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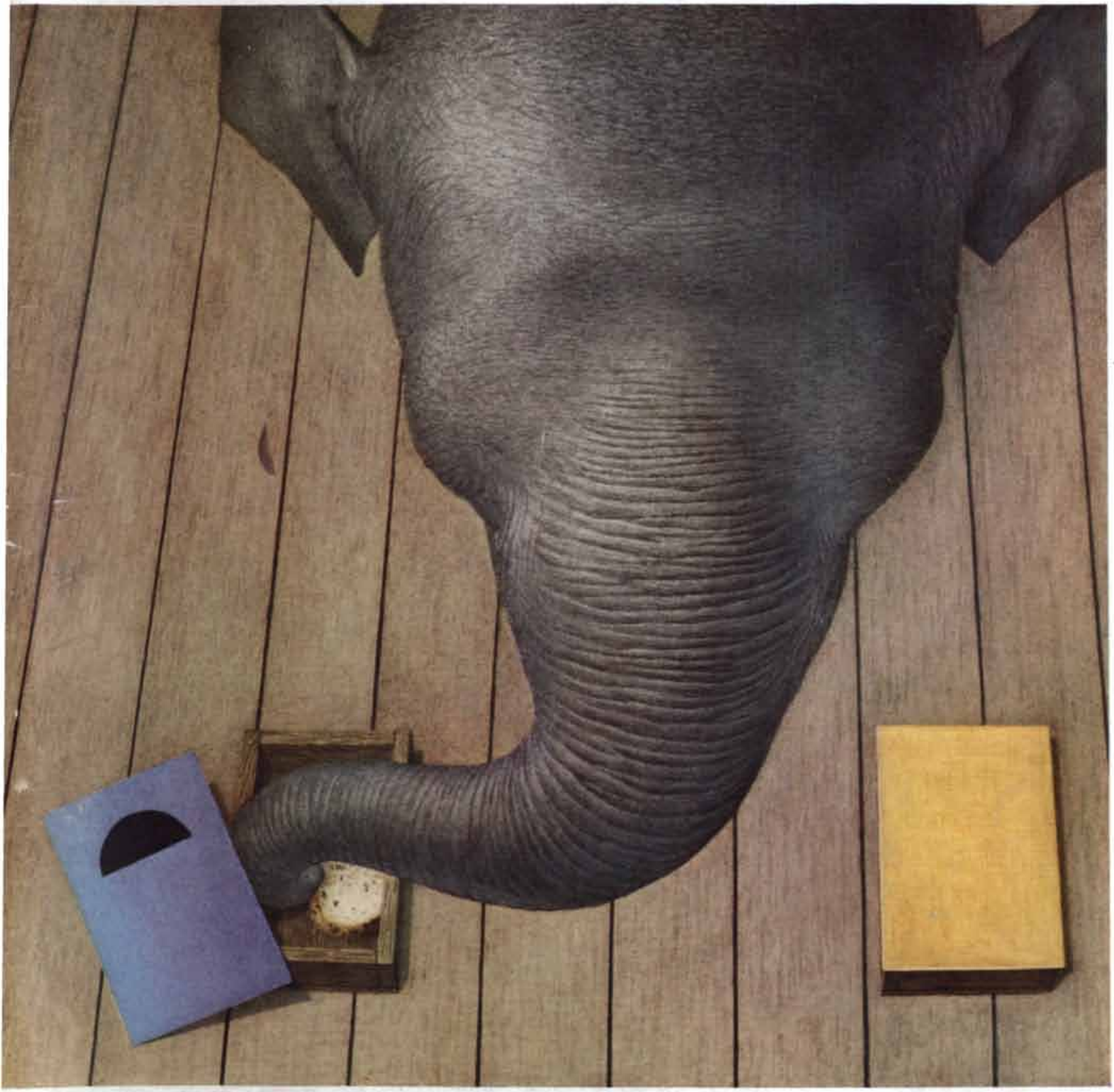

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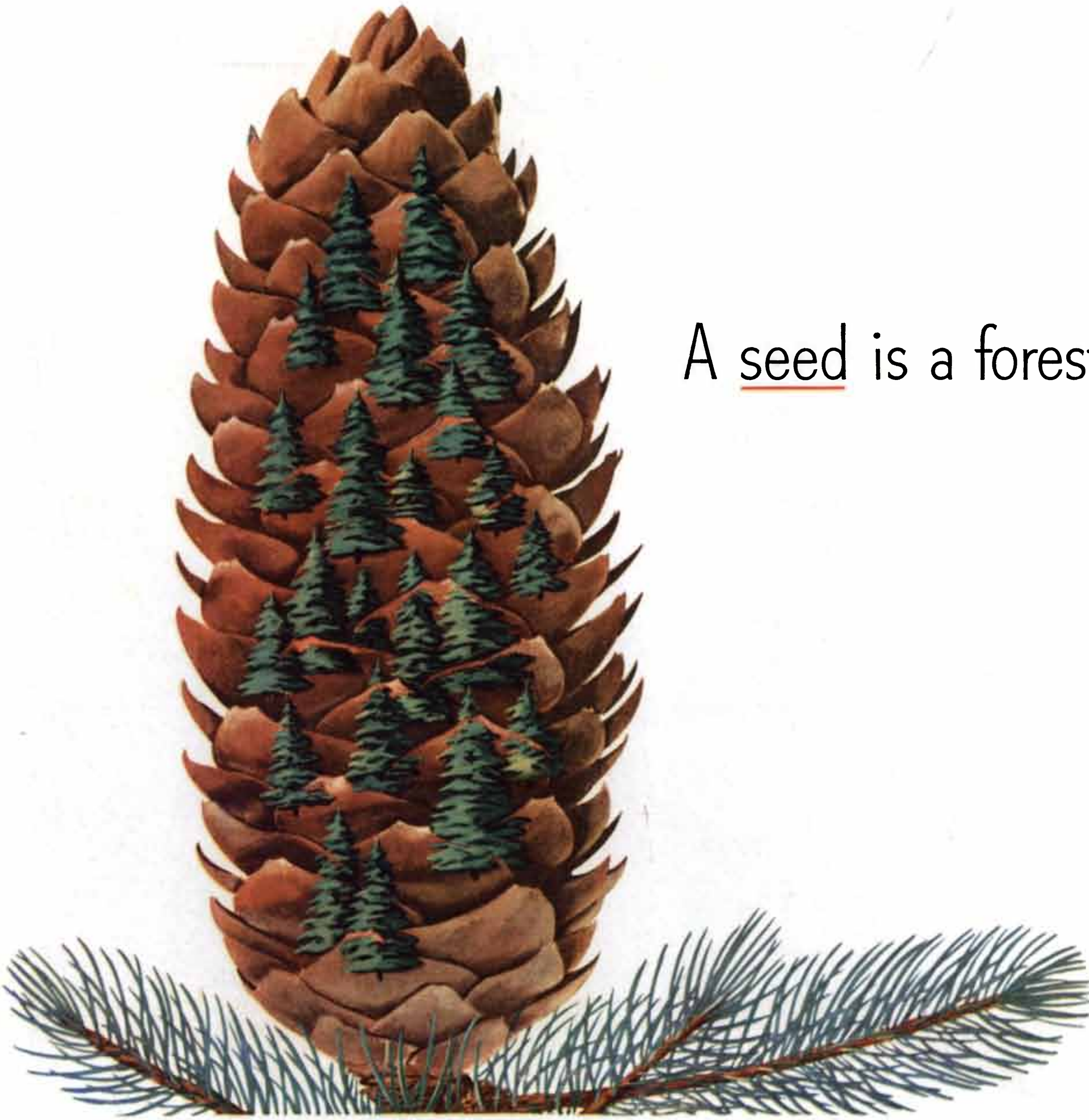

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ARTICLES

DEPARTMENTS

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THE COVER

The painting on the cover is a somewhat fanciful representation of a psychological experiment in the zoo of the German city of Münster (*see page 44*). The subject of the experiment is a female Indian elephant. The object of the experiment is to determine the ability of the elephant to recognize visual patterns. The reward for choosing the correct pattern is a piece of rye bread in a box beneath the card (*lower left*).

THE ILLUSTRATIONS

Cover painting
by John Langley Howard

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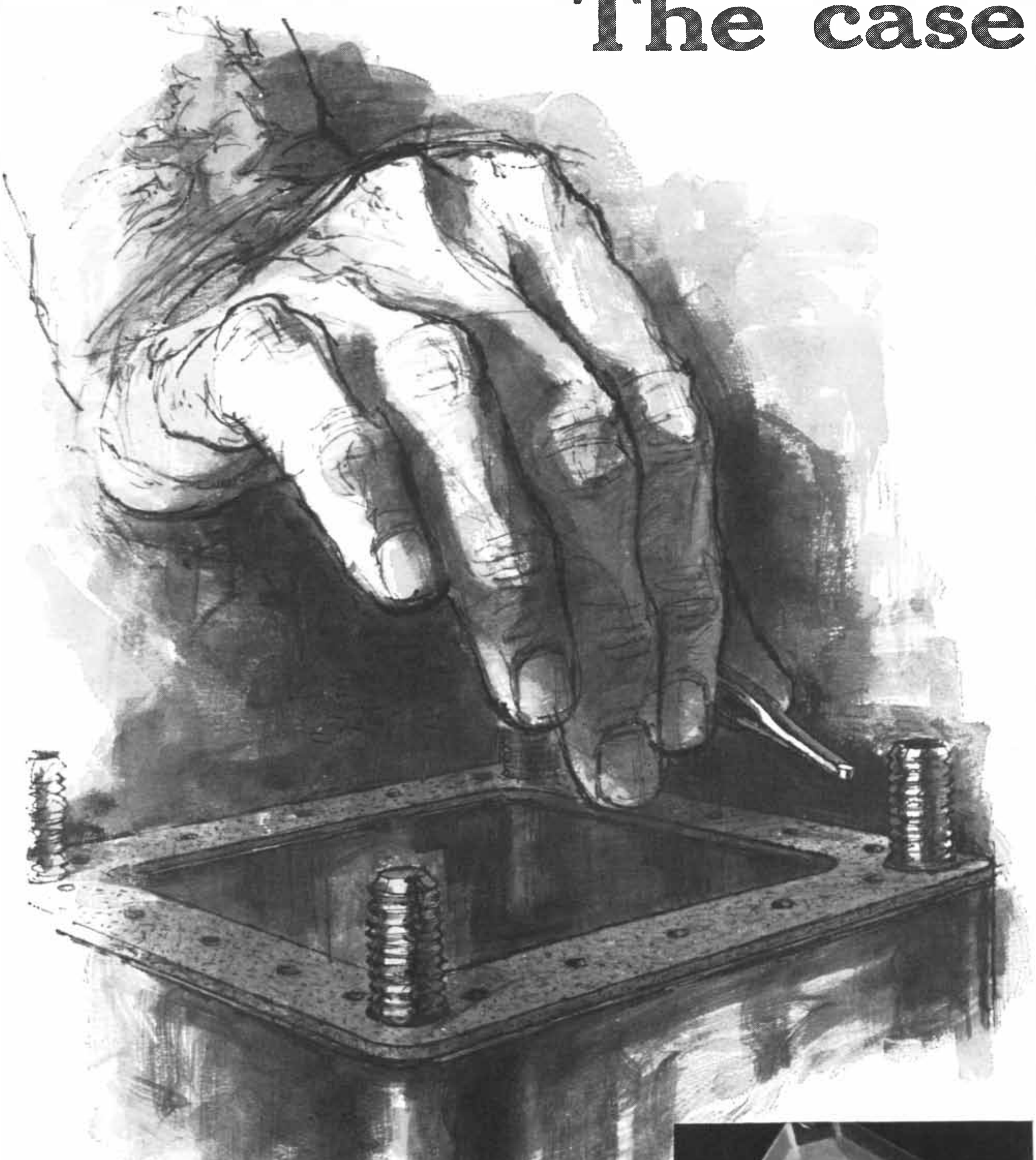
The case



To evaluate flange bowing, a major factor in joint leaks, Armstrong engineers devised a unique test. First, tiny plugs of solder are placed in holes drilled in the gasket where the degree of gasket compression is to be measured.

With top flange in place, bolts are tightened and solder plugs flatten. Resilient gasket returns to original thickness on release of pressure, but plugs remain at compressed thickness.

of the leaky joint

The bolts were tight, the gasket was good . . . yet the joint leaked. Why? Bits of solder helped pinpoint the trouble.

It doesn't take a trained eye to discover that a bolted, gasketed joint is leaking. But finding out why it leaks may call for more than a little scientific detective work.

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Yet, when the joint was bolted together, there it was, the same old leak.

Our research engineers had a strong hunch that the flange was bowing slightly when the bolts were tightened. If that was true, the gasket wouldn't be squeezed evenly enough to seal. To prove this, however, they had either to find some way to see inside the joint in service . . . or to persuade the joint itself to reveal the precise cause of the trouble.

Making a joint talk isn't an easy proposition. The Armstrong research men made a number of attempts before coming up with a simple yet completely new technique. They based it on the principle that a soft, inelastic metal will flatten under pressure and stay that way. By contrast, a compressed, resilient gasket will spring back to its original thickness on release.

The engineers drilled tiny holes through the gasket and inserted plugs of solder. Then they put the joint together and tightened the bolts. When the joint was reopened, they measured the thickness of the solder plugs.

The plugs that had been nearest the bolts were squeezed flatter than the ones in the center. This proved that the pressure of the bolts was bowing the flange—and by charting the thicknesses of the plugs, the Armstrong men got a clear picture of the extent of the flange bowing.

Now our engineers were able to offer the manufacturer a number of solutions. He could either increase the thickness of the gasket, make it narrower, or stiffen the flange to squeeze the gasket tighter . . . and stop the leak.

By devising a technique to get an inside look at a closed joint, Armstrong research men have found that even heavy, seemingly rigid flanges often bow enough to cause leaks. This kind of work is typical of that done by engineers, chemists, and physicists at the Armstrong Research and Development Center. If you have problems involving the use of gaskets, adhesives, friction materials, or vibration-damping felts, perhaps these men can help you. Write Armstrong Cork Company, 8202 Inland Rd., Lancaster, Pa.

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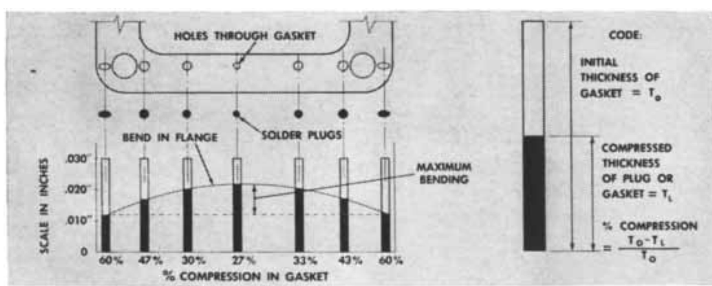

Extent of flange bowing can be shown graphically by charting the thicknesses of the solder plugs. Now the percentage of compression can be calculated (as shown in code at right above) to determine whether the gasket is within its recommended compression range at each point on the flange.

LETTERS

Sirs:

I have read Edward F. Moore's imaginative article ["Artificial Living Plants"; SCIENTIFIC AMERICAN, October, 1956] with a great deal of interest. There is one rather exciting point which he seems to have missed—he says (on page 122) that our understanding "is still not complete enough to enable us to endow a machine with evolutionary abilities." He goes on to say that "it seems safer . . . to let the plant reproduce itself exactly in successive generations, lest it take on undesirable characteristics."

My point is that, because of finite manufacturing tolerances, it would be impossible to avoid some small amount of evolution from one generation to the next. As the first machine constructs the second generation, it must impart to it the instructions for constructing the third generation, and so on. There are bound to be some errors (perhaps due to noise) introduced in this process, whether it be mechanical, electrical or chemical. All we can hope to do is to provide such a high signal-to-noise ratio in the process used by the first generation that the mutation rate for succeeding generations will be very small, for we can never make it zero. Given enough time, and assuming that the offspring do not become extinct, one of the offspring might some day be very much like a man!

DEAN A. WATKINS

Stanford Electronics Laboratories
Stanford University
Stanford, Calif.

Sirs:

Professor Watkins raises one of the very interesting problems about these plants. The problem of slow changes in dimension because of gradual accumulation of tolerances can be eliminated by having each generation recalibrate itself against a primary standard of length such as the wavelength of cadmium light; and any slight changes in chemical composition or electrical resistance will not tend to propagate themselves, since each new generation is built by following the instructions and specifications of the genes (or blueprints). However, I must concede that there will be a finite probability of a definite error in copying the genes, which will give rise to discrete jumps or typographical errors, analogous to mutations.

Anyone who has ever worked with digital computers knows that almost every error made in logical design or programming causes the computer to do something nonsensical rather than resembling its intended behavior. So it seems to me plausible that almost all mutations will be lethal; that is, the plant with an error in its genes will be unable to survive or reproduce itself. However, if we wait enough generations, it would eventually happen that there would be some mutations that could survive.

But it appears to me that the expected rate of mutation would be extremely low. It seems more plausible that some descendant of a dog or an oak tree would some day have near-human attributes, particularly because of the differences in the methods of reproduction. In the case of asexual reproduction, after n generations, each individual will have had only n ancestors. But in the case of sexual reproduction, there will have been 2^n (except for some reduction due to inbreeding).

Thus the dogs and the oak trees have more possible ways in which they can inherit mutations and get new combinations of old mutations. Thus I think that unless very careful thought is given to the design of evolutionary tendencies, the rate of evolution would be extremely slow, at least until the plant had been able to evolve itself a new evolutionary mechanism.

However, to be extremely conservative and safe about this, the designers could build into the plants a circuit which could make the entire population

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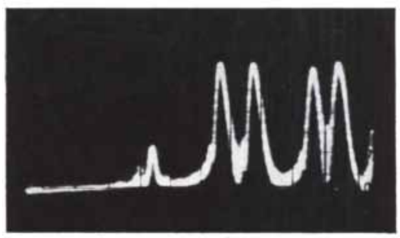
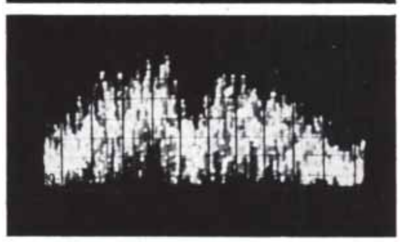
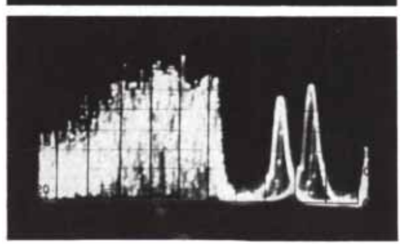


Scope pattern taken from Hoffman CV-157 showing two dualtone teletype channels on upper sideband, carrier partially suppressed. Each sideband can carry 32 teletype channels at one time.



One AM voice channel (made by continuous vowel sound) on each sideband, carrier completely suppressed. CV-157 carries two 3KC voice channels on each sideband.



AM voice on lower sideband, dualtone teletype channel on upper. With suitable multiplexing equipment, the CV-157 handles 64 simultaneous dualtone teletype channels.

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swim into the harvesting plant 500 years after the date they are designed, so that this species of plant would then become extinct. Then, if any mutants fail to do this, they can be exterminated (by designing an artificial living animal to prey on them, if necessary) and human designers can start over afresh to propagate a new species to replace them.

EDWARD F. MOORE

Bell Telephone Laboratories
Murray Hill, N.J.

Sirs:

I have read the article "Time Reversal," by John M. Blatt, in the August, 1956, issue of *Scientific American.* It seems to me that this article may be open to several serious objections, involving both fundamental principles and questions of detail. In order to facilitate subsequent discussion, these objections are numbered.

1. Fundamental principles. (1a) There seem to be at least three senses in which Dr. Blatt speaks of "time reversal": (i) The sense in which history itself is reversed; *i.e.*, the sense in which the (subjective, unanalyzed) relation "before-after" is reversed. (ii) The sense in which the solutions of certain equations, notably certain wave equations, are formally indifferent to the replacement of t by $-t$. (iii) The sense in which a system in state A at time t_1 goes into state B at time $t_2 > t_1$ and returns to state A at time $t_3 > t_2$. Now I do not claim that these senses are unrelated. However they are certainly different, and should be carefully distinguished in an article on this subject. Yet Dr. Blatt has, perhaps unintentionally, apparently confused them throughout, as, *e.g.*, when he asks (page 110): "If all elementary processes allow time reversal, why is time so patently irreversible on the macroscopic scale—*i.e.*, in the world as we see it?" He makes only one brief acknowledgment of possible distinctions, though several such distinctions are not only possible but necessary. (*E.g.*, [i] should be further subdivided.)

(1b) Dr. Blatt tends to argue that because of reversibility in sense (ii), macroscopic systems in general are reversible in principle, if not in practice. This would seem to be pressing physical theories beyond the limits of their known region of validity. Even if it were true that every equation presently known to physics was indifferent to the replacement of t by $-t$—which is certainly not true, as we shall see—it would not follow that a human being, say, could "run backward" in any sense whatever. It is the essence of physical theories and equations that they treat only suitably isolated phenomena, and ignore higher-order coupling effects. But macroscopic objects are not simply agglomerations of uncoupled atoms, and the coupling effects are both vitally important and terribly complicated. Even so relatively simple a subject as the solid-state physics of chemically pure elements is still in a very primitive stage. And the only difference between a sentient, conscious human being and a heap of inert atoms lies in coupling effects of which we have hardly the dimmest suspicion of knowledge. To argue possibilities of observable human behavior on the basis of simple equations governing idealized isolated atoms and nuclei would therefore seem to be very rash speculation indeed.

(1c) At least one type of "time reversal" contemplated by Dr. Blatt would be completely unobservable. If the universe *in toto* were to return to some earlier state, then in particular all of our records, instruments, memories, personalities, etc., would return to the same state, and we should begin again at that point with no suspicion of a gap, or, better, "loop." Such loops could be occurring right now—100 times per year, or any other frequency. One suspects that Dr. Blatt did not perceive that such "loops" were *a priori* undetectable.

2. Questions of reciprocity. (2a) In the first place, there are different types of reciprocity laws, and it is unfortunate that they were not better distinguished. On the one hand, there is a reciprocity theorem for linear, passive, bilateral, lumped electric circuits—it seems to be this theorem that Dr. Blatt has in mind in his transcontinental conversation between Abraham and Becker. However, this theorem is not specifically related to time reversal; it stems from the linearity and certain symmetries of the governing equations. (Indeed, as the phrase "electric circuit" suggests, it is derived for circumstances where the time delay of the system is negligible.) On the other hand, there is a reciprocity theorem for certain nuclear phenomena which does stem from time reversal in the sense (ii), though the content of the theorem is chiefly concerned with transition probabilities and reaction cross-sections (*Theoretical Nuclear Physics*, by J. M. Blatt and V. F. Weisskopf; pages 336-339), and it does not hold in all elementary systems.

(2b) Dr. Blatt states that "time reversal" implies reciprocity (page 108).

Let us stipulate the truth of this, though it would have been more interesting if he had indicated why it should be true in general, and in what senses of "time reversal" and "reciprocity." He then states: "Thus an experimental proof of the reciprocity theorem gives strong support to the possibility of time reversal." This is like arguing that, because a unicorn could dig holes in the ground, the presence of a hole in the ground would give strong support to the possibility of unicorns.

(2c) The use of transcontinental radio transmission as an example of reciprocity was unfortunate. This transmission would be via ionospheric reflection, and, at frequencies appropriate to the situation, the ionosphere is markedly birefringent (due to the presence of the earth's magnetic field) and inhomogeneous. This leads to polarization splitting and other complicated effects; and, as is also the case with optical systems involving birefringent media, there is neither theoretical nor experimental reason to suppose that reciprocity holds in general —quite the contrary. This would be true even if ionospheric reflection were a static, linear process; however, it is not a static, linear process, as is demonstrated by the phenomena of fading and ionospheric cross-modulation (or demodulation), respectively. The present writer has been associated with research in ionosphere physics for several years, and never expected to see it suggested that reciprocity should hold for such circumstances; the best that one could hope for would be some kind of approximate statistical reciprocity in path loss. Perhaps the failure of electric-circuit reciprocity in this case is somewhat related to the failure of nuclear reciprocity in certain microscopic events, as ". . . in systems which involve external magnetic fields, and in which time reversal is therefore not possible, the reciprocity theorem fails to hold in general." (Blatt and Weisskopf, page 529). This, by the way, is in direct contradiction to the statement in the caption of Dr. Blatt's article that "Nothing in the laws of physics prevents time from running backward . . . in microscopic events," and to the implication of the question, "If all elementary processes allow time reversal, . . ." quoted in (1a) above.

3. Ergodic questions. Dr. Blatt states (page 114) that "There is a generally accepted principle in mathematical physics, known as the 'ergodic theorem' (referring to energy), which says that in a closed, isolated system every elementary state is as likely to occur as every other." Now, there is some question as to what Dr. Blatt means by "elementary state." In any event, however, there are several ergodic theorems, no one of which refers specifically to energy, and no one of which says the thing alleged; each deals with certain types of convergence of certain types of averages. There is also an "ergodic problem," or "ergodic principle," which is concerned with the interchange of certain types of averages with certain other types of averages. See, for example, *Probability Theory*, by M. M. Loève, pages 410-454 and *Statistical Mechanics*, by A. Y. Khinchin, pages 44-69. Perhaps Dr. Blatt had something of this sort in mind, though the connection does not seem to be obvious; his language suggests that he may have been thinking of something like the principle of equipartition of energy. If so, however, it would not seem to support the conclusion he draws, namely, that there is a positive probability that the universe will return to its present state; such thermodynamic principles as equipartition seem rather to support such pessimistic conclusions as the "heat death" of James Jeans. . . .

D. G. BRENNAN

Lincoln Laboratory
Massachusetts Institute of Technology
Lexington, Mass.

Sirs:

I shall do my best to reply to these comments.

First of all, as a theoretical physicist I am mostly concerned with the fact that certain equations are invariant under the replacement of the time coordinate $+t$ by $-t$, its negative. Indeed, all fundamental equations of physics do have this property. We will come to the apparent exceptions later. It is this sense, primarily, in which I meant to use the word "time reversal."

There is, however, an immediate connection to our more intuitive experience. Anyone who has seen a movie played backwards knows that it looks "all wrong." Things happen which just "couldn't happen" in real life. Yet, since the basic equations allow the replacement of $+t$ by $-t$, the movie played backwards should *not* look all wrong, and in principle the sequence of events *could* happen. The problem to which the article was addressed was the understanding of this apparent discrepancy.

As regards the extrapolation of microscopic theories to macroscopic systems such as living organisms, beyond the

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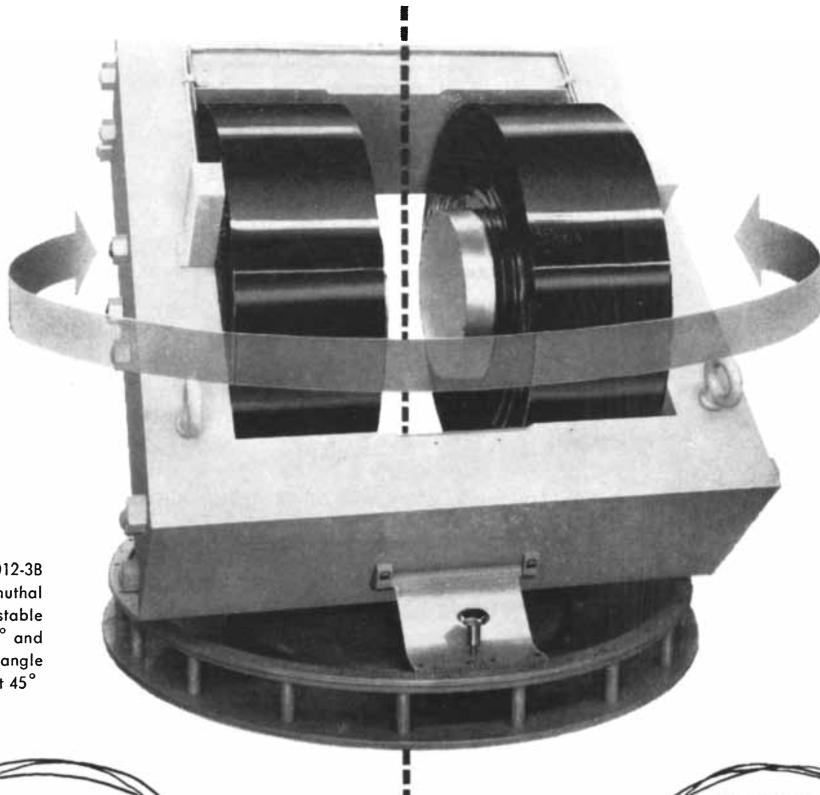

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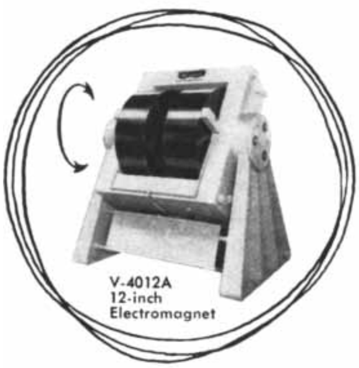

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limits of their known region of validity, a fundamental point is indeed involved here. Either there is a "life force" or some similar nonphysical or extraphysical agency at work, or else living organisms are just as much subject to the laws governing the behavior of elementary particles as pieces of stone or rivers of water. Of course, there may be a life force. But before we assume that, it is certainly desirable to explore the contrary hypothesis very carefully indeed.

While a new force, such as the "life force," could invalidate reversibility in living organisms, mere complications and "coupling effects" *cannot* do so. It is precisely the strength of arguments based upon symmetry properties of the fundamental equations that they are quite independent of the degree of complexity of the composite system under study.

Hence, even though we are very far indeed from understanding just how the basic equations satisfied by individual atoms result in the observed behavior of a living organism, we can nevertheless assert that these equations will lead to the possibility of reversibility, be it ever so unlikely to happen in practice. This is not rash speculation, but straightforward deduction.

I agree with Dr. Brennan that one type of "time reversal" discussed in the article would be unobservable. This is a good point, which I had indeed overlooked.

But I must disagree most strongly with Dr. Brennan's statement that the reciprocity theorem for linear passive networks "is not specifically related to time reversal" but rather "stems from . . . certain symmetries of the governing equations." The question is: Whence stem these symmetries? The answer is precisely from the basic time-reversal symmetry. Indeed, the proof of the reciprocity theorem for electrical networks is identically equal (except for wording) with the proof for nuclear reactions given in the reference cited; mathematically, the theories of nuclear reactions and of electrical networks are so closely related as to be practically indistinguishable. Time *delays* do not matter.

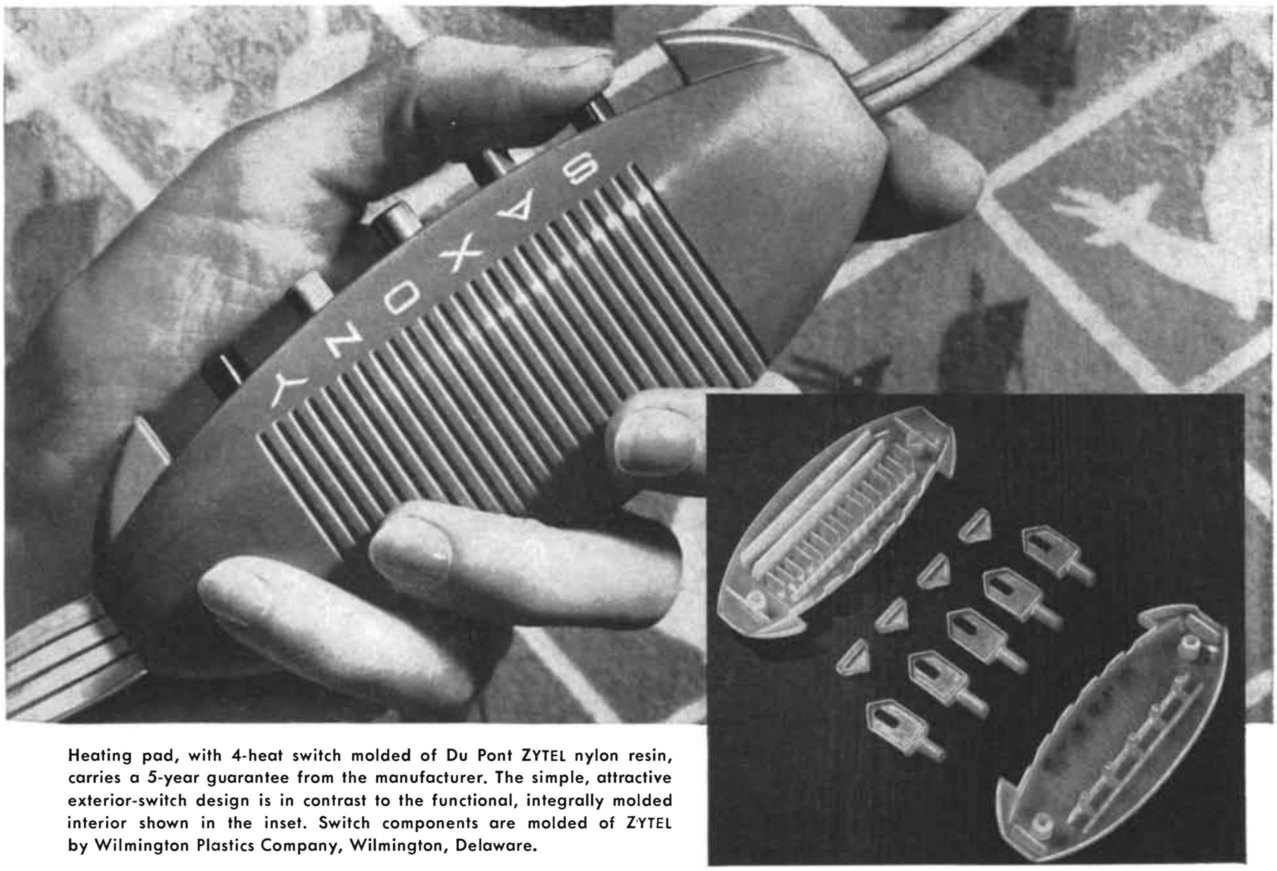
The unicorn argument is a good logical point, but it loses much of its force when one reflects that not only can reciprocity be proved directly from time reversal, but also a time-irreversible system (say, containing fixed magnetic fields) can be made to violate the reciprocity law, *in all cases known so far.* Thus the relation between time reversal and reciprocity is much more direct indeed than the relation between unicorns and holes in the ground.

Now, what about these "time-irreversible systems" which seem to contradict all I have said so far? The most important systems of this kind involve fixed magnetic fields, for example a magnetic loudspeaker. The irreversibility is then only approximate, not exact: it holds if, and only if, the reaction of the process back on the state of the magnet is ignored. In a fundamental analysis, the state of the magnet must be included in the description of the system under study. When this is done, the processes which seem to violate the reciprocity law are seen not to be really reciprocal processes at all!

For example, when different radio signals travel through the ionosphere under the influence of the magnetic field of the earth, apparently reciprocal transmissions are not really reciprocal events because they affect the magnetic field of the earth in different ways. In practice, this makes extremely little difference and is quite unimportant, but in principle the action on the magnetic field cannot be ignored.

To see the importance of this distinction, assume that a passive, linear, truly nonreciprocal network could really be constructed, not merely approximated in some useful technical sense. We could then use this network to violate the second law of thermodynamics! This is seen most easily by considering the special case in which the lack of reciprocity appears in the form of a "one-way" system, which transmits energy in one direction only. Let us connect this one-way network between two resistors at the same temperature initially. We can then derive useful work from the heat energy contained in the resistors, both resistors cooling down as the process continues, in contradiction to the second law of thermodynamics. Of course, the actual, practical "nonreciprocal" networks used by engineers cannot violate the second law, because they do not really violate the reciprocity theorem. So much for the "failures" of the reciprocity theorem—they are only apparent and approximate, of great practical but no fundamental interest.

Finally, I admit freely that the statement of the ergodic theorem given in my article was extremely loose, but surely one should not look for precise mathematical rigor in a popular article. "Every elementary state is as likely to occur as any other" is the nearest I could get to stating the rather abstruse ergodic theorem (or, more precisely, the "quasi-ergodic hypothesis") in language under-



Heating pad, with 4-heat switch molded of Du Pont ZYTEL nylon resin, carries a 5-year guarantee from the manufacturer. The simple, attractive exterior-switch design is in contrast to the functional, integrally molded interior shown in the inset. Switch components are molded of ZYTEL by Wilmington Plastics Company, Wilmington, Delaware.

Du Pont ZYTEL® solves a difficult design problem . . . improves product performance

The industrial designer at Saxony Electronics, Inc., of Wilmington, Delaware, was developing a new heat-control switch for a quality heating pad. As in any new design, many factors were involved in the selection of the material to be used for this switch.

For instance, the designer wanted moving parts that would require no lubrication. Durability, impact resistance and electrical insulating qualities were required. What about weight, color and cost of fabrication? What of the "feel" of the switch, its dependable operation and its attractiveness to the consumer?

One engineering material — Du Pont ZYTEL nylon resin — solved all these problems. The switch of ZYTEL (shown above) is designed to give years of satisfactory service. It has "molded-in" eye appeal, and is pleasing to the touch of the user.

This switch is just one example of how the many useful properties of ZYTEL may help you make a good product better, or help design a completely new product. Bearings and moving parts of this material are frequently operated with little or no lubrication. Electrical stand-off insulators are molded of this material because of its good insulating properties at commercial frequencies.

In addition, mass production of parts of ZYTEL by injection molding is both economical and rapid . . . the pieces can be molded in many colors . . . and generally require no special finishing operation.

ZYTEL® nylon resin	**ALATHON®** polyethylene resin
LUCITE® acrylic resin	**TEFLON®** tetrafluoro-ethylene resin

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

E. I. du Pont de Nemours & Co. (Inc.), Polychemicals Department
Room 402, Du Pont Building, Wilmington 98, Delaware
In Canada: Du Pont Company of Canada (1956) Limited, P.O. Box 402, Montreal, Quebec

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____

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Position ____________
Type of Business ____________
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City ____________ State ____________

standable to the layman. I certainly did *not* confuse the ergodic theorem with the equipartition law in my own mind, and I am sorry if any of the readers were misled that way.

As regards the relevance of the ergodic theorem for a closed universe, what I said in the article stands. If the quasi-ergodic hypothesis is assumed to hold for the universe as a whole, then a state arbitrarily close to its present state should eventually recur. Thus, *after* its "heat death" the universe would again "revive." Personally, I prefer to assume that the universe is not a closed system.

I realize that little of what I said in the article, or of what I have said now, is directly connected with the basic philosophical problem of "What Is Time?". Perhaps your readers would welcome a future article on this subject by a professional philosopher. As a physicist, I am reluctant to venture too far into strange territory; I hope your readers will forgive me for this caution.

JOHN BLATT

Princeton University
Princeton, N.J.

Sirs:

I read with interest the article "Radioactive Tuberculosis Drugs" by Lloyd J. Roth and Roland W. Manthei in the November issue of *Scientific American*, but I was disappointed to find that it lacked the perspective commonly found in articles published in your splendid journal.

It failed to reveal what has long been known, namely, why tracer studies with carbon-labeled Isoniazid have little or no bearing on the problems of chemotherapy of tuberculosis with that drug. The authors themselves pointed out—near the end of their exposé—that Isoniazid is extensively modified metabolically in animals and human beings to antimicrobially inactive derivatives which, unfortunately, are also labeled. What they did not disclose is that this occurs at widely different rates in different individuals. Thus such studies with carbon-14 labeled Isoniazid have been essentially useless for the analysis of the distribution of the chemotherapeutically active drug in various tissues.

The authors have also disregarded the one problem which is paramount to an understanding of the mode of action of anti-TB drugs and their practical clinical applications: that is, the observation that it makes little biological difference whether or not the drugs reach the TB germs in tubercles "walled off by scar tissue." In such recesses the germs don't multiply; and the drugs have long been known to be unable to exert their specific poisonous effects against "resting" bacteria.

In view of these considerations, the shortcomings of this article have wider implications, in my opinion. They suggest that today's bandwagon of "atomic medicine" may be misleading some of our less biologically oriented colleagues in chemistry into losing their biological perspective much as did the bandwagon of the Warburg apparatus in the 1930s and 1940s.

GARDNER MIDDLEBROOK, M.D.

National Jewish Hospital at Denver
Denver, Col.

Sirs:

Those interested in the above letter are referred to *The Tubercle Bacillus*, by Georges Canetti, Director of Laboratory, Pasteur Institute, and a world authority on tuberculosis. Our work, the significance of antitubercular drugs in the tuberculous lesion, and the presence of viable bacilli in such lesions is adequately discussed on pages 184-191.

Para-aminosalicylic acid (PAS), a widely used antituberculostatic synthetic drug, was discovered in the 1940s as the result of chemical studies utilizing the Warburg procedure to follow the *in vitro* respiration of the tubercle bacillus. See "Evolution of Chemotherapy in Tuberculosis," by Glenn Malley, *Archives of Internal Medicine*, 93, 967-981, 1954.

LLOYD J. ROTH

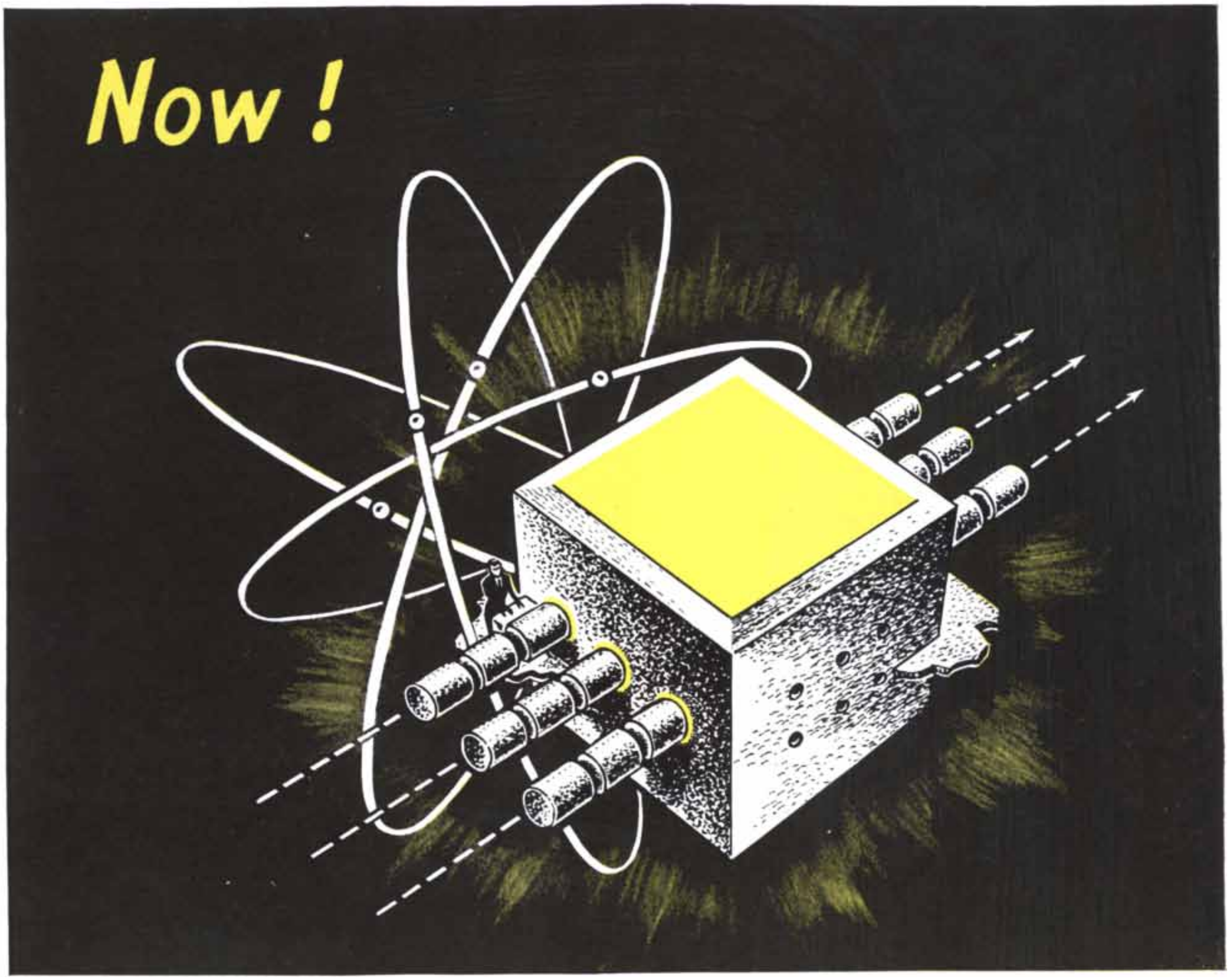
The University of Chicago
Chicago, Ill.

R. W. MANTHEI

Jefferson Medical College
Philadelphia, Pa.

ADDENDUM

The article "Appetite and Obesity" (SCIENTIFIC AMERICAN, November, 1956) described an adaptation of the Skinner box technique to the study of food intake in mice. This adaptation was developed by James Anliker.



Norton ceramic fuel elements

Separate facility now producing ceramic fuel elements and various reactor components

To meet the demand for more-economical, more-efficient reactor fuels, the trend is towards ceramic types — because of their greater resistance to corrosion and radiation, the ease with which they can be reprocessed, and their ability to operate at higher temperatures. Norton Company's long experience in the development of high-purity ceramics has now led to the commercial production of ceramic fuel elements.

Take Advantage of Norton Assistance in bringing special nuclear materials into successful use in the development of nuclear power plants. In addition to the development and production of ceramic reactor components, Norton experience includes highly specialized refractories for missile, metallurgy, chemical, and furnace applications. These top-performing Norton refractory R's — *engineered and prescribed* for the widest range of uses — are of increasing interest to nuclear engineers. They include alumina, silicon carbide, thoria, urania, zirconia, magnesia, dolomite, and numerous borides, carbides and nitrides — that have benefited nuclear as well as general industrial developments.

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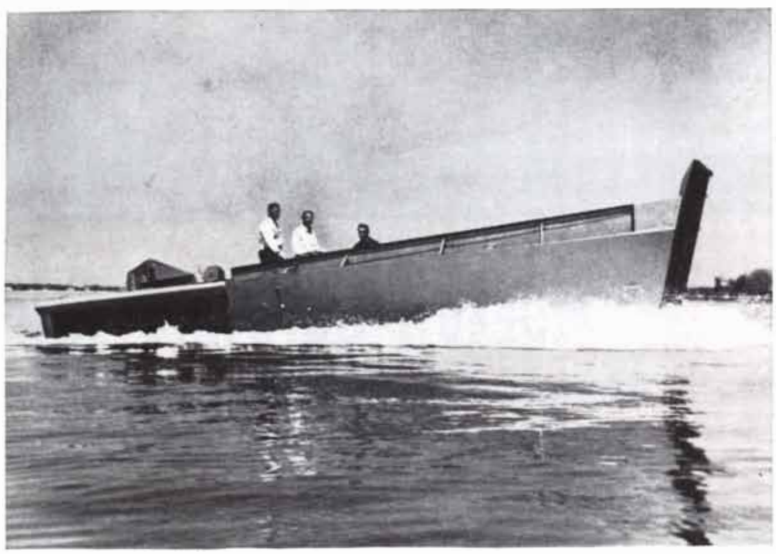
Life on the Chemical Newsfront

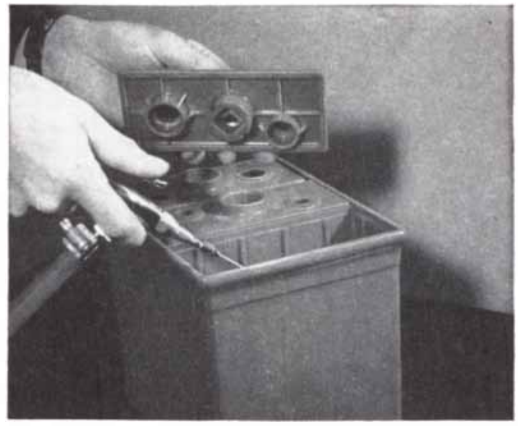
ATTRACTIVE PRINTED DESIGNS are produced on chintz and similar fabrics by two dye processes working together. First the fabric is dyed to a solid shade with a "discharge" dye, then it is printed with vat dye to create the decorative pattern. When the vat dye is "fixed," the dyed background in the same area is simultaneously destroyed, leaving a crisp, clear design on a solid background. The use of vat dyes insures fastness to light and laundering. Calcosol* Vat Dyes for printing are particularly suitable for this type of work. (Organic Chemicals Division)



A PLASTIC "NAVY" is in the making at Lunn Laminates Inc., of Huntington Station, N. Y. Successful U. S. Navy tests on a 36-foot landing craft hull led to an initial order for a small fleet of these one-piece reinforced plastic vessels. Fabricated of Laminac® Polyester Resin and glass fiber with a honeycomb core, the hull is rust-free and rotproof, insuring many years of service—or moth-balling—with negligible maintenance. The seam-free hull is exceptionally strong, but any damage can be quickly repaired by on-the-spot patching. Laminac Resin also is used to produce "navies" of sailboats, cabin cruisers, dinghies and other pleasure craft—and to cover old wooden hulls. Owners can spend more time enjoying their boats, less time maintaining them. (Plastics and Resins Division)

GREASE PENETRATION OF PAPER IS STOPPED by a very thin film of Cyanamid's new Cypel® Paper Resin. The photo shows how dyed turpentine penetrates untreated paper almost instantly—yet has not penetrated the stock coated with Cypel after many hours. This greatly accelerated test of grease penetration proves the exceptional value of Cypel Resin for papers requiring indefinite resistance to grease, oil and similar materials. Supplied as an anionic emulsion, Cypel Resin is compatible with most coating and sizing materials. The films are very flexible and have good heat-sealing properties.

*Trademark (Industrial Chemicals Division, Dept. A)



MORE ECONOMICAL WEED KILLERS are in prospect as costs are cut on herbicides made from cyanuric chloride. The new low price announced by Cyanamid on this reactive intermediate is expected to reflect itself in an increased market for the weed killers currently made from it. Other derivatives based on the remarkably stable triazine ring of cyanuric chloride will now have greater commercial promise than before in other agricultural products, such as insecticides and fungicides. Specialty resins, surfactants and rubber chemicals are among the industrial applications that will also benefit from the lower price of Cyanamid's AERO® Cyanuric Chloride.
(Industrial Chemicals Division, Dept. A)

BETTER ADHESIVES FOR PLASTICS utilize the excellent solvent properties of Cyanamid's 1,1-ditolylethane for polystyrenes and other polymers. Crazing and distortion, often associated with adhesive applications, are greatly reduced or eliminated when high-boiling, slow-penetrating ditolylethane is used. Liquid from —35° to 300° C, it is suggested for use in plasticizers, and as a solvent in organic reactions. Ditolylketone, 2-methyl anthracene and mixed sulfonic acids are typical derivatives of ditolylethane. (New Product Development, Dept. A)

HIDE-ATTACKING BACTERIA ARE DESTROYED by adding small amounts of beta naphthol to the hide-soaking solutions and other tanning chemicals used in leather processing. Extensive evaluation of beta naphthol under practical tanning conditions proves it to be an outstanding antiseptic from the viewpoint of effectiveness as well as cost. Organic finishing chemicals are also protected almost indefinitely by very small percentages of beta naphthol, assuring trouble-free operation in finishing processes such as that pictured above. A detailed summary of beta naphthol's mold-suppressing properties is available on request.
(Organic Chemicals Division)

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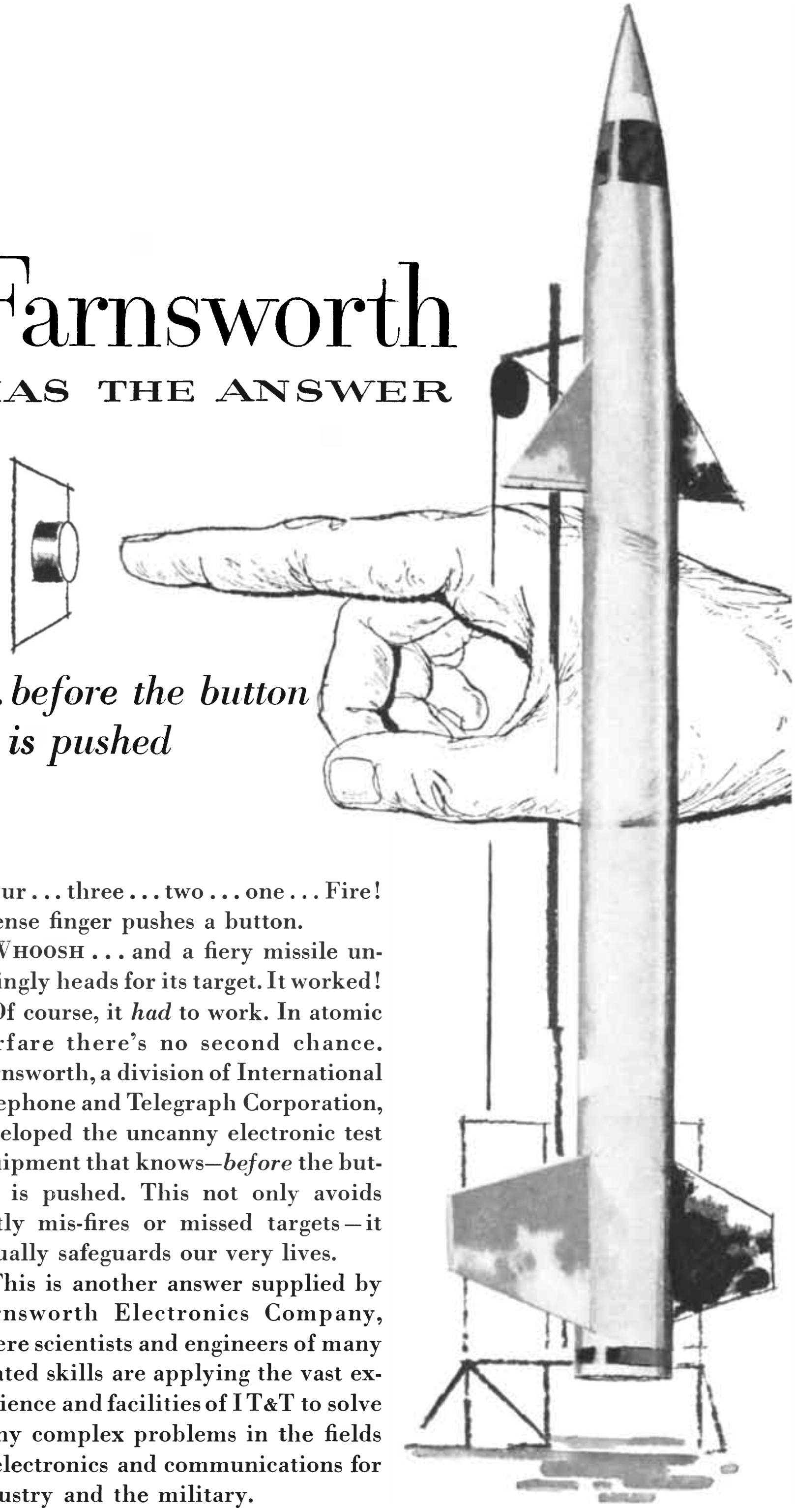


50 AND 100 YEARS AGO

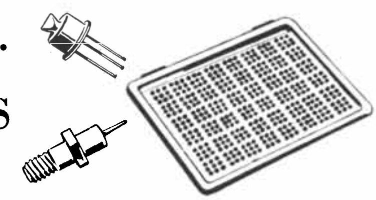
SCIENTIFIC AMERICAN

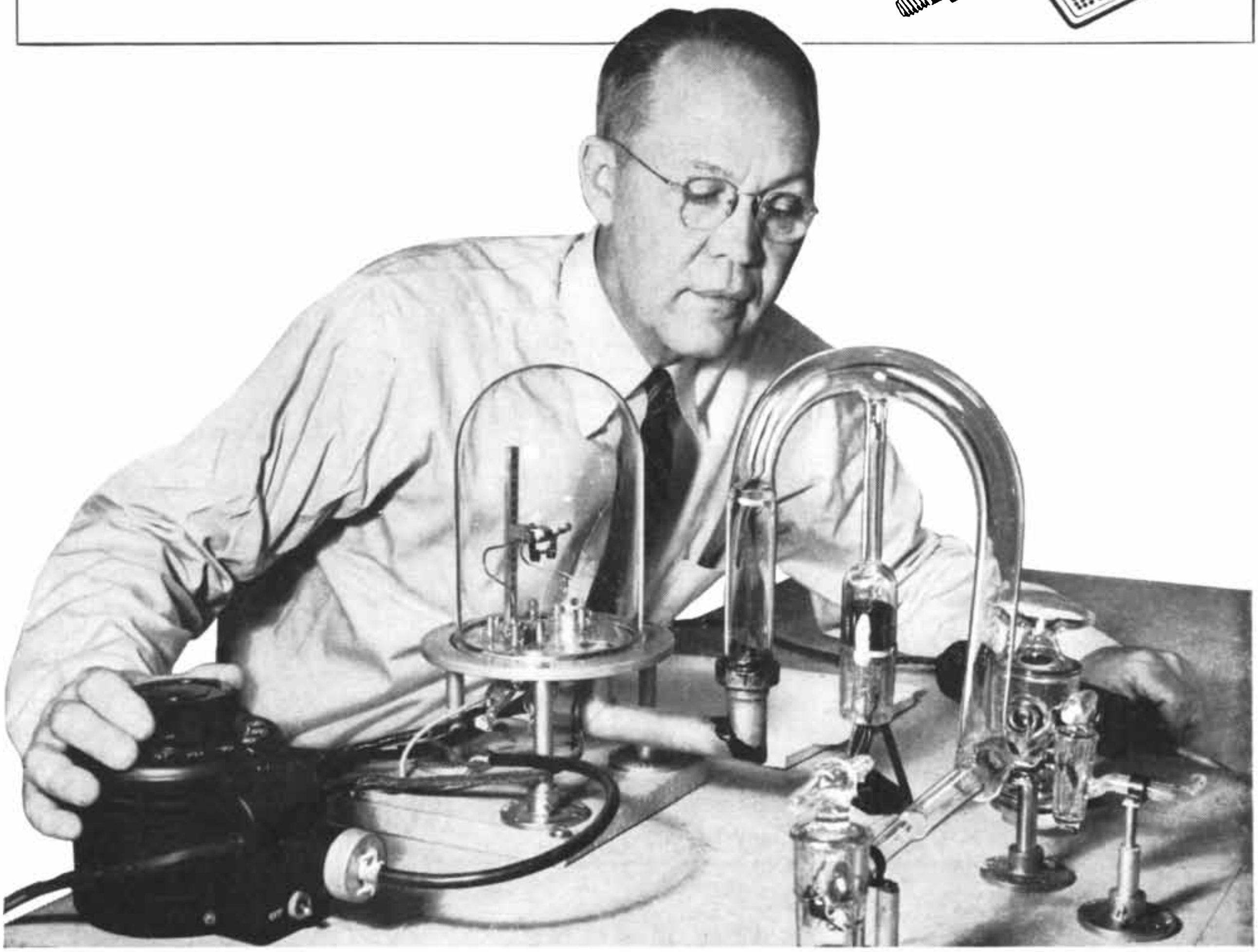
FEBRUARY, 1907: "Prof. Dmitri Ivanovich Mendeleyev, one of the greatest chemists in the world, died recently in St. Petersburg. He was born in Siberia in 1834, and when a young man went to St. Petersburg, where he received his education. In 1863 he became professor of chemistry in the Technological Institute in St. Petersburg and became famous, not only as a chemist and a teacher, but also as a geologist and philosopher. In a few years he succeeded to the chair of chemistry in the St. Petersburg University. His field of original research was wide, and in 1871 he foretold the existence and general properties of three new chemical elements now tabulated under the names of gallium, scandium, and germanium. He wrote many papers on chemical topics, and his book, *The Principles of Chemistry*, was reprinted in many languages. He received the Copley gold medal at a meeting of the Royal Society in London last year."

"In 1903, Prof. Svante Arrhenius stated that the theory called panspermy, according to which the germs of organic life are conveyed through interstellar space from one heavenly body to another, had advanced greatly in probability from the establishment of the pressure exerted by light and other cosmic radiations. The theory was suggested after the repeated failures of many eminent biologists to discover a single case of spontaneous generation. A great difficulty of the theory had consisted in the apparent impossibility of conveying germs even from one planet to another in a time through which their life could be preserved. Most germs can be kept alive only a few years, although certain spores live for decades. By introducing the pressure of radiation as a motive power, however, these journeys can be reduced to 20 days' travel to the nearest planet, Mars, and 9,000 years to the nearest star, Alpha Centauri. But even these intervals may appear to be of formidable length, especially in view of the absolute dryness and intense cold and light to which the germs would be sub-

New technique shapes future of transistors...

LEADS TO THREE MAJOR INVENTIONS





Calvin S. Fuller, Ph.D. in Physical Chemistry from the University of Chicago, is a pioneer in development of the diffusion technique. Here he controls a heating current through a strip of silicon while diffusing into its surface a film of aluminum less than 1/50th of a hair's breadth in thickness.

Transistor makers have a very difficult problem. They must add a mere trace of an "impurity" to a semiconducting metal. But they must add it only in very thin layers, without affecting the bulk of the material.

Bell Laboratories scientists developed an efficient new way to produce such layers. They expose the metal to a hot gas containing the impurity. Atoms bombard the surface and—through a process known as "diffusion"—force their way into the metal to form a microscopic film which can be controlled in thickness to a few millionths of an inch.

The diffusion technique opened the way to three major Bell Laboratories inventions in the semiconductor field: the Bell Solar Battery, Silicon Power Rectifier and the Diffused Base Transistor. Right now the technique is providing a key to many other developments of great promise for telephony. It is another example of how Bell Labs works to improve telephony through fundamental research in materials.

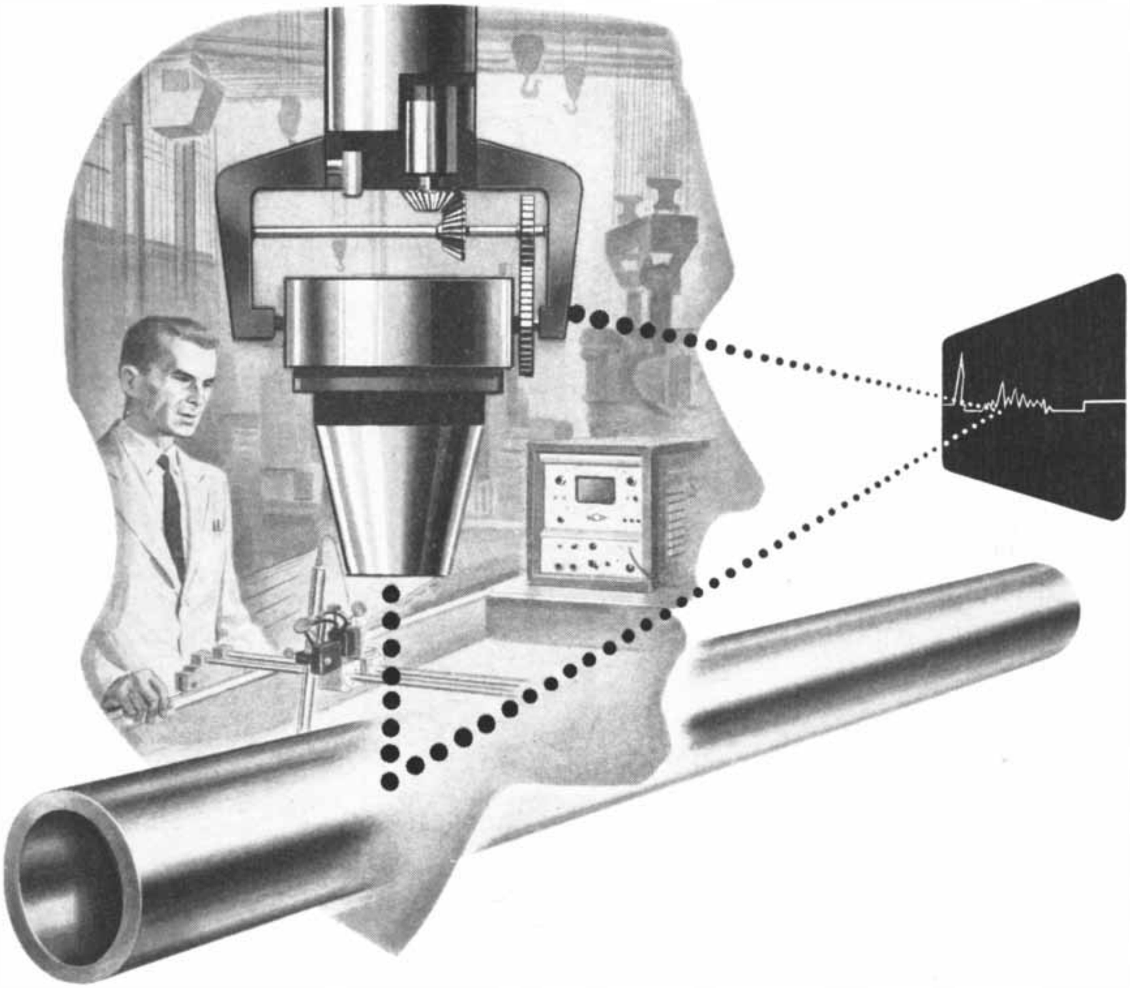
BELL TELEPHONE LABORATORIES

WORLD CENTER OF COMMUNICATIONS RESEARCH AND DEVELOPMENT ject in transit. Arrhenius argues, however, that recent experiments by Roux prove that germs are not killed by light but by air. Furthermore, it has been demonstrated that intense cold is not injurious to all germs and that certain algae are not killed by being kept in a desiccator for over 20 weeks. With these objections removed, concludes Arrhenius, it would appear that interstellar space can be traversed, at enormous speed, by living germs which bring organic life to planets as soon as a crust capable of sustaining life has been formed."

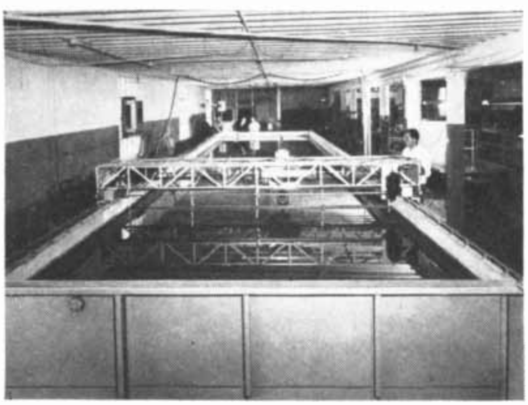
"Three of the leading hydraulic engineers of the country have recently reported favorably upon what is probably the most daring municipal water supply scheme that has ever been projected. We refer to the proposal, which we understand has every prospect of being successfully prosecuted, to supply the city of Los Angeles and the surrounding district with an abundant supply of water drawn from the distant Sierra Mountains. The scheme involves, first, the construction of a conduit 226 miles in length, capable of supplying the city with a quarter of a billion gallons of water daily; second, the construction of large storage reservoirs, a single one of which will have the enormous capacity of 85 billion gallons of water; and lastly, the development of a total of 100,000 horsepower, available for six days of the week and nine hours of each day, the greater part of which can be developed within a distance of 45 miles of the city. The total cost of this very ambitious undertaking will be about $25,000,000. The guarantee for planning this work on a scale of such magnitude is to be found in the certain and very large income to be derived from the sale of water for irrigation purposes and for power, in and around a city which doubled its population in the 10 years preceding the last census, and is recognized today as being, next to San Francisco, the most important commercial center in the flourishing State of California."

"Of a somewhat sensational nature is the late announcement of a $50,000 prize offered at Paris for the first aerial flight from Paris to London."

FEBRUARY, 1857: "Great facilities are afforded by microscopes, chemical



Finding the invisible with the inaudible



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tests, and the researches of modern physiology in affirming or disproving circumstantial evidence as to murders. Dr. H. Burdell was found stabbed in his own room in New York City on the morning of the 29th ult. There was bad feeling existing between him and his housekeeper, and many circumstances fastened suspicion on her and one of the boarders, but science has removed some of what were at first strong indications of guilt. A dagger was found in her drawer faintly stained with blood; these stains are proved by chemical analysis to be rust. A very palpable bloody stain on a blue silk dress proves to be sugar or fruit preserves, and blood found on various clothing about the house is traced to other sources by the same agency. A knife from the place of business of the suspected boarder, and a newspaper found in his room, showed stains which responded to the chemical tests for blood, and under the microscope showed the blood disks, or red globules, to be arterial. This will probably weigh as evidence against him."

"As the old copper coins are about to give place to new small cents made of nickel and copper, an obituary of the 'red cent' will not be uninteresting. It was first issued as a United States coin in 1792. It then bore the head of Washington on one side, and 13 links on the other. The French Revolution soon after created a rage for French ideas in America, which put on the cent, instead of the head of Washington, the head of the Goddess of Liberty—a French Liberty, with neck thrust forward and flowing locks. The chain on the reverse was replaced by the olive wreath of peace. But the French Liberty was short-lived, and so was her portrait on our cent. The present staid, classic dame, with a fillet around her hair, came into fashion about 30 or 40 years ago."

"We have been informed that the Maelstrom, that great whirlpool on the coast of Norway, laid down in all geographies, and of which we have heard such wonderful stories, has no existence. A nautical and scientific commission, composed of several gentlemen appointed by the King of Denmark was sent to approach as near as possible to the edge of the whirlpool, sail around it, measure its circumference, observe its action and make a report. They went out, and sailed all around and all over where the Maelstrom was said to be, but could not find it; the sea was as smooth where the whirlpool should have been as any other part of the German ocean."

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S-816 is used currently for turbine blades in two of the production jet engines, also in a number of experimental aircraft and commercial gas turbines. Except for seamless drawn tubing, it is available in practically all forms and shapes in which stainless steels are processed, including hot extrusions.

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S-590 was developed at the Watervliet Laboratory and field-proved during the same years as S-816. It is available in the same shapes and forms, and is currently being used for turbine blades and wheels in experimental commercial gas turbines.

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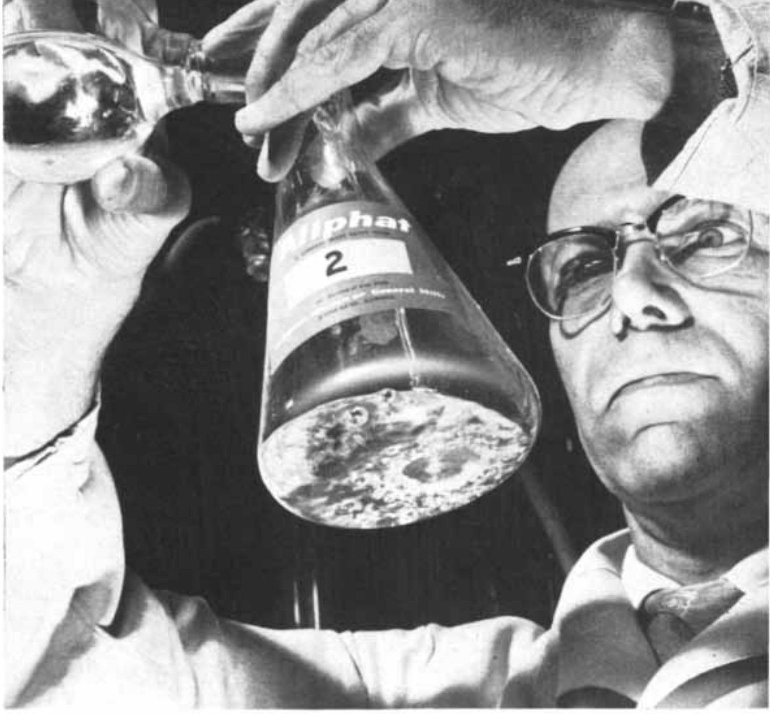

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Soybean Division, Minneapolis

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THE AUTHORS

SIR MACFARLANE BURNET ("The Structure of the Influenza Virus") is director of the Walter and Eliza Hall Institute of Medical Research at the Royal Melbourne Hospital in Australia. In the course of his long career there (he received his M.D. from Melbourne University in 1923) he has made many fundamental contributions to the study of virus diseases: one of these is the technique for culturing viruses in chick embryos. He was knighted in 1951 and is a Fellow and Royal Medalist of the Royal Society. Burnet is a popular writer, lecturer and a skillful amateur painter. His previous contributions to Scientific American include an article on the influenza virus which appeared in the issue of April, 1953.

B. RENSCH ("The Intelligence of Elephants") is professor of zoology and director of the Zoological Institute of the University of Münster in Germany, where he conducted the psychological experiments described in his article. After graduating from the University of Halle, he spent 11 years at the University of Berlin's Zoological Museum as head of the mollusk department. In 1937 he went to Münster to direct the Biological Museum there. He recently participated in scientific symposia in New York and in Brisbane, Australia.

RICHARD J. BING ("Heart Metabolism") is professor of medicine at Washington University in St. Louis and director of the Washington University Medical Service. A native of Nuremberg, Bavaria, he holds the degree of M.D. from universities in Germany and Switzerland. After a year as fellow of the Carlsberg Institute in Copenhagen, he was invited to the Rockefeller Institute by Alexis Carrel in 1937. Later he went to the Johns Hopkins University as an instructor and was a member of Alfred Blalock's "blue-baby" team. During explorations with a catheter, it accidentally slipped into a coronary vein, and this opened up the study of heart metabolism by catheterization. From 1951 to 1956 Bing was director of the Cardiac Clinic and professor of experimental medicine at the Medical College of Alabama. For recreation he plays the piano or (preferably) composes music, an activity which he finds less disturbing to his neighbors. "I have written a series of string quartets in a sort of modern-romantic style,"

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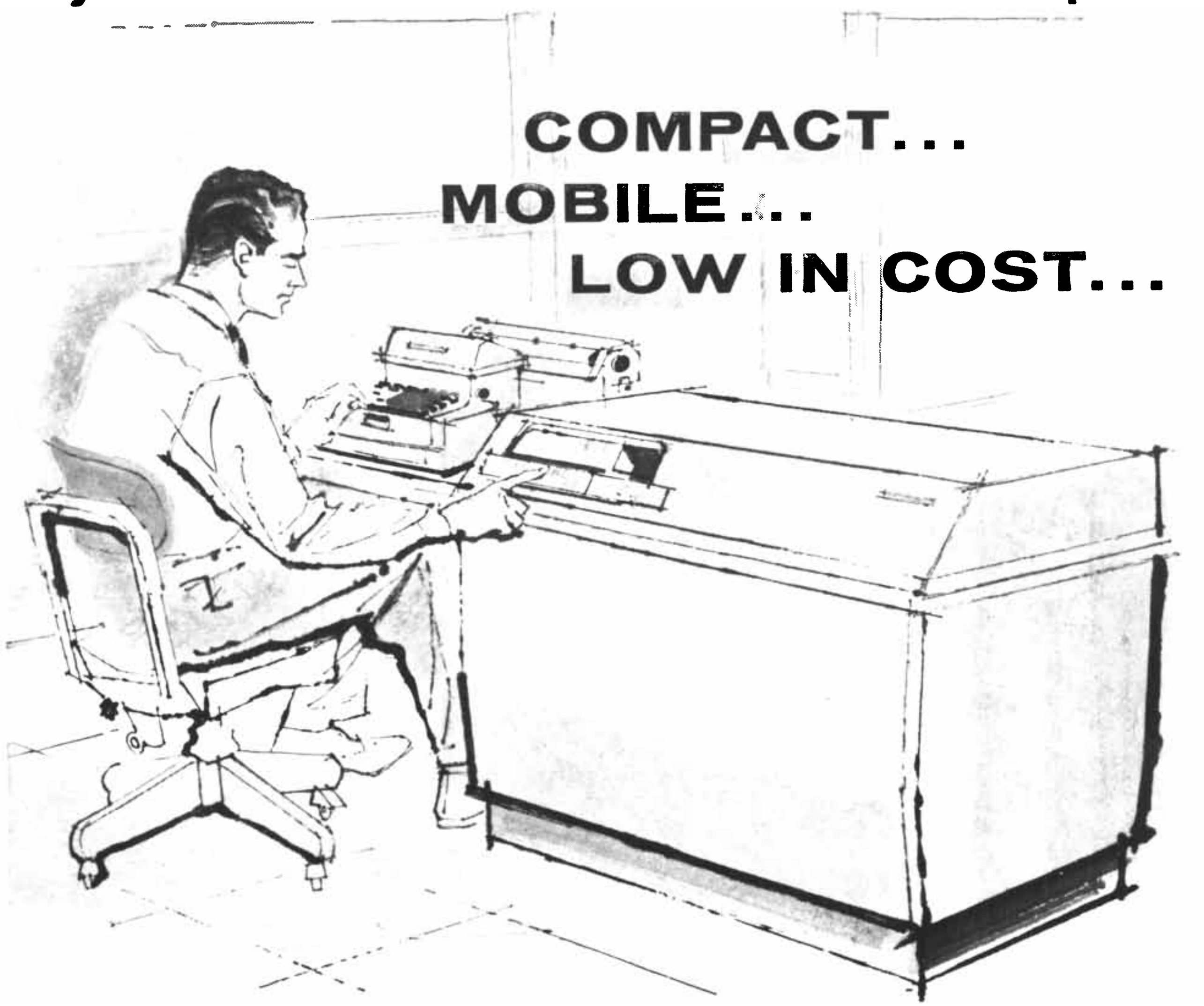

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he reports, "and continue this sort of work, particularly when the research is not going well."

HAROLD LYONS ("Atomic Clocks") is a leader in atomic research at the laboratories of the Hughes Aircraft Company. He was born in Buffalo in 1913. After taking a Ph.D. in physics from the University of Michigan, he went to work for the Naval Research Laboratories and later for the U. S. National Bureau of Standards, where he was chief physicist from 1946 to 1955. Lyons developed the first two atomic clocks, in response to the Bureau's need for an invariant measure of the time and frequency of microwaves. Lyons has won many honors for his work with atomic clocks. Among them are the U. S. Department of Commerce Gold Medal for Exceptional Service, the Arthur S. Flemming Award and an award from the Washington Academy of Sciences.

AMEDEO S. MARRAZZI ("Messengers of the Nervous System") is the first director of the Veterans Administration Research Laboratories in Neuropsychiatry in Pittsburgh, and research director of the Pittsburgh Veterans Administration Hospital. He is also professor of physiology and pharmacology at the University of Pittsburgh School of Medicine. In his new laboratory Marrazzi is developing an interdisciplinary approach to studying the nervous system and its reactions to drugs. Born and educated in New York City, he has collaborated on many research projects with his wife, who was his classmate at the New York University College of Medicine and for a time practiced as a pediatrician. They became interested in drugs as research tools and introduced electric recording techniques into this work in 1938. The Marrazzis have a son and a daughter who plan to become research scientists.

DENNIS W. SCIAMA ("Inertia") is a cosmologist at the University of Cambridge. He recently spent a year at the Institute for Advanced Study in Princeton and a year at Harvard College Observatory. For his Ph.D. thesis on inertia at Cambridge he was awarded a prize research fellowship at Trinity College. Much of his present work is on the "steady-state" cosmological theory [see "The Steady-State Universe," by Fred Hoyle; SCIENTIFIC AMERICAN, September, 1956].

JOHN READ ("Sir William Perkin") is professor of chemistry and director of the chemistry research laboratory in the

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United College of St. Salvator and St. Leonard at the University of St. Andrews in Scotland. He is a Fellow of the Royal Society. Besides papers on terpines and stereochemistry, he has written numerous books and articles for the general public, one of which, *A Direct Entry to Organic Chemistry*, won him the millionlire European Cortina Prize in 1949. His historical books include *The Alchemist in Life, Literature and Art* and *Humour and Humanism in Chemistry*. He contributed the chapter on chemistry to *What Is Science?*, edited by James R. Newman of the editorial board of this magazine. Read's first master in chemistry, at the University of London, was a close personal friend of Sir William Perkin, and later Read himself collaborated in research with Perkin's son William. Read has published a number of plays and sketches in Somersetshire dialect.

GORDON W. HEWES ("The Anthropology of Posture") is assistant professor of anthropology at the University of Colorado. Born in San Francisco, he graduated from the University of California before World War II and took his Ph.D. there in 1947. His knowledge of geography and the Japanese language involved him in wartime mapping operations in the Far East for the U. S. Board on Geographic Names and the Office of Strategic Services. Although primarily an anthropologist, Hewes has also studied psychological aspects of posture, such as "handedness" or lateral dominance. He has recently returned from a year in Japan, where he led a seminar on the development of U. S. anthropology and was a Fulbright lecturer.

M. E. L. MALLOWAN, who reviews Samuel Noah Kramer's *From the Tablets of Sumer* in this issue, is professor of Western Asiatic archaeology at the University of London, and director of the British School of Archaeology in Baghdad. He was educated at New College, Oxford, and assisted Sir Leonard Woolley in his excavations at Ur of the Chaldees from 1925 to 1930. Later he participated in the excavation of Nineveh and led several British Museum expeditions to Iraq and Syria. During World War II he was an acting wing commander in the Royal Air Force, served in the military government of Tripolitania, and advised the British Government on Arab affairs. His latest digs have been in the Zab valley and at Nimrud in Iraq. He is married to the distinguished mystery-story writer and amateur archaeologist, Agatha Christie.

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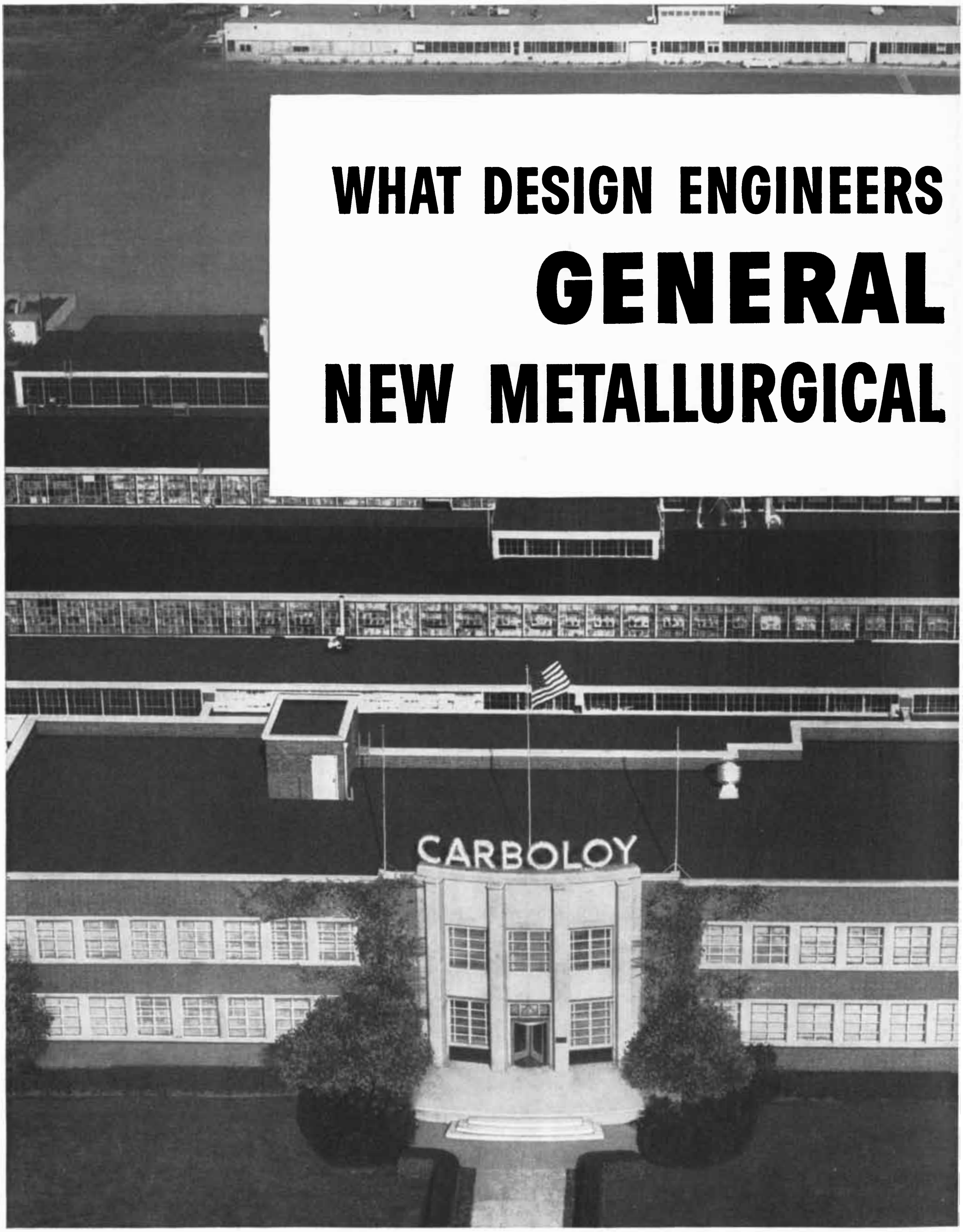

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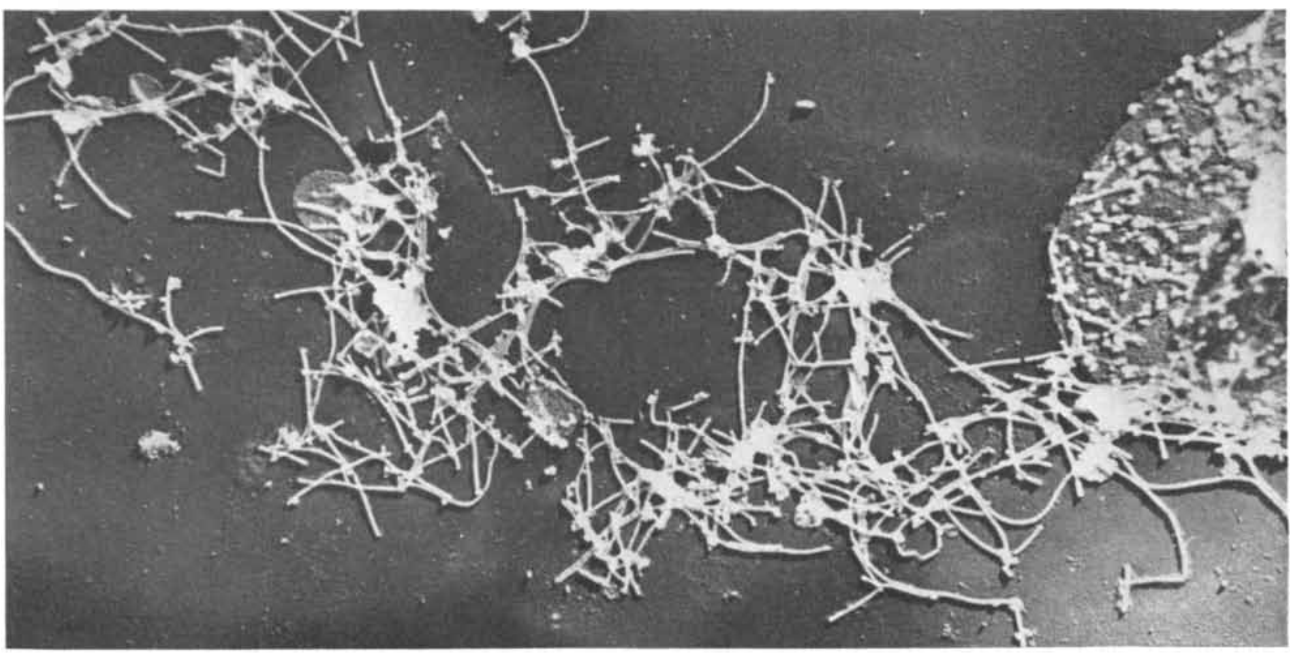
The Structure of the Influenza Virus

A sequel to "The Influenza Virus," published in the April, 1953, issue of this magazine. Since that time the behavior of the virus has been increasingly related to its physical and chemical nature

by Sir Macfarlane Burnet

Nearly 40 years ago the influenza virus took on an exceptional virulence and within less than two years caused, directly and indirectly, at least 50 million deaths. In 1918 and the decade following, influenza was the great unsolved mystery in the field of infectious diseases: the isolation and taming of the virus was the greatest prize that any bacteriologist could strive for. In the next three decades much of the mystery was removed from the disease. The influenza virus was isolated, first in swine by Paul A. Lewis and Richard E. Shope at the Rockefeller Institute for Medical Research in 1931 and then in the form infecting man by Wilson Smith, Christopher H. Andrewes and Patrick Laidlaw in England in 1933. Various methods of studying the virus in the laboratory were developed. It was found that influenza virus could be grown readily in fertile chicken eggs, and ways of measuring accurately the amount of virus grown were discovered.

Thus we have today a most convenient system for studying the character and activity of the influenza virus. Not the least convenient feature of the



TWO DIFFERENT FORMS of the influenza virus appear in this electron micrograph. At the right is the "ghost" of a red blood cell; the tiny white balls on its surface are spherical virus particles. In the middle of the micrograph are filamentary virus particles.

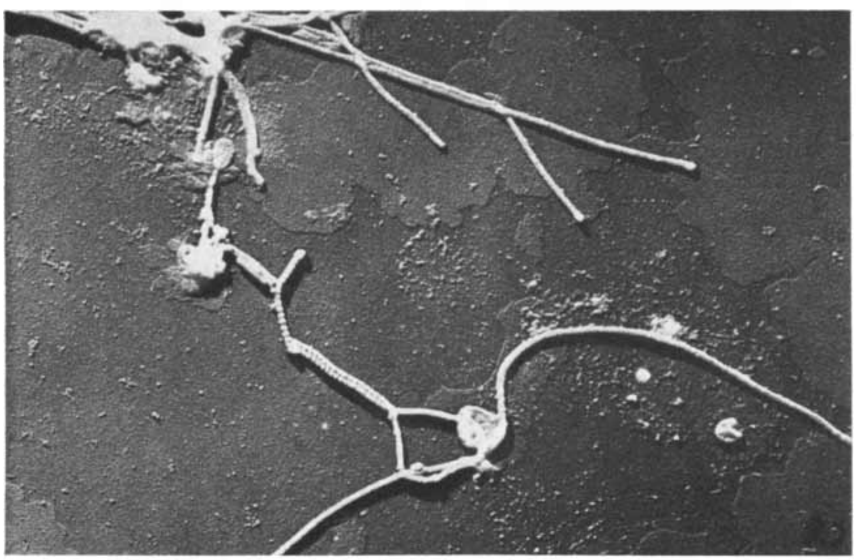
system is that after the virus has been cultivated in chick embryos it seems to lose all its virulence for human beings. It is almost a joke that nobody in an influenza virus laboratory ever catches influenza from his cultures. Yet in all essentials this domesticated, harmless virus is still influenza virus. Anything that can be learned of how it multiplies in the cells of the chick embryo may one day be relevant to matters of life and death.

Basically the question we are now seeking to answer is: What is the influenza virus and how does it become what it is? At one moment we have a single virus particle and a normal living cell. Some hours later we find many virus particles plus a damaged and dying cell. The problem is to understand how this takes place. In investigating the matter we have three different entities to consider: the virus particle itself, the host cell and the infected cell, which is more than a simple association of the two. The virus particle has a relatively simple structure which we may hope to understand fairly well. The normal living cell is something of which our knowledge is both enormously extensive and utterly incomplete. The infected cell presents us with a far more complex problem. It is perhaps characteristic of the growing edge of biology that when a new phenomenon like virus multiplication comes to be studied, almost all the knowledge of cellular chemistry and function gained from other types of study turns out to be irrelevant. Any attempt to picture what is happening in the infected cell must necessarily therefore be provisional and oversimplified. At best it can provide only a framework which makes it easier to grasp relations and sequences and to devise approaches to more adequate knowledge.

To study the production of virus experimentally, the first need is a means of measuring the amount produced under given conditions. Three methods of measurement have been developed. The most direct is an assay of the infectivity of the fluid containing the virus. In the fluid taken from a chick embryo two or three days after it has been infected, there is a very large amount of virus. If we dilute this fluid and inoculate fresh chick embryos, they will show the characteristic results of infection with all dilutions up to perhaps one part in 100 million. At a certain dilution exactly half the embryos will show infection. This method, suitably elaborated, serves to establish a unit of infectivity which gives a measure of the amount of virus present in the original fluid.

The second method of estimating the amount of virus is to count the virus particles made visible with the electron microscope. In suitable preparations an infected fluid can be seen to contain characteristic particles whose number is closely correlated with the degree of infectivity of the fluid.

The third method uses the hemagglutinin reaction (clumping of red blood cells) developed in 1940 by George Hirst at the Rockefeller Institute. Influenza virus particles have a special surface quality which makes them stick rather firmly to the surface of the red blood cell. If virus-containing fluid is mixed with a suspension of red cells (say from chicken blood), the virus particles stick to any cell with which they collide and can act as bridges holding two red cells together. Provided there are at least as many virus particles as red cells in the mixture, the cells will be tied together into clumps. These clumps settle to the bottom of the tube much more rapidly than normal cells. The hemagglutinin reaction is a very convenient tool for measuring the amount of virus in a given fluid, as well as for many other uses in biology.

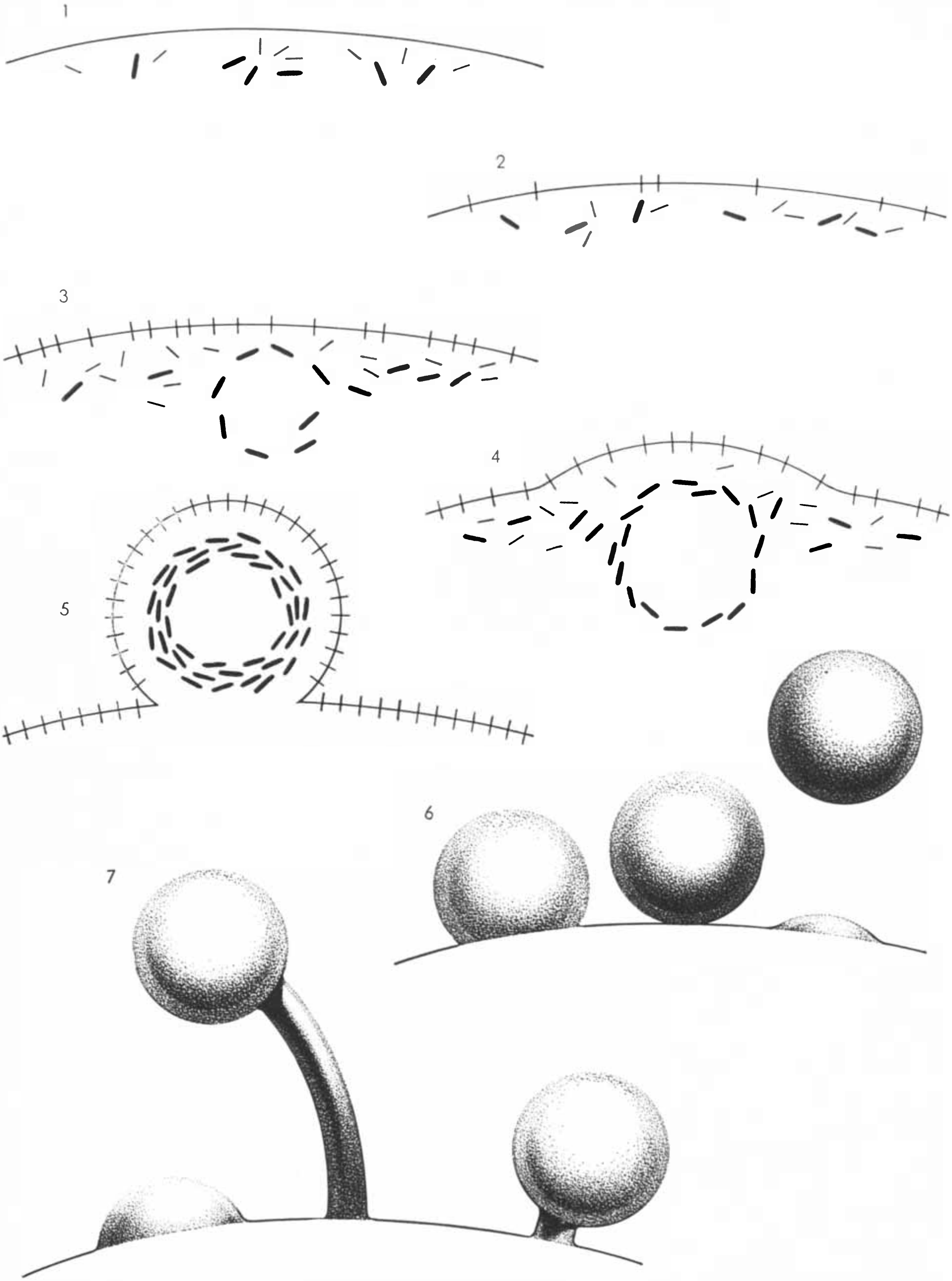


FILAMENTARY PARTICLES of the virus are further enlarged. The filament at left center is beaded, but this may be due to the bombardment of electrons in the microscope.

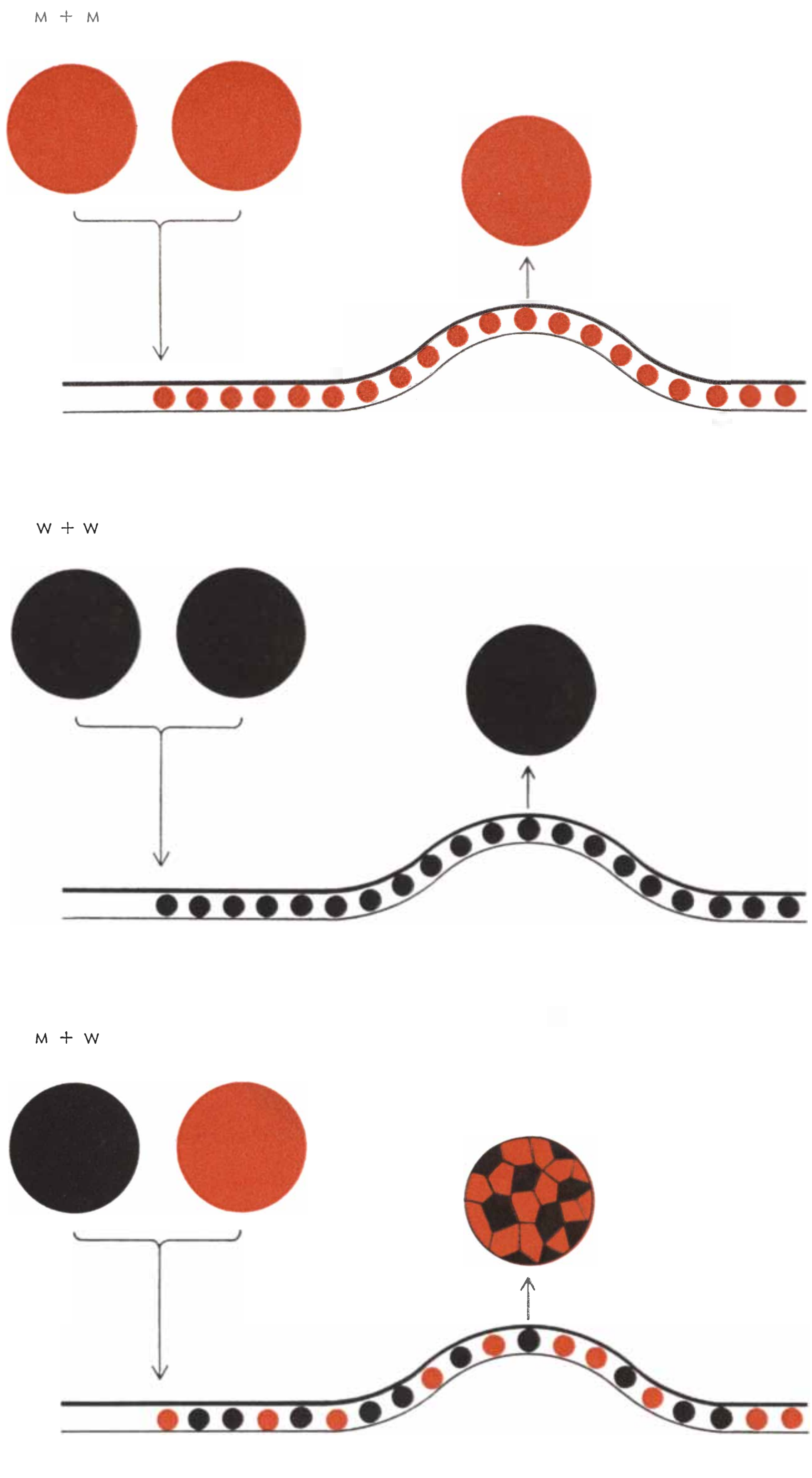
What, then, do we learn of the influenza virus once we have grown it in sufficient amount for analysis? Chemically the virus is found to be built up of materials common to most living cells. Around 30 to 40 per cent of it consists of the same lipids (fatty substances) as are found in vertebrate cells. It contains proteins and carbohydrates which are indistinguishable by gross chemical methods from similar material in the chick embryo cells in which the virus was grown. The only component in which the virus differs chemically from the host cell is its nucleic acid. In the virus the sole nucleic acid present is ribonucleic acid (RNA), and Gordon L. Ada of our laboratory in Melbourne has shown that the RNA of the virus is chemically distinct from the RNA of the host.

If the virus particle is almost indistinguishable from a tiny blob of protoplasm chemically, it is nonetheless highly individual functionally. Aside from its capacity to infect a cell, it has other distinctive activities. It sticks to red blood cells because it carries molecules which fit appropriately to certain complex compounds of carbohydrate and protein (mucoprotein) which are present on the surface of all vertebrate cells. Virus particles in time can liberate themselves from their attachment to cells by means of an enzyme which breaks off the portion of the mucoprotein to which they are held. Furthermore, they react in specific ways to antiserum. Serum from an animal or man convalescent from influenza will inactivate one sort of influenza virus, but is ineffective against any other type.

It is easy to see that by a series of only moderately complex manipulations with red cells, mucoprotein solutions and antiserums, one can learn a great deal about individual differences between viruses and by implication about the protein molecules on their surfaces which are responsible for the various



REPRODUCTION OF THE INFLUENZA VIRUS may occur as outlined in these drawings. The long curved line in each drawing is the surface membrane of the cell. Upon entering the cell the virus loses its individuality as a particle, but its hereditary material (ribonucleic acid, or RNA) enters the cell's synthetic mechanism. Early in the reproduction of the virus both virus RNA (*thick rods*) and virus protein (*thin rods*) materialize beneath the membrane (1). Then the virus protein begins to infiltrate the membrane (2). After a time the virus RNA begins to assume a spherical form (3 *and* 4). Finally the sphere of RNA pushes out through the membrane (4 *and* 5). How this process may result in the formation of spherical virus particles (6) and filamentary particles (7) is also depicted.



TWO ANTIGENIC CHARACTERS may be incorporated in a single virus. In the top drawing two virus particles with the antigenic character M enter the cell (*large balls at left*). Their replicated proteins (*small balls*) infiltrate the surface membrane of the cell and ultimately form the sheath of a new virus particle (*large ball at right*) with the same character. The middle drawing illustrates the same process for the antigenic character W. The bottom drawing indicates that when one virus with the character M and another with the character W enter the same cell, the sheath of the new virus is a mosaic of the two characters.

reactions. We can summarize what such experiments have shown by saying that each type of virus has its own structure, consisting of protein molecules arranged probably in a more or less symmetrical pattern over its surface with lipid and mucoprotein molecules in between. The pattern of these protein molecules is determined genetically, and we believe it must be carried by the virus's RNA.

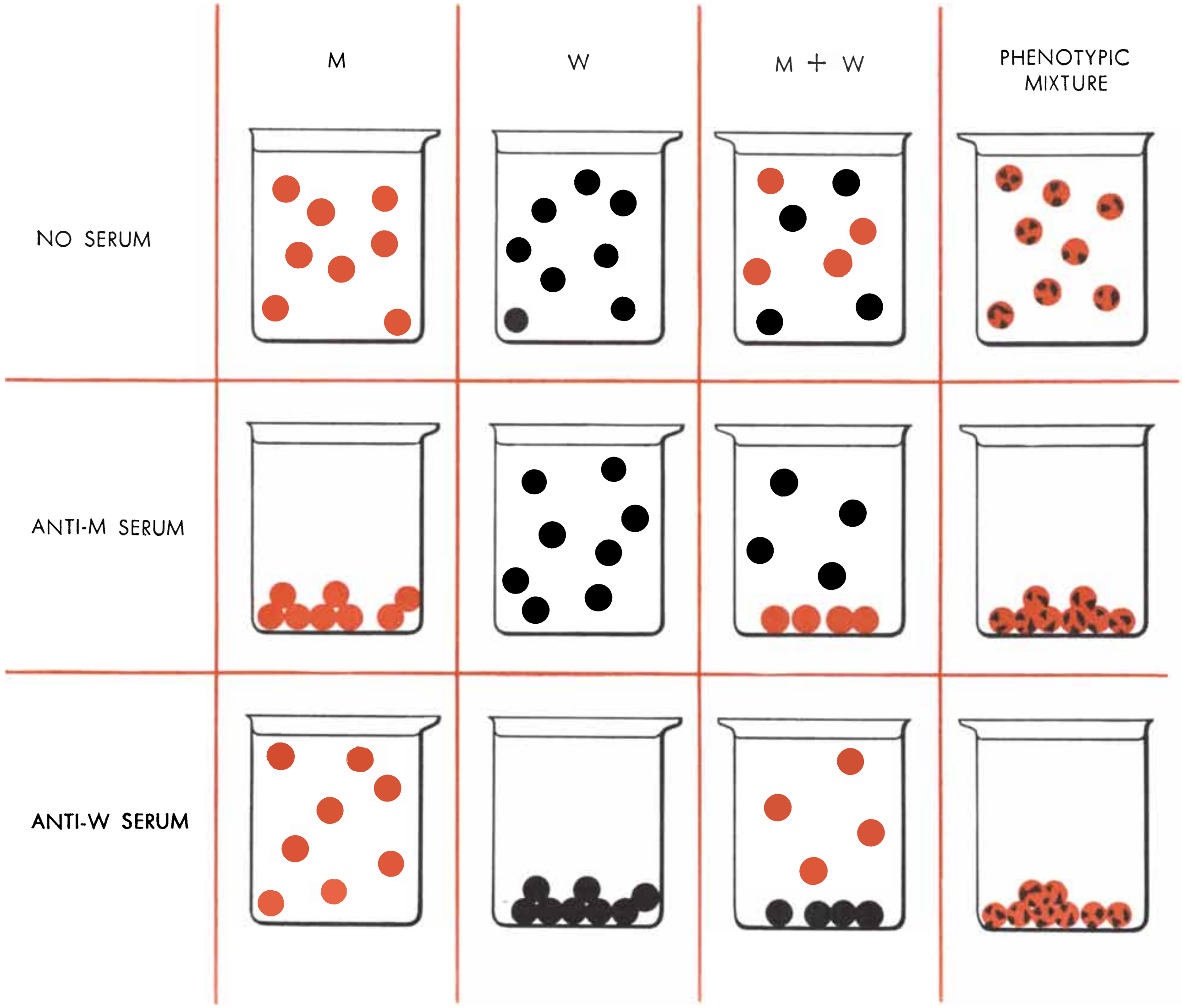
In the electron microscope we can see two differently shaped kinds of virus particles [*see micrograph on page 37*]. The most common kind are spheres, about a tenth of a micron in diameter. But often we see particles in the shape of filaments, sometimes as long as 20 microns. The spheres are known to be infective. The filaments, however, appear to have the power to infect only when they contain a "knob," usually at one end.

Recently Councilman Morgan, Harry M. Rose and Dan H. Moore of the College of Physicians and Surgeons have produced some magnificent pictures of virus multiplication, and these tell us some important things. First of all, the virus particles that emerge from an infected cell appear only at a free surface of the cell, where it is exposed to fluid and is not in contact with another cell. At the peak of multiplication, buds of virus units can be seen along the free surface of the cell, and immediately below the surface there are little opaque concentrations, which are clearly fated to become virus particles once they pass through the surface layer.

The pictures suggest too that the virus particle actually derives its own outermost coat from the membrane of the cell. We get the impression that a filament is produced when the cell surface membrane fails to close neatly around an emerging virus particle, so that the virus core, instead of becoming a spherical virus, goes on pulling out an indefinitely long cylinder of material.

The filaments are far too thin to be seen by standard light microscopes, but when they are examined by indirect dark-ground microscopy at a magnification of about 500 times, they are easily visible as flexible lines of light. We can count them and determine their length and formations. This allows us to note changes in these features and thereby carry out various experiments which would be difficult to manage if we had to use the complicated manipulations needed for electron microscopy.

Only one or two such types of experiment need to be mentioned. We have



ANTISERUMS may be used to differentiate between a mixture of two viruses with different antigenic characters and a "phenotypic mixture," *i.e.,* a virus which incorporates both characters. When anti-M serum is added to the virus solutions depicted here, both the phenotypic mixture and the virus with the character M are deposited at the bottom of the beaker. When anti-W serum is added, the phenotypic mixture and the virus with the character W are deposited. The virus deposited by both serums is the phenotypic mixture.

found that every physical or chemical agent which causes red blood cells to release their hemoglobin will also produce visible damage to filaments under the same conditions. Sometimes the filaments disappear altogether; more often their number decreases and those remaining appear irregularly angulated and abnormally rigid. The effective agents include heat, distilled water, ether, chloroform, many detergents and such substances as saponin and cobra venom. The suggestion is strong that the surface of the filament is basically very like the surface of an animal cell.

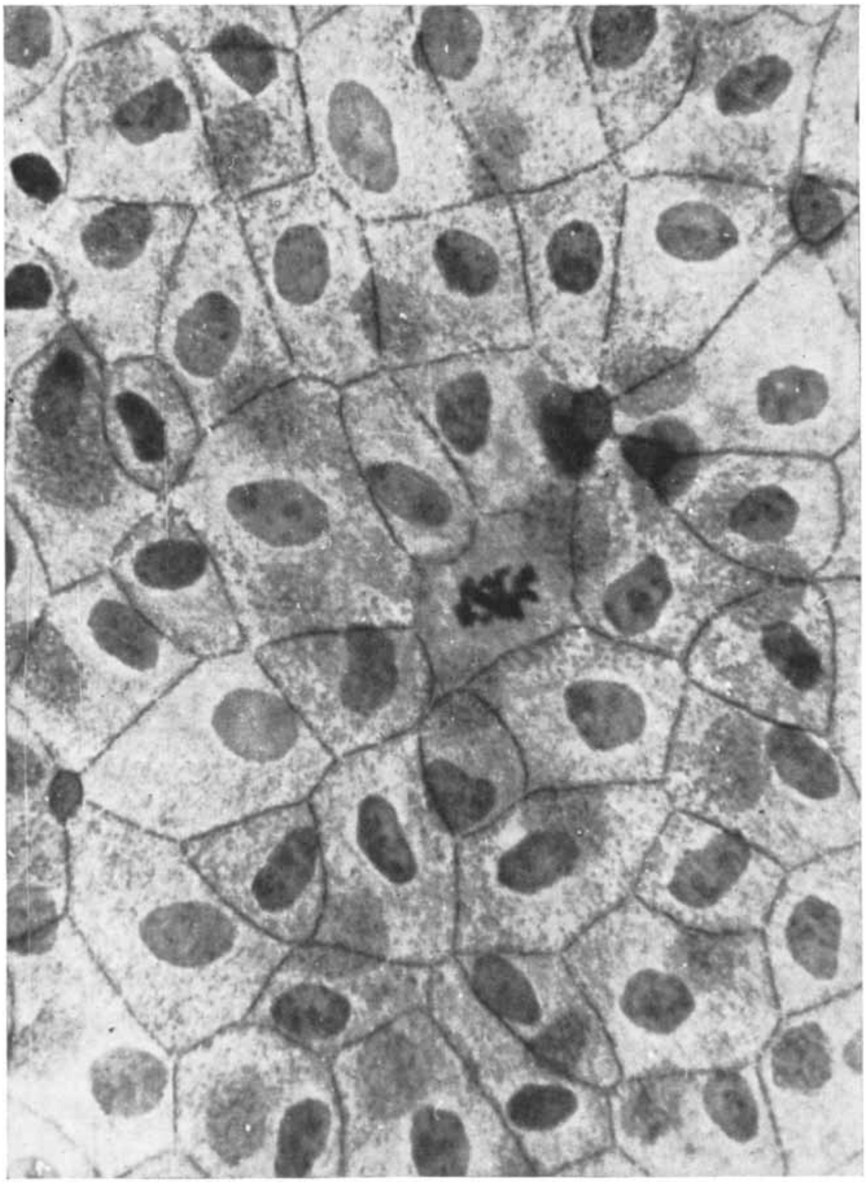
In nearly every respect the surface of a filament has the same qualities as that of a spherical virus particle. Even a little piece of broken filament can attach itself to a red cell and later release itself by enzyme action. Mix an antiserum against influenza with a suspension of filaments and the filaments clump into fluffy balls, showing that they have the same characteristic protein antigen on their surface as the normal influenza virus does. We are almost compelled, therefore, to regard the surface of the filament as a mosaic of components, some from the host cell, others whose structure is determined by the virus. There is in fact much to suggest that in the surface of a filament, the protein is virus protein, but the lipids and carbohydrates are unchanged components derived from the cell membrane.

There is one final point about filaments that is vital to their understanding. The production of filaments is a hereditary trait: some viruses produce a high proportion of them, others a low proportion. We have completed experiments which show that the power to produce filaments can be lost by mutation rather readily, other recognizable characters remaining the same.

In the course of genetic experiments, we have been able to produce "hybrid" viruses. This is accomplished by infecting the same cell with two distinct viruses. We can take two viruses which differ in their antigenic pattern so that each is inactivated by a different serum but neither serum is effective against the opposite type. We then arrange things so that in a group of cells each is infected with at least one virus particle of each type and we collect the new virus liberated from these cells seven or 10 hours later. If each new-formed virus particle has inherited its traits from only one parent, we should find that one antiserum inactivates about half of the progeny and the other serum also about half. When the test is made, however, we find that either serum inactivates about 90 per cent of the new virus. The only possible interpretation is that the great majority of the new virus particles partake of the surface properties of both types of parental viruses. This suggests very strongly that both parents have contributed to what may be called a pool of virus components from which the new virus particles are fabricated.

The process by which a new generation of virus particles is produced in the infected cell will never be fully understood; the complexity of the cell processes concerned will see to that. But at a fairly superficial level a useful picture of the process is already emerging. Much more has contributed to this picture than we have been able to mention in this article.

When an infectious virus particle makes contact with a susceptible cell, the specially patterned proteins on its surface become attached to mucoprotein of the cell. The virus then sinks into the cell, and there it unfolds itself in a way which destroys its individuality as an identifiable virus particle but allows the vital carrier of that individuality—its RNA—to make contact with the synthetic mechanisms of the cell. At this stage we have what is really the intrusion of one genetic mechanism into a territory shaped and controlled by another. It is not too fantastic an analogy to compare the virus to a sperm entering the ovum. In each case the intrusion results in the cell taking on a new character which depends as much on the intruder as on the occupier.

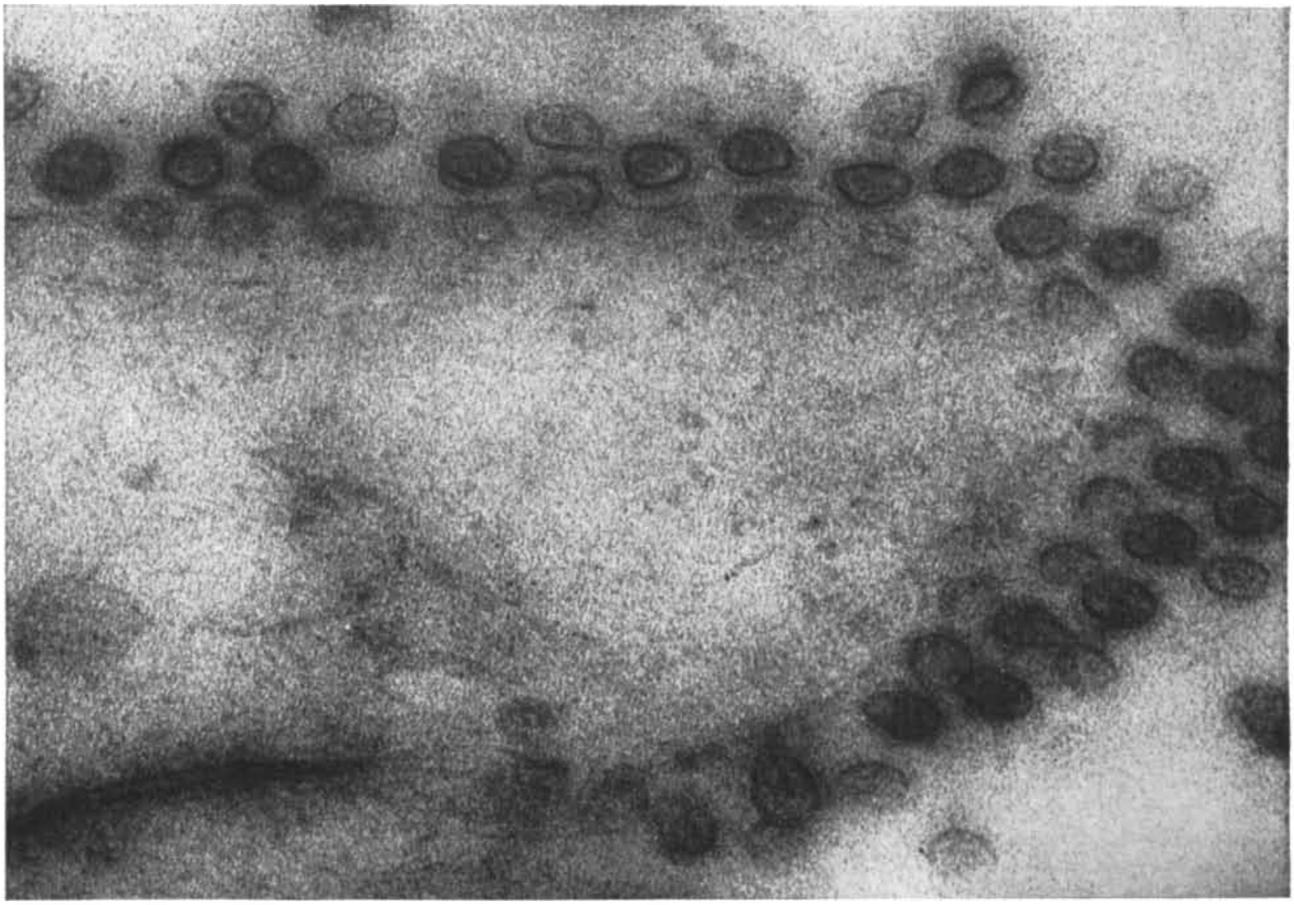


SHEET OF CELLS lining the allantoic cavity of the chick embryo is used to observe the multiplication of the influenza virus. This photomicrograph, made by John Cairns of Australian National University, shows not a section through the cells but the surface of the cell pavement. The boundaries between cells are made visible by impregnation with silver.

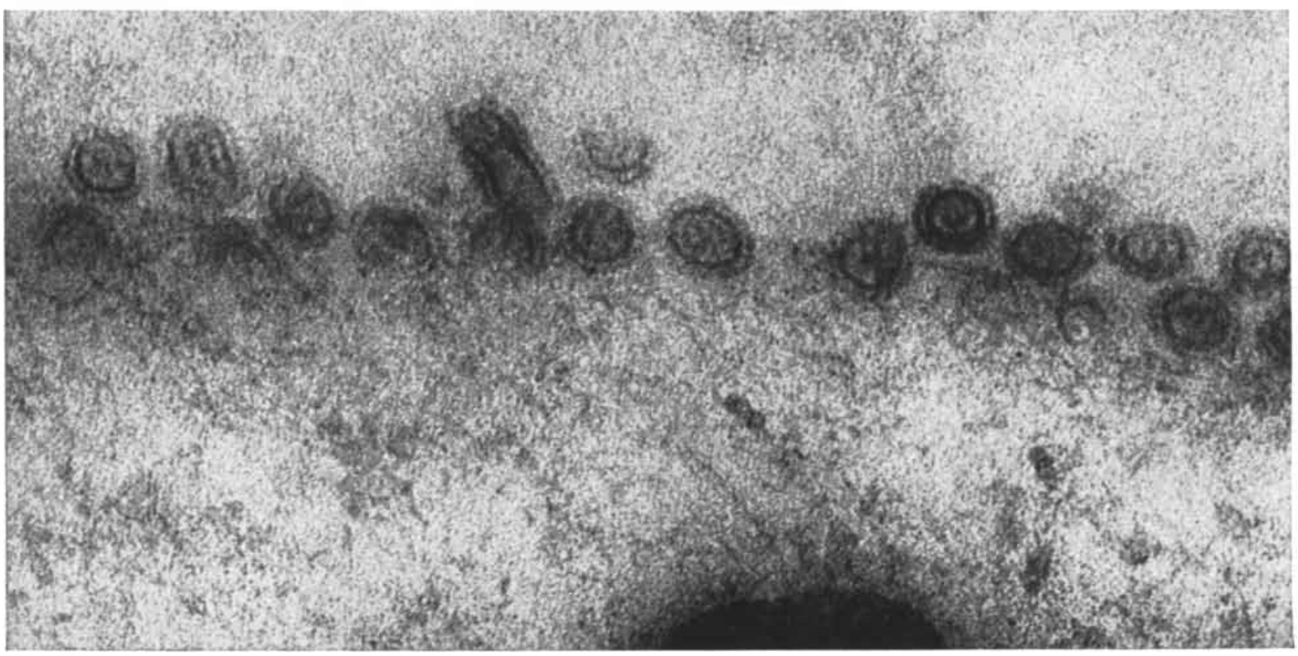
We have only the most general picture of what ensues in the infected cell, but we do know that the total amount of RNA in the cell increases, and that recognizable virus protein begins to appear at an early stage. It seems that there develops in the cell a "replicating pool" of virus components, especially nucleic acid and protein. We can picture a swirl of activity by which the chemical building blocks needed for synthesis of the giant molecules are brought into position by the cell's normal synthetic mechanisms, but because of the intrusion of the virus, the newly formed protein and nucleic acid are built to the virus pattern instead of the host pattern.

Out of this turmoil, appropriate groups of virus molecules come together to produce what can without too much violence to the meaning of the word be called "nuclei" of viruses. Simultaneously viral protein molecules must move into the cell membrane to produce a new fabric, as it were, with which to coat the virus nuclei as they emerge from the cell. It seems likely that there is some spatial regularity in the distribution of virus molecules amongst the lipid and carbohydrate constituents of the cell surface. Perhaps there are two types of spatial symmetry—one which is best satisfied by a spherical distribution and another which determines the indefinite extrusion of a cylindrical filament.

So we can catch a glimpse in broad outline of the process by which the new generation of virus particles emerges from the cell. If we look at the process from an even broader point of view, we can perhaps summarize it as a continuing alternation between two modes of life. A virus is not an individual organism in the ordinary sense of the term but something which could almost be called a stream of biological pattern. The pattern is carried from cell to cell by the relatively inert virus particles, but it takes on a new borrowed life from its host at each infection.



INFLUENZA VIRUS PARTICLES in these electron micrographs are clustered on the surface of cells from the allantoic membrane of the chick embryo. The micrograph above, which enlarges the particles 165,000 diameters, shows a very thin section (about 30 millimicrons) through the cell. Just beneath the surface membrane at the top are several vaguely defined particles; their incomplete structure suggests that they are in the process of formation. The micrograph below, which enlarges the particles 164,000 diameters, shows a somewhat thicker section of the cell. One particle at the right clearly shows an inner body, a dense membrane and a diffuse outer coat. At left center is a filamentary particle. The micrographs are from an investigation by Councilman Morgan, Harry M. Rose and Dan H. Moore of the microbiology and medicine departments in the College of Physicians and Surgeons.



THE INTELLIGENCE OF ELEPHANTS

How much can an elephant learn? Do elephants really possess a good memory? If so, is it associated with the fact that they have large brains? The answers are sought by experiments at a zoo in Germany

by B. Rensch

The bigger the brain, the greater the brain power—this seems to be a general rule among comparable members of the animal kingdom. In view of that interesting relation, it is rather surprising that so little scientific attention has been given to the brain of the elephant. It is not only the biggest of all land animals but also has the most massive brain (about 6,000 grams, or more than 13 pounds). Zoo keepers, circus trainers and jungle dwellers who use elephants as work animals have long known that the elephant is an intelligent creature. But just how intelligent is it? We have recently been examining its mental capacity in a systematic way at our Zoological Institute in Münster in Westphalia.

We had started to compare the brain anatomy or learning ability of closely related animals of different size: rats *v.* mice, a giant Indian squirrel *v.* a dwarf Indian squirrel, large *v.* small races of chickens and so on. Broadly speaking we found that the larger animals had developed the complicated parts of the cerebral cortex to a greater degree and also had greater learning ability. These findings suggested the idea of testing the learning ability of the elephant. It is true that the elephant is somewhat unusual and not particularly convenient as a "laboratory animal," but we had a five-year-old female Indian elephant available to work on in the Münster Zoo and we made some field trips to study working elephants in the jungles of southern India.

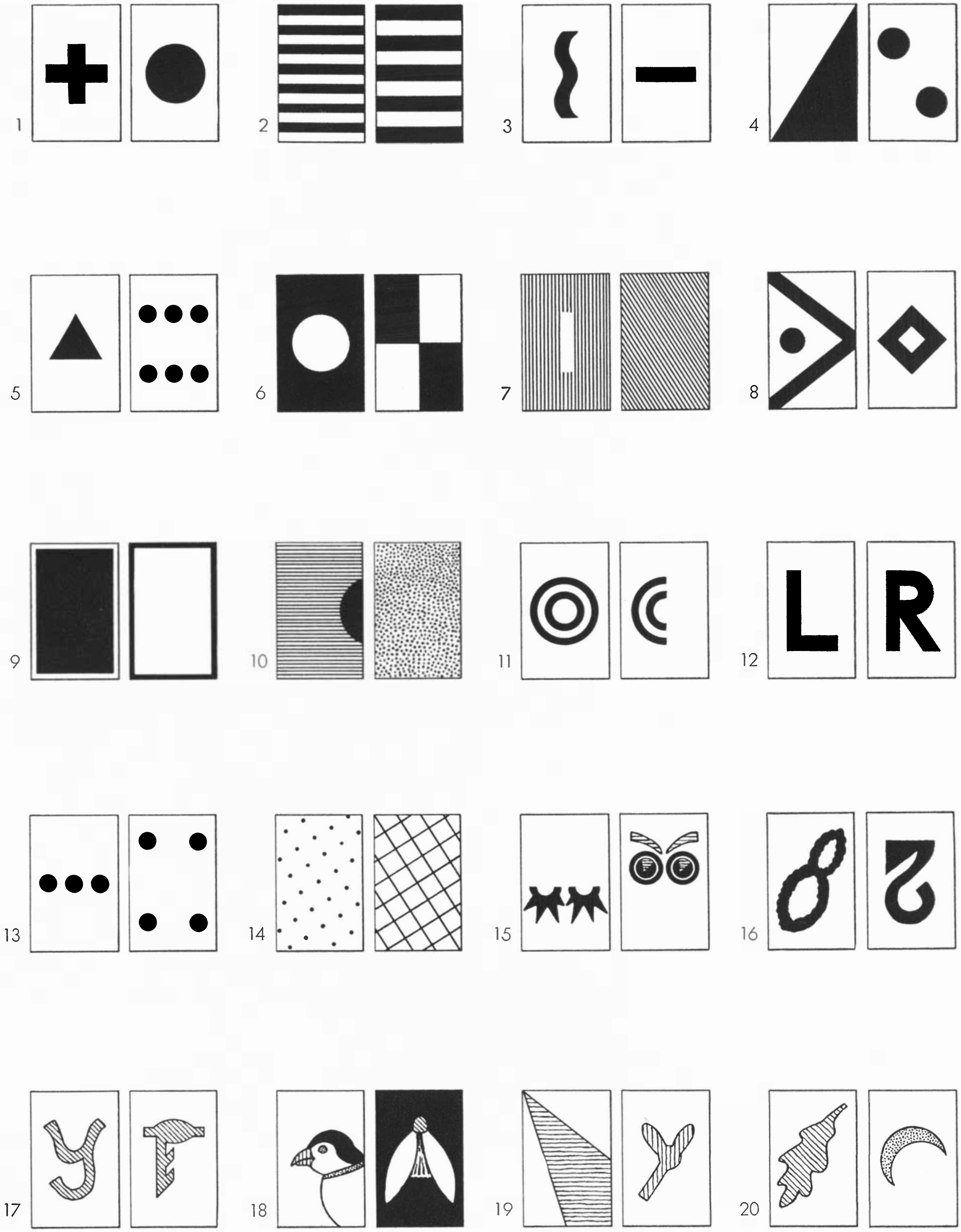
In India people tell fantastic stories about the feats and "cleverness" of elephants. Even so experienced an observer as J. H. Williams, who worked and lived with elephants in the forests of Burma for 25 years, says in his excellent book *Elephant Bill* that the elephant "never stops learning because he is always thinking." Williams reports quite seriously that domesticated elephants have been known to stuff mud into the bells round their necks to muffle them before going forth to steal bananas at night. Most of these tales credit elephants with far too much insight into the future to be believable. But authentic reports of their performances are not lacking. It is known that they sometimes use a branch to switch away flies and will take a stick to scratch parts of their bodies unreachable by the trunk.

When we went to India, we were offered a good opportunity to study the taming and training of working elephants in the southern part of the state of Mysore. A newly caught elephant is fettered and assigned to a mahout (elephant boy). The trainers calm the animal and accustom it to the presence of man by rubbing its back and flanks with grass and leaves and singing monotonous, soothing melodies. After two or three weeks of daily training the elephant learns to respond to the commands "Go!", "Stop!", "Kneel down!" and "Get up!" given in the Urdu language. In the training procedure the new elephant is tied between two tame ones, which drag the "apprentice" along at the command "*Mall-mall*" ("Go forward"). The young animal soon learns the meaning of this and a few other expressions, but it takes several years to master all the verbal commands necessary to qualify it for work in the forest or in road building.

One of our main objects was to find out how large a vocabulary a trained elephant could "understand" and whether it was capable of ideational behavior. We found that fully trained animals between 20 and 60 years old knew some 21 to 24 commands. The most important words of their vocabulary were: *mall-mall* (go forward), *tschoro* (stop), *datt-datt* (go backward), *tschei beri* (turn around), *tol-tol* (lift your foot) and the

INDIAN ELEPHANT obeys the command "*Derr-tol*" ("Squirt water on your back"). A trained elephant can distinguish this command from one to squirt water under its belly.

TWO INDIAN ELEPHANTS delicately coordinate their efforts in response to commands. At the top the elephants obey the command "*Toker-toker*" ("Push the object with your feet"); at the bottom, the command "*Djouk*" ("Push the object with your head").



VISUAL VOCABULARY of an Indian elephant in the Münster Zoo is represented by these 20 pairs of cards. The card at the left in each pair is "positive"; *i.e.*, when the elephant chose the card, she was given a piece of bread. The card at right is "negative."

Urdu expressions for "Lie down on your belly," "Lie down on your side," "Lift up your trunk," "Give me the object," "Drink," "Squirt water under your belly," "Squirt water on your back," "Duck under [the water]," "Push the object with your foot," "Push it with your head," "Pass the obstacle," "Break the obstacle" (*e.g.*, a wooden bar).

Actually, experienced elephants did much of their work with only a minimum of commands, as if they "knew" what they were expected to accomplish. The main task of the elephants we observed was to push and drag heavy logs through the jungle to a road and there load the logs on trucks. They did all this with only occasional orders and shouts by the mahouts. It was remarkable how efficiently the elephants used their feet, trunks and heads to push the heavy logs up a pair of inclined bars onto a truck. Two elephants worked together in a team, assisting each other with wonderful balance and coordination [*see photographs on page 45*]. Their performances suggest that elephants must be credited with true ideation, *i.e.*, anticipating what will come of certain actions.

In Münster we carried out a series of experiments with our five-year-old zoo animal to measure the learning capacity of elephants more precisely. Her task was to discriminate among various visual patterns. The training apparatus was simple enough. Two small wooden boxes with cardboard lids were placed on the ground one meter apart, and the elephant had to remove the correct lid to get a food reward, a piece of bread. The lids were marked with different patterns: in the first pair presented, one had a black cross and the other a black circle [*see top of opposite page*]. Since the elephant showed a slight spontaneous tendency to prefer the circle, we made the circle the negative, nonrewarded stimulus and the cross the positive one. We took precautions to avoid giving the animal any clues except the visual pattern itself and uncovered both patterns simultaneously. It took the elephant about 330 trials, over a period of several days, to learn that the cross was the "correct" symbol. She learned by trial and error, though we tried to assist her at first by shouting "*Nein*" when she tried to open the "wrong" lid. Once the elephant had learned the correct pattern, she opened only that lid: if she started to reach toward the other, she would back away as soon as she saw it was the circle and go for the right one. This behavior clearly showed that she really knew which pattern was "wrong."

After she had mastered this pair we presented a series of others: a pattern of narrow black stripes *v.* one of broad stripes, a curvy line *v.* a straight line, three dots in a row *v.* four dots arranged in a square, the letter L *v.* the letter R, and so on [*see opposite page*]. All these patterns were well within the discrimination ability of the elephant's eyesight, as my assistant R. Altevogt proved later by experiment. (He found that the visual acuity of the elephant is considerably inferior to man's and about equal to that of the goat and the deer.)

Our elephant learned to discriminate more and more rapidly in the successive tests, apparently gaining "know-how" as she proceeded (*e.g.*, acquiring the "idea" that there was one "wrong" and one "right" pattern in each pair). By the fourth pair she was able to choose the right one after only 10 trials.

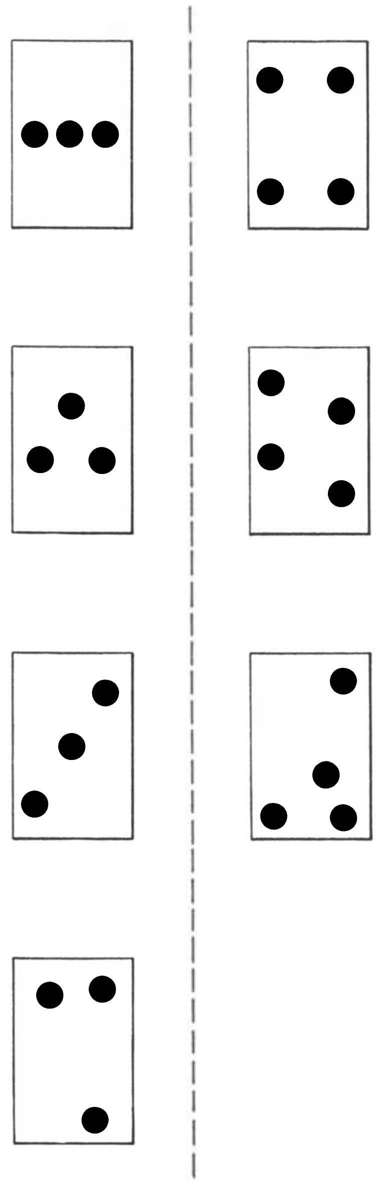
As she added to her "vocabulary," we kept her refreshed on what she had learned by repeated tests, so that she was able to choose the correct one of each pair when they were presented in a series in irregular rotation. These tests required quite a tough effort from the elephant, but apparently the method of serial rotation aroused her interest, and she did not flag in the task.

We were surprised to find that the elephant could keep simultaneously in memory the "meaning" of 20 stimulus pairs. In a final multiple choice test in serial rotation, each of the 20 pairs was presented 30 times according to a previously established sequence. The elephant mastered all 20 discrimination pairs superbly. In most of them she made only one or two wrong choices or no error at all. The test covered 600 trials lasting several hours, yet the elephant not only showed no symptoms of fatigue but actually improved in performance toward the end.

Her excellent scores in this test on 40 patterns suggest that the elephant could have mastered a bigger vocabulary, but we did not pursue this because the teaching would have taken long months and would not have added any fundamentally significant information about learning ability.

I have mentioned that our elephant gave evidence of recognizing a "wrong" pattern as negative by backing away from it. To find out whether she also knew the meaning of positive patterns we gave her a special test. We presented her with four patterns at a time, one of which was positive and the other three negative. In a long series of tests she recognized the positive pattern at first sight on about half of the occasions and after one wrong choice in the remaining trials. When she was given a choice between a positive pattern and a "neutral" card without any visual pattern, she almost always chose the positive pattern, showing that she very well knew its "meaning."

On the other hand, the choice between a negative card and a neutral one disturbed her. When she made a choice, she would often take the neutral one. But sometimes she would become excited and tear or bite the cardboard lid or



POSITION OF DOTS in the pair of cards numbered 13 on the opposite page was changed in several experiments. No matter what the position of the dots, the elephant was able to distinguish the positive card from the negative without further training.

trample on it. Her behavior suggested the kind of experimental neurosis that has been produced by conflict situations in many other subjects, from fish to man.

After the elephant had learned a good deal of her visual vocabulary, we tried some experiments to see whether she would recognize patterns when they were altered. This was a test of her ability to transpose learning or to form an abstract concept. For example, we turned the black cross (a positive stimulus) to the X position, we changed the relative length of the arms, and so on. Regardless of such changes, the elephant still recognized the figure as a positive sign, and she would choose the altered version as often as the original one. We may say that the elephant had got the "idea" that the essential feature of the pattern was the crossing of two black bars. (She did not respond to a white cross on a black background.)

An even clearer case of her ability to grasp an idea emerged in experiments with the striped patterns. In the original pair the stripes were respectively two centimeters and four centimeters wide (roughly three quarters of an inch *v.* an inch and a half), and the positive card was the one with the narrower stripes. We changed the widths to 1.5 and two centimeters, respectively. The elephant then chose the 1.5-centimeter pattern rather than the two-centimeter one. In short, she had mastered the idea that the pattern with the narrower stripes was the right choice. Presented with a choice between stripes of three centimeters and four centimeters, she again took the narrower stripes.

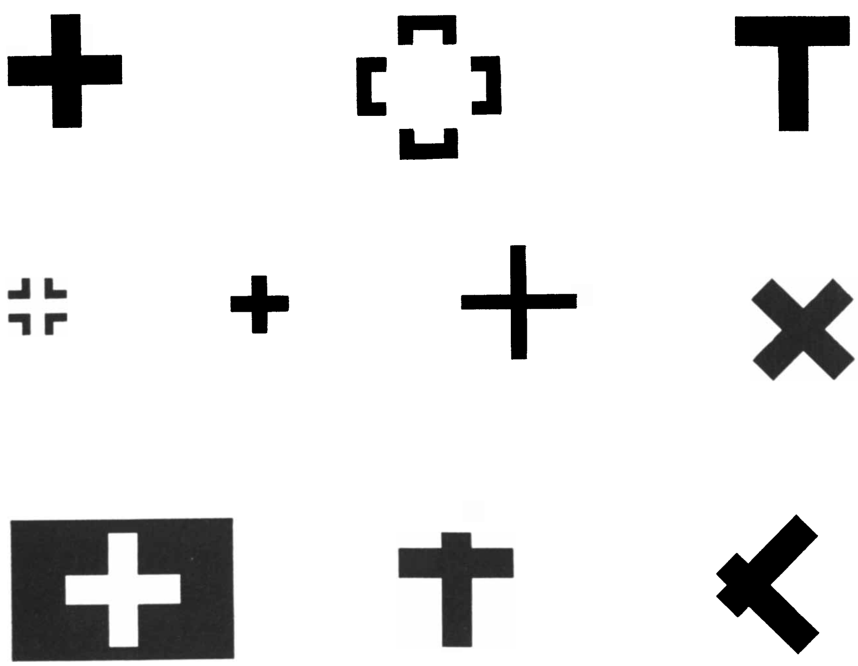
We tested our elephant's comprehension of numbers. Using the pair of cards with three dots and four dots, we first tried shifting the three dots on the positive card in various arrangements [*see preceding page*]. The elephant still chose this card in the majority of trials. We then switched about the positions of the four dots on the negative card as well. The elephant seemed at a loss for a while and made some wrong choices, but soon she solved the problem. She was able to distinguish three from four circular dots of equal size regardless of their arrangement, not by new learning but by extension of what she had learned. When we changed the objects to irregularly shaped spots instead of circular dots, she had to start anew, and it took her 440 trials to learn which was the "right" card.

We proceeded to a test of the elephant's memory, with very interesting results. She was presented with 13 pairs of cards which she had learned earlier but had not seen for about a year. In a total of 520 trials she scored between 73 and 100 per cent on all the pairs except one which was a difficult discrimination problem (*i.e.*, the double circle *v.* the double half-circle, on which she scored 67 per cent). In other words, the elephant had retained the meaning of 24 different visual patterns for the period of about one year. This was a truly impressive scientific demonstration of the adage that "elephants never forget."

Our observations of the Indian working elephants' ability to learn a vocabulary of verbal commands prompted us to make a precise laboratory examination of our elephant's acoustic discrimination. Our collaborator J. Reinert carried out these experiments. He started with a pair of pure tones: the tone at 750 cycles per second was the positive stimulus and 500 cycles per second (three full notes lower in pitch) was the negative one. The sounds were produced electronically through a loudspeaker. To make the elephant's learning behavior more easily observable she was taught to "stand at attention" at the beginning of each series of trials: she had to grasp the lower iron bar of her cage with her trunk. If the sound presented was the "wrong" one, she was supposed to remain in this position. If it was the right one, she was to knock on the lid of a switch box in front of her cage with her trunk: this caused an electrical gadget to bring a food reward within reach of her trunk. The experimenter sat behind a screen watching the animal by means of a mirror system.

The elephant learned to discriminate six pairs of sounds, one of which differed by only a single full note. In tests on all of them in irregular rotation she was able to distinguish all 12 tones and to know their positive or negative meaning. From these results one may conclude that the elephant possesses an excellent memory of absolute pitch. Again in this case she demonstrated remarkably long retention: after a lapse of a year and a half, during which she went on to other acoustic learning, she was able to get nine out of 12 of the pitch discriminations correct on a return to the test.

In the meantime we had examined the elephant's ability to learn short melodies. The positive sound pattern was a melody consisting of three tones—low, high and low. The negative melody also had three tones, but the pattern was reversed: the second tone was lower than the first and the third higher than the second. After the elephant had fully learned these two melodies, they were altered by all possible means: shifted toward higher or lower frequencies, changed in intensity, rhythm or timing, played on various instruments that varied their timbre. In



VARIATIONS OF A CROSS were presented to the elephant to determine whether she would respond to the abstract idea of a cross. The elephant had been trained to recognize the cross at upper left as a positive signal. She chose all the other figures as positive except the ones in the middle of the top row, at the left in the middle row and at lower left.

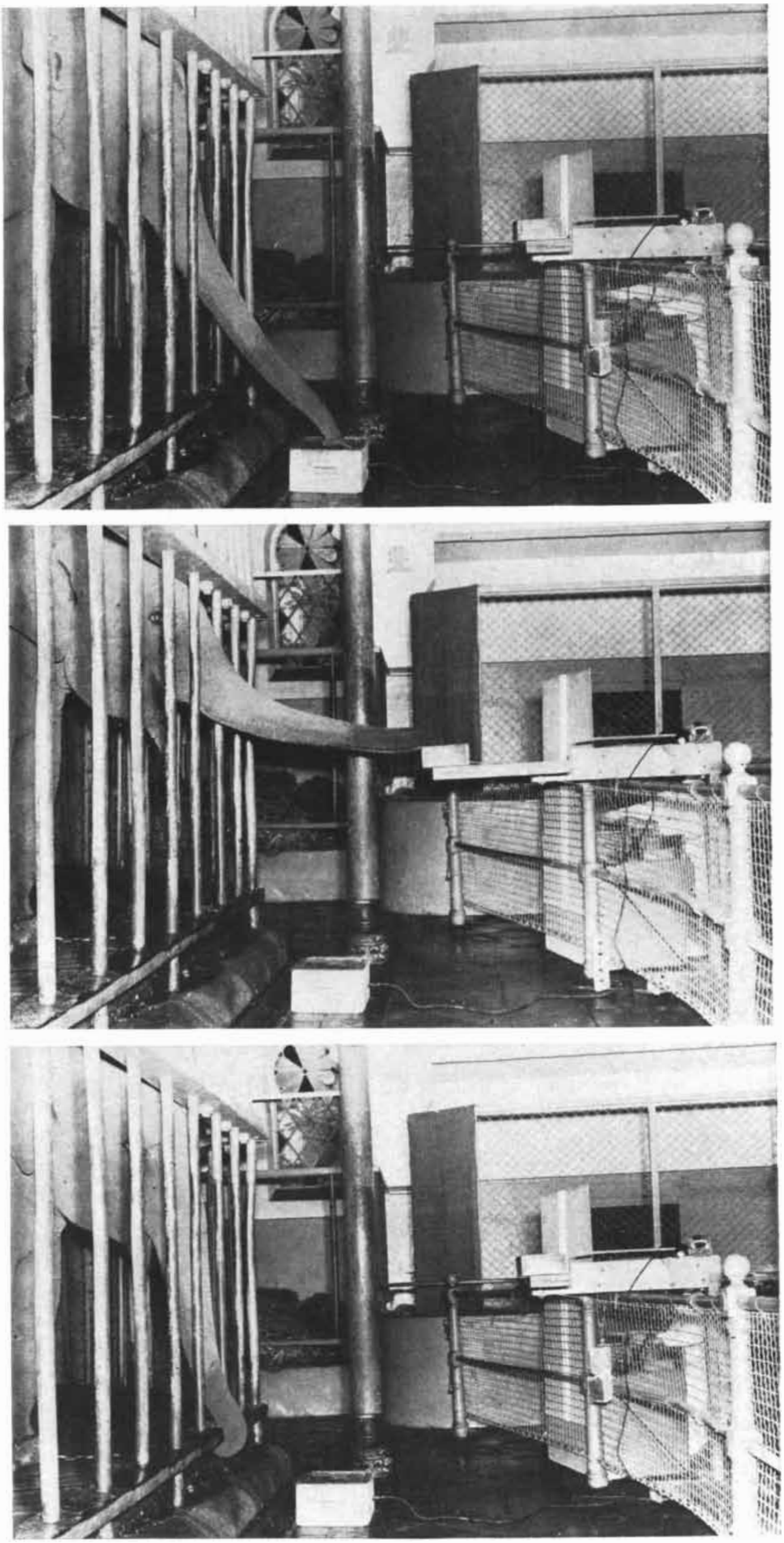
spite of all these alterations the elephant was able to recognize the positive and negative melodies (*i.e.*, the relations of notes) in the overwhelming majority of the trials.

To what extent are the elephant's remarkable learning ability and memory attributable to its big brain? For any meaningful answer to this question, we would have to compare its performance with that of a proboscid (trunk-bearing) relative of smaller body size. Unfortunately the elephant has no closely related, small-sized cousins. The best we could do was to compare it with horse-like animals.

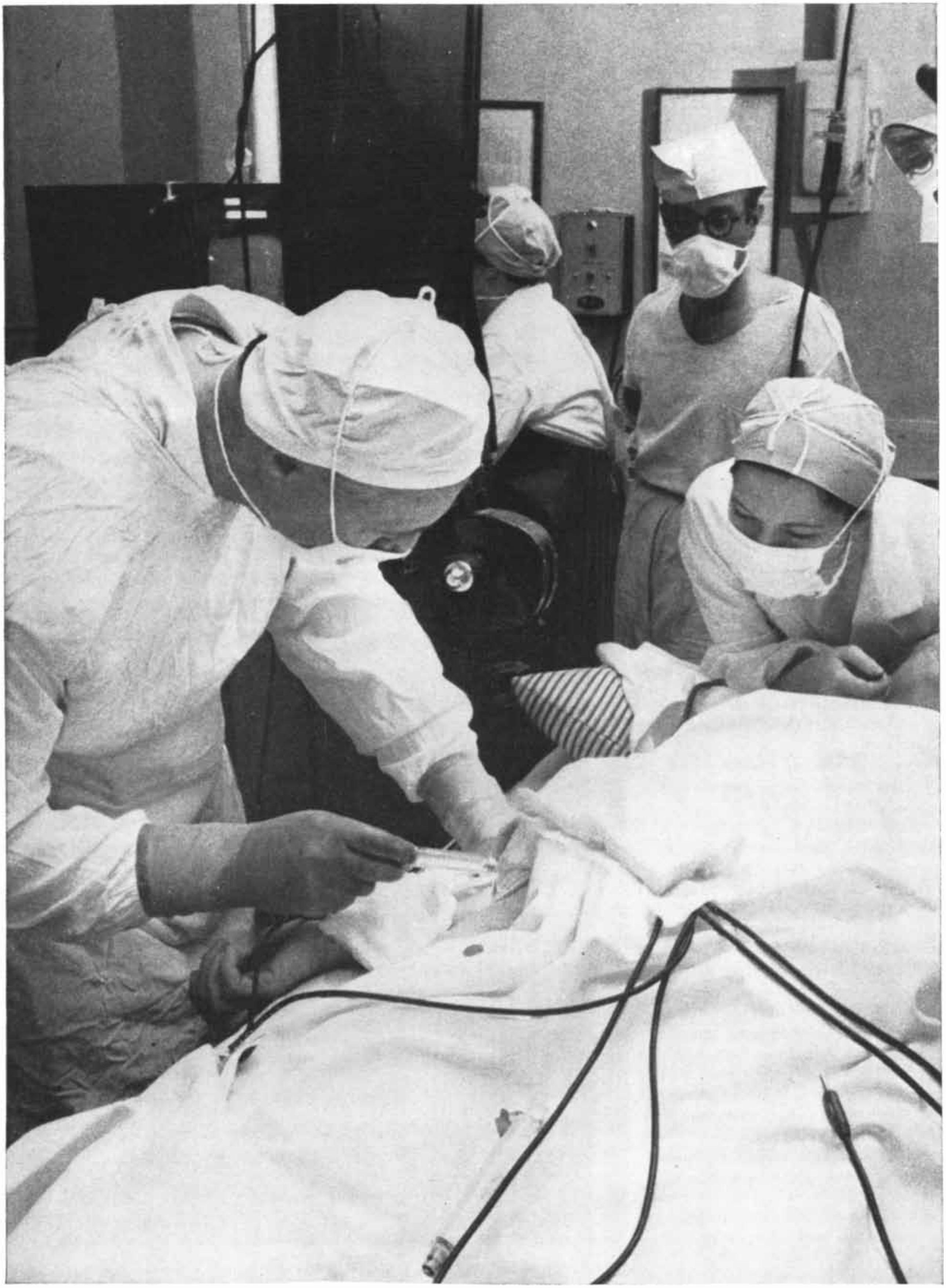
Recently one of our collaborators attempted to teach the patterns that had been learned by the elephant to a horse, an ass and a zebra in the Münster Zoo. Some minor alterations had to be made in the experiments, of course, to suit them to the new animals. As we had more or less expected, the ass and the zebra could not compete with the elephant in the number of stimulus pairs learned. The ass could master only 13, the zebra only 10. But the horse, surprisingly enough, learned all the 20 pairs that the elephant had mastered. This seems to indicate that the horse possesses a very efficient visual learning capacity. We have not yet had time to compare its memory span with that of the elephant, but in a retest after three months it performed well.

These experiments and our earlier studies of other animals permit us to advance a few general hypotheses about brain size. Size quite evidently is a decisive factor in the brain's learning capacity. Of course this applies not only to the size of the forebrain as a whole but also to the relative size of the various brain regions, especially that of the seven-layered cerebral cortex. The density of brain cells (number per unit volume) also seems to be an important factor. Another significant fact is that the larger animals have bigger ganglion (gray-matter) cells than their smaller cousins. These larger cells have more branching fibers, and therefore probably allow more complicated associations for learning. Moreover the nerve fibers from large cells are bigger in diameter, and it seems reasonable to suppose that this may be responsible for good retention and long memory: the larger the fibers, the more stable and lasting connections can be established between cells.

How much truth there is in these hypotheses will have to be determined by further experiments.



DISCRIMINATION BETWEEN SOUNDS was also tested. When the elephant heard a positive tone, she knocked on a box with her trunk (*top picture*). This closed an electrical circuit and moved another box containing a piece of bread toward the elephant (*middle*). At a negative tone she wrapped her trunk around a horizontal bar of her cage (*bottom*).



SAMPLE OF BLOOD is withdrawn for diagnostic purposes from a vein in the heart of a patient with heart disease. The sample is obtained through a plastic tube or catheter inserted through a vein in the arm. The tubes in the foreground distribute the sample.

Heart Metabolism

The muscle of the human heart continuously does twice as much work as the muscles in the arms and legs of a man running at top speed. This prodigy is studied by inserting a tube into the heart itself

by Richard J. Bing

No machine made by man or nature can compare in efficiency with the heart. From its formation in the embryo until the moment of death, the human heart beats steadily at the rate of about 70 times per minute—36 million times in a year, two billion times in 50 years. At each beat it pumps out 160 cubic centimeters of blood; in 50 years it pumps some 300,000 tons. At its normal beat the heart performs about 70 foot-pounds of work per minute, more than 100,000 foot-pounds per day. This is about twice the rate of energy output by the muscles in the legs and arms of a man running at top speed. The leg or arm muscles are soon exhausted by such strenuous activity. But the heart keeps on working at its high rate decade after decade throughout a man's lifetime.

On what fuel does this dynamo feed? What is the secret of its endurance and efficiency? What causes it to weaken or fail? The metabolism of the heart is a subject of more than ordinary interest, particularly in view of the steady rise in mortality from heart disease in modern times. The subject has not been easy to investigate, but help is now forthcoming from a technique which permits study of the metabolism of the living heart in its natural condition.

The technique was born in an amazing *tour de force* performed by a German physician who (with two other pioneers) has just received the 1956 Nobel prize in medicine for his accomplishment. In 1929 Werner Forssmann thrust a thin plastic tube into a vein in his arm and threaded it through the passages of the blood vessels until its tip reached his heart. (He verified its position by X-ray inspection.) Forssmann's catheter became an invaluable instrument for medical diagnosis and research. Ten years ago a more or less accidental discovery opened the way for use of the catheter to study the heart's metabolism. While using the instrument in studies of heart disease at the Johns Hopkins Hospital, we found that the tip of the catheter could be guided into one of the large veins of the heart—the coronary sinus. This made it possible to examine samples of the blood just after it leaves the heart muscle, and so to find out how much oxygen the muscle has taken up and what foodstuffs it has consumed.

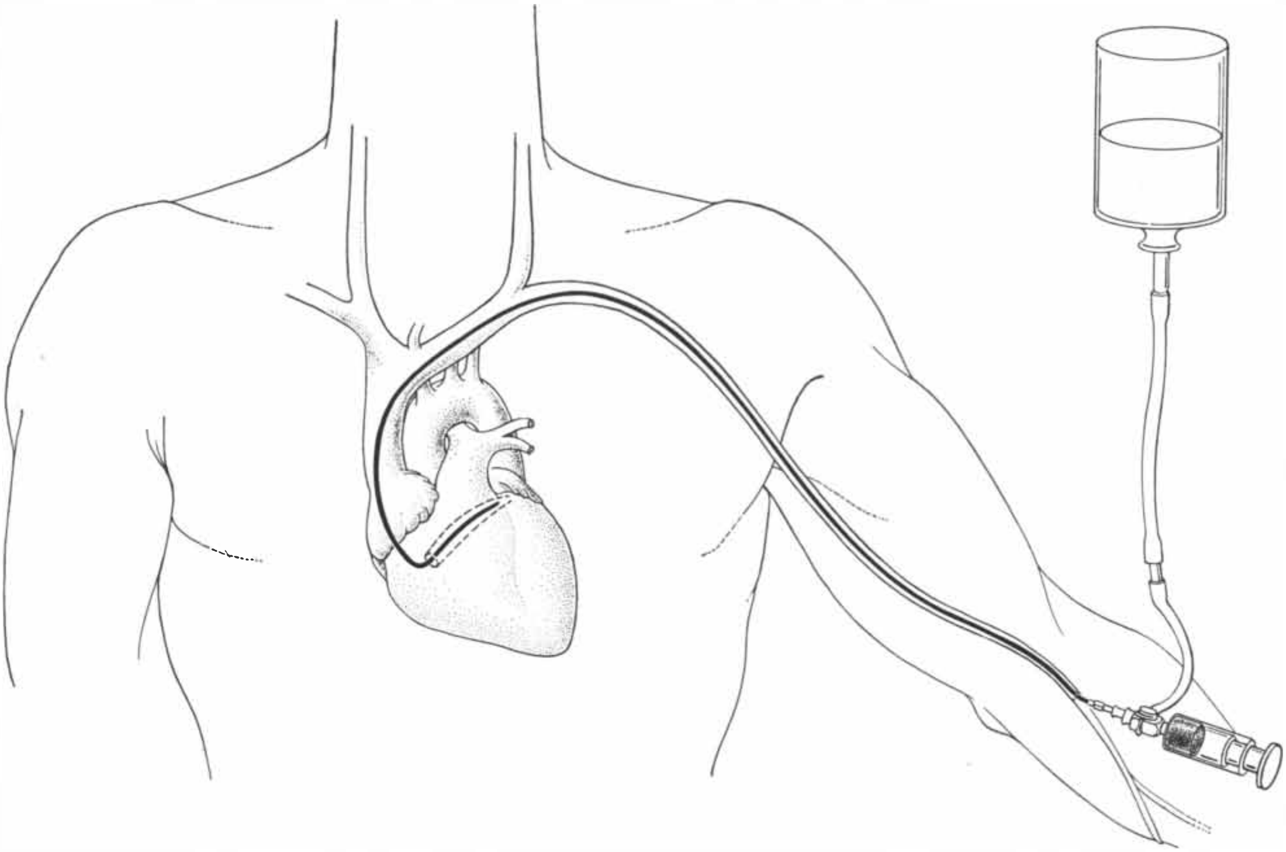
The composition of the venous blood coming from the heart muscle is compared with that of arterial blood, which is much the same throughout the body and therefore can be sampled at any artery. Chemical analysis of the blood before and after it has fed the heart muscle discloses what changes the muscle has produced in the blood's freight of fuel and nutrients. It does not tell exactly what has gone on within the muscle. We do not see the play itself—only the actors entering and leaving the stage. But by closely observing the appearance, costumes and attitudes of the actors as they pass in and out at the door to the stage, we can reconstruct some of the play.

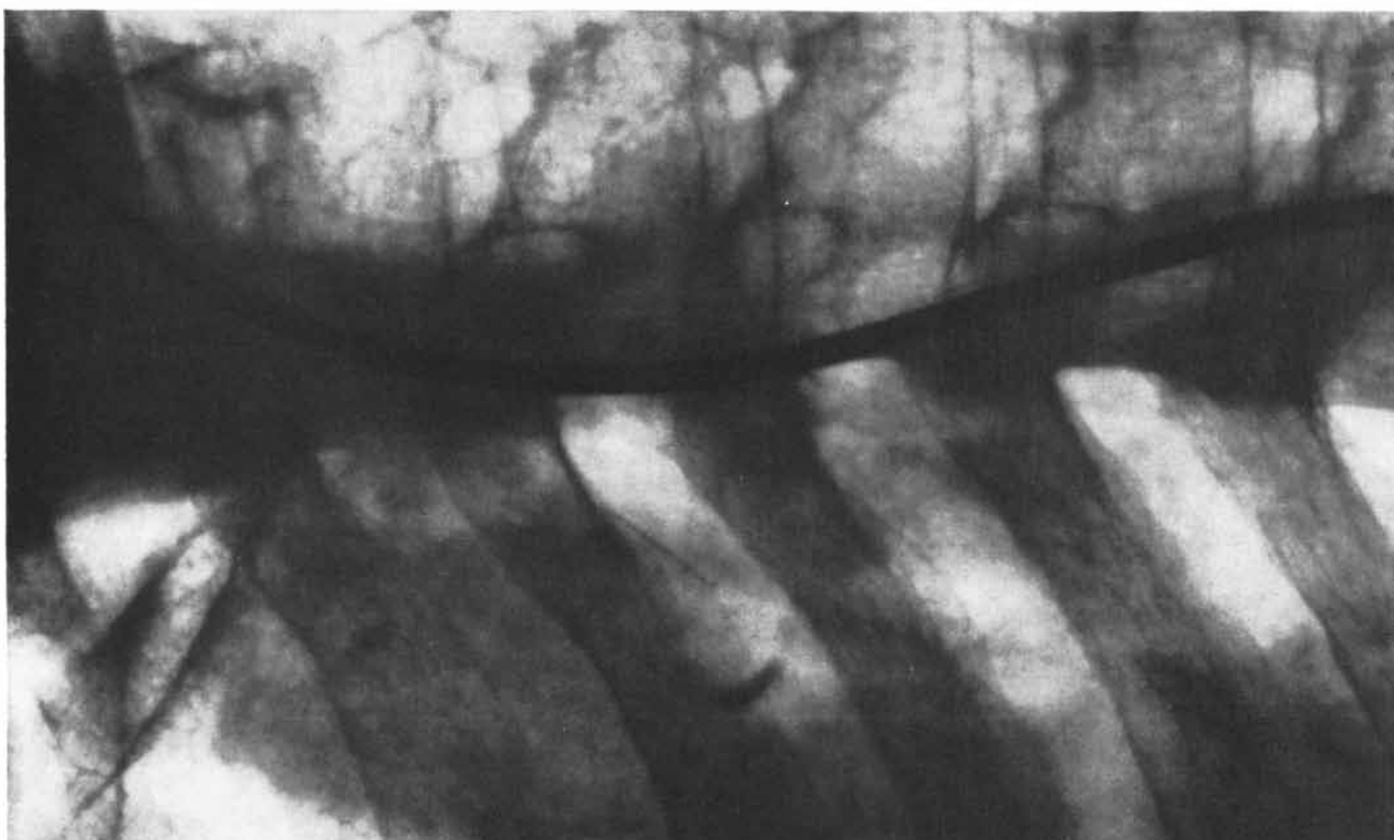
The metabolism of heart muscle has been studied in slices of heart tissue and in a complete heart kept alive outside an experimental animal's body. But the biochemical changes which take place in tissue slices are not necessarily the same as those in the living organ, and the isolated heart does not live longer than a few hours. Consequently a technique which allows investigation of the heart's metabolic behavior *in situ* offers many advantages.

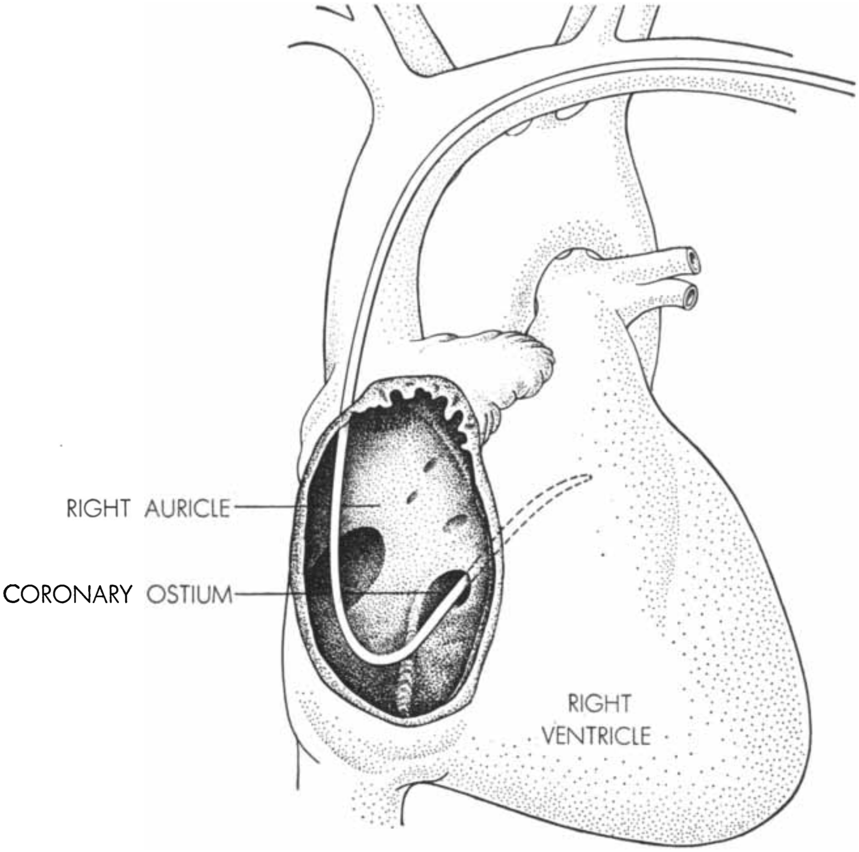
One thing it has made possible for the first time is a calculation of the heart's efficiency in converting the energy of its fuel into useful work. A rough measure of the energy the heart obtains from foodstuffs (by metabolic oxidation) is the amount of oxygen the heart consumes. Measurements of its oxygen uptake by means of the catheter indicate that the human heart ordinarily converts 25 per cent of the energy derived from its food into mechanical work, while during exercise, when the heart may double or treble its work output, its efficiency may be as high as 50 per cent.

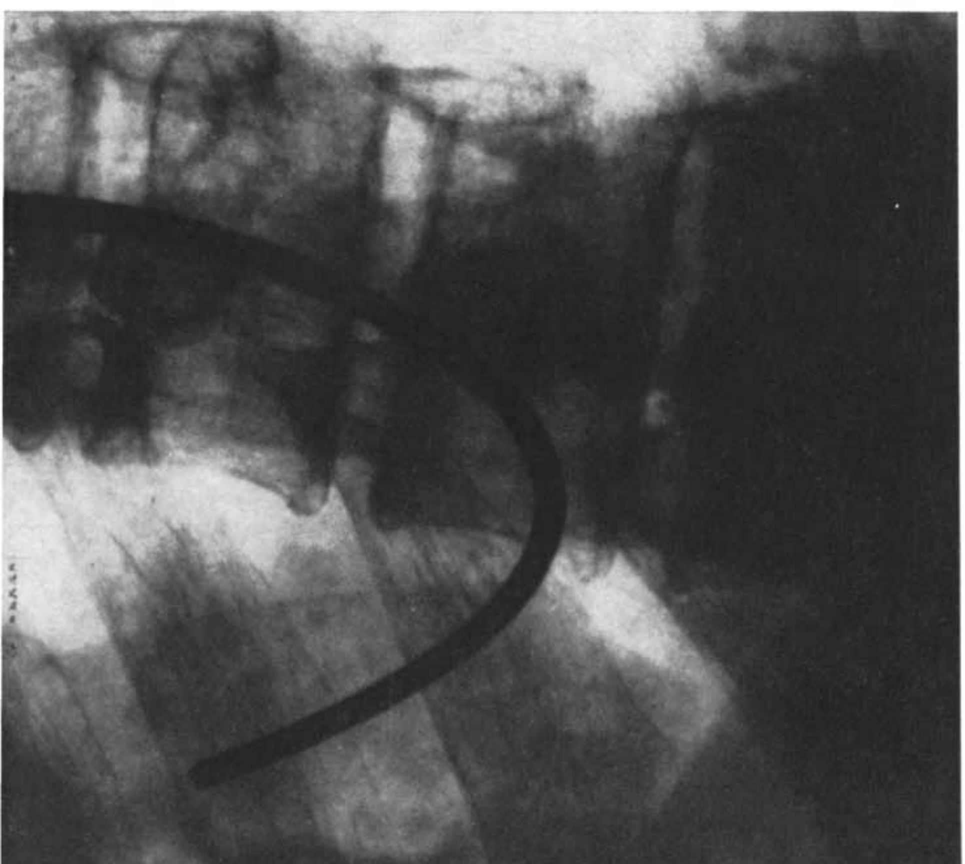
Like other living tissues (and even microorganisms), the heart muscle produces energy by breaking down carbohydrates, fats and proteins into simple compounds which, in the presence of oxygen, are oxidized to energy-storing substances, notably adenosine triphosphate (ATP). The major question here is: Precisely what foodstuffs does the heart use, and which foods are the most effective?

It has been known for some time that the heart burns carbohydrates, particularly the sugar glucose and some of its breakdown products, such as lactate and pyruvate. In fact, experiments on tissue slices and the isolated heart had suggested that carbohydrates are the heart's principal fuel. But our investigations of its oxygen uptake show that carbohydrates actually account for only about 35 per cent of its fuel supply. We have found that the human heart muscle burns considerable amounts of other substances, among which fatty acids seem to be especially important (apparently they are even stored in the heart muscle as an insurance supply). Indeed, the heart apparently can utilize as fuel any of the foodstuffs circulating in the blood. It is endowed with a metabolic









versatility which guards it against the vagaries of the food supply. Like the opossum, it can live on almost anything.

Nevertheless, the heart is not immune to nutritional deficiencies. A lack of vitamin B-1 will produce what is known as beriberi heart disease, which may eventually lead to heart failure. This disturbance impairs the heart's ability to convert fuel into energy. Other metabolic defects of the heart are not so easy to pinpoint. They may involve either the heart's production of energy from foodstuffs or its liberation and utilization of energy. To determine just where the defect lies is a complicated matter, and inspection of the actors' exits and entrances with the catheter can give only indirect clues.

Diabetes, our studies strongly suggest, impairs the metabolism of the heart, reducing its ability to metabolize not only sugar and its breakdown products but also proteins and fats.

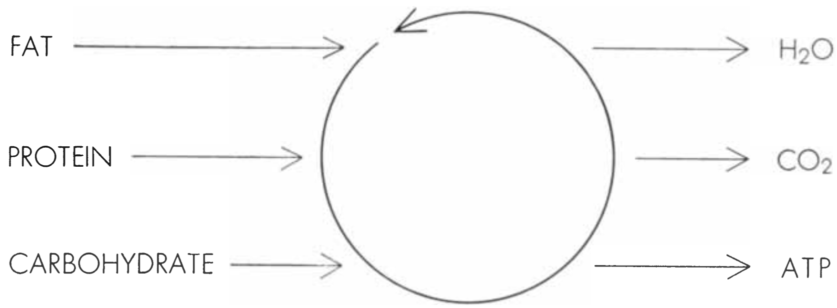
Most types of heart failure, however, arise not from a deficiency in production of energy but from a defect in liberation of energy for use by the heart muscle. High blood pressure, thickening of the coronary artery walls, damage to the heart valves by rheumatic disease, or the process of getting old—all these must disturb energy liberation rather than energy production, because the heart retains its normal ability to take up oxygen.

Any increase in the load upon the heart causes it to contract more strongly provided it can function normally. Starling's "law of the heart" [see "Ernest Starling," by Ralph Colp, Jr.; SCIENTIFIC AMERICAN, October, 1951] says that an increase in the volume of blood in the heart chambers stretches the heart muscle fibers and heightens the force of their contraction. The validity of this law has been debated by scientists al-

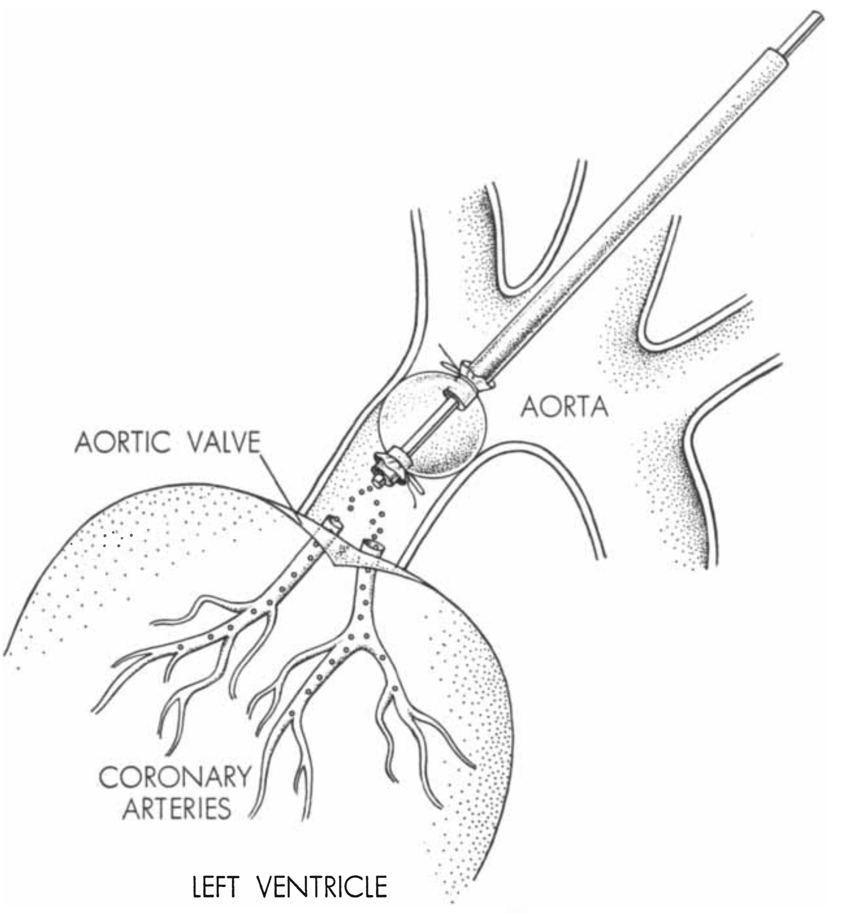
PATH OF THE CATHETER used to withdraw a sample of blood from a vein in the heart is traced by the pictures on this and the opposite page. The drawing at upper left shows how the catheter passes through the basilic vein of the arm into the heart vein: the coronary sinus (*broken lines*). The sample is taken with a syringe. Suspended above the syringe is a vessel of saline solution; this is allowed to run through the arm vein when the sample is not actually being taken. The drawing at upper right shows how the tip of the catheter passes through the right auricle and the opening of the coronary sinus: the coronary ostium. The X-ray photograph at the bottom shows the catheter in place in the coronary sinus of a patient.

most as heatedly as some of the legislation before Congress, but it certainly holds in some circumstances. At all events, there is no dispute about the fact that if the heart muscle is stretched too far, the heart's contractions weaken and eventually it fails. In failure something happens to the heart muscle which interferes with the liberation of energy. What this something is we do not know. We do know that certain drugs, such as digitalis, can restore some of the heart's contractility. This suggests that some disturbance of the heart muscle's physical chemistry is responsible for its failure.

The most dramatic disturbance of heart metabolism comes when the flow of blood to the heart muscle is suddenly blocked. The hard-working heart muscle constantly demands oxygen. It receives only about 8 to 10 per cent of the total amount of blood pumped through the body—much less than the kidney, which gets about 25 per cent. The heart muscle makes the most of its supply by an extraordinary efficiency in extracting oxygen from the blood. This efficiency is so high that it cannot be raised much in response to stress. When the heart is called upon for extra work, as during exercise or emotional stress, it must increase the flow of blood through the muscle. If for some reason, such as narrowing or obstruction of one or more coronary arteries, it cannot increase its blood supply, its shortage of oxygen may be signaled by heart pains. A sudden occlusion of a heart artery—*i.e.*, a coronary thrombosis—leads to death of cells in the heart muscle for lack of oxygen and so disrupts the metabolism of the muscle that it loses its strength of contraction and may fail altogether.



KREBS CYCLE, named for H. A. Krebs of the University of Sheffield, converts the raw fuels for the contraction of the heart and other muscles into adenosine triphosphate, or ATP.



SMALL PLASTIC SPHERES were introduced through a catheter into the coronary arteries of an experimental animal. This caused coronary occlusion. The catheter was then used to withdraw samples of blood from the arteries and to investigate the effect of occlusion.

We have made experimental studies in animals which throw some light on what happens during a coronary occlusion. We blocked some of the coronary arteries with tiny plastic spheres injected into the vessels, and then used the catheter to probe the blood flow and changes in blood composition. We found that the flow to the heart muscle does not diminish as much as might be expected. Some of the unblocked coronary arteries dilate to bigger caliber, taking an extra volume of flow. Meanwhile that part of the heart muscle which is deprived of oxygen, by the occlusion of the arteries that feed it, apparently tries to adjust itself to its diminished oxygen supply by a change in its pattern of metabolism. But this adjustment is short-lived (lasting only about 10 minutes), and it does not suffice to avoid damage to the tissues. Within 20 minutes after the occlusion, cells in the oxygen-starved part of the heart muscle begin to die. Their death rate rises to a peak 24 hours later. The dying cells release enzymes into the bloodstream. (This finding, incidentally, provides blood tests which can verify the occurrence of a coronary occlusion.)

The catheter has already proved itself a tool of great value in heart disease. It enables heart surgeons to pinpoint certain defects in the heart or the aorta, and thereby has greatly reduced the risk of their operations. Now the information the catheter has yielded about the metabolism of the heart is giving us a better understanding of the physiological results of coronary occlusion and shock, and of the processes that lead to heart failure. It appears likely that within 10 years this knowledge will bear fruit in treatment of sufferers from heart disease.

Kodak reports to laboratories on:

our activity in infrared-activated devices . . . staying a trigger of corruption . . . new materials for electronically modulated photographic printing

The tallish building is our headquarters. From a laboratory of ours, a breadboarded infrared scanning device we are working on looks across the city and picks out in broad daylight, in a window of the distant office building, a 480-cycle infrared flicker from a lamp filament scarcely warm enough to glow visibly. We choose this odd tidbit of technology as a means of announcing dramatically our desire to enter into conversations looking to research, engineering, and manufacturing undertakings which involve infrared-activated devices. We are rich in talent, facilities, and downright actual experience for work in all infrared domains: the photographic and metascope region to 12,000Å, the lead sulfide region to 3μ, the selenide-telluride region to 6μ, and the bolometer region to 15μ.

Inquiries should be addressed to Eastman Kodak Company, Military and Special Products Division, Rochester 4, N. Y.

Against ozone

Ozone is a noxious gas. (The man in the street, if he recognizes the word "ozone" at all, congratulates himself on knowing it to be a high-toned synonym for pure, invigorating air. When he hears that ozone is being used as an index of urban air pollution, he is confused, poor fellow—all the more if he is bright enough to remember from high school chemistry that ozone is O_3, nothing but oxygen.)

A little ozone goes a long way. It triggers corruption. It attacks double bonds, the weak links in chains of carbon atoms. The "sun-cracking" that puts those growing fissures in GR-S (the vulcanizable butadiene-styrene copolymer that insulates us a little from winds that blow in southeast Asia) has been unequivocally pinned on ozone.

As a major producer of antioxidants, we have a clear duty to contribute arms to the fight on ozone. So we draw from our forges on the banks of the Holston in Tennessee the new *Tenamene 30 Antiozonant* (N,N′-di-2-octyl-p-phenylenediamine) and the new *Tenamene 31 Antiozonant* (N,N′-di-3-(5-methylheptyl)-p-phenylenediamine).

Here are no laboratory curiosities, coyly offered in little bottles without claims beyond identity. This is big business, for a recently tightened Army Ordnance specification tells in effect how much ozone exposure rubber goods must be able to stand under dynamic stress-and-relax conditions. Both the new *Tenamene* compounds help rubber weather and age more gracefully in non-dynamic use, too. *Tenamene 30*, in particular, survives heating of the GR-S very well, so as to be on hand to combat ozone.

These antiozonants may be purchased and introduced into rubber goods at the compounding stage even by manufacturers who have no Army Ordnance inspectors to get by.

Isn't it nice that all your favorite rubber goods manufacturer has to do, if he wants to find out what would be involved in giving you longer-lasting satisfaction from your purchases, is to write for information about Tenamene 30 *and* Tenamene 31 *to Eastman Chemical Products, Inc., Kingsport, Tenn. (Subsidiary of Eastman Kodak Company)?*

Faster paper, artlessly dodged

We have doubled the maximum speed available in photographic paper—the kind on which pictures can be printed from negatives.

Great as this news is, we must in candor admit that with the exception noted below there has been no strong demand for more paper speed than has been provided for many years now in *Kodabromide Paper*. Most photographers prefer a printing time long enough to permit a little artful dodging that compensates for local excesses or deficiencies in the density of the negative.

Actually the new paper is more than just muscle-flexing by our emulsion makers. It seems that there is some dodging now being done electronically. The faster paper is our contribution to certain recent developments that involve electronic scanning of the negative and modulation of the light source in accordance with the density of the particular portion of the negative being printed.

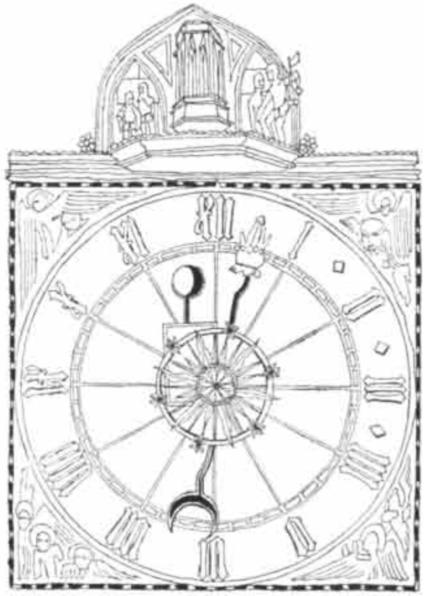
Among people who have a great many negatives from which to print a great many of the most informative possible positives, electronically modulated photographic printing is a very lively subject at the moment. This we can say without promising that the best and cheapest route from an uneven negative to a more even positive will forever remain electronic.

Nevertheless, finding we can bring out a paper that gives an electronically modulated print in 10 seconds where 20 would be required with papers that are plenty fast enough in conventional printers, we deem it a privilege to be of service, and let the future bring what it may.

The new material is tentatively designated Kodak Photographic Paper, Grades 1370 *and* 1371, *the former lying between* Kodabromide *Contrasts 1 and 2 and the latter approximately matching Contrast 3. For information about sizes, weights, surfaces, prices, etc., write Eastman Kodak Company, Professional Sensitized Goods Sales Division, Rochester 4, N. Y.*

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

Kodak
TRADEMARK



Scientists' Pay

According to the most recent available figures, half of the scientists in the U. S. make less than $6,525 a year. This was the median income reported by some 50,000 respondents to a questionnaire of the National Science Foundation during 1954 and 1955.

Physicists have the highest rate of pay, with an annual median of $7,275. They are followed in order by geologists ($7,250), mathematicians ($6,300), biologists ($6,275), meteorologists ($6,050), astronomers ($5,950), and psychologists ($5,850). (About 33,000 chemists and chemical engineers also were included in the survey, but were not asked to report earnings. The American Chemical Society reported in a recent survey that their median salaries range from $5,136 for beginners to $13,488 after 39 years' experience.)

The median age of the scientists who answered the NSF questionnaire was 38. Some 41 per cent of them held Ph.D. degrees. The salary value of a doctorate, as reflected in median salaries for the various specialties, ranged from $500 to $1,600 per year.

About half of the respondents held jobs in industry; 18 per cent worked for some governmental organization, and one third were employed by educational institutions. Private industry claimed nearly 90 per cent of the chemical engineers, 70 per cent of the chemists, 45 per cent of the physicists, but only 20 per cent or less of the other groups.

Almost half of the scientists are occupied chiefly in research and development. About one fifth are primarily administrators; 16 per cent are teachers. The NSF says that the percentage of scientists engaged in teaching has declined since 1951.

Women accounted for 7,000 of the replies. Most of them are psychologists, biologists or chemists.

The NSF survey, made cooperatively with professional societies, was conducted for the National Register of Scientific and Technical Personnel which the NSF is directed by law to maintain. It heard from more than 94,000 of the estimated 235,000 workers in natural science in the U. S.

Chemical Purity

To meet an intensifying competition for engineering help, industry is wooing college seniors with methods reminiscent of college football recruiting. Last month the Manufacturing Chemists Association agreed on an Ivy League type of recruiting code.

The new rules, reports *Chemical and Engineering News*, require that "all statements made by company representatives and printed material be completely factual, objective and restrained, and that job openings and advancement opportunities be described as they actually exist." The payment of bonuses for signing up, and of half-salary from the time of signing until reporting for work, are officially frowned on. "Lavish all-expense trips" and "wining, dining and partying" the prospective employees are banned. So are bonuses to recruiters based on the number of bodies they bring back.

Big Business in Research

Industrial research and development in the U. S. is being concentrated more and more in a few large companies, and Government policies in awarding research contracts foster this trend, the U. S. Attorney General's office declared last month in its annual report on the Defense Production Act.

Big corporations (those with more than 5,000 employees) now perform 69 per cent of all industrial research and development. In the chemical industry the figure is 74 per cent; in petroleum, 80 per cent. The report estimated the total annual expenditure for industrial research and development at $4.5 bil-

THE CITIZEN

lion, of which the Government is paying one third. In the past year the Department of Defense, the largest single dispenser of research and development funds, awarded less than six per cent of its contracts to small business.

The report pointed out that companies doing Government research and development gain competitive advantages by accumulating valuable technical information and particularly by their ownership of patents growing out of the research.

To spread research contracts more widely the Attorney General recommended that bidding procedures be simplified, that the Government make lists of small firms competent to do research, that boards of experts be set up to advise Government contracting officers on selection of contractors and that patent policies be revised.

Person to Person

Western physicists who visited the U.S.S.R. last year brought back reports that their eminent Soviet colleague Peter Kapitza had been in disfavor for refusing to work on the atomic bomb project. According to a recent item in *Science*, a British reporter decided to check the story with Kapitza himself. The newspaperman put in a person-to-person telephone call, and to his surprise pierced the iron curtain without difficulty. Kapitza unhesitatingly confirmed that he had indeed refused, and still refuses, to work on military applications of atomic energy.

For High-School Science

The National Science Foundation is financing two new programs for the improvement of science teaching in secondary schools. It has given a grant of $303,000 to the Massachusetts Institute of Technology for a broad study of physics courses in high schools. A committee of scientists and educators headed by Jerrold R. Zacharias, professor of physics at M.I.T., is reviewing subject matter, textbooks, teaching methods, lecture demonstrations, laboratory exercises and equipment. After a two-year investigation the group intends to translate its findings into a revised curriculum. new texts and other teaching aids, probably including an extensive series of motion pictures.

The second NSF-supported project will provide a year of graduate training in science and education for 750 high-school and junior high-school teachers, starting next fall. Their tuition will be free and each will receive a cash stipend of $3,000, plus allowances for travel and dependents which may bring the total as high as $4,400. Courses will be offered in mathematics, physics, chemistry and biology as well as in education, and in most instances will be credited toward a master's degree. The program has already started on an experimental basis at the University of Wisconsin and at the Oklahoma Agricultural and Mining College. It will be extended to the following universities and colleges: Illinois, Chicago, Ohio State, Pennsylvania State, Stanford, Washington (at St. Louis), Colorado, Michigan, North Carolina, Texas, Utah, Virginia, and Oregon State. Applications for the training are to be made directly to the individual institutions.

A.A.A.S.

How scientists can play a more effective part in public affairs was one of the chief problems considered by the American Association for the Advancement of Science at its annual meeting in New York. The council of the Association had before it a report saying there was a "pressing need that scientists concern themselves with social action." It voted to appoint a committee which is to "suggest a practical program" to the A.A.A.S. board.

The report was the work of a Committee on the Social Aspects of Science, headed by Ward Pigman, a biochemist at the University of Alabama. Among the matters which the Committee considered to require action are: public ignorance of and indifference to science; the lopsided development of science (favoring fields of military and industrial importance); inadequate support of basic research; new hazards growing out of advances in science and technology (*i.e.*, atomic radiation, fumes and smogs); abuse of natural resources. The A.A.A.S. should take "urgent steps," said the report, "to develop means for bringing before the appropriate policy-making groups, and the public generally, the pertinent facts and opinions regarding the great social issues which have emerged from recent scientific advances."

As usual, the meeting featured symposia on broad topics. Some of the subjects: frontiers of science, the origin of life, Neanderthal man (on the occasion of the 100th anniversary of his discovery), measurement, communication in insects.

The $1,000 Newcomb Cleveland Prize for a noteworthy paper representing an outstanding contribution to science was divided between two experimental psychologists, Neal E. Miller of Yale University and James Olds of the University of California at Los Angeles. Both have worked on electrical stimulation of the brain [see "Pleasure Centers in the Brain," by James Olds; SCIENTIFIC AMERICAN, October, 1956]. Miller's report at the meeting summarized a large number of experiments in stimulation. When certain areas of an animal's brain are stimulated, the creature acts as if it were being punished; stimulation of other areas appears to function as a reward; for still other areas the behavior indicates reward followed by punishment. Miller emphasized a need for caution in interpreting the "motives" behind the animals' behavior. Olds described the effects of hunger, sex hormones and various tranquilizing drugs on the reward centers of the brain. In experiments where the animal itself is able to set off the electrical impulse, hunger reinforces the self-stimulation of some brain areas, sex hormone of others. Different drugs suppress the reward reaction for different regions of the brain.

Among other interesting reports:

J. Herbert Taylor of Columbia University told of tracer experiments which demonstrate that chromosomes consist of two complementary, unbroken chains of desoxyribonucleic acid, each extending the entire length of the chromosome. When the cell divides, the chains separate intact and each manufactures a complete new partner.

A new method for dating rocks, which depends on the decay of radioactive potassium to argon, was described by George W. Wetherill of the Carnegie Institution of Washington. By means of this technique it has been found that large areas of North America, Africa and Australia contain rocks which are 2.7 billion years old.

Felix Wroblewski of the Sloan-Kettering Institute reported that the amounts of various enzymes in the blood or other body fluids are important diagnostic clues. Different enzymes are produced by different organs of the body, and an abnormal level of an enzyme in the blood may signal a disturbance at a particular site. One enzyme is being used in estimating the extent of heart damage after coronary attacks [see

SILICONE NEWS

DOW CORNING

Smart Marketers Sell "Convenience"

- Silicone insulation makes possible "Powermatic" toaster
- Perk-up electric percolator with Silicone laminate
- New "jet fast" window cleaner made with Silicones

CONVENIENCE, CONVENIENCE AND STILL MORE CONVENIENCE — that's what today's buyers demand. And they're getting what they want — thanks to Dow Corning Silicones. Here are a few examples of how silicones aid manufacturers in providing features that spell more convenience — and more sales.

LOOK, NO HANDS—Now McGraw Electric has produced a "Powermatic" Toastmaster that takes a slice of bread from your hand, lowers it lovingly, toasts it just right, then wafts it gently back up, all under its own power. Nothing to push or pull. Secret? A tiny motor insulated with Dow Corning Silicones.

The motor, which is toasted at 400°F right along with the bread, would not be possible without silicone insulation. And Dow Corning silicone insulation can take years and years of toasting without damage. That's been proved in thousands of hard-working industrial motors and transformers. Add it all up and you have a more convenient, super-skilled appliance that does everything but butter the toast for you! No. 45

DUNKING ALLOWED — An accidental dip in dishwater won't wreck the electrical connections in the new Mirro-Matic Percolator, made by Aluminum Goods Manufacturing Company. Reason? The plug-in

insulators are now fabricated from silicone-glass laminate. Why? The silicone laminate has only one hundredth the moisture absorption of the phenolic insulators formerly used . . . a big difference when you're dealing with electricity! Silicone-glass also has greater physical strength, more heat resistance . . . it's more reliable all around. Yet, the silicone laminate doesn't cost a penny more . . . plain low-cost stampings are used instead of molded parts. More savings are realized through less breakage during assembly. No. 46

FRY PANS, TOO — find strong sales appeal in easy washability and controlled electric heat. The Sunbeam Automatic Frypan gets its extra convenience from Silastic* seals that protect the electrical connections. Silastic, Dow Corning's silicone rubber, keeps them dry even when the Frypan is almost totally immersed in water. No. 47

GOT WINDOW "PAINS"? Window-cleaning has always been one of the most miserable household chores. But now to the rescue: new "Jet Spray Bon Ami", an aerosol bomb that does all the dirty work. You just spray it on, wipe it off and the glass sparkles like new again. It's that simple.

At the press of a button, the Bon Ami bomb sprays foam containing Dow Corning Silicones. Remaining on the window pane after the foam is wiped away, the silicones form an invisible water repellent film that keeps the glass sparkling longer and makes it easier to clean next time.

The foam, by the way, prevents splatter and "run-off" . . . a special convenience to housewives. Jet Spray is fine for other surfaces, too: tile, enamel, chrome, painted wood to name a few. No. 48

*T.M. REG. U.S. PAT. OFF.

FOR MORE INFORMATION on silicones used in these applications, circle reference nos. in coupon.

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"Heart Metabolism" on page 50 of this issue]. Others, said Wroblewski, may give the first evidence of a developing cancer.

Prizes worth $1,000 each were given at the meeting to:

Lawrence R. Hafstad, vice president in charge of research of General Motors Corporation, for scientific achievement.

Oscar Touster, associate professor of biochemistry at the Vanderbilt University School of Medicine, for work on genetically determined diseases.

Herbert C. Kelman of the National Institute for Mental Health, for an essay dealing with social influences on behavior.

Jacob Furth of the Harvard Medical School, for investigations of abnormal cell growth.

C. Walton Lillehei and Richard A. DeWall of the University of Minnesota School of Medicine, for research in cardiovascular disease.

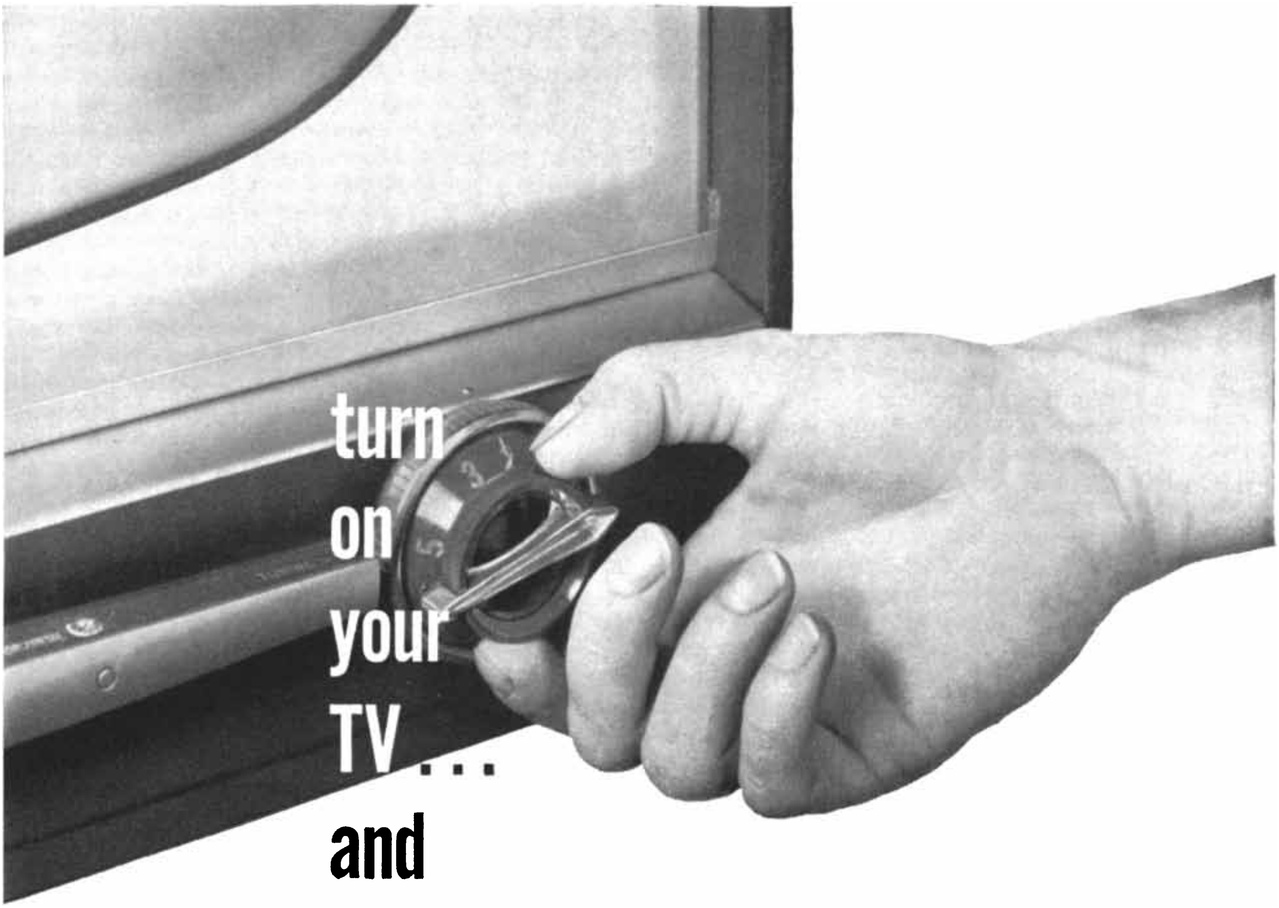
Chosen as president-elect of the A.A.A.S., to serve in 1958, was Wallace R. Brode, associate director of the National Bureau of Standards. The retiring president, Paul B. Sears of Yale University, became chairman of the board of directors and Laurence H. Snyder of the University of Oklahoma took office as president for 1957.

Fusion Catalyzed

A totally new type of nuclear fusion reaction has been discovered by physicists at the University of California Radiation Laboratory. It permits nuclei to combine at ordinary speeds, rather than the high energies heretofore thought necessary. The California group has found that slow-moving nuclei of ordinary and heavy hydrogen can sidle up to each other and blend peaceably into helium 3, while releasing the usual quantity of fusion energy. This is made possible by using the negative mu meson as a catalyst.

The meson cancels the electric repulsion between nuclei (which all carry a positive charge). Negative mu mesons have the same negative charge as electrons, and in effect they perform in this case the same role that electrons do in neutralizing the nuclear charge in an atom. When the negative mesons are attached to a nucleus, they form a "mesonic" atom. A mesonic atom is 200 times smaller than an ordinary one; hence such atoms can come 200 times closer together than usual. In the case of a mesonic hydrogen molecule, they turn out to be close enough to fuse.

The reaction was detected in a liquid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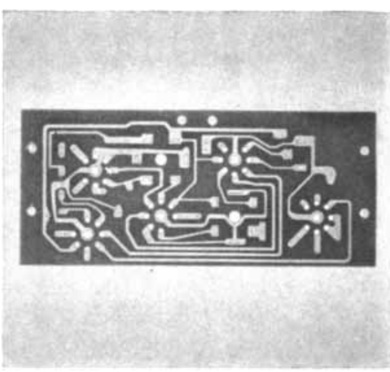
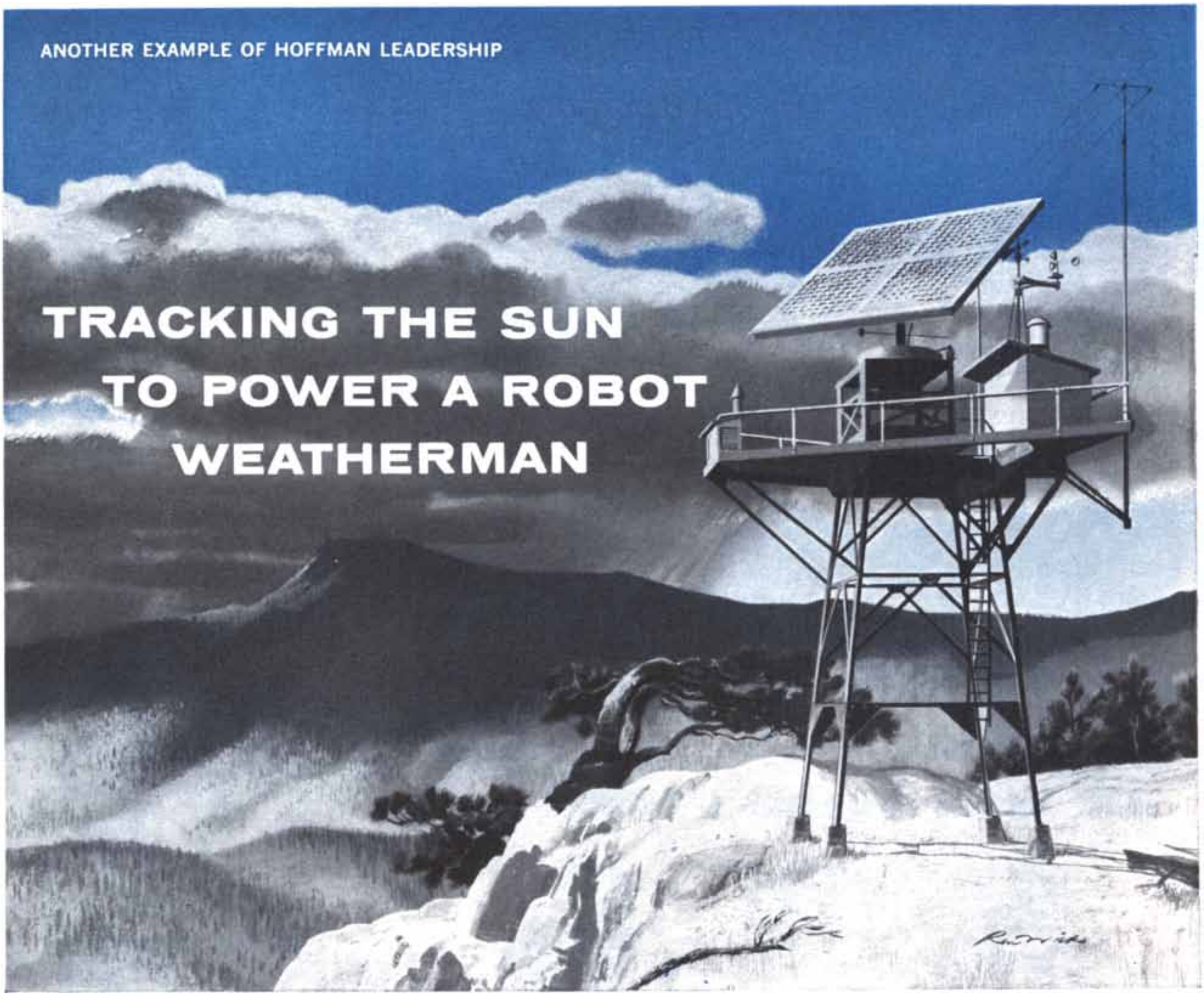


hydrogen bubble chamber exposed to mu mesons from the Bevatron accelerator. The Berkeley physicists occasionally found a track which showed a mu meson apparently coming to rest and then mysteriously giving off another mu. At first they thought that some "super-mu" particle had been found which decayed into an ordinary mu. But after 15 of the strange events, they concluded that an ordinary negative mu meson combines with a nucleus of heavy hydrogen, forms a mesonic deuterium atom, and the new atom then attaches itself to an ordinary hydrogen atom to form a mesonic molecule. The deuterium and hydrogen nuclei fuse and the meson is thrown off, carrying away 5.4 million electron volts released by the fusion. The meson's part is like that of a chemical catalyst, which promotes a reaction but is not consumed by it.

The discovery set off speculation about obtaining useful power from the "catalyzed" fusion reaction. The idea is attractive because it would avoid the high temperatures (millions of degrees) which are necessary to produce thermonuclear fusion. However, Luis W. Alvarez, who reported the discovery to a West Coast meeting of the American Physical Society, pointed out that mu mesons would be prohibitively expensive to manufacture in quantity and that their short lifetime would prevent their sustaining a long chain of reactions. He said that there would be "interesting possibilities" if a similar particle of much longer life could be found. A U.S.S.R. physicist has reported evidence for such a particle, but his work has not been confirmed.

Timing Light

K. S. Vulfson, a physicist in the Soviet Union, has proposed a simple new method for measuring the speed of light. As he described it in the *Proceedings of the Academy of Sciences of the U.S.S.R.*, the scheme would require only an electronic flash tube (such as is used in photography), a photoelectric cell and a mirror. A flash from the tube would travel to the mirror, be reflected back to the photocell and the resulting current from the cell would then fire the tube again, repeating the flash. Thus light would continually bounce back and forth between the tube and the mirror. To determine the velocity it would only be necessary to measure the distance from the tube to the mirror and the frequency of the tube's firing and to make the necessary calculations, deducting the delay between the arrival of the



BIG BERTHA

Solar Energy Converter Panels

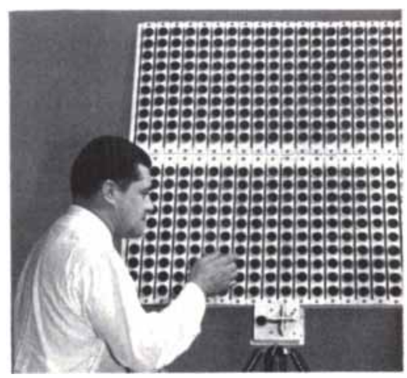
Powering unmanned weather stations is just one of the many uses for Big Bertha—newest, most exciting product of Hoffman electronics research. Solar Energy Converter Panels like this can be installed wherever an economical and efficient source of electrical energy is needed to power transistorized signal, telemeter, communications and similar electronic equipment.

Hoffman silicon junction Solar Cells blanket the face of Big Bertha, convert sunlight directly into electricity to charge batteries and operate equipment —produce 80 watts of power output for each square yard of surface. Panels of almost any size or configuration can be built at modest cost.

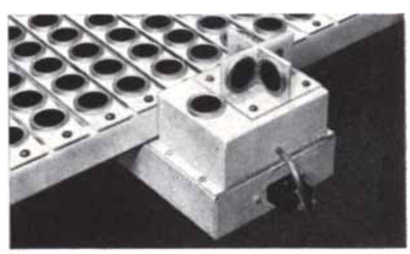
Important potential applications for Hoffman Big Bertha Converter Panels include: untended telephone repeaters, unmanned radio relay stations, pipeline transmitters, Forestry Service radio units, telemetering equipment, railroad signaling apparatus, and all types of transistorized radio, TV, telephone and telegraph equipment

Solar Energy Converter Panels can be supplied in tracking and non-tracking models, with special mounting stands or brackets designed to meet individual requirements. For additional technical information, please write the Applications Engineering Division, Hoffman Electronics Corporation, 3817 South Grand Avenue, Los Angeles 7, Calif.

Hoffman ELECTRONICS CORPORATION



BIG BERTHA consists of banks of Hoffman Solar Cells interconnected to attain specified power requirements—produces 80 watts per square yard of surface.



SUN TRACKER automatically turns Converter Panel to "follow" sun's transit across sky, assures maximum conversion efficiency throughout the daylight hours.

light signal at the photocell and the firing of the tube.

The method sounds so easy and straightforward that Western physicists believe it has already been put into execution in the U.S.S.R.

History in Bricks

The strength of the earth's magnetic field may have decreased substantially within the last 2,000 years, according to a pair of French geophysicists. E. and O. Thellier have reached this conclusion by measuring the magnetism of ancient bricks.

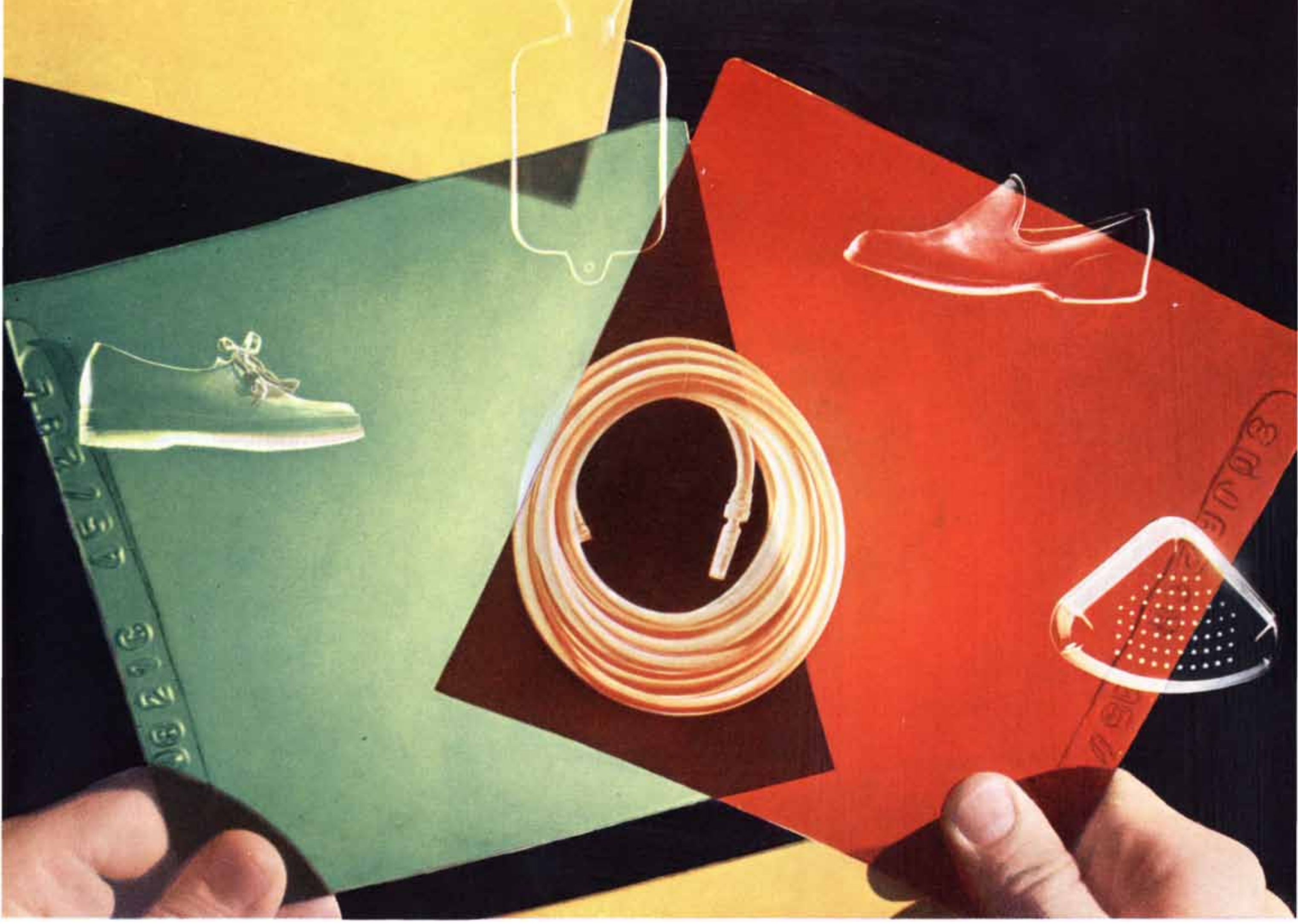
When bricks cool off after being fired in a kiln, small particles of iron which they contain tend to freeze into alignment with the earth's magnetic field. The extent of the alignment and hence the amount of magnetism exhibited by the bricks depend on the strength of the earth's field at the time of cooling. The Thelliers measured the magnetism of bricks made in France in 1933, 1465 and 200 A.D. Then they heated the samples hot enough to destroy their magnetism and allowed them to cool again so that they were remagnetized by the present geomagnetic field. The comparison shows that today's field is some 18 per cent weaker than in 1465 and 35 per cent weaker than in 200.

Some consequences of this decrease were pointed out in a recent paper in *Nature* by Walter Elsasser of the University of Utah and E. P. Ney and J. R. Winckler of the University of Minnesota. They reason that if the earth's general magnetic field has weakened, the intensity of cosmic rays reaching the atmosphere must have increased, because the field deflects cosmic ray particles away from the earth. This would mean that the rate of formation of carbon 14 in the upper air has changed, and therefore that the radiocarbon dating method gives incorrect dates.

The authors calculate that the error for 1,700-year-old samples would be about 240 years. This margin of error is within the limits of uncertainty of radiocarbon age measurements. But for 4,000-year-old samples the error may be as much as 1,000 years.

Storm on Mars

When Mars made its close approach to the earth last September (the closest in 32 years), astronomers, who had long prepared for the event, were disappointed to find the planet obscured by disturbances in its atmosphere. Gerard P. Kuiper of the University of Chi-



What new use for synthetic rubber do you see here?

Clearly different is the sample of compounded PLIOFLEX—the lighter colored synthetic rubber—pictured above. It's the first time ever that such clarity has been achieved in rubber. And what a host of possible uses it brings to mind—shoe soles, hose, tubing, toys, housewares, novelties.

Easier said than done, however, was finding the right combination of materials to produce this "clear" compound. Over 700 formulations were evaluated before success was realized. And of all the rubbers and pigments tested only combinations of PLIOFLEX 1778 and a silica pigment, Hi-Sil 233, permitted the maximum clarity for both hard and soft products.

The reasons why PLIOFLEX fills the bill so well are its extremely light color, its purity and its excellent general physical properties, not to mention its economy. These, incidentally, are the same reasons why PLIOFLEX is so frequently specified for other, more common uses.

What can you do with PLIOFLEX in "clear" rubber or other applications? Start finding out by writing for full details to: Goodyear, Chemical Division, Dept. B-9457, Akron 16, Ohio.

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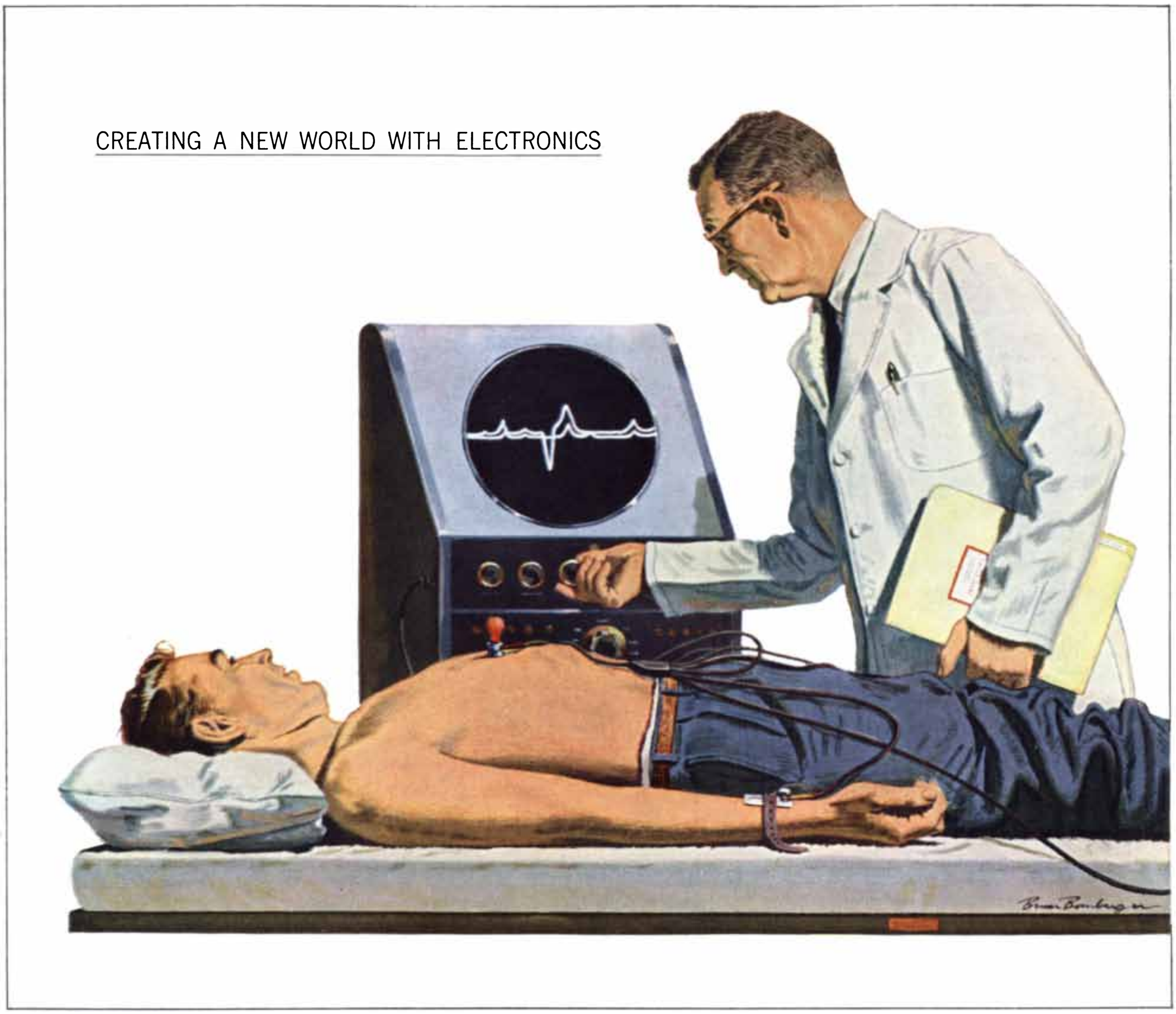

How soon can you have a better heart check?

It probably isn't too far away. The Hughes MEMOTRON direct display storage tube will enable your doctor to study several waveforms of your heartbeats at the same time. This uncanny tube can hold and superimpose any number of patterns for immediate visual comparison.

The MEMOTRON is but one of many electronic achievements that attest to Hughes Products leadership in research and development of electron tubes, as well as transistors and diodes. Advances like these will accelerate the dynamic electronics era—when you will be able to see over the phone, to control factory production electronically, and to enjoy countless other marvels.

As one of the country's largest electronics research and manufacturing firms, Hughes Products backs its semiconductors, cathode ray tubes, and industrial systems and controls with a long record of technical accomplishments. These include the "thinking" FALCON air-to-air missile, and the self-directing Hughes Automatic Armament Control which is standard equipment on all Air Force interceptors.

In your own business there is undoubtedly an application of Hughes electronic products which will save you time and money. A Hughes Products sales engineer will gladly work with your staff. Please write: Hughes Products, Los Angeles 45, California.

HUGHES MEMOTRON

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cago, after studying the photographs closely, now concludes that Mars had a gigantic snowstorm.

The storm occurred in mid-September, which is late spring on Mars. The planet's polar caps of snow and ice had already melted. Over a period of four days a "brilliantly white cloud," estimated to be 800 miles across, formed at one of the poles. By September 14 it was gone, leaving behind a fresh snow cover. Part of it survived through the summer.

Kuiper suggests that the unseasonable weather may have resulted from a very dry spring on Mars. Areas which normally are blue-green (believed to bear lichens) were a dull gray this year. On August 30 a massive W-shaped dust storm appeared and spread most of the way around the planet.

This may have lowered the average Martian temperature below its average of 65 degrees below zero Fahrenheit. As for canals, Kuiper was unable to see any. "The surface of Mars looks entirely 'natural'," he said.

Man-Made Genes

Scientists have found a way to make viruses and bacteria assimilate artificial gene materials and then produce stable, mutant offspring. The discovery was reported on the same day by separate groups working at the Universities of California and Columbia.

The California scientists worked with bacteriophages, the viruses that attack bacteria. They first treated the viruses with sulfanilamide to prevent them from synthesizing thymine, a building block of the nucleic acid DNA. Next they added a uracil compound which is structurally similar to thymine and forms a different DNA. The virus assimilated the substitute and produced mutant offspring. The frequency of mutations is 1,000 times greater than the natural frequency, and is the largest ever achieved. The work was done by Rose Litman, Abraham R. Fellow, and Arthur Pardee.

The Columbia group, under Stephen Zamenhof's direction, worked with coli bacteria. They fed the bacteria a broth which contained little thymine but considerable quantities of uracil compounds. These, too, made counterfeit DNA, which produced mutants. Some of the mutant bacteria grew to 80 times normal length, had eight times the normal number of nuclei and were 1,000 times more easily killed by ultraviolet radiation. When the abnormal bacteria were put on normal rations, most of the colonies returned to normal size, but a few remained small for 140 generations.

Why reliability engineering is not enough

There's more to reliability than meets the eye . . . a thousand inspectors cannot put reliability into an item that is inherently weak in engineering or production design . . . highest reliability in a component is obtained only when the manufacturer is aware of the problems in obtaining reliability . . . plus providing a proper climate in which employees are motivated by pride in product to surpass specifications.

In our humble opinion, the building of reliability into a product requires an alert *awareness* of the many, many facets of the problem. We'd like to submit these . . .

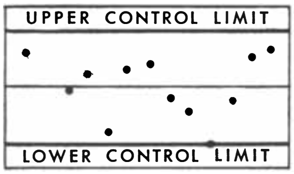
* ***"Integrity of intent" on the part of the manufacturer to meet the problems . . . coupled with provision of a proper climate for the carrying out of reliability objectives***
* ***Financial ability to take the necessary steps***
* ***Modern manufacturing equipment and methods***
* ***Plant capacity and flexibility***
* ***Design and engineering know-how that recognizes end-use requirements and environmental conditions***
* ***Careful employee selection and training***
* ***Long-range master planning***
* ***In-plant industrial and production engineering***
* ***Research, testing, development laboratory activities, including complete testing of prototype to end-use requirements***
* ***Continuous reliability assurance testing during the manufacturing operation, and institution of required corrective action***
* ***Collection, in the field, of failure data, analysis, and corrective action***
* ***All of these facets in depth***

Important as all of these are, the most important is the provision of proper climate, in the form of spirit and attitude of all personnel in pride of product, to carry out reliability objectives. In preceding articles in this series we've touched on some of the more technical aspects of reliability engineering. The manufacturer must naturally have an awareness of the problem, the integrity of intent to turn out the best product it can for a particular market or application, the financial ability to establish a Reliability program, the management ability to install it, the necessary manufacturing equipment and engineering organization to carry it out. But *all of these are not enough, if they are not instituted in a climate where an attitude will prevail that makes such things effective.*

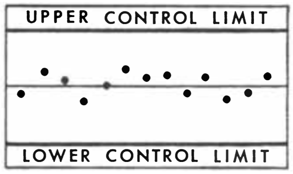
The manufacturer's integrity must necessarily be carried out, also, in the design, in manufacturing, and in finally warranting the product created . . . but, again, with every man and woman in the organization trying to meet or exceed the standards that have been created. This latter aspect we call "pride of product" on the part of the people who are producing it. And such pride must exist not only for the final product but for each part of that product, and in each step in the process. There is also an added dividend to reliability; the reputation of the product will cause the user to handle it with the same pride and care as was put into its manufacture.

It is interesting that people who are proud of a product, and enjoy what they are doing, can keep closer tolerances on the parts they work with and produce than those who are merely working for their pay. An assembler, who's proud of the product turned out, sees questionable components and avoids putting them into the assembly, while a disinterested person leaves them for "inspection" to catch. It is interesting in this connection, too, that some of the finest watch

parts made in Switzerland are produced in little shops where modern quality control techniques are unheard of . . . produced by a craftsman whose major technique is pride in his work . . . and thereby builds everything to the exacting tolerances required.



Quality control graph . . . without pride in product.



Quality control graph . . . with pride in product.

The atmosphere here at Cannon, since our inception in 1915, has included a design and manufacturing philosophy embracing the highest quality and reliability in each Cannon Plug for the specific application for which it is to be used. *To these principles all Cannon Plugs are built*! Even on connectors designed to customer or MIL-spec we constantly strive to give even more . . . to increase the safety factor . . . to give that "something extra" according to our own high "Cannon Standards", as exemplified in our Cannon Credo.

THE CANNON "CREDO"

TO DEVELOP ***an organization of exceptional people possessed of respect for the dignity of the individual and imbued with the spirit of the team.***

TO PROVIDE ***a facility with which we can produce to our utmost in an efficient and pleasant environment.***

TO DEVELOP ***and produce products of such quality, and render such service, that we may always be proud of our efforts.***

TO MARKET ***the product of our endeavor at a reasonable profit for continuing growth, reward for effort and a return on investment.***

TO ACCEPT ***our responsibility to our community, our country, and our fellow man.***

The Cannon "Credo" is posted through all departments of all Cannon plants . . . Copy available to you on request.

On the more technical side . . . we at Cannon have attempted not only to provide the proper climate for a complete reliability program from the viewpoint of mental attitude, but to provide the necessary facilities in which that attitude may work effectively. One of the most important of such fields is that of engineering organization and proper utilization of specialized engineering personnel. As a purchaser of Cannon Plugs, with a personal stake in their reliability, you will be interested to know that our engineering divisions are grouped as follows:

Master Planning Group . . . men who look to the future . . . investigating the newest in technological improvements, providing interplant project coordination for maximum flexibility to meet the challenges of our ever-changing future.

Industrial Engineering Group . . . experts who call out the materials, methods, and processes to be used in the manufacturing cycle . . . experts who collect, analyze, and institute corrective action in accordance with field failure data.

Sales Engineers . . . fully qualified technical men who contact our customers.

Design Engineers . . . specialists in past and present design methods who analyze failure data caused by design inadequacies and initiate corrective action.

Development Engineering and Model Shop Group . . . specializing in the development of prototypes. In these Laboratories, your prototype is tested to see that all specifications are met . . . physical, operating, environmental. Test reports are made up, and presented to you for review and approval. Not until all these steps have been taken is your order placed in production.

Product Engineers . . . specialists in particular types of connectors.

Quality Control Group . . . well qualified to administer the high requirements of "Cannon Standards" . . . staffed by well trained inspectors and analysts equipped with the most modern equipment.

Quality Engineering Group . . . handling the technical aspects of sampling plans . . . preparing inspection and test procedures to realize the customer's desired quality level and the over-all quality level of the entire Cannon manufacturing operation. Materials are processed through receiving inspection. Process, re-work and final inspection barriers are set up. In addition to standard Military and Cannon manuals of quality control procedures, specific jobs . . . such as yours . . . may require additional special inspection or testing. If so, these requirements are established throughout the process, and where necessary, coordinated with you. Our failure data collection and analysis in this field has given us intimate knowledge of the critical points at which such control should be used. Recognized statistical control procedures are used both in process and at the inspection points.

Materials and Processes Laboratory Group . . . working in both the research and production phases. This is the group that checks performance of new designs, constantly investigates new materials and processes, and (over and above normal manufacturing supervision and quality control operation) runs continuous reliability and assurance tests on the manufacturing cycle.

* * *

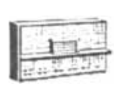
Each of our 20,000 Standard Cannon Plugs are of highest quality and were designed to meet exacting reliability requirements. We also produce special designs to meet the most exceptional AQL end-use requirements.

If you have a problem requiring high-reliability Cannon Plugs, we would appreciate the opportunity working with you.

Cordially,

Robert J Cannon *President*

CANNON ELECTRIC COMPANY
3208 Humboldt Street, Los Angeles 31, California



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CANNON PLUGS

Eight plants around the seven seas!

ATOMIC CLOCKS

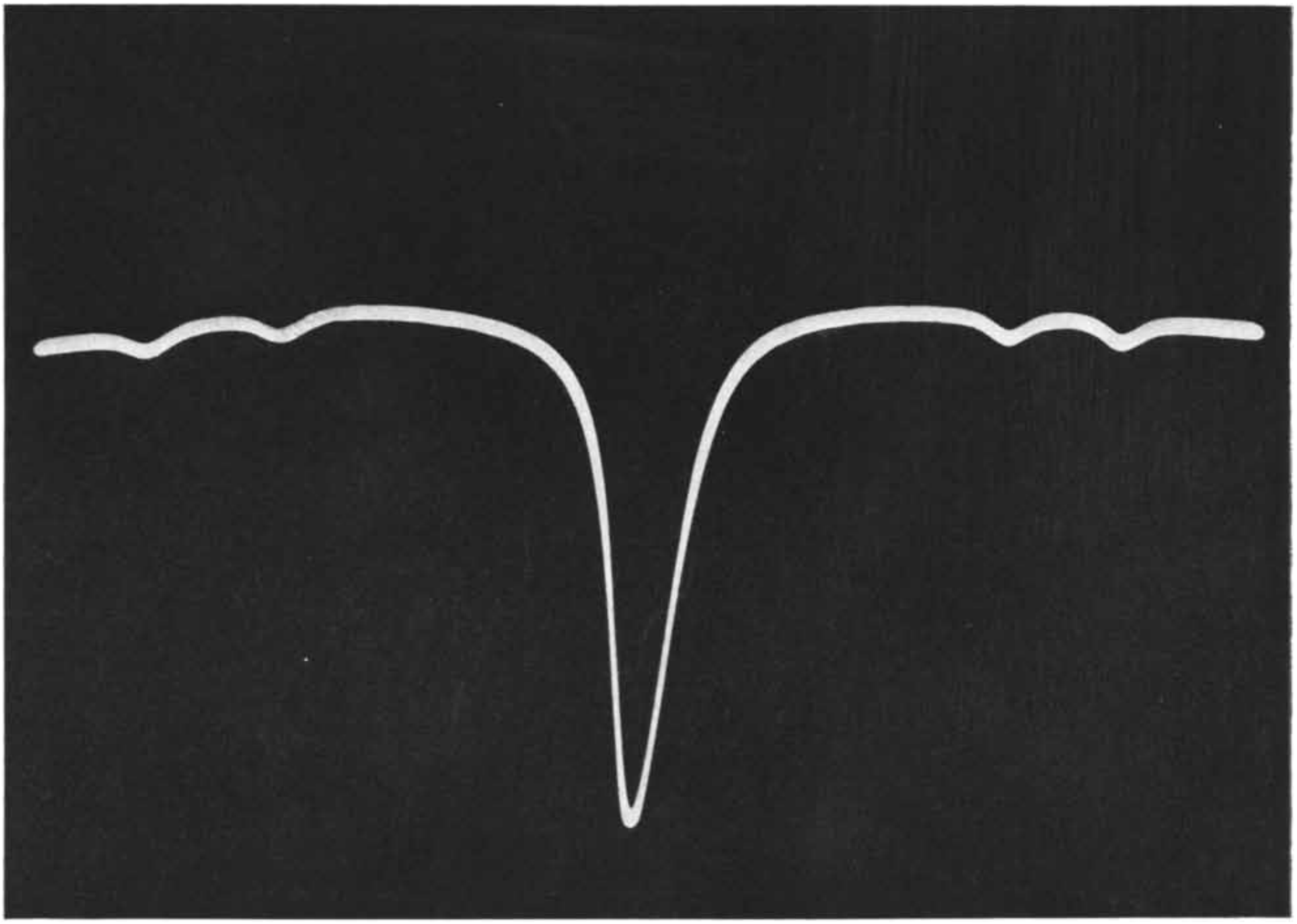
The "pendulums" which regulate them are the vibrating parts of atoms or molecules. So steady are these oscillations that atomic clocks keep better time than the spinning earth itself

by Harold Lyons

Philosophers and scientists in all ages have been fascinated by the mysteries of time—its relentless, arrow-like flight in one direction, its psychological vagaries, the difficulty of measuring it with absolute precision. In our atomic age the last of these aspects affords the most intriguing speculation and exploration. Because "the pendulum's swing is a variable thing," and the motions of the earth and stars are inconstant, today "the atom's vibrating has the highest rating" among chronologers. Let us then consider atomic clocks.

Most of us, when we ask for the right time, are satisfied with an answer accurate to a few seconds or so. For the "split-second" timing of a race, tenths of seconds will do. But in many areas of modern science and technology the question of the right time enters a different realm. In the laboratory we must deal with thousandths, millionths, even billionths of a second.

The measurement of any physical quantity reduces in the last analysis to a matter of counting units. To find the dis-



ABSORPTION CURVE of ammonia is recorded on an oscilloscope. The trace shows power received from a beam of radio waves transmitted through ammonia gas. Frequency varies along the horizontal axis. At the resonant frequency most of the wave energy is absorbed, as is shown by the dip in the curve. The range of frequencies indicated by the dip limits the accuracy of ammonia clocks.

tance between two points, for example, we choose some convenient yardstick and count the number of times it can be laid end to end from one point to the other. To find the elapsed time between two instants we choose a convenient unit, such as the time required by a certain pendulum to complete one swing, and count the number of swings in the interval. However, the swings of a pendulum are not precisely the same from one to the next. The central problem of exact time measurement is to find some periodic cycle that never changes, or changes so little that the variation can be disregarded. For ages immemorial we have reckoned time by the rotation of the earth relative to the stars. Now we have begun to seek more precise standards in the tiny world of molecules and atoms. There we find processes whose regularity makes it possible to measure time with undreamed-of accuracy.

The Clock on the Wall

Before looking into these cosmic clocks in more detail, let us consider briefly how ordinary clocks operate. In the household electric clock the "pendulum" is the cycle of the alternating current. Hence the accuracy of the clock depends on the steadiness of the rate of alternation of the current. For household purposes the 60-cycle rate maintained by the power-generating station is steady enough.

For higher precision, laboratories and observatories use quartz crystal clocks. Here a quartz crystal controls the frequency of an electronic oscillator, such as is used in radio broadcasting. A crystal of quartz, when subjected to an alternating electric field, tends to vibrate at its own specific, sharply defined rate. Placed in an oscillator circuit, the crystal imposes its steady natural frequency on the circuit. The resulting current can run a synchronous clock motor with an error of no more than one part in a billion or so, depending on the length of the interval involved. However, changes in temperature and other conditions produce tiny shifts in the crystal frequency, and as a crystal ages its frequency drifts.

Fundamentally all man-made clocks are set by some master clock in nature, which at present is the 24-hour rotation of the earth. The complete rotation is timed precisely by recording the instant a point on the earth passes under a chosen star in the sky on successive nights. The interval is divided into 86,400 parts, which gives the length of a second.

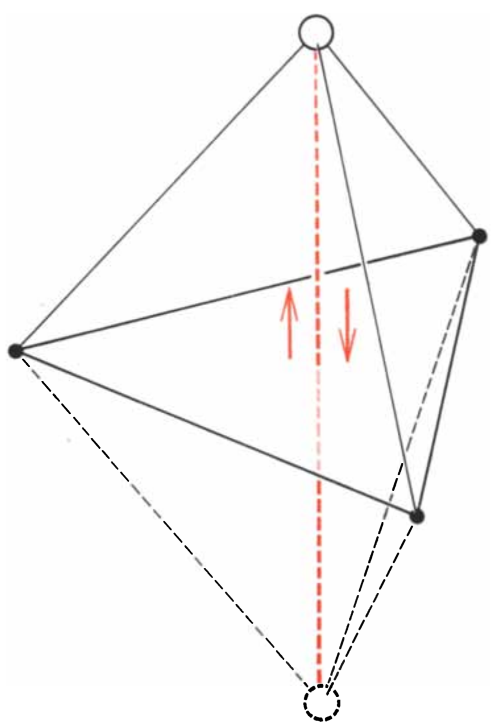
But in the computation of the length of the day, corrections have to be made for a number of irregularities, including wobbles in the earth's rotation on its axis. When all the corrections have been made, an insurmountable uncertainty still remains: the rate of rotation of the earth itself fluctuates unpredictably. So in the end there is an irreducible variation which can be as large as one part in 20 million.

All this explains why so much effort is being devoted to finding clocks which will keep better time than the earth and stars. The atomic clocks offer great advantages. The motions of atoms and molecules, which can serve as "pendulums," are absolutely pure and regular. Their rates are inexorably fixed by the laws of the atomic world.

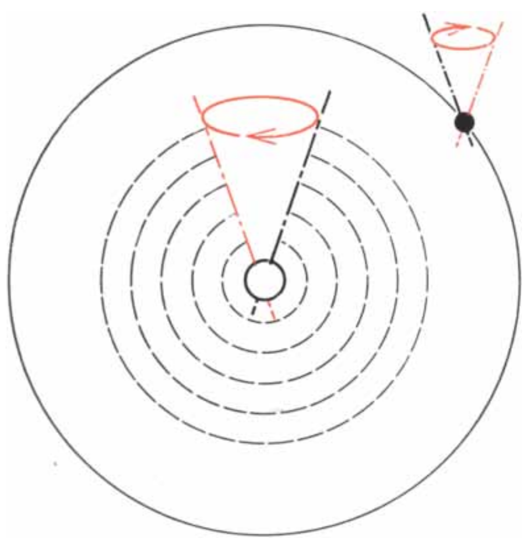
Some of the motions in the atomic world—*e.g.*, the vibrations of electrons that radiate visible light—are much too rapid to be counted. But there are atomic oscillations in the radio microwave region, with frequencies in the range of a few billion cycles per second, which can be counted accurately by present-day techniques and equipment.

The Ammonia Clock

The first atomic clock devised is the one based on vibrations of the ammonia



AMMONIA MOLECULE has the shape of a pyramid. Hydrogen atoms (*black dots*) form a triangular base. Nitrogen atom (*open circle*) is at apex. It can oscillate between positions above and below the base, traveling along the path marked by colored line.



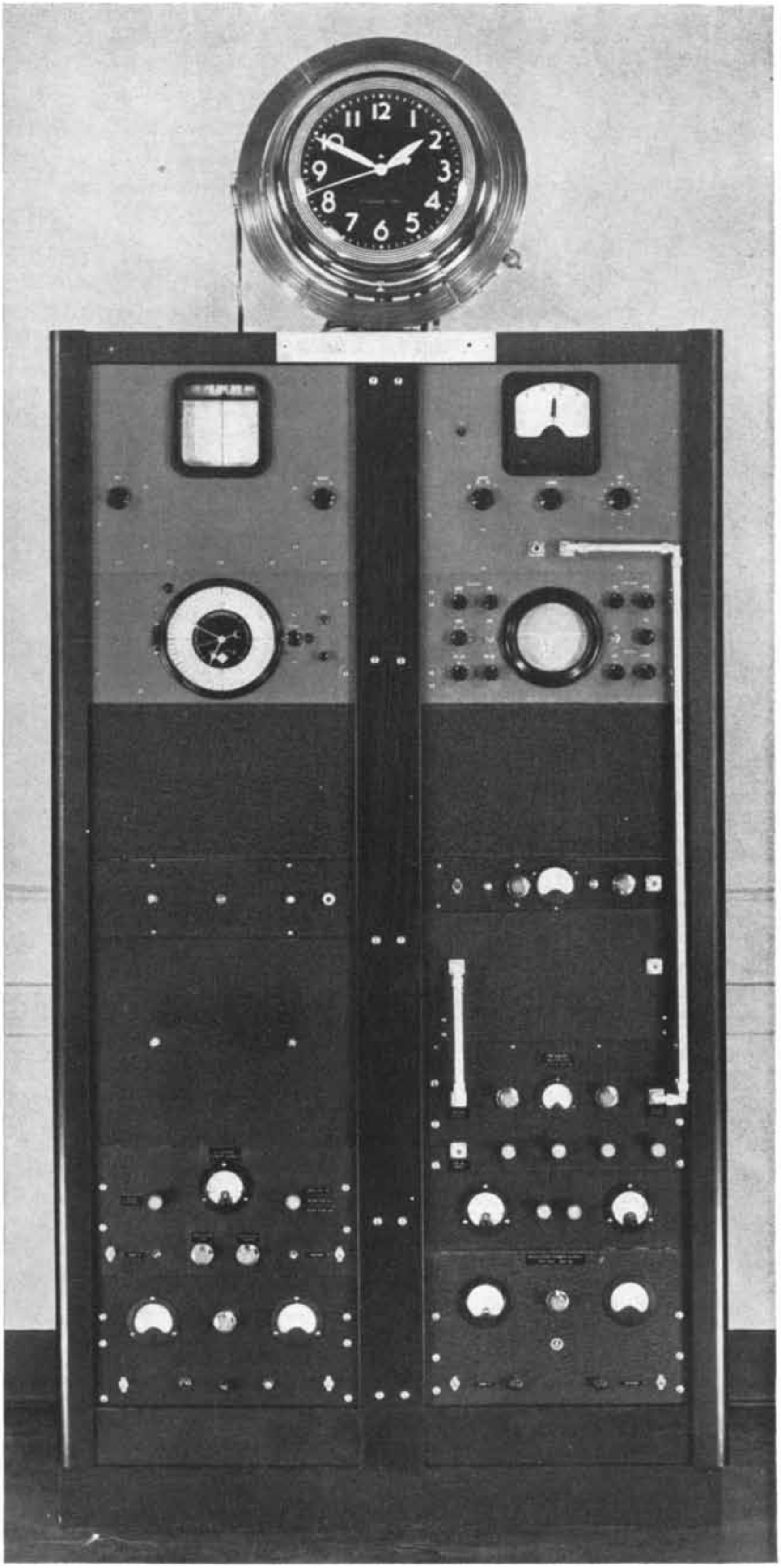
CESIUM ATOM has a single electron (*black dot*) outside of a number of filled electron shells (*broken circles*). The electron and nucleus are spinning magnets; each wobbles on its axis, as is indicated by colored arrow. Wobble is the ticking of a cesium clock.

molecule [see "Radio Waves and Matter," by Harry M. Davis; SCIENTIFIC AMERICAN, September, 1948]. This molecule, made up of three hydrogen atoms and one nitrogen atom, has the shape of a pyramid. The hydrogens are at the corners of the triangular base, and the nitrogen is at the apex [*see diagram on opposite page*]. According to the rules of classical physics, the forces between the atoms should hold the nitrogen in place at the top of the pyramid. But experiments have shown that the nitrogen can actually plunge down through the triangular base and come out to an apex position on the other side —a phenomenon which can be explained by quantum mechanics. The motion is merely hindered, not prevented, by the interatomic forces. And of course if the nitrogen can pass through in one direction it can also reverse its path; in other words, it can vibrate up and down through the base. As we should expect from quantum theory, the vibration can take place only at a sharply defined frequency, which happens to be 23,870 megacycles.

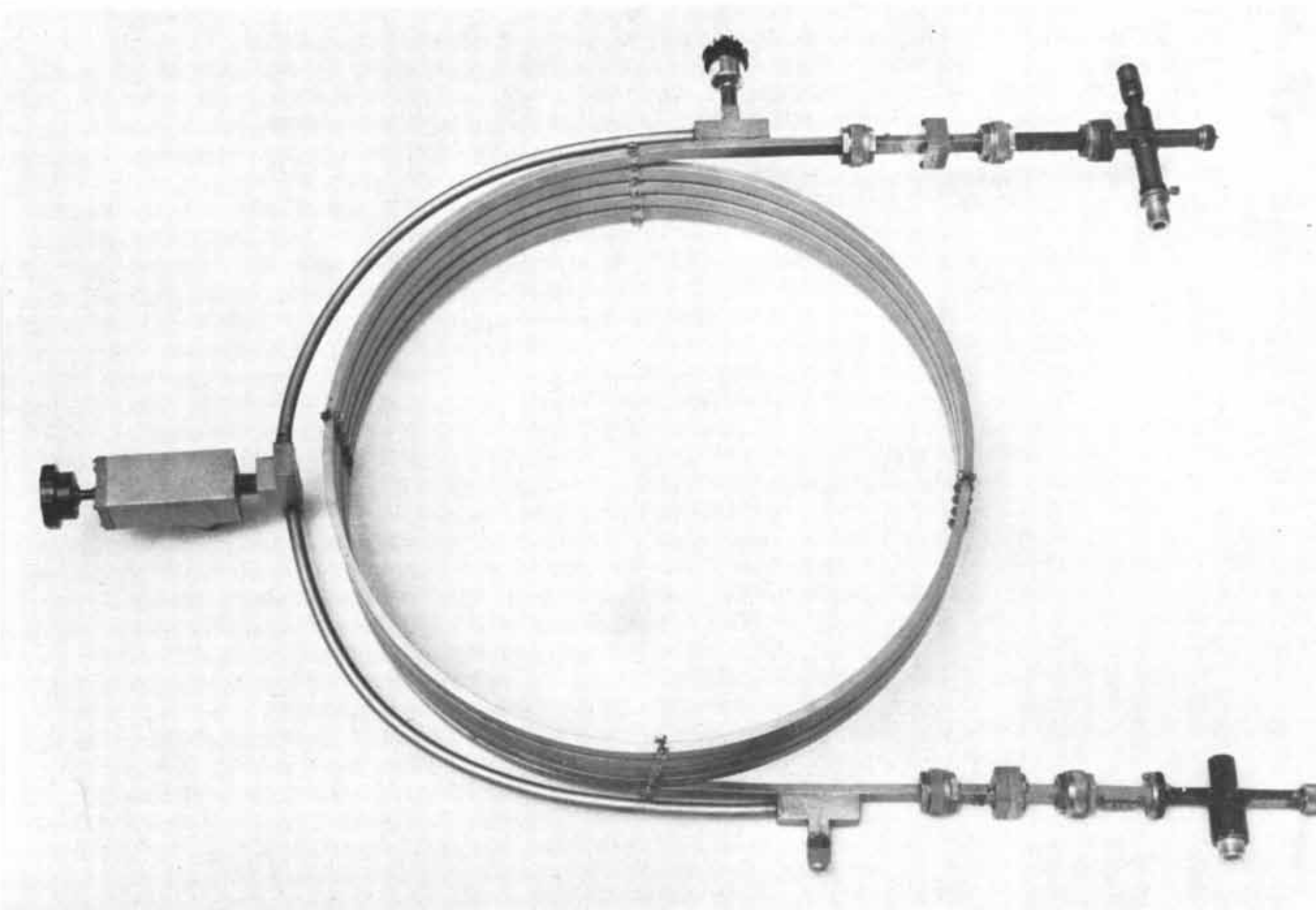
Whenever it is excited by a sufficient amount of energy, the ammonia molecule starts to vibrate with its characteristic frequency. It is like a pendulum which is set swinging by a push. If the push is supplied rhythmically, and in time with the natural frequency of the pendulum, the resulting swing is much more vigorous. That is, the molecule absorbs more energy from the source of supply and converts it into the energy of its own oscillator. A radio wave at a frequency of 23,870 megacycles makes the nitrogen atom absorb large quantities of energy and vibrate strongly.

In 1948 a group of workers at the National Bureau of Standards built an ammonia clock. Their design contains essentially two pendulums: a quartz crystal and a collection of ammonia molecules. The ammonia serves to correct small errors or irregularities in the crystal-controlled oscillator. The oscillator in turn runs an ordinary synchronous electric motor like the one in a kitchen clock. For this purpose its frequency has to be reduced to that of an alternating electric current suitable for running the motor—*i.e.*, to the neighborhood of 60 cycles per second. The crystal frequency is cut down to a precise fraction of the original by means of electronic circuits analogous to a train of gears which converts the rapid rotation of a small gear to the slower rotation of a large one.

The ammonia clock works as follows.



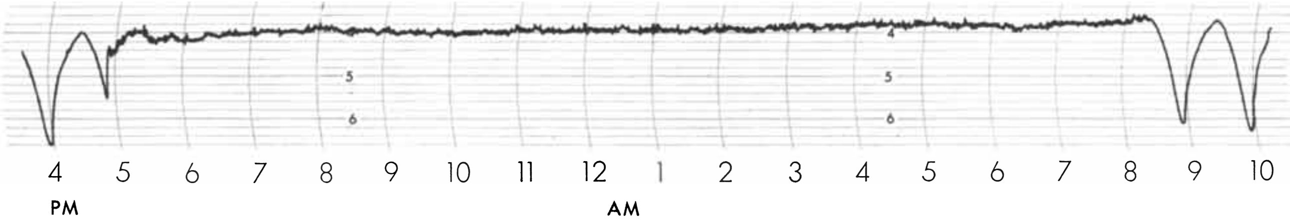
FIRST AMMONIA CLOCK was completed at the National Bureau of Standards in 1949. The wave guide that contains the ammonia gas can be seen wound around the face of the electric clock. The cabinet below houses crystal oscillator and other electronic circuits.



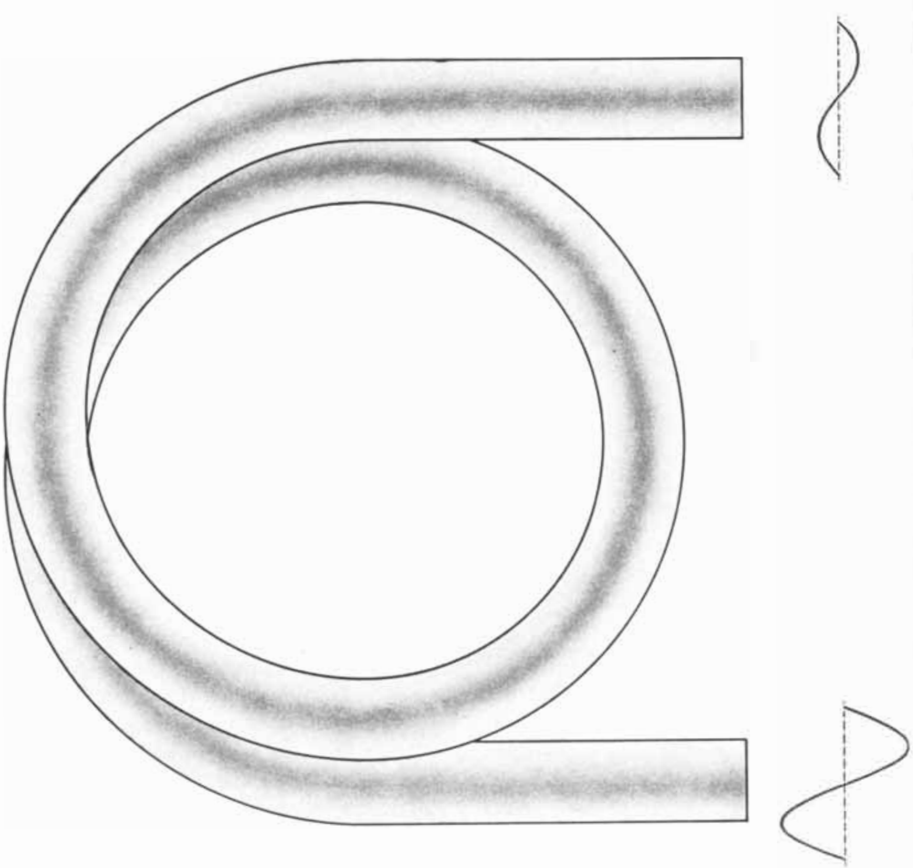
ABSORPTION CHAMBER for the ammonia clock is a hollow, rectangular, spiral wave guide which contains ammonia gas at low pressure. A radio signal is fed in at one end and detected at the other. When the frequency of the wave falls within the absorption

First the quartz crystal is set vibrating at a frequency which, when multiplied electrically, yields a frequency close to that of the ammonia molecule. These rapid oscillations are then converted into radio waves by means of a small antenna and are fed into a long chamber, or wave guide, containing ammonia gas. If the oscillations happen to be at the same frequency as that of the ammonia molecule, most of the radio energy will be absorbed by the ammonia, and little will get through the chamber to the other end. But if the two frequencies do not quite agree, most of the radio energy will pass through the chamber to a receiver at the far end. The receiver acts as a feedback mechanism, feeding a servomotor which adjusts the frequency of the oscillator circuit to agree with the ammonia vibration rate.

The feedback circuit has a time lag, and its corrections are not absolutely exact. The vibration of the molecules themselves exhibits an inherent fuzziness. In an assembly of ammonia molecules there is some spread of the rates of vibration. There are two chief reasons for this. First, the moving molecules of ammonia gas constantly collide with one another and with the walls of the chamber. At every collision the atoms of the ammonia molecule are subjected to outside forces which slightly spread the molecule's frequency from its normal value. The second factor in shifting the frequency is a Doppler effect. To radio waves passing through the chamber, the vibration frequency of ammonia mole-



STABLE PERFORMANCE of an ammonia clock over a 15-hour period is demonstrated by a record of its frequency changes. The frequency is measured on the vertical scale of the chart, each small division corresponding to a change of less than one part in 10 million. During the period from 5 p.m. to 8 a.m. the quartz crystal oscillator was locked to the frequency of the ammonia molecules.



band of the ammonia molecule the output signal is sharply reduced. At right is a schematic diagram of the unit showing the input signal at the bottom end and the output at the top.

cules moving away from the waves appears to be slightly lower than it actually is, and the frequency of molecules moving toward the waves appears to be higher. Both the collision and Doppler shifts are sufficient to give a measurable spread around the central frequency and thus to limit the possible accuracy of the ammonia clock.

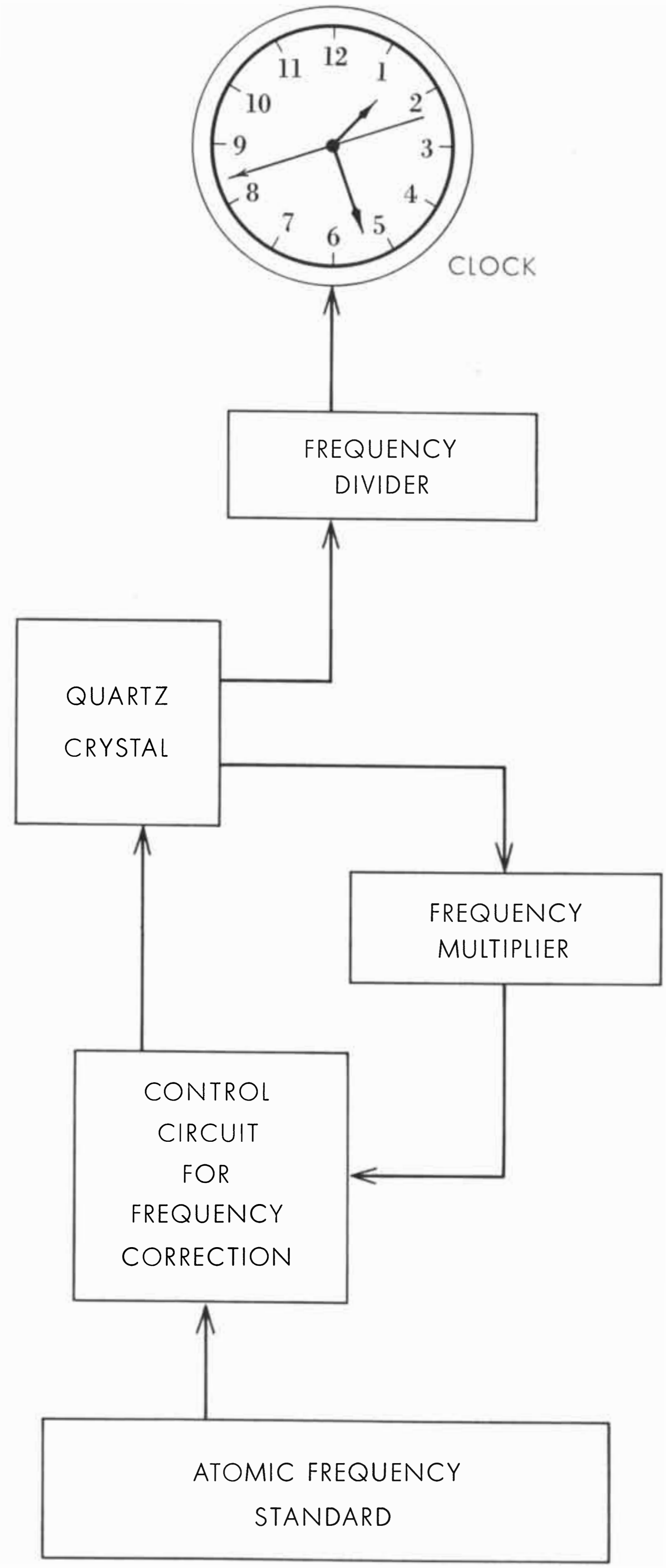
The accuracies that have been obtained are quite impressive, however. An improved version of the original Bureau of Standards ammonia clock is stable to within one part in 100 million. J. Rossel of the Swiss Laboratory for Time-Keeping Research has reported that a newer ammonia clock built there can be held steady up to two parts in a billion. K. Shimoda of Japan also has designed a new form of ammonia clock which can control frequency to two or three parts in a billion.

The Cesium Clock

Now an atomic clock of considerably greater precision—the most accurate yet built—has been made with cesium, a silvery metal which is liquid at room temperature. It was designed by the Bureau of Standards group who made the first ammonia clock.

The cesium atom, like the ammonia molecule, has a natural vibration whose frequency is in the microwave region. Its frequency is 9,192 megacycles. This puts it, very conveniently, in the range of three-centimeter microwaves, a region which has been intensively exploited for radar work. Thus the necessary equipment and techniques are ready to hand.

What can go on in the cesium atom at this comparatively leisurely pace? It turns out to be a magnetic process. Cesium is an alkali metal, which means that outside its filled electron shells it has a single outermost electron whose spin makes it a magnet. (The magnetisms of the electrons in the closed shells do not count, because they cancel one another.) The spinning nucleus of the cesium atom also is a magnet. Thus the atom contains two small, spinning magnets, each in the force field of the other. Neither magnet maintains a rigidly fixed direction. They are both like tops spinning in a gravita-



CONTROL CIRCUITS for an atomic clock are shown in this schematic diagram. Part of the output of a quartz crystal oscillator is reduced by a frequency dividing circuit to about 60 cycles per second and fed into an ordinary electric clock. Another part of the output is multiplied to the atomic vibration frequency and fed to a circuit which compares it with the atomic frequency itself. Any difference is translated into an electric signal which feeds back to the oscillator and brings its frequency into agreement with the atomic standard.

tional field. That is, they wobble or precess around a fixed line [*see diagram on page 72*]. The rate of precession is 9,192 megacycles per second. This represents, in effect, the ticking of the cesium clock.

If cesium atoms are placed in an electromagnetic field which oscillates at 9,192 megacycles, the electrons can absorb or emit energy and flip over to a different orientation. This change of energy state is the mechanism of the clock.

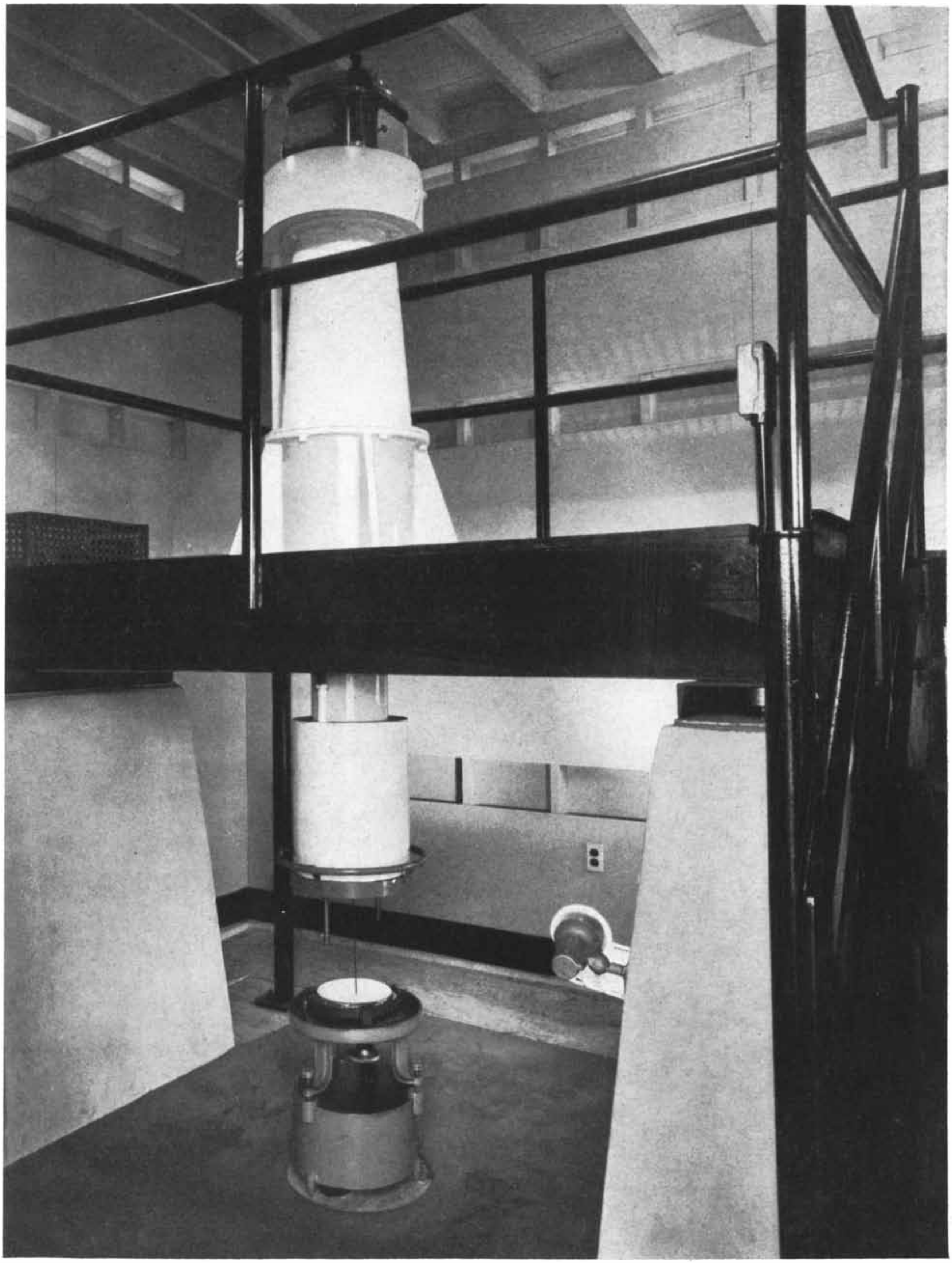
For the cesium clock the element is heated to the gaseous state in an electric furnace, and the cesium atoms are discharged through a small opening into a long, evacuated tube. They travel down the tube in a beam like a file of marching soldiers, thus avoiding collisions with one another. The beam is sent through a magnetic field which acts to select only atoms in certain energy states. Next the beam passes through a section where it is exposed to radio waves at the frequency of 9,192 megacycles. Finally it passes through a second magnet just like the first and then approaches a detector wire where the cesium atoms will produce a current if they hit it [*see diagram at top of page 80*].

If the radio field is on the correct frequency, large numbers of atoms in the beam change their energy. The second magnet now deflects these atoms so that they reach the detector. On the other hand, if the radio frequency does not agree with the natural frequency of the cesium atoms, they pass through the second magnet and are deflected so that few reach the receiver. As in the ammonia clock, the receiver actuates a mechanism which adjusts the oscillator frequency so as to keep the received current at a maximum.

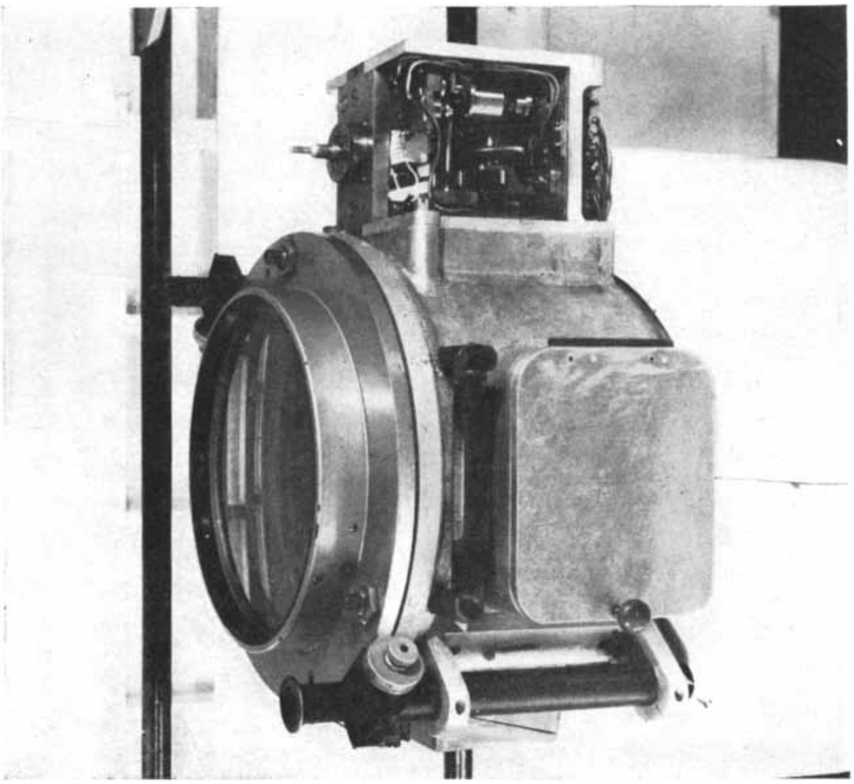
The cesium clock is extremely accurate because the spectrum line is very sharp. The device eliminates collisions between atoms and the Doppler effect, which broaden the absorption band in the ammonia clock. There is no Doppler effect because the radio waves attack the passing beam at right angles instead of moving along the same line of travel.

With precise control of the radio frequency it is possible to achieve accuracy to at least one part in 10 billion in the cesium clock. This would correspond to an error in timekeeping of one second in 300 years!

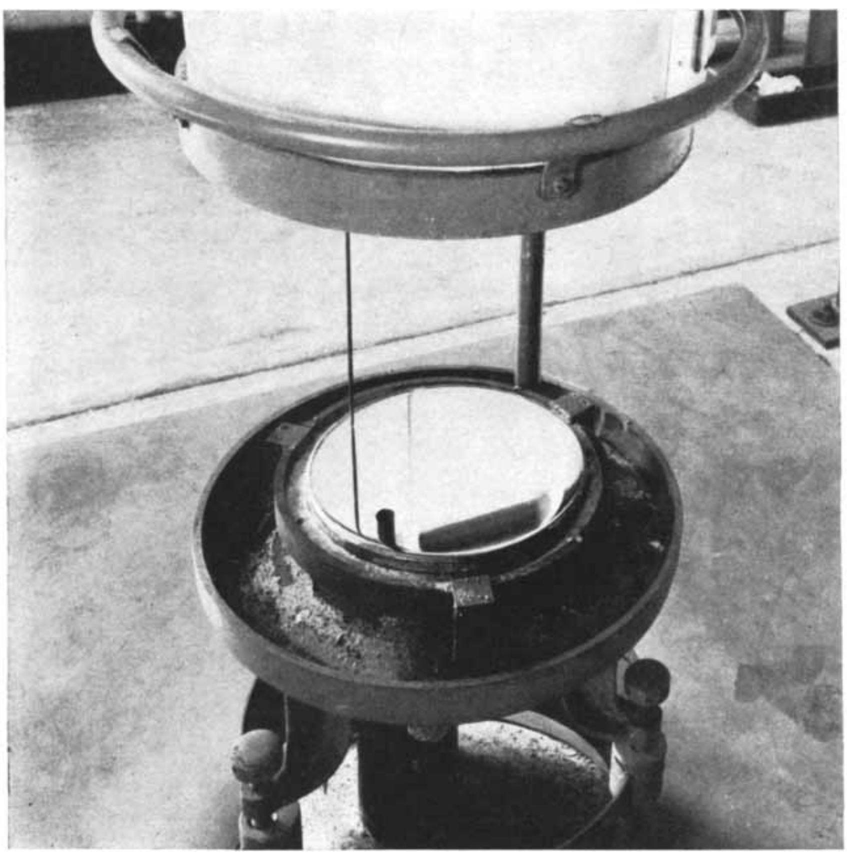
Already a cesium clock at the National Physical Laboratory in England has operated to an accuracy of one part in one billion. L. Essen and J. V. L. Parry have determined the center frequency of the cesium spectrum line in terms of a pro-



PHOTOGRAPHIC ZENITH TUBE makes pictures of stars as they pass directly overhead. The time between transits on successive nights determines the length of the solar day. The tube is fixed; below it is a basin of mercury which acts as a mirror. Because the mercury is liquid, it is absolutely level. The mirror reflects the light of stars to a photographic plate within the tube (*see picture at top of next page*). This instrument is at the U. S. Naval Observatory in Washington, D.C. A similar instrument is at Richmond, Fla.



LENS of photographic zenith tube has an aperture of eight inches. It is shown mounted on a housing which contains the photographic plate. The motor at top moves the plate to keep star image tracked for 20-second exposure. About 15 stars are photographed a night.



MERCURY MIRROR provides a flat and truly level surface. It is raised or lowered to focus the star image on the photographic plate under the lens. Above the surface of the mercury is a rod; its reflection can also be seen in the mercury. When the tip of this rod just touches the surface of the mercury, the image is in exact focus at the photographic plate.

visional, uniform time scale estimated by the Greenwich Observatory. Their answer is 9,192,631,830 cycles per second, with a possible error of 10 cycles. A cesium clock of at least this accuracy has also been built by the National Company in the U. S.

An ingenious scheme to improve the cesium clock's potential accuracy is being explored by Jerrold R. Zacharias and his group at the Massachusetts Institute of Technology. Zacharias plans to increase the length of exposure of the cesium beam to the radio waves, which will sharpen the absorption line. He proposes to do this by shooting the cesium atoms upward and exciting them with the radio field near the top of their trajectory, when they are about to fall and are moving slowly. His plan may give the cesium clock an accuracy to one part in 1,000 billion or better.

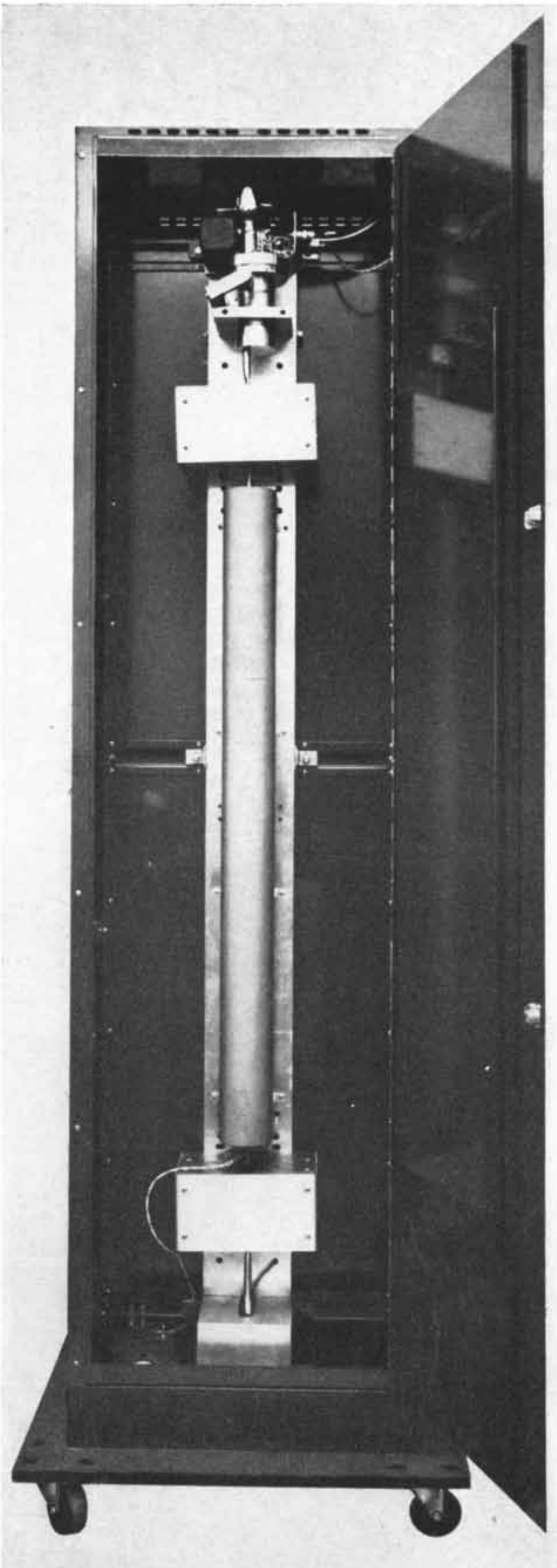
The Maser Clock

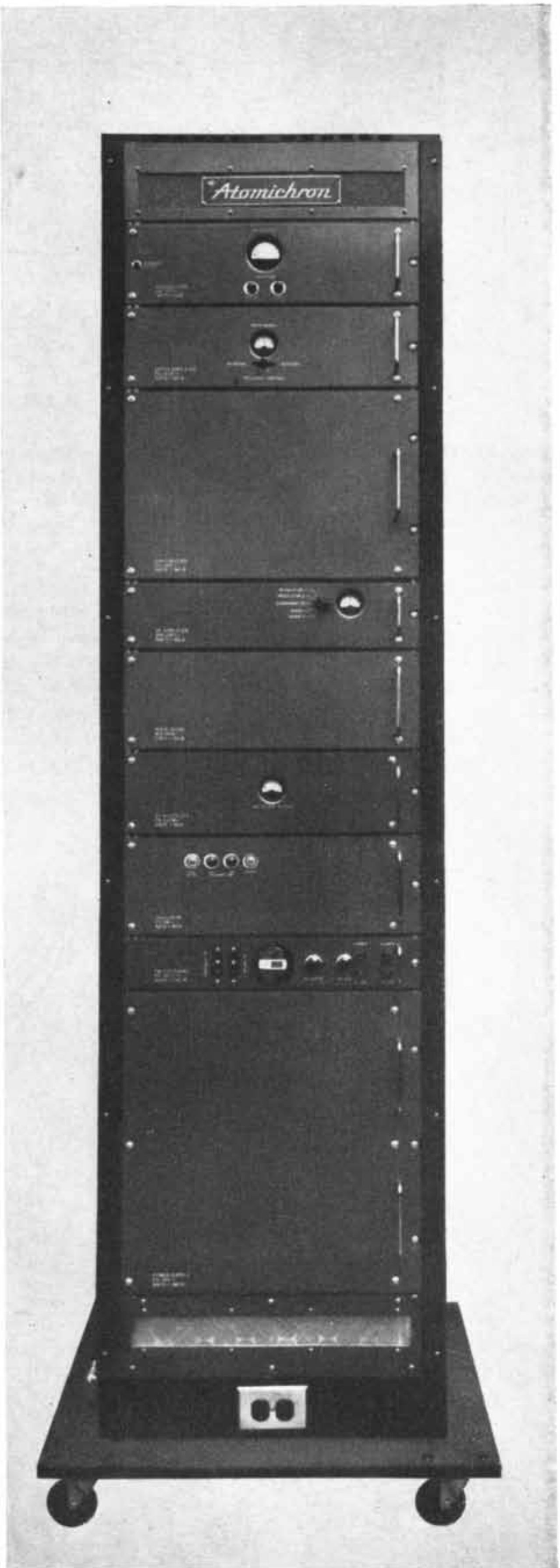
Why not tell time directly from an atom's own vibrations, instead of by the roundabout method of seeking its absorption frequency? The idea is indeed feasible, and a new atomic clock based upon it has been developed by C. H. Townes, J. P. Gordon and H. J. Zeiger at Columbia University. They call it the "maser" (for "microwave amplification by stimulated emission of radiation"). Their timekeeper is the ammonia molecule in the excited state, in which it emits rather than absorbs energy.

A beam of ammonia gas molecules coming from a high-pressure bottle enters a tube where it is first subjected to an electric field. This field acts as a focuser that disperses molecules in the low-energy, absorbing state and concentrates the emitters. The beam of emitters then flows into a "cavity resonator," where the molecules radiate their microwave energy. The size of this cavity is adjusted so that it resonates at precisely the frequency of the ammonia's radiation. Thus the energy emitted by the molecule is reinforced, and a strong oscillation is set up. The oscillation can be used to control the synchronous motor of an electric clock by means of a servomechanism.

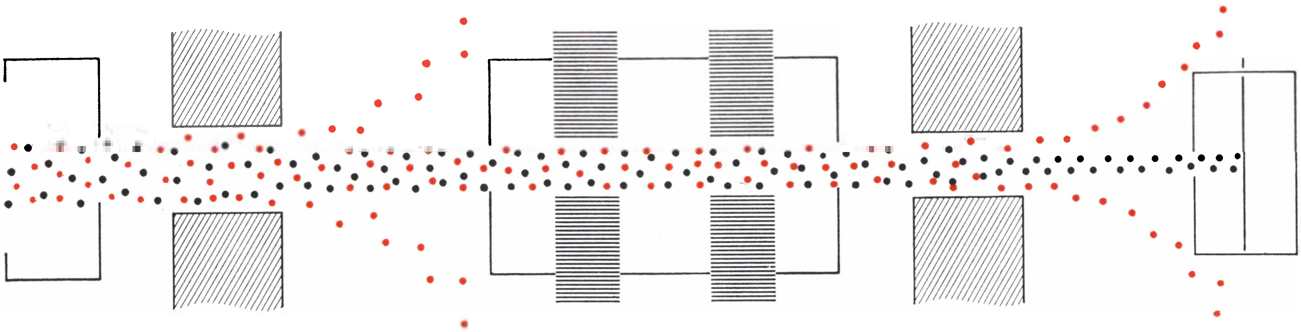
The maser has produced the purest oscillations ever generated—a signal very close to a single frequency. The frequency was stable to one part in 10 billion or better for more than an hour. This performance can probably be improved.

If the number of molecules fed into the maser's resonator is reduced below the level needed to sustain oscillations, and a small amount of energy in the





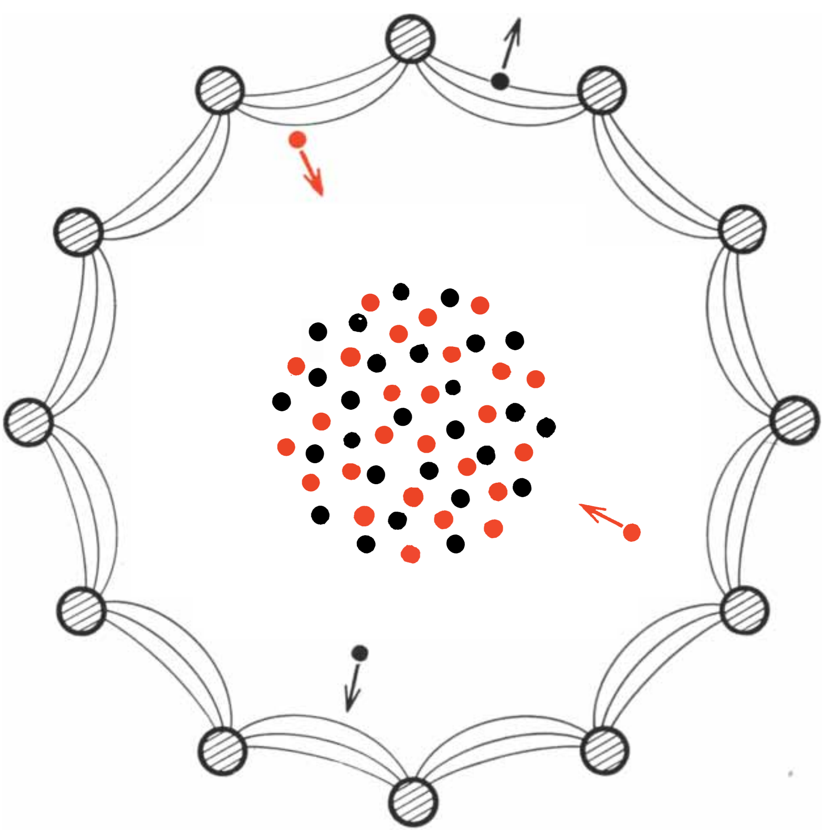
CESIUM BEAM EQUIPMENT at the Naval Research Laboratory in Washington is seen from the back at left and front at right. Cesium atoms are injected at the bottom and travel up the vertical tube to target chamber at top. Deflecting magnets are behind the two rectangular plates. This device is made by the National Company. It is the first commercial atomically controlled oscillator.



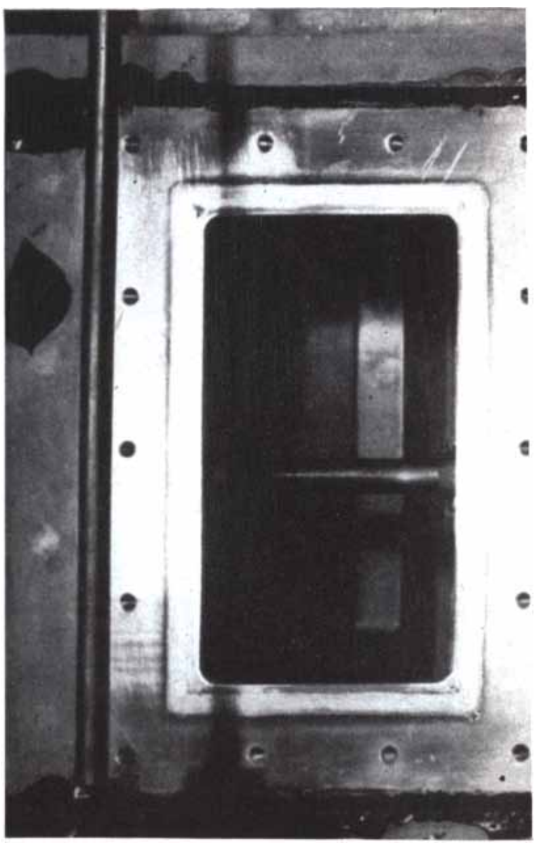
CESIUM BEAM PRINCIPLE is illustrated above. The beam emerging from the source (an electric furnace) contains atoms in two energy states. These are deflected by the first and second magnets in such a way that they miss the detector wire at right. When the atoms are excited by the radio field during their passage between the two magnets, they make transitions between the two energy states. The second magnet now deflects them in opposite direction so that they either land on detector wire or are refocused.

form of a radio wave of the right frequency is then added, the vibrations of the ammonia molecules will amplify the input signal. In this form the maser is an exquisitely selective and noiseless amplifier. It produces strong amplification when a weak signal at the proper frequency is fed into the cavity. Even if the input signal is contaminated with other frequencies, the ammonia responds only to its own vibration rate, so that its tuning is very selective.

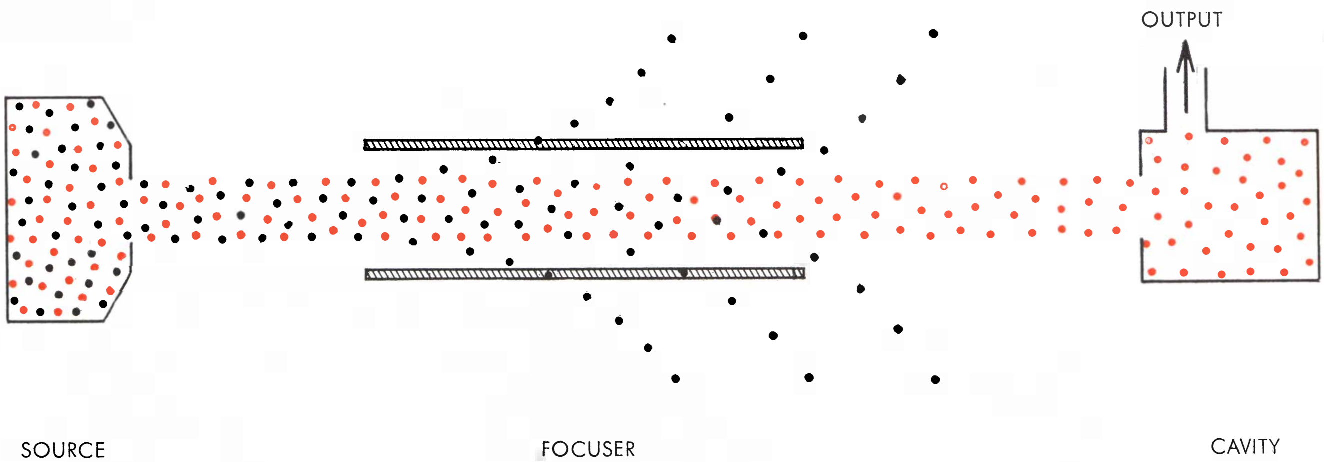
A number of laboratories are now building masers and applying them in many areas of research. Some experimenters are testing new designs which may give even higher degrees of accuracy. R. H. Dicke of Princeton University proposes to use rubidium atoms instead of ammonia molecules and to include argon gas as a buffer to insulate the rubidium atoms against collisions with one another. D. D. Babb, formerly of the Signal Corps Engineering Labora-



MASER FOCUSER seen end-on shows rods as hatched circles and the electric field as black curved lines. The colored dots are emitting molecules; black dots, absorbers.



MASER at Columbia University is seen with the front plate of the vacuum chamber removed. The



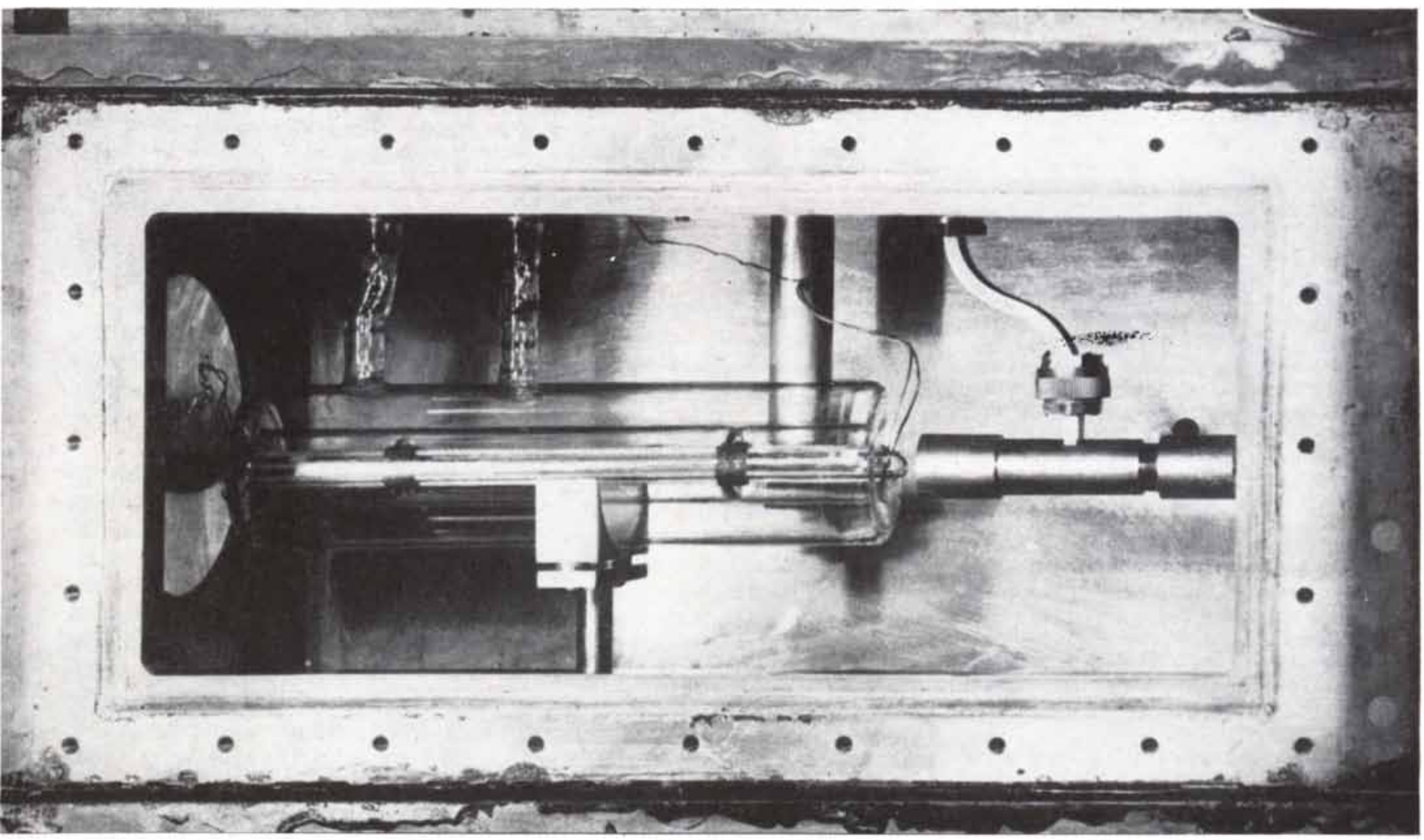
MASER PRINCIPLE is diagrammed above. Ammonia gas emerging from source (a high-pressure tank) contains high-energy molecules (*colored dots*) which emit radiation and low-energy molecules (*black dots*) which absorb it. The focuser is a ring of long electrodes. The electric field within the ring acts to disperse the low-energy molecules and concentrate the emitters. These find their way into the cavity, which is tuned to the frequency of the molecule. The oscillating energy is taken out through a wave guide.

tories, hopes to build a maser with radiating cesium atoms, and he estimates that this clock would be stable to one part in 10,000 billion for long periods.

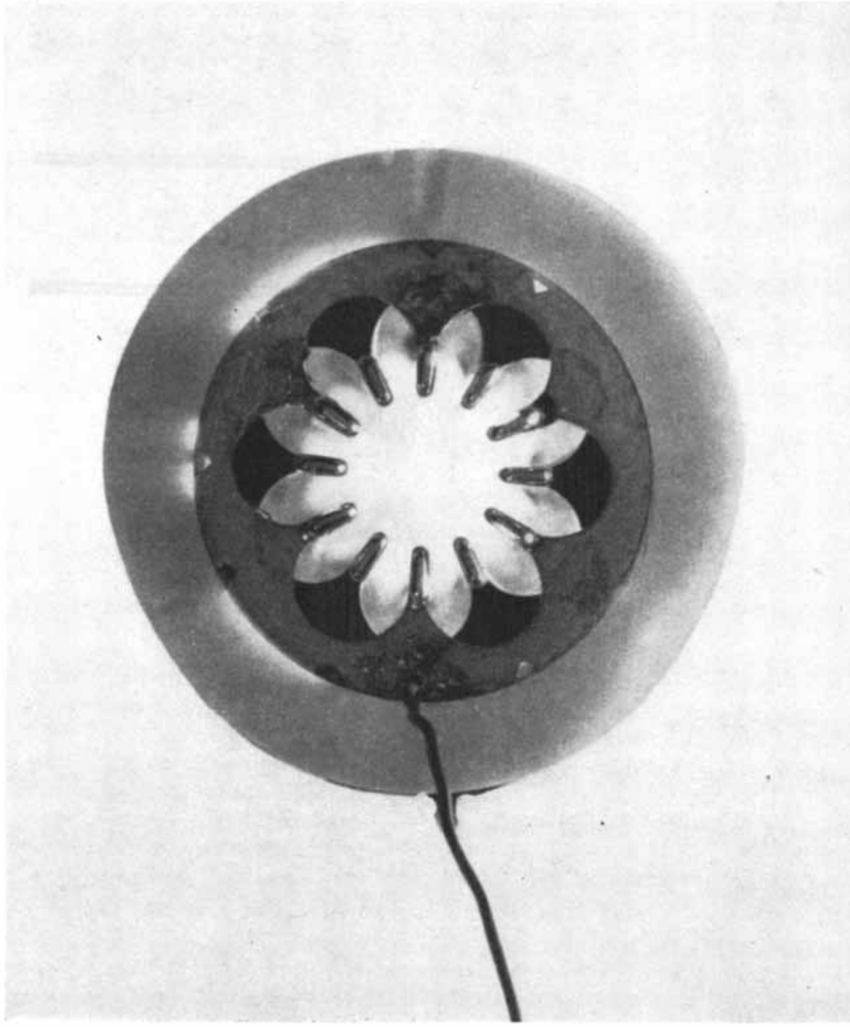
Uses for Atomic Clocks

When these remarkable timepieces have been built, what will they be used for? The list of needs is long and varied.

To begin with, atomic clocks would establish a more precise and invariant standard for the length of time units (*e.g.*, the second) than the astronomical one. The right time could be checked instantaneously, without waiting days or years for correcting astronomical measurements. The standard for distance could be related to the standard for time by means of an atomic clock coupled to an interferometer using microwaves. This would give the system of scientific units greater coherence and logic, for



ammonia "gun" is at left. Its gas stream is injected into the focuser, which is the assembly of horizontal rods in the center of the picture. The pipe at right is the resonant cavity, from which oscillating energy is withdrawn through rectangular pipe at upper right.



FOCUSER OF THE MASER, explained in the diagram on page 80, is photographed from the end. This component is from an early model of the maser built at Columbia University.

length and time are now measured in independent ways.

The establishment of a really accurate terrestrial time scale will permit more precise measurements of the earth's rotation, which in turn will help geophysicists to chart motions of the earth's molten interior, believed to be responsible for some of the irregularities in rotation. Atomic clocks also will play a major role in basic atomic research, making possible easier and more accurate measurement of the vibrations and rotations of molecules, atoms and nuclei.

Another imminent application is to aircraft navigation. Some of the present radio navigation instruments could give accurate position fixes over at least 3,000 miles if the frequency of the radio signals could be held stable to one part in a billion. Only 30 stations would be required to cover the entire globe.

The maser would even be useful in astronomy and cosmology. As a noiseless amplifier it would eliminate the noise generated in the circuits of radio telescopes and thus permit the resolution of weak signals, extending our vistas into space. Further, atomic clocks should make possible a check of the question whether the world of the atom runs on the same time as the universe.

There is a possibility that atomic clocks could furnish a test of Albert Einstein's general theory of relativity. The theory predicts that a light (or radio) wave traveling away from the earth should be slowed, or reduced in frequency, because of the work it does against gravity. A pair of atomic clocks, one at the bottom and the other at the top of a mountain, should be able to settle the point. The experiment would be of enormous interest, because there are few ways to check relativity theory.

Thus the atomic clock may reveal stories yet untold about our universe. Time will tell.

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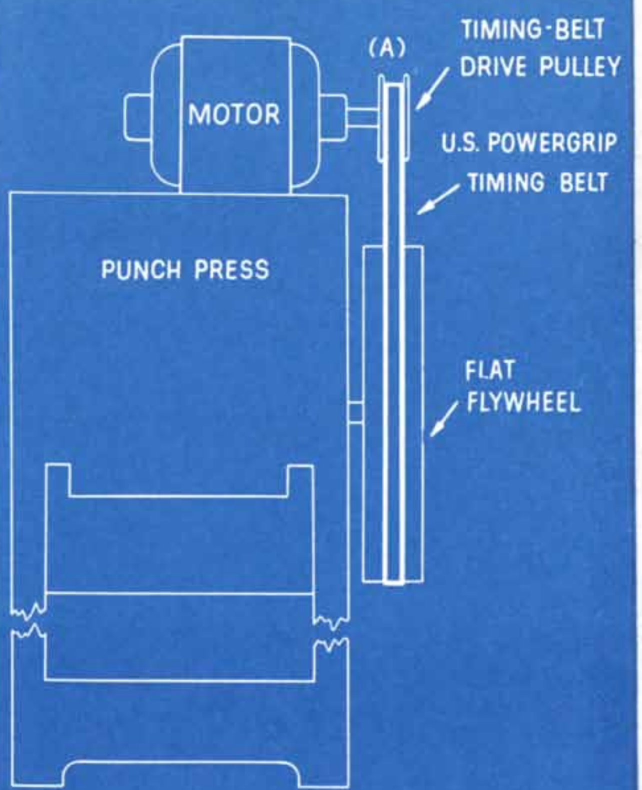

To eliminate severe belt slippage and consequent burning of belt (at point A) when 5 h.p. motor was started, the conventional pulley and belt drive from the motor shaft were replaced with a grooved pulley and a U. S. PowerGrip "Timing" Belt driving the flat flywheel. The positive engagement of the "Timing" Belt eliminated slippage on the motor pulley completely. The slight remaining slippage is now dissipated over the much greater area of the flywheel. Result: Flywheel gets up to speed *without burning the belt*, thereby reducing maintenance and downtime costs.

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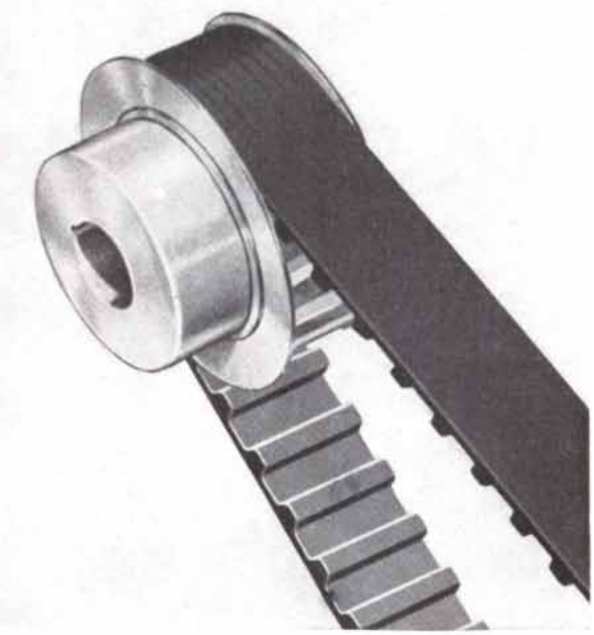

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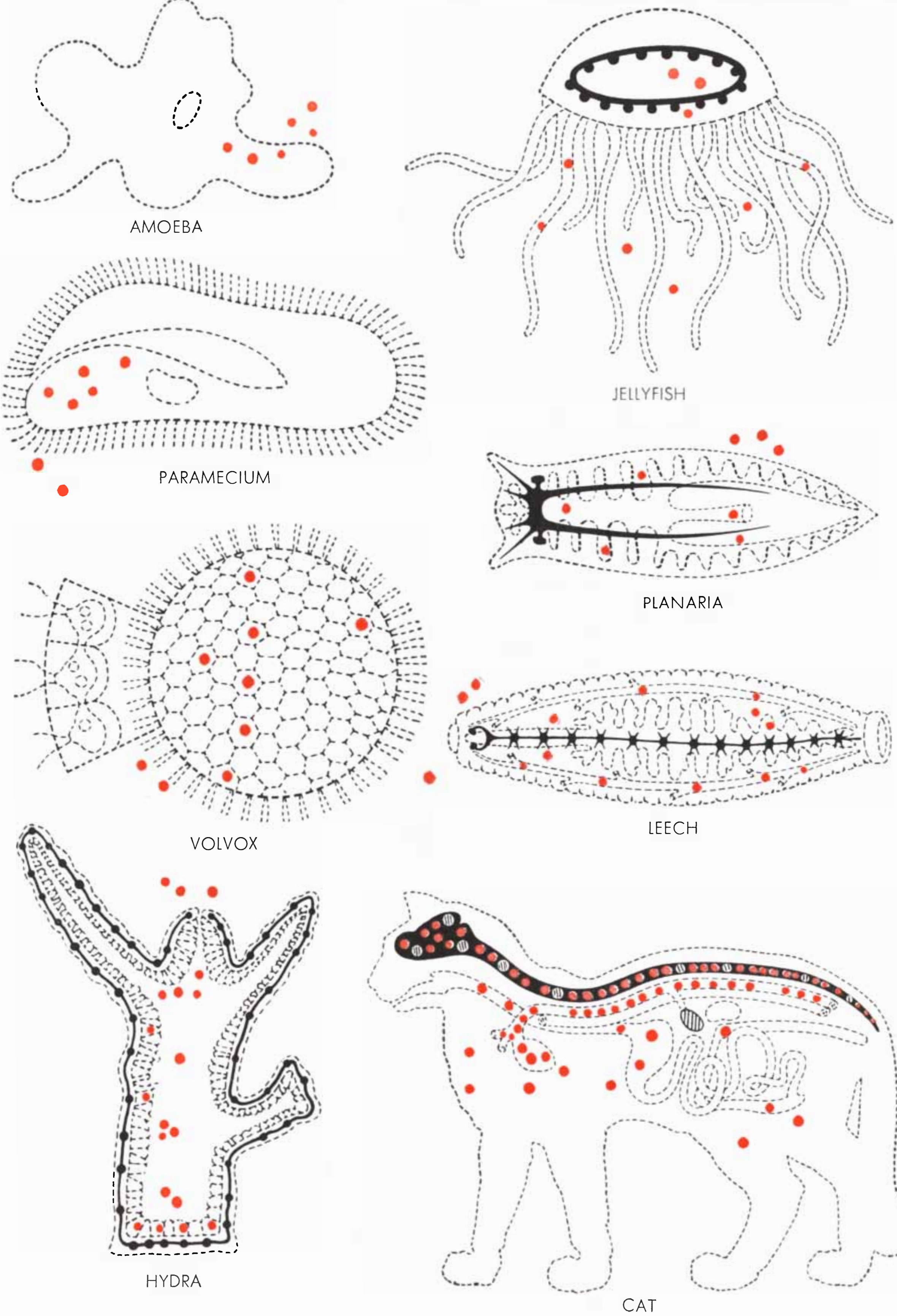


COMMUNICATION SYSTEMS of varying degrees of complexity are diagrammed here. Dots of solid color signify chemical mediators originating within the organism and outside it. Nervous systems, where they occur, are schematized in heavy black lines. In the complex vertebrate system, at lower right, the chemicals secreted by the nerves themselves are shown as light-colored (excitatory) or crosshatched (inhibitory) dots. In the latter, note also that some chemicals are transported in the circulatory system and some diffused in the tissues, and that glands, such as the adrenals represented by the crosshatched oval, may be the source of chemicals.

Messengers of the Nervous System

The internal communication of the body is mediated by chemicals as well as by nerve impulses. Study of their interaction has developed important leads to the understanding and therapy of mental illness

by Amedeo S. Marrazzi

Disorders of the mind, like disorders in human relations, often arise from a failure of communication. Something goes wrong in the coordination of the brain, and this something can sometimes be traced to what appears to be a disturbance in the normal communications among the nerve cells. The heroes and villains implicated in this research are the chemical messengers which are responsible for transmitting signals from cell to cell. We have been investigating the role of these messengers by "tapping in" on the communication lines (somewhat in the fashion of a trouble-shooting telephone lineman) and by experiments with drugs. The experiments have yielded new information about the chemical processes in mental health and disease.

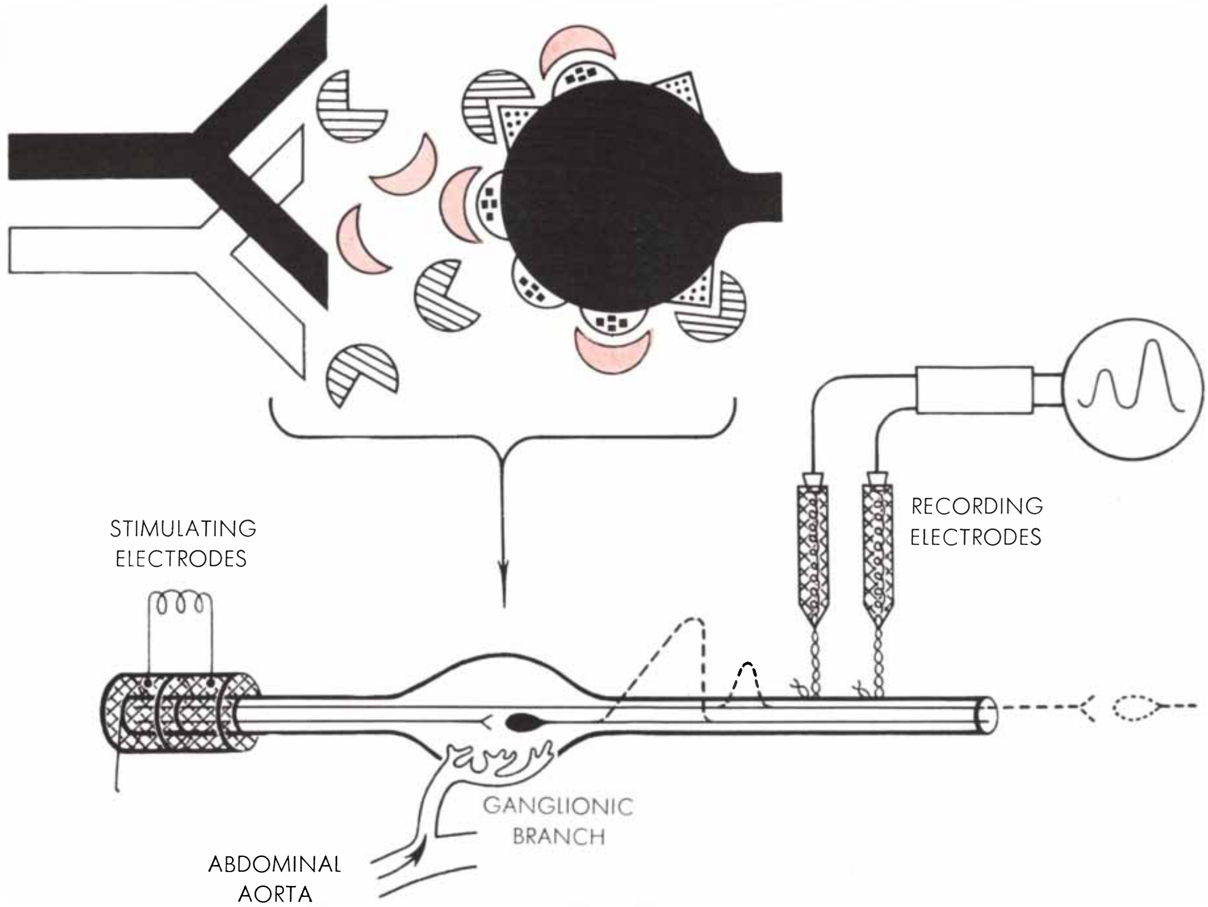
Internal communication is a basic need of all living things. Even the single-celled organisms have a communication system: when an amoeba is stimulated by food in its environment, signals are transmitted throughout the cell body and cause it to move in a coordinated way to engulf the bit of food. The paramecium likewise is coordinated to beat its cilia in unison. How are the signals transmitted? It appears that these organisms already possess two methods which foreshadow the two communication mechanisms of higher forms of life. One system transmits messages by relaying energy, like a chain of firecrackers, each touching off the next. This corresponds to conduction of electrical impulses in the higher animals' nervous system. It seems reasonable to credit the single-celled organisms also with a system of chemical communication by diffusion of stimulating substances through the cell, and these correspond to the chemical messengers (*e.g.*, hormones) that carry stimuli from cell to cell in the more complex organisms.

When we come to a multicelled animal such as the hydra, we find the cell masses connected by special bridging cells which form a rudimentary nervous system. The hydra also passes chemical messengers from one cell to another. And so, going up the animal scale, the two systems develop in specialization and complexity, becoming better suited to the more complex needs with which the higher forms of life must deal—and also creating more opportunities for things to go wrong. The flatworm has a nervous system reaching from end to end, with a particular concentration of nerve cells at the head end. The leech has not only a well-defined nervous system but also a circulation system which transports chemical messengers, along with food and other substances. Finally, in the vertebrate animals there are special glands (*e.g.*, the adrenals) for producing chemical messengers, and the nervous and chemical communication systems are intertwined: for instance, release of adrenalin by the adrenal gland is subject to control both by nerve impulses and by chemicals brought to the gland by the blood.

But there is a still more intimate cooperation of nerves and chemistry. In the nervous system itself the nerve cells transmit signals from one cell to the next (and finally to the body cells that the nerves activate) by means of chemical messengers. Transmission of signals across the junction between two nerve cells (the synapse) is largely controlled by two chemicals—adrenalin and acetylcholine. Acetylcholine incites transmission and adrenalin inhibits it. The two chemical messengers, working counter to each other, regulate communication in the nervous system. Nervous and chemical communication have become interlocked, so that the nervous is a step in the initiation of the chemical, and the chemical is a step in the completion of the nervous.

We have been especially interested in what goes on at this "switchboard," the synapse. The method we have devised for studying events there is to apply a weak, measured electrical shock to the incoming nerve and record what happens to the signal across the synapse by "tapping" the outgoing nerve. An electrode picks up electrical changes, representing impulses, and these tiny signals are amplified. With this setup we can determine how transmission of a test signal across a synapse is affected by various chemicals acting on the synapse. The chemical is injected into the bloodstream. Its effect on the synapse is reflected in a change in the electrical impulses emerging in the outgoing nerve. If the action potential in the outgoing nerve increases, while the incoming impulses are kept constant, this indicates that the chemical has promoted transmission across the synapse; if the potential drops, the chemical has inhibited transmission.

We started our experiments with comparatively simple systems—the autonomic ganglia. These are groups of nerve cells connected to the spinal cord; they constitute outlying bits of the nervous system. Each ganglion contains only one group of synapses, and the incoming and outgoing nerve fibers are easily accessible to the stimulating and recording electrodes. Later we extended the experiments to the brain of the cat, using especially nerve pathways which cross


STIMULATING
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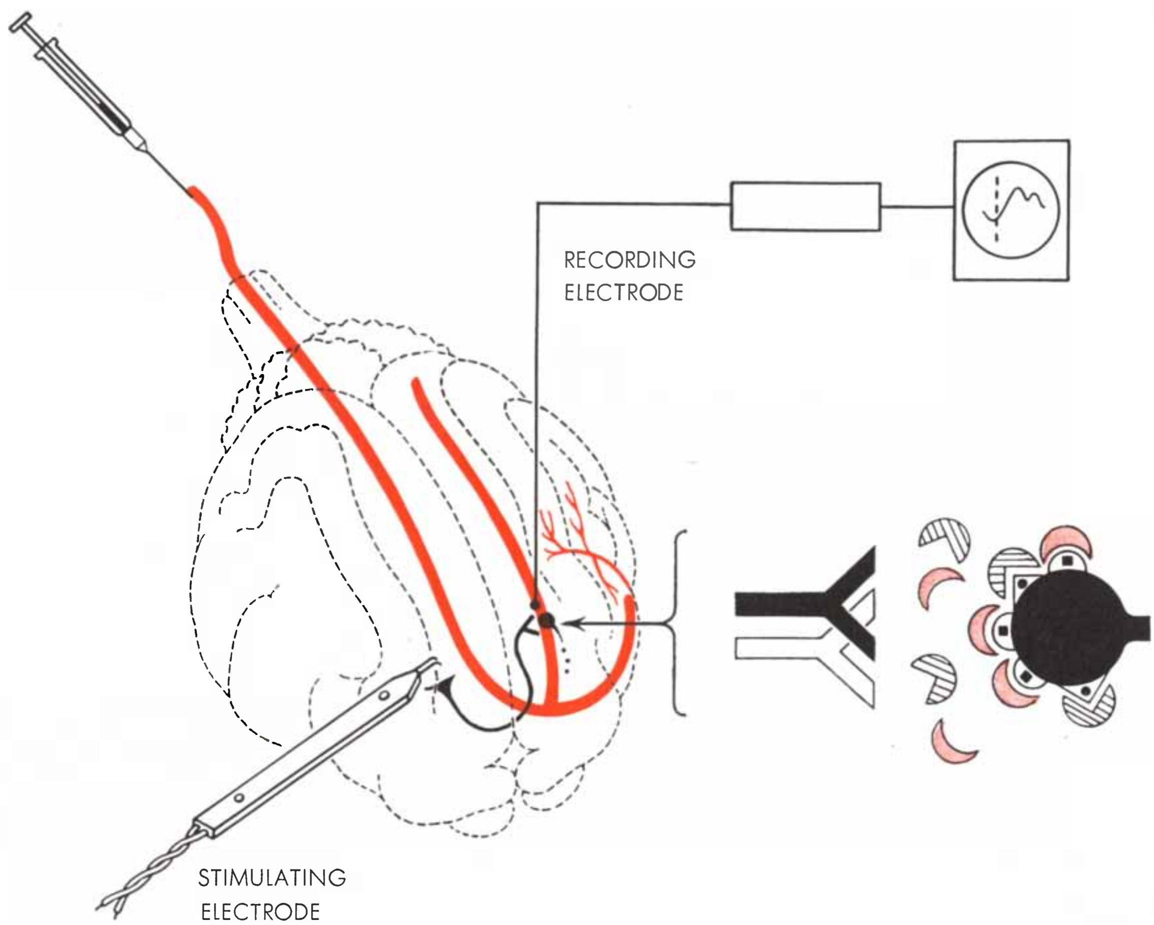
RECORDING
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STIMULATING
ELECTRODE

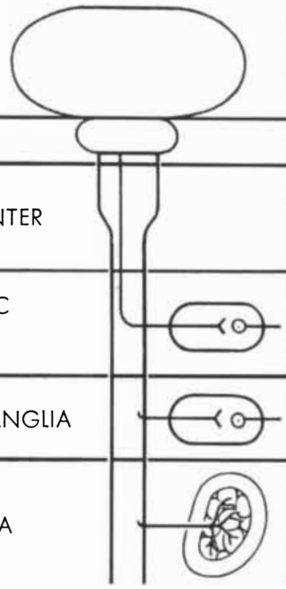
from one side of the brain to the other. The experimental chemical was usually injected into a blood vessel going directly to the brain, so as to avoid the complicating effects that might arise from its action elsewhere in the body.

The experiments clearly demonstrated that acetylcholine (and related substances) and adrenalin (and its relatives) exert opposing actions which maintain a balanced regulation of the transmission of nerve impulses. This is true everywhere we have looked in the nervous system, including the most interesting portion of it, the brain. It would appear that the acetylcholine-adrenalin system serves, with suitable modifications, to regulate communication throughout the nervous system as well as at the nerve endings in the tissues of the body.

What are the relatives of adrenalin that act in the same way to block communication? They include substances which have aroused great interest recently because of their power to evoke mental quirks or induce states resembling psychoses. One of them is mescaline, the peyote drug used by Indians

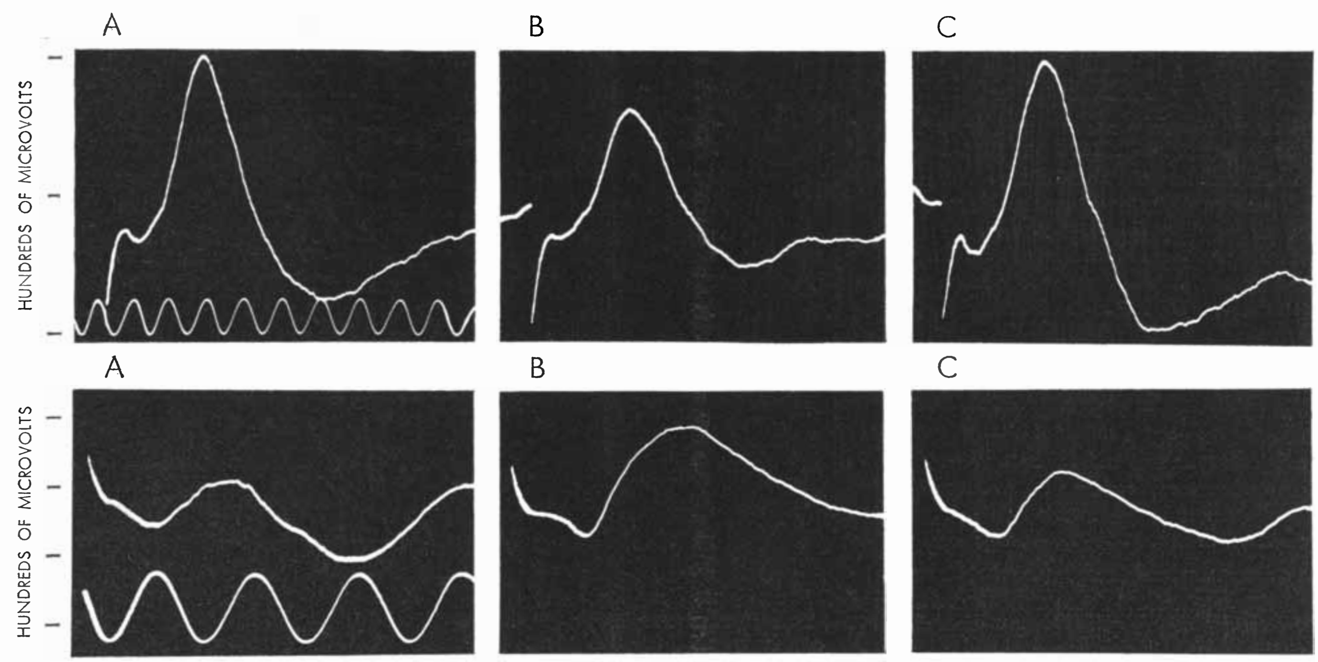
CHEMICAL MEDIATION of nerve impulse at synapse is demonstrated in the two experiments diagrammed here. The upper diagram shows a ganglion, cut from a nerve but still attached to its blood supply via the ganglion branch from the abdominal aorta. The fibers in this ganglion are stimulated by a mild electric shock from the electrodes at left. Those fibers that run uninterrupted through the ganglion conduct the resulting impulse (*smaller pip at right*) to the recording electrodes at a somewhat faster rate. Through the fibers that synapse in the ganglion, the impulse is relayed at a slower rate (*larger pip at right*) and may be modified by chemical stimulants introduced into the ganglion. As indicated in the enlarged schematic diagram of the synapse at top, such chemicals are liberated by the nerve ends and carry the impulse across the synaptic gap to the next cell in the chain. The excitant, acetylcholine, is released by one nerve end, and the depressant, adrenalin, is released by the other. Each chemical, as indicated, has its appropriate receptor in the cell on the far side of the gap. The lower diagram shows a similar experiment on the intact brain of an experimental animal. Here a pair of electrodes stimulates a point in one hemisphere of the brain; the stimulus is transmitted via nerve fibers to the complementary point in the other hemisphere of the brain. The impulse picked up by the recording electrodes will be modified at the synapse by chemical mediators introduced into the blood supply.

	Acetylcholine or Anticholinesterase		Atropine, Curare, Tetraethyl-ammonium bromide	Adrenalin, Noradrenalin, Amphetamine, Ephedrine
CORTEX	+	(–)	B	–
MIDBRAIN	+	(–)	B	–
RESPIRATORY CENTER	+	(–)	B	–
PARASYMPATHETIC GANGLIA	+	(–)	B	–
SYMPATHETIC GANGLIA	+	(–)	B	–
ADRENAL MEDULLA	+	(–)	B	–

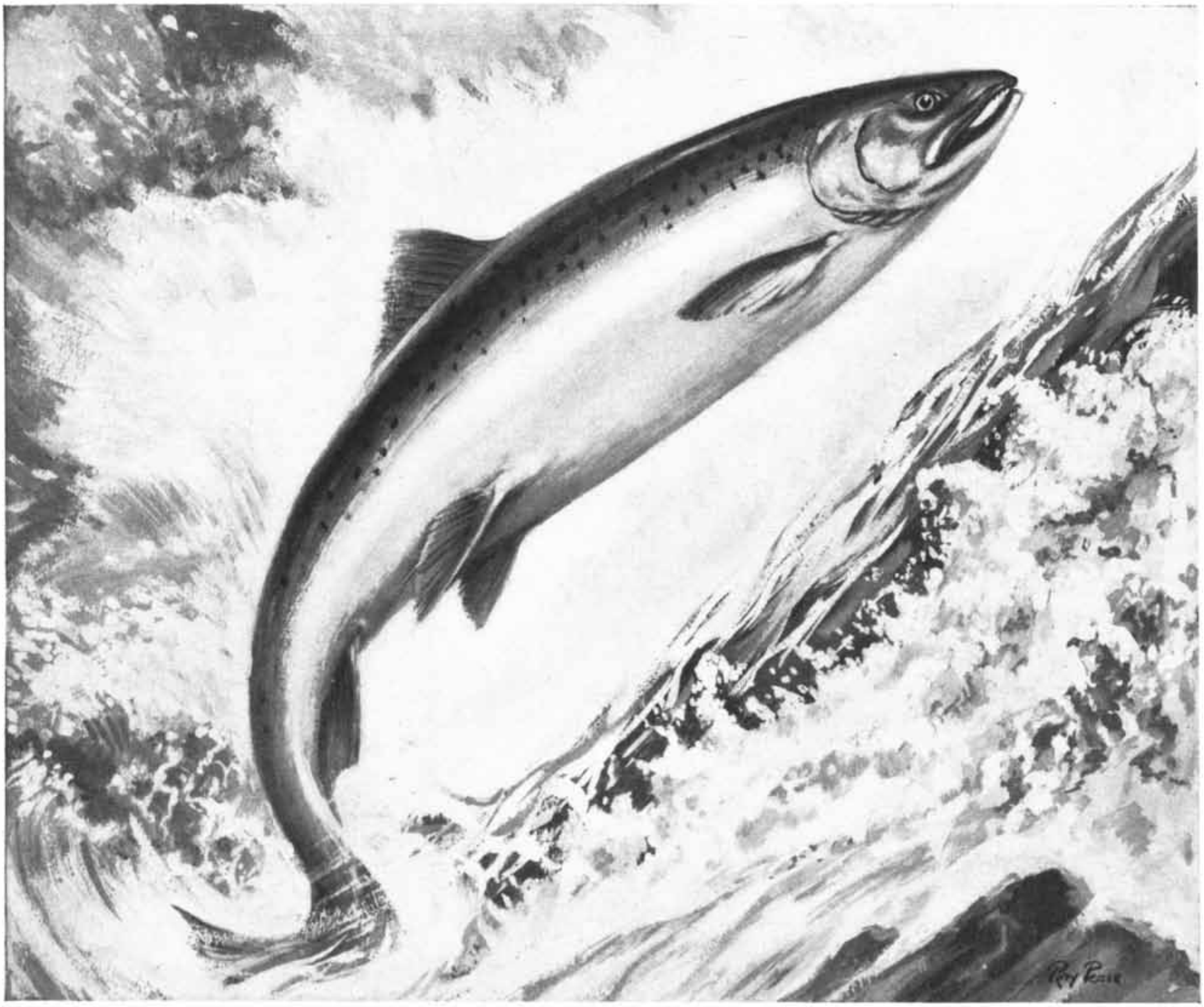


EFFECTS OF CHEMICALS on the nervous system are charted here. Acetylcholine and anticholinesterase have a primarily excitatory effect upon the transmission of nerve impulses, but when present in excess may have a secondary paralytic effect. Atropine and other substances block acetylcholine. Adrenalin and related compounds inhibit transmission of nerve impulse across a synapse.

of the Southwest, which induces multicolored "visions," or hallucinations. Another is lysergic acid (LSD-25), extracted from ergot, whose powerful effects in producing psychotic states have been explored extensively [see "Experimental Psychoses," by Six Staff Members of Boston Psychopathic Hospital; Scientific American, June, 1955]. Other substances of the same family are bufotenin, a plant extract long used by some primitive people for its mental effects; serotonin, a brain hormone normally present in animals and human beings, and benzedrine, which in excessive doses can produce mild mental disturbance. All of these substances are chemically akin to adrenalin, and in varying degrees all of them inhibit transmission of signals across synapses. The hormone serotonin proved to be the most



INHIBITION AND EXCITATION of nerve impulses by chemical agents are shown in these two sets of curves taken from an experiment on a cat's brain. The curves marked A in each set are the control; those marked B show inhibition of the impulse (*above*) or enhancement (*below*), and the curves marked C show return to normal. Adrenalin and acetylcholine were the agents employed.



Upstream!

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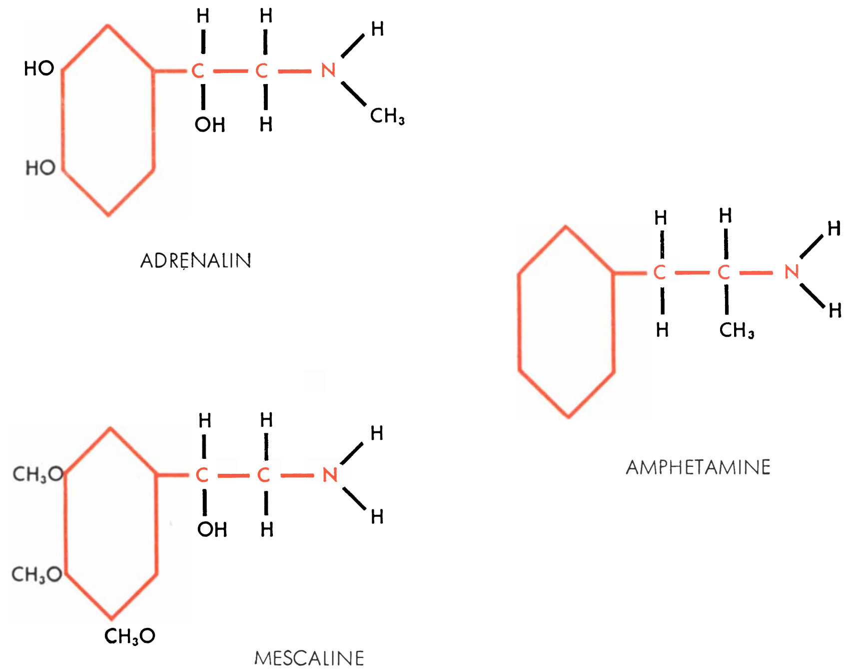
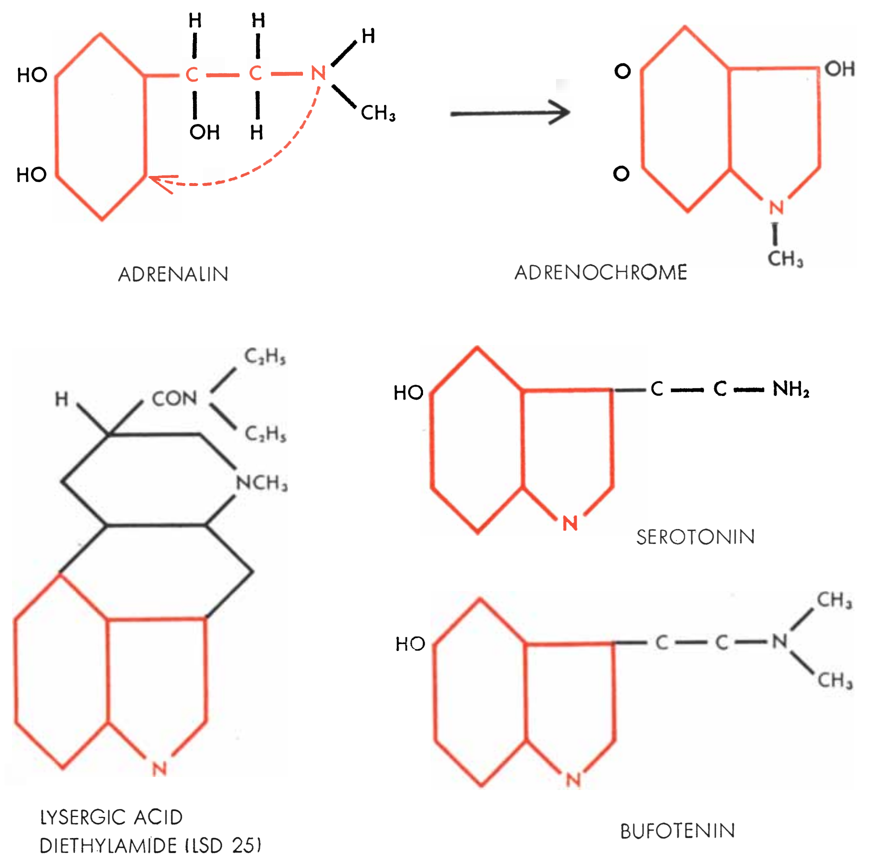


ADRENALIN-LIKE COMPOUNDS are shown here. Ephedrine and amphetamine differ from adrenalin only in the side groups attached to main structures shown in color.



ADRENALIN-RELATED COMPOUNDS all incorporate indole, the basic structure of adrenochrome, which is made by oxidation and modification of adrenalin as at top left.

powerful inhibitor of all those we tested. Evidently it occupies a key position among the chemical messengers of the brain, and interference with it may readily disrupt normal operation.

These findings led us to conclude that restriction of communication in the brain, diminishing the normal control by the higher centers, can produce mental disease. The inhibition of communication may be brought about by an abnormal accumulation of, or abnormal sensitivity to, some natural substance in the body, such as serotonin. The effect is much like that of alcohol. There is a general release of restraints, which is due not to "stimulation" but to inhibition of the normal control mechanisms. The depressant action of alcohol becomes obvious when it is taken in large doses. Like some of the other drugs, alcohol may produce hallucinations, such as "pink elephants." Large doses of benzedrine induce similar but milder effects, notably a pronounced anxiety and sometimes jumpiness. In both cases the inhibition of communication manifests itself first in exaggerated activity but eventually shows itself in its true light as an inhibition. All this we have made the cat's nervous system write out for us electrically.

Just as an excess of inhibitory substance generates mental disturbances, so too does an excess of an exciting substance—acetylcholine or an acetylcholine-like compound. An accumulation of this substance, speeding up communication and overwhelming the brain with a flood of messages, leads to a chaotic state and unusual behavior or even death. This is the way the lethal nerve gases work: they destroy the enzymes responsible for breaking down acetylcholine and thus permit unlimited accumulation of that substance in the body. Nerve gas can be counteracted, however, by atropine or a similar substance, which blocks acetylcholine from reaching the synapses.

The metabolic system of the body normally maintains a proper balance of the opposing chemical messengers: acetylcholine on the one hand and adrenalin and serotonin on the other. It regulates both their production and their destruction (generally by enzymatic action) so that they do not accumulate to excess. This is accomplished by homeostatic or feedback mechanisms. In other words, the body has a number of built-in devices for automatic correction of imbalances of its chemical messengers. For example, when adrenalin rises to an abnormally high level in the bloodstream, this automatically slows down

further production of adrenalin by slowing down communication and so reducing stimulation of the adrenal gland via the nervous system. Thus the flooding of the body with adrenalin (when the body reacts to an emergency) is to some degree self-limiting.

Mental health, then, depends on proper functioning of the homeostatic mechanisms that maintain an appropriate balance of chemical messengers in the body. When the metabolic system responsible for regulating this balance is thrown out of kilter in some way, the effects may show themselves as a mental disturbance. The underlying causes of the aberrations in metabolism are still mysterious, but at least we are beginning to understand the chemical processes well enough to treat the disturbances chemically.

Experiments on the cat's brain show, for instance, that the tranquilizing drugs (*e.g.*, Thorazine, reserpine, Frenquel) block the inhibitory action of mescaline on communication across the synapses. It is always precarious to translate animal findings to the human situation, but our experimental results correspond closely to the effects of the tranquilizers in man. It is reasonable to suppose that the tranquilizing drugs counteract the inhibitory effect of excessive adrenalin or serotonin or some related inhibitor in the human nervous system. They reduce mental anguish and anxiety without noticeably dulling the mind. In doing so they tend to break the vicious cycle that makes mental patients so difficult to reach and their disturbances so difficult to treat by psychotherapy. Even at this early stage the tranquilizing drugs have already revolutionized the treatment of psychiatric patients.

The technique we have been using looks very promising as a method of testing the action of drugs. It offers an unusually precise and objective touchstone of communication in the nervous system. But more important, it serves as an excellent tool for studying the workings of the mind in health and disease. Tapping in on the messages and communication system of the brain, we are in a position to dissect its many functions and perhaps identify more exactly its various disorders, which are now unsatisfactorily lumped together in groups. under titles such as "anxiety neurosis" and "schizophrenia." With better definition of mental disorders and their underlying mechanisms, we may begin to make swifter strides toward solving the number one health problem of present-day society.

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Harry Branning (center): B.S.E.E. 1950, Syracuse. Design Engineer in circuit design, 1951; October, 1954, promoted to Associate Engineer; April, 1956, promoted to Staff Engineer, Systems Planning. In June, 1956, appointed Project Engineer and Manager of the 110 Computer Circuit Design Department; discussing the performance and packaging details of a transistorized read amplifier.

William Dunn (standing): M.E. 1950, M.S.E.E. 1952, Stevens Institute. Technical Engineer, 1955; April, 1956, promoted to Associate Engineer; August, 1956, transferred to Development Engineering in charge of Logical Design for digital computers in advanced weapons systems; here discussing Boolean Algebra method of optimizing the logical design of an airborne digital computer.

Eli Wood (left): B.S.E.E. 1950, Connecticut. IBM Customer Engineer, July, 1950; September, 1952, transferred to ACL Field Engineering. February, 1954, in charge of Field Engineering at Hunter AFB; May, 1955, Associate Engineer; appointed Project Engineer, Manager of Systems Evaluation in August, 1956; here investigating a problem in radar data presentation set evaluation testing.

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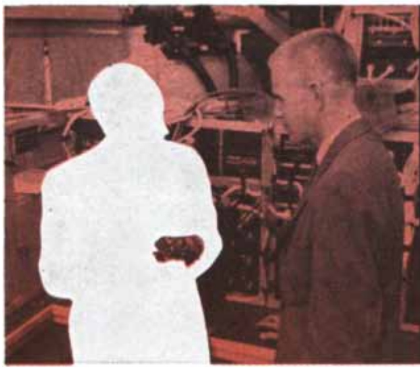

Systems Engineers oversee the engineering support provided by the Systems Coordination and Specification Group to the factory on the AN/ASB-4 Bombing-Navigational System. Air Force requirements are analyzed and the resulting engineering changes evaluated to determine effect on system performance and accuracy. Mathematical error analyses are run. *Do you belong on this team?*

Systems Analysts anticipate performance and recommend design criteria before and during development of equipment. Later, they compare dynamic performance accuracy and reliability characteristics with what has been anticipated. Other assignments include Digital Computer Systems Engineering, Input-Output and Analog-Digital Conversion Engineering. *Do you belong on this team?*

Quentin Marble (left): B.S.M.E. 1951, Syracuse. Joined IBM in 1951; promoted to Design Engineer in 1952; May, 1955, promoted to Associate Engineer, and then to Project Engineer, Manager of the Systems Coordination and Specification Group, Production Engineering Department, in February, 1956; shown here describing a unique cooling design to a new employee in his group.

Monroe Dickinson (left): B.S.E.E. 1952, W.P.I.; M.S.E.E. 1954, M.I.T. Technical Engineer in analog and alternate computer techniques for weapons systems, 1952; Associate Engineer responsible for systems design and analysis, 1954; December, 1955, Staff Engineer, responsible for research planning; here reviewing set-up on laboratory analog computer of a sampled data control problem.

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INERTIA

Newton supposed that inertia was an independent property of matter. Some later physicists have argued that it is due to the interaction of all the matter in the universe

by Dennis Sciama

Everyone knows that a force is required to start a body moving. This is usually expressed by saying that the body has inertia. Ever since the time of Isaac Newton the classical view has been—and experiments have seemed to prove—that inertia is an intrinsic property of matter, *i.e.*, that the inertia of a body is in no way affected by its environment. But a few physicists and philosophers have insisted on the opposite view: that a body has inertia only because it interacts in some way with other matter. I propose to uphold the second view here and to review the evidence, which seems to me strongly to favor the conclusion that the inertia of any body depends on the rest of the matter in the universe.

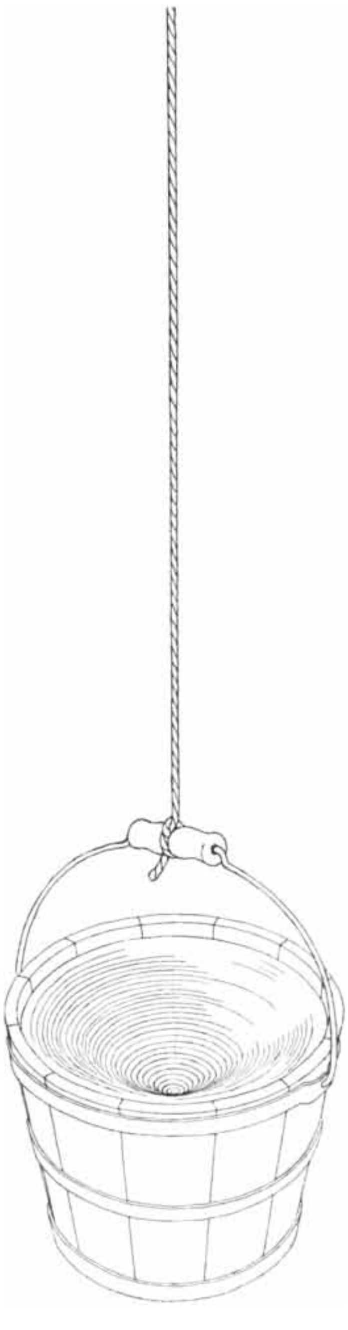
It is a remarkable fact that the issues involved in the controversy can be summarized by considering three simple experiments. I shall start with experiment number one, which was first performed by Newton. A bucket of water is suspended by a rope and the rope is twisted so that upon release the bucket rapidly rotates. This motion is soon communicated to the water and it, too, rotates, forming a concave surface. Then the bucket is stopped and held motionless. The water continues to rotate for a time, keeping its concave surface, but eventually it comes to rest and its surface becomes flat again.

Newton performed this experiment in an attempt to resolve a basic difficulty in his second law of motion. This law, as every schoolboy knows, says that the acceleration of a body is equal to the force acting on it divided by its mass; or, to put it another way, that the force is equal to the mass times the acceleration. The trouble is: How shall we measure acceleration? For instance, the acceleration of the moon relative to the earth is different from its acceleration relative to the sun, and of course for someone on the moon itself there is no acceleration. For someone on the earth, the earth is not accelerating, yet we know that the force of the sun's gravitational field is acting on it. This leaves us with the paradox that a finite force produces zero acceleration, so far as our standard of measurement goes. Newton's answer to the dilemma was to postulate that there was such a thing as "absolute space," and his law applied to "absolute" motion. But since apparently one can observe only relative motions, how is one to detect absolute motion? Newton asserted that "the thing is not altogether desperate" and proceeded to perform the experiment with the bucket. He maintained that the concave surface of the water in the bucket demonstrated the reality of absolute rotation (a particular case of absolute acceleration). As he pointed out, the *relative* motion of the water and the bucket was irrelevant to the shape of the water surface. The water had a curved surface while the bucket was rotating with it and also after the bucket was held motionless. He concluded that the water was absolutely rotating when it had a curved surface, and not otherwise.

Newton would have applied the same

FOUCAULT PENDULUM is a weight suspended so as to be free to swing in any direction. To an observer on the earth it appears to change its direction as the day advances (at the poles the direction would rotate 360 degrees in 24 hours). Newton would have said that the pendulum's direction is fixed in "absolute" space and that the apparent change establishes the absolute rotation of the earth.

reasoning to the Foucault pendulum, invented in the 19th century by Jean Foucault to demonstrate the rotation of the earth. This device, simply a long, heavy pendulum which is free to swing in any direction, is in effect a variation of the bucket and water experiment. If the pendulum is set swinging in a certain direction at one of the poles of the earth, its plane of rotation will move around as the earth rotates, and in 24 hours the plane will turn through a complete circle. Newton would have said that the direction of the pendulum's swing is fixed in absolute space and the shift of this direction shows that the earth is in absolute rotation.



ROTATING BUCKET of water was Newton's method of demonstrating the existence of absolute motion in absolute space. When the water is absolutely rotating its surface is concave; when it is not absolutely rotating with respect to space its surface is flat.

About 20 years after Newton published his theory of inertia in the *Principia,* it was strongly attacked by the famous philosopher Bishop Berkeley. He maintained that motion had meaning only when measured relative to matter, and that there could be no such abstraction as "absolute space." "All space," Berkeley might have said, "corrupts, and absolute space corrupts absolutely."

Berkeley supported this view by pointing out a fallacy in Newton's interpretation of his experiment with the rotating bucket of water. On the basis of the fact that the relative motion of the water and the bucket did not affect the surface of the water, Newton had argued that the surface was unaffected by the water's relative motion with respect to any other matter whatever. Berkeley suggested that it might indeed be affected by the great bulk of matter in the universe—that is, the "fixed stars" (or, as we would say now, the distant galaxies). If there were no fixed stars, he asserted, the water surface would always be flat.

This suggestion was received with scorn. Leonhard Euler, the mathematician, derided the alleged influence of the fixed stars as "very strange and contrary to the dogmas of metaphysics." As time went on, the success of Newton's methods in accounting for the detailed orbits of the planets was so complete that his theory of inertia came to be regarded as above criticism.

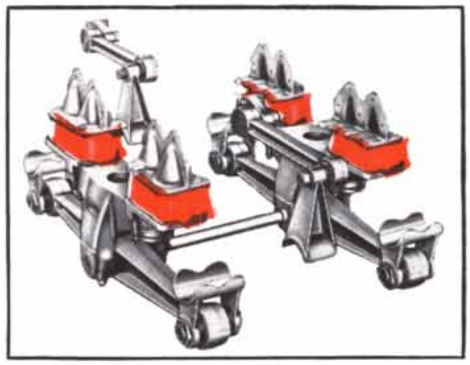
But about 200 years later a formidable modern scientist, Ernst Mach of Austria, revived Berkeley's view that the fixed stars are responsible for inertia. His argument, very similar to that of Berkeley, is summarized in the following quotation:

"Obviously it does not matter if we think of the earth as turning round on its axis, or at rest while the celestial bodies revolve around it. Geometrically these are exactly the same case of a relative rotation of the earth and the celestial bodies with respect to one another. But if we think of the earth at rest and the other celestial bodies revolving around it, there is no flattening of the earth, no Foucault's experiment, and so on—at least according to our usual conception of the law of inertia. Now one can solve the difficulty in two ways. Either the earth is in absolute motion, or our law of inertia is wrongly expressed. I [prefer] the second way. The law of inertia must be so conceived that exactly the same thing results from the second supposition as from the first. By this it will be evident that in its expression, regard must be paid to the masses of the universe. . . . All bodies, each with its share, are of importance for the law of inertia."

Mach's reassertion of the Berkeley theory evoked much the same response that greeted it the first time. Most people found it difficult to believe that a local phenomenon such as the behavior of a Foucault pendulum could be a result of the action of the fixed stars. Their reaction was partly emotional and partly based on the fact that Newton's methods were very successful despite their apparent complete lack of reference to the physical properties and distances of the fixed stars. If Mach were right, and Newton's calculations also were correct, one would have to conclude that the effect of the fixed stars could be calculated without knowing anything about them except their existence! Bertrand Russell declared that Mach's principle "savors of astrology and is scientifically incredible."

Yet there were those who took Mach's arguments seriously. Convinced of the correctness of his view, they sought to frame a theory which would recognize the crucial influence of distant matter on local phenomena, *i.e.,* which would show how, in Mach's words, "regard must be paid to the masses of the universe." The problem was to specify the nature of the interaction between local and distant matter that gives rise to the inertial behavior of local matter. Albert Einstein, shortly after his discovery of special relativity, set out to answer this great question. By a stroke of genius he realized that the clue to the answer lay in Galileo's experiment with falling weights.

This is the second simple experiment to which I referred at the beginning of this article. Galileo is alleged to have dropped stones of different weight from the Leaning Tower of Pisa to determine whether their acceleration by the force of gravity would be the same or different. It is doubtful that this experiment ever actually took place, but Galileo did make a *gedanken* (thought) experiment which convinced him that the acceleration would be the same for a heavy body as for a lighter one. Consider a heavy falling body. Now in imagination split this body into two halves. Each of these halves will have the same acceleration as a body just half the weight of the heavy body. Presumably if the halves are brought together again they will con-



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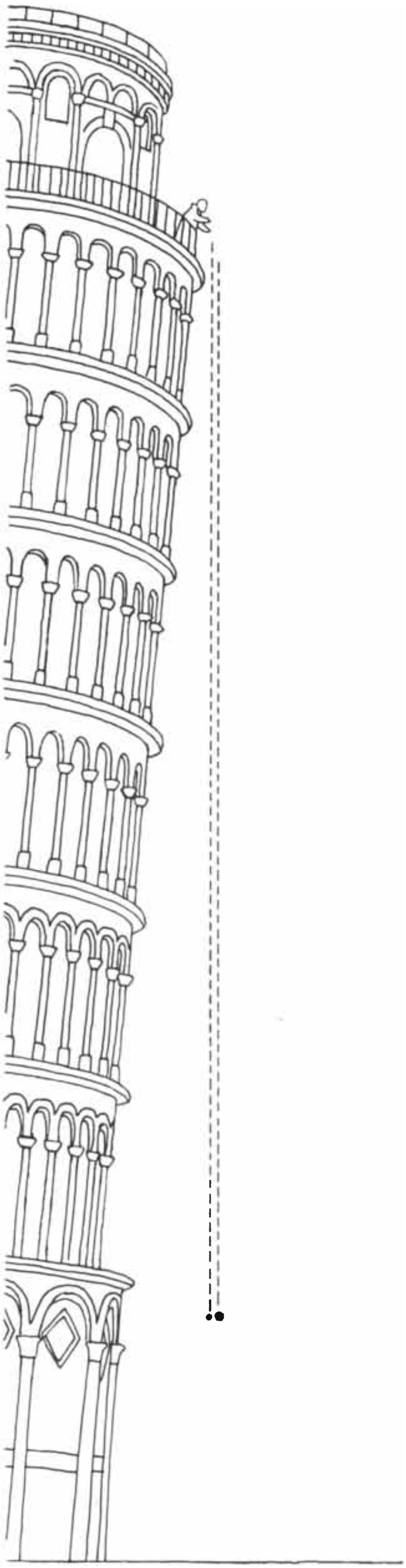


GALILEO'S EXPERIMENT with weights dropped from the leaning tower, whether he did it or not, shows that the force of gravity is similar to an inertial force on every body. Inertia may be the interaction of the body with the rest of the matter in the universe.

tinue to have this acceleration. Galileo therefore concluded that bodies of different masses would be accelerated to equal speed by gravity. Very accurate measurements have confirmed his reasoning.

Now Einstein was struck by the fact that in this respect the force of gravity was similar to the so-called "inertial force" postulated by Newton. Newton introduced the concept of inertial force to enable him to apply his law of motion to motions as we observe them, where the acceleration is not measured relative to absolute space. Consider, for instance, the situation in which we take the earth to be at rest, despite the action of the sun's gravitation upon it. To make this state of affairs consistent with Newton's law of motion, we must introduce an "inertial force" to counteract the effect of the sun. In this case it is called centrifugal force. To balance the effect of the sun it has to be just equal to the mass of the earth times its absolute acceleration. In other words, the inertial force is proportional to the mass of the body. Now, as Galileo's experiment showed, the force of gravity also has exactly this property: since it accelerates all bodies, whatever their mass, to the same extent, the gravitational force exerted on a body must be proportional to its mass.

This similarity between the force of gravity and inertial force suggested to Einstein that they must be related. The inertial force of Newton's theory is fictitious, because it does not arise from matter. Einstein suggested that the inertial forces are not fictitious but are gravitational in origin. Taking a relative reference system in which we suppose the earth to be at rest and the universe to be rotating around it, we must conclude that centrifugal force arises from the gravitational field of the rotating universe. In other words, it is the gravitational influence of the stars that gives rise to inertia.

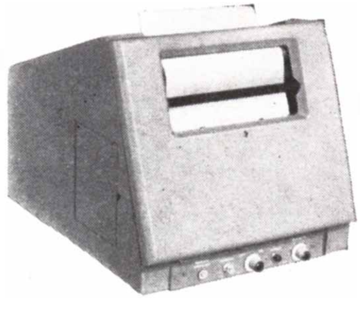
In order to explore this view Einstein tried to set up a theory of gravitation from which the inertial properties of matter could be deduced. Thus he was led to propose the general theory of relativity. This remarkable theory has had many striking successes to its credit, but the extent to which it accounts for inertia is still a matter of controversy. One reason for this is the mathematical intricacy of the theory, which prevents a general attack on most problems. Only very special cases can be considered in detail, and it is hard to draw reliable general conclusions. In view of this I shall end this article by describing an approximate theory which, while lacking the range of validity of Einstein's theory, is sufficiently simple for one to be able to work out its implications concerning the inertial properties of matter.

Our theory is based on two postulates: (1) the gravitational influence of a particle is to be calculated by means of the rules used to calculate the electromagnetic effects of a charge; (2) if a particular particle is considered to be at rest, then the total gravitational force on that particle arising from all the other particles in the universe is zero. In other words, from its own point of view a particle is never acted on by a gravitational field. The second postulate implies that there are no fictitious forces: all forces have their physical origin in actual matter.

In order to illustrate the significance of these postulates, let us consider the motion of a particle subject to the earth's gravitation. We can imagine ourselves sitting on the particle and regarding ourselves as at rest. According to our postulates, the motion of the earth and the fixed stars must be such that their total gravitational effect on us is zero. Now the effect of the earth is much the same in our theory as in Newton's. This means that the stars must move in such a way that their gravitational effect is exactly opposite to that of the earth. This physical force corresponds to the inertial force used in the Newtonian treatment. Now calculation by the formula assumed in our first postulate shows that the net gravitational force of the stars is proportional to their acceleration. Hence the acceleration of the stars relative to the particle (and so the acceleration of the particle relative to the stars) is determined by the gravitational effect of the earth.

But we can go further. The gravitational effect of the stars depends not only on their acceleration relative to the particle, but also, of course, on their masses and distances. Hence the value of the relative acceleration also depends on these properties of the stars, and specifically on the mean density of all the matter of the stars in the universe. This brings us to the third simple experiment that I mentioned.

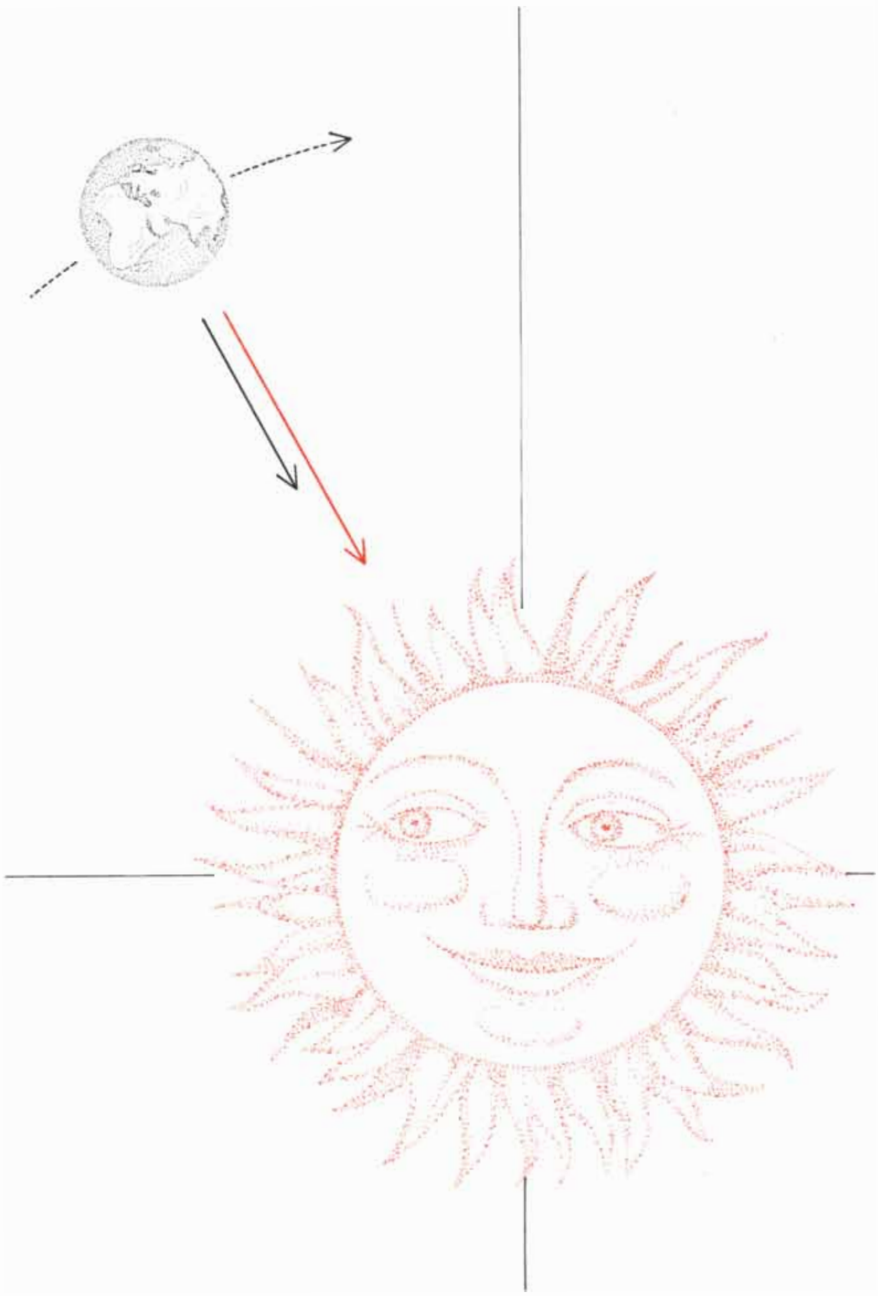
According to Newton's law of gravitation, the gravitational force between two bodies is proportional to the product of their masses and inversely proportional to the square of the distance between them. The constant of proportionality is called the gravitational constant. This constant has been determined by very precise laboratory measurements of gravitational attractions between bodies. Now in the Newtonian theory of



inertia the value of the constant is completely arbitrary. But if our theory is valid, we see that this constant is the mean density of matter in the universe in disguise! Hence a measurement of the constant is really a measurement of the universe's matter. Using the best modern determination of the constant, we arrive at about one hydrogen atom per 10 liters of space as the mean density of matter in the universe. This value is within the range of the rather uncertain direct measurements of the density of matter by astronomical methods.

We can now explain why Newton's methods are very successful despite their complete lack of reference to the properties of the universe. The universe affects local phenomena at just the two points where Newton's work contains arbitrary elements: namely, in the choice of absolute reference systems and in the value of the gravitational constant. In other words, an arbitrary assumption and an arbitrary value of a constant enable his calculations to account for the observed facts. In view of this, the argument that Newton's methods work is not a refutation of Mach's reasoning.

There remains the question of absolute rotation. If we suppose the earth to be at rest and the universe to be rotat-



MOVING EARTH, considered as revolving around a stationary sun, obeys Newton's laws of motion. The force of the sun's gravitational attraction (*colored arrow*) produces an acceleration (*black arrow*) which is in the direction of the force, *i.e.*, inward toward the sun.

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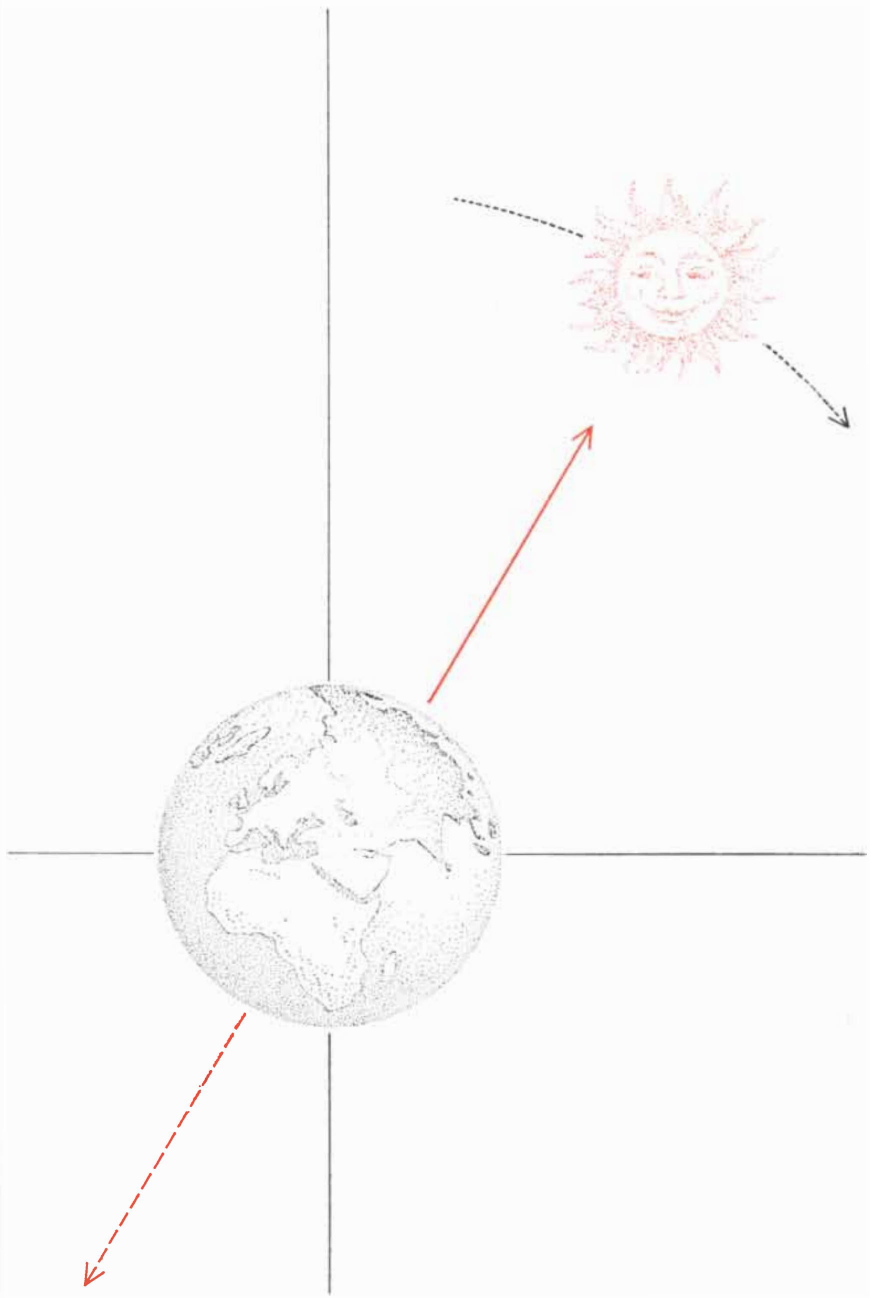
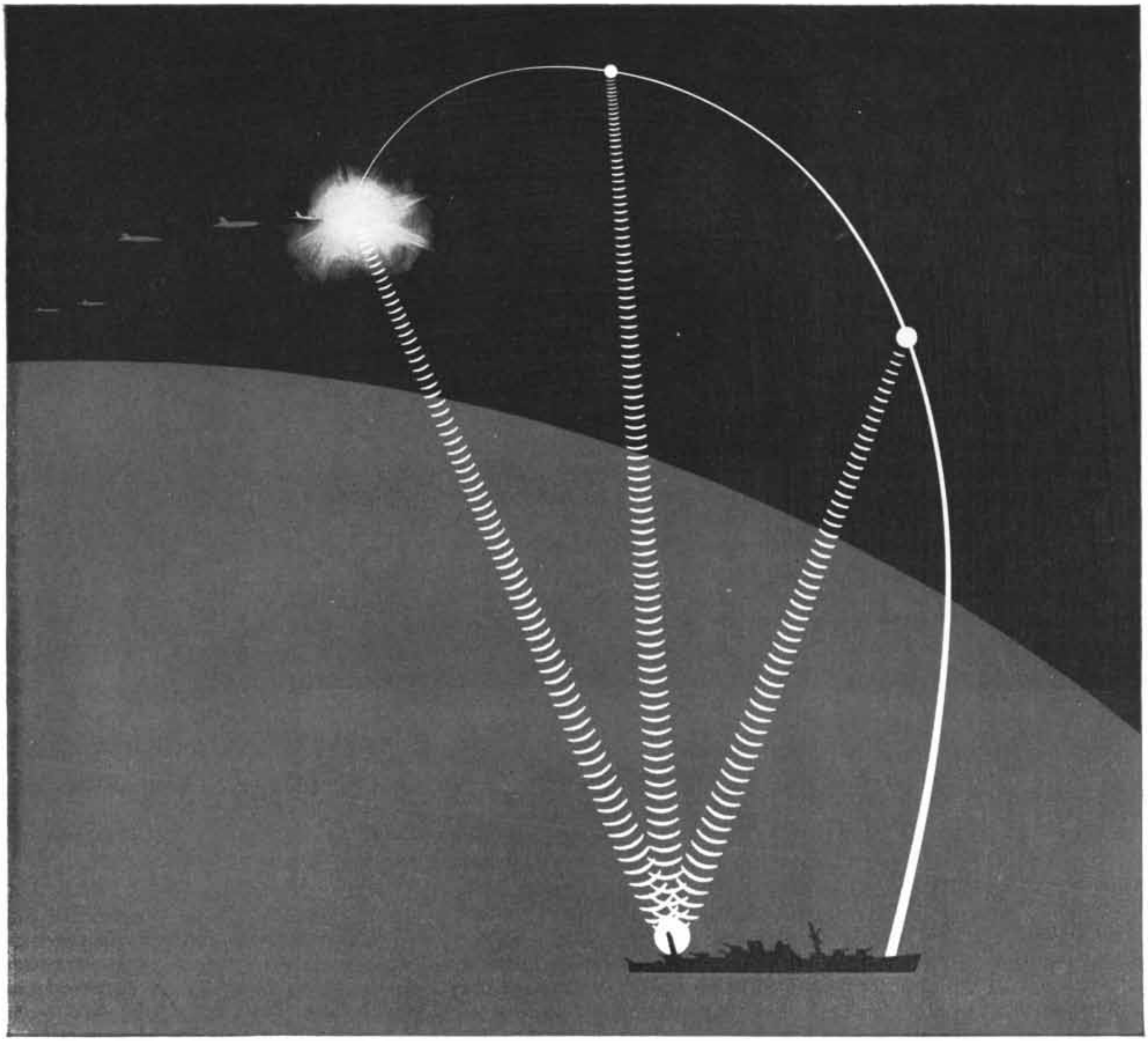
I should like to end by emphasizing the general significance of this work. If inertia arises from the interaction between a particle and the rest of the universe, then we should expect that the amount of inertia is related to the amount of matter in the universe. This is why the gravitational constant (which is a measure of the amount of inertia) can be related to the mean density of matter in the universe. Now distant matter is far more important than nearby

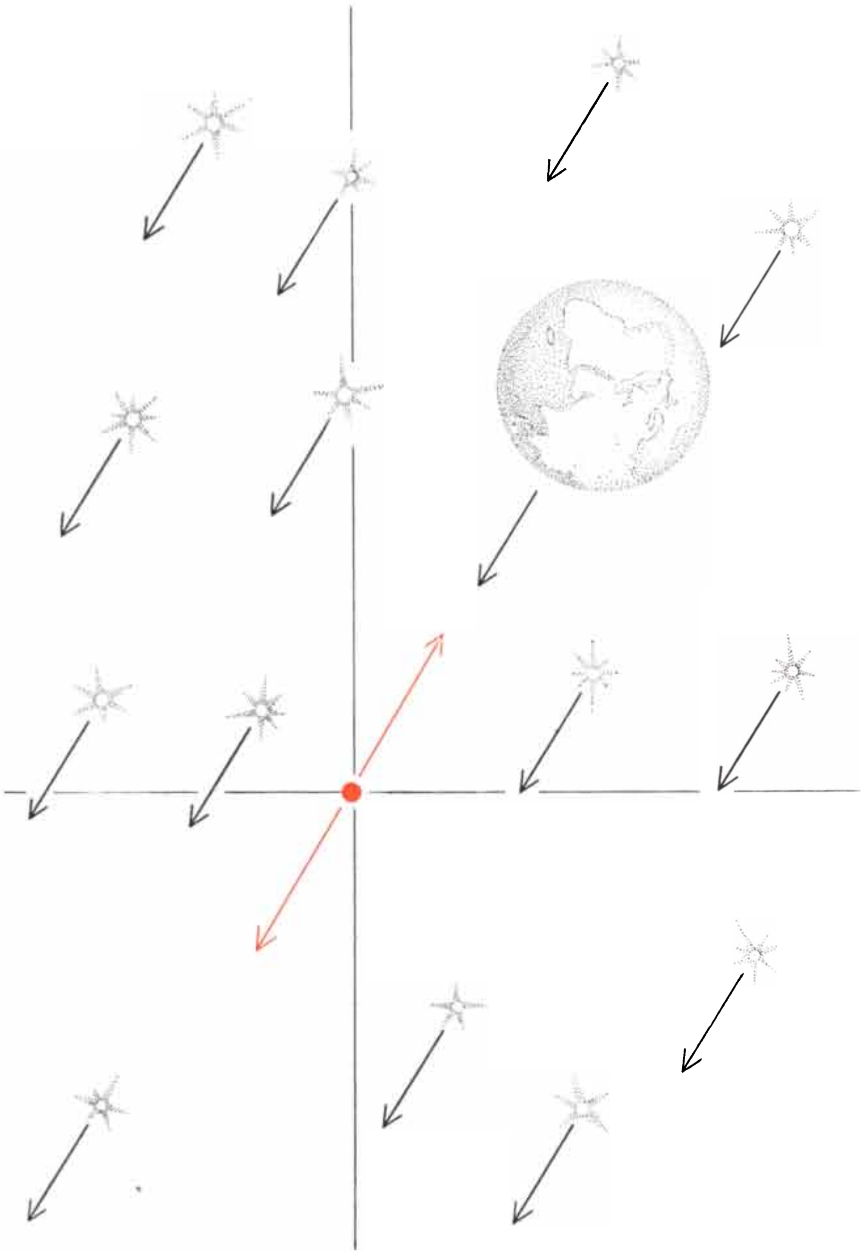


STATIONARY EARTH, considered as the observer's frame of reference, requires a fictitious inertial force to save Newton's laws. Force of sun's gravity (*solid arrow*) is balanced by a "centrifugal" force (*broken arrow*) to explain the absence of accelerated motion.

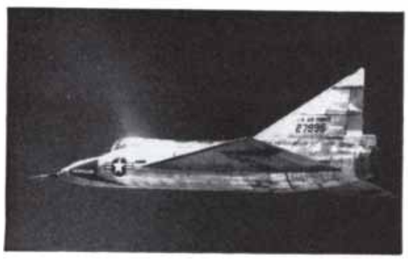


matter in determining local inertia, for its great bulk more than compensates for its great distance. For instance, the sun's contribution to local inertia is only about one hundred-millionth of the total from the universe as a whole. Hence the value of the gravitational constant tells us the mean density of matter at great distances from us—in fact, distances greater than those to which the 200-inch telescope can penetrate.

It is of course a very exciting result that such basic information about distant regions of the universe can be obtained by purely local experiments of great simplicity. At the same time, this result should warn us that the universe may play a hitherto unsuspected role in other phenomena. For example, the charge on an electron appears to be independent of environment, and indeed is classed as a fundamental constant of nature, but this property, like inertia, may also be the result of some long-range interaction. If atomic properties are in fact so determined, we shall again be faced with the dual situation: distant matter influencing local phenomena and local phenomena giving us information about distant matter. The scientist would then be able to claim that his imagination had outstripped the poet's. For he would see the world not "in a grain of sand" but in an atom.



FALLING BODY (*colored dot*) **can also be considered as being at rest. Then the earth and the fixed stars have accelerations with respect to it** (*black arrows*)**. The gravitational attraction of the earth, and the force due to the rest of the mass in the universe** (*colored arrows*) **balance each other exactly. This suggests a method for measuring the mass of the universe.**



Sir William Perkin

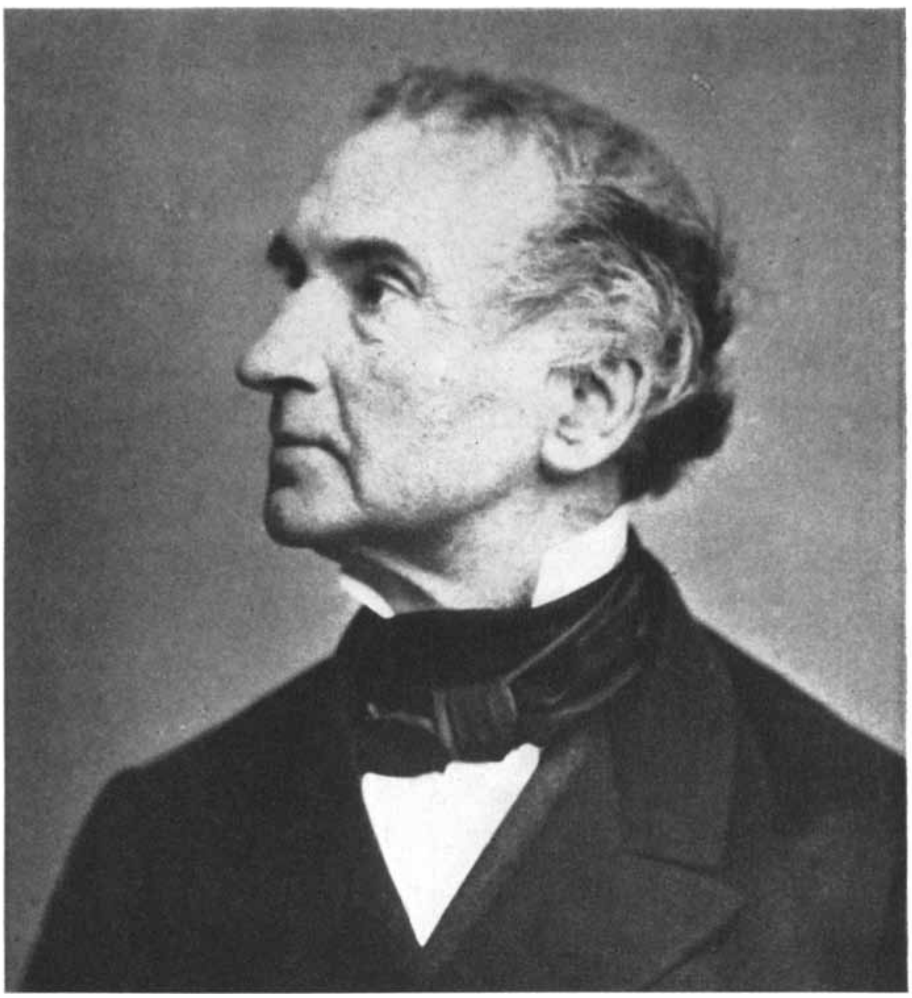
A century ago a young English chemistry student made a mauve-colored dye from coal tar, thus launching one of the central themes of the modern chemical industry

by John Read

It was just over 100 years ago that a young chemistry student in England, William Henry Perkin, discovered the synthetic dye called mauveine. The centennial of this event was celebrated recently by an international meeting in New York, at which the principal speaker was Sir Robert Robinson, Nobel prize winner in chemistry. Perkin's discovery is a great landmark in the history of chemistry: it gave birth not only to the synthetic dyestuffs industry but also to the rich freshet of organic chemicals which has so transformed life in the past century. Perkin's synthesis of mauve and the researches of his chemical contemporaries led quickly to an appreciation of the latent chemical possibilities in coal tar. The original trickle of research swelled into a mighty flood, which has not yet subsided. Coal tar has become an almost inexhaustible fount of useful substances—dyes (in the thousands), perfumes, drugs, explosives, photographic developers and many other fine chemicals.

The centennial of Perkin's achievement gives us a good occasion for a look back at that historic turning point and the state of chemistry at the time. The story really begins with Baron Justus von Liebig, the great German chemist who deserves to be called the father of organic chemistry. In 1824, at the age of 21, Liebig was appointed to the chair of chemistry and given a laboratory in the charming little university town of Giessen in Upper Hesse. Organic chemistry was then in its very infancy. Its studies were limited to the substances of living ("organized") matter. A number of these substances, including natural dyes, had been analyzed, and a good deal had been learned about their composition—carbon in combination with various proportions of hydrogen, oxygen and often nitrogen. But nothing was known concerning how the atoms were linked together: that is to say, concerning the structure of the molecule. Moreover, it was supposed that some "vital force" was necessary to synthesize organic substances, and that they could not be produced artificially.

However, in 1828 Friedrich Wöhler of Berlin achieved a laboratory synthesis of urea, a typical animal substance. Liebig was intensely interested in this discovery, and the two young chemists together soon began to bring the first bright gleams of light to the mystery of the structure of organic molecules. By 1840 aspiring chemists from all parts of



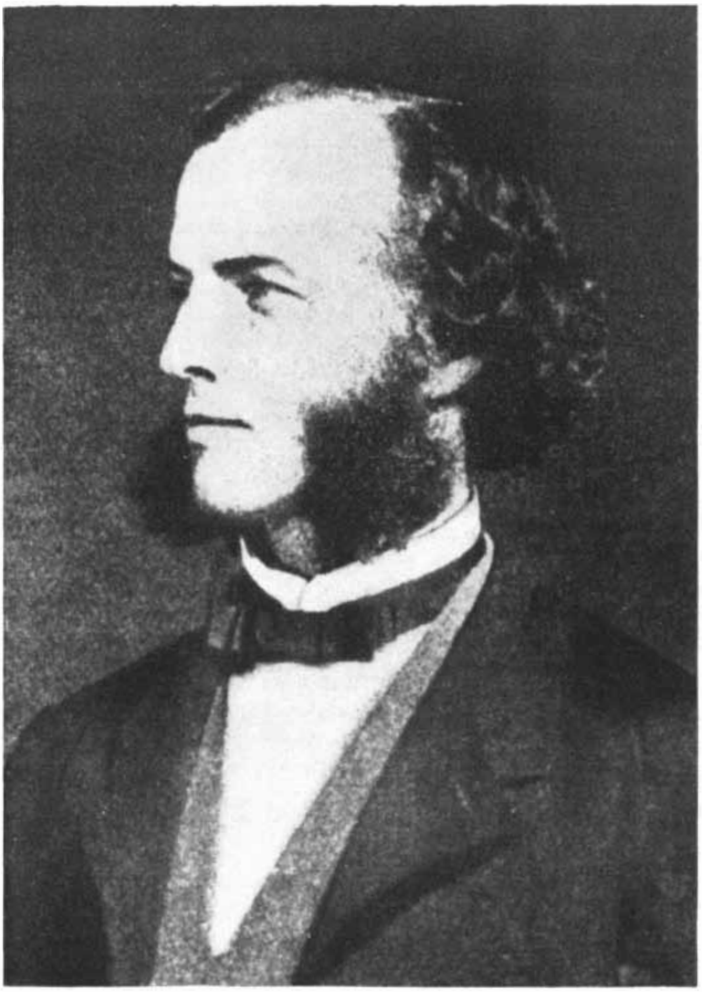
THREE IMPORTANT FIGURES of the early history of organic chemistry are shown in these photographs. At the left is Baron Justus von Liebig, known as the father of organic the world were flocking to Liebig's laboratory at Giessen and to Wöhler's at Göttingen to learn the new chemistry. New organic compounds unknown to nature (*e.g.*, ether, chloroform) were being produced artificially. Enthusiasm ran high. Liebig wrote: "We worked from break of day till nightfall. Dissipation and amusements were not to be had at Giessen. The only complaint . . . was that of the attendant, who could not get the workers out of the laboratory in the evening when he wanted to clean it."

Britain did not at first share in this ferment. In 1837, after a visit to England partly at the behest of his friend Michael Faraday, Liebig wrote to the Swedish patriarch of chemistry Jöns Jacob Berzelius: "England is not the land of science. It can show only a widespread dilettantism. . . ." But in 1842 Sir Lyon Playfair, a prominent Scottish chemist and man of affairs, who had worked with Liebig at Giessen, brought "the illustrious Baron" back to England for "a sort of triumphal tour." By that time wealthy British landowners had become interested in Liebig's work because of its bearing on agriculture. They therefore decided to support the founding in London of a Royal College of Chemistry, framed on the Giessen model.

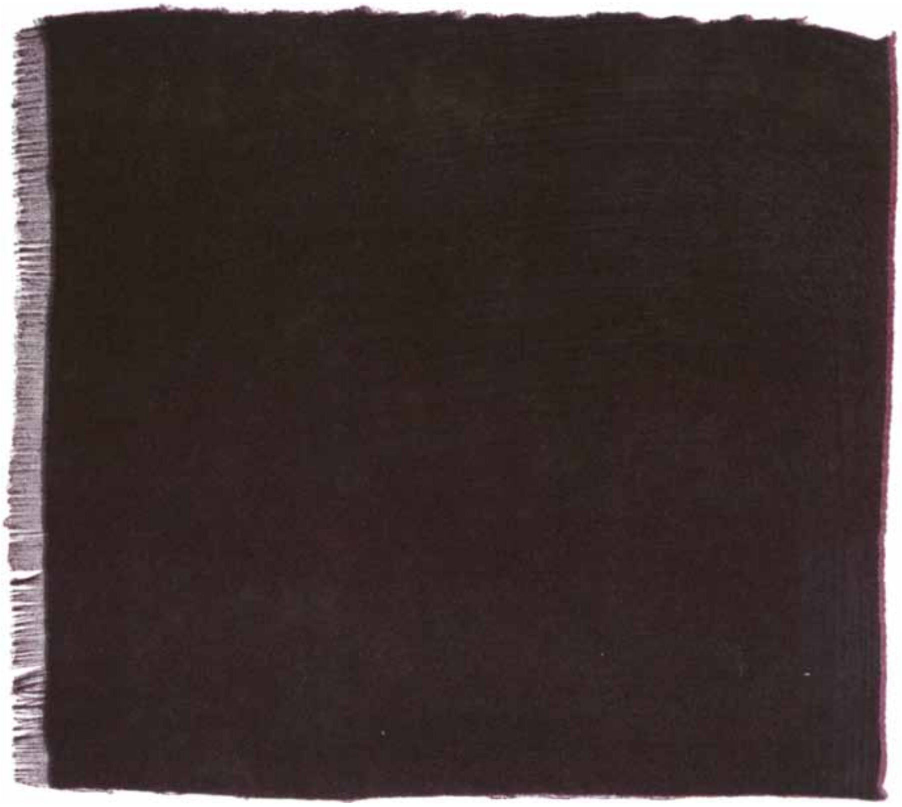
In 1846 the new college, housed in a small building with a frontage of only 34 feet on Oxford Street, opened its doors. Its director was A. W. Hofmann, the brightest of Liebig's galaxy of brilliant pupils. Hofmann had already made pioneering studies of naphtha, a distillate from coal tar, showing that it contained benzene, and at the Royal College he and his pupils proceeded to prepare almost pure benzene, fairly pure toluene and then toluidine. During his researches Hofmann also worked with aniline, a near relative of toluidine. It was aniline that was destined to be the seed for the discovery of Perkin's synthetic dye.

William Henry Perkin was a son of a builder, George Fowler Perkin, who lived in a house called King David's Fort in London. The father wished his son to become an architect, but at the age of 13 young Perkin came to a different decision: "A young friend was good enough to show me some chemical experiments; amongst these were some on crystallization, which seemed to me most marvelous phenomena: as a result my choice was fixed, and it became my desire to be a chemist." Perkin was greatly assisted in this desire by one of his teachers at the City of London School—Thomas Hall, a former pupil of Hofmann at the Royal College of Chemistry. Hall prevailed upon the boy's father to send him to the Royal College to study under the great Hofmann.

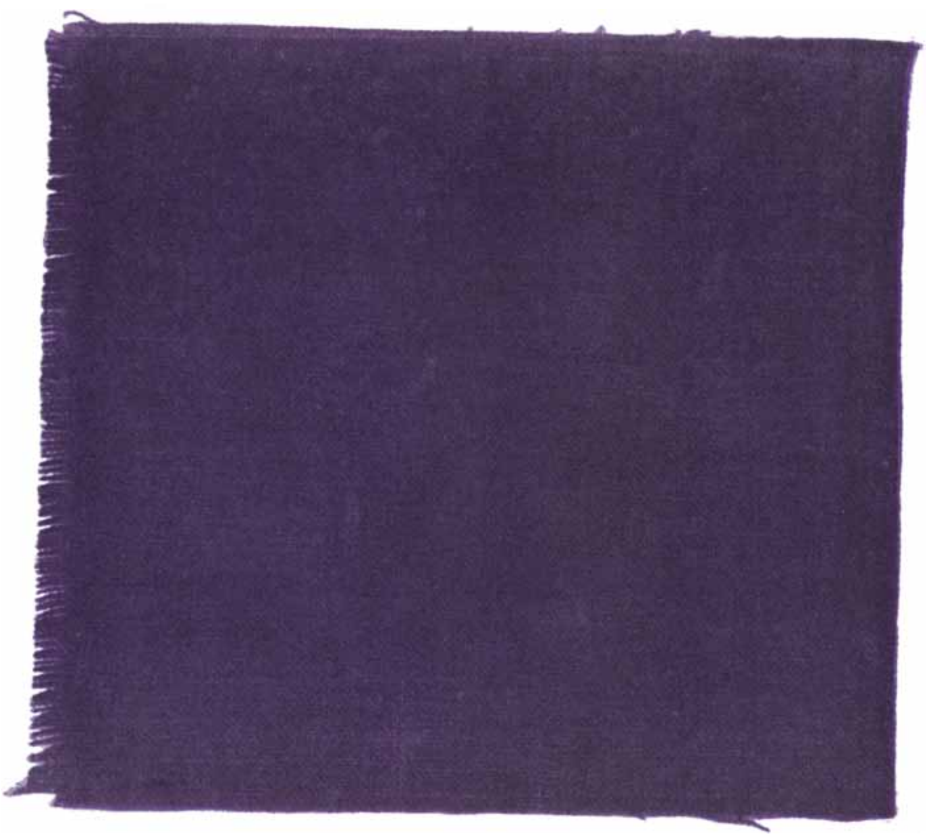
So it was that Perkin, at the age of 15, started his work in chemistry. After some preliminary studies and work on two assigned research projects, Hofmann made him an assistant in his own research laboratory. Perkin was then 17, and his enthusiasm for chemistry had become greater than ever. In his own words: "Whilst assistant under Hofmann, I had but little time for private work in the daytime; as, however, I wished to continue research work, part of a room at



chemistry. In the middle is Friedrich August Kekulé, who saw that carbon atoms were linked in chains and the six-sided benzene ring. At the right is William Henry Perkin. In 1856, when he synthesized mauveine, Perkin was 17. This photograph of him was made in 1860.



SILK AND COTTON are dyed with mauveine. The silk, which takes a reddish-violet color, is at the top. The cotton, to which the dye imparts a somewhat bluer shade, is at the bottom.



home was fitted up as a rough laboratory, and there I was able to work in the evenings or during vacations."

It was here that he made his momentous discovery of mauveine. The discovery was entirely accidental. What Perkin set out to produce was quinine. Hofmann had said that the artificial synthesis of quinine was "a great desideratum," and Perkin ambitiously went to work on this project on his own. During the Easter vacation of 1856 he began some experiments "in my rough laboratory at home." He had no chart or compass to guide him, for precise knowledge concerning the construction of organic molecules—the four valences of the carbon atom, the concept of the benzene ring and so on—was still to be discovered in the future. Perkin knew only that the formula of quinine was $C_{20}H_{24}N_2O_2$. He started with the naive idea that if he could by some means assemble a molecule containing 20 carbon atoms, 24 hydrogen atoms, two oxygen atoms and two nitrogen atoms, he would have quinine—not realizing that the same atoms could form scores of different structures, just as a given number of bricks and pieces of glass can form many different kinds of houses. Perkin conceived a scheme of making quinine from toluidine by a process of adding and subtracting atoms, which in the final step would involve oxidation of two molecules of allyltoluidine to yield quinine and water, thus: $2\ (C_{10}H_{13}N) + 3\ O \rightarrow C_{20}H_{24}N_2O_2 + H_2O$.

In his first experiment he oxidized a salt of allyltoluidine with potassium dichromate as the oxidizing agent. The product he got was a dirty reddish-brown precipitate. "Unpromising though this result was," Perkin wrote later, "I was interested in the action, and thought it desirable to treat a more simple base in the same manner." The base he selected was aniline (containing some toluidine). When he oxidized a salt (the sulfate) of aniline with potassium dichromate, he obtained a black precipitate. "On examination, this precipitate was found to contain the coloring matter since so well known as *aniline purple* or *mauve*, and by a number of other names. . . . Very soon after the discovery of this coloring matter, I found that it had the properties of a dye, and that it resisted the action of light remarkably well."

Up to that time the only useful dyes had been natural ones, derived mostly from plants. The outstanding dyes were the indigo and alizarin of the ancients; these were supplemented with extracts of logwood, safflower, the dried body of a scale insect and many other plant and

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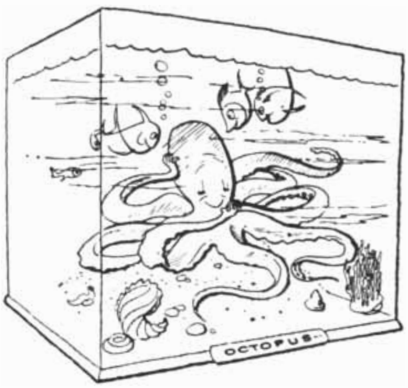
But the octopuses now happily cavort the day long in water that's cool and pure. The answer—three Corning Glass Works PYREX brand Shell and Tube Heat Exchangers.



O.K., you don't own (or intend to acquire) a pet octopus that needs pampering. Still, there's considerable to be learned from a practical standpoint. To wit—there might be a PYREX brand glass that will answer that knotty problem you're working on right now.

Take contamination, for instance. For most purposes, glass is inert—it just won't mix with, add to, or detract from what you put *in* or *around* it. In the case of PYREX brand glass No. 7740 this aloofness applies to most acids and alkalies, as well as steam under pressure.

Then, too, this glass handles thermal changes with what might be termed indifference since it has a linear coefficient of expansion of 32×10^{-7} between 0 and 300° C.

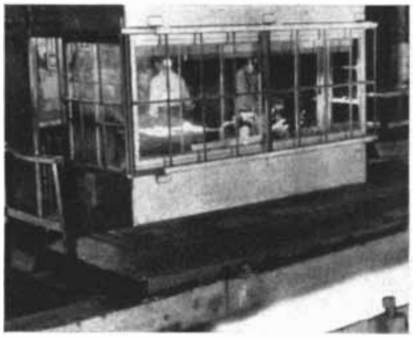
You'll also find that this glass is rugged, readily workable, and available in a wide variety of economical forms.

Suggestion: Put all kinds of useful facts about glass and glass applications at your fingertips. Send for free copies of B-83, "Properties of Selected Commercial Glasses"; and B-84, "Manufacture and Design of Commercial Glassware."

Or, spell out exactly what you need in terms of your problem and let us see if we can't come up with a *glass answer.*

Helping hand in "hot spots"

That's a *glass* shield you see in front of the steel mill shear pulpit operators in the picture.



The glass is a PYREX brand infrared reflecting type. It's heat-resistant, chemically stable and coated on one side with a thin, transparent film of metallic oxide.

Installed with the coated side facing the heat source, it reduces temperature behind the glass 34° F. Yet, operations are still kept under visual observation since this glass transmits about 75% of the visible spectrum.

This glass application is just one of the many that may interest men in your shops. They may also have need for such items as fume duct windows, sight glasses, and chemical-resistant surfaces.

Details on all these (along with facts about blue observation glass and the astounding VYCOR brand glass No. 7900) are summed up in the revised version of our Bulletin PE-34. Get a free copy and be set to lend a helping hand in "hotspots."

How to keep a mummy dry

Dampness is no laughing matter to museum keepers—or for that matter for makers (and users) of TV sets, pianos, and such.

That's why Dampp-Chaser, Inc., is in business. They make an ingenious item called, quite logically, Dampp-Chaser.

Behind the top frame (see arrow) is a Dampp-Chaser to keep rare museum pieces dry. Glass tubing by Corning helps in this unusual assignment.

The damp gets chased by a heating element; the heating element is inside glass tubing; the glass tubing is inside an aluminum tube.

We make the glass tubing. Dampp-Chaser, Inc., buys it because it makes a fine insulator, provides protection against leakage, plus an important safety factor in case of accidental over-loading of the circuit. To this we add—glass tubing by Corning is also economical and readily available, no small considerations in the profit picture.

During the past ten years, Dampp-Chasers have rolled up some 6-billion hours of protection against dampness. Glass helped make this a trouble-free record.

Offer: Two booklets to show you the varied ways in which glass is being put to use. "Glass and You" is a sweeping survey that even the people in the front office will appreciate. And for your own files, Bulletin IZ-1, "Glass . . . its increasing importance in product design."

Corning means research in Glass

CORNING GLASS WORKS, 49-2 Crystal Street, Corning, N.Y.

Please send me the following material: Illustrated booklet, "Glass and You" ☐; Bulletin IZ-1, "Glass . . . its increasing importance in product design" ☐; Bulletin B-83, "Properties of Selected Commercial Glasses" ☐; Bulletin B-84, "Manufacture and Design of Commercial Glassware" ☐; Bulletin PE-34, "Corning Flat Glasses" ☐.

Name________________ Title________

Company________________

Street________________

City________________ Zone______ State________ animal products. The "thin red line" of the British Army was indebted to the cochineal insect, and the famous Turkey red of French uniforms came from alizarin, extracted from the root of the madder plant. But the natural dyes offered no fine gradation of shades, and they were often fugitive. Now art was to surpass nature and to produce more durable dyes in far greater variety and at less expense. Perkin's discovery led eventually to almost complete supersession of natural dyes by synthetic ones.

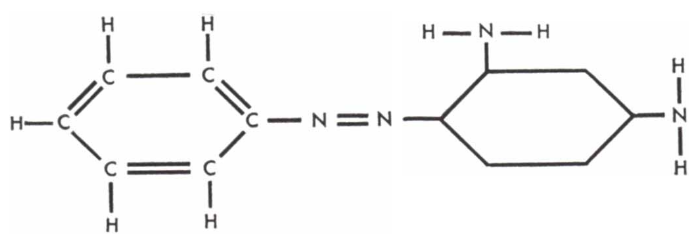
Mauveine has been assigned the molecular formula $C_{27}H_{25}N_4Cl$. The molecule has a very complicated structure, the details of which were not completely worked out until about half a century after Perkin's discovery. It dyes silk a reddish-violet color and imparts to cotton a somewhat bluer shade. Mauveine was used to print a lilac one-penny postage stamp during Queen Victoria's reign.

When Perkin made his exciting discovery, he was confronted with a painful decision: Should he remain in Hofmann's laboratory or leave to develop his product? The laboratory was at a peak of productivity and enthusiasm. Hofmann and his pupils had struck an amazingly rich vein: their pioneering experiments in coal-tar chemistry had opened a new world before their delighted gaze. Like "stout Cortez" and his men, they "look'd at each other with a wild surmise," as new and astonishing compounds tumbled in rapid succession out of their test tubes and beakers. Perkin himself, describing this enchanted chemical scene, related an incident in which Hofmann one day picked up a new substance from a student's bench: "Taking a little of the substance in a watch glass, he treated it with caustic alkali, and at once obtained a beautiful scarlet salt of what we now know to be orthonitrophenol. Several of us were standing by at the time, and, looking at us in his characteristic and enthusiastic way, he at once exclaimed, 'Gentlemen, new bodies are *floating* in the air.' "

Nevertheless Perkin decided to leave the College in order to manufacture mauveine. The master's feelings can well be imagined. Many years later Perkin wrote: "He appeared much annoyed, and spoke in a very discouraging manner. . . . I have sometimes thought that, appreciating the difficulties of producing such compounds as aniline and this colouring matter on the large scale, Hofmann perhaps anticipated that the undertaking would be a failure."

It was indeed a bold decision for a lad of 18 to enter into the untried field of industrial chemistry. But his father gave him full support. He put most of his life's savings into building a factory at Greenford Green, near Sudbury. Young Perkin took out a patent on mauveine, and by the end of 1857 the new dyestuff, under the name of "Aniline Purple," or "Tyrian Purple," was being supplied in quantity to silk dyers in London. Thenceforward Perkin was immersed in extending its application to cotton dyeing and calico printing, and to manufacturing the basic materials, nitrobenzene and aniline, on an unprecedented scale.

Meanwhile Friedrich August Kekulé of Germany conceived his brilliant theories of the structure of organic molecules, envisioning four-valent carbon atoms linked together in chains and in the form of the closed benzene ring (which came to him in a vision of a snake biting its tail). Kekulé's structural ideas and the work of Hofmann and others made possible a rational attack on the synthesis of dyes and other organic chemicals. In 1868 C. Graebe and K. T. Liebermann of Germany produced alizarin by a method starting from a coal-tar derivative, anthracene—the first artificial synthesis duplicating a natural dye. Perkin found two other methods for producing this dye, and within two years



STRUCTURAL FORMULA of the simple azo dye chrysoidine ($C_{12}H_{13}N_4Cl$) shows the feature characteristic of azo dyes. This feature is the azo group (—N=N—) linking benzene rings. The ring at left is shown with all its atoms; the ring at right, in abbreviated form.

Tough housing for a soft drink

The young lady serving delicious Coca-Cola has reason to smile. Part of her job is keeping this new dispenser, housed in tough Tenite Butyrate, clean and sparkling at all times. That's where Tenite Butyrate's smooth surface and high impact strength save her time and effort, help keep the dispenser free of annoying cracks and crevices which mar any product's appearance and are so difficult to clean.

Handsomely styled, the dispensing machine is a complete, self-contained unit, readily usable on any counter. The bright white top, brilliant red sides, and the rich, metallized grill are all vacuum-formed from sheeting of Butyrate. The colors go all the way through the plastic—they can never chip off. The deep-drawn top, incidentally, is one of the largest one-piece plastic housings ever produced by vacuum-forming.

Tenite Butyrate can be rapidly injection molded or extruded in sheets to serve a variety of other uses as well. For example, color telephones, football helmets, signs, and handles for tools and appliances all owe their strength and beauty to this versatile product.

If you are considering a new or improved product design, you may discover the strength and beauty of Tenite Butyrate are just what you need. Write today for more information concerning its uses and physical properties. Inquire, too, about Eastman's other useful plastics, Tenite Acetate and Tenite Polyethylene. Write to EASTMAN CHEMICAL PRODUCTS, INC., subsidiary of Eastman Kodak Company, KINGSPORT, TENNESSEE.

1932—EASTMAN'S 25TH YEAR IN PLASTICS—1957

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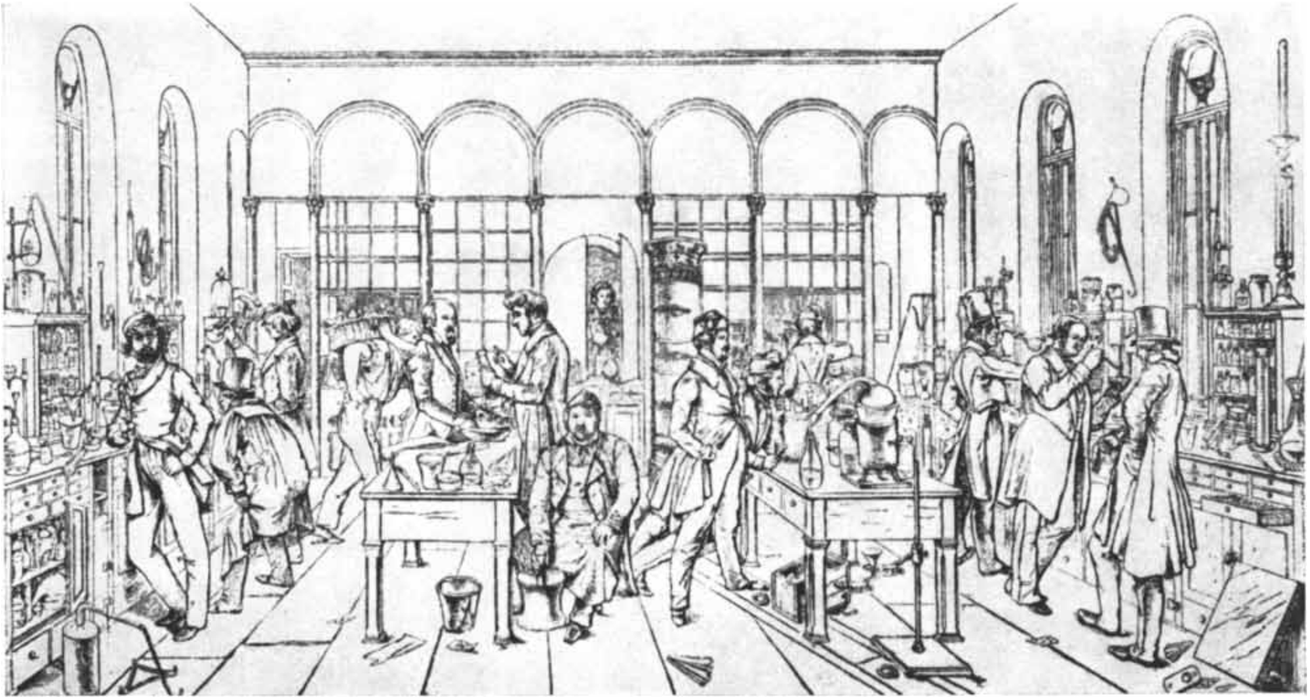


LIEBIG'S CHEMICAL LABORATORY at Giessen in Upper Hesse was drawn in 1842. Chemists from all parts of the world came to this laboratory and Friedrich Wöhler's in Göttingen to learn the new chemistry. In this drawing A. Hofmann is second from the right.

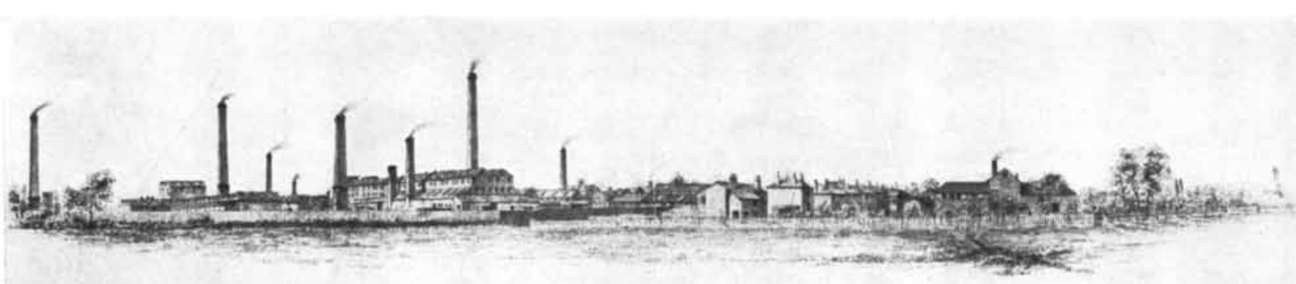
he manufactured 220 tons of alizarin. Eventually natural indigo, too, went the way of its ancient partner, being replaced by synthetic indigotin made from naphthalene.

Perkin's works at Greenford Green went on to synthesize many other dyes and associated substances, among them dahlia, aniline pink, Britannia violet and Perkin's green. Meanwhile the coloring properties of dyes were specifically identified with certain groups in the molecule, especially with the so-called azo group—a pair of doubly linked nitrogen atoms fitted into the structure between rings [*see illustration on page 114*]. This group is not found in natural compounds. About half of the common synthetic dyes today are azo dyes.

Perkin did not restrict himself to tinctorial chemistry. He synthesized the natural perfume coumarin, discovered the famous "Perkin reaction" for preparing unsaturated acids and made other investigations in industrial chemistry.

Perkin's leadership in founding a synthetic dyestuff industry in Britain was so powerful that Hofmann was moved to predict: "England will, beyond question, at no distant day, become the greatest colour-producing country in the world [sending] her coal-derived blues to indigo-growing India, her tar-distilled crimsons to cochineal-producing Mexico," and so forth. But the promise was short-lived, largely because the inspiration and enthusiasm which had animated it died at the source. Hofmann himself, who might have become the Handel of British chemistry, eventually returned to Germany to take up a professorship in Berlin, because financial support for the Royal College of Chemistry dwindled after British agriculturists realized that "Liebig's book was not a muck manual" (in Playfair's words) and that Hofmann's work on coal-tar chemistry made no paying return to agriculture. And in 1874 Perkin, having rendered himself financially independent at the age of 36, sold the Greenford Green works and retired to basic research in chemistry.

England's early advantage in the rapidly expanding dyestuffs industry was lost. Perkin has sometimes been criticized for deserting the industry, but it must be remembered that he left it in a flourishing condition. Actually no one could have foreseen at the time how vitally important dyestuffs and the industries growing out of it would become, or that by 1913 the manufacture of dyes alone would amount to some 20 million pounds sterling a year (with Germany account-



PERKIN'S CHEMICAL WORKS at Greenford Green is depicted as it appeared in 1873. It had been founded in 1858, two years after his synthesis of mauveine. In 1874, at the age of 36, Perkin sold the Greenford Green works and retired to basic chemical research.

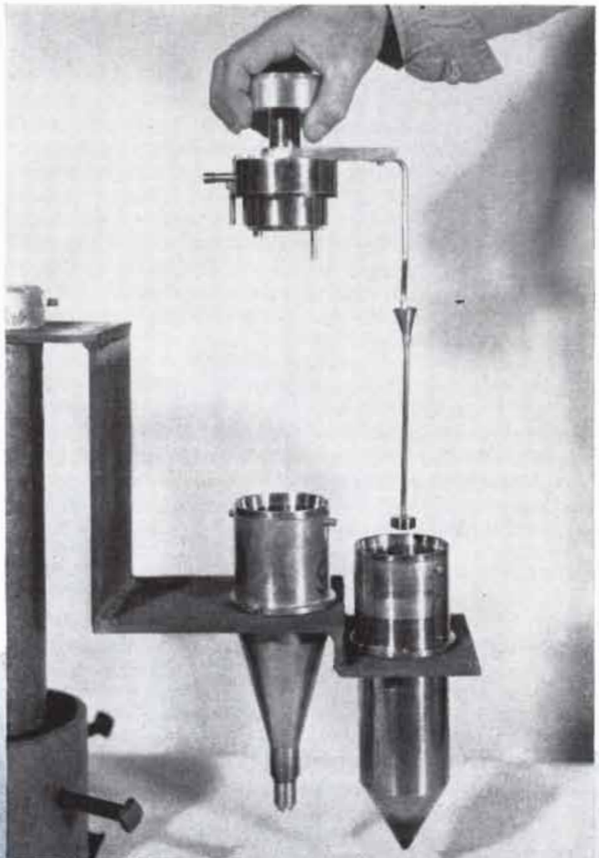
ing for most of the production). It took World War I to arouse Britain and the U. S. to the realization that coal-tar dyes were a key industry, linked inseparably with the manufacture of explosives, leather, paper, paints, inks and other essential commodities of modern life.

Perkin devoted much of the remainder of his life to studying chemical structure. He discovered that the light-polarizing property of organic molecules—their rotation of the plane of polarized light in a magnetic field—was a powerful weapon for examining chemical constitution, and he investigated the "magnetic rotatory power" of a number of the organic compounds he had prepared.

Perkin had three sons, and all three of them made their mark in chemistry. William Henry junior held chairs of chemistry at Manchester and Oxford and became one of the foremost organic chemists of his day.

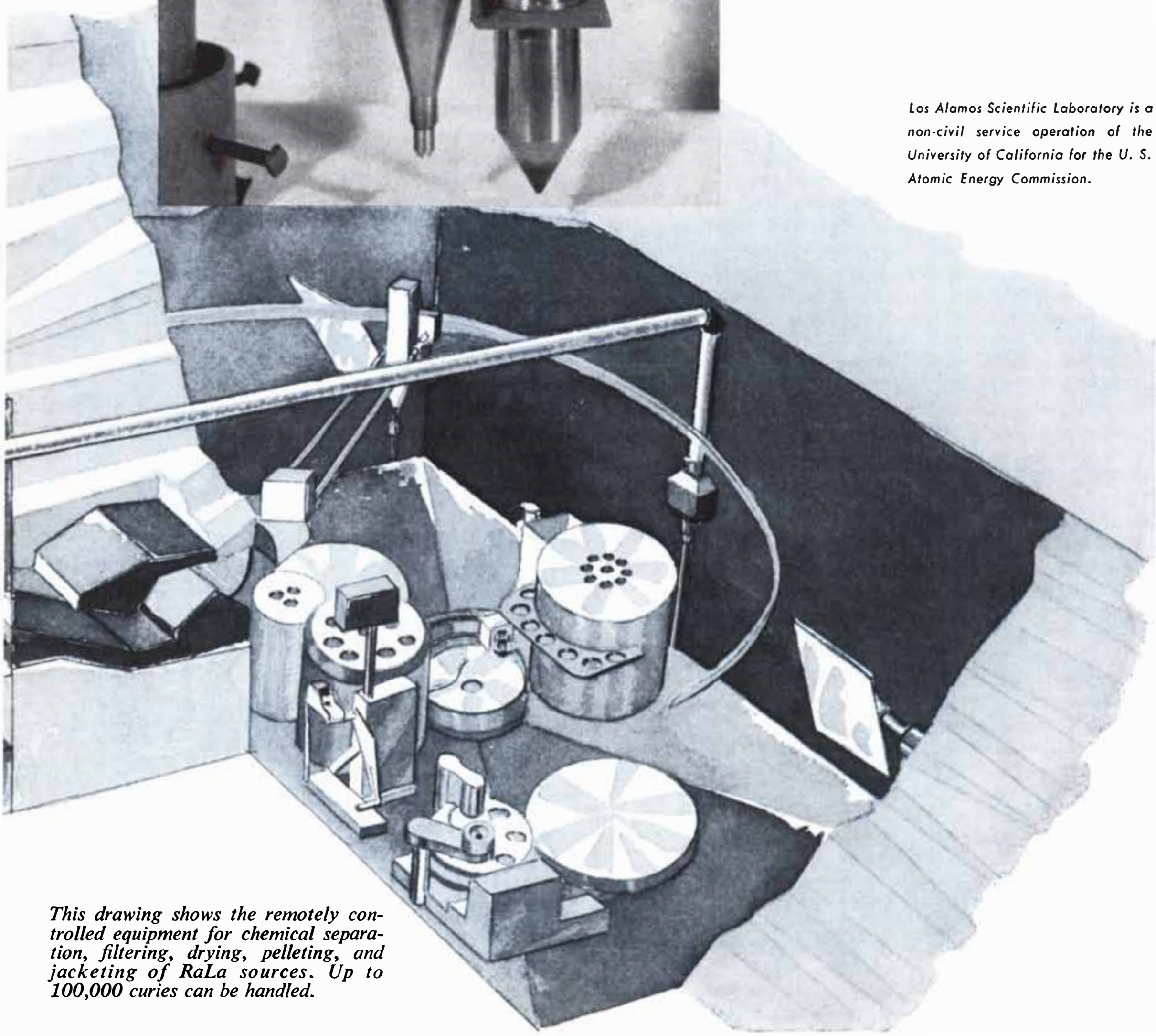
Their illustrious father was an exceptionally modest man—simple, religious, retiring, taking pleasure in the quiet pursuits of art and music. Notwithstanding his commercial success, he actually had no great instinct for business, and left the management of the plant at Greenford Green to the acumen and enterprise of his older brother Thomas. During his lifetime he was almost unknown to the general public, but received many honors from the world of science. In 1906 the 50th anniversary of his discovery of mauveine was celebrated by jubilees in the U. S. and Britain. Perkin visited the U. S. and received honorary degrees from Columbia and Johns Hopkins universities, the latter from the hands of his colleague Ira Remsen, who had synthesized saccharin —"the sweetest thing on earth"—from toluene. Perkin was awarded medals by Germany and by France; permanent Perkin medals for chemical achievement were established by chemical societies in Britain and in the U. S. In the same year he was knighted—a very rare award to scientists in those days.

A portrait of Sir William Perkin, made by A. S. Cope in 1906, hangs in the National Portrait Gallery in London. It represents him in his laboratory with a skein of mauve-dyed silk in his hands. Perkin died at Sudbury in the following year. The full significance of his achievement as a founder of coal-tar chemistry was not yet realized. Today, half a century later, we are in a better position to appreciate the wealth of chemical wonders—still far from exhausted—that was released by Perkin's experiments and Kekulé's visions.



The apparatus to the left is used for precise alignment of the filtering assembly used in hot cells for RaLa processing. When in actual use it is operated by remote control.

Los Alamos Scientific Laboratory is a non-civil service operation of the University of California for the U. S. Atomic Energy Commission.



This drawing shows the remotely controlled equipment for chemical separation, filtering, drying, pelleting, and jacketing of RaLa sources. Up to 100,000 curies can be handled.

JAPANESE POSTURE is typified in this print by Harunobu (1725-1770), an artist best known for his scenes from the daily lives of girls and young men. This picture is called "The Beginning of Spring," from the series "Customs of the Four Seasons." The man at left has struck a formal pose. Kneeling on the *engawa*, or porch, he indicates to the young lady the first signs of an approaching shower.

THE ANTHROPOLOGY OF POSTURE

Man differs from the apes by his standing posture, but this is only one among some 1,000 body positions of which he is capable. Here an anthropologist discusses their distribution and rationale

by Gordon W. Hewes

The ways in which we sit, kneel or stand are determined not only by the human anatomy but also by culture. The peoples of the world differ in posture styles just as they do in styles of clothing, housing, cooking and music. Yet curiously this important touchstone of cultural differences has received little serious attention from science. About 20 years ago the French sociologist Marcel Mauss called attention to such matters in a stimulating paper called "The Techniques of the Body," but he did not go much beyond the suggestion that their investigation might open up a fertile field for research on the borderline between culture and biology. A few anthropologists have written about the postural habits of particular tribes or countries. And that is about the limit of the literature on the subject.

It is hard to understand why students of man and society have left this chapter of his behavior so blank. Studies of postural patterns could tell us a great deal about man's biological and cultural evolution. And the subject is not without practical importance. Postures and related motor-habits are intimately linked with many aspects of daily life: they affect the design of our clothing, footgear, furniture, dwellings, offices, vehicles, tools and machines. Moreover, they speak an eloquent language in social intercourse. Most of us look to postural cues, as well as facial expressions and speech itself, in our never-ending efforts to interpret or evaluate people's motives, moods or behavior.

Information on which to base a world-wide survey of postural habits is scarce, but sufficient to make at least a beginning. Happily the anthropologists' cameras often make up for omissions in their notes. From their photographs and others it is possible to obtain a surprising amount of information about postural habits in many of the world's cultures. One must take care not to be misled, however, by posed or group pictures of natives in which the photographer has lined up his subjects like members of a baseball or basketball squad. The older anthropological literature, especially, contains a great many such pictures, partly because of slow emulsions and poor lenses and partly because of inability to break away from the tradition that having a picture made is a situation calling for the greatest formality—a tradition which seems to have developed long before photography was invented, and which is not limited to Western civilization. In more recent publications there is a higher frequency of candid shots, showing people in ordinary positions and engaged in ordinary tasks.

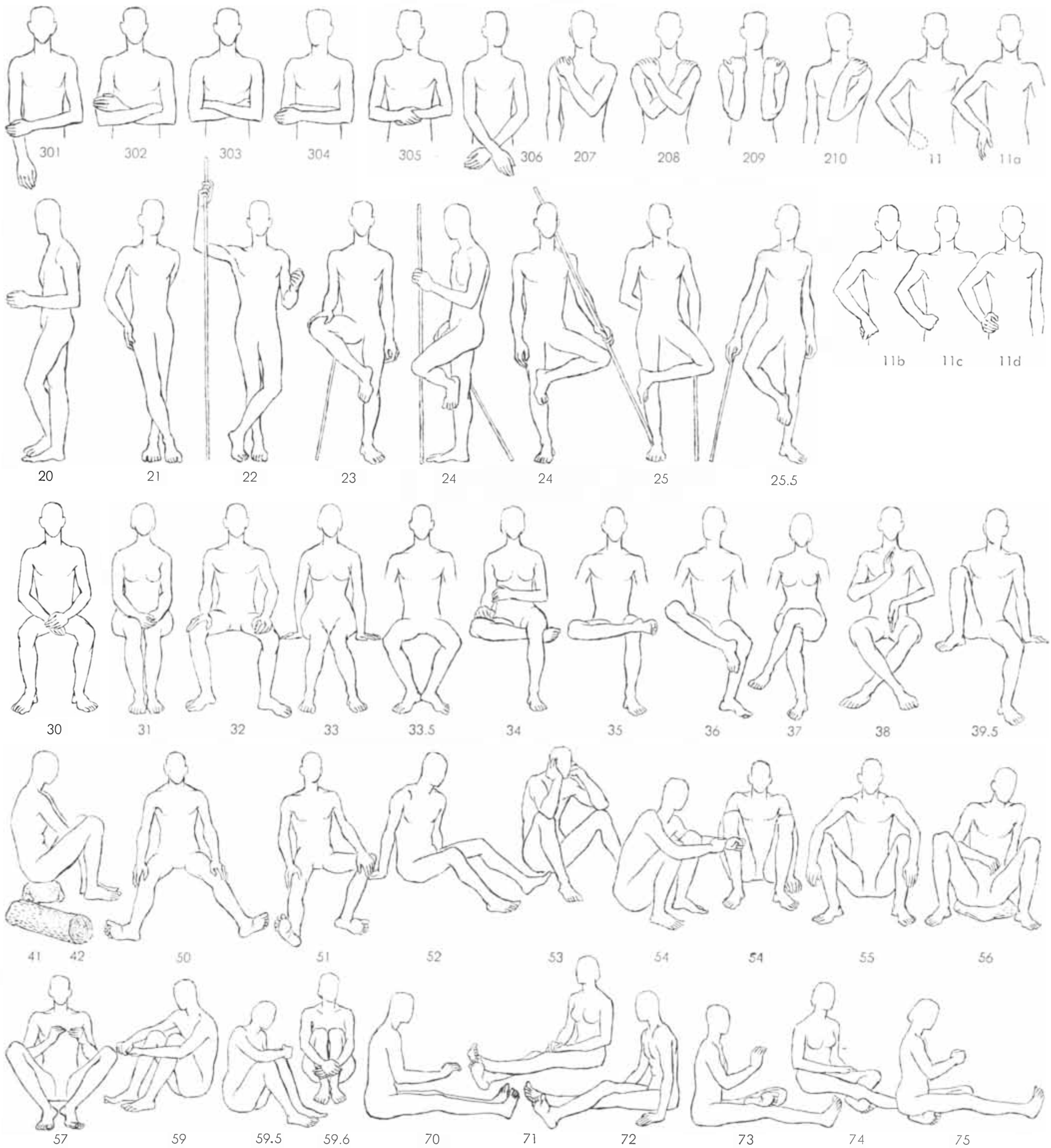
Other valuable sources of information on posture are the paintings and sculptures of the artists from all ages, taking us back to the Stone Age. The sculptors of ancient Greece produced anatomically realistic figures in a rather limited range of postures—partly dictated by their use of marble and other heavy stone and partly by the monumental function of so many of their works. The art of ancient India depicts supernatural beings, ascetics and other extraordinary persons engaged in prayer, meditation, religious dances or preparation for rituals. Much the same thing is true of the art of ancient China, Mexico, Peru and Egypt. Painting and sculpture generally tend to depict formalized, ceremonial, idealized or otherwise artificial poses. Ancient Egyptian art is particularly noted for the rigid and unnatural postures of its figures. Nevertheless we have more definite information on the everyday postural habits of the Egyptians than of any other ancient people. The early Egyptians considerately left us little models showing figures pulling at the oars of boats, handling various tools, butchering cattle, grinding grain, and so forth.

For world-wide comparisons we must limit ourselves to static postures—sitting, squatting, kneeling and standing—because the data on cultural differences in body movements are still too scanty. The human body is capable of assuming something on the order of 1,000 different steady postures. By "steady" we mean a static position which can be maintained comfortably for some time. Obviously there are basic anatomical and physiological factors which prevent us from standing on our heads for any great length of time, whatever our cultural background. But aside from such limitations, it is surprising to see what a variety of positions various peoples find comfortable. Culture and training have accustomed millions of people in the world to sit restfully in postures which to Western chair-sitters seem not only bizarre but extremely uncomfortable.

There are, of course, postures which can be considered universal, because they are common in all cultures and times. The ordinary upright stance, with the arms hanging straight down or with the hands clasped in front or behind, certainly belongs in this category. Chair-sitting does not, however. At least a fourth of mankind habitually takes the load off its feet by crouching in a deep squat, both at rest and at work.

Fully aware of the limitations of our information, we have made a preliminary set of world maps showing the distribution of various static postures. Two of the maps are shown here [*see* *these two pages*]. They represent data from some 480 different cultures, 34 of which belong to the past.

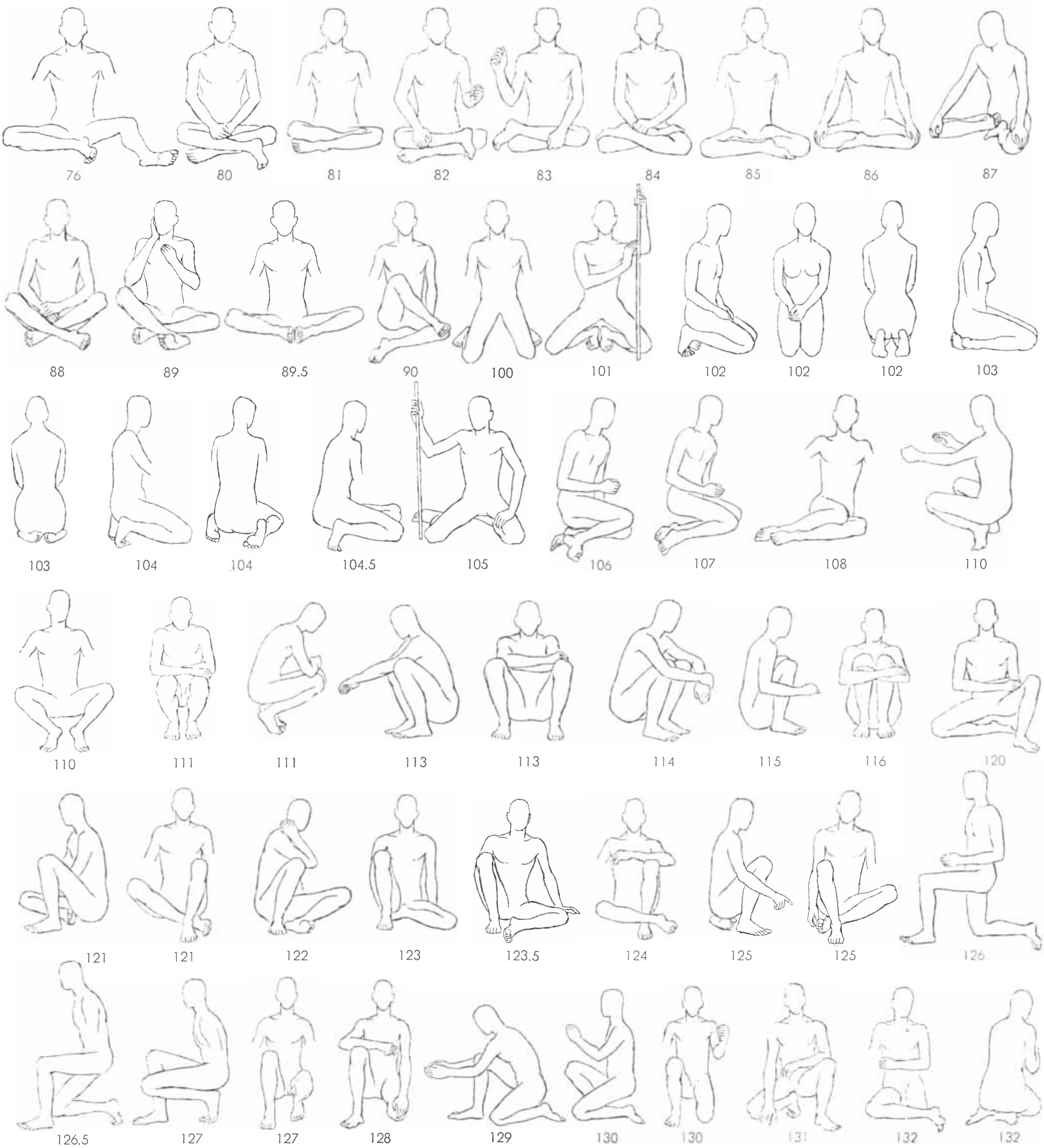
Chair-sitting and furniture, possibly the chief distinguishing postural attributes of Western civilization, go hand in hand, though it is difficult to tell which is cause and which effect—whether the habit of sitting on a support led to the invention of stools, benches and chairs or *vice versa.* It is true that a rock, ledge, log or house platform may serve as a bench, but the fact is that people who lack special furniture for the purpose seldom sit the way we do. Growing up in a "furnished" environment evidently fosters sitting postures which the casual use of rocks or logs does not. In Japan, where people are accustomed to sit on the floor at home, you will sometimes see a person sitting on his heels on a seat in the thea-



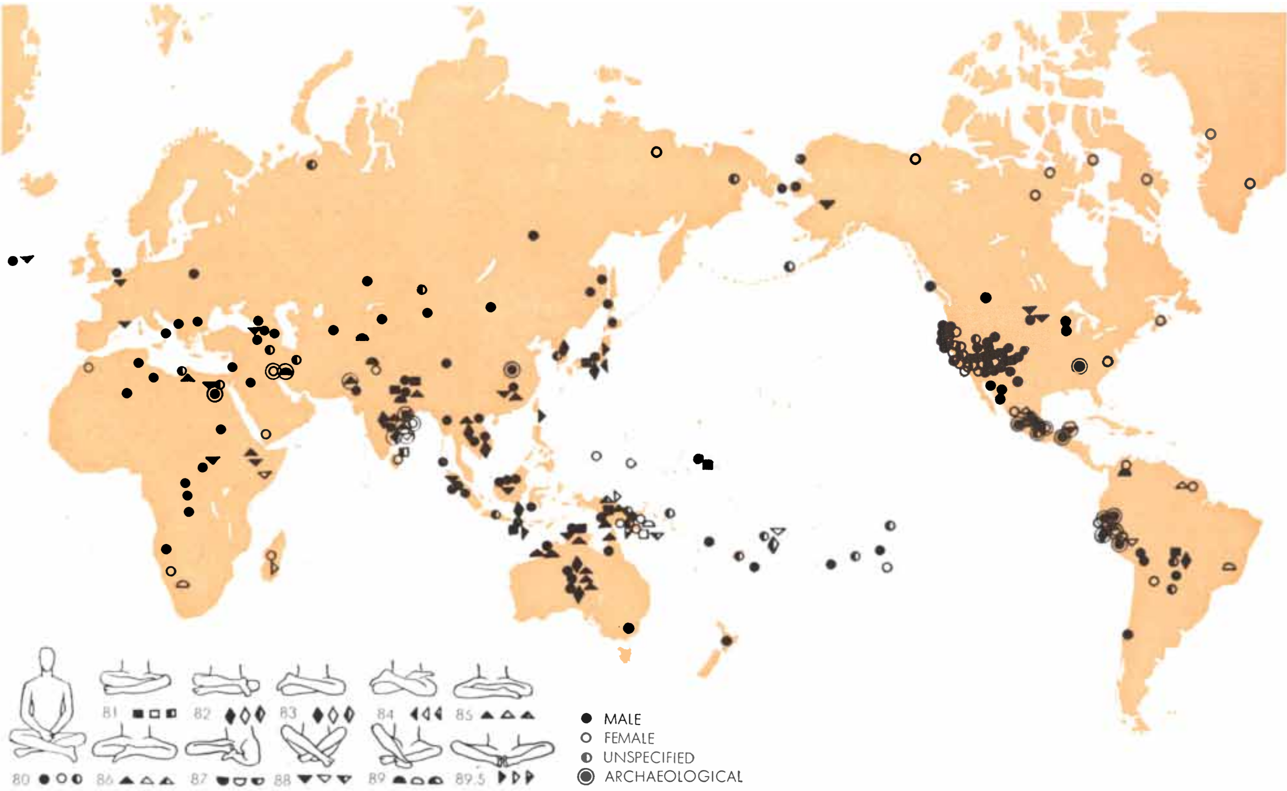
POSTURE TYPES are shown in this sampling from the classification scheme of Hewes. The figures numbered 301 through 306 (*top row on this page*) are common resting positions; by contrast, the arm-on-shoulder postures of the next four figures are found mainly among western American Indians. In the next row are variations of the one-legged Nilotic stance, found in the Sudan, Venezuela and elsewhere. Chair-sitting (*third row*) spread from the ancient Near East, but the Arabs there have replaced it with floor-sitting

ter or a train. Among habitual chair-sitters over the world there is a surprising variety of cultural differences in sitting posture, many of which can be classified on the basis of the way the legs or ankles are crossed.

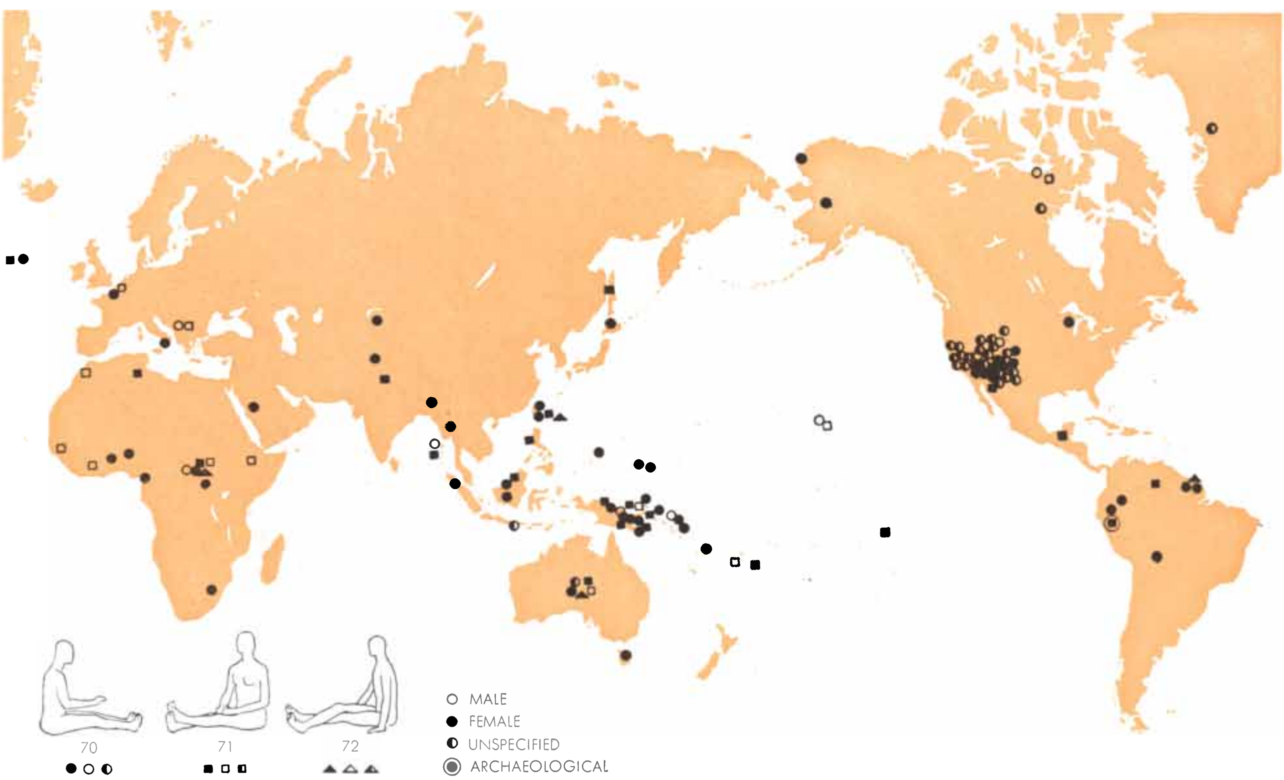
Chairs, stools and benches were in use in Egypt and Mesopotamia at least 5,000 years ago. While commoners and slaves sat on stools or benches, the kings, priests and other exalted personages in ancient Egypt used chairs. The Chinese began using chairs fairly late in their history: 2,000 years ago they sat on the floor, as the Japanese and Koreans do today. In southern and southeastern Asia chairs have never become items of common use. Even in the Middle East and in North Africa the Islamic peoples seem to have returned to sitting on the floor—possibly because of the cultural prestige



postures (*fourth and fifth rows*). Sitting cross-legged (*top row on this page*) predominates south and east of Near Eastern influence. Sedentary kneeling postures (102 *to* 104) are typically Japanese; sitting with the legs folded to one side (106 *through* 108) is a feminine trait, a rare exception being the male Mohave Indians. The deep squat (*fourth row on this page*) is uncomfortable for adult Europeans but replaces the sitting posture for at least a fourth of mankind. The last two rows show various asymmetrical postures.



CROSS-LEGGED POSTURES occur widely throughout southern Asia and aboriginal America, especially among men. Complicated variants such as the yoga or lotus posture (84) do not occur outside Asia, where they are practiced by religious adepts.



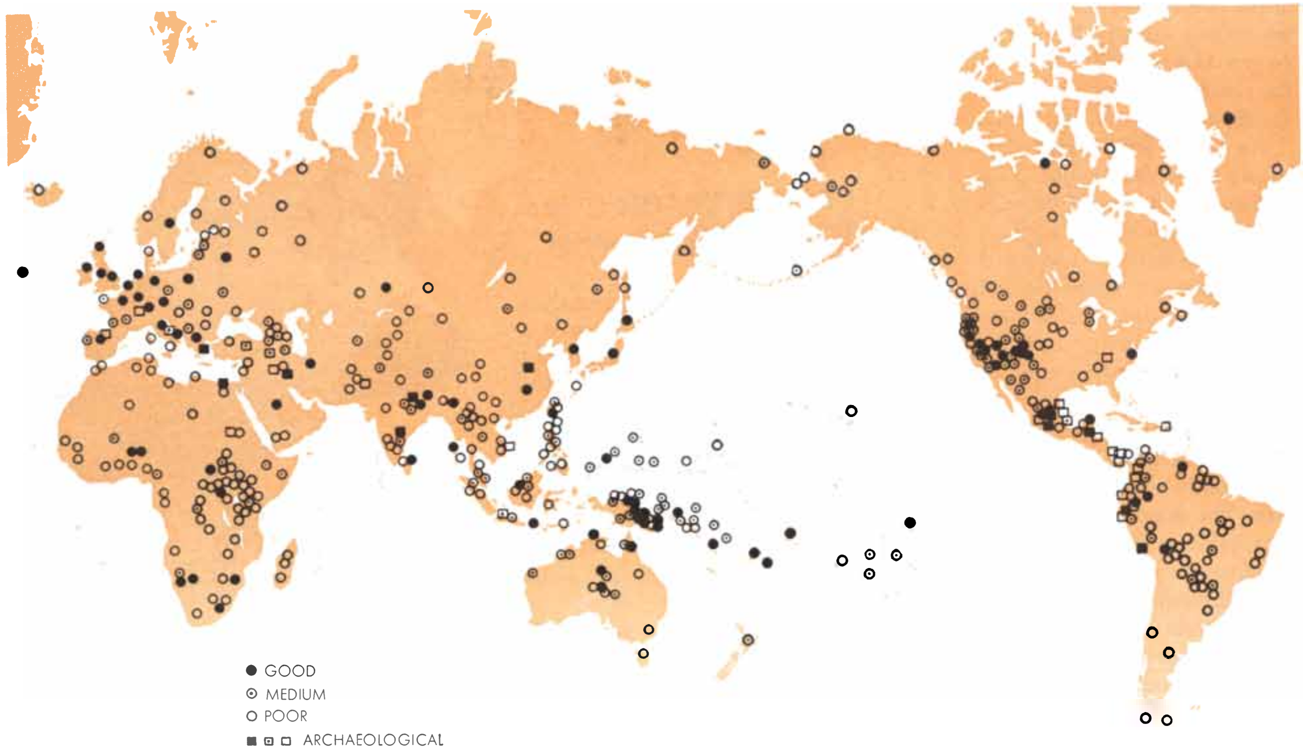
SITTING WITH LEGS EXTENDED is especially common among American Indians and in Melanesia. It is often used by women, perhaps because it allows them to hold or nurse an infant while carrying out sedentary tasks such as craft work or preparing food.

of the nomadic Arabs. Stools and similar low sitting supports have cropped up in Negro Africa, where they are reserved for chiefs or kings, and in parts of the Pacific and of Latin America.

No less widely practiced than chair-sitting is the deep squat. To us it seems perhaps the height of primitivity, if not of indecorousness: adults in Western culture are likely to use the deep squat only when far from the amenities of plumbing. It was considered uncouth by the ancient Greeks, as is suggested by the fact that satyrs sat in this fashion when they piped tunes on Pan's pipes. Yet millions of people in many parts of Asia, Africa, Latin America and Oceania customarily work and rest in this posture. The deep squat is very similar to the habitual resting position of the chimpanzee, and perhaps all of us might squat throughout our lives if our cultures did not train us into other postures. It is a position perfectly easy for young children in any culture to assume, but difficult and uncomfortable for an adult who has not been accustomed to it.

Ranking slightly behind chair-sitting and the deep squat is the cross-legged sitting posture that we call sitting "Turkish" or "tailor" fashion. This is the predominant way of sitting among peoples in a great arc from North Africa through the Middle East to India, southeast Asia and Indonesia, with outliers in central Asia, Korea, Japan, Micronesia and Polynesia. The position with each foot tucked under the knee of the opposite leg is most common, but there are eight or 10 distinct variations of the cross-legged posture, some of which are practically limited to adepts trained in these special forms, as in Hindu or Buddhist temples. Cross-legged sitting was very common among Indians in the New World: it appears in ancient Mayan sculptures and mural paintings and in figurines and pottery of many tribes of North and South America. And of course people in modern Western culture sit cross-legged on occasion—either at work (*e.g.*, some tailors) or informally at parties and picnics. A sizable minority of adults in our culture retain sufficiently flexible joints and tendons to sit in this manner. But convention and clothing restrict the practice. Women are unlikely to sit cross-legged in mixed company if they are wearing short or tight-fitting skirts, but may do so in slacks, shorts or a full skirt.

Sitting on the floor with the legs stretched straight ahead or crossed at the ankles or knees is definitely a feminine posture, according to our survey. The



SOURCES OF INFORMATION used by Hewes are here mapped and rated for reliability. The data cover the postural habits of some 481 human cultural groups, ancient and modern, as well as postures used by the gibbon, orangutan, chimpanzee and gorilla.

reasons for its being sex-linked are not clear. Perhaps the habit was acquired because the position permits a woman to nurse a baby and at the same time carry on other tasks. Sitting in this manner fits in well with working on a belt-loom, mat-weaving, basketmaking and other crafts usually carried on by women in so-called primitive societies. The posture is particularly common in Melanesia and in Indian cultures of western North America.

Sitting on the heels with the knees resting on the floor is the formal sitting position for both men and women in Japan, and is the regular prayer position in the Islamic world and many other cultures of Eurasia. In Negro Africa, Mexico and parts of Indonesia this position is used mainly by women. Sitting with the legs folded to one side is a widespread feminine practice, both in "primitive" and highly developed civilizations: when chairs or benches are unavailable, women in our own culture frequently sit this way. The habit might be supposed to be dictated by narrow skirts, but it occurs among many peoples where no such clothing is worn.

The "cowboy squat," a semikneeling position with one knee up and the other down, represents another class of sitting postures which has an extremely wide and ancient distribution. Ancient Greek sculptures show the cowboy squat, often as a shooting position for archery, and bowmen are depicted in the same position in cave paintings of the Middle Stone Age in Spain. Crapshooters still work in this position. Versions of the posture are popular among the Australian aborigines, North American Indians and African Negroes. It is primarily a male position, rarely encountered among females.

The posture that has received the most attention from anthropologists, probably because it strikes us as most bizarre, is the so-called "Nilotic stance"—a storklike pose consisting of standing on one leg with the sole of the other foot planted against it somewhere in the knee region. It is a favorite stance of the tall tribesmen on the Upper Nile in the southern Sudan, and it crops up elsewhere in Africa, among hill folk in India, among the aborigines of Australia and among Indian tribes in South America. In the Sudan it is a common resting position for cowherds, who go barefoot and naked and therefore have no problem in assuming the posture. If they wore shoes and had to worry about getting clothing dirty, they would find it less convenient. The Nilotic stance is hardly likely to be adopted by a person wearing hobnailed boots or French heels. But it is a rarity in any case: there are a great many barefoot and naked or nearly naked peoples in the world who apparently would never dream of standing around on one leg.

Plainly a whole complex of factors—anatomical, physiological, psychological, cultural, environmental, technological—is involved in the evolution of the many different postural habits that the peoples of the earth have assumed. There are sex-linked factors, such as clothing, pregnancy, nursing and carrying a baby on the back, which lead to differences in the sitting positions of men and women. Clothing and footgear obviously affect the ways of sitting and standing, both for men and women. Nutrition plays a part, for the amount of fat in strategic places may determine whether squatting is comfortable or not. Styles of house construction have their influence: houses built on platforms or with porches, affording opportunities for dangling the legs over the edge, help develop sitting habits which call for furniture. Terrain and vegetation may determine sitting or standing habits out-of-doors. Herdsmen in regions of tall grass have to stand to watch their stock, while in a short-grass or tundra area the herder may sit or squat. Cold, wet or snowy ground does not invite sitting, but in dry areas people readily form the habit of resting directly on the ground. Occupational activities and techniques give rise to special postures: sitting positions

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and stances are affected by a people's tools and vehicles—*e.g.*, the loom, the implements for grinding food, the canoe or kayak, the longbow, the bicycle, the racing sulky.

It is conceivable that the handling of infants may shape their eventual posture, making some postures easy and others difficult. If tight swaddling or cradling, or being carried on the mother's back or hip for two or three years, can affect motor habits to anything like the extent that some investigators claim it affects the development of personality, significant cultural differences in posture should be traceable to these practices.

Probably the most interesting aspect of the whole subject is the question of cultural attitudes toward posture. Postural etiquette varies from culture to culture, and from one period to another. Religious taboos or concepts of decorum ban certain postures in a given culture. Some societies go to great lengths to ensure propriety in the manner of sitting, kneeling, bowing or standing on all public occasions, maintaining careful distinctions on the basis of sex, age and social status.

Western culture has undergone a relaxation of its postural code in the last several generations, and this change is reflected in the designs of furniture and clothing. The chairs of the 16th and 17th centuries, with vertical backs and hard seats, were remarkably uncomfortable by modern standards. The 18th century saw the introduction of curved chairs and couches, with soft upholstery. Along with this came much greater latitude for informal sitting postures—though costume styles, especially for women, prevented much genuine relaxation. In the 19th century Europe and America returned to fairly rigid postural standards, and it was not until about the period of the First World War that the avant-garde began taking to the floor at parties and the studio couch began to replace the settee. Certain segments of our culture, of course, preserve severe postural codes: for example, formal military drill, ceremonialized duties and some forms of religious worship. Correct "form" is also indispensable in calisthenics, classical ballet, fencing, golf and so on.

We train our children to conform to cultural norms of posture by verbal instruction, by actual physical positioning of the body in the "proper" posture for specific occasions and by ridiculing or otherwise punishing deviations. We may go so far as to denounce deviations as disrespectful, immoral or as evidence of

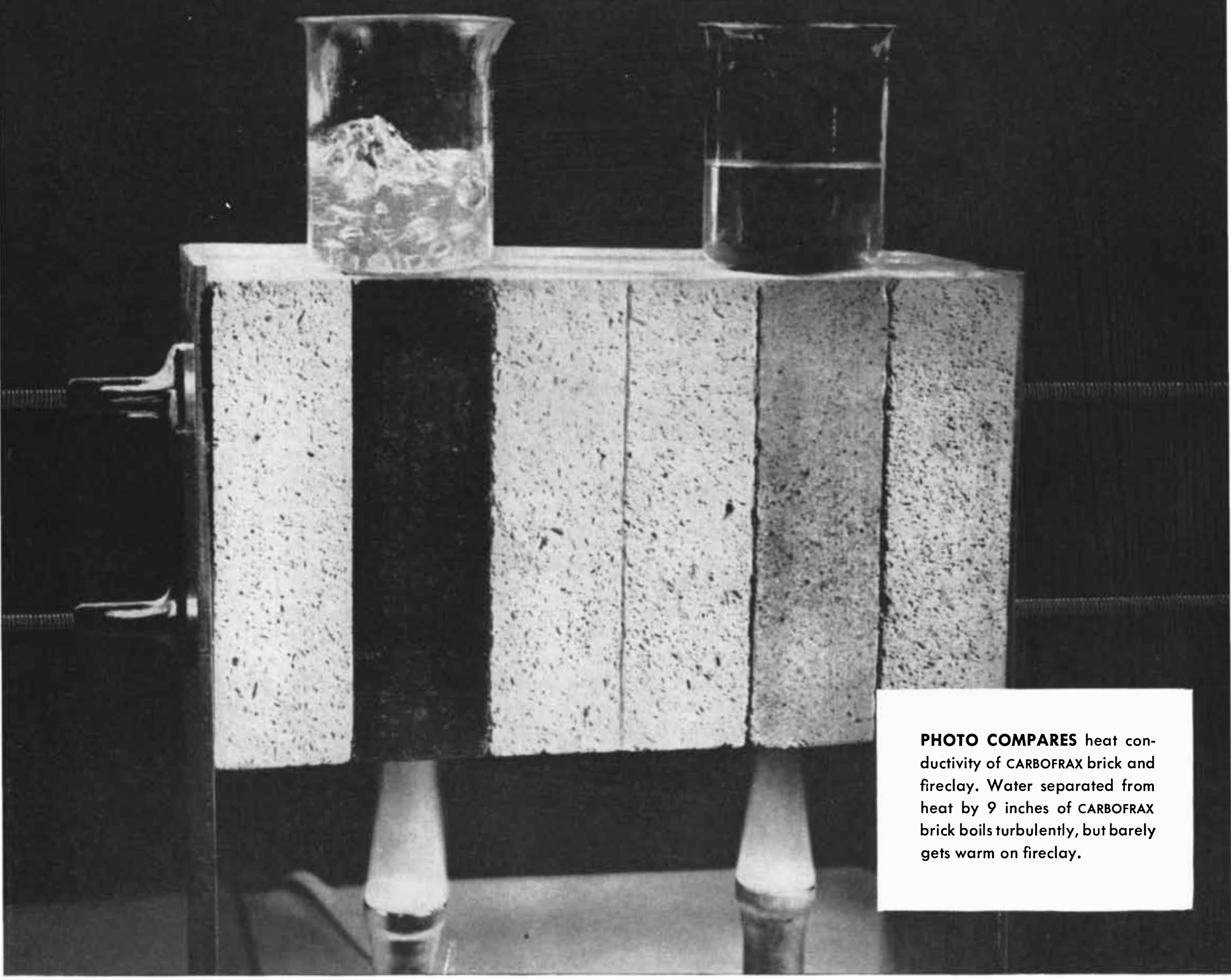

PHOTO COMPARES heat conductivity of CARBOFRAX brick and fireclay. Water separated from heat by 9 inches of CARBOFRAX brick boils turbulently, but barely gets warm on fireclay.

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City__________ Zone______ State__________ drunkenness or mental abnormality. Our language has terms that carry overtones of disapproval for postural noncomformity: *e.g.*, "sprawling," "slumping," "lounging," "cringing."

It seems quite clear that a better knowledge and understanding of postural habits could benefit us in many ways. At present nearly all our complex tools, instrument panels, control boards, benches, lathes, etc., have been planned for the use of people accustomed to the postural traditions of Western cultures. Human engineers might profitably consider a wider range of postures in planning for working or resting space requirements, not only because some of our traditional postures may be less efficient than those employed by Asians or Africans, but also because it might be easier to train our people to use a wider range of postures than to keep on trying to fit furniture designed for drawing rooms, throne rooms or banquet halls into crowded quarters. Some work has been done to adjust the human body to travel in very fast-moving aircraft (*i.e.*, the prone position has been found best). But we ought to go much further and explore the possible usefulness to us of the various cross-legged, squatting, kneeling and other postures which so many millions of people outside the orbit of Western civilization have found convenient for their daily work.

At a more basic level, the study of postural behavior could tell us much about functional relationships between postures and environment, about relationships between different cultures and about human history. One of the questions on which it might throw light is the biological evolution of man from our primate ancestors. The role of postural and motor-habit patterns in the processes of adaptation and selection which brought about changes in the shape of the pelvis, in limb proportions and in foot structure is one of the most important themes in our attempt to understand the emergence of man. It has been ably discussed by a number of anatomists, paleontologists and physical anthropologists, but so far not within the context of a coordinated program of postural research on all levels.

The well-known cultural anthropologist A. L. Kroeber once remarked that posture "is one of the most interesting matters in the whole range of customs." Even those who may not agree with this view must at least grant that we ought to learn a great deal more about human postural habits than we know at the present time.

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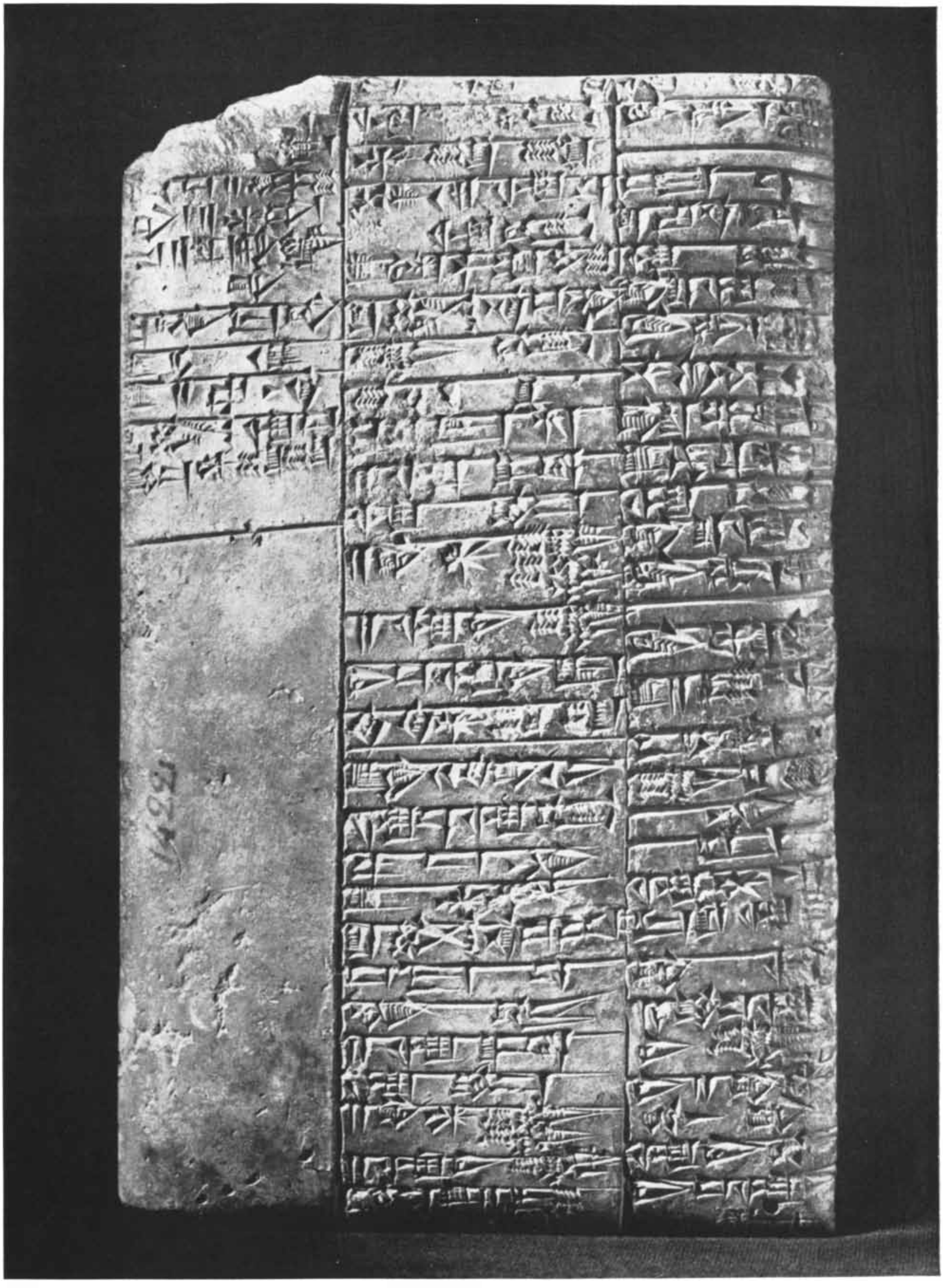

This cuneiform tablet, found in the ruins of Nippur, is the oldest known medical prescription

BOOKS

The story of the Mesopotamian civilization of Sumer, as told by its cuneiform tablets

by M. E. L. Mallowan

FROM THE TABLETS OF SUMER, by Samuel Noah Kramer. The Falcon's Wing Press ($5).

Sumer is the ancient name for the southern portion of the country now known as Iraq. Its boundaries were never exactly defined, but it embraced the broad alluvial belt between the rivers Tigris and Euphrates from the Persian Gulf north to the bottleneck where they converge to within 30 miles of each other. In this fertile plain the Sumerians developed a complex network of city-states, of which Kish, Nippur, Lagash, Erech, Ur and Eridu are perhaps the most familiar.

The Sumerians were a very intelligent people endowed with a forceful character which has left its imprint far beyond their homeland. Their enduring influence is all the more remarkable when we recall how long ago they lived and how small was the territory they administered. Their period of greatest flowering was between about 3000 B.C. and 2000 B.C. During that time the Sumerians developed the art of writing the cuneiform script. On imperishable clay tablets they left a rich literature which, together with that of Egypt, is the earliest transmission in the world of man's recorded thoughts. Toward the end of the third millennium B.C. peoples speaking Semitic languages, of whom the best known were the Babylonians, took over political domination of the country, and King Sargon of Agade established a new and more ambitious political dynasty. But these successors learned almost everything they knew from the Sumerians. Indeed, it is often difficult to say what part of their contribution was new, so deeply were they steeped in the older Sumerian culture. The Sumerian language, however, gradually died out, and within a few centuries had become a dead language, studied only by scribes and scholars. Yet Sumerian was still being studied in learned circles as late as the seventh century B.C., and the Assyrian king Assurbanipal organized a tablet hunt which rescued many a Sumerian text from oblivion and demonstrated how in almost every branch of learning the original contributions had come from Sumer.

This great body of learning made itself felt in many Near Eastern cities long after the last Sumerian king had ceased to reign. In geography therefore, as in time, their legacy was far-reaching.

Samuel Kramer, the author of this book on the Sumerian culture, is one of the world's leading Sumerologists. Thirty years of concentration, together with a natural bent for decipherment and linguistics, have given him an intimate knowledge of that civilized people. Perhaps only scholars can appreciate what such a quest involves: backbreaking labor often pursued into the small hours; prolonged straining of the eyes before the hand dare copy the signs; will power and mental stamina to stay with the task until it has been solved. Kramer also has the ability to write clearly about his discoveries. The book consists of a series of accounts of Sumerian literary tablets which he has deciphered, transcribed and translated. In each case he explains what the writings may mean in terms of the Sumerians themselves and in the progress of human thinking. The subjects treated by the tablets include Sumerian schools and education, civil war, justice, social reform, medicine, agriculture, ethics, proverbs, myths, epics and poems. Some of the texts may have been source books for parts of the Old Testament. The Sumerians were much given to the making of lists: as they acquired names, they wrote them down. Intelligent though these people were, it is clear that their intellectual development was in many ways at a comparatively unsophisticated, childlike stage in the growth of knowledge. "This is what I know; this is what I have collected," we can hear them saying to themselves. And so they wrote down the names of trees and stones in no order that could possibly be termed scientific.

The recovered tablets of Sumer run into tens of thousands. They are now scattered in many different museums, and thus enjoy a greater variety of access than if they were the monopoly of any single center. Kramer pays generous tribute to the learned Sumerologists of America, Europe and Asia whose combined efforts during a century of study have gradually extracted the meaning of the Sumerian tablets. There are still many obscure and untranslatable passages, but year by year one expression comes to illuminate another, a new Semitic reading makes some old Sumerogram comprehensible.

Most of Kramer's tablets come from Nippur, an early religious city which lay approximately in the center of Sumer. This site was first excavated in 1889 by a U. S. expedition, and between then and 1900 a rich collection was unearthed. In those days tribal warfare and banditry made digging hazardous; techniques were primitive; the strain of work in the field was so severe that John Haynes, the field director of the excavations, broke down. I well remember in 1926, when I was a junior assistant to Charles Leonard Woolley at Ur of the Chaldees, being called upon to examine packing cases which had been abandoned in a wayhouse 30 years before by the Nippur expedition. Field boots, cases of tinned meat, an ancient plate-camera, a few books and articles of clothing—these forlorn objects gave me a strange personal glimpse of the lonely Haynes and his co-workers, who had labored bravely without previous experience in a world utterly unfamiliar to them.

The great collection of Nippur tablets is one of the major sources of our knowledge of the Sumerian language and literature, thanks to Kramer's lifetime of work upon them, supplemented by decipherment of tablets from other sites and a pooling of knowledge with other scholars.

What sort of people, then, do the tablets show the Sumerians to have been? They were a practical people, extremely clever craftsmen, as has been learned from the excavation of their cities. There used to be a tendency to look on these early progenitors of civilization as living in a mysterious world, bound by religious taboos and magical inhibitions which were poles away from our modern way of thought. It is indeed true that their lives were severely regulated by fear of the gods and that their struggle against the forces of nature was conducted on lines very different from ours. But in their everyday life they thought and felt much as we do; they could have enjoyed much the same jokes. Kramer has two delightful chapters on the first schools and on what he calls the first case of "apple-polishing." One favorite Sumerian text, of which there are many versions, describes in some detail the life of a young schoolboy. He rose early, collected his round flaps of bread for lunch from his mother and hurried "with pounding heart" to reach the schoolhouse in time. If he was late or had failed to prepare his lesson, he was caned by the schoolmaster. Examinations were no less dreaded by him than by us. One tablet tells of the father of a backward student wining, dining and bribing the boy's teacher with expensive gifts. Sumerian headmasters enjoined their boys not to wander in the streets, not to stare at passersby, to show proper respect to their supervisors. The students, in the invariable tradition of schoolboys, sometimes engaged in fighting, and one tablet contains a list of invectives which passed between them—of which idiot, bungler and ape are among the milder expressions.

At Ur of the Chaldees, in an open unroofed courthouse, were found nearly 2,000 tablets, of which hundreds were school exercises written on flat, bun-shaped tablets. It is evident that scribes and pupils worked in the open air, like many of the Koranic schools of modern times, to take advantage of the best lighting. At Mari a school of much the same period was fitted with rows of brick benches, evidently intended for a young class, because only small knees could pass between them. A clay box contained shells which may have been mathematical counters, like the modern abacus.

Most enlightening are the Sumerian proverbs, preserved on tablets. Of such folk sayings Kramer justly observes: "More than any other literary products, they pierce the crust of cultural contrasts and environmental differences, and lay bare the fundamental nature of all men, no matter where and when they live." Through the Sumerian philosophy runs a marked strain of pessimism. Some of their writings sound like the characters of Theophrastus: there is the whiner ("I was born on an ill-fated day"), the neglected husband, the restless woman.

Why is it that the Sumerians, who possessed in their society many acute minds, never achieved that philosophic and scientific approach to life which characterized the Greeks, heirs to much of their learning? Kramer says of the Sumerian limitations: "The more mature and reflective Sumerian thinker had the mental capacity of thinking logically and coherently on any problem, including those concerned with the origin and operation of the universe. His stumbling block was the lack of scientific data at his disposal. Furthermore, he lacked such fundamental intellectual tools as definition and generalization, and had probably no insight into the processes of growth and development, since the principle of evolution, which seems so obvious now, was entirely unknown to him."

The main barrier that stopped the Sumerians from taking the intellectual steps which might have led to advanced concepts of science and philosophy was their anthropomorphic view of nature. They had much of the equipment for science. Classification and catalogues of a simple kind constantly preoccupied them; they were masters of the unitary method, highly skilled geometers whose learning was not exclusively applied to practical problems. Moreover the philosophical approach was not altogether unknown to them. But most interesting and significant was their list of what they believed to be the 100 fundamentals of civilization. All were comprised under an operative word, *me,* and they presented a picture essentially man-centered. The Sumerians conceived of the gods in the likeness of men, and their capricious behavior was thus wholly understandable. If the gods failed to extend to men the benefits which they could bestow, it was because man had sinned, and human sin was simply explained as pollution—an offense often contracted unwittingly, but nonetheless one which inevitably brought retribution and punishment. These fundamental theological concepts, embodied in an elaborate cosmology, were not questioned until nearly a thousand years after Sumerian became a dead language.

Thanks to archaeological work in Mesopotamia it has been possible to reconstitute the Sumerian way of life within the city-states, both from mate-

rial remains and from the complementary cuneiform records. The Sumerians created a brilliant architecture, built lavishly adorned temples, reached high accomplishment in the arts, especially in stone sculpture, and achieved triumphs of metallurgical skill. The royal tombs of Ur particularly were lavishly endowed with portable wealth, amongst which the small carvings of animals are perhaps supreme.

When did the Sumerian civilization begin? This topic is treated by Kramer in a chapter entitled "Man's First Heroic Age." He divides the history of cultural development in the lower Tigris-Euphrates Valley into five main stages: (1) a peasant-village culture, introduced by the Iranians from the East, which culminated in an urban and predominantly Semitic civilization; (2) arrival between 3250 and 3000 B.C. of invading Sumerian hordes, not yet literate, who took advantage of an era of "stagnation and regression" to conquer the country; (3) a "Heroic Age" of the conquering Sumerians, about 3000 to 2900 B.C., which is illustrated by their epic poems; (4) a protoliterate stage during which the people first applied the name Sumer to the region, developed a high level of architecture, the arts and administration and probably invented writing; and (5) a stage in which "the largely pictographic and ideographic" original script was molded "into a thoroughly conventionalized and purely phonetic system of writing," about 2700 to 2300 B.C.

In my opinion this extremely interesting account of Sumerian beginnings cannot be reconciled with the archaeological evidence, and is chronologically improbable because it compresses a complex series of material developments into a comparatively short span of time. Stage 1 is a purely artificial and hypothetical reconstruction. There is no good evidence for the suggestion that this earliest culture was introduced from Iran, though it is by no means unlikely that a Semitic element was present from the beginning. As for the second stage, nothing in the archaeological evidence warrants the assumption that there was an era of "stagnation and regression" at any early stage of the region's history. On the contrary, the rise of the cities of Ur, Erech and Eridu bear witness to a long period of uninterrupted development, especially in architecture and temple plans, which were essentially Sumerian in their layout. The early temple-building era represented by structures found at Erech can hardly have taken less than three or four centuries, which may well carry us back to at least 3500 B.C. for the beginning of the Sumerian communities. I should be inclined to assign the early development of writing to about 3250 to 3000 B.C., partly on account of a strong parallelism in the material culture of Egypt at a corresponding date. Finally, it appears that the "early dynastic" era of development of the Sumerian cities must have lasted at least five centuries (say from about 2900 to 2400 B.C.). All this argues for a longer chronology than Kramer allows for the Sumerian occupation of lower Mesopotamia.

We may never know when the Sumerians first entered their homeland, how they came, or from where. Kramer's chronology seems to me wrong, considering all the evidence. Nonetheless, any scholar or reader must be grateful to him for the light he has thrown on the Sumerian culture itself, and above all for having written a fascinating book.

Short Reviews

Trolley Car Treasury, by Frank Rowsome, Jr. McGraw-Hill Book Company, Inc. ($5.95). Once upon a time streetcars were not diners. The trolley will soon be only a memory, but not long ago it was the principal conveyance of millions of Americans—their sturdy transport to and from work, their carriage when they visited friends, their vehicle of pleasance when they took the air in the evening, explored the city, went to the ball or beer park on Saturday or to the beach on Sunday. The story of the rise and decline of the U. S. trolley is told in this richly illustrated, highly entertaining book. In the 1880s there were 500 horse railways in 300 cities and towns of the U. S., powered by 100,000 animals. The horsecars changed the patterns of city growth. A workman could commute six or eight miles instead "of being tied to a tenement close to his job." The cars themselves evolved with the times. There were double-deckers, open cars, extra-fare parlor cars for "refined passengers." Mail, freight, sheep, chickens, sand and gravel were carried in special cars. One could rent a horsecar for a wedding or an outing, and one could look forward to the final journey in a black-curtained horsecar, manned by a driver of "guaranteed decorum." Then mechanization took command and the horsecar became the horseless car. The first choice was steam, but it was not a good choice. Steam trolleys were noisy, billowed smoke, scattered soot, alarmed passengers and caused horses to run away. To meet the last of these nuisances, engineers designed a little four-wheeled loco-

B. Ellis (center), head of the Propulsion Department, discusses methods of accurate thrust termination for a ballistic rocket with Dr. Howard M. Kindsvater (left), propulsion staff engineer, and André P. Bignon, propulsion research specialist.

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motive for towing the cars which was camouflaged by a boxy false body and had aprons over the connecting rods on the wheels to conceal them "from the sensitive equine gaze." This gave the horses peace of mind but not the passengers. Moreover, the steam dummy was too costly, heavy and dirty. The next step was to make a "fireless locomotive," driven by superheated water, but it was never satisfactory. Compressed-air cars were tried; also trolleys driven by air pressure drawn from underground pipes, by ammonia, by naphtha, by stern-wheel paddles (which had imitation hoofs that pawed the paving stones), by spring motors, by storage batteries, by underground moving cables. The cable car thrived for years. It was a conveyance which, as a Chicago cable car company executive boasted, "has no will of its own to thwart the will and efforts of its faithful driver." The faithful driver was known as a "gripman." He had to be skillful as well as strong to operate the big levers that gripped and disengaged the thick cable. He had to know when to let go and coast, when to get up speed. He developed a special vocabulary of cries, the most famous of which was a hoarse "Kowfadakuv!" ("Look out for the curve!"). Riding a cable incline up a steep hill was thrilling; in San Francisco the ride up Nob Hill is still a tourist attraction. But the main development in trolley history was, of course, the electric car, deriving its power from overhead wires or from a rail in a slotted conduit beneath the surface. "Sparkers," as they were called, began to appear in the 1870s. Baltimore saw the first established electric line, built by an Englishman named Leo Daft. Other pioneers were Charles J. Van Depoele and Frank Sprague, whose cars were startlingly good. New Orleans had a streetcar named *Desire*. There were poems and songs about the trolley, among them:

I am coming, I am coming,
hark you hear my motor humming.
For the trolley's come to conquer,
so you cannot keep it back;
And Zip! the sparks are flashing,
as the car goes onward dashing
While the wheels are whirring smoothly
along a perfect track.

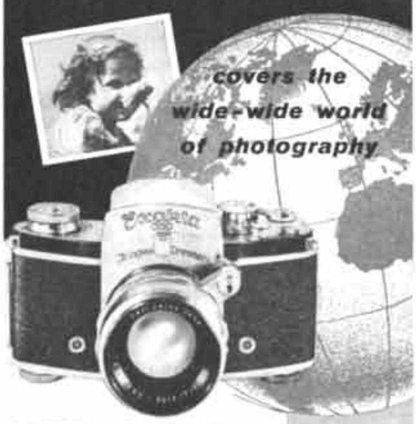
In 1900 there were 15,000 miles of electrified track in the U. S. and more than 30,000 trolleys. By 1919, having survived the first competitive brush with auto jitneys, trolleys were toting passengers at the rate of 11.3 billion annually over 45,000 miles of track. But the trolley was already on its way downhill. It was no match for gasoline engines that were even moderately dependable. Subways took a big chunk out of the trolley business in big cities. Buses began to take over, and the private automobile. The number of trolley riders dwindled. Streetcar systems fell into financial difficulties. Equipment deteriorated. By the late 1920s many localities were holding sad ceremonies over the last run of their trolley cars. Trolley yards became crematoria, where, after the steel was salvaged, the frames were set to the torch. A few lines are still left, but the Golden Age has vanished. Now there are trolley museums where classic specimens, from the Toonerville to the dashing interurban, are enshrined. There are also trolley-diners, but most of these were never really trolleys: they are only reproductions intended to awaken in the older patrons the warm, snug feeling that only this noble vehicle could instill.

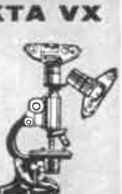
NEW LIVES FOR OLD, by Margaret Mead. William Morrow & Company ($6.75). In 1928 Miss Mead spent some months on the south coast of Great Admiralty Island, popularly known as Manus, lying in the South Pacific a little north of New Guinea. The problem she went to study was whether children in primitive societies were "as animistic and magical in their thinking as they were said to be in Europe." The report of that work appeared in her book *Growing Up in New Guinea*. In 1953 Miss Mead returned to Manus to learn what transformations in culture had taken place, what changes had occurred in 25 years among a people who, it was reported, had more drastically altered their ways and had made a more radical advance than any other of the peoples of the Pacific. This book is an account of her second visit. Miss Mead was able to re-establish contact with some of the very same persons with whom she had lived in 1928. The grown-ups she now observed were the children she had known; their surviving parents were the elders of the community. She could trace the exact lineaments of change, study individuals rather than compile statistics, investigate how and why persons with different characteristics had modified their lives in the small and intimate details, in economic practices, in basic social and ethical outlook and institutions. The great changes in the world during the intervening quarter century would not in themselves have been expected to affect profoundly the culture of these remote people. However the Second World War had had a considerable impact on them. A million

U. S. troops had poured through the Admiralty Islands. The Manus had seen the astonishing tools, machines, equipment and organization of the military forces; they had observed the social habits and relations of U. S. soldiers, the "behavior of one American to another." All this came at a time when the Manus were hungry for change. They had finally come to realize that they were warped into a wretched framework of existence. They were eager to find something better, and the ways of our society, built on change, caught the people's imagination. They were prepared, says Miss Mead, to abandon the entire primitive pattern of their society: "not merely patch and botch the old way of life with corrugated iron or discarded tin cans," but adopt new ways so that they and their children might share "in the benefits the great civilizations have made possible for mankind." It was not merely a matter of replacing G-strings with white ducks, of cultivating new tastes, of taking up new techniques and embracing a new religion. All these were involved, but much more besides. "The people of Peri all changed together as a unit—parents, grandparents and children—so that . . . they could move into a new kind of village, live in new kinds of houses, participate in a new form of democracy, with no man's hand against another, no child alienated from the self or from the others." In the last 25 years, says Miss Mead, the Manus have "skipped over thousands of years of history." Their lives had been hard, custom-ridden, full of bitter conflict and frustration; they have now eliminated some of the evils of the past, have become more self-respecting, self-determining and hopeful. Miss Mead attempts an assessment of what this accomplishment signifies to us and others of the Western world. By studying the Manus, she says, we can learn to renew our respect for democratic civilization, for values which we are too apt to take for granted, if not indeed to depreciate. Miss Mead is a self-centered observer and inclined to make more of her findings than the evidence seems to justify. The book is verbose, didactic and not infrequently pretentious. But there is material in it which deserves wide attention.

MAN'S ROLE IN CHANGING THE FACE OF THE EARTH, edited by William L. Thomas, Jr. The University of Chicago Press ($12.50). A good symposium is hard to bring off. It is a form which by its very nature lacks unity; it is apt to sprawl and its parts overlap; the subject matter is oftentimes not so much encompassed as merely covered with patches. This immense work—some 1,200 closely printed double-column pages—suffers from all these defects, yet there is treasure in it. The editor describes the theme as a first attempt to provide an "integrated basis for . . . an insight to understand what has happened to the earth under man's impress." Never mind the overblown definition of the undertaking, there are several solid contributions to knowledge and a few which are lit with imagination. The symposium, organized by the Wenner-Gren Foundation for Anthropological Research, was held in Princeton in 1955. Participants came from all parts of the world and represented many disciplines. A geographer discussed the "changing ideas of the habitable world," an anthropologist the "world expansion of human culture," a historian the use of the grasslands of North America, a fishery specialist the "harvest of the seas," a meteorologist the subject of artificial rainfall, a zoologist the role of man in the spread of organisms, a biologist the effects of fission products on the earth and on living species, a sanitary engineer the disposal of man's wastes, a botanist the processes of environmental change by men, a housing authority recreational land use, an oil geologist the age of fossil fuels. Among the most interesting of the some 50 papers are those dealing with future prospects—the population spiral, the limits of raw-material consumption, the limitations to energy use, the threat of "technological denudation." The future, as Lewis Mumford points out in one of the summaries, is not a blank page, nor is it an open book. Man has gone far in increasing his control over nature, and through these increments of power he has done both good and harm to the face of the earth and to himself. Unless he is prudent and shows a respect for life, his tenancy is not likely to be pleasant and perhaps not even much prolonged.

PHYSICS IN MY GENERATION, by Max Born. Pergamon Press ($6.50). Max Born is an engaging and lucid writer as well as a distinguished physicist. In this volume are collected a number of his addresses and articles. He describes the essays as popular, which is not to be accepted without mild reserve. Still, they offer much to readers of even moderate scientific competence. The first selection is the introduction to Born's *Einstein's Theory of Relativity*, published in 1921; the last is the postscript to his *The Restless Universe* of 1951. There are articles





on quantum mechanics, philosophical aspects of modern physics, Einstein's statistical theories, the uncertainty relationship, the evolution of physical concepts. Thus one may trace in this book the revolutionary and fateful changes in scientific thought over the last three decades. Born observes that his own attitude has undergone a startling transformation in this period. In his early years he believed, as did most of his contemporaries, that science afforded an objective knowledge of a world governed by deterministic laws: "I even thought the unambiguous language of science to be a step towards a better understanding between human beings." Today he is sadder and wiser. Determinism has gone out the window, the border between object and subject is blurred, and although physicists "understand one another well enough across all national frontiers, they have contributed nothing to a better understanding of nations but have helped in inventing and applying the most horrible weapons of destruction." While he now regards his former confidence in the superiority of science over other forms of human thought and behavior as "a self deception due to youthful enthusiasm," he clings to his faith in science "in the search for truth and a better life." Indeed, he makes the specific point that Niels Bohr's grand principle of complementarity, which has effected a reconciliation of apparently contradictory and mutually exclusive situations of physics, provides "a healthy way of thinking" which may be applied fruitfully to the violent disputes and apparently irreconcilable positions in other spheres of life—politics as well as philosophy.

LECTURES ON ROCK MAGNETISM, by P. M. S. Blackett. The Weizmann Science Press of Israel ($5). This volume contains the Second Weizmann Memorial Lectures given at Rehovoth in December, 1954. Blackett says that his interest in rock magnetism was first aroused by a 1948 paper of three U. S. scientists (E. A. Johnson, T. Murphy and O. W. Torreson) which showed that it was possible to trace back the history of the earth's magnetic field "far beyond historic times by the measurement of the weak magnetism of certain sedimentary rocks." This lengthening of the measurable record was of course a discovery of first-rate importance for the effort to understand the physical mechanism producing the earth's field and for tracing its changes. Experimental work based on the discovery has yielded results as beautiful as they were unexpected. For example, it was found that a large number of rocks of widely differing types and ages are magnetized "in roughly the opposite direction to that of the [earth's] present field." This, together with many other observations, suggests that the earth's field has been completely reversed many times in the past. One of the ways in which rocks, igneous rocks in particular, acquire their magnetism is by "thermomagnetic remanence" (*i.e.*, during cooling through their curie temperature), and wherever this is the ruling process, the rock is magnetized in the direction of the earth's local field at that time. Taking this as their point of departure, investigators have devoted themselves to testing the "much discussed and highly controversial" theories of continental drift and of polar wandering. Blackett's well-written survey tells a remarkable story of the research on rock magnetism and what it has disclosed about the history of our planet.

WREN AND HIS PLACE IN EUROPEAN ARCHITECTURE, by Eduard F. Sekler. The Macmillan Company ($12). This distinguished book by a Viennese scholar and architect who spent many years in Britain presents a thoughtful analysis of Wren's work as an architect, of the development of his style and its relation both to his intellectual background and the culture in which he lived. The volume is admirably illustrated with Wren's own drawings, reproductions from contemporary sources and many photographs.

INFORMATION THEORY, edited by Colin Cherry. Academic Press Inc. ($11.50). The 35 papers in this volume were presented originally at the Third London Symposium on Information Theory held at the Royal Institution in 1955. One is struck by the extraordinary range of subjects into which the theory has poked its nose. Besides discussing the fundamentals of information theory, these papers expand its applications to no fewer than a dozen disciplines, from optics and linguistics (*e.g.*, "Negative Entropy of Welsh Words") to semantics, physiology and psychology.

OEUVRES DE LAVOISIER: CORRESPONDANCE, edited by René Fric. Albin Michel (no price given). This is the first of two volumes, published with the financial help of UNESCO, which will present all the known correspondence of the famous chemist Antoine Lavoisier. It cannot be said that the letters are of great interest to general readers, but to historians of science and students of Lavoisier's life they are undeniably important. Louis de Broglie in a preface to the collection reminds us of Lavoisier's extraordinary versatility and energy. Besides being a foremost chemist, he turned his attention at various times to physics, mathematics, geology, biology, finance, economics, agriculture and government. The letters reflect his many-sidedness and his tireless capacity for work. A major group covers a trip he made to Alsace-Lorraine in 1767 with a geologist on a mineralogical survey; another batch of correspondence describes his activities on behalf of the Farmers-General (which cost him his head in the French Revolution). In the letters Lavoisier touches on such matters as the physiology of snails, the adulteration by local merchants of tobacco with water, the character of various petty local officials of the Farmers-General, the health of his horse, the appearance of the countryside, the chemical composition of mineral water, an aurora display seen in Rheims, the cost of living in an Alsatian village, the parsimonious diet of sundry affluent cowherds, who ate neither meat nor bread but subsisted on cheese, milk and, much to Lavoisier's horror, water instead of wine.

AMERICAN MEN OF SCIENCE, VOL. III: THE SOCIAL & BEHAVIORAL SCIENCES, edited by Jaques Cattell. R. R. Bowker Company ($20). This volume completes the ninth edition of *American Men of Science*, which for the first time divides the biographies of scientists into three volumes in place of the traditional one. In the preface Cattell points out that this volume on the social sciences is neither as large nor as complete as its counterparts in the physical and biological sciences—understandable because this is the first venture of its kind in the sphere of social studies. Even so, as it stands, it is a most useful addition.

WEATHER ANALYSIS AND FORECASTING, VOLS. I AND II, by Sverre Petterssen. McGraw-Hill Book Company, Inc. ($14.50). This standard work by a well-known meteorologist is issued in a thoroughly revised second edition to incorporate advances of the past 15 years. Petterssen writes with exceptional lucidity, and his book will serve both as a text and as a manual for professional meteorologists.

Notes

DISCOVERY OF THE ELEMENTS, by Mary Elvira Weeks. Journal of Chemical Education ($10). The sixth edition

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of this most useful compendium has been enlarged and revised by Henry M. Leicester and contains an additional chapter by the editor on elements discovered by atomic bombardment.

Automatic Digital Computers, by M. V. Wilkes. John Wiley & Sons, Inc. ($7). The director of the Cambridge University mathematical laboratory presents a general introduction to the principles underlying the design and use of digital computers. Illustrated with plates and diagrams.

Wing Theory, by A. Robinson and J. A. Laurmann. Cambridge University Press ($13.50). A monograph on airfoil dynamics from both the practical and the theoretical points of view.

What Is Life? and Other Scientific Essays, by Erwin Schrödinger. Doubleday Anchor Books (95 cents). This paperback volume includes the author's celebrated little book on the nature of life, chapters from other books and the provocative essay "Are There Quantum Jumps?"

Sodium: Its Manufacture, Properties and Uses, by Marshall Sittig. Reinhold Publishing Corporation ($12.50). An American Chemical Society monograph.

Progress in Cosmic Ray Physics, Vol. III, edited by J. G. Wilson. Interscience Publishers, Inc. ($10.50). Surveys of experiments.

Molecular Beams, by Norman F. Ramsey. Oxford University Press ($12). A detailed and up-to-date survey of the experimental and theoretical sides of the subject.

Immigrants and Their Children, 1850-1950, by E. P. Hutchinson. John Wiley & Sons, Inc. ($6.50). Professor Hutchinson's book is an analysis of the immigrants' role, so far as statistics can illuminate it, in the development of the U. S. A valuable social study.

Common Exotic Trees of South Florida, by Mary F. Barrett. University of Florida Press ($8.50). This handsome illustrated monograph describes what amounts to "an open-air museum of trees from all the continents that have tropical or subtropical climates."

The Fighting Cheyennes, by George Bird Grinnell. University of Oklahoma Press ($5). A reissue of a classic work

describing the heroic but inevitably futile attempts of the Cheyennes to maintain their freedom.

THE THEORY OF GROUPS, by A. G. Kurosh. Chelsea Publishing Company ($9.90). A two-volume English translation of a comprehensive work on the general theory of groups by a noted Soviet mathematician.

PROGRESS IN PSYCHOTHERAPY, edited by Frieda Fromm-Reichmann and J. L. Moreno. Grune and Stratton ($8). Articles reviewing the current work of various psychotherapeutic schools.

PHYSICS AND CHEMISTRY OF THE EARTH, edited by L. H. Ahrens, Kalervo Rankama and S. H. Runcorn. McGraw-Hill Book Company, Inc. ($8). This volume begins a new series devoted to surveys by leading specialists of progress in geophysics and geochemistry.

A HISTORY OF SWEDEN, by Ingvar Andersson. Frederick A. Praeger ($7.50). A translation of a most readable and authoritative history.

THE STATE OF THE SOCIAL SCIENCES, edited by Leonard D. White. The University of Chicago Press ($6). This volume consists of 32 essays by American social scientists, delivered at a congress held at the University of Chicago in November, 1955. The subjects include anthropology, economics, political science, sociology, psychology, history, psychoanalysis.

THERAPEUTIC USES OF ARTIFICIAL RADIOISOTOPES, edited by Paul F. Hahn. John Wiley & Sons, Inc. ($10). Twenty-nine specialists contribute research papers on the uses of radioisotopes in the treatment of various disorders.

QUANTUM FIELD THEORY, by Hiroomi Umezawa. Interscience Publishers, Inc. ($9.75). The author, professor of physics at the University of Tokyo, discusses relativistic field equations and particles.

A FIELD GUIDE TO THE FERNS, by Boughton Cobb. Houghton Mifflin Company ($3.75). An illustrated pocket book of Northeastern and Central North American ferns and related families.

HISTORICAL ATLAS, by William R. Shepherd. Barnes & Noble, Inc. ($12.50). This classic atlas has long been out of print. As reissued it contains, in addition to all the original maps, a supplement for the period since 1929.

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U. S. Navy Photo

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◀ **FJ-3 Fury goes aloft** from one of the after catapults of the U.S.S. Forrestal. An F2H-3 Banshee is in the foreground. Electronics developed by BuAer's Avionics Division provides planes such as these with their highly effective weapons and control systems.

▲ **Engineer at Ford Instrument Company** opening salt spray chamber in which equipment for BuAer is being subjected to environmental test.

This is one of a series of ads on the technical activities of the Department of Defense.

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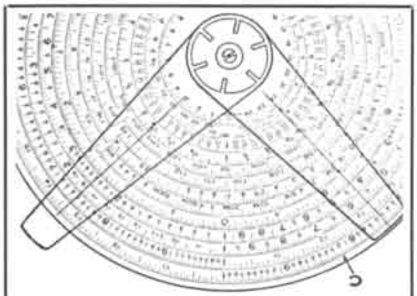


MATHEMATICAL GAMES

An assortment of maddening puzzles. Warning: The solutions will not be given until March

by Martin Gardner

Mathematical brain teasers are an ancient sport, and really good new ones do not come along very often. A puzzle of this genre must be simple enough not to require elaborate calculation yet difficult enough to tax a clever mind. Its solution should have elegance as well as surprise. The best ones seem very difficult but yield their solutions easily to a happy insight, with much gratification to the ego.

I have collected nine brain teasers which may be relatively fresh and not known to many readers. The answers will be published here next month.

1.

An old riddle runs as follows. An explorer walks one mile due south, turns and walks one mile due east, turns again and walks one mile due north. He finds himself back where he started. He shoots a bear. What color is the bear? The time-honored answer is: "White," because the explorer must have started at the North Pole. But not long ago someone made the discovery that the North Pole is not the only starting point that satisfies the given conditions! Can you think of any other spot on the globe from which one could walk a mile south, a mile east, a mile north and find himself back at his original location?

2.

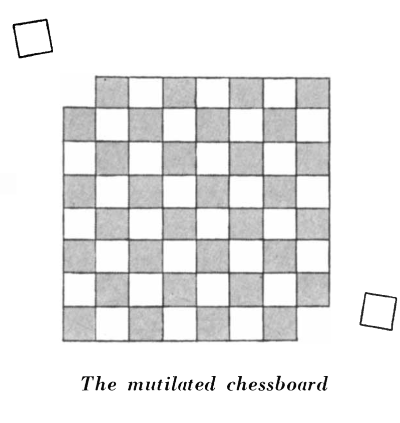
Two men play a game of draw poker in the following curious manner. They spread a deck of 52 cards face up on the table so that they can see all the cards. The first player draws a hand by picking any five cards he chooses. The second player does the same. The first player now may keep his original hand or draw up to five cards. His discards are put aside out of the game. The second player may now draw likewise. The person with the higher hand then wins. (There is one exception from ordinary poker values: all the suits are given equal value, so that two flushes tie unless one is made of higher cards.) After a while the players discover that the first player can always win if he draws his first hand correctly. What hand must this be?

3.

The props for this problem (which the mathematician Max Black published in his *Critical Thinking*) are a chessboard and 32 dominoes. Each domino is of such size that it exactly covers two adjacent squares on the board. The 32 dominoes therefore can cover all 64 of the chessboard squares. But now suppose we cut off two squares at diagonally opposite corners of the board [*see diagram below*] and discard one of the dominoes. Is it possible to place the 31 dominoes on the board so that all the remaining 62 squares are covered? If so, show how it can be done. If not, prove it impossible.

4.

Here's a fairly recent twist on an old type of logic puzzle. A logician vacationing in the South Seas finds himself on an island inhabited by the two proverbial tribes of liars and truth-tellers. Members of one tribe always tell the truth, members of the other always lie. He comes to a fork in a road and has to ask a native bystander which branch he should take to reach a village. He has no way of telling whether the native is a



The mutilated chessboard

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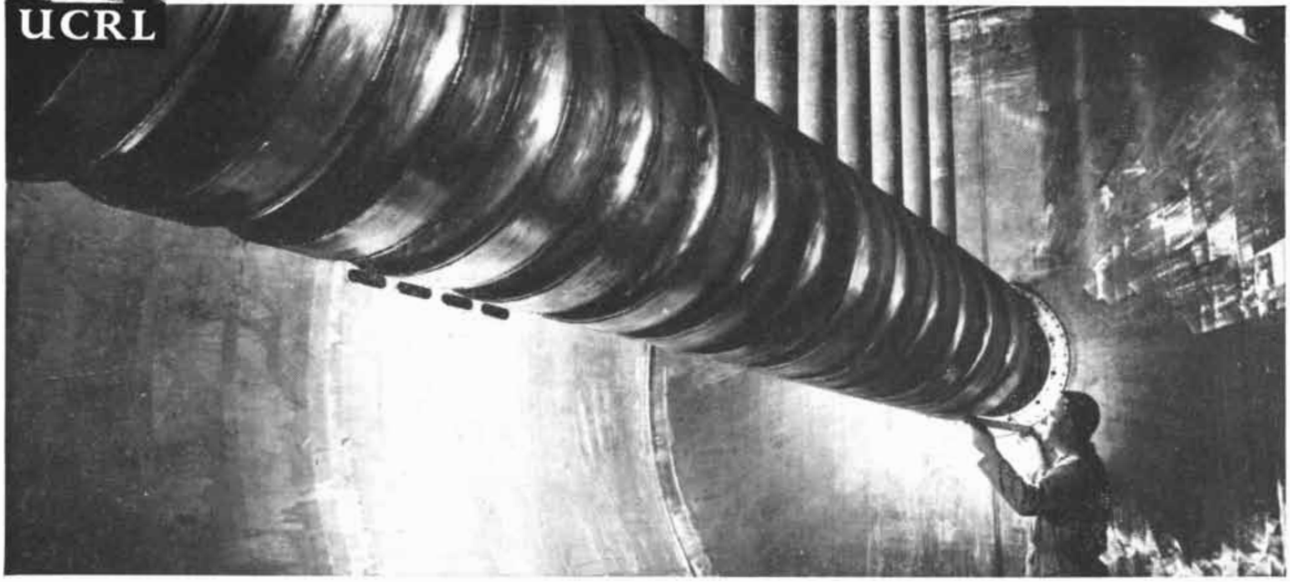

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*City*__________*Zone*_____*State*__________ truth-teller or a liar. The logician thinks a moment, then asks *one* question only. From the reply he knows which road to take. What question does he ask?

5.

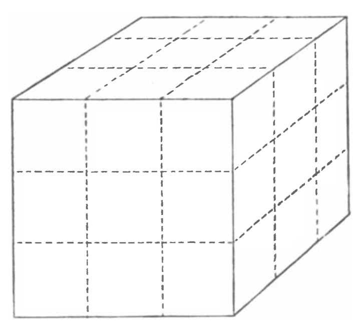
Imagine that you have three boxes, one containing two black marbles, one containing two white marbles, and the third, one black marble and one white marble. The boxes were labeled for their contents—BB, WW and BW—but someone has switched the labels so that every box is now incorrectly labeled. You are allowed to take one marble at a time out of any box, without looking inside, and by this process of sampling you are to determine the contents of all three boxes. What is the smallest number of drawings needed to do this?

6.

A young man lives in Manhattan near a subway express station. He has two girl friends, one in Brooklyn, one in The Bronx. To visit the girl in Brooklyn he takes a train on the downtown side of the platform; to visit the girl in The Bronx, on the uptown side of the same platform. Since he likes both girls equally well, he simply takes the first train that comes along. In this way he lets chance determine whether he rides to The Bronx or to Brooklyn. The young man reaches the subway platform at a random moment each Saturday afternoon. Brooklyn and Bronx trains arrive at the station equally often—every 10 minutes. Yet for some obscure reason he finds himself spending most of his time with the girl in Brooklyn: in fact on the average he goes there nine times out of 10. Can you decide why the odds so heavily favor Brooklyn?

7.

A carpenter, working with a buzz saw, wishes to cut a wooden cube, three



Cutting the cube

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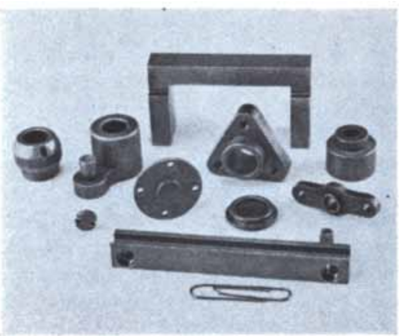


Small parts manufactured by the sintered metal technique.

In his technical paper, "The Use of Sintered Metal Parts in IBM Products," Athan Stosuy of the Poughkeepsie Product Development Laboratory cites the details behind the two major reasons for the company's interest in sintered metals—economics and machine improvement.

In addition to illustrating a number of sintered metal applications, the author details several special functions of sintered metal products—magnetic cores, the "memory" units for electronic computers, for example—and outlines the typical procedures used at IBM to maintain the highest possible standards of quality and usefulness of sintered metal parts.

Mr. Stosuy's paper was presented at the Metal Power Association meeting at Cleveland on April 11, 1956. Write for IBM Bulletin No. 600.

Connections are important

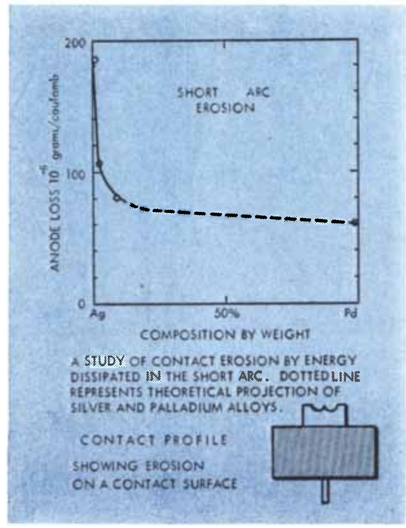
"What won't they think of next?" is a question that can certainly be applied to electronic computers. At the Product Development Laboratory, though, we more often say "What did they think of *this* morning?" We keep up with the newest things this way. Such things, for instance, as a special three-dimensional printed wire back panel for interconnecting circuit packages. This new panel has helped lick two problems in the application of printed wiring techniques to complex computing machines. These problems were the design of individually printed circuit cards for economical mass-production, and the interconnection of these printed wiring packages.

IBM's E. R. Wyma explains how this has been accomplished in his recent paper, "The Three-Dimensional Printed Back-Panel." He begins with a section devoted to "Back Panel Design Requirements," then proceeds to the "Three-Dimensional Array" itself, in which circuit connections are made by terminating the machine's printed wiring cards at a large printed panel—a big step, obviously, in machine simplification, cost reduction, and time saving.

"The purpose of this paper is to show how the three-dimensional printed circuit concept satisfies the requirement for flexible design of the panel and permits mechanized production of the connecting devices." Write for IBM Bulletin No. 601.

Contact erosion studies

To see what could be done to meet the vital need for more reliable electrical components such as circuit breakers and relays, a contact studies team headed by Dr. William B. Ittner, III, was organized in IBM's Product Development Laboratory at Endicott, New York. The group studied the electrical and metallurgical phenomena affecting contact life and performance.



There were three distinct types of arcs where investigations were most needed: the short arc, the normal arc, and the high-powered arc. During the investigation, pure forms and alloys of palladium, copper, platinum, silver, tungsten and other materials were tested. The fundamental behavior characteristics of these arcs were observed to determine bridging and erosion by such arcs on all types of contact materials. Measurements of anode and cathode erosion or bridging were also made.

When all the facts were in, the group made specific recommendations for metals and alloys to be used in IBM relays, circuit breakers, and contact points for particular circuit parameters.

Full details are described in IBM Bulletin No. 602.

●RESEARCH at IBM means IDEAS at work. For bulletins mentioned above, write International Business Machines Corp., Dept. SA-22, 590 Madison Avenue, New York 22, New York.

IBM DATA PROCESSING

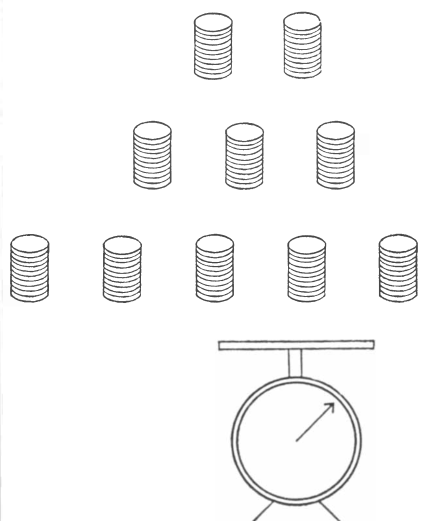
DATA PROCESSING • ELECTRIC TYPEWRITERS • TIME EQUIPMENT • MILITARY PRODUCTS inches on a side, into 27 one-inch cubes. He can do this easily by making six cuts through the cube, keeping the pieces together in the cube shape. Can he reduce the number of necessary cuts by rearranging the pieces after each cut?

8.

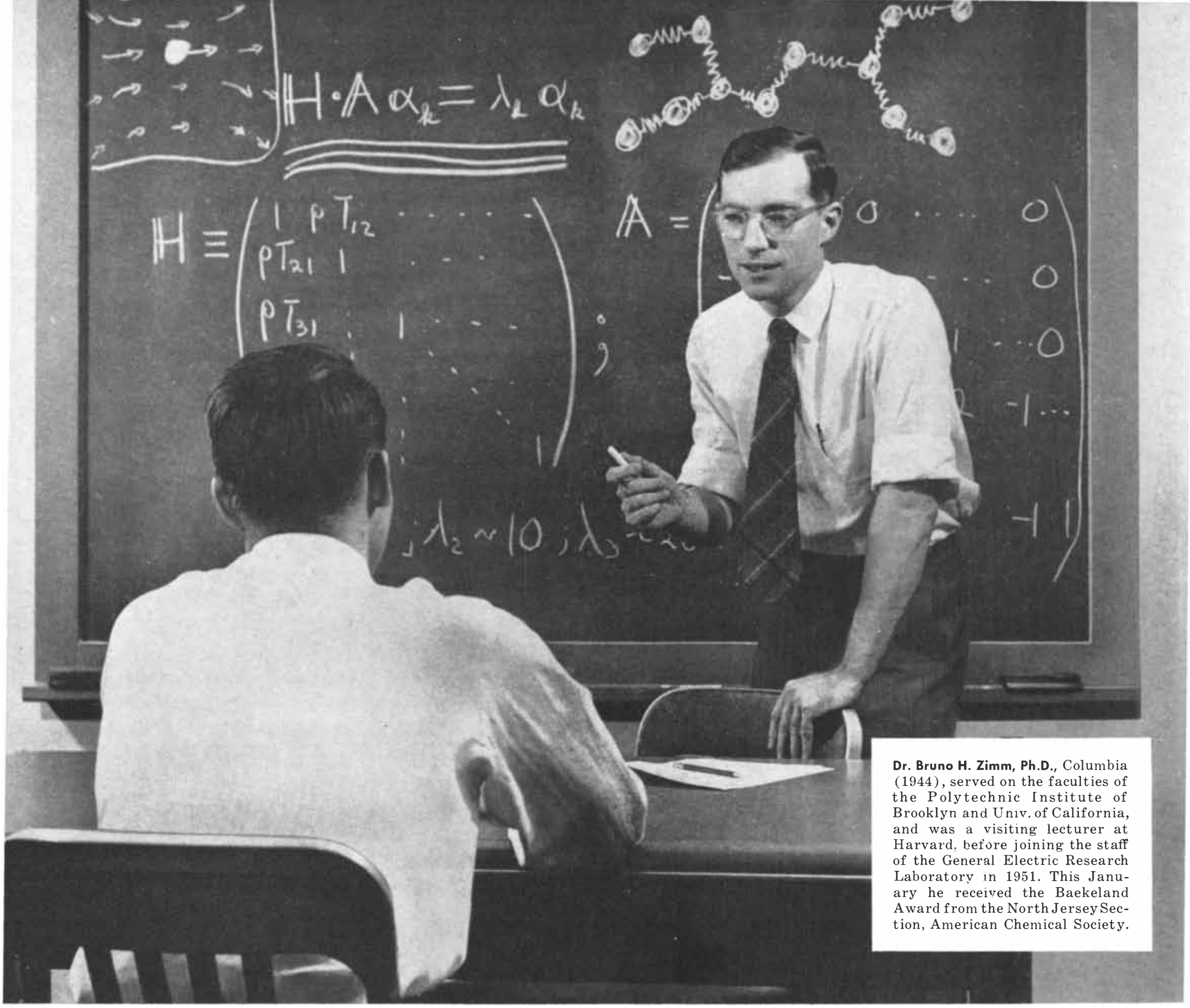
A commuter is in the habit of arriving at his suburban station each evening exactly at five o'clock. His wife is always waiting for him with the car to drive him home. One day he takes an earlier train, arriving at the station at four. The weather is pleasant, so instead of telephoning home he starts walking along the route always taken by his wife. They meet somewhere on the way. He gets into the car and they drive home, arriving at their house 10 minutes earlier than usual. Assuming that the wife always drives at a constant speed, and never varies her route, can you determine how long a time the husband walked before he was picked up?

9.

In recent years a number of clever coin-weighing or ball-weighing problems have aroused widespread interest. Here is a new and charmingly simple variation. You have 10 stacks of coins, each consisting of 10 half-dollars. One entire stack is counterfeit, but you do not know which one. You do know the weight of a genuine half-dollar and you are also told that each counterfeit coin weighs one gram more than it should. You may weigh the coins on a pointer scale. What is the smallest number of weighings necessary to determine which stack is counterfeit?



The counterfeit coins



Dr. Bruno H. Zimm, Ph.D., Columbia (1944), served on the faculties of the Polytechnic Institute of Brooklyn and Univ. of California, and was a visiting lecturer at Harvard, before joining the staff of the General Electric Research Laboratory in 1951. This January he received the Baekeland Award from the North Jersey Section, American Chemical Society.

Learning more about molecules

General Electric's Dr. Bruno H. Zimm attacks the problems of polymer chemistry both as theoretician and experimentalist

The *weight* of molecules is more easily determined than their *size* and *shape*, but an understanding of these latter properties is equally essential in the designing of plastic materials.

At the General Electric Research Laboratory, Dr. Bruno H. Zimm and his associates are using the most recent techniques for studying molecules by projecting light beams through polymer solutions. How the light is scattered, its intensity at various angles, and similar observations have been related to the shape and dynamic properties of polymer molecules and thus to the eventual characteristics of plastic materials: strength, insulating properties, and flexibility.

For such experimental work, and for theoretical contributions to the understanding of how polymer chain molecules react when stress is applied, Dr. Zimm recently received the Baekeland Award of the American Chemical Society.

At General Electric, such research is motivated by a belief that providing scientists with the tools, the incentives, and the freedom to seek out new knowledge is the first step toward progress for everyone.

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GENERAL ELECTRIC

THE AMATEUR SCIENTIST

How a young amateur mastered the carbon-14 method of dating ancient organic materials

A couple of years ago Junius Bird, associate curator of archaeology at the American Museum of Natural History, yielded to a generous impulse and shipped a small package of charred bone to an amateur who had written him from Highland Park, N.J. The amateur had built a homemade apparatus for dating by the carbon-14 method and had asked for a sample of ancient material to test his apparatus. Such requests to museums are not uncommon, but few are granted. The material is precious and the carbon dating technique is usually beyond the skill or resources of an amateur.

In this case the curator's cooperation paid off. In about two weeks the amateur submitted his report: The ancient owner of the bone had died 8,639 ± 450 years ago.

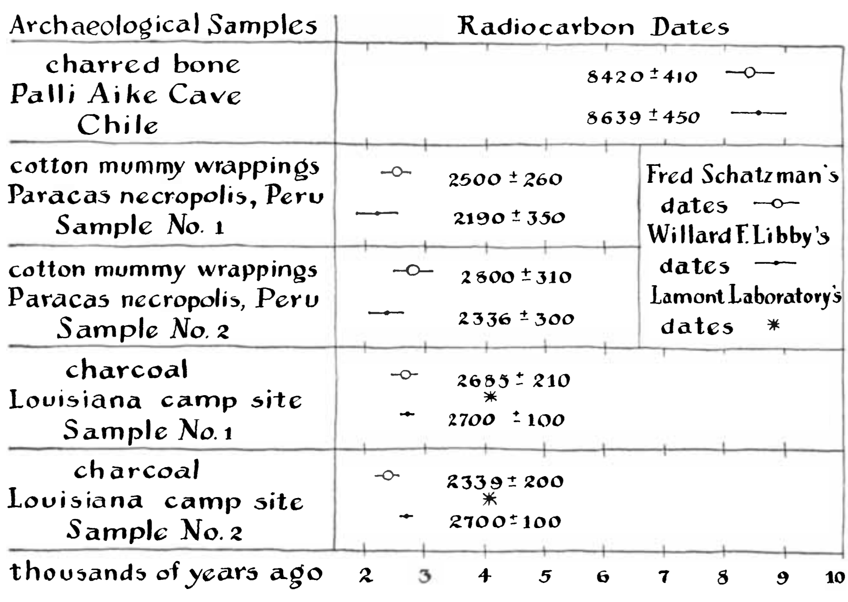
This figure compared so well with that previously established for the same specimen by Willard F. Libby, who developed the carbon dating method in collaboration with E. C. Anderson and J. R. Arnold, that Bird sent other samples to Highland Park. They were two pieces of cotton cloth from a Peruvian mummy of the Paracas Period. The amateur promptly obtained dates of 2,500 ± 260 and 2,800 ± 310 years for the two samples. Libby had measured the ages at 2,190 ± 350 and 2,336 ± 300, respectively. The Museum next sent the amateur undated charcoal samples from a Louisiana site. He got measurements of 2,685 ± 210 and 2,339 ± 200. These dates were later supported by studies of the material by professionals at the Lamont Geological Observatory of Columbia University.

The curator decided the amateur should be sent for and looked over. Very likely he had contrived some interesting short-cuts in the very rigorous procedure of carbon dating. When the amateur turned up at the Museum, Bird felt a momentary shock. He was only 15 years old! The boy, Fred Schatzman, had no short-cuts to offer. His samples had been dated the hard way.

That the youth had succeeded brilliantly in a field which defeats some veteran experimenters can be explained in part by the fact that he had learned well how to make a very little go a long way, including the contents of his wallet. The apparatus required for radiocarbon dating is expensive, even if you make most of it yourself, as Schatzman did. But even more important is the necessity for economy and skill in handling the material. The substance being measured, a radioactive isotope of carbon, exists in trace amounts too small to be seen. Schatzman's original pound of ancient bone yielded less than an ounce of purified carbon in which the radiocarbon amounted to only one atom in some three trillion atoms of stable carbon. At this ratio 50,000 tons of charred bone would yield just about enough carbon 14 to serve as pigment for the ink consumed in printing one line of text in this magazine. Schatzman is able to measure the minute amount of radiocarbon contained in a fifth of an ounce of purified carbon.

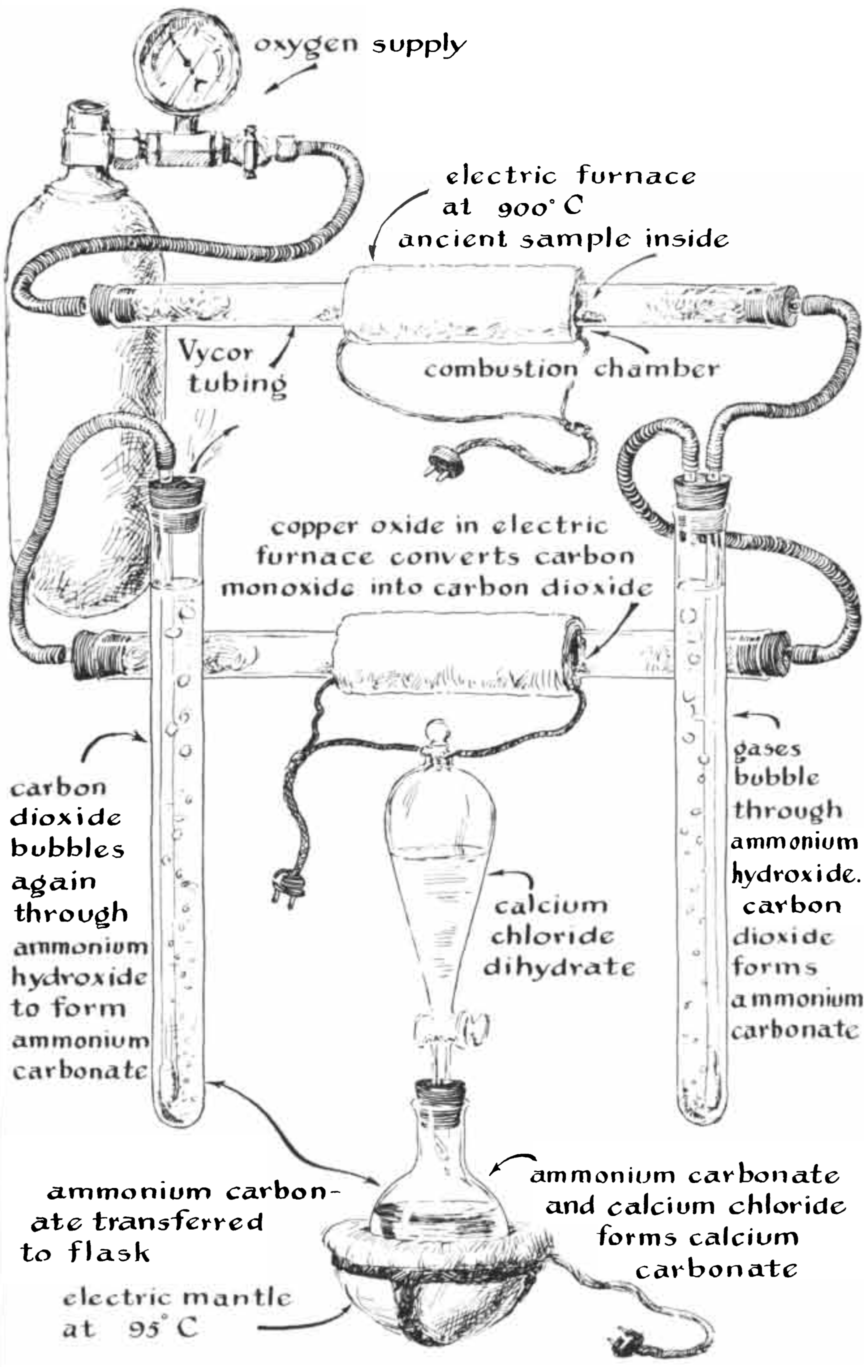
What he is measuring is energy stored in atoms by cosmic rays that struck our atmosphere thousands of years ago. Atomic nuclei from outer space continuously plunge into the upper air at great speed. Such nuclei are called primary cosmic rays. They collide with and shatter atoms in the air. The resulting debris, somewhat less energetic, flies off in all directions and collides with still other atoms. Eventually, after a series of these secondary encounters, the initial energy is widely distributed and the velocity of the rebounding particles drops to a value which depends on the temperature of the gas. Some neutrons in this drifting debris are captured by nitrogen, which has a great affinity for "thermal" neutrons. When stable nitrogen 14 captures a thermal neutron, it immediately ejects a proton and is transformed into an atom of carbon 14. This radioactive isotope of carbon has a half-life of 5,568 years.

Cosmic-ray physicists estimate that this process produces about a billion billion carbon-14 atoms per second in our atmosphere. Balancing the rate of formation against the rate of disintegration, Libby estimates that the earth's total stockpile of carbon 14 amounts to about 90 tons. This quantity does not



Comparison of an amateur's radiocarbon dates with those previously established appear to have varied appreciably for many thousands of years.

Where is the radiocarbon stored? The newly formed atoms of radiocarbon in the atmosphere quickly combine with oxygen to form carbon dioxide. On diffusing to the surface, much of this gas is dissolved in the oceans and there reacts to form inorganic carbonates and bicarbonates. Some radiocarbon, both in the air and in water, is ingested by plants and bound in carbon compounds by the process of photosynthesis. Animals eat the plants and also acquire radioactivity. So long as the organisms live, they keep on taking in carbon 14; after death the processes of decay usually return the carbon to the air for another round trip—air to organism and back again. But not all organic material is consumed by decay. In the case of sea shells the carbon may be locked up for impressive periods in the form of calcium carbonate. Charred wood or bone can also resist decay for long periods. Even wood and similar organic substances can be preserved for many centuries if protected from the elements by



Steps involved in extracting carbon from a sample and reducing it to calcium carbonate

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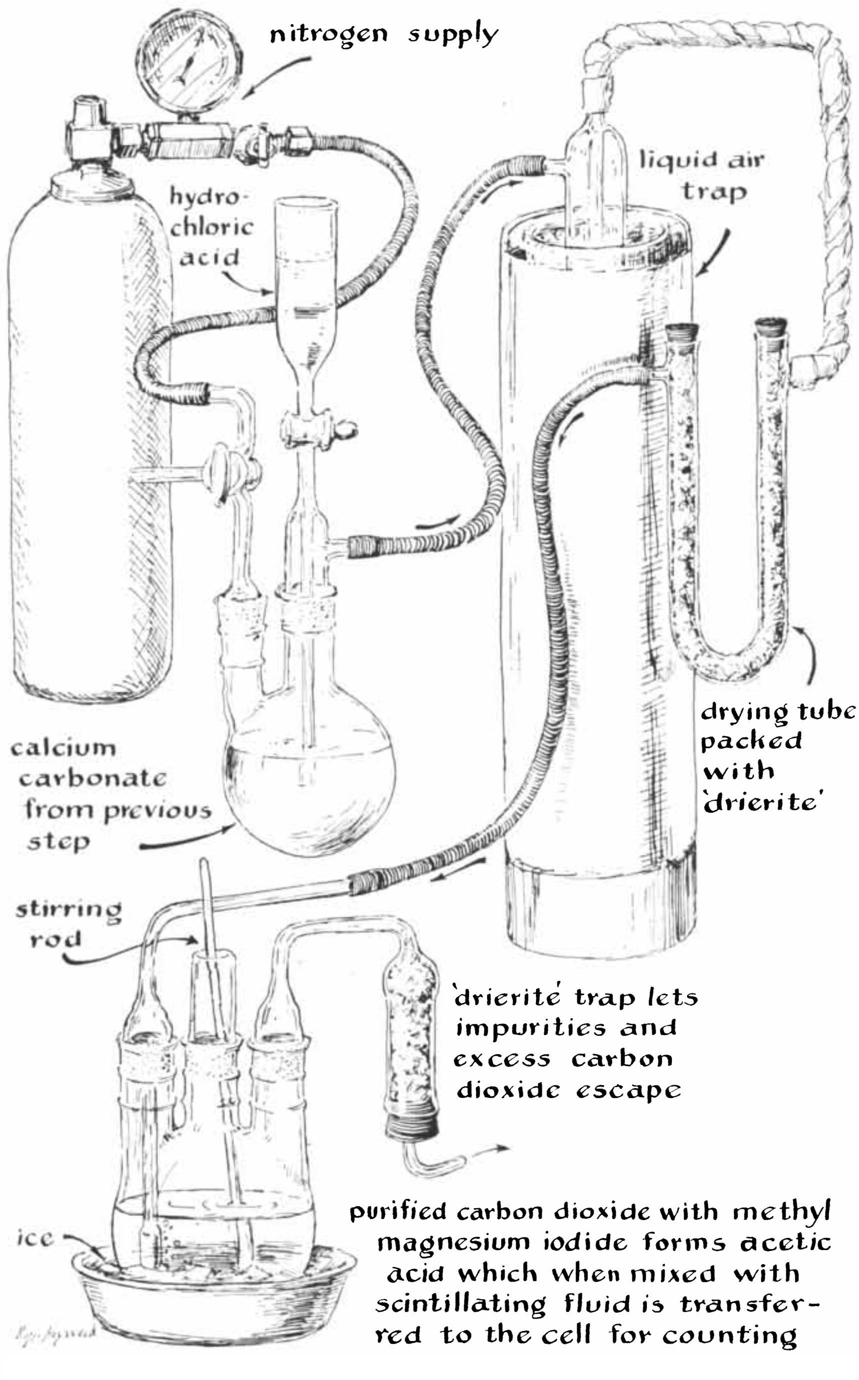
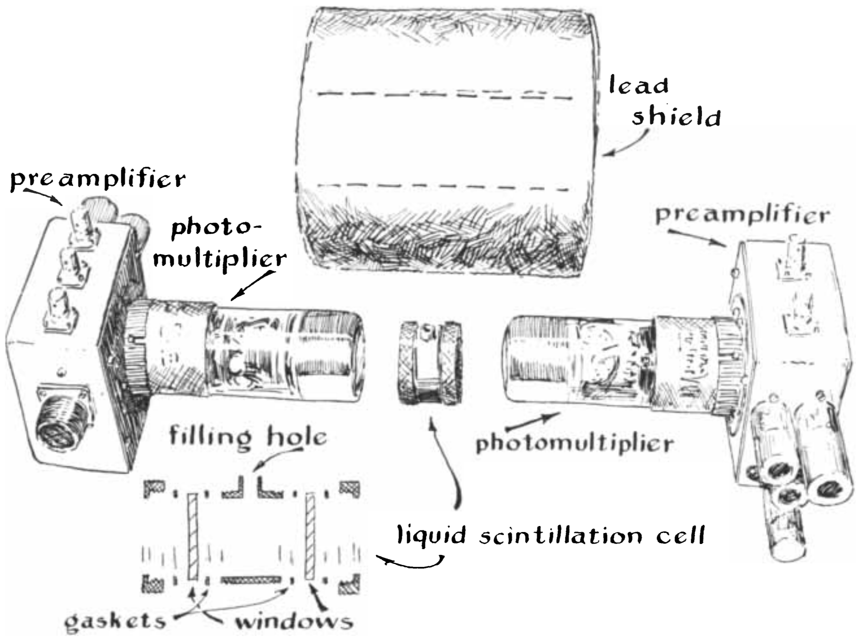
a dry climate which discourages bacterial invasion.

Libby suggested that carbon 14 would disappear from such materials at precisely the rate at which it disintegrates. This would mean that an ounce of carbon extracted from a quantity of modern material would show just double the radioactivity of a like amount taken from a sample 5,568 years old. Libby's prediction was sustained by a series of elegant experiments concluded seven years ago.

Dating by the carbon-14 method involves two major steps: one chemical, the other electronic. The chemical step is extraction of the carbon from the sample in a highly purified state. It may be reduced either to elemental carbon or to a gas or liquid compound, depending upon the type of instrument to be used in measuring its radioactivity. The earliest measurements were made with a Geiger counter of the "screen-wall" type. The carbon was extracted as a solid and reduced to powder by grinding. It was then mixed with a little water as a slurry and painted on the inner wall of the



Steps involved in purifying calcium carbonate and reducing it to acetic acid



Components of a scintillation spectrometer to measure the decay of radiocarbon

counter tube. In another technique, developed later, the specimen is burned to carbon dioxide and the Geiger tube is charged with the gas. A newer method bubbles the carbon dioxide through a reagent and converts it into acetic acid or an aliphatic hydrocarbon such as hexane for measurement by a scintillation counter employing a liquid scintillation cell. The liquid scintillation counter has several advantages over the Geiger counter, including much greater sensitivity. It records nearly every radiocarbon disintegration.

In essence the radiocarbon dating method is simple. You extract the carbon from the specimen, place a known weight of it in the counter, measure the intensity of the radioactivity and compare this with the radioactivity of a sample of the same weight and of known age, usually recent. Calculations based on the difference of radiation intensity between the two give the age of the unknown specimen.

But the method turns out to be astonishingly complicated in practice. Most of the difficulty stems from contaminating radioactivity. The experimenter himself gives forth more radioactivity from his own carbon 14 than does the specimen he is trying to date. A hail of cosmic radiation from all directions continually penetrates the scintillation cell. These sources plus emanations from naturally occurring radioactive elements in the soil and air will add hundreds of counts per minute in the counter unless elaborate precautions are taken. Moreover, the spurious count may be increased to thousands by electrical disturbances in the circuits of the measuring apparatus. The photoelectric cell, for example, is designed around a cathode of an alkali metal, such as cesium, which ejects electrons when bombarded by atomic particles. It is also sensitive to heat. This source alone can give thousands of false counts per minute. In contrast, carbon-14 atoms in a gram of modern carbon disintegrate at the rate of only 15 per minute. Hence the accuracy of the dating method hinges on the effectiveness with which the background disturbances can be suppressed.

The following is young Schatzman's account of his experiments:

"When I decided to go in for radiocarbon dating, I had no apparatus. I was looking for a project to enter in a science fair at school. I liked mathematics, chemistry and electronics. Radiocarbon dating seemed a good bet because it involved all three. I soon learned that counters cost more than I could afford. So I made friends with the staff of a local laboratory which had a good gas counter. They agreed to let me use the counter if I would do the chemical separations at home. Even this turned out to be expensive. So I first had to become an amateur glass blower.

"All the archaeological specimens I have come across have been heavily contaminated not only with other radioactive substances, such as radon, but usually with modern radiocarbon as well. Chemical processing begins, therefore, with a careful examination of the speci-

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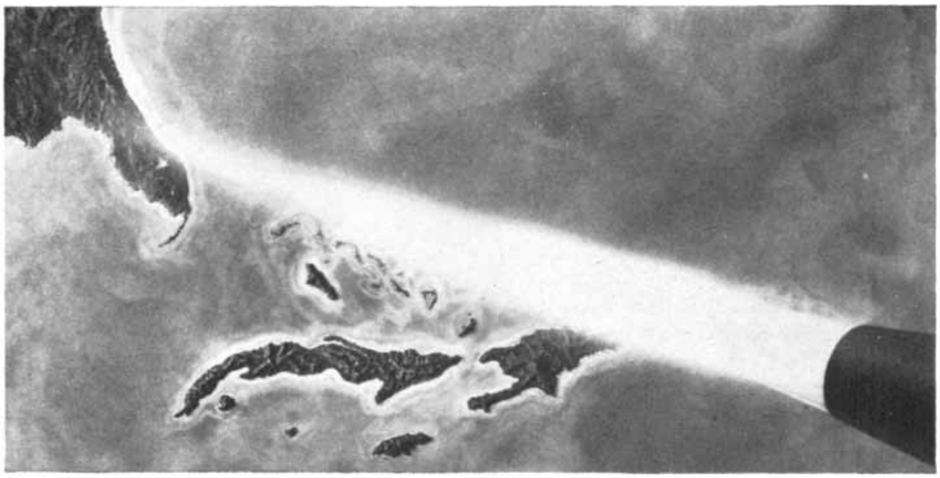

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DOUGLAS K. BAILEY received his BS degree from the University of California. He joined North American ten years ago as a senior design engineer. Today he is chief, Missile Design Section—responsible for missile design engineering and analysis. Doug and his family live in Long Beach where he participates in golf, bowling and sports car activities. He is currently organizing road races in Southern California for the Long Beach MG Club.

Unprecedented programs have been completed and more are to come. Others are being developed, modified and perfected as we enter another exciting phase following a successful flight test program at Patrick Air Force Base using a test vehicle known as the X-10.

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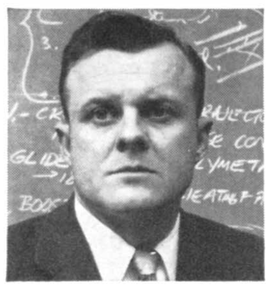

Navy vet **GEORGE W. JEFFS** earned both his BSAE and MSAE from the University of Washington. About 9 years ago he started his professional career with North American as a junior aerodynamics engineer. Now, 5 promotions later, this 30-year old veteran of missile work is chief, Advanced Design Section. He lives in Downey, California with his wife and 3 children. His hobbies include fresh-water fishing and hunting for quail and pheasant.

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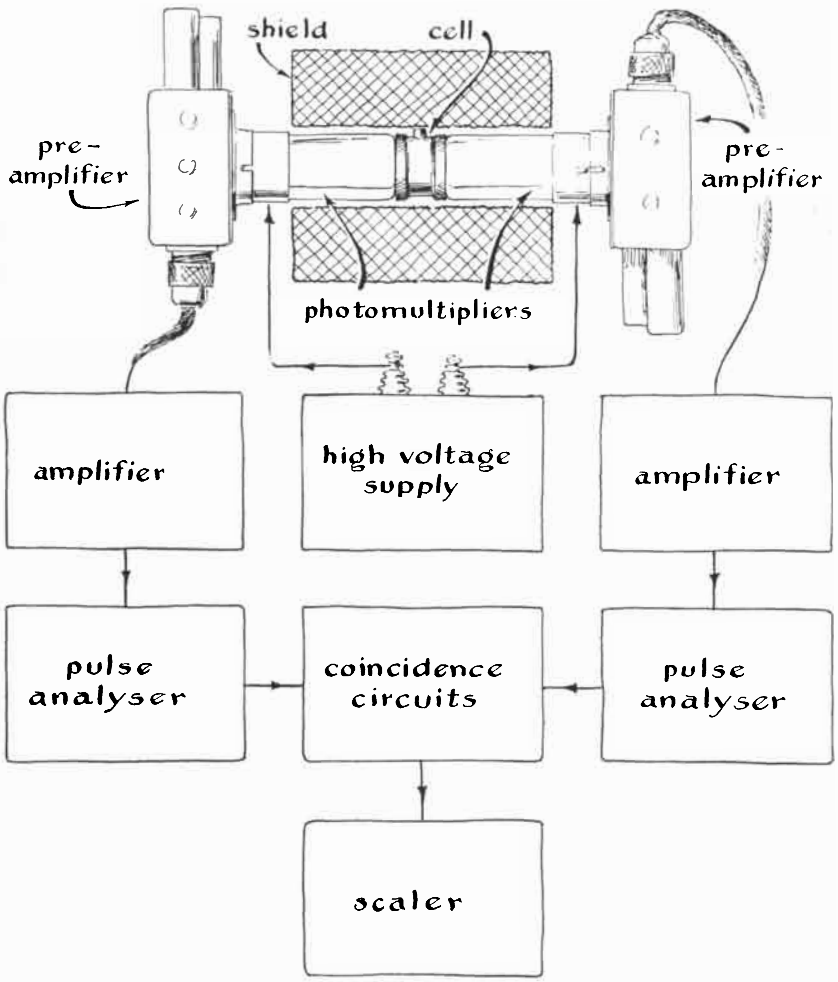
men. Finely divided charcoal from a camp site may contain rootlets, bits of dried grass or mold and so on. This must be cleaned away, usually under a magnifying glass. If you detect evidence of recent decay or other changes which indicate contamination, the affected parts must be cut out and discarded. The cleaned material is then thoroughly washed.

"The sample is next tested in a hydrochloric acid solution. Bubbling indicates the presence of lime. Lime is apt to be present if the specimen has been recovered from a dig situated in a wet or humid region where limestone or chalk, leached away from underground deposits, has collected in the fissures of the specimen. If the slightest trace of bubbling is observed, the sample is treated for several hours in hydrochloric acid, washed until the acid has been fully removed and then dried. It is then stored in a clean, tightly capped glass jar.

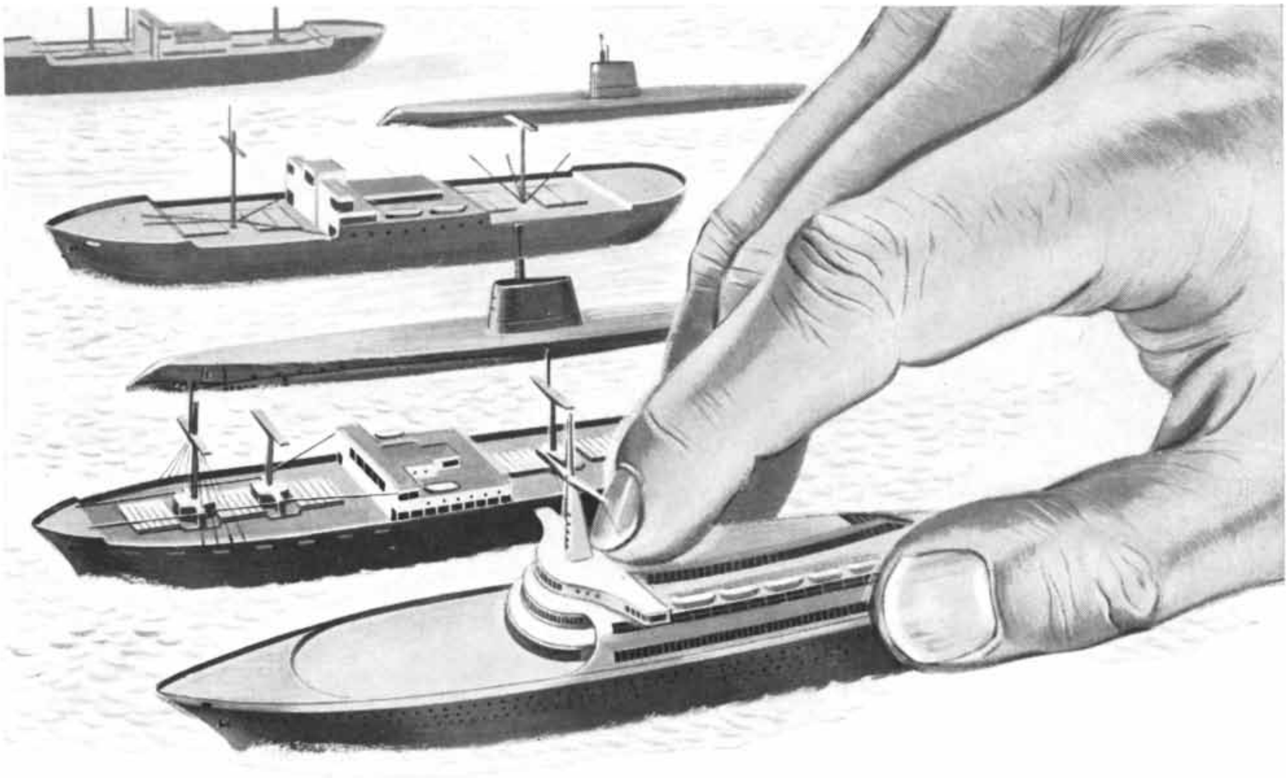
"The extraction process begins with controlled burning of the specimen. A measured quantity of the material to be dated is placed in the center of a tube of high-silica glass, such as Vycor, capable of withstanding 2,000 degrees Fahrenheit. The ends of the tube are stuffed with glass wool and closed by stoppers fitted with entrance and exit tubing. The tube is then inserted into an electric furnace made by winding successive layers of Nichrome wire on concentric tubes of asbestos sheeting. The length of the heating unit overhangs the sample by an inch or so. After the furnace has reached a working temperature of about 1,100 degrees, oxygen is admitted to the sample at a pressure of slightly less than one atmosphere, and the combustion gases are passed through a bubbler [*see drawing on page 160*]. The carbon dioxide reacts with ammonium hydroxide in the bubbler to form ammonium carbonate.

"The remaining gases, mainly carbon monoxide, are then passed to a second furnace identical with the first. In this step the Vycor tube is packed with cop-



Schematic diagram of the scintillation spectrometer

SCIENTISTS...



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per oxide, which usually consists of short lengths of fine blackened wire. When heated to about 1,250 degrees, the carbon monoxide reacts with the copper oxide to give carbon dioxide and copper. The carbon dioxide is then absorbed in a second ammonium hydroxide bubbler. At the end of the run the bubbler solution contains not only ammonium carbonate but also the oxides of nitrogen, sulfur and assorted 'crud' of incomplete combustion together with radon.

"Purification is accomplished in two succeeding steps. The ammonium carbonate is transferred from the bubblers to a flask and heated on an electric mantle. A solution of calcium chloride is then brought to a boil and added. Calcium carbonate precipitates rapidly. The precipitate is next washed completely free of ammonia, the salts and the radon.

"The carbon dioxide is then reconstituted by transferring the precipitate to a flask and adding hydrochloric acid. The liberated carbon dioxide is led through a liquid air trap for removing the water and then through a 'U' tube packed with a drying agent.

"If a gas-type counter is being used. the dried carbon dioxide can be stored in flasks at this stage to await subsequent measurement. If elementary carbon is desired, however, the oxygen must be removed from the gas. The reduction is made in a furnace much like that used for burning the specimen, except that an iron tube is substituted for the glass. This is packed with three or four ounces of magnesium turnings and about a thirtieth of an ounce of powdered cadmium. After an inlet tube has been sealed into the iron tube, the system is evacuated and tested for leaks. Carbon dioxide at a pressure approaching one atmosphere is then introduced into the furnace, and the entrance end of the iron tube is heated to about 1,200 degrees with a torch. The magnesium (with the cadmium serving as a catalyst) burns intensely, burning off the oxygen from the carbon dioxide. Carbon, magnesium oxide and unburned magnesium are deposited on the tube. The reaction is self-sustaining, and its intensity is controlled by the rate at which carbon dioxide is admitted. The flow of gas must be carefully regulated or the reaction will melt the iron tube. When reduction is complete and the tube cools, the deposited carbon, etc., is scraped off, moistened with a little water and treated with concentrated hydrochloric acid. After standing overnight the contents are brought to a boil and then filtered. The residue consists of acid-soaked carbon. This is washed in

boiling water, thoroughly rinsed and finally dried on a hot plate. After drying, it is again treated for two hours with hydrochloric acid, then washed and dried as before and transferred to an airtight storage bottle for subsequent measurement.

"I follow the simpler method, working with carbon dioxide rather than carbon. The dried carbon dioxide is bubbled through a three-necked flask containing methyl magnesium iodide, with which the gas reacts to form acetic acid as shown [*see drawing on page 162*]. The gas enters through one neck, a stirring rod to agitate the fluid is introduced through a second neck, and unreacted gas escapes through the third neck. The escape neck is fitted with a drying tube to prevent entry of water vapor from the air into the flask. If the chemical steps have been taken with care, the specimen, now in the form of clear acetic acid, is free of all radioactive substances except the original carbon 14. It is bottled promptly to prevent contamination.

"The scintillation cell of my counter consists of a pipe nipple about an inch long and two inches in diameter. The ends are closed by glass windows held in place by a pair of internally threaded bezels. The inner wall of the cell is coated with a special white paint impervious to the scintillation fluid. The fluid itself consists of toluene with four tenths of 1 per cent of diphenyloxazole and 20 parts per million of diphenyloxazolylbenzene, the latter chemical serving to shift the color of the scintillations to the portion of the spectrum to which the cathodes of the phototubes are most sensitive. The cell is filled through a small entrance tube in the side [*see drawing on page 164*]. The scintillation fluid has the property of fluorescing when excited by the emission of radioactive substances as well as by light and other radiations.

"The scintillation cell is shielded from the background by a tube of lead three inches thick. How to lay hands on that much lead had me stumped for a while. Then I learned that a manufacturer of toothpaste tubes lives in our neighborhood. I introduced myself, and when he learned about the project he not only supplied the lead but cast the shield for me. The shield reduces the effect of background radiation by about 80 per cent. The rest, and 'noise' from the electrical system, must be suppressed electronically.

"The scintillation cell is sandwiched between a pair of photoelectric cells of the photomultiplier type, consisting of a photocathode plus a self-contained amplifier. Each scintillation triggers a sub-

stantial pulse of current, which appears at the output terminal of each photomultiplier. Electrons dislodged from the cathode by heat cause similar pulses. These are minimized by refrigerating the entire pickup assembly—the scintillation cell, the photomultipliers, the preamplifiers and the lead shield. I talked my mother into locating the family's food freezer in my corner of the basement. The compartment assigned to me holds the pickup assembly at 20 degrees below zero centigrade.

"A number of tricks have been developed for reducing background electronically. One takes advantage of the fact that scintillations created by the disintegration of carbon-14 atoms are fairly uniform in brightness. Flashes touched off by other forms of radiation vary in intensity over a wide range. Only a few of them coincide in intensity with the flashes of the carbon 14. The electrical pulses that appear at the output terminals of the photomultipliers vary in proportion. A circuit has been designed which favors the pulse size of carbon 14. It employs a set of vacuum tubes controlled by the signals from an auxiliary circuit. The size of each pulse is measured as it enters the device and is then routed into a branch circuit called a delay line—a kind of electrical blind alley. In the meantime the charge on the grids of the vacuum tubes is being adjusted in accordance with the measurement so that the tubes will conduct or not conduct according to the size of the pulse. The control action is timed for completion just prior to the instant the pulse returns from its side trip. Only those pulses meeting the specification get through. A significant number initiated by sources other than carbon 14 pass muster, however.

"Most of the remaining background is blocked out by a screening device of a somewhat different sort. The scintillation cell is watched by a pair of photomultipliers. After amplification, the current pulses from the two photomultipliers, screened by the previous device to uniform size, are presented to a 'coincidence' circuit. Essentially this is a pair of electric 'check valves,' or diodes, comprising the input circuit of an amplifier designed to ignore pulses of current below a predetermined minimum size. The pulse from a single photomultiplier is not energetic enough to activate the amplifier. Therefore the circuit is activated only when a pair of pulses from the photomultipliers arrive simultaneously. Thus only pulses generated by flashes in the scintillation counter, where the pair of watching photomultipliers is triggered

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simultaneously, gain admittance to the electromechanical counter.

"By these various methods I have reduced the spurious counts in my instrument to about 25 per minute. My equipment contains some 80 vacuum tubes and cost somewhat more than $1,000.

"In dating an archaeological specimen the counting equipment is first calibrated. A measured quantity of standard fluid is mixed with the scintillation fluid and put into the cell. The cell, the shield, the photomultipliers and the pre-amplifier assembly are refrigerated overnight. I then operate the counter for 48 hours, take the accumulated reading, reduce it to counts per minute and compute the efficiency. Having established this, I remove the cell, clean it scrupulously and proceed to measure the activity of the actual sample. The difference between the count of modern carbon and that of the specimen provides the basis for computing the unknown date. If the calibration step can be omitted, as is the case when you are working with a series of specimens, you can date an average of about one specimen per week if everything goes well. It rarely does. Without the help and encouragement of a lot of friends in science I would have made slow headway in what has now become a fascinating hobby. In particular I am indebted to J. R. Arnold, who has advised me from the beginning, and to Junius Bird, who supplied the specimens with which I started."

Sydney Chapman, president of the Special Committee for the International Geophysical Year, who last month outlined the program of auroral observation for amateurs, writes that manuals for the project are being prepared. Information concerning various observing techniques will be made available through this department at an early date. Chapman adds the names of a number of regional auroral reporters to the list published last month. The new names are: for Central America: Julian Adem, Instituto de Geofisica, U.N.A.M., Torre de Ciencias, 3er Piso Ciudad Universitaria, D. F., Mexico; for South America: O. Schneider, Paseo Colon 317, Buenos Aires, Argentina; for Great Britain: J. Paton, University, Drummond St., Edinburgh 8, Scotland; for Japan: M. Hurahata, Tokyo Astronomical Observatory, Mitaka, Japan; for New Zealand: I. L. Thomsen, Carter Observatory, Wellington, New Zealand; for India: A. P. Mitra, N.P.L. Building, New Delhi, 12, India; for Germany: G. Lange-Hesse, Max-Planck Institut, Lindau über Northeim, Germany.

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BIBLIOGRAPHY

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

THE STRUCTURE OF THE INFLUENZA VIRUS

ELECTRON MICROSCOPY OF EARLY CYTOPLASMIC CHANGES DUE TO INFLUENZA VIRUS. Carl G. Harford, Alice Hamlin and Esther Parker in *The Journal of Experimental Medicine*, Vol. 101, No. 6, pages 577-589; June 1, 1955.

PRECIPITIN REACTIONS OF HIGHLY PURIFIED INFLUENZA VIRUSES AND RELATED MATERIALS. C. A. Knight in *The Journal of Experimental Medicine*, Vol. 83, No. 4, pages 281-294; April 1, 1946.

STRUCTURE OF INFLUENZA VIRUS. F. Macfarlane Burnet in *Science*, Vol. 123, No. 3,208, pages 1,101-1,104; June 22, 1956.

VIRUSES AND MAN. F. M. Burnet. Penguin Books, 1953.

THE INTELLIGENCE OF ELEPHANTS

INCREASE OF LEARNING CAPABILITY WITH INCREASE OF BRAIN-SIZE. Bernhard Rensch in *The American Naturalist;* March-April, 1956.

VISUELLES LERNVERMÖGEN EINES INDISCHEN ELEFANTEN. Bernhard Rensch and Rudolf Altevogt in *Zeitschrift für Tierpsychologie*, Vol. 10, No. 1, pages 119-134; September, 1953.

ZÄHMUNG UND DRESSURLEISTUNGEN INDISCHER ARBEITSELEFANTEN. Bernhard Rensch and Rudolf Altevogt in *Zeitschrift für Tierpsychologie*, Vol. 11, No. 3, pages 497-510; December, 1954.

HEART METABOLISM

CARDIAC CATHETERIZATION IN CONGENITAL HEART DISEASE. André Cournand, Janet S. Baldwin and Aaron Himmelstein. The Commonwealth Fund, 1949.

THE MOTION OF THE HEART: THE STORY OF CARDIOVASCULAR RESEARCH. Blake Cabot. Harper & Brothers, 1954.

CATHETERIZATION OF THE CORONARY SINUS AND THE MIDDLE CARDIAC VEIN IN MAN. R. J. Bing, L. D. Vandam, F. Gregoire, J. C. Handelsman, W. T. Goodale and J. E. Eckenhoff in *Proceedings of the Society for Experimental Biology and Medicine*, Vol. 66, No. 1, pages 239-240; October, 1947.

PATHOLOGIC PHYSIOLOGY OF MITRAL STENOSIS AND ITS SURGICAL IMPLICATIONS. Lewis Dexter in *Bulletin of the New York Academy of Medicine*, Vol. 28, No. 2, pages 90-105; February, 1952.

ATOMIC CLOCKS

THE ACCURATE MEASUREMENT OF TIME. Dirk Brouwer in *Physics Today*, Vol. 4, No. 8, pages 6-15; August, 1951.

THE MASER—NEW TYPE OF MICROWAVE AMPLIFIER, FREQUENCY STANDARD, AND SPECTROMETER. J. P. Gordon, H. J. Zeiger and C. H. Townes in *The Physical Review*, Vol. 99, No. 4, pages 1,264-1,274; August 15, 1955.

MICROWAVE SPECTROSCOPY. C. H. Townes and A. L. Schawlow. McGraw-Hill Book Company, Inc., 1955.

A STUDY OF THE CHANGES IN THE RATE OF ROTATION OF THE EARTH. Dirk Brouwer in *The Astronomical Journal*, Vol. 57, No. 5, pages 125-146; September, 1952.

TIME AND ITS MEASUREMENT. G. M. Clemence in *American Scientist*, Vol. 40, No. 2; April, 1952.

MESSENGERS OF THE NERVOUS SYSTEM

CHEMICAL STRUCTURE AND DEFINITION OF SYMPATHIN E. Amedeo S. Marrazzi and Rose N. Marrazzi in *Science*, Vol. 106, No. 2,761, pages 520-521; November 28, 1947.

RELATIONSHIP OF HALLUCINOGENS TO ADRENERGIC CEREBRAL NEUROHUMORS. Amedeo S. Marrazzi and E. Ross Hart in *Science*, Vol. 121, No. 3,141, page 365; March 11, 1955.

A SELF-LIMITING MECHANISM IN SYMPATHETIC HOMEOSTATIC ADJUSTMENT. Amedeo S. Marrazzi in *Science*, Vol. 90, No. 2,333, pages 251-252; September 15, 1939.

SOME INDICATIONS OF CEREBRAL HUMORAL MECHANISMS. Amedeo S. Marrazzi in *Science*, Vol. 118, No. 3,066, pages 367-370; October 2, 1953.

INERTIA

COSMOLOGY. H. Bondi. Cambridge University Press, 1952.

THE MEANING OF RELATIVITY. Albert Einstein. Princeton University Press, 1956.

THE ORIGIN OF INERTIA. Dennis Sciama in *Monthly Notices of the Royal Astronomical Society*, Vol. 113, page 34; 1953.

THE SCIENCE OF MECHANICS. Ernst

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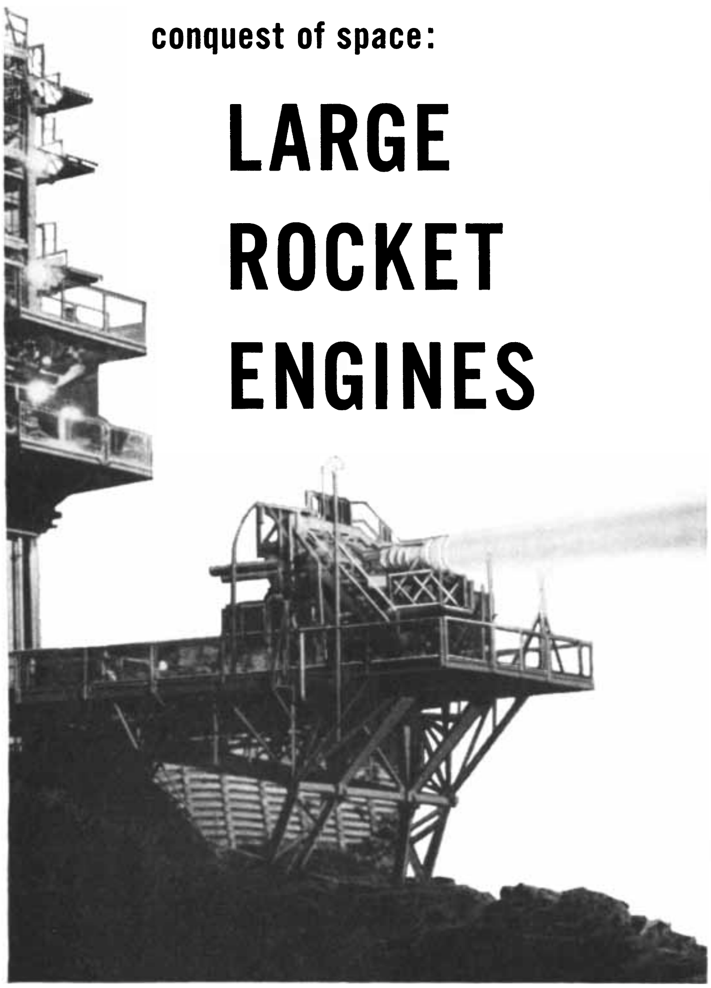

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Mach. Open Court Publishing Company, 1902.

SIR WILLIAM PERKIN

HOFMANN MEMORIAL LECTURE. Lord Playfair, Sir F. A. Abel, W. H. Perkin and Henry E. Armstrong in *Journal of the Chemical Society*, Vol. 69, Part 1, pages 575-732; 1896.

HUMOUR AND HUMANISM IN CHEMISTRY. John Read. G. Bell and Sons Ltd., 1947.

THE LIFE AND WORK OF PROFESSOR WILLIAM HENRY PERKIN. A. J. Greenaway, J. F. Thorpe and R. Robinson. The Chemical Society, 1932.

PERKIN AND THE DYESTUFFS INDUSTRY IN BRITAIN. R. Brightman in *Nature*, Vol. 177, No. 4,514, pages 815-821; May 5, 1956.

THE ANTHROPOLOGY OF POSTURE

ARCHETYPE POSTURES. H. M. Quackenbos in *The Psychiatric Quarterly*, Vol. 19, No. 4, pages 589-591; October, 1945.

GROWTH AND CULTURE: A PHOTOGRAPHIC STUDY OF BALINESE CHILDHOOD. Margaret Mead and Frances Cooke Macgregor. G. P. Putnam's Sons, 1951.

THE MIRROR OF GESTURE: BEING THE ABHINAYA DARPANA OF NANDIKEŚVARA. Translated by Ananda Coomaraswamy and Gopala Kristnayya Duggirala. Harvard University Press, 1917.

NAVAHO MOTOR HABITS. Flora L. Bailey in *American Anthropologist*, Vol. 44, No. 2, pages 210-234; 1942.

THE ONE-LEG RESTING POSITION. Gordon W. Hewes in *Man*, Vol. 53, Art. No. 280, page 180; November, 1953.

WORLD DISTRIBUTION OF CERTAIN POSTURAL HABITS. Gordon W. Hewes in *American Anthropologist*, Vol. 52, No. 2; April, 1955.

MATHEMATICAL GAMES

RIDDLES IN MATHEMATICS. Eugene P. Northrop. D. Van Nostrand Company, Inc., 1944.

THE AMATEUR SCIENTIST

ELECTRONICS: EXPERIMENTAL TECHNIQUES. William C. Elmore and Matthew Sands. McGraw-Hill Book Company, Inc., 1949.

RADIOCARBON DATING. Willard F. Libby. The University of Chicago Press, 1955.

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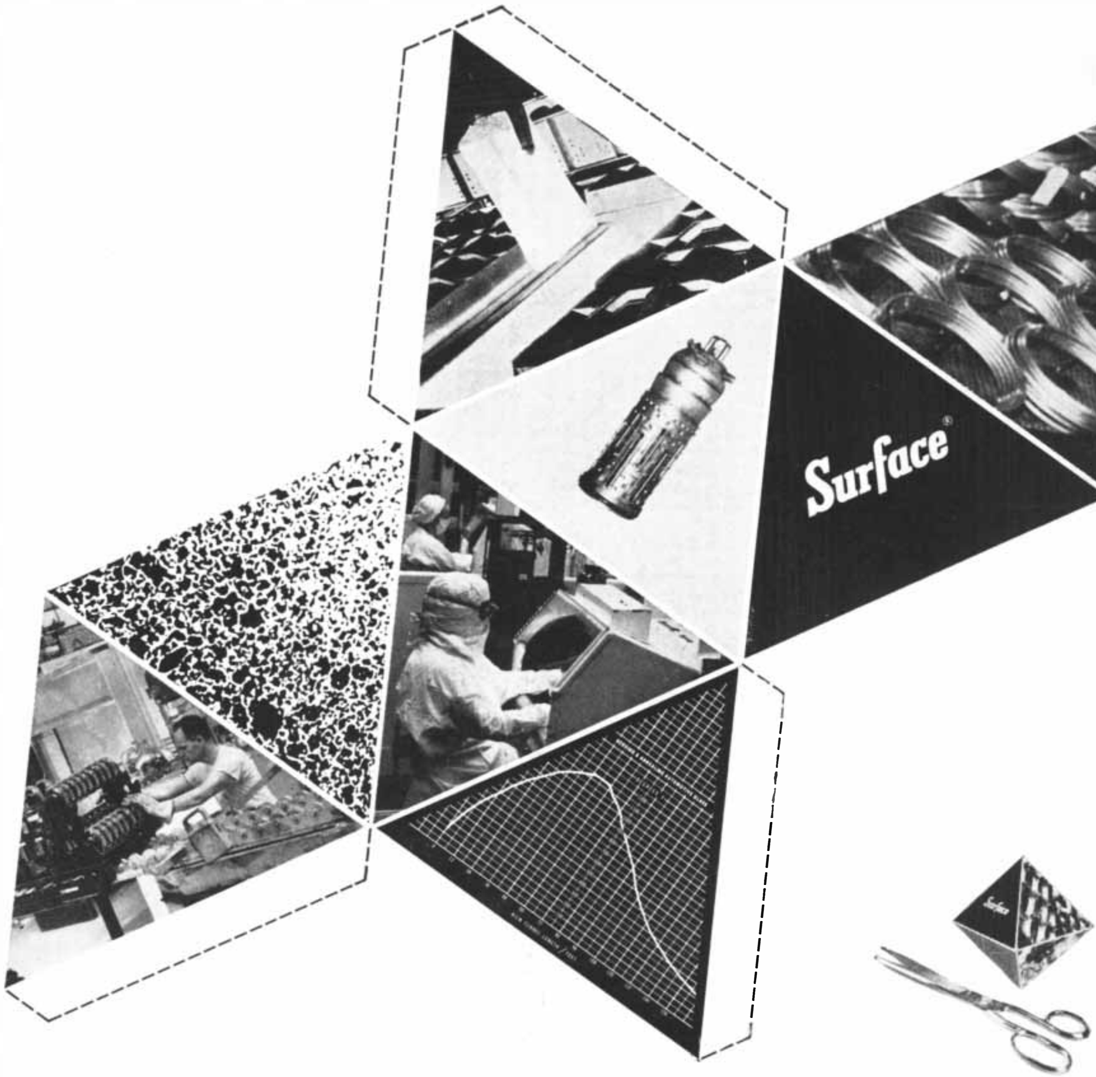

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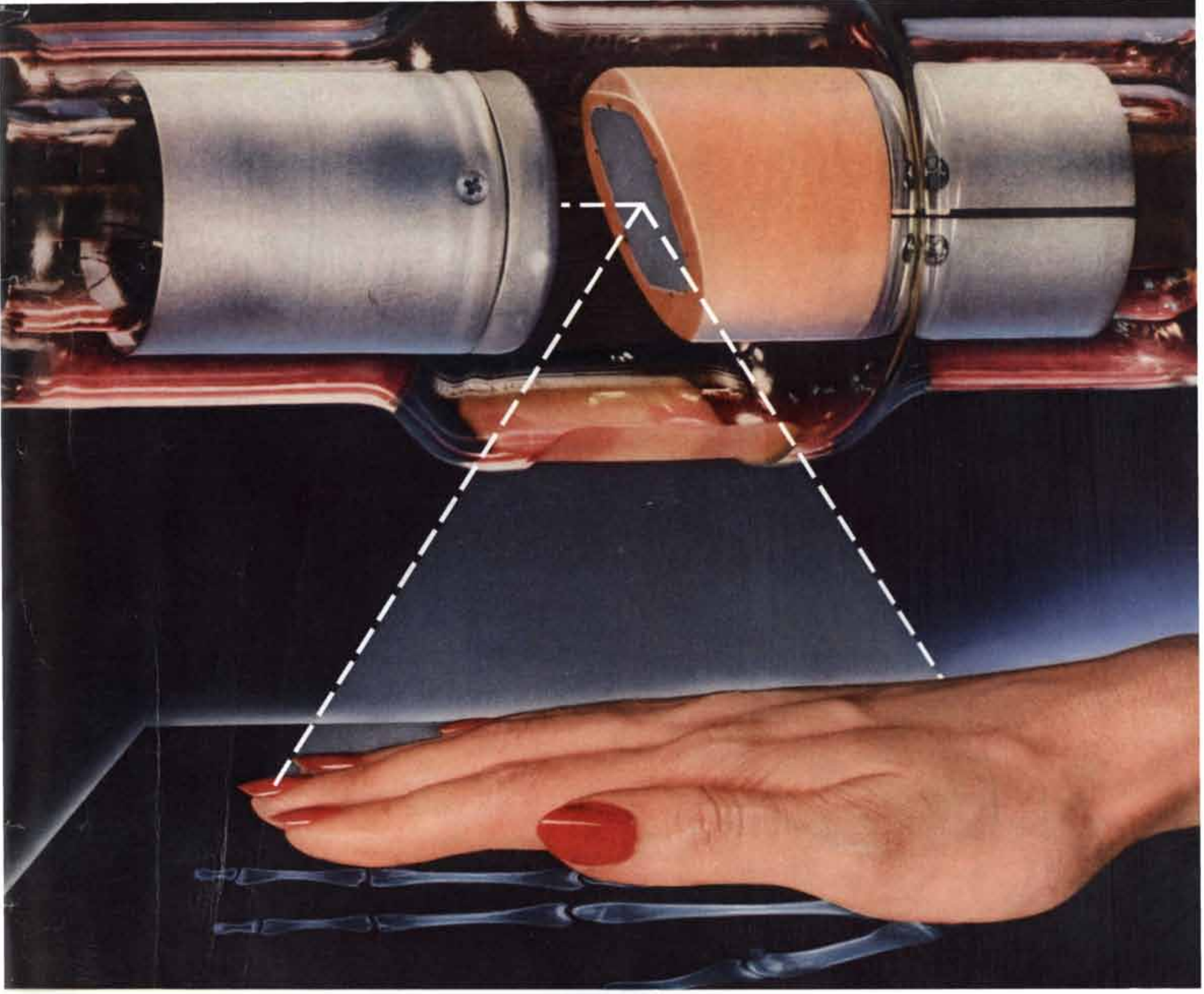

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