements reminded the dog of food. The explanation seemed obvious, and to a man of lesser scientific stature than Pavlov it might have been acceptable. To Pavlov, however, an explanation of this sort was both deceptive and distasteful. It was deceptive because it really explained nothing. To assume that the dog was 'reminded of food' was to substitute one mysterious process for another. The explanation was distasteful because it implied the action of mechanisms that were unlikely to provide a quantitative account of these puzzling responses. As a scientist Pavlov asked: 'What stimuli cause the salivation? How do they acquire their control of the behavior and what quantitative relations are involved?' He recognized that under normal circumstances the stimuli were constantly shifting and changing and could not be identified by an undisciplined search. To simplify the problem,

Pavlov designed an experiment to control such variables as light, sound and other factors in the environment as well as the availability of food. The thoroughness of his preparations is indicated by the fact that when the dog in the experimental chamber was loosely restricted for 10 minutes, all spontaneous salivation ceased; the dog salivated only when food (in the form of a meat powder) was presented. In short, Pavlov had succeeded in gaining control of the animal's spontaneous secretions and could begin his analysis of the responsible mechanisms.

"The analogue laboratory [see bottom illustration on next page] was conceived to represent the control room of Pavlov's laboratory. When the button marked 'Meat powder' is depressed, for example, the meter on the face of the instrument promptly indicates an appropriate salivary response as though real meat powder were being presented to a living dog in a full-scale laboratory. The operation of the 'Tone' switch and those marked 'Green' and 'Yellow' simulate the presentation of a tone or of colored lights. As in the case of the meat-powder button, the operation of these controls evokes simulated responses that would be expected if equivalent stimuli were presented to a living animal.

"The apparatus is based on the electrical characteristics of circuits composed of resistances, capacitors and switches. The rate at which a capacitor acquires charge when it is connected to a battery or to a previously charged capacitor depends principally on its size and the resistance of the circuit, just as the time required to fill a container with water varies with its size and the resistance presented to the inflow by the plumbing. In the case of capacitors the charging rate is maximum at the beginning and diminishes as full charge is approached. Similarly, capacitors discharge at maximum rate when first connected to a load circuit; the rate diminishes as discharge approaches completion. Such nonlinear characteristics are observed in aspects of animal behavior. For example, a dog takes disproportionately greater interest





Pavlov's laboratory

in food at the beginning of its meal than it does after it has eaten. Good capacitors can also retain charge, much as the brain stores sense impressions, and can therefore be made to function as memory units. In the analogue laboratory an appropriate pattern of such characteristics has been built into a circuit that simulates the behavior of Pavlov's dog and the remote-control apparatus [see illustration on page 162].

"The design represents a compromise between practical and theoretical considerations. The object was to devise an instrument that would duplicate a wide range of phenomena associated with conditioning, and to keep the cost low. The result is an apparatus that performs well, is inexpensive, rugged and easy to build. It will operate continuously for about three years on a single dry battery. The operation of the circuit centers in the capacitors C7 and C8, which charge continuously through the resistor R9. When the meat-powder switch is operated, C7 discharges through the meter and C8 through R6. When either a light switch or the tone switch is operated in conjunction with the meat-

powder switch, C7 discharges through the meter and the charge on C8 is transferred through R6 to the capacitors controlled by that switch. Once a charge has been placed on the capacitors that are associated with a given switch, the experimenter can discharge the capacitor to the right through the meter by closing the switch. When the switch is released, the capacitor to the left discharges into the capacitor to the right until both attain equal charge.

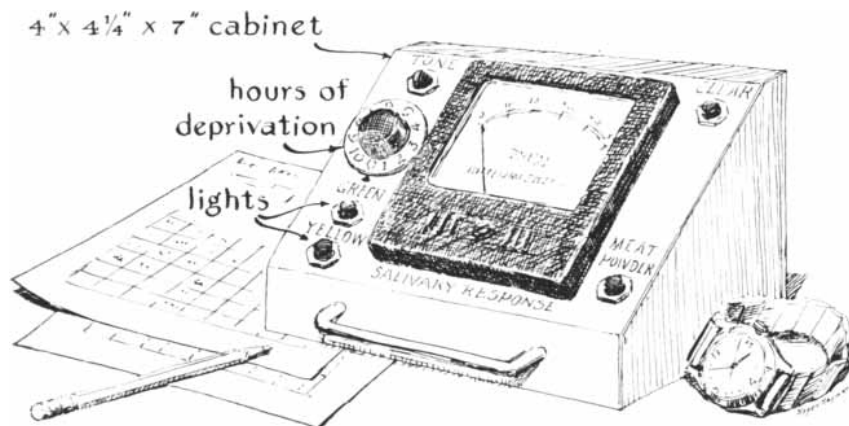
"The operating procedure requires a watch equipped with a second hand, a notebook and graph paper for tabulating and analyzing results. With these materials at hand, depress the 'Clear' switch (S5) in conjunction with switches S1, S2 and S3. This simulates placing a naive dog in the experimental chamber. Then set the 'Hours of deprivation' dial to 10. This establishes the number of hours the simulated dog has been deprived of food. Now depress the meat-powder button. Note the prompt response of the meter. Record the peak amplitude of the response, arbitrarily taking the meter reading as the number of 'drops' of saliva. When the amplitude

begins to fall, release the switch and after a few seconds 'present' the meat powder again. Observe that the second exposure to meat powder evokes somewhat less response. Next operate the tone switch and observe that no response follows. The sequence indicates that meat powder is an unconditioned stimulus for salivary response. It evokes salivation even though the experimenter has not trained the dog. Note also that the repeated presentation of meat powder to even a hungry dog—in this case one that has been deprived of food for 10 hours—produces successively smaller responses. One would not expect the tone to evoke a response because in this sequence we are working with a dog that has not been conditioned to associate the sound of a bell with food. When plotted, the results resemble the top curve in the accompanying set of three schematic graphs [top of page 164].

"The results differ when the tone is sounded a fraction of a second before meat powder is presented and continued so that both stimuli overlap in time. This sequence is shown in the second graph. The initial salivary response again appears with the presentation of meat powder. But the effects of the paired stimuli appear with the second trial. Tone now evokes salivation even before the meat powder is presented. This reaction becomes increasingly pronounced as the experiment continues. It is a conditioned response, one that will last for an appreciable period. In humans conditioned responses have persisted for at least 16 weeks and in dogs for more than two years.

"In the case of the analogue laboratory, time alone causes little reduction in the strength of a conditioned response; typically a decline of 10 per cent is observed after the apparatus has remained idle for 12 hours. As with living organisms, the strength of a conditioned response in the analogue laboratory can be reduced (extinguished) by withholding the unconditioned stimulus and repeatedly presenting the conditioned response, in this case by presenting the tone repeatedly in the absence of meat powder, as shown in the third graph. Observe that each presentation of tone evokes a diminished response. These reactions are similar to those observed in living organisms.

"To obtain an overview of the conditioning process clear the apparatus and, with the dog 10 hours hungry, depress first the tone button and then the meat button as in the first experiment. After 15 seconds depress the tone button again; when the conditioned response



Analogue laboratory

Basic Research at Honeywell  
Research Center  
Hopkins, Minnesota



# Correlation of Mechanical Properties and Microstructure of Polytetrafluoroethylene

Metallurgical techniques applied to the study of a polymer have enabled scientists to correlate the mechanical properties with its microstructure leading to possible improvements in its properties.

Polytetrafluoroethylene (PTFE) has the lowest coefficient of friction of any solid. Being chemically inert it is also impervious to almost everything except liquid metals. These characteristics have prompted its use in many design situations. PTFE, however, has a high degree of cold flow, low tensile strength and low hardness limiting its applications.

The chemists have clearly described PTFE's molecular properties. Its mechanical properties as measured by the engineer are readily available.

It now appears that the techniques of the metallurgist may be useful in determining what mechanical phenomena occur in PTFE under varying conditions which in turn may lead to improving its properties by changing its microstructure. The goal is to correlate mechanical properties with microstructure and propose a physical model.

Studies of the fracture surface of PTFE, made heretofore by Bunn and his associates, have indicated a structure consisting of a polycrystalline aggregate having individual crystallites of long chain molecules assembled side-by-side to form fairly thin sheets.

Since PTFE normally contains from 20% to 50% non-crystalline material, a more specific definition of the compound's microstructure requires a more definite indication of where the non-crystalline material is located.

Honeywell scientists have made a number of experiments which throw further light on the microstructure of PTFE.

Fracture surfaces were obtained by impacting the specimens at liquid nitrogen temperatures. These surfaces were replicated with collodion. This collodion layer was then shadowed with chromium and

carbon-backed in a vacuum chamber for observation with an electron microscope.

The first phenomenon observed was the variation in the size of the band structure or crystallites induced by varying the cooling rate from the sintering temperature. Quenching in iced water produced crystallites averaging  $0.2\mu$  by  $10\mu$ . Cooling at  $180^\circ\text{C}$  per hour resulted in crystallites averaging  $0.4\mu$  by  $50\mu$ . Cooling at  $150^\circ\text{C}/\text{hr}$ . produced dimensions of  $1\mu$  by  $100\mu$ . At all cooling temperatures, however, the dis-

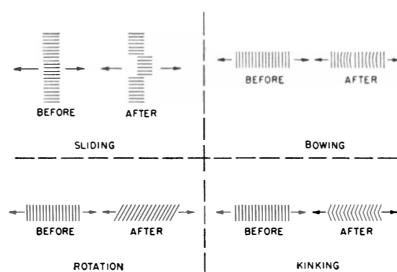


Illustration A

tance between the striations of the crystallites remained at approximately 200 Å.

In the course of the deformation experiments at room temperatures, comparison was made of specimens before and after deformation. This revealed two general types of distortion within a band. First, there was a relative displacement between the striae in the band; second, there was a change in the geometrical shape of the striae.

As shown in diagrammatic illustration A, these deformations took the form of sliding, rotation, bowing and kinking. Sliding occurred when the tensile axis was nearly

parallel with the striae; rotation was more common when the striae were perpendicular to the stress. Incidentally, neither of these cases involved a distortion of the individual striae. Bowing and kinking, although present, appeared to a lesser degree.

However, when the temperature was changed bowing and kinking became more pronounced. At  $-196^\circ\text{C}$ , only kinking and bowing occurred; at  $-70^\circ\text{C}$  kinking, bowing and sliding were in evidence; at  $0^\circ\text{C}$  all four modes were present (kinking, bowing, sliding and rotation).

An interesting feature of the microstructure of the deformed PTFE was the manner in which the striae themselves responded to stress. They either underwent bowing or kinking or slipped past one another. There was no indication that the individual striae had ruptured.

The fact that the striae slipped easily past one another indicated the presence of a finite layer between the striae which deformed very readily. This and other observations led to the proposal that the band structure which constitutes PTFE consists of two phases, with the crystalline striations or platelets separated from one another by a viscous non-crystalline matrix.

Continued research should eventually lead to methods of improving the mechanical properties of PTFE. It may also provide a better understanding of other polymers, elastomers and epoxy resins.

If you are engaged in scientific work involving PTFE and wish to know more about Honeywell's research in this area, you are invited to correspond with Mr. Charles J. Speersneider, Honeywell Research Center, Hopkins, Minnesota.

If you are interested in a career at Honeywell's Research Center and hold an advanced degree, you are invited to write Dr. John Dempsey, Director of Research at this same address.

## Honeywell



First in Control

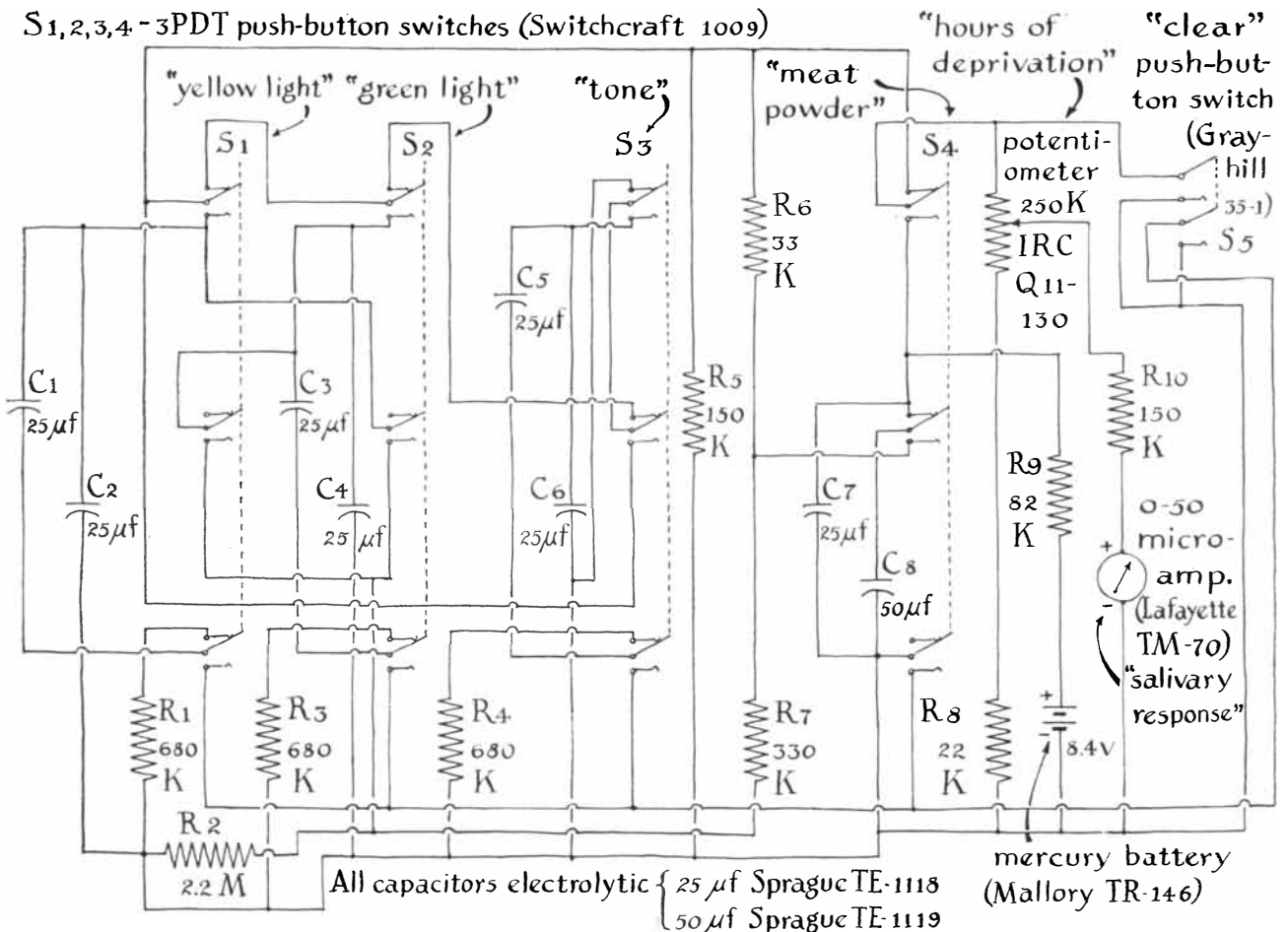
reaches peak amplitude, record it, quickly depress the meat button, hold both buttons down until the unconditioned response peaks and quickly release both buttons. Repeat every 15 seconds for eight additional trials. Plot the results. Then extinguish the conditioned response: depress the tone button alone until peak amplitude is reached and record that peak. Do this for 10 trials and plot the results. The acquisition and extinction plots should resemble the large curves in the accompanying graphs [bottom of page 164]. The colored curves placed beside them for comparison give the results of conditioning experiments with human subjects. In the experiments with humans a tone was paired with an aversive stimulus (a mild electric shock). The response consisted of changes in the electrical resistance of the skin, a phenomenon known as galvanic skin response. It is a sensitive index of emotional reactions that interests psychologists because it sheds light on the mechanisms underlying the learning of fear and anxiety. Observe that with

the analogue laboratory, as in the experiment with humans, the largest effects during both conditioning and extinction occurred during the early trials.

"The analogue laboratory enables one to investigate the variables that affect the acquisition of a conditioned response. Experiments with the instrument show that the timing between the presentation of the two stimuli (the 'interstimulus interval') and the interval between presentations (the 'intertrial interval') [shown in color in middle graph at top of page 164], as well as the duration of the stimuli and the concurrent motivational level (the hunger of the dog), all affect conditioning substantially. Similar effects have been observed in experiments with live subjects. In general the instrument yields reproducible results when a given set of operations is repeated. Certain effects can be obscured by random errors in timing and recording, however. This is an advantage when the apparatus is used as a teaching device: it requires the experimenter to decide whether or not a given observation rep-

resents a fortuitous configuration of random errors, and it requires him to devise experiments that will reliably eliminate such results.

"One approach to coping with random error involves averaging data from identical experiments with several groups of subjects. For example, the effect of altering the intertrial interval can be explored by running an experiment on three groups of dogs. The analogue laboratory is cleared and set for '10 hours hungry,' and a series of runs is made with meat and tone for the first group of animals at an intertrial interval of three seconds. Identical runs are then made with groups at intertrial intervals of 10 and 20 seconds. If the results are carefully tabulated and plotted, the curves will resemble those of the accompanying graph [top of page 166]. The colored inset graph depicts the behavior of humans in a comparable experiment that required the subjects to learn to hold a stylus on a small disk fastened near the edge of a rotating turntable. In spite of gross differences in procedure the data are strik-



All resistors IRC fixed carbon composition, 10%, 1/2 watt

Schematic diagram of analogue laboratory circuit

ENGINEERS • SCIENTISTS



## One big systems field known only to a handful of engineers (...outside of PAN AM's Guided Missiles Range Division)

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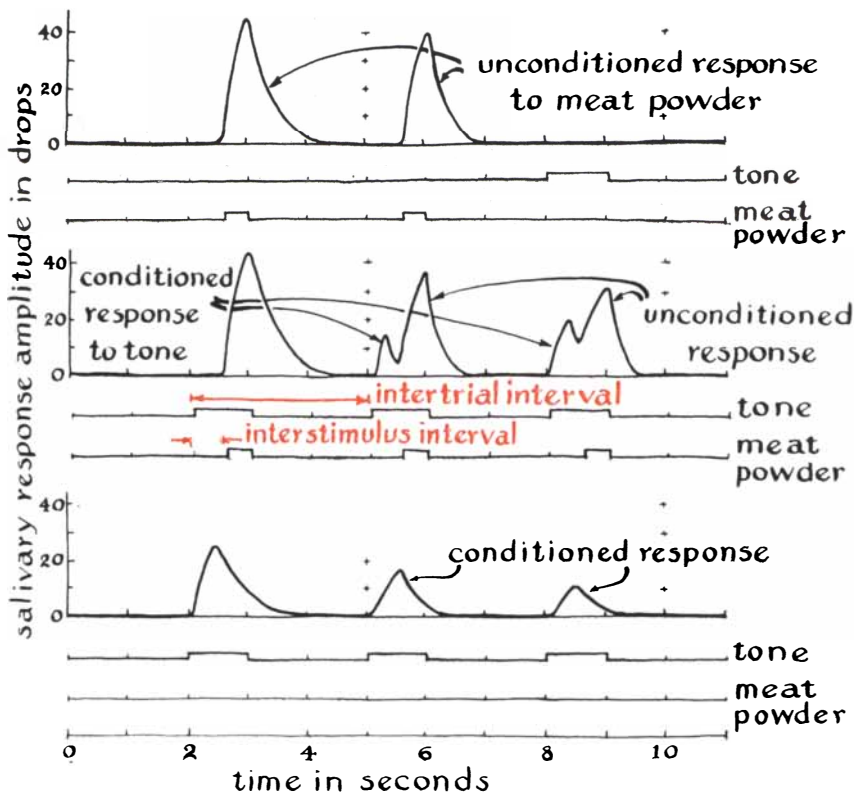
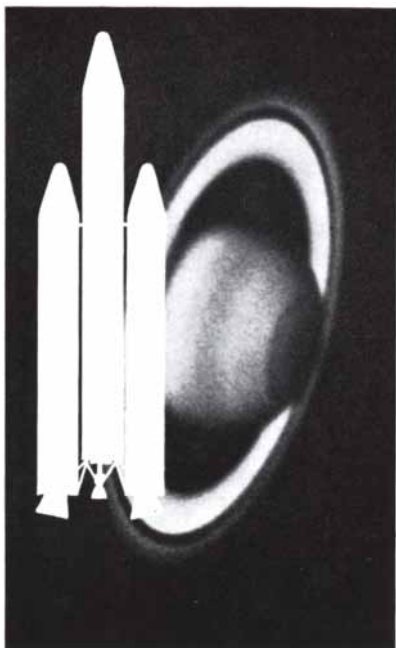
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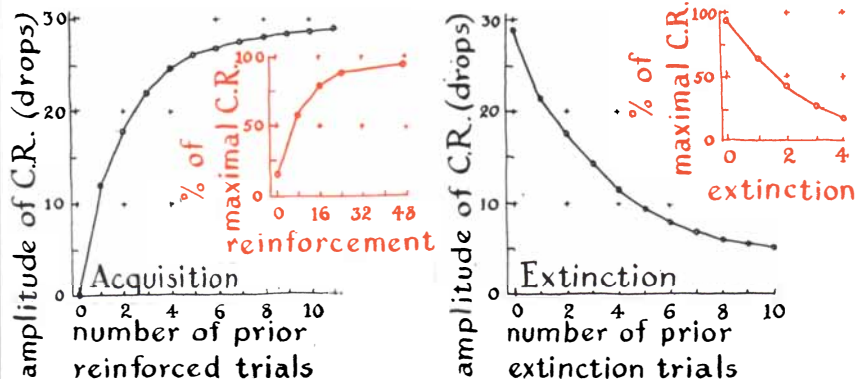
Unconditioned response, conditioning and extinction of conditioning

ingly similar. Both experiments tell the same story: Spacing the trials facilitated learning, whereas massing the trials interfered.

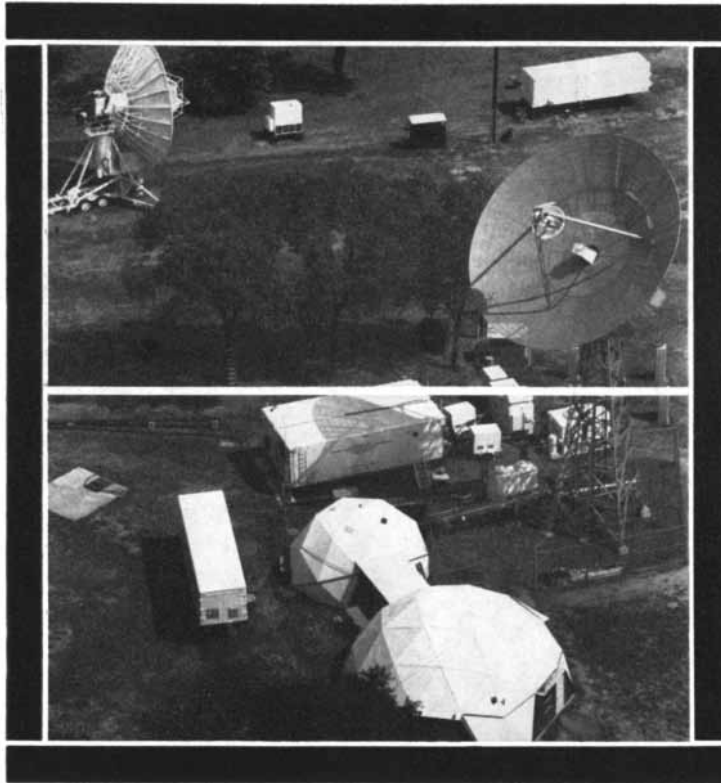
“The device can also be used to explore the effects of the intertrial interval on the course of extinction, as shown in another graph [bottom of page 166]. The inset depicts the extinction of conditioning in humans, in this case a conditioned eyelid response. In both experiments the massing of trials appears to have speeded the process of extinction.

“What happens when a rest period is injected into a period of concentrated learning? Typically it exerts a facilitating effect, called ‘reminiscence.’ As can

be observed with the analogue laboratory, a rest interval after a conditioned response has reached maximum intensity produces an initial rise in the amplitude of the conditioned response during subsequent conditioning trials, followed by a gradual decline to the pre-rest level. The effect is most pronounced when trials are massed and increases as the duration of the rest is increased. When a rest interval is introduced following a series of extinction trials, it is frequently observed that the response exhibits partial recovery. In general the magnitude of this phenomenon, known as spontaneous recovery, is influenced by the previous level of conditioning, the num-



Course of acquisition and extinction of conditioned response



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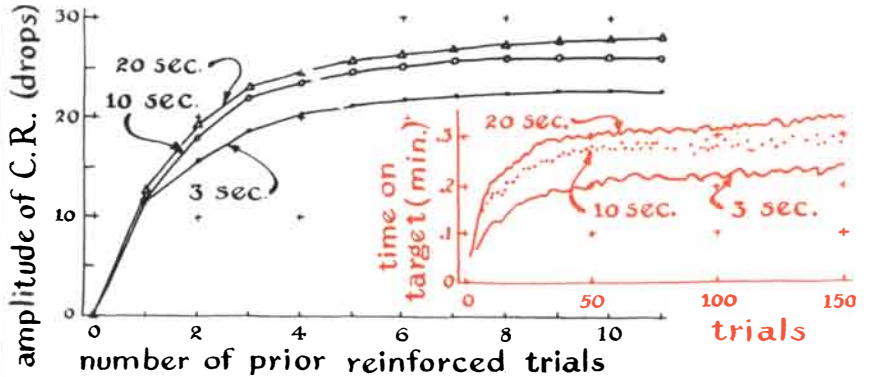
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Effect of intertrial interval on acquisition

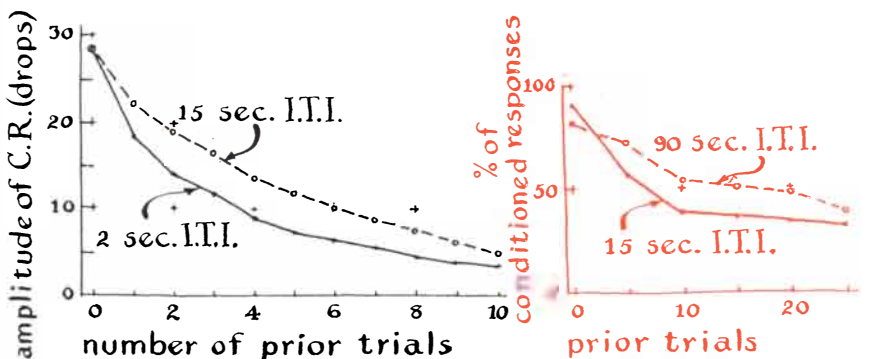
ber of prior extinction trials and the length of the recovery interval.

"If a green or yellow light is used in place of the tone as the conditioned stimulus, the results remain virtually identical. Once a stimulus has acquired the capacity to elicit a conditioned response, however, it can be used to bring the response under the control of a second stimulus. This phenomenon is called higher-order conditioning. It was first described by Pavlov in 1927. Experiments on higher-order conditioning can be conducted by developing a conditioned response to tone and then using the tone, rather than meat powder, to condition a response to one of the lights.

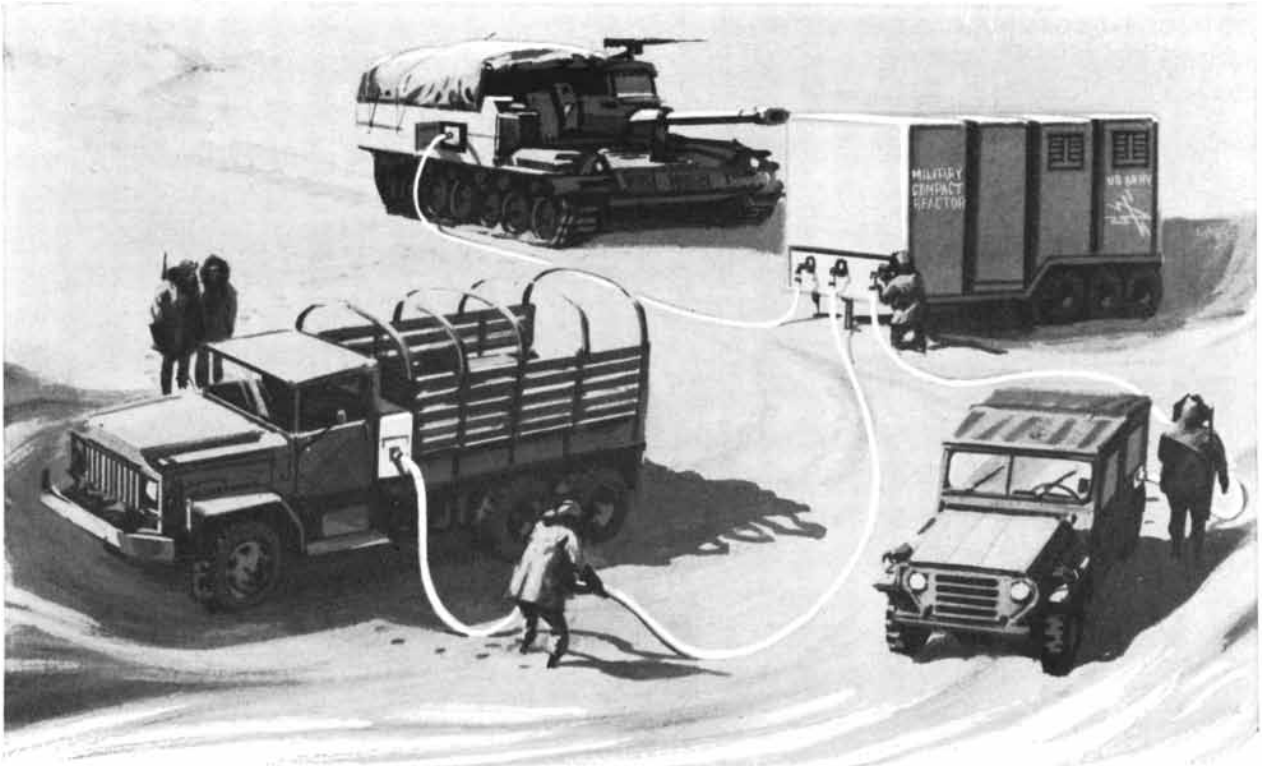
"When a given stimulus has acquired the capacity to evoke a given response, stimuli like it frequently evoke the same response. This phenomenon, called stimulus generalization, was also described by Pavlov in 1927 and has since become the subject of numerous experiments. It can be examined with the analogue laboratory by conditioning a response to a given stimulus and then testing the response by presenting one of the other stimuli. In the analogue laboratory stimulus generalization occurs between the lights but not between the tone and the lights. This is consistent with Pav-

lov's observation that stimulus generalization can usually be expected between closely related stimuli.

"These experiments illustrate the variety and scope of research experience that can be provided by the analogue laboratory, but they do not exhaust its possibilities. Anyone who builds the device is likely to find his greatest satisfaction in designing, conducting and analyzing his own experiments. Since research in psychology (or in any scientific discipline) never proceeds best in an intellectual vacuum, it is well to do some reading in the field. Periodicals such as the *Journal of Experimental Psychology, Comparative and Physiological Psychology and Experimental Analysis of Behavior* are strongly recommended, as are the references listed in 'Bibliography' [page 183]. Above all, do not make the mistake of assuming that an experiment run with the analogue laboratory is equivalent to one performed with an animal in a full-scale laboratory, and do not allow simulated results to strengthen or weaken confidence in conclusions based on conventional research. Any differences between 'real' results and simulated data serve to remind one that the analogue laboratory is not a perfect replica of reality."



Effect of intertrial interval on extinction



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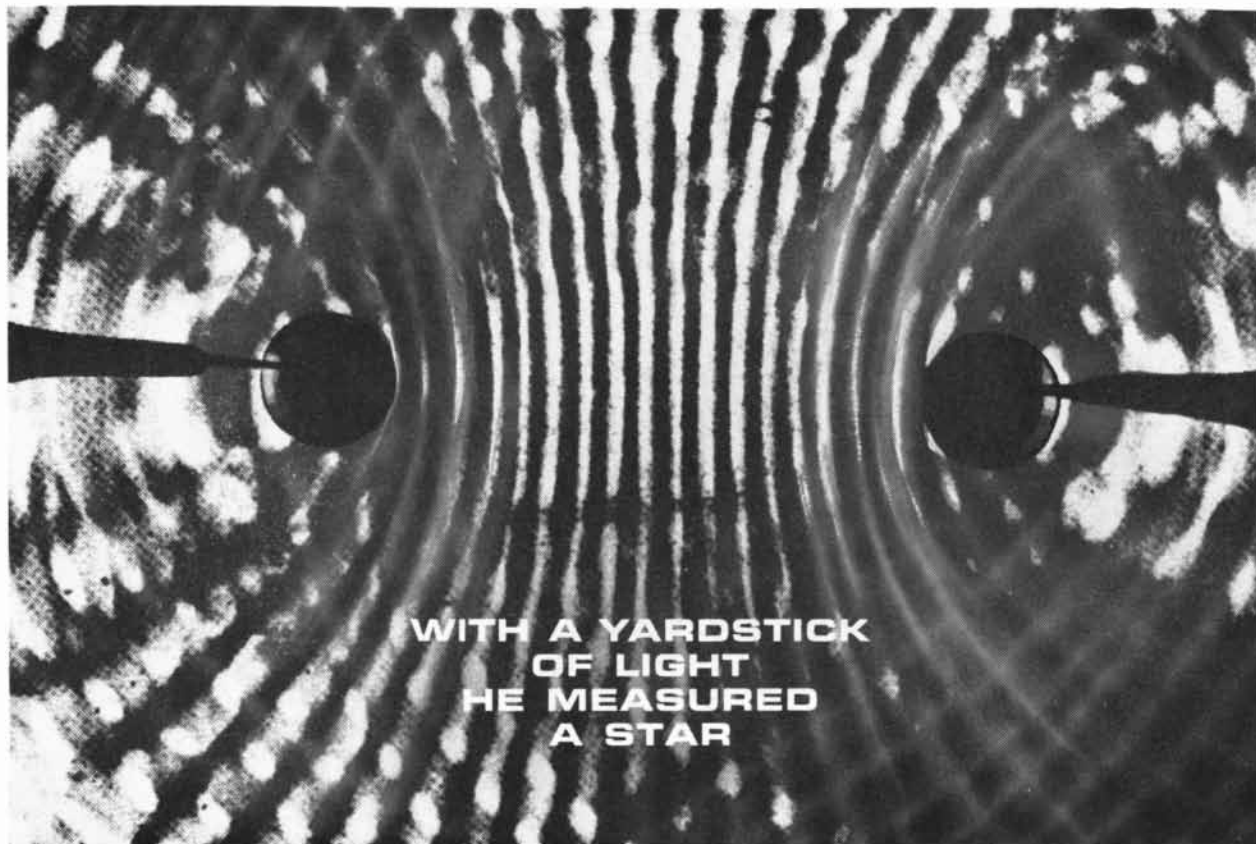


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# BOOKS

## *Leonardo da Vinci's scientific interests as a clue to the character of his genius*

by J. Bronowski

THE WORLD OF LEONARDO DA VINCI:  
MAN OF SCIENCE, ENGINEER, AND  
DREAMER OF FLIGHT, by Ivor B. Hart.  
The Viking Press (\$7.95).

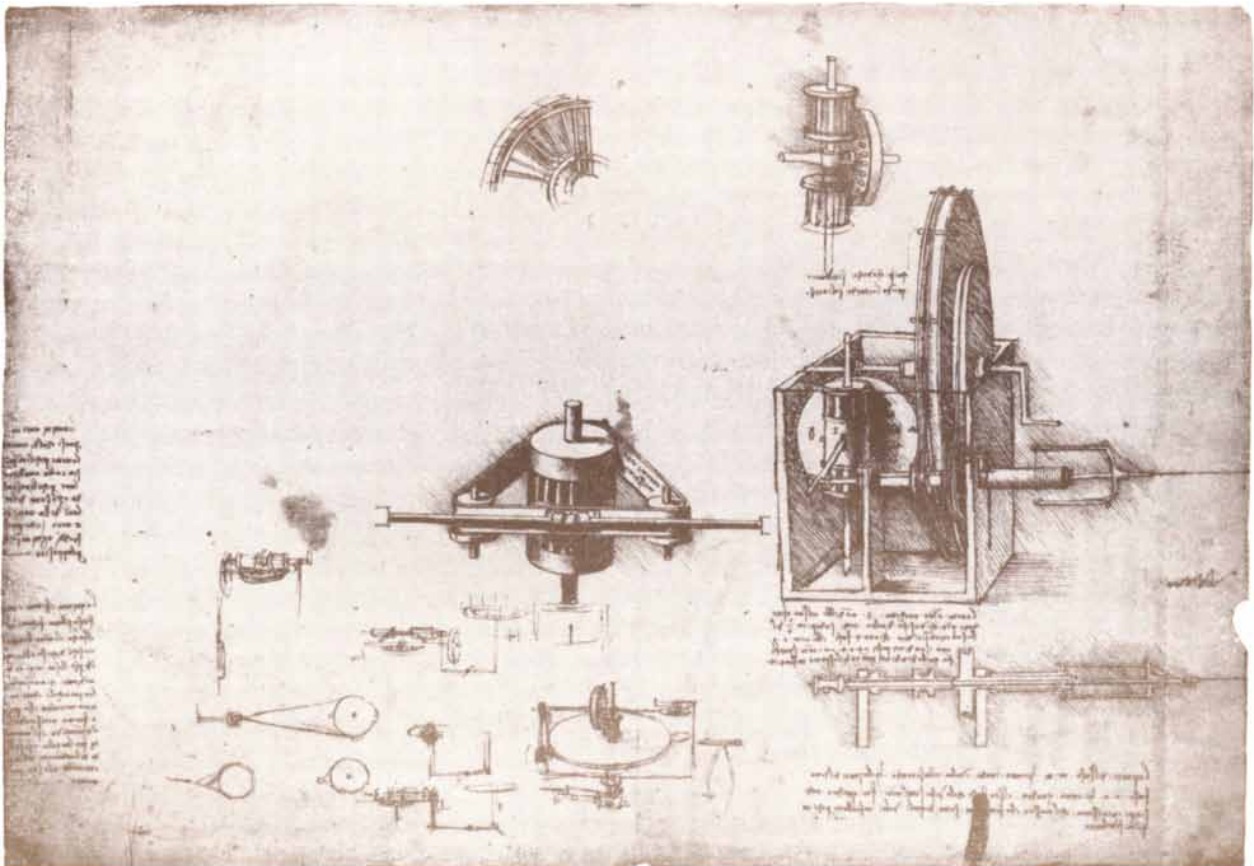
There is something muted about the work of Leonardo da Vinci, something private and remote, that has always had a special fascination. No other artist seems to conceal, as Leonardo does, a talent much larger than his paintings reveal. Indeed, no other artist sustains so great a reputation with so few

paintings—fewer than 20. This past winter the “Mona Lisa” was shown in the U.S., on loan from France, under a guard that would flatter President de Gaulle. Last year England subscribed, coin by coin, more than \$1 million to retain the sketch for a Leonardo painting of “The Virgin and Child.” This extraordinary homage is a tribute to the air of mystery that surrounds Leonardo.

Great artists are usually lavish with their talent, as Raphael was and Picasso is. Lavishness is in fact one touchstone of talent, and the work of an artist is not valued (even in money) for its scarcity. Leonardo also lavished his talent, but not on his pictures. Painting was too obvious for him. He painted with superb

and almost contemptuous ease, and he was too perverse to take pleasure in what came so simply to him. The mystery in his paintings, the smile of the Mona Lisa and the Virgin, comes from the absence of personal involvement. Leonardo is withdrawn from his paintings; he is, as it were, looking through them for something that interests him more than what he puts on the canvas. His pictures are filled with a spectacular sense of absence.

Two things combined in Leonardo to form this detachment from his own art. One was a matter of emotional character: he would not (and could not) share his life with anyone else on equal terms. The other was a matter of intel-



*Leonardo's drawing of a moving spindle to spin wool illustrates his capacity to visualize machines without building them*

lectual interest: Leonardo was not interested in art. In the most direct sense, he was devoted to science.

It may be that the character and the interest are related in Leonardo. At any rate we ought to understand his character before we study his strange devotion to a science that had hardly begun to exist. Leonardo was illegitimate, and his mother was probably a servant in the well-to-do household in which he grew up. Some grave and childish memory of that divided upbringing seems to have shaped his character. He was left-handed to the point of willfulness: all his 13 notebooks are inscribed with mirror writing. His paintings show that he had no personal tenderness for women or children, and no sensuousness. He was a homosexual, and the one lasting relation he had was with his male model Andrea Salai, whom he certainly despised. By choice he worked a good deal for ruthless men of power, and his drawings show that he was obsessed by machines of war.

All this makes up a character that is, by steps, first lonely, then self-sufficient and at last perverse. The character stood between Leonardo and any community with the people he painted. He was fascinated by the world he saw, but it had to be the natural—not the human—world. Even his wonderful and delicate drawings of human anatomy use male models who look brutal.

Leonardo's absorption in science had tangled roots in history as well as in his character. When he was born, in 1452, the Italian Renaissance was just gathering speed. In Florence the first great Medici had begun to build up the library of classical works that later became the center of Renaissance culture. By the time Leonardo was apprenticed, at the age of 14, Florence was under the patronage of the greatest of the Medicis, Lorenzo the Magnificent. The Florentine Academy had been founded, humanistic culture flourished and every gifted artist could find rich men to commission whatever he conceived.

Yet Leonardo deliberately left Florence at the height of his power, at about the age of 30, and for more than 15 years worked at the turbulent and sinister court of Milan. During those years he turned more and more to science and mechanics; he formed a friendship with the mathematician Luca Pacioli; he filled his notebooks with drawings of machines; he had to be bullied into finishing even his painting "The Last Supper." When Ludovico Sforza, the usurper of Milan, was finally defeated by the foreign powers with whom he had long

intrigued, Leonardo's best years were already over, and they had been wasted. He fled from Milan in the last days of 1499, in the company of Pacioli and Salai, and never again had an assured place in the world. He died in 1519 as a pensioner of the king of France, filling his notebooks with drawings of natural disasters and scribbling one sentence over and over again: "Tell me if anything at all was done. . . ."

The notebooks demonstrate that Leonardo left the splendor of Florence because he was out of sympathy with the subjects in which Florence delighted. That golden humanism did not satisfy Leonardo, and it made him impatient and defiant. True, the Medicis had broken the crust of the closed medieval world, destroyed its fears and formalism and dogma and opened a new vision. And yet the new vision was still a vision of the past, and the Schoolmen had been overthrown only by another kind of scholar. The old texts of the Church fathers had given place to older texts from the Latin poets and the Greek philosophers. Florence had broken the authoritarianism of the medieval church, but it had not broken with authority—it had not broken new ground. To Leonardo and others who thought like him this was not a renaissance, not a rebirth, but only a recovery: the recovery of what another past had done before Christianity came to the West.

Leonardo was ill at ease in the lush culture of Florence, by character and intellect together. His childhood had not fitted him to accept with grace the condescension of a patron. He distrusted all conventional ideals. He was indifferent, even in himself, to those talents that merely imitate. He did not want to copy the appearance of nature—least of all as the Romans and Greeks saw her. And he was not a scholar, either by education or by temperament. His Latin was never good; he barely struggled with Greek; he had no taste for philosophy and no head for theories and abstract thought. To Leonardo the Renaissance in Florence was only a palace revolution that deposed one coterie for another. He wanted more than the recovery of what had once been known; he wanted discovery.

There were, of course, others who thought like Leonardo and in the end they changed the Renaissance from an aristocratic to a popular movement. Leonardo is memorable among them, and he continues to puzzle and to excite us, for two reasons. First, he was immeasurably more gifted in the conventional arts than others were, so that his rejection of what he could do so wonderfully well

has a special tartness, a shrug of mutinous contempt. Even in his 50's, when he needed the money, he did not finish the official war picture that Florence had commissioned from him; instead he idled away his visits there in painting a nonentity, the "Mona Lisa."

Second, Leonardo entered into discovery with an immediacy and a penetration that were matchless. On every one of the 5,000 pages of his notebooks he did something at first hand. He studied flowers and anatomy and the flight of birds, he conceived the flywheel and the machine gun, the parachute and the automatic lathe, all in the most practical way and almost without a word, simply by drawing what his superb eye saw or imagined.

This is the intellectual and emotional background to Leonardo's move from Florence to Milan in the 1480's. Milan was politically no more democratic a city than Florence—it was rather less so. But because it had developed later Milan fostered a more popular Renaissance culture. For example, Milan in the 1480's was becoming a center of the art of printing, which was almost exactly as old as Leonardo. Characteristically one of the machines in the notebooks is a printing press that is fed automatically. It was certainly original and, like Leonardo's other original inventions, was never built, and perhaps was never intended to be built.

In Milan, Leonardo could design and invent to his heart's content, in mechanics, in architecture, in ships and canals, in engines of war and flying machines and automatic toys. He was supposed also to be making a mounted statue of the usurper's father, the great *condottiere* Francesco Sforza. But the notebooks show that Leonardo spent his ingenuity in devising ways to cast, transport and erect the statue, which in fact was never made.

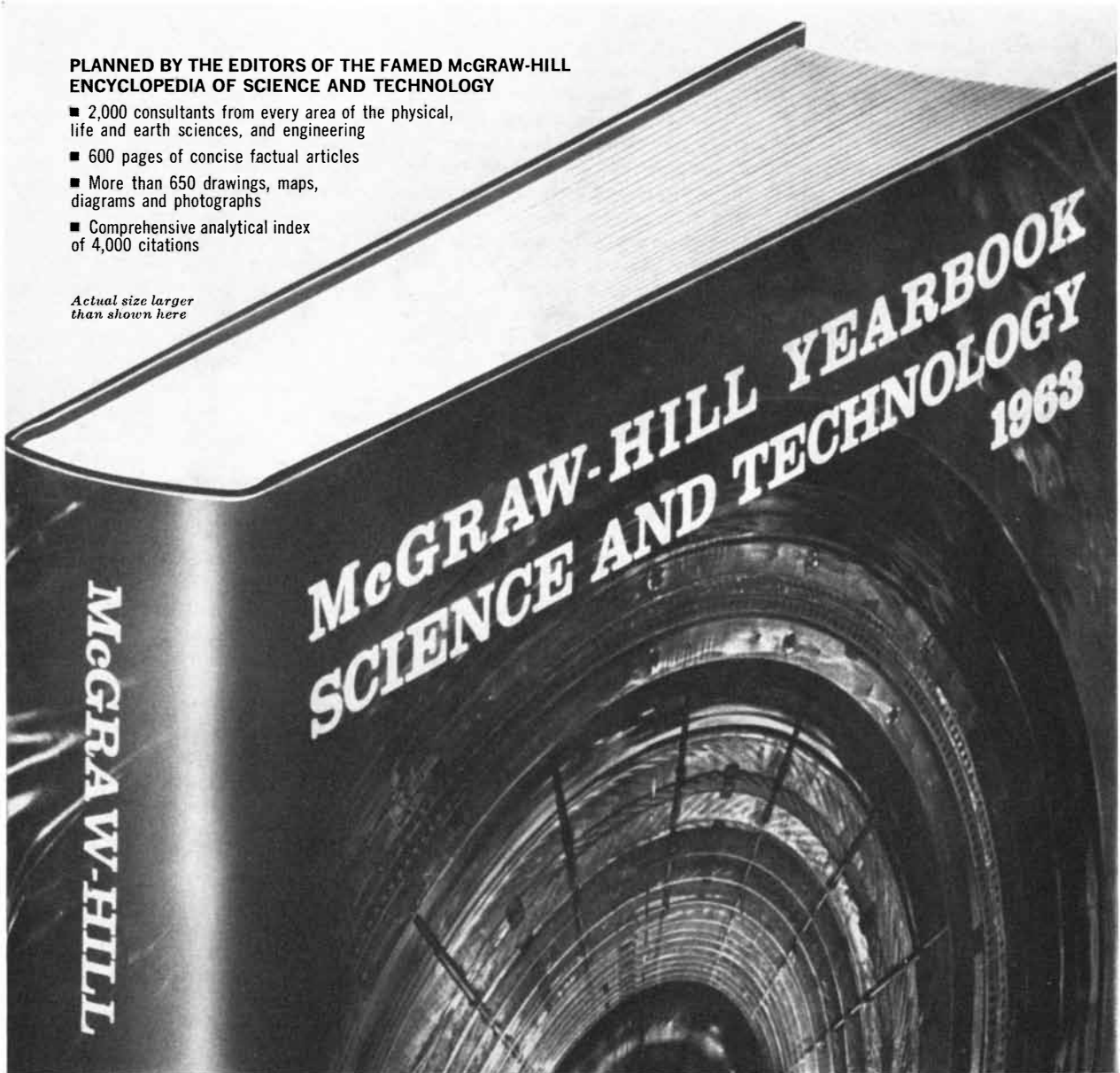
The crowded notebooks contain inventions that anticipate the work of later engineers by 200 years and more. Yet Leonardo was not the only ingenious mechanic of his age, and there has always been some doubt as to how much of what he drew was original and how much was inspired by others or by the primitive industrial practice of his day.

These questions occupy the most interesting part of Ivor B. Hart's new book. The book, however, covers more ground than this. It outlines the life and times of Leonardo. It discusses both medieval thought and the rise of the Renaissance. It has a long chapter on the state of theoretical science in Leonardo's time, and another on the state of tech-

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nology. These two chapters set the scene for Leonardo's own inventions, of which nearly 100 are illustrated and described.

The commentary on these drawings of Leonardo's machines forms the best part of the book. Here Hart is thoroughly at home; it is plain that engineering is his love and the main reason for his interest in Leonardo. He explains each device with care and sympathy and compares it with later inventions and with modern usages. In this way many details in Leonardo's machines are elucidated so that for the first time the nonengineer is able to perceive their relevance to the whole design.

The picture that Hart's exposition forms is impressive. It shows that Leonardo had a natural grasp of mechanisms, an ability to visualize how the different parts of a machine fit and mesh together. This gift has always been striking in Leonardo's paintings and in his anatomical science: the ability to hold the total conception and the detailed execution together, to make a unity of them. The achievement of this book is to demonstrate it as vividly in Leonardo's designs of mechanisms.

Hart himself does not draw this conclusion, and in general his conclusions are less interesting than his detailed exposition. In this respect the book falls short of its aim and does not communicate a sense of what is original in Leonardo's whole work and outlook. But Hart's analysis of what is original in specific inventions is admirable, and he marshals the most recent findings of other scholars as well as his own.

Two findings in particular depart sharply from the accepted canon of Leonardo's inventions. One is the suggestion that Leonardo's drawings of a gun to fire cannon balls by means of steam was a crucial step in the evolution of the steam engine. This analysis comes from a recent Italian study by L. Reti, who showed that there are detailed likenesses between Leonardo's notes on steam and the proposals by later inventors that led Thomas Savery to make the first practical steam engine in 1698.

The other new finding, alas, has the opposite effect and proves that a favorite among Leonardo's inventions, the helicopter, was probably not original. Charles H. Gibbs-Smith, an English art historian whose hobby happens to be the history of flying, has just shown that the helicopter as drawn by Leonardo—that is, a screw or rotor that rises into the air when it revolves—appears as a toy in pictures of the infant Christ before 1500. It has long been known that the toy (it is still made today) originated

much earlier in China; it now seems most likely that it had come to Europe and that Leonardo had seen it before he drew the helicopter.

These opposing examples illustrate again the unpredictable turbulence of Leonardo's gifts. He drew, thought about, used and discarded everything that came into his vision—everything he saw others use and everything he imagined for himself. Did he think about these things profoundly? Did he truly put them to original uses? The two examples I have cited show how oddly inept these questions are and how much beside the point. Leonardo thought about steam, saw some uses for it and guessed others; and now it seems that the thoughts and the guesses went deeper, and had more influence, than we had supposed. In the same way Leonardo saw the principle of the helicopter; and now it seems that in fact he saw it in a child's toy. The reversals are interesting (and there will be others to come), and yet so self-contained was Leonardo that they hardly change our judgment either of him or of the history of these inventions.

Leonardo's mind was so springing, so constantly creative and so careless of what it had once thought that the usual criteria of priority are, at bottom, irrelevant. Nature was an inexhaustible source of excitement to him, and the excitement was the same in all he did: when he worked out how the lens of the eye functions, when he for the first time calculated the center of gravity of a solid figure and when he had the idea for a centrifugal pump. Invention was for him not an engineer's brain storm but part of the ferment of understanding nature. When he invented the roller bearing (or copied it—we can never be sure), he also speculated whether or not friction might be the cause of the music of the spheres.

Discovery was as immediate an activity to Leonardo, as personal and as specific, as his painting or his study of anatomy. He had above all a highly concrete mind. He had heard of the quarrels about the principles of mechanics between the dissident philosophers of Paris and the traditional followers of Aristotle and Aquinas. But these abstractions did not engage his mind. He was not interested in theories, and he was not capable of forming a scientific theory as we understand it today. For example, none of the bird machines to which Hart devotes a loving chapter were capable of flying, simply because they required more energy than a man can generate. Leonardo did not understand this; such gen-

eralized concepts as energy were foreign to his mind. His best machines are wonderful exercises in automation but seldom in the use of power.

There is nothing wrong with the practical cast of mind that is ill at ease with general concepts. On the contrary, at the time Leonardo lived science could not progress until it purged itself of the vague and all-embracing, all-explaining generalizations of Aristotle. A new outlook was needed: the outlook of men who built machines and made them work. Leonardo shared this empirical outlook and took it to the court of Milan and elsewhere, so that it began to influence university men too.

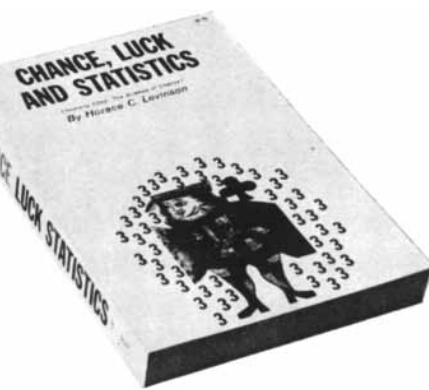
The builders of machines thought with their hands and the university men thought with their heads. Leonardo's unique gift was to think with his eye. His drawings of birds in flight and horses in movement show that he had a photographic eye. But the drawings of machines show that Leonardo had something more: an eye that could also instantly see what he thought, an inner imaginative eye. The most striking pair of plates in this book shows Leonardo's sketch for a moving spindle to spin wool [see illustration on page 169] and a working model recently made from the sketch. Here in extreme form is the constant theme of these drawings: that Leonardo could visualize a complex mechanism as meticulously as if he had sat in front of it and photographed it.

Leonardo's imaginative eye was not a physical gift but an intellectual one. It marked the mind of a man who saw the detail and the whole together, and who could not be satisfied with the whole unless the detail was right. That is why the core of his best inventions is automatic control, the step-by-step co-ordination of a sequence of operations. What Leonardo brought to mechanics was the sense that a machine expresses its principle in the exact integration of its parts. What he brought to anatomy was the sense that the body works with just such mechanical precision as a machine does. What he brought to painting was the understanding that the details of nature, the bone beneath the skin and the bloom on the skin, the shape of a flower and the movement of a paw, are the visible expressions of the inner order of nature. Other Renaissance artists made this last discovery; but to Leonardo they were all one discovery, which no scientist made for another 100 years, until Galileo began. This was Leonardo's fundamental break with the past: he brought the empirical sense from the artist's studio into the laboratory—the sense that the

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laws of nature express themselves not vaguely but exactly, in the detail of her smallest movement.

### Short Reviews

**N**ARCOTIC ADDICTION IN BRITAIN AND AMERICA, by Edwin M. Schur. Indiana University Press (\$7.50). The author of this book, a lawyer and a teacher of sociology, spent two years in England studying the British system of narcotics control. Their methods differ considerably from ours, as do their results. Basically the U.S. position is rigid, punitive and vindictive. Drug addiction is treated by the courts and authorities as if it were a crime to be extirpated. This is somewhat contradictory: although the Federal Narcotics Control Act specifies mandatory minimum sentences for users, the U.S. Supreme Court has twice held that addiction is a disease and a proper subject of medical care. The majority of the officials who in one capacity or another deal with addicts oppose the Control Act provisions, and the most influential medical groups in the country share this attitude. In Great Britain physicians are allowed to give addicts controlled doses of drugs and to continue the practice in each case for as long as the doctor thinks the patient needs the drug in order to function. In some cases this may go on for years and years. Great care is exercised, however, to see to it that the intake is limited, that it does not have to be steadily increased because of the user's growing tolerance. It seems to be well established, according to Schur, that the medical profession in Great Britain has not abused its privileges, and that addiction is not, as it is in the U.S., a major—let alone a growing—problem. One of the fruits of British policy is that there is comparatively little illicit narcotics peddling, another circumstance that stands in glaring contrast to U.S. experience. As Max Lerner once observed: "The British have achieved, with common sense and without any fuss and hysteria, what we are trying for with all our thunder and sleuthing and crackdown." A thoughtful and provocative book about a controversy-ridden subject that deserves the most serious attention.

**I**NEQUALITIES, by P. P. Korovkin; **G**EOMETRICAL CONSTRUCTIONS USING COMPASSES ONLY, by A. N. Kostovskii; **T**HE RULER IN GEOMETRICAL CONSTRUCTIONS, by A. S. Smogorzhevskii; **T**HE METHOD OF MATHEMATICAL INDUCTION, by I. S. Sominskii; **S**OME APPLICATIONS OF MECHANICS TO MATHEMATICS, by

V. A. Uspenskii; **F**IBONACCI NUMBERS, by N. N. Vorob'ev. Blaisdell Publishing Co. (95 cents each). A stimulating collection of paperbacks in this publisher's "Popular Lectures in Mathematics Series." Each volume, originally published in Russian, was designed for secondary school students, for teachers and for laymen who appreciate mathematics. Parts of the material, it must be admitted, may tax even U.S. college students who are mathematics majors, but much of it will suit a wider audience. Korovkin assumes previous knowledge of the basic properties of inequalities, but he gives a brief introductory review, which is followed by discussions of such topics as inequalities relating to  $(1+x)^n$ , maxima and minima and the calculation of certain limits. Sixty-two problems are included, with worked-out solutions of many of them. The volumes on geometric constructions are well handled and can be recommended to geometry lovers; if not to beginners, at least to those who have a degree of sophistication in geometrical reasoning and in the uses of ruler and compass. An attractive item in Smogorzhevskii's book is a proof that, using ruler alone, it is impossible to construct the centers of two given nonconcentric circles if the circles have no common point. Although it is well known that "proofs of impossibility" belong mostly to the class of difficult mathematical problems (e.g., proving the transcendental character of pi) and are usually based on profound and intricate sequences of reasoning, this elegant little demonstration does not demand a high level of expertise. For mathematicians who find the method of mathematical induction an elusive pimpernel, Sominskii's book furnishes both understanding and peace of mind. He explains lucidly what is involved and gives many examples of applications of the method, together with step-by-step solutions of characteristic problems. The lectures by Uspenskii deal with problems for whose solution one can successfully use the laws of physics, for example the laws of equilibrium. He shows how mechanics can be used to determine the relation of a tangent to a circle, an ellipse, a parabola and a hyperbola; how to determine the center of gravity; how to unravel problems in the theory of numbers; how to elucidate the principle of least potential energy. Vorob'ev on Fibonacci numbers is a delight. The theory of these numbers, which goes back many centuries, will fascinate anyone with even slight mathematical tastes and aptitudes. Their simple properties are described, their connection with

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**THE EXPLORATION OF OUTER SPACE**, by Sir Bernard Lovell. Harper & Row, Publishers (\$3). Based on popular lectures given in 1961 at the University of Wales, this small book presents an excellent account of the techniques of investigating outer space. The emphasis is on radio astronomy, in which field Lovell is of course an eminent figure, and on space probes by rockets and satellites. Lovell sketches the history of radio astronomy, recounts its brilliant growth in the postwar years and describes what it has added to our knowledge of the solar system and the structure of the universe, and how it has modified cosmological theory. In the last chapter he allows himself some reflections on ethics and the cosmos. He urges that the new opportunities for exploring other planets, many of which he believes are populated by living organisms, be treated with the utmost circumspection and restraint. We have no right, he asserts, to "contaminate" extraterrestrial space and the planets of the solar system. We know little about their biological situation and if by our actions we interfere with the course of organic evolution in other parts of the cosmos, we are offending both morals and science. Photographs and diagrams.

**WHALES**, by E. J. Slijper. Basic Books Inc. (\$12.50). A large book on a large subject. Whales are of interest not only because of their majestic size but also because of their remarkable physiology, their speed and method of locomotion, their feeding habits, their mating, their distribution and migration, their importance to man as a source of food, fuel and many other products, and their role in fact and fiction since earliest recorded times. (In northern Norway there are rocks on which are scratched Stone Age drawings showing a man in a boat hunting a seal and two porpoises; near Knossos on the island of Crete, the site of the Palace of Minos, there is a drawing of a whale dating from about 1200 B.C.; the bones of whales found in the remains of settlements of the original inhabitants of Alaska show that the Eskimos found whales as early as 1500 B.C.; and ancient Greek vases, coins and buildings were frequently decorated with whale and dolphin motifs.) The author, a Dutch anatomist, has devoted his life to the study of whales. When his book first appeared several years ago in

Dutch, experts pointed out many errors, particularly in the historical section. Slijper enjoys colorful writing, sometimes at the expense of accuracy, and he likes to enliven his account with anecdotes of doubtful authenticity. Nevertheless, even his critics agree that he has written a highly informative survey. Profusely illustrated and with a good bibliography.

**IRRATIONAL DESPAIR**, by Benjamin Wolstein. The Free Press of Glencoe. The Macmillan Co. (\$6). An ably written critique of the theory and practice of existential analysis. The point is made that, although existentialist analysts have added fresh insights into the tormenting anxieties and dilemmas of 20th-century man, the confirmation of their observations by anything approaching scientific method is impossible. Thus, Wolstein concludes, one cannot expect existential therapy to add much to systematic knowledge of human behavior or to become a workable alternative to either Freudian or Neo-Freudian systems.

**THE GROWTH OF THE AMERICAN REPUBLIC**, by Samuel Eliot Morison and Henry Steele Commager. Oxford University Press (\$30). First published as a single volume in 1930, Morison and Commager's history now appears in a two-volume fifth edition. The work has been entirely rewritten, with the narrative carried through the presidential election of 1960. This is a disinterested, scholarly and clear survey, forthright in its expression and free of the nervous treatment of controversial issues, past and present, that so often characterizes histories intended for adoption as textbooks in our schools and colleges.

**INFORMATION STORAGE AND NEURAL CONTROL**, edited by William S. Fields and Walter Abbott. Charles C Thomas, Publisher (\$13.75). Proceedings of the 10th annual meeting of the Houston Neurological Society, with papers and discussions covering such topics as the coding of information, genetic information transfer, communication in human society, feedback and redundancy problems. An introductory paper gives the elements of information theory; an appendix reprints the well-known article by Warren S. McCulloch and Walter Pitts that sketches a calculus of the "ideas immanent in nervous activity."

**NOBEL: THE MAN AND HIS PRIZES**, by H. Schüch, R. Sohlman *et al.* American Elsevier Publishing Co., Inc. (\$10.95). A revised and much enlarged

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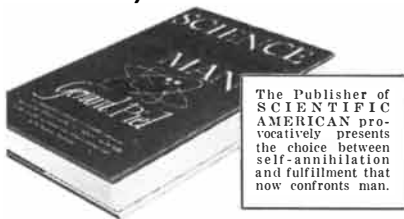
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**T**EXTILES OF ANCIENT PERU AND THEIR TECHNIQUES, by Raoul D'Harcourt. Edited by Grace G. Denny and Carolyn M. Osborne. University of Washington Press (\$22.50). First published in Paris in 1934 in a small edition of 600 copies, this now classic work on Peruvian textiles and on the techniques of pre-Columbian weaving, network, needle-made fabrics and plaiting here appears translated into English, revised and enlarged, with the collaboration of the author, to incorporate additional articles and monographs as well as additional plates. An engrossing volume, with handsome plates (four in color), that pays the tribute of modern scholarship to a beautiful art form that has fallen into complete oblivion.

**T**HE WORLD OF ARCHAEOLOGY, by Marcel Brion. The Macmillan Co. (\$15). A two-volume translation from the French of a general survey of contemporary archaeological research and of the major archaeological advances of the 20th century. The first volume covers India, China and America; the second, Central Asia, Africa and the Near East. Well written, ably translated and dependable, but unfortunately there is no bibliography. The reader will have to fend for himself if he wants to learn more about subjects that Brion has opened up but has not had the space to develop. Plates and diagrams.

**P**SYCHOLOGY: THE SCIENCE OF MENTAL LIFE, by George A. Miller. Harper & Row, Publishers (\$6.95). This book tells the story of psychology: what the science is and how it evolved. The contributions of the major pioneers are discussed, among them Wilhelm Wundt, William James, Francis Galton, I. P. Pavlov, Sigmund Freud and Alfred Binet, and there are vivid biographical sketches of each. Miller courses a wide

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**N**EAR ZERO, by D. K. C. MacDonald. Doubleday Anchor Books (95 cents). A relaxed and informative little book on the physics of low temperature. MacDonald explains why low temperatures are of scientific interest; describes the intricate and ingenious methods and apparatus that have been devised to "suck out" the entropy of a substance so as to reduce its thermal energy, increase its orderliness and make it colder; discourses on superconductivity and the strange properties of liquid helium. He also goes into the many uses of low temperatures. These include the study of free radicals in chemistry and of the creep of metals, the measurement of very small voltages and the detection by exquisitely sensitive instruments of faint signals in radio astronomy. The presentation is lucid and engagingly modest. Recommended.

**A**CCTIONS OF RADIATIONS ON LIVING CELLS, by D. E. Lea. Cambridge University Press (\$2.95). A soft-cover reprint of the late D. E. Lea's pioneering and masterly account of certain of the simplest and most fundamental actions of X rays and other ionizing radiations on living cells. The bulk of the book is concerned with the effect of radiation on viruses and on the genetic material of cells. Clearly written and abounding in fascinating detail, Lea's work, although intended for specialists in medicine, genetics and biology and for physicists interested in biology, can be read by any student of science as a model report of a research undertaking. Photographs and diagrams.

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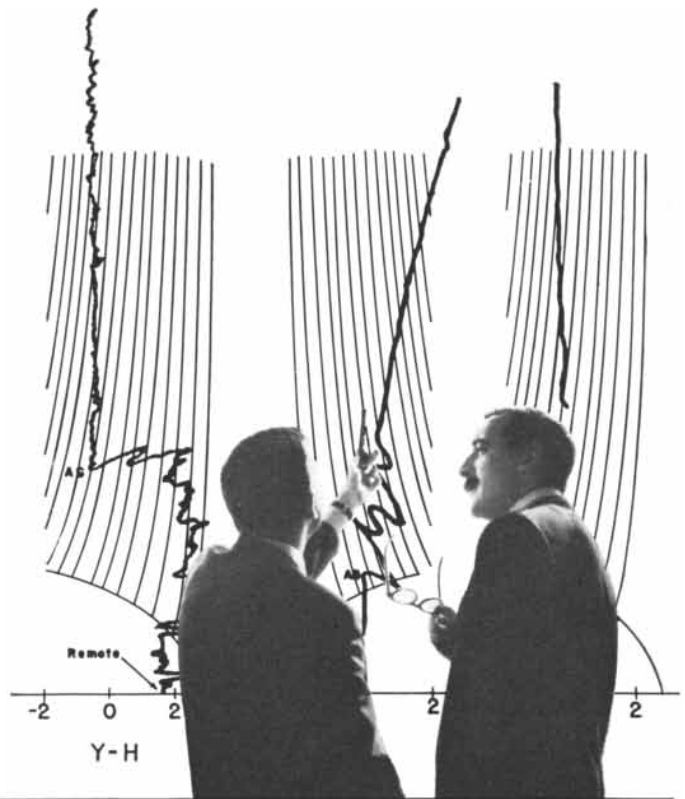
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of documents illustrating the Anglo-American tradition in human rights. The documents span a period from the 14th century to the U.S. Supreme Court decisions of 1951.

A PRECIS OF MATHEMATICAL LOGIC, by J. M. Bocheński. Gordon and Breach Science Publishers, Inc. D. Reidel Publishing Co. (\$5.25). This capsule account covers the general principles of mathematical logic and the logic of sentences, predicates and classes and relations. It appears here for the first time in an English translation, having been originally published in French and later put out in a somewhat enlarged edition in German.

CANON OF ECLIPSES, by Theodor Ritter von Oppolzer. Dover Publications, Inc. (\$10). An English translation of von Oppolzer's standard reference for eclipses, past and future, first published in German in 1887. The book tabulates 8,000 solar and 5,200 lunar eclipses going back as far as 1200 B.C. and includes predictions up to the year 2161.

AN INQUIRY INTO MEANING AND TRUTH, by Bertrand Russell. Penguin Books, Inc. (\$1.25). A soft-cover reprint of Russell's well-known essay on defining knowledge and truth and relating these concepts to our own experience by applying the methods of psychology and logic.

ANALOGUE COMPUTING AT ULTRA-HIGH SPEED, by Donald M. MacKay and Michael E. Fisher. John Wiley & Sons, Inc. (\$11.50). This work is designed to draw attention to "the versatility and reserves of power still latent in analogue techniques."

THE GEOMETRICAL SEAMAN, by E. G. R. Taylor and M. W. Richey. St Martin's Press (\$7.95). An illustrated guide to early nautical instruments, from the lead and line—the oldest for which there is any record—to the sextant and the chronometer.

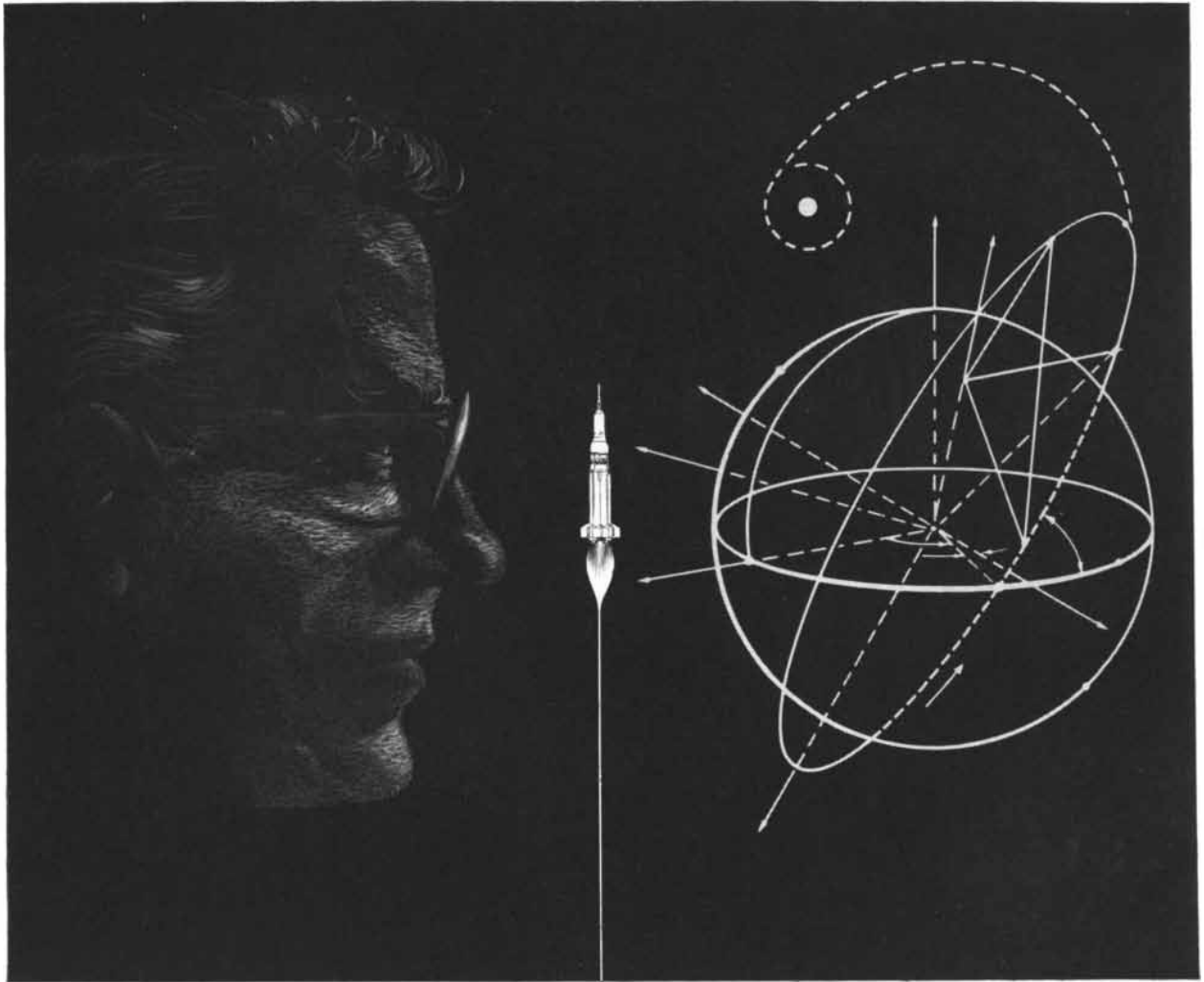
THE ROLE OF SCHOOLS IN MENTAL HEALTH, by Wesley Allin Smith and George W. Goethals. Basic Books, Inc. (\$7.50). The seventh volume in the "Joint Commission on Mental Illness and Health Series" is an inquiry into the things being done in schools—curriculum design, special teachers in classes, teacher training and kindred matters—that influence a student's mental health for better or for worse.

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## THE ECOLOGICAL EFFECTS OF RADIATION

EFFECTS OF IONIZING RADIATION ON TERRESTRIAL ECOSYSTEMS. George M. Woodwell in *Science*, Vol. 138, No. 3540, pages 572-577; November, 1962.

PREDICTION OF THE SENSITIVITY OF PLANTS TO CHRONIC GAMMA IRRADIATION. Arnold H. Sparrow and George M. Woodwell in *Radioecology: Proceedings of the First National Symposium on Radioecology, Colorado State University, September, 1961*, edited by Vincent Schultz and Alfred W. Klement, Jr. Reinhold Publishing Co., in press.

## NOCTILUCENT CLOUDS

COLLECTION AND ANALYSIS OF PARTICLES FROM THE MESOPAUSE. G. Witt, C. L. Hemenway and R. K. Soberman in *Proceedings of the Fourth International Space Science Symposium, Warsaw, Poland, June, 1963*. North Holland Publishing Co., in press.

HEIGHT, STRUCTURE AND DISPLACEMENT OF NOCTILUCENT CLOUDS. Georg Witt in *Tellus*, Vol. 14, No. 1, pages 1-18; February, 1962.

NOCTILUCENT CLOUD OBSERVATIONS. Georg Witt in *Tellus*, Vol. 9, No. 3, pages 365-371; August, 1957.

NOCTILUCENT CLOUDS. F. H. Ludlam in *Tellus*, Vol. 9, No. 3, pages 341-364; August, 1957.

NOTE ON THE NATURE OF NOCTILUCENT CLOUDS. Eigil Hesstvedt in *Journal of Geophysical Research*, Vol. 66, No. 6, pages 1985-1987; June, 1961.

STUDIES OF MICROMETEORITES OBTAINED FROM A RECOVERABLE SOUNDING ROCKET. C. L. Hemenway and R. K. Soberman in *The Astronomical Journal*, Vol. 67, No. 5, pages 256-266; June, 1962.

## KILOMEGACYCLE ULTRASONICS

EFFECTS OF 9.2-KMC/SEC ULTRASONICS ON ELECTRON SPIN RESONANCES IN QUARTZ. E. H. Jacobsen, N. S. Shiren and E. B. Tucker in *Physical Review Letters*, Vol. 3, No. 2, pages 81-83; July, 1959.

EXCITATION AND ATTENUATION OF HY-

PERSONIC WAVES IN QUARTZ. H. E. Bömmel and K. Dransfeld in *The Physical Review*, Vol. 117, No. 5, pages 1245-1252; March, 1960.

EXCITATION OF HYPERSONIC WAVES BY FERROMAGNETIC RESONANCE. H. Bömmel and K. Dransfeld in *Physical Review Letters*, Vol. 3, No. 2, pages 83-84; July, 1959.

EXPERIMENTS WITH PHONONS AT MICROWAVE FREQUENCIES. E. H. Jacobsen in *Quantum Electronics*, edited by Charles Townes. Columbia University Press, 1960.

ULTRASONIC AMPLIFICATION IN CdS. A. R. Hutson, J. H. McFee and D. L. White in *Physical Review Letters*, Vol. 7, No. 6, pages 237-241; September, 1961.

## THE LYMPHATIC SYSTEM

THE LYMPHATIC SYSTEM WITH PARTICULAR REFERENCE TO THE KIDNEY. H. S. Mayerson in *Surgery, Gynecology & Obstetrics*, Vol. 116, No. 3, pages 259-272; March, 1963.

LYMPHATICS AND LYMPH CIRCULATION. István Rusznyák, Mihály Földi and György Szabó. Pergamon Press Ltd., 1960.

LYMPHATICS, LYMPH AND LYMPHOID TISSUE. Joseph Mendel Yoffey and Frederick Colin Courtice. Harvard University Press, 1956.

OBSERVATIONS AND REFLECTIONS ON THE LYMPHATIC SYSTEM. H. S. Mayerson in *Transactions & Studies of the College of Physicians of Philadelphia*, Fourth Series, Vol. 28, No. 3, pages 109-127; January, 1961.

## HYDROGEN IN GALAXIES

COSMIC RADIO WAVES AND THEIR INTERPRETATION. J. L. Pawsey and E. R. Hill in *Reports on Progress in Physics*, Vol. 24, pages 69-115; 1961.

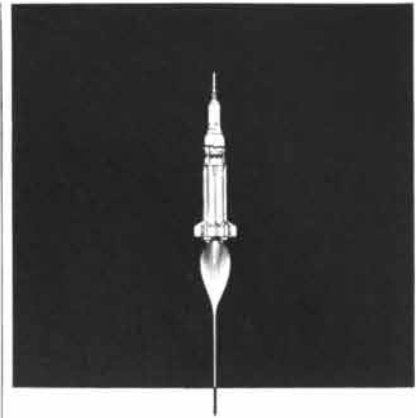
THE NEUTRAL HYDROGEN CONTENT OF LATE-TYPE SPIRAL GALAXIES. Morton S. Roberts in *The Astronomical Journal*, Vol. 67, No. 7, pages 437-446; September, 1962.

## THE SANCTUARY OF ARTEMIS AT BRAURON

THE ANCIENT CITY OF ATHENS: ITS TOPOGRAPHY AND MONUMENTS. Ida Thallion Hill. Methuen & Co., Ltd., 1953.

ATTISCHE FESTE. Ludwig August Deubner. Akademie-Verlag, 1956.

THE COASTAL DEMES OF ATTIKA FROM AIXONE TO ATENE. C. W. J. Eliot. University of Toronto Press, 1962.



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DESCRIPTION OF GREECE. Pausanias. English translation by W. H. S. Jones. Harvard University Press, 1954.

## MACHINE TRANSLATION OF CHINESE

MACHINE TRANSLATION. *Proceedings of the Institute of Precision Mechanics and Computer Engineering, Academy of Sciences of the U.S.S.R., No. 2; Moscow, 1961.* English translation in *Foreign Developments in Machine Translations and Information Processing, No. 94.* U.S. Department of Commerce, Office of Technical Services, JPRS 13543; April 24, 1962.

A TABLE LOOK-UP MACHINE FOR PROCESSING OF NATURAL LANGUAGES. J. L. Craft, E. H. Goldman and W. B. Strohm in *IBM Journal of Research and Development, Vol. 5, No. 3, pages 192-203; July, 1961.*

## EARLY EXPERIENCE AND EMOTIONAL DEVELOPMENT

AN ATTEMPT TO ISOLATE THE CRITICAL PERIODS OF DEVELOPMENT IN THE RAT. Victor H. Denenberg in *Journal of Comparative and Physiological Psychology, Vol. 55, No. 5, pages 813-815; October, 1962.*

EFFECTS OF ENVIRONMENTAL COMPLEXITY AND SOCIAL GROUPINGS UPON MODIFICATION OF EMOTIONAL BEHAVIOR. Victor H. Denenberg and John R. C. Morton in *Journal of Comparative and Physiological Psychology, Vol. 55, No. 2, pages 242-246; April, 1962.*

EFFECTS OF MATERNAL FACTORS UPON GROWTH AND BEHAVIOR OF THE RAT. Victor H. Denenberg, Donald R. Ottinger and Mark W. Stephens in *Child Development, Vol. 33, No. 1, pages 65-71; March, 1962.*

## MATHEMATICAL GAMES

DESIGN IN NATURE, VOL. II. J. Bell Pettigrew. Longmans, Green, and Co., 1908.

## THE AMATEUR SCIENTIST

BEHAVIOR THEORY AND CONDITIONING. Kenneth W. Spence. Yale University Press, 1956.

CONDITIONED REFLEXES: AN INVESTIGATION OF THE PHYSIOLOGICAL ACTIVITY OF THE CEREBRAL CORTEX. I. P. Pavlov. Oxford University Press, 1927.

PRINCIPLES OF BEHAVIOR. Clark L. Hull. Appleton-Century-Crofts. Merideth Publishing Co., 1943.



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