SCIENTIFIC AMERICAN

HUMMINGBIRD METABOLISM

FIFTY CENTS
75 CENTS OUTSIDE THE AMERICAS

January 1953

Men, chemistry, and coal!

Science has found a new way to get valuable chemicals from coal

Coal has long been one of man's most useful servants. Now it holds promise of even greater benefits to all of us.

COAL INTO CHEMICALS—Science has at last found a practical way to convert coal into the host of valuable chemicals that nature locked into it.

The people of Union Carbide have developed a way to bring coal and hydrogen gas together under carefully controlled heat and pressure. In minutes, this revolutionary process—called *coal hydrogenation*—converts the coal into a mixture of gases and liquids that are rich in useful chemicals.

A WEALTH OF RAW MATERIALS—Among them are hitherto scarce, and even completely new, chemicals. Some are raw materials for plastics and synthetic rubber, or are vital to medicine and vitamins. Some are valuable in rocket propulsion. Others are necessary in insecticides, surface coatings, and many other important uses.

A NEW SOURCE OF SUPPLY—Today, Union Carbide's coal-hydrogenation process promises steady and vastly increased production of chemicals for these needed materials. What's more, it will provide a host of chemicals that may become the basis of many new products.

A UCC ACHIEVEMENT—With the first coal-to-chemicals plant of its kind in operation, the people of Union Carbide are now well on the way to making abundant coal a source of chemicals important to us all.

FREE: *If you would like to learn more about Union Carbide's exciting new coal-hydrogenation process, write for the illustrated booklet, "Chemicals from Coal." Ask for booklet A.*

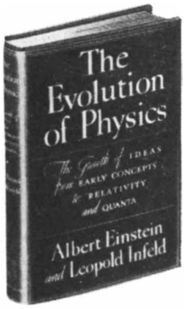
UNION CARBIDE
AND CARBON CORPORATION
30 EAST 42ND STREET UCC NEW YORK 17, N. Y.

UCC's Trade-marked Products of Alloys, Carbons, Chemicals, Gases, and Plastics include

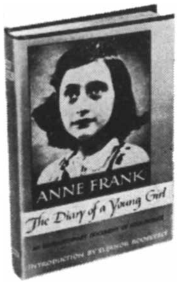
SYNTHETIC ORGANIC CHEMICALS • BAKELITE, KRENE, and VINYLITE Plastics • LINDE Oxygen • DYNEL TEXTILE FIBERS
ELECTROMET Alloys and Metals • HAYNES STELLITE Alloys • PREST-O-LITE Acetylene • PYROFAX Gas
EVEREADY Flashlights and Batteries • NATIONAL Carbons • ACHESON Electrodes • PRESTONE and TREK Anti-Freezes

THE MOST IMPORTANT BOOKS

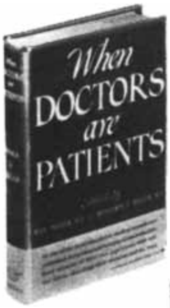
In the Sciences—in Literature . . .



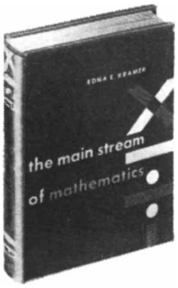
This highly absorbing book traces the growth of ideas in physics through Relativity. Its non-technical style is the essence of beautiful clarity.
List price 3.50
Members Pay 1.89



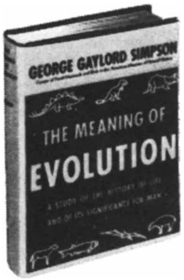
Written while the author hid from the Nazis in Holland, it is at once a remarkably sensitive record of adolescence and an eloquent testimony to the strength of the human spirit.
List price 3.00
Members Pay 1.89



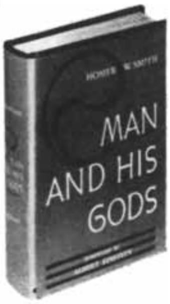
In their own words, thirty-three eminent physicians tell of their personal experiences with shattering mental and physical illness and how they have come to terms with it.
List price 3.95
Members Pay 1.89



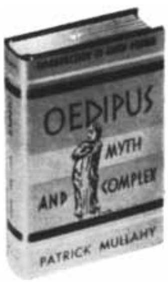
A scholarly yet lively history of this significant science, replete with a wealth of biographical and anecdotal material.
List price 5.00
Members Pay 1.89



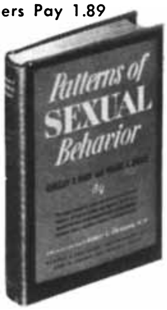
Called by the New York *Times,* "Without doubt the best general work on evolution to appear in our time," this is a vital study of the history of life and of its significance for man.
List price 3.75
Members Pay 1.89



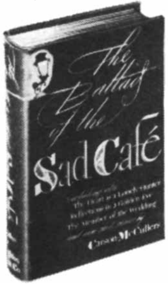
Man's religious beliefs brilliantly examined from a naturalistic point of view. This encyclopedic study has been ranked with Frazer's *Golden Bough.*
List price 5.00
Members Pay 1.89



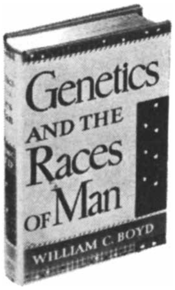
The major psychoanalytic theories from Freud, Adler, and Jung to the present are here set forth in a new and unifying way. The work also includes the great *Oedipus* trilogy of Sophocles.
List price 5.00
Members Pay 1.89



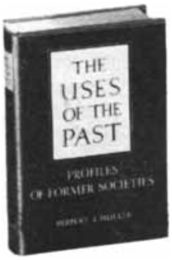
The most comprehensive study ever made of the sexual behavior of human beings and animals, based on a detailed analysis of the sexual patterns of 190 contemporary societies.
List price 4.50
Members Pay 1.89



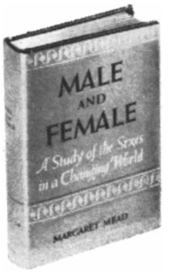
This large volume contains *all the novels* and a *selection of the finest short stories* of one of America's most perceptive writers.
List price 5.00
Members Pay 1.89



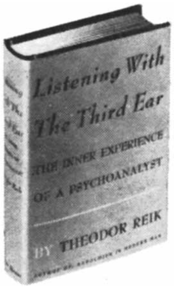
Physical anthropology is here studied, for the first time, in the light of modern science. "The best book on race ever to be published." — Bernard Mishkin.
List price 6.00
Members Pay 1.89



With the vision of both historian and philosopher the author surveys the golden ages of such societies as the Grecian, the Roman, and the 'Holy Russian,' in a search for a pattern for our times.
List Price 5.50
Members Pay 1.89



In this illuminating study, one of America's outstanding anthropologists focuses her attention on the relationship of the sexes in our changing world.
List price 5.00
Members Pay 1.89



Sub-titled "The Inner Experience of a Psychoanalyst," Dr. Reik's book has been favorably compared with Freud's *Interpretation of Dreams.*
List price 6.00
Members Pay 1.89

at only $1.89 *regardless of list price*

The notable books pictured and listed on this page are a sampling of the many distinguished volumes available to you, now, as a member of the Book Find Club—and as you will note, although the publishers' list prices range up to *$6.00,* as a member of the Club you pay only *$1.89 per volume.* Actually, this represents an average saving of more than 50% on the books you buy—*and you buy only the books you want.*

SPECIAL INTRODUCTORY BONUS OFFER

And now as your introduction to the Book Find Club you may select any two books from those pictured or listed on this page—one as your Introductory Bonus Book and the other as your first selection. You can thus receive UP TO $12.00 RETAIL COST OF BOOKS FOR ONLY $1.89.

THE BOOK FIND CLUB

FILL OUT THE COUPON AND MAIL

THE BOOK FIND CLUB, 215 Fourth Avenue, New York 3

Please enroll me as a member and send me the Introductory Bonus Book and first selection I have indicated. I am also to receive each month the Club's literary magazine, the Book Find News. I understand I may accept as few as 4 books a year at the SPECIAL MEMBERSHIP PRICE OF ONLY $1.89 A BOOK (plus 24¢ postage and handling) and may cancel my membership at any time after purchasing 4 selections. *(Check any two of the books listed below, one as your Introductory Bonus, the other as your first selection.)*

☐ THE USES OF THE PAST
☐ THE THURBER ALBUM
☐ EPITAPH OF A SMALL WINNER
☐ ANNE FRANK: Diary of a Young Girl
☐ LAMENT FOR FOUR VIRGINS
☐ WHEN DOCTORS ARE PATIENTS
☐ MAIN STREAM OF MATHEMATICS
☐ PATTERNS OF SEXUAL BEHAVIOR
☐ WHERE WINTER NEVER COMES
☐ GENETICS AND THE RACES OF MAN
☐ MALE AND FEMALE
☐ OEDIPUS—MYTH AND COMPLEX
☐ LISTENING WITH THE THIRD EAR
☐ MATHEMATICS and the IMAGINATION
☐ MEANING OF EVOLUTION
☐ BALLAD OF THE SAD CAFE
☐ RISE OF SCIENTIFIC PHILOSOPHY
☐ EVOLUTION OF PHYSICS
☐ THE AMERICAN MIND
☐ MAN AND HIS GODS

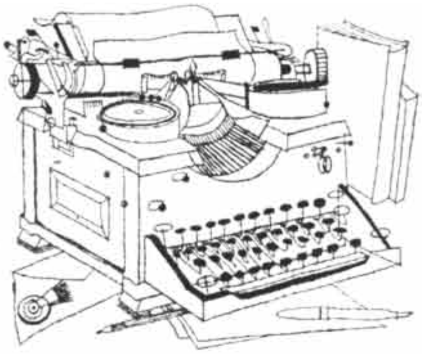
NAME____________________________
Please print

ADDRESS____________________________

CITY________________ZONE______STATE______

(Prices slightly higher in Canada) D21-14

LETTERS



Sirs:

I read with a great deal of interest "A Psychologist Examines 64 Eminent Scientists," by Anne Roe [SCIENTIFIC AMERICAN, November], and agree wholeheartedly on the need for further examinations of this kind. However, I would like to clarify a point which might lead one by inference to a completely erroneous conclusion. Dr. Roe gives as a partial justification for undertaking these studies, ". . . the recruitment of qualified young people into science is a growing problem in our society. Where and how shall we find them?"

The testing of the 64 eminent scientists has resulted in interesting data regarding their mental proficiencies, as well as some startling personal traits and family relations. Notable among these was the high parental divorce rate of social scientists and the physical handicaps, illnesses and introversive tendencies of the theoretical physicists.

Lest we attempt to solve our shortage by looking in divorce courts for our social scientists, or in hospitals for our physicists, we must remember that this survey was taken of exceptions rather than the rule. They are few and far between, and I disagree with Dr. Roe's statement that they are most likely to exemplify the special qualities associated with success in research science. I doubt that these men typify the successful Ph.D. in research, the universities or industry. The successful Ph.D. is far from eminent, has received few awards and honorary degrees and constitutes 90-odd per cent of our leading scientists. It is these men whom we now sorely lack, as well as the genius fringe. Their I.Q. equivalents do not average 150 but probably a good 25 points below this, and attempts at drawing conclusions about these men from surveys of our most eminent scientists have to my mind little meaning.

If it is desirable to obtain statistical information to serve as a tool for the guidance of our youth toward scientific careers, let us be less restrictive and more realistic in our choice of subjects for detailed clinical analysis. Our future Nobel laureates and Einsteins are insufficient in number to be statistically chosen from our vast population no matter how detailed an analysis we may make of our present leaders.

Let us concentrate on our successful, but not necessarily eminent, scientists in order to channel our youth properly, in the expectation that some of them will attain the stature of the eminent discoverer who sets the pace in our rapidly advancing science.

PAUL PEMSLER

Department of Chemistry
New York University
New York, N. Y.

Sirs:

Dr. Pemsler is quite right that more studies are needed. This was pioneer research, designed to open up a new field. I selected the top men to start with on the assumption that if there were elements in personality or in life history that differentiated one kind of scientists from another or scientists from nonscientists, and which were relevant to choice of or success in the vocation, they might be most evident in the men who were most successful. Because I had it clearly in mind that there might also be important differences between the top men and the rest of the group, and because there was no evidence on this as a guide, I also made a study of other men in the fields, but it was not possible to include a report of this in so brief an article. The Rorschach, which can be given as a group test, was administered to 385 members of different

Scientific American, January, 1953, Vol. 188, No. 1. Published monthly by Scientific American, Inc., 2 West 45th Street, New York 36, N. Y.: Gerard Piel, president; Dennis Flanagan, vice president; Donald H. Miller, Jr., vice president and treasurer. Entered at the New York, N. Y., Post Office as second-class matter June 28, 1879, under act of March 3, 1879. Additional entry at Greenwich, Conn.

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

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

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

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

Subscription rates for U.S.A. and possessions: 1 year, $5; 2 years, $9; 3 years, $12.50. Canada and Latin America: 1 year, $6; 2 years, $10; 3 years, $14. All other countries: 1 year, $8; 2 years, $12; 3 years, $16.

AT YOUR END OF THE COAL CHEMICAL PIPELINE . . .

from Sun, Sea and a Plastic Ball—

Fresh Water!

Here's American scientific ingenuity at its best . . . a plastic ball that makes life-saving fresh water from the sun and the sea. The principle is simple: Solar heat evaporates sea water from a black "wick" and the distilled vapors condense on the cooler inner surface of the sphere.

But one of the real challenges was to produce a vinyl plastic that wouldn't succumb to salt water, heat and long storage. That was a job for a good *plasticizer*. As a basic producer we're continually being called upon for plasticizers to meet every demand, from low temperature flexibility in Arctic-bound military coverings to high stability in surgical tubing. Whatever the challenge, plastics manufacturers have learned to count on the uniform high quality of Pittsburgh PX Plasticizers . . . an advantage that accrues from our unique coal-to-finished plasticizer production control. This same *assurance of quality* carries right through the products of our other integrated divisions . . . because we're *basic.*

W&D 4414

DiButyl Phthalate
DiIsoOctyl Phthalate
DiNonyl Phthalate
DiIsoOctyl Adipate
DiButyl Sebacate
DiOctyl Sebacate
DiOctyl Phthalate
DiNonyl Adipate
DiOctyl Adipate
DiIsoOctyl Sebacate
TriCresyl Phosphate
TetraHydroFurfuryl Oleate

PLASTICIZER DIVISION
PITTSBURGH
COKE & CHEMICAL CO.
Grant Building · Pittsburgh 19, Pa.

COAL CHEMICALS • AGRICULTURAL CHEMICALS • FINE CHEMICALS • PROTECTIVE COATINGS • PLASTICIZERS • ACTIVATED CARBON • COKE • CEMENT • PIG IRON

AMERICAN CHEMICAL PAINT COMPANY

AMBLER CHEMICALS ACP PROCESSES PENNA.

Technical Service Data Sheet

Subject: IMPROVING PAINT ADHESION ON STEEL WITH GRANODINE®

INTRODUCTION

"Granodine" is a zinc phosphate coating chemical which improves paint adhesion on steel, iron and zinc surfaces. In the Granodizing process, a non-metallic crystalline coating is formed on the treated metal. This bond holds and protects the paint finish and thus preserves the metal underneath.

Official Dept. of Defense Photograph

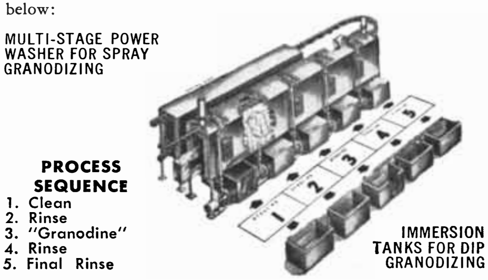
An F4U Corsair with the Navy's new aircraft anti-tank rocket, the "RAM". A Grade I zinc phosphate finish (JAN-C-490) protects the entire external surface of this rocket and provides a durable bond for the specification paint finish.

"GRANODINE" MEETS SERVICE SPECIFICATIONS

JAN-C-490, Grade I	CLEANING AND PREPARATION OF FERROUS METAL SURFACES FOR ORGANIC PROTECTIVE COATINGS
JAN-F-495	FINISHES FOR EQUIPMENT HARDWARE
U.S.A. 57-0-2C Type II, Class C	FINISHES, PROTECTIVE, FOR IRON AND STEEL PARTS
U.S.A. 51-70-1, Finish 22.02, Class C	PAINTING AND FINISHING OF FIRE CONTROL INSTRUMENTS; GENERAL SPECIFICATION FOR
MIL-V-3329	VEHICLES, COMBAT, SELF-PROPELLED AND TOWED; GENERAL REQUIREMENTS FOR

GRANODIZING DATA

Granodizing is an easily applied chemical process. Depending on the size, nature and volume of production, Granodizing can be carried out by spraying the parts in successive stages of a power washing machine, by dipping the work in the cleaning, rinsing and coating baths contained in tanks, or by brushing or flow coating the work with portable hand equipment. Typical process sequence and equipment requirements are shown below:



PROCESS SEQUENCE
1. Clean
2. Rinse
3. "Granodine"
4. Rinse
5. Final Rinse

NOTE: Equipment can be of mild steel throughout, except in the Granodizing stage, where nozzles, risers, and pump impeller should be of acid-resistant material.

MANY APPLICATIONS

Automobile bodies and sheet metal parts, refrigerators, washing machines, cabinets, etc.; projectiles, rockets, bombs, tanks, trucks, jeeps, containers for small arms, cartridge tanks, 5-gallon gasoline containers, vehicular sheet metal, steel drums and, in general, products constructed of cold-rolled steel in large and continuous production are typical of the many products whose paint finish is protected by "Granodine".

CHEMICALS ACP PROCESSES

WRITE FOR FURTHER INFORMATION ON "GRANODINE" AND YOUR OWN METAL PROTECTION PROBLEMS.

CHEMICALS ACP PROCESSES

university faculties in all the fields studied, and the results compared with those from the individual studies. The differences among various groups of scientists were also found in the group studies, and some differences between the most eminent and the others in each field were suggested, but these differences are not the same for all the subgroups of scientists.

Finally, I hope soon to start on a five-year research project involving similar individual study of a random selection of scientists, and later on a questionnaire study of a very large sample. When this has been completed, I believe that we will have some extremely useful data. But the preliminary study reported in *Scientific American* has served well to show us what to look for and what techniques to use.

ANNE ROE

New York, N. Y.

Sirs:

R. B. Carson's letter to the editor, published in your November issue, is, I suppose, just one of many received in similar vein. I think his suspicions and fears are founded on false premises, premises that are (sadly) coming to be common ones nowadays: namely, that engineering and the practical mechanical arts have descended into the pit of "gadgetry."

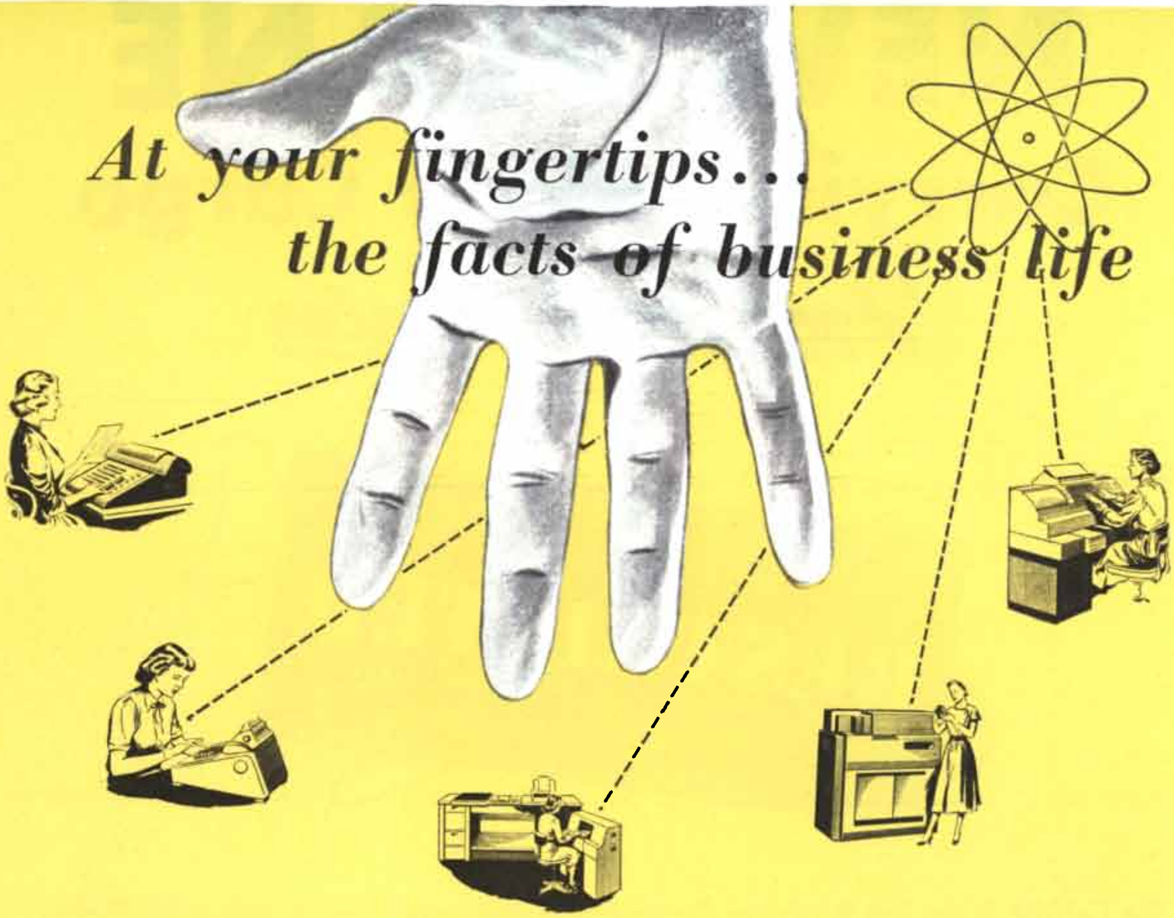
Mr. Carson, and other readers who share his opinion of engineering, would not have very far to search to find an engineer entranced in the problem of how to successfully modify an existing product to incorporate an added part or operating feature desired by the customer. I say "entranced in the problem" because a particular and inherent part of engineering work is its continual alertness and attentiveness to the individual tastes expressed by customers. It is surely not an understatement to say that the wonderful things promised us by automatic control will and do touch only a fragment of the vast scope of manufacturing activities wherein the design and specifications function is classed as engineering.

Many are of the opinion that covetousness is more to blame than the "machine age" in producing the "growing neuroticism" that Mr. Carson claims to be part and parcel of America today. To "love thy neighbor as thyself" takes a lot more than just bright young men studying philosophy instead of engineering. Each man's social, moral and religious outlook is a thing personally chosen, and directed more often than not by forces not common to an occupational group.

JOSEPH P. HESSE, JR.

La Grange, Ill.

© 1952 SCIENTIFIC AMERICAN, INC



At your fingertips... the facts of business life

Everybody is better off these days because the ever-mounting flood of business paper work is meeting its master in the incredible speed and accuracy of versatile office machines.

They go far beyond the limits of pen and pencil work to turn out involved analytical jobs on an up-to-the-minute basis—digging out the facts of business life.

Controlled by simple pushbuttons . . . powered by electricity . . . often employing the magic of electronics, these intricate but easy-to-use machines give management vital facts, currently and accurately.

In most electric office machines—adding machines, computers, calculators, sorters, tabulators, bookkeeping machines, and typewriters—Mallory contacts work to help produce facts at the touch of flying fingers.

Every time a pushbutton or key is touched, these Mallory contacts must speed an electrical "message" on its way. Made of silver, tungsten and special alloys, the tiny but tough contacts must operate with long-lasting dependability through a life measured in millions of on-again, off-again operation.

These contacts are good examples of the precision work Mallory does in metallurgy, electrochemistry and electronics. If you have a product, a process or a problem within these fields, it may be to our mutual advantage to talk it over.

P. R. MALLORY & CO. Inc.
MALLORY

SERVING INDUSTRY WITH THESE PRODUCTS:
Electromechanical • *Resistors, Switches, Television Tuners, Vibrators*
Electrochemical • *Capacitors, Rectifiers, Mercury Dry Batteries*
Metallurgical • *Contacts, Special Metals and Ceramics, Welding Materials*

P. R. MALLORY & CO. Inc., INDIANAPOLIS 6, INDIANA


RESTRICTED


RESTRICTED

50 AND 100 YEARS AGO

JANUARY, 1903: "If one were asked to name the most important scientific achievement of the year just closed, he would, without doubt, give that distinction to a feat which was performed, in the closing days of the year, on a barren headland of the eastern shores of Cape Breton, where Marconi, a few days before Christmas, exchanged messages of congratulation by wireless telegraphy with some of the crowned heads of Europe. At the close of the year 1901, Marconi had given to the world the first pledge that he would before long make transatlantic wireless commercial telegraphy possible, for he had received on a single wire, suspended from a kite, an agreed-upon signal in the form of the repetition of the letter 'S.' It was merely a hint of coming possibilities, for the signal was only perceptible by the use of a sensitive telephone. Between that and the transmission of commercial messages was a wide gap, and that the brilliant young Anglo-Italian should have closed that gap within a period of twelve months must be regarded as certainly the most remarkable scientific achievement of the year."

"The history of aeronautics during the past twelve months has been fraught with tragedy, and each disaster has served to write large the ultimate doom of the balloon-supported airship. Just at present the balloon airship has the field pretty much to itself, and by its doubtful successes and undoubted failures it is clearing the way for the development of the more scientific and more practical aeroplane, some form of which is certain ultimately to be adopted as the only practical means of air navigation; but we are many years distant from that event at present."

"Since a negatively-charged body exposed in the atmosphere becomes radioactive, apparently indicating the presence of some radioactive substance in the atmosphere, it occurred to C. T. R. Wilson to test whether any of this radioactive substance is carried down in rain. He boiled down freshly fallen rain to dryness, and found a radioactive residue. The radioactivity rapidly disappears, falling over 50 per cent in the first hour."

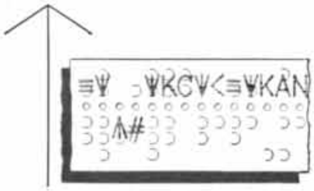
"About a year ago, it will be remembered, Professor Jacques Loeb startled the scientific world by his statement that the vital force of life comes from the electric forces and the food which is eaten, and not from heat. Professor David J. Lingle, also of the University of Chicago, now steps to the fore with an equally startling announcement. He states that it is not only salt, or sodium chloride, which stimulates and causes heart action, but that oxygen gas is often a more important factor in sustaining heart action. He experimented with a piece of the ventricle of a turtle's heart, putting it into a solution of salt, and then into a jar of oxygen gas. Here the beating was sustained for seventy-two hours."

"Rumor has been rife for a long time that Professor Alexander Graham Bell, of telephone fame, is the inventor of a flying-machine. In the interviews which he has given to representatives of the daily press, Professor Bell has been extremely reticent. He states, however, that he has not invented a flying-machine, but that he has been engaged in experiments in kite-flying which he believes will have some bearing on the invention of an operative aeroplane. It is understood that Professor Bell and Professor S. P. Langley have collaborated to a certain extent in carrying out these experiments."

"A Pacific cable, which was, for many years, the dream of the late John W. Mackay, at length is nearing accomplishment, the opening of the first section from San Francisco to Honolulu having occurred on New Year's Day. The cable, when completed, will reach from San Francisco to Manila, in the Philippine Islands, a distance of 6,912 miles. A branch to Hong Kong, China, is contemplated later."

"At the annual meeting of the American Chemical Society, Dr. Ira Remsen, the retiring president, took as the subject of his address 'The Life History of a Doctrine' in the course of which he said: 'The doctrine of atoms is still alive, though it came into being about a hundred years ago. It has been proved to be illogical, as the ether that fills all space has been shown to be incapable of existence. Properties must be ascribed to the atom that it cannot possess, and the same is true of the ether. What are we to do? Throw over the atom and the ether? Although both have been convicted of being illogical, I do not think it would be logical to give them up, for

These signals find the way



SENDING

RECEIVING

When you dial a telephone number, high-speed switching mechanisms select your party and connect you. Through a new development of Bell Telephone Laboratories, similar mechanisms are doing the same kind of job in private wire teletypewriter systems which America's great businesses lease from the telephone company.

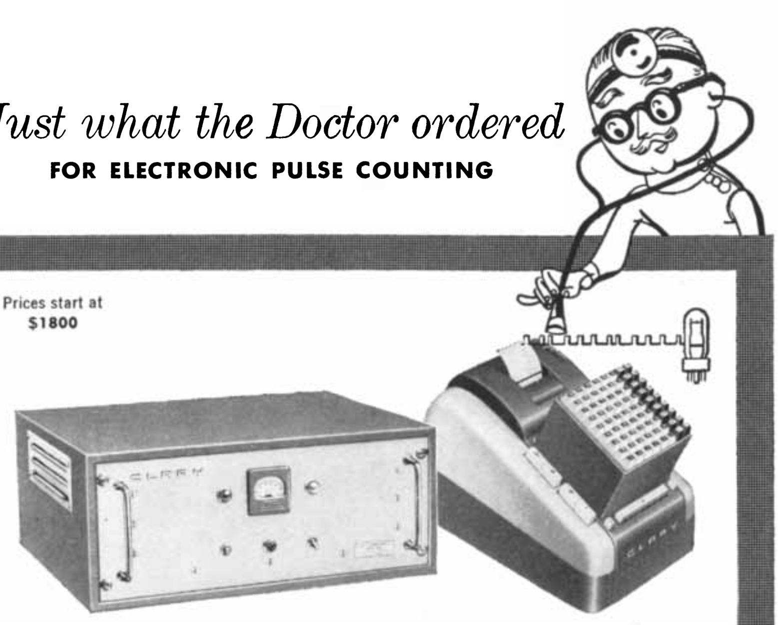
Company X, for example, operates an air transportation business with scores of offices all over the country. At one of these offices, a teletypewriter operator wishes to send a message, let us say, to Kansas City. Ahead of the message, she types the code letters "KC". The letters become electric signals which guide the message to its destination.

Any or all stations in a network, or any combination of stations, can be selected. Switching centers may handle 50 or more messages a minute . . . some users send 30,000 messages a day. Delivery time is a few minutes.

Defense manufacturers, automobile makers, airlines and many other American businesses are benefiting by the speed and accuracy of the new equipment — another example of how techniques developed by the Laboratories for telephone use contribute to other Bell System services as well.

BELL TELEPHONE LABORATORIES

Improving telephone service for America provides careers for creative men in scientific and technical fields.



they are helpful in spite of their shortcomings. While the atomic theory can be used without using atoms, this must involve a great effort for the average mind.' "

JANUARY, 1853: "It appears that an attempt is about to be made to put to practical use the immense water power of Niagara Falls. There can be no doubt but the water power of Niagara is sufficient to drive all the machinery in the world, and some years ago we spoke of its application for factory purposes on a large scale, by cutting a canal from above the falls. There are a number of mills at Niagara now, but to make cotton goods when the raw material has to come from such a distance, it would not be a profitable speculation in our opinion."

"Dr. Kane, at the last monthly meeting of the New York Geographical Society, informed those present that another expedition in search of Sir John Franklin was preparing under his direction in the 'Advance,' the plan of search to be based upon the probable extension of the land masses of Greenland to the far north—a view yet to be verified by travel, but sustained by the analogies of physical geography. The party should consist of some thirty men, with a couple of launches, sledges, dogs and gutta-percha boats. The provisions would be pemmican—a preparation of dried meat packed in cases, impregnable to the appetite of the polar bear."

"M. Petin, the French aeronaut, made an ascension from New Orleans on Saturday, December 25th, 1852, with three companions. M. Petin says that he attained the great elevation of 20,000 feet, at which height the pressure on the lungs was so great that it was with great difficulty that they could speak. During the ascent he encountered no less than six different currents of air, that from east to west being the strongest, but that at no time did he find any difficulty in directing the course of his frail bark at will."

"A correspondent states that the operators of the telegraph running between Buffalo and Milwaukee, working under Morse's patent, have for some time past discontinued the practice of recording the signs, and have instead thereof received their messages by sound. The operator sits by the table in any part of the room where the message is received, and writes it down as the sounds are produced. The different sounds are made by the striking of the pen lever upon a piece of brass; thus three raps in rapid succession are made for the letter 'A,' two raps, an interval, and then two raps more are made for 'B,' and so forth."

NO. FIVE OF A SERIES

Pioneers in Precision

Actual photo of radar screen picture from ship in San Diego Harbor.

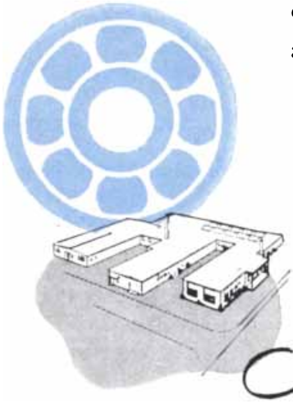
Raytheon Manufacturing Company, a division of which disclosed the world's first complete radar system in 1930. Pioneers in the development and perfection of magnetrons, the "heart" of all radar systems . . . the first to produce marine radar with 16″ presentation. The "Mariners Pathfinder" radar, as installed on vessels of leading steamship lines, is a product of this world's largest producer of marine radar.

Miniature Precision Bearings

are made by the originators and pioneer developers of ball bearings in this size range. **MPB** supplies the finest miniature ball bearings to over three thousand discriminating customers.

Exclusive, exacting production and inspection details (practically every new concept in this field has been by **MPB** designers and engineers) assure highest quality bearings. Fully ground, lapped, honed, and/or burnished to ABEC 5 tolerances or better, **MPB** ball bearings are torque tested, ultrasonicly cleaned, supplied in specific clearances, and classified within the tolerances for prompt assembly and maximum service.

More than a million **MPB** ball bearings have been supplied for many unusual operating applications — extreme temperature — shock — continuous high load capacity. The most extensive engineering knowledge in miniature bearing applications is available to you. Write for Catalog and survey sheet SA-1.



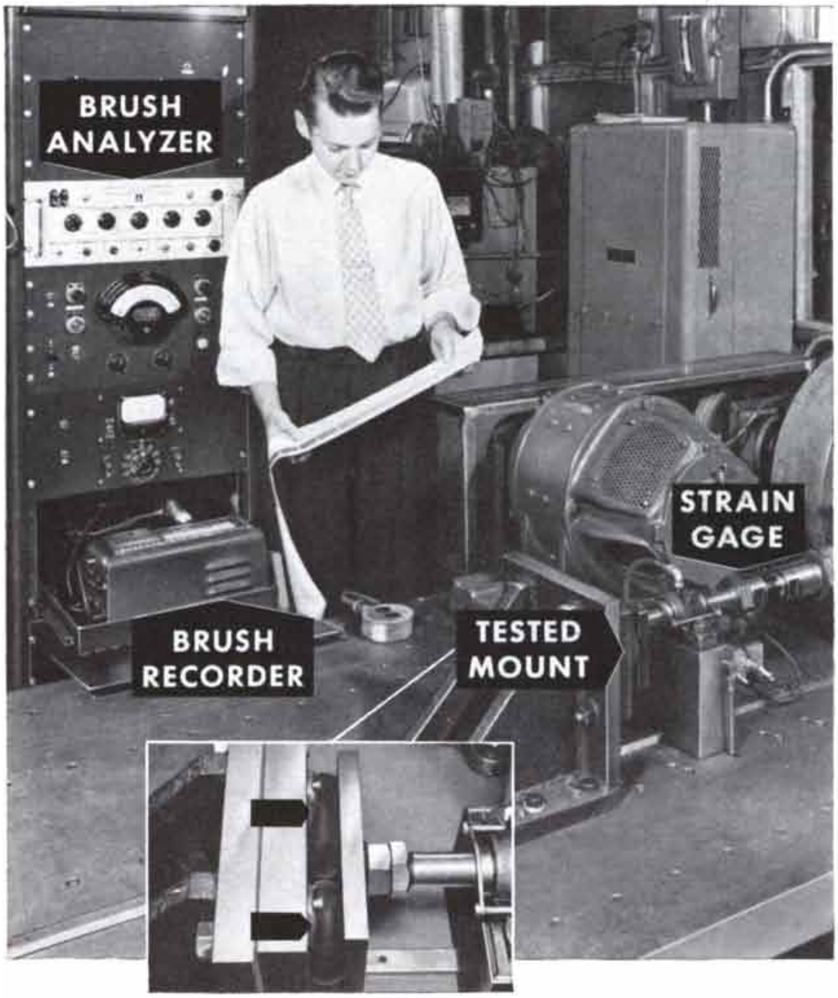
Though recently expanded, our production facilities are still not entirely adequate to always immediately satisfy the demand for ultra quality bearings. Continuing expansion, and newest exclusive processes will soon enable us to supply you promptly.

Miniature precision Bearings

Incorporated Keene, New Hampshire

"Pioneer Precisionists to the World's foremost Instrument Manufacturers"

save
space
weight
friction



THE COVER

The photograph on the cover shows a hummingbird inside a bell jar at the University of California's Museum of Vertebrate Zoology. The experiment, which was performed to measure the hummingbird's oxygen consumption rate, is described in the article beginning on page 69.

THE ILLUSTRATIONS

Cover photograph by Jon Brenneis

Page	Source
17	Mount Wilson and Palomar Observatories
18-19	James Egleson (*top*), John Tremblay (*bottom*)
20	Radiophysics Division, Commonwealth Scientific and Industrial Organization
21	British Information Services
22-23	Jerome Snyder
24-25	Sara Love
26	Istanbul Museum of the Ancient Orient
27	Samuel Noah Kramer
28	University Museum, University of Pennsylvania
41-44	Eric Mose
45	Courtesy Homer W. Smith
46-47	Eric Mose
50-56	James Egleson
59-62	Bernarda Bryson
64	Forest Products Laboratory, U. S. Department of Agriculture (*left*); Eric W. Stark, Purdue University (*right*)
65	Forest Products Laboratory, U. S. Department of Agriculture (*left*); Simon Williams (*right*)
66	Eric W. Stark, Purdue University (*left*); Department of Wood Technology, New York State College of Forestry (*right*)
67	Forest Products Laboratory, U. S. Department of Agriculture
69-71	Irving Geis
80-82	Roger Hayward
84	Harry Ross
86	Roger Hayward

ADVERTISEMENT

How Would You Solve This Problem?

YOU READ a lot of magazines. You see a lot of ads. You've seen many of the printed messages from companies seeking trained scientific men.

Everybody runs them. We do, too. And they help attract important and valuable men.

But somehow they don't quite seem to measure up to the situation we have here.

None of the usual words or phrases gives exactly the picture we'd like people to see.

We Need Engineers

You see, we have a contract with the Atomic Energy Commission. We aren't making bombs or turning out isotopes. We are building a nuclear engine for a submarine—and our next big job is to build one for a large naval vessel. Maybe that sounds more like war work and less like putting atomic energy to useful work for mankind. But—the next steps will be atomic power equipment for peacetime purposes.

Power Is Our Business

And that's our primary purpose. Because Westinghouse's business is power.

We have some great things going on in our Atomic Power Division. And we have wonderful people out here, brilliant and inspiring to work with.

The point is that we need more of them . . . of the right kind. They don't have to know anything about atoms or atomic power, but they do have to know a lot about electronics and electrical and mechanical engineering.

. . . Electronic Engineers

The men we need in the electronics field should have had four to ten years experience with electronic computers employing pulse amplifying, wide range linear amplifying and rate circuits; they must have dealt with null balance devices employing both vacuum tube and magnetic amplifiers, servomechanisms and plant control systems; they should have had experience in liaison in those fields with customers or contractors and designers of component equipment.

. . . Electrical Engineers

The electrical engineers we need should have had experience with the design, development of application switchboards, regulators, motor controllers, especially in electrical ship propulsion . . . with process regulators, indicators and control devices for liquid level, flow, temperature and pressure . . . with servomechanisms, electrical and mechanical system analysis with particular familiarity with electronic controls and simulators and magnetic amplifiers . . . with power systems, apparatus and control equipment and systems.

. . . Mechanical Engineers

The mechanical engineers we need should have four to ten years of experience in the design or application of structural supports for machinery, high pressure piping and systems, rotating machinery, steam turbines, general steam apparatus and steam power systems, heat exchangers and condensers, hydraulic apparatus and systems, fluid flow, systems evaluations, heat balance, valve design, mechanical and hydraulic devices and mechanisms. They should have a thorough knowledge of the properties of materials. They should have experience, too, in liaison and coordination with subcontractors and customers, scheduling and planning of ship trials and customer testing of steam plants.

You'll Like Working Here

When we get people out here and talk to them, we find them ready and eager to work here. There is something fascinating about it. Maybe it's because there aren't many places in the world where the work you do seems to have much influence upon what's happening in the world. Out here, it might. Even if you only find a way to improve a heat exchanger.

We know the men we are after would like it here at Westinghouse. It's an engineer's kind of company. It's big, with thousands of employes, yet every fourth one is an engineer. Many of them have been here 20 and 25 years . . . and more than half the top executives are engineers.

There are good jobs here, at good money. And there will continue to be good jobs in this division . . . no matter what happens. Work on the atomic engines will go on. National security dictates that.

Your Wife Will Like It Here

And the wives of the men we are after will like it here, too. Sure, they'll have to live near Pittsburgh, but that's no punishment these days. This is not the Pittsburgh of old. Someone has said that Pittsburgh is now one of the most exciting cities in America. They've cleaned up the old smoke and dirt. They've torn down many of the old buildings. They're pouring billions into new residential areas, new high-speed boulevards, new parkways and other facilities for good living.

Enjoy Suburban Living

The plant is at the Bettis Field airport, 13 miles southeast of the city, in a suburban section of rolling hills. Not far away is Mt. Lebanon, one of the finest suburban living areas, where many of our people live, and Whitehall and Brentwood, bustling new communities where the downtown department stores have branches with lots of room to park. Your wife would like to know she can get all those Westinghouse appliances Betty Furness talks about at nice discounts.

For people who are just getting started, there are lots of one and two bedroom apartments within easy driving distance. For families with children, there are five colleges and universities and the fine school system that goes with that kind of higher education. For people who like cultural advantages, there is a fine symphony, an outdoor civic light opera, one of the world's great art exhibits, a top-ranking museum, a planetarium, famous Carnegie libraries.

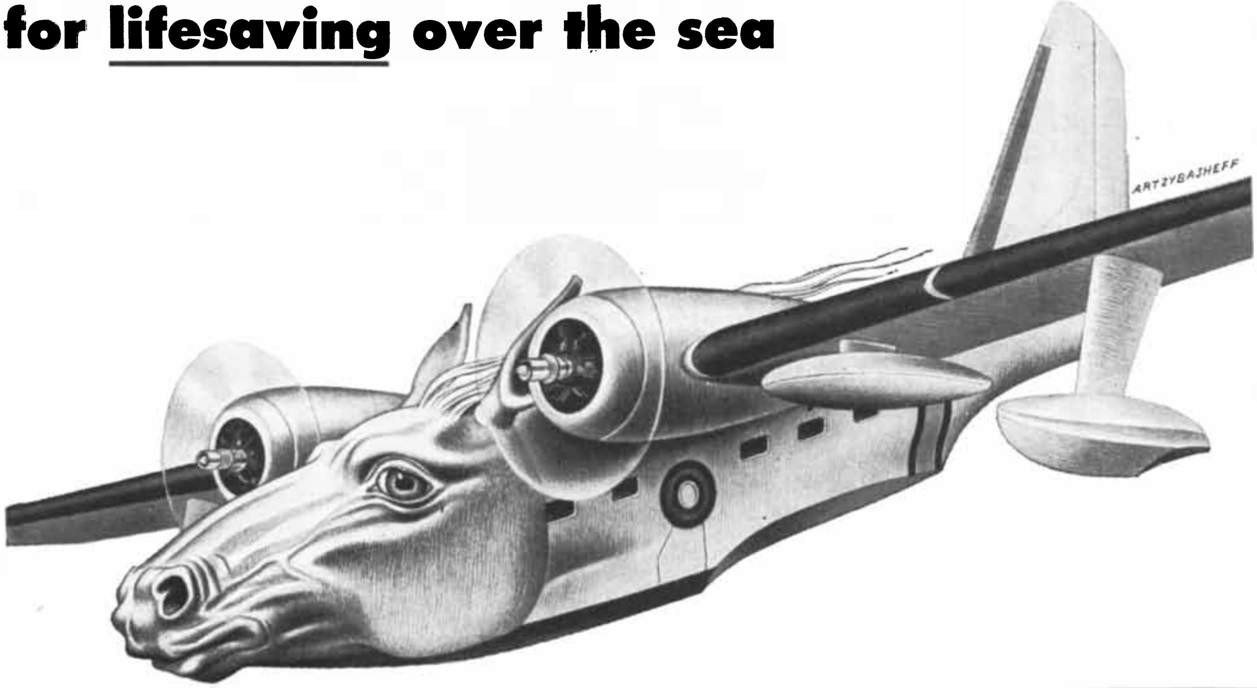
You Get Extra Benefits

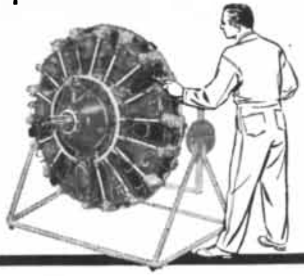
Westinghouse employes enjoy a lot of extra benefits, too—a modern pension plan; life, sickness and accident insurance and hospitalization; and the opportunity to purchase Westinghouse stock at favorable prices.

All in all, there can be great things in store for the right men if they write to C. F. Stewart, Atomic Power Division, Westinghouse Electric Corporation, Box 1468, Pittsburgh 30, Pa.

Our problem is to reach the right men. That's why we say "How would you solve this problem?"

Maybe you know someone who should be out here. *Maybe it's you.*


ARTZYBASHEFF




LYCOMING

SCIENTIFIC AMERICAN

Established 1845

CONTENTS FOR JANUARY, 1953 **VOL. 188, NO. 1**

ARTICLES

DEPARTMENTS

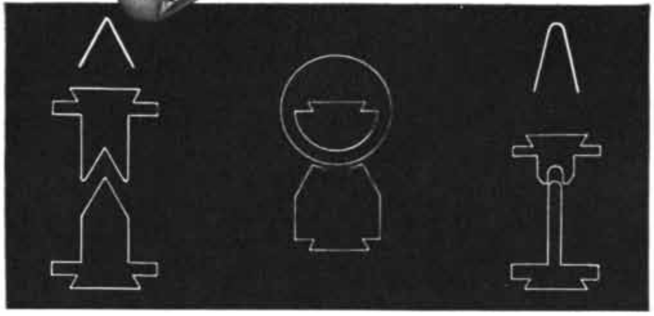
Publisher: Gerard Piel
Editor: Dennis Flanagan
Managing Editor: Leon Svirsky
Contributing Editors: Robert Hatch,
Albert G. Ingalls, James R. Newman,
E. P. Rosenbaum
Art Director: James Grunbaum
General Manager: Donald H. Miller, Jr.
Advertising Manager: Martin M. Davidson

What's Happening at CRUCIBLE

about scoring and cutting rule steel

Lengths of cutting rule steel after edging

Shaped to cut wallet section (note bends, and form-holding method)



Some examples of the many shapes of bends needed

Scoring and cutting rule steel is a cold-rolled specialty steel for use in preparing dies for cutting paper, leather, rubber and other materials.

It is a pre-tempered product manufactured by skilled workmen, using precision rolling and hardening equipment, to close limits for chemistry, grain size and hardness. This product must also be capable of meeting intricate bend requirements in the hardened and tempered condition.

This specialty is furnished with round edges and in coil form to the rule manufacturer who grinds the edges — the one edge square and the other to a knife edge as well as cutting the material into desired lengths. This is sold to a die-maker who bends the rule to the required shape. This is then the nucleus of a pre-hardened die, which when properly brazed and supported is used to cut out material for display cards — aircraft parts — pocketbooks — wallets — gloves — gaskets — washers.

engineering service available

Since there is a great diversity of cold-rolled products, our staff of field metallurgists can help you apply what you require. Take full advantage of Crucible's more than 50 years experience as the first name in special purpose steels. Crucible Steel Company of America, General Sales and Operating Offices, Oliver Building, Pittsburgh, Pa.

CRUCIBLE first name in special purpose steels

52 *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

JANUARY, 1953 VOL. 188, NO. 1

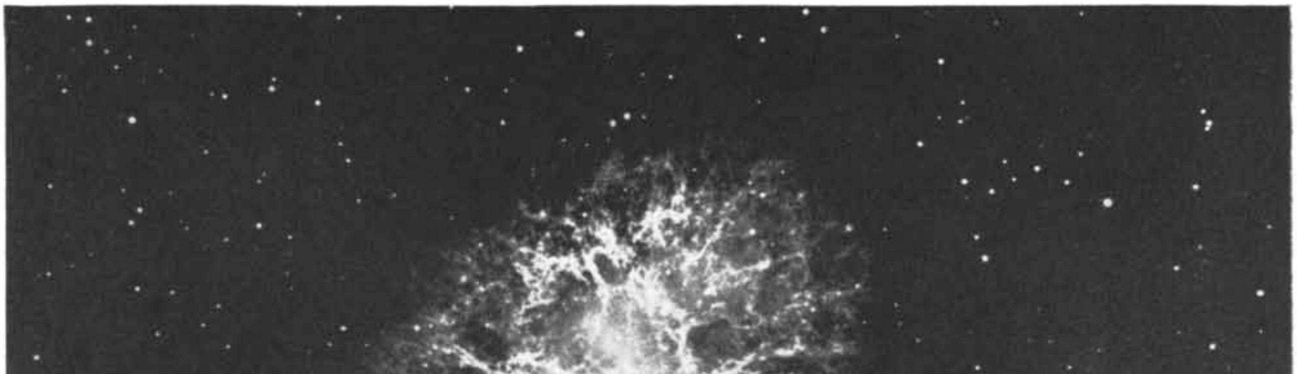
Radio Stars

Radio astronomers have discovered stars that emit little or no light but much radio energy. To study such objects English workers are building the biggest radio telescope

by A. C. B. Lovell

When a country that is struggling with a financial crisis and shortages of raw materials decides to spend a million dollars and 2,000 tons of steel on a single instrument for fundamental research, big dividends must be expected. Great Britain is now making such an investment in a new kind of gigantic telescope. It will be concerned with what may seem a visionary enterprise—the exploration of the universe—but Britain anticipates a rich harvest of discovery from the investment.

The story behind the decision to build this instrument is a thrilling chapter in the history of research. It is the story of radio astronomy. Until 20 years ago our only window into space was the visual region of the electromagnetic spectrum. We knew that our vision was somewhat obscured by dust and vapors clouding the starlight, but it seemed unlikely that outer space had many secrets which our great optical telescopes would not eventually reveal. Then quite by accident a new window was discovered in another part of the electromagnetic spectrum. While studying atmospheric radio disturbances Karl G. Jansky, an electrical engineer at the Bell Telephone Laboratories, picked up radio signals which he decided must be coming from outer space. His now famous discovery was

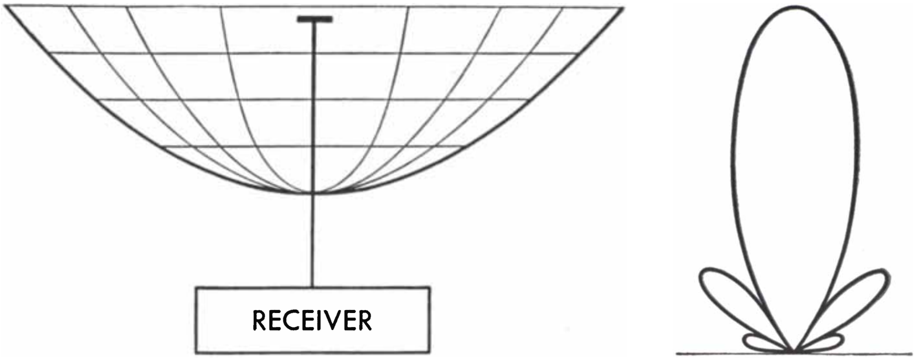


CRAB NEBULA, believed to be the remnant of a supernova recorded by the Chinese in 1054, is a radio star that also emits light. This photograph was made by Walter Baade with the 100-inch telescope on Mount Wilson.

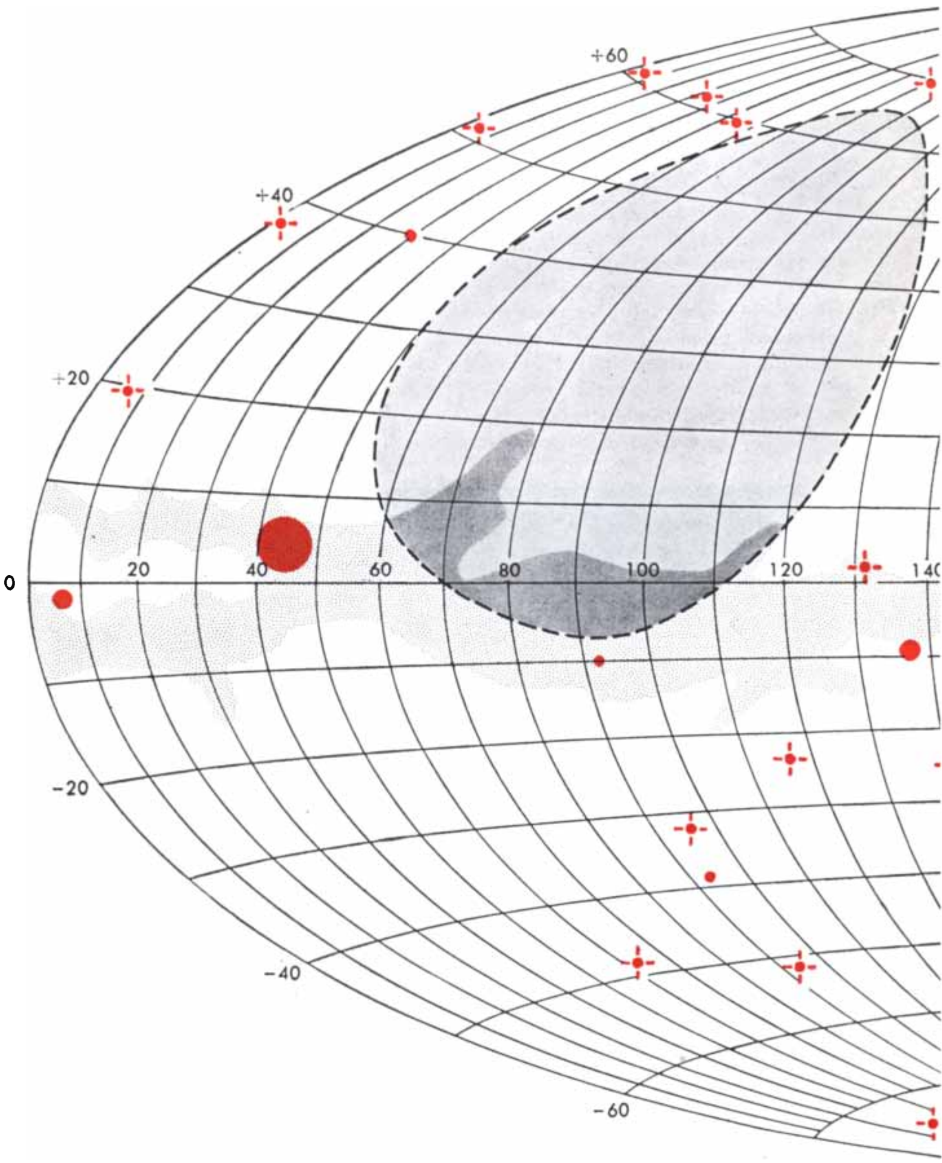
confirmed by the radio engineer Grote Reber, who built in his garden a 30-foot parabolic aerial with which he plotted the first radio map of the sky ["Radio Astronomy," by Grote Reber; Scientific American, September, 1949].

Reber's survey showed that the signals were strongest from the direction of the Milky Way, and that in general the regions of space with the thickest clusters of visible stars emitted the strongest radio waves. But Reber was not able to connect the radio signals with any specific object. He pointed his aerial in the direction of bright stars, extragalactic nebulae and other strong emitters of light, but none of them seemed to be the cause of the radio signals! Reber concluded that the radio waves probably were generated by atomic processes in the hydrogen gas in interstellar space. It was an interesting theory, but apparently not destined to lead to any startling revelations about the universe.

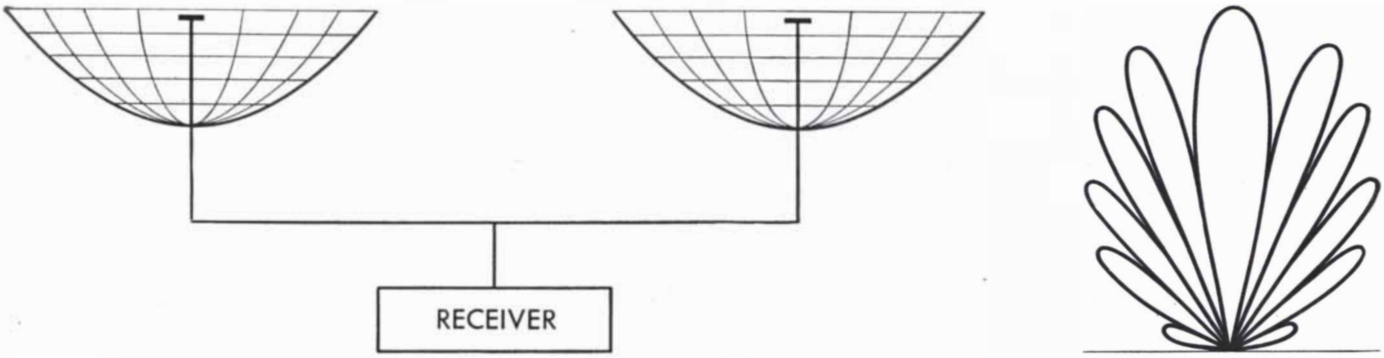
ASTRONOMERS at first took little account of the radio experiments. In 1948, however, there came a new development which decidedly quickened their interest. Reber's difficulty had been that his radio telescope had very poor resolution: it could not separate small objects in the sky because it received radiation in a beam several degrees wide. To focus on a small object a telescope must look into space in a narrow beam, and this requires that the reflector or other radiation receiver be very much larger than the wavelength of the radiation. The wavelength of the light waves collected by an optical telescope is only a few hundred thousandths of an inch. But the radio signals received by Reber's telescope had a wavelength of about six feet, and his 30-foot antenna could receive only a broad beam. In 1948 two experimenters on opposite sides of the world found a way to get better resolution of the sources of the radio signals. They were J. G. Bolton in Sydney, Australia, and Martin Ryle in Cambridge, England. They used a combination of two antennas, placed several hundred yards apart and connected to a single radio receiver. Radio waves coming in obliquely from space reached one aerial slightly before the other and therefore produced an interference effect, either reinforcing or opposing each other. As the earth rotates, this radio "interferometer" sweeps the sky with a fan of fine lobes, thus making it possible to get some idea of the size of the radio-broadcasting region in space; a source smaller than the space between the lobes would produce sharp maxima and minima in the strength of the received signal (*see diagram at top of opposite page*). To the great astonishment of astronomers, Bolton and Ryle found that at least some of the radio waves were coming from sources small enough to be called "radio



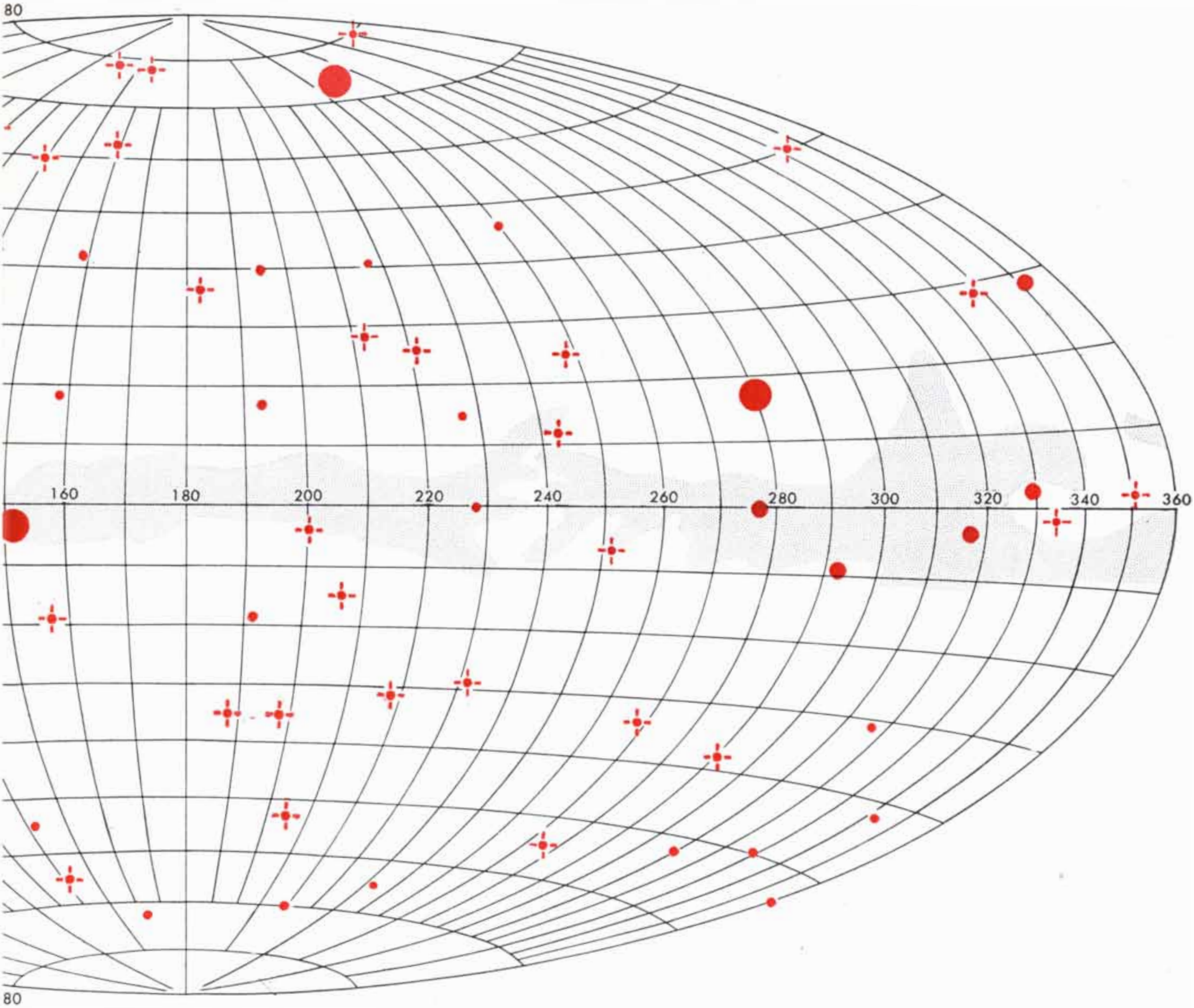
RADIO TELESCOPE is essentially a bowl which gathers radio energy from space. Most of the energy in its beam of reception (*right*) is concentrated in one lobe, thus it poorly resolves very small radio sources.



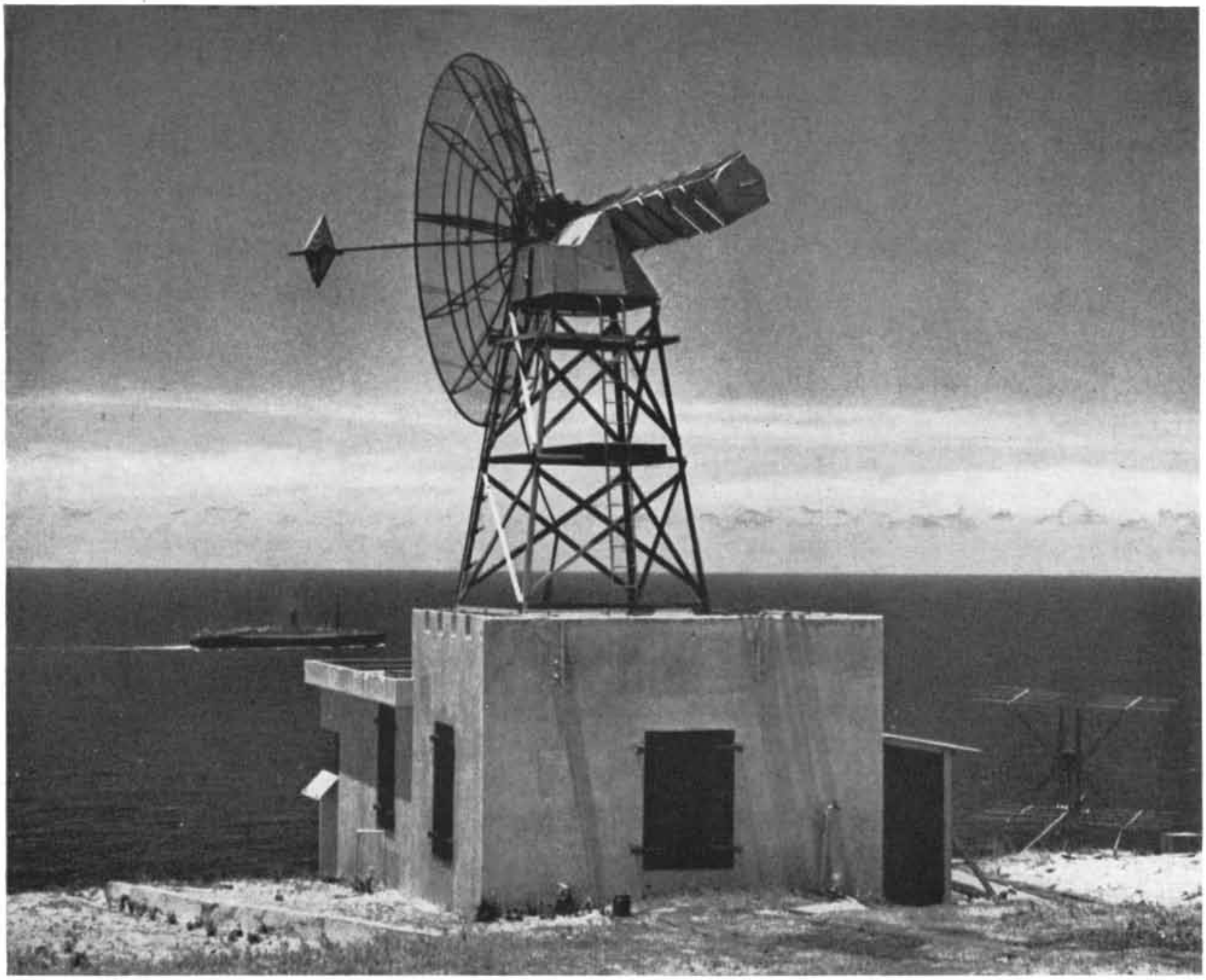
SEVENTY-FIVE RADIO STARS are located on a galactic chart made by Australian radio astronomers. The stippled area running from left to right represents the Milky Way. The gray area at the upper left is the



RADIO INTERFEROMETER is composed of two bowls and two antennae joined by the same receiver. The energy of its beam of reception (*right*) is divided into a fan of several lobes. Because the lobes are narrower than those of a single radio telescope, this instrument can resolve smaller sources of radio noise.



region not visible from Australia. The intensity of the sources is indicated by the following symbols: largest dot, more than 2.5; next largest dot, 2; next largest dot, 1.5; dot with cross, 1; smallest dot, under 1. The Crab nebula is represented by the large dot below the galactic equator between 140 and 160 degrees longitude.



AUSTRALIAN RADIO TELESCOPE overlooks the sea near Sydney. It is part of an interferometer that receives radio waves directly from a source in space and waves from the same source that are reflected from the water.

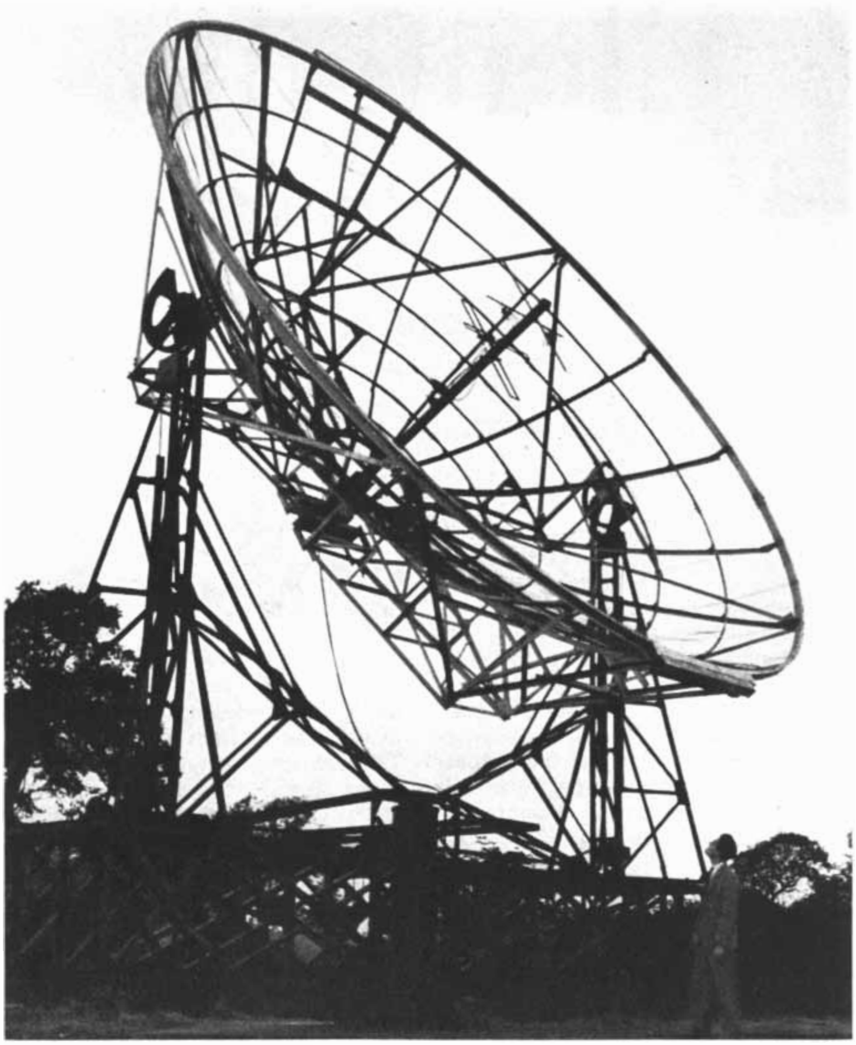
stars." Bolton found one in the constellation of Cygnus, and Ryle discovered an even stronger one in Cassiopeia. Subsequently many more radio stars were located.

The strangest feature of these discoveries was that none of the radio stars seemed to coincide with a bright star or any other visible object. The belief soon arose that the radio stars represented a hitherto unknown type of stellar object —dark or only faintly luminous, but with the facility of emitting intense radio waves. There seem to be a great number of these radio stars: more than 200 are now known, and it is very likely that vastly greater numbers will be found as radio telescopes are improved. In fact, there are grounds for believing that radio stars may be as numerous as the common visible stars.

In 1950 a large radio telescope was built at the Jodrell Bank station of the University of Manchester in England. It is similar in shape to the one originally used by Reber, but 220 feet in diameter, so that it can receive radio signals in a beam only two degrees wide. Its antenna is fixed, however, and it can survey only a small part of the sky. With this telescope R. Hanbury Brown succeeded in recording radio waves emanating from the great spiral nebula in Andromeda and from more distant galaxies. Thus it became evident that radio stars must be common not only in the Milky Way but also throughout the universe.

DETERMINED efforts have been made to unravel this strange mystery of a universe filled with radio-emitting bodies which have no obvious connection with the common stars, and in the last few months a little progress has been made. Among the radio stars detected by Bolton is one in the constellation of Taurus which coincides with an outstanding celestial object known as the Crab nebula. This nebula is believed to be the hot, expanding, gaseous shell of a supernova which exploded in 1054. The position and size of the radio star, the third most intense in the sky, coincide well with the position and size of that gaseous shell. Last summer Brown discovered a radio star in the position of another supernova—the one observed by Tycho Brahe in 1572, the remnants of which are no longer visible in telescopes. Hence it now seems well established that the remains of a great stellar explosion are capable of generating intense radio waves. One more check is needed to place the matter beyond doubt: detection of radio waves from the remains of the third known supernova, observed by Johannes Kepler in 1604. Unfortunately Kepler's object is outside the field of view of the fixed radio telescope at Jodrell Bank, and no other instrument of sufficient size is available to study it.

These three supernovae would account for three radio stars, but what about all the others? To study the situation more closely the astronomers on Palomar Mountain trained their 200-inch telescope on the region of sky containing the two most intense radio stars in Cassiopeia and Cygnus. This search, which began early in 1952, has been very fruitful. Near the Cassiopeia radio



ENGLISH RADIO TELESCOPE has a diameter of 30 feet. It has the same general design as that of the 250-foot telescope now being built.

star the telescope has revealed a region of diffuse gaseous nebulosity with some strange and still unexplained properties. The result of the investigation of the Cygnus region is even more startling. The Palomar observers Walter Baade and R. Minkowski believe that the Cygnus radio star is caused by the collision of two galaxies!

The general findings so far are indeed remarkable. Of the three strongest radio stars in the sky, one seems to be the remains of a star which suffered a violent death, another appears to represent whole galaxies in collision, and the strongest of all seems to be a very faint region of gas in violent motion.

AS THE SKY has been plotted in greater and greater detail with radio telescopes of improved resolving power, it has become clear that the regions with the greatest concentrations of stars generate the most intense radio waves. Even in our present state of uncertainty regarding the source of the radio waves, this relationship is of the utmost importance to astronomy. Our view of the star-rich central regions of the Milky Way is badly obscured by clouds of minute dust particles in interstellar space. In fact, it has been estimated that this dust must hide over 90 per cent of the stars in the Milky Way from visual detection by even our most powerful telescopes. Naturally this is a severe impediment to the study of the structure of our galaxy. Radio waves, however, can penetrate the dust without absorption and bring to the radio telescopes details of the hidden regions. The radio plotting of the sky is, therefore, a most important task. The work needs high resolution, and we have seen that this requires very large radio telescopes. That is the reason for undertaking the new telescope at Jodrell Bank.

Its design is based on the radio telescope which has been in use there for several years, but it will be much bigger, and instead of being fixed in one position it will be movable, so that it can be trained on any part of the sky. Some 500 tons of steel and concrete are now being sunk into the ground as the foundation for the instrument. The foundation will support a superstructure of 1,500 tons, mounted on a circular railway and driven by motors which will enable it to track automatically any object in the heavens. Its great antenna will be a steel bowl 250 feet in diameter and 60 feet deep at the center; the 300-ton aerial will pivot on an axis 180 feet above ground level.

The primary assignment of this great telescope will be to survey the heavens, but it will also be equipped for all other types of work in radio astronomy, including radar tracking of meteors.

The telescope will operate over a wide range of radio wavelengths. Until recently most of the work in radio astronomy was done in the range of wavelengths between one and 20 meters. But there has been increasing interest in the use of shorter wavelengths, and in 1951 this field was given a tremendous stimulus by one of those spectacular discoveries that have been so characteristic of work in radio astronomy. It had been suggested that the hydrogen atoms in interstellar space might, as the result of a certain change in energy state, emit radio energy at a wavelength of 21 centimeters. In 1951 radiation of this wavelength was actually detected, first by Harold I. Ewen and E. M. Purcell at Harvard University and then by others. Thus for the first time astronomers had a specific spectral line to work with in the radio spectrum. The lines in the visible spectra of the stars have been, as everyone knows, of enormous value to astronomy; for one thing, they have been the basis of the studies of the red shift in the light from distant stars and led to the theory of the expanding universe. In the same way studies of slight Doppler-effect shifts in the 21-centimeter radio line will make it possible to determine the relative motion of the earth and the clouds of hydrogen gas in space.

ASTRONOMY has marched forward with the growth in size of its telescopes. The need is always for more light-gathering power and more resolving power. In radio astronomy history will doubtless repeat itself; the building of radio telescopes with more sensitivity and more resolving power should yield striking advances in our knowledge of the universe. High hopes are entertained for the great engineering enterprise now under construction at Jodrell Bank. In combination with visual observations through the giant optical telescopes on the California mountains, it may well open a new era for astronomy.

A. C. B. Lovell is professor of radio astronomy at the University of Manchester.

Trace Elements

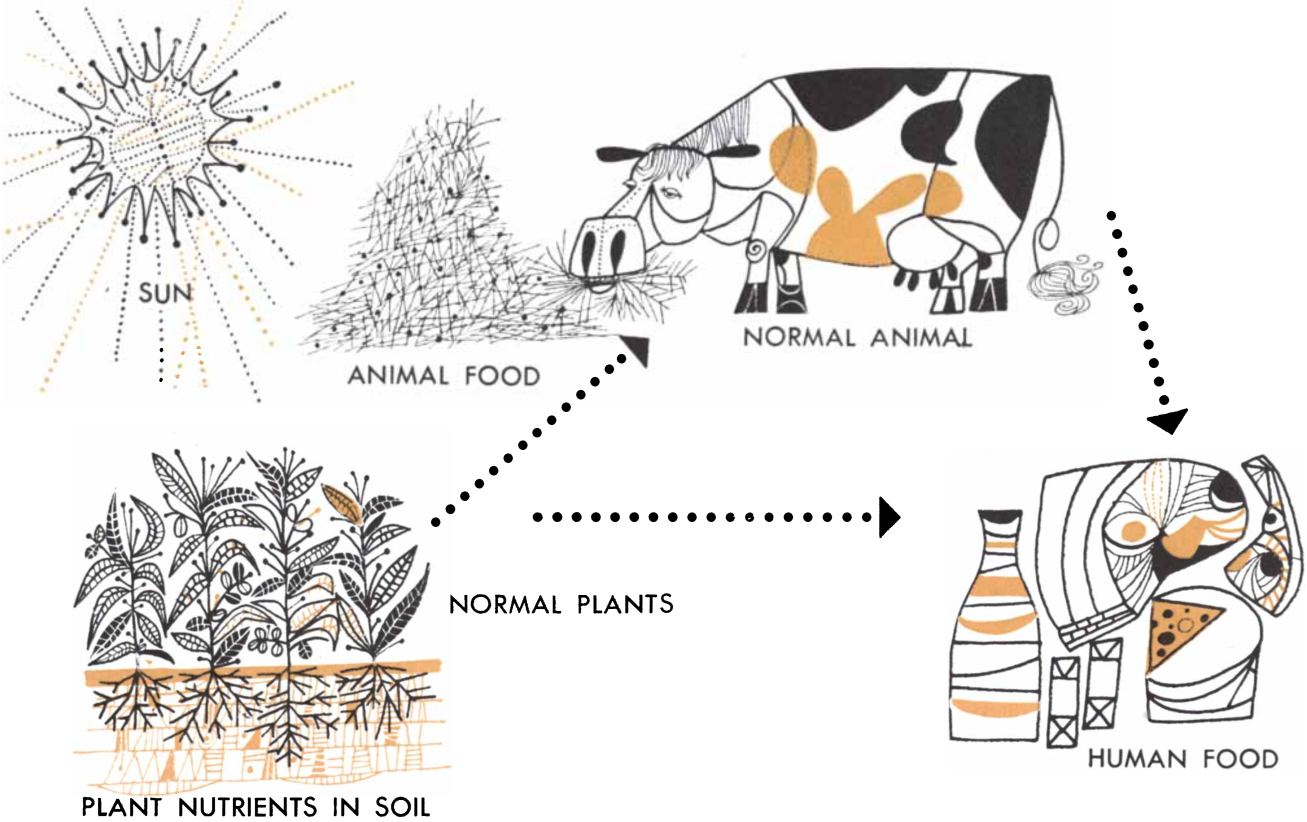
To maintain their health plants and animals require vanishingly small amounts of certain nutrients, the role of which is now under intensive investigation

by W. D. McElroy and C. P. Swanson

GOOD HEALTH is not simply the absence of disease; it is an active state of well-being. It requires the perfect functioning and teamwork of the multitude of structures in the organism, and this in turn depends on an adequate intake of a great variety of substances. The body is as delicately balanced as a fine watch, and can be thrown out of kilter by incredibly small deficiencies of nourishment. Everyone knows, thanks to modern advertising, how important to health the vitamins are. Less well known is the vital role of the so-called trace elements, a group of metals which are needed only in infinitesimally small amounts but without which neither animals nor plants can thrive.

Not all of the 60 elements that have been found in the cells of living things are essential to life. For example, gold, aluminum, fluorine and silicon are ingested by some plants, but they appear to have no nutritional significance. Of the elements used in small amounts (the "micronutrients," as biologists sometimes call them) eight have been found to be important. They are iron, copper, zinc, manganese, cobalt, iodine, boron and molybdenum. The first six of these are essential to animals. The first four and the last two are necessary to plants.

When an organism is deprived of a needed trace element, nutritionists say that it suffers from "hidden hunger." The deficiency may be hard to track down, though its results are obvious. A beautiful example of a trace element that signals its absence conspicuously



ROLE OF TRACE ELEMENTS in human nutrition is illustrated by this chart. When such elements are present in the soil, they are incorporated into the tissues of plants. The same elements are then utilized in the tissues of animals. Human food is plant and animal in origin, so man gets trace elements from both sources.

is iodine. Men have known for thousands of years that iodine deficiency causes goiter, but it took a great deal of study to find out how the lack of iodine produced the disease.

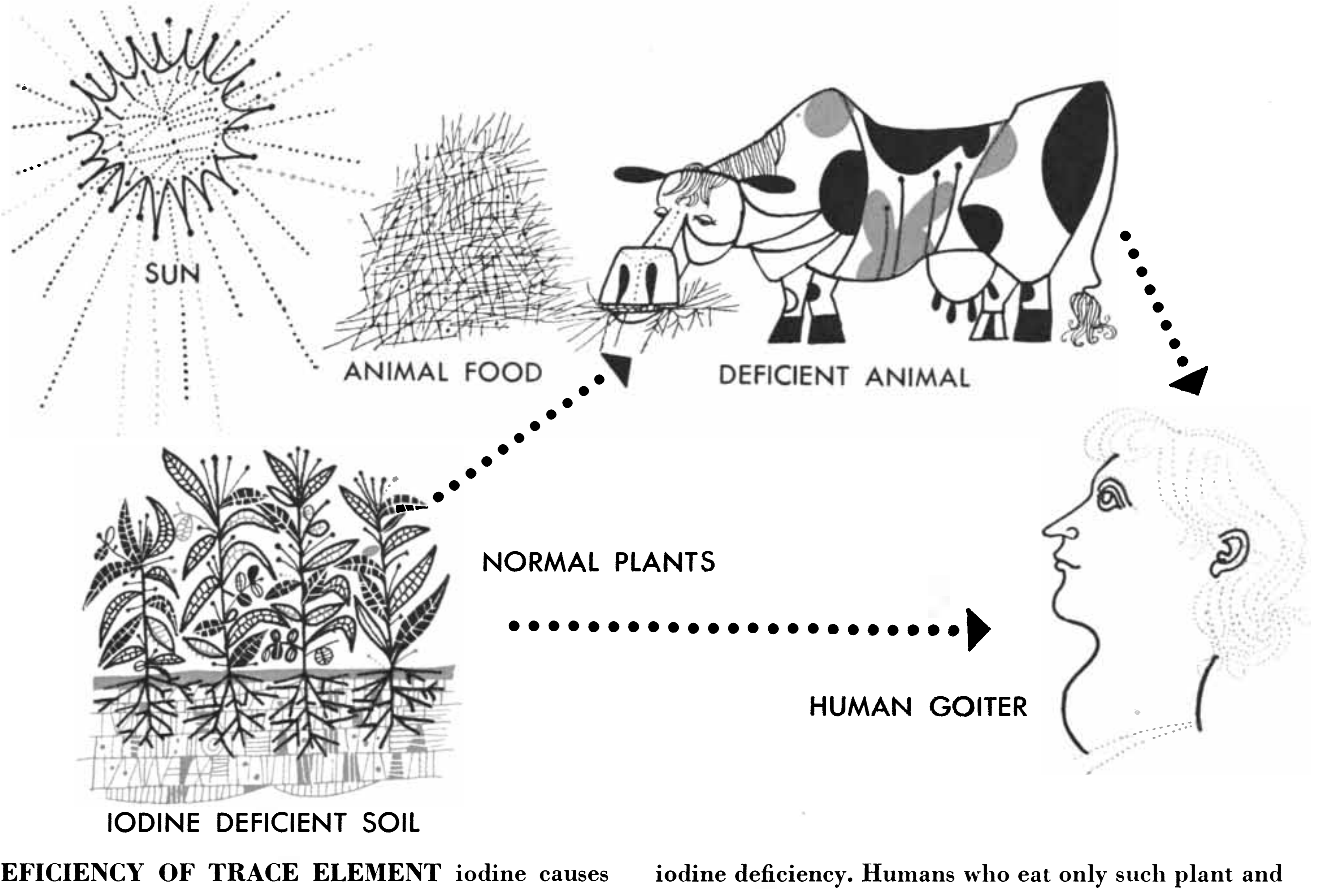
Goiter, whose hallmark is a tumorlike bulge at the neckline, is caused by malfunctioning of the thyroid gland. This gland manufactures thyroxine, a hormone circulated by the bloodstream and highly active in controlling the general metabolic level. Its function is analogous to the throttle of an automobile. If the gland produces too much thyroxine (hyperthyroidism), the effect is like pulling out the throttle when the engine is idle. The body races and the wear and tear are severe. A deficiency of thyroxine (hypothyroidism) produces the opposite effect. It can be compared to a partly clogged gas line. The body becomes sluggish; the patient suffers from physical and mental lethargy; he loses his ability to resist physical and psychological stresses. If the condition appears early in life, the individual fails to develop and becomes a helpless cretin.

THE THYROID gland is unable to make enough thyroxine when it lacks iodine, for this element makes up 65 per cent of the thyroxine molecule by weight. Only a tiny amount of iodine is needed (no more than one part in 10 million in the bloodstream), and the thyroid gland can store and accumulate the element until it reaches the necessary level.

Usually there is more than enough iodine in our ordinary diet, but in some regions the food and water do not supply the minimum requirements. This fact is dramatically illustrated by the distribution of goiter and cretinism in the U. S. The greatest incidence occurs in a Rocky Mountain belt from the Pacific Northwest eastward to Montana and southward to Colorado. There is another goiter region, where it is somewhat less prevalent, around the Great Lakes, in parts of Michigan, Minnesota and Wisconsin. In the Rocky Mountains, which were not inundated by prehistoric seas, and in the Great Lakes region, which was thoroughly scoured by the Pleistocene ice sheet, the topsoil and water have little or no iodine. Some waters of Lake Superior contain as little as one part of iodine per 100 billion, and the water sources of several Michigan villages have no detectable amount.

In these areas, therefore, iodine must be added to the diet. Iodized table salt is the agent most commonly used. The amount supplied in this way is apparently adequate even when iodine is entirely absent from the food and drinking water. In Detroit, for example, the incidence of goiter among school children was cut spectacularly from 35 per cent to less than 1 per cent in 11 years merely by giving them a little supplementary iodine. Iodized salt is now a standard supplement to the diet in iodine-poor areas the world over. The element is also provided to livestock, by means of iodized salt licks and the addition of sodium or potassium iodide to fertilizers for forage crops. As a result healthy sheep and swine can now be raised in iodine-deficient areas where goitrous sheep and pigs without hair (another symptom of thyroid deficiency) used to be common.

The ultimate source of the trace elements is the soil. It may be poor in them because of erosion, leaching, withdrawal by former crops or the absence of rocks containing these metals. Most of our early civilizations began in river valleys or on deltas at the mouths of rivers. They had no lack of inorganic elements, for the flooding rivers washed down silt from a wide and diversified region. As the populations expanded, they outgrew the choice sites and were forced to cultivate poorer soils. In some instances they reclaimed areas which had been abandoned because of their unsuitability. Many of these soils are poor in inorganic compounds. Deficiency diseases are so characteristic of the farm crops



DEFICIENCY OF TRACE ELEMENT iodine causes the effects illustrated here. Animals that eat plants grown in soil lacking iodine suffer the symptoms of iodine deficiency. Humans who eat only such plant and animal foods tend to develop goiter, the disease which is characterized by a tumorlike growth of the neck.

raised on reclaimed lands in Holland, Denmark and Australia that the term "reclamation disease" has been coined for them.

Presence of the essential elements in the soil does not necessarily prove that plants are absorbing them in sufficient quantities. The soil's acidity or alkalinity, its content of organic matter and moisture, its lightness or heaviness and its population of microorganisms—all this may affect the availability of the trace elements to plants. Iron is frequently bound in an unusable form. In waterlogged soils with a low oxygen content the readily available ferric compounds are generally converted into insoluble ferrous compounds. Treatment to increase the acidity of the soil can bring them back into solution. Where zinc is deficient, orchardists often correct the deficiency by driving a zinc nail into the tree trunk or by spraying with soluble zinc compounds. The availability of boron can be increased by making the soil acid, and of molybdenum by neutralizing the soil with lime. Manganese deficiency is prevalent in calcareous peats and other soils with a high organic content and a high water table.

HOW have investigators found out what trace elements are essential? At first thought the problem seems easy: Just eliminate the elements from the diet one by one and note the effects. But this is not as simple as it seems. The amounts required are so tiny that an animal may get enough of the withheld element as a contaminant of other substances in its food. Moreover, one metal may partly substitute for another and mask the deficiency. In the case of plants, however, it has become possible to get precise results by means of hydroponic cultivation; that is, growing plants in water with rigid control of the supply of each nutrient. If a specific nutrient is essential to the plant, its lack may either prevent the plant from developing or produce some visible symptom—in leaf color, fruiting, the ratio of root growth to top growth, the pattern of enzyme formation.

We know much more about the effects of trace element deficiencies than we do about how these substances operate in the organism. To determine that, one must submit to detailed analysis the chemical structure of the compound in which a trace element is found, or test its effect on a defined chemical reaction. So far this has been done for only a few of the trace elements. The most thoroughly studied have been iodine and iron, which occupies a central and irreplaceable position in the hemoglobin molecule.

A deficiency of iron produces anemia in animals, for 66 per cent of the iron in the body is contained in the hemoglobin of the blood and part of the rest is in the liver, spleen and bone marrow, where red blood cells are formed. Cobalt and copper also are in some way tied up with the formation of hemoglobin, for anemic patients who do not respond to iron dosage often do respond when cobalt or copper or both are added to the diet. Cobalt apparently is involved in the formation of the newly discovered antipernicious anemia vitamin B_{12}, but just how it fits into the picture is still unknown. Numerous anemic diseases of sheep and cattle have been traced to a deficiency of cobalt. Coast disease and bush disease in Europe, Morton's Main disease in Australia and New Zealand, lakeshore disease in Michigan and the so-called salt-lick disease in Florida—all forms of anemia—have several characteristics in common. The affected animals are runty, show a low hemoglobin concentration and grow progressively weaker. In severe cases they are unable to rise from the ground and usually die. The animals respond amazingly to cobalt, whether it is given to them directly or applied in fertilizer to the grazing areas.

A disease of Australian sheep which has been traced to a lack of copper produces marked and permanent effects on the nervous system. The first sign of this form of anemia is a deterioration of the wool. The individual strands lose their kinkiness and strength and take on a lustrous sheen. It is easy to detect this early symptom, and copper can be supplied before the damage becomes permanent. Apart from maintaining the hemoglobin content in the blood of higher animals, copper is also an important part of hemocyanin, the respiratory pigment of invertebrates.

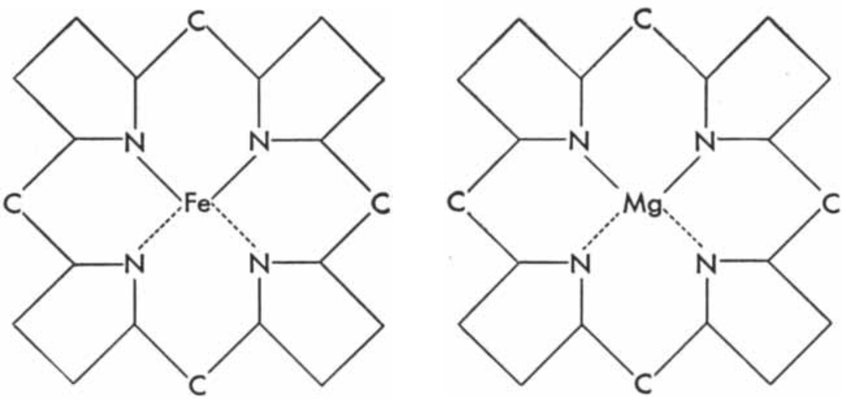
ZINC plays an important role in the respiratory system. It is one of the constituents of an enzyme, carbonic anhydrase, which first accelerates the combining in the tissues of carbon dioxide with water to form carbonic acid, and then helps to reverse this process in the lungs so that carbon dioxide can be exhaled from the body. Animals require about .004 gram of zinc per day.

Boron and molybdenum are the two trace elements required by plants but not by animals. A deficiency of boron causes many well-known physiological diseases among crop plants. The names of these diseases characterize their effects and suggest their economic importance to farmers: heart rot of beets, brown heart of turnips, cracked stems of celery, top sickness of tobacco, internal cork of apples, browning of cauliflower, yellows of alfalfa. The amount of boron needed to correct these conditions is remarkably minute. Many plants show no deficiency symptoms until the boron level in the soil drops below one hundredth of a part per million. The limits of tolerance are narrow; an increase of boron to one part per million will poison the same plants. In other species, one part per million is optimal while five parts per million are toxic.

Molybdenum apparently is involved in the nitrate reduction processes essential for all plants. It also seems to be necessary for nitrogen fixation by the root nodule bacteria of leguminous plants such as the clovers and alfalfa. This element is rarely lacking in the soil; the problem is that plants occasionally accumulate it in concentrations high enough to poison animals.

It would be a mistake to suppose that a deficiency of trace elements in the diet of plants can be corrected simply by adding the necessary substances to the soil. The additions may easily poison the plants; for example, in some soils as little as 20 pounds of borax per acre can ruin a potato crop. Crop yields are poor in the vicinity of tailings from zinc and copper mines, and many a housewife has found to her sorrow that a plant may die after being transplanted to a copper pot.

There is no rule of thumb for supplying the proper amount of trace elements, because every species of plant has its own requirements and tolerances, and the effects of the various trace ele-



IRON AND MAGNESIUM play a similar role in hemoglobin (*left*) and chlorophyll, partial structures of which are shown in highly schematic form.

ments are interrelated. As we have noted, copper and cobalt are associated with iron in the production of hemoglobin. In like manner copper and iron influence the formation of chlorophyll, although only magnesium enters directly into the chlorophyll molecule. An excess of molybdenum in an animal's diet leads to pronounced copper deficiency symptoms, even though sufficient copper is present. Studies of the element selenium give a clue as to why this may be so. So far as we know, selenium is not an essential nutritional element. Plants can accumulate it, however, in rather large amounts, and they are then highly toxic to animals that chance to eat them. Selenium appears to displace sulfur in certain key molecules. It thereby inactivates them and so interferes with the sulfur metabolism of the body. Perhaps molybdenum acts in a similar way on copper.

THE BEST WAY for us to assure ourselves of an adequate supply of trace elements is to eat foods grown on many types of soil. Except in a few isolated and more or less closed communities, the population of the U. S. is reasonably safe in this respect because of its extensive and rapid food transportation facilities. An average dinner may include potatoes from Maine or Idaho, green vegetables from the Imperial Valley or the Rio Grande; meats from the ranges of the West and the South and fruits from California, Florida, Michigan or New York. In other countries, where the food is consumed locally and the diet is less varied, the danger of deficiency may be greater. The problem does arise in our own country, but in a different form. Our milling processes for sugar and flour have so over-refined these foods, once excellent sources of iron, that they must now be "enriched" to bring them back to their former nutritional value.

In general the diet should contain as many of the elements as possible. Many of them, while not essential, are nevertheless beneficial. Fluorine is a case in point. It appears to reduce the incidence of tooth decay, particularly in children, and is now added to the water supply in some fluorine-deficient regions.

ENZYME	REACTION	METAL
Carbonic anhydrase	$CO_2 + H_2O \rightleftarrows H_2CO_3$	Zn
Inorganic pyrophosphatase	Pyrophosphate + $H_2O \longrightarrow PO_4$	Mg
Catalase	$2H_2O_2 \longrightarrow 2H_2O + O_2$	Fe
Cytochromes	Electron transport	Fe
Tyrosinase	Tyrosine + $\frac{1}{2}O_2 \longrightarrow$ hallochrome	Cu
Laccase	Phenols ⟶ ortho and paraquinones	Cu
Ascorbic acid oxidase	Ascorbic acid ⟶ dehydroascorbic A	Cu
Prolidase	Glycylproline ⟶ proline	Mn
Dehydropeptidase	Glycyldehydrophenylanine ⟶ glycine, + NH_3 + phenylpyruvic A	Zn
Carboxypeptidase	Chloroacetyl-tyrosine ⟶ tyrosine	Mg
Glycylglycine dipeptidase	Glycylglycine ⟶ glycine	Zn

ENZYMES use trace elements to catalyze reactions. The elements here are zinc (Zn), magnesium (Mg), iron (Fe), copper (Cu), manganese (Mn).

CLEARLY the trace elements must function in some way as catalysts in metabolism, since the quantities required are so small. In this respect the trace elements are like the vitamins, which also act as catalysts in the metabolic machinery. For example, a form of the vitamin niacin combines with certain large protein molecules to make up some of the body's enzymes—those catalysts of the organism that largely govern its chemistry. These particular enzymes, containing niacin, assist the transfer of hydrogen from one compound to another. Riboflavin acts in a similar manner: in cooperation with hemoglobin-like molecules it enables hydrogen to join with oxygen and form water. This appears to be the main pathway by which animals use oxygen during metabolism. If any of these vitamins are lacking in the diet, the transfer process is seriously impeded, and in the long run the metabolic machinery breaks down.

Now the trace elements appear to be an integral part of certain enzyme systems, just as vitamins are. A great deal of research is now being conducted to determine what specific enzyme or enzymes are affected by deficiencies of particular trace elements. For example, the enzyme which causes a cut apple to turn brown has been found to require copper. The brown color results from the oxidation of certain compounds in the apple when they are exposed to air, and copper facilitates this process. The trace element requirements of many such enzymes are now known, and a few of them are listed here (*see table above*). At least one non-replaceable function in an enzyme system has been identified for every trace element except boron and manganese. Various enzymes that assist in oxidation require iron and copper to do this; no other metal can replace them. Zinc is an indispensable part of the catalyst concerned with the transport of carbon dioxide. We know that molybdenum is essential for nitrogen fixation and nitrate utilization in plants, though we have not yet isolated the enzyme systems in which it participates. There is considerable evidence that cobalt, besides being an essential element in vitamin B_{12}, is important in the metabolism of sulfur-containing amino acids.

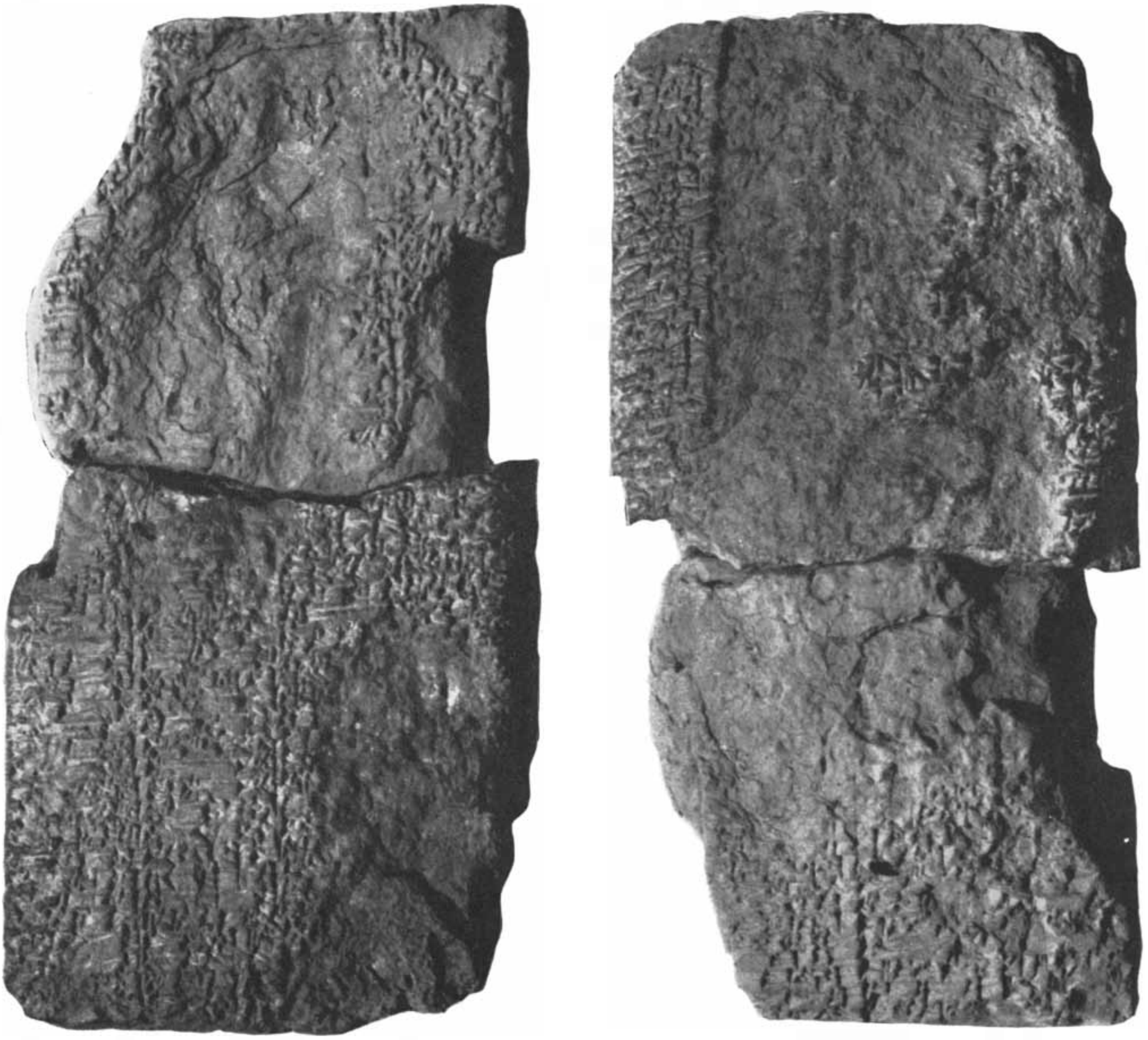
We are now learning that nonessential elements also can play a role in the metabolic processes. There are enzymes which can get along with any one of various metals. It follows that the alternative metals, though not essential, may exert a profound influence on plant and animal metabolism. Furthermore, we have discovered that by varying the trace-element supply we can produce important changes in the enzyme concentration of a growing plant without affecting the final growth of the organism. Both essential and nonessential elements will cause these enzymatic changes. Further study along these lines may yield a means of early diagnosis of deficiency conditions which do not show up in growth measurements. They may also enable us to alter plant and animal enzymes in ways to increase the yield of a given product. Examples of such improvements might be a stronger wool, a higher yield of penicillin or an increase in nitrogen fixation in the soil.

W. D. McElroy is director of the McCollum-Pratt Institute for the investigation of micronutrient elements at The Johns Hopkins University. C. P. Swanson is professor of biology at the same university.

THE OLDEST LAWS

On a clay tablet in Istanbul a University of Pennsylvania archaeologist has found the enlightened code of Ur-Nammu, who reigned over Sumer and Ur more than 4,000 years ago

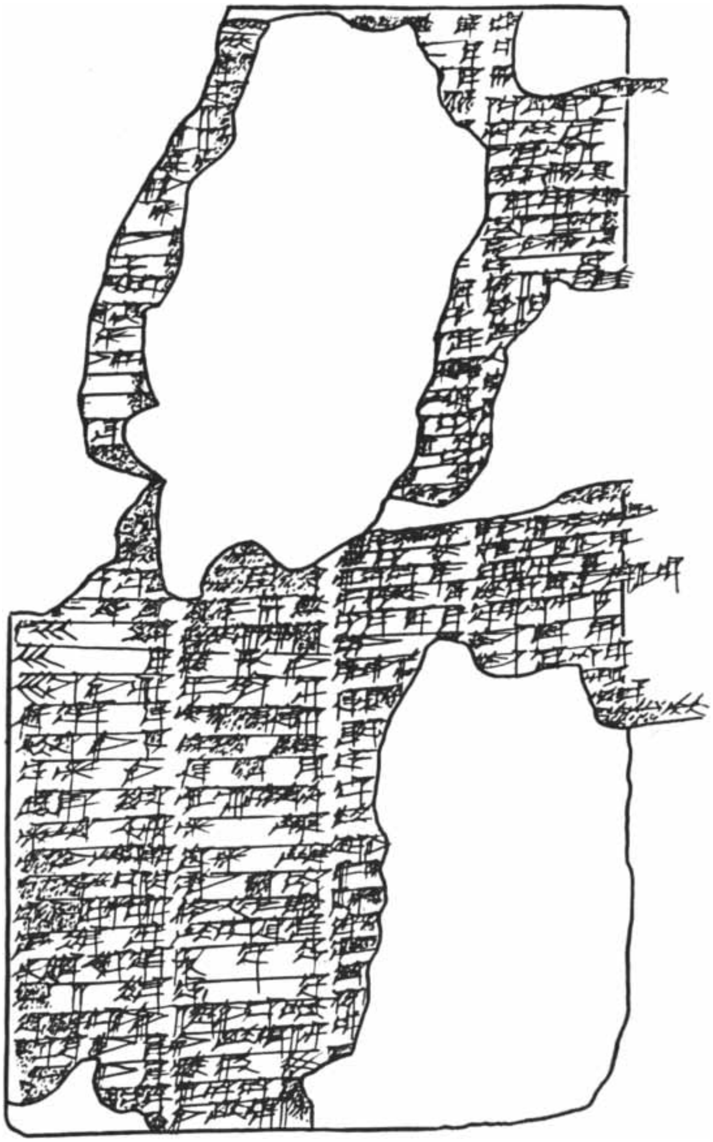
by Samuel Noah Kramer



TABLET is shown in the two photographs on this page. At the left is the obverse; at the right, the reverse. Found 50 years ago in the ruins of Nippur, the tablet is now in the Istanbul Museum of the Ancient Orient.

I PROBABLY would have missed the tablet altogether if I had not received a letter from a colleague in Austria. It was written by F. R. Kraus, whom I had met a number of years before when he was curator of the Istanbul Museum of the Ancient Orient, and who is now professor of Oriental studies at the University of Vienna. Hearing that I was once again in Istanbul, this time as a Fulbright research scholar, he wrote me a letter reminiscing of old times. But one paragraph of his letter talked shop. In connection with his duties at Istanbul, he had once come upon two clay fragments inscribed with Sumerian laws. He had joined the pieces and had catalogued the resulting tablet as number 3191 of the museum's Nippur collection. I might be interested in its contents, he wrote.

Since Sumerian law tablets are extremely rare, I had 3191 brought to my work table at once. It was a sun-baked, light brown tablet about eight inches high by four inches wide. More than half of the writing was destroyed, and what remained seemed hopelessly unintelligible. But after several days of concentrated study I began to make headway. Soon I realized, with no little excitement, that what I held in my hand was a copy of the oldest law code yet known to man. It was promulgated by Ur-Nammu, the Sumerian king who founded what the history books call the Third Dynasty of Ur. By the most conservative estimates Ur-Nammu reigned at least as early as 2050 B.C., some 300 years before the renowned Semitic lawgiver Hammurabi.


COPY of the obverse was made by the author to help in its translation. The tablet is inscribed with the Sumerian language in cuneiform script.

Until only five years ago the Hammurabi code, written in the cuneiform script and in the Semitic language known as Babylonian, was by all odds the most ancient brought to light. It contains, sandwiched between a boastful prologue and a curse-laden epilogue, close to 300 laws, which run the gamut of man's civil deeds and criminal misdeeds. The stone pillar on which the code is inscribed now stands in the Louvre for all to see and admire.

In 1947 an older code than Hammurabi's came to light. Promulgated by Lipit-Ishtar, a king who preceded Hammurabi by more than 150 years, it is written not in stone but on a clay tablet, in the cuneiform script of the non-Semitic Sumerian language. The Lipit-Ishtar code, as it is now generally called, has a prologue, an epilogue and an unknown number of laws, of which 37 are preserved wholly or in part ["If a Slave Girl Fled. . .," by Francis R. Steele; SCIENTIFIC AMERICAN, June, 1948].

Lipit-Ishtar's claim to fame as the world's first lawgiver was short-lived. In 1948 Taha Baquir, the curator of the Iraq Museum in Baghdad, announced the discovery of two tablets containing an older law code. Written, like the Hammurabi code, in the Semitic Babylonian language, it mentions Bilalama, a king who lived some 70 years before Lipit-Ishtar.

Now the code of Ur-Nammu, a far more important ruler than Bilalama, takes us back at least 100 years earlier.

THE ANCIENT scribe who set down Ur-Nammu's laws divided the tablet into eight columns, four on the front and four on the back. The front contains a long prologue, only partly decipherable. Its gist is:

After the world had been created, and after the fate of the land Sumer and of the city Ur—the Biblical Ur of the Chaldees—had been decided, An and Enlil, the two leading deities of the Sumerian pantheon, appointed the moon-god Nanna as the king of Ur. Nanna chose Ur-Nammu to rule over Sumer and Ur as his earthly representative. The new ruler acted first to secure the political and military safety of Ur and Sumer. In particular he waged war against the bordering city-state of Lagash, which was expanding at Ur's expense. He defeated Lagash and put to death its ruler; then, "with the power of Nanna, the king of the city," he re-established Ur's former boundaries. Next Ur-Nammu turned to internal affairs and began to institute social and moral reforms. He removed from office the "grabbers" of the citizens' oxen, sheep and donkeys. He set up and enforced a system of honest weights and measures.

BAS-RELIEF from the ruins of Ur depicts Ur-Nammu wearing a long beard and a close-fitting cap. In the central panel he appears twice making libations to the moon-god Nanna (*seated at right*) and his consort Ningal (*seated at left*). In the bottom panel Ur-Nammu carries tools to build a temple for the two divinities.

He saw to it that "the orphan did not fall a prey to the wealthy," "the widow did not fall a prey to the powerful," "the man of one shekel did not fall a prey to the man of one *mina* [sixty shekels]."

It was no doubt to insure justice in the land and to promote the welfare of its citizens that Ur-Nammu promulgated the laws which followed this prologue. The laws themselves probably began on the back of the tablet. This is so badly damaged that the substance of only five laws can be read and translated with confidence. One seems to concern a trial by the water ordeal, another the return of a slave to his master. The other three laws, fragmentary though they are, have a special importance in the history of man's social and spiritual growth. They show that even before 2000 B.C. the law of "eye for eye" and "tooth for tooth"—still prevalent in the Biblical statutes of a much later day—had already given way in Sumer to the more humane policy of imposing a money fine.

THESE THREE laws follow, at the left in the original Sumerian as transcribed into our alphabet, and at the right the literal translation. The section in brackets is not on the tablet but is surmised from the form of the laws.

tukum-bi	If
[lu-lu-ra	[a man to a man
gish-. .-ta]	with a . .-instrument]
. .-a-ni	his . .
gir in kud	the foot has cut off,
10-gin-ku-babbar	10 silver shekels
i-la-e	he shall pay.

tukum-bi	If
lu-lu-ra	a man to a man
gish-tukul-ta	with a weapon
gir-pad-du	his bones
al-mu-ra-ni	of . .
in-zi-ir	severed,
1-ma-na-ku-babbar	1 silver mina
i-la-e	he shall pay.

tukum-bi	If
lu-lu-ra	a man to man
geshpu-ta	with a geshpu-instrument
ka- . . in-kud	the . . nose (?) has cut off,
⅔-ma-na-ku-babbar	⅔ of a silver mina
i-la-e	he shall pay.

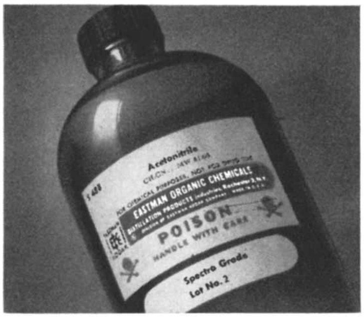
How long will Ur-Nammu retain his crown as the world's first lawgiver? Briefly, I fear, for there are indications that rulers wrote laws in Sumer generations before Ur-Nammu was born. Sooner or later a lucky digger will come up with a law code preceding his by a century or more.

◆

Samuel Noah Kramer is Professor of Assyriology in the University Museum of the University of Pennsylvania. He was author of "Sumerian Farmer's Almanac," which appeared in the November, 1951, issue of this magazine.

Kodak reports to laboratories on:

our new spectrophotometric solvents . . . an *f*/0.75 lens . . . reducing records by microfilming . . . our new guide to successful photomicrography



Spectrophotometric solvents

The solvents employed in infrared and ultraviolet spectrophotometry are mostly such common ones as chloroform, cyclohexane, carbon tetrachloride, methanol, iso-propyl alcohol, etc., but highly uncommon is the freedom required from optically absorbing impurities. The primary producers from whom these solvents flow by the tank car are rarely prepared to supply them in spectrophotometric grade and in contamination-resistant 500 cc packaging. We are. (In special 3-liter bottles, too.) In the new 38th edition of the famous Eastman Organic Chemicals catalog we designate them by the prefix "S" before the catalog number. There are an even dozen of them (so far), and we shall be happy to send you a small wall chart that gives their infrared "windows" and ultraviolet cut-offs.

For a free copy of the catalog and/or the chart, or to place your order for solvents, write Distillation Products Industries, Eastman Organic Chemicals Department, Rochester 3, N. Y.

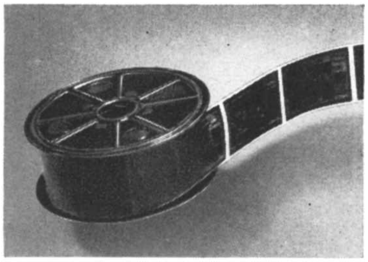
f/0.75

For cases where light must be husbanded to the utmost, as in certain experiments in cine-fluorography, we have developed a lens that forms an image at an effective relative aperture of *f*/0.80 or an equivalent *f*-number of 0.75. Hereby is announced the availability of this lens for any job requiring an optical system capable of laying down an exceedingly sharp, flat image with just about the highest utilization of light rays that today's lens designers can achieve. Here are some vital statistics about this new Kodak Fluro-Ektar Lens, 110 mm *f*/0.75. It's achromatized in the middle of the green (not for ultraviolet use). Designed for 16:1 minification. Gives excellent definition of a 12″-diameter object circle on a ¾″-diameter image, good definition over a 1″-diameter image, acceptable definition out to a 1¼″-diameter image (which corresponds to the corner of the ¾″ by 1″ standard silent 35mm movie frame). Length of element array, 208 mm; distance from object plane to first surface, 1808 mm; distance from rear surface to image plane, 7.3 mm. Price on request.

If you have need for such prodigious lens "speed," we suggest you get in touch with Industrial Optical Sales Division, Eastman Kodak Company, Rochester 4, N. Y.

Microfilming

There comes a day in the growth of a laboratory when the sheer physical volume of accumulated records becomes a menace. One way to keep from being inexorably drowned in paper is to take recourse in a giant-sized wastebasket. But, as night follows day, what is thrown out now winds up next week as a vitally needed scrap of paper reposing somewhere in a bale of waste. The answer, of course, lies in a well-planned system of microfilming which lops off some 98% of the bulk of a mass of records. If you'd like to start thinking about it now, you can find all the facts in a new 60-page booklet we have prepared.



Just ask your Kodak dealer for the Kodak Industrial Data Book, "Microfilming with Kodagraph Micro-File Equipment and Materials." It costs 50 cents.

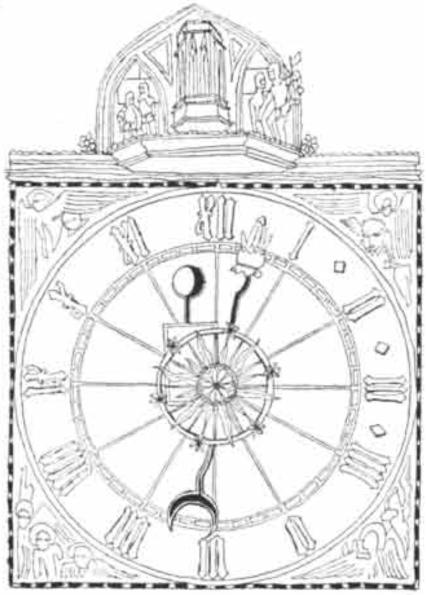
Photomicrography

Books, good ones, on the microscope and its use are not particularly scarce. One of them came out in its 17th revised edition in 1947, running to 617 pages. We have just published a brand new one on photography through the microscope that has just 68 pages, in the course of which our photomicrographic experts hit the highlights on such matters as resolution, choice of camera and light sources, characteristics of photographic materials for photomicrography, determination of exposure, and the use of filters. Rung by rung, we take the reader up the ladder of procedural sophistication from a simple hand camera setup through bright-field, dark-field, reflected light, and polarized light techniques and on into the realms of color. We discuss the salient facts about ultraviolet, infrared, phase contrast, cinephotomicrography, and electron micrography. It's quite a booklet, and you can get it for just 50¢ from your Kodak dealer. Ask him for the Kodak Industrial Data Book, "Photography Through the Microscope."

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



Trouble in UNESCO

TWO developments shook the United Nations Educational, Scientific and Cultural Organization at its Paris General Conference last month. First was the admission of Spain as the 66th member nation. This step had been bitterly opposed by a number of individuals and nations, and led to the resignation of some delegates.

A few days later UNESCO's Director General, Jaime Torres Bodet, resigned in protest against the failure of the Conference to approve his budget for the next two years. Torres Bodet's request for $20.4 million was trimmed to $18 million by a vote of 29 to 21, with four countries abstaining. In presenting his budget Torres Bodet remarked that "ever since UNESCO came into being, the gap between its aims and its resources has been abysmal, and notwithstanding the views of many skeptics, there is still today an enormous contrast between its technical possibilities and its financial means." He resigned, he said, because the $18 million represented "a true budget lower than that of the preceding year," and because the closeness of the vote was "evidence of disaccord" among the members.

Many delegates from countries in Asia, Africa and Latin America joined Torres Bodet in attacking the budget reduction. Although the drive for economy had been spearheaded by the British Commonwealth nations and the Scandinavian countries, most of the criticism was directed against the U. S. The small-nation delegates pointed out that this country's additional expense under Torres Bodet's budget would have come to $90,000, and contrasted this figure with U. S. military appropriations. Howland H. Sargeant, Assistant Secretary of State and chairman of the U. S. delegation to the Conference, drew attention to the fact that $5.5 million will be available to UNESCO this year from the UN technical assistance funds. He affirmed the U. S. belief in UNESCO and pledged continued support.

The Conference appointed John W. Taylor of the U. S. as interim director general, pending a meeting next spring. Taylor is a former president of the University of Louisville.

Thermonuclear Experiment

HAS the "hydrogen age" dawned? Whether or not it has is known only to a few scientists and top officials in the Government. Early in November the Atomic Energy Commission conducted a nuclear bomb test in the Marshall Islands which evoked excited letters home from some of the servicemen with the task force. They wrote of a bomb that had been carried across the Pacific behind welded doors, of an explosion as bright as "10 suns," of an entire island that had burned up and disappeared. Newspapers published some of the letters. The syndicated newspaper columnist Stewart Alsop wrote: "The fact that the U. S. has tested the world's first hydrogen bomb is now, surely, the world's most open secret."

The AEC simply announced that "experiments contributing to thermonuclear weapons research" had been included in the Eniwetok tests, and that "scientific executives for the tests have expressed satisfaction with the results." Comment from prominent scientists ranged from Harold Urey's remark that "it sounds like official language for a successful H-bomb" to Enrico Fermi's more limited conjecture that "some sort of large-scale explosion took place." In a television interview Vannevar Bush, former director of the Office of Scientific Research and Development, emphasized the word "experiment" in the AEC statement. "The Commission says this was an experiment in thermonuclear reaction," he said, "and I think there is a great difference between experiments and practical application."

William L. Laurence, science reporter of *The New York Times*, interpreted the Commission's announcement to mean that a hydrogen fusion reaction involving deuterium, tritium or both had been accomplished; that the questions of whether a sufficiently high temperature could be generated by an atom bomb, and whether the materials could be held together long enough for fusion to begin, had been answered affirmatively. He concluded that a "test-tube" hydrogen bomb had been exploded.

The closest approach to an appraisal

from an "informed source" came from J. Robert Oppenheimer, chairman of the AEC General Advisory Committee, who said that "these tests are very remarkable technical developments and technically a very impressive piece of work." But the military significance of the work remained speculative. If a fusion reaction was accomplished, there were still the questions of how large an effective hydrogen bomb could be made and how useful such a weapon might be from a military point of view.

New Chairman

WHO will succeed the late Brien McMahon as chairman of the Joint Congressional Committee on Atomic Energy when the new Congress is organized? In Washington speculation last month the leading candidate was Republican Representative W. Sterling Cole of New York. Cole is a lawyer who has been in the House since 1935. He has been a member of the Committee since its beginning, and was its first vice-chairman. He also serves on the House Armed Services Committee.

Scientific Manpower in Russia

THE U.S.S.R. has more than doubled its professional force in science, technology and medicine in the past 15 years, according to Demitri Shimkin of the Russian Research Center at Harvard University. From official Russian figures he calculates that 860,000 graduates of higher education are now employed in professional positions in the U.S.S.R., against 358,000 in 1937. Of the present total, 475,000 are engineers and natural scientists, 240,000 physicians, dentists and pharmacists, and 145,000 agricultural specialists. In 1952 there were 974,000 students enrolled in schools of higher education, and the latest available estimate (1950) of the number of graduate students is 21,000. Shimkin believes that these figures do not include military institutions, which play an important role in Soviet education and research.

"As a whole," Shimkin concludes, "this qualitative improvement of the Soviet labor force opens up possibilities of profound new developments in science, technology and other fields. It is a phenomenon that permits of no complacency on the part of the West."

Operations Research

THE rather ill-defined discipline of operations research, which is at least as old as Archimedes but did not flower

until World War II, has now formally set itself up in business with the organization of a professional society. Last month the Operations Research Society of America held its first national meeting at the National Bureau of Standards in Washington. More than 500 mathematicians, physicists, economists and other specialists attended the sessions.

Their papers reflected the breadth of the new field. Operations Research claims to itself any tactical problem to which mathematical (usually statistical) methods can be applied. There were discussions of quality control in aircraft maintenance, of the problems in dispatching trains over a single-track road, of the reliability of airborne radars, of the effect of climate on agricultural crops. A Bell Telephone engineer described how the tendency of telephone users to talk louder on long-distance than on local calls must be compensated for in designing telephone equipment. Another paper analyzed the practices of universities in respect to faculty promotions and tenure, using a set of equations which turned out to be similar to those set up for describing the states of the hydrogen atom. The conclusion was that, just as in the nuclear case, present academic practices do not make for a "stable hierarchy."

One of the most popular sessions was a symposium on the "Monte Carlo method," a technique for analyzing problems in which a number of factors, many of them governed by chance, are interrelated in a complex way. The Monte Carlo method sets up a working model of the system, varying its elements by a series of "random walks" (random changes in value), and recording the behavior of the model. This observed behavior is considered not an indication of the answer to the actual problem but the answer itself. The exponents of the method remarked that "its simplicity and tediousness are characteristics which appeal to computing machines."

Another paper of high interest was a mathematical analysis of optimum distribution of effort—how to decide on the best apportionment of a limited amount of "effort" (money, time, physical or human resources) among a number of tasks.

Bad Air

SOUTHERN California recently had five straight weeks of the eye-smarting, rubber-cracking, plant-wilting pall called Los Angeles smog—the longest siege on record. John T. Middleton, in charge of an air pollution research project of the University of California, estimated crop damage at $500,000. He blamed the smog on hydrocarbons, "apparently" caused by "operations of the petroleum industry."

That petroleum operations are mainly

IDEA-CHEMICALS

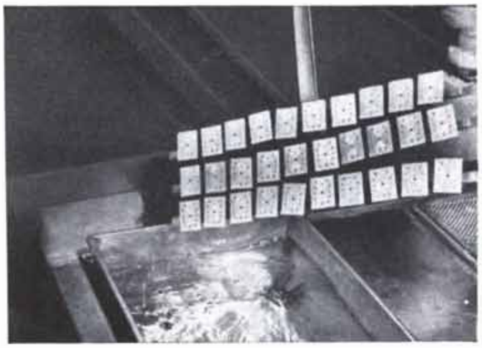
. . . from Du Pont Polychemicals Department

DU PONT METHANOL

volatility plus purity—for clean, fast drying of watch dials

The drying agent used after brushing, plating and cleaning a delicate watch dial must meet high standards. To one manufacturer, the value of preventing stains on their dials is calculated in hundreds of thousands of dollars. To prevent stains . . . to dry the dials quickly without oxidation or mineral deposits left by the wash water, the chemical drying agent must be highly volatile for fast drying . . . must leave no film, either from impurities or because of its chemical nature.

To meet these standards, Du Pont Pure Synthetic Methanol is used . . . another example of the many ways this versatile chemical helps industry. Du Pont Methanol is also used as a solvent in many processes, to manufacture streptomycin, as an ink and dye solvent and to clean electric filaments. The low freezing point of Methanol makes it valuable in still other uses.



Your business may find opportunities for profitable use of Du Pont Methanol—or others of the more than 100 Polychemicals Department products: amides, alcohols, ammonia, organic acids, resins, esters, solvents and plastics.

Write for technical booklet on Polychemicals products for your industry

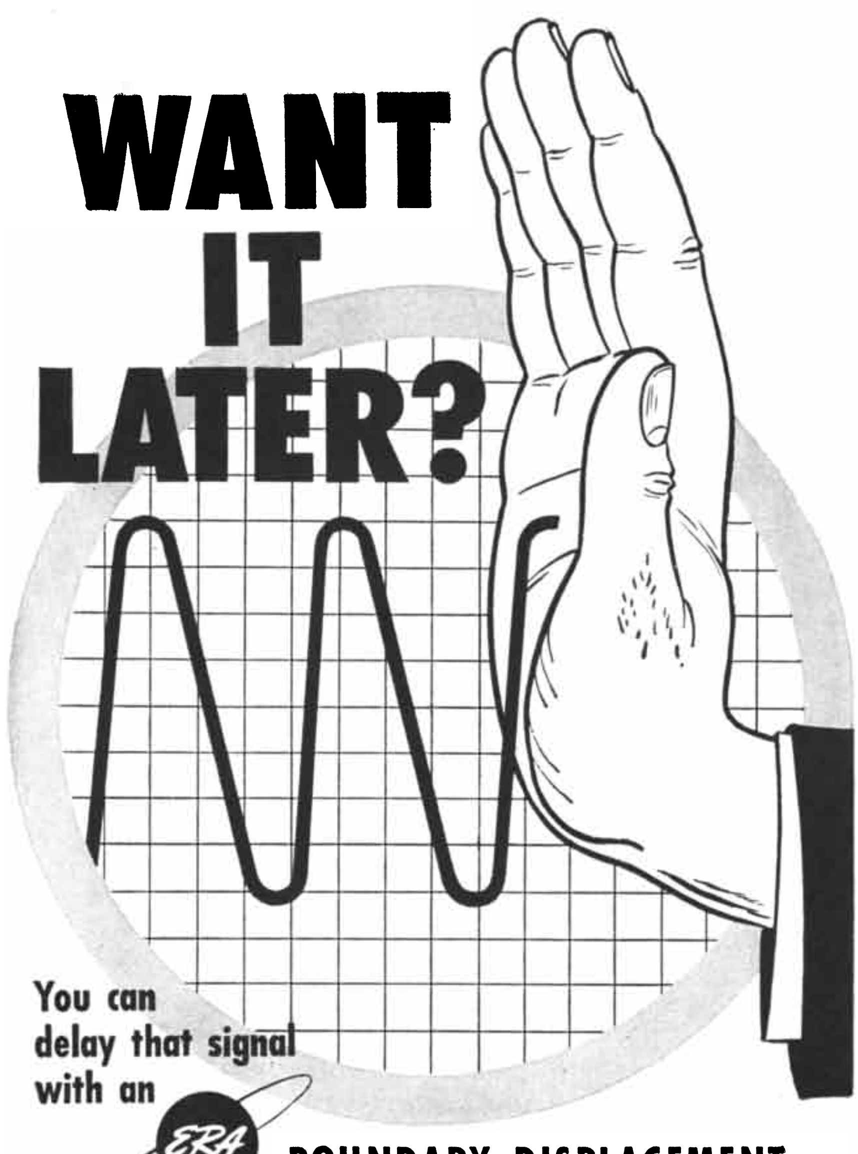
Technical bulletins on Pure Synthetic Methanol and the chemicals and plastics used in your industry are available. Each product bulletin in the booklet presents physical and chemical properties, description, specifications, uses and possible applications, bibliography and other data. Write us on your business letterhead for your copy—and please tell us the type of application that you have in mind.

E. I. du Pont de Nemours & Co. (Inc.)
Polychemicals Department, 151S Nemours Building
Wilmington 98, Delaware

DU PONT
REG. U. S. PAT. OFF.
BETTER THINGS FOR BETTER LIVING
. . . THROUGH CHEMISTRY

Polychemicals
DEPARTMENT
CHEMICALS • PLASTICS

© 1952 SCIENTIFIC AMERICAN, INC



responsible for Los Angeles' smog is also the conclusion of the biochemist A. J. Haagen-Smit of the California Institute of Technology, who made a recent study for the Los Angeles County Air Pollution Control District. He reported that the smog-producing materials seem to boil down to two interacting substances: oxides of nitrogen, which are released in all combustion processes, and gasoline. Gasoline hydrocarbons interact with ozone to form organic peroxides and acids that cause the characteristic crop damage and eye irritation. The troublesome hydrocarbons are of the unsaturated type. Haagen-Smit attributes the worsening of the smog problem in Los Angeles since 1940 to the introduction of catalytic cracking, which yields unsaturated compounds. He estimates that some 2,000 tons of unsaturated hydrocarbons get into Los Angeles air every day, half of them from the products of incomplete combustion in automobiles and half from refineries. One of the chief sources of the gasoline vapor is the refineries' open skimming ponds, where pools of petroleum bake in the sun.

Southern Climate

An expedition of scientists who camped for four years on the shore of the Antarctic Continent to gather data about this still largely unknown part of the world has rendered a preliminary report. The expedition was sponsored by Norway, Great Britain and Sweden. The report, published in the Penguin *Science News*, was written by E. F. Roots, Princeton University geologist who was with the expedition.

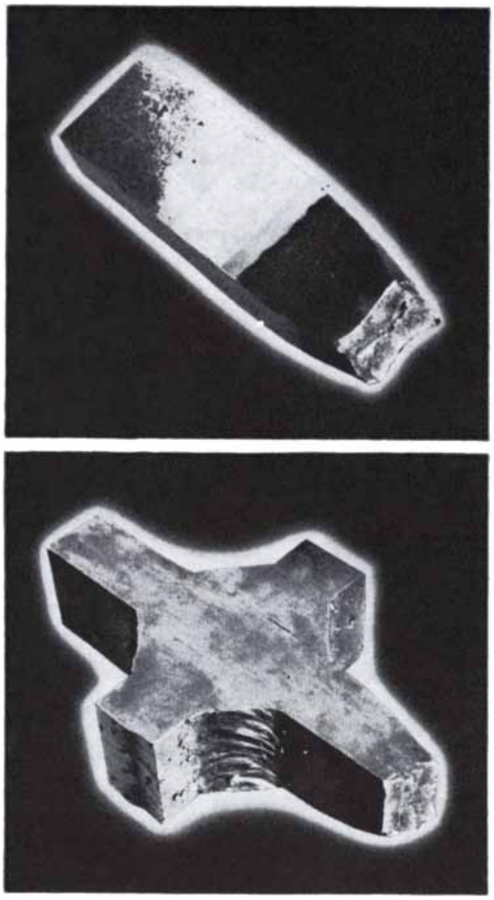
His article answered a question which has interested meteorologists: the expedition found that the Antarctic has not been growing warmer in recent years as the Northern Hemisphere has. This finding seems to bear out the theory that volcanic dust is largely responsible for periods of cold climate ["Volcanoes and World Climate," by Harry Wexler; SCIENTIFIC AMERICAN, April, 1952]. While the Northern Hemisphere has had no major volcanic explosion in 40 years, the Southern Hemisphere has had at least two in recent years.

Sunshine

Since 1938, when Hans A. Bethe of Cornell University discovered the series of nuclear reactions known as the carbon cycle and thereby offered the first reasonable theory of what makes the stars shine, physicists have been refining his calculations. They now know some of the factors and reaction rates more accurately. In *The Physical Review* E. E. Salpeter, a Cornell University colleague of Bethe, reports that it has been found that in our own sun the proton-proton chain of reactions, rather than the carbon cycle, provides most of the energy

90° BEND AT 98 BELOW! This sample, flame-cut from 1″ CARILLOY T-1 plate, was chilled to –98°F., and then bent to a full 90° angle. Even though the raw, flame-cut edge made up the outer radius of the bend, there was no sign of failure!

New steel has yield strength of over 90,000 psi yet remains ductile at 70°F. below zero even after welding or flame-cutting



100% WELD STRENGTH—Tensile tests on T-Steel specimens like these were made to determine the strength of the welds. These welds develop the full strength of the parent metal. Note that breaks occur outside the heat-affected zone, showing that the heat of welding has not harmed the strength of the material. No special pre-heating or post-heating treatments are required beyond those used with ordinary structural steels.

THIS remarkable steel, U·S·S CARILLOY T-1, offers great promise to those who need a super-strong steel that can be welded, flame-cut or cold-formed.

CARILLOY T-1 is unique. It differs from all other very strong steels in important respects: Its yield strength of over 90,000 psi is *not* lowered by welding or flame-cutting. In these operations, no pre-heating or stress-relieving is required. As a result, CARILLOY T-1 can be readily field welded.

Usually, welded steels of such high strength level suffer a loss of ductility at low temperatures unless elaborate precautions are taken in the welding operation. In striking contrast, notched bend weldability tests show that T-1 steel will remain ductile and tough down to the lowest atmospheric temperatures. As a matter of fact, T-1 steel, after flame-cutting, has been bent to a full 90° angle at temperatures as low as –100°F., without any sign of cracking.

Service tests show that CARILLOY T-1 is well suited for extremely abusive service, and the fact that it can be field welded should greatly lower the difficulties and cost of major repairs. In applications in which tension is the principal stress, thicknesses can often be reduced to one-third of those required with ordinary structural steels.

CARILLOY T-1 steel is another result of United States Steel's active research program which has enabled manufacturers to improve their production methods and make better products, too. A folder outlining the properties of this new steel is available. Write United States Steel Corporation, Room 2807-S, 525 William Penn Place, Pittsburgh 30, Pa.

USS

UNITED STATES STEEL

—about five-sixths. The proton-proton sequence goes as follows: Two protons combine to form deuterium, in an average period of eight billion years. Then the deuterium captures another proton in 4 seconds to make an atom of helium 3. In 400,000 years a pair of helium 3 atoms fuse to yield an atom of helium 4, two protons and a large amount of energy.

Sheep and Goats

A POWERFUL new technique for separating organic compounds from inorganic salts has been announced by the Dow Chemical Company. The process, called "ion exclusion," differentiates ionized from non-ionized material, using conventional ion-exchange resins in a novel way.

When a solution passes through a resin column, it exchanges ions with the resin until the ionic composition of the resin and solution become the same. Thereafter the resin rejects ions in the solution. Non-ionized materials are still freely adsorbed by the resin, however. In the Dow process a mixture of ionic and non-ionic substances is poured into an exchange column and rinsed down with pure water. After one or two cycles the resin comes into equilibrium with the ionic material and thereafter excludes it. This material moves quickly down the column through the spaces between the resin particles. The non-ionic material, passing back and forth between solution and resin, moves down much more slowly and emerges in a separate fraction.

Ion exclusion will be particularly useful in handling high concentrations, where ion exchange does not work well, say Dow engineers. Petroleum processors and organic chemical and pharmaceutical manufacturers are among the potential industrial users.

Vacuum Pump

A NEW and neater way to produce a high vacuum has been developed at the University of California's Radiation Laboratory. Instead of sweeping molecules out of the evacuated vessel with a stream of oil or mercury vapor, as present pumps do, the California device sucks them out by electrical attraction of their ions.

The exhaustion chamber of this ion pump, as it is called, is a thin tube across which a stream of electrons shuttles back and forth. Molecules diffusing into the chamber are ionized by the electrons and then pulled out by electrostatic forces. The electrons originate from a hot cathode at one end of the tube, and bounce back from a cold cathode at the opposite end. A strong magnetic field keeps them on the desired path.

The pump is reported to work on any type of gas and to produce pressures as

What GENERAL ELECTRIC People Are Saying

E. DALE TROUT
JOHN VLACH

X-Ray Department

New Tool for Medical Research: Completion of the Cobalt-60 irradiator marks the beginning of an era which medical researchers look hopefully toward. Their need is for a simple low-cost source of high-energy radiation.

Pile-produced isotopes for teletherapy must, among other things, emit gamma radiation and have a half-life longer than 150 days. Radioactive Cobalt-60 emits gamma radiation, has a half-life of 5.3 years, and is obtained from the waste by-products of plutonium production. A 1000-curie Cobalt-60 source should produce a radiation intensity about equal to 1500 grams of radium.

Availability and cost of the source will generally determine the future of Cobalt-60 teletherapy.

The chief saving comes from the need for a smaller space in which to house the Cobalt-60 source. Until it becomes available at much lower cost, or another artificial source is accessible, the super-voltage x-ray machine will not be supplanted by artificial radioactive sources.

General Electric Review
November, 1952

★

C. G. SUITS

Research Laboratory

The Engineer in Industry: Technology is based on science, and science seems to be boundless. Engineering is becoming more complex and specialized as new subject matter is added at an ever-increasing rate.

Increasing complexity of engineering practice is not leading to greater regimentation of the engineer, but rather to the contrary. While a project such as the development of an atomic reactor requires a high degree of co-ordination of many technical skills, the variety of such skills employed by modern industry provides a broad selection from which an individual may choose his field of specialization.

Thus, a great range of individual interests may be accommodated within the confines of a large co-ordinated project activity.

Continuing research will undoubtedly lead to new developments in science which will lead to new applications in engineering. This technological process appears to be an inexhaustible natural resource.

Yale University
New Haven, Connecticut

★

H. A. WINNE

Engineering

The Atomic-Electric Power Industry: It is unfortunate that our entry into the atomic energy era was by way of the atomic bomb—and when I say that I am not thinking at all of the use of the bomb. It seems to me that we may have entered the development path at the wrong end.

Most people undoubtedly feel that atomic energy development is so vastly expensive that it would not have come about unless government undertook it.

We certainly would not have had the atomic bomb, at the present time, nor submarine atomic power plants scheduled for the near future, without government financing, but I am not at all sure that we shall have a sound atomic-electric power industry sooner than we would have had if this development had taken a more normal course in the interested private industries.

Various studies now under way contemplate the possible construction of atomic-electric power plants, designed to produce plutonium, with electric power as more or less of a by-product.

This situation would not constitute a sound basis for an atomic-electric power industry. Certainly, barring war, at some time in the future our atomic bomb stockpile should reach an adequately high peak, and the government would not then be justified in continuing to purchase the plutonium output.

Atomic-electric power will be economically sound only when it can compete with conventional electric power without requiring a government-supported weapons market. It could not do that today—unless in some very peculiar and unusual circumstances—nor, in my opinion, for a good many years to come.

AIEE Machine Tool Conference
Albany, New York

★

R. BLOUNT

Lamp Division

Elimination of TV Camera Limitations: TV pictures with three-dimensional qualities are within reach of TV engineers today. With proper lighting methods and equipment this goal is immediately obtainable.

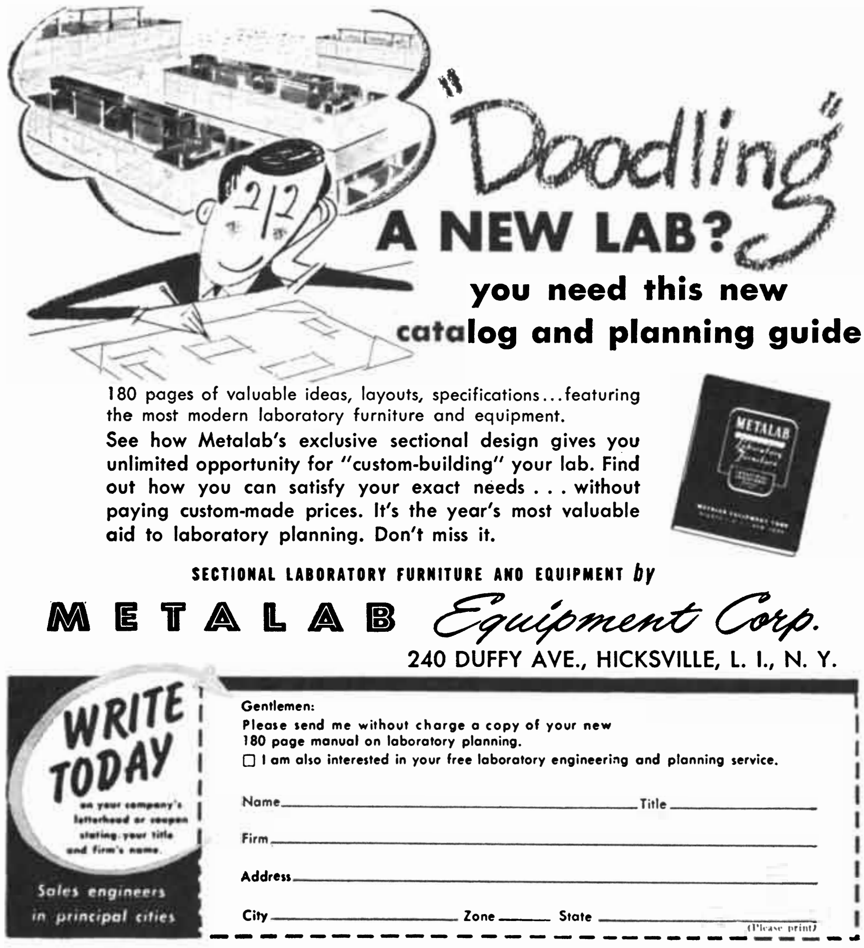
As an example, a brighter foreground increases the feeling of depth and makes the background seem to recede from the viewer, while lighter backgrounds appear closer to the viewer.

The following methods will help in obtaining required brightness differences: 1) providing 100 vertical foot-candles of base light; 2) developing form by applying modeling light 30 to 50 per cent greater than base light; 3) separating actors from the background by applying backlight 50 to 100 per cent greater than the base light; and (4) adjusting background brightness with respect to foreground subjects.

Television Studio Clinic
Cleveland, Ohio

You can put your confidence in—

GENERAL ELECTRIC



low as a billionth of an atmosphere. Its capacity is approximately 250 cubic feet per second. The device was designed by John S. Foster, Jr., Ernest O. Lawrence and E. J. Lofgren.

Vanishing Unicorn

THE *Encyclopaedia Britannica* describes rhinoceroses as having "little intelligence and a bad temper." Both qualities seem to be fast leading to the extinction of the animals, at least in Asia. Their stupidity makes them easy prey for hunters, who are killing them off at a great rate for their horns. (Asiatics consider powdered rhinoceros horn a potent aphrodisiac.) And their wicked temper hampers their mating.

The rhino's problems were outlined in a recent issue of *Ecology* by S. Dillon Ripley of the Peabody Museum at Yale University. Ripley estimated that in 1949 fewer than 300 rhinoceroses of the Great Indian species were left, and hardly 50 of the Sumatran species. The physiology and life habits of the Indian rhinoceros seem ill-suited to the increase, or even maintenance, of its numbers. Most of the year it lives sullenly alone in a territory marked by a dung heap which it accumulates over the course of the season. When a male gets the mating urge, he may have to look far and wide for a mate, because there is no sharply defined season of heat. The period of gestation is about 19 months, and the cow rhino keeps her calf with her for a long period. Ripley calculates that a female cannot breed more often than once in three or three-and-a-half years.

To save the rhinoceros, Ripley suggests, man may have to study its habits further and find some way to help nature.

Animal, Vegetable or Mineral

IN playing the old parlor game of 20 Questions two heads are better than one, but four are no better than two. So report two Stanford University psychologists in the *Journal of Experimental Psychology*. They are using the game in a study of problem solving; its problems, they believe, are more nearly like those found in everyday life than the artificial problems usually employed in psychological research.

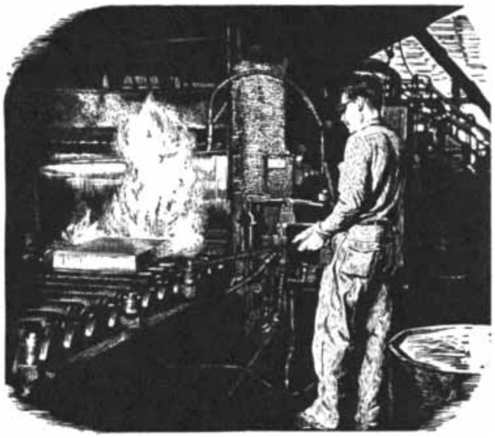
Working in pairs or groups of four, student subjects solved the problems with fewer questions and in shorter times than working alone. Measured in man-minutes, however, the performance of groups was not as good as that of individuals; a pair is faster than one person, but not twice as fast. The subjects rapidly grew more skillful at the game over a five-day period, cutting the time required for solving a problem about in half and using four or five fewer questions.

BUSINESS IN MOTION

To our Colleagues in American Business . . .

According to the popular conception it is the function of a mill or factory to fill orders, control costs, and maintain quality. However, in the case of Revere the mills in addition serve creatively in close cooperation with Sales, the Technical Advisory Service, and Research. This four-way organization is closely-knit in the common interest of serving the customer.

When an order comes to a Revere mill, it is of first concern to the Methods Department, which sets up the mill procedures required to meet customer specifications, thus in effect acting as a representative of the customer. Methods may consult with the T.A., the Laboratory, the Works Manager, and even individual operators.



The long experience of our people is an important factor in customer satisfaction. Pins denoting 20 and 25 years of service are common. Three out of five employees have been with us for 10 years, and one out of four for 20 years or more. At each mill we maintain exhibits of products into which our copper and brass, aluminum and steel tube go, products as diverse as band instruments, automobile radiators and heaters, flatware and hollow ware, furniture, architectural items, refrigerators and air conditioners, valves, and so on. These exhibits are changed frequently, and give our men a personal interest, a feeling that their work in making strip, sheet and plate, tube and pipe, bar and rod, and extruded shapes contributes to better products and better living. Our internal house organ, the "Revere Patriot," carries articles about customers and how they use our metals, and about our distributors and how we help them serve their customers.

So important are the Revere mills and the people who man them that quite often customers visit them to learn about mill operations. And mill personnel in turn go into customer plants. This interchange of information about mill methods on the one hand and customer fabrication processes on the other is extremely valuable. Adjustments on both sides make possible either better customer products or lowered costs, or both.

The mills, in other words, are just as important to Revere customers as Sales, Technical Advisory Service and Research, which in combination give mills and customers the help needed, and in return receive it from them. When we have an order that literally must be handled with gloves and especially wrapped, all the people in the mill take great pains with it, not only out of a sense of pride in a good job, but because they realize that satisfied customers produce the orders that make jobs possible for us all.

REVERE COPPER AND BRASS INCORPORATED
Founded by Paul Revere in 1801
***Executive Offices:* 230 Park Avenue, New York 17, N.Y.**
SEE REVERE'S "MEET THE PRESS" ON NBC TELEVISION EVERY SUNDAY

THE KIDNEY

This remarkable organ not only filters wastes from the blood but also regulates the volume and composition of the fluids that constitute the subtle internal environment of the body

by Homer W. Smith

THE URINE of man is one of the animal matters that have been the most examined by chemists and of which the examination has at the same time furnished the most singular discoveries to chemistry, and the most useful applications to physiology, as well as the art of healing. This liquid, which commonly inspires men only with contempt and disgust, which is generally ranked amongst vile and repulsive matters, has become, in the hands of the chemists, a source of important discoveries and is an object in the history of which we find the most singular disparity between the ideas which are generally formed of it in the world, and the valuable notions which the study of it affords to the physiologist, the physician and the philosopher.

So wrote the chemist Count Antoine François de Fourcroy, a disciple of Antoine Lavoisier, in 1804. For all his enthusiasm Fourcroy scarcely knew how significant his remarks really were. The study of the urine had indeed yielded many "singular discoveries," and largely in consequence of Fourcroy's own researches. But the studies up to that time had considered the urine merely as a vehicle for the excretion of waste products; they had not even begun to realize how much this fluid had to tell about the wonderful world of the body.

Three quarters of a century later the great French physiologist Claude Bernard caught the first vision of the remarkable nature of that world. He pointed out that every higher animal lived not in the external environment but in an internal liquid environment of its own—"a kind of hothouse" with a controlled, unchanging atmosphere which made the organism independent of outside conditions. Bernard wrote: "All the vital mechanisms, however varied they may be, have only one object, that of preserving constant the conditions of life in the internal environment."

It has been said that no more pregnant sentence was ever framed by a physiologist. We know today that the internal environment—the blood and plasma which the heart keeps in constant circulation throughout the body—contains a multitude of compounds the concentrations of which are regulated with remarkable precision, and that in this regulation the kidneys play a crucial role. Where Fourcroy saw the kidneys merely as organs for excretion, the modern physiologist finds them the chief agents for the control of the vitally important body fluids.

The importance of the kidneys in our vital economy can be judged in part from the fact that the two kidneys in man, although representing less than one half of 1 per cent of the body weight, receive about 20 per cent of the blood volume pumped by the heart. Each day more than 1,700 quarts of blood flow through the kidneys. Yet only about one thousandth of this huge flow is converted into urine. To understand this extravagant procedure, the first question we must ask is: How does a kidney manufacture urine from blood?

Malpighi's Corpuscles

All the higher vertebrates normally have two kidneys of about equal size, one attached on either side of the spinal column on the posterior abdominal wall. Each kidney is supplied with blood through a single large artery, from which an elaborate system of smaller arteries and a maze of capillaries distribute the blood to the kidney tissues and filtering units. After being filtered, the blood is collected in a confluent system of veins and returned to the circulation through a single large vein.

William Harvey discovered the circulation of the blood, but it was a young Italian of the 17th century named Marcello Malpighi who first fathomed how the blood conducts its traffic with the tissues. Malpighi was one of the earliest biologists to use the microscope, and he became the founder of microscopic anatomy. Apparently from youth he had been amusing himself with this instrument, and shortly after completing his training in medicine he turned it to the study of the fine structure of animal organs. In 1661, four years after Harvey's death, he discovered the capillaries. Watching the lungs and viscera of a living frog under a microscope, he saw the blood "showered down in tiny streams through the arteries, after the fashion of a flood." He saw also that instead of escaping into empty spaces in the tissues, as had been thought, the blood flowed in definite channels. "Hence it was clear to the senses," he wrote, "that the blood flowed away along tortuous vessels and was not poured into spaces, but was always contained within [vessels], and that its dispersion is due to the multiple winding of the vessels."

When he later came to examine the microscopic structure of the kidneys, Malpighi found some other highly interesting formations. Not long before, a 19-year-old student of physics named Lorenzo Bellini had discovered minute hollow ducts in the cut surface of the kidney. He called them urinary *canaliculi* (little canals), and he observed that they coalesced into larger canals which in turn emptied into the hollow space, or pelvis, of the kidney. Here, then, was the route by which urine was excreted; it was clear that urine collecting in the kidney pelvis would drain by way of the ureter into the bladder. Malpighi now went on to show that Bellini's ducts drained a system composed of thousands of still smaller tubes in the kidneys. He had found that the kidney capillaries were bunched in innumerable little spherical tufts, which he called corpuscles. Malpighi inferred, though he did not prove, that each of his capillary tufts was connected with one of the tiny tubes ("tubules").

His surmise was correct, and he had actually located the place where urine is formed in the kidney, but not until nearly 200 years later was there much further light on the problem. In 1842 William Bowman, a young demonstrator of anatomy at King's College, London, completed the anatomical picture. He showed that each Malpighian corpuscle is in effect formed by the intrusion of a tuft of capillaries into the end of a tubule, wholly in the manner in which the fist would be enveloped if thrust into a large inflated rubber ball. The thin, greatly expanded walls of the tubule form a capsule surrounding the capillary tuft. The fluid in the space within this capsule (corresponding to the space within the indented ball) can drain freely into the tubule. Blood flows into the capillary tuft by one artery and flows out through another which breaks up into a second series of capillaries that is closely intertwined with the tubules (*see drawing on page 43*).

We now know that each of the two kidneys in a human being contains about one million such units, called nephrons. The spherical tuft of each unit, known as the glomerulus (the diminutive of *glomus,* meaning ball), is located in the outer zone or cortex of the kidney. The tubule leading from it twists in a complicated manner around the glomerulus and then plunges in a more or less straight course into the interior of the kidney, where it makes a sharp hairpin turn (loop of Henle) and runs back to the glomerulus again; there it winds about in a second series of twists and finally discharges into a urine-collecting duct. These intricate twistings of the tubule in the kidney cortex apparently serve no purpose other than to give it length; the average tubule in a human kidney is about an inch and a quarter long. If the two million nephrons in the two kidneys were put end to end, they would stretch for nearly 50 miles.

The typical mammalian tubule has a different cell structure in its various sections. The first segment, where it twists around the glomerulus, is composed of thick, irregular cells possessing brushlike filaments on the inner side, forming a so-called brush border. The second segment, which plunges into the kidney to the loop of Henle, has a much smaller diameter and much thinner walls. The third segment, which leads into the collecting ducts, is made of somewhat flatter cells than the first and lacks the brush border. The glomeruli and the twisting segments of the tubules form the cortex, or outer layer, of the kidney, while the thin segments of the loop of Henle, together with the collecting ducts, make up the kidney's medulla, or central part.

The Filter

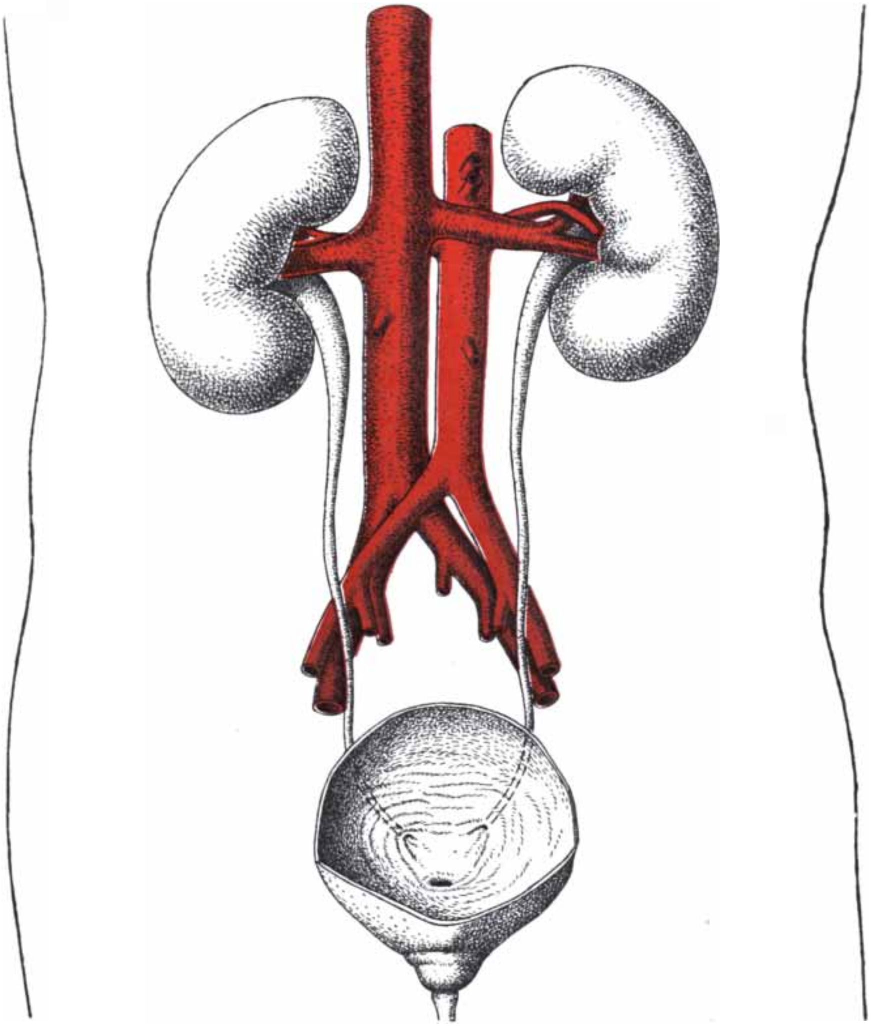
The picture as Bowman saw it was this: Blood flows into the glomerulus, and somehow urine is formed in the tubule connected with the glomerulus. He proposed a working theory of how this was done. The tubule cells, he said, "secrete" the substances that make up the urine, and the glomeruli secrete the water necessary to wash these substances into the collecting ducts. In Bowman's day the word "secretion" implied that the cells carried out this operation by virtue of their "vital activity."

But two years after Bowman's paper was published, the German physiologist Carl Ludwig advanced another idea. He suggested that the glomeruli are simply mechanical filters, beautifully contrived to permit the filtration from the blood of a cell-free and protein-free fluid. This filtrate passes down the tubules in large amounts, and as it does so a considerable part of its water is reabsorbed through the tubule walls into the bloodstream. The residue, greatly reduced in volume and increased in concentration, passes into the kidney cavity as the urine.

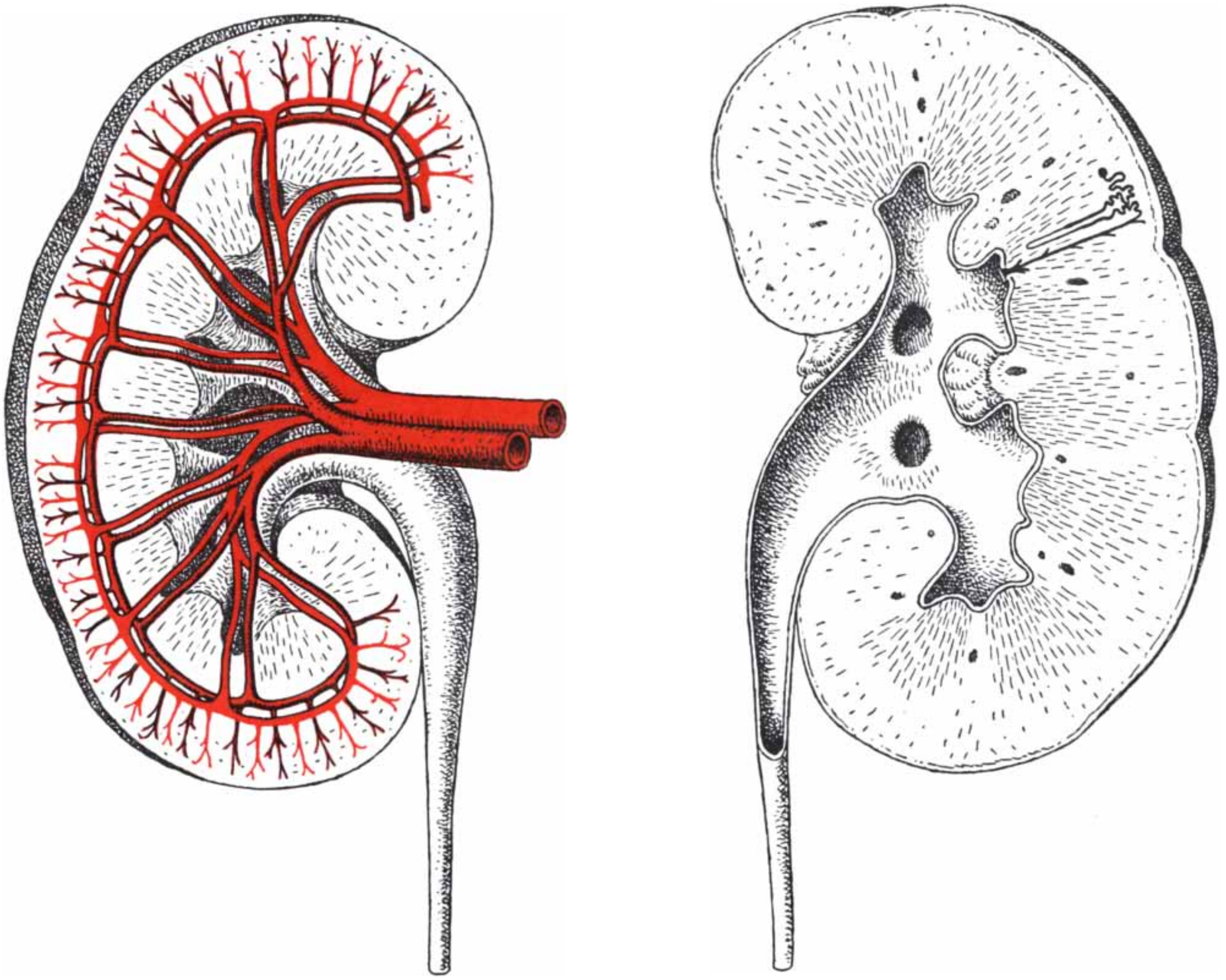
Ludwig's hypothesis was ably defended many years later by Arthur Cushny of University College, London, and it was validated by direct experimental evidence in 1921 by A. N. Richards and his co-workers at the University of Pennsylvania. They collected and analyzed by exquisite micromethods minute quantities of fluid removed from the glomerular capsules of the frog and the salamander. Supplementary if indirect evidence supporting the filtration hypothesis in other species of animals has since been supplied by many other investigators, and it may now be taken as well established that water and all other diffusible substances in the blood (which excludes the plasma proteins, fats and the cellular elements) pass through the glomerular membrane into the capsular space by a simple process of filtration. The energy for this filtration is supplied by the heart and transmitted to the glomeruli by the hydrostatic pressure of the blood.

The Tubules

Yet filtration through the glomeruli does not account for all the substances



KIDNEYS OF MAN are located behind the other abdominal organs. The vessels that connect them with the circulatory system are shown in red. The large vessel at the right is the aorta; that at the left, the vena cava. Descending from the kidneys are the ureters, which empty into the bladder (*bottom*).



CROSS SECTION of the kidney shows two aspects of its internal structure. Depicted at the left is the circulation of the kidney. At the right the blood vessels have been eliminated to show the renal pelvis and the ureter, into which the urine empties. At the upper right in the right-hand drawing is the outline of the individual unit of kidney function, the nephron. Each kidney of man contains about a million such structures.

found in the urine, nor indeed for the removal of all waste products from the blood. The tubules also play a part in this transfer of substances. The determination of precisely what substances the tubules subtract from and add to the urine became possible when methods were found for measuring the rate of filtration of plasma through the glomeruli. A convenient way to do this is to inject into the blood the starchlike substance inulin, obtained from dahlia tubers and other vegetable sources. All of the inulin injected is filtered from the blood plasma into the urine through the glomeruli, and the tubules do not add to or subtract from it. From the known proportion of this test substance in the plasma it is possible to compute the over-all rate of filtration of the substances filtered by the glomeruli in the two kidneys.

These measurements show that the filtration rate in man averages about 125 cubic centimeters per minute or about 180 quarts per day—a figure which would have seemed scarcely credible to Ludwig or Cushny, the pioneer proponents of the filtration theory. Of the 180 quarts of filtrate, 178 are reabsorbed into the blood through the tubules, and only one to two quarts are excreted as urine. Most of the salt and of many other substances in the filtrate is reabsorbed. The excreted urine contains urea, creatinine and other products of protein metabolism; it also contains foreign substances that enter the body and the excess of sodium, potassium, phosphate, sulfate and other substances beyond the body's needs.

The extravagant nature of this filtration-reabsorption process is emphasized by the fact that about 2.5 pounds of sodium chloride passes from the glomeruli into the tubules each day, but normally only from one sixth to one third of an ounce of this leaves the body in the urine. Similarly nearly one pound of sodium bicarbonate and a third of a pound of glucose are filtered, but only trivial fractions of these amounts are excreted. The tubules likewise reabsorb from the filtrate substantial quantities of potassium, calcium, magnesium, phosphate, sulfate, amino acids, vitamins and other substances valuable to the body. These reabsorptive processes operate to recover valuable constituents from the glomerular filtrate which otherwise would be lost from the body, and it is in part by these processes that the tubules maintain the constancy of the chemical composition of the plasma and body fluids. They synthesize the body's internal environment by operating in reverse, so to speak, on the glomerular filtrate. To this end, they filter and reabsorb our entire fluid internal environment nearly 15 times a day.

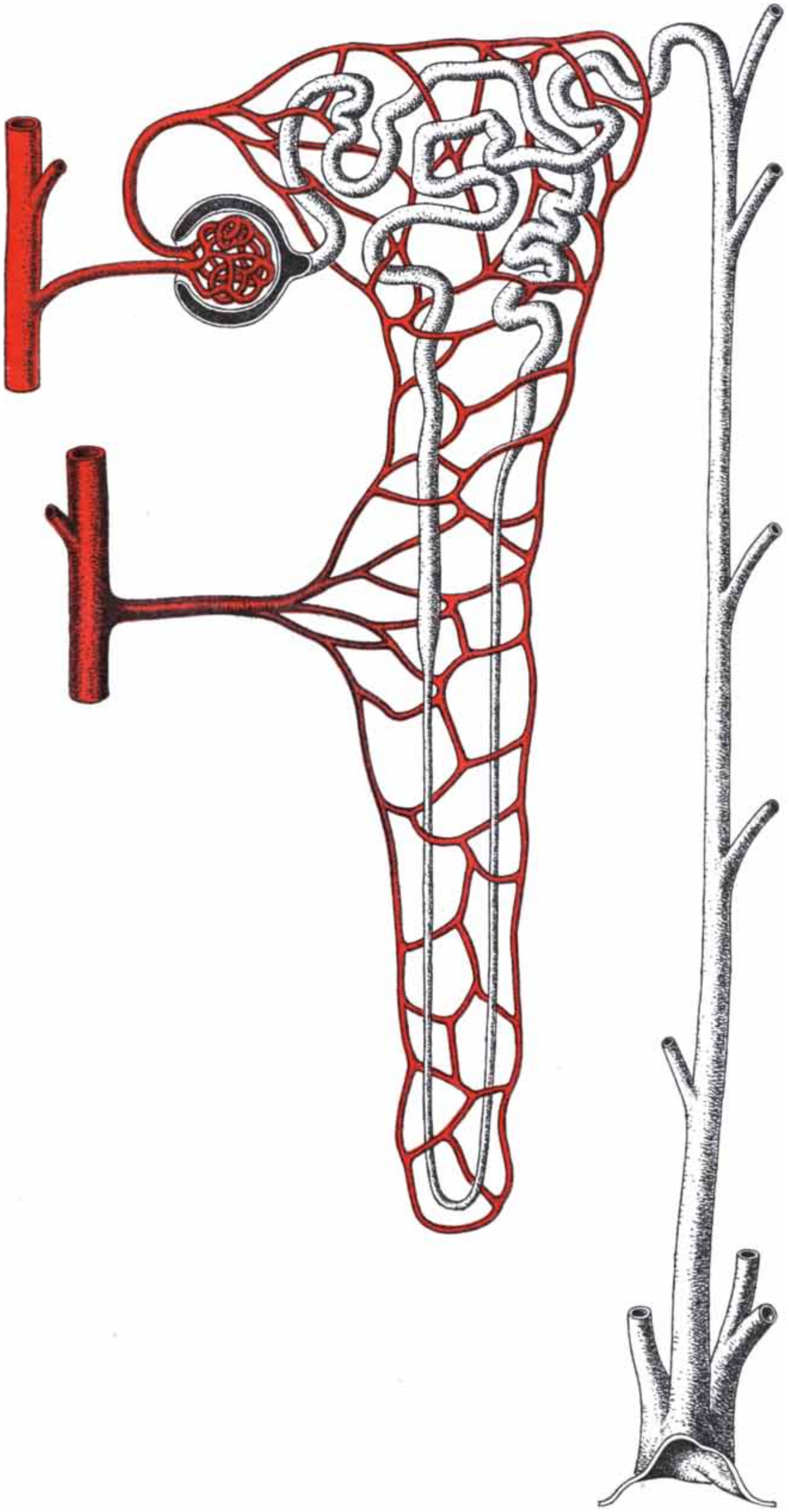
It has been noted that the energy for glomerular filtration is supplied by the heart and that the glomeruli play an entirely passive role in this process. But in reabsorption the tubules play an active role. They must remove each reabsorbed substance from a low concentration in the filtrate and transport it to a higher concentration in the blood. This operation requires the expenditure of energy by the tubule cells. The energy must be made available within the cells by the metabolism of suitable fuel stuffs, and then put to work by suitable enzyme systems. These circumstances impose a limit on the rate at which any given substance can be reabsorbed. In many cases the maximal rate of reabsorption can be measured quite accurately by presenting to the tubules more of the substance than they can handle and finding the saturation level. The transport system for each substance is independent of the others; for example, when reabsorption of glucose reaches the saturation level, this does not interfere with reabsorption of another substance, such as phosphate.

Two-way Traffic

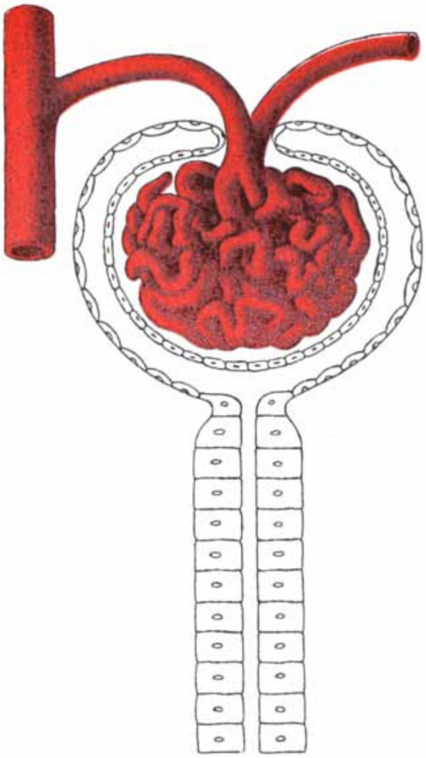
As I have already mentioned, we now know that the tubules not only take substances out of the filtrate and transport them back to the blood, but they also work in the opposite direction: they take some of the waste products from the blood and deposit them in the urine. E. K. Marshall, Jr., and his co-workers at the Johns Hopkins University first proved this in 1924 by quantitative excretion studies with the dye phenol red, known to all physicians as PSP. Marshall and others later showed that certain marine fishes, whose kidneys have no glomeruli or arterial blood supply, form urine solely by tubular excretion.

This process of tubular excretion supplements glomerular excretion and thus increases the over-all efficiency of extraction from the blood. The list of substances known to be excreted by the tubules in man is rapidly expanding. It includes hippuric acid and other derivatives of benzoic acid, and many other organic waste products which are difficult to metabolize. As in the case of tubular reabsorption, tubular excretion requires the local expenditure of energy by the tubule cells, and its rate is limited. Unlike tubular reabsorption, it apparently involves only a few enzymatic transport systems, each of which handles a particular type of compound.

Tubular excretion supplies the physiologist with a most valuable subject for study. It presents for examination some highly specific enzyme systems, the exploration of which throws light on fundamental protoplasmic processes. It affords useful quantitative measurements of tubular function in health and disease and of the effects of the endocrine glands, particularly the anterior pituitary, which excretes a hormone with a powerful influence on the activity of the tubules. But most importantly it provides a method of measuring the blood flow in the kidneys of man or experimental animals without disturbing the



NEPHRON consists of (1) the glomerulus, the ball of capillaries at upper left, (2) the tubule, which twists from the glomerulus to the urine-collecting duct at right, and (3) the bed of capillaries around the tubule. The water of the blood, containing small molecules such as urea and sodium chloride, is filtered out of the glomerulus into the tubule. There virtually all of the water and the other useful substances are reabsorbed.



GLOMERULUS is encapsulated by the cells at the end of the tubule.

subject's physiological functions, so that one can observe the changes in blood flow produced by natural hormones, disease and drugs.

The method of measuring the renal blood flow is as simple as that of measuring the filtration rate. Given a test substance which is excreted both by the glomeruli and by the tubules, the substance may be completely or almost completely removed from the blood and excreted into the urine during a single passage of blood through the kidney, provided it is administered in less than saturation amount. If one divides the rate of excretion of the test substance by the quantity contained in each cubic centimeter of plasma, one obtains the total flow per minute through the kidneys. A simple calculation then gives the flow of whole blood. The substance now most widely used for measuring the renal blood flow is *p*-aminohippuric acid (PAH), a compound which lends itself to easy and accurate chemical determination. When given to a human subject, about 91 per cent of this substance is removed from the blood during a single circulation through the kidneys.

The Kidney's Evolution

We have seen that of all the blood pumped out of the heart (some 8,000 quarts per day) one fifth, or nearly 1,700 quarts, goes to the kidneys for the purpose of making a trifling one to two quarts of urine. One would have thought that nature would have found a more efficient method of making urine than this! To understand how this circuitous method developed, we must look into the evolutionary history of the kidney.

It is now established that the first chordates, the forerunners of the animals with backbones, arose in the brackish estuaries or fresh-water rivers of the continents. Their ancestors unquestionably came from the sea, and the migration from salt to fresh water required many physiological adjustments, the most important of which concerned the osmosis of water. A salt solution, if separated from fresh water or a more dilute solution by a membrane permeable to water, draws water into itself until the osmotic pressure on both sides of the membrane is the same. Because of the salts contained in their tissues and body fluids, these early chordates tended to absorb water from their fresh-water environment by simple osmosis through the permeable gills and oral membranes, which had to be left naked for the purposes of respiration. Consequently provision had to be made to excrete this water from the body. The excretory system which the vertebrates inherited from their marine ancestors consisted of a series of tubules which opened freely into the primitive body cavity. These tubules served to drain the fluid in the cavity to the exterior, and they doubtless reabsorbed some substances from the fluid and added others before it was discharged from the body. In retrospect it seems that it was physiologically beyond the capacity of either the cavity membranes or the primitive tubules to excrete water as such. Hence the vertebrates evolved a device to pump water out of the body. This device consisted simply of a tuft of capillaries, juxtaposed to the mouth of the tubule, through which water could be pumped into the body cavity by the heart. Since all the salts and other valuable substances in the plasma water also passed into the filtrate, the introduction of the filtering device required that the tubules step up their reabsorptive processes to conserve these substances. By the time the true fresh-water fishes evolved, the glomus had become invested within the closed, expanded end of the tubule, forming the typical nephron.

Even as the kidney was being improved as a device for excreting water, the armor in which the early vertebrates had enclosed themselves acquired new flexible articulations, permitting the animal to swim or to crawl upon the bottom. Certain spines in the armor became paddles or fins to promote mobility, and the armor about the head acquired new articulations in the form of jaws so that the animal could eat. All these changes required major reconstruction of the animal's muscles, nerves and sense organs, as well as of the excretory and reproductive ducts. Thus the evolution of the glomerular kidney as a device for excreting excess water from the body constituted but one in a large number of adaptive changes which arose in response to the requirements for living in fresh water. The entire sequence of such adaptations may be said to comprise the evolution of the vertebrates.

The situation with respect to water balance was scarcely changed in the amphibia that evolved from the air-breathing fresh-water fishes, for these amphibia spent most of their lives in fresh water or very moist areas, just as do frogs, toads and salamanders today. However, when the reptiles, the first truly terrestrial animals, arrived, the balance did change drastically. The reptiles once again acquired waterproof scales (as in lizards and snakes), but now it was not to keep water out but to prevent excessive loss of water by evaporation. For the first time the egg became covered with a waterproof shell—a device to prevent the embryo from drying up during its development. This required that the egg be fertilized in the body of the female before it was enclosed by the shell. Internal fertilization became the rule among the reptiles, birds and mammals.

The reptiles went a step further in the conservation of water: they overhauled the intimate biochemical machinery for the combustion of protein. Instead of degrading the nitrogen of their protein food to the highly soluble compounds urea and ammonia, they degraded it to uric acid, a substance which is almost insoluble in water. Under appropriate conditions uric acid may form supersaturated solutions with a high uric acid content. In this form uric acid is excreted by the tubules directly into the tubular urine. In the renal collecting ducts the uric acid precipitates out of solution, leaving the water free to be reabsorbed, so that the acid is left as a white paste (guano) which is discharged from the cloaca with a minimum of water loss. Birds, like reptiles, degrade their protein nitrogen to uric acid and excrete this waste product by the renal tubules; it is often said that birds are only reptiles that have acquired wings and lost their teeth. In reptiles and birds, which have little water available for urine formation, the glomeruli are degenerate, the capillary tuft being reduced to one or two relatively short channels.

Backward Step

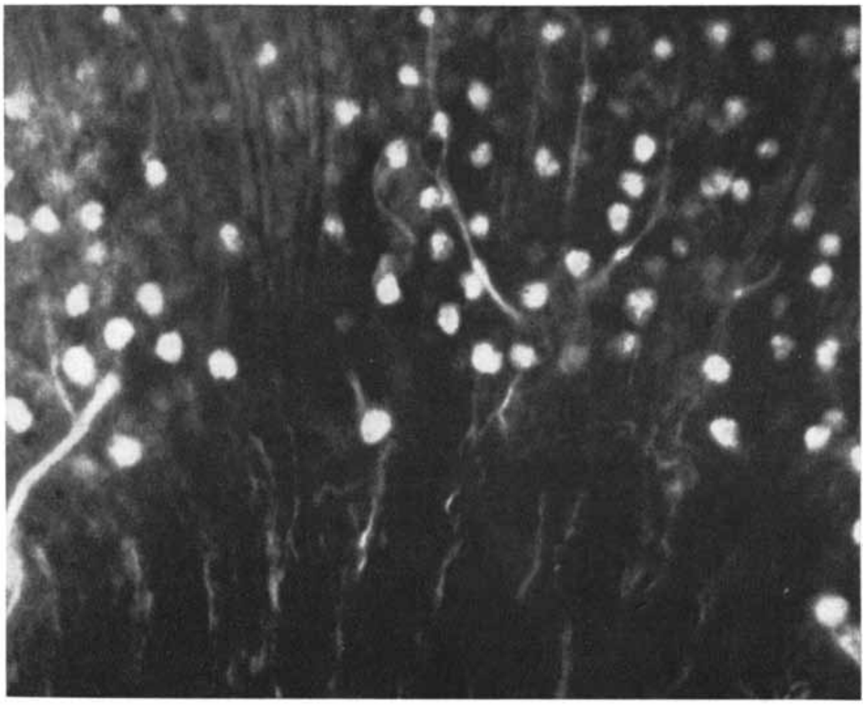
The story of water conservation has been quite different among the fishes. Some of the ancient fishes returned to the sea, and in so doing reversed the osmotic circumstances that had fostered the evolution of the glomerular kidney. The osmotic pressure of sea water is greater than that of the body fluids; consequently water tends to be drawn out of the body by osmosis. The organism is perpetually faced with a deficit of this precious substance. Adaptation to this circumstance among the marine fishes has taken two routes.

One of these is exhibited by the class represented by the sharks, skates, rays and chimaeras. Like the primitive fresh-water fishes, they produce urea, but instead of treating it as a waste product and excreting it as fast as it is formed, as all other vertebrates do, they reabsorb urea through the renal tubules until the concentration in the blood reaches the spectacular figures of 2,000 to 2,500 milligrams per 100 cubic centimeters. This accumulation of urea in the blood raises the osmotic pressure of the latter to a level above that of the sea water, so that the animals absorb water by osmosis through the gills and oral membranes in small but adequate quantities. Here again, however, the young must mature within the body of the mother, or the egg must be covered with an impermeable shell to protect the embryo until it has developed to the point where it can take care of its own water balance. In either case internal fertilization is required. To aid the process of internal fertilization the males of this class of fishes generally have enlarged pelvic fins or specialized organs called claspers. From the presence of such pelvic fins and claspers in the fossil record we can infer that internal fertilization, and therefore the tubular reabsorption of urea, goes back as far as the late Silurian or early Devonian period.

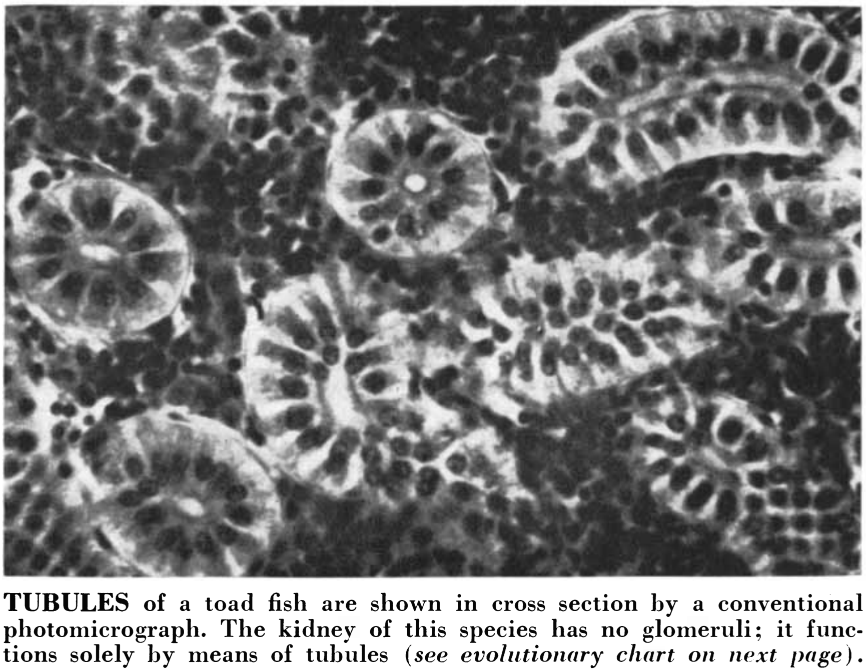
The other great group of marine fishes, the bony fishes, did not return to the sea until the Mesozoic or even later times. Never having acquired the trick of conserving urea to increase the osmotic pressure of the blood, they could obtain water for urine formation only by drinking sea water. The fish kidney cannot, however, make a urine more concentrated than the body fluids. Consequently with every gulp of sea water these fishes are potentially worse off than they were before, because they have taken in more salt than water. They solve their dilemma by excreting the excess salt directly from the blood through the gills, leaving free water available to the body for urine formation. The more urine they excrete, the more sea water they must drink and the more salt they must excrete through the gills. It is vitally necessary, therefore, to keep urine formation to the lowest possible level, and it is not surprising to find that in many marine fishes the glomeruli are degenerate, while in those whose ancestral lines perhaps have had the longest continuous marine history (*e.g.*, the goose fish, toad fish, sea horse and many deep-sea fishes) the glomeruli are gone, leaving a kidney which functions entirely by tubular excretion.

The Mammalian Kidney

Among all these animals living under conditions where fresh water is at a premium (the reptiles, birds, marine fishes) the development and activity of the glomeruli declined. But among the warm-blooded mammals the adjustment was in the other direction. Elevation of the body temperature above that of the environment entailed a considerable increase in metabolism, which in turn entailed increased respiration and increased circulation of the blood. The speed-up in circulation of the blood was accomplished in part by an increase in mean blood pressure. All this promoted development of the glomerular capillary tuft and a greater amount of filtration. And the more fluid was filtered, the more the body required tubular reabsorption to recover valuable constituents. By the time the mammals were



GLOMERULI of a cat appear when they are dyed with a fluorescent material and photomicrographed with ultraviolet light. The method was developed by J. U. Schlegel and J. B. Moses at the University of Rochester.

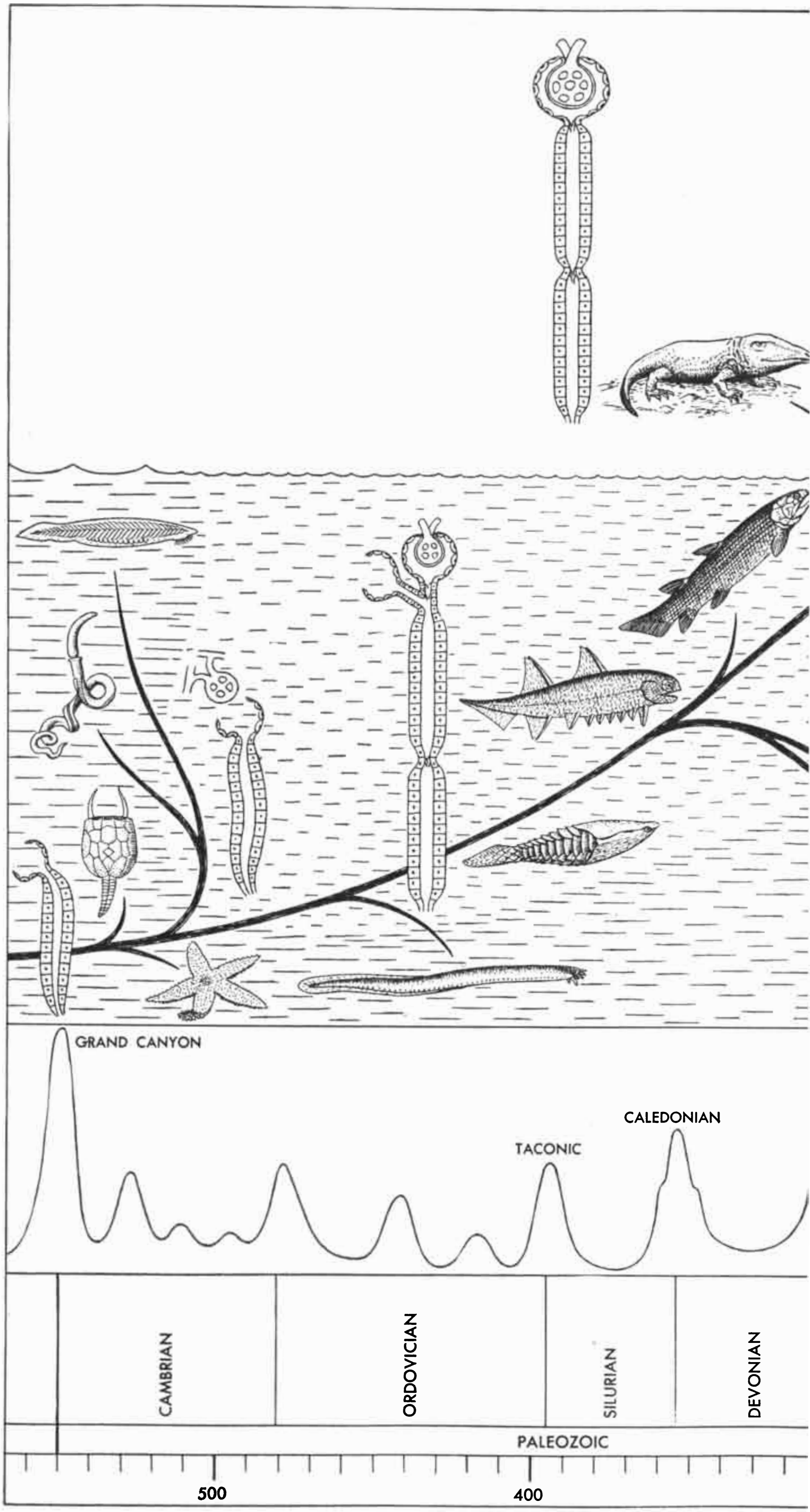


TUBULES of a toad fish are shown in cross section by a conventional photomicrograph. The kidney of this species has no glomeruli; it functions solely by means of tubules (*see evolutionary chart on next page*).

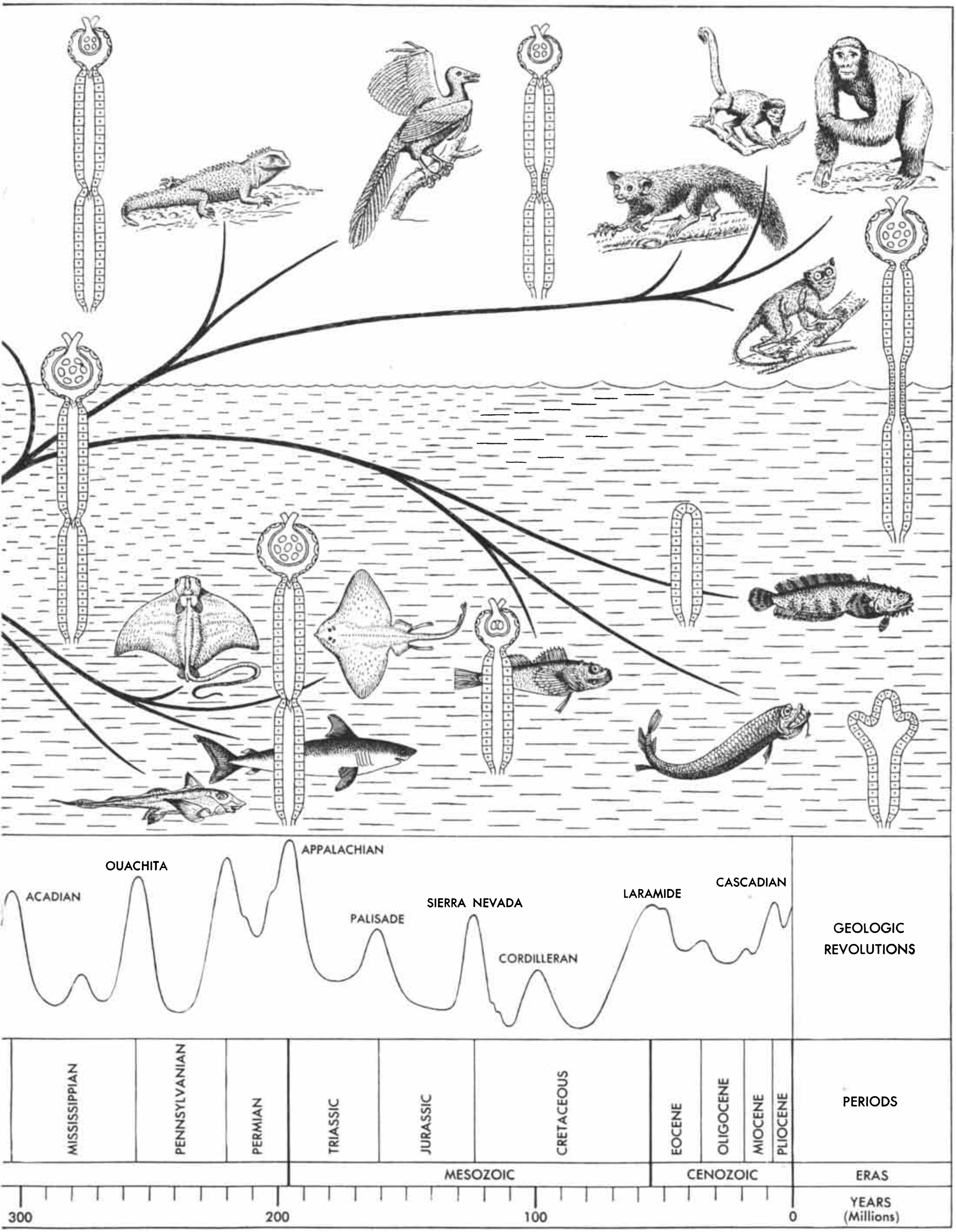
evolved, it was too late to change either the basic pattern of the kidney or the mode of protein metabolism; the mammals had to improve the functioning of the kidney they had inherited from the amphibia and the fresh-water fishes. They simply speeded up its processes—glomerular filtration and tubular reabsorption—and subjected them to more delicate and more precise control.

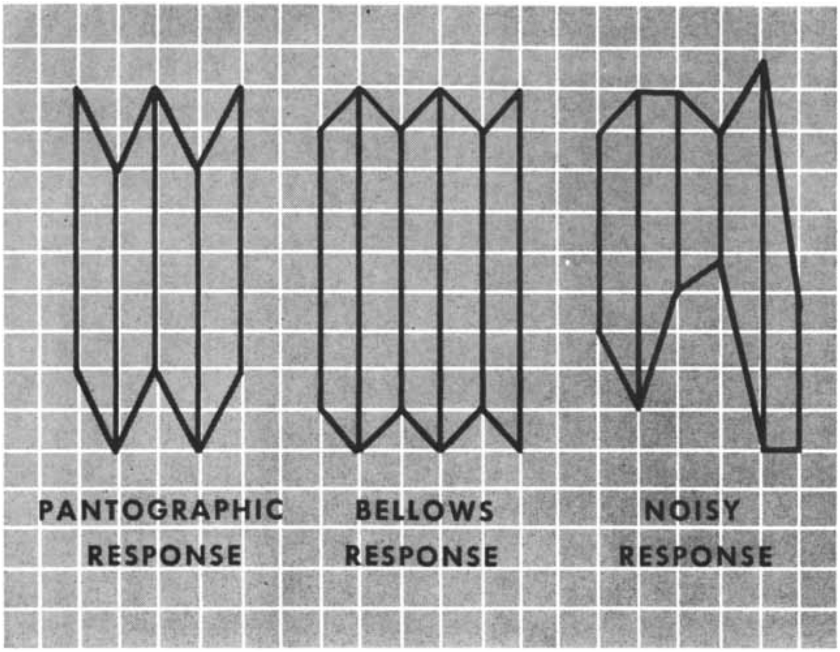
One of the new things added to the kidney by the mammals is a mechanism for improving the control of water balance. It is a matter of common knowledge that the rate of urine formation is quickly and substantially increased by the ingestion of water, and is substantially reduced by dehydration. This regulation is achieved by changes in water reabsorption in the tubule. Normally the first section of the tubule, which twists around the glomerulus, reabsorbs about seven eighths of the water of the glomerular filtrate, along with sodium chloride and other substances, leaving about one eighth to be reabsorbed optionally by the last segment of the tubule. The latter reabsorption is mediated by a hormone secreted by the pituitary gland: in the absence of the hormone, reabsorption drops to zero and the water which would otherwise have been reabsorbed is excreted in the urine. In the presence of maximally effective concentrations of the hormone, almost all the water is reabsorbed and the urine flow decreases to a minimal level. For this reason the hormone is called the antidiuretic hormone.

In a classic series of studies extending over many years at Cambridge University, E. B. Verney and his colleagues have shown that an increase in the osmotic pressure of the blood causes increased secretion of the antidiuretic hormone into the blood. Thus lack of water makes the rate of hormone secretion rise, conserving water, while drinking water causes the secretion rate to fall



EVOLUTION of the nephron is depicted in the chart at the right. On the tree running from left to right are various vertebrate forms in the order of their development. At the bottom is the time scale in years, eras, periods and mountain-building revolutions. The creatures at the far left lived in salt water; most of their descendants, in fresh water. The latter, however, gave rise to forms which returned to salt water. Here salt water is indicated by closely spaced lines; fresh water, by open lines. The diagrams of the nephrons are highly schematic, with the tubule straightened out for clarity. The earliest nephrons are composed only of a tubule. The latest nephrons of land animals have a complex glomerulus and a tubule with two segments.


ACADIAN
OUACHITA
APPALACHIAN
PALISADE
SIERRA NEVADA
CORDILLERAN
LARAMIDE
CASCADIAN
GEOLOGIC REVOLUTIONS
MISSISSIPPIAN
PENNSYLVANIAN
PERMIAN
TRIASSIC
JURASSIC
CRETACEOUS
EOCENE
OLIGOCENE
MIOCENE
PLIOCENE
PERIODS
MESOZOIC
CENOZOIC
ERAS
300
200
100
0
YEARS (Millions)



nearly to zero, so that more water is excreted into the urine. So delicate is the mechanism that, aided by the sensation of thirst, and assuming that water is freely available, the body is normally maintained in an almost perfect state of water balance despite wide changes in fluid intake or correspondingly large changes in our external environment.

Alcohol inhibits the secretion of the antidiuretic hormone and therefore increases the urine output. M. G. Eggleton reports that 100 c.c. of water are excreted for every 10 grams of alcohol consumed (within a physiological range). The diuresis associated with beer-drinking is attributable chiefly to the water consumed rather than to the alcohol, since beer contains only 4 per cent alcohol. But in the case of whiskey, which is 40 to 45 per cent alcohol, the alcohol increases the loss of fluid from the body and has a dehydrating effect; undiluted whiskey will not quench one's thirst.

The Master Laboratory

A proper view of the kidney sees that from the beginning of its evolution in the lowly Paleozoic chordates this organ has been more than just a device for excreting waste products: it has always been charged with the regulation of the volume and composition of the body fluids. It fulfills this task by operating in reverse—conserving some constituents by reabsorbing them from the glomerular filtrate, while rejecting others. The kidney acquired its glomerular structure because of the necessity of removing large quantities of water from the body in the Paleozoic fishes. To carry out this operation by a filtration-reabsorption system the kidney tubules had to regulate with great precision the excretion of sodium chloride, water and other substances. Thus the kidney came to be the master chemical laboratory controlling the composition of our internal environment—a laboratory working in reverse by overhauling all the blood many times a day.

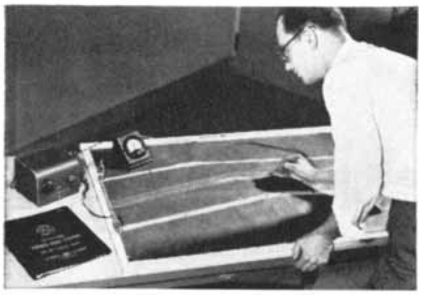
The great importance of the kidney is revealed not only by the serious consequences of specific diseases of the organ itself, but also by the many remarkable adjustments in its functioning that accompany various other diseases and physiological disorders which do not directly involve the kidney. It is not surprising that the kidney is one of the most extensively studied organs in the body, having as much interest for the obstetrician, pediatrician, internist, surgeon and geriatrician as for the physiologist—and, as Fourcroy said, for the philosopher.

◆

Homer W. Smith, author of the book Kamongo *and the recent* Man and His Gods, *is professor of physiology at New York University.*

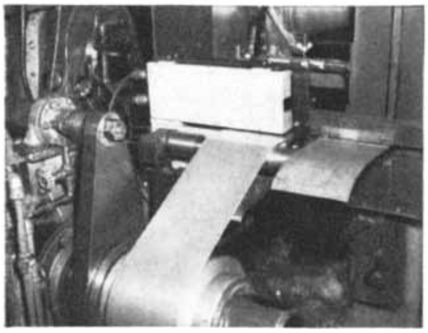
FINDS HIDDEN SHORT CIRCUITS

G-E 10-kv a-c winding insulation tester "finds" insulation defects that ordinary high-potential tests miss. Photo above shows actual waves on scope indicating several short-circuited turns in a coil. Correction of these hidden faults can improve and lengthen the life of your electric apparatus. Quick and easy testing makes equipment ideal for production use. Write for Bulletin GEC-321*.



SIMPLE INDUSTRIAL FIELD PLOTTING

Two dimensional problems in electrical field theory are easily plotted and solved with the G-E analog field plotter. Electric current flow patterns are set up in a sheet of thin conducting paper and analogy between the electrical field in the paper and related field problems as exist in electrostatics, electromagnetics, thermal and fluid flow allows rapid solution of the problem. See Bulletin GEC-851*.



FAST THICKNESS MEASUREMENT

General Electric's new beta-ray gage continuously measures deviations in weight of fast-moving sheets of rubber, plastics, paper, and metals with an accuracy of ±1%. Continuous monitoring saves material, improves quality and reduces scrap losses. Noncontacting beta-ray gage will measure sheets which are wet, sticky, soft or highly polished without marring or damaging. See Bulletin GEC-485*.

*** To obtain these publications, contact your nearest G-E Apparatus Sales Office, or write to General Electric Co. Section 687-111, Schenectady 5, N. Y.**

NACA RESEARCH SCIENTIST inspects airplane model after a test run at Langley Aeronautical Laboratory.

G-E recorder provides constant check of dewpoint temperature

Continuous, accurate indication of dewpoint temperature is provided by General Electric's dewpoint recorder.

As an aid in their aerodynamic research on supersonic aircraft and guided missiles, the National Advisory Committee for Aeronautics installed a dewpoint recorder at Langley Field, Virginia, to help avoid excessive condensation and flow disturbances in their supersonic wind tunnel.

Monitoring of moisture content is important in many other laboratories and industries. Dewpoint equipment is used to control chemical or mechanical air dryers; to study effects of condensible vapors; and to measure the moisture content of gases in various stages of manufacture. Further information about G-E dewpoint recorders is given in Bulletin GEC-588*.

Here is an example of the type of developmental engineering . . . a specialty at General Electric . . . which provides more and better instruments and processes for modern industry.

FROST SPOT is checked for proper adjustment at NACA Laboratory.

You can put your confidence in—

GENERAL ELECTRIC

Crystals and the Future of Physics

A dialogue in which the author attempts to show Empeiros how the laws of physics, so many of which now elude us, may form a finite system that will some day soon be entirely worked out

by Philippe Le Corbeiller

MY PHYSICIST friend Empeiros walked into my office in a very bad mood. He had just read an article, and in a very respectable monthly, which claimed that the field of physics was limited, and moreover would soon be completely mapped out.

"Such nonsense makes me mad," said Empeiros. "Physics is being renewed all the time by someone discovering something completely unexpected. Look at X-rays, look at radium, look at cosmic rays. How could a physicist ever sit back and say that from now on nothing new will ever be found?"

"That does not seem so impossible to me," I replied. "I agree that physics seems today to be without boundaries, but that may be because its field is not yet organized. Look at the history of the great explorations. After Columbus had discovered America, one might have expected the discovery of any number of continents. Yet by the end of the 18th century the whole surface of the globe was sufficiently well mapped out to preclude the discovery of any new continent. I think exploration in physics might well repeat this pattern."

"That is begging the question," said Empeiros. "At the time of Columbus all competent people knew that the earth was round. They must therefore have known that the amount of ground to be discovered was limited. It is absurd to compare the earth to physics, which is limitless."

"The comparison is *not* absurd," I replied. "People did not always know that the earth was a globe, and as long as the earth was thought of as flat its surface could be either finite or limitless; there was no telling. Intellectually speaking the argument was clinched not when Magellan's ship circumnavigated the earth, but when your ancestor Eratosthenes gave the first estimate of the circumference of the spherical earth. The check came 2,000 years later, but the argument was not concerned with the time interval."

"You sound like a Platonist," said Empeiros, obviously soothed by my allusion to his Greek descent.

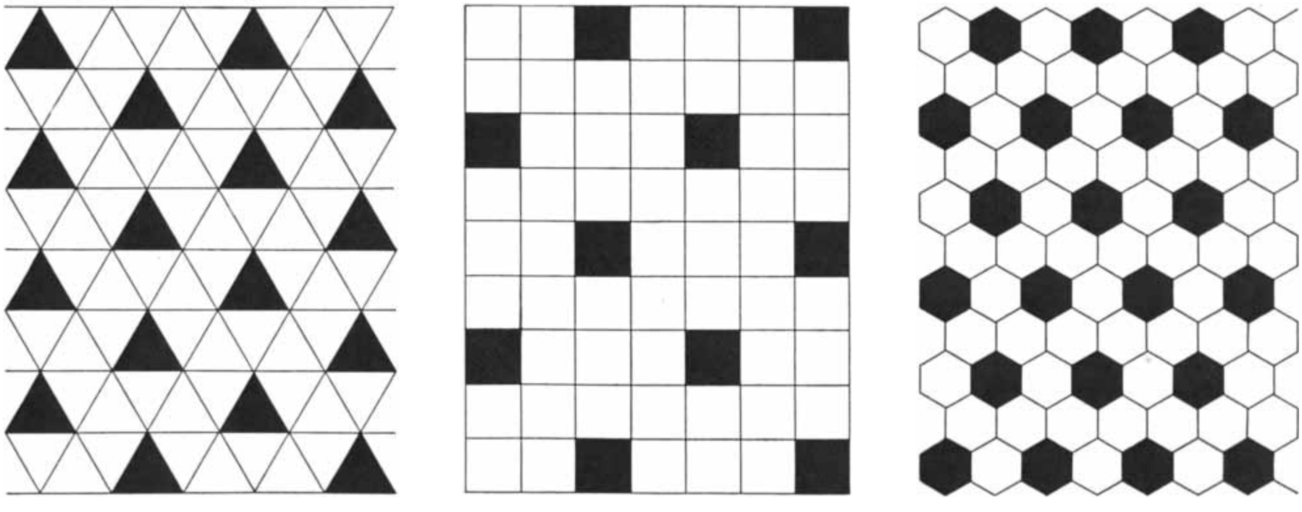
"Of course I am," I answered. "My Ph.D. work was in the theory of numbers and arithmetical groups."

"Very fine," said Empeiros, "but that isn't physics."

"It isn't physics?" I exclaimed indignantly. "Look at crystals!"

"What have crystals to do with the future of physics?" inquired Empeiros.

"Everything," I said with glee. "Crystallography is the image of the physics of tomorrow. Now I know just how to



REGULAR TILES, *i.e.*, tiles of which each side has the same length, will pave a floor in only three shapes: the triangle, the square and the hexagon. Tiles of other shapes will not fit to cover the entire area of the floor.

convince you. Sit down and be convinced.”

Bullied, Empeiros sat down.

“THERE ARE theorems in mathematics,” I began, “which tell us that there are just so many ways of combining certain things, and no more. Here is an example. Square tiles are common enough, and so are six-sided tiles. Long before Euclid, geometers asked themselves: Can we pave a floor with regular tiles of any number of sides? The answer is no. Only three kinds of regular tiles can be used: the triangle, the square and the hexagon. Regular tiles of other shapes will not fit together to cover the whole area.

“This first result may not be very exciting, but the next one is—at least Plato found it so. A regular cube is a solid limited by six equal square faces. Can we build solids with any number of equal, regular faces? Again the answer is no. Only five regular solids are possible, and no more. Some day I want to show you how to build these solids out of a sheet of strong paper; it is a fascinating game.”

“I like games,” said Empeiros, “but I wish you would come to physics. In mathematics we know the rules of the game, since we make them up ourselves. Here, for instance, the rule is to use nothing but regular polygons to limit our solids. I see nothing surprising in the fact that there should be exactly five solids obeying that arbitrary rule. But in physics we don’t make the rules; therefore we shall never be able to say that a chapter of physics is closed.”

“Your argument,” I answered, “is perfectly plausible. But it does not fit the case. There are ‘regular solids’ in physics also; we call them crystals. So here we have geometry again, and arithmetic, but this time it does not all take place in our heads. Here nature invents the rules of the mathematical game, and of course it finds itself bound by the consequences of the rules.”

“Sounds like nonsense to me,” said Empeiros.

“The ancients,” I continued, disregarding the comment, “noticed several beautifully shaped crystals, such as quartz, growing, as it were, out of shapeless rocks. The first scientific crystallographer was a Danish bishop called Steno, who in 1669 published a dissertation *Concerning Solids Naturally Contained within Solids.* Other naturalists carried on his research, and by 1782 a Frenchman, the Abbé René Just Haüy, had found the basic rule of the game of crystals: he had found how to obtain the shape of any crystal from that of some standard simple form.

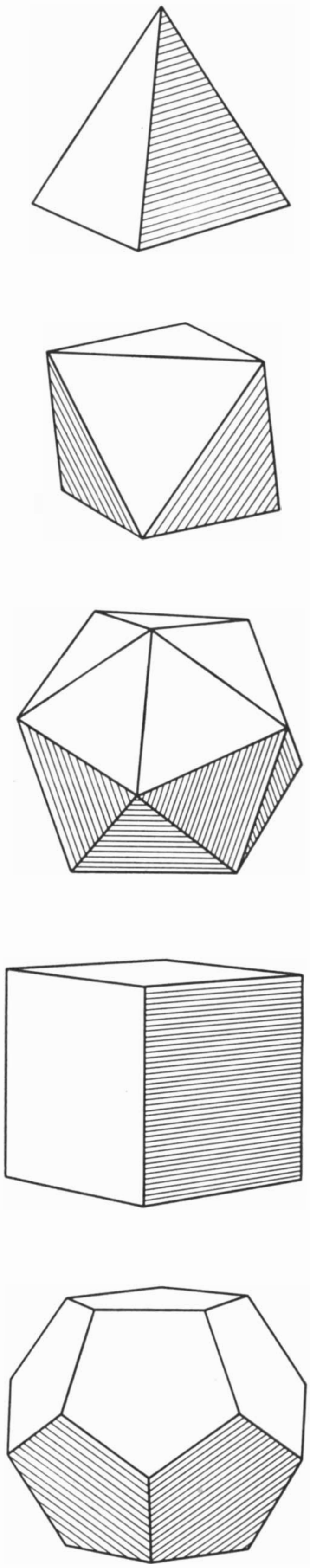
“Ever since Steno, mineralogists had been measuring angles between the faces of hundreds and hundreds of crystals, and the accumulation of all these data was a holy mess. Haüy noticed that a very simple rule held for those angles relating to a specific mineral. Since it is difficult to describe geometrical things in space, allow me to use a flat plane to tell you what Haüy’s Law says and what it implies. Assume that in a flat crystal a corner seemed cut off by the face BC, so that the contour of the crystal was XBCY [*see diagram at the bottom of next page*]. On edge AX Haüy marked off equal distances AB, BD, DE, EF, and on edge AY also equal distances AC, CP, PQ, QR. Then, joining any of the points marked off on edge AX, say E, to any of the points marked off on edge AY, say P, he found the angles formed by the cut EP and the two edges equal to angles actually observed on other specimens of the same mineral.

“This, Empeiros, was a momentous event in the history of science. For the good Abbé Haüy thus became the first experimental atomist. His successors were John Dalton, Gregor Johann Mendel, J. J. Thomson, Max Planck, Albert Einstein—each discovering a new type of ‘atom.’ From such geniuses . . .”

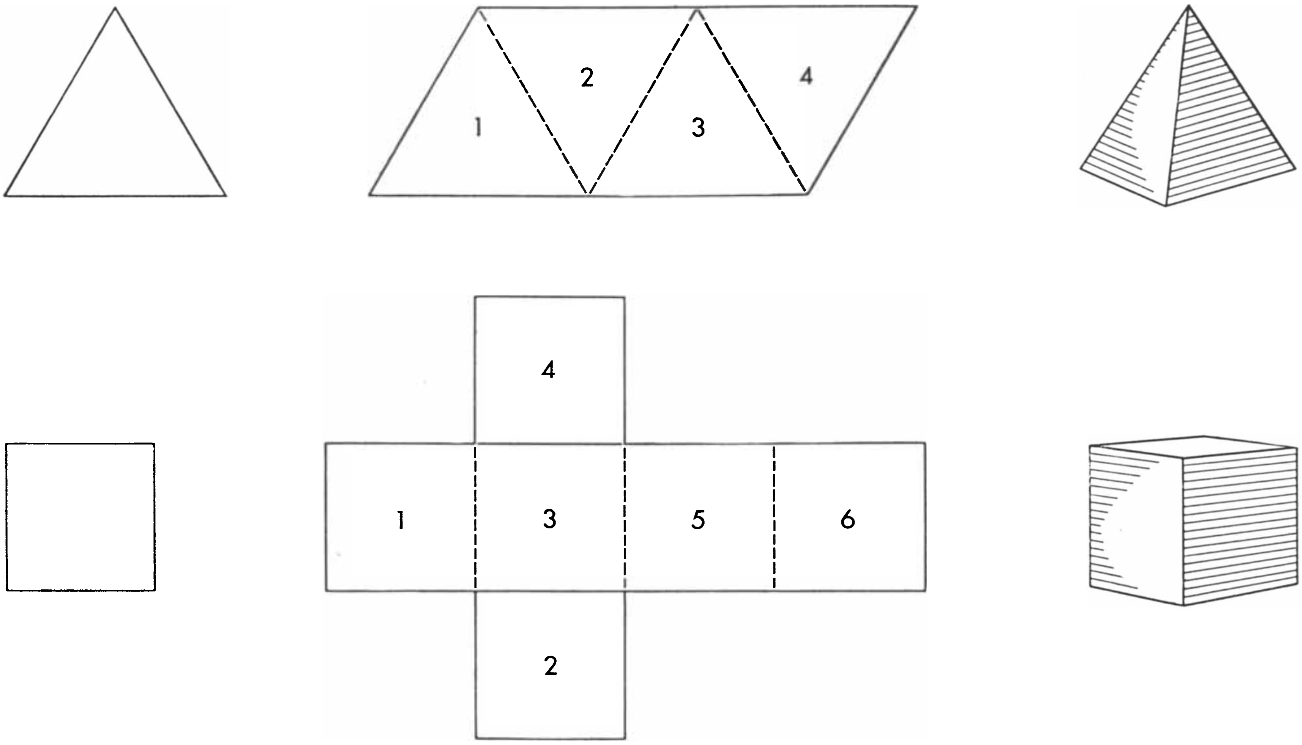
“Now wait a moment,” interrupted Empeiros good-humoredly. “I am interested in your story, and I want information, not enthusiasm. Would you mind telling me quietly how atomism enters here?”

“THAT is plain enough,” I answered. “Don’t you see that nature does not make cuts at random? She limits herself to a specific set of orientations; those in between are forbidden, so to speak. This is what we call space quantization. Why ‘quantization?’ Because we had to lay out along the crystal edges equal chunks of length, equal quanta of distance, to reproduce the observed angles. Now of course one is free to say that this is just a geometrical construction without physical significance. Haüy himself did not think so. He pictured a crystal as made up of an enormous number of very small, *identical* bricks. Later there came objections to the idea of solid matter consisting of stacked-up little bricks with no free space between. However, the essential point in Haüy’s system was not the little bricks themselves, but the regular distances defined by them—the quantization of space. So that if we assume that a crystal is made of minute atoms, all identical, distributed in space in some regular lattice, we shall have retained the basic reason why a crystal face, cutting off a whole number of atoms, must necessarily cut the edges of the simple standard form in whole-number ratios and satisfy Haüy’s law in an automatic way.”

“I follow all that,” said Empeiros, “and am ready to accept this model



REGULAR SOLIDS, of which each face is regular, are five in number.

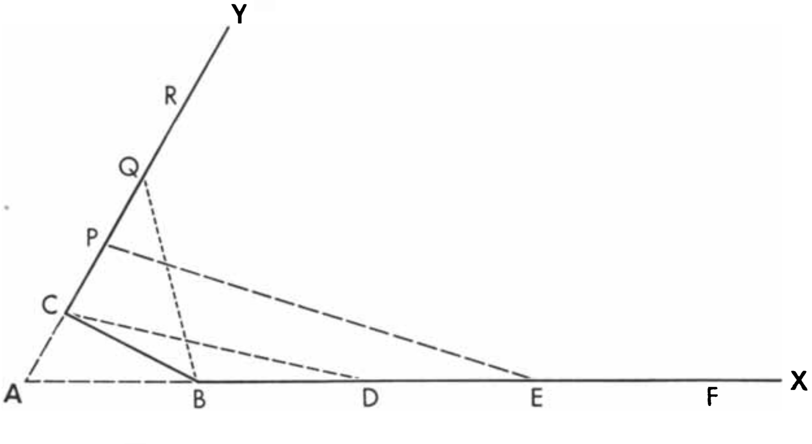


REGULAR SOLIDS MAY BE MADE from paper to demonstrate the limitation of their class. If four regular triangles are pasted together as shown at the top of this illustration, they will form a regular tetrahedron. The same can be done to make a regular hexahedron (cube), dodecahedron, octahedron and icosahedron.

(without believing in it literally) since it fits the angle measurements. But I note that nature is not so limited as you say, since around each crystal vertex it has an infinity of directions to choose from. Hence we have here no such drastic limitations as in the mathematical problem of the regular solids.”

“That’s what you think,” I replied, “but you are already in a mathematical trap. From the simple fact that the atoms are arranged into a regular lattice it follows that certain crystal symmetries are allowed—and no others. For instance, given a square made up of little dots, it is impossible to turn it into a regular octagon—a polygon of eight equal sides. To make an octagon of it we would have to divide each side of the square into three parts, with lengths in the ratios $1:\sqrt{2}:1$. And this is impossible to achieve with evenly spaced dots, because $\sqrt{2}$ is not the ratio of two integers—as Pythagoras found to his amazement some 2,500 years ago.

“And now the final step: If we turn the original square around by one right angle, or one fourth of one full turn, the appearance of the square will not be changed; crystallographers say that a square has a rotation axis of order four. A regular octagon could be turned around one eighth of a turn and still look the same; we say it has a rotation axis of order eight. But we have just found that a regular square array of points can never be made into a regular octagon. So we conclude that crystals may have a rotation axis of order four but not of order eight.”

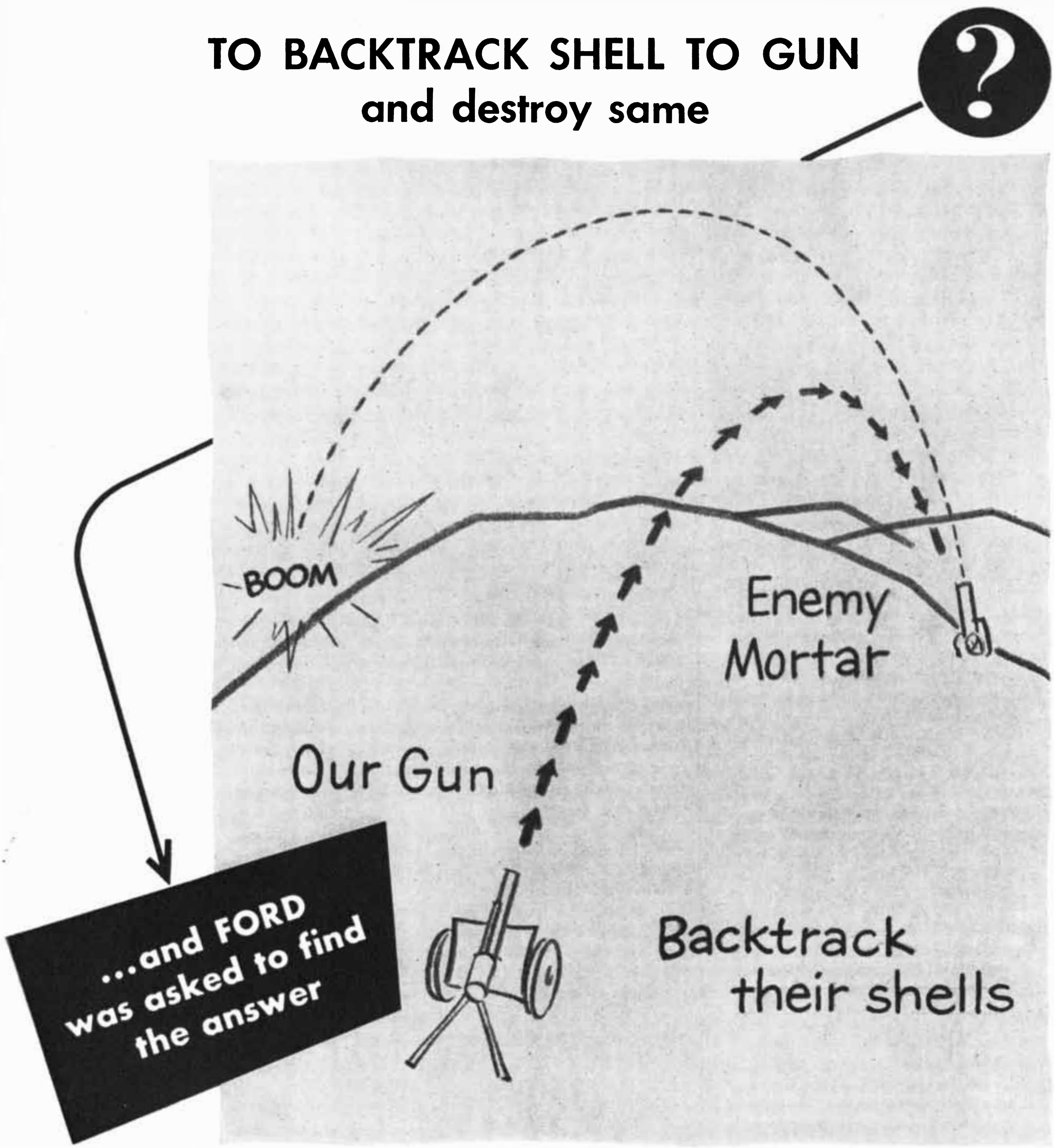


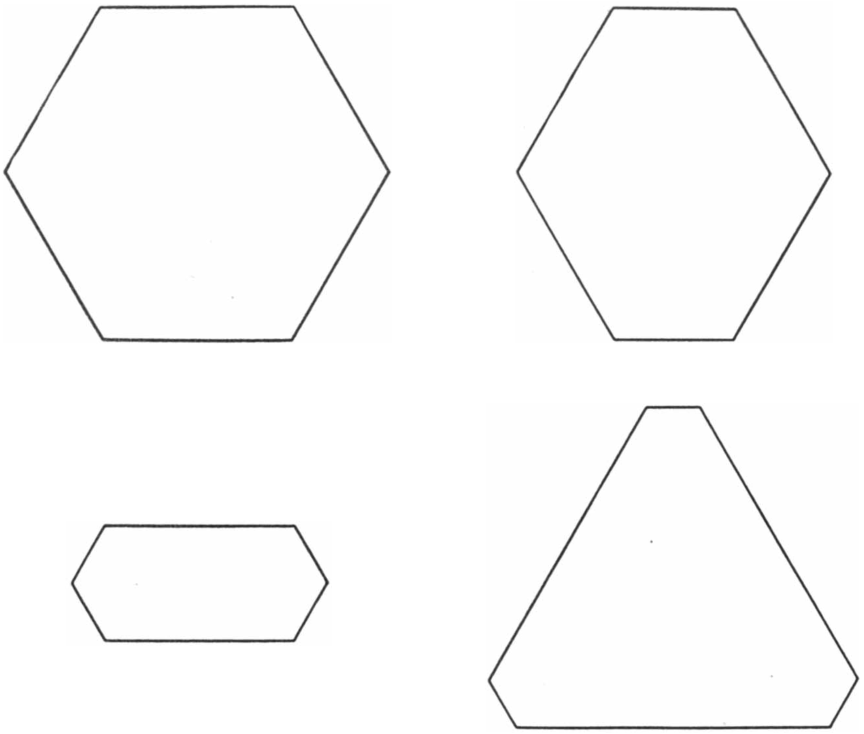
CRYSTALLOGRAPHIC LAW, here depicted in two dimensions instead of three, states that the facets of any one crystal type can have only such angles as are formed by cuts from equidistant points on the axes AX and AY.

“I MUST admit,” said Empeiros, “that this is amazing. Tell me one thing: How is it that I was taught a good deal of mathematics, and that I never heard of anything like that?”

“That,” I answered, “is because you were taught the geometry of Euclid, and the crystals follow the geometry of Pythagoras. Euclid’s geometry is one of continuous lines; Pythagoras’, of arrays of points. After Euclid invented his geometry, the earlier geometry of Pythagoras was dropped. Later scientists—Archimedes, Descartes, Newton, Maxwell—went deeper and deeper into the mathematics and the physics of the continuous, and brought out such things as the calculus, universal gravitation and electromagnetism.

“In the last 60 years, however, a new revolution has taken place, and everywhere we look we find that what seems to be continuous is really composed of atoms. Atoms of all kinds: chemical atoms, molecules, ions, electrons, quanta, photons, neutrons, chromosomes, genes. And everywhere the presence of atoms is revealed by the empirical discovery of laws expressed in terms of whole num-


?
BOOM
Enemy Mortar
Our Gun
Backtrack their shells
...and FORD was asked to find the answer



SIZE AND SHAPE OF CRYSTALS are unimportant in establishing their identity; the angles between facets are what count. These four hexagons, all of whose angles equal 120 degrees, are thus equivalent in this sense.

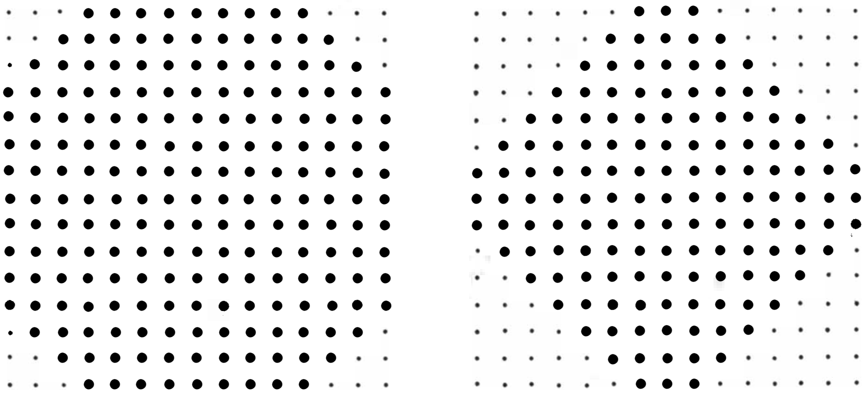
bers. So you see that Haüy's Law—the Law of Rational Indices—was a forerunner of all the other atomic laws."

"But are not modern mathematicians interested in such things?" asked Empeiros.

"They are," I answered, "but they give them other names. They call them Number Theory and the Theory of Discontinuous Groups. Actually they have found much more than we can use as yet in physics, but we have in crystals illustrations of some of their simpler theorems. Mathematicians have proved, for example, that the symmetry elements of crystals can be grouped in 32 different ways, and no others. Crystallographers have classified every known crystal into one of these 32 crystal classes. It is true that examples of two of these 32 classes have not yet been found in nature. But mathematics is the science of the logically possible. It tells us that these 32 classes are possible, and while we do not happen to know any example of two of them, we may find them next year, or in 10 years. Whether or not we shall ever find them is quite immaterial."

"IS THE science of crystals, then, entirely closed?" asked Empeiros.

"By no means," I answered. "Crystallographers have been digging deeper than this first set of symmetries which is reflected in the outward shapes of the crystals. Until now we have imagined



SQUARE MADE UP OF DOTS cannot be changed into a regular octagon. Here two octagons have been made, but neither is regular. This illustrates a limitation of crystal form (*see the illustration at the top of page 56*).

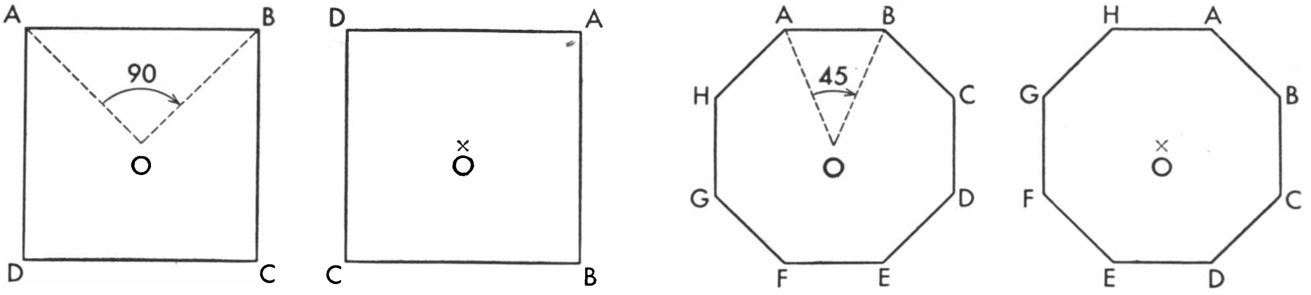
the atoms inside the crystal to be simple little dots. If we assume that the atoms have a certain shape, the question arises in how many ways this unique shape can be twisted around in space as we jump from one corner of the lattice to the next. Again one finds that only certain possibilities are open. This very difficult problem was solved in the 1890s by three scientists working independently—Fedorov, a Russian; Schoenflies, a German, and Barlow, an Englishman. All three got the same result: there are just 230 different ways of distributing identical objects of arbitrary shape regularly in space. We say that there exist 230 different space-groups.

"These 230 space-groups fit into the 32 crystal classes in a relatively simple way. Each commands a certain external symmetry, and therefore belongs to a specific class. The various space-groups (*i.e.*, internal arrangements) within a given class cannot be distinguished from one another by investigating the crystal faces. But in 1912 the German physicist Max von Laue found a means of exploring this internal structure—a beam of X-rays.

"From that moment the 230 space-groups, which previously had been considered a mere mathematical game, assumed great practical importance. X-ray analysis enables us to say to which space-group a crystal belongs. It even gives us clues from which we may find out how the atoms are arranged in a crystal. For a simple substance such as common salt this is relatively easy; you simply try out a few likely arrangements until you hit upon the one which in all respects fits the pattern of dots made on the photographic plate by the X-ray beam passed through the crystal. But with complicated molecules the problem becomes very difficult. It requires the same tedious kind of work, guided by much ingenuity and flair, as the breaking of an intricate diplomatic code. X-ray analysis is now part of the arsenal with which the problem of the structure of proteins, of such basic importance in biochemistry, is being attacked."

"ALL THIS is fascinating," said Empeiros, "but I don't see that we have advanced a bit in the question we were going to discuss. You believe that the field of physics is finite. Are not crystals the only regular arrays in nature? They appear to me, more so now than ever, as a beautiful exception."

"They are, and they are not," I answered. "The tiles, the regular solids, the spatial arrays we have been talking about seemed to be problems in geometry. However, this geometry, the geometry of Pythagoras, merely illustrates theorems from Number Theory, the name we give to higher arithmetic. When we say there are three kinds of regular tiles, five regular solids, 32 crystal classes, 230 space-groups, we are

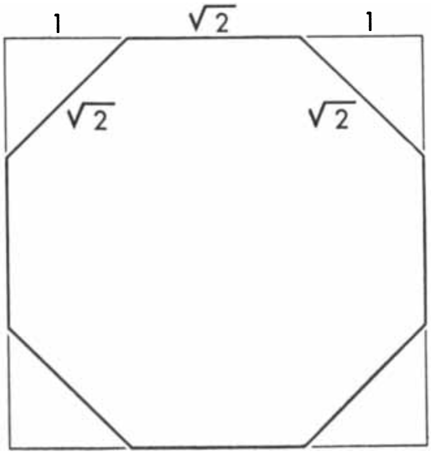


ROTATION AXIS of a square has the order four: it can be turned 90 degrees, or four times in 360 degrees, and still look the same. An octagon has a rotation axis of the order eight. Crystals cannot have such a rotation axis because an octagon cannot be made out of a regular array of points (*see illustration at bottom of page 54*).

only giving geometrical illustrations of four arithmetical problems, which have respectively 3, 5, 32 and 230 solutions. You see, then, that the essential circumstance about our problems was not that they were about geometrical arrays: it was that they were dealing with integers.

"By now we have found so many other types of particles besides those that are built up into crystals that the field is wide open for other applications of Number Theory and of an allied chapter of mathematics, Group Theory. Indeed quite a few have already come to light. The quantum theory of the atom is full of such relations, and the enumeration of the successive elements in the periodic table, is very similar to the enumeration of the crystal classes. Just as it would be impossible to discover tomorrow a crystal with some 33rd type of symmetry, so are we assured that no new chemical element can ever insert itself anywhere within the succession which today stretches from hydrogen to californium: it is a system of 98 elements filling all the steps from 1 to 98 electrons.

"The implications of this have crept almost unnoticed upon the chemists and physicists. Placing such limitations upon nature runs quite contrary to the traditional tenets of empiricism. That it has not received much notice shows that we are not yet adjusted to thinking in terms of atoms and quanta, and are unaccustomed to the absolute character of the counting of combinations of integers."



OCTAGON CAN BE MADE out of square only by dividing each side of the latter in the ratio $1:\sqrt{2}:1$.

"YOU HAVE marshaled," said Empeiros, "a collection of results which I admit is quite impressive. You may be right in thinking that this line of thought makes a dent in the solid doctrine of empiricism. But again I remind you of your statement that the field of physics is finite. You have not yet proved that."

"And I cannot prove it," I answered. "It is a hunch and a prediction. All I can do is to show you why I think it is the trend along which physical science has been developing these last 350 years. In any new science purely descriptive knowledge is the first stage of advance. Next comes the establishment of quantitative laws, such as Boyle's law for the 'spring' of air, Newton's law of universal gravitation, Maxwell's equation of electromagnetism. In this stage we learn that things in nature are related by such and such numerical laws. But we don't understand why. Why should crystal faces always obey Haüy's Law, the Law of Rational Indices? That understanding came in 1912 when the periodic space-structure of crystals was experimentally established. We could then conclude, not from observation but led by mathematical necessity, that there are exactly 32 possible crystal classes and 230 possible types of space arrangements of atoms in a crystal.

"In the third stage of scientific knowledge, which we might call deductive or axiomatic, the natural laws obtained by observation are shown to be necessary logical consequences of a few hypotheses or assumptions. The surprising thing about the examples of deductive knowledge which we know today is the extreme simplicity of the assumptions, and how rich and far-removed are their consequences. For instance, the single assumption that any crystal is a periodic space lattice carries with it the whole theory of crystal classes and of space groups.

"At the present time some of our leading scientists, following early attempts by Einstein, are trying to merge together the experimental laws of gravitation and of electromagnetism. It is unthinkable that these two fields should be unrelated. We know from measurement that the electric repulsion of two electrons is a certain number of times greater than their Newtonian attraction. This is the empirical stage. We want to know why this ratio is that number and no other. The recent discovery of several new types of elementary particles, which just now are in meaningless disorder, makes the problem all the more pressing.

"We cannot rest satisfied with numerical statements without logical justification. Crystallography is a perfect example of how a numerical statement becomes justified. It may not be very long before we obtain deductive knowledge, on the basis of some few fundamental assumptions, of the main features of the physical universe."

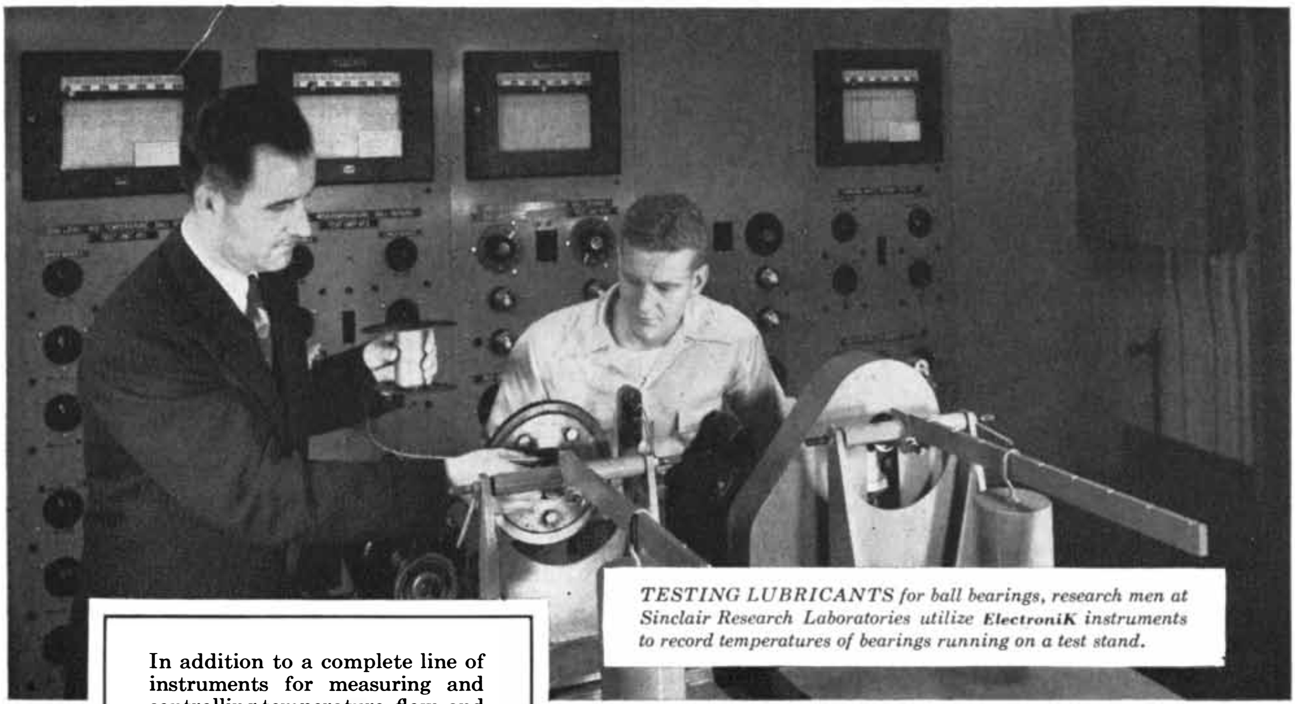
"YOU MAY surely project anything you wish into the future," said Empeiros. "But you must admit that the realization of your daydream would be without precedent in the development of science."

"I admit no such thing," I retorted. "Geometry was once quite as empirical as physics is today, and the first 'theorems' were found experimentally. It took the Greeks 300 years, from Thales to Euclid, to establish a set of assumptions upon which geometry could be built logically. Now consider that practically all we know in physics has been found in 350 years, and that in the last 50 years we have traveled all the way from the phenomena of common experience to fissions in atomic nuclei. Wouldn't you think that in the next 50 years—taking us to the year 2000, a nice round figure—we should have a sporting chance of establishing in our turn a set of assumptions on which physics can be built?"

Empeiros shook his head skeptically.

Philippe Le Corbeiller is professor of general education and of applied physics at Harvard University.

How many research hours in a day?



TESTING LUBRICANTS for ball bearings, research men at Sinclair Research Laboratories utilize **ElectroniK** *instruments to record temperatures of bearings running on a test stand.*

In addition to a complete line of instruments for measuring and controlling temperature, flow, and dozens of other variables, Honeywell offers these special *ElectroniK* instruments of interest to research men:

Function Plotter: automatically plots the relation of two independent variables.

Two-Pen Recorder: simultaneously measures two variables on a single chart.

Extended Range Indicator: featuring automatic range-changing, readable to one part in 5000.

Narrow Span Recorder: measures spans as narrow as 100 microvolts, without external pre-amplifier.

Brown Electrometer: measures currents as low as 10^{-15} ampere.

High Speed Recorder: features pen speed of only one second for full scale travel.

OBSERVING tests, measuring critical conditions, collecting data, plotting curves . . . the routine labor of research takes a lot of time out of each day . . . each week . . . each month.

You'll find that *ElectroniK* instruments can save countless scientific man-hours by doing all these laborious but essential jobs for you. They free highly trained scientists for more important work . . . giving them an opportunity to use their brainpower most effectively. And these instruments do the routine work faster, more accurately than could be done by human hands.

ElectroniK potentiometers are accelerating the pace of research in academic and industrial laboratories, atomic energy projects, pilot plants, and test centers throughout the world. For a discussion of how they can help your own research programs, call our nearest engineering representative . . . he is as near as your phone.

MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Division,* 4580 Wayne Ave., Philadelphia 44, Pa.

REFERENCE DATA: *Write for Research Bulletin 15-14,"Instruments Accelerate Research" . . . and for Data Sheets on specific instruments.*

MINNEAPOLIS
Honeywell
BROWN INSTRUMENTS

First in Controls

Psychotherapy for Schizophrenia

The psychosis ranks with cancer as a problem of public health. It is treated by shock and surgery and now by psychoanalysis, which, though slow and difficult, has had encouraging success

by Don D. Jackson

SCHIZOPHRENIA accounts for about half of the patients in mental hospitals and about one quarter of all hospital patients in the U. S. The total number of schizophrenics in the nation is estimated to be approximately two and a quarter million (325,000 of them in hospitals), and some 125,000 new patients with this disease are admitted to mental hospitals each year. Thus schizophrenia ranks with cancer and heart disease as one of the major problems of U. S. medicine.

In the face of the overwhelming size of the problem, most psychiatrists today are disposed to resort to the quick, drastic treatments developed during the past 20 years—shock treatments of various kinds (with electricity, Metrazol, insulin, carbon dioxide) or prefrontal lobotomy. Yet there are indications that the enthusiasm for these procedures has begun to wane. The shock treatments have not lived up to the original expectations. Although they produce dramatic immediate results, after a number of years of experience it has now become clear that the results are often temporary; a large proportion of shock-treated patients sooner or later relapse. As for the lobotomy operation, it is not a cure at all: it replaces the schizophrenia symptoms with a brain deficit which may make the patient more tractable but reduces him to childishness and permanent dependence. As the relatives of the lobotomized patient often remark: "It is as if he has lost his soul."

Within the past 10 years more and more psychiatrists, especially among the younger ones, have been treating schizophrenia by psychotherapy. There are understandable reasons why this approach was long thought to be futile. Sigmund Freud believed that schizophrenics were too narcissistic (turned in on themselves) to be reached by psychoanalysis. Moreover, there was a wide belief that schizophrenia stemmed from some organic or constitutional defect. But no convincing evidence that the disease is hereditary or constitutional has ever been found. And in recent years it has been shown that, contrary to Freud's early conclusion, it is possible to achieve a workable transference relationship between a schizophrenic and his therapist.

Of course a psychotic patient is much more difficult to treat by psychoanalysis than a merely neurotic one. The treatment takes at least two years, and usually longer; it is incomparably more expensive than the quick method of shock treatment. But shock treatment at best merely restores the patient to the state in which he was before he became psychotic; it cannot teach him anything about how and why he became sick, or how to avoid another breakdown. Psychotherapy is the only treatment that offers a chance for a lasting, major change in the patient's personality.

SCHIZOPHRENIA is a highly complex, unpredictable disease. It is officially defined as "a group of psychotic reactions characterized by fundamental disturbances in reality relationships and concept formations, with affective behavior and intellectual disturbances in various degrees and mixtures." It expresses itself in many behavior aberrations, but most of all in a strong tendency to retreat from reality. The schizophrenic speaks a language so strange that it seems completely unintelligible. Yet it is possible to learn to understand the language. Psychiatrists now see in the productions of the psychotic mind many similarities with the dreams of healthy people and neurotics. The schizophrenic himself in many cases is fairly clear on the meaning of what he says. He is not so completely regressed as to be unreachable, and the psychiatrist can reach him provided he has the patience to learn the language and understands the causative factors in the disease.

Such an understanding has been developed by various workers in the U. S. and Europe. Most of them agree that schizophrenia tends to arise from emotional trauma that occurred very early in life, usually in infancy. Whereas most cases of neurosis are traceable to difficulties in early childhood, the schizophrenic begins his thwarting experiences earlier. He is likely to have been made extremely insecure in the first years of life, at his most helpless time. His parents or caretakers were extremely anxious themselves and communicated this anxiety to the child. It is rare to find a schizophrenic without a long history of difficulty from very early infancy. This would include feeding difficulties, fretfulness, prolonged crying and other obvious signs of a disturbed child. Almost every infant displays such behavior on occasion, but in the schizophrenic it is longer-lasting and occupies a greater per cent of his infancy.

Anyone who deals with the schizophrenic is impressed by the intensity of his longing for love, his helplessness and his rages. Probably this is the reason schizophrenics fear to get close to the psychiatrist; they are afraid of exposing the extreme degree of their feelings. The psychotherapy of a schizophrenic resembles the labors of Sisyphus. The therapist must go over sensitive material again and again with the utmost patience and delicacy. It is by far the most time-consuming, demanding and exhausting work that confronts any psychiatrist. Always he must be wonderfully alert, gentle and unsurprisable—yet not inscrutable. There is always a great deal of anxiety, which is communicated to and affects the psychiatrist.

Schizophrenics in general are people who have had tremendous difficulty in establishing relationships with other people. Almost invariably they have found it difficult to participate in adequate emotional relationships and have met with constant rebuff and disapproval. They therefore feel that any idea that may originate in them is ridiculous and unworthy of communication to others. This leads to a fear to expose themselves, to a tremendous loneliness and to a great deal of resentment. The feeling of having been rebuffed and of not being loved leads to the patient's defending himself by rebuffing and withholding love from others. This will naturally include the therapist, who must be prepared to carry on without any show of gratitude from the patient. Many workers in this field believe, indeed, that the psychiatrist's own emotional reactions are the most critical factor in the treatment; if psychiatrists were unfailingly tender and anxiety-proof (in short, superhuman), with almost unlimited time, they could cure any schizophrenic.

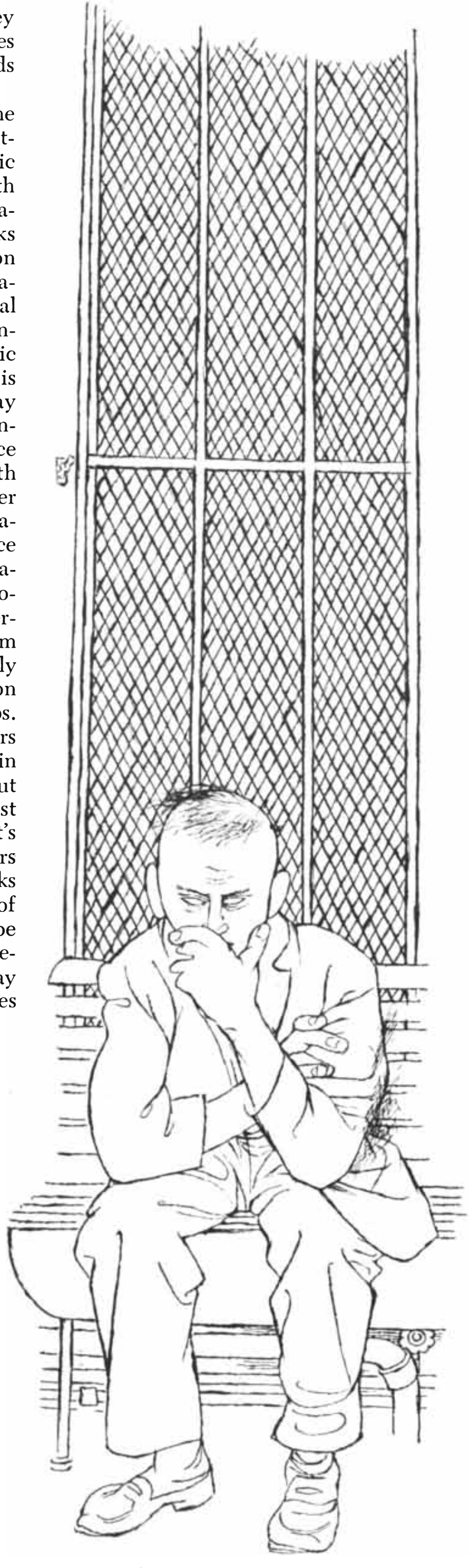
Here is a case that illustrates the problem. The patient was a young man who had been seriously ill and hospitalized for several years. He was mute, suspicious, generally had to be fed by tube because he refused to eat, and on occasion was destructive. He was completely aloof from the rest of the patients. Then a psychiatrist began to treat him, visiting his room for an hour a day five times weekly. At first the patient left the room whenever the therapist entered. If the psychiatrist followed him into the hall, the patient generally returned to the room. There was no verbal communication between them other than the psychiatrist's occasional "thinking out loud" about what the patient's behavior seemed to mean. After some weeks the patient came to stand at the door, with one foot on either side of the threshold, during the doctor's visit. When the psychiatrist said something that interested him, the patient would swing toward the room; when the therapist's remarks bothered him, he faced out toward the hall. At length, after three months without a word, the patient finally said, almost inaudibly: "If you take it easy, perhaps we can get somewhere." Despite the therapist's efforts not to press matters, the patient had sensed his unspoken urging to communication. The patient had reacted against this, but at the same time he had also been encouraged by the doctor's hopeful attitude.

IN APPLYING psychotherapy to schizophrenics, psychiatrists have sought to strengthen its effectiveness by studying the disease itself, by achieving better control of their own emotions and reactions by psychoanalysis, by enlisting ancillary hospital services (such as occupational therapy, psychiatric nursing and clinical psychology) and by explaining the patient's behavior and needs to his relatives and friends. They have also modified the classic techniques of psychoanalysis to adapt it to the needs of schizophrenics.

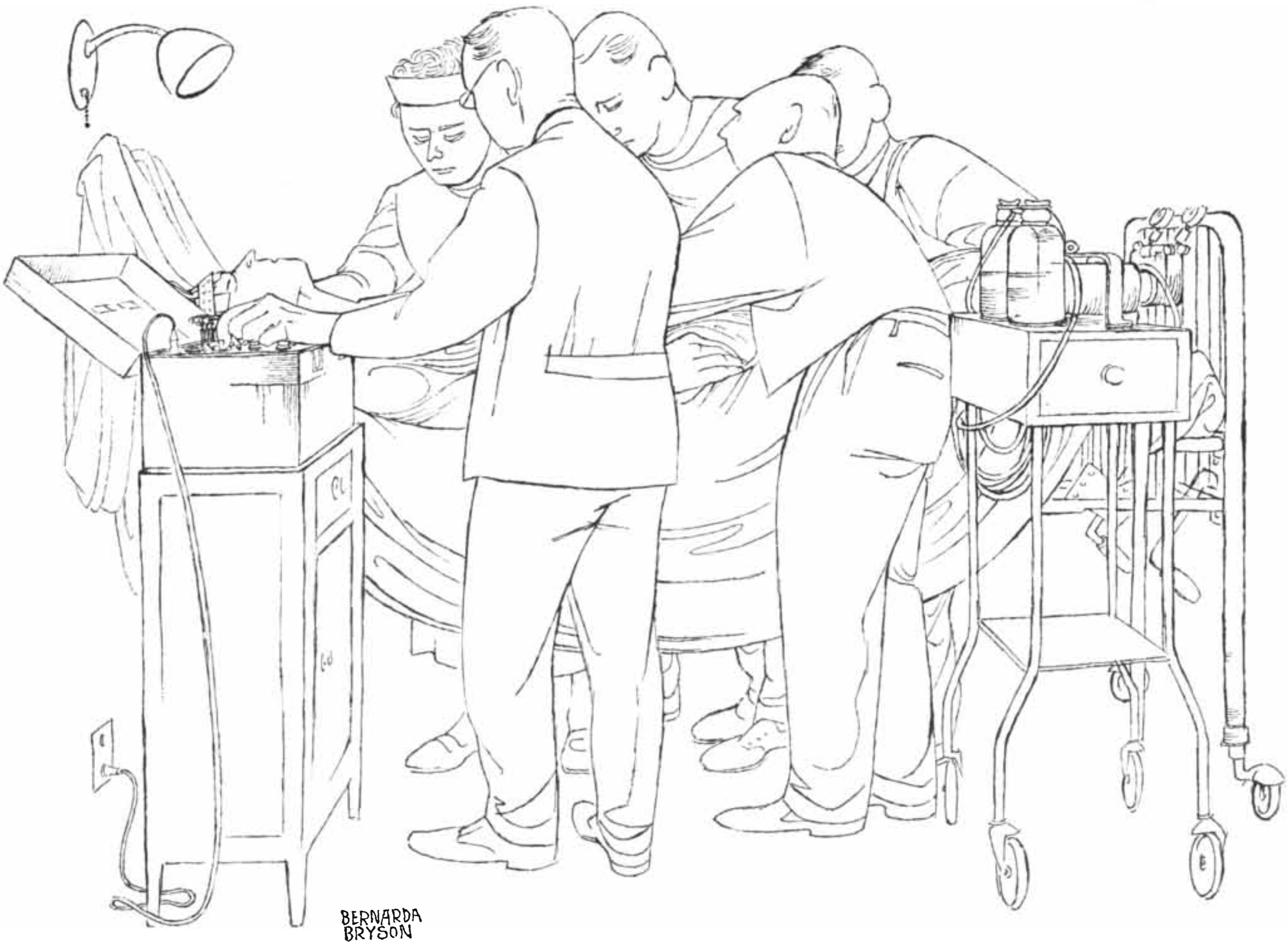
The analyst does not sit behind the head of the couch as he would in treating neurotic patients. The schizophrenic is much too fearful to be at ease with the doctor out of sight. Hence the therapist sits facing him, or, if need be, walks around the hospital grounds or sits on the floor with him. Nor does the therapist confine his role, as in traditional analysis, to listening and occasional encouragement to talk. For a schizophrenic the classic method of free association is inadequate; even if he is able to say what comes to his mind, it may be confusing and hopelessly obscure. Hence the therapist must help the patient with adroit questioning and try to decipher and indicate understanding of the patient's confusing productions. Silence and passiveness on the part of the therapist will only increase the schizophrenic's hopelessness. Instead of permitting the patient's thoughts to roam where they will, the therapist generally tries to focus the patient's attention on his current interpersonal relationships. Often the first insight in therapy occurs when the patient recognizes certain gross distortions in his views about people around him. The doctor must also bring into the open the patient's feelings toward him, in order to lay fears at rest. If, for example, the patient thinks that the therapist is one of a gang of murderers hired by his family, it will be imperative to clear up that matter before the patient can be expected to say much of anything about what troubles him.

As therapy progresses, the patient's current problems can be related to his past. The patient as well as the doctor can begin to understand the stresses that led to his schizophrenic break with reality. A case in point is a patient who felt that she was the Queen of England. She was eventually able to relate this delusion to her parents' "nobility"—their coldness and lack of humor—and to her intense feeling of inferiority. Her delusion had arisen in part from a desire for power and the wish to control people so they would respect her and not be in a position to hurt and humiliate her.

When the patient has developed a feeling of confidence and trust in his doctor, some of the dreaded emotions of his early life may emerge from his unconscious—his intense loneliness, hate, hopelessness and frustration. This process is one of the most important and most difficult aspects of the treatment. As the patient is brought to understand that he



The patient



Therapy by electric shock

can expose these feelings to the therapist without fear and without retaliation, he gains confidence in his ability to have dealings with other people. Always the therapist must demonstrate to the patient, and persuade him to demonstrate to himself, the linkage between the present and the past.

The last step in the treatment is to remove the patient's dependence on the therapist and leave him free to regard himself and the doctor as competent, separately functioning human beings. During this process there may be an upsurgence of the patient's symptoms, but usually the period of insecurity is short-lived. After the treatment is ended, the patient may need to see the psychiatrist occasionally as special problems arise.

IN SEVERE cases the treatment must be carried on in a hospital. Any successful attack on a schizophrenic's psychotic defenses inevitably releases a great deal of anxiety. Such a release may lead to suicide, homicide or destructive acts, unless the patient and those about him are protected, as they can be in a hospital. In addition a hospital offers the patient several significant figures in his environment, thereby diluting his reaction to any one individual. The hospital environment also helps in many other ways: the patient's association with other mentally ill people shows him that he is "not the only one"; the restrictions may make him realize that his illness is taken very seriously; the routine helps distract him and channel his energies in a non-anxious way.

A large per cent of schizophrenic patients enter the hospital against their will. Somehow they must be convinced of the desirability of this measure if they are not to continue regarding the hospital and its personnel as "crooks," "murderers" or members of the F.B.I. The patient must be helped to recognize that he is sick and in need of treatment. The privileges allowed him, especially how much he is permitted to go about unaccompanied, can be crucial in this process. If a patient demands an increase in privileges, a refusal runs the danger of crushing his strivings toward mental health, while on the other hand a grant of increased responsibility may add to his anxiety. The patient's daily living conditions in the hospital form a large part of his discussions with the therapist. Here are fought the battles which his healthier brethren resolved during childhood and adolescence. The staff, by frequent conferences on the patient, attempt to keep *au courant* with the shifting (and at times tumultuous) fortunes of his struggles with his inner difficulties. Most therapeutic hospitals maintain indoctrination courses for aides and nurses and hold fairly frequent meetings, designed not only to elicit information about the patient but to educate the personnel and alleviate their anxieties. The ward administrator or the clinic director must be available for on-the-spot discussions with staff members.

WHEN the patient improves to the extent that he may live and be treated outside the hospital, the therapist faces one of the most difficult phases in therapy. There are features of this phase which may convince the physician that his proper calling is life insurance. He must be responsive day or night to the patient's demands, to the patient's "acting out" and to the weathering of storms of emotion the like of which the therapist will not encounter elsewhere.

Therapy by analysis

The schizophrenic since his early days has been living in what he regards as a hostile jungle, and he has had to develop means to combat potential dangers. One of these is to suspect that people don't mean what they say and to search for the hidden meaning. The following incident illustrates this. A therapist and his patient had inadvertently occupied another doctor's office. When the owner of the office appeared at the door, the therapist apologized. The second physician remarked it was "perfectly all right" and retired. The patient immediately told his therapist, "Gosh, Dr. X was angry." The therapist had not detected such a reaction in his colleague, but on checking later he discovered that the patient was correct. Indeed, therapists are sometimes a little frightened and disconcerted to learn that their schizophrenic patients have an uncanny way of nosing out things about their personalities which they have unconsciously tried to cover up.

The patient naturally has a reaction against the therapist's attempt to change his way of living. Many a therapist unfortunately feels it necessary to guide the patient along strictly conventional cultural lines, unconsciously insisting that his patient become a success or fulfill popular notions of how people ought to behave. The patient has generally had an overdose of this sort of pressure from his early days, and he resists. The doctor must consider the individual's own needs. Even after recovery some patients will need to live a relatively secluded life, with a great deal of time to themselves. Some may never tolerate marriage; some may marry successfully but be too anxious to cope with children. The physician should not have preconceived ideas about the performance to be expected of his patient.

AS TO the results of the treatment of schizophrenics by psychotherapy, statistics are scarce, and when available are often misleading. To evaluate the results one needs to know how severe the illness was and how recovery is defined. Some therapists speak of a "cure" when the patient is brought out of his psychotic state—so far as his observable behavior is concerned. Others use "cure" to mean that the patient has gained sufficient insight into himself to give reasonable insurance that he will not become

Introducing "Subminiature Engineering" a dominant factor in instrument and component designs of the present and the future.

The modern tempo of industry emphasizes the need for instrumentation combining compactness, light weight, space conservation, stability and durability, to keep pace with the expanding requirements of new instruments in research and production.
Victoreen has specialized in subminiature components such as electron tubes, hi-meghom resistors, vibrators and power supplies. Flexible equipment permits moderate pilot production to meet specific specifications.

Better Components Make Better Instruments

Consult us on your problems of subminiaturization. An engineering staff with this kind of "know-how" is at your service.

COMPONENTS DIVISION
Victoreen Instrument
3800 PERKINS • CLEVELAND 14, O.

OUTSTANDING OPPORTUNITY for APPLICATION FIELD ENGINEER

Rapidly expanding markets for Beckman instrumentation has created unusual opening for man with chemical degree and previous application engineering or plant instrumentation experience. His duties will include work with customers in developing and testing new applications of Beckman equipment, including Flow Colorimeters, pH Meters, and Spectrophotometers. He will also obtain information on applications of wide industrial interest.

Sales personality desirable—no selling required in this position. Ability to write clearly is essential. Some travel out of Pasadena, California.

Beckman Instruments is a leader in the fast-growing instrument industry, not dependent on military contracts but of prime importance to all types of research and industry.

Address replies to:
Don Strauss
Employee Relations Director
Beckman Instruments, Inc.
1001 El Centro
South Pasadena 48, California

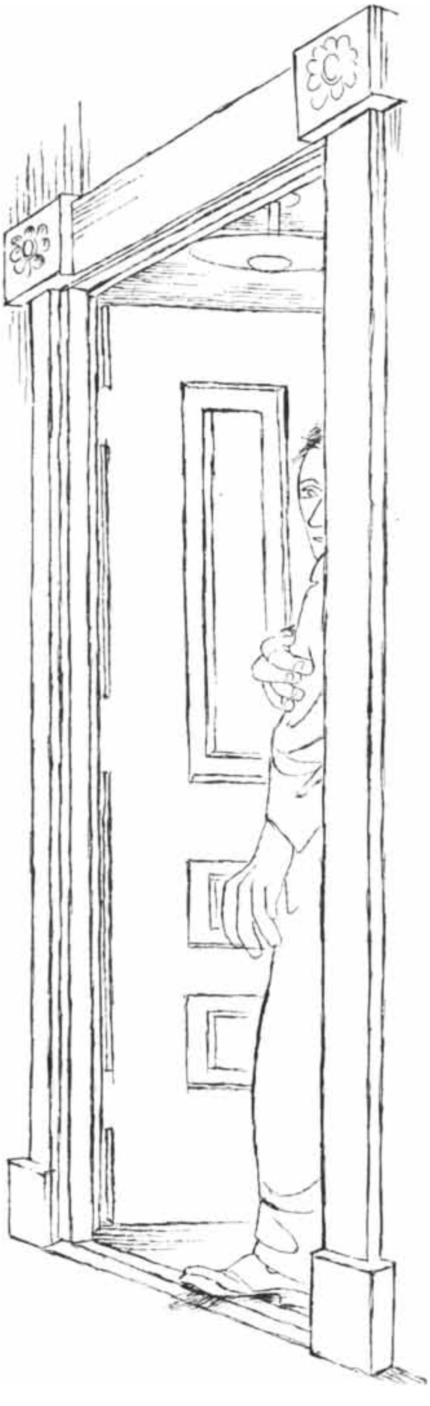
MATHEMATICIANS PHYSICAL SCIENTISTS

Openings now exist for a number of qualified physical scientists (all levels) or experienced operations analysts in the country's oldest established organization engaged in Operations Research. The necessary minimum qualifications are: U. S. citizenship, demonstrated ability to solve problems, and a broad scientific background and interests. Desired age range 25-45 years.

Salaries are comparable with those in industry, although the positions offer many of the advantages of the academic world.

Write for additional information about long term careers in one of the newest and most challenging fields of applied science. Replies will be considered confidential.

OPERATIONS EVALUATION GROUP
Post Office Box 4955
Washington 8, D.C.



The patient distrusts the analyst

psychotic again. Still others reserve "cure" to imply a personality change comparable to that in the successful psychoanalysis of a neurotic.

Certain gifted therapists treating young schizophrenics suffering from the acute disease (of relatively short duration) have achieved striking results—80 to 90 per cent of the patients have been brought out of the obviously psychotic state. There are no follow-up studies to indicate how large a percentage of these patients maintained their health. Most therapists believe that there will be a higher percentage of permanent re-

© 1952 SCIENTIFIC AMERICAN, INC

coveries among these than among patients treated only with shock therapy.

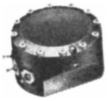
The results in cases of chronic schizophrenia are more difficult to estimate. Nearly all the chronic patients have run the gamut of shock therapies before the attempt is made to treat them by psychotherapy. We have no study of a large series of psychologically treated patients with follow-up examinations and with an adequate control group. Therapists connected with hospitals where psychotherapy is being carried out believe, however, that 50 to 60 per cent of the patients are returned to society. Some of these would be considered "recovered"; a smaller per cent, "cured." The "cured" patients have usually had a minimum of two to three years of treatment; many have had much more. Thus it is apparent that the treatment of this disease is no evangelical cure of the Billy Sunday variety but a gradual metamorphosis which results from years of studying the patient's interpersonal processes. Those engaged in dramatic types of therapy often report a striking proportion of cures. Careful inspection shows, however, that these patients have merely been brought out of the psychotic stage of the illness; they cannot be said to have a recovery with insight into the causative factors or their personality.

THERE SEEMS to be an increasing interest in the use of psychotherapy for psychotic patients. The training centers that specialize in intensive long-term psychotherapy are crowded with applicants for admission, and articles and books on the subject create widespread interest within the profession. It may perhaps be said that the psychotherapy of schizophrenia has been the outstanding achievement of psychiatry in the last 10 years.

Not the least important aspect of this work is what it has taught us about other types of emotional illness. Schizophrenia is a caricature of the extremes of perturbation to which the human psyche is heir. There is nothing unique about the difficulties of schizophrenics except in degree. As the late psychiatrist Harry Stack Sullivan once said: "The most peculiar behavior of the acutely schizophrenic patient . . . is made up of interpersonal processes with which each one of us is . . . familiar. Far the greater part of the performances . . . of the psychiatric patient are exactly of a piece with processes which we manifest some time every 24 hours. . . . *We are all much more simply human than otherwise,* be we happy and successful, contented and detached, miserable and mentally disordered or whatever."

◆

Don D. Jackson is a psychiatrist on the staff of the Palo Alto Clinic in Palo Alto, Calif.



WOOD STRUCTURE

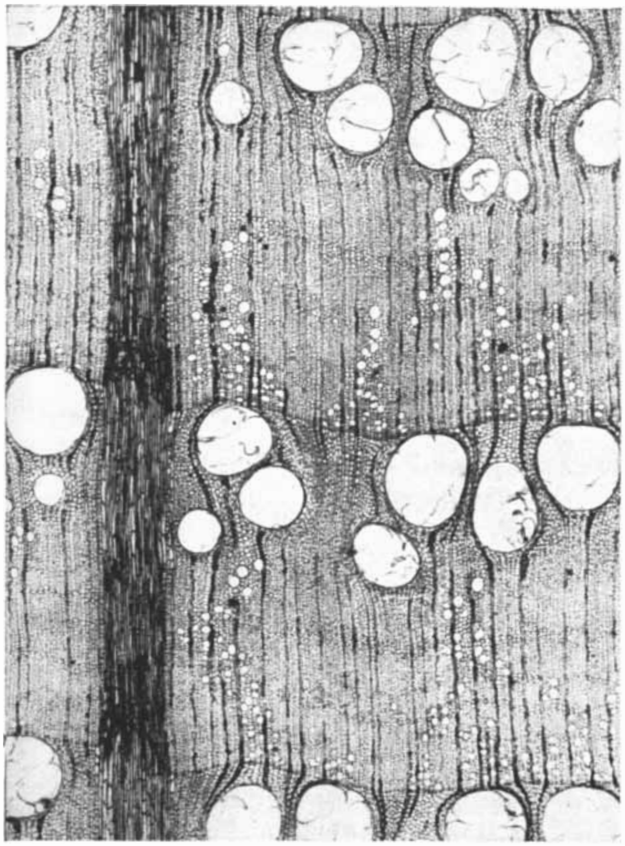
Trees are still the most versatile source of structural material. Each species has a characteristic organization of cells due to the special conditions of its existence

by Simon Williams

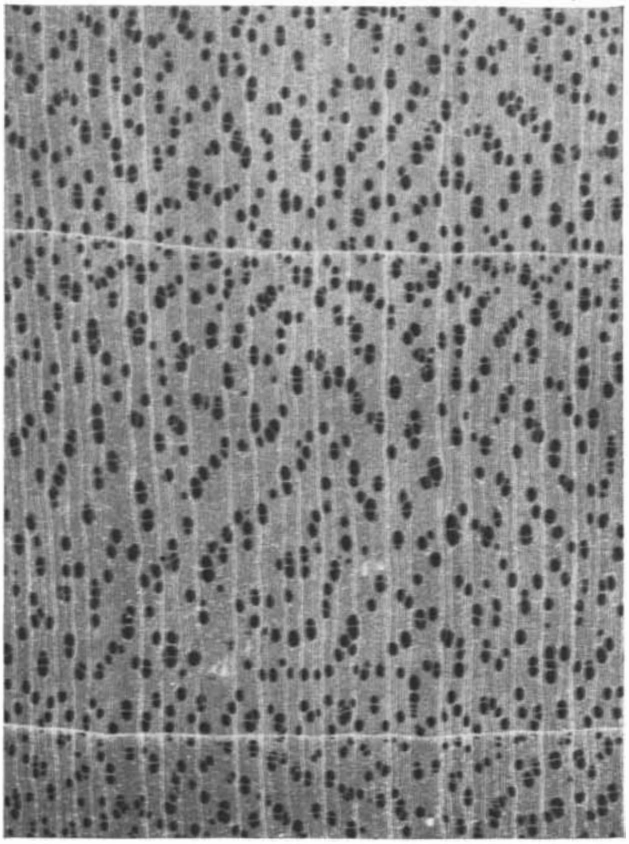
WOOD is still the most versatile and most used building material, exceeding plastics, light metals and all its other new competitors combined. Each year mankind harvests and consumes some 55 to 60 billion cubic feet of lumber. But the forests of our planet, covering about one fourth of the land surface, are growing only about 35 to 40 billion cubic feet of new wood per year. Thus we are eating into our lumber capital at an alarming rate. Foresters insist that with proper forest management we could grow more than enough wood each year to meet our needs. It would be helpful if there were a wider understanding of the various kinds of wood—their uses and their production by growing trees.

Botanists divide the tree species of the world into two major groups: the Gymnosperms (naked seeds) and the Angiosperms (enclosed seeds). The Gymnosperms, commonly known as evergreens and softwoods, are typified by such trees as pine, spruce, fir, redwood and yew. The Angiosperms, usually called deciduous or hardwoods, include the oak, hickory, maple, elm and mahogany. The popular names cause some confusion: for example, the cypress, classed as an "evergreen" tree, is deciduous; the "deciduous" live oak is evergreen; the southern pine, called a softwood, is harder than most hardwoods; and the cottonwood, classed as a "hardwood," is one of our softest woods. But in general the terms hardwood and softwood conveniently distinguish the two types of trees. About 75 per cent of all the timber cut is softwood, not only because it is easier to work but because most of the world's hardwood is in the economically inaccessible tropics.

To see how the structure of wood af-



WHITE OAK has pores obstructed by processes that inhibit the flow of air and water. Thus the wood is desirable for tight cooperage. Magnification: 30 diameters.



YELLOW BIRCH is punctured by many pores. There is little difference between the volumes of these pores in slow- and fast-growing trees. Magnification: 10 diameters.

fects its uses, we must begin by examining how a tree grows. It grows in height by the division of cells at the tips of its twigs. It grows in thickness by another kind of cell division which each year lays down a new coat of wood around the stem under the bark. This layer grows rapidly during the spring and more slowly during the summer, and the difference in density between the spring and summer growth is what produces the visible growth rings in the cross section of a tree trunk.

THESE RINGS have an important bearing on the mechanical qualities and appearance of the timber cut from the tree. Think of each ring as a slice across a hollow cone which tapers gradually from the bottom of the trunk to the top of the tree. The growing tree is like an expanding nest of cones, each cone representing a year's growth. The cones are not uniform in thickness, either in cross section or as they go up the tree. Any board cut from a log will contain sections of various cones, and the cone structure of the cut piece critically controls its appearance and mechanical behavior.

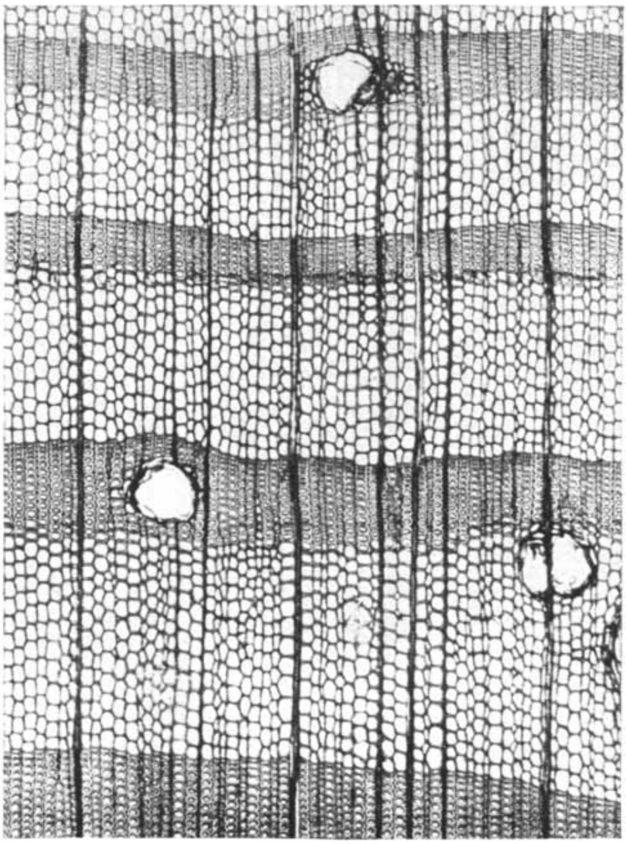
Next we have the effect of the wood tissues' cell and molecular structure. The woody cells, overlapping one another and firmly cemented together, spiral up the tree with their long axes roughly parallel to the long axis of the tree. Similarly the long-chain cellulose molecules, which chiefly make up the cell walls, spiral along the long axes of the cells. This explains why wood splits easily along the grain but must be sawn or chopped across the grain. It also explains why wood shrinks so little in length (less than 1 per cent) when it dries. Water in the cell walls is held mainly between the molecular chains, not inside them, and when the water evaporates the chains come closer together, so that the shrinkage is lateral rather than longitudinal.

Then there is another factor that determines the gross structure of the wood: knots produced by branches going off from the main stem. A branch originates as a lateral outgrowth of a single growth cone. As long as it remains alive, it grows outward from this point source, becoming thicker with its own rings year by year. Thus as the main stem grows around and envelops its base, the knot within the main stem steadily widens; this is why a knot always has the shape of a wedge with the point toward the heart of the stem.

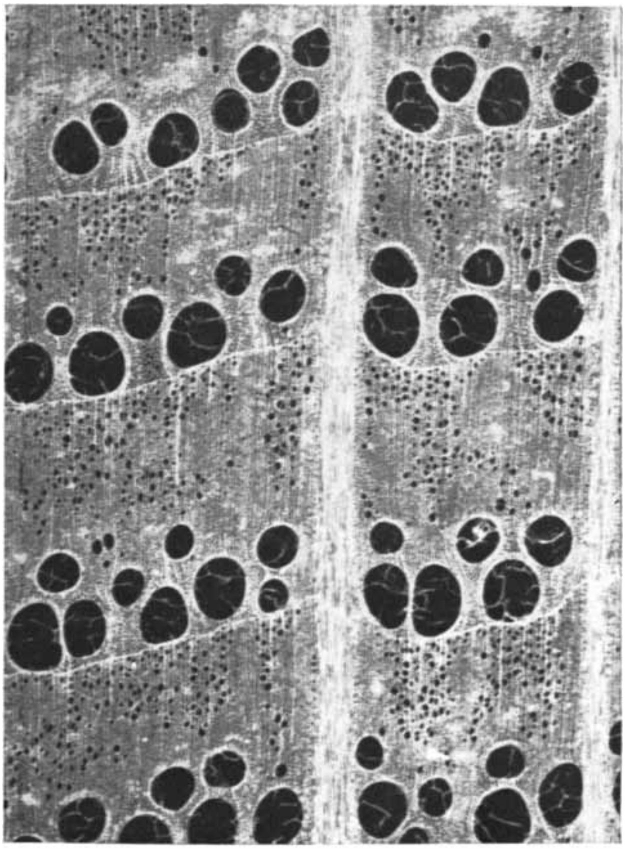
Most of the branches that start to grow in a tree soon die and are shed like leaves. They leave little evidence of their existence in the wood. If a branch that has grown big enough to leave a visible knot dies and promptly drops off the tree, the knot will become tightly buried and may not seriously damage the wood. But a dead branch that stays on the tree, as often happens in the softwoods, usually leaves a loose, resinous knot. Insects and fungi invade the branch stump and bring decay. The loose knot may fall out of a board cut from this part of the tree.

In some woods, knots enhance appearance and may be prized: *e.g.*, knotty pine. But usually they bring only woe. They weaken the board structure and distort shrinkage. As every carpenter knows, a knot can ruin a saw, bend a nail and fiendishly split a piece of wood.

LET US see now how wood is affected by its fine cell structure. Softwoods are made almost entirely of one type of cell, called the tracheid. In the spring growth these cells have relatively thin walls; the wood's strength depends mainly on the thicker-walled tracheid cells laid down during the summer. There is a fixed limit to the amount of summerwood a given species of tree can grow in a single season. Hence in a period of very rapid growth, or in an unusually fast-growing tree such as southern pine, the proportion of summerwood is relatively small and the wood may be



SOUTHERN HARD PINE has an abrupt transition between the springwood (*fine structure*) and summerwood (*coarse structure*). Magnification: 40 diameters.



CHESTNUT OAK has pores that vary between slow- and fast-growing trees. The slower the growth the larger the pores and the lighter, softer and weaker the wood.

very weak. Yet the wood will also lack sufficient summerwood if the tree grows too slowly. Softwoods are considered usable for structural purposes only if the number of growth rings is in the range of 6 to 20 per inch.

In hardwoods an important part is played by the pores, which transport liquids in the sapwood, or living part, of the tree. The pores affect the grain and texture of the wood. Grain is defined as the pattern of light and dark resulting from differences in tissue density; texture refers to the ease with which the wood works under tools and the ultimate smoothness to which the wood can be finished.

In woods such as oak, ash, elm, black locust, Osage orange and teak, the springwood pores are much larger than those of the summerwood. Such woods are called "ring-porous." In maple, birch, cherry, basswood, gum, magnolia and some other woods the pores are uniform in size and the wood is called "diffuse-porous." The pores of diffuse-porous woods can seldom be seen with the unaided eye and have little effect on grain or texture. Large open pores, however, may limit the uses of a wood. For example, red oak is rarely suitable for tight cooperage, because the pores permit liquid to seep through the wood. In white oaks, by contrast, an internal growth clogs the springwood pores, and the wood has other properties, not yet wholly defined, which make it highly prized for barreling liquor.

During periods of slow growth the volume of pore space in a ring-porous wood increases sharply at the expense of mechanical tissue. Such wood is relatively soft, weak and light.

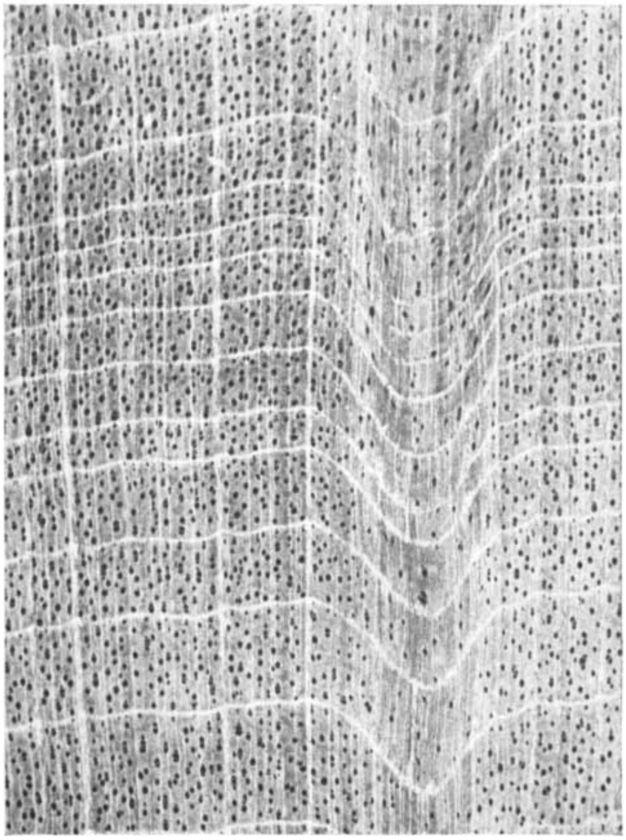
Hardwoods have another type of cell, the relatively thick-walled fibers which spiral along the length of the tree in an interlocking, intertwined system. The steeper (more nearly vertical) the spiral within each cone, and the more constant the helix angle radially across the tree, the straighter and more even-grained is the lumber. Wood of this kind is the strongest and the most stable dimensionally. The path followed by the fibers often varies mysteriously, sometimes reversing so that the fibers alternately spiral clockwise and counterclockwise. When split, boards of this wood have a wavy surface; when sawn through the grain they show a striped or ribbon figure, highly prized for veneer. Maple and mahogany wood of another wavy variety has long been used for violins and is called "fiddleback."

Many of our most beautiful veneers—"blister," "quilted," "bird's-eye" and others—result from some modification of the fiber spiral.

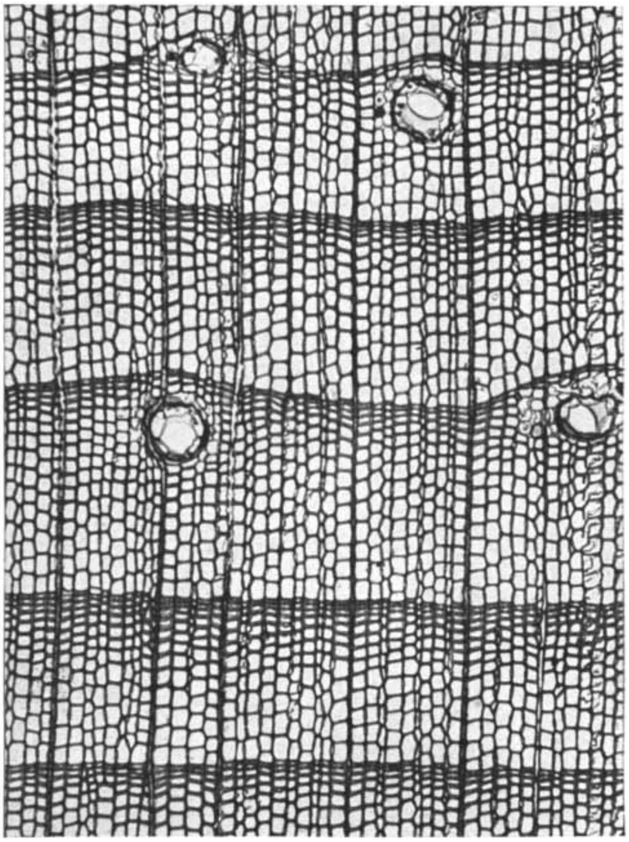
The more highly prized a wood is for its grain, the less valuable it is likely to be as a structural material. The distortions in fiber organization throw the distribution of stresses out of balance, decrease strength and encourage cracking, warping and splitting.

MOST WOODS, hard or soft, have cells of the type called parenchyma which remain alive long after all the other cells have lost their protoplasm. The parenchyma are involved in many vital life processes, including the transport and storage of the tree's food and disposal of its wastes. Of the two types of parenchyma in wood, the one that interests wood users is the type that gives rise to "wood rays." The rays may produce pleasing grain effects. Their cells have their long axes at right angles to the long axis of the tree, and as might be expected, they greatly reduce shrinkage in width during drying. But they sometimes cause uneven shrinkage, and in hardwoods such as oaks, in which rays constitute more than 30 per cent of the wood volume, this can cause considerable trouble.

Some woods, as everyone knows, have a tendency to "bleed" resin. The pine, larch, spruce and Douglas fir, which have resin canals, may produce excessive resin, naturally or as the result of injury. Bleeding resin can ruin a paint or varnish finish. If the resin hardens, it can change the wood into a refractory



SUGAR MAPLE has a "bird's-eye" pattern when it is flat-sawn. When such a piece of wood is split, its face is covered with pimples. Magnification: 10 diameters.



WHITE PINE is traversed by resin canals (*large holes*). The smaller holes that make up the structure of the wood are the tracheids. Magnification: 50 diameters.

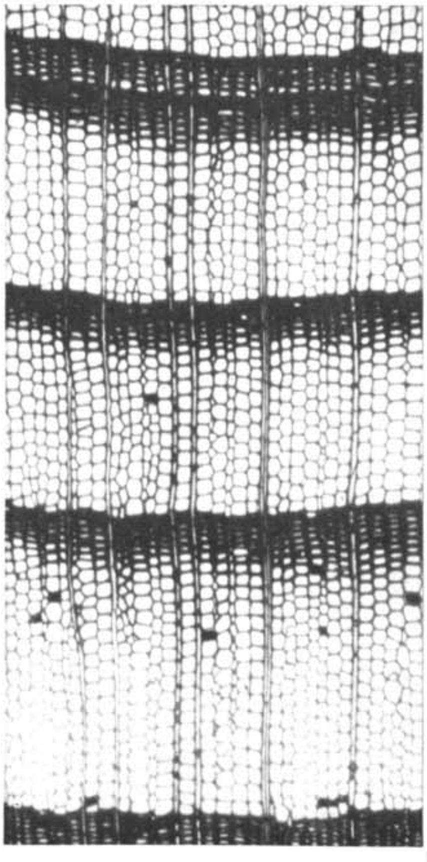
mass that will take the edge off the hardest tool steel.

As a tree grows, the new layers of wood may remain physiologically active for from 2 to 70 years or more. This sapwood is very light in color, ranging from off-white to pale shades of yellow, tan and red. Sooner or later all the cells die and become part of the tree's "heartwood." The heartwood accumulates many organic compounds not found in the sapwood, including tannins, gums, resins, dyes and chromogens. They impart to the wood an amazing array of colors, ranging from the bright yellow of black locust to the deep black of ebony. Some of the colors change on exposure to air. Mahogany, for instance, gradually mellows from a purplish red to a rich red-brown.

Most of the wood sawn from trees is heartwood. It is generally more durable than sapwood, better able to resist oxidation and the biological actions which occur when wood is buried in the ground. Contrary to a common misconception, dried heartwood is no harder than sapwood, nor any more difficult to process.

◆

Simon Williams, who received his Ph.D. in wood technology, is a member of the staff of the Fabric Research Laboratories in Boston, Mass.



REDWOOD shows an abrupt break between springwood and summerwood. Magnification: 40 diameters.

PRODUCT CONTROL BY INFRARED ANALYSIS

One of a Series of Data Sheets for Better Process Control from The Perkin-Elmer Corporation, Manufacturers of Infrared Spectrometers, Flame Photometers and Electro-optical Instruments.

PROBLEM:
Determining oil and phenols in effluent water.

DEVELOPED BY:
The Atlantic Refining Company,
Philadelphia, Pennsylvania.

SOLUTION:
Infrared analysis. Method is based on bromination of the phenols, extraction of the bromides from water with carbon tetrachloride, and measurement of optical density at 2.84 microns (for phenols) and 3.40 microns (for oils).

INSTRUMENTATION:
Perkin-Elmer Model 12-A Infrared Spectrometer, LiF Prism, 50 mm glass cell with quartz windows.

DISCUSSION:
The petroleum industry has long been concerned with elimination of both hydrocarbon oil and phenols from its effluent waters. A number of analytical methods are now in use but none has both sensitivity and accuracy desired for future pollution abatement programs.

Classical methods for determination of oil in water are limited to concentrations above 1 ppm.

Infrared Analysis:
Sensitive to 0.1 ppm of oil and 10 parts, or less, per billion of phenol, with an accuracy better than that obtainable by existing methods. Not affected by volatility of material being determined.

REFERENCE:
Anal. Chem. 23, 10 (1951).

Model 12 Spectrometer at The Atlantic Refining Company.

We will be glad to discuss your Product Control problems with you. A brochure of Product Control data sheets is yours for the asking.

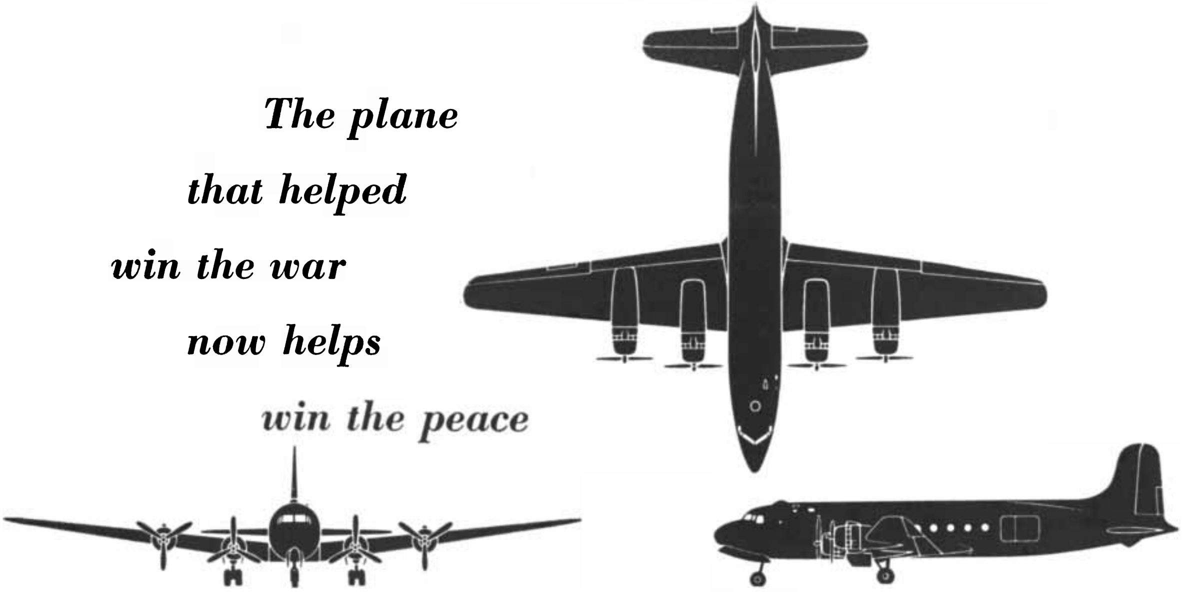
The Perkin-Elmer Corporation, 875 Main Avenue, Norwalk, Conn.
Southern Regional Office: New Orleans, Louisiana

For Optical Design and Electro-Optical Instruments

PERKIN ELMER

© 1952 SCIENTIFIC AMERICAN, INC

The plane that helped win the war now helps win the peace



—the Douglas C-54

Last August nearly 4,000 Moslem pilgrims bound for Mecca were stranded in Beirut 800 miles from the holy city.

In one of the finest demonstrations of international good will, the Department of Defense provided a "magic carpet" in the form of the Military Air Transport Service to speed these pilgrims on their way.

Fourteen U.S. Air Force Douglas C-54s roared into Beirut from Europe and Tripoli and then flew the 12-hour shuttle to Jidda (near Mecca). Four days later the last pilgrim arrived at Jidda with two hours to spare.

The performance of the rugged C-54 on this occasion was in keeping with the history of this great airplane. For it was the C-54 which flew billions of transport miles during the war and performed so nobly on the "Berlin Airlift."

Again the C-54 proves Douglas leadership in aviation. Planes which can be produced swiftly and in quantity, *to fly farther and faster with a bigger payload,* are a basic Douglas concept.

Depend on *DOUGLAS* **First in Aviation**

The Metabolism of Hummingbirds

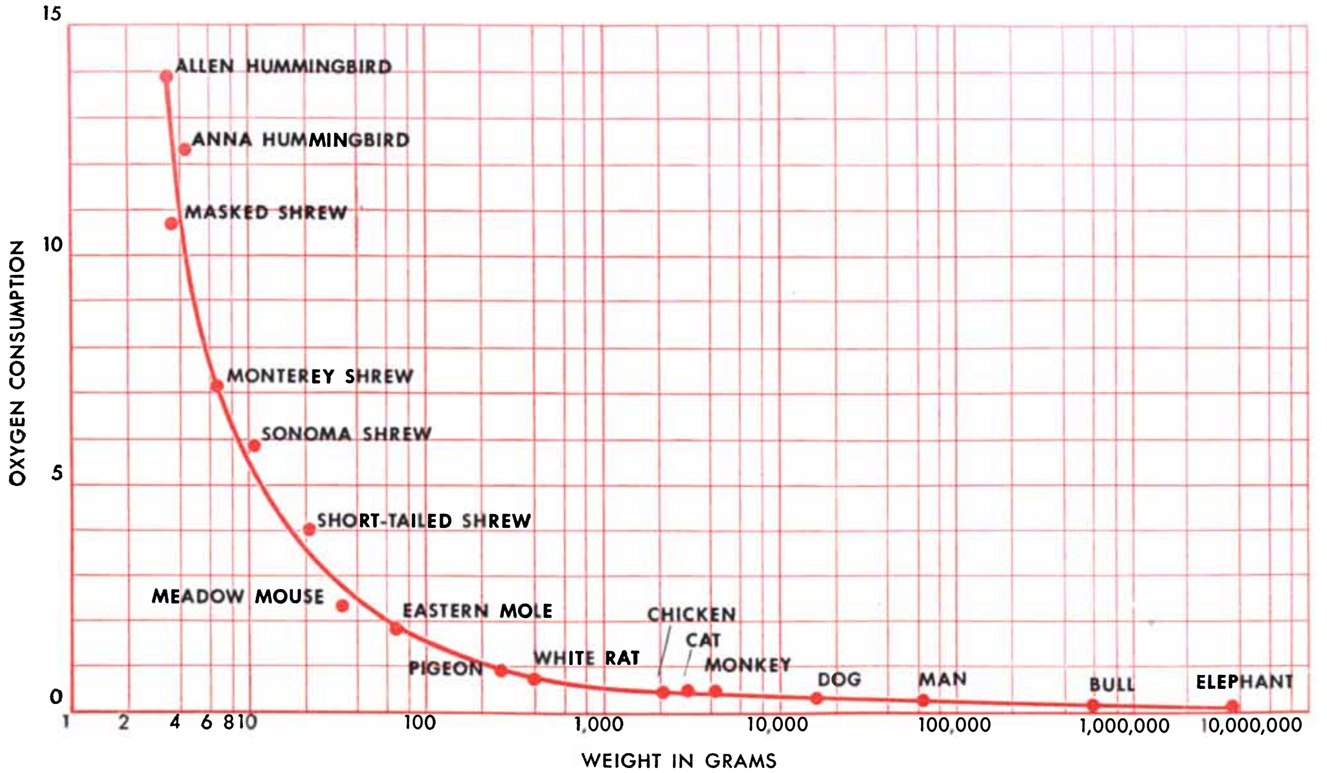
Its remarkably high rate raises such questions as what keeps these tiny creatures from starving at night and how they are able to migrate across the Gulf of Mexico

by Oliver P. Pearson

THE living rate of an animal depends on its size: the smaller the animal, the faster it lives. This does not necessarily mean that its life span is shorter (a man is smaller than a horse), but pound for pound the more diminutive animal eats more food, consumes more oxygen, produces more energy—in short, has a higher rate of metabolism. Each gram of mouse tissue, for example, metabolizes much faster and uses much more oxygen per minute than each gram of an elephant's tissues. If the elephant's cells were to live at the pace set by mouse cells, the ponderous animal would be unable to dissipate the resulting heat rapidly enough. It would perish within a few minutes from overheating.

Life has been compared to the flame of a candle. The candle's wax combines with oxygen from the air and produces heat and carbon dioxide. The rate at which the flame burns can be measured by any of these four factors: its consumption of wax or oxygen or its production of heat or carbon dioxide. Similarly, one can measure how "alive" an animal is, how intense are its life processes, by determining how fast it consumes food or oxygen or how fast it produces heat or carbon dioxide. For practical reasons the easiest and most satisfactory yardstick is oxygen consumption. Such measurements have been made on a host of animals from protozoa to mice to elephants.

We are interested here in the small end of the scale. Among the warm-blooded animals about the smallest is the hummingbird—some species of hummingbirds weigh no more than a dime. As we should expect, the hummingbird has the highest rate of metabolism of any bird or mammal. In a resting hummingbird each gram of tissue metabolizes 15 times as fast as a gram of pigeon and more than 100 times as fast as a gram of elephant. When the metabolism rates of various animals are plotted on a chart (*see below*), the curve



METABOLIC RELATIONSHIP of small and large birds and mammals is shown by plotting their oxygen consumption against their weight. The oxygen consumption is given in cubic centimeters per gram per hour.

goes up steeply at the small-animal end, and it indicates that at 2.5 grams the rate of metabolism would be infinitely rapid. No bird or mammal so small could exist without resorting to some metabolic legerdemain unknown to its larger relatives, for it simply could not eat fast enough to avoid starvation.

THE hummingbird wins the honor of living at a rate faster than any other animal at the cost of an enormous food consumption. The bird must devote much of its day to gathering food, mainly nectar and insects. But what happens at night? Hummingbirds are not adapted for night feeding. If their intense metabolism continued undiminished through the night, as it does in other birds, they would be in danger of starving to death before morning.

The trick by which hummingbirds avoid overnight starvation was disclosed by means of a continuous record of their oxygen consumption over a 24-hour period. Each hummingbird was confined in a bell jar with a food supply in a vial. During the afternoon the bird alternately perched and hovered in front of its feeding vial. For an hour before nightfall it indulged in intensive feeding, and much flying and wing-buzzing. During that hour it consumed 24 cubic centimeters of oxygen per gram of body weight. Then the bird settled down for the night. Twenty minutes later its rate of metabolism had dropped to eight cubic centimeters per gram per hour. By the middle of the night the bird was living at a metabolism level only one fifteenth as rapid as the daytime rate.

Now this is the level at which certain mammals hibernate. The hummingbird at night showed many signs of hibernation. It was completely torpid, practically insensible, scarcely able to move, and when it did stir, it moved as though congealed. Its body temperature had dropped to that of the surrounding air—75 degrees Fahrenheit. Hibernation, then, is the metabolic magic by which hummingbirds stretch their food stores from dusk to dawn.

Before daybreak the bird's body spontaneously returns to its normal temperature and high metabolic rate. By early morning it is again warm, awake, ready to dart off in search of food.

That hummingbirds behave in the same way in nature as they did in my bell jars was proved by examining them in their natural roosts. One hummingbird of the Anna species was watched while it settled down to sleep at dusk on a tree branch. When I returned to it at 3 a.m., it was completely torpid and allowed itself to be picked off like a ripe fruit. Most hummingbirds live in the tropics. A few are found in the high Andes, where temperatures fall so low at night that the birds would probably freeze to death if they stayed in the open air; there they retreat at night into caves.

We know of no other bird that hibernates overnight like the hummingbird. Bats, which are not birds but mammals, do the trick in reverse: they forage by night and slow to torpor by day.

The metabolic profit which a hummingbird gains by nocturnal hibernation can be measured by comparing it with a tiny mammal of about the same size—the shrew *Sorex cinereus*. When they are awake and going about their business in the bell jar, the shrew and the hummingbird have about the same rate of oxygen consumption. But the shrew cannot hibernate. It must keep busy most of the night feeding itself. In the chart on the bottom of the opposite page we can see what this means in terms of energy expenditure. The total amount of energy each animal must spend in 24 hours to keep each gram of its tissue alive is represented by the area between the animal's hour-to-hour energy line and the base line. Almost the entire area between the line for the shrew and that for the hummingbird represents the metabolic profit the hummingbird gains by hibernating at night.

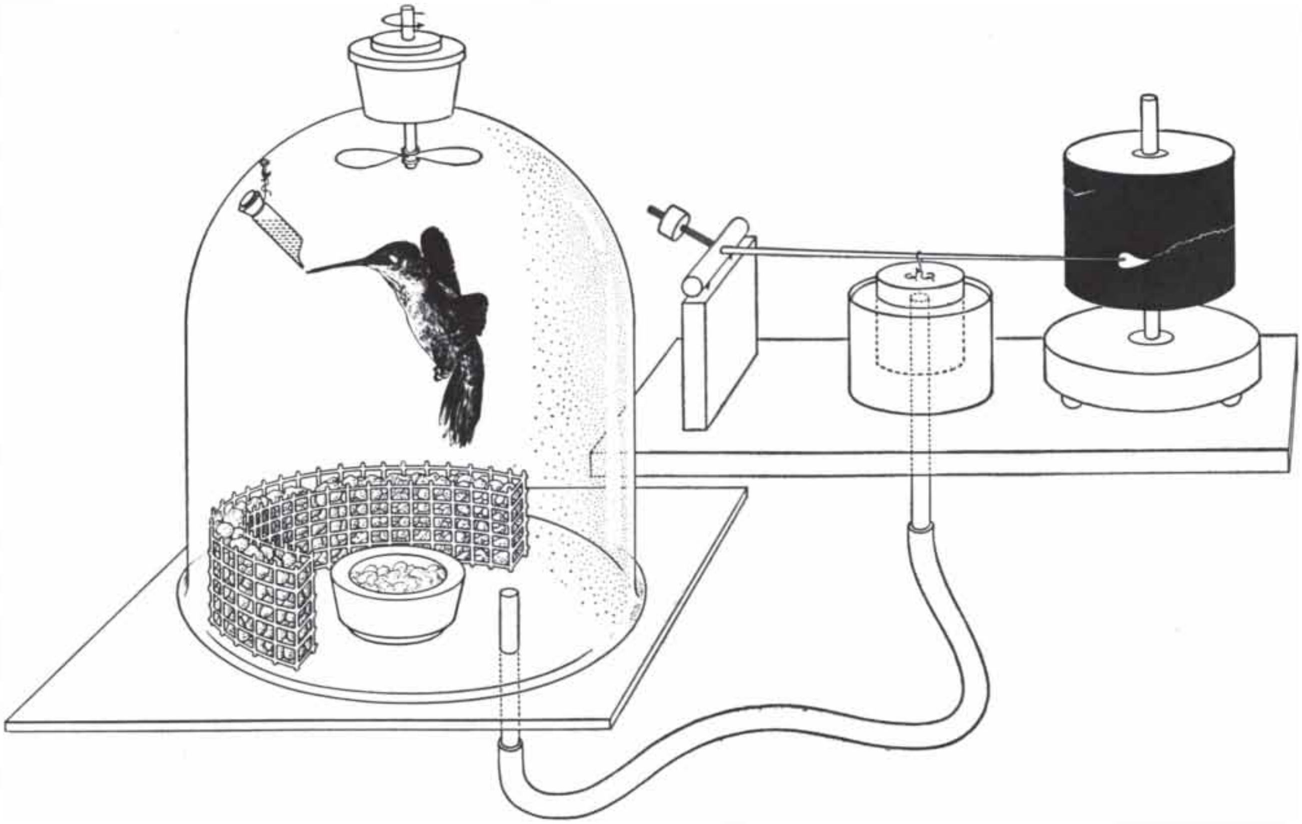
WHEN the hummingbird is not sleeping, it is eating, and it does this entirely on the wing. How strenuous is it for a bird to fly? Hummingbirds can hover in a small space, and this attribute makes them ideal subjects for investigation in laboratory confinement.

A bird is put into the bell jar, and the jar is entirely submerged in a large tank of water to ensure a constant temperature. The bird sits quietly on its perch while a continuous record of its rate of metabolism is being made on a smoked drum. After 10 or 15 minutes the bird becomes hungry, flies up to the feed vial suspended near the top of the bell jar, hovers there while feeding, then returns to the perch. The observer times the flight with a stop watch. From the continuous metabolic record he can easily calculate the comparative rates of metabolism during rest and flight.

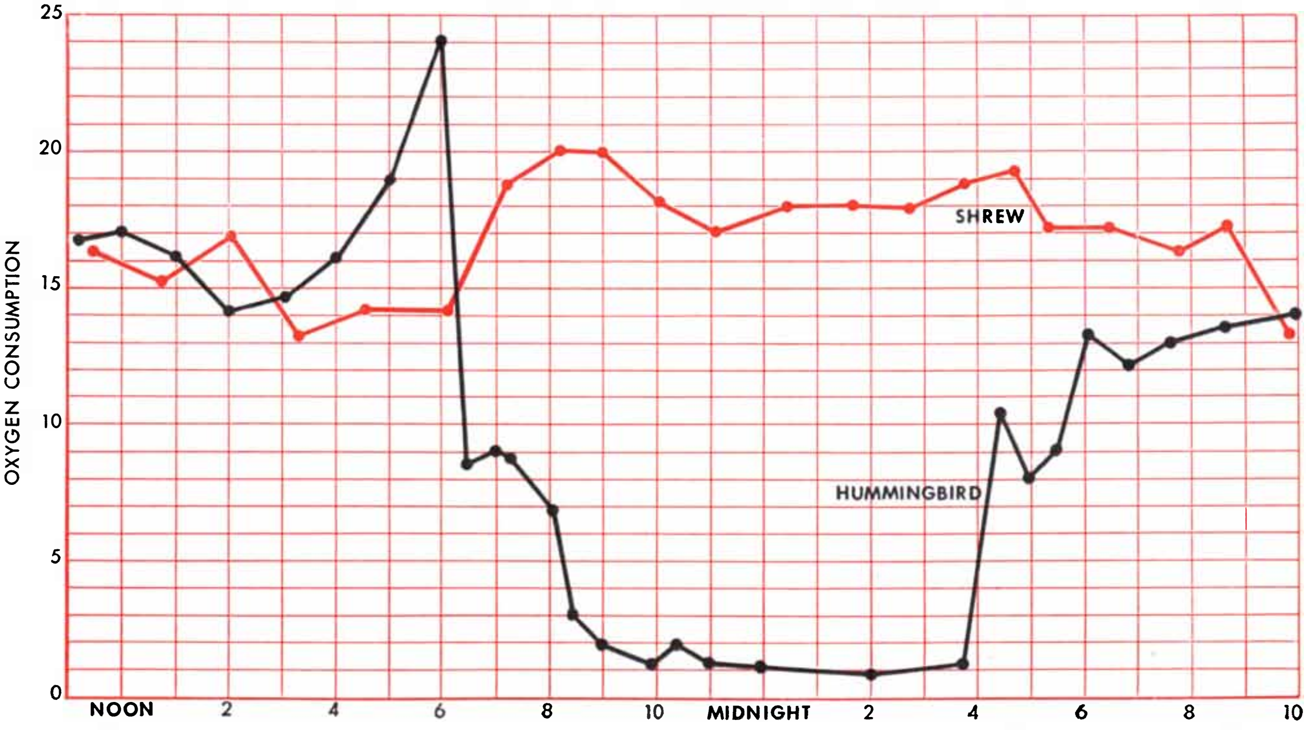
On the average a small hummingbird consumes somewhere around 80 cubic centimeters of oxygen per gram per hour while hovering. This is about six times its resting rate. The British physiologist A. V. Hill once calculated that a man walking at five miles per hour uses six and a half times as much oxygen as he does when standing still. It is reasonable to say, therefore, that a hummingbird works as hard when it hovers as a man does when he walks rapidly.

James L. G. Fitzpatrick, an engineer associated with the Institute of Aeronautical Sciences in New York, has calculated that hovering hummingbirds consume about 726 British thermal units of energy per pound per hour. This figure, interestingly enough, is very close to the energy consumption of a modern helicopter—750 B.T.U. per pound per hour.

How much energy does a humming-



OXYGEN CONSUMPTION of a hummingbird was measured by placing it in a bell jar. As the bird consumed the oxygen of the air in the jar, an equivalent amount of oxygen was drawn from the tank at the right. This lowered the marker so that the oxygen consumption was recorded on the smoked drum. The carbon dioxide exhaled by the bird was absorbed by soda lime in the mesh container; the water vapor, by calcium chloride in the dish. The propeller at the top of the jar stirred the air to accelerate the absorption of these waste products.



METABOLIC RATES of a hummingbird and a masked shrew were recorded for 24 hours. The two animals have about the same weight and use oxygen at about the same rate during the day. At night, however, the body temperature of the hummingbird drops almost to that of the surrounding air. This represents a considerable metabolic economy for the 24-hour period. The oxygen consumption is given in cubic centimeters per gram per hour.

bird spend when flying about? We do not know exactly, but probably it takes somewhat less work than hovering. Like an airplane, a bird probably gains some lift from its forward motion and thus does not have to spend so much energy to stay aloft. At very slow speeds the lift would be negligible, and at very high speeds it would be more than offset by resistance. Between these extremes, however, there is probably a speed range in which birds use less energy to fly forward than they do to hover in one place.

OUR laboratory findings may have a bearing on a puzzle which has long mystified ornithologists. The ruby-throated hummingbird spends its summers in the eastern U. S. and its winters in Central America. How does it get across the Gulf of Mexico in its annual migrations? One school holds that it must fly around the shoreline, arguing that it is ridiculous to think that this tiny bird, with its exceedingly high rate of metabolism, could carry enough fuel to make a nonstop flight across the Gulf. On the other hand, many people have repeatedly seen flights of hummers head out over the Gulf, and they insist the birds must be able to make the trip, for they would not set out on a flight which was certain to be fatal.

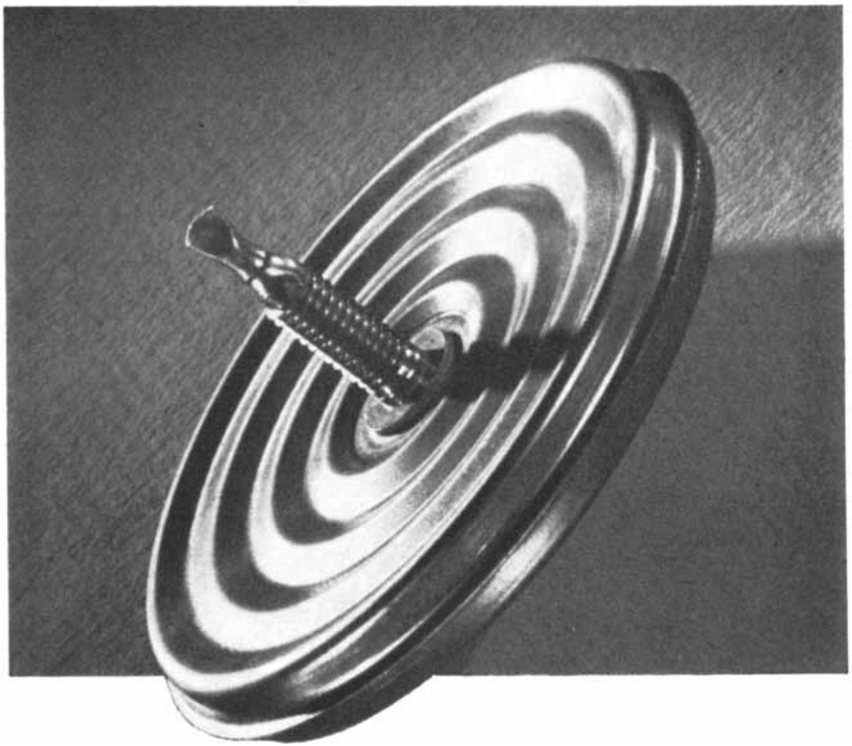
In the face of two such unthinkable alternatives, any laboratory answer may seem foolish. But we can at least attempt a calculation, if only for the amusement of playing with the figures.

Let us assume that the hummingbirds cruise at 50 m.p.h., the speed at which they have been timed by automobiles. At this speed they might consume 80 cubic centimeters of oxygen per gram per hour. A three-gram ruby-throated hummingbird (the average weight) would burn 240 cubic centimeters of oxygen per hour, and in doing so would release 1.17 calories of heat. Now we can assume that the bird might carry one gram of fat as reserve fuel, for a fat bird of this species is about one gram heavier than a lean one. One gram of fat yields nine calories. Consequently the bird could fly 7.7 hours on its fat (9 divided by 1.17). At 50 m.p.h., this would carry it 385 miles. Impressive though the figure is, it does not get the hummingbird to shore. The shortest distance across the Gulf is more than 500 miles.

It may be argued that because of the crudity of some of our assumptions, we still have not thrown much light on the subject in dispute. Perhaps we have contributed only more heat, but if so, at least it can be measured in calories.

◆

Oliver P. Pearson is Assistant Curator of Mammals and Assistant Professor of Zoology in the Museum of Comparative Zoology at the University of California.



... are headed for a better future —when you come to RCA

If you want to work where you enjoy the highest professional recognition among your colleagues, come to RCA. Here your accomplishments are recognized and rewarded. Here your future is brighter, through challenging assignments that lead to better opportunities, better positions. Here you set goals for future attainment at advanced levels.

If your talent and skill are not being used in a way for which your education and experience has equipped you, come to RCA. Here you will find unusual opportunities to work in close association with distinguished scientists and engineers in research . . . development . . . design . . . and application of specialized electronic equipment for military projects as well as for an ever-increasing line of diversified commercial products.

Positions open are lifelong *career* opportunities. They are not "temporary" jobs. Unlike "feast or famine" industries, RCA has forged ahead regardless of war or depression. You can continue advanced study at recognized universities under RCA's modern tuition refund plan. You and your family enjoy outstanding Company benefits. Yes, your future is better at RCA.

LIFETIME OPPORTUNITIES FOR

ENGINEERS—Electronic . . . Electrical . . . Communication . . . Mechanical . . . Computer . . . METALLURGISTS and PHYSICISTS

In Research—Development—Design—Application: in the following fields:

RADAR • MISSILE GUIDANCE • SERVO MECHANISMS • COMPUTERS • TRANSFORMERS AND COILS • NAVIGATION AIDS • TELEVISION • ELECTRON TUBES • COMMUNICATIONS TECHNICAL SALES • ELECTRONIC EQUIPMENT FIELD SERVICE

Send a complete résumé of your education and experience.

Personal interviews arranged in your city.

Send résumé to:
Mr. ROBERT E. McQUISTON, Manager
Specialized Employment Division,
Dept. 201A
Radio Corporation of America
30 Rockefeller Plaza, New York 20, N. Y.

RCA

RADIO CORPORATION of AMERICA

BOOKS

Fifty years of the airplane, with special reference to its effect upon civilization

by Edward Warner

AERONAUTICS AT THE MID-CENTURY, by Jerome C. Hunsaker. Yale University Press ($3.00).

THE history of aeronautics is a story of organized research, backed by government on an unprecedented scale. The results have been far-reaching and varied, and many of them seem remote from their first causes in the laboratory. In 1903 the airplane was merely a technical marvel. In the half-century since Kitty Hawk the technical marvels have increased prodigiously, and in increasing they have spawned political, economic, legal, strategic and ethical dilemmas which were undreamed of by the pioneers. Each advance in aeronautical science and aircraft performance—in speed, range, altitude, aircraft size and complexity—has raised problems far outside the realm of aeronautics. A pebble is dropped in the laboratory, and the ripples beat on distant shores.

In this book Professor Hunsaker, himself one of the pioneers in aeronautical research and education, considers the effects of the airplane upon our civilization. The book is made up of his Terry Lectures at Yale University. The general objective of this annual series of lectures is "the assimilation and interpretation of that which has been or shall be hereafter discovered, and its application to human welfare—to the end that the Christian spirit may be nurtured in the fullest light of the world's knowledge and that mankind may be helped to attain its highest possible welfare and happiness upon this earth." Professor Hunsaker therefore concerned himself more with aircraft's purposes and operations than with their design. It is the way in which aircraft are used, not their design characteristics, that determines whether they will, in fact, "help mankind to attain its highest possible welfare and happiness." The book is divided into three sections: one on aircraft development through research, one on air transportation and the third on the social and political effects of human flight.

Aviation's present place in the world is evident in every day's newspapers. In considering its social and economic consequences Professor Hunsaker writes as a philosophical observer of the struggle to make effective use of a new instrument of vast, varied and rapidly growing potentialities. The struggle is handicapped by the "huge disproportion between human wisdom and human power." We can only hope that the continuing growth of power will not too far outrun the development of wisdom, and especially of wisdom applied to the direction of the affairs of nations. "The dedicated research man is not unaware of the perils of his success"; but it is not the research man who determines the uses to which his results will be put.

That the machine is neutral, equally ready to serve good or evil purposes, has become a cliché. But only a couple of generations ago, in the time of the Wrights' first flight, such a viewpoint would often have been indignantly attacked. Men assumed then that advances in technology led inevitably toward ultimate "welfare and happiness," just as philosophers of a somewhat earlier period widely believed that virtue was the natural concomitant of knowledge and that education would wither evil. From much hard experience we have grown less confident. Moral and ethical judgments must still be taken by men, and no degree of perfection in machinery and physical equipment, including the airplane, can guarantee that those judgments will promote the objectives of the Terry Lectures. Professor Hunsaker attempts no forecast; he warns his readers to be prepared for the unpredictable. But he is optimistic.

The diverse branches of applied physical science and technology have supported one another almost miraculously during the past half-century. Aeronautics in 1952 is the expression of 50 years' progress not only in aerodynamics but in radio, metallurgy, internal-combustion engines and the technology of petroleum. If any one of those developments had been lacking, aircraft and their applications could not be what they are. Professor Hunsaker points out the particularly dramatic link between the development of aeronautics and the availability of gasoline. Less than four years intervened between the day when the Wright brothers made the world's first controlled flight in a heavier-than-air craft (informing their father of the event in a modest telegram beginning "Success" and ending "Home Christmas") and the day when the world's first gusher began to spout petroleum in production quantities.

These sciences and their associated industrial arts have advanced in unison, but social and political invention move in a different tempo. They are controlled and often retarded by emotions and suspicions which technical development largely escapes. "Aeronautics," says Professor Hunsaker, "can be a tool to implement a world-wide regime of law and order." To permit aeronautics fully to perform that function, the conditions for such a regime must first come into existence. Even in the present troubled state of the world, however, aircraft are the indispensable vehicles of international affairs. Thanks to air transportation national leaders who would otherwise know each other only through diplomats' dispatches can meet around a table on a few days' notice. The airplane has affected the conduct of international relations as nothing else has done since the invention of the telegraph.

Although political innovations come slowly, there have already been some cases of political invention in specific relation to aeronautics. Hunsaker calls attention to the exceptional character of the Civil Aeronautics Act as "a social document." The act establishing the National Advisory Committee for Aeronautics in 1915 was the first to provide governmental support of research in a particular field of applied science, and the first to set up a continuing executive function under the direction of a committee outside the regular executive departments.

In his opening chapter, on the history of aircraft development, Professor Hunsaker writes with personal authority. He entered the U. S. Naval Academy less than a year after the Wrights' first flight. A couple of years after graduating he began the work in aeronautical research and the guidance of aeronautical development which he still continues. He received the first advanced degree to be given for studies in aeronautics at the Massachusetts Institute of Technology, and he organized and directed the first full-time graduate course in aeronautical engineering in the U. S. During World War I and for some time afterward he was in charge of aircraft development in the U. S. Navy. For a number of years he has been chairman of the National Advisory Committee for Aeronautics, the most significant post in the direction of aeronautical research in the U. S. Government. He was for a time engaged in the development of aeronautical radio aids. He was a member of the Federal Aviation Commission of 1934-35, and of the President's Airport Commission of 1952. He has had something to do with almost every field of aeronautical science and policy.

Aircraft development in the 49 years since the Wrights first flew has followed an irregular cadence of periods of rapid progress and periods of digestion and consolidation of gains. We are now in the midst of a period of revolutionary change in aircraft, perhaps more far-reaching than any of its predecessors. One of the great leaps forward in airplane development came in 1929-34, when the engine was enclosed in a cowling which could be mounted in the leading edge of a wing—with an enormous reduction in drag—and cylinder-baffles were added to make possible air-cooling of the enclosed engine. In close association with those developments, and largely as their consequence, came the almost universal acceptance of the metal cantilever monoplane; the general use of retractable landing-gears; the application of flaps to wings to reduce stalling speed and steepen the glide, and the invention of the controllable-pitch propeller. Today the revolutionary innovation is jet propulsion. Its foundations were laid long before World War II when Flight Lieutenant Frank Whittle started his work on the gas turbine, but the effects began to show in actual aircraft design only toward the end of the war.

In genetic imagery, Professor Hunsaker graphically describes the change: The gas turbine is a "mutation" which nullifies all predictions based on past trends. It reduces the unit weight of the plane motors and permits a large increase in power per unit of load.

Between 1921 and 1950 the power loading (at maximum take-off power and weight) of representative transport aircraft was reduced from about 16 pounds per horsepower to about 10 pounds. Now the first jet transport, the British Comet, has cut that figure in half; its equivalent power loading at sea level take-off thrust is only about five pounds per horsepower. In fighter planes the equivalent power loading is now around two pounds per horsepower, less than half the figure for World War II fighters, and in the experimental supersonic aircraft it is lower still.

The Comet, cruising at 480 miles per hour at 40,000 feet, uses more power than a 15,000-ton Victory ship. We have arrived at an age of superpower in aviation. The propeller-driven plane, whose cruising speed was tripled in 30 years, derived its gain in speed mainly from improvements in the aerodynamic design of the craft and from the supercharger, which permitted it to fly at higher altitudes. The jet-propelled plane, on the other hand, gets its increase in speed from an increase in power per unit of weight. The reduction in unit weight of the power plant, and the consequent possibility of radical reduction in power loading, has brought supersonic flight within reach. The difference in air flow between subsonic and supersonic speeds in turn has created a wholly new branch of aerodynamics, as well as new and extraordinarily difficult problems of control. It has made airplane design even more dependent on aerodynamic research than in the past.

Hunsaker describes some of the problems that arise in the supersonic range and in the further improvement of gas turbines, and suggests how some of them may be solved. Supersonic possibilities are of great military importance, but Hunsaker is not optimistic about the early attainment of supersonic speeds in air transportation. He sees much virtue in the turbopropeller combination for transport use, even in competition with straight jet propulsion. In the distant future he believes we can expect aircraft powered by nuclear reactors, with fuel consumption so low as to permit a practically unlimited range.

All this is the product of research, past and future. The book dwells on the problem of balancing the needs of research against those of design development and production. In World War II the U. S. subordinated fundamental research to production. "Research was restricted to what could be completed quickly and applied to help win that war, not some future one." However, the policy which was correct for a relatively short war may be entirely wrong for protection in a situation of international strain that may continue for generations. Hunsaker stresses the need for pressing on with research to ensure progressive improvement in military aircraft and to promote the discovery and development of completely new ideas.

The coming of the jet has coincided with an accelerated increase in the dependence of aviation on electronic instruments. The book touches lightly but informatively on these developments. It considers the possibility of reducing the pilot's burdens through a larger use of automatic control, leaving him free to concentrate his attention where judgment is needed.

In his discussion of air transportation Hunsaker reviews the progressive reduction of fares, the increase in traffic, the growth of the major airlines and the problem of airports, especially the risk that our present airports may become obsolete as airplanes change. He notes the attraction that airports have for special types of business, and their capacity to create new communities directly dependent on them.

Hunsaker also takes note of the failure of private flying to grow to anything like the proportions that had been prophesied. He expects larger growth, but only "in the long run" and as the result of "unpredictable inventions." The helicopter may be the answer, he suggests, but he is more confident of its future in air transportation and in industrial and military flying.

Written from a rich experience, and covering a wide range of subjects within its 116 pages, *Aeronautics at the Mid-Century* is a welcome addition to aeronautical literature intelligible to the layman.

Edward Warner is President of the Council of the International Civil Aviation Organization.

LEONARDO DA VINCI ON THE HUMAN BODY, by Charles D. O'Malley and J. B. de C. Saunders. Henry Schuman ($25.00). The earliest anatomical drawings by Leonardo are attributed to about 1487; thereafter he maintained an active interest in the subject until his death, studying the classical writings, attending many dissections and performing a few himself. He kept elaborate notes in his extraordinary mirror-writing and made drawings of almost every part, organ and system of the human body. It was his intention to expand these materials into a systematic treatise. Unfortunately the project progressed scarcely beyond an introductory chapter. In this handsome and scholarly volume appear more than 1,200 of da Vinci's anatomical, physiological and embryological drawings, a new translation of his accompanying text, a biographical introduction and a large number of useful and interesting explanatory notes. O'Malley is a historian of science; Saunders, an anatomist. The drawings are from the magnificent collection of the Royal Library at Windsor by way of the "Buroe of His Majesty's Great Closet.at Kensington." Leonardo, as the authors make clear, was no great innovator in anatomical thought. His resources in dissection were meager. He had no knowledge of the circulation of the blood, was not a venturesome theorist and subscribed to most of the vague and erroneous traditions of his day. Moreover, he was unable to overcome the confusions of the prevailing terminology. Nevertheless his contribution to anatomy was of the highest order, both scientifically and artistically. His knowledge of mechanics is reflected in his "examination of the action of the bones as levers, and especially in the mechanism of pronation and supination of the forearm." The superb representation of bones and muscles and of their function and relationship, the vivid description of arteriosclerosis (based mainly on Leonardo's dissection of a Florentine centenarian), the drawings and notes on the cardiovascular system (derived primarily from dissections of the heart of an ox), the studies, in picture and text, of the nervous system—these are among the notable features of an exciting and beautiful book.

KING SOLOMON'S RING, by Konrad Z. Lorenz. Thomas Y. Crowell Company ($3.50). Konrad Lorenz is an Austrian naturalist who knows more about birds and fishes, and cares more about them, than anyone since St. Francis. The feeling is plainly mutual. Lorenz has shown the most extraordinary patience and gone to the most exceptional lengths to gain the confidence of ducks, geese, jackdaws, starlings, water shrews, water beetles, cockatoos, parrots, crows, eagles, fighting fish, jewel fish, land-climbing fish, hamsters, guinea pigs, monkeys and dogs. His observations are marvelously acute and delightfully reported. He notes, for example, that baby mallards will follow anything that quacks like a mother duck. He has quacked like one himself and thereby persuaded a brood of newborn ducklings to scuttle after him. The call note "Quahg, gegegegeg, Quahg, gegegegeg" has to be kept up without cease; otherwise the ducklings stretch their necks longer and longer ("corresponding exactly to long faces in human children") and soon begin to weep shrilly. Imagine "a two-hour walk with such children, all the time squatting low and quacking without interruption." Another of the Lorenz antics in the interests of science was to disguise himself in a "gorgeous, black, furry devil's costume," with a mask, horns and tail, so that some jackdaws he was banding would not develop a "permanent shyness" of him. This particular costume was not essential, but it was the only one handy. One learns, among other interesting facts, that the singing nightingale is a male (to attribute this beautiful but loud song, as poets do, to females is as incongruous as to "invest Guinevere with a beard"); that lions are content when caged because they are lazy; that eagles are too stupid to pine when deprived of their freedom; that the water shrew, "the most terrible predator of all vertebrate animals," has been known to kill fish 60 times heavier than itself by "biting out their eyes and brain"; that a peacock can fall in love with a giant tortoise, or, for that matter, with any animal with which it is raised; that Lorenz' jackdaws had the jolly habit of feeding him by pushing into his mouth or ears a mass of "finely minced worm, generously mixed with jackdaw saliva." This is a charming, original and immensely informative book, a little sentimental, but in no sense a piece of nature-faking. Lorenz is simply a wonder.

RAILWAY MOTIVE POWER, by Harry Webster. Hutchinson's Scientific and Technical Publications ($6.75). This gives technical information about steam, electric, Diesel and gas-turbine locomotives, their history and development, together with interesting sidelights on record-making runs, outstanding engineers and kindred "high-balling" esoterica. The book should be indispensable to connoisseurs and agreeable to the rest of the male population. Illustrations.

The Kings of the Road, by Ken W. Purdy. Little, Brown and Company ($5.00). This delicious book about fine cars will forever spoil the reader for the bulbous, assembly-line junk heap he is probably driving. At any rate, that is Mr. Purdy's intention, and he is dangerously persuasive. He describes most lovingly Bugatti cars which accelerate from zero to 80 miles per hour in 19 seconds (the latest Cadillac takes 32 seconds) and "if tuned" can do 135 m.p.h.; the imperishable Rolls-Royce (the price, you will be glad to know, has come down from $20,000 to $10,000); the indestructible Bentley; the "wicked, loud and very fast" Mercedes-Benz; the Alfa-Romeo; the brilliant handmade American Duesenberg; the Hispano-Suiza and other fabulous automobiles, conceived not for mere transport "but as instruments of pure sensuous pleasure." The book has several exciting chapters on cross-country auto racing.

Children In Trouble: An Experiment In Institutional Child Care, by Frank J. Cohen; edited by Hermine I. Popper. W. W. Norton & Company, Inc. ($3.50). The story of the theories and methods used at Youth House, New York City's detention home for the temporary care of delinquent children. This practical, sensible book holds that neither the cure nor the reform of troubled children can be brought about except by understanding their needs and behavior in terms of past and present relationships.

Understanding Your Child, by James L. Hymes, Jr. Prentice-Hall, Inc. ($2.95). Another handbook of child care that interprets behavior developmentally. It covers physical and emotional growth from infancy through adolescence. Better than some studies of its kind, but not outstanding either in content or style.

Mental Prodigies, by Fred Barlow. Hutchinson's Scientific and Technical Publications ($1.75). A miscellany of facts and theories about lightning calculators, memory experts, musical geniuses, infant chess wizards and such all-round intellectual terrors as John Stuart Mill, Sir William Rowan Hamilton and Thomas Babington Macaulay. Mr. Barlow, described as a "magician and psychical researcher," has gathered a good deal of material, mainly from older sources, and recounts it in a straightforward, if somewhat naive, fashion. His explanation of how and

SPANISH FRENCH GERMAN ITALIAN

Start to Speak a Foreign Language Correctly IN ONLY 7 DAYS

Now you can learn Spanish, French, German or Italian easily, inexpensively and in an amazingly short time.

Funk & Wagnalls' **Language Phone Method** with brand-new R.C.A. high-fidelity phonograph recordings, brings you the actual voices of expert teachers speaking in their native tongues.

The phonograph method of learning a foreign language is the amazing new method you have heard about and been reading about in national publications. With this method you learn right in your own home, your teacher is always there to instruct you, your manuals always there to help you. You learn as fast as you wish, repeat lessons as often as you need.

Send today for the FREE booklet that explains this remarkable new way to learn a foreign language. Let us tell you how you can try out the Funk & Wagnalls' **Language Phone Method** for a whole week right in your own home and without obligation of any kind.

MAIL THIS COUPON

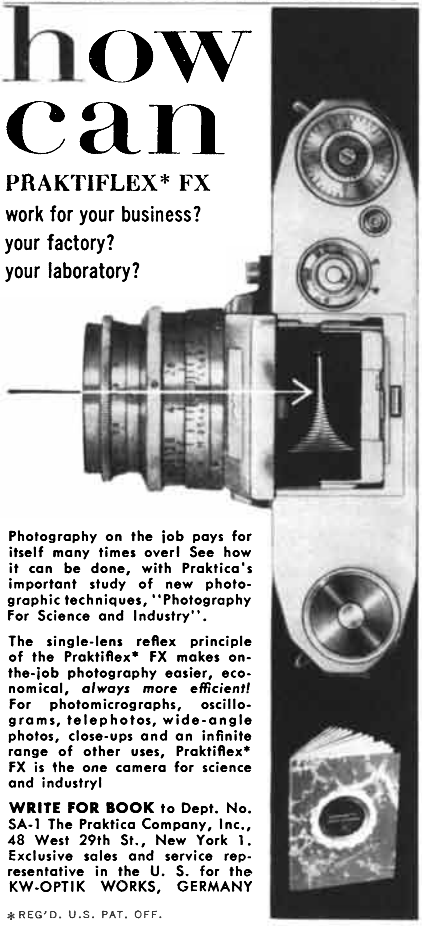
Funk & Wagnalls Company
Dept. SA-13, Foreign Languages
153 East 24th St., New York 10, N. Y.

Please send me FREE descriptive booklet about your easy method of learning ( ) Spanish, ( ) French, ( ) German, ( ) Italian, and tell me how I may obtain a complete Language Phone Kit for seven days' free trial.

Name..........

Address..........

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


how can

PRAKTIFLEX* FX

work for your business?
your factory?
your laboratory?

Photography on the job pays for itself many times over! See how it can be done, with Praktica's important study of new photographic techniques, "Photography For Science and Industry".

The single-lens reflex principle of the Praktiflex* FX makes on-the-job photography easier, economical, *always more efficient!* For photomicrographs, oscillograms, telephotos, wide-angle photos, close-ups and an infinite range of other uses, Praktiflex* FX is the one camera for science and industry!

WRITE FOR BOOK to Dept. No. SA-1 The Praktica Company, Inc., 48 West 29th St., New York 1. Exclusive sales and service representative in the U. S. for the KW-OPTIK WORKS, GERMANY

*REG'D. U.S. PAT. OFF.

why mental prodigies get to be prodigious is as unconvincing as the profundities put forward on this subject by the learned; on the other hand, he is himself an old hand at mental magic and offers a number of amusing hints on such matters as large-scale mental multiplication, the extraction of square and cube roots, calendar tricks, mnemonics and the like. There are many errors and misprints in this book, but it will entertain those unacquainted with the literature on the subject.

GALEN'S HYGIENE, translated by Robert Montraville Green. Charles C. Thomas ($5.75). The first translation into a modern language of Galen's *De Sanitate Tuenda*, a book on personal hygiene prescribing—for those who could afford it—the regimen best suited to each, according to his years and nature. Galen, as Henry Sigerist points out in the introduction, was an eclectic who, though primarily a follower of Hippocrates, borrowed from every school. The touchstone of a healthy life was to keep the humors that constitute the human body in proper balance and proportion. Food, drink, sleep, physical activity, sexual relations—all were to be taken in such manner and amount as to promote the proper equilibrium of the individual's humors, depending, of course, on whether he was of sanguine, phlegmatic, choleric or melancholic complexion. Galen was a brilliant practitioner, which is to say that he had "a real thirst for knowledge," was a sharp observer, and tempered his doctrinal convictions with an abundance of common sense. Most of his recommendations as to personal care can be followed with profit today. It must be said, however, that as a writer he was a long-winded quibbler and a bore. Not even Dr. Green's smooth, capable translation can make the *De Sanitate* a text to lighten an idle hour.

PRELUDE TO HISTORY, by Adrian Coates. Philosophical Library ($4.75). A solid, up-to-date account by a nonprofessional archaeologist of what is known about human origins. It considers the appearance of prehistoric man, the tools he made, how he used them in hunting, in preparing food and clothing and in building, the nature of the primitive mind and society, how man emerged from savagery, the character of Paleolithic culture and of the remarkable art of the period. Mr. Coates is not an easy writer, but the deficiencies of style are more than offset by his grasp of the subject, the comprehensiveness of the survey and by the boldness and originality of his conjectures (this last is the happy privilege of the informed amateur). The result is that his book, as Glyn Daniel says in the foreword, is much more than a mere digest of other men's facts and theories.

AROUND THE-WORLD SHOPPERS CLUB

Beautiful Gifts From Abroad Direct By Mail Only $2 ea.

From Denmark, Holland, Spain, India, Italy, France — wherever our treasure hunters find a rare and exquisite bargain—come fabulous gifts for our club members. American dollars obtain tremendous values abroad, gifts worth $3 to $5 for only $2 each. Mailed direct to your home from overseas, duty free, and postage paid. Every package contains the fascinating story of the origin and significance of the article you receive. And an EXTRA GIFT FROM ABROAD awaits you if you join now! Send at once for FREE illustrated brochure, or enclose $6.00 for 3 months' trial membership. Satisfaction guaranteed!

AROUND THE-WORLD SHOPPERS CLUB

Dept. 547, 22 Treat Place, Newark 2, N. J.

Opportunities at

BECKMAN

for

ENGINEERS — SCIENTISTS

To Develop Instruments and Electronic Components

Use your training, aptitudes and experience in the following (or allied) fields:

Spectroscopy . . . Precision Electronics
Optics . . . Physics . . . Electromechanics
Mechanics . . . Feedback Systems

Men who combine fields will find our projects especially interesting. Typical developments include spectrophotometers at all wavelengths, pH meters, electrometers, flame photometers, computers, radiation instruments, titrators and others to be announced.

Unusual opportunities in all divisions: Helipot and Beckman Instruments—So. Pasadena, California; Berkeley Scientific —Richmond, California. Our company is a leader in the fast growing instrument industry, *which is not dependent for its future on military contracts, but is of fundamental importance to all types of research and industry.*

Write for application and information about our company.

Personnel Department

BECKMAN INSTRUMENTS, INC.

1001 El Centro St., South Pasadena 48, California

© 1952 SCIENTIFIC AMERICAN, INC

A Source Book in Animal Biology, by Thomas S. Hall. McGraw-Hill Book Company, Inc. ($10.00). The series of excellent source books in the history of the sciences, to which this volume is a recent addition, was founded in 1924; it includes collections of classical contributions to mathematics, astronomy, physics, geology and Greek science. Professor Hall's book ranges from da Vinci's writings on anatomy through excerpts from Alfred Russel Wallace's monumental work on the geographical distribution of animals. The selection is unusually skillful, considering the vastness of the literature; it has been ably edited. A number of the entries come from writings difficult to find. Altogether a wonderful panorama of scientific imagination, primarily intended for the student and specialist, but rich in material which will entertain and instruct anyone interested in the development of biological thought.

The Love and Fear of Flying, by Douglas D. Bond. International Universities Press, Inc. ($3.25). Dr. Bond's book is based on a survey of "emotional casualties" among members of the U. S. Eighth Air Force air crews and other flyers stationed in England during the war. He presents case studies of various phobias about flying and discusses the sexual meaning of flight, the aircraft as a symbol of woman, the extraordinary superstitions prevalent among flyers, the temptation to defy death (a "common disciplinary problem among pilots" which "contributes heavily to 'pilot-error' "), the role of aggression, the exaltation and release experienced, especially by introverted, frustrated or inarticulate men. ("Nothing can bother me upstairs"; "if it gets too tough on the ground, I take that thing [aircraft] up and beat it around and then I'm all right.") An engrossing book, provoking sober reflections.

The Phase Rule and its Applications, by Alexander Findlay, A. N. Campbell and N. O. Smith. Dover Publications, Inc. ($5.00). The ninth edition of Findlay's handbook on Willard Gibbs' principle has been substantially rewritten and broadened by Campbell, professor of chemistry at the University of Manitoba, and Smith, a physical chemist at Fordham University. Sections have been added, new topics introduced and many of the diagrams redrawn. This is an introductory work for graduate students and research workers, rather than a reference book.

Colour Cinematography, by Adrian Cornwell-Clyne. Chapman & Hall, Ltd. ($13.50). This is the third enlarged edition of a standard work dealing with every aspect of motion picture photography with color film. It is an extraordinarily comprehensive handbook.

THE AMATEUR SCIENTIST

On the fascination of microscopy and some curious amateur observations of the moon

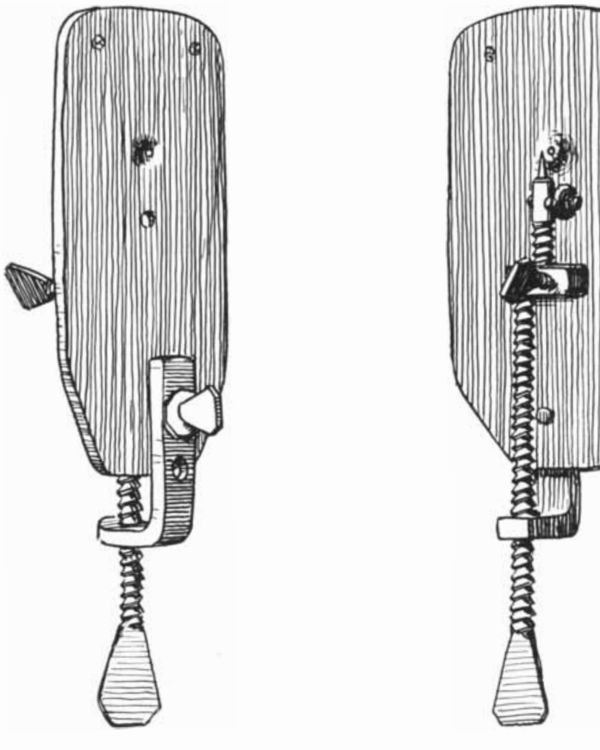
Conducted by Albert G. Ingalls

ADAM'S lack of foresight when he named the creatures of the earth (Genesis 2:19) certainly made things difficult for his scientific descendants. If he had made a list of the animals as he named them, how easy it would now be, for instance, to label a microscope slide! As it is, the rediscovery and renaming of the world's organisms has been slow, painful work. Aristotle knew about 520 animals and Theophrastus could identify approximately the same number of plants. Today, thanks largely to Linnaeus and to the invention of the microscope, our catalogue has grown to about a million species of animals and 336,000 species of plants. But the census of life on the earth is far from complete; no one knows how many thousands of species remain to be discovered and identified.

The quest to complete the roundup of organisms and to name them is one of science's most rewarding challenges. And for amateurs in science it offers a sport second to none. An amateur can engage in it simply by acquiring a microscope, since the biggest remaining field for exploration is in the world of small organisms.

Amateur microscopy has other lures besides the discovery of new organisms. According to Harry Ross of New York City, an amateur who became so fascinated with the microscope that he abandoned a successful career in electrical engineering to deal in optical supplies, "the microscope and its applications cut across the field of nearly every science—any one of which can become a lifetime avocation."

Ross points out that it is possible to make a workable microscope at home in less than an hour, and that one does not need to look far for material to study. "The saliva from your own mouth," he says, "will provide enough varied specimens to keep you going for months on end. The more organisms we find and identify, the more, it seems, await discovery.



A Leeuwenhoek microscope

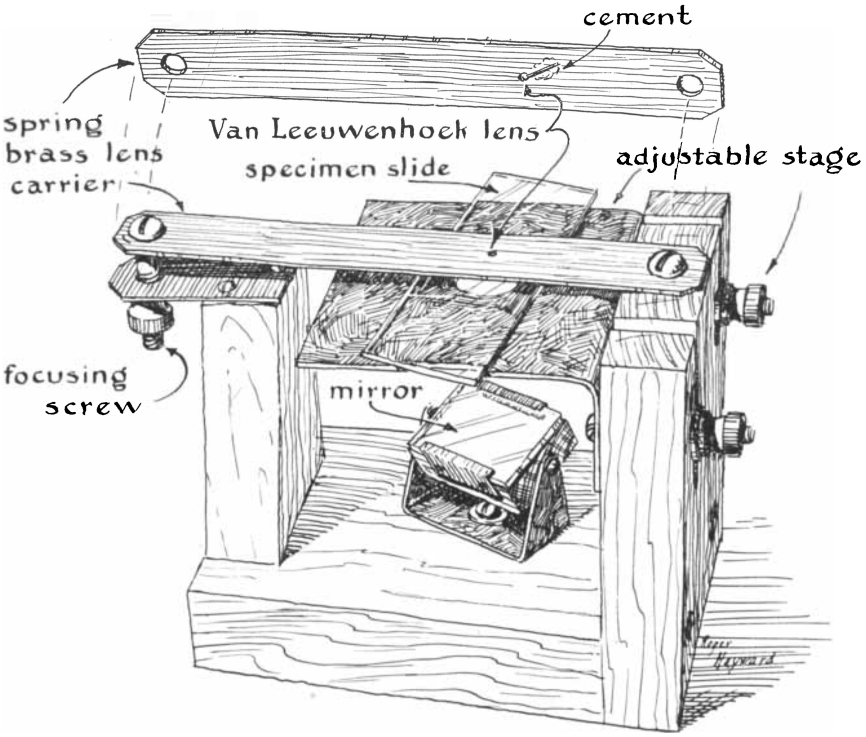
"In microscopy the problem is not so much finding things to study as developing the will to stick with one thing. We are constantly tempted to embark on a Cook's tour of every avenue opened by the instrument. Suppose, for instance, that someone upsets the salt and its crystals attract your attention. You get to thinking about crystallography. Within arm's reach you can find material enough to keep your microscope busy for hours as you examine the cubic form of salt, the glittering structure of sugar. A particle of dirt from the edge of your shoe provides a comprehensive collection of mineral crystals—quartz, mica, silica, calcite. You chip a flake of ice from the cube in your glass, put it on the slide and look quickly. You are startled by the violence of the transformation as the needle-like crystals melt away. Check the resulting drop of water for purity. Does it hold specks of suspended matter, perhaps dormant organisms? Examine a few grains of pepper. Has its strength been cut, as is sometimes the case, by the addition of starch? If so, you instantly spot the oval-shaped grains. Are you interested in fats? Contrast the appearance of a smear of butter with a bit of grease from whatever meat the cook served. After fat, something else attracts attention. Thus within minutes you may be lured from your initial interest in crystals!"

Historians are not sure who invented the microscope. Like many products of technology, the instrument seems to have evolved from many tidbits of accumulated knowledge as intertwined and difficult to trace as the roots of a thousand-year-old redwood tree. The oldest magnifying lens so far discovered was found in the ruins of Nineveh by the British archaeologist Sir Austen Layard. It was a crudely polished plano-convex lens of rock crystal which magnified rather well. Pliny the Elder in 100 B.C. mentioned the "burning property of lenses made of glass." But the science of optics in the modern sense did not begin until about the 13th century.

Roger Bacon seems to have been the first to suggest its principles. His writings predicted the telescope and the microscope, and he can probably share credit for the invention of spectacles. Bacon taught the theory of lenses to a friend, Heinrich Goethals, who visited

Florence in 1285. From Goethals the information found its way through a Dominican friar, Spina, to one Salvina D'Armato. D'Armato's tomb in the church of St. Maria Maggiore today carries the inscription: "Here lies Salvina D'Armato of the Amati of Florence, Inventor of Spectacles. Lord pardon him his sins. A.D. 1317."

The simple microscope—the single lens—must have been used as soon as spectacles were invented, or perhaps it even preceded them. Who was the first to use it we do not know. But the first to make any important discoveries with it was the Hollander Anton van Leeuwenhoek, born in 1632. After examining some common materials through a simple, single-lens instrument he had made himself, he wrote excitedly to the Royal Society in London about all the seemingly unbelievable objects it revealed. He discovered "wigglers" and "worms" in water taken from the canal of his native Delft and in scrapings from his teeth. Perhaps his greatest contribution was the observation of red corpuscles in blood. Leeuwenhoek not only identified the red cells but made accurate drawings of their shape and forwarded them, along with measurements of their approximate size, to the Royal Society.



Leeuwenhoek's microscope adapted for modern slides

Anyone with a little time to spare can make a duplicate of Leeuwenhoek's microscope and enjoy a thrill now 300 years old. Ross urges beginners in microscopy to start with a Leeuwenhoek instrument. It is easy to make and will give the beginner valuable experience in preparing and handling specimens.

For materials you need only a small length of thin glass rod, a piece of about 20-gauge iron or brass one inch by three inches, two machine screws with nuts, a tube of quick-drying cement and a bit of cellophane. We have made several satisfactory miscroscopes of these simple scraps of material.

For the glass rod a clear "swizzle stick" of the kind used for stirring drinks will do. First you hold the center of the rod in the flame of a Bunsen burner or a burner of the kitchen stove. The rod is introduced into the flame gradually to avoid the breaking stresses set up by abrupt heating. The center of the rod will quickly reach red heat and become plastic. Withdraw the rod from the fire quickly and stretch it. The plastic center will pull into a hairlike filament about two feet long. After the rod has cooled, break off a convenient length, say six inches, from the middle section of the filament. Then slowly bring one end of this thread into contact with the flame. The tip will reach incandescence almost at once, and a tiny bead will form. Keep on feeding the filament into the flame until the bead grows to a diameter of approximately one sixteenth of an inch. The lens of your microscope is now finished. This little bead, if it has been made carefully, will yield a magnification of approximately 160 diameters. (The power of such a lens is roughly equal to the number 10 divided by the diameter of the bead in fractions of an inch.) The quality of the lenses made by this primitive method is far from uniform; hence several should be made and the best selected.

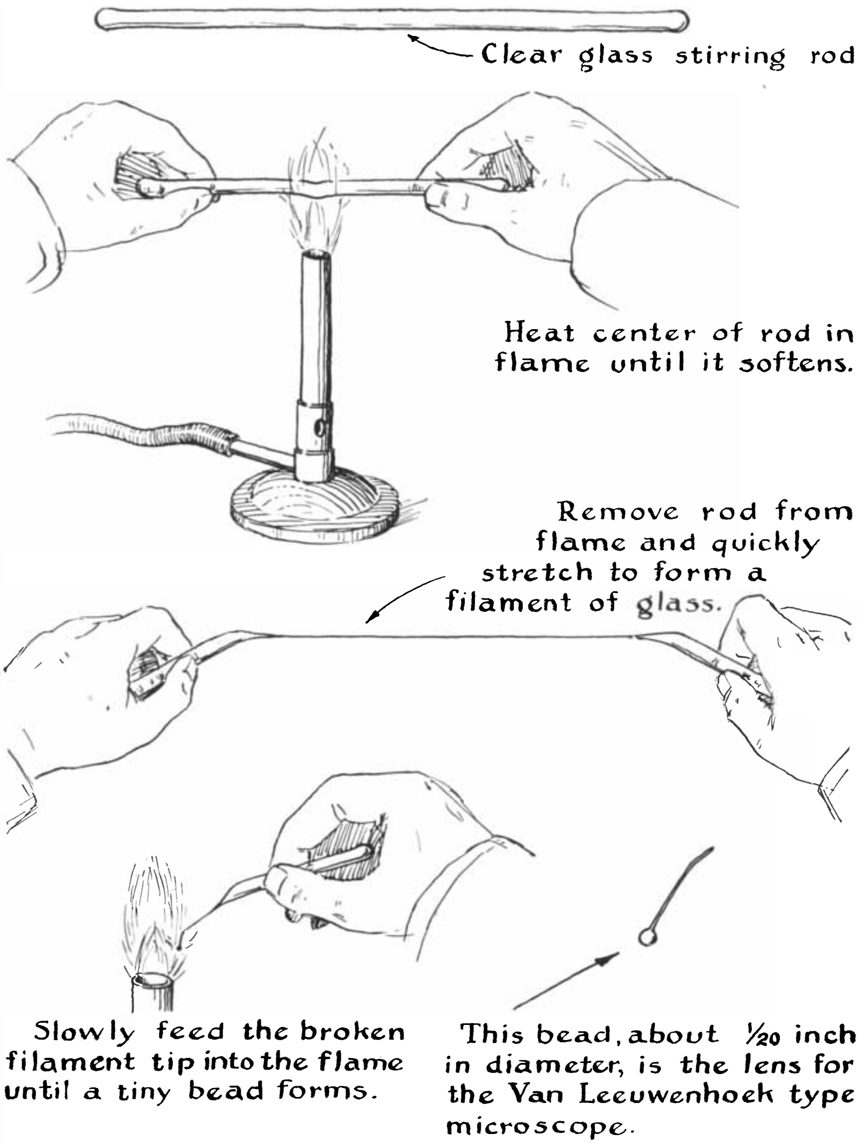
A bit of the glass filament may be left attached to the bead and used for mounting the lens to its base. Leeuwenhoek mounted his lens in a sandwich of two brass plates with a hole for the lens. But we find it more convenient to drill a hole in a single plate and fasten the glass piece to the plate by its stem, with the bead over the hole. The hole should be slightly smaller than the bead, so no light will leak past the lens and thus dilute the contrast of the image. The glass is fastened to the plate with quick-drying cement.

The focal length of this tiny lens is of course very short. This means that the stage on which a specimen is mounted must be close to the lens, sometimes nearly touching it. For focusing his microscope and moving the specimen into its field Leeuwenhoek used a set of interacting screws, manipulating a metal point as the stage (*see Roger Hayward's drawing on the opposite page*). In our version of his instrument we substituted a bit of cellophane for the point and fastened it to the adjustment mechanism with cement. Specimens are cemented to the cellophane.

Unfortunately Leeuwenhoek's microscope lacks the viewing comfort of modern instruments. To see the enlarged image you must bring the lens very close to the eye. Hayward has drawn a larger model which employs a conventional slide as the stage, a mirror for controlling the light and a more convenient focusing adjustment. This arrangement adds to the instrument's convenience but does not eliminate the necessity of bringing the eye close to the lens (*see drawing above*).

Considering its primitive design, Leeuwenhoek's microscope reveals an astonishing amount of detail. Leeuwenhoek is supposed to have worked successfully with smaller beads, which gave higher magnification, but he quickly learned to value resolution over magnifying power and to work with the lowest power possible. A big fuzzy image has no advantage over a small fuzzy one.

Leeuwenhoek handed down at least one other fundamental lesson—the importance of preparing objects carefully for microscopic examination. As the 18th-century mathematician Robert Smith wrote in his *Compleat System of Optiks*: "Nor ought we to forget a piece of skill in which he [Leeuwenhoek] very particularly excelled which was that of preparing his objects in the best manner to be viewed by the microscope; and of this I am persuaded anyone will be satisfied who shall apply himself to the examination of some of the same objects as do remain before these glasses. At least I have myself found so much difficulty in this particular, as to observe a very sensible difference between the appearances of the same ob-



How to make the glass-bead lens of a Leeuwenhoek microscope

ject, when applied by myself and when prepared by Mr. Leeuwenhoek, though viewed with glasses of the very same goodness."

Since Smith's day generations of slide makers have developed techniques for the preparation of specimens which are almost as fascinating as the operation of the microscope itself. Some relatively huge specimens, such as the dry root of a hair or a dried flea from a dog, require no more preparation than being attached to a slide with a dab of Canada Balsam or some other slide cement and covered with a thin glass. Minute objects such as red blood corpuscles can be viewed with reasonable satisfaction if they are merely smeared on a slide and protected with a cover glass. But others which are thick and opaque, or transparent, or contain water in their structure, require special treatment.

If the interior of a specimen is to be studied, either its top must be cut away or, if it is translucent, it must be lighted from below. Some specimens must be cut into extremely thin slices. There are slicing machines called microtomes which can cut frozen tissue or tissue embedded in wax into sections almost as thin as a single wavelength of light. In addition to solving the lighting problem, thin sectioning simplifies the image, for the microscope magnifies in all dimensions. Amateurs do not, however, need an elaborate cutting machine; they can prepare slides with a safety razor blade.

When an organism is completely transparent, it may have to be dyed or embedded in a light-refracting substance. The staining process is an art in itself, because staining substances always produce a chemical change in the organism. Sometimes the stain affects one part of the cell and not another. By using different chemicals one may dye the nucleus one color and the surrounding cytoplasm of the cell another color.

Many bacteria can be distinguished from one another only by the way they take a stain; this is the basis, for example, of the classification of "gram positive" and "gram negative" bacteria.

The preparation of slides for the microscope has developed its own special literature, with whole volumes devoted to such subjects as techniques of desiccation; cleaning; bleaching to remove pigments which obscure the view; methods of floating objects in liquid cells; the selection of cover glasses with optical properties matching those of the instrument; the polishing and etching of metal surfaces to reveal crystal structure—processes almost as numerous and varied as the objects that go under the instrument's objective lens. Like all other scientific avocations, the preparation of specimens for the microscope invites the amateur to plunge in as deep and stay down as long as he likes.

After building and using a Leeuwenhoek instrument you may very well decide to go further. A conventional compound microscope will save a lot of squinting. It should be an instrument of good quality, capable of showing fine detail. Its power should match the ability of the beginner. High-power objectives invariably prove disappointing to beginners, because their successful use calls for substantial skill. A good secondhand beginner's microscope can be purchased for $60 or less.

Having acquired an instrument, what next? According to Joseph F. Burke, who like Ross is a member of the New York Microscopical Society, the minute plants called diatoms are ideal subjects for the beginner.

"Diatoms grow," says Burke, "wherever there is light and moisture. This means that they can be collected in nearly every part of the world. They can be found on the beach, among the plankton at sea, on the mud bottom of ditches, on the stems of water plants, in the scum on stagnant pools, even in desert sands, for their silica shell remains as a fossil after they have died. A formation of living diatoms usually has a brownish tint, caused by a pigment which obscures the plant's chlorophyll. Deposits of fossilized diatoms, laid down on the bottom of ancient seas, are mined as diatomaceous earth, valued for its mild abrasive action. Many silver polishes are rich in fossilized diatoms—a convenient source the beginner should not overlook.

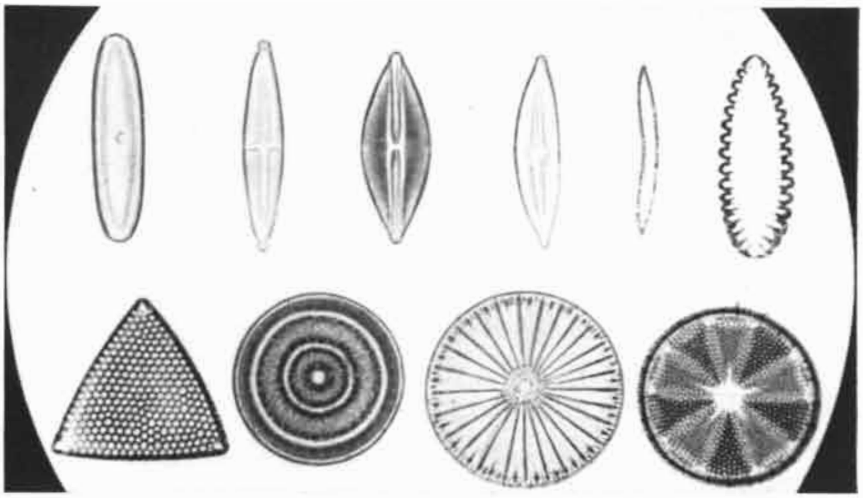
"For live collecting the amateur should equip himself with a few widemouthed jars, a spoon and an ordinary coffee or tea strainer of 40 or 50 mesh. As specimens are taken in the field, the collector records the date, time and location along with other data that will assist in the subsequent identification of the material.

"To prepare diatoms for mounting, the amateur will need: technical sulfuric acid, technical hydrochloric acid, hydrogen peroxide, powdered potassium bichromate, distilled water, strainers of 40 to 50 mesh, two Pyrex beakers holding 30 cubic centimeters, a Pyrex custard dish, a conical flask of 125 c.c., an assortment of pint and quart jars, glass stirring rods, half-ounce storage bottles with caps, and clean pipettes.

"The collected material should be transferred to a large jar. Filtered water is added and the material is thoroughly beaten with a glass stirring rod to dislodge the diatoms from foreign objects. The organisms should then be strained and permitted to settle; allow an hour per vertical inch of solution. Living diatoms should be processed in a darkish place, because their metabolic processes release tiny bubbles of oxygen which cause the organisms to rise to the surface. Having settled, the diatoms will form a brown layer on the bottom of the jar. The water should then be poured off without losing the specimens. This washing process should be carried out three or four times, particularly when the diatoms are salt-water species. Distilled water should be used wherever the local water supply carries a heavy content of lime.

"Part of the material is then transferred with the pipette to the Pyrex beaker to form a layer about an eighth of an inch thick. The beaker should be placed in the custard cup. The excess water is removed with the pipette, leaving the specimens moist but not wet. Next powdered potassium bichromate, approximately one third the bulk of the diatoms, is stirred into the mixture. Then comes an operation which must be performed outdoors or in a window with a strong outward draft, as the reaction produces poisonous fumes. Slowly add approximately five c.c. of technical sulfuric acid to the diatom-bichromate mixture. A violent reaction will follow. Beat down the resulting bubbles with a stirring rod. Should the heat of the reaction break the beaker, the custard cup will prevent the loss of the specimens.

"The material is then transferred to a quart jar and washed with distilled water five times, allowing about an hour of settling time for each vertical inch of water. The diatoms are now ready for separation according to size. This is accomplished by the familiar process of elutriation. The material is transferred to the first of a series of uniform glass containers. Water is added, and after a certain interval, say half an hour, the water is poured off carefully into the second jar of the series. Again at the end of the predetermined interval, the second jar is poured off into the third. This is repeated until the diatoms are separated into the desired sizes. The diatoms are now ready for individual storage bottles, to which a



Upper row: marine diatoms. Lower row: fresh water diatoms

few drops of hydrogen peroxide may be added as a preservative.

"For mounting diatoms, select a cover glass of 12-millimeter diameter and a thickness of .11 to .20 mm. The slide itself should have a thickness of 1 mm. (A supply of cover glasses, slides and mounting cement or 'medium' is available at most optical shops.) Clean the slide and cover glass thoroughly with soap and water. Select a storage bottle containing diatoms and shake it until they are in suspension. With the pipette place a drop of distilled water in the center of the cover glass. If the glass has been cleaned properly, the water will spread to the edge but not overflow. Next add a drop from the storage bottle which holds the diatoms in suspension. The diatoms will spread evenly and settle on the glass. Allow the water to evaporate overnight. Protect the glass from dust.

"You will next need a small hot plate and a bottle of medium. I prefer Hyrax for mounting diatoms. Warm the slide on the hot plate and place a drop of Hyrax on the slide's center. Then remove the slide from the hot plate and place it on a wooden support to prevent rapid cooling. With sharp pointed forceps, pick up the cover glass, invert it so that the diatom side is down and press it gently onto the medium until the fluid reaches the edge of the cover glass. The slide is then returned to the hot plate and the Hyrax is brought to a state of vigorous bubbling. As the bubbling slows down, remove the slide to the wooden support. Experience will teach the proper moment of transfer.

"After cooling, the slide is placed under the objective and examined. If the washing and mounting have been performed carefully, the amateur is in for a thrill he will long remember. Diatoms have been called 'nature's jewels,' and man has yet to fashion anything more exquisite.

"Although more than 10,000 species of diatoms have been recorded thus far, the list continues to grow. The beginner should equip himself with a reference book on the subject. He will find it essential for classification. Then, at last, he can experience the satisfaction of labeling his first slide."

ASTRONOMERS define selenography as the study of the surface of the moon. They are so busy with the stars and the universe, however, that they have no time for selenography. Thus the moon has long been left almost entirely to advanced amateur astronomers, who find it made to order for their more limited resources—and also endlessly fascinating, with its maze of more than 30,000 craters, cliffs, rills and rays.

When a telescope user ceases to look at the moon in a merely desultory manner and begins to observe it, he has begun to be a selenographer. He singles out small areas or formations and studies them minutely throughout the long lunar day, at every hour of which the changing angle of the sunlight alters their appearance. While doing this he learns the lunar map, partly by copying and then drawing it from memory, partly by making sketches directly at the eyepiece of the telescope. If these sketches are dated and saved from the very beginning, his observations will be all the sharper. The ability of the eye to see detail improves immensely with practice.

The training of the powers of observation would be tedious if the telescope owner did not fan his interest by reading the literature to learn what other selenographers are doing. Perhaps the easiest way to start is by joining the Association of Lunar and Planetary Observers, 1203 North Alameda Street, Las Cruces, N. M., and reading its monthly organ *The Strolling Astronomer*. By following up the leads in its articles the beginner soon learns his way about in the world of selenography and is introduced to the many controversies in this field.

Of these perhaps the most interesting is the question: Does the moon's surface ever change? Most astronomers believe that it does not, even in fine details. On the other hand, most selenographers believe that small changes do occur. Dismissing the theories of the astronomers on the ground that they do not observe the moon, the selenographers insist that their minute and systematic observations over many decades have confirmed a number of changes.

The most noted change was the disappearance of the crater Linné, six miles in diameter, some time between 1843 and 1866. After its disappearance, a white spot surrounding the crater steadily diminished in size and brightness until 1897, but then grew again and has now regained its earlier size. For many years the American selenographer William H. Pickering noted irregular changes in the sizes and shapes of dark regions within the ring plain Eratosthenes. Then there is the ring plain Plato, which is obscured at irregular intervals by some kind of haze or vapor.

In 1942 Walter H. Haas, now editor of *The Strolling Astronomer,* summarized changes that selenographers had seen in 21 lunar formations in a series of articles in *The Journal of the Royal Astronomical Society of Canada.* Last year the selenographer H. P. Wilkins, director of the lunar section of the British Astronomical Association and maker of the best detailed map of the moon, described 15 anomalies that he had observed in 40 years of lunar observation with telescopes from 3 to 15 inches in aperture. Wilkins said: "Things do happen and are continually happening on the moon." It is not a dead world.

Some astronomers treat these many claims more open-mindedly than they did 50 years ago, when the U. S. astronomer Simon Newcomb said dogmatically that the moon was a world on which nothing ever happens. Most open-minded is the textbook *Astronomy* by William T. Skilling and Robert S. Richardson. They describe the work of selenographers and note that "astronomers are extremely skeptical of changes on the moon, considering them to arise from differences of illumination, unsteadiness of the earth's atmosphere and the inherent difficulty of seeing and recording fine details which are just at the limit of visibility." But they concede that "most astronomers have not systematically studied the moon."

In the last two years readers of *The Strolling Astronomer* have followed a long account (15,000 words) of a lunar formation which seems to the Baltimore selenographer James C. Bartlett, Jr., to be playing a game of hide and seek. It is a puzzle that has fascinated selenographers for over 100 years.

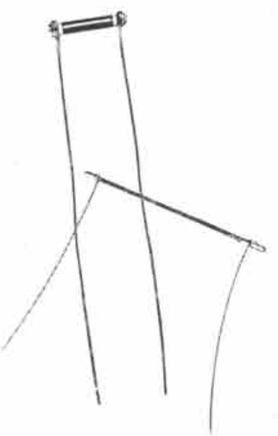
Some time prior to 1837 Johann

made right to work right

BENDIX-FRIEZ

high-precision thermistors

Whether you use these temperature responsive resistors in standard or special models, you can be sure of this. *They'll match your needs* for resistance values, size, temperature coefficient, mountings and quality. Made in our own plant under carefully controlled conditions, Bendix-Friez Thermistors know no equal.



Used in this typical application for sensing the temperature of hydraulic oil.

STANDARD TYPES FOR IMMEDIATE DELIVERY

Size (inches)	@ +30°C.	@ 0°C.	@ −30°C.
.140 x .75	45.0 ohms	86 ohms	194 ohms
.040 x 1.5	12,250 ohms	26,200 ohms	65,340 ohms
.018 x 1.5	35,000 ohms	82,290 ohms	229,600 ohms

Write for details.

FRIEZ INSTRUMENT DIVISION of . .
1422 Taylor Avenue, BALTIMORE 4, MARYLAND
Export Sales: Bendix International Division
72 Fifth Avenue, New York 11, N. Y.

Bendix
AVIATION CORPORATION

For Music Lovers

Here is the quality your ear demands
Here is the value selected by experts

Best Buy in a High-Fidelity Music System Recommended by *Saturday Review's* E. T. Canby

Now you can revel in full-fidelity, distortion-free reproduction of your records. Here is an easy-to-assemble custom music system at a sensible price — selected and recommended by E. T. Canby and associated authorities on the reproduction of recorded music. Complete system includes: Bogen DB-10-1 High-Fidelity Amplifier, Garrard RC-80 3-Speed Changer with two G. E. cartridges and diamond stylii, Electro-Voice SP12B Coaxial Speaker. Complete with cables (no soldering connections required), hardware, and full instructions. Shpg.wt., 65 lbs. **93-572.** *Only*.......... **$162.75**

98-650. Pilot AF-821 FM-AM High-Fidelity Radio Tuner for above system. *Only*...... **$99.95**

Other fine custom quality home music systems from $108 to $1250

Bogen Amplifier

Garrard Changer

Electro-Voice Speaker

Outstanding Book on High-Fidelity. If you're interested in recorded music, you'll want a copy of *"The Saturday Review Home Book of Recorded Music and Sound Reproduction."* Complete, authoritative information on all aspects of high-fidelity reproduction and recording techniques. **37-946.** *Postpaid*........ **$4.40**

FREE 236 Page Hi-Fi, TV and Radio Catalog

Send for the complete Buying Guide to everything in High-Fidelity, TV, Radio and Electronic Equipment. Unsurpassed selection of quality apparatus and fine values. Ask for your FREE copy today.

ALLIED RADIO

833 W. Jackson Blvd., Dept. 40-A-3, Chicago 7, Illinois

● **MATHEMATICS FOR PEOPLE WHO DIDN'T LIKE IT:**

Course M15: A new kind of mathematics course. The psychology of dislike, fear, and avoidance. The maturing of personality. What mathematics essentially is. The languages of mathematics, what they refer to, and how to understand them. The techniques of mathematics, what they involve, and how to use them. Introduction to the branches of mathematics.

AND 25 OTHER COURSES*

By Mail—Easy or Hard—Individuals or Study-Groups—Scholarships, Incentives, and other Plans—Low Cost

". . . Your replies to my submitted answers and my own questions have always been most kind and prompt."

—a member of the faculty, Johns Hopkins Univ., Maryland

*Symbolic Logic, Computing Machinery, Robots, Pure and Applied Mathematics, Operations Research, Cybernetics, Statistics, Probability, etc. We have students in 39 states, Alaska, Hawaii, and 10 foreign countries. We are Edmund C. Berkeley and Associates: instructors, publishers, writers (*Giant Brains* or *Machines that Think,* Wiley, 1949, etc.), consultants, makers and exhibitors of small robots (Simon, Squee, etc.)

MAIL THIS COUPON

EDMUND C. BERKELEY and Associates
19 Milk St., R49, Boston 9, Mass.

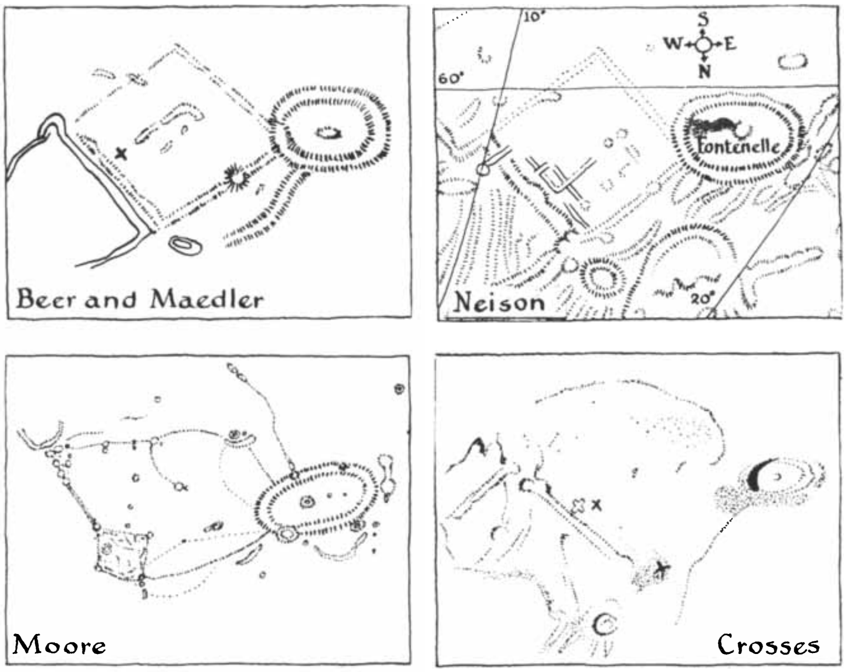
Please send me free information on all courses.

I am interested in

Name

Address

© 1952 SCIENTIFIC AMERICAN, INC



Drawings of the same lunar formation by four observers

Maedler of Berlin saw a remarkably perfect square on the region of the moon between the ring plain named Fontenelle and the walled enclosure called Birmingham. The square was 65 miles on a side and had walls one mile thick. It is shown in Roger Hayward's drawing above, reproduced from a drawing published in 1837 by Maedler and his collaborator Wilhelm Beer. On the floor of the square Maedler saw a very regular cross. In 1876 Edmund Neison, director of the Natal Observatory in South Africa, also published a lunar map containing Maedler's square, which he had observed himself with a six-inch refracting telescope. He described it as "a square with regularity and perfect form, its walls from 250 to 3,000 feet in height." Neison's drawing is reproduced here by Hayward, himself a selenographer.

Thus two of the founders of selenography testified that the square was real in their time. Yet in 1949 Bartlett, after studying the area of the square for more than an hour with his 3.5-inch reflecting telescope on a very fine night, failed to find it! The "fact emerged," he says, "with the impact of a hydrogen bomb. No such formation existed." Another selenographer, E. J. Reese, confirmed the disappearance. Bartlett later found two walls of the "square" (the ones on the lower left-hand and right-hand sides of the drawings), but he could detect no trace of the other sides.

Bartlett then examined old photographs of the moon made in Maedler's and Neison's time. (The first photograph of the moon was made in 1840 by the U. S. astronomer Henry Draper.) The primitive photographs were inconclusive, but in the first clear ones, made during the 1870s by the U. S. amateur astronomer L. M. Rutherfurd, the "square" did not appear. Bartlett concluded that what Maedler and Neison had seen with their telescopes actually was a square, which had "ceased to exist by 1874 and perhaps earlier."

The next participant in the discussion in *The Strolling Astronomer* was Patrick A. Moore, secretary of the lunar section of the British Astronomical Association. In July, 1951, he said that the Bartlett article had aroused a great deal of interest in Britain. He sketched the area with his 8.5-inch reflector, using powers from 200 to 400. Moore, a very experienced observer, found three walls of the square clearly visible and the fourth faintly so at times. But the square was not the neatly geometrical, fortress-like form Maedler had described, and all but one of its walls were very low.

Moore's findings are pictured in the drawing labeled with his name. The wall at the bottom of the drawing is extremely low. At its left end is a small quadrilateral bounded by four hills connected by low ridges. It contains a small crater and fine detail of the kind selenographers delight in delineating as a test of their observing skill. The left wall, extending upward from this corner, ends in a series of heights which are very conspicuous during the times of the month when the shadows reveal them. The wall at the top of the drawing is very low indeed and perhaps discontinuous. At its right-hand end is a prominent crater. Finally, on the fourth side of the square is a trace of a wall so low that it has to be caught under favorable conditions of illumination to be seen at all.

Have changes occurred since Maedler and Neison described the prominent, fortress-like walls they thought they had seen? Moore declares: "The evidence for change is totally inadequate." He excuses Maedler on the ground that he had only a small telescope (a 3.75-inch Fraunhofer refractor with magnification 300) and that it is human "to err sometimes." And he disqualifies Neison because the latter's map was made mainly from Maedler's. Supporting Bartlett's observations, Moore suggests that "it would be a fitting gesture to attach the name of Bartlett to the curious formation that has been referred to as Maedler's square."

Moore's careful observations seemed to have settled the question. But 14 months later Bartlett announced new evidence. Photographs taken with the 36-inch Lick refractor, he said, fail to show any eastern wall for the square. He suggested that the extremely low object seen there by Moore could not have been seen by Maedler and might possibly be the remains of a wall that was actually present in Maedler's time. He dismissed the idea that Maedler's observation was due to the inadequacy of his telescope, noting that Maedler was able to see objects much smaller than the square.

The Lick pictures, incidentally, raise a question. Since anyone can purchase prints of photographs made with large telescopes, including the 100-inch, why do selenographers strain to see minute lunar details with their own small telescopes? One reason is given by Walter Goodacre, a former director of the lunar section of the British Astronomical Association. He points out that under the best seeing conditions an observer can see as much detail with a high-quality 10-inch refractor as is shown on photographs made with a 100-inch telescope. When used visually, the large telescopes give better detail, but they are rarely available to selenographers.

Recently Bartlett rediscovered Maedler's cross—a dull, whitish formation—and Reese verified the find. "Now," says Bartlett, "this wonderfully establishes Maedler's accuracy. Have we any further reason to doubt that Maedler had faithfully depicted the square?" A few months later, with Maedler's cross plainly visible, Bartlett observed to the east of it a smaller, dark gray cross very difficult to see. Neison discovered this cross long ago when Maedler had missed it—proving, Bartlett says, that Neison did not merely rehash Maedler's book for his own.

Is Bartlett's comeback on the accuracy of the early selenographers a proof? The most he asks is that the square be closely watched in the future. Meanwhile Moore and Wilkins have made a change in Maedler's square. On the great Wilkins map of the moon they have renamed it "Bartlett."

INDEX OF ADVERTISERS

JANUARY, 1953

BIBLIOGRAPHY

Readers interested in further reading on the subjects covered by articles in this issue may find the lists below helpful. The lists are not intended as bibliographies of source material for the articles. The references selected will provide supplementary information.

RADIO STARS

THE DISTRIBUTION OF THE DISCRETE SOURCES OF COSMIC RADIO RADIATION. B. Y. Mills in *Australian Journal of Scientific Research*, Vol. 5, No. 2; June, 1952.

RADIO ASTRONOMY. Grote Reber in *Scientific American*, Vol. 181, No. 3; September, 1949.

TRACE ELEMENTS

THE DIAGNOSIS OF MINERAL DEFICIENCIES IN PLANTS. T. Wallace. His Majesty's Stationery Office, 1943.

MINERAL NUTRITION OF PLANTS AND ANIMALS. Frank A. Gilbert. University of Oklahoma Press, 1948.

THE OLDEST LAWS

ANCIENT NEAR EASTERN TEXTS. Edited by James B. Pritchard. Princeton University Press, 1950.

THE KIDNEY

THE KIDNEY: STRUCTURE AND FUNCTION IN HEALTH AND DISEASE. Homer Smith. Oxford University Press, 1951.

CRYSTALS AND THE FUTURE OF PHYSICS

AN INTRODUCTION TO CRYSTALLOGRAPHY. S. C. Phillips. Longmans, Green and Co., Inc., 1946.

PSYCHOTHERAPY FOR SCHIZOPHRENICS

CONCEPTIONS OF MODERN PSYCHIATRY. Harry Stack Sullivan. William Alanson White Psychiatric Foundation, 1947.

WOOD STRUCTURE

TEXTBOOK OF WOOD TECHNOLOGY. H. P. Brown, A. J. Panshin and C. C. Forsaith. McGraw-Hill Book Company, Vol. I, 1949; Vol. II, 1952.

THE MECHANICAL PROPERTIES OF WOOD. S. J. Record. John Wiley & Sons, 1914.

THE METABOLISM OF HUMMINGBIRDS

RESPIRATION AND METABOLISM. David W. Bishop in *Comparative Animal Physiology*. W. B. Saunders and Company, 1950.

VITAL ENERGETICS: A STUDY IN COMPARATIVE BASAL METABOLISM. Francis G. Benedict. Publication No. 503 of the Carnegie Institution of Washington, 1938.

Buttoned-up and navigating blind

Operating tanks with full effectiveness in featureless arctic or desert terrain presents a new problem in "blind" navigation.

Dead reckoning and navigating under such conditions requires electronic and electromechanical systems that are highly complex yet simple to operate and maintain.

This growing field of vehicular navigation is another place where Arma is a leader in basic research, design, development and production. Over 34 years of close cooperation with the Armed Forces—and more recently the Atomic Energy Commission—stand behind Arma's reputation. *Arma Corporation, Brooklyn, N. Y.; Mineola, N. Y.; Subsidiary of American Bosch Corporation.*

ARMA ADVANCED ELECTRONICS FOR CONTROL