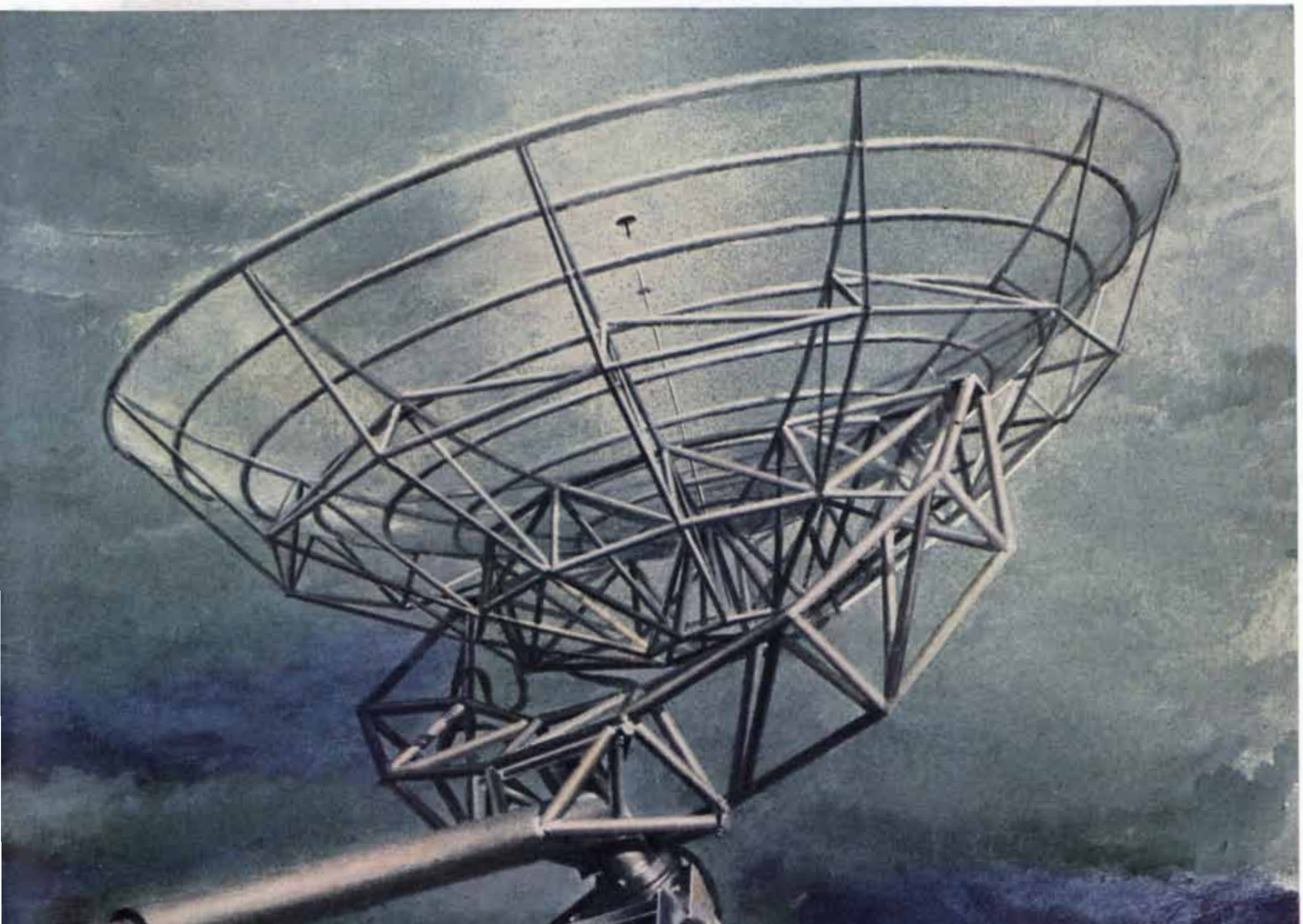
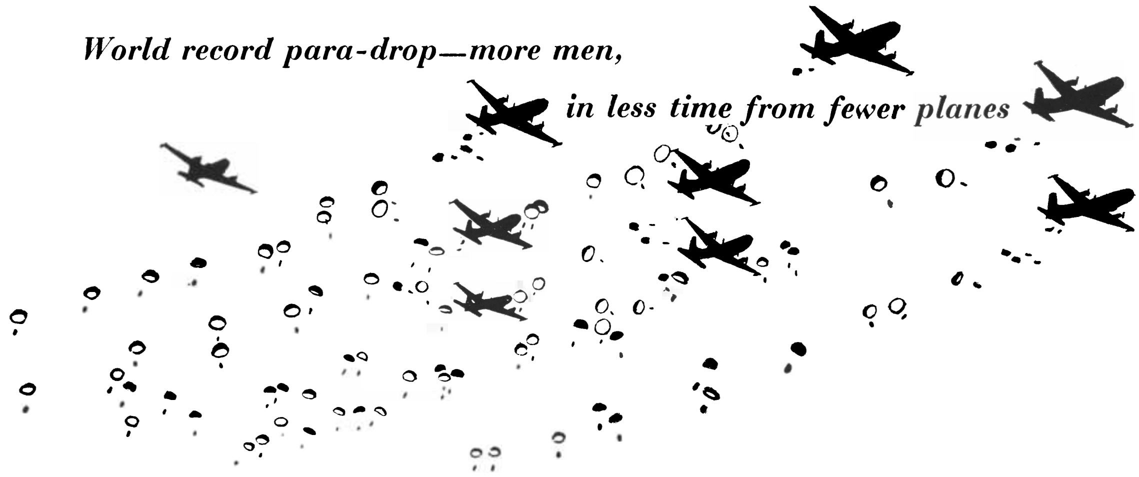
SCIENTIFIC AMERICAN



RADIO TELESCOPE

FIFTY CENTS

December 1953



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LETTERS

Sirs:

The brief review on page 54 of the October *Scientific American* under the title "The Calculus of ESP" does justice to the original article in *Nature* but not to the published experiments in ESP. Two questions may be raised concerning G. S. Brown's thesis that the standard methods of measuring statistical significance may be fundamentally defective. First, does he offer a reasonable basis for tentatively accepting his revolutionary supposition? And secondly, if true, does his statistical discovery invalidate the evidence for ESP?

Regarding the first question, as Mr. Brown himself points out, if his hypothesis is true, it will affect other branches of science in which dependence is regularly placed upon criteria of statistical significance. When publishing a proposal that would jeopardize a considerable fraction of the published findings of biology and psychology, it would seem proper to publish also the experimental evidence for that proposal. As of October, Mr. Brown has not done so.

The second question as to the relevance of his hypothesis to the evidence for ESP, was discussed at the First International Conference of Parapsychological Studies held at the University of Utrecht, Holland, in early August. Mr. Brown was invited to present his theories to a special session of the conference. After a lengthy discussion it was the con-

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sensus of opinion of the scientists present at that session that Mr. Brown's proposition, if true, might have proved embarrassing to the proponents of ESP had it been offered 15 years ago when ESP was known only as a marginal laboratory anomaly. Since that time the discovery of several high-scoring subjects and the detailed examination of repeatable changes in their scoring rates with changes in psychological and physical variables have established the reality of ESP without reference to possible fundamental errors in the theory of statistics. This will be shown in a book by S. G. Soal titled *Modern Experiments in Telepathy*, to be issued next spring by Yale University Press.

R. A. McCONNELL

Department of Biophysics
University of Pittsburgh
Pittsburgh, Pa.

Sirs:

The attention you have given Professor Brown's criticism of the statistical basis of parapsychology is gratifying; the field is too largely ignored by those who ought to be its attentive observers and critics. Professor Brown is to be commended for the effort he is making to rationalize the claims for extrasensory perception (ESP) and psychokinesis (PK) in terms of subtle aberrations of statistics, even though his attitude would appear to fall a bit short of the detached impartiality commonly attributed to scientists.

Certain aspects of parapsychological findings—the apparent indifference to physical factors, including time and space relations; the similar degree of success in telepathy and clairvoyance; the failure to develop a generally applicable technique for raising the scoring level of a subject—all of these peculiarities strongly suggest a common statistical origin. The fact that critics have tried unsuccessfully for 15 years to explain the experimental results in terms of faulty statistics is no reason for not pursuing the possibility further.

Certain other aspects, however, argue strongly for a phenomenological interpretation. The response of a subject's scoring level to drugs, to specific motivating situations, to emotional states; the correlations between scoring levels and measurable personality traits of subjects; the maintenance by a subject of a characteristic individual scoring level through months and even years of experiments; the systematic decline of scoring level from beginning to end of a single experi-

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mental series, particularly in PK—none of these relationships can plausibly be ascribed to random influences.

It is not possible to criticize Professor Brown's position in detail here. Certain logical shortcomings are apparent, particularly in his comment on the significance of Coover's "telepathy" experiment, and in his obscure argument that the hypothetical interaction between PK and ESP vitiates the evidence for both. On the other hand, his references to statistical anomalies in random number tables and in zoological experiments are intriguing, and I hope he will soon publish this work in detail.

Perhaps his most immediate service has been to direct attention to the seriousness of the challenge that this controversial field presents to scientists generally. Parapsychology no longer can be shrugged off as delusion or charlatanry; it poses a well-established anomaly of experience, the elucidation of which—whether it be statistical or phenomenological—ramifies significantly into other fields. The antipathy shown by many scientists to such work is not a creditable attitude. If the hypotheses of ESP and PK are valid, their implications justify the best efforts of the most gifted minds; if they are fallacious, every interest of the scientific community requires that the basis of the fallacy be demonstrated as promptly as possible.

J. H. RUSH

High Altitude Observatory
Climax, Col.

Sirs:

Professor Morrison's letter in your September issue prompts me to make some remarks on the bearing of the miracle concept on the scientific acceptability of the new cosmologies of Bondi and Gold and of Hoyle.

Historically there have been reports of occurrences, which, though avowedly observable, were so unusual and baffling that some have seemed to be "outside the natural order." . . . The canons of scientific inquiry remind us that what we conceive to be "natural" we have wrested from limited experience and thus have come to regard as "the laws of nature" up to that time. Constant revision of previously accepted generalizations to accommodate new findings is characteristic of scientific theory-construction.

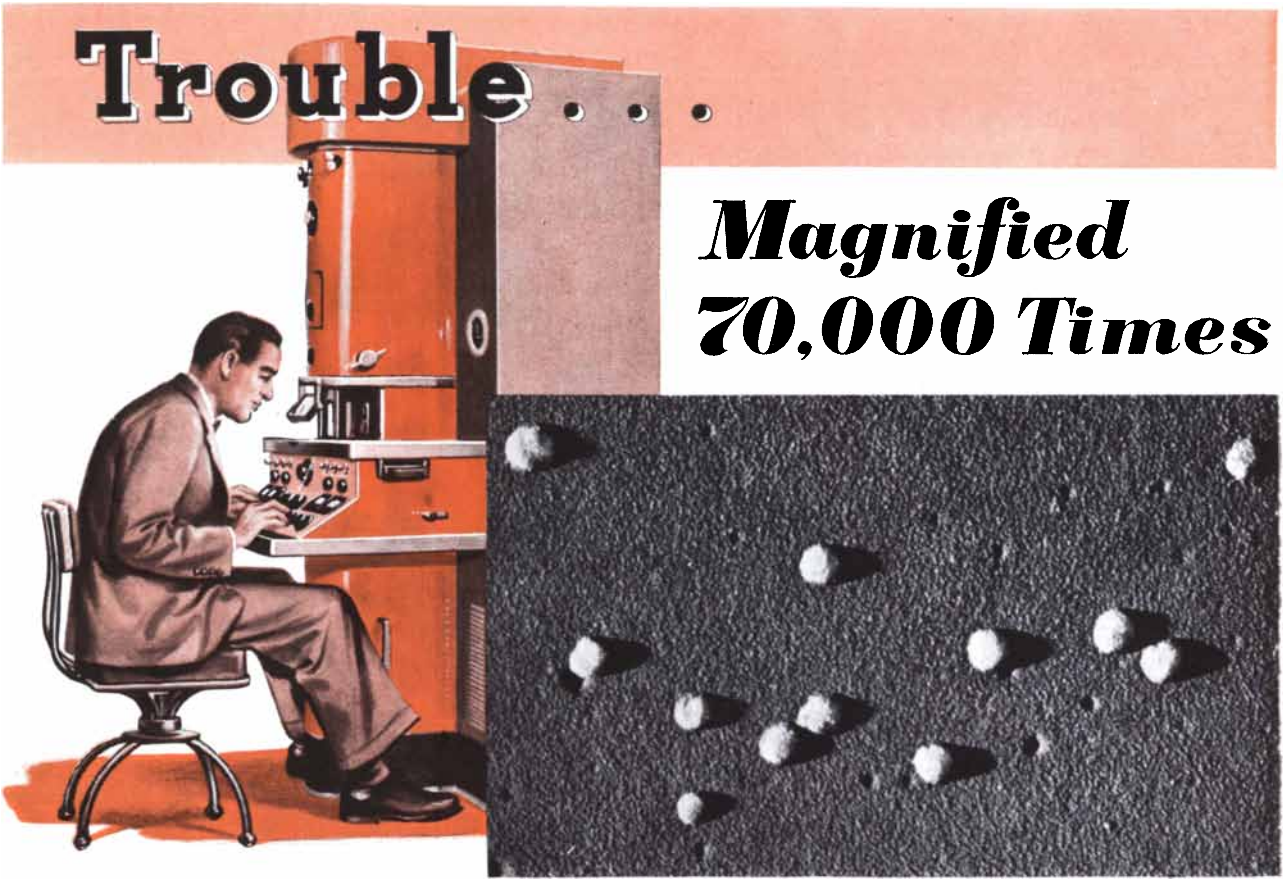
On what grounds then, and by what criterion, does the proponent of miracles achieve a differentiation between those newly observed facts which merely com-

pel the revision of previous generalizations and which he regards as part of "the natural order" on the one hand, and those observed facts which have the alleged status of being "outside" the "natural order" on the other? The proponent of miracles dogmatically affects to be able to select from the body of scientific principles at any given time those that are the "true" laws of nature and allegedly immune to revision by any occurrence "within" the "natural order." Hence, if it turns out that we observe an instance contrary to one of the principles in this gratuitously selected élite, then the occurrence in question automatically acquires the status of a "miracle" or "violation of the laws of nature." But there are no grounds other than narrow habits of thought or fiat for making such a selection among the principles of science. Once we abandon the gratuitous division between "natural" and "supernatural" observable events, it becomes clear that it is a contradiction in terms to speak of a "violation" of the natural order by miracles. By definition, the true laws of nature, as distinct from what we regard to be the laws of nature at any given time, cannot disallow any authentic observable fact of nature.

Those who reject the steady-state cosmology of Bondi and Gold or of Hoyle on the grounds that such a theory requires an "unnatural" or miraculous accretion ("creation") of matter unwittingly commit the same logical blunder as the conscious proponent of theological miracles and as the Aristotelian opponents of Galileo's mechanics. For just as Galileo's intensive observations had led him to see that the "natural" behavior of moving bodies was indeed different from what his critics had supposed it to be, so now it *may* turn out, on the basis of future large-scale observations, that it is "natural" for the universe to exhibit a mass (energy)-increase with time. Far from requiring the invocation of the theological miracle-concept, a theory of continuous accretion ("creation") of matter will therefore be fully acceptable scientifically, if borne out by observable facts. It is only a dogmatic insistence on the claim that the conservation of mass (energy) is cosmically the "natural" state of affairs which can lead to Herbert Dingle's characterization of the Bondi-Gold hypothesis as requiring "a continuous series of miracles."

ADOLF GRUNBAUM

Department of Philosophy
Lehigh University
Bethlehem, Pa.



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50 AND 100 YEARS AGO

SCIENTIFIC AMERICAN

DECEMBER, 1903: "On December 17 the Messrs. Orville and Wilbur Wright made some successful experiments at Kitty Hawk, N.C., with an aeroplane propelled by a 16-horsepower, four-cylinder, gasoline motor, and weighing complete more than 700 pounds. The aeroplane was started from the top of a 100-foot sand dune. After it was pushed off, it at first glided downward near the surface of the incline. Then, as the propellers gained speed, the aeroplane rose steadily in the air to a height of about 60 feet, after which it was driven a distance of some three miles against a 20-mile-an-hour wind at a speed of about eight miles an hour. Mr. Wilbur Wright was able to land on a spot he selected, without hurt to himself or the machine. This is a decided step in aerial navigation with aeroplanes, and it is probably due to the increased degree of controllability resulting from the Wright Brothers' novel form of horizontal rudder, which is a small guiding aeroplane placed in front of, instead of behind, the aeroplane proper. The present aeroplane has the very large surface of 510 square feet, making its apparent entire controllability all the more remarkable."

"What is becoming of our science of chemistry? Our century-old atomic conceptions have received a rude shock; the law of the conservation of energy, to which everything in this universe was supposed to be subservient, is attacked; and now we seem to be reverting to the dream of the medieval alchemist—actually thinking of the transmutation of metals. This is apparently what we have come to after the announcement made by Sir William Ramsay that radium changes to helium. When he compares the resultant product of radium with helium, Sir William Ramsay is sure of his ground: he caught the heavy gas which radium emanates, a gas so evanescent that it disappears after a time; he found that gradually its spectrum, entirely different from any hitherto recorded, displayed the characteristic yellow line of helium. Day by day the hel-

ium line grew brighter. In a word, one element seemed to have changed to another. Are we not perhaps on the verge of some great generalization which will ultimately prove that just as we have many kinds of forces, all manifestations of one great force, so we may have 70-odd elements, hitherto regarded as simple forms of matter distinct from each other, but in reality mere manifestations of but one matter? 'What is this?' asks Sir William, 'but an actual case of that transmutation of one element into another in which the ancient alchemists believed when they painfully sought to change lead into gold and incidentally founded the science of chemistry?' "

"H. Becquerel has succeeded in completely establishing the identity of polonium rays, 'undeflected' radium rays and canal rays. As he pointed out before, the 'undeflected' rays are only non-deviable by comparison with the radium rays, which consist of negative electrons and constitute Rutherford's beta radiation. Actually these rays can be deflected, and the deflection is always in a sense opposed to the deflection of the negatively charged beta rays. Uranium rays are now found to consist of negative electrons, polonium rays of positive ions, and radium and thorium rays of both. Radium also emits a third kind of radiation, which is non-deviable and yet very penetrating. It presents most of the characteristics of Roentgen rays, and traverses a quartz prism of 60 degrees without deflection."

"C. Runge and J. Precht have succeeded in obtaining a complete radium spectrum. They find that the brightest radium lines correspond strictly with the strongest barium lines and the analogous lines of magnesium, calcium and strontium. According to Runge and Paschen, the strongest lines of the alkaline earths may be arranged in pairs belonging to three series which they call the main series, the first side series and the second side series respectively. Radium has a place on the Mg-Ca-Sr-Ba line. But its atomic weight would have to be 257.8 instead of 225 as claimed by Mme. Curie. The authors attribute the discrepancy to barium impurities."

"On December 8 Herbert Spencer, heralded as the 'last of the great thinkers of the Victorian age,' passed away at the age of 83. What the world owes to him chiefly is the destruction of old prejudices and traditions, the forcing of educators to make allowances for youthful immaturity in the bringing up of

children. He did what he could to introduce a more rational consideration of things, particularly in the sphere of religion. Perhaps the book by which he is best known is his *First Principles,* issued at his own expense in 1862—a book which brought him into notice, it is true, but which made him the object of a storm of abuse from philosophical conservatives. His argument that force never disappears, but is only transferred, is now a commonplace scientific axiom, but in his day it was the height of impiety. His *Principles of Psychology* shows how much he owed to Darwin, particularly in the physiological point of view which he took."

"The cinematograph seems to have been rather successfully used by Paris surgeons for a very novel purpose, namely, that of exhibiting to medical students how typical surgical operations should be carried out."

DECEMBER, 1853: "Mr. Goddard has arrived at the acme of aeronautic achievement in Paris. He has come down from a balloon in a parachute on horseback! Two years ago to *go up* in a balloon on horseback was a marvel. The parachute was immense, and the cords, extending from its edges to the framework that sustained the horse, were a hundred feet long. The umbrella was by some contrivance opened before the cord of connection with the balloon was cut in order to avoid, under the peculiar circumstances of the descent, the rapid fall that ensues till the silk unfurls. The aeronaut above (his brother) let him off at the height of a mile; the descent was easy and gentle."

"The U. S. Navy steamship *Alleghany* was built at Pittsburgh, and has altogether cost the Government more than $800,000. She was repaired and furnished with new machinery, &c., at Norfolk under the direction of the Navy. It was intended to send her to China with the Minister, R. J. Walker, who refused to go out in her. But the other day she was ordered for the Brazil station, and pronounced to be one of the finest ships in the service. With a great flourish of trumpets the *Alleghany,* after her contractor had been discharged, proceeded on a trial trip from Norfolk. She got under weigh on the 5th of October at noon,

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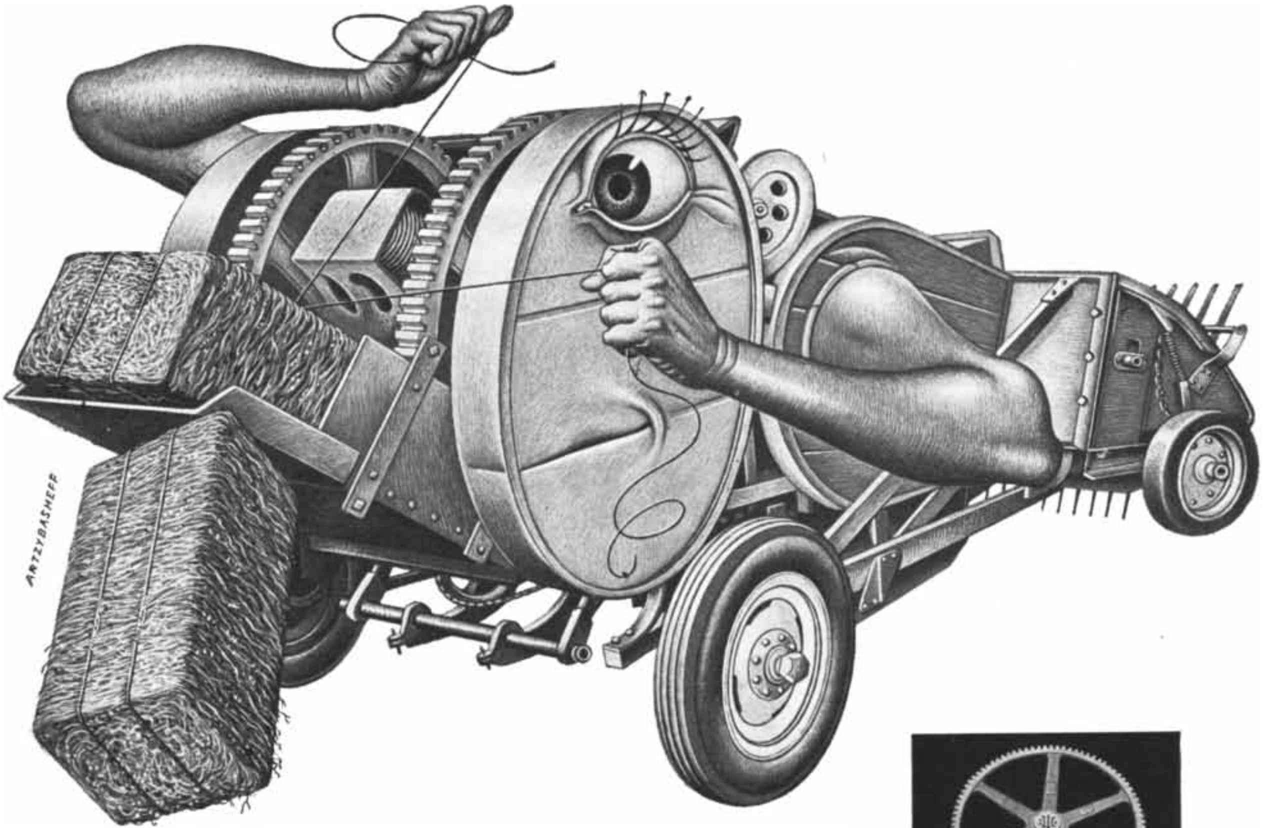
"Lord Palmerston declares that the cholera is caused by gaseous exhalations, and censures the Scotch Presbyterian Church for requesting a day to be appointed for fasting, instead of exerting their faculties for the removal of such noxious influences."

"The New York Central Railroad Company have assumed the expense of laying one or two miles of India rubber under their tracks, intended to obviate materially the present destruction of rails and machinery and do away with the noise attendant upon the motion of the trains. We are glad to learn that this invention is to be tried in this country. A patent was taken in England two years ago, but we have never heard of its adoption there."

"An Australian journal exposes what the editor thinks a most impudent but amusing humbug of some Yankee speculator, the attempt to palm off anthracite coal as something that will burn. He denounces the imposition in this style: 'We feel bound to warn the public against a species of coal which at present is being offered for sale in Melbourne, and which, although it looks like coal, breaks like coal, smells like coal, and feels like coal, has this trifling difference—that coal has a tendency to burn, and this has not. A greater imposture was never palmed off upon a fire-loving world. The great blocks lie piled on the fire like stones, not only not burning, but apparently incapable of being warmed through sufficiently to fly.' Our Australian colleague has much to learn in the way of burning coal. We do not wonder at his ignorance, for the anthracite coal when first tried in Philadelphia and Cincinnati, was treated in the same way as it has been in Australia."



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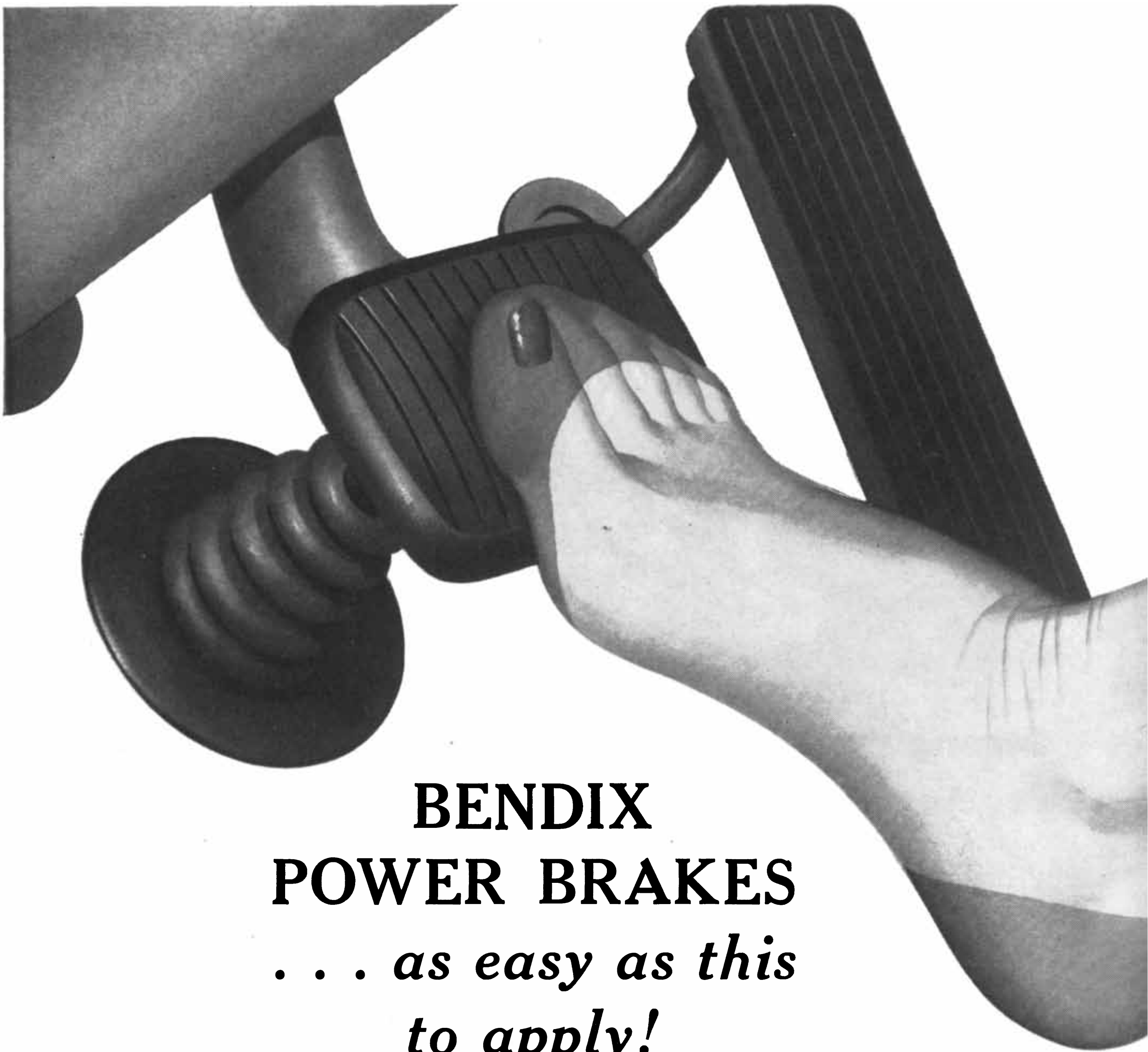

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THE AUTHORS

JOSEPH W. EATON and ROBERT J. WEIL ("The Mental Health of the Hutterites") pooled their skills as sociologist and psychiatrist to conduct the investigation they describe in their article. Eaton first encountered the Hutterite groups in 1940, when, as a Cornell University graduate, he directed a study of cooperative farm communities in the U. S. Eaton went to live in one of the colonies, but had to leave for military service after a few weeks. Upon his discharge from the Army he took a doctorate in sociology at Columbia University and joined the faculty at Wayne University, where he is now assistant professor. In 1949 he returned to the Hutterite colonies to begin the mental health study. Weil, a native of Czechoslovakia, is assistant professor of psychiatry at Dalhousie University in Halifax. In their sojourn in the Hutterite settlements Eaton and Weil were accompanied by their wives and children. Eaton reports that some of the reticent Hutterite women were "charmed into cooperation" by his two infant sons, who "may well be the world's youngest anthropologists." A full report of the study is to be published by the Free Press under the title *Culture and Mental Disorders.*

JOSEPH L. MELNICK ("Viruses within Cells") is associate professor of microbiology at the Yale University School of Medicine. Trained as a biochemist, he has devoted himself to virus research for the past 12 years. His major field is poliomyelitis; he has also investigated Coxsackie virus diseases and is now working on a newly discovered group of viruses. His polio studies earned him the 1949 International Award of the Argentinian Foundation against Infantile Paralysis. Melnick was born in Boston in 1913 and educated at Wesleyan and at Yale. Except for a year spent at the Caroline Institute in Stockholm as an American-Scandinavian Research Fellow, he has passed his entire academic career on the Yale faculty. He is a member of the Committee on Growth of the National Research Council. This year he represented Yale at the International Congress on Microbiology in Rome. He wrote an article called "A New Era in Polio Research" for the November, 1952, issue of this magazine.

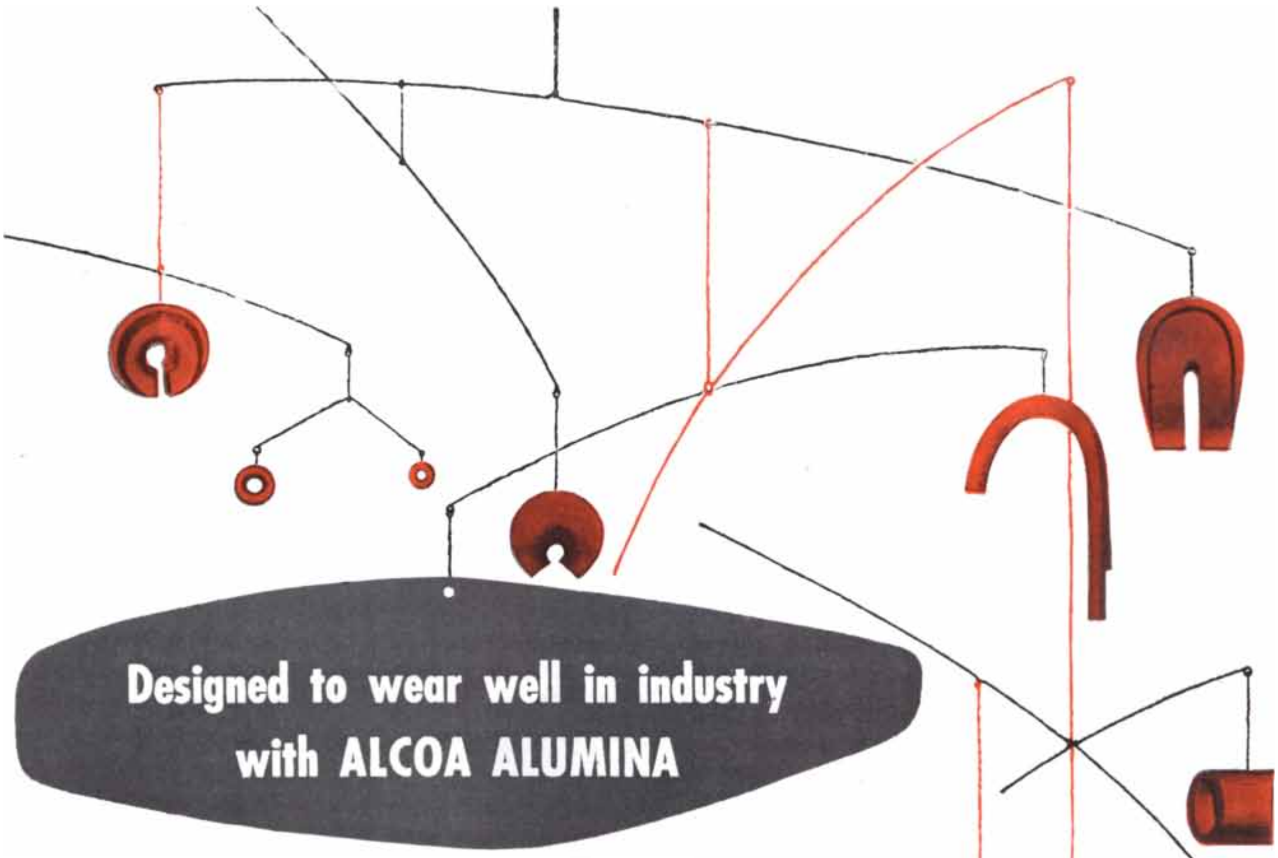
HAROLD I. EWEN ("Interstellar Hydrogen") was the first to detect radio

waves from the hydrogen gas in space. He was a graduate student at Harvard University, working for his Ph.D. under the physicist Edward M. Purcell. As a topic for his thesis, Purcell suggested that he investigate the hydrogen radiation. Ewen designed and built an exceedingly sensitive receiver and succeeded in picking up the predicted radiation. He is now a research associate at the Harvard Observatory. He also heads a company, the Ewen Knight Corporation, which does special jobs in applied physics. Ewen was graduated from Amherst College in 1943 and served with the Navy as an airborne radar observer and in the Office of Research and Invention as aide to the Chief of Research.

LOREN C. EISELEY ("Fossil Man") is chairman of the department of anthropology at the University of Pennsylvania. He has written several articles for SCIENTIFIC AMERICAN, most recently "Is Man Alone in Space?" in the July issue. The biographical sketch accompanying that article mentioned that Eiseley was taking time off to do some writing. It is to be a "somewhat personal, philosophical book dealing with my outlook upon evolutionary matters."

PAUL D. BARTLETT ("Free Radicals") began to study these short-lived molecular fragments in 1941 in connection with wartime research on resins. His work on free radicals was a logical extension of an early interest in the mechanism of chemical reactions. Bartlett received his Ph.D. in chemistry from Harvard University in 1931. After a year at the Rockefeller Institute for Medical Research and two years as instructor at the University of Minnesota, he returned to Harvard where he has remained since. He is now Erving Professor of Chemistry and chairman of the chemistry department. During World War II he served as a consultant to the National Defense Research Committee. He is a member of the Chemical Advisory Panel of the National Science Foundation. In his spare time he enjoys climbing, skiing and photography.

FRITZ HABER ("The Heat Barrier") is a German engineer who has been doing research for the U. S. Air Force on human engineering problems involved in space flight. Born in 1912, he was trained as a mechanical and aeronautical engineer at the University in Darmstadt. During World War II he was a project engineer with the Junkers Aircraft Company. After the war he worked as an



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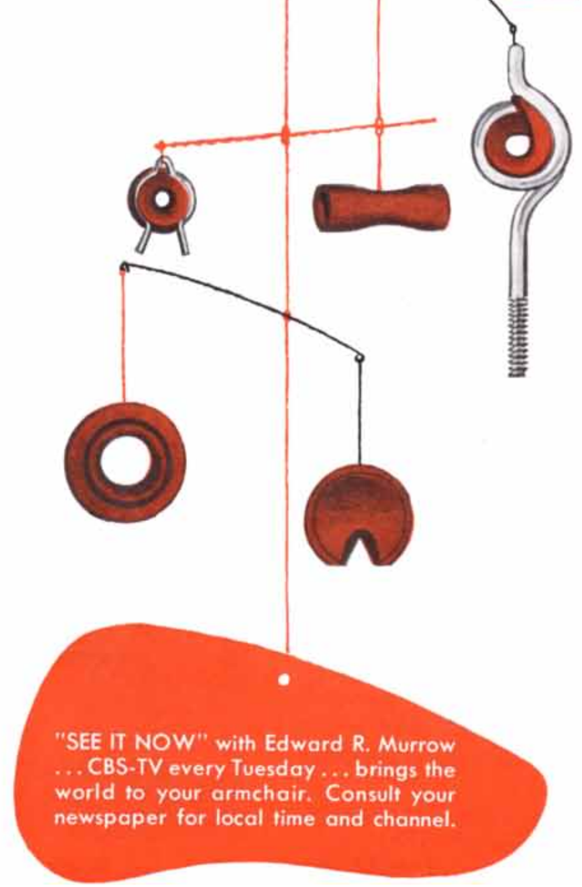

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ALUMINUM COMPANY OF AMERICA

engineer with a pencil manufacturer, wrote engineering textbooks and sold automobile brake linings. He came to the U. S. in 1950 and was a member of the research team at the Air Force School of Aviation Medicine at Randolph Field in Texas until a few months ago. He is now with the Baltimore Instrument Company. He is married, has two sons and is a high-fidelity addict in his leisure time. His brother Heinz has written two articles for SCIENTIFIC AMERICAN: "The Human Body in Space" (January, 1951) and "Flight at the Borders of Space" (February, 1952).

LEON A. GREENBERG ("Alcohol in the Body") has pioneered in the study of the physiological effects of alcohol. He was born in New Britain, Conn., in 1907 and trained as a physiologist at Yale University. After receiving his Ph.D. in 1933 he joined the Yale Department of Applied Physiology, where he specialized in research on noxious compounds. He is now an associate professor and director of the Department. Greenberg was one of the founders of the Yale Center of Alcohol Studies and of its *Quarterly Journal of Studies on Alcohol.* The Alcometer, a device used in medico-legal work to determine intoxication, is his invention. He has lectured extensively in the U. S. and abroad on problems of alcoholism and frequently serves as an expert consultant. During World War II he did military research on poison gas.

C. H. WADDINGTON ("The Inheritance of Acquired Characteristics") has devoted most of his career to "pure" research in genetics. As professor of animal genetics at the University of Edinburgh he now directs a large laboratory whose 40-odd research workers deal "with the whole range from hard-headed operational research into actual livestock breeding practice to the most purely theoretical implications of genetics for development and evolution." He is currently spending most of his time on radioactive tracer work to study chemical processes in the embryo and also on the inquiry about which he writes this month—the influence of environment on evolutionary change. Waddington contributed an article on cell differentiation to the September issue of SCIENTIFIC AMERICAN.

JAMES R. NEWMAN, who edits the book review department of SCIENTIFIC AMERICAN, this month presents his annual Christmas roundup of science books for children.

THE COVER

The painting on the cover shows the new radio telescope of the Harvard College Observatory. Built at the Observatory's Agassiz Station in Harvard, Mass., the telescope consists of a 25-foot parabolic reflector on an equatorial mounting. The counterweight of the telescope projects at the lower left. The telescope is especially designed to receive radiation at a frequency of 1420 megacycles (or a wavelength of 21 centimeters). This radiation is produced by clouds of hydrogen in space (*see page 42*). By measuring the intensity of the radiation, radio astronomers can locate such clouds; by measuring the Doppler shift from 1420 megacycles they can also determine the motion of the clouds.

THE ILLUSTRATIONS

Cover by Walter Murch

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DESIGNING WITH ALUMINUM

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

NO. 5

STRENGTH AFTER WORKING

RATES OF GAIN IN YIELD AND TENSILE STRENGTHS VARY FOR DIFFERENT ALLOYS

WROUGHT ALUMINUM alloys are being increasingly used for formed pieces, parts and articles where specified strength is a prime requirement. This makes more important the development of quantitative data concerning the increase in yield and tensile strengths that occurs during forming operations.

The phenomenon of strain or work hardening, of course, has long been known. It applies to both the non-heat-treatable and heat-treatable aluminum alloys. But its influence is of major practical concern only in the case of the non-heat-treatable (sometimes loosely called "common") alloys because the final strength of a product formed from them is determined by that of the original material plus whatever is added by the working of the metal during fabrication.

The non-heat-treatable alloys are logically the first to be considered, and are in fact most generally used in applications where forming requirements are moderate to severe. Where development of their fullest strength is desired, it is frequently possible to start with metal in an intermediate, rather than the annealed, temper if the required forming is not too severe.

Research Tests Show Changes from Stretching

Tests conducted by Kaiser Aluminum's Division of Metallurgical Research have produced interesting and significant data concerning the relative increases, after varying amounts of stretching, in both yield and tensile strengths and the rate of work hardening for four of the alloys usually used for forming. These data may be helpful as a guide in both design and alloy selection.

Specimen strips of .040" thick 2S, 3S, 50S and 52S sheet were first tested in the annealed ("O" temper) condition, then stretched specified amounts in a Baldwin-Southwark testing machine and tested again after stretching. The tests were made with the grain of the metal, and in the same direction in which the samples were stretched.

The results are shown in Figs. 1 to 4. These curves are plotted in terms of yield and tensile strength after stretching, the relative percentage increase in yield strength for a given amount of stretching and the rate of work hardening.

Emphasis was placed on the changes in yield strength because of its importance as a guide to dent resistance in many formed products, where denting frequently is a cause for rejection.

The relationships between these four alloys as shown in the charts are of particular interest when they are considered in conjunction with cost, fabrication problems and service requirements. For instance, it is clear why use of 2S, although it is the most economical of these alloys and possesses high ductility, is declining except where there are minimum strength requirements. It is evident as well that good strength in the finished product may be obtained with 52S, although its more rapid work hardening rate indicates the fabrication considerations which may be involved by comparison with 3S and 50S, whose work hardening rates and strengths are more moderate.

Fig. 1. Effects of stretching upon yield strength.

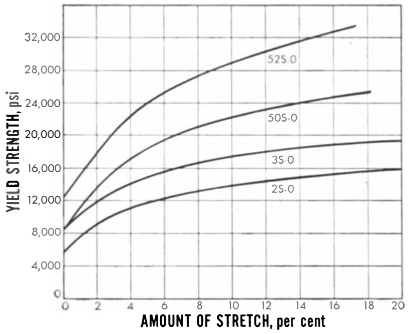


Fig. 2. Effects of stretching upon ultimate strength.

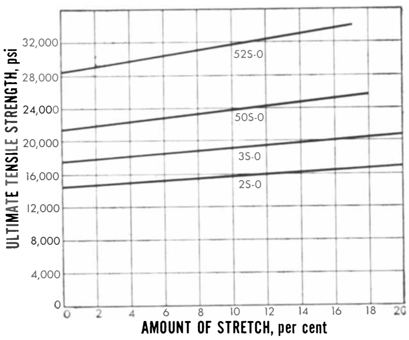


Fig. 3. Rate of work hardening during stretching. Curves plotted from tangents to curves in Fig. 1.

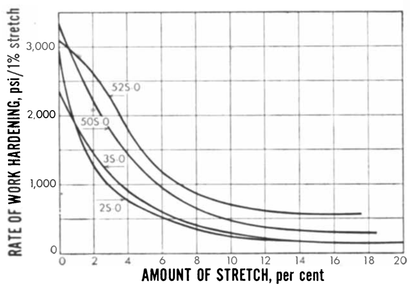
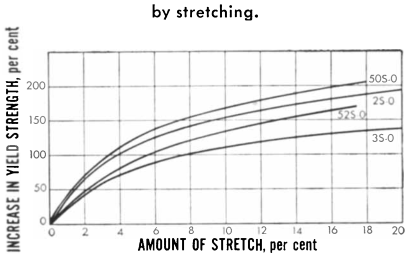


Fig. 4. Increases in yield strength caused by stretching.



PLEASE TURN TO NEXT PAGE ➡

TABLE 1 Comparison of Properties in Crisper Pans Drawn from .040″ 3S-0 and 50S-0 Sheet

Alloy	Location	Thickness, inches	Direction of Test	Ultimate Strength, psi	Yield Strength, psi	% Gain in Yield Strength For 50S
3S	Flanges	.0426	....	18500	17700	
50S	Flanges	.0440	....	25600	24500	38
3S	Ends	.0373	With grain	17250	16400	
50S	Ends	.0386	With grain	25700	22300	36
3S	Ends	.0346	Across grain	17950	17700	
50S	Ends	.0352	Across grain	27080	25100	42
3S	Sides	.0338	With grain	20000	19200	
50S	Sides	.0349	With grain	27550	26100	36
3S	Sides	.0375	Across grain	17625	16750	
50S	Sides	.0385	Across grain	25750	23200	38

50S, 3S Performance in Identical Piece

Along with the tests of specimens described above, tests were also made of production-formed pieces made from alloys 50S and 3S. The test specimens were taken both with and across the grain from identical refrigerator crisper drawers drawn from .040″ sheet in each case.

The results, tabulated in Table 1, demonstrate the advantage obtained in this application deriving not only from the higher original strength of 50S over 3S but also from its greater percentage increase in yield strength for a given amount of stretch. This latter factor can be of decided advantage in strengthening sections of an item which by their nature receive minimum working during fabrication.

Depending upon the location from which the specimens were taken, the yield strength due to forming was from 36% to 42% greater for the 50S drawer, a substantial gain over the increase in yield strength of the 3S pan.

These tests all serve to re-emphasize the importance of giving careful consideration to all factors involved in selecting the aluminum alloy for a particular application, as well as the versatility provided by the entire family of aluminum alloys.

Many Alloys Provide Good Formability

Aluminum is generally known as one of the most easily formed metals. An accurate measure of formability has yet to be developed, although it is possible to draw general conclusions from an analysis of mechanical properties.

The spread between the tensile and yield strengths, and the per cent elongation provide indications of the formability of a particular alloy. In general, the more severe the operation, the greater both these measures should be.

Elongation is a measure of ductility, but cannot be considered by itself as a criterion of formability in practice. Material must be stressed beyond the yield strength to deform plastically and retain the desired new shape. However, if the forming stresses should exceed the tensile strength, the material will rupture (fracture): hence, the importance of the spread between the yield and tensile strength values. In this connection it is often found that a stronger temper of the same alloy may provide better formability because of its ability to withstand higher forming pressures.

Most of the generally used wrought aluminum alloys possess good spreads and elongation in their annealed (O) tempers. This is true of the heat-treatable alloys as well as the non-heat-treatable alloys.

It is not to be overlooked, however, that even complicated forming can be and is being done regularly with the heat-treatable aluminum alloys, including those of the highest strength, after solution heat treatment but before aging to maximum strength. This is possible because after the quenching that concludes solution heat treatment the heat-treatable alloys remain quite soft for varying periods of time. Within a few minutes the alloying constituents begin to precipitate as extremely small particles in the solid metal, and the strength at room temperature begins to increase. Some alloys, 24S for example, "age" rapidly to maximum strength; normally, others are artificially aged by a process termed precipitation heat treatment, which is a low-temperature thermal treatment.

It is in the interim period between quenching and aging that much forming can be done. This period may be prolonged by refrigerating the metal, which prevents or retards precipitation of the alloying particles. Formed parts are subject to a minimum of distortion in the low-temperature precipitation heat treatment that then follows. This general method is used extensively by aircraft manufacturers in stretch forming sections of considerable area.

Technical assistance in connection with aluminum alloy selection and fabrication techniques may be obtained through Kaiser Aluminum & Chemical Sales, Inc., 1924 Broadway, Oakland 12, California. Copies of a product information book on aluminum sheet and plate, containing comprehensive tables, may also be obtained on request.

SCIENTIFIC AMERICAN

Established 1845

CONTENTS FOR DECEMBER, 1953 VOL. 189, NO. 6

ARTICLES

DEPARTMENTS

What's Happening at CRUCIBLE

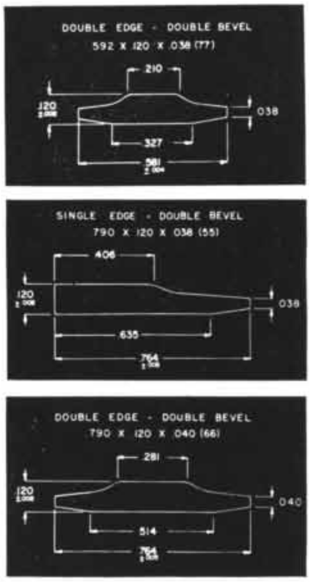
about clicker die steel

what it is

Clicker die steel is a special cold rolled alloy steel. It is used in making clicker dies for cutting leather, rubber, plastic, felt and fabrics of other compositions that go into the making of shoes and similar products.

Finished clicker die ready for cutting shoe leather.

Some of the clicker die steel standard shapes.



Wider shapes are used when dies are sized by surface grinding after forming and welding. Standard widths are provided when the dies are not to be surface ground.

how it is used

Clicker die steel is furnished to the die maker in either single or double edged form in one of several standard shapes. The die maker first shapes the die by bending the die steel to a pattern that provides the desired configuration, and then welds the two ends at a corner. He finishes the die by grinding a bevel on the outside of the cutting edge and filing the inside edge. Before the finished die is hardened and tempered, the die maker forms identification marks — combinations of circles and squares — in the cutting edge so that the material cut from it may be easily identified as to its size and style.

In the cutting operation, the leather or other material is placed on an oak block in the bed of the clicker machine. Then the die is placed by hand on the material which is cut as the aluminum faced head of the machine presses the die through it. The clicking sound which the head makes as it strikes the die is where the term "clicker machine" derived its name.

what it is composed of

Clicker die steel as produced by the Crucible Steel Company of America is a controlled electric steel in which the combination of carbon and alloy is designed for maximum toughness and proper hardness after heat treatment.

Experience has proved that cold finished clicker die steel is superior to hot rolled material for sizes approximately ¾ inch and narrower because of its lower degree of surface decarburization which permits the use of slightly thinner sections. Cold finished material also has a better surface finish with closer width and thickness tolerances and thinner edges that require less grinding and filing to complete the die.

CRUCIBLE'S engineering service

As with clicker die steel, the Crucible Steel Company of America is the leading producer of special purpose steels. If you have a problem in specialty steels, our staff of field metallurgists with over 50 years experience in fine steel making is available to help you solve it. Crucible Steel Company of America, General Sales and Operating Offices, Oliver Building, Pittsburgh, Pa.

CRUCIBLE first name in special purpose steels

53 *years of* *Fine* *steelmaking*

Midland Works, Midland, Pa. • Spaulding Works, Harrison, N. J. • Park Works, Pittsburgh, Pa. • Spring Works, Pittsburgh, Pa.
National Drawn Works, East Liverpool, Ohio • Sanderson-Halcomb Works, Syracuse, N. Y. • Trent Tube Company, East Troy, Wisconsin

SCIENTIFIC AMERICAN
DECEMBER, 1953 VOL. 189, NO. 6

The Mental Health of the Hutterites

How a small German religious sect of the western U. S. and Canada was studied to determine whether its unique cultural background affected the occurrence of neuroses and psychoses among its people

by Joseph W. Eaton and Robert J. Weil

Is modern life driving many people insane? Would insanity diminish or disappear if mankind could return to a simpler life? From Virgil to Thoreau the philosophers have had little doubt about the answer to these questions, and some modern anthropologists have offered data which seem to bear them out. They say they have found mental disorders rare among technologically primitive peoples. For instance, recent cursory studies of the people on Okinawa and of the natives of Kenya have suggested that these groups are virtually free of some psychoses. Contrasted with this picture is the civilized U. S., where some authorities have estimated that one person in 10 suffers an incapacitating mental illness at one time or another during his life.

Whether a culture can cause psychoses is not easy to discover, but one way to get at the question is to examine the mental health of a secure, stable society. The Hutterites, an isolated Anabaptist religious sect who inhabit a section of the North American Middle West, provide an ideal social laboratory of this kind. These people live a simple, rural life, have a harmonious social order and provide every member with a high level of economic security from the womb to the tomb. They are a homogeneous group, free from many of the tensions of the American melting-pot culture. And they have long been considered almost immune to mental disorders. In a study during the 1930s Lee Emerson Deets said that psychoses were almost nonexistent among them. The Manitoba Provincial Legislature received in 1947 a report which said that the Hutterites "do not contribute to the overcrowding of mental hospitals, since the mental security derived from their system re-

EAST CARDSTON COLONY in the Canadian province of Alberta is one of 98 Hutterite settlements in the Dakotas, Montana and prairie provinces of Canada. It is a ranch of 2,700 acres inhabited by 85 people. Its main crops are wheat, poultry and vegetables.

STAFF DIAGNOSIS OF ILLNESS	LIFETIME MORBIDITY: TOTAL NUMBER EVER ILL	ACTIVE CASE MORBIDITY: ILL IN SUMMER 1951	ACTIVE CASE MORBIDITY: ILL BUT IMPROVED ON AUGUST 31, 1951	OTHER CASES: RECOVERED BY OR BEFORE AUGUST 31, 1951	OTHER CASES: STATUS UNKNOWN
PSYCHOSES					
SCHIZOPHRENIA	9	7	1	1	0
MANIC DEPRESSIVE REACTION	39	3	5	27	4
ACUTE AND CHRONIC BRAIN DISORDERS	5	4	0	1	0
TOTAL	53	14	6	29	4
NEUROSES					
PSYCHONEUROTIC DISORDERS	53	24	15	12	2
PSYCHOPHYSIOLOGICAL, AUTONOMIC AND VISCERAL DISORDERS	16	7	3	5	1
TOTAL	69	31	18	17	3
MENTAL DEFICIENCY					
MILD	14	14	0	0	0
MODERATE	23	23	0	0	0
SEVERE	14	14	0	0	0
TOTAL	51	51	0	0	0
EPILEPSY	20	12	5	3	0
PERSONALITY DISORDERS	6	6	0	0	0
TOTAL CASES	199	114	29	49	7

MENTAL ILLNESS among U. S. and Canadian Hutterites living in the summer of 1951 is classified in this table. The total Hutterite population on December 31, 1950, was 8,542.

sults in a complete absence of mental illness."

Three years ago a research team consisting of the writers of this article—a sociologist and a psychiatrist—and the Harvard University clinical psychologists Bert Kaplan and Thomas Plant undertook a more intensive study of the Hutterites' mental health. The investigation was administered by Wayne University and financed largely by the National Institute for Mental Health. The Hutterite people cooperated generously. In the interest of science they opened their "family closets" and helped us to obtain a census of every person in their community who was then or had ever been mentally ill.

The Hutterites, whose origin as a sect goes back to 1528, are a closely knit group of German stock who had lived together in neighboring villages in Europe for a long time before they migrated to the U. S. from southern Russia between 1874 and 1877. The immigrants—101 married couples and their children—settled in eastern South Dakota. Their descendants have now spread over a wide area in the Dakotas, Montana and the prairie provinces of Canada. They live in 98 hamlets, which they call colonies. But they remain a remarkably cohesive group; each grown-up is intimately acquainted with hundreds of other members in the settlements. The Hutterites believe it sinful to marry outside the sect, and all of the present descendants (8,542 in 1950) stem from the original 101 couples.

Cardinal principles of the Hutterites are pacifism, adult baptism, the communal ownership of all property and simple living. Jewelry, art and overstuffed chairs are regarded as sinful luxuries. Radio sets and the movies are taboo. Children are the only possessions to which there is no limit: the average completed family has more than 10. The Hutterites cling to their own customs and are considered "different" by their neighbors. But they are not primitive in the ethnographic sense. They get a grammar-school education and speak English fluently. They read daily newspapers, have a telephone in most colonies and own trucks. Since their own members are not encouraged to seek formal education beyond the primary grades, there are no doctors or lawyers among them, but they utilize such professional services from outside. Each hamlet engages in a highly mechanized form of agriculture. Their business with the "outside world," as Hutterites are apt to refer to their neighbors, usually exceeds $100,000 per year per colony.

On the surface it seemed that the Hutterites did indeed enjoy extraordinary freedom from mental illness. We did not find a single Hutterite in a mental hospital. The 55 outside doctors patronized by these people said they showed fewer psychosomatic and nervous symptoms than their neighbors of other faiths. But this appearance of unusual mental health did not stand the test of an intensive screening of the inhabitants, carried out colony by colony. Among the 8,542 Hutterites we discovered a total of 199 (one in 43) who either had active symptoms of a mental disorder or had recovered from such an illness. Of these illnesses 53 were diagnosed as psychoses, all but five of them of a functional (non-organic) character.

In short, the Hutterite culture provides no immunity to mental disorders. The existence of these illnesses in so secure and stable a social order suggests that there may be genetic, organic or constitutional predispositions to psychosis which will cause breakdowns

FOUR YOUNG HUTTERITES are photographed at the Birch Creek colony in Montana. Each baby is held by an older sister, each of whom wears the usual Hutterite polka-dot kerchief. The day was hot, but the babies were dressed in the Hutterite custom.

HUTTERITE CHILDREN stand outside their school at the Ayers Ranch colony in Montana. When the children enter the first grade, they know more German than English. Nearly all Hutterite children finish the eight grades, but they leave school at the age of 15.

among individuals in any society, no matter how protective and well integrated.

The distribution of symptoms among the Hutterites was quite unusual. There were few cases diagnosed as schizophrenia, although elsewhere this is the most common psychosis. Only nine Hutterites had ever manifested the pattern of delusions, hallucinations and other recognized symptoms of schizophrenia; the group lifetime rate was 2.1 per 1,000 persons aged 15 and over. On the other hand, the proportion of manic-depressive reactions among those with mental disorders was unusual; this disorder accounted for 39 of the 53 psychoses, and the rate was 9.3 per 1,000 aged 15 and over. The name of the disorder is misleading; manic-depressives often are not dangerous to other persons, and none of the Hutterite patients was. Their symptoms were predominantly depressive. There was much evidence of irrational guilt feelings, self-blame, withdrawal from normal social relations and marked slowing of mental and motor activities. Five of the patients had suicidal impulses. Two Hutterites had actually killed themselves.

The fact that in the Hutterite society manic-depression is more common than schizophrenia, reversing the situation in all other populations for whom comparable data have been obtained, suggests that cultural factors do have some influence on the manifestation of psychoses. A Johns Hopkins University team of researchers who recently made an extensive analysis of mental hospital statistics concluded that schizophrenic symptoms are most common among unskilled laborers, farmers, urban residents in rooming-house sections and other persons who are relatively isolated socially, while manic-depressive reactions are more prevalent among professional, socially prominent and religious persons, who have a stronger need to live up to social expectations. Our data fit this theory well. Religion is the focus of the Hutterite way of life. Their whole educational system, beginning with nursery school, orients the people to look for blame and guilt within themselves rather than in others. Physical aggression is taboo. Like the Catholic orders, Hutterites own everything in the name of their church. They eat in a common dining room, pay medical bills from the communal treasury and work at jobs assigned to them by managers elected by the males of the colony. The group, rather than the individual, comes first.

In projective psychological tests the Hutterites, like other groups, show antisocial and aggressive impulses, but in their daily lives they repress these effectively. Their history showed no case of murder, arson, severe physical assault or sex crime. No individual warranted the diagnosis of psychopath. Divorce, desertion, separation or chronic marital discord were rare. Only five marriages were known to have gone on the rocks since 1875. Personal violence and childish or amoral forms of behavior among adults were uncommon, even in persons

HUTTERITE WOMEN pluck geese at the Hutterville colony near Magrath, Alberta. The best animals are sold to hotels and restaurants in the neighboring towns; the rest are stored in the community's freezer. The goose feathers are used to make bedding.

with psychotic episodes. There were no psychoses stemming from drug addiction, alcoholism or syphilis, although these disorders account for approximately 10 per cent of all first admissions to state mental hospitals in the U. S. In general our study tends to confirm the theory of many social scientists and public health officials that a favorable cultural setting can largely prevent these forms of social maladjustment.

All this does not entirely rule out the possibility that genetic factors play some part in the unusual proportions of manic-depression and schizophrenia symptoms among the Hutterites. There is some evidence that these disorders tend to run in families. The Hutterites are biologically inbred. Three surnames—Hofer, Waldner and Wipt—accounted for nearly half of all families in 1950. It is possible that the Hutterite group has a disproportionate number of persons genetically prone to becoming depressed—if there is such a predisposition. A team of Harvard University workers is planning to make a follow-up genetic study of the Hutterites.

The question of the relation of mental disorders to culture is difficult to investigate quantitatively. No country has a really complete record of mental disorders among its population. Censuses of patients in mental hospitals are almost worthless for this purpose; they leave out patients who have recovered and mentally ill persons who have never come to the attention of doctors.

The Hutterite study attempted to track down every case of a mental disorder, past or present, hospitalized or not, in the whole living population. It probably succeeded in finding virtually all the cases of psychosis. Similar studies have been made of seven other communities in various parts of the world, and the results are shown in the tables on page 37. They give the comparative rates of psychosis, as standardized by the Hutterite lifetime rate and corrected for variations in age and sex distribution. (The Hutterite population is predominantly youthful—50 per cent under 15 years of age.)

On this basis the Hutterites apparently rank second highest among the eight populations in the rate of psychosis, being exceeded only by an area in the north of Sweden. But there is considerable evidence that the count of mental disorders was less complete in the other seven groups; that is, in those studies many cases were missed because their illness was not a matter of public record, while the Hutterite population was thoroughly screened. It is probable that the psychosis rate among the Hutterites is actually low compared with that in other populations. It seems to be only one third as high as the rate in New York State, for instance, taking into consideration the common estimate that even in that State (where mental hospital facilities are among the most extensive) there is at least one undetected psychotic person for every one in an institution.

The statistical comparison of mental

WHEAT HARVEST is observed by the preacher and manager of the King colony in Montana. He had heard that rain was predicted and came out to tell the men to hurry.

NEW TRACTOR draws a baling machine after the harvest at the King colony. Hutterites do not buy radios or similar "modern luxuries," but they like efficient farm equipment.

BOY HELPER to the "sheep boss" at the Deerfield colony in Montana drives his sheep into corral. The Hutterites sell most of their wool, but keep some for their own knitting.

disorder rates has many limitations, but it does offer several promising leads to the puzzle that the problem of functional psychoses presents to modern science. Among the Hutterites, as in all the other populations, the frequency of psychoses increases rapidly with age. Among those who showed manic-depressive reactions, females predominated. The social biology of the aging process and of sex probably holds worthwhile clues to some of the problems of cause and treatment.

Neuroses were more common than psychoses among the Hutterites, as elsewhere. Four fifths of the 69 discovered neurotics were female. Melancholy moods were regarded by teachers as the number one emotional problem of Hutterite school children. Hutterite neurotics showed the same tendency as psychotics to take out mental stress on themselves instead of on others. Self-blame and remorse were common, as were psychosomatic headaches, backaches and hysteric paralysis of a limb. There was little scapegoating or projection of hostile feelings by imputing them to others.

There is no evidence of any unusual concentration of hereditary mental defects in the Hutterite population. A total of 51 persons was diagnosed as mentally deficient, and 20 normal persons had suffered epileptic attacks. These epilepsy and mental deficiency rates are not high in comparison with other groups.

How does the Hutterite culture deal with mental illness? Although it does not prevent mental disorders, it provides a highly therapeutic atmosphere for their treatment. The onset of a symptom serves as a signal to the entire community to demonstrate support and love for the patient. Hutterites do not approve of the removal of any member to a "strange" hospital, except for short periods to try shock treatments. All patients are looked after by the immediate family. They are treated as ill rather than "crazy." They are encouraged to participate in the normal life of their family and community, and most are able to do some useful work. Most of the manic-depressive patients get well, but among neurotic patients recovery is less common. Most of the epileptics were either cured or took drugs which greatly relieved the condition. No permanent stigma is attached to patients after recovery. The traumatic social consequences which a mental disorder usually brings to the patient, his family and sometimes his community are kept to a minimum by the patience and tolerance with which most Hutterites regard these conditions. This finding supports the theory that at least some of the severely antisocial forms of behavior usually displayed by psychotic and disturbed patients are not an inherent attribute. They may be reflections of the impersonal manner of handling patients in most mental hospitals, of their emotional rejection by the family and of their stigmatization in the community.

In the Hutterite social order people are exposed to a large number of common experiences. Their indoctrination begins in infancy and is continued by daily religious instruction and later by daily church-going. Hutterites spend their entire life within a small and stable group. Their homes consist only of bedrooms, all furnished in an almost identical manner. The women take turns cooking and baking for everybody. Everyone wears the same kind of clothes; the women, for example, all let their hair grow without cutting, part it in the middle and cover it with a black kerchief with white polka dots. The Hutterite religion provides definite answers for many of the problems that come up.

Despite this uniformity in the externals of living, Hutterites are not stereotyped personalities. Differences in genetic, organic and psychological factors seem to be sufficiently powerful to produce an infinite variety of behavior, even in a social order as rigid as this one. It appears that the nightmare of uniformity sketched in George Orwell's *Nineteen Eighty-four* is actually unachievable in a living society. At least our study in depth disclosed no simple standardization of personality structure among Hutterites.

There is considerable objective evidence that the great majority of Hutterites have a high level of psychological adjustment. Their misfortunes and accidents are alleviated greatly by the group's system of mutual aid. The sick, the aged, the widows and orphans are well taken care of. In the last three decades only about 100 persons (most of them male) have left the community permanently. During World War II about one third of the men between the ages of 20 and 40 served in camps for conscientious objectors; more than 98 per cent of them ultimately returned to their colonies.

There has not, however, been any rush of applicants from outside to join the Hutterite sect. Mental health involves value judgments and depends on what people want from life. Only 19 adults have joined the sect in America during the last few decades. The austere and puritanical customs of the sect impose restrictions which even the members, who learn to accept them, regard as a "narrow path." Their culture is therapeutic only for conformists. There are occasional rebels; the more able ones find a means of expressing themselves by becoming leaders, the less brilliant have difficulties.

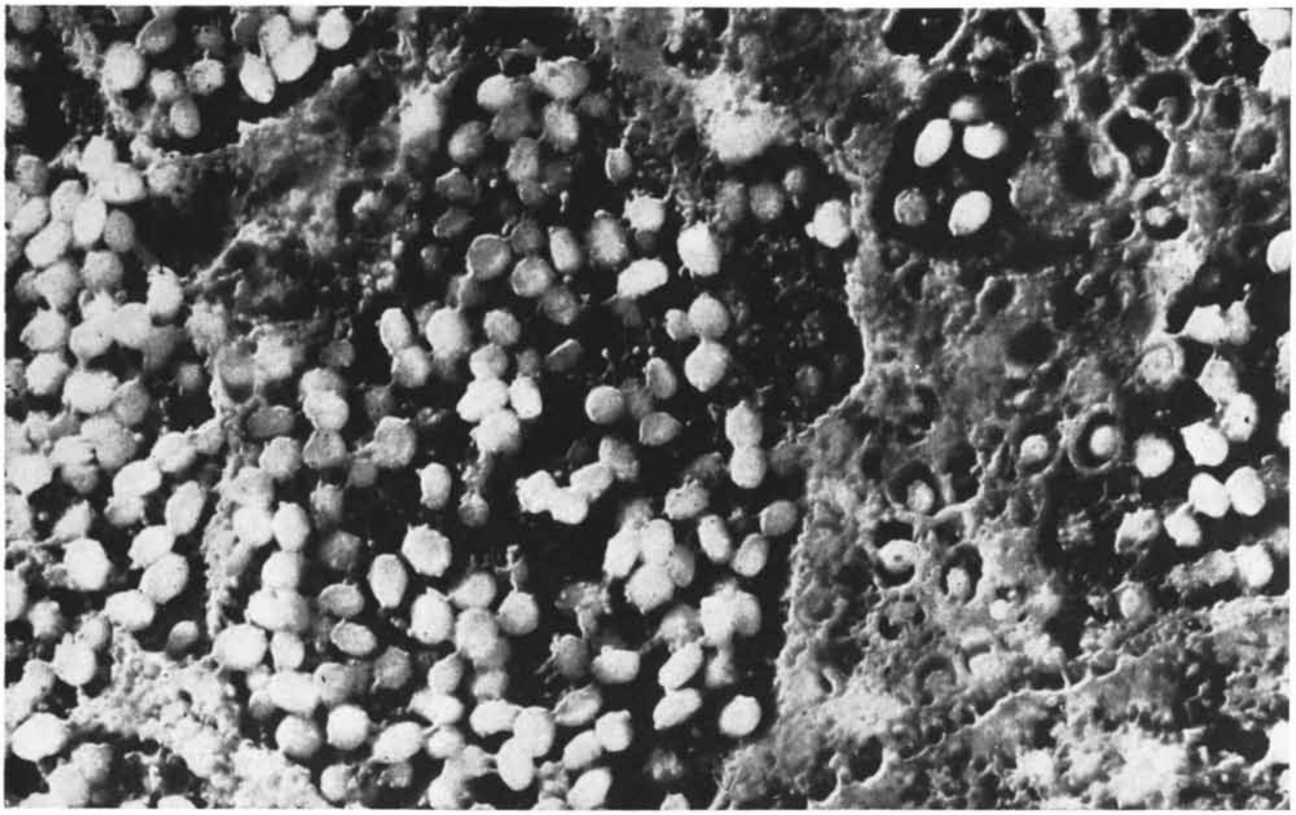
STUDY	NUMBER OF CASES DIAGNOSED	PER CENT OF CASES DIAGNOSED			
		SCHIZOPHRENIA	MANIC DEPRESSION	ALL OTHER DIAGNOSES	TOTAL
ETHNIC HUTTERITES	53	17	74	9	100
NORTH SWEDISH AREA	107	87	2	11	100
WEST SWEDISH ISLAND OF ABO	94	43	27	30	100
BORNHOLM ISLAND	481	31	25	43	100
WILLIAMSON COUNTY, TENN.	156	27	26	47	100
BALTIMORE EASTERN HEALTH DISTRICT	367	43	11	46	100
THURINGIAN VILLAGES	200	37	10	53	100
BAVARIAN VILLAGES, ROSENHEIM AREA	21	38	10	52	100

EIGHT GROUPS investigated by independent studies, including the one described here, are analyzed for percentage of each major diagnostic category among their psychotics.

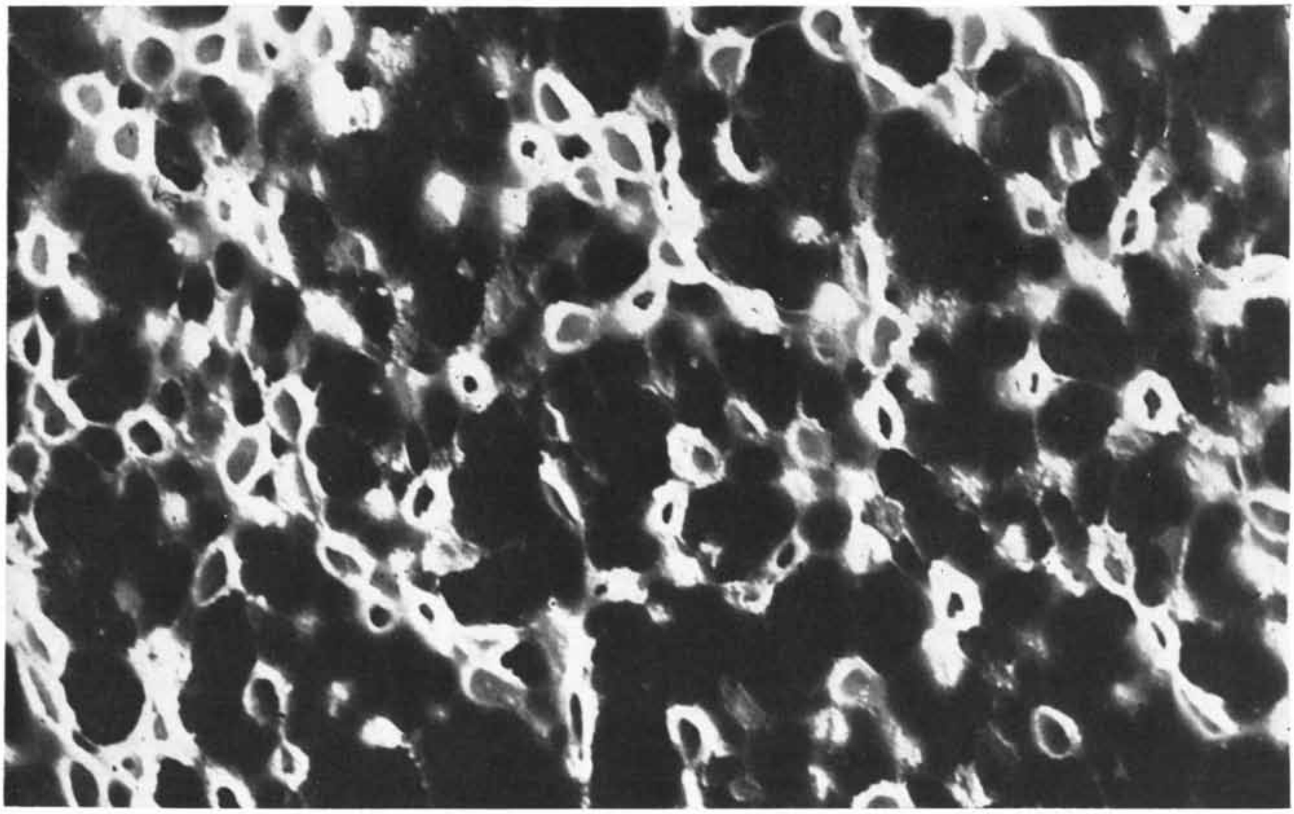
SURVEY	TOTAL POPULATION	ACTUAL NUMBER OF CASES FOUND	EXPECTED NUMBER OF CASES BY HUTTERITES NORMS	EXPECTANCY RATIO
NORTH SWEDISH AREA	8,651	107	94	1.14
ETHNIC HUTTERITES	8,542	53	53	1.00
BORNHOLM ISLAND	45,694	481	773	.62
BALTIMORE EASTERN HEALTH DISTRICT	55,129	507	822	.62
WILLIAMSON COUNTY, TENN.	24,804	156	271	.58
WEST SWEDISH ISLAND OF ABO	8,735	94	186	.51
BAVARIAN VILLAGES, ROSENHEIM AREA	3,203	21	49	.43
THURINGIAN VILLAGES	37,546	200	617	.32

ONE GROUP, the Hutterites, is compared to the other seven by the standard expectancy method. The frequency of *diagnosed* cases of psychosis among Hutterites is relatively high.

The survival of this 16th-century peasant culture in the heart of the most 20th-century-minded continent is a vivid demonstration of the power of values and beliefs. Although our data on the Hutterites' mental disorders clearly demonstrate the inadequacy of a purely cultural approach to the problem of mental health, they do show that culture has a large influence in shaping personality. Psychiatrists who work exclusively in hospitals or clinics cannot see the whole patient as he functions in his total environment. Our findings lead us to conclude that the social relations of the patient and his culture, including the things in which he believes, deserve more attention from psychiatric researchers and clinicians than is commonly given to them.



VIRUSES of the skin disease molluscum contagiosum are the round white bodies in this electron micrograph of human skin cells. Embedded in the material at the right are hollow developmental forms of the virus, within which may be seen immature virus particles. The tissue was impregnated with plastic and sliced; then the plastic was removed and the section shadowed with palladium.



SLICED VIRUSES of molluscum contagiosum are shown in this electron micrograph of human skin cells. Unlike the section in the micrograph at the top of the page this section cuts through the bodies of the viruses themselves, showing their thick walls. Both of the electron micrographs printed on this page were made by William G. Banfield of the Yale University School of Medicine.

Viruses within Cells

Until recently the electron microscope could make these small organisms visible only if they were isolated. Now an ingenious technique of preparation reveals them in their natural habitat

by Joseph L. Melnick

Viruses, the tiniest of all living things (if indeed they are living things) have not been easy to track down. Much can be learned about viruses by indirect means, but naturally an investigator wants to see the creatures, especially to follow their development and behavior. It is less than 15 years since man obtained his first look at a virus through the electron microscope. In the last decade studies have been made of the sizes and shapes of a number of viral agents which infect plants, animals or man. But these still lifes of isolated, inactive specimens, interesting as they are, have told little about how viruses propagate and grow in their natural home—the cell.

Two and a half years ago the world-famous Australian virologist Sir Macfarlane Burnet wrote in this magazine ("Viruses," Scientific American, May, 1951): "Electron microscopists who are interested in viruses are seeking to devise ways in which clear pictures of what is happening in the early stages of cell infection can be obtained. This is obviously not going to be an easy task, but one can feel reasonably certain that it will be accomplished." The task is now on its way to being accomplished. The door has been opened and we have begun to explore a fascinating territory.

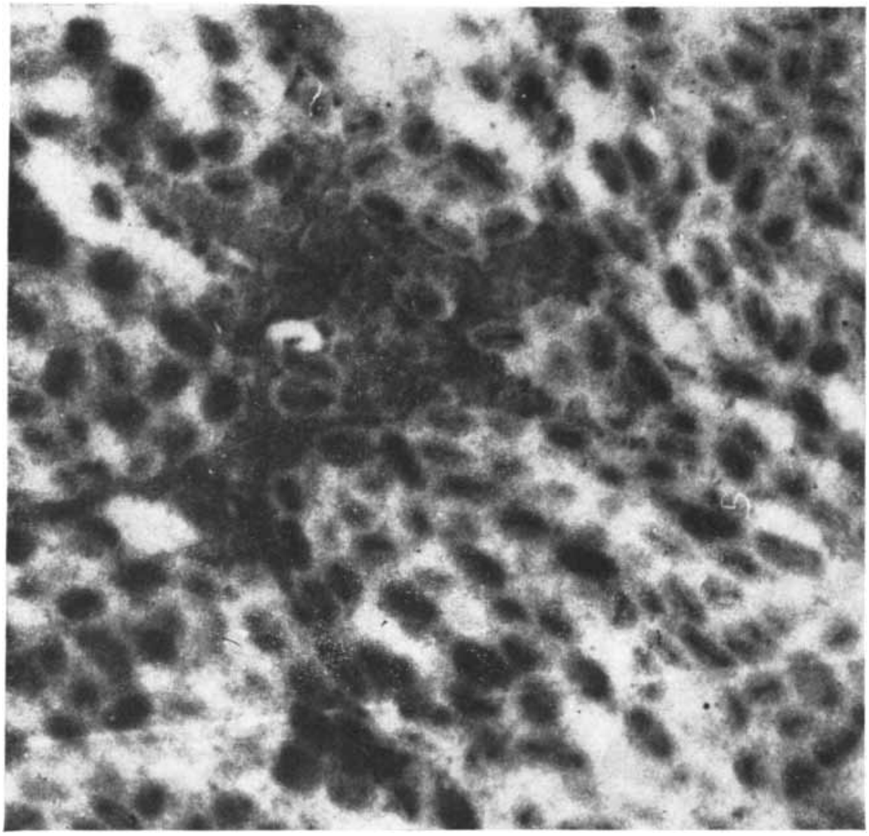
Before describing the new technique for catching viruses in the process of propagation in the cell, I would like to outline the most recent theory as to how this process takes place. G. S. Stent explained it in detail in his article on "The Multiplication of Bacterial Viruses" in the May issue of Scientific American. In infecting a bacterium a bacterial virus first attaches itself to the cell by a needle-like structure which was once believed to be a tail but is now thought to be its proboscis. Through this needle the virus injects into the cell its internal gene-like material, the nucleic acid known as DNA. The emptied protein coat of the virus is left outside, like a disposable container, and plays no further part in the production of offspring. Within the cell the virus's DNA—its reproductive, genetic substance—proceeds to sabotage the bacterium's metabolism, forcing it to produce virus nucleic acid and protein instead of the materials it normally manufactures for its own growth. After a short incubation period, parts of new viruses—just the protein coats—begin to form. Then, a little later, a large number of fully formed viruses rapidly appear in the cell; that these structures are mature viruses is proved by the fact that if extracted and put to the test they show the ability to infect bacteria. When the cell becomes filled with these progeny, it bursts open and the new viruses emerge.

Now it seems clear that the incipient virus growing in the cell is not at all the same thing as a mature virus which circulates outside and has the power of infecting new cells. A great mystery is what happens during the early stages of propagation, when the invading virus has disappeared and no virus can be found in the cell at all. How do the new viruses start and how do they develop? This is, of course, a crucial question, important not only in connection with bacterial viruses but for virus infections in general, for it seems that some of the viruses that attack animals follow a cycle like that of the bacteriophages.

To see what is going on in the small world of the viruses we must use the electron microscope, and our problem is that this is a radically different instrument from the optical microscope. The standard fixing, staining and slicing procedures which generations of investigators have developed to prepare tissue for optical work are of little value in electron microscopy. The tissue slices ordinarily used in optical microscopes are 40 times too thick to be penetrated by an electron beam; for the electron microscope we need slices no thicker than one to two tenths of a micron (four to eight millionths of an inch). It is impossible to cut sections as thin as this with ordinary preparations and the conventional tissue slicer called the microtome.

New methods had to be developed, and a number of laboratories in this country and abroad contributed to that end. The virus is first grown in some hospitable tissue, such as the chorio-allantoic membrane of a chick embryo. Then small bits of the infected tissue, about four square millimeters in cross section, are treated with osmium tetroxide in a solution of controlled acidity. After this the tissue is placed in a plastic solution, liquid methacrylate, which readily penetrates the tissue's cells. The addition of a suitable catalyst transforms the methacrylate into the hard, transparent plastic known as lucite. Now the cells, firmly embedded in this hard material, can be sliced to the required thinness. The slicing is done with a knife made of the sharp edge of a cracked piece of plate glass. The tiny block of plastic tissue is made to advance ever so slightly between each stroke, and the knife shaves off a tiny section from the forward end. The cut tissue is floated on water and then placed on a 200-mesh grid for viewing in the electron microscope. Only that part of the section over the holes in the grid can be seen. If desired, the plastic in which the tissue is embedded may be dissolved and the tissue covered with a thin coat of metal, deposited on it in a high vacuum, to give shadow pictures.

The electron micrographs illustrating this article were taken by William H. Gaylord, Jr., and William G. Banfield in



MOLLUSCUM CONTAGIOSUM VIRUSES have many forms. In dark area at upper left are ghostly virus precursors. Also visible are forms with bar- and dumbbell-shaped interiors.

association with Henry Bunting, Maurice J. Strauss, and the writer. They show pox viruses in the process of multiplying within animal cells. The viruses studied were those that produce mouse pox, vaccinia (closely related to small pox) and the human skin infection called *molluscum contagiosum*. These viruses are well suited to investigation under the electron microscope, because their appearance is so well known that they can easily be recognized wherever they appear.

Mature viruses show up conspicuously in these pictures. As the micrographs disclose, they are round to oval in shape. Their exact size is difficult to determine in the slices, because the particles are cut at all sorts of angles, but it is of the same order of magnitude as the known measurements of purified pox viruses—about 210 to 260 thousandths of a micron. The viruses are easy to distinguish from other cell bodies because of their uniformity of size, shape and density.

The micrographs on these pages picture various stages in the development of viruses in the cell. From many, many such pictures Gaylord and the writer have deduced the following working hypothesis about how the development proceeds after infection of the cell with a pox virus.

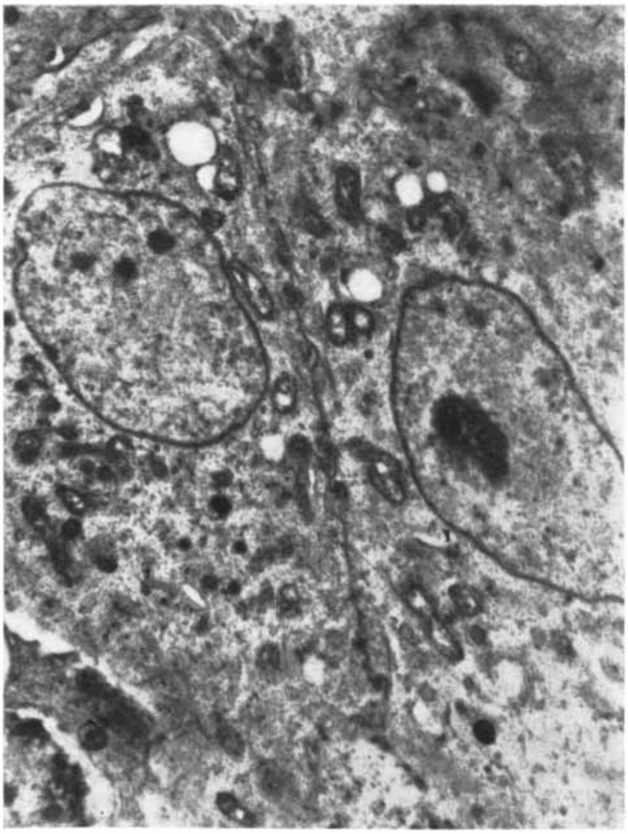
It begins in the cell's cytoplasm. In certain tissues inclusion bodies are produced first and the viruses develop within them; in others there are no inclusion bodies. In the latter case early stages of the multiplication cycle can be seen. First a dense matrix forms near the nucleus. In this matrix one can see "hollow" spheres, which are assumed to be the earliest observable form of the virus. The matrix area steadily expands, and as it does the structures within it increase in number and complexity. We have called them the developmental forms of the virus. These developmental bodies differ from mature viruses in several respects. They are not randomly distributed through the cell but appear only in groups or nests within the matrix or inclusion body. They are more nearly spherical than mature viruses and slightly larger—about 300 thousandths of a micron in diameter. And they are more transparent to the electron beam.

It seems that the early hollow sphere is followed by a form which is filled with a homogeneous material of low density. A granule of variable size appears inside the sphere, and our hypothesis suggests that it grows at the expense of the homogeneous material. Just how a developmental body changes into a mature virus is still obscure. Sometimes a new virus just after formation has an internal structure, as the developmental body does: a bar- or dumbbell-shaped section can be seen inside it. No such structure can be seen in viruses outside the cell; it is found only in new ones at the sites of multiplication. In any case, as the number of developmental forms in the cell increases, so does the number of finished or mature viruses. Presumably the change from the developmental to the mature form is accomplished at the expense of the matrix in which the particles are embedded. The matrix area disappears, the developmental bodies diminish, and the cell becomes filled with mature viruses. The infection—meaning the process of multiplication of the original virus that invaded the cell—is now complete.

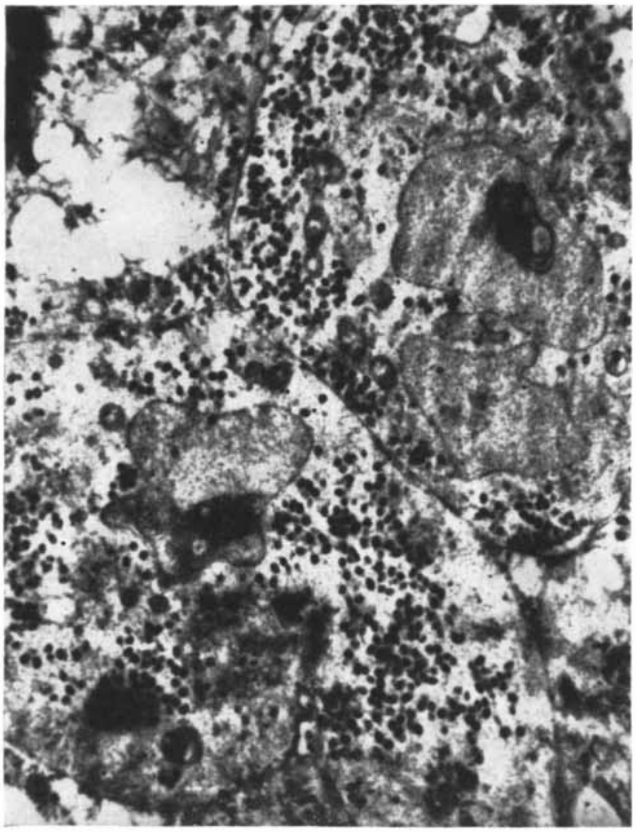
All this still leaves important gaps. Little is known about the reproductive cycle of small viruses, such as those of poliomyelitis and yellow fever, and much has yet to be learned about the cycle of the large pox viruses. There are no pictures to throw light on how the virus enters the cell or how the matrix area or inclusion body—the site where development starts—is formed. It should also be emphasized that although the observations described are real, the proposed sequence of development is only a hypothesis at this point; there may be other ways of interpreting the phenomena we have seen.

We can point up the question by comparing the infected cell to an automobile factory and the viruses to the cars being produced. We have suggested that the factory first manufactures the automobile bodies (developmental forms) and then puts in the engines to produce complete cars (mature viruses). But it may be that the structures we have seen in the cell are not really developmental forms but alternative end-products. In other words, the factory may produce bodies either with or without engines, depending perhaps on the availability of certain raw materials (such as nucleic acids) at the time when the bodies are laid down. The factory may have no mechanism for installing engines inside bodies after the bodies have been rolled from the site of their production.

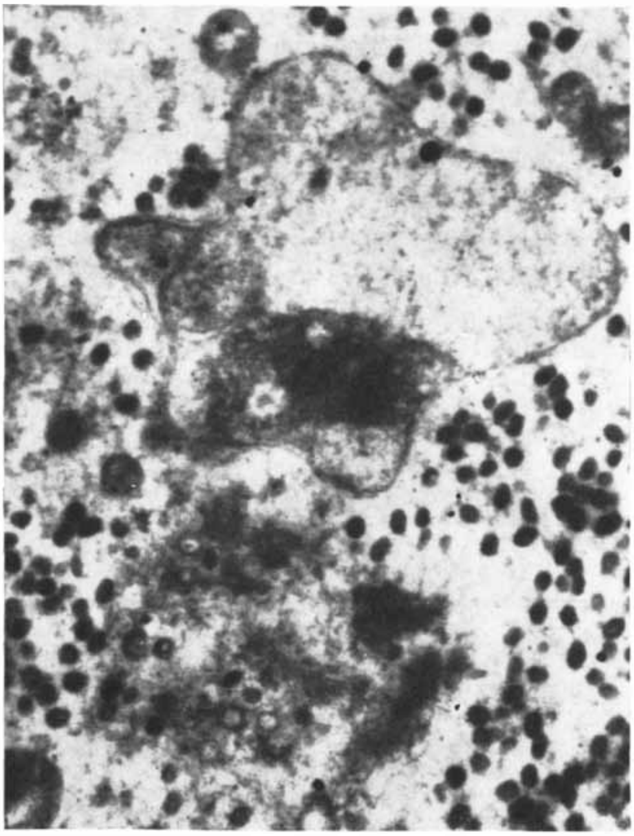
However close to or far from the mark these tentative hypotheses may be, the important fact is that the virus has now been followed into the factory, and the possibilities for investigating the fundamental mechanism of viral infection have been greatly increased.



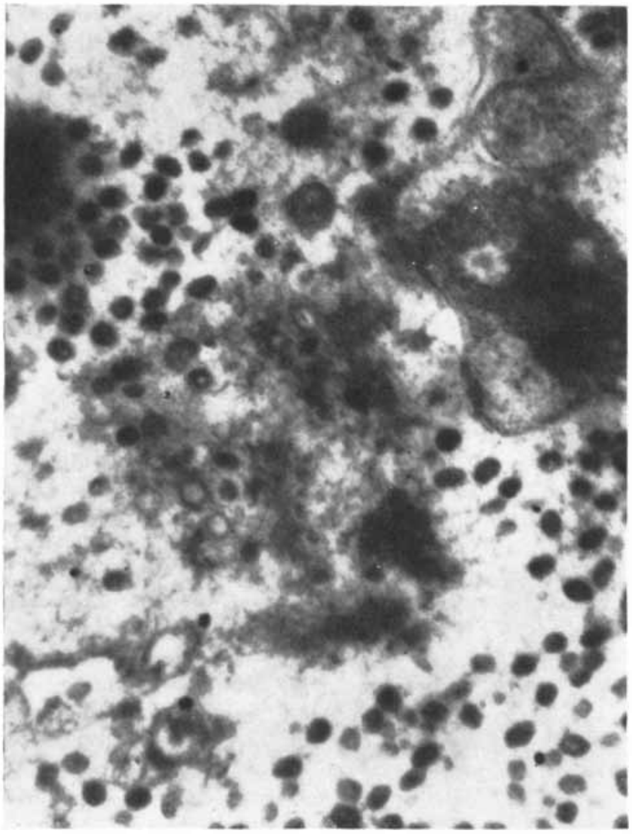
TWO UNINFECTED CELLS of a chick embryo are separated by cell membranes in center. The nuclei are at the left and right.



TWO INFECTED CELLS of a chick embryo are filled with vaccinia viruses, which are the small, round, dark particles.



HIGHER MAGNIFICATION of the material at upper right shows nucleus of one cell surrounded by viruses in the cytoplasm.



STILL HIGHER MAGNIFICATION of the same material shows developmental forms of the virus as small transparent particles.

RADIO WAVES FROM INTERSTELLAR HYDROGEN

The thin clouds of hydrogen in space radiate energy at a frequency of 1420 megacycles and a wavelength of 21 centimeters. Astronomers use the phenomenon to locate the clouds and to detect their motion

by Harold I. Ewen

The young science of radio astronomy, now barely 15 years old, has developed with remarkable speed and in an unexpected variety of exciting directions. It began with investigators simply picking up "noise" from the sky. The radio broadcasts coming to us from outer space can be compared to sounds from a boiler factory: they are a jumble of vibrations covering a broad band of frequencies. It has not been easy to figure out what these messages mean. But about a year and a half ago a single significant note was discerned through the din. Today listening posts all over the world are tuning in on this high-pitched monotone at 1420 megacycles, and from it they are obtaining a new picture of the universe.

The situation is somewhat like the revolution that came with the arrival of the spectroscope in astronomy a century ago. Up to that time astronomers looking through their telescopes had seen stars and nebulae only as objects in the sky. The stars were simply points of light. The spectroscope, which analyzed starlight into spectral lines, made it possible to learn the story of the motions of the stars and what they were composed of. Now radio astronomy has, in the 1420 megacycle signal, its first spectral line. The signal carries information about the hydrogen floating in space. To the music of the spheres it has added the song of interstellar space.

With the new hydrogen radio-telescope we can observe what the most powerful optical telescope could never make visible; we can examine the cold vacuum and look far into space through the interstellar dust and other obscuring clouds that block vision. It will give us a more detailed picture of the structure and dynamics of our galaxy; it will tell us more about neighboring galaxies, and it will fill in more of the answer to the ancient question as to what fills the void between the stars.

The visible spectrum has already told something about interstellar matter. Light-absorption studies have shown it to consist of gas molecules and dust particles so sparsely scattered that the space they "fill" is a vacuum far higher than we could ever hope to achieve on earth. The average energy of the particles corresponds to a temperature about 50 to 100 degrees above absolute zero. In a few regions near very hot stars, the gas is ionized and glows with a light of its own. The spectrum of this light indicates that most of the gas particles are neutral hydrogen atoms.

In 1944 the Dutch astronomer H. C. van de Hulst made the startling prediction that it should be possible to detect the hydrogen atoms not only near the stars, where they are excited to glow, but in the extremely cold, tenuous reaches of space. He said that the atoms there should emit a detectable amount of energy at the radio wavelength of 21 centimeters (another way of saying 1420 megacycles). To many his prediction seemed fanciful, but in 1951 this radiation was indeed detected by means of supersensitive radio receivers.

Let us briefly review the facts about the hydrogen atom that explain this discovery. The hydrogen atom has a positively charged proton as its nucleus and a negatively charged electron revolving around it as the earth revolves around the sun. Unlike the earth, however, the electron can jump from one orbit to another—as if the earth could jump to the orbit of Mercury or Saturn. When the electron moves to an orbit farther from the proton, it absorbs energy; when it moves to one that is closer, it emits energy. The orbits allowed to the electron are fixed, and when it jumps from one to another it absorbs or emits a certain definite quantum of energy, which is measured by the difference in energy levels between the two orbits. The quantum of energy involved in the jump is expressed by $h\nu$; in this expression h is a constant and ν is the spectral frequency at which the energy is emitted or absorbed. The bigger the jump, the higher the frequency.

The frequencies of the quantum jumps of the hydrogen electron are largely in the visible range, and these have provided most of the information about the atom. But some of the permitted jumps are so small that the frequency falls in the very much lower range of the radio spectrum. The jump in this case is not a large-scale transition from one orbit to another but a shift between sublevels, for the electronic orbits are split into closely spaced energy levels which also are permitted to the electron. These small-scale energy differences are known as the "fine" and "hyperfine" structure of the atom. The fine structure is due to relativistic effects. We are interested here in the hyperfine structure, which arises from spin effects.

Both the proton and the electron in a hydrogen atom spin on their own axes. Since they are electrically charged, their spins produce magnetic fields. This means, of course, that they may attract or repel each other. When the electron is in the so-called ground state, meaning the orbit closest to the proton, the magnetic interaction between the two particles is strong enough to have a measurable effect on the total energy of the system. When the magnetic axis of the electron is parallel to that of the proton, the system is in a higher energy state; if the electron flips over so that the spins are antiparallel, it falls into a lower energy state. This circumstance splits the ground state into two hyperfine energy levels. And the jump between these two levels absorbs or emits energy at the frequency of 1420 megacycles.

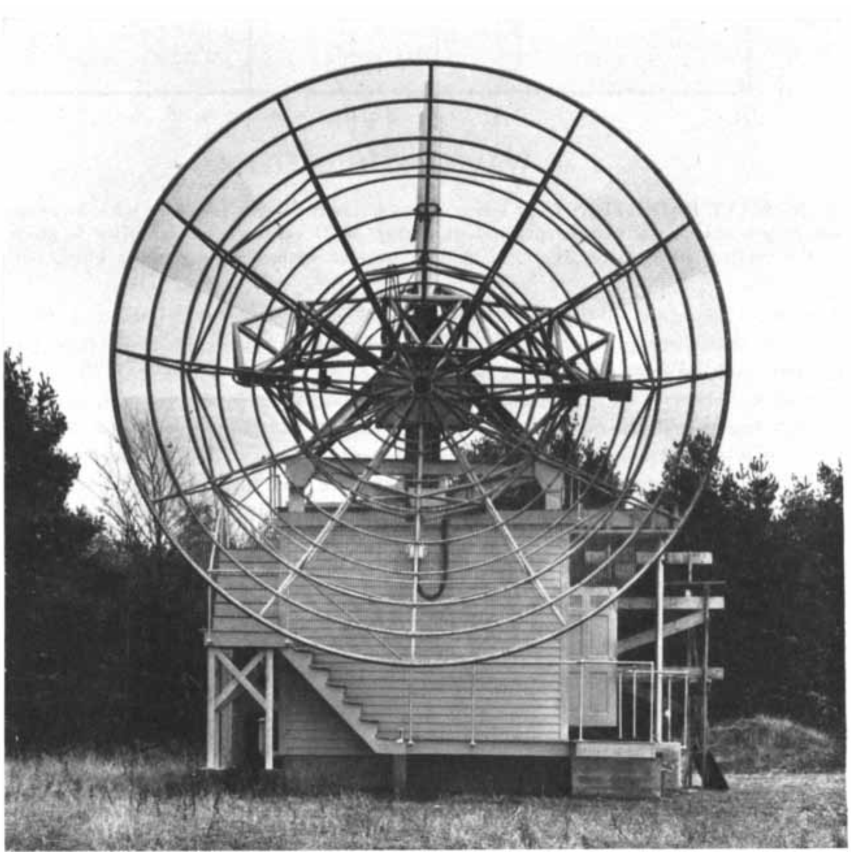
It should now be apparent why this frequency has become so important to astronomy. The neutral atoms of hydrogen in the extreme cold of space must be in the lowest or ground state of energy.

There is not enough energy available there to raise many of them to a higher state. But the energy is sufficient to excite the hyperfine levels of the ground state. Consequently the system as a whole radiates and absorbs energy at 1420 megacycles, corresponding to the difference between these hyperfine levels.

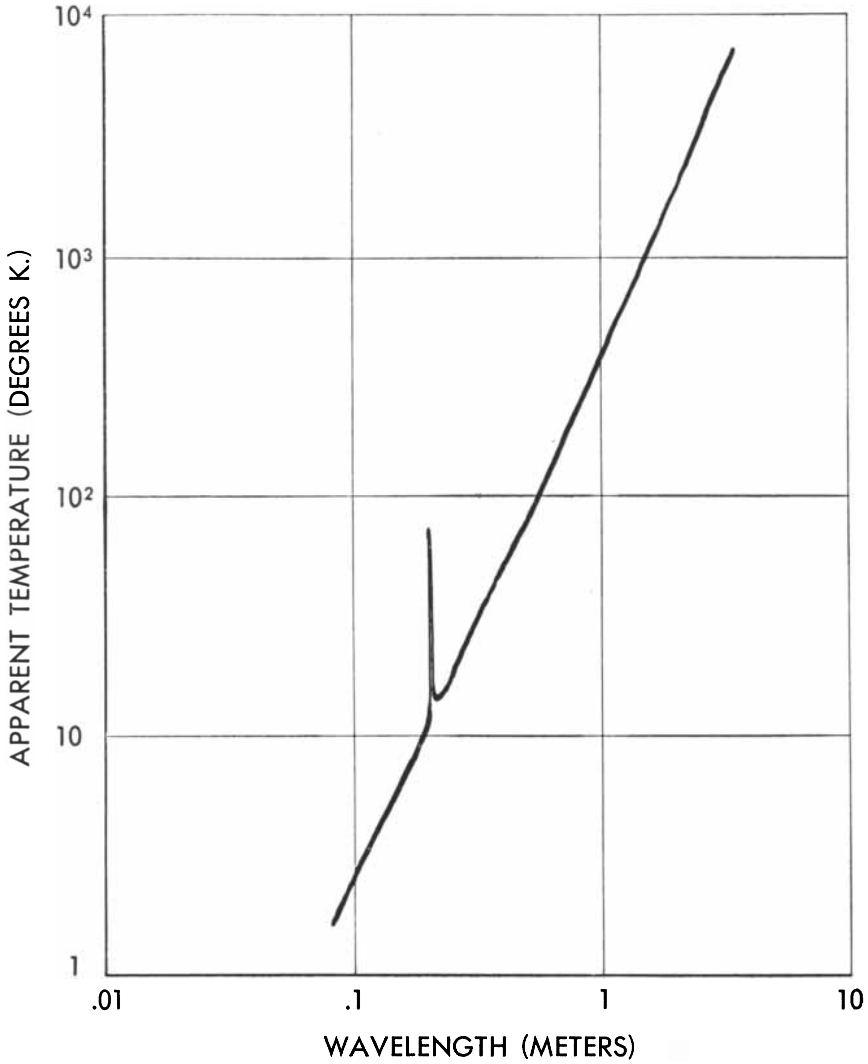
When van de Hulst suggested the possibility of detecting the "hydrogen line" in 1944, there was considerable speculation among astronomers as to whether the equilibrium conditions in space would provide an emission or an absorption line. Many believed that the line would be undetectable. When it was detected in 1951, it turned out to be an emission line. This showed that the "hydrogen spin temperature" in space was higher than the temperature of the background field.

Since that discovery, many theories have been proposed to explain why the radiation occurs as an emission line. It is now generally agreed that the most convincing one is a "collision" hypothesis suggested by N. F. Ramsey and V. L. Weisskopf and worked out in detail by E. M. Purcell and R. H. Dicke. Their explanation as to what makes the electron flip over and yield an emission of energy is rather complex, and perhaps the best way to give an account of it is to follow a hydrogen atom through space.

Imagine that we have hopped on the proton of a neutral hydrogen atom and are riding it through the space of our galaxy. The atom is assumed to be a truly representative one, so that we shall see not the unique career of an individual atom but the average of the effects on all atoms. We see our electron revolving around us and notice that it is also spinning on its axis like a top. The proton likewise is spinning, and its spin axis



NEW RADIO-TELESCOPE at Harvard College Observatory is shown with its movable 25-foot reflector in two positions. The instrument was designed to operate over a frequency range from 300 to 1600 megacycles, which includes the radiation from interstellar hydrogen.



MICROWAVE RADIATION from space shows a steady rise in intensity with increasing wavelength except for the sharp burst of energy at 21 centimeters. Intensity is plotted on the vertical scale in terms of the temperature of a similarly radiating black body.

happens to be parallel to that of the electron. We shall keep an eye on the relation between the two spins. As we begin the trip, we observe, by means of a radio receiver tuned to 1420 megacycles, that we are moving through a weak radiation field at this frequency. The radiation is composed of energy from diffuse starlight, from the ionized gases around stars, from collisons between clouds of gas and dust, and from various other energy-emitting processes. The total strength of the field is about equal to the radiation at 1420 megacycles that would come from a black body (a body that absorbs all radiation striking it) at a temperature of some 10 degrees above absolute zero.

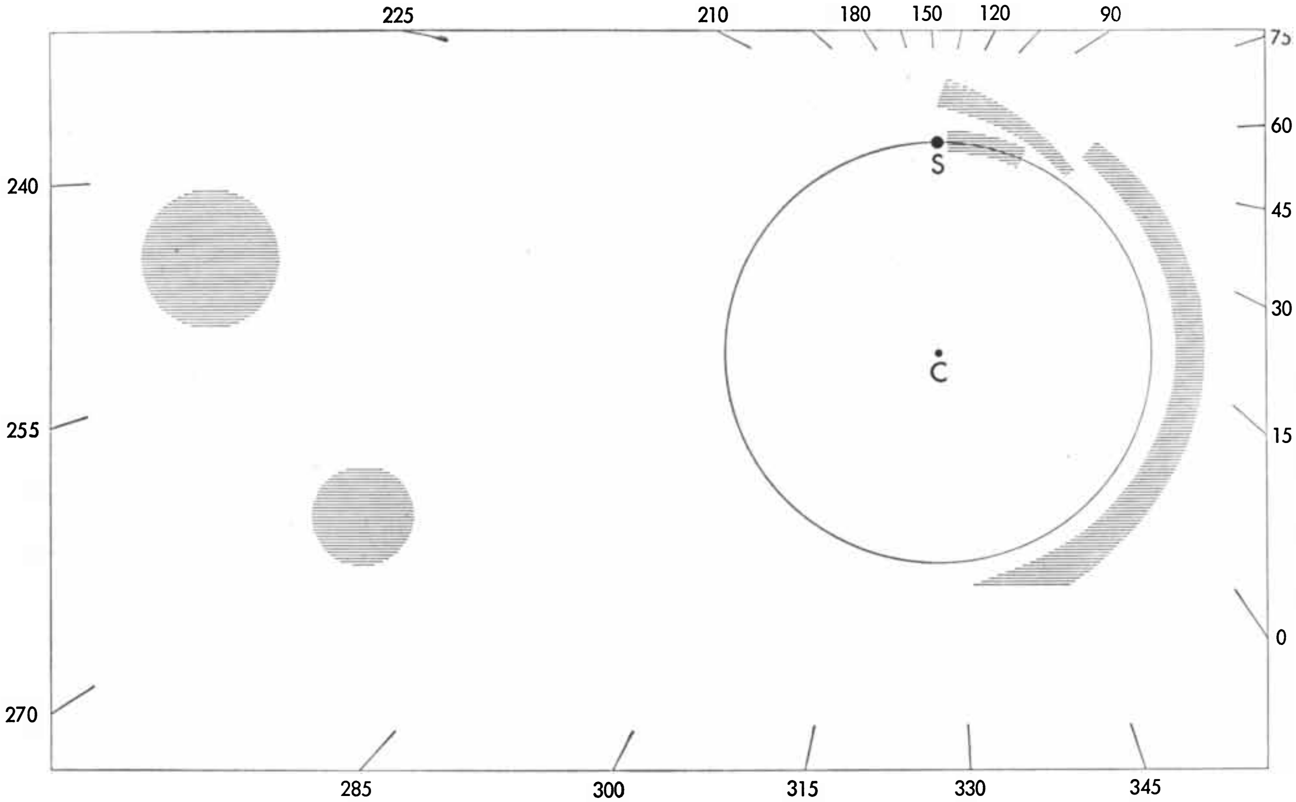
This radiation field, though weak, is strong enough to provide the energy to flip over the electron in our atom. It will take nearly 10 million years to do so (in our average atom). When the electron flips, our atom emits a quantum of energy at 1420 megacycles. However, we can deduce that this event is not detectable on Earth. If the coupling of the hyperfine energy levels of the hydrogen atoms with the radiation field were the only source of energy for flipping the electrons, in the three billion years of the universe's history the whole system of hydrogen atoms in space would have reached an equilibrium of spin orientations in which it would be radiating and absorbing energy like a black body at 10 degrees absolute. In other words, to an observer on the earth the emissions from the hydrogen atoms resulting from the flipping over of the electrons by the field must be indistinguishable from the radiation field itself!

What, then, is the energy reservoir that accounts for the hydrogen broadcasts detected on the earth? The answer is available to us. We are flying through a space in which there is an average of one hydrogen atom in each cubic centimeter, but our atom is so small that, even though we are traveling at three miles per second, we rarely hit another atom. Once in about 50 years, however, we do collide with one. Almost as likely as not, we will come out of the collision with a flipped electron. Obviously this event occurs so much more often than the flipping of the electron by the background field that the radiation must be distinguishable from the background, assuming that this energy coupling results in a different equilibrium temperature.

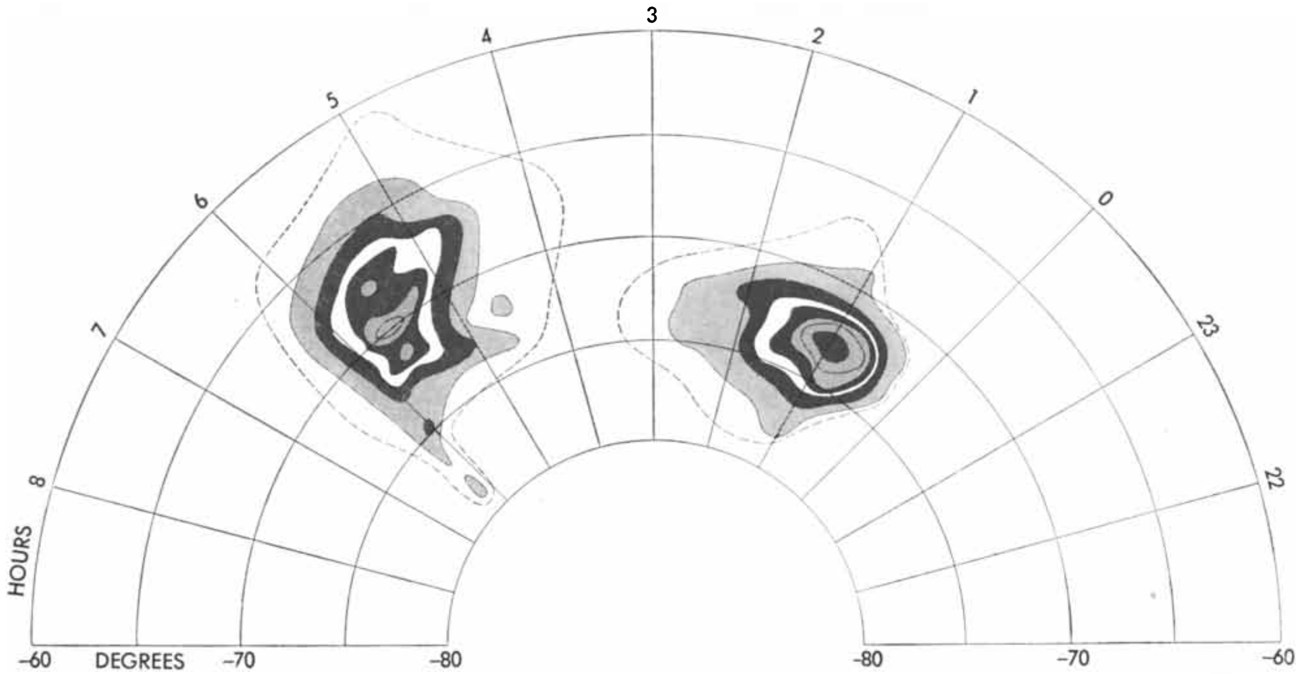
The collision is not a simple experience; it is difficult to make out what goes on. The other atom spirals in toward us, but it does not actually hit us. When the two protons are closest, their two electrons shuttle back and forth between them. The electrons lose track of which proton they came with, and when the collision is over, the chances are even that our electron has departed with the other proton and we have taken its electron in exchange. Now if it happens that our new electron has a spin opposite to that of the old one, our atom will radiate or absorb energy at 1420 megacycles.

The story is not really so simple as this account: the physical model we have been discussing is at best a crude approximation. Calculations from quantum mechanics show that three out of every eight collisions will result in a hyperfine transition of the right kind. Thus if the average atom has a collision every 50 years, it will emit or absorb radiation every 133 years. No other process in space which might affect the hyperfine levels provides anywhere nearly as strong a coupling for this event as do collisions. The energy they yield of course is related to the energy of motion of the hydrogen gas atoms. This kinetic energy is equivalent to a black body temperature of about 50 to 100 degrees absolute. The 40- to 90-degree difference between the kinetic energy of interstellar gas and the background radiation field is what makes it possible to detect the hydrogen radiation.

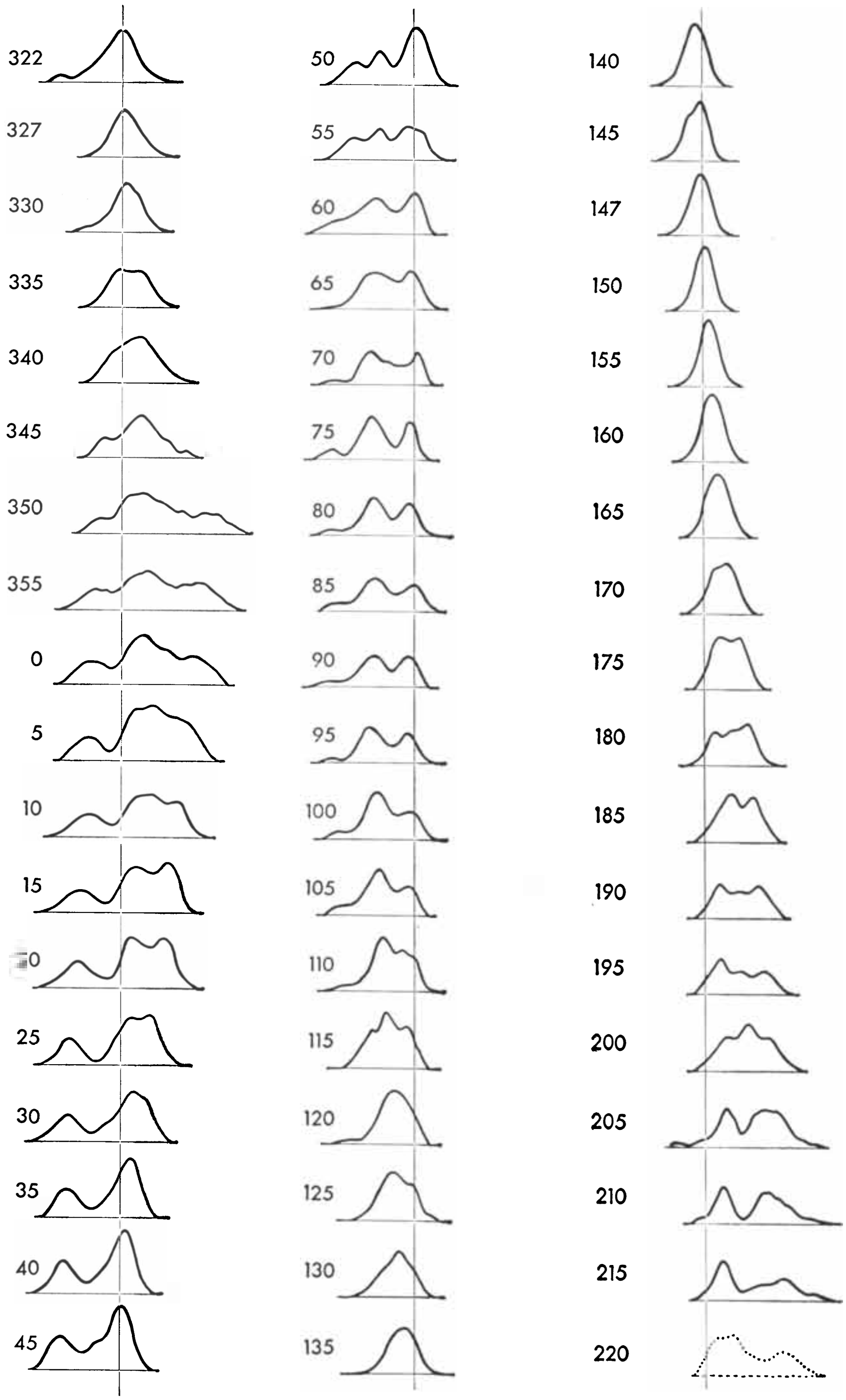
The radio-telescope used to receive this radiation is in principle much like a home radio. It has a rather large, horn-shaped antenna which feeds the signals from space by way of a wave guide to an extremely sensitive receiver. The total energy of hydrogen radiation from space falling on the entire earth is no more than one or two watts. The signal an antenna picks up is actually a great deal



HYDROGEN DISTRIBUTION in our galaxy and in the Magellanic clouds is being revealed by its 21-centimeter radiation. Shaded areas indicate hydrogen clouds found thus far. At right is our galaxy, with the sun at S and the galactic center at C. At left are the large and small Magellanic clouds. The numbers around the border of the map are degrees of arc in the plane of the Milky Way.



MAGELLANIC CLOUDS were studied with a 21-centimeter radiotelescope in Australia last spring. This diagram shows areas of different radio "brightness" for the large cloud (*left*) and the small cloud (*right*). Dotted lines indicate the outer limits within which radiation could be detected. Right ascension is shown by the numbers around the outer circle; declination by those across the bottom.



HYDROGEN RADIATION outlines are shown at five-degree intervals around the entire Milky Way. Displacement of peaks from vertical line (21 centimeters) are due to Doppler shifts. Multiple peaks indicate two or more separate clouds with different velocities.

weaker than the noise in the receiver circuit itself. Radio-telescopes have been made so sensitive, however, that the best of them now can pick up and amplify a signal only one six-thousandth as strong as the circuit noise.

The antenna is pointed to a selected portion of the sky. The tunable receiver slowly scans the frequencies around 1420 megacycles, and as it does so a moving pen charts on a paper sheet the intensity of the radiation at each frequency.

Hydrogen radiation was first detected at Harvard University on the night of March 25, 1951. The signal came from the constellation of Ophiuchus toward the center of the Milky Way. It appeared that the source of the radiation extended at least 3,000 to 5,000 light-years into space.

Van de Hulst, who happened to be visiting Harvard as a guest lecturer, at once got in touch with his observatory in Holland. The news was also sent to Sydney, Australia, another world center of radio-astronomy research. Eleven weeks later the Dutch group, under the direction of Jan H. Oort, confirmed the discovery, and within the following month a cable from Australia added a final confirmation.

The first signal received had most of its energy concentrated at a frequency 170 kilocycles higher than the laboratory measurement of the hydrogen radiation —1420.4 megacycles. If a broadcasting station were to shift its frequency by such an amount, it would be in serious trouble with the Federal Communications Commission. Actually it was soon determined that the deviation from the laboratory value was due to a Doppler shift resulting from the relative motion of the earth and the hydrogen cloud from which the radiation came.

The Dutch astronomers have detected as many as three or more hydrogen signals of different frequencies (about 200 kilocycles apart) along a single line of sight into the galaxy. This suggests that the telescope looked through several hydrogen clouds, traveling at different speeds. One of the first puzzles the hydrogen telescopes are seeking to unravel is the manner in which our galaxy is rotating. From plots of the distribution and relative velocity of hydrogen clouds in various directions from the earth, it will be possible to map the distances, positions and general shapes of the clouds. Oort, van de Hulst and C. A. Muller have already discerned a spiral arm structure of hydrogen clouds in the Milky Way system.

Last summer Australian radio astronomers succeeded in picking up the first 1420-megacycle radiation from outside the Milky Way. F. J. Kerr and J. V. Hindman, of the Radiophysics Laboratory in Sydney, detected the hydrogen line in the Magellanic Clouds. In a few days of observation they were able to add a great deal to the fund of knowledge about our nearest extra-galactic neighbors. The Large and Small Magellanic Clouds were found to be revolving about each other as a binary system, and they seemed to be moving away from our galaxy. A long-standing issue also was settled. Many astronomers had thought that the small cloud, which is almost completely clear of dust, would have very little hydrogen. The Australians found that it has just about as much hydrogen as the larger, dust-filled member.

Kodak reports to laboratories on:

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(The number of species seems to grow with every meeting where high-energy physics is on the agenda; the theoreticians are way behind on their explanations.)

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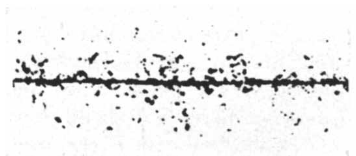
Associating *Type NTB3* with urgency in our minds, we hadn't thought till just the other day of a leisurely experiment with them: let us, we said, simply leave a few dozen packages of *NTB3* plates and pellicles on the lab roof for a while, somewhat after the casual manner



in which M. Becquerel opened the field of nuclear physics. After processing, will we find tracks of interesting particles and events? How much searching with a good high-power microscope will it take to find the interesting tracks against the camouflaging background of secondary electron tracks that the professionals avoid by exposing in high-altitude balloons? We'll let you know if we find anything that might be encouraging to the dedicated amateur.

A dozen 1″ x 3″ Kodak Nuclear Track Plates, Type NTB3, *cost $6.40 in 25-, 50-, or 100-micron emulsion thickness. Orders are placed with a local Kodak Industrial Dealer, whose name is obtainable from Eastman Kodak Company, Industrial Photographic Division, Rochester 4, N. Y. Larger sizes, 150- and 200-micron emulsions on plates, and pellicles cost more. A pellicle, by the way, is a sheet of unmounted emulsion one-quarter millimeter thick.*

Thorium

Without previous experience in the manufacture of m-cresoxyacetic acid, we accepted an order for several kilos of the compound the other day. This is not exceptional. The generalized nature of our synthetic operations often permits us to make chemicals in larger-than-laboratory quantities more efficiently than our customers can do it for themselves. Accustomed as we are in these cases to keep our nose out of other peoples' business, we didn't ask any questions. Nevertheless, we did note that a team from a university in South India had broken into print not long ago with the tidings that m-cresoxyacetic acid makes an excellent reagent for separating thorium from the rare earths of the local monazite sands and from uranium. Impressed, we called the compound *m-Toloxyacetic Acid* in accordance with *Chemical Abstracts* nomenclature and added it as Eastman 6883 to our list of more than 3500 Eastman Organic Chemicals.

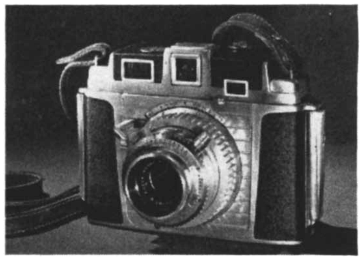
By writing to Distillation Products Industries, Eastman Organic Chemicals Department, Rochester 3, N. Y., you can obtain any or all of the following: 1) a frank appraisal of our readiness to supply larger-than-laboratory quantities of any organic compound you require; 2) a catalog of the organics we stock; 3) an abstract of the procedure for thorium; 4) 10 grams of m-Toloxyacetic Acid *for $3.50 to carry it out with; 5) an explanation of the system by which we renamed it as we did.*

The Chevron

The world's best known camera manufacturer has just announced its finest roll-film camera. While not surprising, this is nevertheless news.

The camera provides the size advantage of 2¼ x 2¼″ negatives or color transparencies, yet is used at the eye-level position preferred by many. It has the world's fastest between-the-lens shutter, with rotating blades for smoother, more accurate exposure. There are ten speeds from 1/800 second to one second, plus "B." Flash synchronization is continuously adjustable for top efficiency at all shutter speeds with both Class F and Class M flash bulbs and electronic flash equipment like the Kodatron Speedlamp.

The lens is a 78mm *f*/3.5 Kodak Ektar Lens—a finer one we doubt



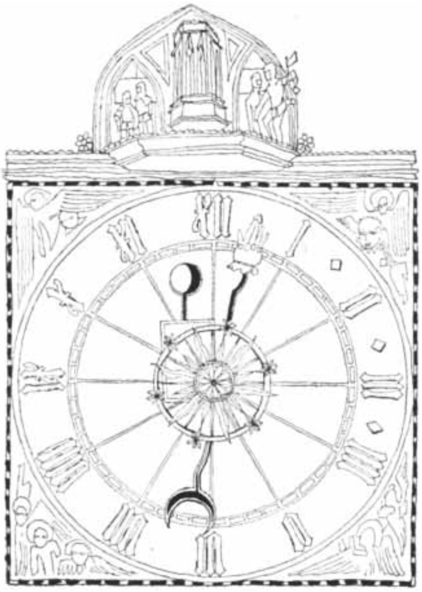
you can buy. To provide the focusing accuracy such a lens merits, there is a split-field rangefinder operating from 3½ feet to infinity and based on such advanced design features as double V-bearings for moving its mirror, ball-bearing mounting for the focusing tube, and cams almost eight inches long machined to accuracy within .0005″ throughout their length. The rangefinding operation automatically applies the proper parallax correction to the adjacent viewfinder. An adapter is available to take No. 828 film for the larger 28 x 40 mm Kodachrome slides. Weight: 2½ pounds. Price: no fortune but a sensible $215 for a piece of equipment of strictly professional calibre. (Worth keeping in mind, for example, as a retirement gift for someone who respects noble instrumentation.)

Superlatives in print tire the eyes. If you want to see a well-built camera, go down to your Kodak dealer and ask him to show you the Kodak Chevron Camera. *Since quantities are still limited, there may be a little wait for delivery.*

Prices include Federal Tax where applicable and are subject to change without notice.

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

Kodak
TRADE-MARK



SCIENCE AND

A Start on Atomic Power

The Atomic Energy Commission announced last month that it is proceeding to build a full-scale nuclear power plant. Commissioner Thomas E. Murray told the Electric Companies Public Information Program in Chicago that the reactor, a "power-only" type with no provision for recovering plutonium for weapons, will produce a minimum of 60,000 kilowatts of electric power "with good possibilities of much higher output." It will cost "many tens of millions of dollars" and is expected to be finished in three or four years. It will probably be located at one of the Commission's gaseous diffusion plants and will supply a small portion of the plant's power needs.

The decision to "launch out into the reactor depths," said Murray, was motivated by the fact that "our uranium supply may be, to some extent, dependent on early success in the power race." The uranium-supplying countries are looking to the U. S. to develop a nuclear power technology. When it became evident that private enterprise is not now ready to "enter aggressively" into such development with its own funds, the AEC decided on a government project.

The reactor will be patterned after one designed for naval use. Murray conceded that some scientists and industrial groups are critical of this choice, but he pointed out that the design is much farther advanced than any of the other types. Furthermore, he declared, the Commission will propose the construction of other types "in the immediate future." The Westinghouse Electric Corporation has been selected as principal contractor for the first reactor because of experience with the Navy prototype. Rear Admiral Hyman G. Rickover, who was in charge of building the first atomic-powered submarine, will direct the project for the Commission.

Another proposal for a large nuclear power plant had been made by the General Electric Company shortly before the Commission's announcement. G.E. said it would undertake to build, at government expense, a 50,000-kilowatt station at the Hanford plutonium works, which it operates for the AEC. This was to be a dual-purpose reactor which would furnish some of the power needed at Hanford and produce plutonium for weapons. Murray indicated in his speech that the Commission does not favor dual-purpose reactors, as the present reactors and those nearing completion can supply current military demands for plutonium.

The U. S. is not first in the nuclear power field. Great Britain is already building a 50,000-kilowatt station in Cumberland, near one of its big atomic research centers.

Nobel Prizes

The 1953 Nobel prize in physiology and medicine was awarded jointly to Fritz A. Lipmann and Hans A. Krebs for their discoveries in cellular metabolism. Lipmann, now professor of biological chemistry at Harvard University, isolated and identified coenzyme A, a substance which plays a key part in transferring energy and in the synthesis of many cell chemicals. Krebs, professor of biochemistry at Sheffield University in England, discovered the citric acid cycle, also called the Krebs cycle (see "Progress in Photosynthesis," by Eugene I. Rabinowitch; SCIENTIFIC AMERICAN, November). The Krebs cycle is one of the most important of the burning processes by which cells convert foods into energy. The two German-born scientists, both refugees from the Nazi regime, will divide the cash award of $33,840.

The Nobel prize in physics went to Frits Zernike, professor of mathematics and physics at Groningen University in the Netherlands, for his invention of the phase-contrast microscope. His instrument has made it possible to observe in living cells structures which previously could be seen only if the cells were killed and stained.

The award in chemistry was given to Hermann Staudinger, professor emeritus of the Freiburg University in Germany, for his pioneer work on macromolecules. He developed the theory of polymerization and, in 1927, put together the first long-chain synthetic fiber.

The Atlantic Weather Ships

The Federal government announced last month that next June the U. S. will withdraw its ships from the network of North Atlantic weather and rescue stations maintained by the International Civil Aviation Organization, a United Nations agency. Since the U. S. has supplied 14 of the 25 vessels required to man the 10 stations, this decision will probably put an end to the service. The announcement from Washington states that the stations are "no longer required by the U. S." and that the benefits derived from them are "no longer commensurate with the cost." Airlines, steamship companies and professional meteorologists disagreed, and indicated that they will try to obtain in other ways at least some of the information now available from the ship network.

Fifteen nations have participated in the North Atlantic service, sharing the costs according to the number of transatlantic flights made under their flags. U. S. officials object that this is unfair because European nations obtain valuable weather-forecast information from the ships. Since weather moves from west to east, American continental forecasters get no help from the Atlantic data. It costs the U. S. $1 million per year for each ship assigned to the service; European costs per ship are much lower.

The World Meteorological Organization, with headquarters in Geneva, has announced that it will do what it can to fill the place of the weather-ship network by collecting and distributing information from commercial vessels. The airlines will set up exchange centers for weather data coming in from east- and west-bound planes. However, ships normally give only sea level information and planes can report conditions only at the altitudes of their flights. The ships on ICAO duty took regular radiosonde samples of weather conditions at a wide range of altitudes. Such information is essential to long-range forecasting and to atmospheric research. Meteorologists are therefore disturbed by the threatened break-up of the Atlantic system.

O.K. for the Bureau of Standards

The committee of scientists evaluating the operations of the National Bureau of Standards last month turned in its report to Secretary of Commerce Sinclair Weeks. The group, headed by Mervin J. Kelly, director of Bell Telephone Laboratories, found the Bureau "an organization with a splendid record and tradition" and praised the "high quality of the professional staff, their dedication to the Bureau and the integrity of their scientific and engineering work."

Among the major conclusions of the report:

There is increasing need for the Bureau's work.

Recent reductions of the Bureau's budget, curtailing the scope of its basic activities, "must be considered as tragic." The lost ground should be regained and its activities expanded. Its laboratories should be enlarged and modernized.

The quality of the Bureau's staff has begun to deteriorate and will fall off badly unless the decrease in support of basic programs is reversed.

Other agencies of the government should make more use of the Bureau's services.

Ordnance development work has occupied too much space and manpower. (This work has been transferred to the Defense Department, but continues to be done in Bureau laboratories.)

Advisory groups representing eight scientific and technical societies should confer regularly with the director of the Bureau to provide him with "a more intimate tie with the science and technology of the country."

Responsibility for non-technical aspects of tests on commercial products should be transferred from the director to the Secretary of Commerce.

Hormone from a Test Tube

The first synthesis of a pituitary hormone was announced last month. The substance, called oxytocin, was put together from its constituent amino acids by a group of biochemists at Cornell University Medical College, headed by Vincent du Vigneaud. Its artificial preparation was the climax of 20 years of work by du Vigneaud on the chemistry of pituitary secretions.

He began in 1932 with the knowledge

that extracts from the rear half of the body's "master gland" stimulate uterine contraction, release milk, increase blood pressure and inhibit excretion from the kidneys. Ten years of experiments on the glands of some 100,000 cattle showed that two hormones were involved. These were named oxytocin and vasopressin. The substances are so unstable and are present in such tiny amounts that it was another 10 years before du Vigneaud succeeded in separating pure, crystalline samples of each. He was then able to take the oxytocin molecule apart, and found that it was made up of eight amino acids and ammonia. Further experiments indicated the complex arrangement of the constituent acids (there were more than 500,000 possibilities) and led to an idea of how they might be put together. In achieving the synthesis, du Vigneaud's group accomplished the first construction of a polypeptide hormone (one composed of amino acids) in the test tube.

Oxytocin is used in obstetrics and in veterinary medicine to stimulate labor. The new discovery will provide a larger supply. Also, it may be possible to identify the active portion of the molecule and discover a simple chemical with the same physiological action.

The Cornell chemists are now attacking the other hormone, vasopressin. They have just announced a proposed structural formula for it and are beginning efforts to synthesize it.

Working with du Vigneaud on the oxytocin synthesis were Charlotte Ressler, John M. Swan, Carleton W. Roberts, Panayotis G. Katsoyannis and Samuel Gordon. They reported their work in a letter to the *Journal of the American Chemical Society*.

Polio Vaccine Progress

Poliomyelitis vaccine has now been developed to the point where it is ready for large-scale field tests. The National Foundation for Infantile Paralysis has announced that such tests will be carried out early next year.

Jonas E. Salk of the University of Pittsburgh told the American Academy of Pediatrics that his test vaccines, prepared in oil and water emulsions, have now been inoculated in more than 600 adults and children and none had unfavorable reactions. He is certain that the serums are harmless and that for all three types of polio they produce antibodies in numbers which should be sufficient to confer immunity. The immunity lasts at least several months. In agreeing that the time has come for mass inoculations designed to test the effectiveness of the vac-

cines under conditions of natural contagion, Salk emphasized that the work is still experimental; routine immunization for polio will not be possible for some time.

Salk's report suggested two alternative plans for field tests. The first would be the standard control method; giving half of a group of children the vaccine and half an innocuous injection. The second would be to inoculate all the children of a given age group and then to compare their resistance with that of older and younger children or of children in the same age group in other communities. The test inoculations will probably be made early next year.

Lethal Odor

Because insects evolve resistance to insecticides, some entomologists have been investigating an entirely different approach to insect control. Male insects are known to be attracted to females by a scent characteristic of the species. If the odoriferous substances could be identified and synthesized in quantity, they could be used to lure the males to their death in traps. The beauty of the scheme is that any males which evolved a resistance to the blandishment would not propagate their kind anyway. Moreover, the specific species odors could be aimed accurately at harmful insects without destroying useful ones.

To isolate the enticing substance of a female insect is difficult, because it is more volatile than ether, so that ether cannot be used in the conventional manner to extract it. Several groups of workers have nonetheless turned to the task. In Germany the laboratory of the Nobel prize winner Adolf Butenandt has prepared a seductive extract from the female moth of the commercial silkworm. Another German worker named H. Inhoffen imprisoned thousands of moths in a shed; when air was blown through the shed and chilled, the scent of the moths condensed. L. M. Roth, an entomologist at the Army Quartermaster Depot in Philadelphia, has extracted a substance which drives male cockroaches into a frenzy of sexual excitement. There is a story, possibly unfounded, that workers in one laboratory prankishly put a drop of extract from female gypsy moths on the dress of a colleague and she was followed home by a cloud of male gypsy moths.

Supergalaxy

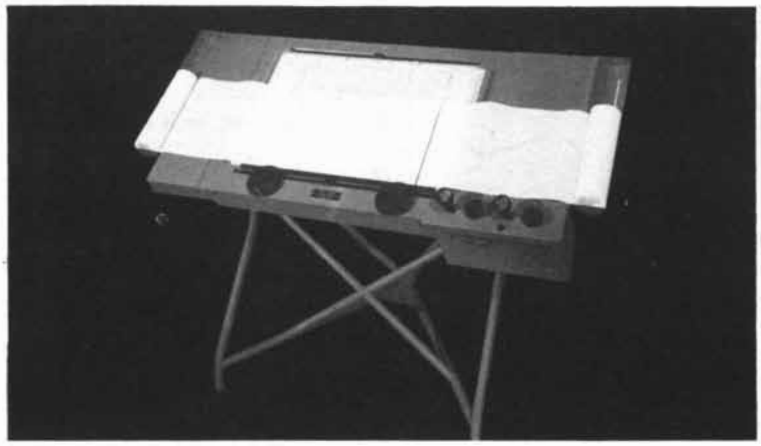
The Milky Way is not an island unto itself in space. Astronomers have found evidence that our galaxy is part of

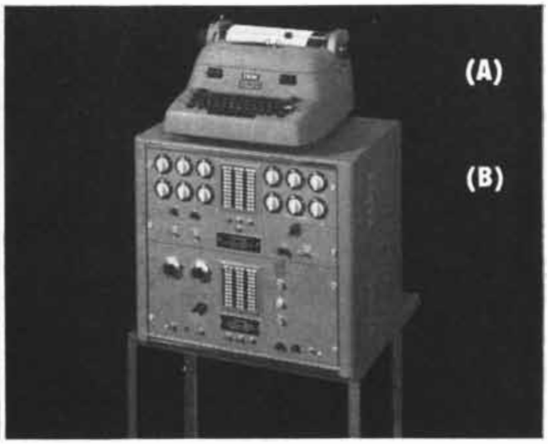
Telecomputing announces:

the first low-cost data reduction system

Everyone concedes the value of modern data reduction instruments; but not every organization feels it can "afford" them—just yet.

A pioneer in the field of data reduction, Telecomputing has long sought a solution to this problem. It now presents the first low-cost data reduction system which offers speed, accuracy and flexibility at a price most organizations can afford: $5,555.





1 The Contact Telereader **$2195**
measures oscillograms and other graphic records. It handles single sheet or roll records—any length, any width up to 18″; performs linear and non-linear calibrations; provides accuracy to .01″ per count; permits up to 40 measurements per minute by means of X-Y crosswires.

Operates Alone

The Contact Telereader also can be used independently of the data reduction system to perform rapid, accurate measurements. Readout, however, must then be made by manual methods.

2 The Teleducer **$1690**
electronically converts Contact Telereader measurements into digital form.

Other Teleducer Applications

The Teleducer can be used by itself as a laboratory digital voltmeter with an accuracy of 0.1%. It can also be used independently to digitize output of strain gauges and thermocouples without D. C. amplification. It provides for minimum full-scale input of 10 millivolts (10 microvolts per count) and maximum full scale input of 1.0 volt without external attenuation.

The Teleducer and accompanying Program Unit are housed in the same cabinet.

3 Electric Typewriter (A) **$920**
The Program Unit (B) **$750**
prepares parallel digital data for serial readout to the electric typewriter shown on top of the Teleducer-Program Unit cabinet.

Readout can also be in punched cards or punched tape.

Engineers—Telecomputing offers you a future in fields of the future—data reduction, computing, and the solution of mass record-handling problems for Business.

Specifications on the new data reduction system, as well as detailed information showing how the Contact Telereader and Teleducer can be used independently, will be mailed you upon request. Coupon is for your convenience.

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a cluster of galaxies, also arranged in the shape of a disk, which appears to be rotating as a whole.

The French astronomer Gérard de Vaucouleurs described this "supergalaxy" in a recent issue of *The Astronomical Journal* and located its trace across the sky. J. D. Kraus and H. C. Ko of Ohio State University have confirmed the idea through radio astronomy. Mapping radiation at 250 megacycles per second, they found a relatively strong signal coming from a region of the sky which is in just about the position of de Vaucouleurs' "Milky Way of galaxies" and has approximately the width he attributes to it. In a letter to *Nature* the Ohio State astronomers suggest that the "extended source is caused by radio radiation from our local supergalaxy."

How to Stall

At a time when most aeronautical engineers are trying to make airplanes go faster, one group is finding out how to make them go more slowly. The Cornell Aeronautical Laboratory, Inc., of Buffalo, N. Y., has developed a means for flying in a permanent stall.

The slower a plane flies, the greater the angle at which its wings must meet the air in order to provide the necessary lifting force. If the angle gets too large, however, the smooth flow of air over the wing is disturbed, the lift drops off sharply and the plane is said to be stalled. When this happens, controls become much less effective and the plane usually goes into a spin.

The Cornell Laboratory engineers, studying stalled flight for the Air Force, succeeded in modifying an automatic pilot so that it stabilized their experimental ship in a stalled condition and prevented it from spinning. They suggest that their modification might be built into every autopilot so that it could operate in two ways, one for normal flight and the other for stalls. Such a device would permit a plane to be flown right up to its stalling angle so as to give it maximum lift. Stabilized stalls would allow slower, shorter landing runs.

Helpful Obstacles

A radically new method of sending very-high-frequency radio waves which may make it possible to transmit television and FM over mountain ranges has been announced by the National Bureau of Standards. Called "obstacle-gain transmission," it overcomes the line-of-sight limitation on short radio waves.

As long ago as 1933 a group of U. S.

Positioning that tolerates no plus-or-minus...

no problem even in a 2500-mile-an-hour gale

Within the foot-square throat of a new adjustable wind tunnel, adjusted by a device that has scores of amazing commercial applications, winds are generated to "fly" sleek scale models of tomorrow's aircraft at speeds as high as 2,500 miles an hour.

The throat of this supersonic wind tunnel can be quickly and precisely adjusted to an infinite variety of shapes to produce air speeds up to 2,500 miles an hour. A battery of 158 AEROL Ball-Screw Actuators move up or down to flex a stainless steel throat lining to any shape desired . . . then they *hold* that shape against the 40-mile-a-minute buffeting.

The AEROL Actuators we make combine the power or the speed of a steel screw with the friction-free rolling of steel balls. Friction loss is held to less than 10% of the power input . . . motor size can be cut practically in half with no loss of output; less space is required for motors; power costs are reduced.

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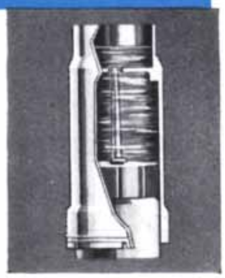


radio engineers calculated that a large knife-edge obstacle midway between a transmitter and a receiver should enhance transmission. The effect is due to the way in which waves diffracted over the obstacle top interact with the energy in other signal paths. Recently the idea was tried in the field, with a 9,000-foot Alaskan mountain as the obstacle in a 160-mile circuit. A research team from the Bureau of Standards, the Army Signal Corps and the Radio Corporation of America found the signal considerably stronger and steadier than over a flat circuit of the same length.

Stonehenge Revisited

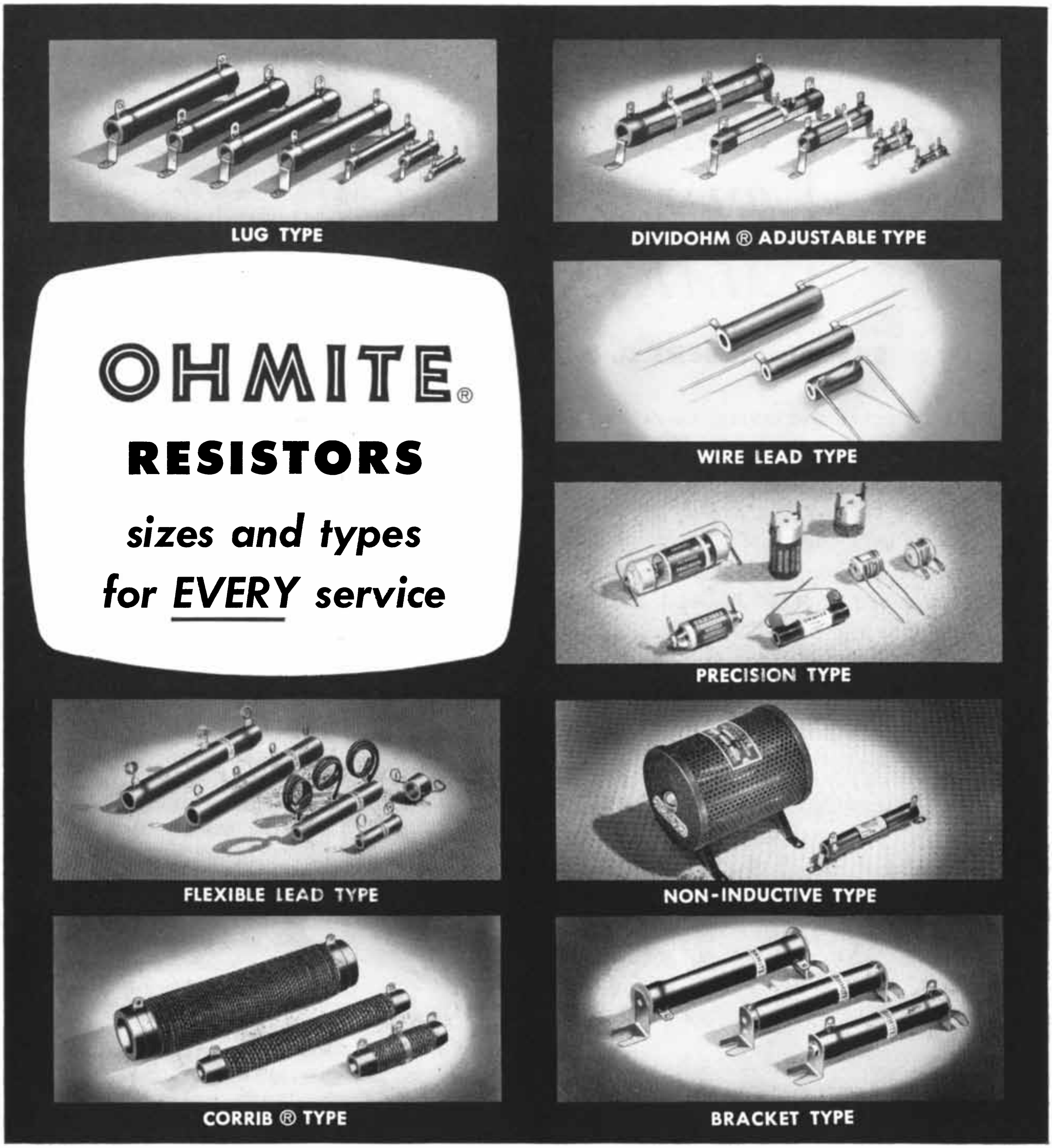
Last summer British archaeologists dug further into the secrets of Stonehenge (see "Stonehenge," by Jacquetta Hawkes; Scientific American, June). What they found underground, however, did not tell them as much as a chance discovery of some carvings on one of the huge sarsen stones. Though exposed for all to see, the carvings had never been noticed. They represent four axheads and a dagger. R. J. C. Atkinson, Stuart Piggott and J. F. S. Stone, the members of the investigating team, believe that the find gives the first definite evidence on when the stones were erected.

The axheads are of a type made in Ireland from about 1600 to 1400 B.C. Atkinson therefore dates the erection of the stones at about 1500 B.C. "The presence of these obviously ritual representations," he writes in *Nature*, "points to the existence in Britain of an ax-cult comparable to the cult of the double-ax in the contemporary Minoan civilization of Crete."

An even closer connection to pre-Greek civilization is afforded by the dagger. This weapon is an accurate picture of a type found in Mycenaean graves of around 1500 B.C. Atkinson feels sure that the man who carved the dagger came from Mycenae. He hazards the additional guess that the "architect of Stonehenge was himself a Mycenaean, a suggestion which has already been prompted by the architectural refinements exhibited by the monument."

Scientists' Psyches

The psychiatrist Lawrence S. Kubie thinks that the personalities of scientists need looking into. In a recent issue of *American Scientist* he wrote: "Science in the abstract and scientists as human beings pay a high price for the fact that during the preparation of young people for a life of scientific research their emo-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tional problems are generally overlooked." He argued that a thorough study should be made of the part played by such unrecognized neurotic forces in the choice of science as a career and in the shape that career subsequently takes.

To support his plea for the investigation, Kubie cites a number of examples drawn from his scientific acquaintance and clinical practice. He finds that young scientists, like other young intellectuals, are apt to have a lopsided personality. Often, says Kubie, a scientist has "put every emotional egg in the intellectual basket" and is then amazed and dismayed to discover that even great success does not satisfy his hidden needs. The early scientific bent of children often turns out to be a cover for other interests that are forbidden. Kubie mentions in this connection a gynecologist whose "ancient and infantile curiosities" were not appeased by the legitimate activities of his profession and who was a compulsive patron of burlesque shows. An X-ray technician discovered under analysis that he had been attracted to his specialty by an unconscious curiosity about the internal structure of his mother's body. Kubie proposes to save young people from building their careers on such "psychological quicksands."

He holds that hidden subjective problems often guide scientists' work. Some men set up interminable studies because they dread the day of reckoning; others look for quick solutions because they cannot endure suspense. What appears to be unusual "originality" may be no more than a revolt against all authority. Kubie mentions a scientist who invariably designs experiments to give ambiguous results, another who falsifies evidence even though his honest findings give a successful result. Kubie compares this last aberration to the kleptomania that compels a wealthy man to steal trivial objects.

The proposed study, says the psychiatrist, would show what psychological qualities and emotional backgrounds are conducive to success in the various branches of science. He quotes extensively from Anne Roe's examinations of 64 eminent scientists (see her article in SCIENTIFIC AMERICAN of November, 1952). Dr. Roe's findings, he says, point to real differences in the mental processes and personalities of biologists, physicists and social scientists.

Kubie does not suggest that the need for psychological study of scientists is more pressing than for those in other vocations. But he thinks a start must be made somewhere, and science is an especially useful place to begin.

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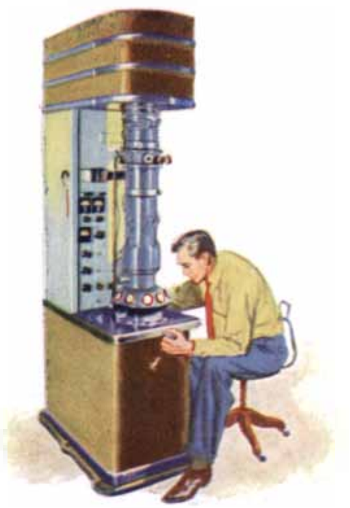
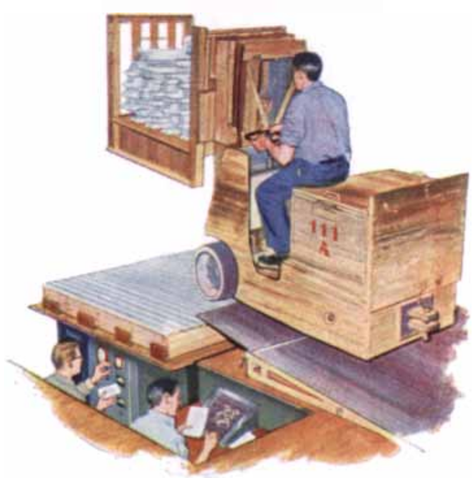


Electron microscope capable of magnification up to 100,000 diameters.



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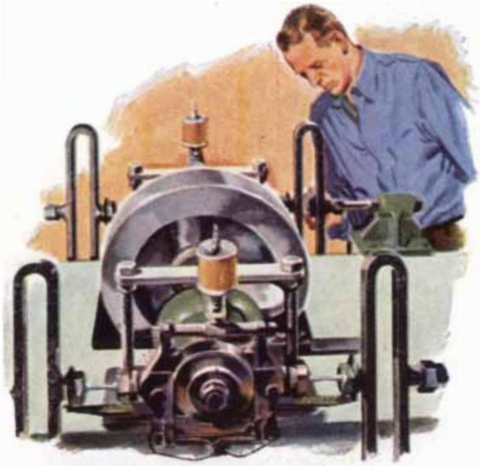
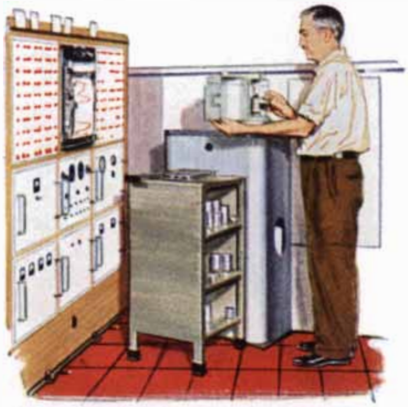


Fatigue testing sections cut from fabricated parts.

Whirlpit for testing performance of rotating parts up to 80,000 rpm.



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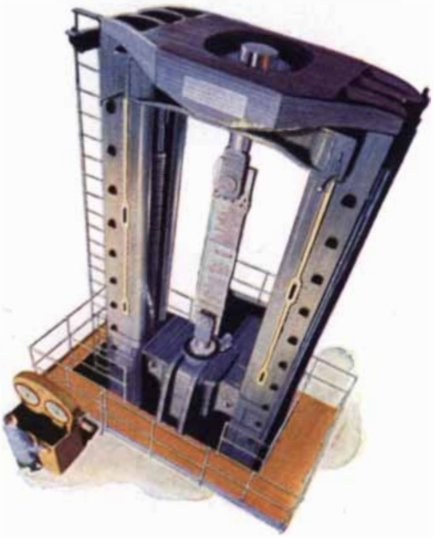

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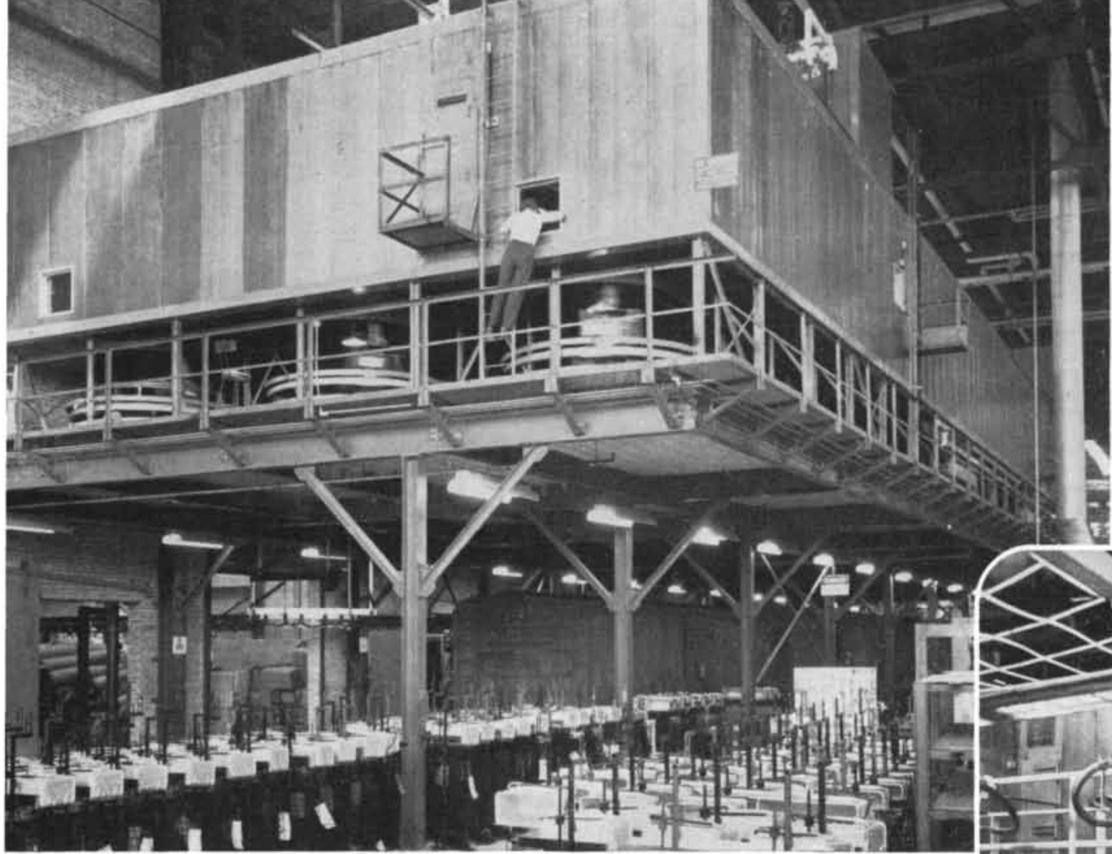

Left: Rear view of oven (36′ x 137′ x 8½′) through which refrigeration units pass six times while under high vacuum pumping.

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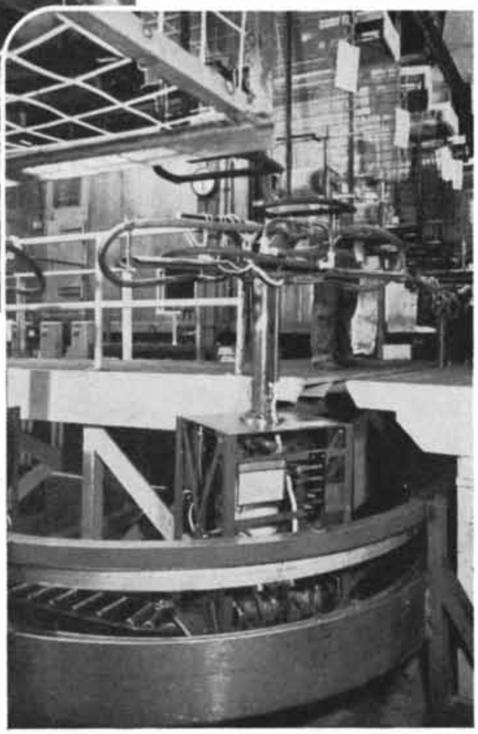
Below: Operators connect four refrigeration assemblies to each CVC vacuum pumping dolly as the conveyor approaches the oven.



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Fossil Man

Modern man has taken from the earth the remains of many creatures that dimly outline his evolution. Their bones offer no clue, however, to the forces which caused the rapid development of his unique brain

by Loren C. Eiseley

A student of man's evolution on the earth is confronted today with an odd paradox. From a wealth of skulls and bones unearthed in the last few decades we can now piece together a reasonably convincing account of how and from what forebears man first came into existence more than a million years ago. But there the story trails into mystery. How the primeval human creature evolved into *Homo sapiens*, what forces precipitated the enormous expansion of the human brain—these problems ironically still baffle the creature who has learned to weigh stars and to tamper with the very fabric of his universe.

To gain some perspective on the problem and on how much man has learned in the 20th century about his prehistory, let us go back to 1895. In that year scientists were celebrating "with a fearful joy" the news that Eugène Dubois had discovered, in a deposit near the village of Trinil on Java, the remains of a very primitive man, or a very manlike ape. Dubois regarded his discovery, which he named *Pithecanthropus erectus* (the erect ape-man), as a link about midway between the anthropoid apes and man. Putting together Pithecanthropus, some fragmentary fossil remains of earlier anthropoid apes that had been found in the Siwalik Hills of India, and the Neanderthal skull, which had been discovered in a cave in Germany nearly 40 years before, evolutionists of that day composed a simple story of human evolution. The Java man was dated at about the beginning of the Pleistocene epoch, approximately a million years ago. Neanderthal man, possessing a much larger brain, was reckoned to be about half as old. Many evolutionists agreed with W. J. Sollas in concluding that the evolution of the human race had "proceeded at a very uniform rate throughout the whole of Pleistocene time," and that man had originated from "the stem of the gorilla or chimpanzee, before these species had acquired their existing specialized characters."

There was a strong tendency then to overlook the "specialized characters" and to equate the ancestor of man with a creature not very different from a modern chimpanzee or gorilla. Few appreciated the fact that man and the living apes represented quite opposite adaptations: man having developed an erect posture for walking, and the apes long arms for swinging through the trees. Man was supposed to have come down from the trees in this stage and acquired an upright posture in some mysterious manner about which there were ingenious but unconvincing theories.

This, then, was the general conception that reigned at the close of the 19th century. How far have modern discoveries substantiated or disproved it?

The Influence of Grass

If there is one thing that can be stated with absolute certainty today, it is that man arose and went through the main stages of his evolution upon the Old World land mass—Africa, southern Asia and Europe. There is no paleontological evidence whatever that early man ever penetrated the New World or Australia, and his inability to navigate the oceans kept him out of the world's oceanic islands. Man's swarming numbers and ubiquitous distribution over the earth are late manifestations in his history. He arose in a limited area, probably as a quite isolated and rare experiment of nature. But from the beginning he was the most restless of all earth's creatures, and across two million years of time we can dimly make him out venturing on his first experiment: trying to walk and live on the grass.

Now grass, we are accustomed to believe, is even more ubiquitous than man; it seems as fixed as the stars. Nevertheless grass, like man, has had a history, and perhaps even more than man has changed the face of the earth and the course of life. In the closing period of the Age of Reptiles some 100 million years ago, a new form of plant life, the Angiosperms or true seed plants, began to spread over the world with almost explosive rapidity, supplanting the jungles and fern forests. By the Middle Tertiary the grasses, an Angiosperm adaptation, were widely distributed over the uplands and savannahs of the continents. We can trace the emergence of this new world through the transformations of the animals that got into it. In many areas the old-fashioned shrubbery-eating animals began to disappear. Their teeth were not adapted to the abrasive silica content of grasses. New forms of grazing animals, such as horses, began to evolve in the grass corridors. Then came carnivores adapted to preying upon the grass eaters. Into this new and sunny world, rather late in its history, there ventured a queer, somewhat old-fashioned mammal which had evolved, for reasons still not clearly understood, a fantastically awkward mode of progression. It walked on its hind feet, like something out of the vanished Age of Reptiles. The mark of the trees was in its body and hands. It was venturing late into a world dominated by fleet runners and swift killers. By all the biological laws this gangling, ill-armed beast should have perished, but you who read these lines are its descendant.

It has often been assumed that the first men must have been massive animals of gorilla strength, armed with formidable teeth. Strangely enough, we are beginning to find the story quite otherwise. Let us look at these primitive "men." We can call them men only by courtesy: though they walked upright and bear an undoubted family relationship to ourselves, they were on an evolutionary level below Java man—semi-human creatures oddly advanced in some respects and backward in others.

Charles Darwin's great contemporary Alfred Russel Wallace seems to have glimpsed very early this intermediate, ground-ape stage. In 1898 he said: "When [man] had reached the erect form, and possessed all the external appearance of man, his brain still remained undeveloped, and the time occupied by this development was not improbably equal to that required for the specific modification of the lower mammalia."

The Man-Apes

The finds that disclosed this early phase of human evolution began inconspicuously in 1925, when the fossil of the Taungs child was discovered in the Harts Valley of South Africa. Raymond Dart, Robert Broom and J. T. Robinson later dug up large numbers of bones of the famous Australopithecines, which have been called by various interpreters our true ancestors, late survivors of our "structural ancestors" and divergent ground apes. We can describe only a few of their more salient characters and then attempt to indicate what general conclusions can be safely drawn from the evidence as it stands. The reader must bear in mind that adequate reports on much of this material are still not available. Discoveries have been coming in so rapidly that many bones still lie imprisoned in their stony matrices in the laboratories.

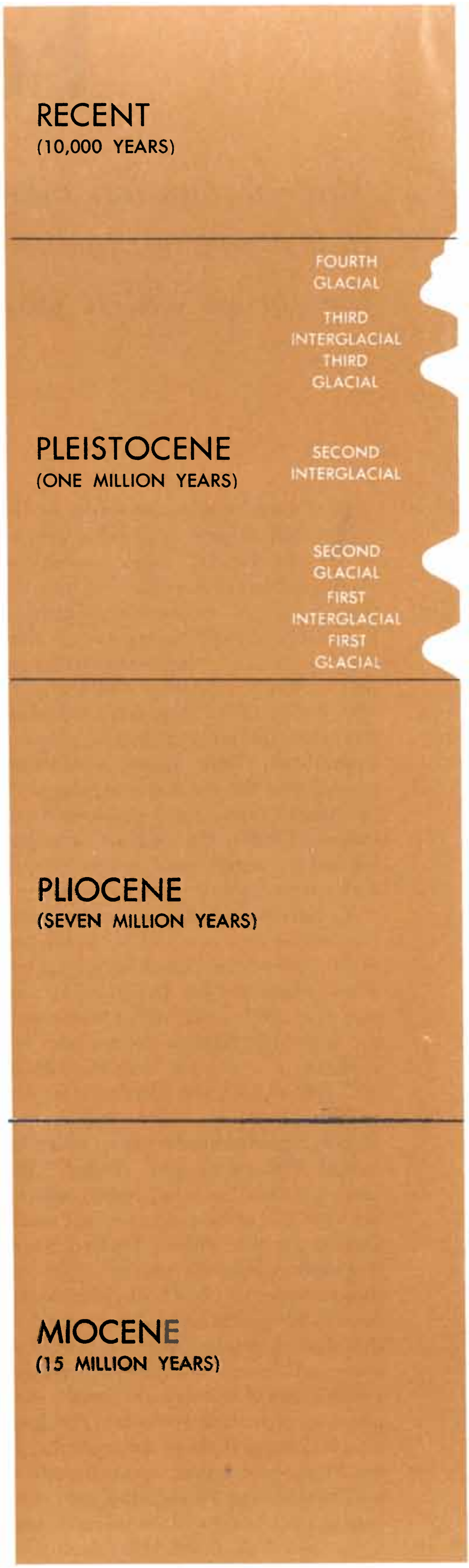
The teeth of these creatures were remarkably human: they had small incisor teeth, broad molars with complicated crowns and no pronounced canine teeth (such as apes have). They seem to have walked erect. Their cranial capacity was no larger than that of a modern anthropoid ape, but it is possible that their brains may have been more complex than an ape's. There has been much debate as to whether the Australopithecines were intellectually capable of using simple tools or of speaking.

Remember that we are dealing not with a single skull but with a whole group of forms of varying geological age and somewhat differing features. Unfortunately the age of the fossils has not been established: estimates range from the Middle Pleistocene to the Pliocene, the period before the Pleistocene. There is controversy over which of the species are the oldest and which the most recent. Many are inclined to believe that the Swartkrans man-ape (*Paranthropus crassidens*)—a big-faced, huge-jawed creature—may represent an extinct animal line which diverged from the group that later evolved into man by expansion of the brain. Paranthropus, incidentally, has taught anthropologists to be warier when estimating the size of fossil men from their teeth. Its teeth are almost as large as those discovered in Java during World War II by G. H. R. von Koenigswald—a find which led to talk of the "Java giant" and caused a sensation in the press and even in scientific journals. The only thing extraordinary about the size of Paranthropus is the massiveness of its jaw and teeth, and as a consequence the notion of supposedly giant forms of man deduced from other large teeth, such as the "Java giant" and Gigantopithecus of China, has been considerably deflated.

Of the place of the Australopithecines in the scheme of things it must be said that anthropologists at present are torn between whether to regard them as direct ancestors of man or as a specialized sideline. For all we know the Pliocene may eventually yield such a variety of ground apes as to make the selection of our true ancestor a quite embarrassing task.

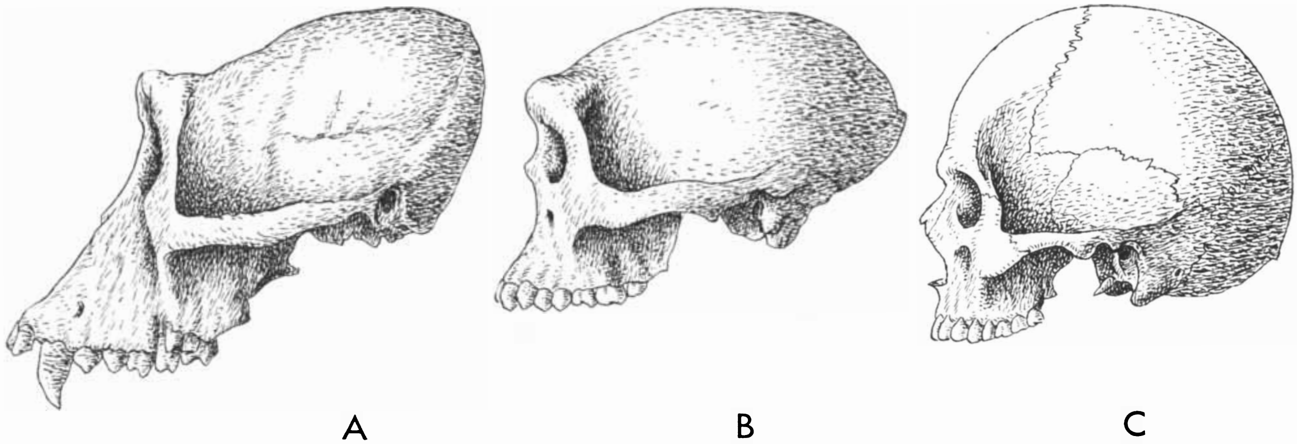
An important point under debate is: did man achieve his upright posture by preliminary training as an ape swinging hand over hand, or did he somehow manage to straighten up from the position of a monkey-like ape who jumped and ran on all fours among the branches? The latter interpretation would cause us to search further back in time for the point where man diverged from the trunk of the primate family tree. William Straus of The Johns Hopkins University believes that the "line leading to man became independent at a relatively early date, probably no later than the end of the Oligocene, and that the stock from which it arose was far more monkey-like than anthropoid-like."

Keeping this point in view, let us descend into the Lower Miocene of East Africa. Here we encounter a curious monkey-like ape known as *Proconsul africanus*. Although its teeth seem to ally it to the anthropoid line, its skull lacks brow ridges and its body is quite monkey-like. It was apparently a light, gracile creature, and the length of its limbs sug-

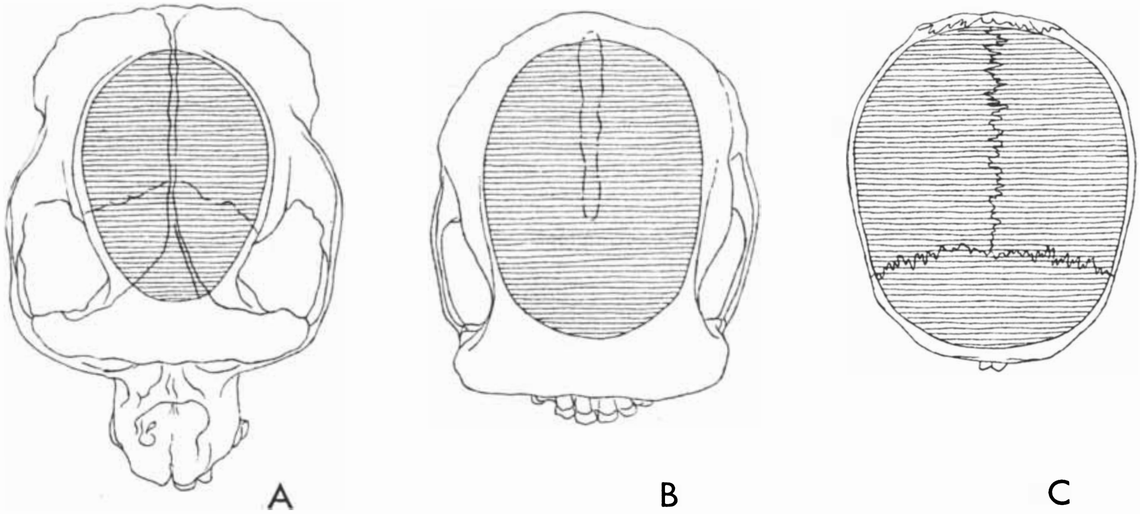


PRINCIPAL FOSSILS of man and his close relatives are arranged in time by this chart.

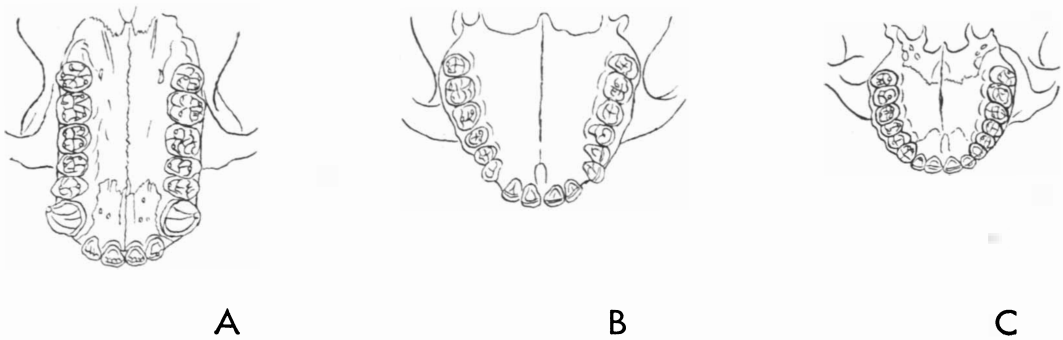
The time scale is at the left. The depth of each epoch does not represent its length but only its place in the sequence of time. The white strip running from top to bottom of the time scale represents the advance and retreat of the ice sheets during the Pleistocene.



Skulls of a male gorilla (A), *reconstructed male Pithecanthropus* (B) *and modern man* (C).



The same three skulls are shown from the top. The space occupied by the brain is shaded.



The palates and dental arches of the same three skulls are shown from the bottom.

gests that it probably ran and climbed on all fours and was not a highly specialized arm-user like the present-day apes. "Indeed," remarks the English paleontologist D. M. S. Watson, "Proconsul is perhaps at least as good an ancestor of the Australopithecines as it is of the modern 'manlike' apes."

If we assume that Proconsul or a similar form lies at the parting of the ways between man and the great apes, a considerable revolution in our thinking is in order. For many years man's bodily similarity to the existing apes has been taken as a sign of his descent from a tree-swinging anthropoid. Now there is at least a growing suspicion that some of the resemblances are the result of parallelism—that the broad chest and shortened trunk would have had equal survival value for hanging in trees and for bipedal locomotion on the ground. Only more fossils will satisfy our curiosity. If it be true that the Miocene anthropoids traveled largely on all fours, then arm-locomotion, at least in its full, elaborated phase, may be no older than bipedal walking. In that case, instead of one giving rise to the other, we may be forced to envision both as end specializations of the quadrupedal Proconsul line.

The Emergence of Modern Man

At about this point the reader is apt to inquire wistfully as to the present health and circumstances of Dubois' "missing link" of 1892. Is *Pithecanthropus erectus* safe from the heretical hands of the modern generation of anthropologists? The answer requires a little further review.

In the 1890s all that was needed to tell the story of human evolution was to arrange on a classroom desk the skull of a chimpanzee (with certain generally unheeded cautions), the skull cap of Pithecanthropus and the skull of Neanderthal. If the instructor placed his own head at the end of the line, a student could comprehend in a glance the full course of human evolution. There were then no obscurities, no anomalous apes, no poor relations whose genealogy was obscure, no little men with enormous teeth, no structural ancestors who persisted in fooling everyone by living deyond their time. The scheme was simple mainly because anthropology had scarcely any fossils.

Today this state of affairs is vastly changed. We have a series of low-vaulted massive skulls with jutting brow ridges whose faces bear hints of the primordial past—a fairly comprehensive gallery of "cave men." Pithecanthropus belongs in this gallery. Though at various levels of development in brain size, we can say with assurance that they are all men. They represent the true human plateau. We know that some used fire and had traditional flint-working techniques, though one group had a cranial capacity almost 500 cubic centimeters less than our own. They ranged from Java and China to the Middle East, Africa and Europe. Man was still Old World in distribution.

Pithecanthropus no longer can be considered as old as he was once thought to be; indeed, except for a human jawbone found near Heidelberg, Germany, it is difficult to pursue a single man with jutting brow ridges further back than the early Middle Pleistocene. This brings us down to the last 400,000 or 500,000 years. We have supposed we know that end of man's genealogical tree pretty well. But do we? Here is the point where tempers rise and staid investigators jab excited fingers at one another. In our gallery of beetle-browed ancestors there are three or four specimens that throw the whole sequence out of order. They are the well-known Piltdown skull, the Swanscombe skull and the Fontèchevade cranium. These three well-documented finds suggest not beetle-browed cave men but true *Homo sapiens* or something approaching him. They have been dated by the reliable method based on the accumulation of fluorine (the radiocarbon method does not work for so vast a time scale). And it turns out that one goes back to the second, the others to the third interglacial period—a time long before *Homo sapiens* used to be thought to exist. The Swanscombe skull is well nigh as ancient as Peking man, and the English anatomist W. E. Le Gros Clark has interpreted it as evidence that the brain typical of *Homo sapiens* had already developed by "early Paleolithic times." To be sure, we have only the back and one side of the Swanscombe skull, but the anatomical evidence compels us to recognize the possibility that Swanscombe was only a slightly more primitive version of ourselves.

Piltdown man has always been something of a riddle. As his name *Eoanthropus* ("dawn man") indicates, he used to be regarded as very old, and though he did not fit into the sequence of heavy-browed men, his peculiarities made it safe to regard him as a kind of specialized sideline. He had a thick-walled brain box, but a forehead as smooth as our own. His lower jaw—at least the one-sided fragment of it that has come down to us—cannot be distinguished from that of an existing great ape. If this is not an accidental combination of fragments from two different individuals (still a possibility in this case), we are forced to recognize a being quite distinct from our array of heavy-browed fossils, but one whose lower face was remarkably primitive. Unfortunately all the parts where the jaw fits the skull, and the palatal area as well, are missing from the specimen. It is this that arouses faint doubts as to the genuineness of the association. No other fossil like it has ever been found. The puzzle is further enhanced by the fluorine dating, which puts it into Upper instead of Lower Pleistocene time.

The skull known as Fontèchevade II was found in 1947 in the province of Charente, France. Its age is established as Third Interglacial, and thus older than many of the Neanderthals. Yet, in the words of the French prehistorian Henri Vallois, "he had a forehead constructed on the same type as our own and totally devoid of the torus so characteristic of the Neanderthals." The cranial capacity is fully up to the modern European average. Only the absence of the lower jaw and lower facial skeleton prevents us from labeling it positively as an early *Homo sapiens*.

Where does this leave the men with big brow ridges? Did they mingle here and there with *Homo sapiens* or the earlier form of him, but pass away leaving little of their blood behind? This is a subject we cannot explore at length, but one curious fact can be noted. In the caves along the slopes of Mount Carmel in Palestine has been found a strange assortment of skeletons showing numerous characters of modern man. These remains suggest either Neanderthals in the course of evolutionary transition to *Homo sapiens*, or, as is more likely, a hybrid mixture between true *sapiens* and some Near Eastern type of Neanderthal. The discoveries are generally dated as Third Interglacial, though they may be slightly later than the Charente deposits in France and there has been one suggestion that they may fall within a fluctuation of the fourth ice advance. Among the recovered remains, however, are lower jaws. The mandible of one in particular shows a prominent chin like that of modern man.

Posture and Brain

Now let me make plain why I chose to remark at the start of this article that man's origin has been greatly clarified but not, paradoxically, the mystery of man. Two facets of that mystery deserve our particular attention: (1) How did man achieve his upright posture, and (2) how did the human brain arise, and what has carried it to its present peak of achievement? Neither of these questions has, in my opinion, been satisfactorily answered.

The reason why a given form of life chooses to launch upon a new adventure is always apt to remain mysterious. One thing, however, seems rather plain: Animals do not evolve new organs for the specific purpose of intruding into new environments. Instead they start with what the biologist calls a "pre-adaptation"—an existing organ, habit or other character which offers the possibility of being used successfully under new environmental circumstances. The first vertebrates to leave the water successfully, for example, had already acquired a primitive lung, utilized for survival in swamp waters of low oxygen content. Other pre-adaptations, such as a muscular fin capable of being transformed into a primitive foot, contributed to the success of the venture. What we cannot so readily clarify in certain of these instances is whether events *forced* the movement across into the new corridor, or whether the restless impetus, the exploring curiosity, the vital drive of the animal promoted the crossing.

In the case of man it is easy to see what pre-adaptations promoted the dramatic emergence from the forest world into the world of grass. The hand of the Old World monkeys is one of them. The fingers are free and flexible; they can be put to uses other than climbing. Straus says of the rhesus monkey: "I am convinced that there is not a single primary movement that can be made by the hand of man that cannot be made by the hand of this monkey." Man's developing brain would have been of small use to him, if his forelimbs, say, had been those of a hoofed runner on the open grass. Only an apprenticeship in the trees, only limbs adapted for climbing, made possible man's curious achievement of an upright posture. This trend toward an occasional assumption of the vertical position is documented even among some of the oldest and most primitive of today's primates—the lemurs. A missionary visiting Madagascar in the 1850s recorded with amusement how the pet lemurs kept by some of the villagers would stand on their hind legs, leaning like little men against a wall in the sun with their forelegs spread out like arms, in order to dry themselves after a heavy rain.

It is difficult to see precisely why only one group took to bipedal habits. Other primates, notably the baboons, have taken to a ground existence, but in spite of a considerable manual dexterity, they have retained a four-footed posture. Some factor coming at just the right time in man's anatomical evolution must have provided the impetus for a new adjustment. That factor, it has sometimes been contended, was the great period of mountain building which occurred during the Middle Tertiary.

The primates are an old order of mammalian life. Their roots reach into the Paleocene and perhaps beyond. They have known the damp rain forest which prevailed over vast areas before the Asian world was swung skyward by the Himalayan upthrust. That upthrust of the high Asian plateau, with its enormous destruction of the ancient forests, its desiccation of vast areas, its promotion of steppe and grassland, forced some group of early prehominids out upon the ground, according to the hypothesis. The great geological movement progressed slowly enough so that the human ancestor had time to readjust his body over many thousands of years. Finally he teetered off upon his new adventure, leaving behind him in more favored areas of the earth his old tree-dwelling relatives, who intensified, as the living orang has done, their arm-lengthening adjustment to progression across the forest ceiling.

There is just one troubling thing about this picture: We are no longer sure that the human precursor first arose in Asia. The great tablelands of Tibet and the neighboring regions have yielded no traces of this early stage. One of our greatest authorities upon fossil man in Asia, Pierre Teilhard de Chardin, has become so impressed with the new finds in Africa that he is now convinced that Africa is the original homeland of the human race.

The Rise of Man

Let me briefly re-examine the evidence. In South Africa we have a variable assemblage of walking apes with many human anatomical characters. They are the most primitive bipeds of whom we have any knowledge. Below that point, so far as Africa is concerned, we have to drop 20 million years into lower Miocene times in Kenya. Here we are back among four-footed, agile apes of the Proconsul variety. They possess certain generalized characters, a fact which has promoted the notion that they may represent our four-footed prototype before he had achieved an upright posture. Nevertheless little is known in detail of the Miocene anthropoids. It may be that the dearth of material has caused us to overemphasize characters which may have been widely distributed among numerous genera of Miocene apes or sub-apes. There is no real unanimity of opinion as to whether Proconsul should be placed on the human line.

Do we have anything from the long gap between Proconsul and the upright Australopithecines? Two teeth and a palatal fragment from the Nagri beds of the Pliocene in India are regarded by some as representing ancestral Australopithecines. Perhaps the ancestral ape first rose to the precarious upright posture somewhere in the great green belt that once stretched from Africa to southwestern Asia. Once the venture was made, a rapid spread along the grasslands was possible. The presence of Meganthropus in Java during the early to middle Pleistocene suggests wide diffusion at that time.

The new grass world was sunny and attractive, perhaps particularly so to creatures who relied as greatly upon their visual powers as do the primates. Insects, small mammals, seeds and roots in season—all must have been sought by those eager and nimble fingers. The animals may still have had recourse to trees in times of fright. Century by century the proto-men must have wandered farther and farther afield as the foot and pelvis, under the intense selective forces of the new environment, began to be reworked and modified. By his peculiar structure man escaped the environmental trap of the cursorial grass eaters. He remained unspecialized in everything except his brain and his ground-adapted foot.

His diet was omnivorous but probably more concentrated than that of the tree world behind him. He seems to have increased in size beyond his four-footed predecessors. Probably his habits were not at all nice. It is very likely that he was not above indulging in the carrion left by carnivores of more ferocious propensities than himself. In tooth and claw he was one of the weaker mammals. "It is with powerlessness," says one investigator, "that thought comes." This beast was on the verge of something; he had hands completely divorced from locomotion. They could explore things in the surrounding environment; they could close around sticks and stones, move things from place to place. They could be manipulated in a hundred ways by the brain. The creature had set out on the loneliest road in the universe, though he was not yet aware of it. He was destined to grow aware of the past and the future; he was about to go behind the hitherto accepted face of nature, and to people the dark with gods.

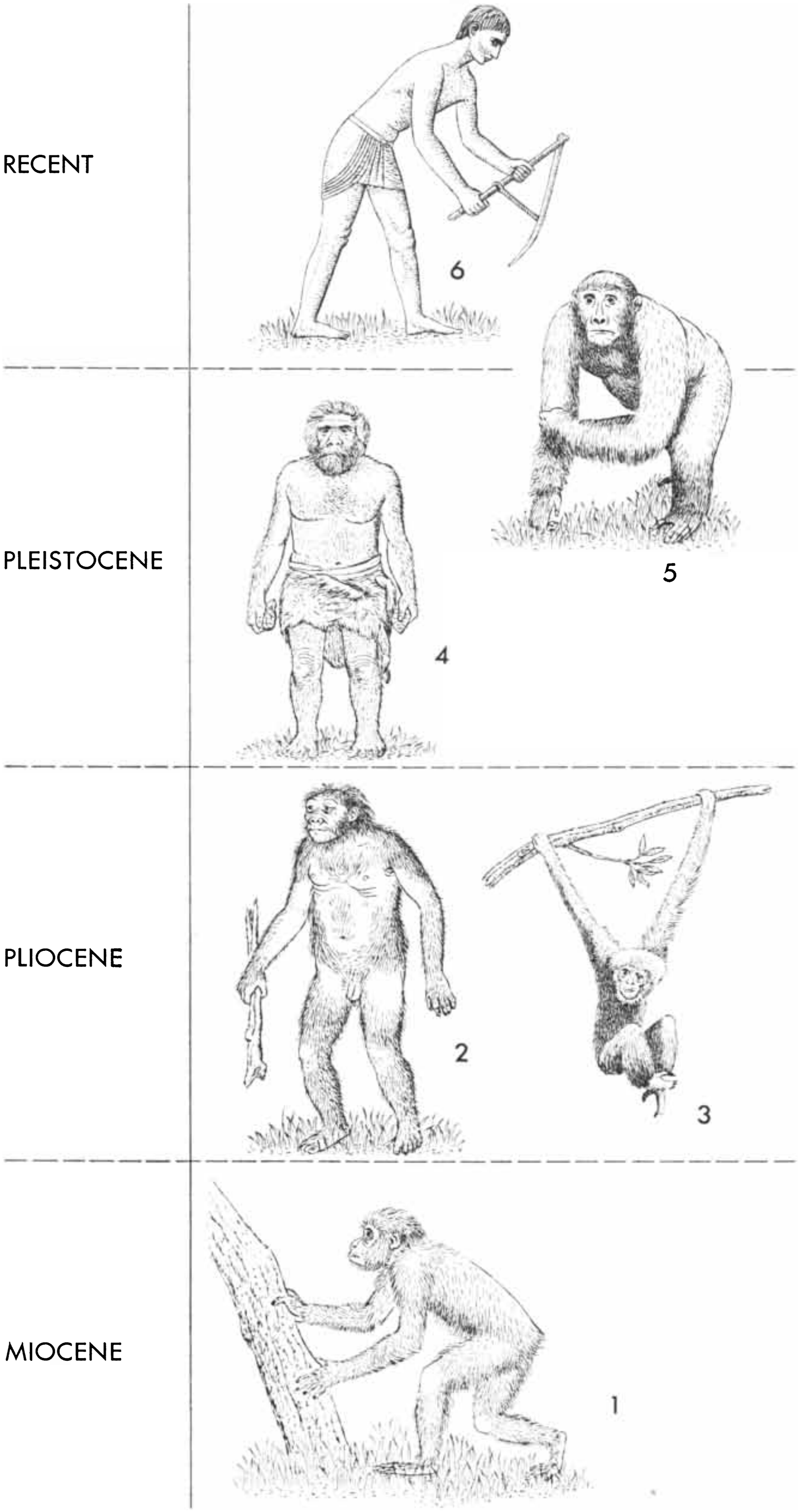
The Explosion of the Brain

"Nature," the philosopher George Santayana remarked with deep insight, "is full of coiled springs." And never did a spring release with more devastating violence than that which projected the human brain upon the helpless living world about it. The event, measured in geological terms, appears to have been surprisingly sudden. If the man-apes of South Africa were in truth our direct ancestors, and not holdovers from an earlier level of evolution, then man has multiplied his gray matter at a prodigious pace. Within something like 500,000 years or less that brain doubled itself. By the time of Swanscombe man in the Second Interglacial it had reached its present size. The brain with which man is plumbing the deeps of space and tampering with the atom is the same as the one that shaped the Acheulean hand ax.

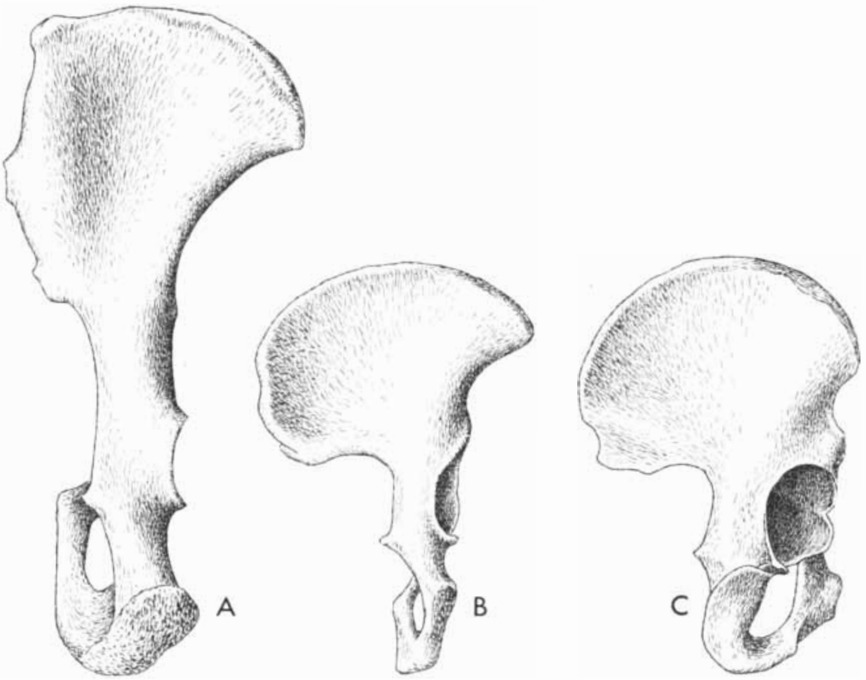
One theory has it that the brain tends to lag after changes in bodily structure, that it catches up, as it were, with the new functions it must carry out. Man, with an anthropoid brain, achieved vertical posture; he entered a new environment where, for a considerable period, he doubtless underwent genetic selection for longer limbs, better-adjusted feet and more complex upright neurological adjustments. Then something happened: tools were invented, and, so it has been argued, under the stimulus of competitive struggle the brain "exploded" into its present position of great size and enormous effectiveness.

That the use of tools, particularly the transmission of toolmaking techniques, has been of inestimable importance in the history of man is undeniable. That it can be regarded as the sole stimulus which precipitated the remarkable explosion referred to above is less clear. The argument threatens to run in a circle. We have to have the tools to get the brain, and the brain to get the tools. Moreover, pursuing the tool argument to its conclusion, we are faced with the problem of explaining why the Stone Age savages of today are capable of learning to fly airplanes, play chess and in general take on readily the virtues and vices of the advanced societies.

This problem so puzzled Wallace that



EVOLUTION OF PRIMATES from the Miocene is depicted in generalized form. In the Miocene numerous four-footed apes such as Proconsul (1) probably inhabited sparsely wooded grasslands. In the Pliocene man-apes such as Paranthropus (2) began to walk and apes such as the gibbon (3) began to swing from trees using their arms as their principal means of locomotion. In the Pleistocene men such as the Neanderthal (4) acquired an advanced brain and used tools, while apes such as the gorilla (5) had returned to the ground. Man of the recent epoch is depicted here as an Egyptian agricultural worker (6).



HIP BONE of the chimpanzee (*left*), the man-ape Plesianthropus (*center*) and man (*right*) are compared. The similarity between the latter two indicatesthat Plesianthropus walked erect.

he proposed a spiritual solution. He felt that the qualities of the human brain could not be explained by the process of natural selection. He was not satisfied with the usual Darwinian explanation that the most effective weapon-makers destroyed other primate groups. He recognized that a present-day savage who lacked modern tools and weapons was not a living fossil but had potentialities far beyond what the struggle for existence, as then conceived, should have given him. "We are driven to the conclusion," said Wallace, "that in his large and well-developed brain he possesses an organ quite disproportionate to his actual requirements—an organ that seems prepared in advance only to be fully utilized as he progresses in civilization. . . . The brain of prehistoric and of savage man seems to me to prove the existence of some power distinct from that which has guided the lower animals. . . ." By way of answer to this view some suggested that modern tribes were not true primitives but "fallen" people who had inherited brains of greater capacity than their needs. Similar observations, it was noted in class-conscious England, could be made among the peasantry.

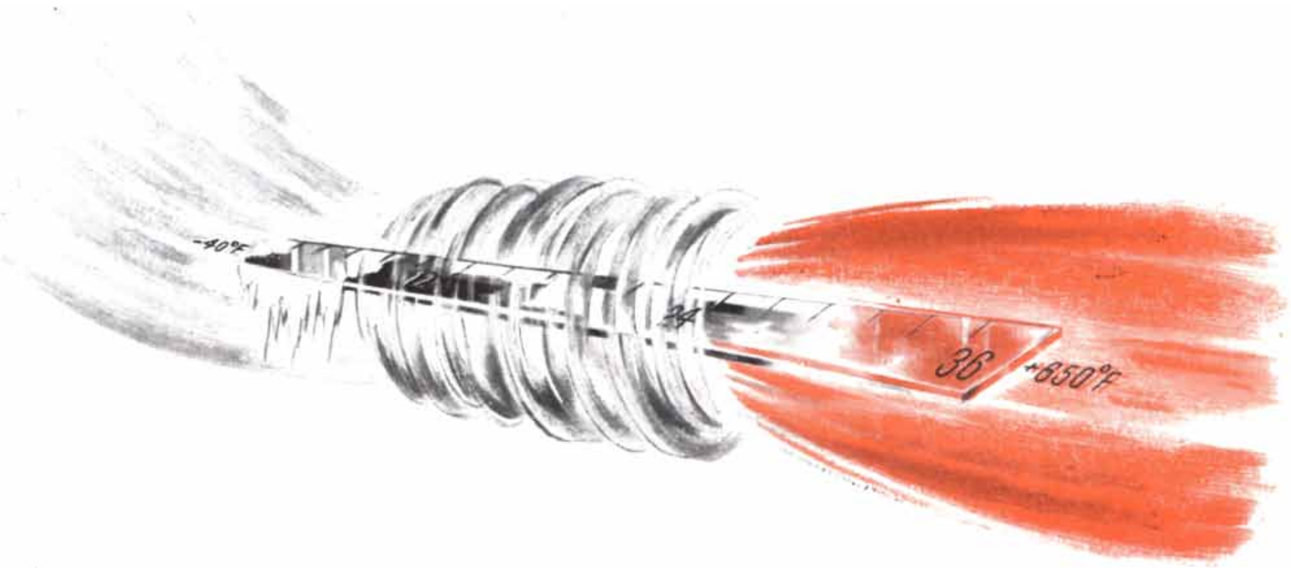
These arguments will not stand careful scrutiny, but I do not believe that the solution of the enigma demands that we follow the road Wallace took, even though one recognizes the importance of some of his comments. It is one thing to say that we can trace man's intellectual capabilities into the past by the tools he used; it is quite another to assume that man has acquired his modern brain through the competitive use of these tools alone. Yet we can do no more at present than hint at a possible solution. It is possible that communication began before tools and is more significant. Moreover, the ability to grasp time, to look toward the future, is of great significance in the awakening of the impulse to *make* rather than merely to pick up and *use* a makeshift tool. Another problem unanswered by simple arguments about tools is the great spurt of human brain growth in the first months after birth and the prolonged infancy of our species. It is apparent that man is an anomaly among apes. Did culture promote these changes, or did the changes influence man's curious evolutionary history? Complex, not simple, forces seem to have been at work.

The Freedom of the Brain

Finally we may observe one curious point in which man's case is perhaps unique. His only really important bodily specialization is this huge mushroom of a brain, which has arisen magically between night and morning. He could have survived in the war of nature with less, but now he shows strange talents of little "practical" importance. He tries to write beautiful things; magnificent symphonies roll from the tissues of his brain; he creates a symbolic world of mathematics which has meaning only to others of his kind. When I said that the human brain exploded, I meant no less. There was nothing to keep it to the careful, limited perfection of a horse's hoof. It does not move in a narrow channel. It is the one specialization which has brought unlimited freedom.

Somehow, when man left his four feet for two, and abandoned the fixed natural world for a social world of vertical moving bodies forever circulating around him, he was promoting flexible, intelligent adjustments rather than the instinctive ones to a fixed environment. Under unhindered mutation pressure evolution built his unbelievably complicated brain. Evidence has accumulated that mutation rates themselves may be inheritable and that this tendency may revolve around particular loci, in this case let us say the genes controlling brain growth. Then, if in the early stages of evolution such growth had a genuine selective advantage, the rate of increase may have well carried the brain beyond what was purely necessary, speaking in a utilitarian sense. Whether this great creative burst has now become completely stabilized, we cannot discuss here. Life, as always, is more strange than the explanations we give of it. Seemingly some brain of the Middle Pleistocene could have written Beethoven's sonatas. It lacked only the necessary cultural background.

Not many months ago I sat in a conference of scholars listening to several distinguished men debate the way in which man had obtained his brain. As the voices rose, my mind wandered far back along the ill-lit road by which we had come to this meeting. This was the way man had come along that whole dark million-year-long road—shouting, arguing, talking boldly to his fellows, whistling by thickets filled with the eyes of night prowlers, devising rickety intellectual houses that a single cold blast of thought would blow away, and then proceeding to reside comfortably within them for millennia. We wouldn't recognize any more, I thought a little wistfully, the world from which we have emerged. We wouldn't recognize the heat that burned us, or the mud we crept through, or the teeth that snapped at us. They are all back behind us there in the deeps of time. Worlds we have passed, worlds where we wriggled and crept or swung and dangled to reach a warm house and a pleasant fire. I think I know at last how man has reached this place, I thought to myself. It has not all been by the use of tools.



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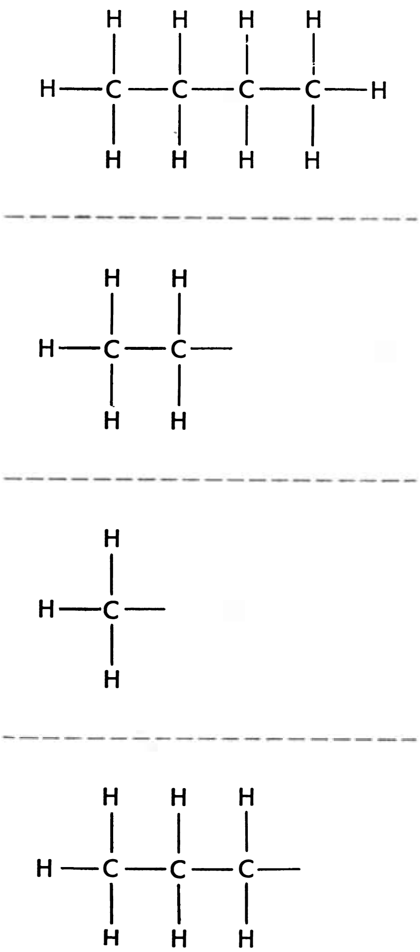
FREE RADICALS

Having nothing whatever to do with politics, they are combinations of atoms which have a brief individuality in the course of chemical reactions and which are studied to show how the reactions proceed

by Paul D. Bartlett

Few things in nature are so elusive as those important but ephemeral fragments of matter that chemists call free radicals. Man has dealt with free radicals, of course, ever since he learned to build and control a fire. The chain reaction of a flame depends upon the formation and interplay of molecular fragments that live for only a few thousandths of a second. Free radicals play their brief but essential role in a great many kinds of organic chain reaction, from explosions to the drying of paint. The art of controlling some of these chain reactions is now highly developed, especially in combustion engines. But the details of how free radicals behave are still not well understood, and this is one of the challenging problems of organic chemistry today.



BUTANE (*top*) is formed by two free ethyl radicals (*second from top*) or by a methyl (*third*) and a propyl radical (*bottom*).

A chemical radical is a group of atoms, joined together in a characteristic structure, which acts as a prefabricated unit in building molecules. For instance, the ethyl radical C_2H_5 has five hydrogen atoms strung around a backbone of two carbon atoms. Two ethyl radicals may unite to form the butane molecule, a highly volatile component of gasoline [*see diagram at left*]. Butane may also be formed by the union of a methyl radical (CH_3) and a propyl radical (C_3H_7). Now the most noteworthy difference between the molecule and the radicals is that the molecule has an even number of hydrogen atoms, while each radical has an odd number. There is no known simple compound of carbon and hydrogen with an odd number of hydrogens. Since radicals must therefore be unstable, chemists in the 19th century believed that there could be no such thing as a "free" radical.

But at the turn of the century the University of Michigan chemist Moses Gomberg actually isolated a free radical. He discovered it unexpectedly while he was performing what might have been a routine synthesis. He had undertaken to treat triphenylmethyl bromide with zinc. In this compound the bromine atom is attached to a radical consisting of three phenyl groups (C_6H_5) clustered around a central carbon atom. The reaction with zinc was expected to knock out the bromine atom and lead to its replacement by another triphenyl radical, forming the compound hexaphenylethane, with six phenyl groups [*see diagram on page 76*]. What Gomberg actually obtained was a compound which possessed not only all the expected atoms but also, surprisingly, two atoms of oxygen. To keep oxygen out of it, he repeated the experiment in the absence of air. This time he obtained the expected six-phenyl compound, but it showed a tendency to split spontaneously into two halves—the two radicals that had formed it. These free radicals were stable enough to survive for long periods. There was no difficulty in recognizing them, for they did not behave like hydrocarbons; they had an intense yellow color, instead of being colorless, and they combined vigorously with oxygen, iodine and certain metals.

Why did these radicals split apart? The main reason is that they consist of bulky groups of atoms which get crowded around the site of the carbon coupling, making the union difficult. After Gomberg's discovery, chemists found that they could prepare other stable free radicals from compounds in which the coupling was similarly hindered.

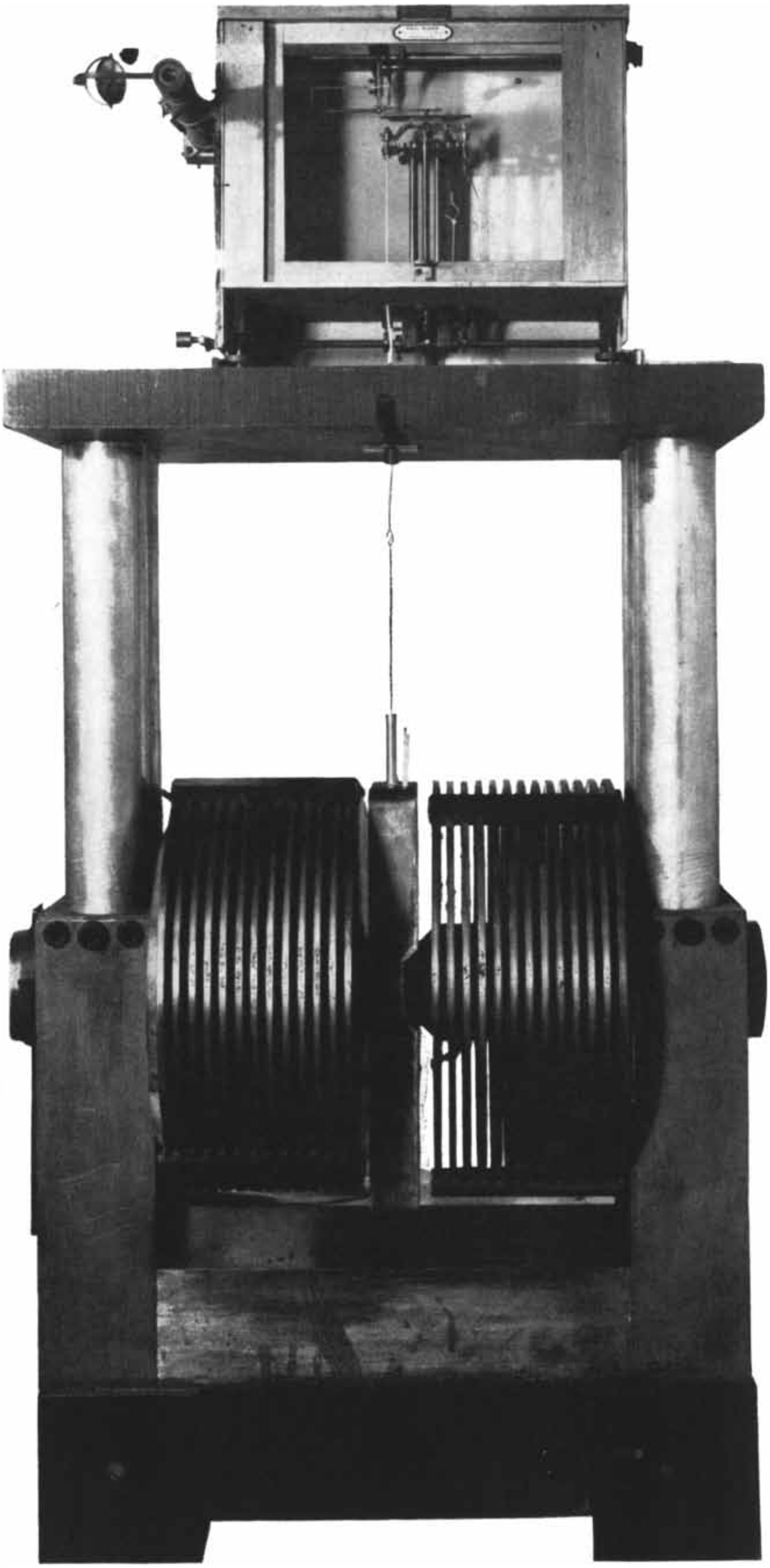
The great University of California chemist Gilbert N. Lewis later suggested the theory that explained why free radicals are usually unstable. All atoms and groups of atoms owe their chemical properties to their electrons. The spinning electrons are magnets. In a molecule these magnetic forces are all neutralized, because electrons of opposite spins pair off to form the bonds that hold the atoms together. But in a system containing an odd number of electrons, such as a free radical with its odd number of hydrogens, one electron of course is left unpaired. The magnetic attraction of the unpaired electrons is substantial. It is easily detectable by weighing a sample of a stable free radical in the absence and in the presence of a magnetic field; the radical is drawn into the field, instead of being repelled as most organic compounds are. This method has become useful for measuring the amount of free radicals present in a sample of reacting material. The magnetic properties of the unpaired electron are also utilized in the new paramagnetic technique for detecting and describing free radicals.

The one thing experimentally in common between the stable free radicals of Gomberg and the unstable ones of man's oldest chain reaction, fire, is their vigorous reactivity toward oxygen. The molecule of oxygen contains two atoms and an even number of electrons. It might therefore be expected to have all its electrons paired, but magnetic investigation has shown that two of them are unpaired. This unusual fact explains why oxygen reacts vigorously with free radicals in a flame and with stable free radicals in a cold state.

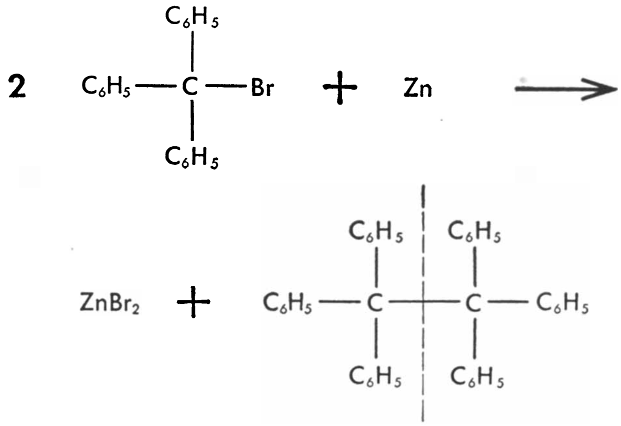
In 1928 F. A. Paneth and his collaborators in Germany devised a technique which made it possible to measure the lifetime of simple free radicals. They passed tetraethyl lead vapor in a swift stream of hydrogen through a quartz tube. When a spot on the tube was heated, lead was deposited on the inside of the tube at that spot. This freed the ethyl radicals. A short distance farther downstream the free radicals encountered a lead surface. The experimenters found that lead was removed from this surface at the same time it was deposited at the heated spot. They were able to prove that the ethyl radicals were combining with this lead to form tetraethyl lead again. They were also able to compute that under the conditions of their experiment the half-life of the free ethyl radicals was three thousandths of a second.

It used to be thought that the ease of formation of free radicals from tetraethyl lead had something to do with the effectiveness of this antiknock agent in controlling combustion in a gasoline engine. A. D. Walsh in England, however, has presented evidence that the antiknock function is due directly to the lead oxide deposited by the compound in the cylinder and not to fragments occurring during its decomposition.

F. O. Rice and his students at The Johns Hopkins University used the rapid-flow technique to show that free methyl and ethyl radicals are produced whenever organic compounds such as those in the lighter fractions of petroleum are heated until they decompose. The temperature required for the formation of free radicals varies according to the



MAGNET is used to detect free radicals at Harvard University. When a vessel containing a solution in which free radicals are present is suspended between poles of the electromagnet at bottom, weight of solution changes and is recorded by microbalance at top.



LONG-LIVED FREE RADICAL is liberated when triphenylmethyl bromide (*upper left*) is treated with zinc (Zn). The reaction yields zinc bromide ($ZnBr_2$) and hexaphenylethane (*lower right*). It also yields radicals which consist of half the hexaphenylethane molecule.

compound—from about 200 to 1,800 degrees Fahrenheit.

Other workers made an important new discovery: that in a mixture of an easily decomposed compound with a more stable one, both compounds broke down at the temperature at which the less stable compound began to decompose into free radicals. In other words, free radicals can initiate chain reactions in otherwise stable molecules. Rice showed that the conversion of acetone into methane and ketene, an industrially important reaction, takes place in this way. Acetone reacts with a free methyl radical to yield methane and a new radical; the latter then decomposes into ketene and a free methyl radical which is available to repeat the cycle. Compounds which decompose and introduce free radicals into a liquid or gaseous system may serve as "chain initiators." The number of cycles or links in a chain reaction produced by a single initiating radical is known as the "chain length." In some processes the chain length may run as high as 10,000 or more.

By now it is known that many other agencies besides heat can produce free radicals. Exposure to intense light, for example, can trigger a chain-reaction explosion in a mixture of hydrogen and chlorine. Chlorine molecules absorb light and break down into chlorine atoms; the free atoms then snatch hydrogen atoms from the hydrogen molecules; the unpaired hydrogen atoms in turn remove chlorine atoms from their molecules, and so the chain proceeds. R. G. W. Norrish of the University of Cambridge has recently constructed an apparatus which will give a light flash powerful enough to convert most of a sample of chlorine instantly to free atoms—a state of matter never before observed even for a fraction of a second.

The mildest and most controlled way to use free radicals in initiating chain reactions is through the use of certain reagents which add to a molecule or remove from it a single electron at a time. An example is the process for making "cold rubber"; it employs a system such as a ferricyanide and a mercaptan and yields a sulfur-containing radical which initiates an orderly chain reaction. The well-known chain reaction called polymerization, which has produced so many synthetic rubbers and plastics, also involves free radicals. Here the initiating free radical, instead of tearing a molecule apart, actually starts a long building process. In the making of rubber from butadiene, for example, the molecule is built up step by step, with a new free radical emerging from each step to initiate the next.

The properties of synthetic rubber depend greatly upon the length of the chain; therefore part of the art of making it lies in controlling the growth of the molecule. Since free radicals have a powerful tendency to combine with one another, the chain reaction will come to an early halt unless they are present in such high dilution that it is unusual for two of them to meet. This can be largely controlled by the choice of the chain initiator, and by the concentration and temperature at which it is used. In making synthetic rubber, more perfect control is attained by the use of a "modifier." This is a substance which rather easily gives up a hydrogen atom to the free radical end of a growing rubber molecule, closing off the chain and producing in the process a new free radical to start another rubber molecule growing. With a controlled frequency the modifier in effect snips off growing rubber molecules into threads of desired length without interrupting the cycle of chain growth. Thiols (mercaptans) are useful modifiers for rubber synthesis.

Sometimes the stored raw materials of which the rubber is to be made are started by some unknown initiator in a process of uncontrolled polymerization. They form a mass of tough, insoluble, porous-looking material called "popcorn polymer." A piece of this material, dropped into liquid styrene, behaves disconcertingly as if it were alive. It grows on the styrene until it fills all the space occupied by the liquid. The formation of popcorn polymer begins when free radicals happen to produce a molecule with internal cross-linkages, so that the molecule grows three-dimensionally instead of lengthwise. Such a mass cannot dissolve, because all the molecules join in a single, cross-linked structure. Many free radical ends remain marooned in the interior, unable to reach others with which to combine. Eventually the growth from the interior cracks the structure, but the broken chemical bonds only provide new points at which the popcorn grain can continue to grow.

With oxygen, as we have observed, free radicals usually react vigorously. In a flame or explosion the reactions are extremely fast. But Gomberg's first experiment showed that oxygen can interact with free radicals in a much less violent way. A familiar example of the slower type of reaction is the drying of paint. In this process, called autoxidation, oxygen from the air interacts with free radicals in the drying oil to produce a tough film. Two stages of this chain reaction have been observed. First the drying oil reacts with the oxygen, either directly or with the aid of an electron-transferring metallic compound that is incorporated as a drier. The reaction converts the oil into a hydroperoxide, which then apparently decomposes slowly, yielding free radicals. They establish cross-links among the linseed oil molecules and thus produce a three-dimensional, insoluble coating.

In any system containing free radicals there is always the problem of preventing premature or unwanted polymerization or autoxidation. These processes largely account for the deterioration of cracked gasoline and of rubber. The way to prevent them, of course, is to remove any free radicals that may be formed before they can start long chains. Appropriate inhibitors to do this have been found for every long-chain reaction. An inhibitor reacts with the free radicals faster than anything else present, and the products of the reaction are not capable of carrying on the chain reaction. Sulfur is a good inhibitor of polymerization, while vitamin E is an

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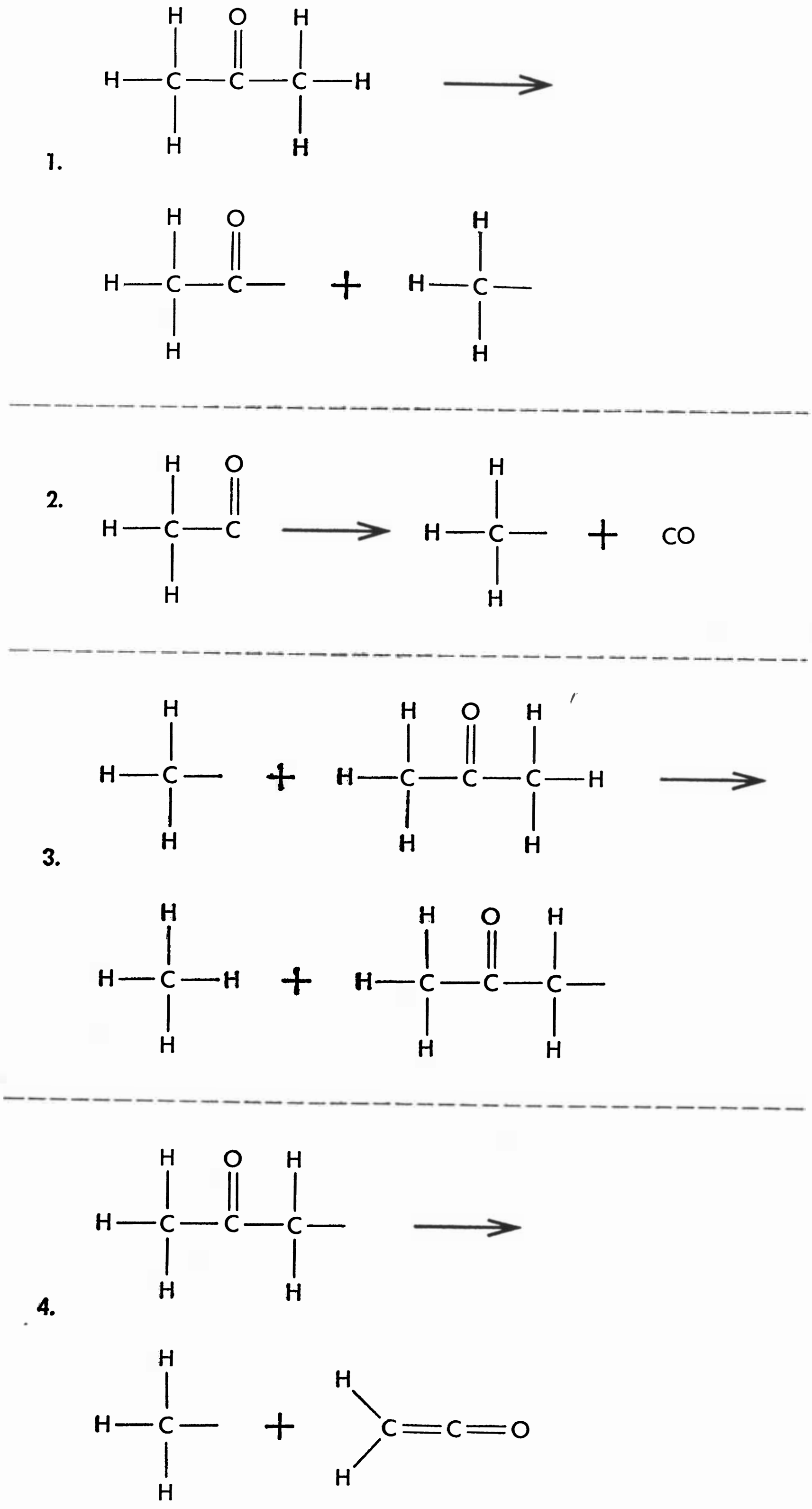
effective inhibitor for autoxidation reactions. Most gasoline, lubricating oil and rubber products and many foods and drugs contain small amounts of inhibitors.

Another place where undesirable chain reactions are suppressed is in the human body. The oxygen we breathe is consumed with remarkably little evidence of chain reactions or free radicals. In fact, most of the complicated series of steps by which oxygen is used to obtain energy from the food we eat proceed by types of reactions in which all the electrons remain paired. It has been suggested that vitamins E and C perform the important function of protecting the fatty and watery phases of the body, respectively, against the destructive effects of possible oxidation chain reactions.

How is it that the same type of reaction can produce so quiet and orderly a process as the drying of paint and also the spectacular chain reactions of flames and explosions? The essential difference between the two types of process is in the temperatures at which they occur. At low temperatures each free radical that enters into a step in a chain reaction produces one new free radical to take its place. Thus a running balance between the initiation and the completion of chains is maintained. In these slow reactions there is time for the heat produced to be dissipated to the surroundings so that it does not affect the reaction. At the temperature of a flame, however, the heat breaks some of the more stable bonds, such as that between two oxygen atoms. When this happens, a free radical, R, instead of reacting with an oxygen molecule to produce the radical RO_2, is likely to dismember it into the radical RO and the very reactive oxygen atom. Each of these products will carry on a separate chain reaction. Thus for each chain initiated we now have a multiplying number of chains, branching out at each cycle. Consequently the reaction is accelerated in geometric fashion. It can only end in an explosion.

A flame is an open-ended explosion which is prevented from coming to a quick end by the controlled rate at which fuel and oxygen are fed to it and by the lack of confinement. An oxygen chain reaction of the low-temperature type is converted into the high-temperature type whenever the heat produced is retained instead of being dissipated. When the temperature rises to the point where the chains begin to branch, the system breaks into flame. This is what happens in the spontaneous combustion of a pile of oily rags or when one piece of dry wood is rubbed against another.



CHAIN REACTION in the important industrial process converting acetone into methane and ketene is perpetuated by free methyl radicals. In the first reaction of the cycle acetone (CH_3COCH_3) is heated to yield an acetyl radical (CH_3CO) and a methyl radical (CH_3). In the second reaction the acetyl radical breaks down into another methyl radical and carbon monoxide (CO). In the third reaction one of the methyl radicals takes a hydrogen atom from acetone to yield methane (CH_4) and an acetonyl radical (CH_3COCH_2). In the cycle's fourth and final reaction the acetonyl radical breaks down into a third methyl radical and ketene (CH_2CO). The recurrently formed methyl radicals keep the reaction going.

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The Heat Barrier

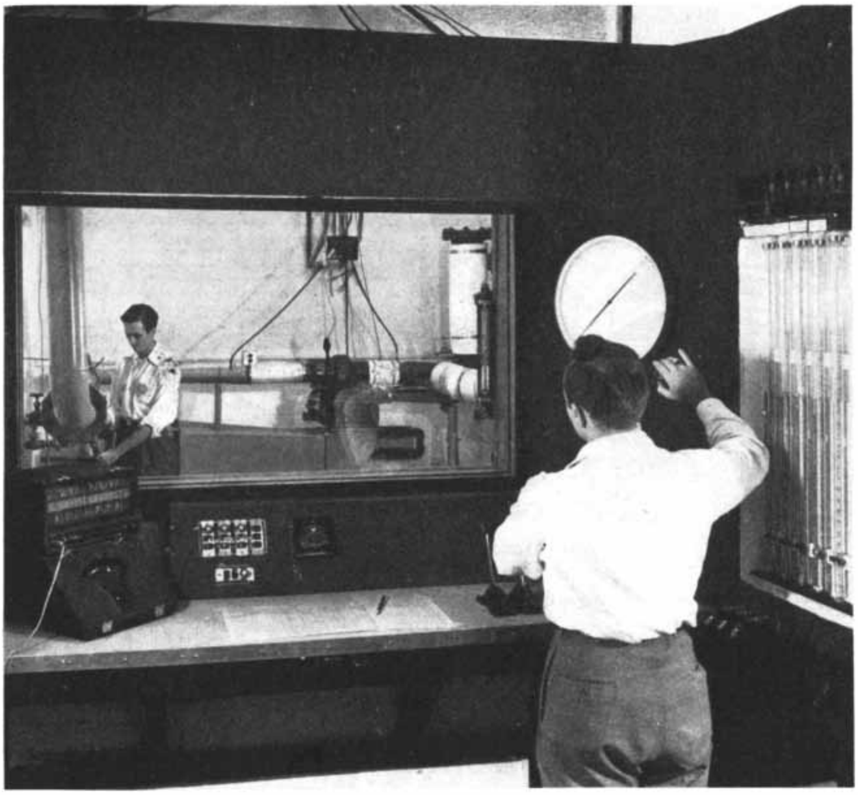
It lies beyond the sound barrier as an obstacle to high-speed flight. If the airplanes of the future are to pierce it, they may bear a surprising resemblance to airplanes of the past

by Fritz Haber

The so-called sound barrier to flight has been punctured full of holes [see "High-Speed Research Airplanes," by Walter T. Bonney, SCIENTIFIC AMERICAN, October]. But through those holes we now can see another obstacle which looks more formidable. This is the heat barrier: the heating of a plane by the friction and piling up of air on aircraft surfaces at supersonic speeds. Some aerodynamicists believe that it will prevent us from flying much faster than at present because of the weight of equipment that would be needed to cool the vital parts of the plane.

In order to investigate the heat barrier and the possibilities of overcoming it, we must first consider the basic physics of the temperature of gases. The kinetic theory of gases assumes that gas molecules continually dart about at random with considerable speed. The higher the temperature of the gas, the greater the average speed of the molecules. Temperature, therefore, is a measure of this average speed.

What happens when the body of gas also moves as a whole? If we visualize a thermometer moving along with the gas, we see clearly that the average speed of the molecules relative to the thermometer is the same and that therefore the thermometer shows the same temperature. In other words, a uniform motion superimposed on the random motion of molecules does not alter the temperature. However, the uniform velocity imparts kinetic energy to the entire mass of gas. When the gas encounters an obstacle, the gas does not rebound as a body, as a billiard ball might do. Because even a highly polished obstacle has many surface irregularities, the individual gas molecules bounce off in random directions. Now the original uniform speed of the mass of gas is distributed among the randomly rebounding molecules, and the average of their random speeds is higher than it was before the impact. In other words, the temperature of the gas is higher.



REFRIGERATION UNIT of a B-47 jet bomber is tested in a special chamber at the Bay Shore, N. Y., plant of Stratos, a division of the Fairchild Engine & Airplane Corporation.

The temperature level associated with the sudden stopping of a moving mass of air is known as the stagnation temperature. It can be extremely high, depending on the speed of the air before the impact. A plane flying at the speed of sound through motionless air at zero degrees raises the air temperature at its leading edges from zero to 95 degrees Fahrenheit. At Mach Number 2—twice the speed of sound—the stagnation temperature rises to 380 degrees, and at Mach 10 to about 9,000 degrees.

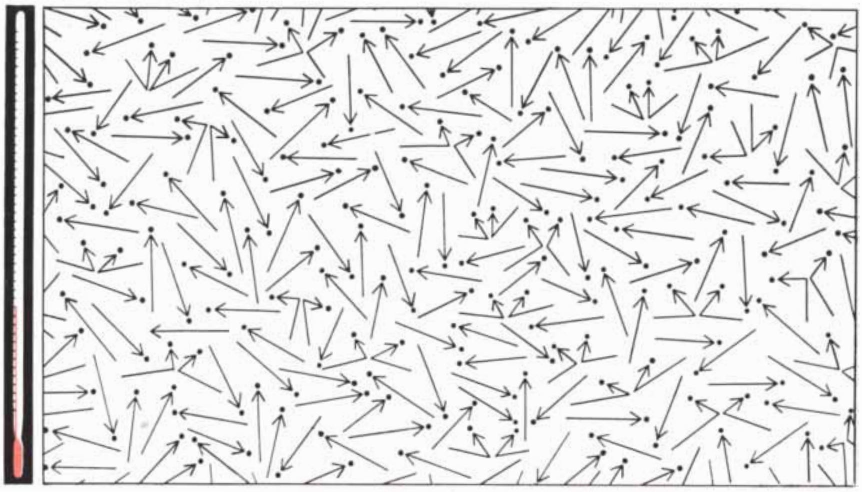
Only a small part of the airplane develops stagnation areas. On the wing and fuselage surfaces there is no stagnation, but here the plane is heated by another process. The entire airplane carries with it a thin film of air which has virtually no velocity relative to the surface of the aircraft. Just outside the film, however, there is a thin boundary zone where the relative air speed increases sharply. The differences of velocity among the air layers within this boundary zone produce friction and heat.

The boundary layer has been extensively studied. It is generally accepted that air in this layer around a moving body is heated to about 85 per cent of the temperature in the stagnation areas. At a speed of Mach 1 with air temperature zero, the boundary layer temperature rises to 80 degrees F. At Mach 2 it goes to 320 and at Mach 10 to 8,000 degrees. Thus the entire airplane is enveloped in hot air. An airplane flying over the North Pole at the speed of sound is actually flying in air as hot as that of a tropical desert.

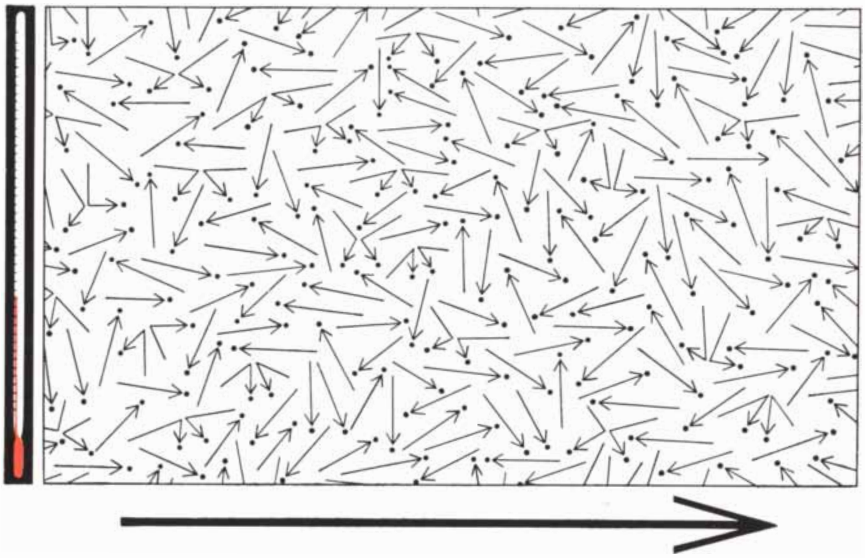
The amount of heat transferred to the plane from the surrounding hot air is determined by the temperature difference between the plane and air and by the coefficient of heat transfer, which depends on the plane's size and speed and the density of the air. We are familiar with the fact that a cold winter's day may be pleasant and comfortable if there is no wind but becomes more chilling, even without any change in temperature, if a breeze springs up. The wind raises the coefficient of heat transfer between your body and the air. For the same reason, the faster a plane flies the more readily heat is transferred from the hot air to the cooler plane. The transfer of heat also increases with air density. Hence at a given speed an aircraft will be less heated at higher altitudes, where the air is less dense. A plane can fly considerably faster without overheating at 75,000 feet than near sea level.

How hot the plane will become, at any speed or altitude, depends on the rate at which it can radiate away the heat it takes up from its surroundings. The point at which the outgo of heat balances the inflow is called the equilibrium temperature. Whatever the final temperature may be, it takes time for the plane to heat up to that point. The very high speeds achieved by present experimental aircraft have avoided a dangerous heat problem only because the planes do not fly long; their fuel supply permits them to fly for only a few minutes and they do not reach equilibrium temperatures.

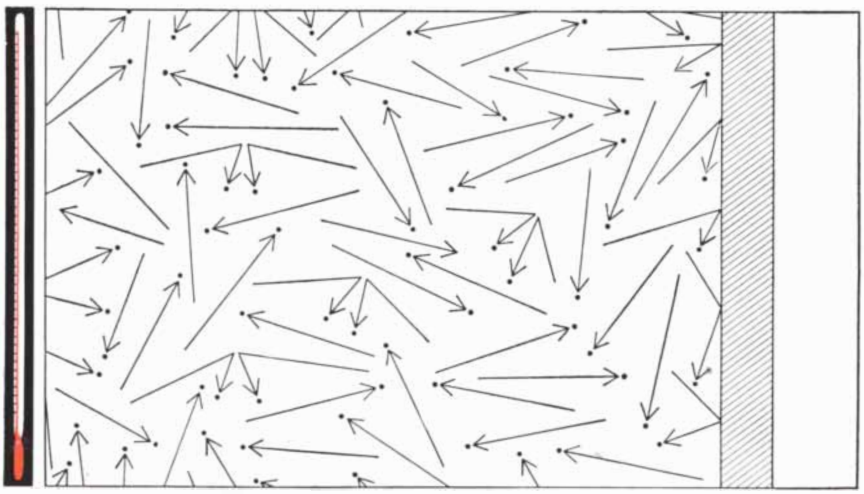
In considering the maximum speed at which planes will be able to fly for extended periods, we must first decide how high an equilibrium temperature we can permit. All metals lose strength



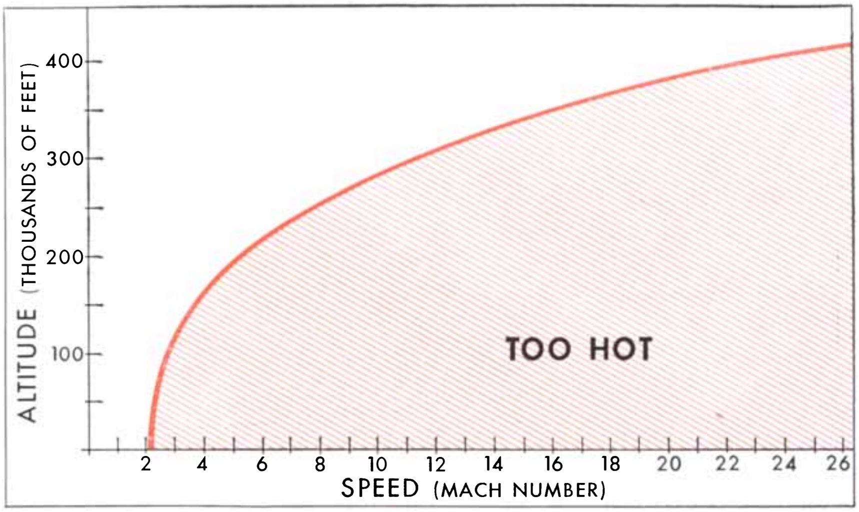
TEMPERATURE of a gas is determined by the average speed of its molecules. In this diagram the molecules are represented by dots and their direction of motion by arrows.



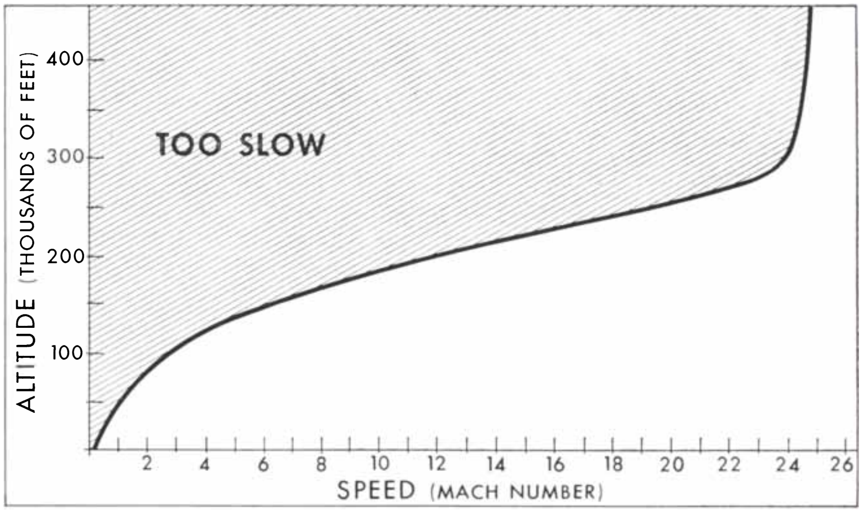
TEMPERATURE IS THE SAME if the gas is moved, because the average internal speed of the molecules is the same. The outside energy is expended in moving the entire system.



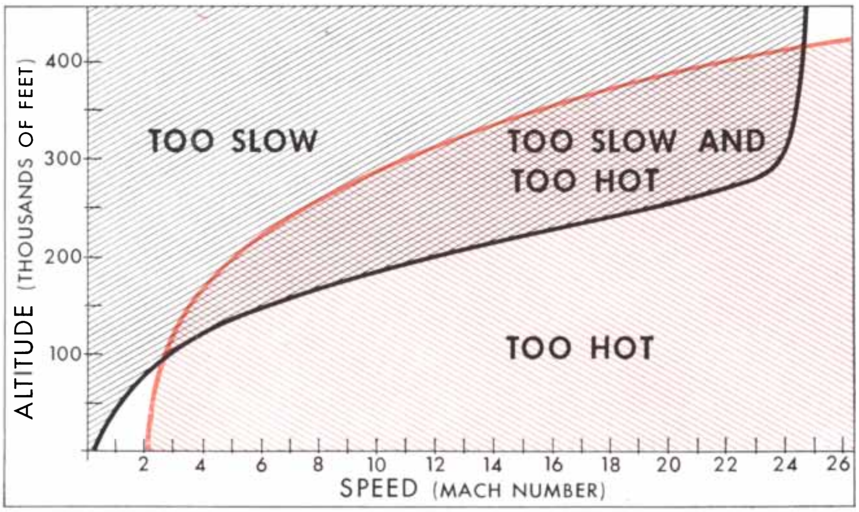
TEMPERATURE RISES SHARPLY when a moving gas is brought to a halt by a barrier. The average speed of the molecules is increased by their collisions with the obstacle.



HEAT BARRIER is plotted on the basis of a hypothetical airplane whose skin can withstand stresses at a temperature of 480 degrees Fahrenheit. Mach 1 is the speed of sound.



LIFT BARRIER, that is, the minimum speed at which an airplane could fly, is plotted on the basis of an airplane kept aloft by the small pressure of 80 pounds per square foot.



BOTH BARRIERS are combined. An airplane with the two characteristics noted above could operate only in the small white area at lower left. At upper right it would be a rocket.

at high temperatures. Suppose we say the limit at which the skin of the plane will be able to stand up to the stresses on it is 480 degrees F.—a figure which may look daring to pessimists but conservative to optimists. On the basis of this figure and the rate at which the material forming the skin surface can radiate heat, we can calculate the permissible speed of a plane at various altitudes.

The results of this calculation are summed up in the uppermost chart at the left. The maximum permissible speed under the given conditions is plotted as a curve against altitude. The shaded area in the chart represents the circumstances under which flying will be too hot: the impermissible speeds at the given altitude.

From this graph it may appear that the problem of aerodynamical heating is easily solved: all we have to do to fly as fast as we please is to go to high altitudes. But unfortunately when we get to those altitudes we have to consider whether it is possible to fly at all. Is the air at such heights dense enough to support an airplane? That depends to some extent on the speed of the plane. An aircraft is kept aloft by the difference in air pressure on its upper and its lower wing surfaces. The pressure difference, in turn, depends on the product of the air density and the square of the speed. As the air becomes thinner, an airplane must increase its speed to maintain the pressure difference. For example, at 100,000 feet, where the air density is only a hundredth of that at sea level, an airplane must move 10 times as fast to stay up.

No propeller-driven plane could fly at the altitudes and speeds we are considering. Turbojets have flown at about 75,000 feet and ramjets may go somewhat higher, but at their probable ceiling the heat factor will limit them to a maximum speed of about Mach 3. The only kind of engine that could fly beyond 100,000 feet is a rocket, which carries its own oxygen. A rocket's fuel requirements, however, are massive, and we have not yet found a way to build a rocket-powered plane that will fly for more than a few minutes; atomic-fueled engines may change this picture, but they are still an unknown quantity.

We might fly a rocket plane as a glider, firing it to high altitudes while its fuel supply lasts and then letting it glide on its momentum until it returns to earth. At the rarefied altitudes where there is almost no air resistance we could fly at very high speeds. Suppose we choose, as a minimum efficient cruising speed, the velocity that produces a dynamic

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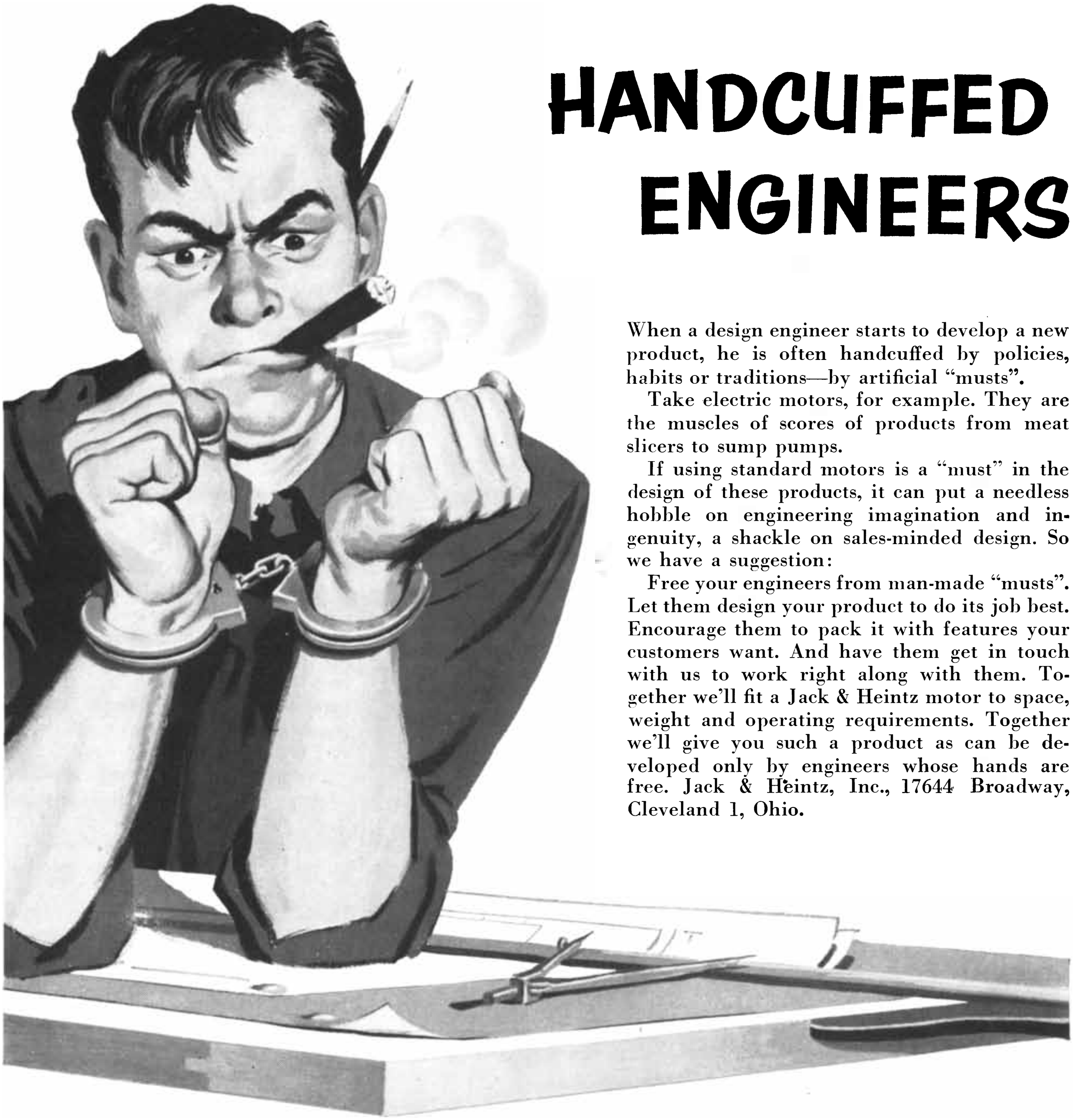

When a design engineer starts to develop a new product, he is often handcuffed by policies, habits or traditions—by artificial "musts".

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JACK & HEINTZ *Rotomotive* EQUIPMENT

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J&H *Rotomotive* Equipment—electrical, hydraulic or mechanical devices designed to solve unusual problems of developing power, controlling it or using it • Custom-built commercial motors • Aircraft accessory equipment • J&H Eisemann Magnetos pressure of 80 pounds per square foot —a very low figure by today's standards. The speeds at which we would have to fly at various altitudes are plotted in the middle graph on page 82. Again we have a shaded area showing the circumstances impracticable for flight: this time labeled "too slow." Incidentally the graph brings out the interesting fact that at the speed Mach 15 the centrifugal force of the aircraft's motion around the earth begins to counteract the earth's gravitational pull, and at Mach 25 the craft becomes completely weightless. No pressure difference is then required to keep the plane up, and we can go as high as we like.

Now if we place the second graph over the first, we can see that the two shaded areas overlap to define a range which is completely "off limits" for flight. In this overlapping area both the pressure and the temperature conditions are unfavorable; we would be flying at once too slow and too hot. To be sure, present-day airplanes can make quick passes through this "no man's land," but they are incapable of sustained flight in it.

Can we open up the no man's land in any way? We can make a beginning by developing a more protective material for the skin of airplanes. It should be highly heat resistant, have good insulating properties, radiate heat rapidly, keep its tensile strength at high temperatures and weigh practically nothing. It goes without saying that it will not be easy to meet these specifications.

Engineers may also crack no man's land by designing an airplane that requires less pressure difference on its wings for flying. This can be done by making the wings larger, thereby decreasing the wing loading. Airplanes would then be able to support themselves in the air at slower speeds at any given altitude. Such a move would reverse the trend in aircraft design, which for many years has been toward relatively smaller wings. The huge-winged airplane we would need to fly at Mach 15 at an altitude of 60 miles would look very clumsy beside present-day planes: at low altitudes it would lumber along like a pterodactyl, and it would land as slowly as the planes in the early days of aviation.

Breaking through the sound barrier was an unconditional "yes or no" proposition. The heat barrier is different. It is not possible to break through it, but by fulfilling certain conditions it will be possible to go around it. To effect this detour, it will be necessary to make radical changes in the airplane as we know it today.

Alcohol in the Body

Because alcoholic beverages have been an intimate part of human life throughout history, their effects have given rise to a large folklore, most of which modern physiology has shown to be wrong

by Leon A. Greenberg

No phase of human behavior has been surrounded with more myth and fallacy than the drinking of alcohol. Man has been using alcoholic beverages since prehistoric times, and in the U. S. today some 65 per cent of the adults drink—most of them occasionally or moderately and without apparent ill effects. But the abuse of alcohol has always been a problem, in some societies more than in others. Many of the misconceptions about the effects of alcohol unfortunately have sprung from the psychology of fear used to discourage drinking. This article will review the evidence on the nature of alcoholic beverages and their fate in the body.

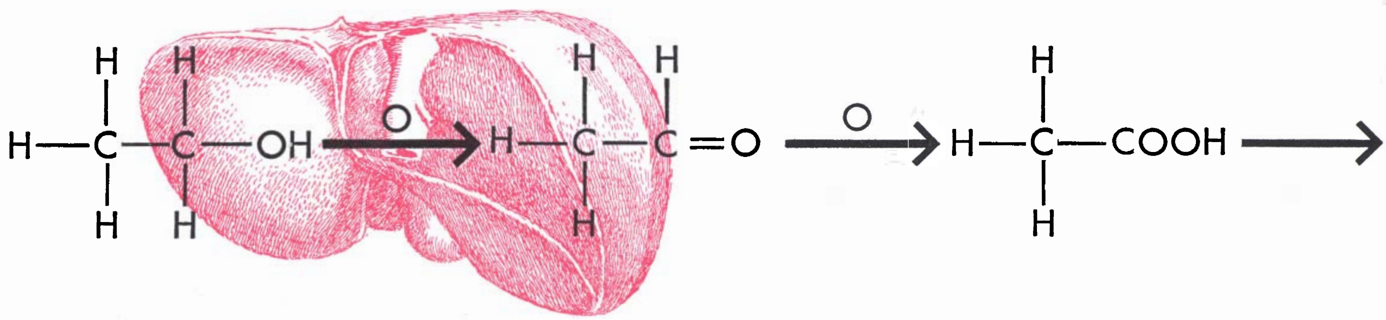
Ethyl alcohol, the beverage kind, is only one of many alcohols. What mainly distinguishes it from the non-potable alcohols is that the body destroys it (by oxidation) rapidly. A man who drinks a pint of whiskey in a day has no alcohol left in his body the next day. But it would take him about a week to get rid of this amount of methyl (wood) alcohol. Moreover, the body oxidizes methyl alcohol into a poison that damages the nerves, often causing blindness by attacking the optic nerve.

Pure ethyl alcohol is a clear, colorless liquid with little odor but a powerful burning taste. No one drinks pure alcohol; it is always taken in wines, brewed beverages or distilled spirits. Wine is as old as prehistoric man; primitive peoples knew that fruit juices exposed to the air in a warm place made a lively beverage. Brewing also is very old, but distillation is a fairly recent development.

The fermentation of fruit juices is effected by tiny yeast plants which settle in the liquid from the dust in the air. In the presence of an abundance of sugar, fermentation can proceed to an alcohol content of about 14 per cent, at which point the alcohol inhibits the yeast. Some wines are fortified by addition of alcohol to a content of 20 per cent. The brewing of beer or ale also is a fermentation process, but in this case the raw material is a broth made from cereals, and malt is added to break down the starch to sugar so that the yeast can act on it. The process is stopped when the alcohol concentration of the brew has reached 3 to 6 per cent, and hops are usually added for flavor. Wines and brewed beverages retain the minerals and some of the vitamins of the fruit or cereal.

The stronger liquors are made by distillation of the fermented beverages—brandy from wine and whiskey from a beerlike brew. In the distilling process all the solids, minerals and vitamins are lost. The distilled beverages usually have an alcohol content of 40 to 50 per cent. The term "proof" as the measure of strength comes from the early distillers, who tested alcohol by wetting gunpowder with it; when the distillate was at least 50 per cent alcohol, the powder would burn. Since combustibility of the gunpowder was 100 per cent proof of this alcohol content, "100 proof" came to mean 50 per cent alcohol.

So much for alcohol in the bottle; our chief subject is what happens to alcohol in the drinker. Unlike most foods, it is absorbed into the blood without digestion. A small part goes into the blood slowly from the stomach itself; the rest passes into the small intestine and there is absorbed by the blood rapidly and almost completely. The alcohol exercises no intoxicating effect until it reaches the brain in the circulating blood. How soon it will do so, and how much effect it will have, depends a great deal on how much food



OXIDATION OF ETHYL ALCOHOL (*first formula*) requires several steps. When it is drunk, it passes into the blood. It is then circulated through the liver, where it is oxidized into acetaldehyde (*second formula*). This substance is oxidized by all tissues into is in the stomach. A full stomach retards the passage of ingested alcohol into the small intestine and thus delays and minimizes the effect. This is why a single cocktail on an empty stomach has more "kick" than three or four drinks after a large meal. A "hollow leg" usually means that the drinker has eaten well. Fatty foods, such as olive oil, are commonly supposed to be most effective as a bulwark against intoxication, but actually some proteins are more effective. A few glasses of milk can provide fortification against a session of social drinking.

Some beverages, notably beer, contain food substances which in themselves slow absorption. A given amount of alcohol has less effect when consumed as beer than when taken as distilled spirits. On the other hand carbon dioxide hastens the passage of alcohol from the stomach into the intestine and thus speeds absorption. This explains the common observation that champagne and other effervescent wines "go to one's head." It also accounts for the fact that soda taken with whiskey tends to minimize irritation of the stomach by the alcohol.

The alcohol absorbed from the digestive tract is held temporarily in the tissues until it is broken down and eliminated. More exactly, it is distributed evenly in the water of the body, and its concentration in any given tissue will depend on the water content of that tissue. Since blood is about 90 per cent water, as compared with about 70 per cent for the body as a whole, it will contain about one and a quarter times as much alcohol per unit as the rest of the body. Consequently it is possible to predict quite accurately from the concentration of alcohol in the blood how much has been absorbed in the tissues, and conversely, from the amount absorbed, the concentration that will occur in the blood. In a 160-pound man the alcohol in an ounce of whiskey or a bottle of beer produces an alcohol concentration of about .02 per cent in the blood; a half pint of whiskey raises the concentration to .15 per cent.

As soon as alcohol is absorbed by the tissues, it begins to break down by oxidation. Ordinarily the rate at which food is oxidized depends on the amount of energy the body is using for work, but this is not the case for alcohol. The rate of oxidation of alcohol is essentially constant. In a man of 160 pounds it amounts to the equivalent of about three quarters of an ounce of whiskey per hour. Thus he could sip whiskey at this rate, consuming more than a pint in 24 hours, without accumulating alcohol in his body or becoming intoxicated. If he drank the same amount within a few hours, the effects would be disastrous.

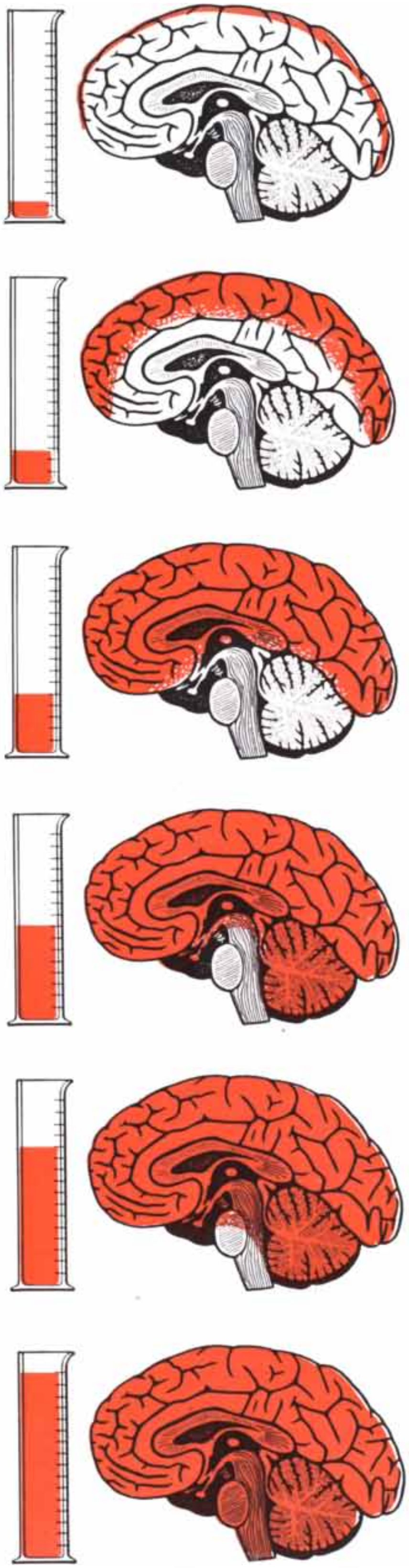
The first stage in the oxidation of alcohol is its conversion to acetaldehyde. This conversion, it has recently been discovered, occurs only in the liver, with the help of a liver enzyme. Acetaldehyde is much more toxic than alcohol itself, but as fast as it forms it is carried to all the tissues of the body, where it is rapidly oxidized further to acetic acid, a harmless substance. Finally the acetic acid is broken down to carbon dioxide and water. An animal whose liver has been removed cannot oxidize alcohol. Ethyl alcohol then acts like wood alcohol, disappearing very slowly from the body. Antabuse, a drug sometimes used to control alcoholism, is effective because it inhibits the oxidation of acetaldehyde. The patient is given a dose of antabuse daily. The drug has no apparent effect as long as he stays away from liquor, but if he takes a drink, even a small one, the acetaldehyde formed accumulates, with severe and extremely unpleasant symptoms. Antabuse thus acts as an automatic check on compulsive drinking.

Many attempts have been made to increase the rate of alcohol oxidation and thus to shorten the period of intoxication. As yet, none has been successful. Such drugs as thyroid extract, which raise the general metabolism, appear to have little or no effect on the rate at which the liver oxidizes alcohol. Inhalation of oxygen does not hasten the process, nor does increased work. There is no basis for the popular belief that intoxication can be "worked off" by exercise. Sobering up is essentially a matter of time.

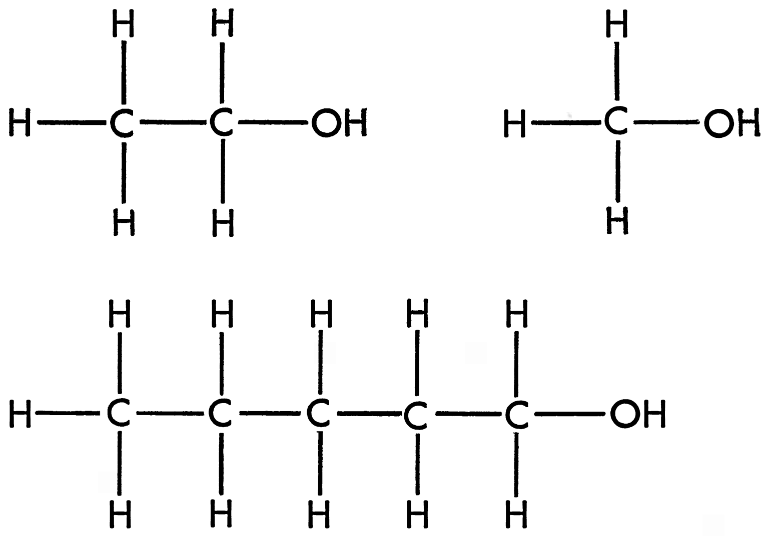
The fact that certain drugs and black coffee appear to have a sobering effect does not mean that they hasten the disappearance of alcohol. These stimulants merely counteract some of the depressant action of alcohol on the brain and

$$O=C=O + H-O-H$$

acetic acid (*third formula*), which is finally converted into carbon dioxide and water.



EFFECT OF ETHYL ALCOHOL on the brain proceeds in stages. About 2 ounces of whiskey affects the higher centers; 6, the deeper motor areas; 10, the emotional centers of the midbrain; 16, the sensory area of the cerebellum; 24, the whole perception area; 32, the entire brain, causing death.



THREE OF THE MANY ALCOHOLS are shown by structural formula. At upper left is ethyl alcohol. At upper right is methyl alcohol. At bottom is amyl alcohol, or fusel oil.

wake the person up. Awake or asleep, the man is still drunk.

Fifty years ago the question of what alcohol does to a drinker used to be disposed of with graphic simplicity. You broke an egg into a tumbler of alcohol. The albumen of the egg turned white, coagulated and shriveled. This was supposed to show how drink affected the organs of the body: the gray matter of the brain clotted and shriveled; the liver dried up until it resembled the sole of an old boot. Research has now established a more accurate and detailed picture. Let us see what really happens.

First of all, the 40 to 50 per cent concentration of alcohol in whiskey is strongly irritating to tissues, as anyone can find out by putting a drop of whiskey in his eye. Straight whiskey irritates the lining tissues of the mouth, throat, esophagus and stomach as it goes down. Frequent and repeated drinking of strong liquor will inflame and may actually damage these tissues: this accounts for the "whiskey tenor" voice and the chronic gastritis of habitual drinkers who take their whiskey "neat." Alcohol also irritates the sensory nerves and thereby provides a momentary stimulation, in exactly the same way as smelling salts do. After passing into the blood, however, the alcohol no longer has an irritating effect, because even in an extremely intoxicated person the blood concentration never rises to the level of irritation (15 to 20 per cent). Thus the alcohol circulated to the body tissues by the blood cannot destroy cells, corrode them, dissolve them or dry them out.

In moderate amounts alcohol stimulates the flow of gastric juice and promotes stomach motility. These effects produce the sensation of hunger and explain the popularity of cocktails and other alcoholic appetizers. There is no evidence that alcohol ever causes gastric ulcers, but doctors forbid their ulcer patients to drink because of the increased gastric flow. Moderate amounts of alcohol do not interfere with digestion; they may even promote it. Amounts leading to intoxication stop digestion.

Pure alcohol has a strong affinity for water, and this has led to the popular superstition that heavy drinking dehydrates the body. The fallacy gains support from the intense thirst that usually accompanies a hang-over. This thirst arises, however, not from a loss of water, but from a shift in its distribution. Normally about two thirds of the water in the body is held within the cells; the rest makes up the fluid in which the cells float. But when one has drunk enough alcohol to become severely intoxicated, water is drawn from the cells into the spaces between them. This shift of distribution explains the powerful morning-after thirst, and also the so-called "wet brain" of the acute alcoholic.

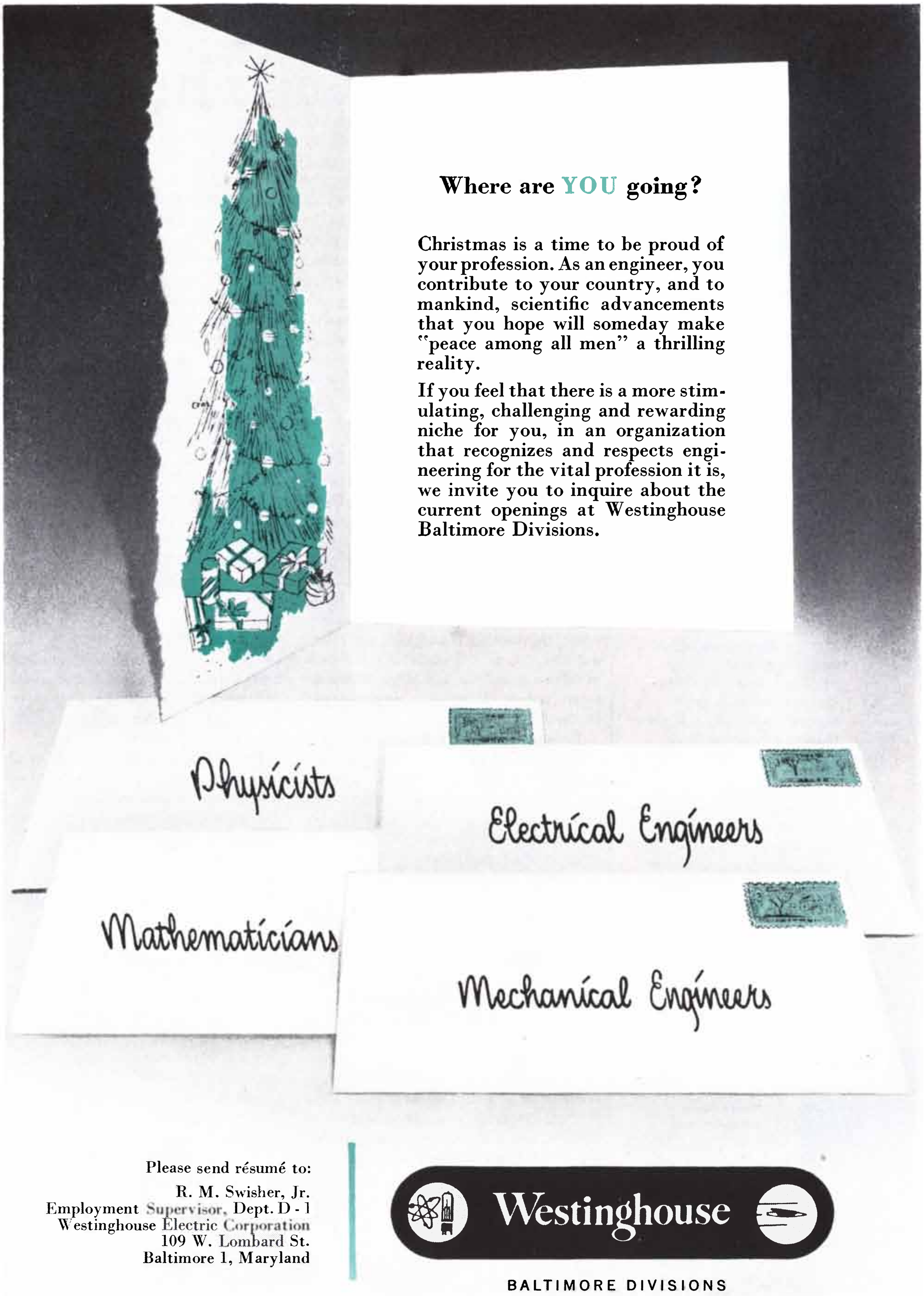
Like other foods, alcohol can be used by the body for energy. An ounce of whiskey liberates 75 calories of energy—about as much as four and a half teaspoons of sugar, one and a half pats of butter or a large slice of bread. Alcohol is fattening, provided the consumption of other foods is not reduced, because it curtails the oxidation of foods. A daily cocktail can be as threatening to a woman's figure as the nibbling of bonbons. On the other hand, a heavy drinker usually cuts down his food consumption severely. His appetite declines, and he gets into the habit of "drinking his meals." If he drinks a pint of whiskey a day, its 1,200 calories will supply half of his daily energy requirements, but he fails to get the minerals, proteins and vitamins that the equivalent amount of ordinary food would provide. Excessive drinkers often suffer deficiency diseases such as beriberi and pellagra and the degeneration of nerve fibers.

Heavy drinking may also produce in some people the condition called pylorospasm—a spastic closure of the valve between the stomach and the intestine. When the valve closes, much of the alcohol drunk may stay in the stomach for hours, and pylorospasm often causes nausea and vomiting. It may spring from an unusual sensitivity of the stomach or from psychological factors. Needless to say, people who are prone to develop pylorospasm from drinking do not become heavy drinkers.

The most pronounced physiological effect of alcohol is on the brain. The amount and the extent of the disturbance depend on the concentration of alcohol in the blood and brain tissues. A blood concentration of about .05 per cent of alcohol, which in a person of average size results from drinking two or three ounces of whiskey, depresses the uppermost level of the brain—the center of inhibitions, restraint and judgment. At this stage the drinker feels that he is sitting on top of the world; he is "a free human being"; many of his normal inhibitions vanish; he takes personal and social liberties as the impulse prompts; he is long-winded and can lick anybody in the country. Such a man has undergone an obvious blunting of self-criticism.

At a concentration of .1 per cent in the blood, from five or six ounces of whiskey, alcohol depresses the somewhat lower motor area of the brain. The individual staggers slightly; he has difficulty in putting on his overcoat; he fumbles with his door key; his tongue trips over familiar words.

These first two states are commonly designated as slight or mild intoxication. Their important feature is depression of sensory and motor functions. Contrary to old and popular belief, alcohol does not stimulate the nervous system. The illusion of stimulation results from the removal of inhibitions and restraints. The effect may be compared to a releasing of the brakes, not a stepping on the accelerator. Even with a few drinks, digital dexterity is reduced; auditory and visual discrimination fall away; tactile perception is lowered; the speed of motor response drops. Despite these measurable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losses, the drinker often asserts that his reactions, perception and discrimination are better.

A concentration of .2 per cent of alcohol in the blood, resulting from drinking about 10 ounces of whiskey, disturbs not only the entire motor area of the brain but also the midbrain, where emotional behavior is largely controlled. At this point the individual tends to assume a horizontal position; he needs help to walk or undress; he is easily moved to rage or tears. At .3 per cent, from about a pint of whiskey, alcohol attacks the still lower, more primitive area of the brain, concerned with sensory perception. The drinker becomes stuporous; although still conscious, he has little comprehension of what he sees or hears. When alcohol reaches the level of .4 or .5 per cent in the blood, it suppresses the whole perception area of the brain and the drinker falls into a coma. Finally, a concentration of .6 or .7 per cent affects the centers that control breathing and heartbeat, and death rapidly ensues.

Throughout this sequence the concentration of alcohol remains far too low to cause any organic damage. The disturbance is entirely one of nerve functions, and up to the last stage it is reversible; when the alcohol disappears the effect goes with it, as in anesthesia. Alcohol is in fact an anesthetic like ether or chloroform. In deep intoxication surgery could be carried out painlessly.

Besides its primary depressant effect on the central nervous system, alcohol has other secondary effects on various organs of the body. It apparently interferes with the liver's handling of fat, for after severe intoxication this organ is often swollen and yellow with fat. Very likely impairment of the liver's handling of fat is responsible for the development of cirrhosis of the liver, a serious disease which occurs with particularly high incidence among alcoholics.

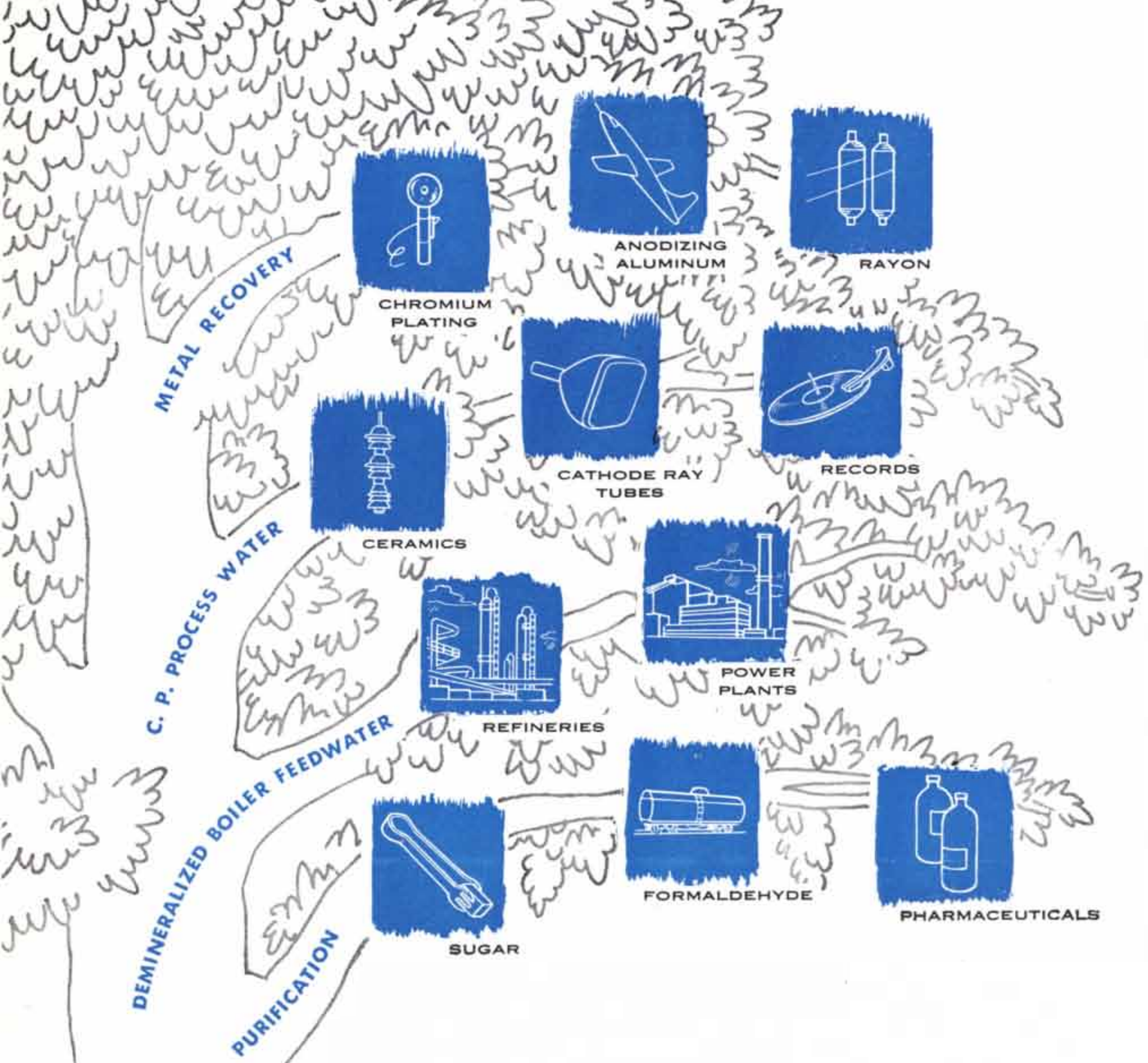
Does tolerance to alcohol increase with prolonged use? The belief that it does is firmly entrenched, but the evidence is far from clear. It is true that different individuals, and the same individual at different times, vary widely in their responses to a given amount of alcohol. But it has already been pointed out that the amount of food in the stomach and the kind of beverage drunk have much to do with the effect; the body absorbs alcohol from beer, for instance, much more slowly than from whiskey or champagne. Furthermore, the individual's temperament plays a large part in his behavior reactions. A few drinks may make a phlegmatic individual normal, a normal person the life of a party and a vivacious person a nuisance. The end result depends on the starting point. As O. Henry once remarked, some people are "half drunk when they are sober."

The folklore of drinking also includes the idea that tolerance of alcohol is affected by mixing drinks: "When I take a drink of rye I'm fine, but if I follow it with a drink of scotch and then gin the effect is amazing." What the drinker overlooks is that in mixing his drinks he has taken more of them. Moreover, at the level of one or a few drinks, intoxication is profoundly influenced by suggestion. A person who thinks he will get drunk quickly usually finds that he does.

The experienced drinker's "habituation" to alcohol may be largely, if not entirely, psychological. He becomes practiced in controlling and compensating for his overt reactions. The Yale University Center of Alcohol Studies compared the effects of a moderate amount of alcohol on two groups, one consisting of habitual heavy drinkers and the other of occasional light drinkers. While the latter showed the usual signs of intoxication (unsteady gait, aggressiveness, noisiness, giggling) the heavy drinkers seemed almost completely sober! But they turned out to be fully as much below par as the inexperienced drinkers in tests of speed of motor response, auditory and visual discrimination, tactile perception, digital dexterity and other faculties. They merely had their "sea legs."

True physiological tolerance to alcohol means resistance of the central nervous system to its depressive effects. By that test the differences detected among individuals have been relatively small.

The scientific evidence, then, can be summarized as follows: Habitual, heavy drinking produces—aside from its social, economic and moral havoc—serious and permanent bodily damage, mainly through nutritional deficiencies and other metabolic disturbances. There is no evidence that small or moderate amounts of alcohol are harmful. By improving blood circulation to the body surface, a little alcohol can bring comfort to elderly patients. A small amount of alcohol increases the appetite and lessens tensions and irritabilities. It does not greatly affect normal blood pressure, but it does prevent the pressure from rising during anxiety. Alcohol certainly does not stimulate thought, but it may relieve worry. Undoubtedly it is because of this relief from environmental stresses and emotional tensions that the moderate use of alcohol has persisted for thousands of years.



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EXPERIMENTS IN ACQUIRED CHARACTERISTICS

Ostrich calluses and many other inherited features are difficult to explain by chance mutation. The author believes that the work of modern embryology now makes a Darwinian explanation possible

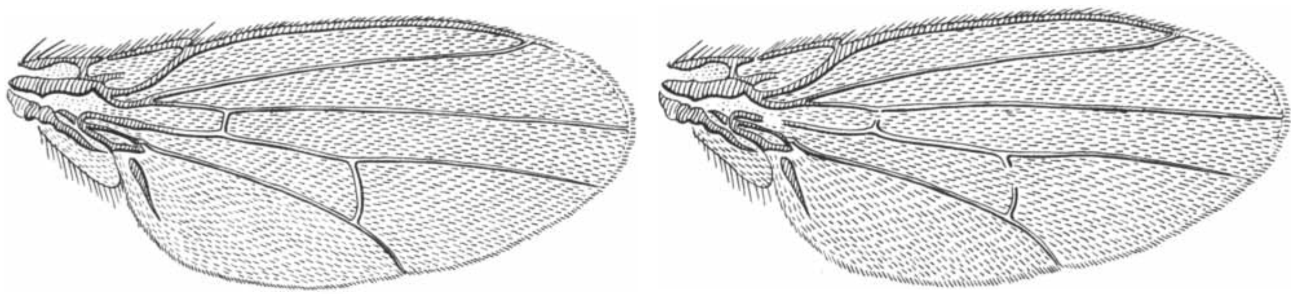
by C. H. Waddington

If a man does more than the average amount of muscular work, his muscles do not get worn out by the extra wear and tear, as an automobile would, but on the contrary become larger and stronger. A burrowing animal such as the mole possesses, even from birth, exceptionally well-developed shoulders and forefeet, conveniently built for digging. Every kind of creature is endowed with or develops qualities—we call them "adaptations"—which are neatly tailored to the requirements of its special mode of life.

How these adaptations come into being is one of the oldest and still one of the thorniest problems of biology. Aristotle and other Greek philosophers discussed the question in Athens 2,000 years ago. A hundred and fifty years ago the French naturalist the Chevalier de Lamarck (who invented the word "biology") tried to explain it by his theory of the inheritance of acquired characters. He supposed that if a type of animal responds, generation after generation, to nature's demands by becoming more efficient, the improvement will eventually become hereditary. Fifty years later Charles Darwin expounded the theory which still provides the most useful general explanation of adaptation. In his great work *On the Origin of Species by Means of Natural Selection*, he argued that the whole of evolution depends on random changes in the hereditary constitution and the selection of helpful changes by the environment. If a change, which we nowadays call a gene mutation, happens to make an animal better adapted and thus more efficient, that animal will leave more offspring than its fellows and the new type of gene will increase in frequency until it finally supplants the old.

There are still some difficulties, however, for which the strict Darwinian solution is not very satisfactory, and the debate goes on. Lamarck's theory has been revived in a modified form by various scientists, most recently by the Trofim D. Lysenko school in the U.S.S.R., who were in a hurry to adapt crop plants to the rigors of the Russian climate. Some types of adaptation are indeed difficult to account for in Darwinian terms. In this article I shall consider a type of phenomenon which has often been thought to demand some sort of Lamarckism. I hope to show that, if data from modern experimental embryology are brought into the picture, Darwin's theory not only can provide a plausible explanation of this kind of adaptation but can be made even more powerful than it has hitherto been thought to be.

Let me first make clear what the area of controversy is. The kind of adaptation illustrated by the first example I cited—the development of muscles by use—of course is not an evolutionary phenomenon and has nothing to do with Darwin's or Lamarck's theories. This phenomenon is known as "direct adaptation." It occurs in response to circumstances, usually external, during an individual's lifetime, and examples of it can be multiplied indefinitely. If an animal has one kidney removed, the other kidney enlarges until it can deal with the animal's excretory needs. If a young puppy loses its forelegs, the bones of the hind legs develop in a way which enables the dog to hop about on its hind legs more easily and efficiently. Just why or how the developing bones react in this



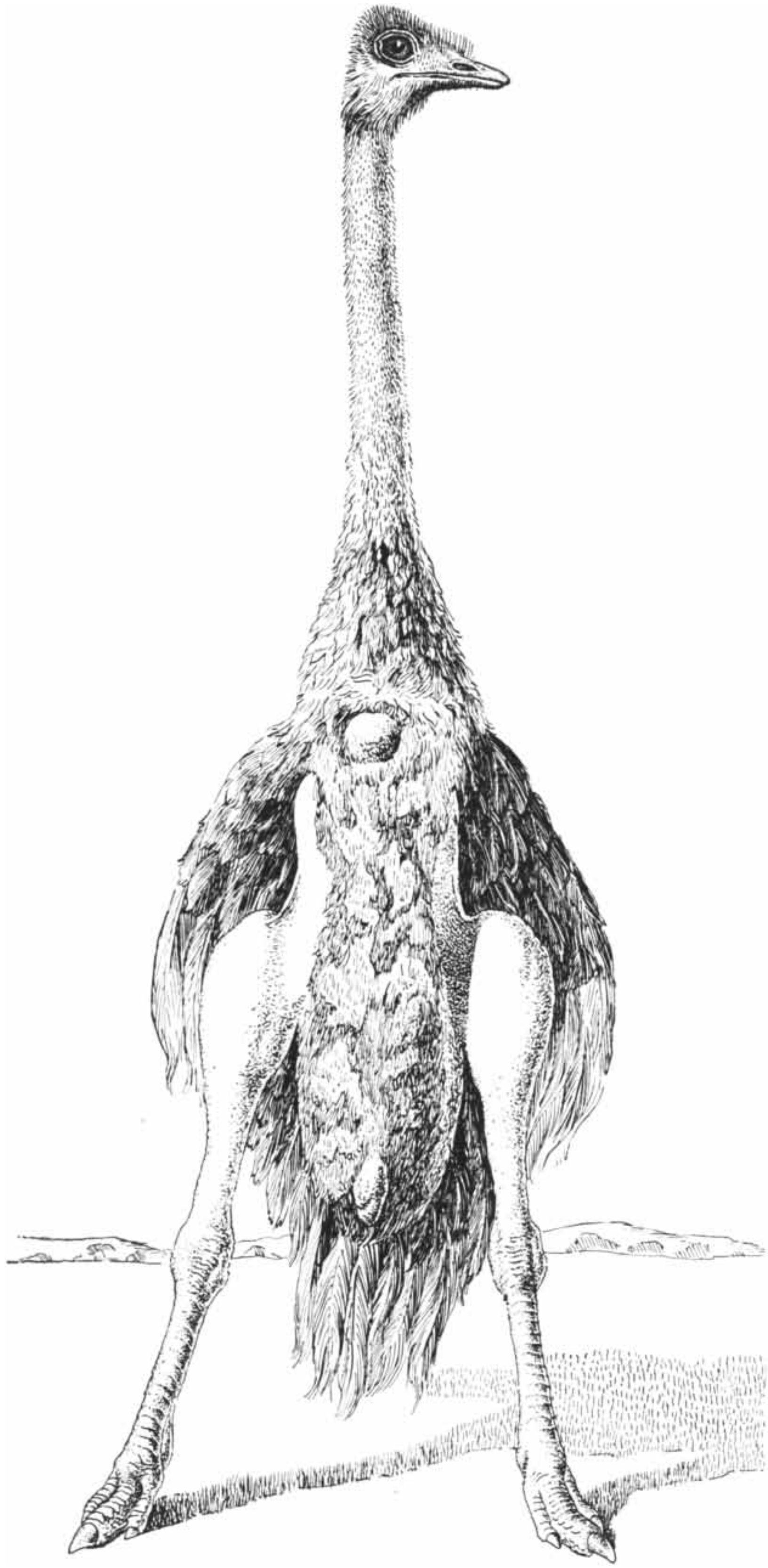
WING OF THE FRUIT FLY Drosophila normally has two cross veins (*left*). When Drosophila pupae 21 to 25 hours old are subjected to a temperature of 104 degrees Fahrenheit for two hours, cross veins of the adult flies are sometimes broken (*right*).

way to the stresses placed upon them is not known. Indeed, the processes underlying direct adaptation in general are still mysterious; very probably they involve fundamental biological activities, such as those of enzymes. But there is nothing hereditary about them.

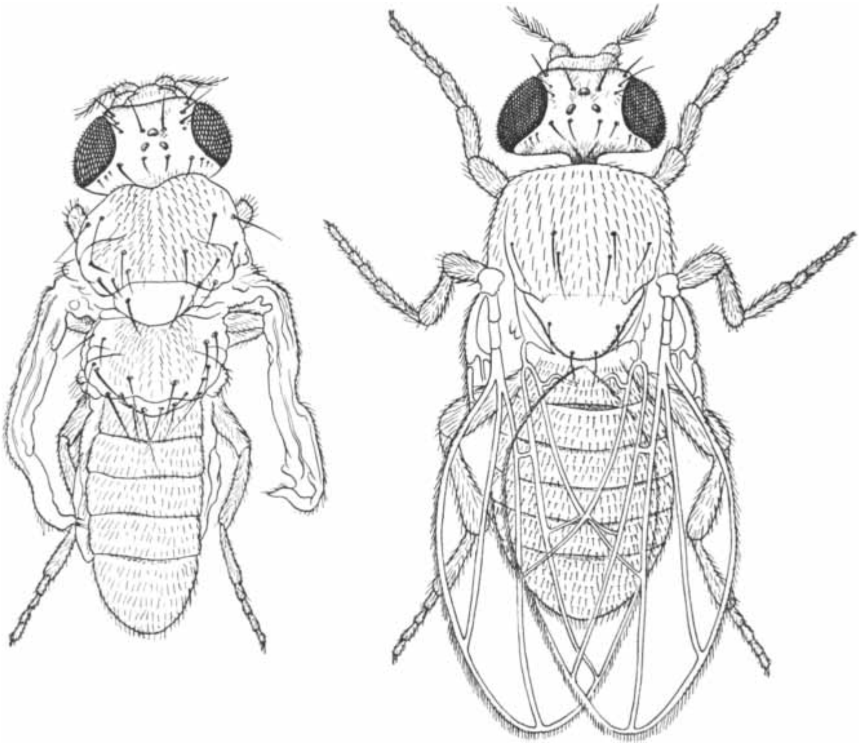
At the other extreme there are adaptations of such a kind that it is difficult to see how they could ever be responses to external circumstances. For instance, birds tend to have hollow bones, by which they gain in lightness without losing strength. It is impossible to see how external conditions could directly produce hollowness of bones. This is the sort of phenomenon on which the Lamarckian theory is weakest and the Darwinian theory most convincing. The Lamarckian idea, that the environment initiates evolutionary changes, cannot explain a bird's hollow bones, or numerous other adaptations in nature which fall into the same class, while the Darwinian theory of mutation and natural selection explains them simply and satisfactorily.

On the other hand there are a great many adaptations which the Darwinian theory has always found hard to explain. Certain adaptations in animals and plants, which are demonstrably hereditary and therefore products of evolution, are of exactly the same kind as changes which can be produced in a developing individual by a direct effect of the environment. A classic example is the calluses of the ostrich. The bird sits on rather peculiar parts of its anatomy: the two load-bearing points are at the front of the breast and near the tail. At these two places the ostrich has large, thick callosities. Anyone who works with his hands or walks in bare feet knows that continual pressure and rubbing cause the skin to grow thicker and tougher, *i.e.*, to form calluses. But the callosities of the ostrich, at the present stage of its evolution, are certainly not produced in this way. They appear on the chick while it is still in the egg, before it has sat on anything. They must in fact be hereditary. Now the orthodox Darwinian theory suggests that there is no essential connection between this hereditary adaptation and any direct environmental effect, that the adaptation could only have arisen by a chance mutation. This is asking us to believe a lot. Can we really be satisfied with a theory which suggests that, purely by chance, a hereditary change has turned up which produces callosities in just the right places, and that the sitting habit of the ostrich had nothing to do with it?

To be sure, there seems to be no limit



CALLUSES OF THE OSTRICH are at two points upon which it rests its weight while sitting: at the front of the breast and near the tail. These growths are present in the embryo.



REAR SEGMENT of Drosophila treated with ether at the age of three hours tends to develop into middle segment (*left*). The hereditary effect is slight. At right is a normal fly.

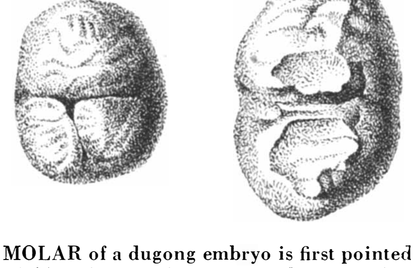
to the possible forms of genetic mutation, and theoretically a mutation producing callosities in the right places to be useful to the ostrich could occur by chance if one waited long enough. If the ostrich case stood alone, one might be willing to accept it as a fortunate accident. But nature is full of similar strange coincidences, even in this matter of callosities. The skin on the soles of our own feet becomes thickened in the foetus before birth, and so do the pads on the feet of dogs, cats and other animals. The African wart-hog, which has the habit of kneeling on its wrists while feeding, is born with thickened skin in those places. Other organs of animals exhibit the same sort of anticipatory adaptations. A striking example is the second molar tooth of the dugong, a tropical cousin of the whale and the manatee. The herbivorous dugong's molar is not conical, as its carnivorous relatives' molars are, but flattened—the better to crush its vegetable food. This flattening develops in the dugong embryo; its molar starts with a pointed tip, but the tip is gradually resorbed during the embryo stage.

Phenomena of this kind certainly seem at first thought to argue for the Lamarckian theory of inheritance of acquired characters; they suggest that the way in which the organ is used has in the course of time, after molding the developing organ generation after generation, brought about a hereditary change. However, the Lamarckian explanation would require us to believe that two implausible things are true. We have to suppose that the stresses which mold a developing organ can (1) alter the genes, and (2) alter them in precisely the way that is required to cause the appearance of the same characteristics as the stresses originally produced in the developing body. There is no convincing experimental evidence for the first of these hypotheses, let alone for the second. It is true that certain very special types of external agents (*e.g.*, X-rays and some chemicals) have been shown to produce mutations, but even these unusual changes fail to fulfill the second part of the theory: the changed traits resulting from the mutations are in no way related to the inducing agent.

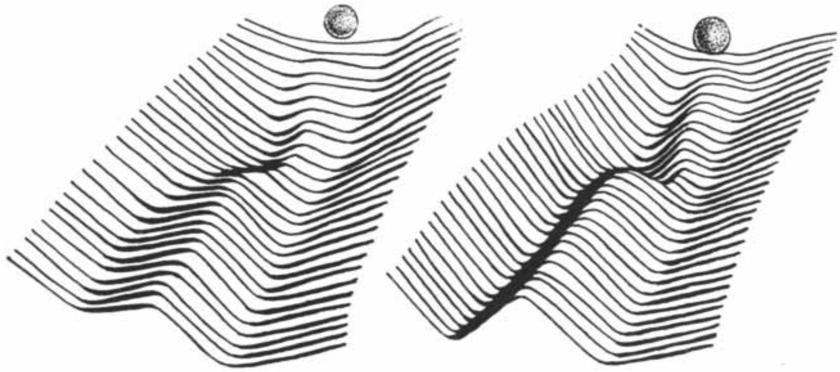
Thus neither the conventional Darwinian theory nor the Lamarckian theory provides a satisfactory account of adaptations of this kind. But in my opinion the Darwinian theory seems unable to explain these cases only because something has been left out of the usual statements of it. The point which has been forgotten is this: Evolution does not necessarily mark time until a chance mutation produces a required modification. If an environmental stress modifies the development of an animal and causes it, during its lifetime, to become adapted to deal with the situation, this response itself becomes subject to evolutionary processes. In a large population of animals, natural selection will favor those whose hereditary constitution makes them best able to respond to a particular environmental stress with an appropriate adaptation. This selection will cause the population of animals to evolve in such a direction that the change necessary to make the adaptation hereditary is much more likely to occur.

Before going any further with the theoretical argument, let me describe some experimental facts bearing on the situation. My experiments were made with the favorite animal of the geneticist, the fruit fly Drosophila. They dealt with an environmental effect, and in order to have something very definite to study I selected an effect which is unusually clear-cut. When Drosophila pupae 21 to 25 hours old are subjected to a temperature of 104 degrees Fahrenheit for two hours, some of them respond to this unusual environmental stress by developing a gap in one of the wing veins—the posterior cross vein. This change probably has no adaptive value in nature, but in the experiment it was treated as if it were useful and also as if it were harmful. In the first case, only those flies that responded to heat by developing a broken vein were selected for reproduction, and this selection was continued in succeeding generations. Meanwhile another line was bred by selection of those flies that failed to develop a broken vein in response to heat. As generation succeeded generation, the two selection lines pulled apart, that in which the response was favored showing an ever increasing proportion of flies which developed a gap in the vein, and the other line an ever decreasing proportion. In the first line, which is the more important one, the selection was in effect gradually improving the animal's hereditary ability to respond suitably to the environmental stress.

Now in this line some of the offspring



MOLAR of a dugong embryo is first pointed (*left*). Then, without use, it becomes flat.



DEVELOPMENTAL PATHS of an organism before environmental selection are depicted by the model at the left. There is a main path separated from a secondary path by a threshold. After selection secondary path has been deepened and threshold lowered (*right*).

in each generation were not given the high-temperature treatment. At first none of the untreated flies showed a broken cross vein. But after 12 generations a few were found with gaps in the vein. In the next generations there were more, and when these were selected and bred from, the selected strains eventually came to have a high percentage of flies with broken veins, even though they were never subjected to the heat stress. In them the break in the vein had become fully hereditary and no longer depended on the heat treatment.

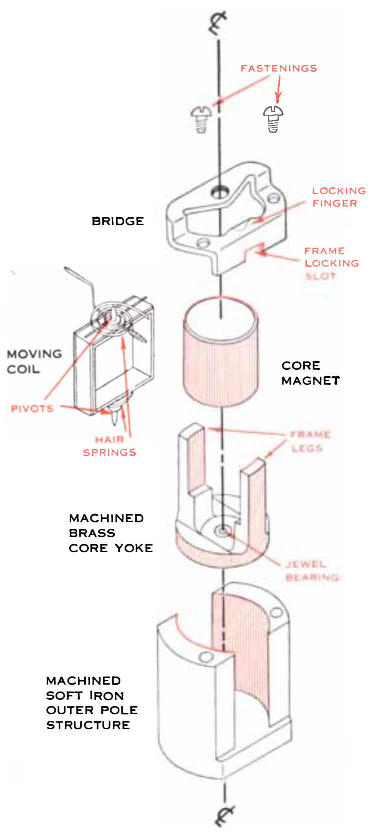
This phenomenon, which we call "genetic assimilation of an acquired character," seems to provide an explanation of the whole category of adaptations which were so difficult for conventional Darwinism to deal with. How does the genetic assimilation work? Roughly speaking, the answer must be that the genetic constitution becomes so ready to make this particular response—is set on such a delicate hair trigger to do so—that finally the response occurs on its own without requiring the environment to touch it off. Recent work in experimental embryology has shown that developing tissues very commonly get into unstable states in which comparatively minor influences will shunt them into one or another of various possible paths of development. For instance, in the early embryo of a vertebrate the outer layer of tissue (the ectoderm) is capable of becoming either skin or nerve or tissue of the middle layer (mesoderm). Some slight stimulus from the tissues with which it is in contact decides which path a given piece of ectoderm will follow in its development.

We are probably dealing with a similar situation in genetic assimilation. At an early stage in the evolution of an adaptive character, we can picture the relevant part of the animal's developmental system as consisting of a main developmental track which leads to the normal nonadapted adult condition, with a rather ill-defined alternative leading to a roughly adapted condition. Development will go on along the main track unless at the appropriate time an environmental stress pushes it over into the alternative path. Now suppose that an external stress is acting on a population where natural selection is favoring the members that respond best to this stress. After a time we shall find that the path leading to the adapted condition is better defined than the main path, and also that it has become easier for development to choose that path. The threshold between the adapted alternative and the original main track will have been lowered. If this lowering goes far enough, the alternative will become the main track, and genetic assimilation will be complete.

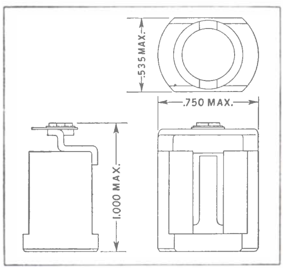
So far very few cases of genetic assimilation have been studied experimentally, and there is still a great deal to be discovered about it. One point still to be settled arises in connection with the examples of the ostrich and the dugong. Their anticipation, in the embryonic stage, of the need for their peculiar adaptations has not yet been imitated experimentally. But I think there is no difficulty in explaining it. It is clearly an advantage to an animal if it has its adaptive features ready before they are needed. In exactly the same way as natural selection will cause the genetic assimilation of an adaptive character, it should eventually cause the character to appear early enough to be of maximum use. There is, in fact, a general tendency for developmental modifications in an animal to occur earlier and earlier in its life history as its evolution proceeds. Of course one should expect that it will take much longer for an anticipatory adaptation to evolve than for the adaptive feamarion

advancement in instrument design

TWO VIEWS SHOWING COAXIAL MECHANISM
ACTUAL SIZE
(Total Weight 0.8 oz.)



EXPLODED DIAGRAM SHOWING INTERLOCKING CONSTRUCTION

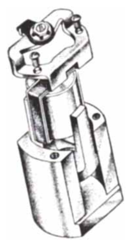


COAXIAL METER MECHANISM DESIGN* OPENS NEW FIELDS OF APPLICATION

A new Marion concept in the mechanical design of the moving coil galvanometer magnetic system has resulted in a "miniature" movement with performance characteristics and durability exceeding existing ruggedized or regular panel instruments of far greater size and weight. The Marion "Coaxial" assembly provides a magnetic field of great strength, uniformity and stability which is self-shielded. Ruggedness and stability are inherent in the basic simplicity of the design. The small size and weight make practical the application of the moving coil mechanism as a component of a great many electrical or electronic instruments or other products. This is especially pertinent in aircraft instruments where size and weight are of critical importance, yet no compromise can be made with performance and durability.

The new assembly (see exploded diagram) consists essentially of a soft iron outer pole structure, a non-magnetic yoke and a magnetized core of such diameters that the yoke fits snugly in the pole structure and the core within the yoke. The assembly is locked by attaching the bridge to the pole structure by means of two screws — the only fastenings in the entire assembly. A locking finger on the bridge holds the core and the frame in position. Rotation of the core yoke is prevented by the slot in the bridge flange which engages one of the legs of the frame. The moving coil is contained by its pivots, and bearings located in the bridge and the base of the frame.

The basic design in which all critical dimensions are machined from a common center (the bearing axis) gives far more precise and uniform alignment than is possible with stamped assemblies. The interlocked assembly assures maintenance of these close tolerances and affords far greater rigidity and strength than is available in conventional mechanisms, particularly when mass is considered.



MECHANISMS BY MARION

The Marion "Coaxial" mechanism has many applications, not only in indicating instruments, but also as a component of equipment utilizing the moving coil galvanometer principle. It is one of a number of Mechanisms by Marion that extend the field of application of moving coil galvanometers where previously size, weight or performance characteristics prevented their use.

Marion Electrical Instrument Company, 416 Canal Street, Manchester, N. H.

*Patents Pending

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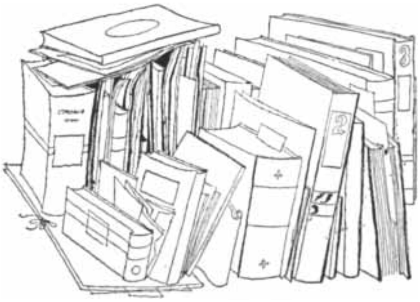
ture itself, and this may explain why it has been impossible so far to produce one in the laboratory.

A more important problem is the question whether genetic assimilation takes place through the rise of new genes by mutation. Lamarckians would, I imagine, insist that it does. The experiments so far do not disprove that idea, but some of the data argue against it. For instance, the assimilated broken-vein character in the fruit flies depends on the action of a rather large number of genes. It is one thing to suggest that the heat treatment might produce one or two mutations acting in the correct way, but surely it is very unconvincing to suppose that it produces large numbers of them.

Actually the assumption that mutations take place is unnecessary; we may more plausibly assume that the genes on which the assimilated character depends were present in the original population, though scattered in it. If this is the case, the process of genetic assimilation can go only as far as the genes contained in the initial population will permit. The real test of whether mutations occur would be to try to produce genetic assimilation in an inbred strain, which should contain very little genetic variability. If mutations are not involved, genetic assimilation should not occur in such a strain. This experiment is under way, but so far no definite conclusion can be reached.

Another experiment, also uncompleted, does suggest, however, that the genetic materials available in the initial population set a limit to the progress which can be made. In this experiment three-hour-old embryos of Drosophila were treated with ether. Under this environmental stress the third segment of the thorax tends to develop into the organs normally formed by the second segment, that is, into the main body of the fly and the wings. Selection of flies which show the most readiness to make this response has produced some degree of genetic assimilation. But the hereditary character produced in this way is only a feeble version of the direct effect of ether on the embryo; usually it consists of no more than a slight enlargement of the "balancer" borne in the third segment, and a tendency for it to show some of the characteristics of a wing. It seems probable that the initial stock did not contain genes which could produce any higher grade of the abnormality than this; also that the treatment has not made such genes appear by mutation. But selection is still continuing and perhaps they will eventually turn up.



CHILDREN'S BOOKS

A fourth annual survey of writing about science for younger readers

by James R. Newman

This is our fourth annual roundup of science books written for children. The yearly output of these books is always large, but the general level of quality remains disappointingly low. Too many writers for children address them in nursery language. Bernard Shaw, commenting on the adults who had gurgled over him when he was a little boy, once remarked: "They all made the same mistake. Instead of being natural, in which condition they would have been quite childish enough to put me at my ease, they affected imbecility —a very different thing to childishness, and open to instant detection by any sane infant."

The purpose of this report is to survey the field and separate the rubbish from the nuggets of good reading.

Physical Sciences

FUN WITH ASTRONOMY, by Mae and Ira Freeman. Random House, Inc. ($1.50). Nine- and ten-year-olds will be well pleased with this most recent of the Freemans' able popularizations. The Rutgers University physicist and his wife explain the cycle of the seasons, how stellar distances are measured, why we never see the other side of the moon, how air bends sunlight, what causes eclipses and so on. The text is perfectly clear and direct, and the suggested experiments, illustrated by photographs, are the simplest and most compelling I have ever seen for illuminating ideas which even adults often find difficult to grasp. Recommended.

THE TRUE BOOK OF TOYS AT WORK, by John Lewellen. Children's Press, Inc. ($2.00). The principles of physics are illustrated here by the operation of wheels, roller skates, bicycles, spring toys, toys with weights, walking dolls, balloons, whistles, electric trains (for children of 8 and up). The pictures by Karl Murr are attractive but the text is thin. There are better books of this kind.

THE MARVELOUS MAGNET, by Harry Sootin; OLIVER SOUNDS OFF! by Jack Bechdolt; PLANET X, by Mildred S. Kiefer. Julian Messner, Inc. ($1.60 each). Each of these is an illustrated book of 64 pages in a new series of "Everyday Science Stories" addressed to children of 10 to 12. Elementary information about magnetism, electricity, sound, planets and so on is woven into what are called "thrilling stories." This is a well-meaning program which one hesitates to disparage; nevertheless it seems to me that a child indifferent to the fascinations of Neptune or electromagnets is unlikely to shake off this sluggishness on reading of a lad named Cope (short for Copernicus) who is crazy about telescopes and loses his pet rabbit, or of another spirited urchin named Kenneth who designs an electromagnetic buzzer which he first uses to drive his family to the brink of a nervous collapse and then to catch a burglar whom the police were about to catch anyway.

THE SUN, by Herbert S. Zim. William Morrow and Company, Inc. ($2.00). An interesting sampler of information for children of 10 to 12. Zim reports on the size, mass and temperature of the sun, the chemical and physical transformations that keep it going, sun spots and eclipses, magnetic storms, northern lights, the effect of sun storms on the earth's rabbit population, the sun and the weather. A sound, readable primer with some mediocre drawings by Larry Kettelkamp.

WHAT MAKES THE WHEELS GO ROUND? by Edward G. Huey. Harcourt, Brace and Company ($3.00). A revised reissue of one of the best physics books for children of 10 and older. One may be thankful that Huey has deemed it unnecessary to include in his revision the breathtaking marvels of nuclear fission.

WHAT'S INSIDE THE EARTH? by Herbert S. Zim. William Morrow and Company, Inc. ($1.75). This slim volume of 32 pages for youngsters 6 to 10 presents a few facts about the earth's core, the inside of a mine, caves, wells, volcanoes, the causes of earthquakes and the structure of mountains. It is puzzling to find nothing about oil or gas wells. Colored drawings by Raymond Perlman.

YOU AND SPACE NEIGHBORS, by John Lewellen. Children's Press ($1.50). A primer of modest merit for ages 10 and up. It deals with the planets of our solar system, the stars and the galaxies. A good deal of the discussion centers on the habitability of Mars, Venus, Mercury and the likelihood of living creatures adorning other celestial bodies. Lewellen suggests there are "billions of other people on millions of other planets wondering whether we exist, just as we wonder whether they exist."

THE TRUE BOOK OF AIR AROUND US, by Margaret Friskey. Children's Press ($2.00). A singularly maladroit attempt to tell children of 7 or 8 about the air, wind, thunder, rain, lightning, sleet, snow and so on. The facts are visible as through a glass darkly, and the style can be illustrated but not described: *e.g.*, in a thundercloud the rain, hail, snow and sleet are "shaken up . . . and broken apart. Electricity is built up. There is too much of it to be quiet. It wants to jump."

WATER, WATER EVERYWHERE! by Mary Walsh. Abingdon-Cokesbury Press ($2.00). Since water is everywhere, Miss Walsh has no difficulty introducing (for youngsters of 8 and up) almost any subject on which her fancy lights: rivers, pools, marine life, dams, canals, rainfall in Washington, D.C., and Tucson, Ariz., glaciers, fishing, canoes shooting rapids, hydroelectric power, ferryboats, bridges, Victoria Falls, the Grand Canyon, floods, soil conservation, erosion, alligators, pelicans, sandpipers, oysters, lobsters, ships, harbors, the Statue of Liberty, lighthouses, reefs, breakers, the heroism of the Coast Guard, tides, divers, the 10-armed squid, the compass and sectant, loran navigation, hurricanes, cyclones, rainbows, etc. Her book lacks unity.

THE MOON, by George Gamow. Henry Schuman, Inc. ($2.50). In this book, suitable for high-school youngsters and adults, Dr. Gamow, a proved hand at popularization, explains the moon from several angles: its eclipses and the relation of its orbit to the orbits of the sun and earth, its gravitation (including its tidal effects), its origin, chemical constitution, atmosphere and terrain, the possibility of voyaging to the moon in rocket ships. The section on eclipses is too long and detailed, but the rest of the book is very well done–readable and highly instructive.

ALL ABOUT THE WEATHER, by Ivan Ray Tannehill; ALL ABOUT VOLCANOES AND EARTHQUAKES, by Frederick H. Pough. Random House, Inc. ($1.95 each). These are competent science primers in a new series for 9-to-12s called "Allabout Books." Tannehill, a senior meteorologist of the U. S. Weather Bureau, describes how storms are made, how we measure, observe and predict the weather. His style is straightforward and readable. Pough's book about volcanoes and earthquakes is scientifically sound and is enlivened by tales of famous catastrophes.

THE WAY OF SCIENCE: ITS GROWTH AND METHOD, by John Somerville. Henry Schuman, Inc. ($2.50). The author's purpose is to explain (for high-school youngsters) the nature of scientific thinking and method. This is a praiseworthy object, but the execution is uneven. Somerville has a capable grasp of the essential blending in scientific work of facts, logic and imagination, and an admirable awareness of the social function of science. But he is painfully long-winded and often clumsy in his expression; moreover his list of recommended readings, an important feature in such a book, exhibits a total incomprehension either of what youngsters would or should read. His book is, however, one of the few discussions of scientific method addressed to beginners.

Biological Sciences

WONDERS OF THE WOODLAND ANIMALS, by Jacquelin Berrill; WONDERS OF THE TREE WORLD, by Margaret Cosgrove. Dodd, Mead and Company, Inc. ($2.50 each). Miss Berrill tells little stories about the family lives of raccoons, harvest mice, bats, porcupines, woodchucks, squirrels, chipmunks, bears and other furry creatures; Miss Cosgrove explains the structure and function of trees and describes many different species. The books are for children of 8 and up. The quality of the text and illustrations is average.

ALL KINDS OF BABIES AND HOW THEY GROW, by Millicent Selsam. William R. Scott, Inc. ($2.00). A simple story for 4-to-7s, explaining with the help of Helen Ludwig's illustrations how various babies from tadpoles to elephants grow up to be replicas of their parents, regardless of what the babies look like at birth. Miss Selsam's text flows easily, but the pictures are no better than so-so and the book costs too much.

WHAT'S INSIDE OF ANIMALS, by Herbert S. Zim. William Morrow and Company, Inc. ($1.75). What's inside a clam, a starfish, an earthworm, a grasshopper, a fish, a frog and a dog, ably explained by Mr. Zim for 6-to-10s. Pictures in color by Herschel Wartik. The book attempts to satisfy the needs of three age groups by using different sizes of type for different levels of discourse. This omnibus style of presentation is awkward, but at any single level it makes a satisfactory book.

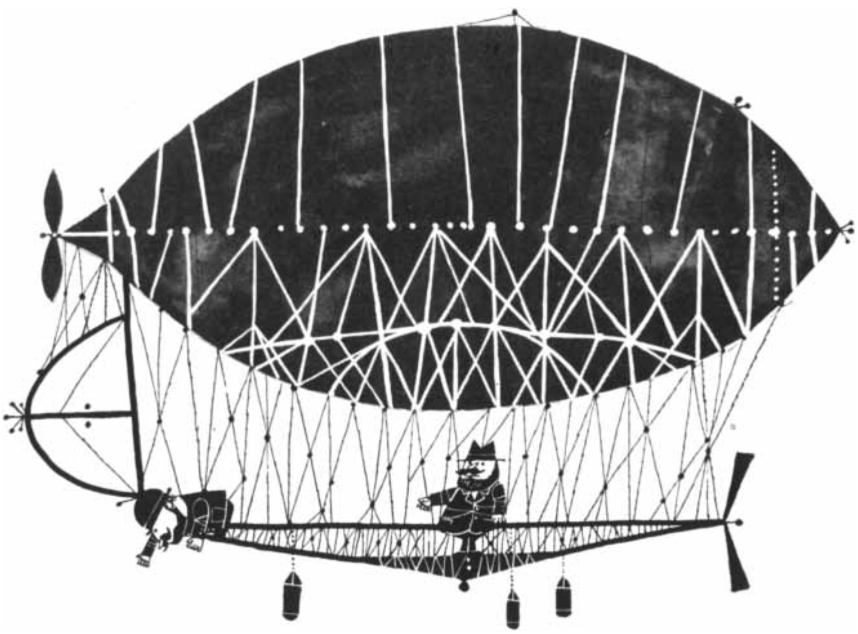
SEA SHELLS, by Ruth H. Dudley. Thomas Y. Crowell Company ($2.00). Limpets can find their way home; the pecten is a fast swimmer; mussels spin horny threads by which they fasten themselves to ocean rocks; the piddock carves its home out of rock; the conch can turn somersaults; the chiton has eight shells; sea urchins grind up sand to mince their food. Miss Dudley has a nice sense of what to say and how to say it in her nature stories for 7-to-10-year-olds. It would be better if she controlled her tendency to gush; nevertheless her book can be warmly recommended.

PARAKEETS, by Herbert S. Zim. William Morrow and Company, Inc. ($2.00). A brief description of the appearance, habits, life history, care and training of this popular bird. The text is simple, clear, accurate and unimaginative.

THE TRUE BOOK OF HONEYBEES, by John Lewellen. Children's Press ($2.00). For children of 8 or so this offers a tour of the hive, with the usual fiddle-faddle about the indolent queen, the dance of the bees, the dispiriting career of the drones and the workers, and so on. A commonplace story presented in an uncommonly ugly book.

THE WONDER WORLD OF INSECTS, by Marie Neurath. Lothrop, Lee and Shepard Company, Inc. ($1.50). This rather alarming but interesting little book for youngsters of 9 and older tells about insect eggs that hatch themselves, ball-rolling beetles that raise their young in sheep droppings fashioned into spheres, leaf-cutting bees, trapdoor spiders, ant lions, praying mantises, slave, weaver and parasol ants, soldier termites and Brazilian beetles the size of full-grown sparrows.

THE TRUE BOOK OF ANIMALS OF SMALL POND, by Phoebe Erickson. Children's Press ($2.00). Miss Erickson's book is about the animals that live in or around the pond near her house in New



Milford, Conn.: minks, otters, raccoons, beavers, and muskrats. Seven- or eight-year-old children will find her story and pictures cosy and instructive.

An Otter's Story, by Emil E. Liers. The Viking Press, Inc. ($2.50). This is a much better than average nature story, telling of the adventures, tragic and gay, of two otters in the North Woods named Ottiga and Beauty. Mr. Liers, a Minnesota naturalist, loves and knows these beautiful animals and also knows how to write. His fictionalized account, based upon actual experiences, is dramatic, well-paced and informative. Anyone older than 9, say, can read it with pleasure.

Fast is not a Ladybug, by Miriam Schlein. William R. Scott, Inc. ($1.75). This agreeable book for small children compares the fast and slow moving things of the world—jets, ladybugs, lightning, snails (398 hours to travel a mile), trains, dogs, fire engines, clouds. It has relaxed and unpretentious illustrations by Leonard Kessler.

Animals Under Your Feet, by Ivan Green. Grosset and Dunlap, Inc. ($2.75). About moles, badgers, chipmunks, woodchucks, muskrats, ants, worms, cicadas and other creatures that live underground. Miss Green's stories about "Mrs. Trap-Door Spider," "Mama Owl," "Little Chippy-Munk," "Fatso the Woodchuck" include monologues by each of the animals about themselves. This comes as close to cruel and unusual punishment of animals and readers as any nature book in many a season.

Trees and Trails, by Clarence J. Hylander. The Macmillan Company ($3.00). A dependable but dismally dull book cataloguing the facts about 150 different trees: where they grow; what their bark, wood, fruit, seeds, leaves look like; their height, shape, girth and so on. For "young naturalists" with a passion for statistics and systematics rather than trees.

Trees And Their Story, by Dorothy Sterling. Doubleday and Company, Inc. ($2.50). This is another uninspired tree-identification book, with a large assortment of photographs (by Myron Ehrenberg) which need never have been taken.

John and Juan in the Jungle, by Ivan T. Sanderson, with 25 original paintings by Miguel Covarrubias, Dodd, Mead and Company, Inc. ($3.00). This

very attractive children's book (10 and up) was put together in the reverse of the usual order. Covarrubias made a series of colorful paintings of Central and South American mammals, birds, reptiles and insects; Sanderson, a well-known British zoologist and writer on wild life, was prompted by the paintings to write a story about two small boys who have exciting but perfectly plausible adventures on short trips into the jungle. The product of the collaboration comes close to being a book of distinction. Some of the Covarrubias paintings are stunning, and the text is eminently readable and full of sound information.

Microbes At Work, by Millicent E. Selsam. William Morrow and Company ($2.00). About the various little bugs that keep you alive and those that tear you down if you're not careful and get you in the end whether you're careful or not. Miss Selsam, a gifted naturalist-writer for children, describes the microbe world, the behavior of bacteria, molds and yeasts, the effect of microbes on the soil, and simple home experiments by which the destructive and helpful action of these organisms can be observed. An instructive and enjoyable book for youngsters of 10 and up.

The Junior Book of Insects, by Edwin Way Teale. E. P. Dutton and Company, Inc. ($3.75). Revised reissue of a well-known handbook for insect lovers. It gives descriptions of the lives and habits of common insects, and instructions for collecting beetles, butterflies, moths and other bugs, for photographing insects, for keeping an insect aquarium and zoo, for building an ant house, and so forth. Good photographs and helpful drawings.

Zoo Babies, by William Bridges. William Morrow and Company, Inc. ($2.50). A delightful collection of stories by the curator of publications of the New York Zoological Park. It tells about the high jinks, small mishaps and adventures of animal infants in the Bronx Zoo, including Dusty, the grizzly bear cub; Mambo, the baby gorilla with a face like an overburdened Supreme Court Justice; Spotsy, the Chinese water-deer fawn the size of a small cabbage; Candy, the one-year-old 752-pound elephant; the baby walrus from Greenland that likes to play games. Mr. Bridges writes simply and naturally and the accompanying photographs are charming. A book for children of 6 and up and their parents.

Nature Notebook, written and illustrated by Robert Candy. Houghton Mifflin Company ($3.00). Mr. Candy, on the pretext of describing a day's field trip with his son, has stuffed into this book as into a dufflebag a random collection of facts and pictures about birds, bird houses, flowers, bough beds, squirrels, deer droppings, fish and fishing flies, cooking, making fires, frogs, canoeing, raising moths and butterflies, first aid, the mating dance of the woodcock, the habits of beavers, and so on. Children of 8 to 12 will find it agreeable to glance through these pages as through a catalogue, but it is not much of a book.

The Animal's World, by Doris L. Mackinnon. Thomas Y. Crowell Company ($3.50). Miss Mackinnon succeeded Julian Huxley in the chair of zoology at the University of London in 1927 and is now retired as professor emeritus. She brings to this book for older children an authoritative grasp of the subject and a clear, informal (though occasionally condescending) writing style. Her survey is arranged on unusually interesting lines; sample chapter headings are: Getting Over the Ground; How Animals Move in Water and Air; Creepers and Crawlers; How Animals Breathe, Feed, Keep Warm, Talk to One Another, Look at the World, Hide; The Sense of Smell, Taste and Touch; The Childhood of Animals. A praiseworthy, solidly instructive introduction to the science of living things.

Life on the Earth, by Rose Wyler and Gerald Ames. Henry Schuman, Inc. ($2.50). A wide field is covered in this book for youngsters in the first or second year of high school. The authors deal with the habitat of living things, metabolism, the chemistry of protoplasm, how cell colonies are organized, evolution, how life began on earth, the age of man. The book is organized in a peculiar way, but it is ably written and unfailingly interesting. The hypotheses regarding the origins of life are handled with unusual skill.

PETS, WILD AND WESTERN, by Elmo N. Stevenson. Charles Scribner's Sons ($2.50). The author, president of the Southern Oregon College of Education, makes a hobby of raising wild animal pets. Here he describes his experiences in raising a western badger, a Great Basin coyote, a magpie, a porcupine, a waxwing, a prairie falcon, a fence lizard or swift, squirrels, doves, jays, hawks and grosbeaks. He writes clearly, unpretentiously, unsentimentally, without a trace of nature-fakery. A very good book (for 9 and up) with photographs.

ALL ABOUT THE SEA, by Ferdinand C. Lane; ALL ABOUT DINOSAURS, by Roy Chapman Andrews. Random House, Inc. ($1.95 each). Among the topics discussed by Dr. Lane are how the sea began, the rise and fall of continents, exploring the ocean floor, the behavior of the tides, how the sea became salty, sea meadows and sea gardens, marine life, land animals that put to sea, farming, mining and sailing in the seas, how the seas control our climate. This uncommonly good book is recommended for children of 9 to 12. Dr. Andrews retells the dinosaur story which his explorations and writings have helped to make famous. His book is interesting and will appeal to children under 12. Older children who want more information on this fascinating subject are advised to read Edwin H. Colbert's excellent popular monograph *The Dinosaur Book* (McGraw-Hill Book Company, 1951).

HOW ANIMALS MOVE, by James Gray. Cambridge University Press ($3.00). This book consists of the 1951 Royal Institution Christmas Lectures by the professor of zoology at Cambridge University. Professor Gray explains the methods of locomotion of bats, fleas, greyhounds, grasshoppers, mudskippers, snakes, leeches, eels, trout, bears, dolphins, flying squirrels, kangaroos, horses, newts, marine worms, amoebae, pigeons, men and all the other creatures of land, sea and sky. With the help of high-speed photography, ingenious models and other apparatus, he shows how fish push their way through the water; how a salmon ascends a waterfall (sometimes by jumping but more often by swimming up the sheet of water), how the leg and arm muscles work in lifting, prying, walking, running, jumping; how a swordfish traveling at only 10 miles per hour can drive its head through the planking of a stout boat; how an eel can glide over a board studded with smooth pegs but cannot progress over a clear board; how a grass snake can glide through a sinuous glass tube but not through the arc of a circle or along a straight line; how a kangaroo supports its body on its two hind feet and tail; how the python wriggles along a perfectly straight path. This is one of the most fascinating books, for children or adults, published in many years. It is beautifully designed and richly illustrated. Whatever else you buy for Christmas, set aside $3 for this item.

Technology

THE FIRST BOOK OF SPACE TRAVEL, by Jeanne Bendick. Franklin Watts, Inc. ($1.75). What it will be like to live and work in a space ship: the gadgets, the clothing, the new experiences in a gravitationless region where the happy voyager will have a magnet sewed into the seat of his pants to keep him from drifting away from his dinner. Miss Bendick makes it all moderately clear and faintly horrifying. For 10-to-14s.

THE GOLDEN BOOK OF AIRPLANES, by Paul Jensen. Simon and Schuster (50

cents). A miscellany of facts about all sorts of planes—fighters, racers, commercial and cargo ships—airports, balloons, the history of flight, famous flyers, air navigation, how to fly, how to make loops and Immelmanns, and so on. This diverting and instructive package is for 9-year-olds and up. Illustrated.

Experiments with Airplane Instruments, by Nelson Beeler and Franklyn Branley. Thomas Y. Crowell Company ($2.50). A little imagination goes a long way—in writing children's books no less than in designing zippers or electronic computers. Beeler and Branley are not always professional in their presentation, but their books have a full share of ideas and are honestly and carefully worked out. Here they explain for ages 11 to 14 how fuel, oil, temperature and pressure gauges work; the principle of the altimeter, the air speed indicator and the tachometer; the design of a magnetic compass and of a drift indicator; the uses of the gyroscope in the turn indicator, directional gyro and automatic pilot. In addition, they give instructions for making simple gadgets illustrating linkages and other important features of airplane instruments. The diagrams are cleanly drawn and helpful; altogether this is a superior book written by men who evidently care about their readers.

Birds And Planes: How They Fly, by John Lewellen. Thomas Y. Crowell Company ($2.00). A smoothly written, effectively illustrated introduction to aerodynamics. It explains the theories of air pressure, Bernoulli's principle, the use of ailerons, propellers, wing slots, flaps and streamlining, the remarkable resemblance between the principles of birds' flight and those controlling the action of modern aircraft. The jacket says this book is for ages 10 to 14, but it is a bit too difficult for anyone below the level of a bright 12-year-old.

How the World Was Explored, edited by Lancelot Hogben; prepared by Marie Neurath and J. A. Lauwerys. Lothrop, Lee and Shepard Company, Inc. ($1.50). A synoptic account (for 8 and up) of what men have done since prehistoric times to enlarge their living space: their methods of travel over land and water, the roads and vehicles they built, their military conquests, explorations, colonizations and the like. Miss Neurath carries the story with her isotype drawings, and Lauwerys presumably provides the text.

What's Inside of Engines? by Herbert S. Zim. William Morrow and Co. ($1.75). Another "inside" item by the apparently inexhaustible Dr. Zim, but this is a disappointing effort. It is claimed that 6-to-10-year-olds can gain from these pages some notion of the operation of the various types of engines and of an atomic pile. The fact is, however, that the author fails to get inside either his engines or his readers. The pictures by Raymond Perlman are not much help; they are like the useless drawings that adorn the booklet one gets gratis when buying a new car.

The Tractor Book, by Margaret and Stuart Otto. William Morrow and Company ($2.50). There are at least 43 different types of tractors, and all of them are pictured and described in these

pages. Among the more unusual items are a ferocious looking contraption called a tree-dozer which can cut down an acre of trees in an hour, a trencher which trundles along gouging a deep ditch for laying a pipeline, and a 50-ton mechanical reptile called a funnel-dozer and root-plow tractor which can convert almost any piece of land into a tennis court in something under 60 seconds. This machine is being used, we are told, to subdue Texas. The Ottos are not always luminous in explaining their machines, but this is a fascinating book for almost anyone.

Photography, by William P. Gottlieb. Alfred A. Knopf, Inc. ($1.50). How to load, take care of and understand your camera, how to take black and white and color pictures, how to compose shots, how to use a flash, how to judge exposures. A nice, honest, simple, helpful book which will teach your child (7 to 11) how to use his box camera before he starts yammering for a fancier gadget.

Radar Works Like This, by Egon Larsen. Roy Publishers ($2.00). A moderately clear account of the theoretical principles of radar and its manifold uses. It is now employed in harbor supervision, ocean navigation, whaling (it picks up the markers on whales that have been killed), channel swimming (it keeps track of small escort boats), iceberg patrolling, aircraft landing, cloud and collision warning, weather forecasting and so on. For bright 12-year-olds and their seniors.

Science Fun with Milk Cartons, by Herman and Nina Schneider. McGraw-Hill Book Company, Inc. ($2.50). The Schneiders dispel the idea that a milk carton is useful only for holding milk; in their hands it begins to live after it is emptied. It can be used to make box and cattle cars, all kinds of bridges, trucks, cranes, flatcars, gondolas, canals, elevators, houseboats, windmills, waterwheels, hoists, and so on. On the whole this building program strikes me as being contrived and a bore, but it is said to have been well received in the schools. If you can't afford to give your children all the electronic and jet-powered toys they need, milk cartons may be the very thing.

Miss Pickerell and the Geiger Counter, by Ellen MacGregor. McGraw-Hill Book Company, Inc. ($2.25). Miss Pickerell is a Mary Poppins type who likes peppermint candy, her two nephews, nuclear physics and her Jersey cow. She is also energetic and curious and friendly. The result of stirring these and a few other ingredients is that the cow becomes radioactive, and Miss Pickerell, with the help of a Geiger Counter belonging to a redheaded sheriff who has the measles, finds a rich lode of uranium and gets a $10,000 award from the Atomic Energy Commission, which she uses to set up a scholarship fund for the sheriff, who always wanted to be a scientist. The story as Miss MacGregor tells it is impeccably logical and more cheerful than most atomic energy stories.

Mail for the World, by Laurin Zilliacus. The John Day Company ($3.00). An interesting popular history of postal services from ancient times to the present. It includes the ancient courier systems of kings, the *cursus publicus* of the Roman Empire (which functioned both as a letter-carrying service and a secret police), the lucrative private postal monopolies of the University of Paris and the princely house of Taxis, the struggles in France and elsewhere to establish the principle of inviolateness of private correspondence and to prevent the contents of letters being used as a basis for political persecution, the growth of national postal systems and the creation of the Universal Postal Union—a constant reminder of the benefits of international cooperation.

SHIPS AND LIFE AFLOAT FROM GALLEY TO TURBINE, by Walter Buehr. Charles Scribner's Sons ($3.00). The author and illustrator of this popular survey (for 12 and up) has had extensive experience in operating all kinds of vessels and tries hard to impart his knowledge and his enthusiasm. In this he is only moderately successful.

FLIGHT TODAY AND TOMORROW, by Margaret O. Hyde. McGraw-Hill Book Company ($2.50). How and why an airplane flies, how a pilot operates the plane, principles of blind flying, how jets, rockets, gliders and helicopters work, the future of space travel. Simple experiments illustrate the fundamentals of aerodynamics. A competent account for ages 11 and older.

THE STORY OF LOCKS, by Walter Buehr. Charles Scribner's Sons ($2.00). This is a perfect subject for a children's book but Buehr muffs the opportunity. His explanation of the working principles of locks is murky and his illustrations are uninformative.

MORE POWER TO YOU, by Herman and Nina Schneider. William R. Scott, Inc. ($2.50). A clearly written, well designed book for 10- to 12-year-olds describing the sources of power and the engines men have made and hope to make. The discussion of electricity is unusually good. The volume has simple experiments and useful illustrations.

FAMOUS AIRPORTS OF THE WORLD, by Ansel Talbert; FAMOUS BRIDGES OF THE WORLD, by David B. Steinman; FAMOUS HARBORS OF THE WORLD, by Eugene F. Moran, Sr.; FAMOUS RAILROAD STATIONS OF THE WORLD, by Adele Gutman Nathan and William C. Baker; FAMOUS SUBWAYS AND TUNNELS OF THE WORLD, by Edward and Muriel White. Random House, Inc. ($1.75 each). These are the first five volumes of a new series, "Gateway Books," for readers aged 10 and up, describing some of the principal architectural and engineering works of the world's network of communications. The series is freshly and intelligently conceived; the books are nicely designed, have excellent photographs, supplementary line drawings in color and useful indexes. They vary considerably in merit. The airport book is a machine job. The book on harbors is mediocre. Miss Nathan's story of railroad stations is reasonably well written and moderately interesting. Mr. Steinman, a distinguished bridge designer, writes *con amore* and conveys to his reader a vivid sense of the wonder and beauty of bridges and a clear understanding of their technical features. The palm, however, goes to the Whites' book on subways and tunnels. White is an experienced civil engineer; Mrs. White is an able journalist and reporter. Their collaboration produces an exciting story of courage and achievement in tunnel-building, told simply and with a nice sense of humor. I look forward to more books by the Whites.

SUPERLINER S.S. UNITED STATES, by Henry Billings. The Viking Press ($3.00). The central figure of this attractive book is the fast new liner which holds the Atlantic Ocean crossing record. The author takes the opportunity to present a good deal of related information about the North Atlantic, the history of steam vessels and navigation, the evolution of propulsion engines, the record of the American merchant marine. This is an interesting, ably illustrated volume, despite the fact that some of the chapters pant like a publicity handout.

Social Sciences

RAIN IN THE WINDS, A STORY OF INDIA, written and illustrated by Claire and George Louden. Charles Scribner's Sons ($2.50). The story (for 6-to-10s) of a little Indian boy Arun, of his friendship with a great elephant Moti, and of the desperate dependence of the people of Arun's village on the monsoon rains for the water they need to stay alive. The elephant is lent to a group of engineers building a dam which will assure a year-round water supply and provide electricity to light homes and run machines. Thus Arun and his friends come to realize that they can emancipate themselves from the bondage of ancient tradition and primitive methods.

WHY WE LIVE WHERE WE LIVE, by Eva Knox Evans. Little, Brown and Company ($3.00). Miss Evans boldly takes a crack at a question which science has scarcely begun to answer. It must be said that her enterprise is rewarded. She does a good job, in a cluttered but unpretentious and untroubled way, of de-

scribing some of the principal factors that determined how the U. S. was settled—geological, biological, climatic, economic, social, political and technological. For 7-to-11s. Recommended.

FREEDOM AND PLENTY: OURS TO SAVE, by Wilfrid S. Bronson. Harcourt, Brace and Company ($2.95). A somewhat long-winded but admirably motivated and clear conservation primer for 7- to 10-year-olds. Mr. Bronson surveys the country's resources, describes how wickedly, greedily and stupidly we have wasted them, tells of the measures already taken to mend our profligacy, and suggests how everyone, children included, can help. The many illustrations are in Bronson's familiar cartoon style—a trifle lurid, ugly, but full of good will.

HOLIDAYS AROUND THE WORLD, by Joseph Gaer. Little, Brown and Company ($3.00). The origin, history and meaning of national and religious holidays, pleasingly illustrated and moderately interesting.

THE STORY OF PEOPLE, by May Edel. Little, Brown and Company ($3.00). An introduction to anthropology for youngsters of 12 and up. Dr. Edel, who has had field experience among the Indians and lived alone in a native African village for nearly a year, tells of the pioneering work among the Eskimos of the great American anthropologist Franz Boas and then extends her story to include some of the important things that have been learned about several other peoples. Her

grasp of the subject is sound, but her book, alas, is feebly and condescendingly written and comes out pretty dull.

The Young Traveler in England and Wales, by Geoffrey Trease; The Young Traveler in France, by Alexander Reid; The Young Traveler in Holland, by Liesje Van Someren; The Young Traveler in Sweden, by George L. Proctor. E. P. Dutton and Company, Inc. ($3.00 each). The volumes in this pleasant new series are designed to acquaint readers of 12 and up with the geographical features, places of historical interest, industries, schools, amusements, holidays, eating habits, manners and customs of various foreign countries. The books, like their famous predecessors by Lucy Fitch Perkins, are cast in fictional form: in each case one or two young American children visit with children of other countries and share experiences with them. Competently written, agreeably illustrated with line drawings and photographs.

Biography

Thomas Alva Edison, Inventor, by Ruth Cromer Weir. Abingdon-Cokesbury Press ($1.50). Edison slept less than most of us, was a tireless tinkerer, lost his hearing when a helpful conductor yanked him on to a train platform by his ears, had a kind and understanding mother, made $40,000 when he was 23 years old, and invented *an* (not the only) electric light. Miss Weir gives an acceptable account of the familiar facts for children about 8 to 11.

La Salle of the Mississippi, by Ronald Syme. William Morrow and Company ($2.50). This is an unpretentious biography (for 12 and up) of a strange, gloomy, courageous, tirelessly dedicated explorer. Mr. Syme knows how to use the richly dramatic material available. The illustrations by William Stobbs are good. Altogether a fine book for young people.

William Crawford Gorgas, by Beryl Williams and Samuel Epstein. Julian Messner, Inc. ($2.75). An absorbing biography of the Army doctor who cleaned up yellow-fever-ridden Havana, freed Colon and Panama from yellow fever and malaria, thus contributing perhaps more than any other single person to the building of the Canal, and served as Surgeon General of the U. S. Army during the First World War. The authors, a husband-and-wife writing team, published two years ago an excellent youngster's biography of Houdini; here again they give a good performance. For 12 and up.

Bicycle in the Sky, by Rose Brown. Charles Scribner's Sons ($2.50). The story of Alberto Santos-Dumont, the diminutive, intrepid Brazilian who made pioneering contributions to the development of aviation. When Santos-Dumont was 18, his father, a wealthy coffee grower, gave him a million dollars and told him to go to France and follow his bent as an aeronaut. He became the first to construct and fly a gasoline-powered airship in 1898. In his early airplanes he perched on the frame of a bicycle, including the saddle and handlebars, while guiding the ship. He scooted all over Paris, circling the Eiffel Tower and landing on city streets and lawns. A pleasant and interesting book.

Christopher Columbus and His Brothers, by Amy Hogeboom. Lothrop, Lee and Shepard Company, Inc. ($2.50). A young people's (9 or 10 and up) biography presenting not only the main elements of the oft-told story of Columbus but less familiar material on his close relationship with his brothers Diego and Bartholomew, who supported him in all his undertakings. Miss Hogeboom's book has some pretty implausible imaginary conversations, but she is a capable writer and this is an agreeable tale.

Famous Humanitarians, by William Oliver Stevens. Dodd, Mead and Company ($2.75). Brief biographies of men and women who in medicine, nursing and related fields have tried hard to keep pace with the effects of poverty, disease, natural handicaps and men's vigorous efforts to devour one another. The subjects include Edward Jenner, Walter Reed, Dorothea Dix (the one who helped to improve the treatment of the insane), Louis Braille, Florence Nightingale, Father Damien, Jane Addams, Clara Barton, Sir Wilfred Grenfell, Albert Schweitzer. The biographies could have been copied out of any encyclopedia, but this is not an uninteresting book. For children of 12 and up.

The Story of Eli Whitney, by Jean Lee Latham, Aladdin Books ($1.75). For 9- or 10-year-olds, a biography of the man whose persistence and drive were as striking as his contributions to technology—the invention of a practicable cotton gin and of the use of interchangeable parts in manufacturing processes. Whitney was not a lovable man, but Miss Latham sentimentalizes him.

THE AMATEUR SCIENTIST

Two optical matters: the making of a "fish eye" camera and the buying of a microscope

Conducted by Albert G. Ingalls

William M. Sinton, a graduate student in physics at The Johns Hopkins University, is responsible for the weird photographs on the opposite page. Removing the normal lens from his camera, he inserts in its place a simple hemispherical lens that he made on his own bench. It yields these extraordinarily wide-angled pictures. The human eye can see clearly over an angular field of 20 degrees at one time; common cameras photograph 50 degrees; those with wide-angle lenses take in 90 or more degrees; but Sinton's lens photographs a full 180 degrees—the entire hemisphere in front of it. The lens will photograph at one time three walls and the whole ceiling and floor of a room. At a street intersection it will photograph down three of the four streets and from the ground at the foot of the camera tripod clear up to the zenith. Pointed straight up, it will photograph the entire dome of the sky down to the horizon all around.

Standard camera lenses are composed of a number of separate lens elements, each of a different kind of glass with different curvatures, to minimize optical aberrations. But the Sinton lens, which we may call the "Sintar," is made of a single element, which an amateur can produce in a few evenings at a kitchen table, using only a dollar's worth of glass and very little equipment. The catch is that the Sintar lens reeks with optical aberrations. However, instead of bemoaning these, Sinton has fun with them. His is quite frankly a trick lens for taking distorted photographs. He writes: "One of the photographs, taken with a camera held close to my forehead, shows me as a highbrow; another, taken close to my nose, leaves me a lowbrow; as in true life, it is all in the point of view" [*see photographs at top of page*].

A photograph along a colonnade on the Johns Hopkins campus shows the distant end little distorted and the columns and steps increasingly curved closer to the camera. A photograph of the entire campus made from a captive balloon 300 feet aloft makes the University look like a spherical "asteroid" in space. "I would like to put the lens on a V-2," says Sinton, "and photograph the earth from 100 miles aloft. The photograph would include most of the U. S. and the earth would look like a planet.

"The hemispheric lens," he continues, "has three major aberrations. The first is barrel distortion, which makes a rectangle look like the outline of a barrel. The effect is well shown in the view from the balloon, in which the rectangular pattern of the campus paths is changed to the outline of a barrel. The second aberration is curvature of field, due to the fact that, while the lens focuses the rays on a spherical imaginary surface in the space behind it, the film is flat. This aberration is tolerable if the lens is given an aperture no larger than $f/32$. The third aberration is lateral chromatism. Light rays entering the glass near the edge of the field of view are bent slightly differently for different colors and fall in different places. This aberration, which cannot be diminished by stopping down the lens, may be reduced by narrowing the wavelength range with a filter."

Barrel distortion and curvature of field are illustrated in the photograph of a straight brick wall which seems to bulge like a balloon, and of a building and sidewalk which appear to thrust their middle toward the camera. The silhouette of the photographer and his camera tripod is visible in each of these photographs. Sinton comments: "With this 180-degree lens one could get both the sun and his own shadow in the same photograph."

The Sinton lens is not merely a freak but had scientific origins. Half a century ago the Johns Hopkins physicist R. W. Wood set out to learn how the world looks to a fish. He published a paper describing his experiments in *The Philosophical Magazine* in 1906. Says Sinton: "The fish is able to see everything in the whole hemisphere of sky and landscape above the water, because the refraction of the water surface crowds the hemisphere into a cone having an apex of only 97.2 degrees. By putting a plate and a lens in a bucket, Wood recreated a fish's field of view. In an improved model he substituted for the lens a pinhole scratched in a piece of mirror glass which was cemented, glass side out, over a hole in the end of a watertight box. It had a watertight cover which could be opened for loading the camera in the dark room. The camera in this set-up could be pointed in a horizontal direction, because it was watertight. Wood's exposure time for these pinhole cameras was about one minute in bright sunlight.

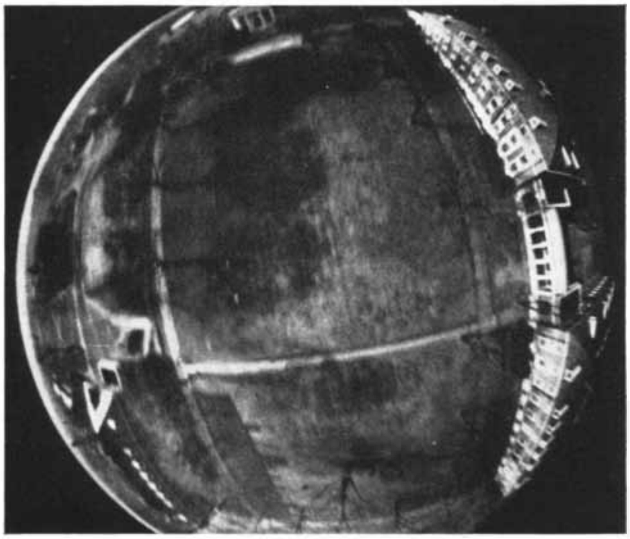
"I made one of Wood's improved cameras and took pictures with it but wearied of loading the wet, mussy thing in the darkroom. I then hit upon a way to do away with the water, at the same time having a lens in the air, where it could refract the light. This in turn would permit a higher relative aperture than a pinhole affords and reduce exposure time while increasing resolution. The design would have a large glass diaphragm to support and position the attached hemispheric lens in the center of the metal lens mount. The diaphragm would be painted black, with a small $f/32$ hole scraped in the center. The incoming rays would be refracted at the front surface of the glass—a typical plate glass having an index of refraction of 1.525. The angle of refraction of the rays shown would be about 82 degrees. The rays would pass through the aperture, on through the lens and to the film.

"So I set out to make one of the lenses. This principally involved making the hemisphere. I started with a sphere of radius R, given by the formula in the left-hand drawing on page 113, where w is half the width of the film and n is the index of refraction of the glass. For a Leica the formula called for a hemisphere having a radius of approximately one quarter inch. To make the hemi-

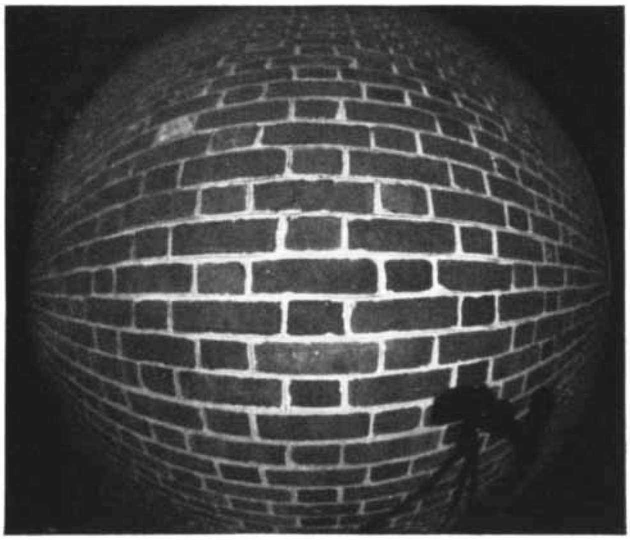
Sinton as a highbrow

Sinton as a lowbrow

A colonnade on the Johns Hopkins campus

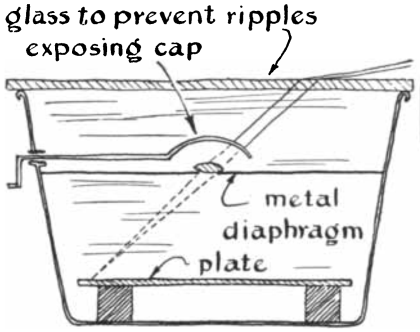


The Johns Hopkins campus from a balloon

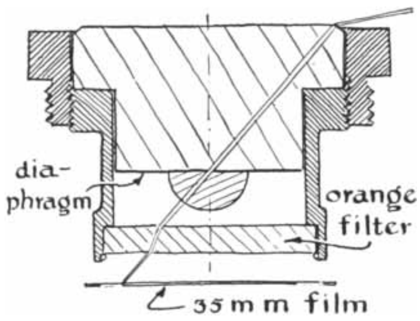


A distorted brick wall

A distorted building



Wood's first fish-eye camera



The lens and its mount

sphere I first formed a sphere, by the ancient Chinese method for making a quartz-crystal ball. This was described by John M. Holeman in SCIENTIFIC AMERICAN of August, 1948, pages 60 to 63. A chunk of glass is sawed, chipped and ground by hand to a subangular sphere, then ground to a perfect sphere between two rotating brass tubes charged with abrasive grains [*diagram at the bottom of page 114*].

" 'The tubes should have walls from about 1/16 inch to 1/32 inch thick,' Holeman wrote, 'and have a diameter about two thirds that of the rough sphere of glass. One tube is fastened to a vertical spindle and rotated at a moderate speed by a motor. The ball is placed on top of this tube. The other tube is of the same size and is held on top of the sphere at an angle of about 15 degrees. The sphere is charged by means of a paintbrush dipped in coarse Carborundum grains and water. The grains embed themselves in the soft brass and cut the glass on a curve. The ball rotates and is cut on all surfaces by the two tubes. This is the principle of the lens generator and of the centerless grinder. The more the ball rolls, the smoother it becomes.'

"Starting with too large a piece of glass, I had to grind it down considerably. It went nicely and became rounder and rounder. When it became too small for the half-inch tubes, I changed to 3/8-inch tubes and to finer abrasive grains. Then the sphere suddenly started to become less and less round—like the oblate earth. So I waxed a rod to one of its poles and ground on its Torrid Zone while twirling the rod, and thereafter I had little trouble. After polishing the sphere with Barnesite on felt, I ground away half of the ball to get my hemisphere and polished the flat side on felt with Barnesite.

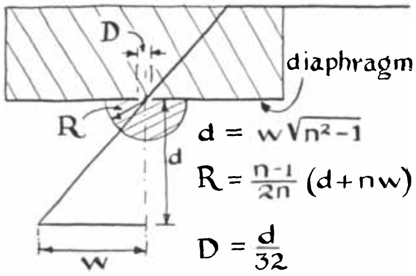
"To mount the lens in my Leica I made the plane front element, giving it enough thickness to raise its front surface above the camera shutter-speed knob, otherwise the knob would have eclipsed a portion of the picture. I ground the shoulder on this front element with a lathe-made opticians' cookie cutter using wet abrasive grains [*diagram at the top of page 114*]. The front element could have been made of two separate disks cemented together with balsam. Had I taken pains to paint the beveled outer edge of the front element black, its surface would not have been photographed as rings surrounding each picture. On the other hand, these rings, which are close-up photographs of the rough-ground bevel, serve to demonstrate dramatically that the depth of focus of the lens extends all the way from infinite distance down to only an inch away. Thus no focusing adjustment was needed on the camera. In another camera, where the knob is not in the way, the front element could consist merely of a thin glass disk.

"I then made an aluminum mount to screw the lens into the Leica. The first films showed that the lateral color aberration was blurring the edges, so I added a filter. For panchromatic film a yellow-orange filter probably is best, with an exposure time of one half-second in bright sunlight. With Kodachrome and no filter, the exposure time should be two seconds. The camera can be held steady enough in the hand, because a wide-angle lens has more tolerance of shake, just as the tolerance decreases for narrow-angle telephoto lenses and for telescopes.

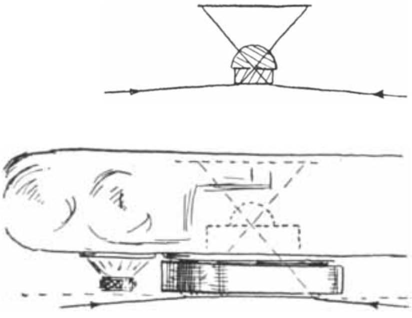
"My 'fish-eye' lens is simple and easy to make, and has been a lot of fun to use."

One of the Sinton photographs is a fish-eye view of the world, including the entire dome of the sky. Sinton appears on one side of the picture and an automobile on the opposite horizon. Sinton's face is almost undistorted, because it is not too close to the lens.

After conceiving and making his hemispherical lens, Sinton discovered that the



Finding the lens size for your camera



Two kinds of front elements

idea was proposed in *The Philosophical Magazine* in 1922 by W. N. Bond of University College in Reading, England, for photographing cloud formations and lightning flashes. "So I have done nothing new," he says. But there is no evidence in *The Philosophical Magazine* that Bond did more than propose the lens, while Sinton has made several.

Detailed instructions for making such a lens will be published next month.

Several months ago Edwin Hausle, a business executive and amateur botanist of New York City, dropped into our office for advice on the purchase of a microscope.

"I am making a study of plant parasites, particularly the effects of radioactivity on aphids," he explained, "and I need a good microscope. How much power do you think I can buy for, say, $100. Is it safe to pick up something on the secondhand market?"

Judging by our mail, many amateurs have the same problem. Some, like Hausle, want the microscope for a specific research project. Others are toying with the idea of adopting microscopy as a full-scale avocation.

We decided to put their problem up to Julian D. Corrington, professor of zoology at the University of Miami, whose book, *Working with the Microscope*, has become the amateur microscopist's standard reference text. Here are his views:

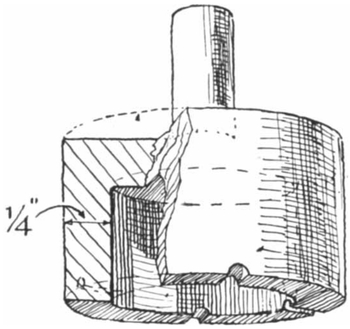
"Amateur microscopy has long flourished as a hobby in both England and America, though the emphasis has been quite different on the two sides of the Atlantic. The British have the collector's attitude: they go in for diatoms, pond life and objects for polarized light. Here the interest is at once more scientific, more practical and less naturalistic. Gadgets are always more or less in the foreground and the stress in subjects is distinctly toward the medical. U. S. amateurs like, in order of preference, bacteriology, histology and botany.

"Concerning the instrument, no one should make the mistake of thinking that for amateur work one needs only an 'amateur microscope,' which usually means a toy or something that should be called a miniature microscope. A serious amateur demands as good an instrument as his professional brother. Amateurs in this field carry with pride the shining banner of Anton van Leeuwenhoek, the greatest of all amateur scientists. They are, however, at a serious disadvantage compared with a modern professional microscopist: they must pay for their own instruments. A professional, whose institution foots the bills, has at his disposal more instruments than any save the wealthiest of amateurs can afford.

"We may dismiss the toy microscopes and give only passing mention to beginner's microscopes, though I have worked with a miniature Japanese instrument which is very good indeed. Unless you have only a limited or temporary interest in microscopy, you will want a full-sized, standard instrument sooner or later.

"Nothing is gained by paying for more microscope than you can use. If a beginner's model satisfies your every need, then settle for that one; if not, consider next the standard laboratory model. This is the familiar monocular, monobjective instrument, generally called a biological microscope because it is used mainly in biology courses. It can actually deal with a tremendous variety of objects, in such diverse fields as botany, zoology, histology, crime detection and industrial work. The simplest type has a double nosepiece with 'low' and 'high' objectives and two eyepieces, likewise low and high.

"The next advance is the so-called medical microscope, which is equipped with a triple nosepiece, an oil-immersion objective, a substage condenser and a mechanical stage. The oil-immersion objective permits higher resolution and magnification, and the mechanical stage enables the operator to cover a field of view completely and systematically and



A tool for grinding the front element

to make measurements. With this instrument an investigator may study bacteria, cells, nerve tissue, chromosomes and many other subjects requiring high power and precision. Only a photomicrographer or a highly trained specialist needs any better equipment. A binocular body for two-eyed vision is a convenient luxury with this instrument.

"Of the more advanced types one is the wide-field binocular, actually named the binocular-binobjective microscope. It consists of two separate microscopes arranged side by side, like binocular field glasses. Since it doubles the number of lenses and prisms needed, a buyer is prepared for the sad news that its price is also considerably higher. Its magnification is low, running from twofold to 20-fold, and it is used for relatively large objects. Its great advantage is true stereoscopic vision, and it is unexcelled for work with animal embryos, insects and the small forms of life in general, including parasites, plants and dissected organs, such as bones, teeth, plant parts, the brain and spinal cord and the like. It is also much used for examining coins, stamps, fingerprints, ballistics, textiles, paper and other industrial subjects.

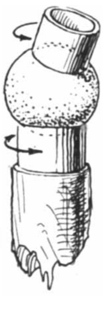
"People who work primarily in the field of crystals, notably rock and mineral structure, use a petrographic microscope with accessories for applying polarized light. There are also many other specialized types: *e.g.*, the centrifuge microscope, the slit-ultramicroscope for observation of fine particles, the comparison microscope, the dark-field, ultraviolet, monochromatic, phase-contrast and electron microscopes.

"This bewildering array need not confuse the amateur-in-search-of-a-microscope, for in 99 cases out of 100 he will want either the biological, medical or wide-field binocular instrument. In selecting the type to be bought, the first question is: What is the microscope to be used for? If one wants to study bacteria, nothing less than the medical microscope will serve. It is no good buying a lesser instrument and then hoping that gadgets or stains will supply the deficiency. If a medical instrument is out of your reach, you had better change your hobby or postpone the purchase until you have saved enough money.

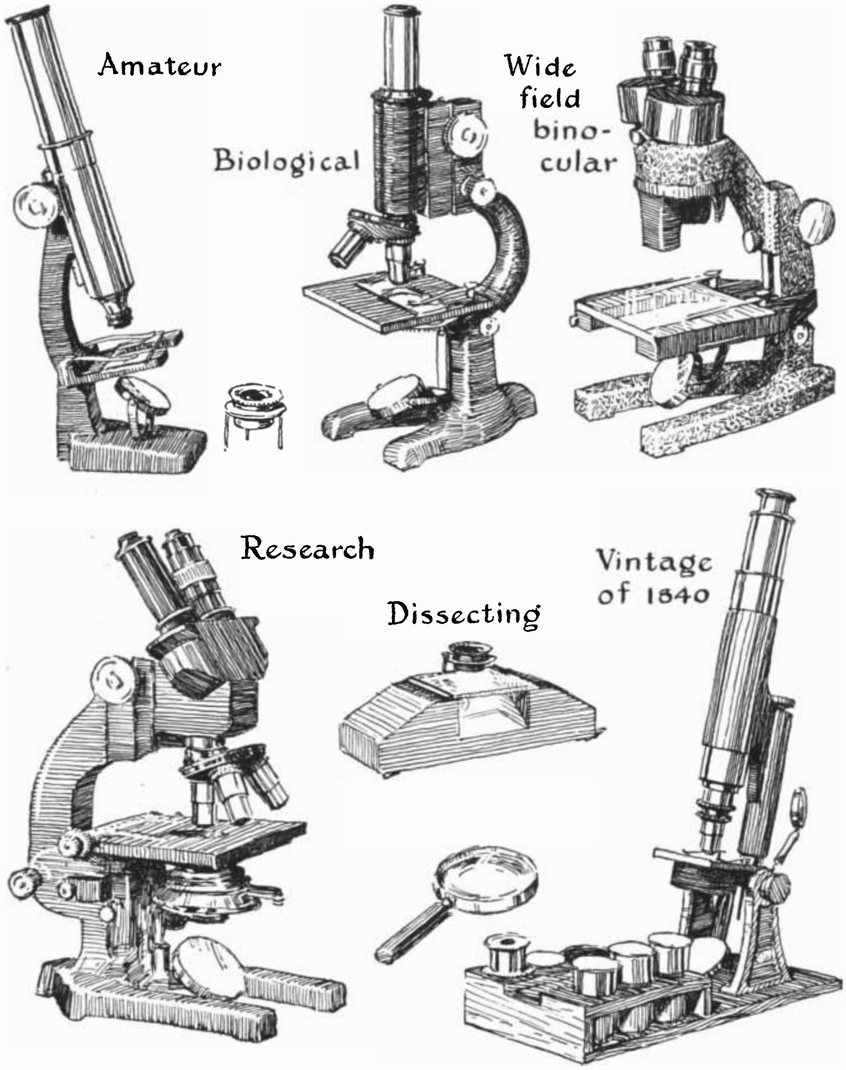
"Whether you should buy a new instrument or a secondhand one is in some respects like the question whether you should buy a new or used automobile: it may be partly a matter of taste. But there is little in a microscope to wear out or deteriorate, and an older model, though perhaps not quite as smart looking as the latest, may be every bit as good in performance. Unless the microscope has been abused by generations of students or has been dropped, it should be as good as new for all practicable purposes for many years. Doctors often sell instruments in excellent condition after they no longer have use for them; most young doctors today have no time for work with the microscope and seldom keep their instruments after graduation. If an older model has had good care and can be obtained cheaply, it is a good buy. The metal parts may be brass instead of chrome and the fine adjustment will probably be vertical instead of horizontal, but such things have no bearing on the performance.

"If opportunity permits, submit the secondhand microscope you are considering to a qualified judge. Sometimes this may be a teacher of biology, but not all biologists know much about microscopes. An optician is likely to be more expert. If you must rely on your own examination, begin by inspecting the objectives. Unscrew and remove each one in turn, remove the eyepiece and look at the front lens of the objective through the eyepiece, holding the latter inverted. With good oblique lighting this should disclose any scratches. Any considerable amount of pitting or scratching should be cause for rejection. But the lens may simply be stained or soiled; wash it with soap and warm water, or clean it with alcohol or xylene (used sparingly).

"The cost of eyepieces is so small that



Chinese method of grinding a sphere

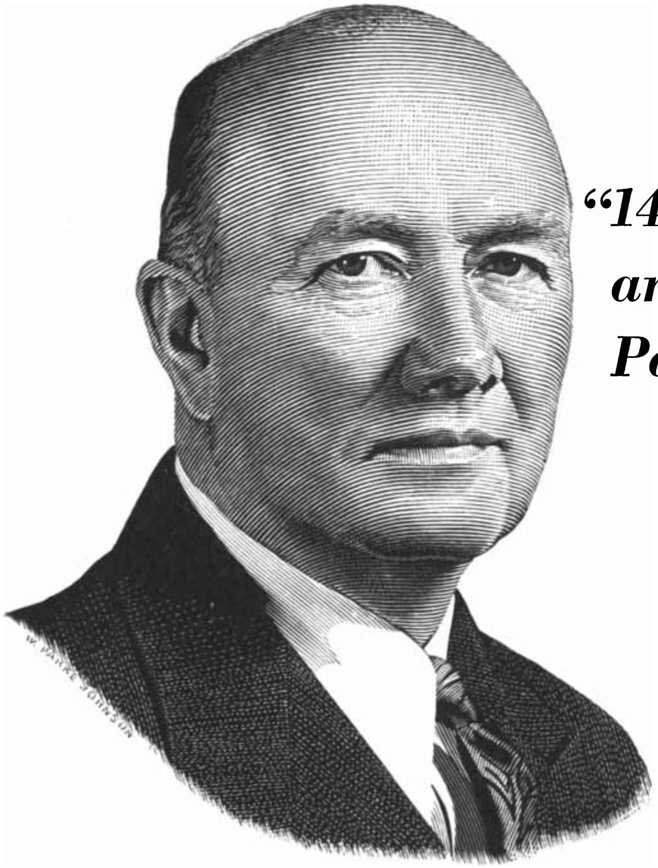


Various microscopes

if one is scratched or chipped it can readily be replaced. After the objectives, the most important part is the fine adjustment, which is expensive to repair. It should work easily, without wobbling, backlash or lost motion. The coarse adjustment is less critical. If the tube runs up and down too stiffly, or if it is loose, the repair is trifling and the trouble of no consequence. Likewise a key can fix up an inclination joint which is too tight or too loose. Inspect the iris diaphragm for meshing of the leaves and freedom from rust. Look at the mirror, the substage condenser and its gears, the mechanical stage.

"Removal of fungus and repairs of the objectives, adjustments, condenser and diaphragm require factory-trained personnel. You may send the parts or entire instrument back to the factory to be rebuilt or repaired. Most of the larger cities now have one or more repair men, former employees of the major optical companies. They may safely be entrusted with your job if universities in your area use them. The total cost of a secondhand instrument, including repairs and replacement parts, should not go over two thirds that of a new microscope of the corresponding model. If the model is out of production, even though its parts are in excellent condition the price should not be more than one half that of the corresponding new model.

"The rules for care of a microscope are simple. Handle it gently, remembering that it is a precision instrument. Keep it covered when it is not in use; dust is a microscope's greatest enemy. Wipe dust away with a soft, lint-free linen handkerchief or piece of chamois. Use a camel's hair brush on the lenses, mirror, gears and diaphragm. To clean glass surfaces, use a handkerchief or lens paper, moistening it with the tip of the tongue. Do not touch these surfaces directly with the fingers, for that is bound to leave oily



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fingerprints on them. Do not oil the microscope. Once every five or ten years, depending on the amount of use, have an expert repairman clean and adjust the whole instrument.

"Neither price nor power should be the deciding factor in your selection of a microscope. The most expensive or the most powerful instrument is not necessarily the 'best' for your purpose.

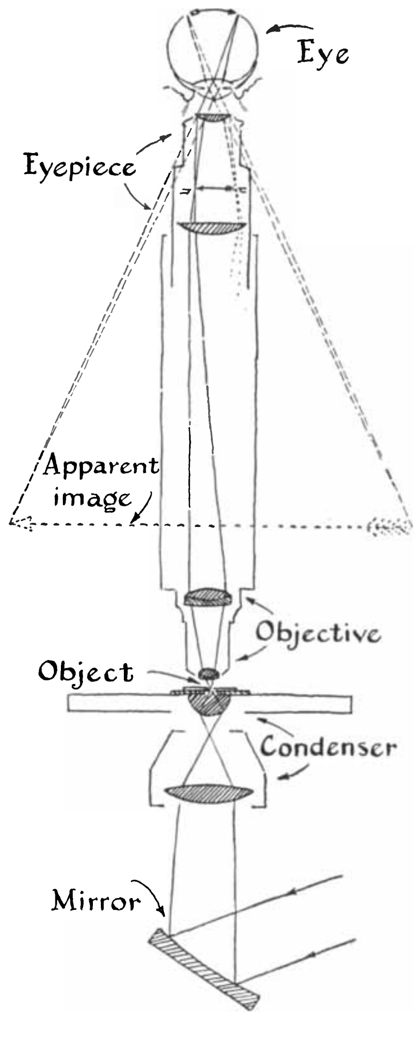
"I shall answer briefly a few of the common questions about microscopes:

"What is the limit of their power? In an optical microscope the limit of resolution is an object the size of one half a wavelength of light. An electron microscope can distinguish much smaller objects because the wavelengths of electron beams are much shorter than those of visible light.

"Why is the laboratory instrument called a compound microscope? Because the image is compounded: the objective first forms a magnified real image of the object, and the top lens of the eyepiece then magnifies this real image further and makes a virtual image. The latter cannot be magnified, because it exists only in the mind of the observer. To increase magnification of the real image by projecting it a greater distance is no help, because it does not improve resolution, that is, show more detail.

"What is resolution? If you project a silhouette of your hand on a blank wall by means of a light, you show no structural details of the skin. This is magnification without resolution. Resolution is the capacity of a lens to show two close objects as two, rather than as a single fuzzy one. Diatom shells, which often have exceedingly fine lines of pores very close together, are favorite test objects.

"Why does a high-powered lens cost so much? Because they must be built to correct certain inherent defects of lenses. One is spherical aberration: the failure of all the rays of light to meet in exactly the same focal plane. The peripheral rays are refracted more sharply than the ones passing through the center of the lens. The other serious defect is chromatic aberration; this results from the fact that a lens refracts the shorter wavelengths of light more sharply than the longer ones. The image is therefore fogged by a halo of separated colors. To correct these defects requires the grinding of lenses of different composition, such as crown glass and flint glass, and the cementing of these elements into a compound lens. The higher the magnification required, the more complex the problem of correction. This calls for numerous very small elements, carefully ground and assembled with the greatest degree of precision. Lenses that have been corrected to a degree satisfactory for visual work are termed achromatic. Those corrected still further are called apochromatic; they are over-corrected and require compensating eyepieces. They are used only for advanced research in special fields or for photomicrography.



The optics of a microscope

"Can you be cheated in buying a microscope? Yes, you may be if your instrument is obtained from a dealer who has no reputation to sustain. Never buy a microscope in a pawnshop unless you are granted full opportunity to test it thoroughly. A new microscope made by any major optical company is always trustworthy; each instrument is thoroughly inspected before it leaves the factory.

"Which make of microscope should you buy? I am asked this question more often than all the others combined, and the answer is: It is entirely a matter of personal preference. The question is silly —like asking whether you should buy a Chevvy or a Ford. You can't go wrong on any of the major makes."

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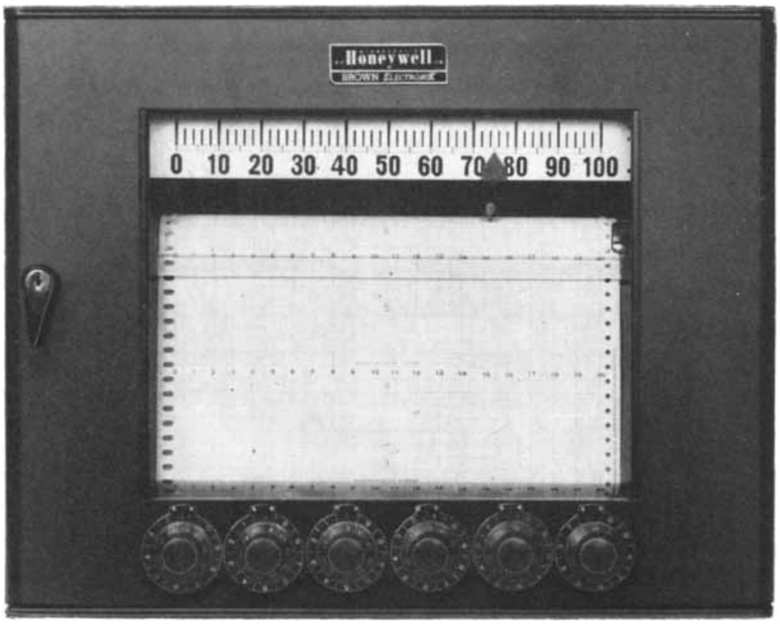

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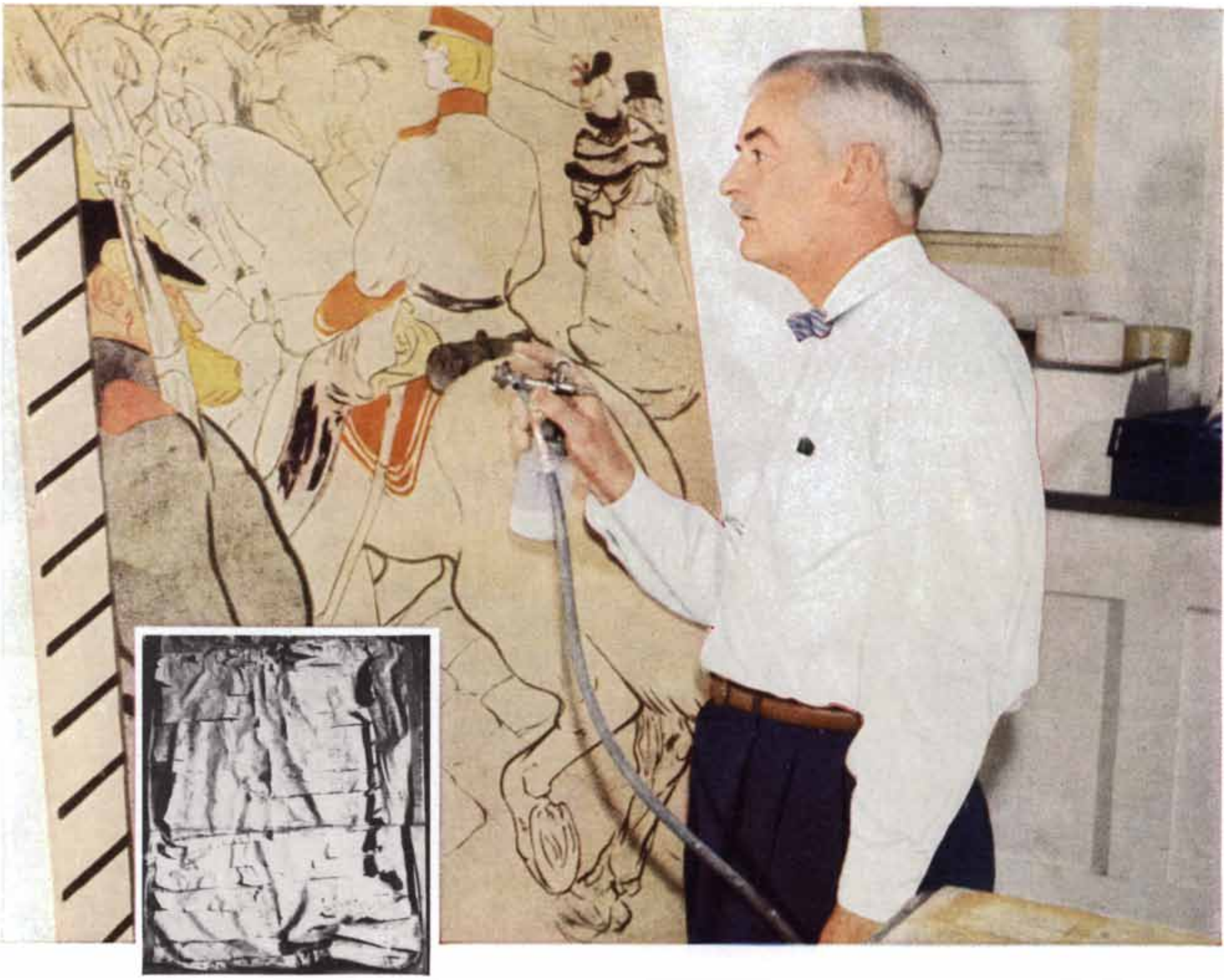

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THE crotchety genius of the last century, French artist Toulouse-Lautrec, produced some wonderful posters that rate today as works of art. As you can imagine, they are scarce—and the Boston Museum of Fine Arts acquired for their collection the time-tattered poster shown (rear view) in the small photo. With a complex and painstaking restoration process, a member of the museum staff restored its original beauty.

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As a child believes

Christmas . . . brightest of all bright days in the lives of children, a day made memorable by a child, a day that children love.

And because nobody believes as a child believes, may we who are no longer children get back once again the shining faith of childhood; that for this one day at least we will see the world as a child sees it . . . big, and kind, and candy-good, and peaceful.

To shape this modern world of ours more to a child's image of Christmas is a challenge to us all. It is a challenge to industry, too, especially to the chemical industry which through research is charting progress in many fields and helping to bring about new developments and discoveries that make life better, healthier and happier for young and old everywhere.

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