# ENGINEERING | AND | SCIENCE

OCTOBER/1951

*Structure of Proteins . . . page 7*

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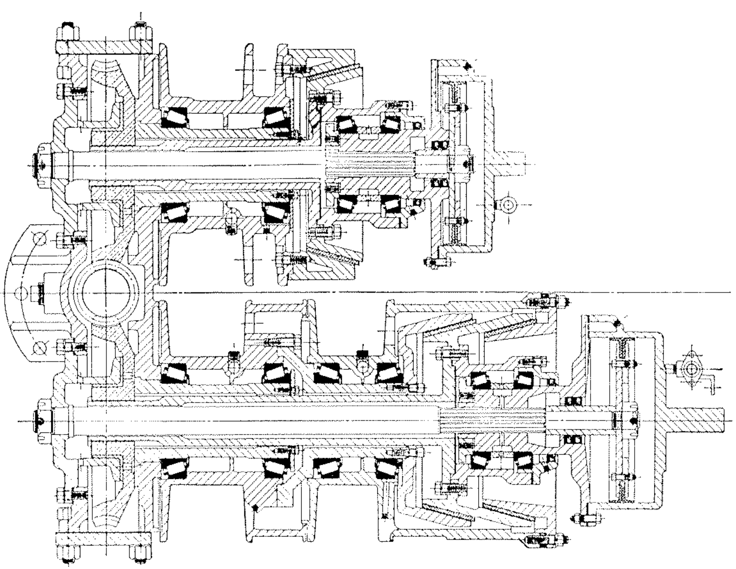

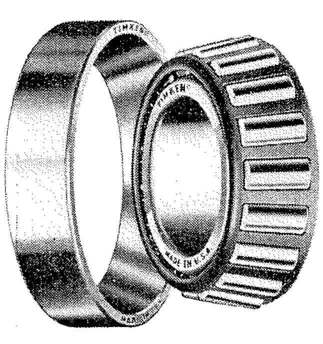

# BOOKS

## THE GROWTH OF SCIENTIFIC IDEAS

by William P. D. Wightman

Yale University Press, New Haven, $5.00

*Reviewed by Charles E. Bures*
*Assistant Professor of Philosophy and Psychology*

DR. WIGHTMAN is the first holder of a new Lectureship in the History and Philosophy of Science at the University of Aberdeen. This book, which appeared last year in England, joins the work of a distinguished company of recent British interpreters of the history of science: Singer, Taylor, Pledge, Wolf, Butterfield and others.

The scope of this survey extends from the Ionians to the end of the 19th Century. The starting point rests on the authority of Gordon Childe who maintains that, although the Ionians did not create science, they were the first to seek the generalized scientific knowledge. In the main, the content of the book is conventional. About two-thirds is devoted to physics and one-third to biology. Somewhat more space is given to the corpuscle-wave controversy in the 17th and 18th centuries than is usual in introductory books.

In procedure, Wightman has been influenced by the "strategy and tactics" study of conceptual development as outlined by Conant and the Harvard group. Philosophically, Wightman mentions Collingwood and Whitehead as his main creditors. The debt to Collingwood's *The Idea of Nature* is apparent. The author shows more sympathy for vitalism in biology, which is likely due, at least in part, to the influence of Whitehead's organicism. Both Collingwood and Whitehead stand outside the main movement of accepted thinking on the philosophy of science in England and America today. Collingwood's attempt to reduce philosophical interpretation to the single category of "history" was a failure. Whitehead's organicism, while influential in certain groups, is a sterile approach to the analysis of contemporary scientific ideas.

The influence of these philosophers is relatively minor in the bulk of the volume because of the reliance on conventional sources. It is strange that the student is nowhere referred to the fundamental work of George Sarton. However, this book should be ranked alongside Sedgwick and Tylor as a good usable introductory text for courses in the history of science.



## INTRODUCING THE UNIVERSE

by James C. Hickey

Dodd, Mead, New York, $3.50

*Reviewed by Robert S. Richardson*
*Mount Wilson and Palomar Observatories*

THIS BOOK is designed for those whose interest in astronomy has been aroused and who wish to know something about it without wading through the details of a textbook.

Mr. Hickey writes in an easy conversational style, including just enough anecdotes and personal incidents to enliven the factual material. He starts by answering the question so often asked astronomers: "What is the use of studying the stars anyhow?" He handles this chapter very ably by showing how astronomy has enlarged our original narrow conception of the universe as well as contributing in a practical way by leading to the discovery of the basic laws of motion. With that out of the way it is an easy matter to proceed with the description of the various bodies of the solar system, the stars, nebulae, and the expanding universe.

This book is the only one of its type I can recall that pays a long overdue tribute to the curbstone astronomers. My first observation was made through the telescope of

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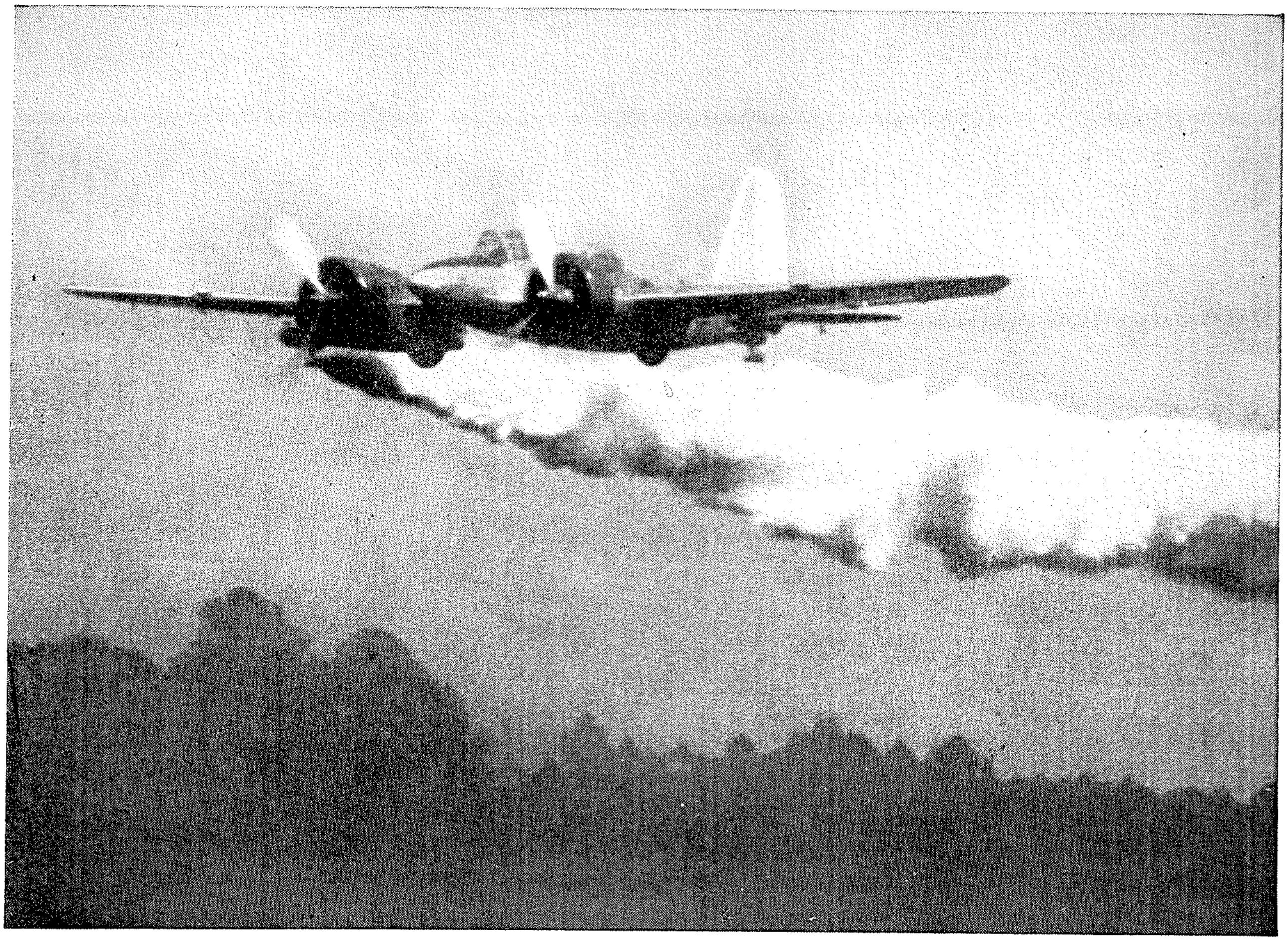

# How to open a can of fog

**The pilot** pushes a button on the instrument panel.

And instantly, from metal tanks fixed to a warplane's fuselage, thick streams of artificial fog pour forth.

Today it is possible for a fast plane to obscure an Army division or a Navy squadron in a matter of seconds. For scientists and engineers at Corning Glass Works, working with the Armed Forces, have developed a new way to open a can of fog.

A specially engineered disc of one of the tough Corning glasses is used to form the end of the metal fog chamber. In the center of this glass disc, which is sealed to the metal can, is a percussion cap—connected electrically with the plane's instrument panel.

When the pilot pushes the button, the percussion cap is detonated, breaking the glass disc and opening the end of the cylinder.

Since the containers have to be stored at depots scattered from the tropics to the polar regions, the discs are made of heat- and cold-resistant glass which sudden temperature changes won't break. The glass has to be strong to prevent releasing the fog-making ingredients prematurely.

**And the discs are made** so that they will break evenly and completely from the force of the exploding percussion cap.

The design for this strong, heat-resistant glass disc that will break in a predetermined way is only one of the more than 37,000 designs for glass products developed by Corning engineers in a full century of glass-making.

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**CORNING**
**means research in glass**

1851—100 YEARS OF MAKING GLASS BETTER AND MORE USEFUL—1951 a curbstone astronomer, and it was a much greater thrill than a peek through the 200-inch some 40 years later. As Mr. Hickey says, the curbstone astronomer often has a much deeper knowledge of his subject than one might expect.

In a short popular book it is often difficult to be strictly accurate, but this one seems remarkably free from errors. Kepler might better be described as an inspired computer rather than a "brilliant mathematical light." The temperature at the center of the sun is now believed to be 19,000,000°C instead of 25,000,000° C. It has decreased alarmingly in the last ten years. A campaign is being launched to scotch the statement that a sunspot endured for 18 months in 1840 and 1841. Mr. Hickey doubtless got this from the *Astronomy* by Russell, Dugan, and Stewart; who, in turn, got it from Young's *General Astronomy*. The longest authentic record for the duration of a spot group is that of 134 days in 1919. Some of the statistical data on the planets might better have been put in a single table instead of the text, but this is a matter of opinion. Mr. Hickey has done a good job. His book is a well organized, thoroughly enjoyable introduction to the universe.

### INTERNAL COMBUSTION ENGINES
by Lester C. Lichty

McGraw-Hill, New York $7.00

*Reviewed by Peter Kyropoulos*
*Assistant Professor of Mechanical Engineering*

LICHTY'S BOOK on internal combustion engines has for years been an outstanding text as well as reference work for the practicing engineer. The new (sixth) edition follows the previously established pattern which includes thermodynamics, structure and performance. There are a goodly number of examples showing current practice, yet the book is not burdened with excerpts from catalogues. Since the last edition (1939) there have been many new developments in automotive engines. These have been treated and correlated with basic theory. Probably the most important addition is the inclusion of gas turbines and rocket engines.

The pertinent cycle analyses as well as an extensive treatment of fuels other than gasoline and fuel oil are included. Numerous references give material for further study.

The chapter on abnormal combustion, formerly called "Detonation and Knock Testing," has been renamed in accordance with present practice, "Combustion Knock and Knock Rating," and the contents of the chapter have been considerably refined. The effect of design and operating variables on octane requirements are discussed at length and the concept of knock-limited performance is given its full significance.

A short section on lubricating oil additives has been added, in which unfortunately no references are given, which is disappointing in such an important subject. A comprehensive section on cylinder wear is added, including numerous references which will ultimately expose the reader to additional data on additives.

A comparison of high-speed engine indicators is given in the section on performance.

In spite of all these additions, the number of pages has been kept the same, which shows that the existing material has been carefully reviewed.

I should call Lichty's book the most comprehensive and concise text available at present.

### GAS TURBINES
by H. A. Sorensen

Ronald Press, New York $6.50

*Reviewed by R. H. Sabersky*
*Assistant Professor of Mechanical Engineering*

DR. SORENSEN'S BOOK discusses in some detail the subject of gas turbines, with particular emphasis on aircraft gas turbines, which is in accordance with the recent technical developments. The book contains twelve chapters, and the first five are devoted to a review of thermodynamics and basic gas turbine cycles. The later chapters treat in some detail the thermodynamic design of the gas turbine components, i.e., the axial flow compressor, the centrifugal compressor, the combustion chamber and the turbine proper. A brief chapter on structural design problems is also included. A considerable amount of practical information is given in these chapters and the information is well up to date. The book does not require any extensive mathematical background.

# ENGINEERING AND SCIENCE


## IN THIS ISSUE

**Dr. Linus Pauling,** shown on this month's cover, has been working with Dr. Robert B. Corey and other Caltech researchers for nearly 15 years to find out how proteins, the principal building blocks of the body, are put together. The structure of proteins has baffled scientists for almost 75 years, and has long been one of the most important problems in the field of biochemistry.

On page 7 of this issue you'll find the story of how Pauling and Corey have made the first significant progress in the solution of this great problem. "The Structure of Proteins" explains how they discovered the structure of a protein molecule—and what this discovery means.

**Carl Anderson** entered Caltech as a freshman in 1923, and he's been here ever since—to the mutual satisfaction and benefit of both Anderson and the Institute. On page 11 of this issue there's a biographical sketch of Carl Anderson which tells some of the reasons for the existence of this mutual admiration society, as well, of course, as everything we could find out about the life and times of Anderson. This is the first in a series of short biographies of Caltech faculty members.

PICTURE CREDITS

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# THE STRUCTURE OF PROTEINS

Caltech researchers discover the essential atomic structure of several proteins—including those found in bone, muscle and red blood cells

*Linus Pauling and Robert B. Corey with molecular model showing configuration of atoms in a protein molecule*

ONE OF THE MOST important problems in the field of biochemistry is to find out how proteins, the principal building blocks of the body, are put together.

At the Diamond Jubilee meeting of the American Chemical Society in New York last month, Dr. Linus Pauling, Chairman of the Institute's Division of Chemistry and Chemical Engineering, and Dr. Robert B. Corey, Professor of Chemistry at the Institute, reported "significant progress" after some 15 years of work on this fundamental problem. They have, in fact, discovered the essential atomic structure of several proteins—including those found in bone, muscle, and red blood cells. And work with other proteins has progressed to the point where knowledge of their structures appears to be imminent.

In learning how proteins are put together, we are gaining a deeper insight into the nature of living matter. We are on the way to a better understanding of the nature of physiological reactions—and on the way to gaining greater control over disease.

The major components of all living cells are proteins, fats, carbohydrates in various forms, salt and water. Though all of them are essential, the proteins among these are responsible for many of the activities which we associate primarily with living things—and, in this respect, they may be considered more important than any of the other components of living cells.

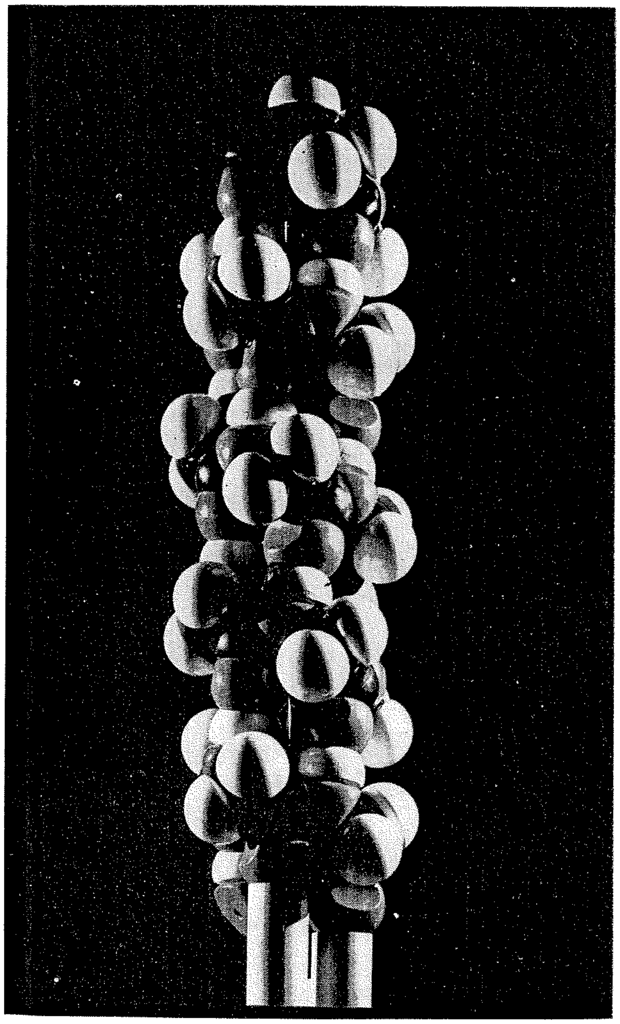
Some of the most important proteins include hair, wool, horns, fingernails and feathers. The major components of skin and muscle are proteins. Egg white is chiefly protein.

Hemoglobin, the red coloring matter of the blood, is another kind of protein. Some of the hormones, which regulate bodily activity, are proteins. All antibodies, all viruses, and the genes, the carriers of the mechanism of heredity, are proteins.

Altogether, there are thousands of different kinds of proteins in the human body. Unlike most other chemicals, which consist of a score or two individual atoms, protein molecules are made up of many thousands—and sometimes even millions—of individual atoms, each occupying a specific place in the architecture of the molecule.

Protein molecules, as one of their characteristic properties, are very large. For instance, the molecular weight of sodium chloride is about fifty-five; the molecular weight of the smallest protein that we know, insulin, is 12,000, and that is something of an exception. Of the common proteins, the smallest molecular weight is about 35,000.

Proteins are important constituents of foods. They are digested by the digestive juices in the stomach and intestines, being split in the process of digestion into small molecules. The small molecules are able to pass through the walls of the stomach and intestines into the blood



*Wooden molecular model (250,000,000 linear magnification) of the 3.7-residue helical configuration of the polypeptide chain of some proteins*

stream, by which they are carried around into the tissues, where they may then serve as building stones for the manufacture of the body proteins.

Proteins act by interaction with each other and with other substances, and what they interact with and how they interact are governed by their structure. Each protein has a special structure which enables it to do a specific job.

The first great advance toward an understanding of protein structure was made in 1900 when Emil Fisher, a German, found that a protein molecule is composed of simpler substances known as amino acids (of which there are 24 in all). The amino acids, in turn, were found to be linked together into larger groups known as peptides, and the peptides are linked together into even larger groups, known as polypeptides.

The problem of determining the structure of proteins then became one of finding the sequence of various amino acids in the chain and the way in which the chain is coiled.

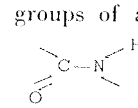
Thirty years ago scientists in Germany and England began making x-ray diffraction photographs of proteins in the hope that photographic analysis would reveal their structure. Work along these lines — the x-ray analysis of simple substances — was begun at the California Institute of Technology in 1916, by Burdick and Ellis, and was continued with great energy by Professor Roscoe G. Dickinson. Thus Caltech was a pioneer in the use of the technique in the United States. In making such photographs, x-rays, played on the substance, are scattered by the atoms. The resultant photographic pattern, as given by simple substances, allows scientists to determine the arrangement of their atoms—which, of course, can't be seen themselves. But protein structures proved to be too complicated for x-ray analysis to reveal their structure.

## Indirect attack

Some fifteen years ago Dr. Pauling and Dr. Corey decided to attack the problem by a more roundabout method. Instead of trying to study the complicated proteins directly, the researchers went to work on the component parts of the proteins. They began an investigation of the crystal structure of the amino acids, of simple peptides (those made of two or three amino acids, rather than several hundred), and of other simple substances related to proteins.

In this way Drs. Pauling and Corey were ultimately able to obtain enough structural information to permit the precise prediction of reasonable configurations of the polypeptide chains (the backbones of several proteins). Intricate scale models of these molecules were then constructed.

The whole process was necessarily slow, of course. It took from six months to two years each to find the atomic structure of the four simplest amino acids, for example.

The structural units with which Drs. Pauling and Corey worked are rigid groups of atoms, in the form of planar amide groups  which are held together by carbon atoms. Each of these linking carbon atoms has a hydrogen atom and a side chain, characteristic of the amino acid, attached to it. The two bonds formed by each of these carbon atoms with the two adjacent amide groups are at an angle of 110° with one another. At first the assumption was made that any orientation could be assumed around each of the bonds.

## An engineering problem

The investigators were then faced with a geometrical or engineering problem—the problem of finding orientations around these bonds that would not lead to steric hindrance between one part of the chain and another part of the chain, and also that would permit the oxygen atom and the NH group to form hydrogen bonds, N—H . . . O, with length 2.8 A.

Only four acceptable structures were found in three years of search. It was also found that all of the structures that had previously been proposed for proteins had to be rejected, as not conforming to the requirements of interatomic distances, bond angles, and other structural features indicated by the investigations of the simpler substances.

One of the structures which has been found is shown in the adjacent figure. It is a helical structure (a spiral structure), in which each amide group forms hydrogen bonds with the amide groups that are removed by three in either direction along the chain. This helix has approximately 3.7 residues per turn, and it satisfies all of the structural requirements.

In a later stage in the investigation Drs. Pauling and Corey have assumed that certain orientations around the N—C bond and the C—C′ bond (the two bonds between the linking carbon atom and the adjacent amide groups) are favored relative to other orientations, 60° apart.

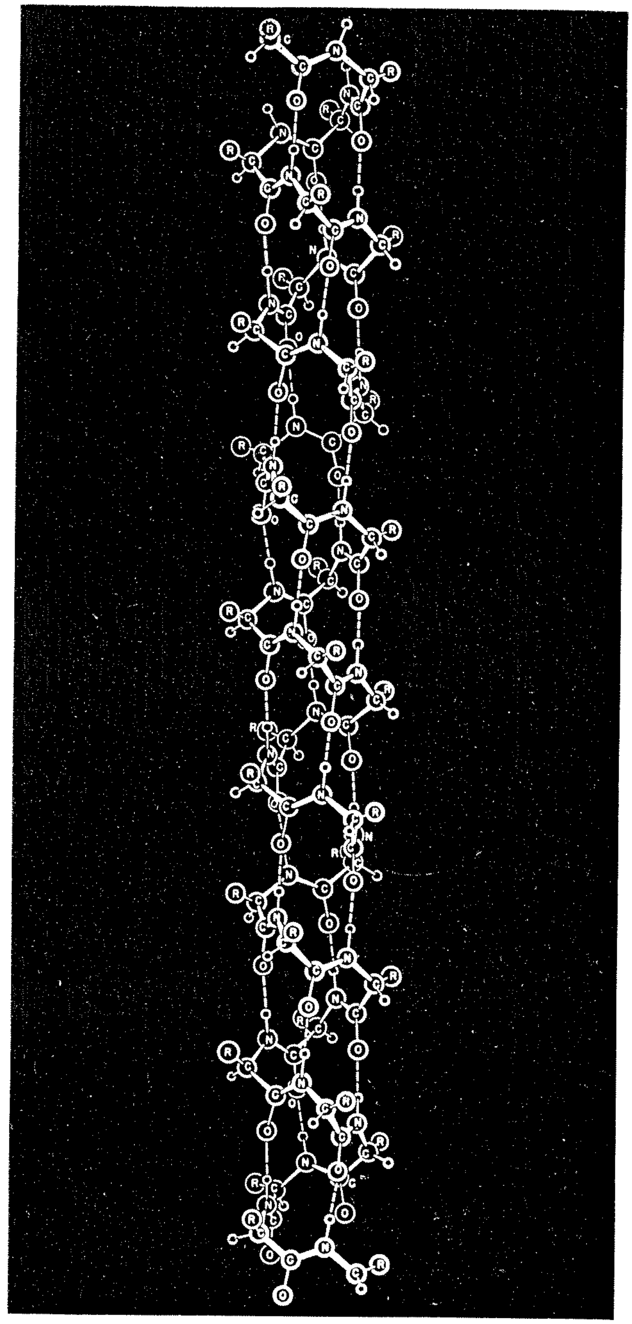
If this assumption is made, it becomes possible to make an exhaustive analysis of conceivable structures of different stages of complexity. The simplest stage of complexity is that in which the amino acid residues are assumed to be all equivalent except for differences in the side chains. There are then six possible orientations around the N—C bond, and six around the C—C′ bond, and hence a total of 36 structures.

## Molecular models

Using a special set of molecular models built by Dr. Corey, on a scale of 250,000,000 linear magnification (that is, with 1 inch = 1 Angstrom), and fitted with set screws to give rigidity to the model, Dr. Pauling investigated the 36 structures. In a short time he found that 32 are impossible: either the chain is required to bend back on itself in such a way as to try to force two atoms into the same position in space, and thus to give rise to steric hindrance that would make the molecule unstable, or the NH groups and CO groups are oriented in such a way as not to permit them to form hydrogen bonds.

Two of the remaining four structures were found to be the 3.7-residue helix that had already been discovered. These two structures differ from one another in having all the side chains pointing upward or all pointing downward, relative to the axis of the helix. The other two structures were entirely new ones, in which the polypeptide chains have a zig-zag configuration that permits them to form hydrogen bonds with adjacent chains, producing a layer or sheet. There is evidence that these two structures occur in silk, stretched hair, stretched muscle, and some other fibrous proteins.

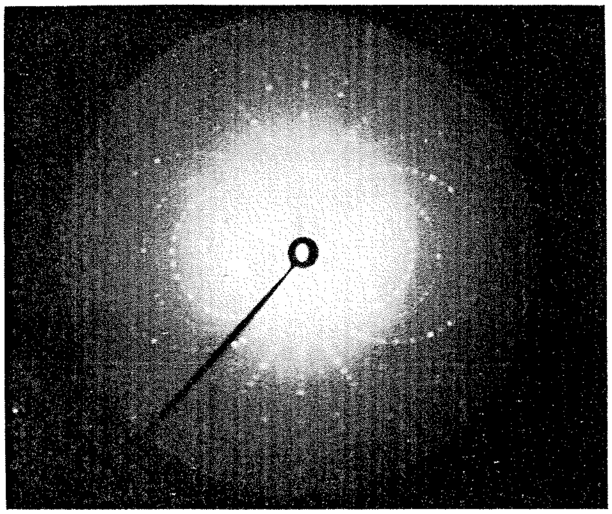
The 3.7-residue helix shown in the adjacent photograph and drawing is indicated by x-ray data to be present in ordinary hair, contracted muscle, horn, finger nail, and other proteins, and also in synthetic polypeptides. X-ray data for these proteins and the synthetic polypeptides provide values for the diameter of the spring-shaped molecules, and for the distance between the successive turns of the spring. These experimental values are in excellent agreement with the values predicted from the data for simple substances.

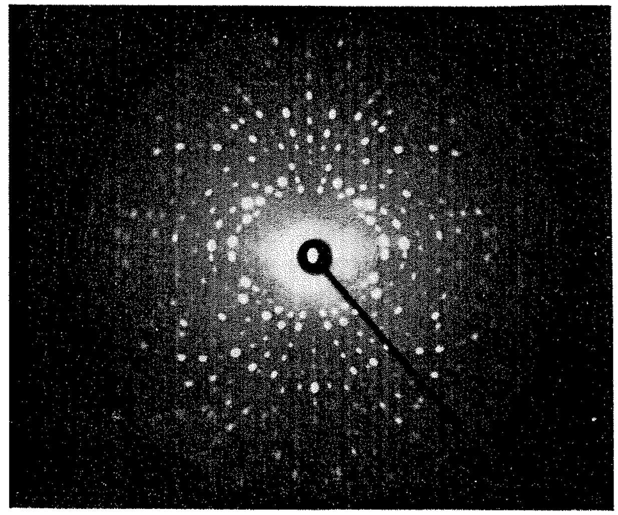


*A drawing of the 3.7-residue helix shown on page 8*

The fact that the number of amino acid residues in each turn of the spring is a fraction, 3.7, was surprising. Professors Pauling and Corey pointed out that Sir Lawrence Bragg and his collaborators in the Cavendish Laboratory at Cambridge, England, who had been working with great vigor on the same problem, had been led astray by making the unjustified assumption that the number of residues per turn in a helical structure had to be integral.

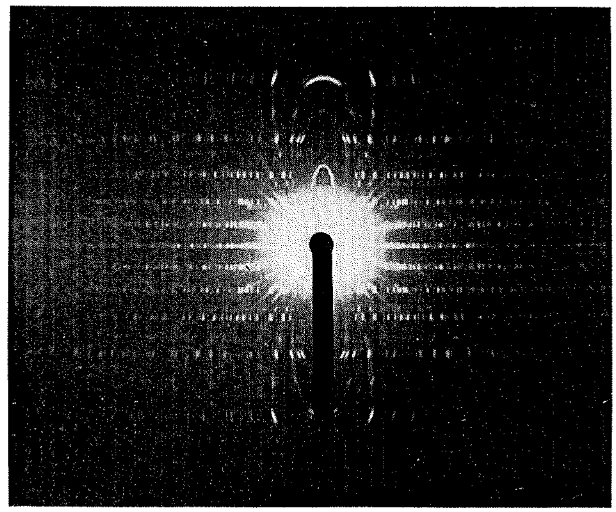
The same spiral structure has also been found to occur in the molecules of hemoglobin, the red protein inside the red cells of the blood. This protein contains iron





## X-ray Diffration Photographs

*X-ray diffraction photographs of amino acid crystals helped Caltech researchers determine how amino acid residues link up in protein molecules. The spots on the photographs shown here are reflections from the planes of atoms in various amino acid crystals. Positions of the atoms can be determined from the positions and intensities of the spots.*



atoms (four to each molecule) and has the power of combining with oxygen in the lungs in order to transport the oxygen to the body tissues.

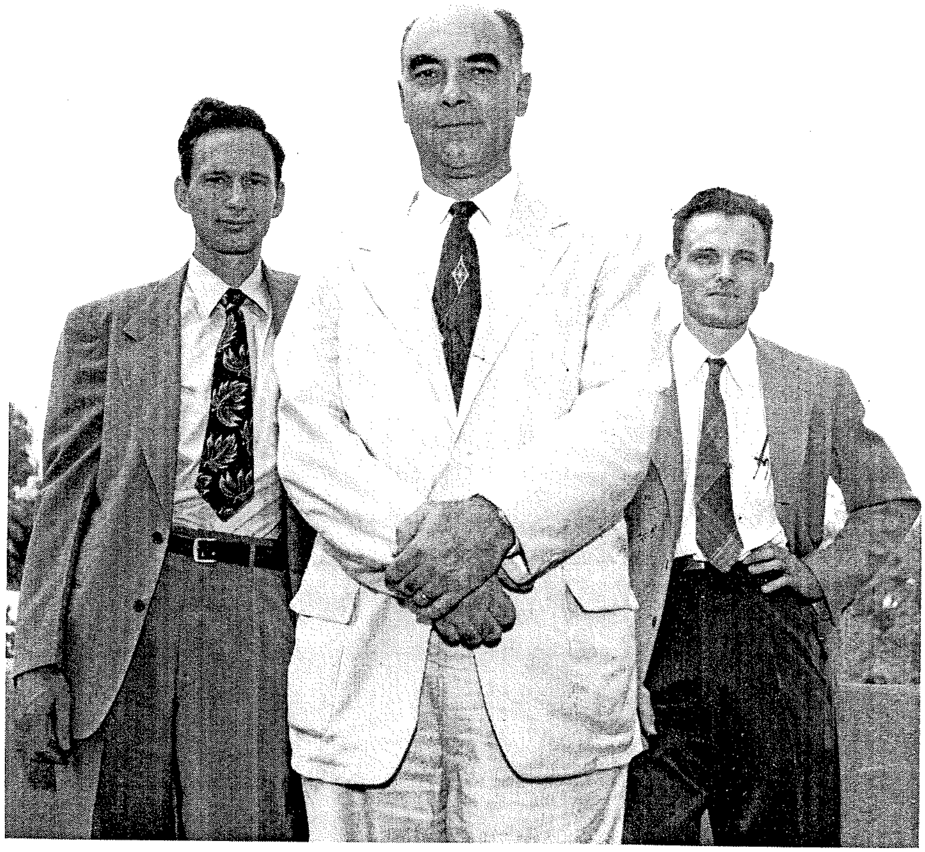
A surprising atomic structure has been found for another protein, collagen, which makes up tendons and is also present in skin and bone. The collagen molecule consists of three chains twisted around each other to form a three-strand cable. The chains are fastened to one another by means of hydrogen atoms. The molecules of gelatin also have this twisted three-strand structure.

### Possible applications

The hope is, of course, that knowledge of the atomic structure of proteins will be found useful in medical research. The diseases treated with ACTH and cortisone, for example, are sometimes called collagen diseases because this protein—whose structure has now been determined—is thought to be involved in the diseases. Also, Dr. Pauling and other Caltech researchers have recently discovered that certain types of anemia, such as sickle-cell anemia, are associated with an abnormality in the hemoglobin molecules of the patients. In general, it is believed that drugs act by combining with proteins.

These are not the only possible fields of application of the research findings. They may also be found useful in the synthesis of proteins, since a knowledge of the atomic structure of a substance is fundamental in any attempt to synthesize it.

Dr. Pauling and Dr. Corey were assisted in their research at Caltech by E. W. Hughes, J. H. Sturdivant, Jerry Donohue, Verner Schomaker, D. P. Shoemaker, Gustav Albrecht, Henry A. Levy, W. J. Moore, Jr., G. B. Carpenter, H. R. Branson, and H. L. Yakel, Jr. The work has been supported by grants from the Rockefeller Foundation, the National Foundation for Infantile Paralysis, and the United States Public Health Service.



*Carl Anderson, flanked by his co-workers in cosmic ray research — Eugene W. Cowan at the left, Robert B. Leighton on the right.*

# CARL ANDERSON

## Some notes about his life and work at Caltech

IN 1932, Carl Anderson's discovery of the positron—one of the elementary building blocks of matter—was described by R. A. Millikan as "probably the most fundamental and far-reaching development in physics since the discovery in 1900 by Max Planck of the quantum of action."

Characteristically, Anderson took great pains to explain that the discovery was unexpected, and that it was by no means a one-man job, but a cooperative effort involving himself, Seth Neddermeyer (now Professor of Physics at the University of Washington) and R. A. Millikan.

Nevertheless the discovery won Anderson the Nobel Prize in Physics in 1936. He was one of the youngest men (31) ever to receive a Nobel award, the fourth American to receive the award in physics and the third member of the Caltech faculty to become a Nobel prize winner. Significantly, he shared the 1936 award with V. F. Hess, one of the "discoverers" of cosmic radiation in 1912. Anderson's discovery of the positron was made through studies of the cosmic rays.

Anderson, who was Assistant Professor of Physics at Caltech in 1936, was teaching a class when Robert A. Millikan broke in to tell him he had won the Nobel award. Anderson made the trip to Stockholm to receive it, and surprised King Gustav at the ceremonies by conversing with him in his native tongue.

Carl's parents were Swedish-born. They grew up on farms near Stockholm, and came to America in about 1900, when they were both in their twenties. They met in New York.

Carl was born in New York on September 3, 1905. The family moved to Los Angeles when he was seven years old. By the time he was graduated from the Los Angeles Polytechnic High School in 1923 Carl's chief, and practically only interest was electrical engineering. Not until 1925, when he was a sophomore at Caltech did he turn to physics, under the influence of R. A. Millikan.

In 1926 Carl Anderson won the annual Caltech travel prize for a six-month trip to Europe. After graduation in 1927 he stayed on at Caltech as a teaching fellow while doing graduate research on X-ray photoelectrons. In 1930 he received his Ph. D. *magna cum laude* and became a research fellow at the Institute, working under Millikan on cosmic ray studies.

## Millikan and cosmic rays

Cosmic rays were given their name by R. A. Millikan shortly after the first World War. It was Millikan who first recognized that cosmic rays represented a very important field for investigation. He did more than anyone else to stimulate general interest in cosmic-ray research.

In these rays—coming from somewhere beyond the stars to bombard the earth like a continuous shower of invisible rain—scientists discovered that they had the sharpest tool possible for probing into the structure and composition of the nucleus of the atom. In the cosmic rays nature has provided us with the greatest concentration of energy known anywhere—higher than energies released in atomic fission, higher than any energies that can yet be produced by man-made "atom-smashing" machines. And these concentrations of energy are necessary for penetrating into the atomic nucleus.

Because the cosmic rays are invisible scientists have had to devise ingenious machines to record their presence. The most useful, in recent years, has been the Wilson cloud-chamber—a glass-windowed chamber filled with moisture-saturated gas. When a cosmic ray shoots through this chamber, it leaves a trail of charged fragments of air molecules. The vapor immediately condenses on these fragments, and a visible trail marks the passage of the invisible ray.

By 1932 scientists had identified two elementary particles of matter—the electron, with a negative electrical charge and a mass about 2,000 times less than the hydrogen atom, which is the lightest of all chemical atoms; and the proton, the positively charged nucleus of the hydrogen atom, and a constituent of all other chemical atoms.

In 1932 two more elementary particles were discovered—the neutron, which was immediately welcomed as a constituent of the nucleus, and the positron, or positive electron, which is identical with the electron in everything but charge.

Carl Anderson's discovery of the positron came during a series of experiments being performed for the purpose of measuring the energies of the particles produced by cosmic rays.

Under Millikan's direction, in 1932, Anderson built an apparatus designed to make the first direct measurements of the energy of cosmic rays. Weighing more than a ton, it included a giant electromagnet, a cloud chamber and an automatic arc light camera. Cosmic rays entering the steel chamber cylinder struck and shattered the atoms of the earth's atmosphere to fragments. The fragments, beating through the vapor chamber, caused droplets of moisture to condense along their paths. The magnetic field bent the positively charged particles to the right and the negatively charged particles to the left, while the arc light camera recorded the process.

It was expected that all particles with positive charges would be protons, while the negatively charged particles would be electrons, but when the photographs showed what appeared to be an electron, deflected to the *right*, Anderson realized he was on the track of a new particle.

The discovery of this new particle, the positron, represented the first instance in which it was recognized that an elementary particle of matter may have a transitory existence. In fact, the average life span of the positron is just a few *billionths* of a second; when a positive electron (or positron) and the negatively charged electron come close to each other they annihilate each other. In their place is found only radiation. In reverse, when the ultra-high energy particles in the cosmic rays strike an atomic nucleus, electrons and positrons are created out of the energy of the collision.

## Discovery of the meson

In 1935 Carl Anderson and Seth Neddermeyer discovered two more fundamental particles of matter—the positive and the negative meson. This discovery was no quick accident, like that of the positron. It came after an exhaustive four-year search for the particle.

Public announcement of the discovery was made in 1936. By the time he received the Nobel award for his discovery of the positron, then, Carl Anderson had already gone on to discover two *more* of the fundamental particles of matter. It was proof enough that his original discovery—made, like most of the great discoveries in physics, when he was a very young man (26)—was no freak. At the time, it meant that Carl Anderson had to his credit the discovery of three of the six known particles of matter.

As the physicist I. I. Rabi once said, "Every time a scientific problem is solved it gives birth to twins." And the discovery of the meson created problems from the beginning—starting with its name.

Anderson had had name trouble with the positron too. When he decided to call the positive electron the positron, he suggested that the electron, with its negative charge, have its name changed to negatron. But 40 years usage was too much and the old name stuck.

Some British physicists with classical leanings thought the positron might better be called the oreston, on the grounds that this name would suggest its close relationship with the electron—since Orestes was the brother of Electra. And another group of British physicists, more sports minded, came up with an analogy to cricket. Since the positron came from cosmic ray tracks which seemed to be bent in the wrong direction, they were reminded of how, in cricket, the peculiar hops of a ball in front of a wicket were known as "googlies"—and so suggested that googlie would be an ideal name for the new particle.

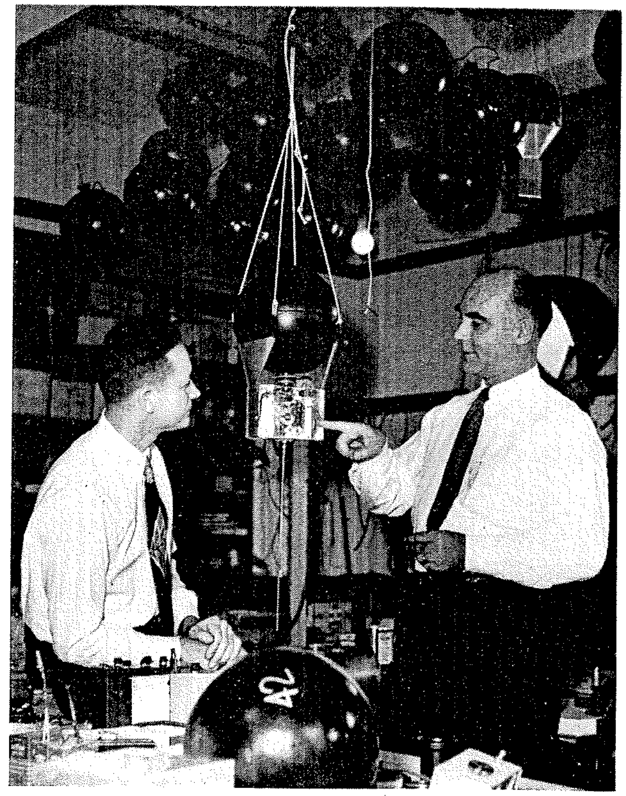
But the particle is still known as the positron. The meson was christened "mesotron" by Anderson and Neddermeyer but it's been knocked down to the simpler form by now.

Like the positron—which had been predicted in theory by the British physicist, Dirac, before its actual discovery by Anderson—the meson too had been predicted by the Japanese physicist, Yukawa. Again, it was a demonstration of the inevitability of scientific discovery. Many of the greatest discoverers of science are men who, looking over progress made by others, see a simple answer to a puzzle.

Like the positron, the meson proved to have a very short life expectancy—about two-millionths of a second, after which it disintegrated. Subsequently Anderson, working with Robert Leighton and Aaron Seriff, discovered that the disintegration of the meson resulted in the simultaneous production of an electron and two neutrinos. The neutrino, seventh of the known elementary particles, still exists only in theory. It has neither mass nor charge, but its existence is necessary to explain the balance of energy and momentum in the process in which an electron is produced when a radioactive nucleus decays.

It was becoming clear now that, when ultra-high-energy particles strike a nucleus, new particles come out which were not supposed to have been there in the first place.

Following the Anderson-Neddermeyer discovery of the meson, Powell and his co-workers in Bristol, England, discovered another type of meson, heavier than the Anderson-Neddermeyer particle. The particles then came to be known as light (mu) and heavy (pi) mesons. With the addition of the photon—which, like the neutrino, is not a material particle, in that it cannot be identified with any particle that can be observed at rest, but is identified only with radiation and radiant energy—there was, in 1949, a total of 12 known basic particles. The



*Caltech colleagues Victor Neher and Carl Anderson check over equipment Neher used in high altitude cosmic ray research in Greenland this summer.*

discovery at the University of California in 1950 of a neutral meson brought the total to 13.

But it was nothing like the end. Some four years ago, Rochester and Butler, at the University of Manchester in Great Britain, found in their cosmic ray studies single examples of two new particles. At Caltech Carl Anderson, now no longer one of "Millikan's young men," but with his own group of young men working with him—most particularly Eugene W. Cowan and Robert Leighton—began to run down these particles systematically.

By 1950 the group had proved the existence of the two new particles by finding some 35 examples of them. Subsequently the particles have been found by a number of other researchers. However, not much is known about the two new particles yet. They're still known as V-particles.

Where they fit into our present picture of the elementary particles we don't know. We do know, though, that there is something wrong with our fundamental concept of atomic nuclei. Our ideas about atomic structure, the motion of electrons, the forces that hold particles together in nuclei are going to have to be re-evaluated. It is possible that there may be still other particles in the atomic nucleus.

Carl Anderson and his co-workers are now engaged in an intensive study of the properties of the new V-particles, in an effort to gain a new understanding of elementary particles. Until recently this work has been carried on in two specially-built trailers, fitted out with cloud chambers, which were parked out behind the Aeronautics building on the Caltech campus. Now the trailers are being moved up to Mount Wilson, where there's a chance of getting three times as many of the V-particles, because of the greater intensity of the cosmic radiation at that height.

Another indication of Anderson's intensified research program is the new cosmic ray building, now under construction on the campus, between the two wings of Bridge. Here, Caltech's cosmic ray research work will be concentrated under one roof. A powerful new magnet is now under construction, and will be put into operation when work gets under way in the new building next year.

The fact that Caltech's synchrotron is under construction at the same time doesn't mean it will replace cosmic ray research in attempting to discover the secrets of atomic nuclei. In simple fact, it cannot replace cosmic ray research—nor can any machine yet devised. Some cosmic ray particles have energies up to 10 million billion volts—or a million times more than can be got in Caltech's new synchroton. The synchroton, however, has other important advantages and will complement the studies of the cosmic rays.

## Tedium and excitement

Cosmic ray research is one of the most important branches of modern physics. In a way it's the most tedious—and in another the most exciting.

Carl Anderson's been in it most of his life. During the war years he took time off to serve as a rocket expert, and in 1944 he was flown to the European theater to aid in the first installations of aircraft rockets on Allied fighter planes. When the war ended he returned to his studies of cosmic radiation.

These studies have taken him, in some 20-odd years, half around the world—to the top of Pike's Peak, to Panama, in a B-29 up to 40,000 feet. On the record this sounds like the exciting part of the job. On the record the hours—and months, and years—in the laboratory sound like the tedious part. But to Anderson himself it's all as exciting and adventuresome as any exploration in a faraway jungle.

The job is not only all these things though. It is also exceedingly difficult.

"The atom can't be seen," Anderson once said, "yet its existence can be proved. And it is simple to prove that it can't *ever* be seen. It has to be studied by indirect evidence—and the technical difficulty has been compared to asking a man who has never seen a piano to describe a piano from the sound it would make falling downstairs in the dark."

Carl Anderson has been at Caltech since he entered it as a freshman in 1923. He's been Professor of Physics since 1939. The Anderson family—which includes eight-year-old Marshall and two-year-old David—lives in Arcadia. Though he's given up playing much tennis, Carl used to play a good game—modestly claiming he only played for exercise.

## Anderson's first medal

Modesty is a habit with him however. When the Institute gave him a dinner at the Athenaeum after he had received the Nobel prize, and public praise was poured on him by everyone present—including Caltech's two other Nobel prize winners, Thomas Hunt Morgan and R. A. Millikan—Anderson took the occasion to tell about the *first* medal he'd ever won.

"I won it for physical achievement, while I was a freshman at Caltech," he explained. "I won it for the improvement I showed. To begin with I was the worst runner, broad-jumper and high-jumper of all, but at the end of the term I finished ahead of two or three of the others—so they thought I had improved so much that they gave me the prize."

The reason for the improvement was simple. When he took the physical achievement test at the start of the year, he was under the impression that it had something to do with ROTC, so he wore his heavy Army shoes. For the test at the end of the year he wore sneakers. The improvement, in comfort alone, was immense.

He's had some other prizes since. In 1935 he won the Gold Medal of the American Institute of the City of New York. In 1936 he was named one of America's Outstanding Young Men—along with Thomas Wolfe, Fred Astaire, Edward Stettinius and Lawson Little. In 1937 he won the Elliott Cresson Medal of the Franklin Institute of Philadelphia, received an Honorary Sc. D. from Colgate University and an LL.D. from Temple University. He is a member of the American Physical Society, the American Philosophical Society, the National Academy of Sciences, Tau Beta Pi and Sigma Xi—of which last he was president in 1948.

He keeps his Nobel award in a bureau drawer, underneath his stiff shirt.

*This article is the first in a series of informal biographical sketches of the faculty of the California Institute of Technology*

# THE EXPANDING UNIVERSE

The 200-inch telescope reveals that the universe is expanding at the rate of 38,000 miles a second

EARLY THIS SUMMER Dr. Milton L. Humason reported the first significant results of extragalactic research with the 200-inch telescope since it went into operation at Palomar Observatory almost two years ago.

Specifically, the 200-inch telescope has extended the law of the "red-shift" 50 per cent farther out into space—to a distance of 360 million light years (one light year being equal to 6,000,000,000,000 miles). In so doing it has furnished the best evidence yet that the universe is expanding at a phenomenal rate of speed.

The law of the red-shift was formulated about 22 years ago by Dr. Edwin P. Hubble as a direct result of his discovery of ways of estimating distances of nebulæ.

The few spectra of nebulæ then available went out to distances of only seven or eight million light years.

The spectrum of a nebula shows a number of bright and dark lines, each indicating the presence of light of a particular wave length. In the spectra of the more distant objects, however, these lines are shifted from their normal positions toward the red, or longer wave-length, end of the spectrum. Dr. Hubble discovered that the red-shifts increase in direct proportion to the distances of the nebulæ observed—an indication that the nebulæ (i.e., stellar systems) are rushing away from us, and that the universe is expanding.

Soon after these discoveries were made, Dr. Humason went to work to extend Hubble's relation with the 100-inch telescope at Mount Wilson. By 1942 he had pushed the law of the red-shifts out to about 250 million light years—the spectrographic limit of the Hooker telescope. His data, gathered over a period of twenty years, not only confirmed Dr. Hubble's discovery but permitted the law of red-shifts to be formulated on a more reliable basis. Red-shifts, it was found, increased directly with distance at the rate of about 100 miles per second for each million light years.

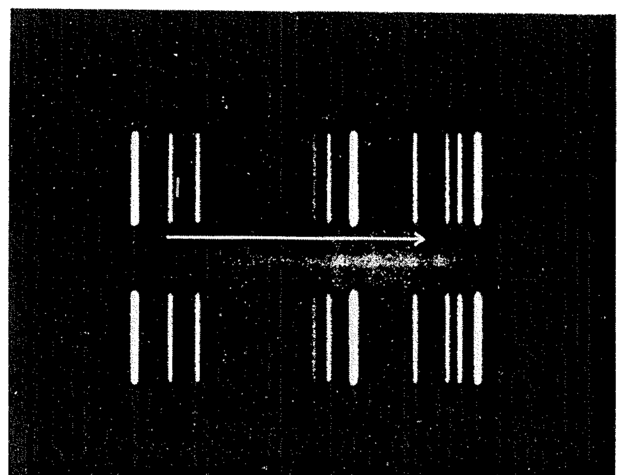
Now, with the 200-inch telescope, Dr. Humason has again extended the observed range of the law—to 360 million light years. As soon as suitable nebulæ can be found, he believes the range can be pushed out to 500 million light years.

This project may take several years. Clusters at great distances, suitable for observation, must be found on photographs taken with the 48-inch Schmidt, the 100-inch and the 200-inch telescopes.

Most of the 48-inch Schmidt plates examined for the purpose are being gathered in the course of the National Geographic-Palomar Observatory Sky Survey, a four-year project of mapping the entire sky visible from Palomar Mountain. Until the telescope went into operation, only about 20 clusters of nebulæ were known. But within the last two years several hundred more clusters and groups have been discovered, all the way out to the limit of the Schmidt.

So many have been discovered, in fact, that it is no longer practicable to identify one as "the" Virgo cluster, or even as the Virgo-A or Virgo-B cluster. Each is now identified by its precise location in the sky.

Discovery of clusters beyond the reach of the 48-inch must depend on chance finds by the 100- and 200-inch telescopes. Although they reach deeper into space, their fields of view are much smaller than the Schmidt's. The



*This un-retouched spectrum photograph represents an observation near the limit of the 200-inch. The horizontal band of light in the center is the spectrum of two nebulae. Vertical lines are comparison spectra of helium. Arrow shows how far the H and K lines of calcium are shifted from their normal position toward the red.*

*The red-shift illustrated on page 15 was measured from spectra of the two brightest nebulae in the Hydra Cluster, indicated by arrow here. The distance of the cluster is estimated at 360 million light years.*

Schmidt can photograph an area as large as the Big Dipper, while the 200-inch is limited to an area equivalent to one-quarter of the moon.

Such unpredictable finds may accumulate slowly, but they are necessary preliminaries to recording the red-shifts at the top spectrographic range of the Hale telescope, Dr. Humason said.

Red-shifts are measured on spectrograms obtained with difficulty in a slow and painstaking observing program. To get them Dr. Humason worked in the prime focus cage suspended in the tube of the huge telescope seven stories above the Observatory floor.

He exposed half-inch square spectrographic plates to the feeble light from the far-off nebulæ for four to six hours each. Similar spectrograms of dim objects, though at a lesser distance, would have taken about 25 hours each with the Mount Wilson 100-inch, the world's second largest astronomical instrument. Photographic work Dr. Humason was able to do in three winter nights of reasonably "good seeing" at Palomar—where the 200-inch mirror gathers as much light as a million eyes—might have taken three years on Mount Wilson.

The light observed from the most distant cluster studied to date left its source some 360 million years ago. At that time, on the velocity-shift interpretation, the cluster was roaring away at 38,000 miles a second. Since then it may have migrated 70 million light years deeper into space. The message that tells what is happening to it today will reach earth several hundred millions of years from now.

A most important astronomical milestone will have been reached, if at some point in his continuing study, Dr. Humason should find that more distant clusters show red-shifts corresponding to velocity increases of less, or more, than 100 miles a second for each million light years distance.

Should the red-shift be less than expected in that distant past, the interpretation would be that the rate of expansion of the universe has been speeding up since then. This would mean that the expansion began earlier than now indicated and that the "age of the universe" is more than the two billion years which present data indicate.

Should the red-shifts be greater than expected, the reverse would be true.

Whether this evidence may be found is, of course, impossible to predict. Its interpretation depends, too, on an accurate knowledge of the distances involved and an answer to the question of whether red-shifts actually are velocity-shifts. A possibility exists that the light from far-off objects may have lost energy during its long, lonely journey through space, causing its wave lengths to increase. In this case, some principle of nature as yet unknown would account for the red-shifts.

However, whether or not they represent speeds of recession, Dr. Humason said, the red-shifts promise to give astronomers a convenient yardstick to establish the distances of new-found objects in space. Once the red-shift is measured, the distance will automatically be known. This will be possible when the range of the law, now regarded as a first approximation, is pushed still further into the cosmos and after uncertainties in distances assigned to outlying nebulæ are removed.

The latter is the province of Drs. Hubble, Walter Baade and their colleagues. They report that construction of a thoroughly reliable scale of cosmic distance is now under way, using all the resources on Mount Wilson and Palomar.

The over-all program involves not only photography but also extremely sensitive photoelectric cells developed during World War II. They are being used to measure the brightness of stars and nebulæ several million times fainter than the faintest stars the eye can see.

Step by step, as outlined by Dr. Hubble, the distance scale will be set up as follows:

Globular clusters, or compact masses of thousands of stars, relatively near the earth, will be used to establish the distance of the great spiral nebula, Messier 31. This will fix the brightness of its Cepheids, or regularly varying giant stars, and its novæ, or exploding stars.

Cepheids and novæ then will be used to measure the distance of other nebulæ as far out as the Ursa Major Cloud and the first cluster found in Virgo. These are roughly six and eight million light years away.

This done, the astronomers will have a collection of about a thousand nebulæ of all types. The nebulæ themselves can then be calibrated as distance indicators. Their average brightness, variations from the average and the brightest nebulæ in clusters will provide a yardstick to measure the distance of more remote clusters.

"When the new scale is available," Dr. Hubble says, "the law of red-shifts can be formulated precisely. It can then be discussed with confidence as a clue to the nature of the universe."

# THE SUMMER AT CALTECH

## JPL

On a tour of Army Ordnance research plants last month, Brigadier General Leslie E. Simon, Assistant Chief of Ordnance, stopped over in Pasadena long enough to answer some vital questions about the Jet Propulsion Laboratory.

JPL has been under fire for a long time now by some of the citizens of Pasadena, who have complained variously that the lab makes too much noise, that it plans to expand right into the residential areas surrounding it, that it would be a bomb target in time of war, and so on.

Most of this criticism, of course, has been levelled directly at Caltech, and there has been so much of it that President DuBridge has stated that, rather than have poor relations with its neighbors, the Institute would give up management of the laboratory.

One of the first things General Simon pointed out to the lab's critics, was that the lab is not owned by Caltech. It is owned by the government, and operated by the Office of the Chief of Ordnance. Caltech merely supplies the technical staff and the management of the lab—without profit.

Under no circumstances, said the General, would the lab be abandoned (at least not until "the nations of the world begin beating their swords into ploughshares") or moved. To reproduce it would cost $22,000,000 and it would take 15 months to duplicate its facilities.

Aside from time and money losses, the government does not want to lose its research staff. And if the lab *were* to be moved to some remote location, many scientists would have to be left behind, since they are permanently attached to Caltech—or they are graduate students here.

The lab, in other words, is here to stay. And even if Caltech should ask to be released from its contract to manage the lab, it would still be here—though there is every indication that an outside agency, either the Government itself or an industrial contractor, would be less responsive to the neighbors' welfare than Caltech has been.

About noise: The General remarked that JPL was the only lab in the nation which has been making any attempts to muffle noise. In fact, reduction of noise due to research testing has become a research project in itself at the lab. Good results have already been achieved, but the noise-abatement program is still being continued, both by suppression and by diversion of noisy tests to other locations.

About safety: Because work on guided missiles is classified, and local citizens cannot be told exactly what goes on at the lab, rumors have it that accidents and deaths are the order of the day there. In the entire history of the lab there have only been two serious lost-time injuries. One resulted in an eight percent loss of hearing; the other consisted of serious electrical burns. There have been no fatalities. In the last five years there have been ten fires at the lab, all of them minor and most of them trash and brush fires.

About the lab being a bomb target: At the end of the recent war General Simon visited most of the German research and development establishments. The only one which had been bombed (Peenemunde, a development testing ground) was hit by a bomb which missed its target five miles away. Military strategic effort, the General noted, is generally directed against objectives that will affect the war now, such as munitions factories, oil refineries and other industrial installations—not against research institutions.

About expanding the lab: There *are* plans to acquire additional land around the lab—but only to serve as a buffer zone to prevent undue proximity to future dwellings, to improve security and to provide more parking space.

## ROTC

THOUGH THE FINAL total's not in at this writing, 153 members of the freshman class (out of a total of 198) have already signed up for the Air Force Reserve Officers Training Corps program which gets under way at the Institute this fall. It's also expected that a good many sophomores will sign up too, since the program has now been opened up to them as well. Last spring it looked as though it would be open to freshmen only.

*Brigadier General Leslie E. Simon, Assistant Chief of Ordnance, and Caltech President L. A. DuBridge discuss the future of the Jet Propulsion Laboratory.*

*Officers of Caltech's new Air Force R.O.T.C. — Lt. Col. Marvin D. Fleming, Lt. Col. Arthur Small, commanding officer of the unit, Capt. Andrew R. Stolarz and Maj. Edward J. Renth, Jr.*

Students may join the unit on a voluntary basis, and during their first two years take two class hours and one drill period weekly, in addition to their regular schedules. During junior and senior years they'll have four R.O.T.C. class hours and one drill period each week. Students will be deferred from induction into the Army as long as they maintain good standing in the air unit and the Institute. At the end of the four-year course, graduates will be commissioned second lieutenants in the U. S. Air Force Reserve, and will be subject to call to duty as non-flying officers.

All students will take certain basic courses, then choose one of three fields of specialization—Communications, Aircraft Maintenance Engineering or General Technical.

Commanding officer of the Caltech unit is Lt. Col. Arthur Small. A graduate (1940) of Southeastern State College, in Durant, Oklahoma, Colonel Small was athletic director and coach at Durant High School for a year after graduation. He entered cadet school in April, 1941, and was commissioned a second lieutenant four days after the Japanese attacked Pearl Harbor. After flying West Coast submarine patrol, Colonel Small spent two years with the Third Attack Group in the Pacific Theater.

Colonel Small has had previous Air Force R.O.T.C. assignments, of a year each, at the University of Oklahoma and Notre Dame. He was transferred to the Caltech unit this summer from Bolling Field, Washington, D. C., where he was a deputy commander of the 110th Special Air Missions Group.

His administrative staff at Caltech includes Lt. Col. Marvin D. Fleming, Major Edward J. Renth, Jr., Captain Andrew R. Stolarz, Master Sergeants Harold J. Keating, LeRoy G. Lee, Earl J. Morrison and Harold Waugh, and Technical Sergeant Lawrence E. Hansen. Colonel Fleming, a graduate of Colorado A. and M., was administrative officer and instructor with the AFROTC unit at the University of Arizona for three years. A West Point graduate, Major Renth was transferred to Caltech from Langley Air Force Base, Virginia. Captain Stolarz, a graduate of the University of California at Berkeley, came to Caltech from the AFROTC unit at Washington State.

## PHS Grants

Institute biologists and chemists have received a total of $89,249 from the U. S. Public Health Service to continue work on special research projects.

The largest single grant, for $30,000, went to Drs. Dan Campbell, Linus Pauling, and Carl Niemann for their blood chemistry work. Their research in World War II turned up the blood plasma substitute, oxypolygelatin.

Dr. Henry Borsook received two grants—one for $20,153 to study the synthesis of proteins in living organisms; the other for $9,504 to study the synthesis of an essential amino acid.

Dr. Pauling and Dr. Robert P. Corey received $19,980 to continue their study of the structure of proteins, which this year produced the structures of

CONTINUED ON PAGE 20


**YOU COULD EXPRESS THIS PROBLEM AS**

$$\frac{(\text{Temperature}) \times (\text{Corrosion}) \times (\text{Fabrication})}{\text{Cost}}$$

The day after VJ-Day, engineers from a leading appliance manufacturer showed us plans for their postwar refrigerator with a great new feature—*a king-size freeze chest.* But the size increase threatened prohibitive costs. And no combination of metals so far had satisfied the requirements: Fast heat transfer; corrosion resistance; ease of fabrication. They asked, "Can we do it economically in aluminum?"

Now the freezer is simply a sheet metal box with passageways around it to conduct the refrigerant. Knowing that aluminum is an excellent conductor of heat, we suggested that the evaporator be made by brazing aluminum tubing to aluminum sheet. "Sounds good," they said and together we started designs.

Aluminum Research Laboratories found the answer to the first important question: Aluminum is compatible with most commonly used refrigerants.

Alcoa's Process Development Shops suggested an amazingly simple fabrication process, "Place the tubing on flat brazing sheet and furnace braze the assembly. Then form the unit into box shape." The first 25 units were made in this manner—a process so practical and economical that it hasn't changed since. You'll find aluminum freezers, formed by this method, in a great many refrigerators today.

This case is typical of the problems Alcoa men undertake and solve. Throughout the Alcoa organization, similar challenging jobs are in progress and others are waiting for the men with the imagineering ability to solve them.

ALUMINUM COMPANY OF AMERICA, 1825 Gulf Building, Pittsburgh 19, Pennsylvania.

*A business built on co-operation*

ALCOA ®

ALUMINUM COMPANY OF AMERICA

such proteins as red blood cells, bone and muscle (see page 7).

Dr. Niemann and Dr. Herschel K. Mitchell received $9,612 for their study of fluorine-substituted amino acids for curing diseases.

* * *

The U. S. Public Health Service also awarded fellowships to two students working for their doctor's degrees at the Institute. David S. Hogness, studying chemical genetics, received a $2,000 fellowship; Otto E. Landman, studying the inheritance of a specific enzyme in Neurospora received a $3,600 award.

## Faculty Notes

SOME RECENT faculty promotions—

To Full Professor:
- Donald S. Clark, Mechanical Engineering
- R. P. Dilworth, Mathematics
- R. W. Paul, History
- Milton S. Plesset, Applied Mechanics

To Associate Professor:
- Arthur W. Galston, Biology
- C. R. De Prima, Applied Mechanics
- W. Duncan Rannie, Mechanical Engineering

To Assistant Professor:
- Y. C. Fung, Aerodynamics
- A. C. Ingersoll, Civil Engineering
- C. W. McCormick, Jr., Civil Engineering
- L. C. Pray, Geology
- G. K. Tanham, History
- D. F. Welch, Engineering Drafting
- Max L. Williams, Aerodynamics

To Professor Emeritus:
- Aladar Hollander, Mechanical Engineering.

## Russian Chemists on the Party Line

JUST A FEW YEARS AGO the study of genetics was proscribed in the Soviet Union. It was banned from all schools and research institutes. Soviet biologists who held to the "reactionary" theories of Mendel and Thomas Hunt Morgan were forced to "recant" or else they were "purged." In place of genetics, the Russians put their official seal of approval on the theory of one T. D. Lysenko, which, though unscientific, was a 100 per cent pure Russian product.

Having straightened out the biologists, the Russians are now moving in on the chemists. As a starter, the Chemical Sciences Division of the Soviet Academy of Sciences recently attacked the resonance theory of chemical bonds—developed by Linus Pauling, head of Caltech's Division of Chemistry and Chemical Engineering. Among other things, the Academy is of the opinion that the theory is "pseudo-scientific," "vicious," and an example of "world-outlooks hostile to the Marxist view."

The resonance theory, based on the physical theory of quantum mechanics developed around 1925, helps to explain the chemical bond structure of various substances. It permits a greater understanding of the highly complex molecules of living cells, for instance, and enables chemists to explain satisfactorily many properties of complicated substances, such as the color of dyes. Though it is still developing, the theory has already become an accepted and valuable part of chemistry.

But not by the Russians.

At a recent conference of Russian scientific workers four Soviet chemists were singled out for criticism for applying the principles of "the harmful resonance theory" in their research, and for failing to give "a comprehensive criticism of this idealistic teaching."

"The theory of resonance," said the Soviet journal *Uspekhi Khimii* (Progress of Chemistry), "undoubtedly constitutes a brake on the further development of knowledge concerning chemical structure as it rests on a methodologically faulty basis. Consistent use of the theory leads to pseudo-scientific conclusions."

But the real basis for disagreement seems to be that Pauling and his co-workers, in their various writings on the resonance theory, consistently failed to give credit to—or even mention—the work of "the Russian scientific genius Aleksandr Mikhailovich Butlerov" or other Soviet chemists.

"Here takes place a tendentious falsification of the historical facts," says *Uspekhi Khimii*, "the essence of which consists in the belittling of the significance of Russian science."

Says Dr. Pauling: "The value of resonance theory in teaching and research is so great that any chemists who try to practice chemistry or teach it without using the theory can expect to be greatly handicapped.

"As President James Bryant Conant of Harvard said recently, if the Russians continue to attempt to force science to follow along a path determined by politics, Russia is sure to grow weaker. If Russian chemists are not allowed to use the resonance theory or are deprived of scientific freedom in any other direction, Russian science will fall behind Western science and Russian technology will also suffer."

## Progress Report on Bacteriophage

AT THE SECOND International Poliomyelitis Conference, held in Copenhagen, Denmark, last month, Max Delbruck, Professor of Biology at the California Institute, reported on some recent interesting experiments with bacteriophages.

Bacteriophages (E & S—February, 1950) are the viruses which attack bacteria—as distinct from the viruses which attack animals and man (and are responsible for such afflictions as polio, influenza and the common cold), and those which attack plants (causing such diseases as tobacco mosaic). Because their action on bacteria can be easily observed, bacteriophages are being used to study how viruses reproduce within the cells they attack.

CONTINUED ON PAGE 22

In the case of bacteriophage, Dr. Delbruck reported, it has been possible to study what happens when one or more virus particles attack a single bacterium. When two related particles enter the same bacterium at approximately the same time, not only do both multiply within the bacterium, but new virus particles are produced which show various combinations of the characteristics of the original virus. But, if one particle enters a bacterium some three minutes later than the first, only the first virus multiplies; the second virus is completely destroyed. Moreover, there is a latent period immediately after the invasion of the cell, in which *no* infective particles can be found, and not even the original virus particle can be recovered.

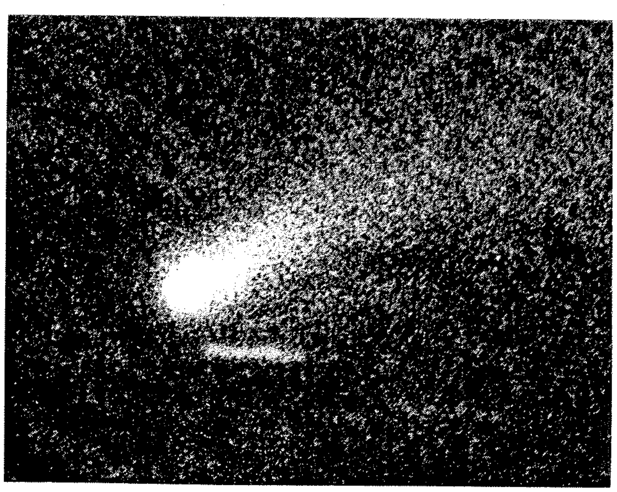
In this "eclipse period" lies the mystery of virus reproduction. And in the solution of this mystery lies the answer to the therapy of all the diseases caused by viruses.

## Comets and Exploding Stars

BESIDES DR. MILTON HUMASON'S discoveries (page 15), two other interesting announcements came from the Mount Wilson and Palomar Observatories this summer.

Dr. E. H. Herzog, Research Fellow in Astronomy, and Dr. Fritz Zwicky, Professor of Astrophysics at the Institute, reported that they had discovered three exploding stars in the Milky Way last year.

For the past two centuries only about a hundred novæ, or exploding stars, have been found in the Milky Way. Besides, most of these discoveries have been more or less incidental. In the winter of 1949, therefore, Drs. Herzog and Zwicky, using the 18-inch Schmidt telescope, started on a determined hunt for more of these novæ. When general search produced exactly nothing, however, Dr. Albert G. Wilson, Senior Research Fellow in Astronomy, suggested another plan.



*New comet discovered at Palomar Observatory. White line under comet is image of star spread out during exposure. It shows how far comet traveled in nine minutes.*

The two astronomers picked out 16 areas where novæ had been found most often and made spectral photos of eight areas every night and eight areas every other night for three weeks of every month, from July to October, 1950.

In examining the photographs, the astronomers put a new film slightly off center over an old one from the same area and studied the pair through low-power binoculars. Exploding stars showed up as images where no corresponding image was visible on the old film.

Three novæ were found by this method—all of them concentrated in the same general area of the Constellation of Scorpius. Oddly enough, the same three novæ were found independently, at the same time, by observers at the Astrophysical Observatory of Mexico at Tonanzintla.

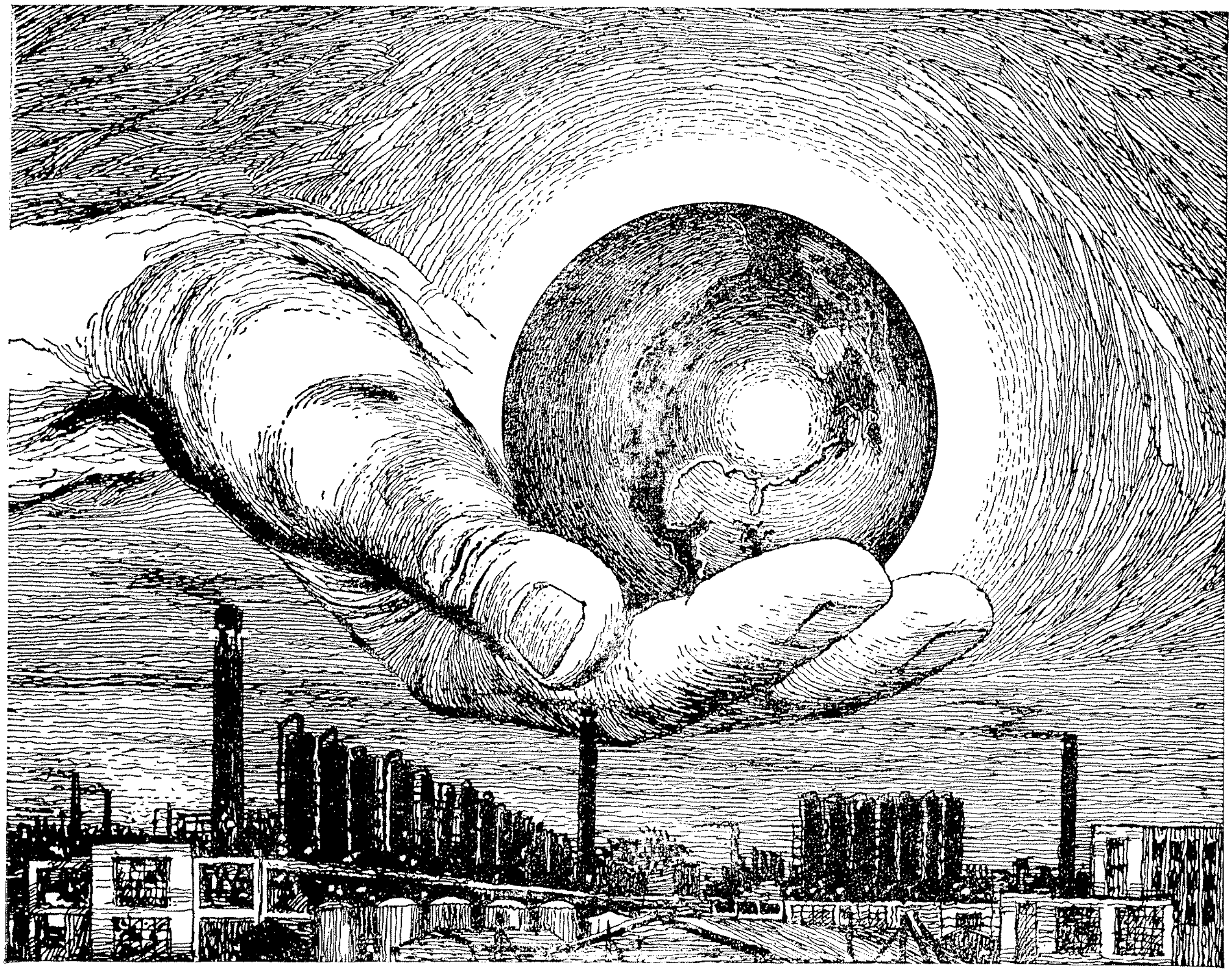
Early in August Dr. Albert G. Wilson and Robert G. Harrington of the Mount Wilson and Palomar Observatories announced the discovery of a new comet—the seventh to show up this year. The astronomers described this one, which was discovered during work on the National Geographic-Palomar Observatory Sky Survey, as a diffuse comet with a nucleus and a tail. The tail was expected to become longer and brighter as the comet neared the sun—possibly even bright enough to be seen with the naked eye. When discovered, however, the comet was only one-hundredth as bright as the faintest object visible to the naked eye.

## Computer Class

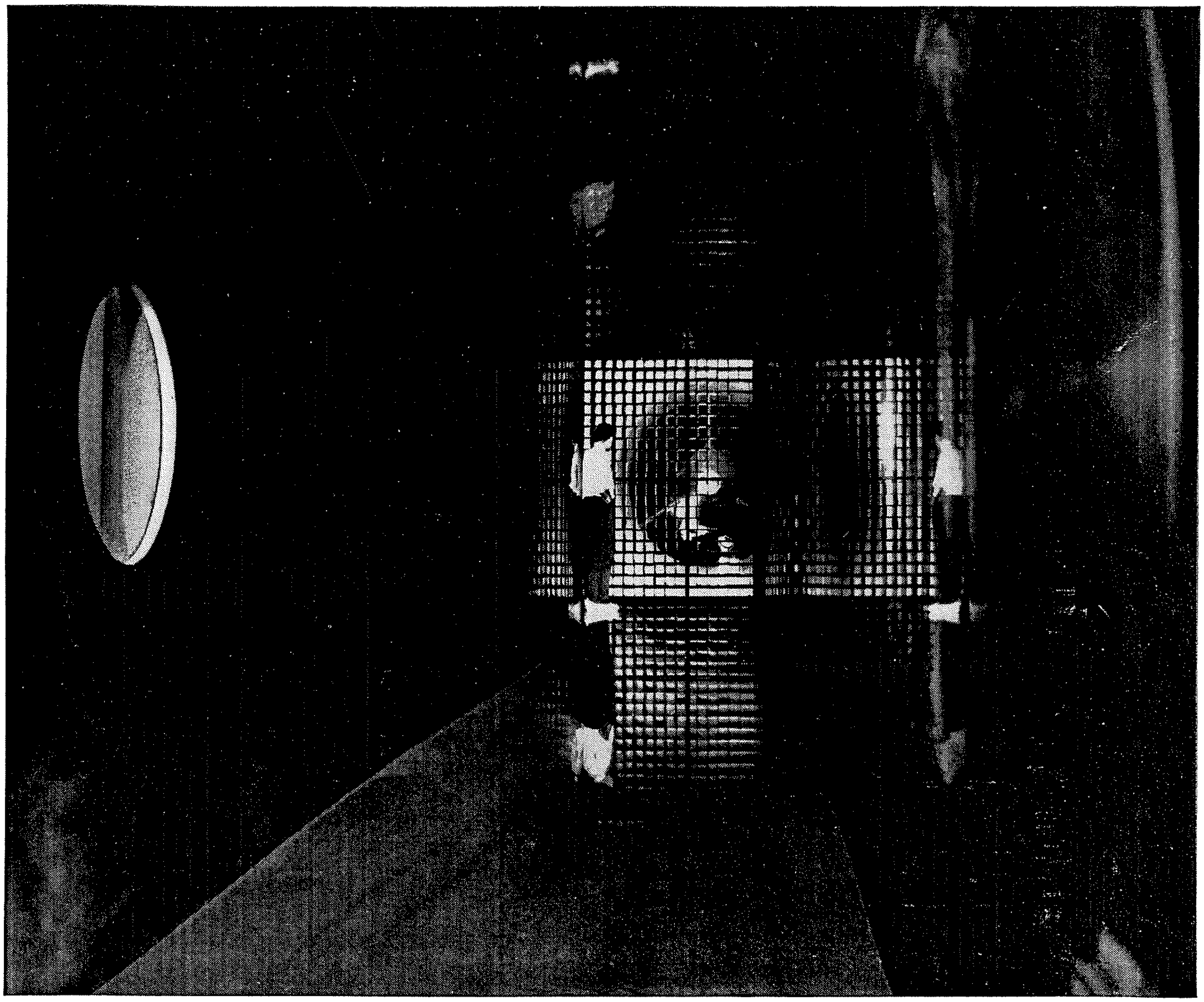
A SPECIAL EIGHT-WEEK COURSE designed to train personnel in the use of the analog computer was given at the Institute during the summer. Representatives of 15 aircraft companies and military installations—all of them planning to install machines similar to the Caltech computer in the near future—were students in this course. Lockheed, North American, Douglas and United Aircraft were represented in the class, as were the Inyokern Naval Ordnance Test Station and the Point Mugu Naval Air Missile Test Station.

The course of study covered design requirements and the basic principles of the computer, plus the necessary background in basic physics and applied mathematics for anyone planning to use the machine for engineering analysis. Most of the participating groups will use the computer to study problems of aircraft vibration, areoelasticity and missile control.

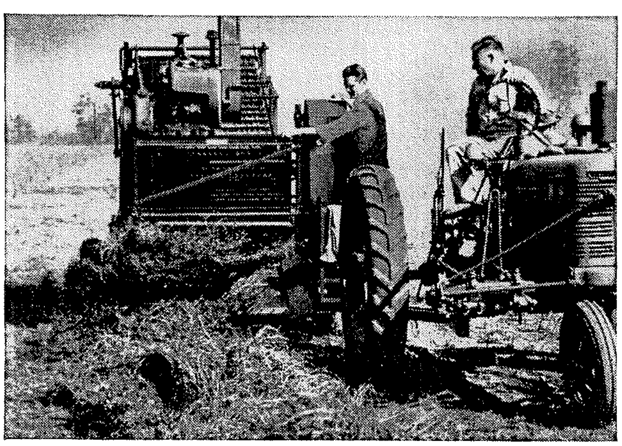
Dr. Gilbert D. McCann, Professor of Electrical Engineering at the Institute, was in charge of the course. Other instructors included Dr. Charles H. Wilts, Assistant Professor of Applied Mechanics; Dr. Richard H. MacNeal, Assistant Professor of Electrical Engineering; Bart Locanthi, Electronics Engineer; and William Dixon of the William Miller Corporation.



# Only STEEL can do so many jobs



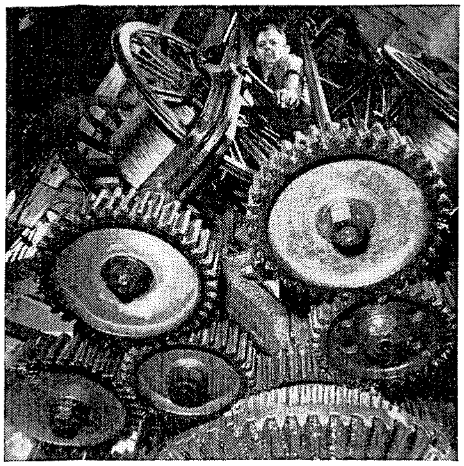
**CAVE OF THE WINDS.** This largest "supersonic" wind tunnel in the world—at the National Advisory Committee for Aeronautics, Lewis Laboratory, Cleveland—is capable of providing air velocities up to twice the speed of sound for aeronautical research. The tunnel's testing chamber measures 8 by 6 feet, and has flexible walls of highly-polished U·S·S Stainless Steel plates, specially made by U.S. Steel for this vital defense project.



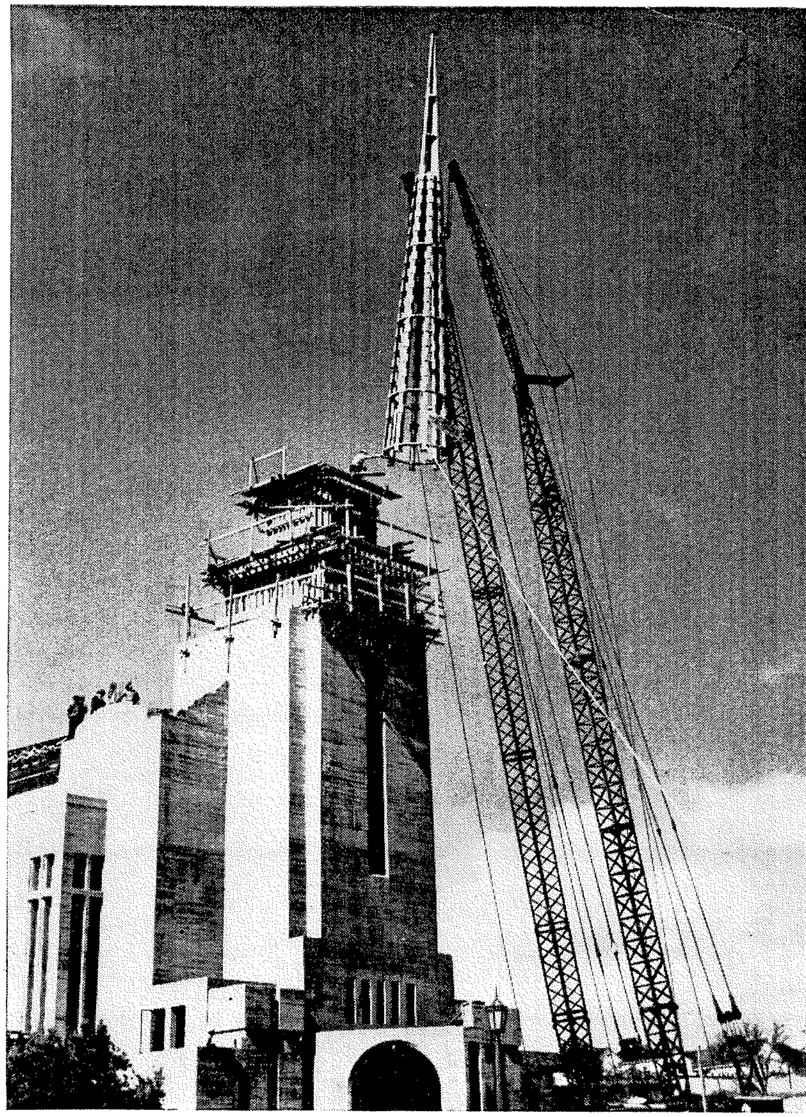
**NEW WAY TO GATHER GOOBERS.** This new peanut combine threshes along the row where the peanuts are grown, gathers up nut-laden vines, picks them clean, and deposits the mulch to condition the soil for the next crop. In tests, it has reduced harvesting man-hours per acre from 30 to 4, lets two men do the work of 12, saves $40 an acre. By supplying steel for such equipment, U.S. Steel helps build a more productive America.

AMERICAN BRIDGE COMPANY • AMERICAN STEEL & WIRE COMPANY and CYCLONE FENCE DIVISION • COLUMBIA STEEL COMPANY • CONSOLIDATED WESTERN
TENNESSEE COAL, IRON & RAILROAD COMPANY • UNION SUPPLY COMPANY • UNITED STATES STEEL COMPANY • UNITED STATES STEEL EXPORT COMPANY

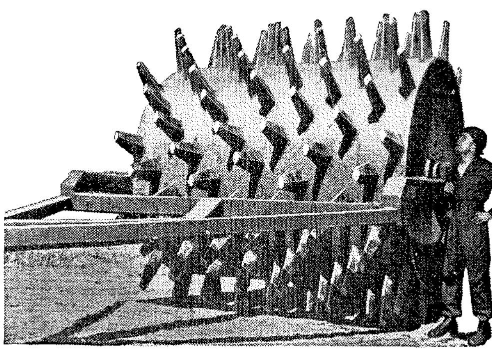
# so well...



**WHEELS WITHIN WHEELS.** Here you are looking into the driving gears of a 10-ton vertical closing machine, making U·S·S TIGER BRAND Elevator Rope to lift and lower the elevators in many of our country's famous skyscrapers. This equipment also manufactures general hoisting rope for applications such as the cranes shown in illustration at right. Whether you need enormous steel cables to support a bridge, or wire that's finer than a human hair, United States Steel manufactures a wire suited to your special requirements.



**HOW TO SWING A STEEPLE 80 FEET UP.** Here are two cranes completing the 80-foot lift of a prefabricated steel steeple, and about to swing it over its base. United States Steel has won a world-wide reputation as fabricators and erectors of steel work for everything from football stadia to church steeples, from bridges to television towers.



**GIANT SHEEPSFOOT ROLLER.** Army Engineers find this odd-looking, 36-ton steel roller a very useful tool for compacting and leveling off fill in the construction of airstrips. Although the defense program will require increasing amounts of steel, the constantly-expanding steel-producing facilities of United States Steel should enable it to supply steel for many essential everyday uses, too.

**FACTS YOU SHOULD KNOW ABOUT STEEL**

In 1951, the American steel industry must be able to purchase 30 million tons of high grade scrap *outside* the industry, if it is to achieve the record steel production goals set for it by our defense program. Memo to manufacturers, farmers and proprietors of auto "graveyards": Turn in your scrap! It means money for you, more steel for America!

FIFTY YEARS OF SERVICE
1901 USS 1951
TRADE MARK
STEEL
UNITED STATES STEEL

This trade-mark is your guide to quality steel

# UNITED STATES STEEL

*Helping to Build a Better America*

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UNITED STATES STEEL PRODUCTS COMPANY • UNITED STATES STEEL SUPPLY COMPANY • UNIVERSAL ATLAS CEMENT COMPANY • VIRGINIA BRIDGE COMPANY

# THE BEAVER

## How freshmen become Caltech students

PERHAPS THE MOST interesting weeks for the freshman are those during which he is transformed into a Caltech student. The traumatic effects of being quickly introduced to Institute methods can hardly be over-estimated. The first few weeks are rendered even more crucial, because the freshman will also be making his initial adjustments to his new social environment.

### Meet the People

By the time school begins, however, our freshman has had abundant opportunities to learn about the Institute and meet his future classmates. This summer, Throop Club had a beach party for members of the Class of '55 living in the southern California area. Frosh living outside the southern California area may have been invited to dinner with some of their fellow freshmen by one of the Alumni Association Chapters. The Caltech "Y" arranges for upperclassmen to contact prospective freshmen during the summer, to answer questions and proffer miscellaneous advice. The "Y" also sends representatives to meet freshmen arriving in Pasadena by train.

When the freshman arrives at the Student Houses, he finds that each house has a contingent of upperclassmen, headed by the house president, to greet him. The freshman is given rides to Pasadena's best (economically speaking) restaurants, and may even be furnished with dates during the week before the fall term officially begins.

During freshman rotation, each freshman eats his meals in each of the houses for two-day periods. During the rotation period, the freshman meets many upperclassmen and more freshmen. It is then that the freshman may begin to wonder about his reception. He considers the possibility that each house may be trying to gain his vote, which will largely determine to which house he will be permanently assigned, at the end of the rotation period.

### The Code

In years past some houses would prematurely proselyte freshmen by having them contacted during the summer by upperclassmen. To prevent this, as well as other undue attempts by any one house to entice freshmen, a strict code was promulgated by the Interhouse Committee. This committee, composed of two representatives from each of the houses and Throop Club, has the power to determine the presence and scope of any violations of this code, and to prescribe suitable penalties against the offending house.

In the last few years it has been suggested that any personal difficulties which the rotation system might cause could be eliminated by having the Master of the Student Houses permanently assign the freshmen to the houses from the beginning. The disadvantages of such a change are obvious when one considers how important it is that undergraduates have as much opportunity as possible to choose carefully the men with whom they will spend some of the most important years of their lives. Any revision of the present system like the one just mentioned would most certainly be extremely unpopular with an almost unanimous majority of the undergraduates in the houses.

After rotation, the freshmen generally find the upperclassmen just as considerate as before—except, perhaps, for some informalities in the house initiations. Even if this were not true, it would certainly be foolish to condemn any system which promotes cordiality and friendship among the freshmen and other undergraduates.

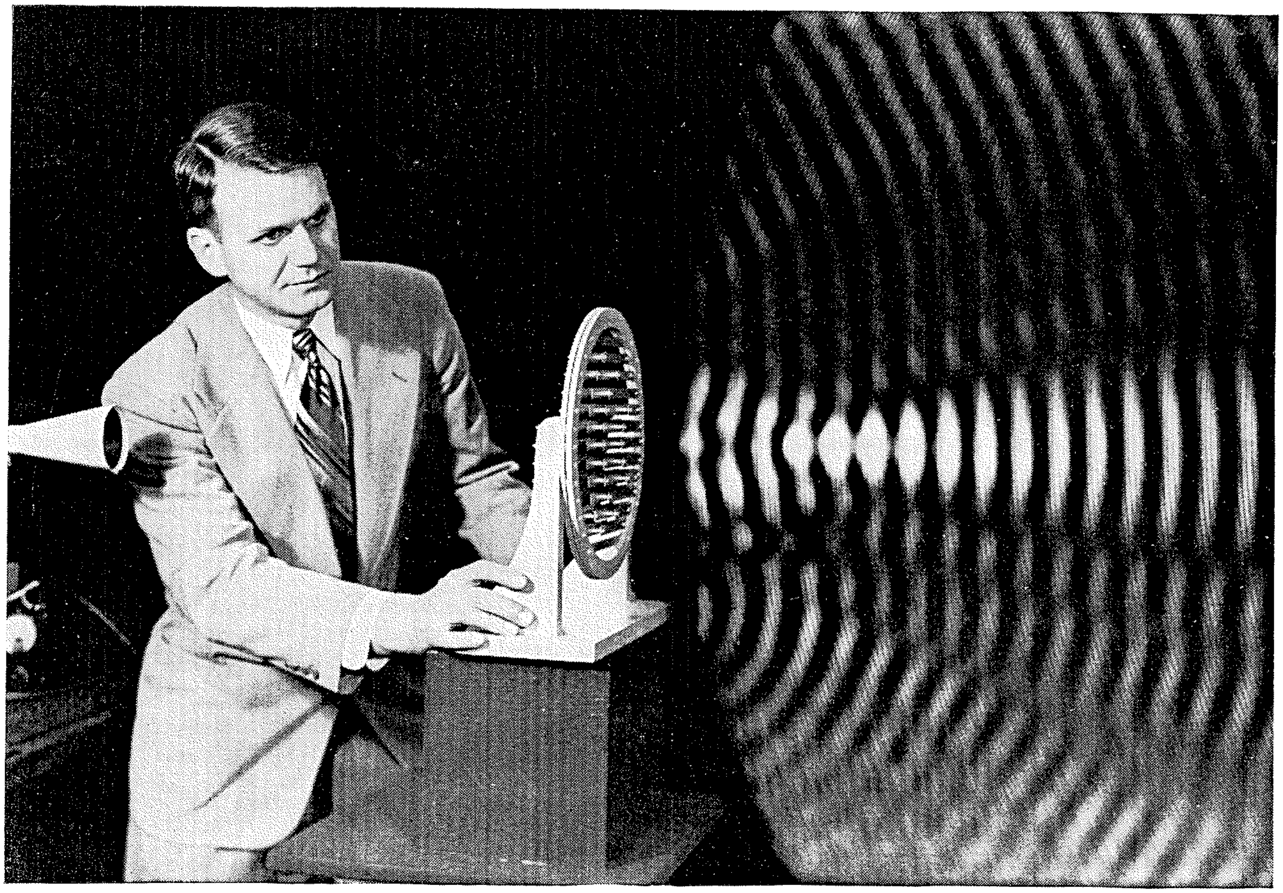
### Take Care of My Little Boy

The only time anyone notes the absence of racial or religious discrimination among the undergraduates is in making the frequent comparison of our Student House system with the fraternity system at other colleges. It seems, however, that most such comparisons entirely miss the point. The Student House system, which has the distinction of being the least criticized by the students of the many facets of the Caltech theory of education, is not to be credited with this freedom from prejudice any more than a fraternity must necessarily assume the attitudes which the name fraternity connotes. The significant point is that the idealized aims of the Student Houses, with respect to this particular question, are habitually and unconsciously practiced by the undergraduates themselves.

The essential difference between the two systems can be seen by looking at the results of the fraternity system: people are segregated into groups on the basis of similar personalities, backgrounds, and aspirations. The Student House system as practiced here promotes the intermingling of students with different personalities and backgrounds, although the nature of the Institute precludes the presence of students with radically diverging aspirations.

If this column has been enlightening in no other way, it does show that Tech students can pat themselves on the back, once in a while—but perhaps that's not news after all.

—*Al Haber '53*



# WAVE MAKING

*–for better telephone service*

*Waves from the sound source at left are focused by the lens at center. In front of the lens, a moving arm (not shown) scans the wave field with a tiny microphone and neon lamp. The microphone picks up sound energy and sends it through amplifiers to the lamp. The lamp glows brightly where sound level is high, dims where it is low. This new technique pictures accurately the focusing effect of the lens. Similar lenses efficiently focus microwaves in radio relay transmission.*

At Bell Telephone Laboratories, the research and development unit of the Bell Telephone System, radio scientists devised their latest microwave lens by copying the molecular action of optical lenses in focusing light. The result was a radically new type of lens — the array of metal strips shown in the illustration. Giant metal strip lenses are used in microwave links for telephone and television.

The scientists went on to discover that the very same type of lens could also focus sound . . . thus help, too, in the study of sound radiation . . . another field of great importance to your telephone service.

The study of the basic laws of waves and vibrations is just another example of how research is put to practical use in the Bell System. It is an example, too, of how telephone people work constantly to keep telephone service one of today's greatest values . . . and one of America's greatest assets.

BELL TELEPHONE SYSTEM

# ALUMNI NEWS

## Directory

An analysis of the 1951 Caltech Alumni Directory, published this summer, reveals that Tech graduates are scattered through 48 states and 37 foreign countries, but 40 per cent live in the Los Angeles-Pasadena area.

The directory lists 5,578 alumni, 1,304 of whom live in the Los Angeles area, and 1,036 in the Pasadena area. Altogether, 3,389 live in the state of California.

A special questionnaire, answered by 3,360 alumni, shows that 951 alumni, or almost one-fourth of the group, now hold executive positions. These are distributed among the 2,727 who are in technical fields and the 633 in non-technical lines.

The questionnaire revealed that 1,863 men are in business or industry, 757 in academic work, 335 in Government, 224 self-employed, and 181 in the Armed Forces (139 of them as officers).

The committee responsible for the new directory was headed by Alumni Association Director John Sherborne. Committee members included Earle Atkins '43, Theodore Mitchel '33, Frederick Scott '30, John Stick '35, Ira Triggs '36, and Nico van Wingen '34.

## Production of Scientists

A five-year survey on the origins of American scientists has revealed that the California Institute leads all technological institutions in the nation in the production of scientists, and ranks second among all types of schools.

The survey was conducted by two members of the faculty of Wesleyan University—Hubert B. Goodrich, Professor of Biology, and Robert H. Knapp, Associate Professor of Psychology. In a study of 500 U. S. institutions these researchers tallied the number of men per thousand, graduated in the years from 1924 to 1934, who went on to earn Ph.D.'s in science and listings in the 1944 edition of *American Men of Science*. The 1924-34 years were chosen to give a stable, peacetime picture.

In a list of the 50 schools which were the best producers of natural scientists, Caltech ranked second, with 70.1 Ph.D.'s per thousand. Reed College, in Portland, Oregon, led the list with 131.8. Of the 50 leaders, 39 were small liberal arts colleges, mainly concentrated in the Midwest. Only three large universities appeared on the list. And the only technological institution, aside from Caltech, which made a showing was the South Dakota School of Mines, in 50th place with 24.6 scientists per thousand.

The poor showing of technological schools in the survey is put down to their vocational emphasis; most of them train engineers rather than scientists. At Caltech (which "occupies a class by itself" according to the survey) where undergraduate training is equally divided between science and engineering, about half of all students who receive the B.S. degree now continue in graduate study.

A survey covering the years since 1934 would undoubtedly show Caltech producing an even greater number of scientists than it did from 1924-34—which were the very early years of the Institute. In fact, a 1947 report made by the President's Scientific Research Board, covering the years from 1936 to 1945, put Caltech in first place among all institutions producing successful candidates for the Ph.D. in science—a total of 130 per thousand.

## Placement Report

The 1950-51 report of the Institute Placement Office reveals that this was the most active of any of the fifteen years since the office came into existence. In general, the office helped get jobs for 191 seniors and graduate students, 38 alumni, got part-time jobs for 65 students and summer jobs for 52—346 men in all. A good many jobs were also secured through contacts provided by the Placement Office and the faculty, but these don't show up in any compilation.

Some sidelights: favorite part-time job is baby-sitting. Offers of jobs to do housework or pay off room and board by gardening went begging.

Summer jobs were mostly (71 percent) in shops and labs; 15 percent in drafting and radio work.

About 96 organizations sent interviewers to the campus during the year, but, probably because of the uncertain draft situation, students were slower in responding than usual. Of 218 men interviewed 146 were offered jobs and 86 accepted.

Median salary offered holders of B.S. degrees was $305 a month; for an M.S. degree, $375, and for a Ph.D. $490.

## Chapter Notes

The San Francisco Chapter's annual picnic and swimming party at Bob Bowman's ranch in Concord, held September 1, was again a most successful event. The

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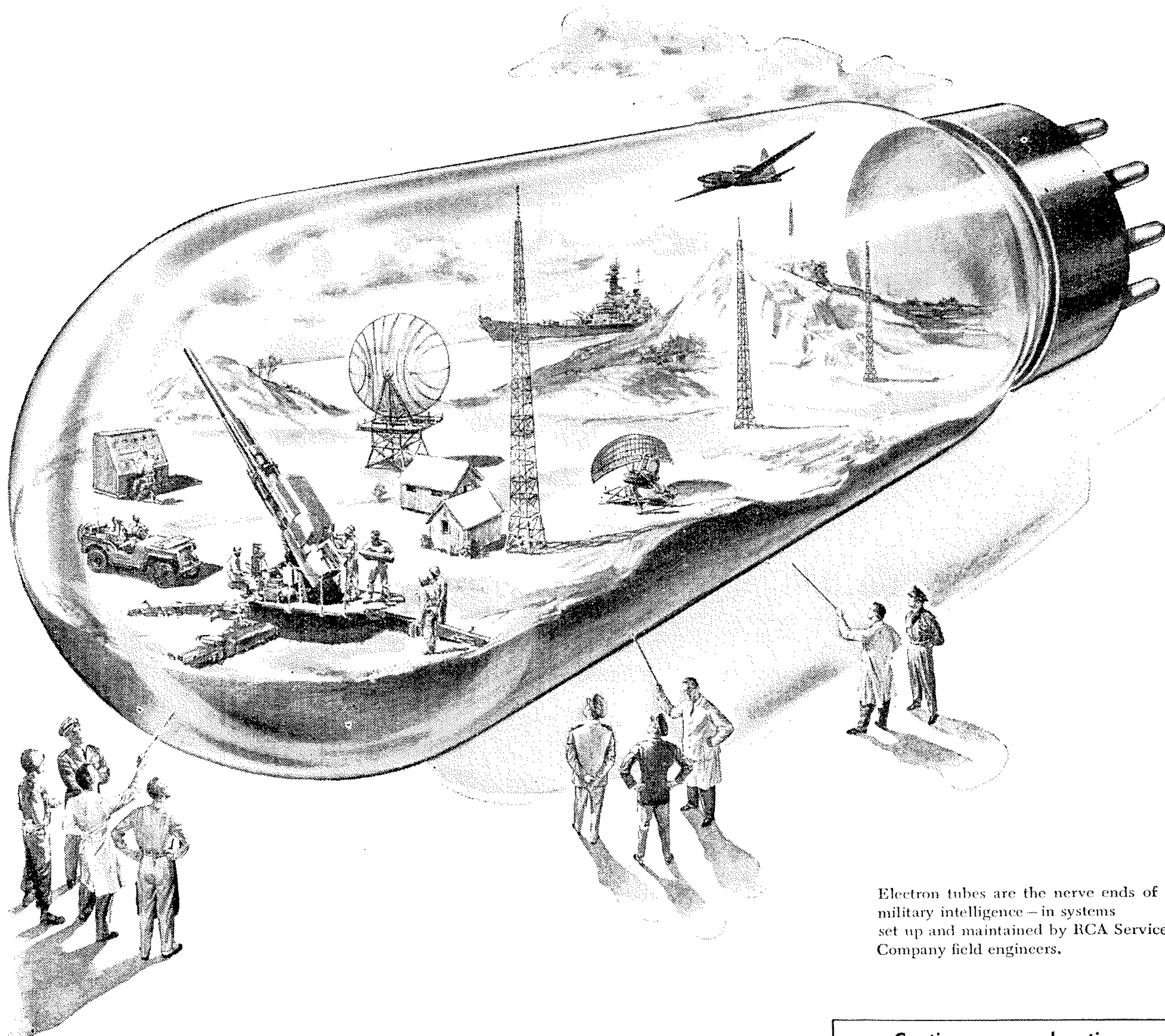

Electron tubes are the nerve ends of military intelligence—in systems set up and maintained by RCA Service Company field engineers.

# *Electron Tube with a military mind*

**W**ith the rapid advance of airplanes, tanks, fast ships, and mechanized weapons of war, a swift, sure means of *communication* and *detection* is as important as are the new weapons themselves. It is provided—by electron tubes and electronics.

So important is this area of military intelligence that RCA Service field engineers have lifted their efforts to new peaks. Working with our Armed Forces, they install and maintain such *communications systems* as shortwave radio and portable radiotelephones. They work with systems of *detection*, such as radar. They help ships and planes *navigate* with loran and shoran. These engineers are the link between research developments made at RCA Laboratories—and America's military strength.

**The number of RCA field engineers has *tripled* since World War II. And they serve where needed, wherever an electron tube's "military mind" can be of military use.**

* * *

*See the latest wonders of radio, television, and electronics at RCA Exhibition Hall, 36 West 49th Street, N. Y. Admission is free. Radio Corporation of America, RCA Building, Radio City, N. Y. 20, N. Y.*

**Continue your education with pay—at RCA**

**Graduate Electrical Engineers:** RCA Victor—one of the world's foremost manufacturers of radio and electronic products—offers you opportunity to gain valuable, well-rounded training and experience at a good salary with opportunities for advancement. Here are only five of the many projects which offer unusual promise:

- Development and design of radio receivers (including broadcast, short wave and FM circuits, television, and phonograph combinations).
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- Design of component parts such as coils, loudspeakers, capacitors.
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- Design of receiving, power, cathode ray, gas and photo tubes.

*Write today to College Relations Division, RCA Victor, Camden, New Jersey.* **Also many opportunities for Mechanical and Chemical Engineers and Physicists.**

RCA

**RADIO CORPORATION of AMERICA**

*World Leader in Radio—First in Television*

## ALUMNI NEWS . . . CONTINUED

sunny day induced more than the usual number of alumni and wives to take advantage of the swimming pool. After the picnic supper under the Bowman's grape arbor, the gathering was treated to an informal concert. Mrs. Heitz and Howard Vesper sang, accompanied by Mrs. Vesper at the piano, Doug Keetch on the banjo and Bob Heitz on the guitar. The annual poker game should not go unmentioned.

The following alumni and their wives attended: Louis Erb '22, Howard Vesper '22, Kenneth Anderson '24, Eugene Smith '24, Ed Dorresten '24, Maurice Jones '26, Doug Keetch '26, Edwin McMillan '28, Richard Folsom '28, Kenneth Miles '30, Francis Wyatt '34, Bob Heitz '36, Jerry Kohl '40, Jules Mayer '40, Arnold Grossberg '42, Leonard Alpert '43, Ken Powlesland '43.

Fred Groat and Mrs. Groat also were present. Fred is president of the newly organized Sacramento Chapter.

—*Arnold L. Grossberg, Sec.-Treas.*

* * *

THE WASHINGTON CHAPTER will have a dinner meeting at Hotel 2400 (2400 16th Street, N. W.) October 11. The main event of the evening will be the showing of the Palomar movie.

### Maass to Sumatra

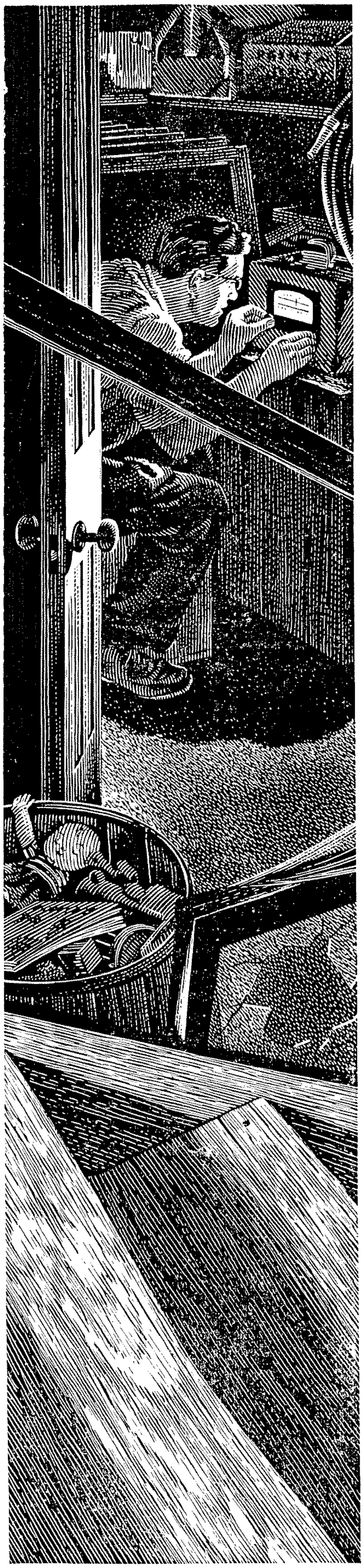
RANDAL MAASS '32 is leaving the General Petroleum Corporation, with which he has been associated since 1934, to become assistant manager of one of the largest petroleum refineries in the Far East.

Maass has joined the Standard-Vacuum organization which produces, refines, and markets petroleum products from Africa to Australia, and Japan. Standard-Vacuum is partially owned by the Socony-Vacuum Oil Company, Inc., of which General Petroleum is Western affiliate. Maass has been assigned to Standard-Vacuum Petroleum Maatschappij's refinery at Palembang, Sumatra, in the Republic of Indonesia. The refinery employs 5,600 people and processes 65,000 barrels of crude oil daily.

Maass will leave for Holland shortly to visit the SVPM office there for a period of orientation. Mrs. Maass will accompany him. After a month in Holland, he will go to Palembang while she will return to California for a short period before embarking for Indonesia.

Maass joined General Petroleum as a laboratory technician in 1934. He worked as a laboratory chemist, a gas engineer and as a refinery engineer before becoming assistant manager of the company's Torrance refinery in 1949.

Long-time residents of the Pasadena area, Maass and his wife had only recently moved to their newly built home in Palos Verdes Estates before he accepted his new post.



# The Hidden Radio

*"It was spooky down in the cellar.*

"The wife had taken over the upstairs radio for her pet soap opera. And the kids had their eyes glued to the western on the TV. So I had to dig up the old portable, hidden away in the basement storeroom.

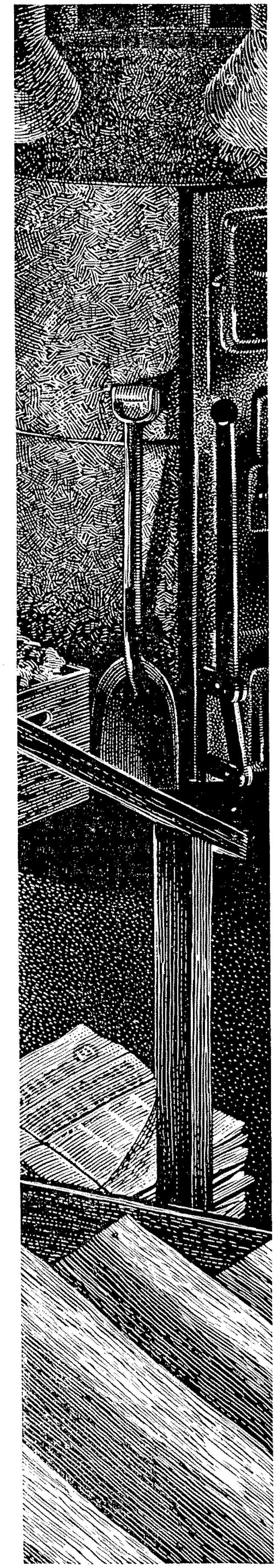
"When the newscast was over, I clicked off the set and just sat there, thinking about other men in cellars of communist-dominated countries. Men listening at the risk of their lives to broadcasts from beyond the Iron Curtain. To words of Freedom.

"The Great *Red* Father doesn't like hidden radios! I don't wonder he cracks down, because Freedom and dictatorship don't mix. *We* took hold of our Freedoms back in 1776 and, through wars and depressions, we've hung onto them mighty hard.

"Those Freedoms are all in our Bill of Rights, and the chances of any *outside* enemies taking them away from us seem pretty slim to me. But we mustn't forget the enemies *inside* our boundaries, too. The religious and race hate-makers . . . the pint-size dictators . . . the wild-eyed reds and the slimy parlor pinks. The woods are full of 'em!

"And if we aim to keep our Freedom of religion and speech and press . . . if we want to keep our jobs safe, like mine down at the Republic mill, helping produce important steel . . . then we've got to keep our eyes and ears wide open to spot these *inside* enemies. They might be miles away . . . or living within our own community.

"In other words, we must keep informed about what's going on today. That's why I didn't want to miss the newscast . . . even if I had to risk my rheumatics in that dark, damp cellar."



**REPUBLIC STEEL**

**Republic Building, Cleveland 1, Ohio**

***Republic BECAME strong in a strong and free America. Republic can REMAIN strong only in an America that remains strong and free***
. . . an America that has built its many industries from infancy to world leadership. *And through all industries Republic serves America.* The Communications Industry is a case in point . . . with its millions of telephones, its miles of telegraph and cable wires, its countless radios and TV sets. Much of the steel used in such equipment . . . carbon, alloy and stainless . . . comes from the many far-flung furnaces of Republic, which is proud to be a part of the voice of America at home and abroad.

* * *

*For a full color reprint of this advertisement, write Dept. H, Republic Steel, Cleveland 1, Ohio*

# PERSONALS

1903

*Richard W. Shoemaker* passed the seventy marker in July, and says he is "still able to shy away from anything that looks like work."

1906

*Edgar S. Maxson* passed away last May 21st after a long illness.

1923

*George T. McKee* is now Director of Architecture and Engineering Services for the Oakland, California, public schools.

*Charles Perry Walker*, who's still an engineer with the Southern California Telephone Company, has retired from his office as Mayor of Manhattan Beach.

1925

*Horace C. Adams* has been transferred from Niagara Falls, New York, to the new new DuPont plant near Memphis, Tennessee, where he will be Technical Superintendent of the Electrochemicals Department.

*Joseph Walker* has been appointed a member of the Monrovia City Council.

1926

*Harold W. Lord*, still with GE in Schenectady, reports that his eldest daughter, Joann, has just graduated from college, and that his 70th patent has been issued to him.

*Domenick J. Pompeo* combined business with his vacation this summer by attending the Third World Petroleum Congress at The Hague, Netherlands, as a Shell Development Company representative.

1927

*William W. Aultman*, after 21 years with the Metropolitan Water District of Southern California, where his most recent position was that of Water Purification Engineer in La Verne, left the job this summer and has now reported for work in a new position as Assistant Director of the Department of Water and Sewers in Miami, Florida.

1928

*John W. Thatcher*, M.S. '30, has been doing war work for his company, Western Electric, for the last year and a half—first in Merced, California, where he was in charge of a shop to recondition bombing radars on B-50's, and now back in Southern California working on a guided missile. Although it's nice to be back home, John says he sure wishes we'd get the war over with. "I was tired of it in 1945—and I still am."

*W. Morton Jacobs*, who is Vice-President of sales for the Southern California Gas Company, was named President of the Pacific Coast Gas Association at the organization's San Francisco convention in August.

1930

*Frank E. Alderman*, formerly with the Consulting Engineering firm of Holmes and Narver, Los Angeles, has now established his own office for civil engineering practice in South Pasadena.

1931

*L. D. Huff*, Ph.D., writes from Clemson, S. C., where he's head of the Clemson College Department of Physics, that a son, Charles Thain, was born last March.

1932

*Worrell F. Pruden*, M.S. '33, is now Chief Engineer of the Columbia Steel Company in San Francisco.

*Robert C. Wherritt* "tired of the big city" and moved to Salinas in 1947. He's manager of the Liquid Ice Company there, which makes ice, freezes food, and rents farm equipment. Bob has been president of the Salinas Toastmasters Club for a term, has taken up folk dancing, and—as his big chore—has been landscaping his new house. There are now two young Wherrits—Bobby, 11, and Irene, 8.

*William R. Shuler* has been promoted from Lieutenant Colonel to full Colonel in the Corps of Engineers. For the last year Colonel Shuler has been District Engineer of the Los Angeles District—the largest one in the United States—and before that was Executive Officer of the Seattle District.

*John B. Miller* writes from Lewisburg, Pennsylvania—he's still Professor of Electrical Engineering at Bucknell University there—that his oldest son has finished his hitch as a Naval Aviator and is back in college, as an EE too. The second is an ET2 in the Coast Guard, and the youngest will be a high school senior this year.

John has added flying to the list of his hobbies (shooting, hunting, fishing and photography) and now does his traveling in his own Cessna 140.

*Glen Miller* has recently announced the opening of his new offices for the practice of mechanical engineering in Pomona and Long Beach, California.

*Frederick W. Bowden*, M.S. '33, is now head of the Department of Electrical Engineering at California State Polytechnic College, San Luis Obispo.

1933

*Madison Davis*, M.S. '34, was listed among the dead in the Oakland crash of a United Air Lines plane on August 24. He had recently been associated with his classmate, *J. Stanley Johnson*, in the Holly Manufacturing Company in Pasadena.

1935

*Louis T. Rader*, M.S., Ph.D. '38, has been appointed manager of engineering for the General Electric Company's Control Divisions at Schenectady, N. Y.

*Jesse E. Hobson*, Ph.D., who is Director of the Stanford Research Institute, spent six weeks this summer studying research developments and possibilities in Europe. During July Dr. Hobson met with government and business leaders in several sections of Italy, to assist in the Stanford Research Institute Technical Mission to Italy, and to advise on Italian plans for an applied research organization to serve industrial and commercial interests there.

In August he joined a team of American experts at The Hague, Netherlands, to map a study of the research potential in West Germany, and determine the possibility of setting up public service research institutes in West Germany.

1937

*Walter L. Moore*, M.S. '38, received his Ph.D. from the University of Iowa this June and has now returned to his post as Professor of Hydraulics at the University of Texas.

1938

*Sydney Bertram* received his Ph.D. in Physics from Ohio State this June. The Bertrams now have three sons.

*Angus C. Tregidga*, Ph.D., who has been Chief Engineer and General Manager of the Phoenix (Arizona) Research Laboratory of Motorola, Inc., has joined the staff of the Johns Hopkins University Applied Physics Laboratory in Silver Spring, Maryland.

1939

*Warren E. Wilson*, M.S., President of the South Dakota School of Mines and Technology in Rapid City, writes that there haven't been any events of a personal nature in his own family but directs our attention to a recent article in *Science* magazine, which rated U. S. colleges on the production of scientists. Caltech ranked second in the country, and the South Dakota School of Mines ranked second only to Caltech among technical schools.

"While I cannot personally claim any credit for the remarkable performance," Warren says, "it is pleasing to find oneself an alumnus of the highest ranking technical school and head of the institution which ranks second."

Incidentally, you'll find further details on the survey Warren mentions on page 28 of this issue.

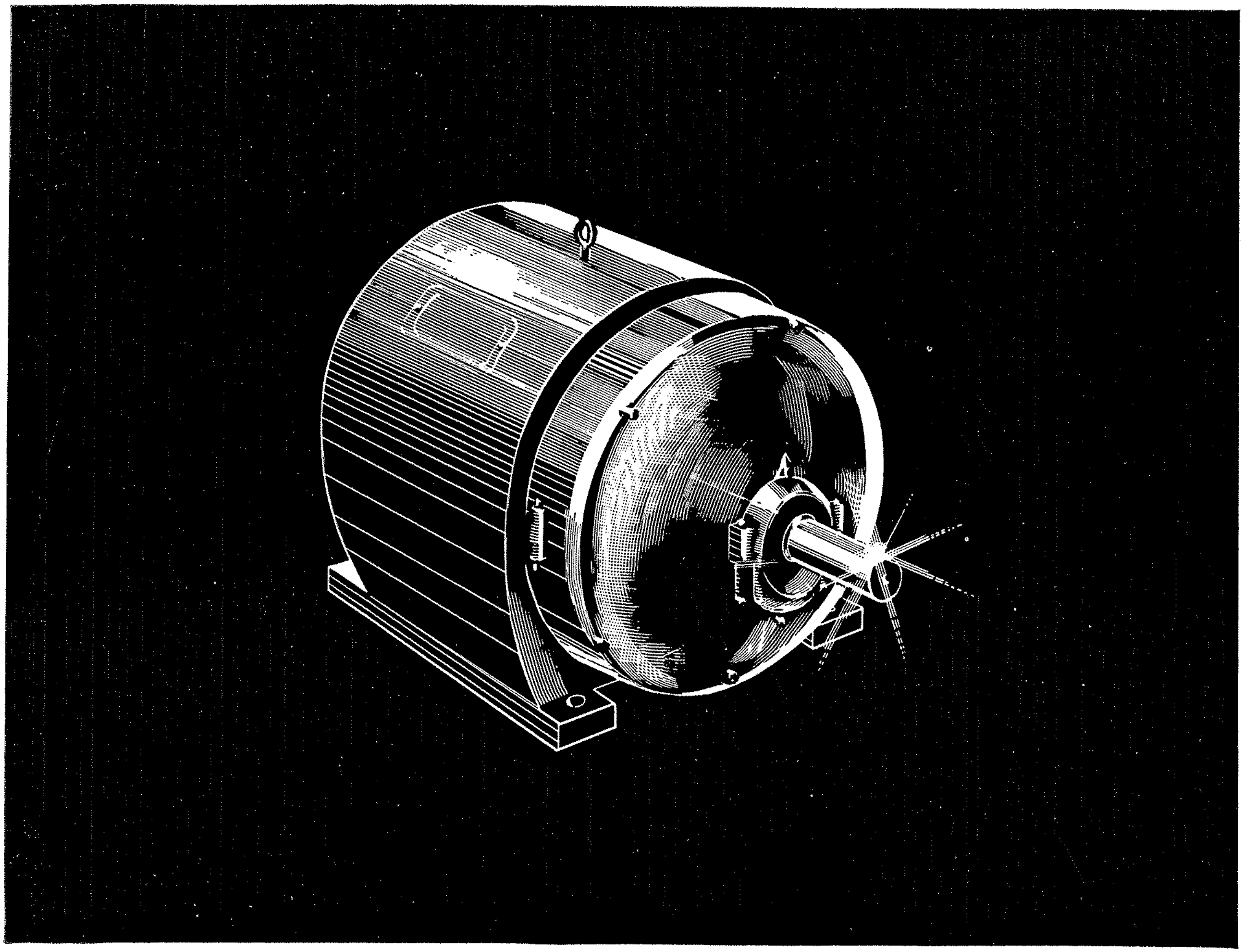
*William Green* is being called back into service in the Air Force this fall.

1940

*Gilbert W. Hoeffler* reports a change in position from Senior FIT Test Engineer with Consolidated Aircraft, to Research Engineer A at Lockheed Aircraft in Burbank, California.

1941

*George H. Bramhall* writes that he is assistant to the Manager of Engineering of the Vacuum Cleaner Division of General Electric in Cleveland, Ohio, and is respon-



## WORKHORSE OF INDUSTRY...

Its granddaddy was a ponderous bi-polar Percheron that weighed hundreds of pounds . . . and cost hundreds of dollars more for the same horsepower. Yet this little miracle of efficiency runs for years without attention . . . has only one moving part. Today, motors are being built that operate safely in dusty, dirty, even explosive atmospheres.

Many nimble minds gave their ingenious best to make these improvements possible. Physicists, chemists, metallurgists, electrical and production engineers, designers, machinists . . . these and a thousand others contributed to the breeding of this alert little workhorse of industry.

## AMERICA WORKS LIKE THAT...

Pulling together toward a worth-while goal is a work method uniquely American. Here, every art, every science, every human skill has the incentive and the opportunity to add its bit of invention or insight to the greater whole.

America can work like that because it has an all-seeing, all-hearing and reporting Inter-Communications System.

## THE AMERICAN INTER-COM SYSTEM...

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# PERSONALS . . . CONTINUED

sible for product design. With his wife and two children he is now living in the Chagrin Falls (Ohio) house which he designed —and is still building.

*Sidney K. Gally* and Helen McCloskey were married in Pasadena in June.

## 1942

*Ray C. Van Orden* received his M.S. from USC (Evening College) last June, and was invited to join the USC Chapter of Chi Epsilon, national civil engineering fraternity.

*William T. Holser*, M.S. '46, geology prof at Cornell University in Ithaca, New York, has a new daughter—born on May 27, and named Jan. Bill has received a research grant from the Geological Society of America for laboratory investigation of the "hydrothermal geochemistry of magnetite" and is still spending his summers in the west working for the U. S. Geological Survey—but he vows that for year-round living he couldn't be dragged away from beautiful Lake Cayuga.

*Arlo F. Johnson*, who has just received his Ph.D. in Mechanical Engineering at Stanford, starts this fall as Associate Professor of Mechanical Engineering at the University of Utah. The Johnsons have two sons.

*George I. Cohn*, who has been teaching at the Illinois Institute of Technology since 1947, received his Ph.D. there in June, and and has been promoted from Assistant Professor to Associate Professor of Electrical Engineering.

## 1943

*Mitchell H. Dazey* writes from El Cerrito, California, that a daughter Susanna was born last April. Mitch is still working at the Radiation Lab in Berkeley.

*N. Orvis Frederick*, M.S., whose family now includes two boys and a dog, has built a new home in Oklahoma City and reports with exclamation points that he has also had a promotion since last year, with the U. S. Geological Survey.

*Doyle F. Mattson* was married in June to Edith Kieling of Pasadena.

*Leonard S. Alpert* has the same job (Engineer at Shell Chemical's Pittsburg, California, ammonia plant) and the same family (though Elizabeth Sue, at fourteen months, is walking like mad). But there are changes in other departments: "Waistline larger—bankroll smaller."

*Lawson Jones* spent the summer in an extended trip around the world—to Europe for Walther-Boland Associates and to India for the Philippine Airlines. He arrived back in San Francisco to continue his work there for Walter-Boland on September first.

*Arnold H. Nevis* received his M.D. from Harvard University last June.

## 1944

*Raymond L. Ely*, M.S., who received his Ph.D. in Mathematics from the Carnegie Institute of Technology in June, was called back to active duty as a Major in the Air Force on June 15. The Elys have a daughter five and a son one year old.

*J. Jepson Garland, Jr.*, was married to Roberta Hutchinson of Pasadena last June. He's still working as a Project Engineer at Fluor Corporation in Los Angeles.

*David R. Jones* has come across with a chronological account of his career since graduation from Tech in February, 1944. He worked for the California Research Corporation until June, 1944, then did a stint in the Navy until March, 1946. He was married in November, 1944, and now has three children—two boys (six and four), and a girl (one). Dave returned to California Research in May of '46 and was transferred to the San Francisco office in 1950. He's still there, and from time to time sees the other Caltech men who work for Cal Research, including *Harry Sigworth* '44, *Bob Bowles* '41, M.S. '42, *Arnold Grossberg* '42, *Bob Bowman* '26, *Bill Stewart* '41, *Bob Adams* '40, and "the boss man," *Howard Vesper* '22.

*Robert M. Weidman* spent the summer as an instructor in the University of Southern California field geology course, working in an area near Ely, Nevada. This fall he'll be back at the University of California's Department of Geological Sciences in Berkeley to continue his graduate work.

*Grant L. Benson, Jr.*, is still on active duty with the Medical Corps, U. S. Naval Reserve, as a Lieutenant (jg). At the moment he's stationed at the Naval Hospital, Oakland, California.

## 1945

*Philip B. Smith* writes from the Universidade de Sao Paulo: ". . . After a few years of silence, I have decided to do all my old buddies the favor of letting them know what the hell I am doing 6,000 miles south of New York.

"In the first place it is not true that I am here to avoid any legal proceedings in the States, as certain snide characters might suggest.

"As nobody knows, and even fewer care, the University of Illinois finally let me have a Ph.D. in physics last year, after nearly five years of struggle. They decided, I guess, that it was the only way to get rid of me, as I was causing havoc with the secretarial staff.

"I chose between a job and starvation, and am now eating quite well here in Sao Paulo. It is a huge city (bigger than L.A.), with good theater and concerts, and lots of gorgeous women. The women, unfortunately, in general wish to get married, and they frequently have heavily armed fathers who have the same desire (not to get married to me, you understand—to get their *daughters* married to me).

"We are building a Van de Graaff here in a beautiful laboratory located on a hill. The work is good, hard, and interesting.

"Needless to say, the concentration of Tech men is approximately $1/n^5$ per square mile, and the only one I ever see is a certain brilliant and charming fellow who looks at me every morning while I am shaving.

"As far as recommendations to anyone else are concerned, I have this to say about Brazil: the climate is wonderful, slightly cooler than Pasadena, but otherwise very similar; the cultural life is every bit as good as in most American big cities. It is unpleasant to arrive here without knowing the language, and, for me at least, Portuguese was not easy to learn. But in 10 months I managed to learn it well enough so that I can get along well, anywhere.

"In case anyone wants to reach me, my address is the Department of Physics, Universidade de Sao Paulo, Caixa Postal 8219, Sao Paulo, Brasil. I would like to hear from any of the old gang, who will be interested to know that the beer here is marvelous, and very cheap."

*Donald H. Sweet* writes from Coos Bay, Oregon, where he's working for the Moore Oregon Lumber Company, that his second son was born last May.

*Richard B. Knudsen* and Theodora Vita were married in La Mesa in June.

*George S. Fenn*, M.S. '46, has a daughter—Elizabeth Irene—born last March. George has recently been promoted to Technical Director of the Special Weapons Division of Northrop Aircraft. The Fenns are now living in the house they built themselves in Rolling Hills, California.

*Adrian C. Anderson* received his M.B.A. from Harvard in June.

## 1946

*Richard Fayram*, M.S., reports that his second child, Margaret, was born on the Fourth of July.

*Theodore R. Goodman*, M.S., has been awarded the Avco Manufacturing Corporation fellowship in aeronautical engineering at Cornell University, where he is working for his Ph.D.

*Donald Dunn* finished Stanford Law School and passed the California Bar exam this summer. He's now with the Stanford Electronics Research Laboratory, doing patent work and vacuum tube research.

*Larry Haupt*, M.S. '47, reports that Caltech has all but "taken over" the Long Beach, California, plant of Proctor and Gamble. He is in the Edible Shortening (Crisco) end of the business there—as are *Dick Schuster* '46 and *Ted Bowen* '50.

*Clint Stickney* '29, *Bill Humason* '36 and *Paul Howard* '48 are in the Soap Division: the Synthetics Division (Tide) has *Bill Adams* '32, *Harvey Lawrence* '47 and *Stan Holditch* '48; *Vic Willits* '35 and *Bob Wilkinson* '45 are in the Mechanical Division; and *M. S. Hodge* '32 is Industrial Relations Supervisor. According to Larry, an even dozen from one school is a new record at the factory.

HERBERT J. RASS

# ENGINEER—in charge of OPPORTUNITIES

*by* HERBERT J. RASS, *Manager, Employment Department*
ALLIS-CHALMERS MANUFACTURING COMPANY (*Graduate Training Course 1942*)

MAYBE that's a far-fetched way of putting it—but I am an engineer (Marquette 1941, Electrical Engineering) and a great many men do pass through the Employment Department to opportunities with Allis-Chalmers. I did the same thing myself.

During my last two years at Marquette in Milwaukee I worked as a cooperative student at Allis-Chalmers on the electrical test floor, in electrical product departments on both design and application work, and in the shops. When I graduated, I continued in the Graduate Training Course, on training location with what is now the Employe Relations Department. After six months—opportunity came around to look me up. The Company officer in charge of Industrial Relations talked to me about personnel work and asked if I'd like to go on with it as a career.

### Liked Working With People

By that time I'd seen a lot of the Company, both product design and manufacturing, and I knew I liked working with people better than with machines, so it was just the break I wanted. During the war I was in the shops on personnel work, got a thorough grounding on operations carried on throughout the plant, and made many contacts. In 1950 I was made manager of the Employment Office.

Recruiting engineers for the Graduate Training Course is one of our functions, and perhaps this is a good place to tell something about the course.

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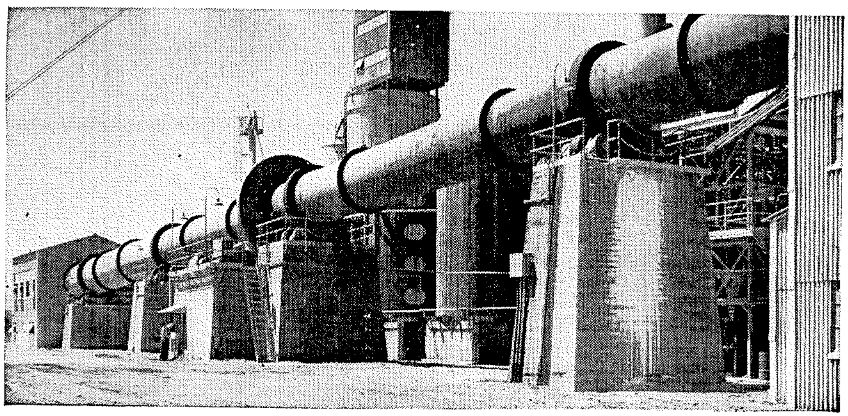

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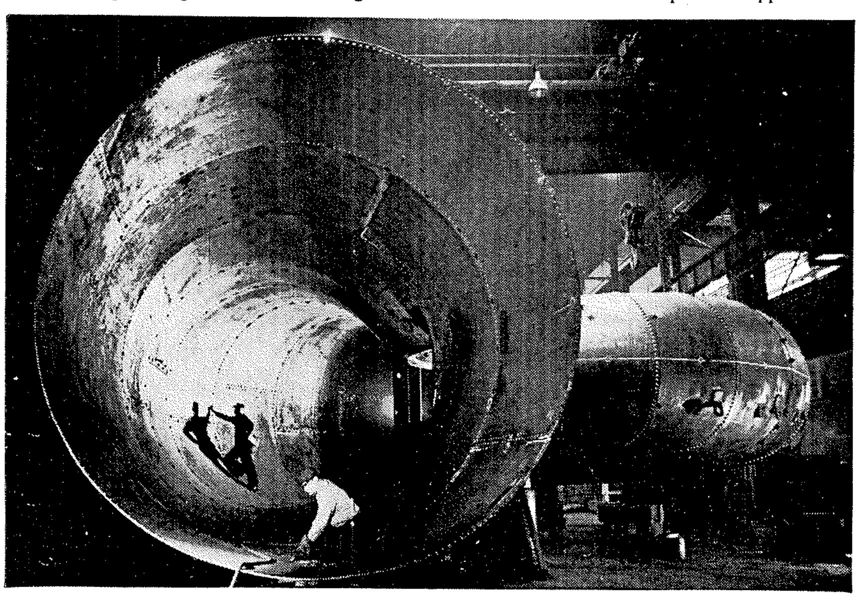

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## PERSONALS . . . CONTINUED

*Edward E. Carr* finished up a grad course in international relations at the University of California this June and now works in the Navy Hydrographic Office in Washington, D. C.

*William H. Libbey* is working as a project engineer for the Western Contracting Corporation—his present job is on the Delta-Mendota Canal, Central Valley Project. The Libbeys now have two daughters.

### 1947

*Don Stewart, Jr.*, was recently made general foreman of electric maintenance at the Kaiser Steel Corporation in Fontana. The Stewarts now have two daughters—Rebecca, three, and Barbara, one.

*George D. Shipway* is still with the Navy Electronics Lab in San Diego, doing shock and vibration work and tests on "Bathythermographs." He writes that his third child—and first boy—arrived on July third.

*Chresten M. Knudsen* was married in June to Marilyn Lieberg of Alhambra. The Knudsens are now living in Redlands.

*William T. Russell*, M.S., Ph.D. '50, has been promoted from the rank of major to lieutenant colonel, according to an announcement by the Department of the Army. Colonel Russell is assigned to the Research and Development Section of the Army Field Forces at Fort Monroe, Virginia. This is the organization which insures that individuals and units of the Army are trained for combat.

*Albert H. J. Mueller*, M.S. '49, and his wife—the former Ardita Williams—took a two and a half month tour of Europe this summer. Al, who received his M.B.A. at Stanford in June, will go to work for Hughes Aircraft in Culver City when he gets back.

*Richard C. Gerke*, M.S., won fame and fortune in August by taking second place in the *Los Angeles Times* Criss-Cross Puzzle contest. Dick's prizes were $3,500 and a new car—*plus* a special one of $3,000 for having submitted subscriptions to the *Times* and the *Mirror!*

Dick's still working for Bethlehem Pacific Coast Steel, has moved into a new home in South Pasadena.

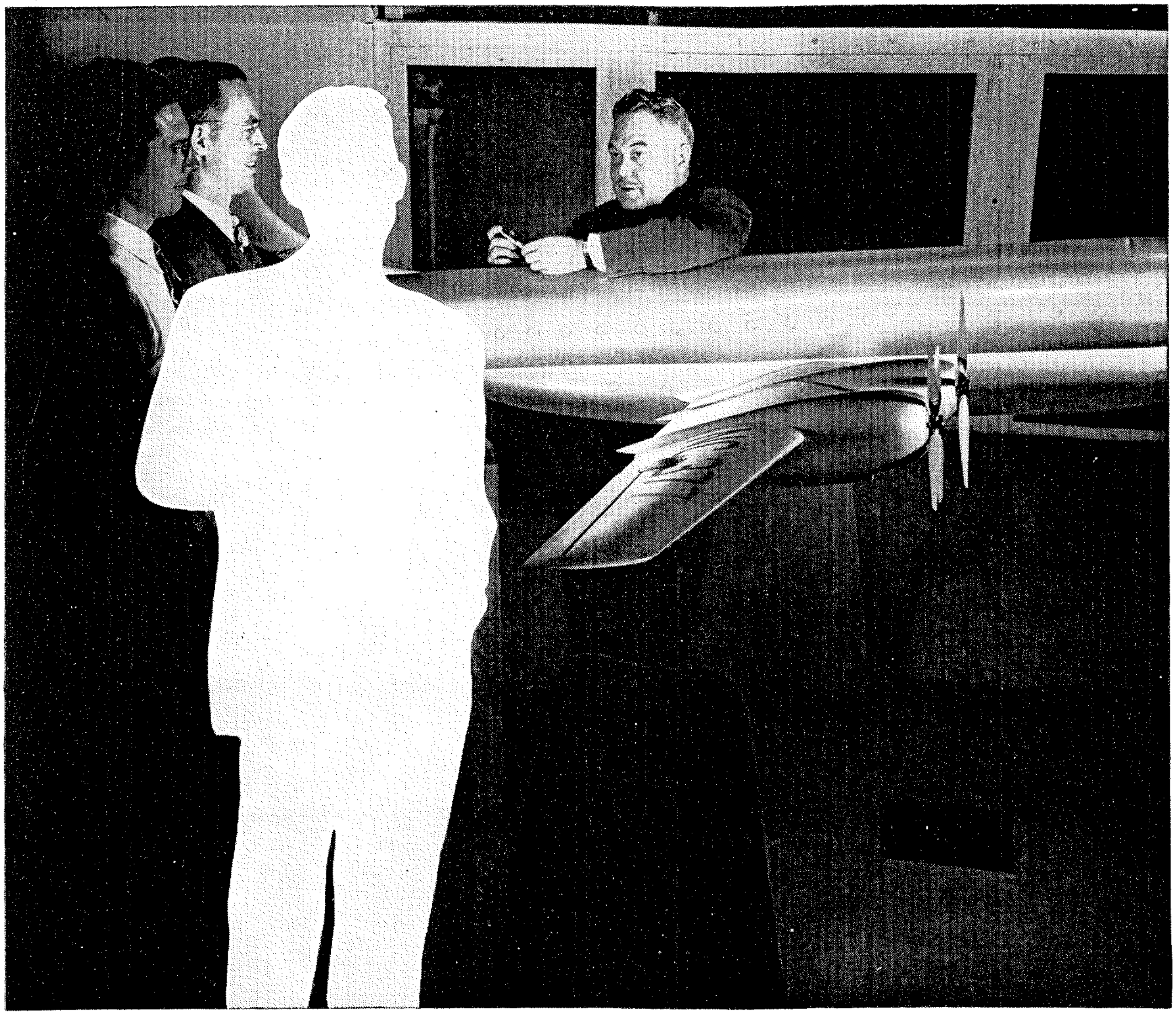
*Jeptha A. Wade, Jr.*, is still working for the Civil Water Service Company in San Jose as Assistant Engineer of Design. He has a daughter one and a half, and is now Registered Chemical Engineer No. 2288.

*Richard A. Boettscher*, M.S.C.E., stopped at Caltech this summer, on his return—with his wife and three children—from a year and a half in Dhahran, Saudi-Arabia, where he was district engineer for the Arabian-American Oil Company. Dick has now been appointed assistant to the Vice-President of the company in the New York office.

### 1948

*Arnold Feldman*, M.S. '48, who has been assistant to the radiological physicist at the Mayo Clinic in Rochester, Minnesota, for the last two years, has now been appointed an instructor in radiological physics in the Department of Radiology of the University of Colorado School of Medicine in Denver.

*Bruce Gavril*, after receiving the degree of Mechanical Engineer from MIT in June, worked for Jackson & Moreland, a Boston consulting engineering firm, during the summer. This fall he starts on his Ph.D. thesis—on compressible fluid mechanics. Bruce has been living at the MIT Graduate House, where *Moose Walquist* '49, *Corbie Corbato* '50, and *John Andres* '49, M.S. '50, also live. *Len Herzog* '48, is on campus too, "winding up his work in geology in between plays at Wellesley."



# PERSONALS . . . CONTINUED

*John P. Davis*, M.S., was recalled to active duty with the Navy last January and was graduated with distinction in May from the Electronics Materiel School on Treasure Island. In June he was sent to Tokyo to join a destroyer for duty in Far East waters.

*William A. Drew* had to send news by proxy this year; he was called back to active service in the Army in July. Mrs. Drew reports that, after working a year for the Occidental Insurance Company in Los Angeles, Bill went to the University of Michigan for a year's study, then went to work in the actuary group of the Reliance Insurance Company in Pittsburg, California. The Army now has him stationed at Fort Monmouth ,New Jersey.

*Harvey Holm* is now a project engineer at Hiller Helicopters, has a new daughter, Christine Ann, born May 10, and lives in Los Altos.

### 1949

*John H. Thomas* is serving aboard the *USS Ernest G. Small* (DD-838) as an Ensign.

*Bill Sylvies* writes from Honolulu that he has been confined to a veterans hospital for the past year with an upper respiratory infection, and expects to be so indisposed for about six more months. "Other than that," he says cheerfully, "everything is fine."

*Virgil J. Berry*, M.S., has recently been employed in the Research Laboratory of the Stanolind Oil and Gas Company, Tulsa.

*Donald W. Peterson*, who received his M.S. in geology at Washington State College in June, left his wife and daughter in Mountain View, California, to return to active duty in the Navy in July.

*Milton C. Vogel*, stationed at Las Cruces, New Mexico, with the Army, the last time we heard from him, was married last March to Donna Galliano, in Arcadia, California.

*Harold W. Davidson*, M.S., A.E. '50, and Elizabeth Friberg were married in Pasadena June 14.

*Ralph E. Darling*, M.S., reports from Fort Worth, Texas, that he is working as an Aeronautical Engineer for Consolidated Vultee, has built a new home, and has a son, Ralph Edward, who was born last October.

*Irv Krumholz* has left his job with the California State Division of Architecture to join the Austin Company in Pittsburg, California. So far he has acquired, with his new job, "some debts, a new house, and a puppy—of which my two daughters prefer the last."

*Charles G. Walance* and his wife had a son, Bruce Newton, born on August 2.

*Richard L. Patterson* was married to Cleo Louise Williams of Eagle Rock in May. They're living in Independence, California.

*Daniel King* spent one short year with an insurance company in San Francisco after he left Caltech, and is now back in the Navy. Dan has spent the last five months aboard the *USS Dennis J. Buckley* (DDR-808) on a European and Mediterranean cruise, while his wife (Meeta Cook of Scripps) has followed him. The Kings have been able to spend short times together while the ship was in port in Italy, France, England, Ireland, Eire, Germany, Belgium, and Trieste. They will be returning to Boston in October.

*Luis E. Benitez*, A.E., is on a Mediterranean cruise too, aboard the aircraft carrier *USS Oriskany* as assistant Gunnery Officer. Benny's wife, the former Sue Oliver of Pasadena, has been working in the Caltech News Bureau during his absence.

*Milt Andres*, M.S. '50, writes that he's still a grad student in physics at MIT, where he spent the summer working at the acoustics lab. Milt's spare time was spent learning to operate a sailboat on the Charles River.

### 1950

*Glenn D. Robertson, Jr.*, M.S., was married in June to Alice Spafford. They're living in Sierra Madre.

*Albert Eschner, Jr.*, was married in June to Margret Roodhouse of South Pasadena.

*Bruce Stowe* and *James Hendrickson* both received their M.A. degrees from Harvard this June.

### 1951

*Richard K. Smyth* makes the first alumni news in the class of '51—he was married on the thirtieth of August to Emilie Manns, in Long Beach.

*Lt. Col. John R. Jannerone*, M.S., has just been appointed Executive Officer of the Los Angeles District Corps of Engineers. Colonel Jannerone was number one man in his class ('38) at West Point—served on the staff of the Eighth Army in New Guinea, the Philippines and Japan—and before his assignment to Caltech for graduate study was assistant professor of Physics at the Military Academy.

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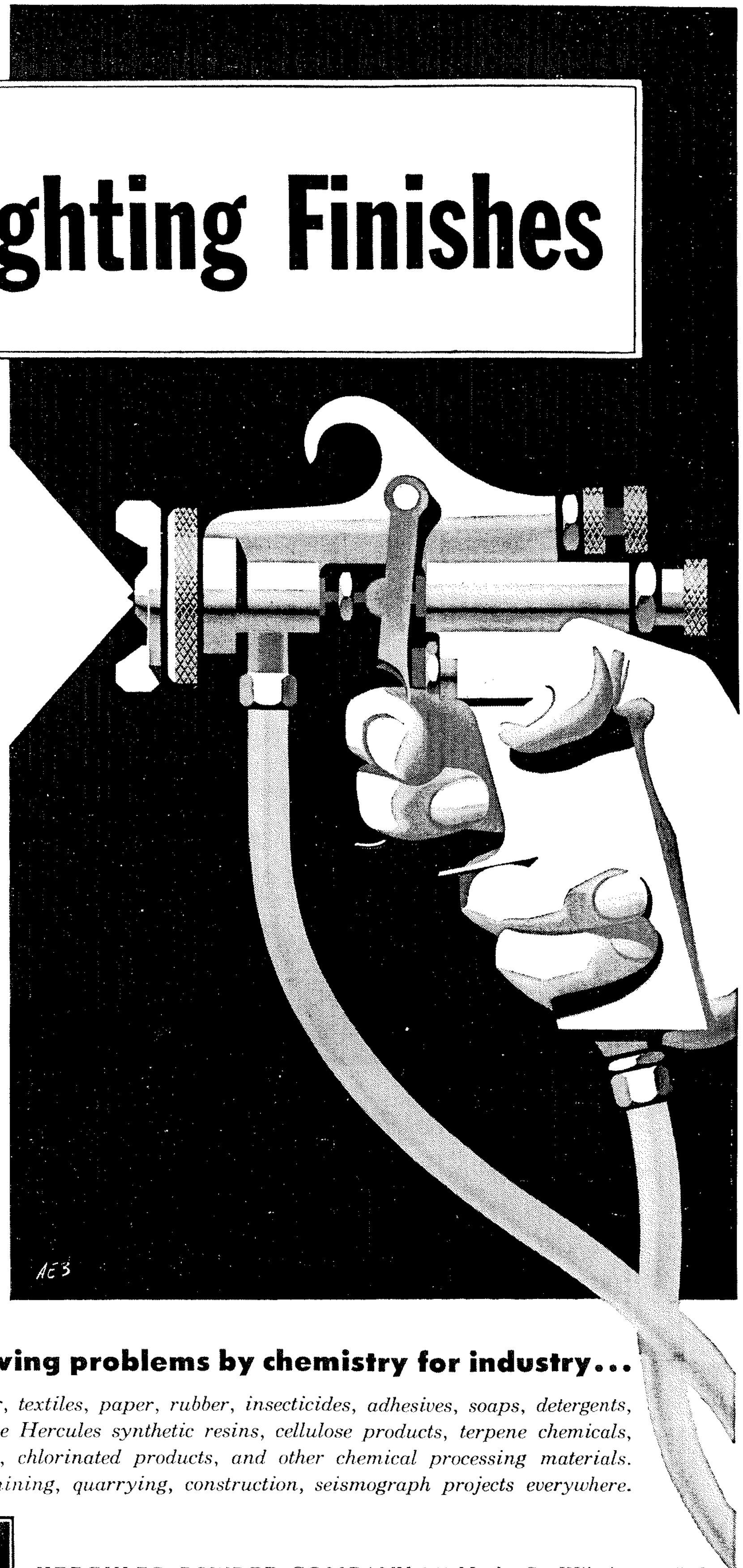

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# ALUMNI FUND

## Report of the Fourth Year—1950-1951

After four years the Caltech Alumni Fund has reached a total of $84,577.27. Perhaps this does not satisfy the early expectation of some, but certainly all Alumni should be proud of the results as compared with those of other schools.

In the year preceding June 30, 1951, there were 924 Alumni who contributed a total of $21,688.08, including income and interest. This means that 49.7 percent of the Undergraduate Alumni and 8.8 percent of the Alumni who received only higher degrees have cooperated in this effort to do something for Caltech. There is no doubt that with the continuance of the generous and loyal spirit of these men, and with increasing help from the non-participating half of the Alumni, the Fund will rise to well over the $100,000 mark.

Inflation, shortages, controls, and regulations indicate something in the way of construction should be started soon. Serious consideration is being given this matter with special studies being made to determine what might possibly be done at this particular stage of the Alumni Fund program.

Undergraduate gifts received by the Fund are tabulated below. The class rankings for average gift and percent of eligibles giving are also shown.

The Fund committee believes recognition should be given those men who have contributed during the past year, and hopes their example will help make the coming Fifth Year the best yet.

The names of all 1950-51 contributors to the Fund are listed on the following pages.

—*Donald C. Tillman*
*Director in charge of the Alumni Fund*

**FOURTH YEAR—1950-51**
**(As of June 30th, 1951)**

| | | | | | | | CLASS RANKING | |
|---|---|---|---|---|---|---|---|---|
| Class | Amount | Number Giving | Number Eligible | Per Cent of Eligibles Giving | Average Gift | Median Gift | Average Gift | Per Cent of Eligibles Giving |
| Prior 1915 | $ 91.00 | 7 | 26 | 26.9 | $ 13.00 | $10.00 | 22 | 13 |
| 1915 | 45.00 | 3 | 8 | 37.5 | 15.00 | 10.00 | 17 | 1 |
| 1916 | 20.00 | 1 | 7 | 14.3 | 20.00 | 20.00 | 10 | 34 |
| 1917 | 50.00 | 3 | 9 | 33.3 | 16.67 | 10.00 | 14 | 5 |
| 1918 | 474.43 | 7 | 30 | 23.3 | 67.78 | 10.00 | 4 | 20 |
| 1919 | 0 | 0 | 3 | 0 | 0 | 0 | 37 | 37 |
| 1920 | 155.00 | 10 | 30 | 33.3 | 15.50 | 12.50 | 16 | 5 |
| 1921 | 681.25 | 12 | 35 | 34.3 | 56.77 | 10.00 | 5 | 4 |
| 1922 | 2,595.00 | 20 | 61 | 32.8 | 129.75 | 20.00 | 2 | 8 |
| 1923 | 2,286.00 | 16 | 49 | 32.7 | 142.88 | 10.00 | 1 | 9 |
| 1924 | 631.00 | 12 | 74 | 16.2 | 52.58 | 10.00 | 6 | 29 |
| 1925 | 696.00 | 24 | 78 | 30.8 | 29.00 | 22.50 | 8 | 10 |
| 1926 | 162.00 | 11 | 101 | 10.9 | 14.73 | 10.00 | 19 | 36 |
| 1927 | 178.00 | 19 | 91 | 20.9 | 9.37 | 10.00 | 31 | 23 |
| 1928 | 371.75 | 21 | 61 | 34.4 | 17.70 | 10.00 | 11 | 3 |
| 1929 | 527.00 | 30 | 84 | 35.7 | 17.57 | 10.00 | 12 | 2 |
| 1930 | 607.43 | 16 | 102 | 15.7 | 37.96 | 15.00 | 7 | 30 |
| 1931 | 1,761.00 | 23 | 97 | 23.7 | 76.57 | 10.00 | 3 | 19 |
| 1932 | 275.00 | 17 | 94 | 18.1 | 16.18 | 10.00 | 15 | 26 |
| 1933 | 207.00 | 14 | 94 | 14.9 | 14.79 | 10.00 | 18 | 33 |
| 1934 | 584.00 | 25 | 104 | 24.0 | 23.36 | 15.00 | 9 | 18 |
| 1935 | 376.00 | 28 | 110 | 25.5 | 13.43 | 10.00 | 20 | 16 |
| 1936 | 466.50 | 27 | 116 | 23.3 | 17.28 | 10.00 | 13 | 20 |
| 1937 | 225.00 | 17 | 113 | 15.0 | 13.24 | 10.00 | 21 | 32 |
| 1938 | 287.00 | 26 | 127 | 20.4 | 11.04 | 10.00 | 27 | 24 |
| 1939 | 222.50 | 22 | 113 | 19.5 | 10.11 | 10.00 | 29 | 25 |
| 1940 | 402.00 | 31 | 140 | 22.1 | 12.97 | 10.00 | 23 | 22 |
| 1941 | 410.00 | 35 | 128 | 27.3 | 11.71 | 10.00 | 25 | 12 |
| 1942 | 359.00 | 43 | 149 | 28.9 | 8.35 | 5.00 | 32 | 11 |
| 1943 | 463.98 | 41 | 124 | 33.1 | 11.32 | 10.00 | 26 | 7 |
| 1944 | 582.50 | 55 | 208 | 26.4 | 10.59 | 10.00 | 28 | 15 |
| 1945 | 368.00 | 30 | 191 | 15.7 | 12.27 | 7.50 | 24 | 31 |
| 1946 | 183.00 | 22 | 163 | 13.5 | 8.32 | 5.00 | 33 | 35 |
| 1947 | 236.00 | 25 | 144 | 17.4 | 9.44 | 5.00 | 30 | 27 |
| 1948 | 332.00 | 52 | 193 | 26.9 | 6.38 | 5.00 | 35 | 13 |
| 1949 | 333.50 | 52 | 213 | 24.4 | 6.41 | 5.00 | 34 | 17 |
| 1950 | 181.00 | 32 | 185 | 17.3 | 5.66 | 5.00 | 36 | 28 |
| TOTAL | $17,825.84 | 829 | 3655 | 22.7 | $ 21.50 | ........ | .... | .... |

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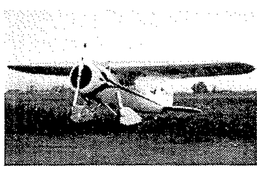

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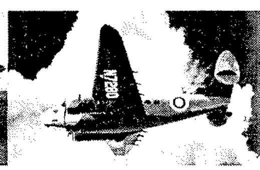

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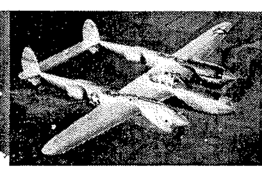

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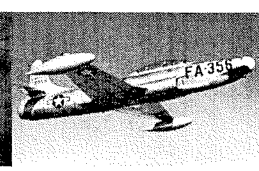

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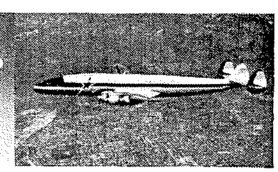

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1915
Holmes, William M.
Holt, Herbert B.
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1916
Rich, Kenneth W.

1917
Kemp, Archie R.
Kensey, Alexander
Youtz, J. Paul

1918
Andrews, Clark F.
Capra, Frank R.
Essick, L. F.
Heywood, Gene B.
Hoge, Edison R.
McDonald, G. R.
Smith, Albert K.

1920
Barton, Paul D.
Hollinger, A. L., Jr.
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Hounsell, Theron C.
Lewis, John C.
Linhoff, Harold R.
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1921
Badger, Richard M.
Case, Henry R.
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Craig, Robert W.
Honsaker, Horton H.
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1922
Ager, Raymond W.
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1923
Baier, Willard E.
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Barnett, Harold A.
Blakeley, Loren E.
Fitch, Charles E.
Fowler, L. Dean
Gilbert, Walton E.
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Lewis, H. B.
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Roth, Lawrence P.
Smith, Elmer L.
Walling, Lloyd A.
Walter, John P.
Woods, Robert E.

1924
Anderson, Kenneth B.
Campbell, Daniel M.
Clark, Rex S.
Goodhue, Howard W.
Irwin, Emmett M.
Losey, Theodore C.
Parker, Cecil N.
Squiers, Willis L.
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Simpson, Thomas P.
Stanton, Robert J.
Thompson, Wilfred G.

1926
Coleman, Theodore
Edwards, Manley W.
Fahs, John L.
Friauf, James B., Ph.D.
Granger, Wayne E.
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Kirkeby, Eugene
Kroneberg, Alex. A.
Laws, A. L.
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Wulf, Oliver R., Ph.D.

1927
Bailly, Florent H.
Baxter, Ellery R.
Blankenburg, Rudolph C.
Bower, Maxwell M.
Boyd, James
Capon, Alan E.
Darling, Mortimer D.
Diamos, G. K. S., M.S.
Farrar, Harry K.
Forster, John B.
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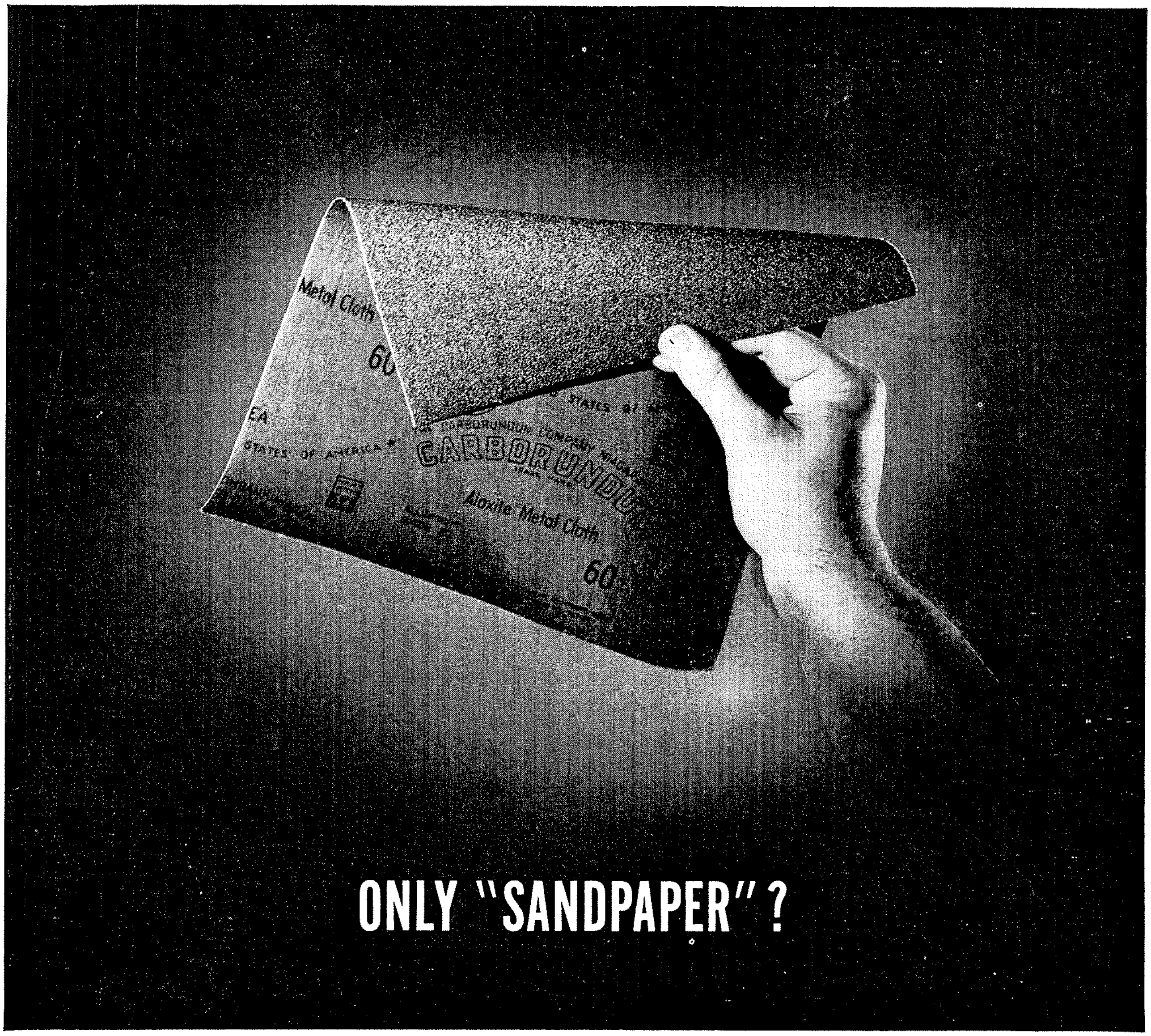
Southwick, Thomas S.
Stanton, W. Layton
Starke, Howard R.
Swartz, Charles A.
Warner, Arthur H., Ph.D.

1928
Armstrong, Dr. Richard C.
Brighton, Thomas H.
Coulter, Robert I.
Cutler, Ralph W.
D'Arcy, Nicholas A., Jr.
Duval, Richard H.
Evans, Robley D.
Gewertz, Moe W.
Hossack, H. A.
Joujon-Roche, Jean E.
Kaneko, George S.
Kuhn, Jackson G.
Lash, Charles C.
Lombard, Albert E.
McMillan, Edwin M.
Minkler, C. Gordon
Olsen, William L.
Righter, Walter H.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Cline, Frederick R.
Cramer, Alphonse M.
Cravitz, Philip
Dunham, James W.
Evans, Thomas H.
Findlay, Willard A.
Fredendall, Beverly F.
Ganssle, Karl A.
Grimes, Walter B.
Grunder, Lawrence J.
Hincke, W. B., Ph.D.
Hugg, Ernest B.
Kingman, Kenneth E.
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Larrecq, A. J.
Lau, H. K.
Lee, Edson C.
Lufkin, George S.
McMillan, Wallace A.
Mohr, William H.
Myers, Albert E.
Niles, Joseph A.
Roberts, Bolivan
Rofelty, Richard G.
Scullin, J. Conrad
Weismann, George F.
Wheeler, Fred A.
Wolfe, Charles M.

1930

Alden, Lucas A.
Alderman, Frank E.
Atkinson, Dr. R. B., Ph.D.
Ayers, Wilbur W.
Blohm, Clyde L.
Bode, Francis D.
Carlson, Chester F.
Hoeppel, Raymond W.
Hopper, Rea E.
Howse, S. Eric
Johnson, Josef J.
Kinney, Edward E.
Levine, Ernest
MacDonald, James H.
Pleasants, J. G., M.S.
Richardson, Burt, M.S.
Sheffet, David
Strong, Austin W.
Thayer, Eugene M.
Zipser, Sidney

1931

Amann, Jack H.
Arndt, William Frederick
Biddle, Russall L., Ph.D.
Boothe, Cdr. Perry M.
Bovee, John L., Jr.
Chamberlain, Glenn J.
Cogen, William M.
Detweiler, John S.
Green, Edwin F.
Johnson, Byron B.
Keeley, James H.
Kinney, E. S.
Kircher, Charles E., Jr.
Kuykendall, Charles E.
Langsner, George
Leeper, L. D.
Lehman, Robert M.
Lewis, George E.
Neher, H. Victor
Peer, Edward S.
Peterson, Raymond A.
Pratt, Leland D.
Smits, Howard G.
Wilmot, Charles A.

1932

Arnerich, Paul F.
Behlow, Lewis B.
Bradburn, James R.
Coryell, Charles D.
Freeman, Robert B.
Harsh, Charles M.
Kent, W. L.
Leermakers, J. A., Ph.D.
Lyons, Patrick B.
McLaughlin, James P.
Mouzon, James C., Ph.D.
Pruden, Worrell F.
Schuhart, Mervin A.
Schultz, William O.
Sheffet, Joseph
Shockley, William
Shull, George O.
Swart, Kenneth H.
Wilson, Chester E.

1933

Berkley, G. Merrill
Davis, Madison T.
Edwards, E. C., Ph.D.
Effromson, Philip C.
Hayes, Edward A.
Hofmann, Oliver D.
Johnson, J. Stanley
Lewis, Wyatt H.
McCleery, Walter L.
MacDonald, Robert G.
Mendenhall, John D.
Palm, Bernhard N.
Prater, Arthur N., M.S.
Randall, John A.
Russell, Richard L.
Widess, Moses B.

1934

Anderson, Robert C.
Babcock, Horace W.
Bollay, William, M.S.
Boykin, Robert O., Jr.
Campbell, James R.
Childers, Milford C.
Cogen, Saul
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Schaak, Frank A., Jr.
Sharp, Dr. Robert P.
Sherborne, John E.
Sluder, Darrell H.
Thompson, A. E.
Ugrin, Nick

1935

Allardt, Frederick H.
Baldwin, Lawrence W.
Davenport, Horace W.
Davies, James A.
Etz, Arthur N.
Fuhrmann, Hans H.
Fussell, Robert G.
Garner, Clifford S.
Gluckman, Howard P.
Higley, John B.
Jahns, Richard H.
Jennison, James H.
Ketchum, M. C.
Keyes, William F., Jr.
Leppert, Elmer L.
Martin, Victor J., M.S.
Miller, Daniel H.
Nies, Nelson P.
Lindsay, Chester W.
Rader, Louis T., M.S.
Ray, A. Allen
Reynolds, Edward H.
Ribner, Herbert S.
Scherb, Ivan V.
Snow, Neil W.
Stanley, Robert M.
Stick, John C., Jr.
Stuppy, Lawrence J.
Taylor, Jay C.
Webster, Donald C.
Wood, Louvan E., M.S.

1936

Boothe, Raymond H. F.
Carley, Glenn R.
Davis, Frank W.
Dickinson, Holley B.
Douglass, Malcolm E.
Elliott, Robert D.
Folland, Donald F.
Frost, Arthur M.
Goodwin, Henry J.
Graham, Ernest W.
Griffith, Everette E., Jr.
Hammond, Paul H.
Heath, Charles O., Jr.
Hicks, Bruce L.
Holland, E. Morton
Johnson, F. L.
Jordan, Charles B.
Klocksiem, John P.
La Boyteaux, Ellsworth
McMahon, M. M.
Marsh, Robert H.
Meneghelli, Hugo A.
Peugh, Verne L.
Ramo, Simon, Ph.D.
Sklar, Maurice

Stitt, Fred B., Ph.D.
Swanson, W. E.
Thompson, Rev. Tyler F.
Unholtz, Karl
Whipp, David M.
Young, Larry L., M.S.

1937

Brice, Richard T., Ph.D.
Briggs, Stanford W.
Carrick, Harry H., Jr.
Feuer, Stanley
Frost, Holloway H.
Gilmore, Hugh M., Jr.
Johnson, Carl B.
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Mann, George E., Jr.
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Miller, Nash H., M.S.
Miller, W. B.
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Owen, Noel L.
Poggi, Martin J.
Strong, Dean Fester, M.S.
Walley, Bernard
Webster, Martin H.
Woolsey, Charles C., Jr.
Wyckoff, Peter H., M.S.

1938

Althouse, William S.
Baker, John R.
Bertram, Sidney
Bower, Clark D.
Cardwell, W. T., Jr.
Claflin, Waldo M.
Dennis, Paul A.
Dixon, Blaine A., Jr.
DuFresne, Armand F.
Forward, Richard B.
Friend, Carl F.
Hopkins, Henry S.
Ives, Philip T., Ph.D.
Jewett, Frank B., Jr.
Jurs, Albert E., Jr.
Keller, Samuel H.
Kelly, Leroy B.
Kyropoulos, Peter, M.S.
Lilly, Dr. John C.
McGraw, John T.
McLean, John G.
Nagamatsu, H. T.
North, Harper Q.
Osborn, E. F., Ph.D.
Reamer, H. Hollis, M.S.
Rosencranz, Richard, Jr.
Velazquez, Jose L.
Weinberger, Edward L.
Wilson, Gardner P.
Wood, Homer J.

1939

Anderson, Clarence R.
Beck, Duane W.
Bishop, Richard H.
Brown, Perry H.
Connelly, Ronald B.
Crozier, George O.
Devirian, Philip S.
Fischer, Richard Alfred
Flint, Delos E.
Frampton, William R., Jr.
Gassaway, J. Scott
Goodell, Jack H.
Green, Albert P.
Green, William M.
Knoblock, F. D., Ph.D.
Lawson, William G.
Norton, William M.
Ortiz, Jose Pulido, M.S.
Pullen, Keats A.
Ruggiero, Ralph J.
Smith, Josiah E.
Smith, Phillip E.
Stones, J. Eugene
Wilson, John N., Ph.D.
Winchell, Robert W.

1940

Barber, George C.
Blackinton, Roswell J.
Brose, Frederic M.
Burton, Clifford C.
Daams, Gerrit
Dickerson, Edward O.
Foster, Gerald P.
Gewe, Robert A.
Glassco, Robert B.
Harper, John C.
Jongeneel, James W.
Kohl, Jerome
Langerud, Rolf O.
Larson, Walter R.
Longwell, Paul A.
Mewborn, A. Boyd, Ph.D.
Moore, Robert S., M.S.
Nakada, Yoshinao
Quarles, Miller W., Jr.
Richards, Raymond G.
Russell, Charles D., M.S.
Samuel, Hubert D., Jr.
Scarborough, W. Bertram
Spear, Robert E.
Staatz, Mortimer H.
Steinmetz, David H., III
Stevens, Jean B.
Stone, William W., Jr.
Streightoff, Frank
Sumner, Herbert C., M.S.
Tomiyasu, Kiyo
Van Dyke, Gilbert R.
Watkins, James M., Jr.
White, H. Jack
Worcester, Herbert, Jr.
Wouk, Victor, M.S.

1941

Acker, Roy M.
Bersbach, Alfred J.
Billman, Glenn W.
Bowles, Robert R.
Bradner, Hugh
Bramhall, George H.
Cooper, Robert G.
Campbell, Donald C.
Casserly, Frank G.
Chapin, William F.
Corcoran, William H.
Davis, Walter Z.
Dawson, Donald E.
Dobbins, Willis E.
Edwards, Gene L.
Eusey, Merritt V., Jr.
Gally, Sidney K.
Greenhalgh, Francis M.
Harr, George B.
Ikawa, Miyoshi
Jones, G. A.
Lewis, Joseph W.
Lockard, Frank P.
Myers, Robert F.
Palmer, John G.
Partlow, John G.
Paulson, John J.
Rominger, Joseph F.
Rubert, Claud S.
Stephenson, William B.
Stewart, Wilton A.
Sturdevant, C. V., III
Svendsen, Norman F.
Wahrhaftig, A. L., Ph.D.
Wahrhaftig, Clyde A.
Wallace, Roger
Widdoes, Lawrence C.
Wood, David S.

1942

Albrecht, Albert P.
Allan, John R.
Almassy, George W.
Andrews, Richard A.
Atkinson, Thomas G.
Baird, Hugh A.
Brandt, Roger
Brockman, John A.
Brown, Charles M.
Brown, Sheldon W.
Bruce, Victor G.
Church, Stanford, M.S.
Cox, Richard H.
Curtis, Thomas G.
Densmore, Robert E.
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Franzini, Joseph B.
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Webster, Paul W.

Weller, LeRoy A., Jr.

## 1943

Benton, Robert F.
Blitzer, Leon, Ph.D.
Buchanan, John W.
Bunker, Earle R., Jr.
Carter, Claude L.
Christianson, W. L.
Dazey, Mitchell H.
Dubbs, Clyde A.
Elmer, David A.
Farmer, Howard N., Jr.
Frost, Robert C.
Gardner, Arthur H.
Garner, Harold K.
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Granicher, Donald I.
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Larson, Robert L.
Lawrence, Theodore G.
Lingle, Harrison C.
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Mead, Orin J.
Merritt, Melvin L.
Moore, Robert A.
Powlesland, Kenneth L.
Pugh, Lawrence R.
Reid, Douglas C.
Schneider, Arthur J. R.
Sherwin, Robert M.
Smith, M. Curtis
Stirling, Cedric W., M.S.
Strickland, C. P., Jr.
Sutton, Richard A.
Tenney, Frederick
Terrell, Oscar D.
Thompson, W. C., Jr.
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Willits, Ralph M.
Young, James A., Jr.

## 1944

Adams, Phillip L.
Allingham, Robert E.
Amster, Warren H.
Andrews, Tway W.
Behrens, F. A., Jr.
Buller, Joseph S.
Carter, Thomas A., Jr.
Chadwick, Joseph H., Jr.
DeRemer, Kenneth Ross
Dethlefsen, Douglas G.
Dodge, Willard A.
Donsbach, Weldon R.
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Knudsen, Richard A. B.
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Lockwood, William E., Jr.
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Shor, George G., Jr.
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Smith, Frank C., Jr.
Smith, George F.
Smith, Philip H.
Soike, Richard J.
Swanson, Wilbur M.
Whitmore, John F.
Winter, Paul H.
Wolfe, Allen E.

## 1945

Bennett, Robert R.
Davy, Louis H.
Elko, Edward R.
Elliott, William J.
Fleming, Wallis T.
Francis, Donald L.
Fulton, Albert S.
Gardner, Paul R., Jr.
Gerber, Raymond C., Jr.
Gerpheide, John H.
Gerty, John M.
Hall, Lawrence G.
Harrington, Jerome S.
Howe, Robert M.
Jasper, Richard N.
Kiechhefer, Robert Jr.
Killian, Roy G.
Kling, Harry P.
Leo, Robert E.
Mac Dougall, Donald D.
Macomber, Mark M.
Markham, Richard G.
Neyland, Charles E., M.S.
Schmoker, Robert F.
Sorenson, Emil L., M.S.
Springer, Richard E. (Deceased)
Stefanoff, John J.
Stern, John L.
Taylor, Edward C.
Tillman, Donald C.
White, Ralph S.
Williamson, Merritt, M.S.
Winter, Ralph D.
Young, Thayne H.

## 1946

Bates, Stuart R.
Bonner, R. D., M.S.
Burdg, Charles E.
Calligeros, John P.
Cambel, Ali Bulent
Chalmers, James F.
Daniels, Jerry, Jr., M.S.
Davis, Donovan C.
Delano, Richard H.
Deodati, Joseph B., M.S.
Elliott, Allan B., M.S.
Fayram, Richard A.
Field, Jerome S.

Fleming, John E.
Gottlieb, Norman A.
Haupt, Laurence O., Jr.
Jensen, Louis K.
Jessen, Howard E.
Lewis, Chas. Hadley, M.S.
Lincoln, David C.
Lockwood, Glynn H.
Neale, Edward G., Jr.
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O'Reilly, James D., M.S.
Rechtin, Eberhardt
Schuster, Richard P., Jr.
Showell, John
Steele, Harry M., Jr.
Strong, Herbert W., Jr.
Stuart, Jay W., Jr.
Weldon, Thomas F.
Zagorites, Jerry A.

1947

Aldrich, Jerry F., M.S.
Bearson, Robert
Belyea, Robert C.
Bennett, Dudley Earl
Billheimer, John S.
Bolles, Arthur S.
Caldwell, David O.
Comlossy, Harold
Cooke, David A.
Cowan, Edwin J.
De Percin, Fernand, M.S.
Felberg, Richard L.
Harris, Robert Blynn
Hawthorne, Robert G.
Hodges, Merwyn E.
Ilfeld, Robert M., M.S.
Lund, LeVal, Jr.
McClure, Gordon
Meier, Dale J.
Mueller, Albert H. J.
Opfell, John B.
Opperman, David R.
Pascoe, Lucien A.
Richey, Eugene P., M.S.
Riedel, John C.
Royden, Herbert N.
Scull, John R.
Shaw, Charles B., Jr.
Six, Lyle D.
Terry, John P.
Vieweg, Arthur F.
Wade, Jeptha

1948

Alexander, Richard C.
Anderson, Roger A.
Barlow, Griffith C.
Brown, James R., M.S.
Brown, Robert J. S.
Burt, Frederick B.
Butler, Stuart M., Jr.
Caprio, Joseph M.
Christopherson, W. A.
Cox, Arthur N.
Davis, Wayne K.
Ferrell, Richard A.
Fletcher, Taylor C.
Fullerton, Paul W., Jr.
Harrison, Stanley R.
Henigson, Robert
Herzog, Leonard F., II
Holditch, James E.
Hybertsen, Horace M.
Jarmie, Wilbur N.
Kaplan, Abner
Lewis, Howard B., Jr.
Lovelace, Donald E.
MacMillan, Robert S.
Markowitz, Irwin L.
Marshall, Warren M., III
Mitchel, Glen H., Jr.
Mittenthal, Lothrop
Moore, Bonde C.
Moore, Harry J.
Mullen, John K.
Olson, Norman E.
Pond, Marshall C.
Poindexter, Robert W.
Rigsby, George Pierce
Roberson, Harvey L.
Roe, George W.
Roehm, Richard M.
Roskowski, Edward F.
Rypinski, Chandos, Jr.
Scott, George R.
Sefton, Wayne E.
Seiden, Wm.
Shippee, William H.
Spooner, Mike E., Jr.
Stix, Thomas H.
Tang, Kenneth K.
Waters, Alfred Earnest
Wechsler, Joseph W.
Whittlesey, John
Williamson, William J.
Wolf, Frank J.
Wright, Harvey W., Jr.

1949

Andres, John M.
Barnes, Stanley M.
Brown, Erle J., Jr.
Browne, Davenport, Jr.
Carter, Hugh C.
Cornelius, Richard C.
Doherty, Patrick D.
Dolan, Edwin J.
Doolin, William A.
Drapes, Alex G.
Englar, Clayton
Fasola, Henry, Jr.
Flam, Frederick H.
Forester, Charles F.
Funk, Robert B.
Gardiner, Kenneth W.
Green, Joseph M.
Hayward, David K.
Hayward, Philip, Ph.D.
Heiman, Jarvin R.
Herzig, Wayne M.
Hibbard, Don E.
Karzas, William J.
Kashiwabara, Naomi
Katz, Eli
Keinonen, Frank W.
King, Daniel W.
Knight, Charles H., Jr.
Kohnen, Keith D.
Kostelac, John F.
Machetanz, Frederick A.
McKay, Richard A.
McPhate, John A.
Mitchell, Orson L.
Morrison, Ralph
Muehlberger, William R.
Myers, Ridley
Nicolai, Fred H.
Palmer, William E.
Patterson, Richard L.
Peterson, Donald W.
Pilling, Robert R.
Prevost, Walter G.
Rosicky, Fred G.
Rudin, Marvin B.
Ryder, Dale D.
Seitz, Clyde R.
Sheriffs, Leigh
Shibata, Harry H., M.S.
Simons, William H.
Six, Gene D.
Stephens, Dale J., M.S.
Vrabec, Arundale
Walance, Charles G.
Walquist, Robert L.
Willard, Robert N., M.S.
Witkin, Donald E.

1950

Amster, Harvey Jerome
Asquith, Donald O.
Corbato, Fernando Jose
Cox, William P.
Forrester, Herbert Amasa
Frick, Leo F.
Friswold, Carroll Leslie
Gage, Boyd M.
Gossot, Michel, M.S.
Greene, John Morgan
Hickey, M. Van Cleve
Howell, Peter A.
Kam, Merle T.
Katz, Louis
Kendall, Donald Vernon
Knipe, Richard H.
Kroll, William
Lutwack, Ralph
Markoff, Daniel
Martin, Harold C., Ph.D.
McCaldin, James O.
McIntyre, Richard M.
McLellan, W. H.
Meghreblian, R. V., M.S.
Mosich, John T.
Oakes, Gibson
Pastan, Harvey L., M.S.
Rains, Dean A.
Reese, John R.
Romero, Marco A.
Solomon, George E., M.S.
Soule, Winsor, Jr.
Spencer, Eugene G.
Staats, William T.
Stevens, Robert T.
Stone, Ralph J.
Stowe, Bruce B.
Walt, Martin, IV
Weeks, LeRoy W.
Welch, Frank, Jr., A.E.

# ALUMNI ASSOCIATION

## CALIFORNIA INSTITUTE OF TECHNOLOGY

### BALANCE SHEET

As of June 30, 1951

| | | | |
|---|---|---|---|
| **ASSETS** | | | |
| Demand deposit in bank | | | $ 8,237.13 |
| Postage deposit | | | 125.97 |
| Investments, at cost: | | | |
| Share in Consolidated Portfolio of C.I.T. | | $26,467.48 | |
| U. S. Treasury bonds | | 222.00 | 26,689.48 |
| Furniture and fixtures, at nominal amount | | | 1.00 |
| | | | $35,053.58 |
| **LIABILITIES** | | | |
| Accounts payable | | | $ 2,530.48 |
| 1951-1952 membership dues paid in advance | | | 4,115.00 |
| | | | 6,645.48 |
| **SURPLUS** | | | |
| Life membership reserve: | | | |
| Fully paid memberships | | $25,600.00 | |
| Payments on life memberships under the installment payment plan | | 1,100.00 | |
| | | 26,700.00 | |
| Unappropriated income: | | | |
| Balance June 30, 1950 | $1,728.67 | | |
| Adjustments to life membership reserve | 167.50 | | |
| Excess of income over expense, year ended June 30, 1951 | 31.97 | | |
| | 1,928.14 | | |
| Less write down of furniture and fixtures to $1.00 | 220.04 | 1,708.10 | 28,408.10 |
| | | | $35,053.58 |

### STATEMENT OF INCOME

For the year ended June 30, 1951

| | | | |
|---|---|---|---|
| **INCOME** | | | |
| Dues | | | $ 7,155.69 |
| Less subscription to Engineering and Science Monthly for Association members | | | 4,634.00 |
| | | | 2,521.69 |
| Income from Consolidated Portfolio of C.I.T.: | | | |
| Normal income | | $1,236,88 | |
| Gain upon sale of investments | | 284.11 | 1,520.99 |
| Share of excess of income over expenses of Engineering and Science Monthly | | | 500.00 |
| Other Income: | | | |
| Annual seminar: | | | |
| Income | | 1,943.25 | |
| Less expense | | 1,459.38 | |
| | | 483.87 | |
| Six social functions: | | | |
| Income | $1,794.99 | | |
| Less expense | 2,029.11 | 234.12 | 249.75 |
| | | | 4,792.43 |
| **EXPENSE** | | | |
| Administration: | | | |
| Directors' expense | | $ 136.99 | |
| Postage | | 421.00 | |
| Supplies and printing | | 399.50 | |
| Miscellaneous | | 74.10 | |
| | | 1,031.59 | |
| Alumni Directory expense | | 2,315.86 | |
| Alumni Fund solicitation | | 1,002.28 | |
| Alumni membership solicitation | | 260.73 | |
| Assistance to student publications | | 150.00 | 4,760.46 |
| **NET INCOME** | | | $ 31.97 |

### AUDITOR'S REPORT

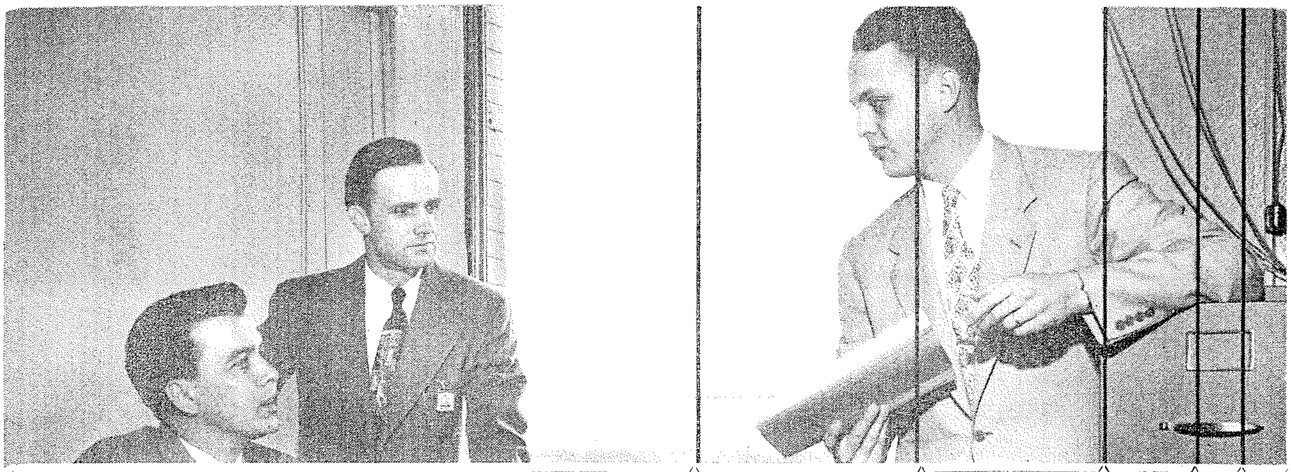
Alumni Association
California Institute of Technology
Pasadena, California

I have examined the balance sheet of Alumni Association California Institute of Technology as of June 30, 1951 and the related statement of income for the year then ended. My examination was made in accordance with generally accepted auditing standards, and accordingly included such tests of the accounting records and such other auditing procedures as were considered necessary in the circumstances.

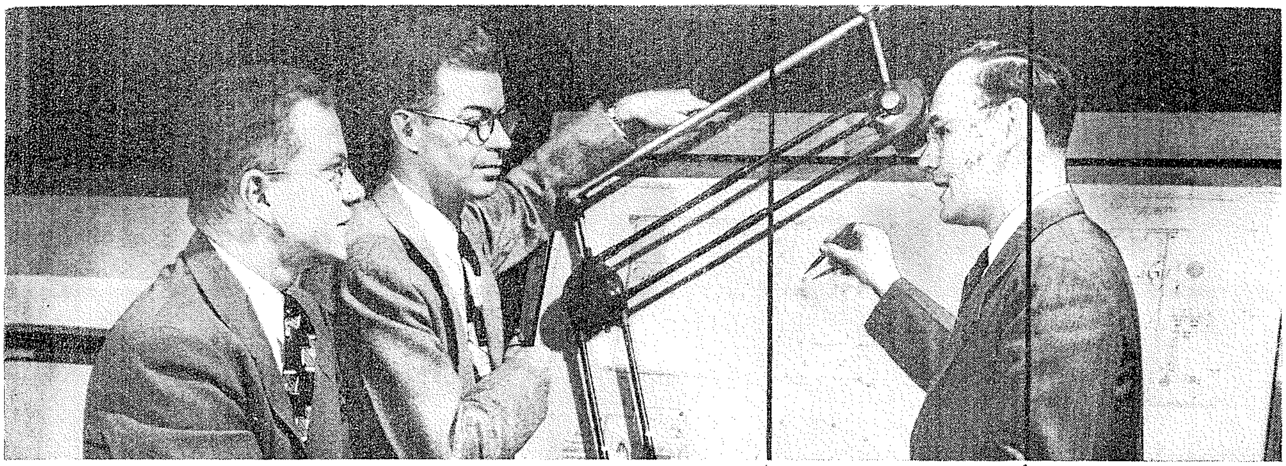
In my opinion, the accompanying balance sheet and statement of income present fairly the financial position of Alumni Association California Institute of Technology at June 30, 1951 and the results of its operations for the year then ended, in conformity with generally accepted accounting principles applied on a basis consistent with that of the preceding year.

Howard W. Finney
Certified Public Accountant

September 17, 1951



Accounting, Auditing, 55% | Marketing, 17% | Admin., 15% | Other Jobs, 7% | Advt., 3% | Mfg., 3%



Research—Development, Design, Production, Application Engineering, 60% | Marketing, Sales, 20% | Other Jobs, 20%

# What happens to all the college graduates General Electric hires?

About 55 per cent of the graduates of General Electric's Business Training Course are now making their careers in accounting and auditing work. About 17 per cent are in marketing; 15 per cent in administrative and management; 3 per cent in advertising; 3 per cent in manufacturing; with 7 per cent in fields ranging from purchasing to employee relations.

Of the more than ten thousand engineers and other specialists at General Electric, about 60 per cent are in some phase of engineering or research, with 20 per cent in marketing, and the other 20 per cent in manufacturing, purchasing, etc.

Figures like these help to prove that there are no fixed paths for college graduates at General Electric. The graduate who enters a G-E training program doesn't commit himself irrevocably to one type of work.

It's a G-E tradition to encourage the newcomer to look around, try several different assignments on for size, find the kind of job which he believes will be most satisfying and to which he can make the greatest contribution.

*You can put your confidence in—*

**GENERAL ELECTRIC**