ENGINEERING | AND | SCIENCE

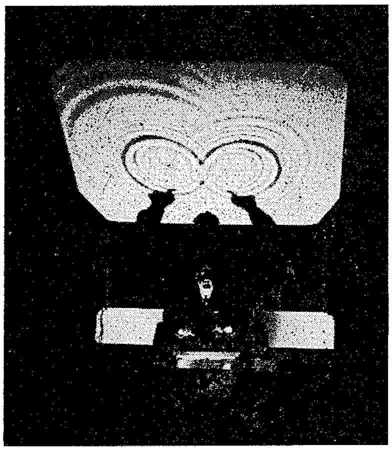
NOVEMBER/1955

Demonstration Lectures . . . page 19

PUBLISHED AT THE CALIFORNIA INSTITUTE OF TECHNOLOGY

ENGINEERING AND SCIENCE

IN THIS ISSUE



On our cover this month is Earnest C. Watson, Professor of Physics and Dean of the Faculty at Caltech, photographed in the middle of his demonstration lecture on "The Nature of Sound." This lecture positively does not include any voodoo rites or incantations; as a matter of fact, on our cover Dean Watson is standing at a ripple tank, having just made some ripples to show how sound radiates. A light under the tank reflects on a large screen behind the demonstrator.

On page 19 of this issue you'll find a short history of the Friday Evening Demonstration Lecture at Caltech, and pictures of a few of the demonstration lecturers—which all go to prove that there's a little ham in every good educator. (As an indication of what a little showmanship can do: Plant Physiologist Arthur Galston used to give a mildly popular Friday Evening Demonstration Lecture every year, entitled "Day Length in Plants." Last year he changed the title to "Day Length and Sexual Activity in Plants." Result? Full house.)

Note that most of the photographs of the demonstration lecturers were taken by Tom Harvey, Lab Technician in Physics, who makes a lot of the materials and sets up all the demonstration lectures. Aside from this—as anyone can tell by his pictures—Tom Harvey is a professional photographer.

PICTURE CREDITS

Cover	Thomas W. Harvey
11, 13, 14 (top) 15, 17, 21, 34	Walter W. Girdner
14 (bottom)	Office of Naval Research
19, 20, 22, 23, 24	Thomas W. Harvey
28	Roger W. Lewis

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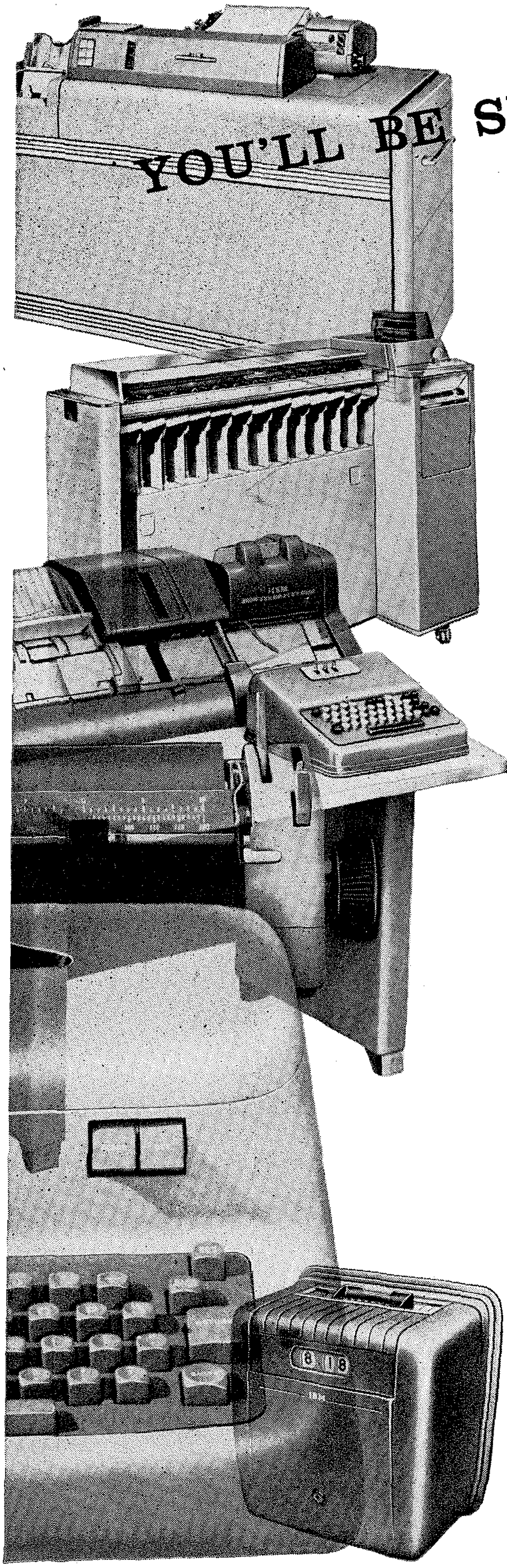

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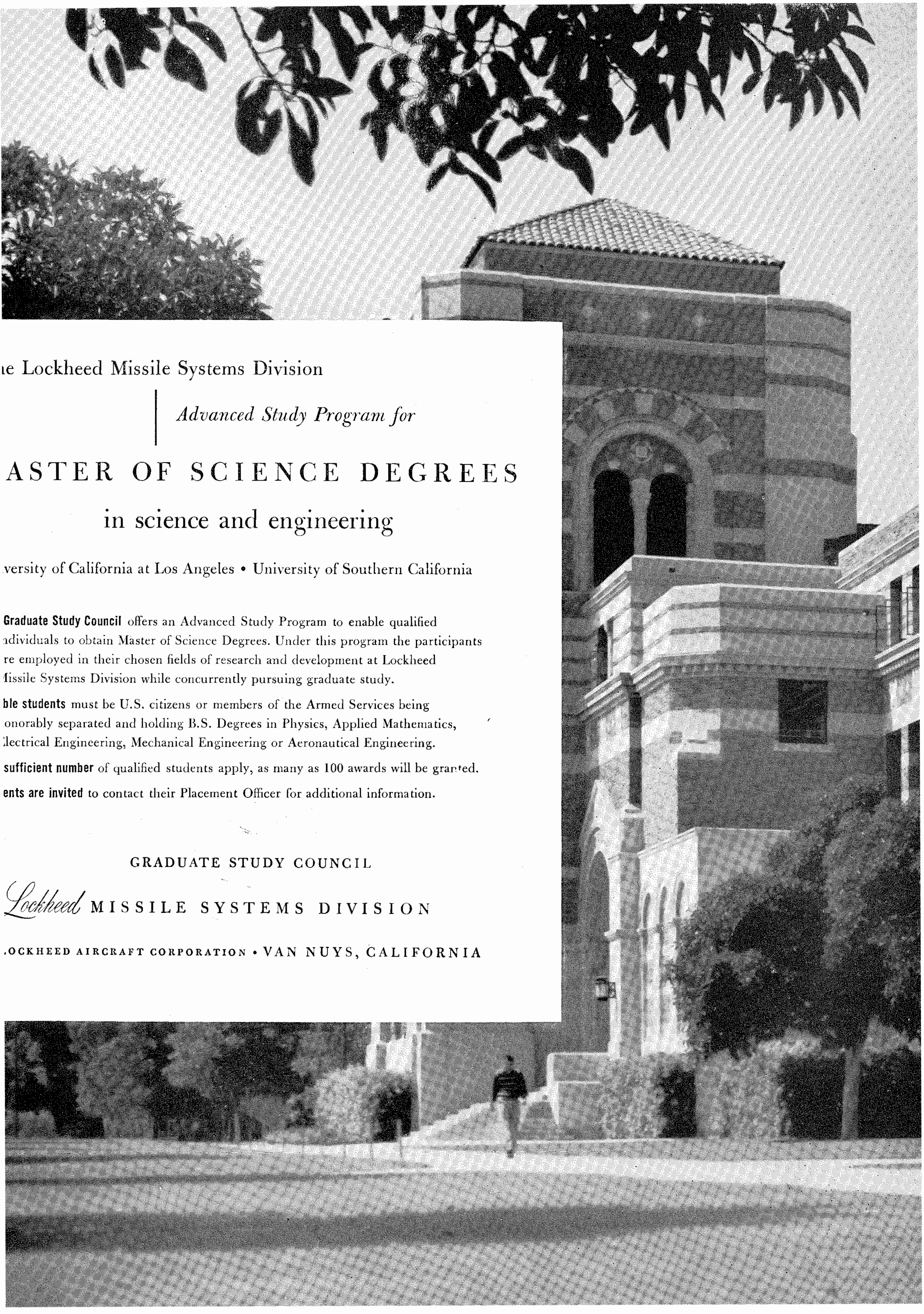
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BOOKS

ELEMENTS OF HYDRAULIC ENGINEERING
By Ray K. Linsley, Jr., and Joseph B. Franzini
McGraw-Hill, New York $9.00

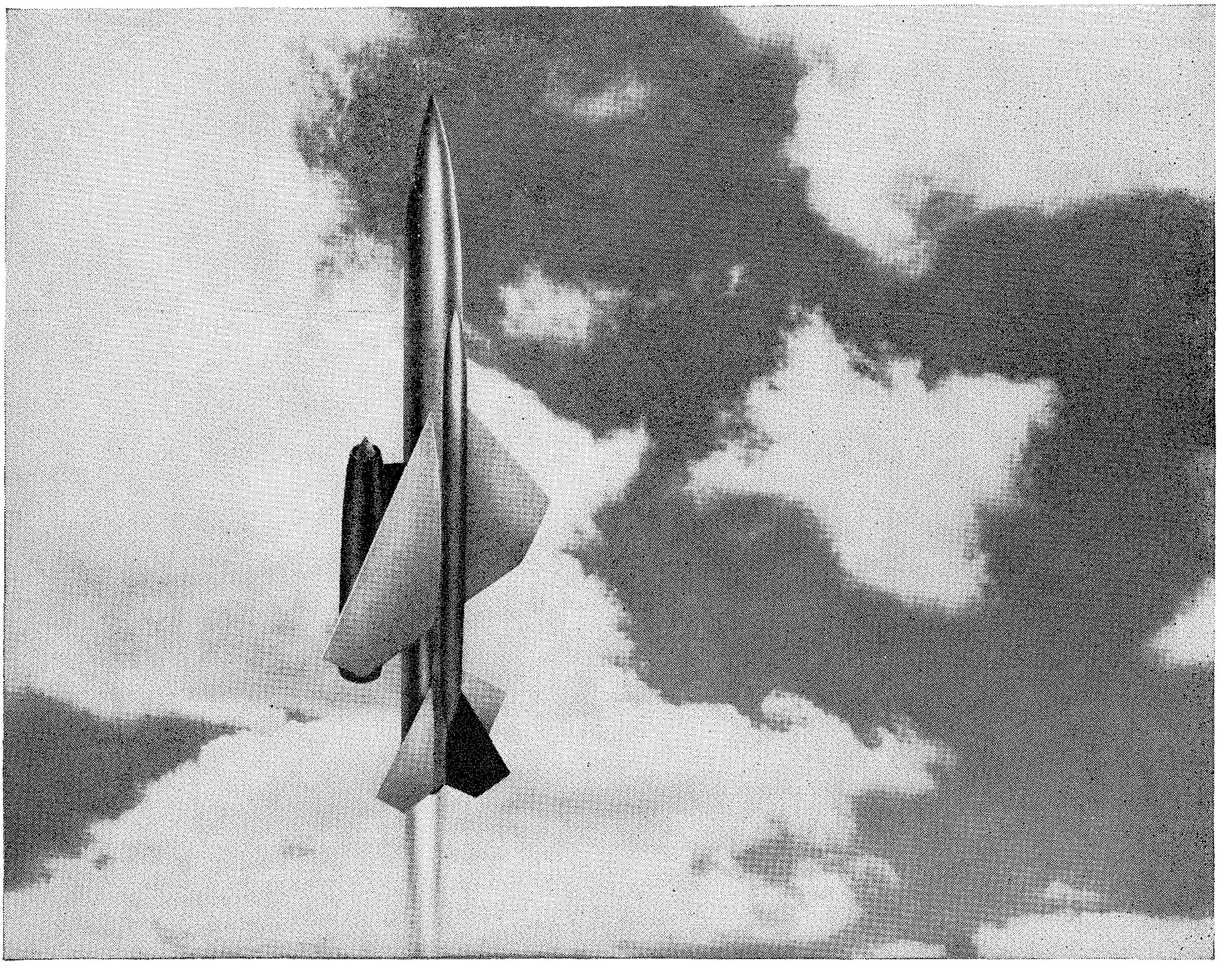
Reviewed by Norman H. Brooks, Asst. Prof. of Civil Engineering

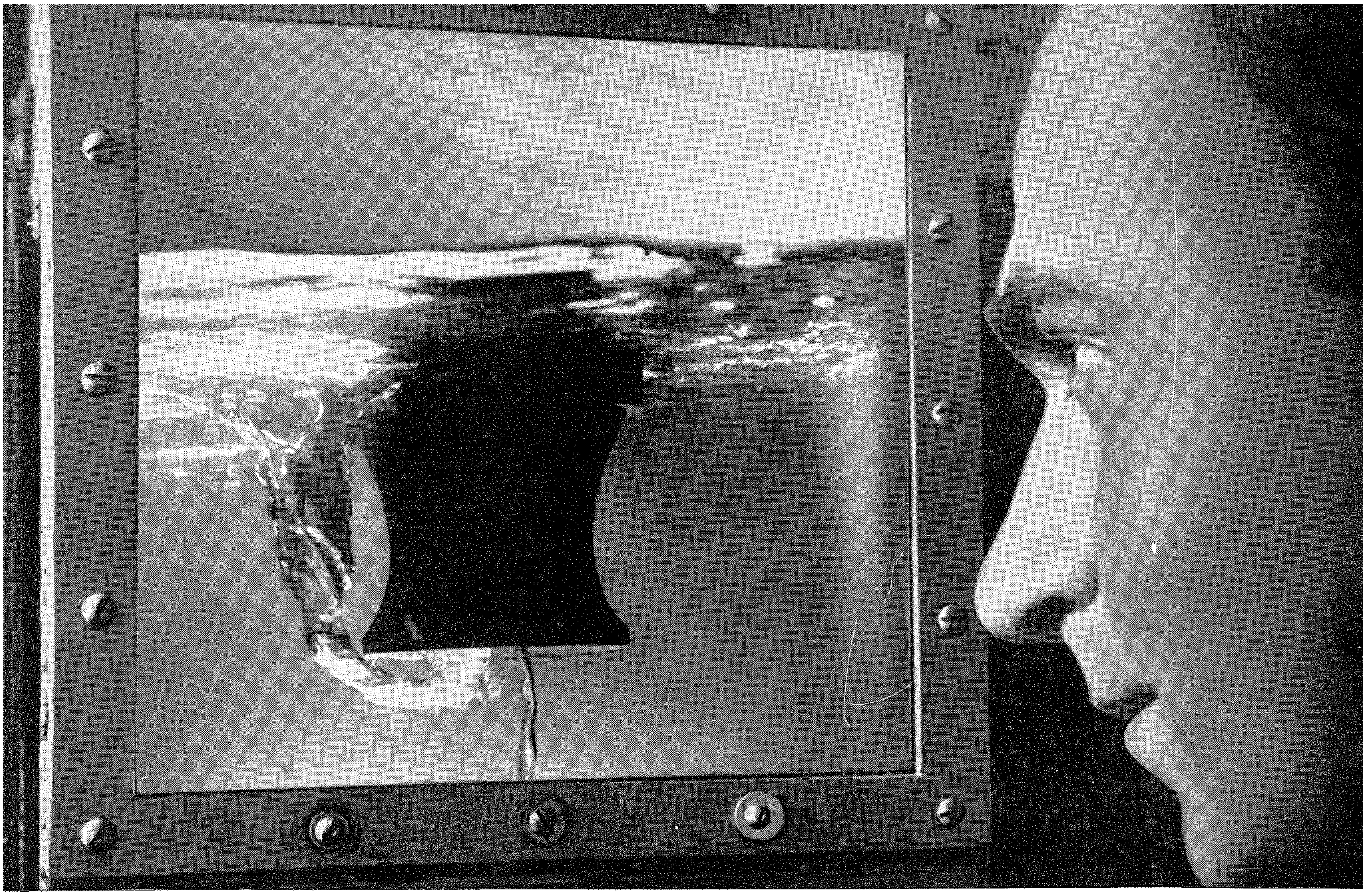
PROFESSORS LINSLEY and Franzini of Stanford have produced an unusual elementary book covering all the principal phases of hydraulics engineering encountered by civil engineers. It is unique in that it attempts to show the common basis of the subjects of irrigation, water supply, hydroelectric power, river navigation, drainage, sewerage and sewage treatment, and flood control—all of which are rarely treated in a single book. It is intended to be a textbook for undergraduates and not a comprehensive reference book for practicing engineers.

The first section of the book deals with the fundamentals of hydrology and water law; the second section includes chapters covering basic hydraulic structures, hydraulic machinery, and economic aspects of hydraulic projects. The third section treats the various hydraulic engineering fields (enumerated above), all of which are based to some extent on the subject matter covered in the first two sections. It is an excellent approach, for the student should learn the fundamentals of all hydraulic engineering before narrowly specializing in irrigation, water supply, or some other specific field. There is no other American textbook with this arrangement of subject matter.

The book is descriptive rather than analytical in nature. Because of its broad scope, none of the subjects is covered thoroughly and the treatment is sometimes superficial and over-simplified. However, numerous references to the literature are included, so that it is not too difficult to find more detailed information. In their efforts to be all-inclusive, the authors are perhaps guilty of trying to include too many topics; for example, the section on stability of slopes could be better left to a soil mechanics textbook.

The readers of this publication will be interested in the fact that the junior author of this fine work is Joseph B. Franzini, a Caltech alumnus, class of '42.





A WHIRLPOOL SPIRALS into the inlet of a model pump. This unique picture shows how air, a common cause of pumping trouble, was carried into the pump in . . .

The Case of the Baffled Whirlpool

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The customer asked us to find the trouble fast. After checking we knew the pumps were okay, so Worthington Research had to answer him.

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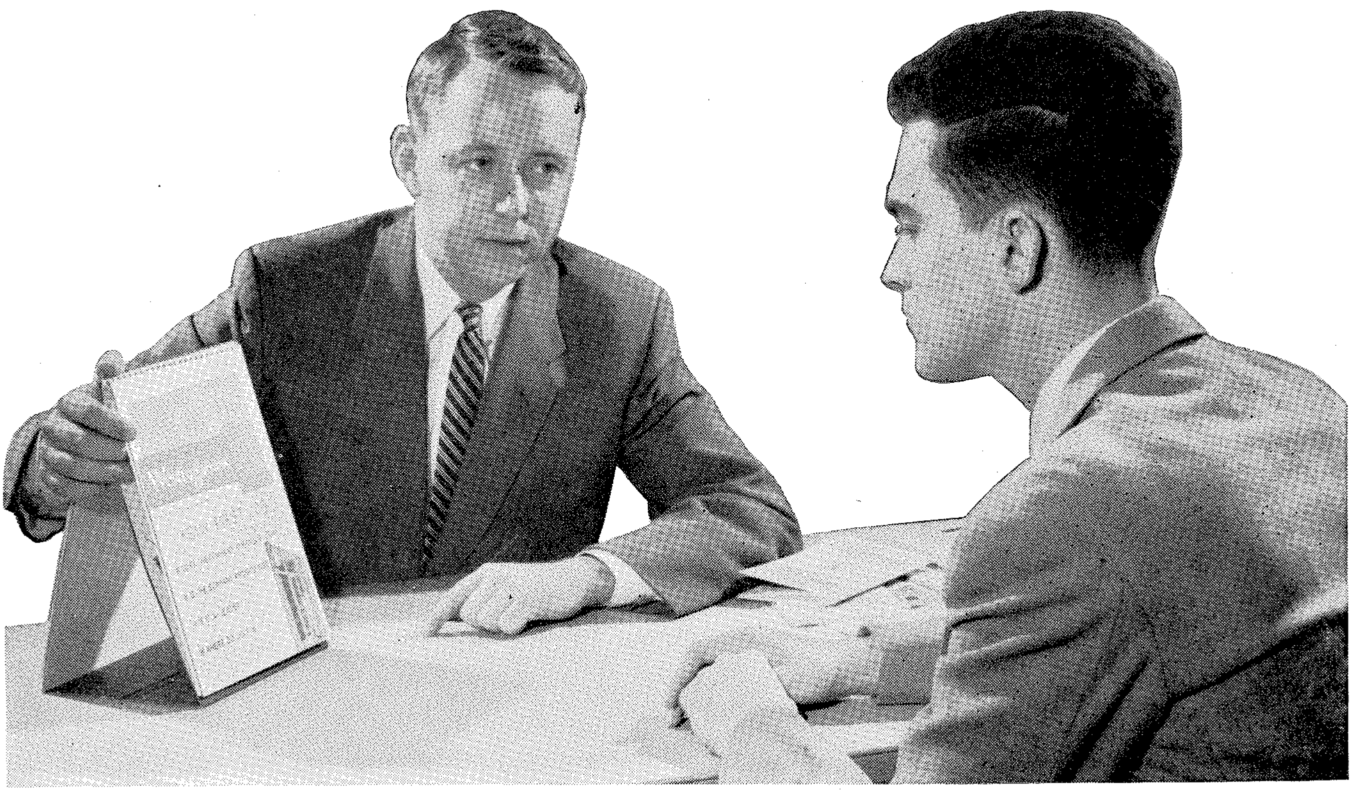

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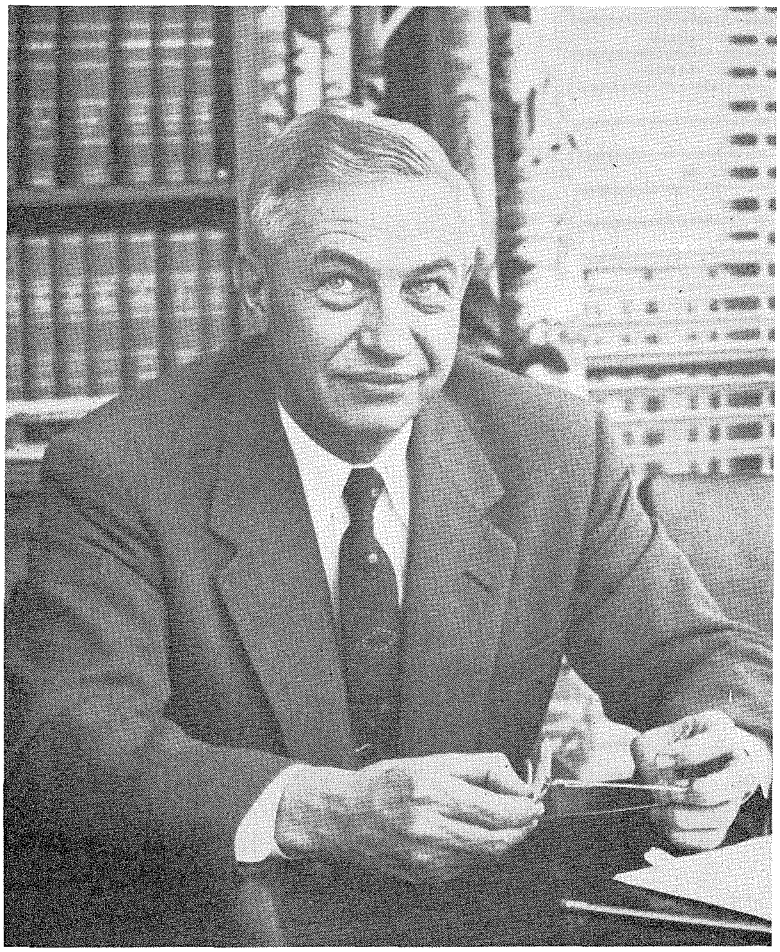


Highlights from Dr. DuBridge's report on the activities of the Institute in 1954-55

THE PRESIDENT'S REPORT

ENROLLMENT FIGURES are not news here at Caltech since we have reached our goal of a stabilized student body of approximately 1000. The undergraduate body numbered 578 in September 1954 and 615 in 1955. It will fluctuate approximately between those limits, depending on cancellations of freshman admissions, academic mortality and transfers to and from other colleges. Graduate enrollment was 429 in 1954 and 420 in 1955.

Although we are fully aware of the flood of young people who will be overtaxing the facilities of American colleges and universities by 1960, the Institute, like many other private institutions, has decided that, in order to maintain high quality instruction and to avoid the frustration of overcrowded laboratories and classrooms, it will maintain a nearly stable enrollment figure.

To enlarge our laboratories and lecture rooms in order to expand the freshman class even only 10 percent above its present limit of 180 would be very difficult. To expand by 20 percent would involve a major construction program. Although we have the problem under study, it now appears wiser for us to devote any building funds we can obtain to creating adequate facilities for a student body of the present size. As has been repeatedly pointed out, our campus is still not complete and we should attain completion before we seek expansion.

The rising flood of college-age students is reflected in the numbers who apply for admission here each fall. Following the veteran flood of 1946-50, the number of applications reached a low point of 407 in 1951. It has since risen steadily. In the fall of 1955, in spite of an increase in tuition from $600 to $750, applicants numbered 1165. It is from that group that we selected 180 freshmen.

The situation has now arisen when we must admit many more students than we can take care of, since only 55 percent of those admitted actually entered this September. The rest chose other institutions. We see no way of avoiding this difficulty, because good students are certain to be admitted to any institution to which they apply; and many unpredictable factors, ranging from family ties and financial developments to competing scholarship offers, will determine the final choice.

The students whom we do admit are mostly among the top 10 percent in the country as judged by the national College Entrance Board examinations; many are within the first 5 percent. They are students that every college would like to admit. (College classrooms may be getting more crowded every year, but there will always be fierce competition among the colleges for that top 5 percent.)

One would think that none of these students would ever fail. The number who do fail here is small in comparison with the average college. But every single failure is something we take very much to heart. Something other than the student's intellectual capacity must have caused it. Was a scientific course not his heart's desire, after all? Did our academic practices fail to challenge or interest him? Did he spend too much time in social life, or in earning his living expenses? We are earnestly trying to understand each case in order to help each individual find the right solution to his problem.

The Dean of Freshmen reports that the freshman class of 1954-55 lost only 9 of its 170 members through academic deficiency—about half the figure for previous classes. If this new low level can be maintained, it will signal a success in our efforts to reduce academic mortality. A more highly organized plan for bringing freshman and faculty members together is credited for a portion of this success.

If our students are so well selected and if they perform so well with such a difficult curriculum, it is natural to be curious about how well they do after graduation. Here we turn with this question to the companies that employ Caltech graduates. There is no mistaking the reply; they want more!

One hundred and twenty prospective employers sent representatives to the campus to interview seniors and graduate students. They conducted 2437 interviews and collectively made from 1 to 13 offers to each student. These figures are, of course, typical of those to be found in any engineering college in these times. But the exceptionally high regard in which Caltech alumni are held by these employers who seek more of the same is a great tribute to the quality of men who have graduated here.

Graduate students

Our graduate students are a cosmopolitan group. Twelve percent received their undergraduate degrees at foreign institutions; 32 percent from American institutions east of the Mississippi; 27 percent from western institutions other than Caltech; and 29 percent from Caltech.

About 200 new graduate students are admitted each year, but this year nearly 3,500 prospective students sent in inquiries—many of whom were discouraged from applying. About 750 applications were finally received.

At the 1955 Commencement we awarded 126 BS degrees and 195 advanced degrees: 101 MS, 19 engineer's degrees (17 AeE and 2 ME) and 75 PhD's. If the past is any guide, some of the leading scientists and engineers of the future are in that group.

It is natural that a much higher proportion of the graduate than undergraduate students receive some form of student aid: scholarships, fellowships, or teaching or research assistantships. The Institute provides tuition scholarships to nearly half (203) of the graduate students, including many of the 197 who also hold assistantships. The Institute also administers 59 fellowship grants from private donors, while many students receive grants directly from both government and private agencies. We are aiming for the situation where no high quality graduate student need terminate his education for lack of opportunity for financial assistance.

Finance

This year was an especially fortunate one financially. Although a substantial excess of expense over income was originally anticipated, we actually ended the fiscal year with a surplus of $24,281. Our endowment income exceeded two million dollars this year, including about $80,000 taken into the income account from the Spalding Trust oil royalties. Gifts for current purposes—exclusive of gifts for endowment or buildings—amounted to $1,445,748, nearly $200,000 more than for the previous year. The total income available to the normal campus programs of instruction and research was $6,500,090, approximately $500,000 greater than the previous year.

Thirty-five companies are now participating in the Industrial Associates program (each at $10,000 per year). Twenty-two of these 35 and also 40 other companies made additional grants for research, for fellowships or for other purposes. This rise of industrial support of higher education and research in recent years is one of the most promising developments insuring the future stability of our private universities and improving the excellence of the public ones.

Research

The completion of the Norman W. Church Laboratory of Chemical Biology will greatly ease the space problem in this field and will expedite many important programs. Within the Church Laboratory, the equipment of a new special laboratory for virus research is already under way and will be completed as soon as funds are found. This will give our important virus program the special facilities it has long needed.

Attention is now focused on the very critical space problem in chemical and electrical engineering. Plans for a new engineering building are now being drawn and funds are being sought with the aim of beginning construction next summer.

The synchrotron has been undergoing the revisions necessary to bring its output of electron energy from 500,000,000 to greater than 1,000,000,000 electron volts. Operation at the new level is expected this fall.

It has become apparent that the time has arrived when the Institute must have on campus a major digital computing laboratory. It is necessary to assist in a variety of computing programs in all the divisions; it is vital as an educational asset and as a tool to prosecute research into the design and use of electronic computing equipment. Funds for this purpose are being sought.

At many points around the Institute research programs of great importance are in progress. About 530 scholarly papers were published this year. The various research-supporting agencies of the Federal Government are contributing about $2,000,000 annually to these research activities. Since these agencies submit all proposed research projects for careful review by leading experts, the many grants and contracts now in force here are an impressive tribute to the quality of the Caltech research program. The very substantial support from private sources—foundations, corporations, and individuals—is an additional tribute.

RESEARCH HIGHLIGHTS

IN THE Annual Report of the Institute, published this month, the various divisions summarize their research activities for the year 1954-55. From these voluminous reports we have extracted the following highlights from each division.

Biology

FROM THE SUBMICROSCOPIC viruses to the largest mammals, every living creature known to man contains, as components indispensable to its structure and function, the two classes of giant molecules known as proteins and nucleic acids. Every living cell in the human body contains myriads of molecules of these types. Proteins come in thousands of varieties. The one found in muscle, for example, is responsible for our movement. Many of our hormones—like ACTH—are protein in nature. The thousands of enzymes that make possible the chemical reactions responsible for life processes are proteins or contain them. Proteins protect us against disease and they are responsible for many of our allergies.

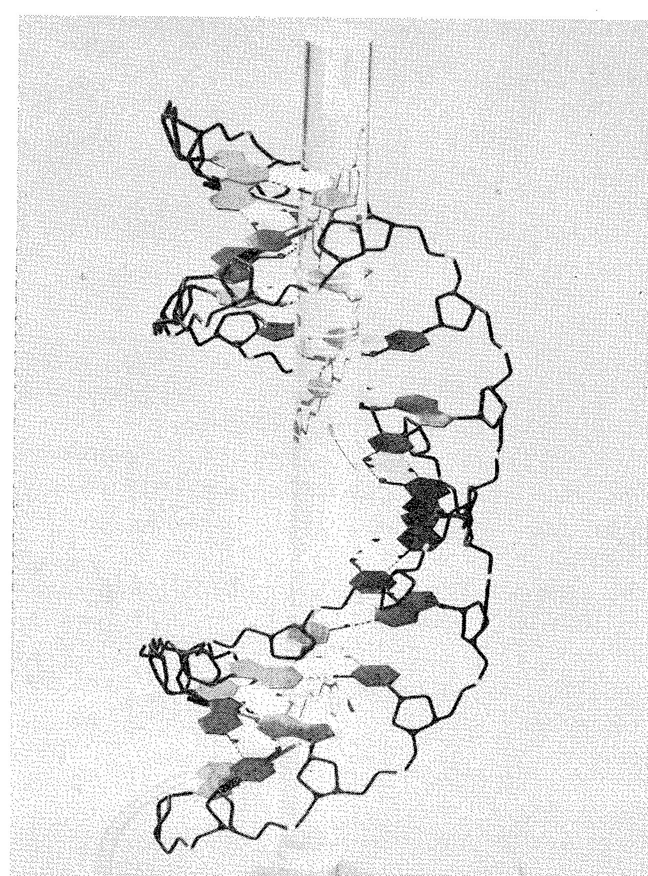
In brief, almost every activity of a living organism is concerned with proteins. Nucleic acids are closely related to proteins. It is natural, therefore, that much of the activity of the Institute's Division of Biology should center around the structures, functions and manner of formation of these remarkable substances.

Members of the Division of Chemistry and Chemical Engineering, as well as those of the Division of Biology, have contributed significantly to our understanding of the structure of proteins. A biologically attractive hypothesis as to the detailed structure of the nucleic acid of hereditary material was formulated at Cambridge University a few years ago. Since then, much attention has been given by Institute workers to problems connected with the reproduction of this type of nucleic acid, and the manner in which it transfers information to a second type of nucleic acid and to cellular proteins.

Molecular structure chemists, biochemists, geneticists, immunologists, and workers in many other related fields are beginning to reach agreement on a working hypothesis as to what these interrelations are and how they are brought about. It is believed by many that units of heredity—genes—contain information in the form of one kind of nucleic acid called DNA.

DNA is thought to be capable of duplicating itself systematically with each cell division, and of serving as a model or template from which a second nucleic acid, known as RNA, is constructed.

RNA, in turn, is believed to serve as a jig or template against which specific proteins are constructed from free amino acid building blocks. On completion of these



A model of the proposed structure for DNA, the nucleic acid of hereditary material.

Bruce H. Sage and William N. Lacey, joint directors of Caltech's chemical engineering laboratory.

specific protein molecules, they are peeled away from the nucleic acid template, and at the same time folded or turned into the shapes characteristic of enzymes and other specific protein molecules.

Wide agreement on a hypothesis of such general significance to biology as this, coupled with many advances in related branches of the field, suggests that the prospects for increasing our understanding of basic life processes have never been brighter.

Chemical Engineering

THE PAST YEAR has seen the essential completion of an extraordinary program of research in the field of chemical engineering—a basic study of the thermodynamic properties of hydrocarbons, which has provided a great amount of fundamental information for the petroleum industry.

Chemical engineering is a complex subject; it incorporates into one field the complexities of both chemistry and engineering, and for this reason many chemical engineering problems have had to be solved in a superficial way. It is clear, however, that these problems should be subjected to fundamental attack, and a program of fundamental research was begun in the Caltech chemical engineering laboratory over twenty-five years ago by Dr. William N. Lacey and Dr. Bruce H. Sage.

This program involved the determination of thermodynamic properties of hydrocarbons. One part of the work was completed sixteen years ago, and summarized in the monograph *Volumetric and Phase Behavior of Hydrocarbons,* by Sage and Lacey, which was published in 1939 by the Stanford University Press. The second, and essentially final stage in this program has now been completed. All of the equilibrium measurements on the volumetric and phase properties of pure hydrocarbons and hydrocarbon mixtures that have been made during the past quarter of a century in the Institute laboratories have now been reduced to a systematic tabular and graphical form, and published by the American Petroleum Institute in two volumes. The second of these two volumes appeared in the spring of 1955, as the book-length monograph, *Some Properties of the Lighter Hydrocarbons, Hydrogen Sulfide, and Carbon Dioxide,* by Sage and Lacey.

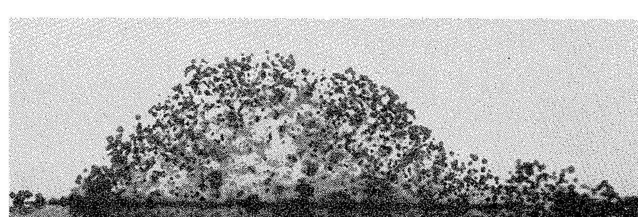
Dr. Lacey, and Dr. Sage, and their associates in chemical engineering have now extended their interests to more complicated properties that do not relate to states of physical and chemical equilibrium; in particular, problems of the transport of momentum, material, and energy in materials in turbulent flow, and the properties of materials, such as diffusion coefficients and thermal conductivities, that depend upon molecular transport.

Another extension of the program of fundamental studies in chemical engineering, in which Dr. William H. Corcoran is especially interested, involves the study of the kinetics of chemical reactions, both at atmospheric pressure and at elevated pressures and temperatures. It is expected that, through investigations along these lines, the workers in chemical engineering at the Institute will be able to make further important contributions to the basic principles of this subject, comparable to those that have been made through the investigations of the thermodynamic properties of hydrocarbon systems.

Engineering

CAVITATION, vapor bubble formation, and collapse due to pressure fluctuations in moving or stationary liquids, has been a subject of continuing interest at the Institute for its hydrodynamic effects and for the material damage which cavitation bubbles cause.

Drs. Albert Ellis, Robert T. Knapp and Milton S. Plesset, in particular, have been concerned with the material damage problems and, through theory and different experimental means, have sought basic under-



Short-exposure photograph taken in the hydrodynamics laboratory shows cavitation bubble at point of collapse.

standing of the mechanism by which cavitation damages materials exposed to its action.

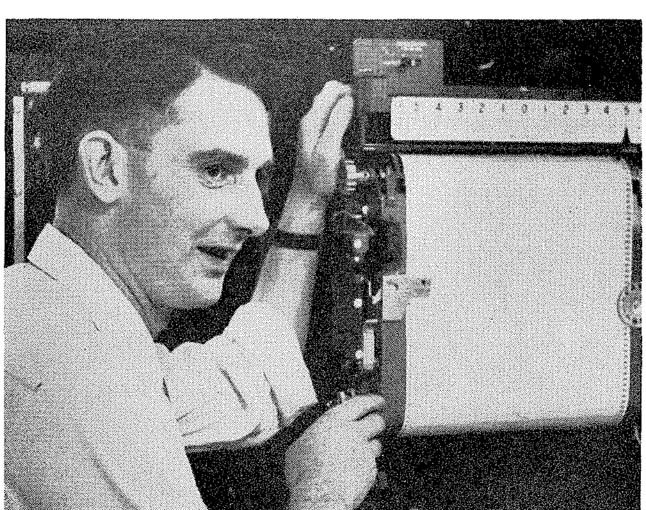
Much evidence points to the collapse of a cavitation bubble at the surface of a test specimen of a material, such as steel, striking an impulsive blow of microscopic size but of high unit stress. Repetitive action of this sort in continuous cavitation appears to be responsible for the surface changes observable by metallurgical and X-ray techniques long before the occurrence of the gross damage characteristic of cavitation in hydraulic machinery. Only recently, through techniques developed by Dr. Ellis, has it been possible to observe in a direct and quantitative manner the collapse of a single microscopic bubble and the impact stress produced in a test specimen.

Dr. Ellis and Dr. George W. Sutton (PhD '53), then a graduate student, developed ultra-high-speed photographic methods using polarized light to show the propagation of stress waves in an impacted plastic piece. These pictures are taken at the rate of approximately one hundred thousand a second and show a sequence of stress patterns from a single impact. By adaptation of these methods to a small cube of plastic about two millimeters on a side, the impact of a single bubble collapse and the stress pattern it produces have now been photographed and the magnitude of the stress determined.

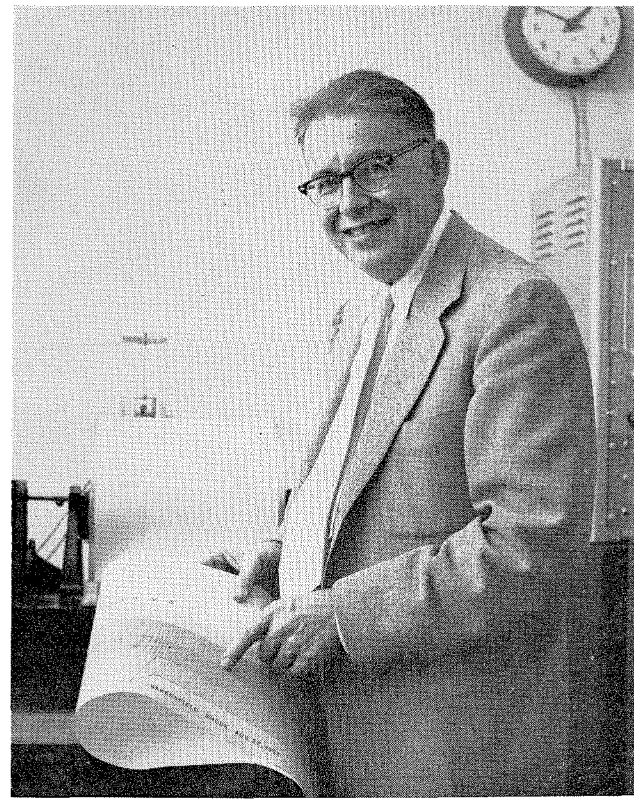
This is a unique accomplishment which is a direct experimental observation of a mechanism which until now has only been inferred from gross behavior. These results should yield new evidence on which to build an understanding of the basic cause of cavitation damage.

Geology

A MAJOR CONTRIBUTION from Caltech's Seismological Laboratory is the magnitude scale now in world-wide use for describing and classifying earthquakes. This scale is based upon empirical relations



John G. Bolton heads up the Institute's new program of research in the field of radio astronomy.



Charles F. Richter checks on the recently revised formulas relating magnitude to energy in earthquakes.

always subject to revision and refinement as more data become available.

A recent revision of the formulas relating magnitude to energy in earthquakes shows that the energy released is many times smaller than earlier calculated. In an earthquake of magnitude 6, for example, the energy released is less than 1 percent of what it was once thought to be. However, even this greatly reduced quantity is more than sufficient to cause widespread disaster. It makes no difference to earthquakes that man in his ignorance has formerly calculated their energy to be much greater than it really is. Earthquakes will go right on creating havoc and destruction until our knowledge is such that we can successfully cope with this menace.

An interesting facet of the new calculations is that they show the energy released by all earthquakes in the world during a single year to be less than the energy represented by the heat conducted to the surface from the interior. In other words, more than sufficient energy to cause all earthquakes exists within the body of the earth.

Physics

IT HAS BEEN KNOWN for some time that radio waves come to the earth from outer space, but recognition of the unusual objects in the sky which are strong sources of radio waves has depended heavily upon cooperation with the staff of the Mt. Wilson and Palomar

Observatories. For several years attempts have been made to establish the origin of strong radio sources.

It has recently become clear that work in the field of radio astronomy will provide additional information to our knowledge of the structure of the universe, and it is toward this end that a program of work in radio astronomy has been started at Caltech. John G. Bolton, who discovered the first six "radio" stars in 1948 while at the Commonwealth Scientific and Industrial Research Organization in Sydney, Australia, will direct the work, which will consist mainly of detailed investigations of the so-called radio stars, including accurate determinations of their positions, angular sizes, radio frequency spectra and, perhaps, distances. In cooperation with the astronomers at Mount Wilson and Palomar, it is hoped to secure further identification of radio stars with visual objects.

Work has already started on the fabrication of electronic receiving equipment and the development of specialized devices. The antenna system is now being designed and will probably consist of two steerable devices about 80 feet in diameter, to be mounted on a system of rail tracks. A search is being made for a suitable location free from radio interference.

Jet Propulsion Laboratory

DURING THE PAST YEAR the story of the Jet Propulsion Laboratory's participation in the development of the Corporal Guided Missile was released by the Army. The Corporal is a long-range supersonic guided missile for use against surface targets. It was announced as the Army's first missile of this type to go into production. It was also announced that Corporal units have been sent to Europe.

The development of the Corporal missile has absorbed approximately half of the Laboratory's effort for the last five years. It has required the Laboratory to carry out an extensive testing program at White Sands Proving Ground and also to establish a rocket motor test facility at Edwards Air Force Base. Much of the growth of the Laboratory during this period has been associated with the Corporal project.

Now that the Corporal is in the hands of the troops, the Laboratory is withdrawing from active participation in the program as rapidly as practicable.

The successful completion of the Corporal is an accomplishment in which the Laboratory can take considerable pride. The Army Ordnance Corps has expressed itself as more than satisfied with the short time scale and modest funds expended by the Laboratory, and with the capabilities of the resulting weapon.

Astronomy

SEVERAL MAJOR PROJECTS were brought to completion at the Mount Wilson and Palomar Observatories during the year 1954-55.

The concept of the expanding universe originated in the announcement by Dr. Edwin P. Hubble, in 1929, of linear relationship between the velocity of recession and the distance of the galaxies. Since that time the observatories have had in progress an extensive program to extend the measurement of velocity and distance to a large number of objects, including several at the extreme limit of observation with the 100-inch and later the 200-inch telescope.

Dr. Milton Humason has now completed the observation of velocities of 620 galaxies and has found velocities ranging up to about 60,000 km/sec or one fifth of the velocity of light. A parallel program, started in 1947 for the photoelectrical determination of the magnitudes of these same galaxies, has also been completed by Dr. Edison Pettit. These velocities and magnitudes provide the observational data for a critical study of the velocity-distance relationship now being carried out by Dr. Humason, Dr. Allan Sandage and Dr. Nicholas Mayall of the Lick Observatory.

A second project has been the establishment of a precise photoelectrically determined magnitude scale. This project, initiated in 1947 by Dr. Joel Stebbin and Dr. A. E. Whitford of the Washburn Observatory, with the 100-inch telescope, has been completed by Dr. William Baum, using the 100-inch and 200-inch telescopes. With the aid of the photon counter, which Baum developed, he has been able to extend the measurements beyond the 23rd magnitude in two selected areas and to the 21st magnitude in six other areas.

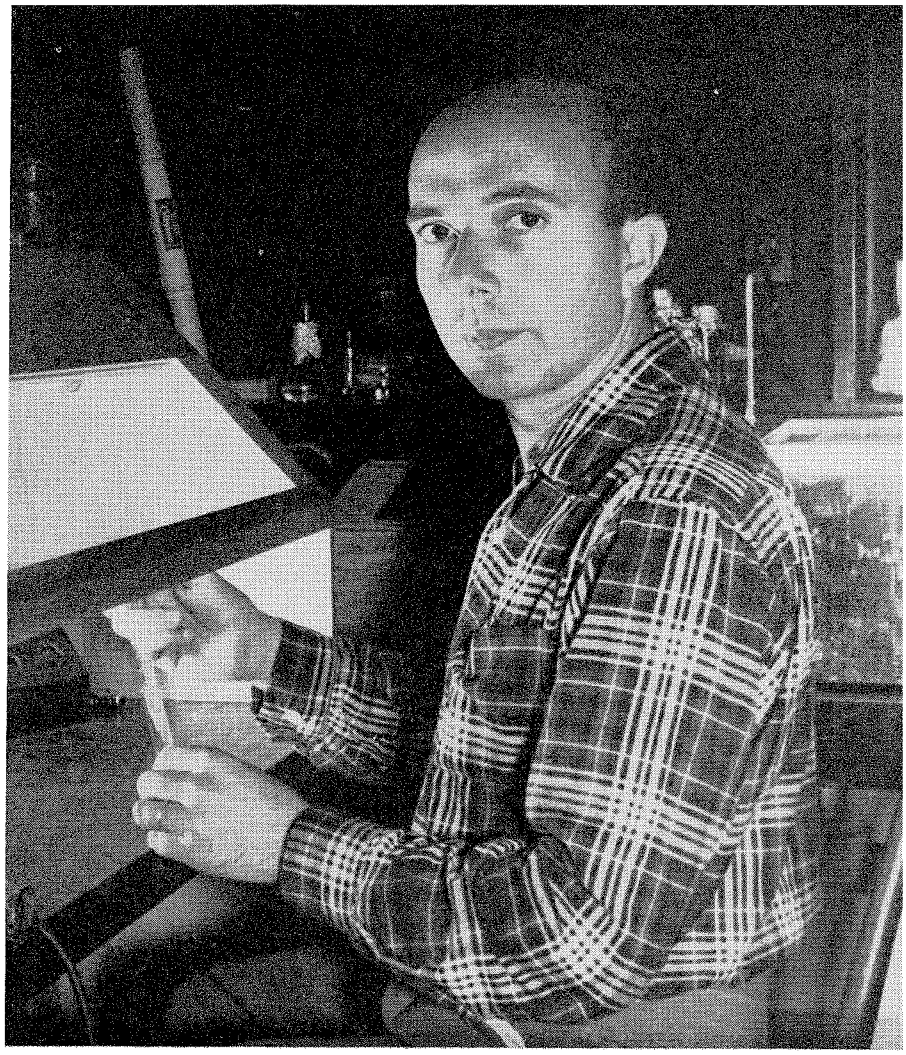
Since the faintest stars that can be photographed with the Hale telescope are of about the 23rd magnitude, this project has made available standards of magnitude extending throughout the range of the instrument. These standards are of great importance to many other projects, since many of these, including "the scale of the universe problem," depend on precise determination of the magnitude of faint objects for their results.

A third major project completed this year has been an investigation of the properties of the stars of the greatest absolute brightness, most of which are variable. For this project Dr. Walter Baade has taken, during the past five years, a long series of plates with the Hale telescope of each of four fields in the Andromeda Nebula. The light curves of approximately 700 very bright variable stars found on these plates have been determined by Dr. Sergei Gaposchking of Harvard College Observatory and Miss Henrietta Swope.

In a parallel investigation, Dr. Halton Arp has obtained a long series of photographs with the 60-inch telescope of several fields of the Andromeda Nebula. In this two-year study, 30 novae were found and their light curves measured. These investigations provide, for the first time, precise information about the properties of these intrinsically very bright stars which are so rare as to prevent satisfactory study in our own galaxy. The results are of great value for other observatory projects since these stars are the indicators used to fix the distances of galaxies and other distant objects.

FACULTY PORTRAIT

RENATO DULBECCO



A versatile virus man

RENATO DULBECCO, Caltech Professor of Biology, is a man who apparently believes that there is no such thing as a thing that can't be done. In fact, he'll do it himself, if necessary. Which helps to account for the fact that, to date, he has become an accomplished plumber, mathematician, physician, carpenter, pianist, dentist and photographer—among other things.

These, of course, are merely sidelines. ("Hobbies" is too flabby a word to describe most of these activities—particularly as practiced by Dulbecco). His chief professional interest is in animal viruses—the viruses responsible for such diseases as influenza, polio, shingles and smallpox. He is in charge of animal virus research at Caltech, and his contributions to the field have not only speeded up this research enormously—they have even revolutionized it.

Renato Dulbecco was born on February 22, 1914, in Catanzaro, Italy, and grew up in Imperia, on the Mediterranean near the French border, where his father was a civil engineer.

At 16, he entered medical school at the University of Turin, and received his MD degree in 1936, at the age of 22. After graduation, he was obliged to serve a year and a half in the Army, and in 1938 he returned to the University as an assistant professor in the department of pathology.

His work was going well, and his future seemed secure, so, in 1939, he was married to Giuseppina Salvo, a girl from his home town. Ten days later Italy declared war.

For four years Dulbecco served as a medical officer in the Italian Army. He spent eight months with the Italian troops in Russia, and there, fortunately, he suffered a broken shoulder and was sent home—fortunately, because his regiment was later wiped out at Stalingrad.

In 1943 Dulbecco packed up his family (there were two children now—Piero, 2, and Maria, just a few months old) and moved to Piemonte, an out-of-the-way village not far from Turin. The town had no doctor at the moment, so Dulbecco set up as a general practitioner, serving all the health needs of the grateful villagers—both medical and dental.

It was typical of the man that, though he knew nothing whatever about dentistry, when he found that the villagers needed a dentist, he studied and read and learned—and became an excellent one.

In 1945, when the war ended, Dulbecco was at last free to return to his scientific work. Professionally, he had lost six years, and he promptly began to make up for them. Even today he sometimes works at such a clip that he seems to be *still* making up for them.

Uncertain, now, of what kind of scientific work he wanted to do, he returned to the University again and spent two years on the study of physics. During this time, because of his medical background, he became interested in the action of radiation on cells, and he began to study more about this, using some of the techniques he had learned in experimental embryology.

Bacterial viruses

S. E. Luria, at Indiana University, was making studies at this same time of the action of radiation on bacteriophage, the viruses found in the human body which attack bacteria. Hearing of Dulbecco's work, he offered the young man a job as research associate in Indiana's department of bacteriology. The salary was too small to support a family on, but Dulbecco was anxious to work with Luria, so he came to America alone, leaving his family in Turin. After a year, his wife and children joined him in this country.

At Indiana, while studying the action of radiation on biological material, Dulbecco made the accidental discovery that bacterial viruses which had been inactivated, or killed, by ultraviolet light could be reactivated by ordinary white light after 24 hours or more. Though he was interested in this merely as a piece of basic research, it did have possible practical applications, for anything that could be learned about how to correct radiation damage might reveal something about what causes it in the first place.

Animal viruses

In 1949 Dulbecco came to Caltech as a Senior Research Fellow in Biology. Shortly after his arrival, the James G. Boswell Foundation sponsored an international virus conference here, at which, for the first time, scientists working on the three different groups of viruses—those which attack plants, those which attack man and animals, and those which attack bacteria—got together to discuss their research in progress.

The two most important facts that Dulbecco carried away from this conference were (1) that very little was known about some aspects of animal viruses, and (2) that Caltech had a fund for virus research.

Dulbecco knew no more about animal viruses than he had once known about dentistry, but he determined to work in this field. To familiarize himself with it, he had himself assigned a review of the field for the *Physiological Reviews.* He visited every animal virus lab he could get to, and read everything that had ever been written about animal viruses in the three languages he could understand. At the end of six months he not only wrote a respectable review, but he had compiled an index on animal viruses that would shame an IBM machine, and — not all incidentally — he had learned almost as much about animal viruses as a lot of the men who had been working in this field all their lives.

For many years viruses had been studied chemically and medically, but never very much biologically—until E. L. Ellis and Max Delbruck began working with bacterial viruses at Caltech 18 years ago. Dulbecco carried over this biological viewpoint to the study of animal viruses, and developed techniques which made it possible, for the first time, to make quantitative studies of them. Like Delbruck, who was trained as a physicist, and Ellis, a chemical engineer, Dulbecco was able to make an important contribution to virus research largely because he was trained in a different discipline, and so was unaware of the things that supposedly could not be done in this field.

Since viruses only grow in living cells, not much was known of the viruses that attack animals. Research was done primarily by infecting monkeys or chicken embryos with a virus, then observing the effect on the animal as a whole. The problem was to find an adequate way of studying the growth of a virus on animal tissue directly.

A practical technique

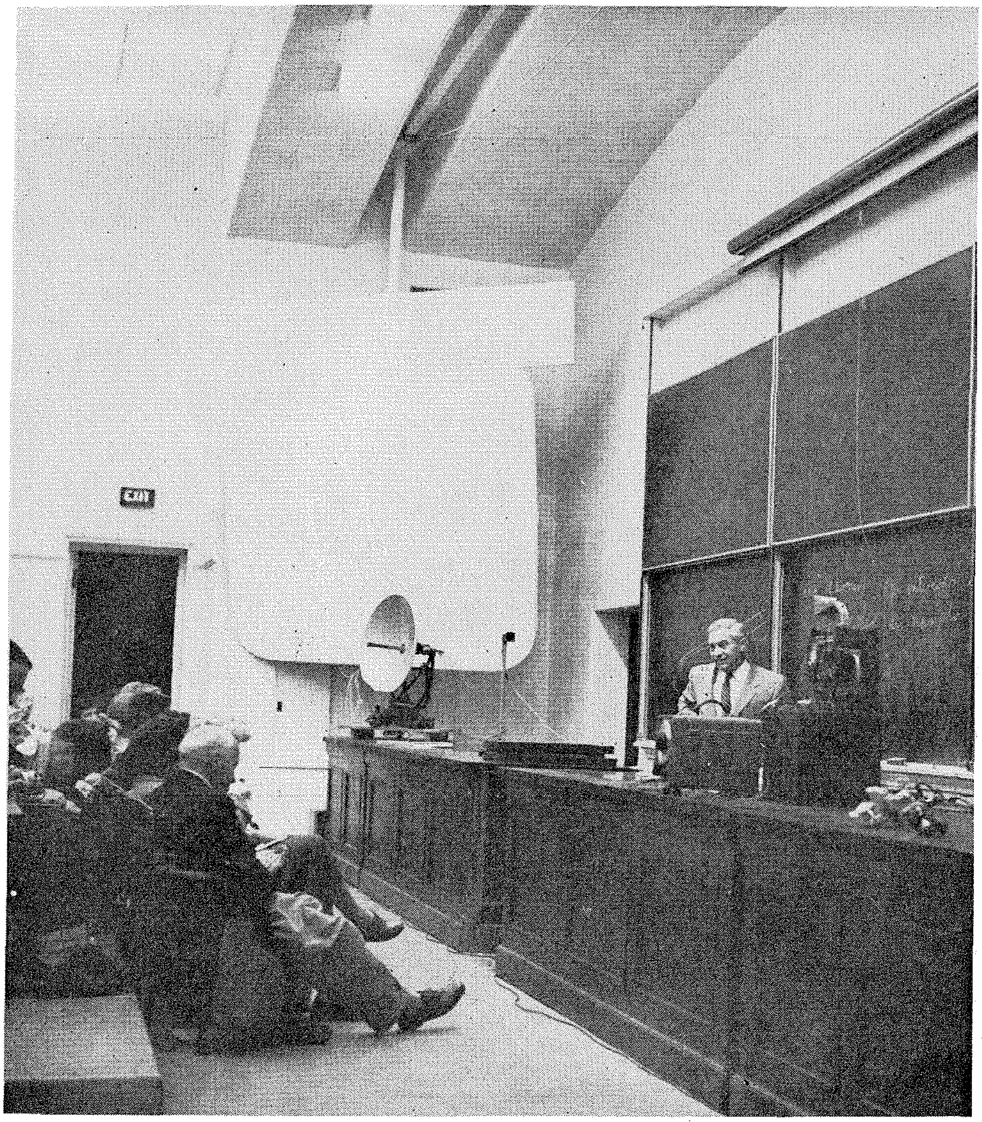
Despite steady skepticism from many of the pros in the field, Dulbecco quickly came up with a practical technique — adapted from methods used in studying bacterial viruses—for studying animal viruses. Working with the western equine encephalomyelitis virus (which causes horse sleeping sickness; though it is of no great medical significance, it is nevertheless a good research tool), he grew a single layer of animal tissue cells in a nutrient medium. A weak suspension of virus particles was then introduced into this, and, as the virus particles attacked the tissue cells, they multiplied and produced small visible areas of dead cells, known as plaques. In this way it became practicable to study the precise effects of a virus on a cell.

Research results

It was definitely established, for example, that infection in an animal, or human, can be produced by a *single* virus particle. Working with the polio virus (also an excellent research tool) Caltech researchers were able to isolate, for the first time, genetically pure strains of the three known types of polio virus, making it possible to start intensive studies of the development and hereditary properties of that virus.

Work is also now in progress at Caltech on a second group of animal viruses, which, instead of growing in a cell and eventually destroying it—as the polio virus does—induce it to grow tumors and stimulate it to multiply.

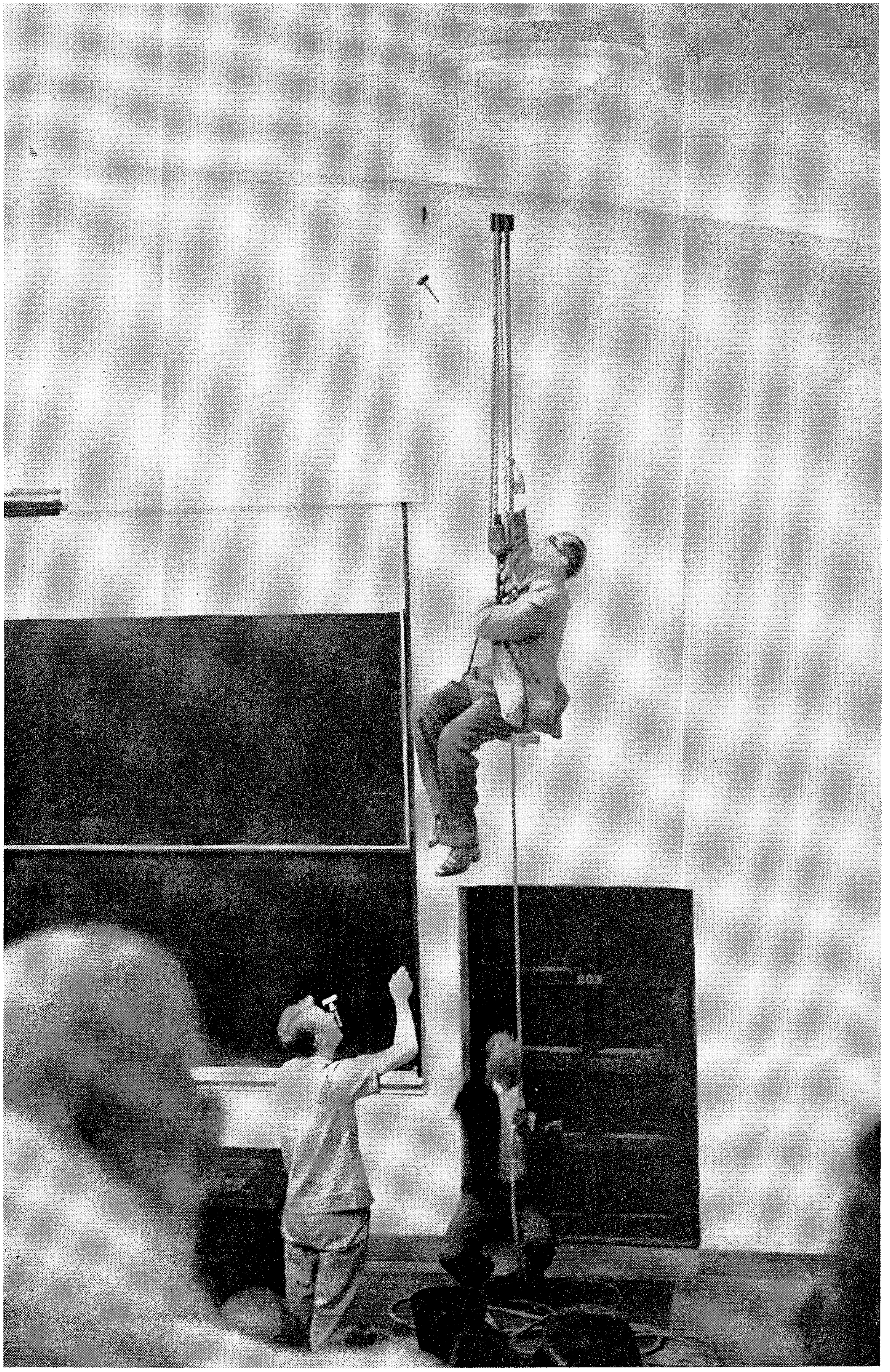
This research is supported by both the National Foundation for Infantile Paralysis and the American Cancer Society, not because any immediate, practical results are expected, but because it is work which may shed light on one of the most fundamental problems of biology. The more we can find out about how a virus grows in a cell, the closer we may come to understand how the cell works.



President L. A. DuBridge gives a demonstration lecture on Radar in Peace and War

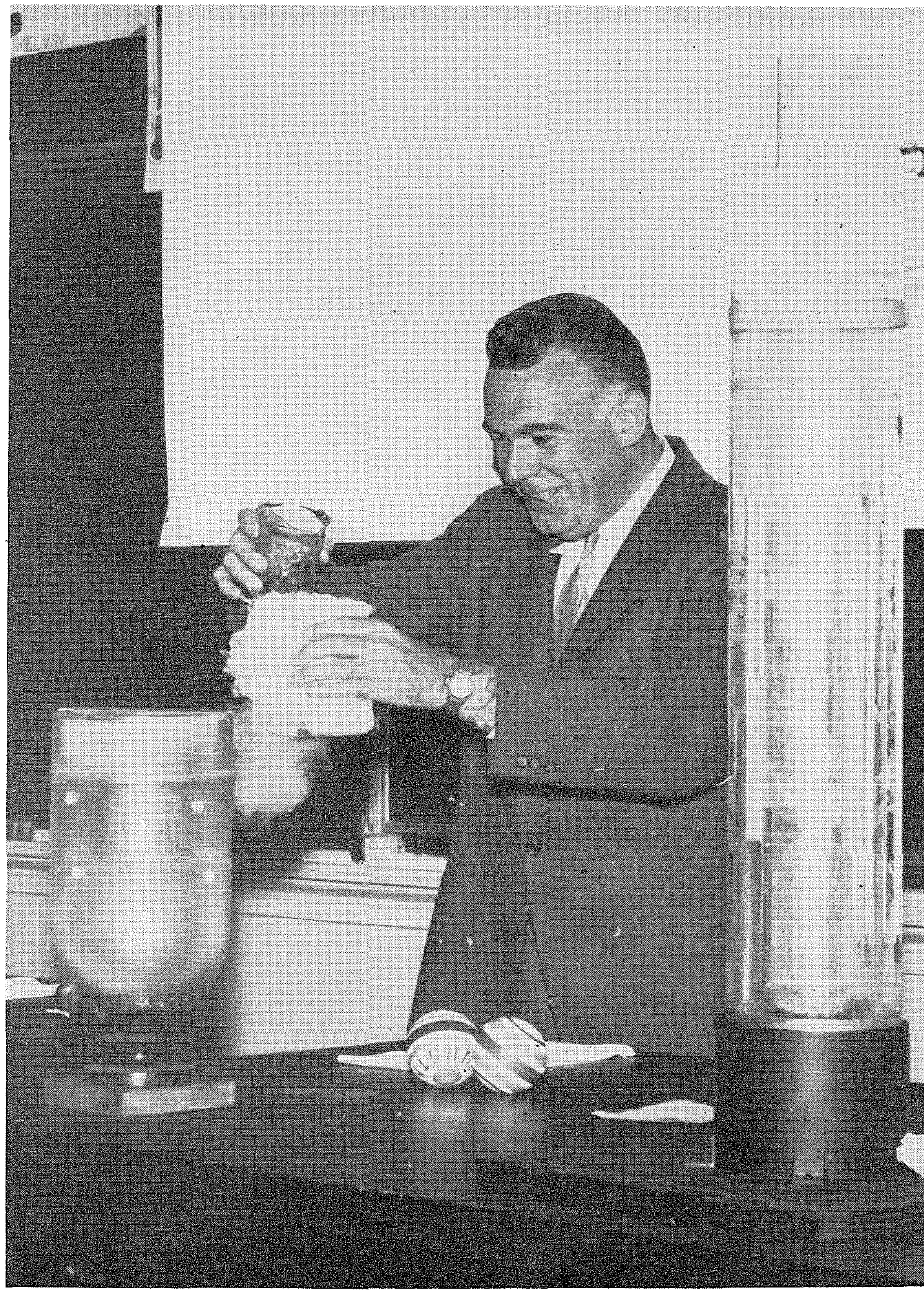
DEMONSTRATION LECTURES

More than 30 years ago Caltech launched a temporary series of lectures on science for the public. It's still going strong today.



Left — Foster Strong, Dean of Freshmen and Assistant Professor of Physics, demonstrates a pulley system in which one of the weights falls with an acceleration greater than that of gravity. No one ever believes it can be done until they see Dean Strong do it, so he makes this trip annually.

Right — John R. Pellam, Professor of Physics, enthusiastically pours below-freezing helium into liquid nitrogen in his demonstration of Phenomena at Absolute Zero.



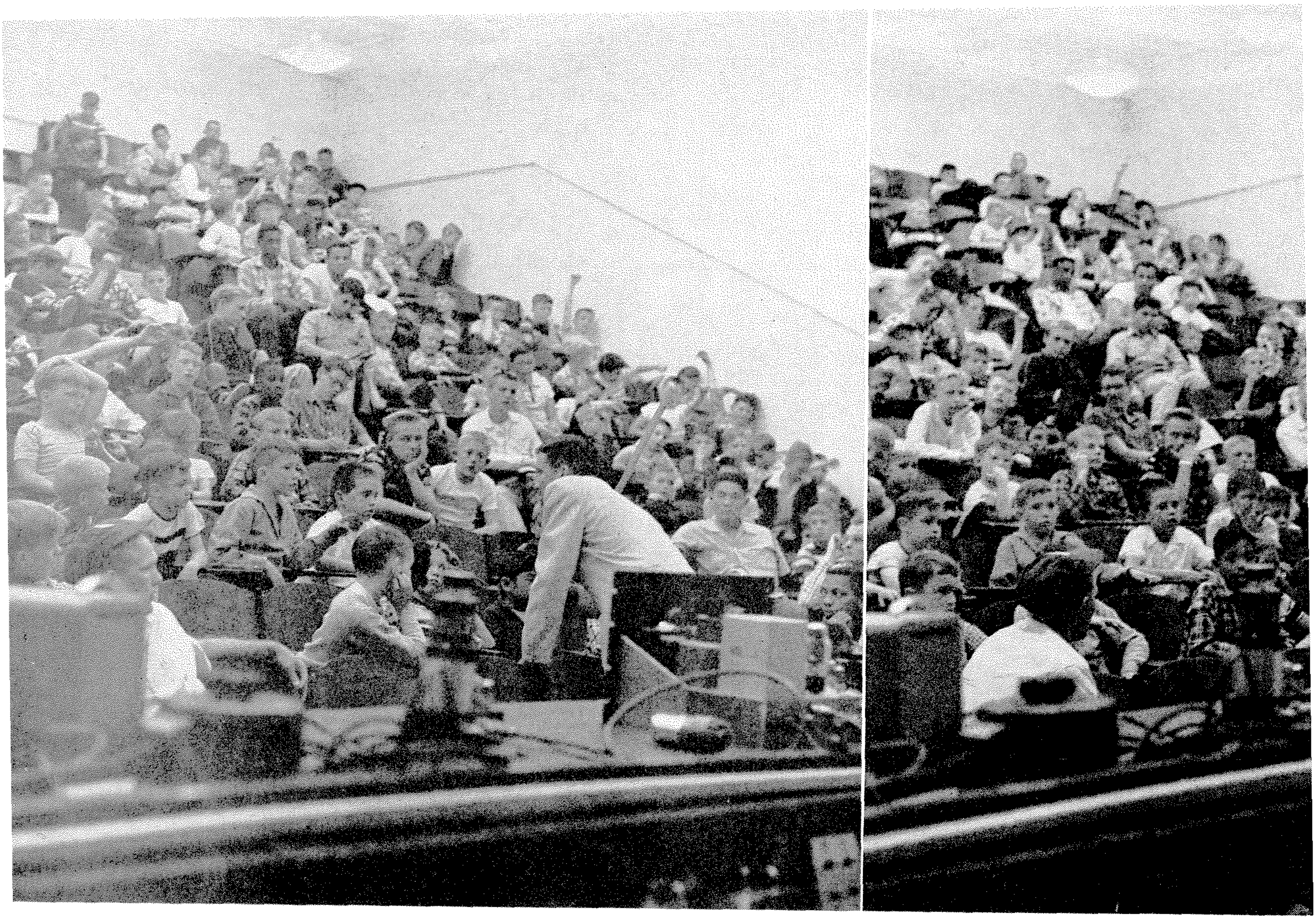
IN 1929 the Caltech physics courses were being revised, and it was decided to start a series of weekly demonstration lectures to give students contact with the principal professors in the department.

The lectures were so successful that, when the Norman Bridge Laboratory of Physics was built, it included special facilities for demonstration lectures. Soon after Bridge was opened, a number of high school teachers came to the Institute to ask for help in keeping up to date on new developments in physics. To accommodate the teachers, the physics demonstration lectures were repeated on Friday evenings, and opened to the public.

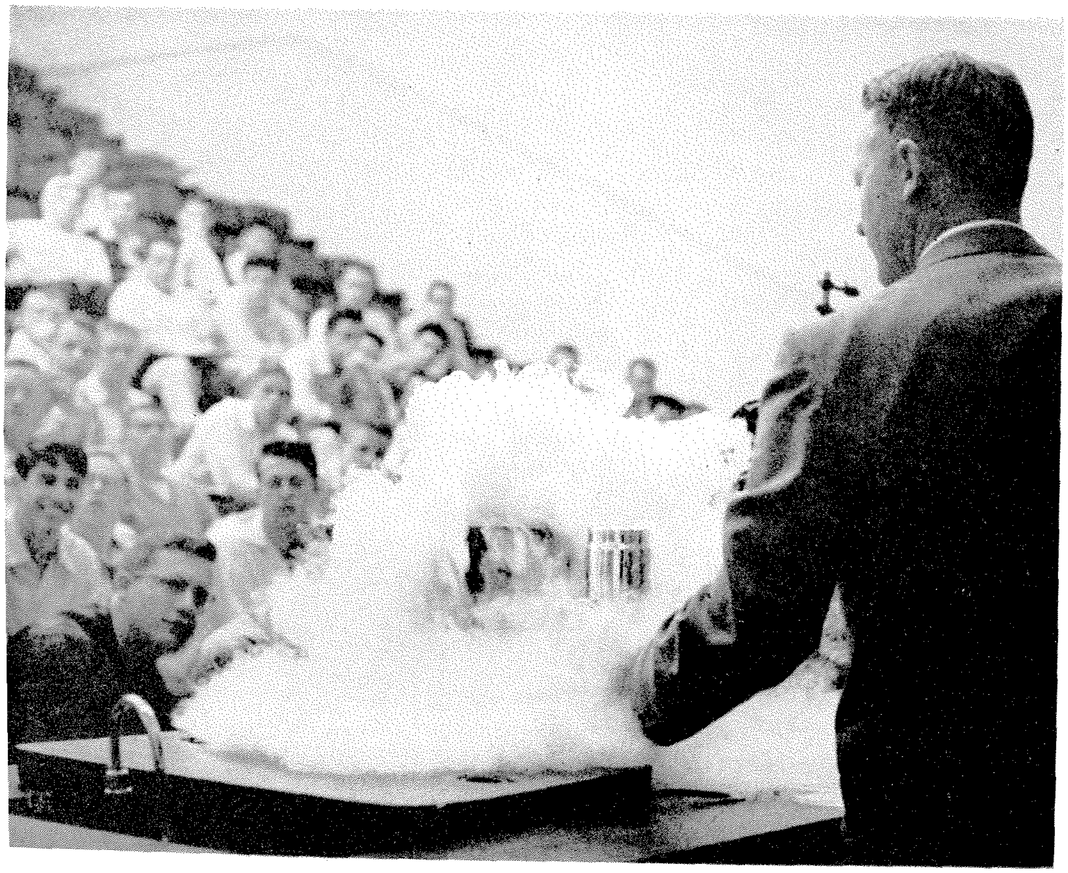
The Friday Evening Demonstration Lectures were expected to run for one year, but the public response was so phenomenal that they are still going on today, more than 30 years later. At the start, the lectures were all concerned with physics. Gradually the base was broadened, though, until the lectures now deal with all branches of science and engineering.

Audiences for the lectures come from all over southern California. Aside from the general public, there is always a scattering of students from junior colleges, high schools and even elementary schools, and the lectures have proved so valuable to teachers that the Los Angeles County Board of Education gives official credit to teachers for attending them.

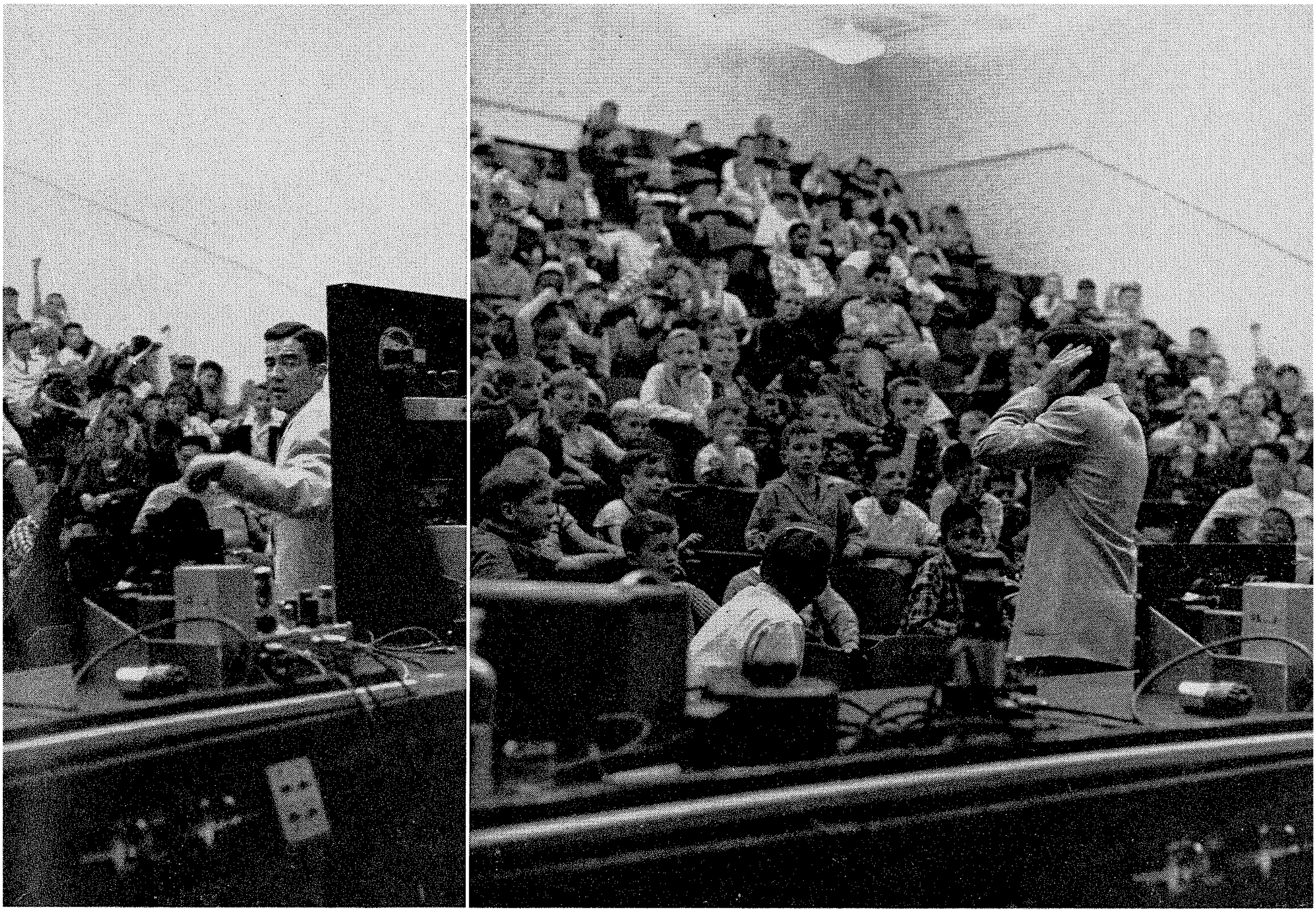
Most of the pictures on these pages were taken during the Friday evening lectures; some when these same demonstration lectures were previewed before freshman and sophomore physics classes at Caltech.



Ward Whaling, Assistant Professor of Physics, demonstrating the use of the Geiger counter t

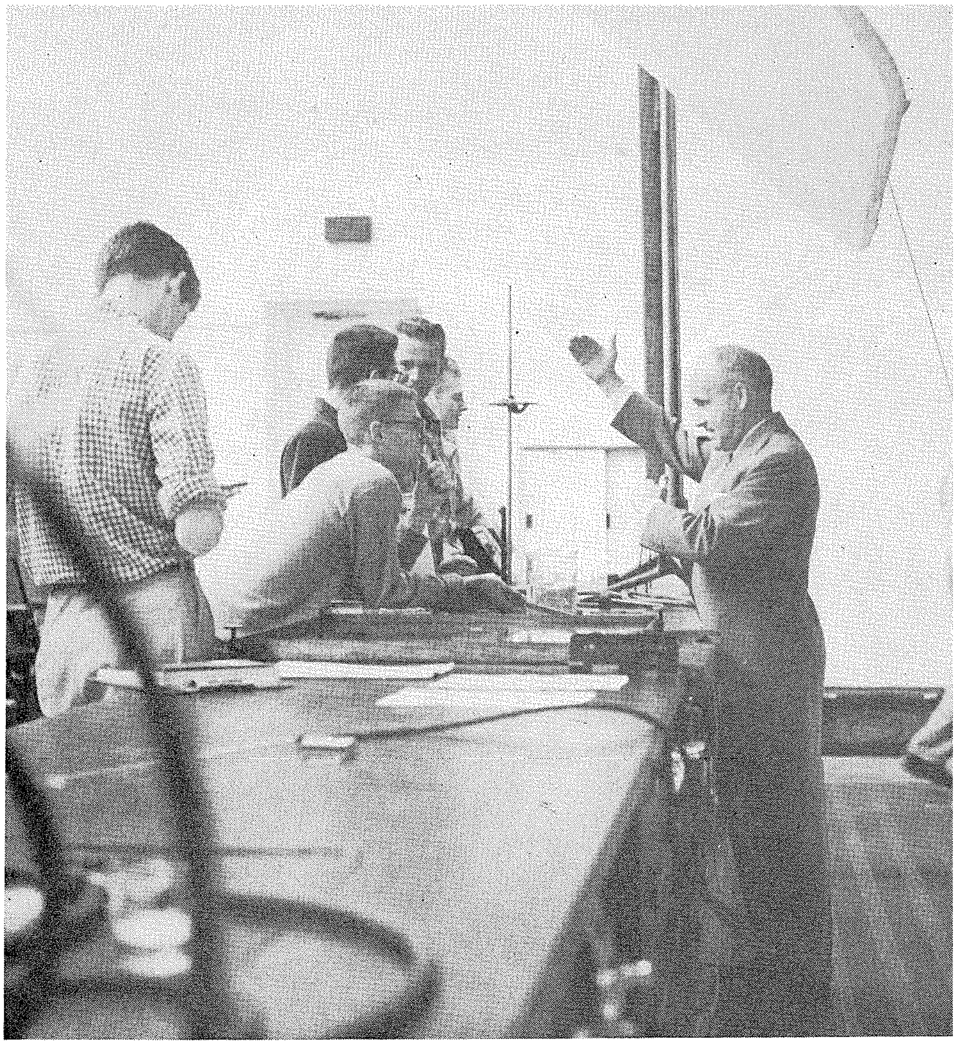


Victor Neher, Professor of Physics, demonstrates a change of state of matter as he mixes liquid air and alcohol.

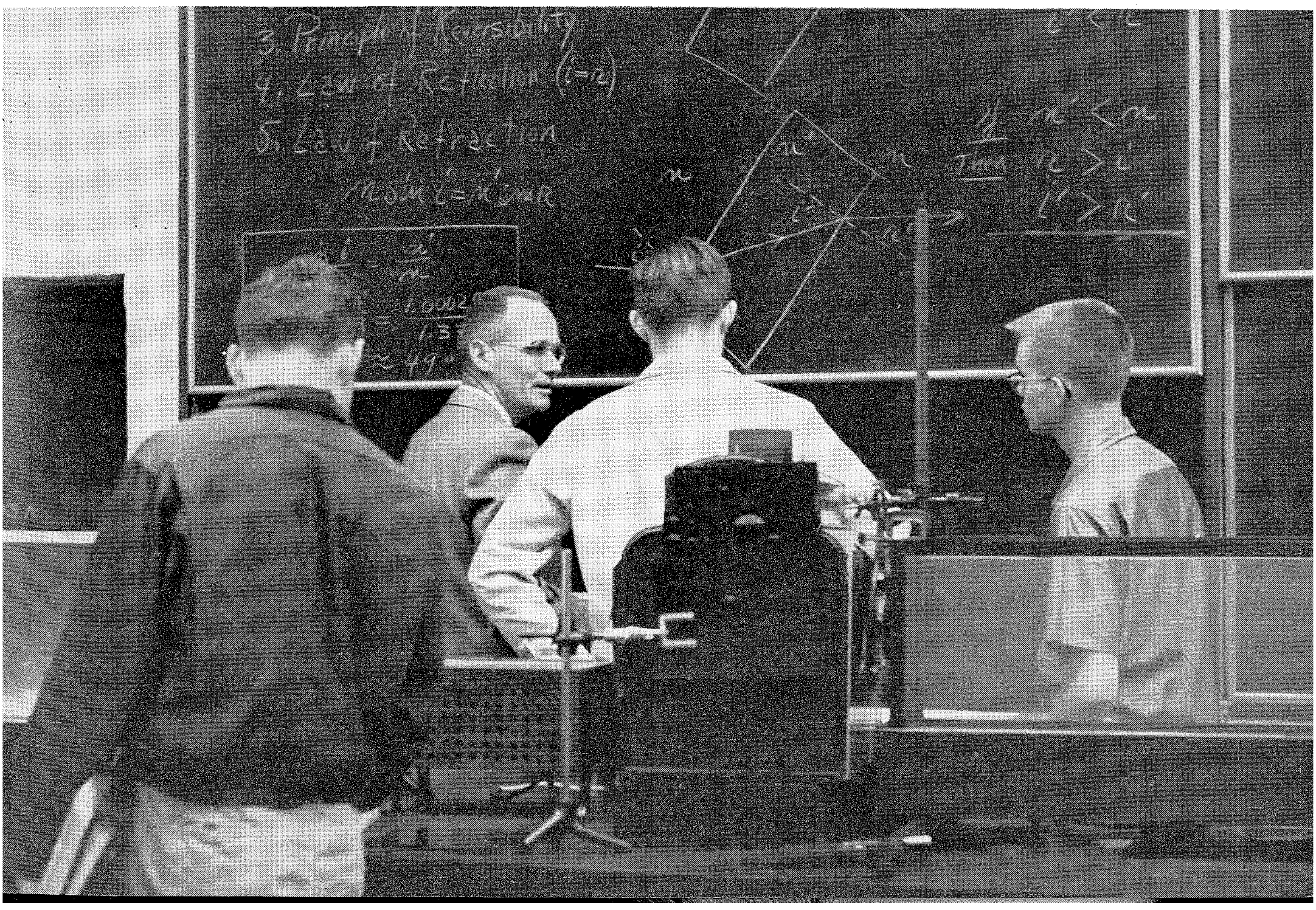


an audience of grade school boys, asks for questions from the floor—and lives to regret it.

Arthur Galston, Assistant Professor of Biology (now at Yale) answers questions after his demonstration of Day Length in Plants.



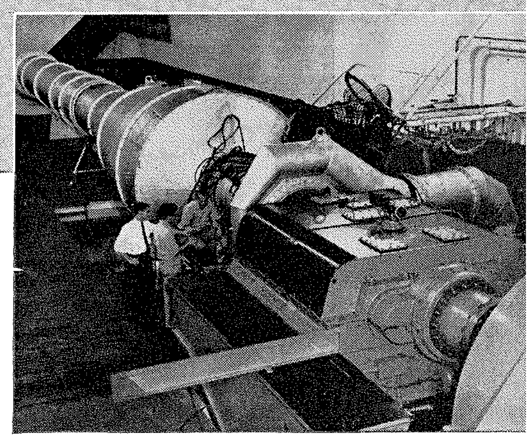
When Earnest Watson, Dean of the Faculty and Professor of Physics, talks on the Nature of Sound, half his audience comes back for more when it's over.



Robert B. King, Professor of Physics, goes deeper into the mysteries of Geometrical Optics after his demonstration.

it takes many engineering skills

McDonnell "Voodoo", *the most powerful jet fighter ever built in America.*



MECHANICAL ENGINEERS are concerned with many phases including experimental testing and development, mechanical design, stress and vibration analysis, combustion research, heat transfer and nuclear reactor development.

J-57 POWERED AIRCRAFT

MILITARY

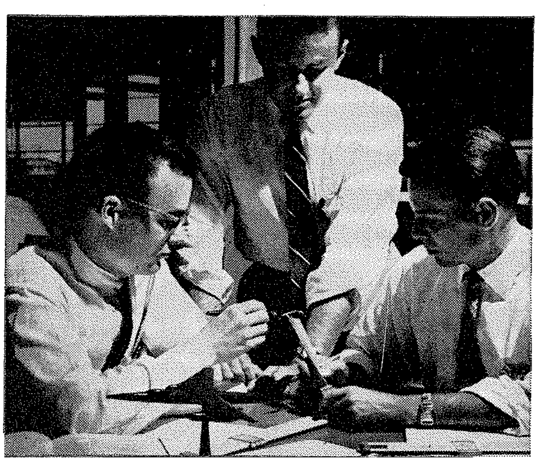
F-100	F8U
F-101	A3D
F-102	B-52
F4D	KC-135

COMMERCIAL

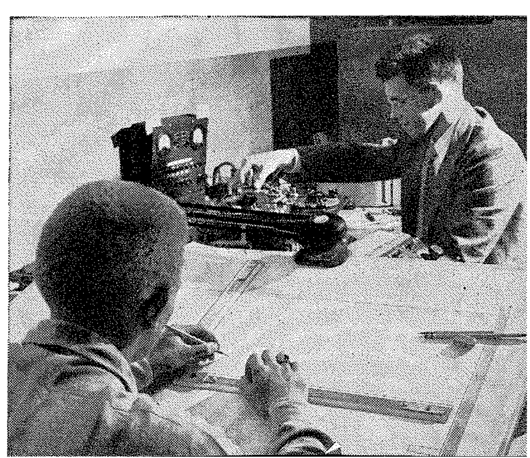
Boeing 707

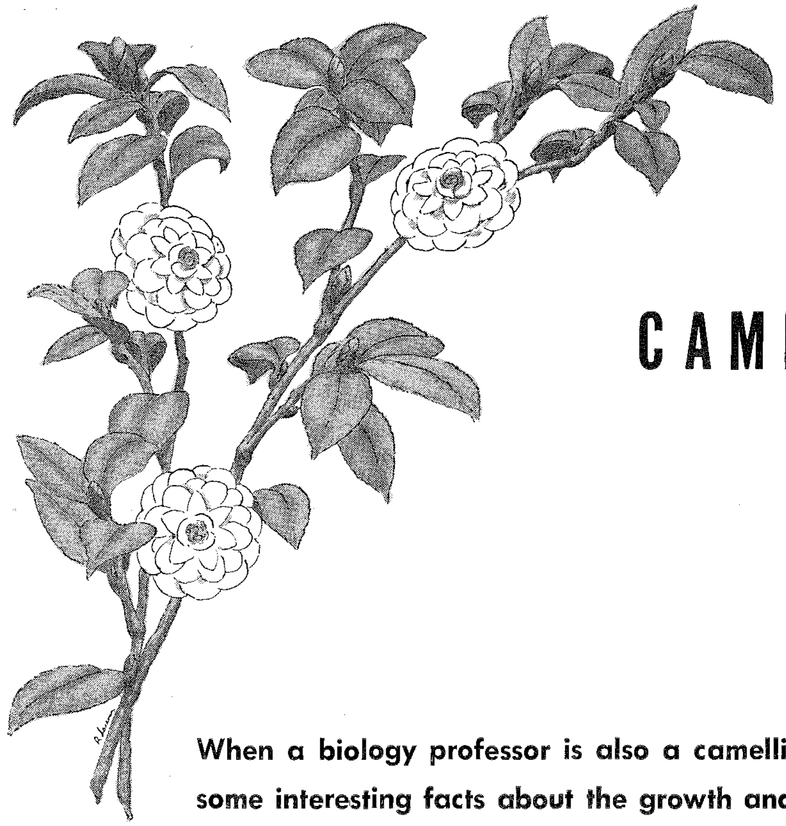
Douglas DC-8

AERONAUTICAL ENGINEERS work on innumerable internal and external airflow problems concerned with design, development and testing of aircraft powerplants. Some who specialize in analytical engineering forecast engine-airplane combinations a decade in advance of design.



ELECTRICAL ENGINEERS directly contribute their specialized skills to the analysis and development of controls, systems and special instrumentation. An example is the "Plotto-mat" which automatically integrates and plots pressures, temperatures and air angles in performance testing.





CAMELLIA RESEARCH

by JAMES F. BONNER

When a biology professor is also a camellia lover, he's bound to turn up some interesting facts about the growth and flowering of this popular plant

THE CAMELLIA is one of our most beautiful and most appreciated ornamental plants. Since it is a native of warm temperate regions (southern China), it cannot be grown in all parts of our country, but it does thrive throughout a wide arc, extending from Washington, D.C., south through Georgia and Florida, west along the Gulf Coast and north along the Pacific Coast as far as Seattle.

The large size and sturdiness and freedom from pests of the camellia shrub have combined to make it a favorite of gardeners throughout this region. The enthusiasm of camellia fanciers for the flower of their choice has led them to form societies dedicated to the advancement of camellia lore, as biologists and chemists band together for the advancement of their chosen disciplines.

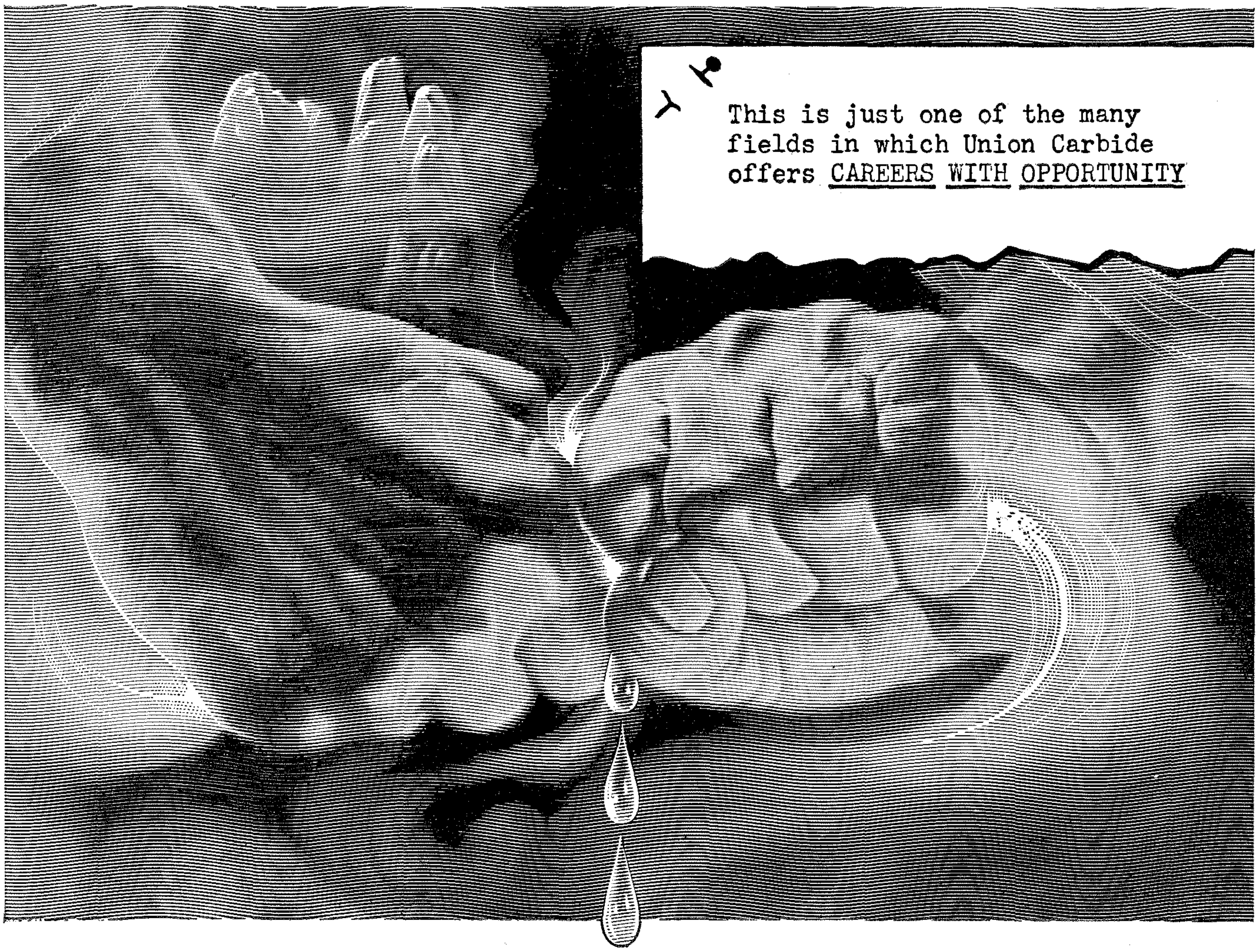
As it turns out, there is real need for study of the camellia as a plant, since, despite a popularity dating back over a hundred years, there has been but little serious investigation of the factors and conditions which control its growth and flower production. It is only natural, therefore, that when a camellia lover and member of the Southern California Camellia Society happens to be also a member of the biology staff at Caltech, as in the case of the author of this article, some study of camellia problems should ensue.

We have been investigating camellia matters at the Institute as a sort of scientific hobby for the past ten years. Camellias have been grown in the phytotron (the Earhart Plant Research Laboratory) to find out what temperatures they like; they have been grown in nutrient solutions to find out what they need by way of minerals; their flowers have been studied under the microscope to find out about their chromosomes so that we may hybridize them more intelligently.

When we grow a plant, we first want it to grow vegetatively—that is, to produce roots, stems and leaves and to grow to a good thrifty size; then we want it to change its mind, to produce buds which will grow into flowers rather than into more stems and leaves; and finally we want it to become reproductive.

The growth of the camellia, as of any plant, depends upon the carbon dioxide of the air, which is taken up by the plant and reduced to plant material by the process of photosynthesis. Camellia growth depends, too, upon the water which is taken up from the soil, and upon the absorption of a small number of mineral elements which, although they make up only a small part of the plant, are nevertheless essential to its welfare.

The study of the uptake of minerals by plant roots and the effect of variations in mineral uptake on plant growth is perhaps the most active aspect of plant science. The mineral nutrition of the camellia is something that we know a lot about. The general method of studying the mineral nutrition of the camellia, as of any plant, consists of growing the plant in some inert substratum; for example, sand or gravel, which supplies only me-



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By growing many plants with many different nutrient solutions, we can determine how well our plant grows in the presence or absence of each, and can determine what constitutes an optimum nutrient mixture for the camellia.

We have done experiments of this kind, in which we have systematically varied the levels and ratios of all the principal mineral nutrients—nitrogen, phosphorus, sulfur, potassium, calcium and magnesium—and have grown camellia plants with these varied solutions over a period of two years. It has been shown that the camellia grows well and is tolerant to a wide range of concentrations of these elements.

Nitrogen, which is the mineral nutrient used in greatest amount by all plants, is most critical. The camellia needs to have continuously available to its roots some ten parts per million of nitrogen in the soil solution. Nitrogen concentrations of ten times this level are, however, quite acceptable to our plant.

Nitrogen deficiency is fortunately easy to detect, since characteristic yellowing of the lower leaves and restricted growth of the plant result from a deficiency of this element. In our experiments, too, it was shown that for supporting the growth of the camellia, nitrate nitrogen, the usual form found in soil, is as good as or better than ammonium nitrogen or urea nitrogen. It was shown, too, that conditions which favor optimal vegetative growth, which favor rapid growth of stems and leaves, are also the conditions which favor abundant bud set and abundant flower production.

The results of these experiments are, then, reassuring to us in that they suggest that we need not worry very much about feeding our camellia plants with any critically balanced nutrient diet. Provided only that we supply enough minerals to the soil in which our camellias are growing, they will not suffer nutritionally.

Soil acidity

Perhaps the most important cultural factors influencing camellia growth and those which have been least understood in the past are the twin matters of soil acidity and soil salinity.

Soil acidity refers to the hydrogen ion concentration in a soil—to its pH. When hydrogen ions are present in low concentration in a soil, it is said to be alkaline.

Most of our ordinary crop plants are not too demanding as to the exact hydrogen ion concentration of the soil in which they grow, and will grow well with hydrogen ion concentrations over a range of at least a hundred thousand fold. Particular plants, as the pines and others, do, however, prefer an acid soil and it has been widely held that the same is true of the camellia. We have grown camellias in soils of a wide range of hydrogen ion concentrations and have found that they grow well even in soils which we would ordinarily consider alkaline.

The camellia is not truly an acid-loving plant. What is true however, is that the camellia grows well under damp, well-drained conditions. Soils which are damp and well-drained are ordinarily acid. So the camellia likes damp, well-drained places, but not on account of their acidity. The camellia likes damp, well-drained places because it is very sensitive to what is called salinity.

Soil salinity

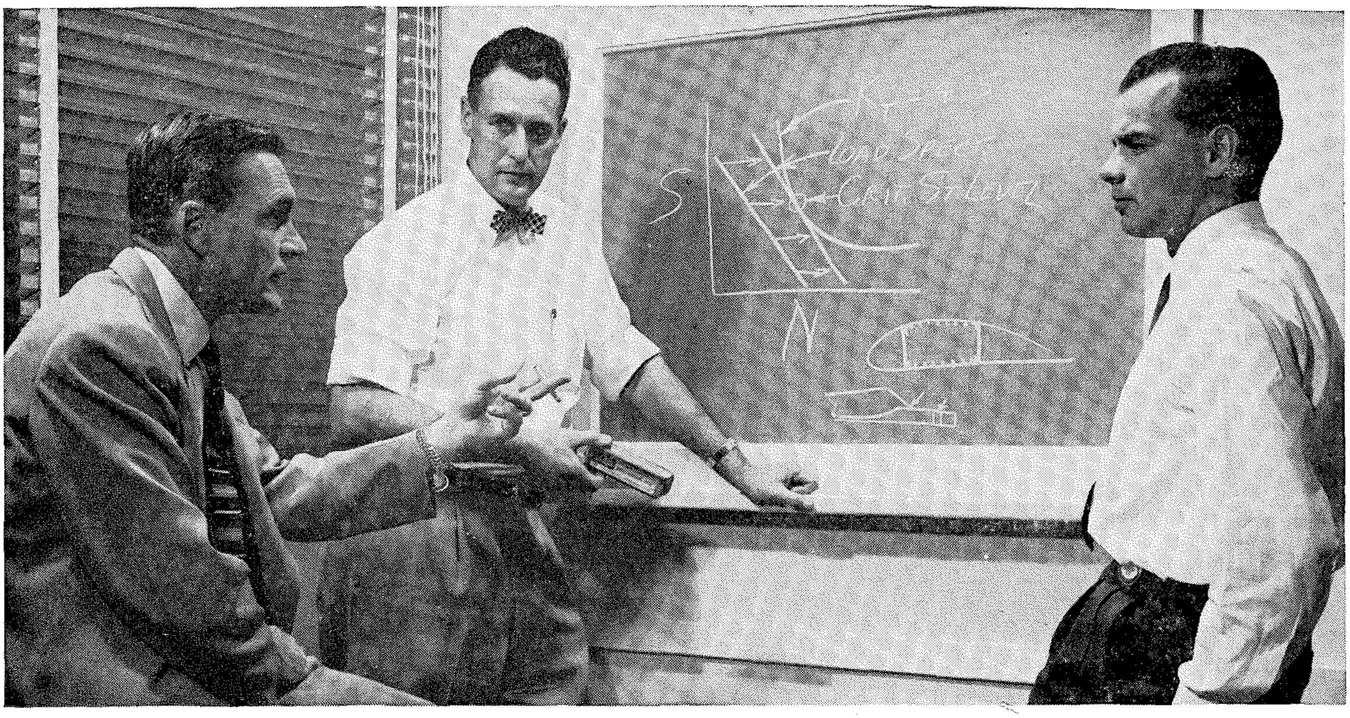
The concept of salinity has to do with the saltiness of the soil solution. When a soil contains a high concentration of soluble mineral salt, it is said to be saline. A saline soil may be either acid or alkaline. It so happens that saline soils are most frequently also alkaline. This is because a part of the salt which is ordinarily supplied to soil in irrigation water is commonly in the form of calcium or sodium carbonates which react with acid in the soil and neutralize it. But alkalinity in itself does no harm; it is the salt which does the harm to plant growth.

We were fortunate in being able to enlist the assistance of Harold Pearson of the Metropolitan Water District in studying the response of camellia plants to varied conditions of soil salinity. He grew plants at different levels of added salt and with different kinds of salt.

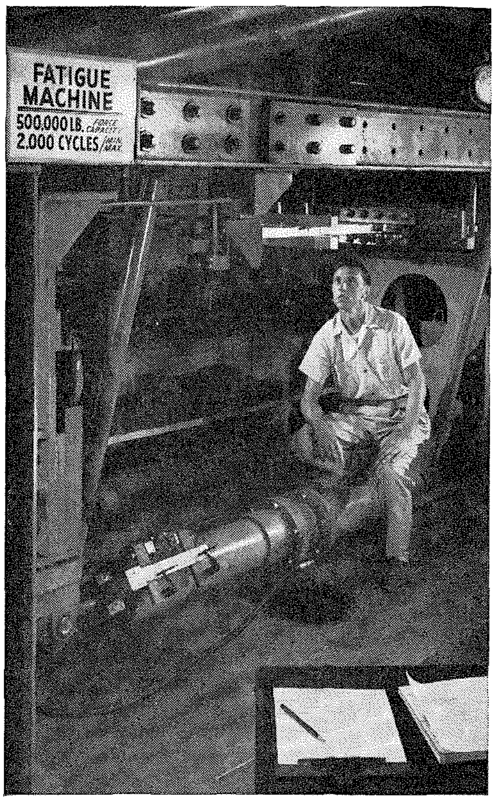
It was shown that camellia plants grown in the presence of 2700 parts per million of salt suffer from a tip burn of the leaves, a typical salt damage symptom. Plants grown in solutions containing 4300 parts per million of salt produced no growth at all. It was concluded that probably not over 1500 parts per million of salt should be present in the nutrient or soil solution if all salt damage to the camellia is to be avoided.

Now, our irrigation water in southern California contains some 800 parts per million of solids, of which about 600 parts per million contribute to soil salinity. If we water a plant with such water, then, of course, we supply the plant with salt as well as with water. The water is taken up by the plant and evaporated through the leaves, especially during the day. The salts do not evaporate and are left behind in the soil and in the plant.

Suppose that our plant evaporates two-thirds of the water which we have supplied, so that one-third of the original water is left behind. The salts carried in with the original water are now concentrated three times as compared with the original water. If the original water had been Metropolitan Water District water, the concentration of salts in the soil solution in our hypothetical experiment would now be 1800 parts per million. This would be a salt solution high enough in concentration to yield some restriction of growth in the camellia and al-



J. F. McBrearty, chief structures engineer (left) discusses fatigue test program of integrally-stiffened wing lower surface structure of a new transport with E. H. Spaulding, structures division engineer and J. G. Leewolt, stress engineer. Lockheed's 500,000 lb. Force Fatigue Machine was used in test program.



Ralph Oliva, research engineer, examines Super Constellation skin for signs of fatigue failure.

most high enough to cause real damage to the plant.

In order to avoid concentration of salts in the soil solution, we must always supply enough water to the camellias, or any other plant, to leach these salts down out of the root zone. This is easily achieved with plants in tubs or pots, where we can always supply enough water to cause visible leaching of water through the container. With plants growing in soil and not in tubs, we must irrigate heavily enough so that the salts accumulated from the previous irrigation are rinsed or leached down below the root zone.

All camellia growers know that, by and large, camellias do better in the shade. This behavior is probably related to the sensitivity of the camellia to the accumulation of salt. When a plant is in the sun, it evaporates more water than it does if it is in the shade. Light does more to increase rate of water loss from a plant than any other single factor except, perhaps, the temperature. The more light, the more water loss; the more water loss, the more rapid the depletion of the water after irrigation and the more concentration of salt in the soil solution.

The more light the camellia receives, the more difficult it will be to be sure that the salinity of the soil solution is kept at all times below the level which causes damage to the plant. The conclusion is, then, that the camellia is sensitive to high salt concentrations.

It is not so particular about the hydrogen ion concentration—the acidity of the soil solution. We should distinguish between these two difficulties. We cannot cure soil salinity by making the soil more acid through the application of sulfur or other acidifying agents; we can only cure the condition of soil salinity by leaching. And for myself, I would favor abolition of the term soil alkalinity. It is a term which confuses the concept of soil salinity with the secondary fact that saline soils are often alkaline.

Climatic control

Now let us turn to the production of flower buds and flowers. In Caltech's phytotron we can grow plants under conditions which simulate different climatic conditions. We can, for example, grow plants under conditions of temperature and humidity which simulate summer in Pasadena, and simultaneously under other conditions which simulate winter in Pasadena.

We have applied this facility to the study of the flowering of the camellia. It has turned out that the flowering of our plant is controlled by two principal climatic factors; namely, the night temperature and the relative length of day and night. Many plants are controlled in their flowering by relative length of day and night and this matter has been much studied.

With the camellia, as with other species, it is in fact the absolute length of the night period which controls the flowering response. Only when the night is shorter than a certain critical length does the production of flower buds take place. Superimposed upon this response to length of night is an effect of temperature. It has been shown that camellia plants of several varieties studied produce flower buds only if the days are longer than about 15 hours and the nights correspondingly shorter than about nine hours. And in addition, the nights must be warmer than about 65° for abundant flower bud formation to occur.

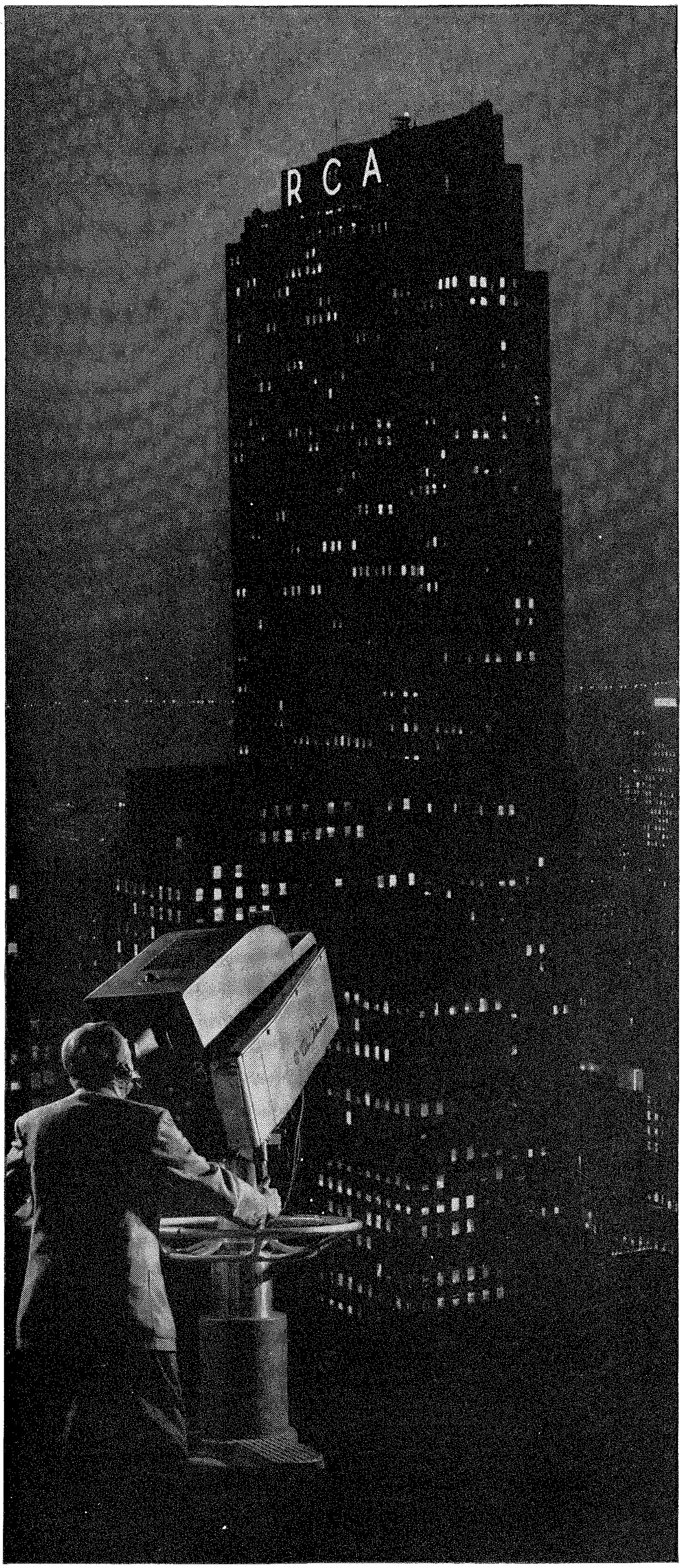
If we maintain a plant under these summer conditions of relatively warm, short nights, flower buds are formed but they do not open into flowers; they fall off. In order to get our flower buds to open and produce flowers, we must supplant the short warm nights with a regime of long cold nights. The optimum opening of flower buds and production of flowers has been shown to take place when the nights are 60° or colder, and longer than about nine hours.

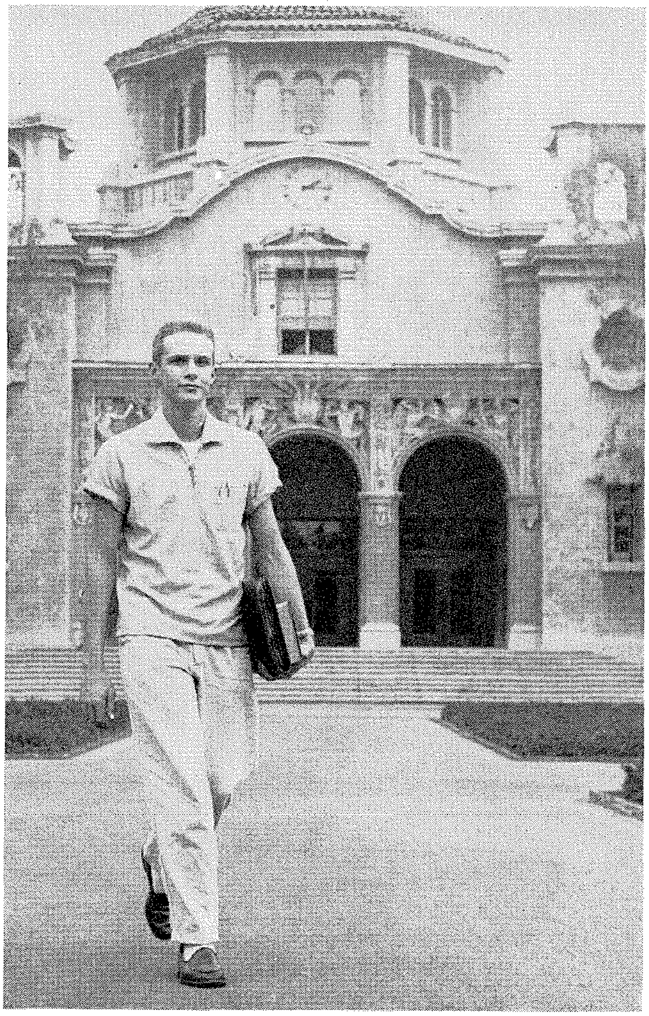
Summer camellias

If, for example, we want to produce camellia flowers in the middle of our Pasadena summer, then what we will do is to take a camellia plant, say on January 1, and put it in a greenhouse with warm nights and with artificial illumination at night to persuade the plant that the days are long and the nights short. After two months of such treatment flower buds will have been formed and we can then move the plant to conditions of colder nights. We should also mask the plants with dark cloths from say 6 p.m. to 8 a.m. to maintain a day length of ten hours. Under these conditions our plant will open normal flowers sometime between May 1 and June 1.

The temperature relations of flower opening in the camellia as determined in the laboratory have an interesting connection with the normal time of flowering for our different varieties. Our night temperatures during the winter in Pasadena and in southern California generally are sufficiently low to greatly slow down the rate of flower opening. We have found by collection of temperature data from a series of growers in different spots in southern California that the earliness of flowering of each camellia is correlated with the temperature of the locality. The warmer the minimum night temperature, the earlier the flowering of each variety. If, for example, our climate should warm up and the winter nights become warmer, we would observe a correspondingly earlier date of flowering for each of our varieties.

We have reviewed some of the factors which are most important in controlling the vegetative growth of the camellia and in determining flowering behavior. We should not get the impression, however, that all of the science of the camellia is already known. As with the study of any plant or any living thing, a great deal remains to be discovered about the camellia.


RCA



Kendall Dinwiddie '59

ALUMNI SCHOLAR

Some notes on the second winner of the Alumni Association's four-year, full-tuition grant

THE CALTECH ALUMNI Association, through contributions to the Alumni Fund, granted its first scholarship last year to Timothy Harrington, of Caltech's entering class of 1958.

This year the Caltech Committee on Undergraduate Scholarships awarded the second Alumni Scholarship —a four-year, full-tuition grant—to Kendall Dinwiddie, of the class of 1959.

Ken comes from Larkspur, California, a small town some 15 miles north of San Francisco, where he lives with his widowed mother. Ken is 17. In high school (Sir Francis Drake, in San Anselmo, California) his scholastic standing put him in the honor society and earned him a life membership in the California Scholarship Federation. At Caltech he received Honors at Entrance, an award for distinguished academic achievement that puts him in the top 10 percent of his class.

Ken worked throughout his high school years—as a gardener, film processor in a photo-finishing agency, and a drug store clerk. This put something of a crimp into his extra-curricular activities, so that he was in and out of track, tennis and the chess and music clubs at school.

Music, skiing and drama are his chief extra-curricular interests now, and he has already joined the Caltech Glee Club (second tenor). He plays the trumpet too, and currently favors the music of such romantic composers as Liszt, Tchaikowsky and Ravel. Though he brought his skis down with him from bucolic northern California, Ken has yet to be convinced that there's enough room left in crowded southern California to ski in.

It's a fact that there wasn't enough room for Ken to move into the student houses this year. They're so full this fall that new students from the state of California have all had to be housed off campus. Ken is a non-resident of Blacker House, and he shares a room on South Hill with another freshman, Phil Harriman, who has been a classmate and friend since the third grade in grammar school. This is a fine, large room (large enough, in fact, that the boys have considered renting out the closets as student-house singles), but Ken nevertheless regrets missing out on student house life. At the same time, he's grateful for the off-campus calm when it comes to studying, which is something that seems to occupy more and more of his time these days—oddly enough.

It's Ken's present intention to become a chemist. According to all present indications, he should do nicely in whatever field he chooses

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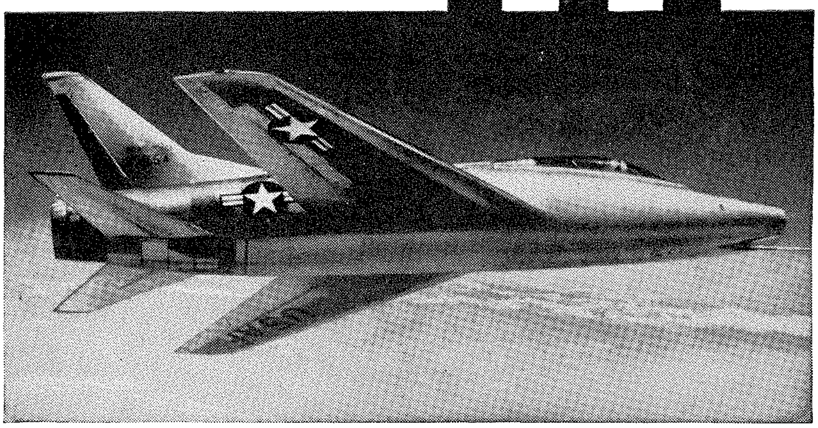

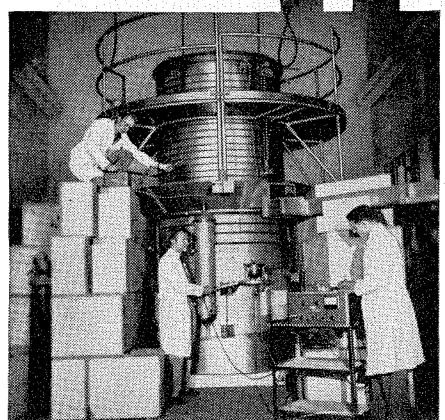

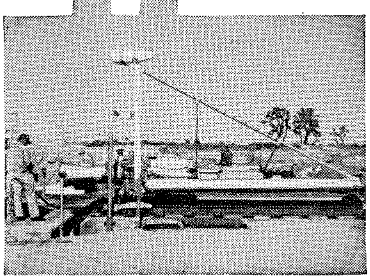

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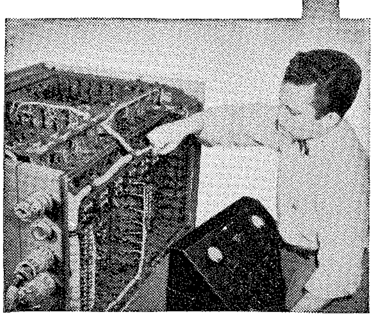

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ENGINEERING AHEAD FOR A BETTER TOMORROW

NORTH AMERICAN AVIATION, INC.

THE BIND

THE JUNIOR put his pencil down and snapped shut the big blue Shakespeare book. Wearily twisting around to get a look at the clock, he discovered with some dismay that it was after two in the morning. Good news, he said wryly—I won't have to go to bed tonight after all.

He stared woefully at the cover of the big blue book. Midterm tomorrow morning, he told himself, and you haven't even read all the plays you were assigned. How do you expect to get by in this school anyway?

Not this way, he decided. He'd been in a bind all week long, and the week before that—and most of the first part of the term besides. He'd been so busy, in fact, that he hadn't had time to take inventory of the things he was behind in.

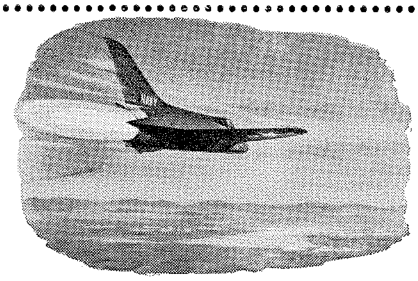
Oughta be a law against rotation, he decided. That's where it all got started, spending his lunch hours and the hours after dinner in the lounge, meeting people, sizing people up, and then spending the evening hours going places with people. That had been the beginning, and by the end of rotation he thought he was pretty far behind.

Have to have a law against initiation, too, came the next thought. When rotation had ended he figured he'd be able to do a little catching up; but then came the waterfights, the alley raids, the pranks lasting late into the night—and the end of initiation week found him worse off than before.

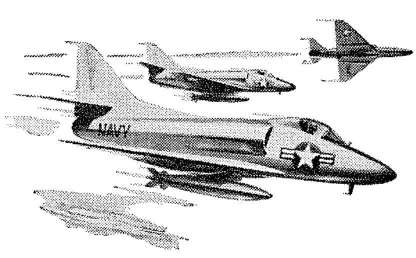
Might be a good idea to have a law against winning football games too. In fact, he thought suddenly with a grin, there might be a law like that on the Pasadena statute books pretty soon. At least there would be if every Tech victory produced the kind of pandemonium that broke out after the Cal Poly game.

He remembered some wise guy saying that the football team really screwed up by winning that game with Cal Poly of San Dimas. If they'd lost it, the story went, they could have tied the national four-year-college record losing streak.

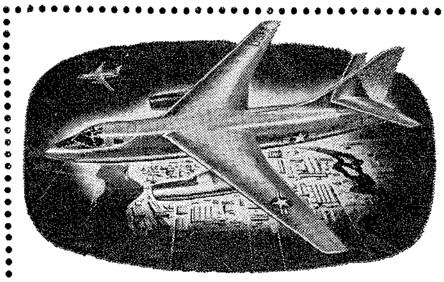
But that hadn't been the reaction of the student body. The whole campus was turned upside down that night. Someone set it off by starting a bonfire at the intersection of Hill and California. After it got warm enough, people danced around the fire, sang, cheered, and just generally had a big, noisy time. In due course, the Pasadena Police Department arrived, without much display, and quietly went about their business of cooling things off a bit. But shortly after that so many things happened so fast that the Junior, who had been right there in the cheering crowd, wasn't sure himself



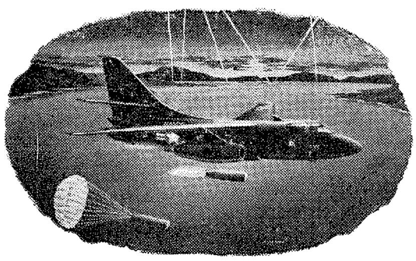
F4D, "SKYRAY"— only carrier plane to hold official world's speed record



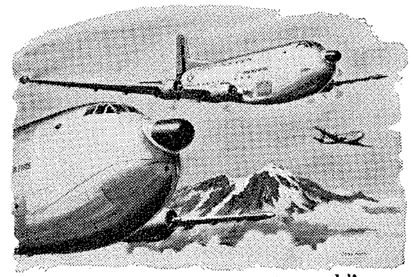
A4D, "SKYHAWK"— smallest, lightest atom-bomb carrier



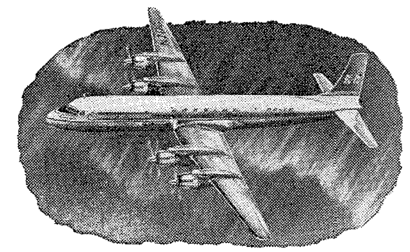
RB-66 — speedy, versatile jet bomber



A3D, "SKYWARRIOR"— largest carrier-based bomber



C-124, "GLOBEMASTER"— world's largest production transport



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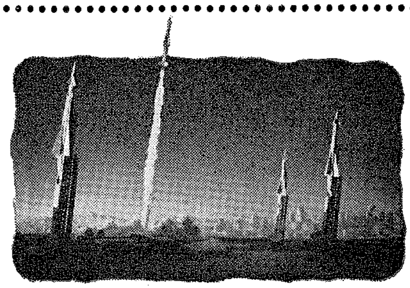
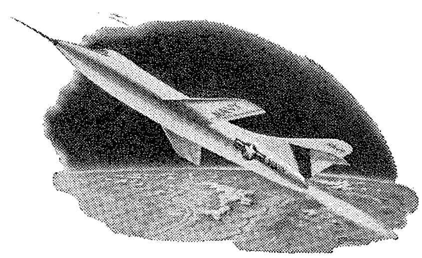


"NIKE"— supersonic missile selected to protect our cities



D558-2, "SKYROCKET"— first airplane to fly twice the speed of sound

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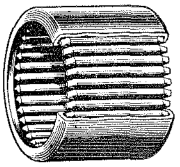
The Torrington Needle Bearing
...designed for easy, effective lubrication



One major advantage inherent in Needle Bearing design is the ease with which the bearing can be lubricated.

The full complement of small diameter rollers continuously carries a thin film of lubricant to all contact surfaces. The turned-in lips of the outer shell retain the lubricant and effectively seal out foreign matter.

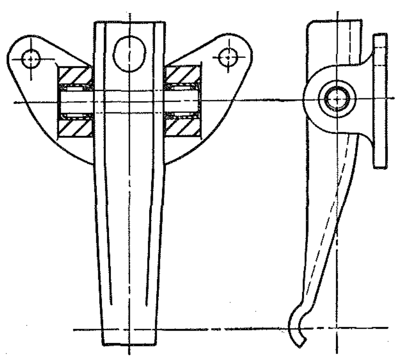
Methods of Lubrication

When Needle Bearings are shipped, they are normally protected with a high-grade slushing compound which has lubricating value at ordinary temperatures. This compound is left in the bearings in most instances. Needle Bearings in many applications run for long periods of time without further attention to original lubrication.

There are several methods of providing additional lubricant to Needle Bearings, as illustrated and described below.

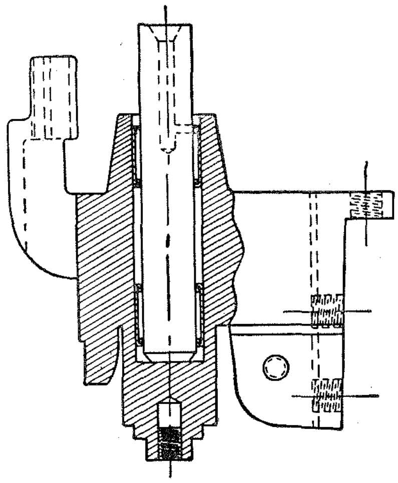
PERMANENT LUBRICATION

For low speed and light load applications, as in the fingers of the automobile clutch illustrated, the Needle Bearings are packed with grease before assembly. No additional lubrication is needed.



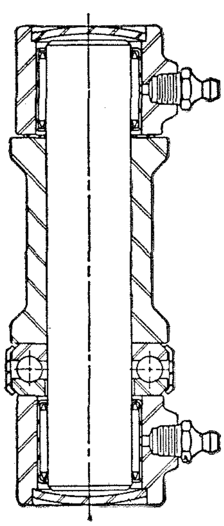
THROUGH THE SHAFT

If it is necessary to lubricate through the shaft, a hole is drilled along the shaft axis, with a cross hole leading under the lips of the Needle Bearing. This hole is located under the lip of the bearing rather than in the roller contact area. Textile machine spindle swing bracket below illustrates this method.



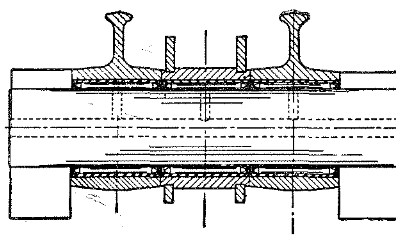
THROUGH THE HOUSING

When lubricant is to be delivered through the housing, an oil hole is furnished in the middle of the outer shell. In automobile king pin below, Needle Bearings are lubricated with Alemite fittings through the oil hole. This oil hole in the outer shell should be outside the load area.



CIRCULATING OIL SYSTEM

For high speeds and heavy loads, a circulating oil system is preferred as it aids in carrying away heat as well as in providing a continuous supply of lubricant to the bearing contact surfaces. A typical example of this method is shown in this Needle Bearing application in the valve rocker arm of a large diesel engine shown below.



Selecting A Lubricant

While oil is the best lubricant, it is difficult in many cases to retain it in the bearing housing. In general, a soda base grease is used in the absence of moisture, and a lime base grease when moisture is present. It is usually advisable to consult a grease manufacturer regarding a particular application.

These features make the Torrington Needle Bearing Unique

- low coefficient of starting and running friction
- full complement of rollers
- unequalled radial load capacity
- low unit cost
- long service life
- compactness and light weight
- runs directly on hardened shafts
- permits use of larger and stiffer shafts

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ALUMNI DIRECTORY

A supplement to the 1954 Alumni Directory will be issued late this fall listing the names and addresses of those who received degrees in 1954 and 1955. Copies of this supplement will automatically be sent to paid alumni who graduated in these years. Other alumni may secure copies by sending the form below to the Alumni Office.

Please send the Alumni Directory supplement to:

Name..

Address..

City.......................**State**.....................

Student Life . . . CONTINUED

exactly what had transpired, and in what sequence.

Someone got away with a billy club from one of the cops, for one thing, though the Junior hadn't even heard about that until hours later. Some other guys tried to let the air out of the paddy-wagon tires, and this unfortunate gesture ended in their apprehension.

The winning move was when somebody, whose identity was still unknown weeks later, got into high spirits, or some kind of spirits, and torched up a palm tree down California Street near Tournament Park. This made quite a show, though it didn't seem to please the PPD (or the fire department either, who were late arrivals at the event).

The cops didn't catch the guy who blazed the tree, but they got hold of a guy who was standing nearby when it happened, and he, with two tire-type vandals, was hauled off by the Riot Squad or something as the party broke up. The three guys had been bailed out much later that night for more than a hundred dollars, and were still legally tangled up with the business for weeks afterward.

Well, maybe there wasn't any law against winning games, the Junior mused, but at least there were regulations against raiding other campuses, and they had been observed in about the same kind of spirit that the Prohibition Amendment was. A Caltech banner flew from Occidental's main flagpole for the second time; it had been raised on the first Monday in October, and, thanks to good old CIT ingenuity, it remained aloft for weeks, while the Occidental administration mumbled about sending bills for professional steeplejacks.

Oxy couldn't get the flag down, and Oxy wasn't too sure about Tech paying the bills in any case, so a few Oxy men, acting unofficially, made a sort of payment of debts owed by twice raiding the parking lot in Tournament Park—once to paste a lot of dirty signs on windshields, and once to let a little air out of tires. The Junior was not one to sit idly by while nasty Occidental students played tricks — and a little such foolery had been sufficient to prevent any kind of catching up in the weeks between initiation and midterm.

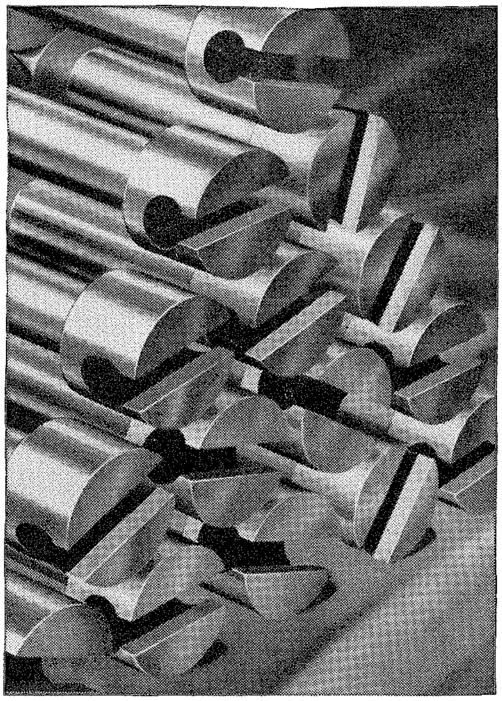
And now, merciless heavens, it was midterm week, and Interhouse Dance week, and who-needs-sleep-anyway week. The Junior was spending his afternoons on interhouse softball, his evenings decorating for the dance, his nights studying just enough to keep from falling even further behind—and the Junior was in a tight bind.

The Junior, acting with quick resolve and huge lack of duty-sense, reached out suddenly and turned off the desk lamp. What the hell, he said, it's only eight units. So I *won't* know the balcony scene by heart. Maybe I'll be lucky and flunk out of this place. In the Army, I hear, they only work an eighteen-hour day.

—*Marty Tangora '57.*

Another page for **YOUR STEEL NOTEBOOK**

The steel that could take anything but a bath



In steel mills and warehouses, a roller leveler straightens wide sheets and heavy plates between powerful steel rolls.

Stress on the rolls is tremendous. To make them strong and tough enough, one manufacturer used an alloy steel, 52100. Then, to make the rolls *hard* enough, they were heated to a high temperature and quenched in a liquid bath. But the severe quench was causing many of the rolls to warp.

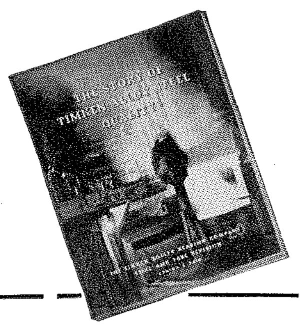
The roll maker took his problem to Timken Company metallurgists, asked if he could make rolls from 52100 steel that wouldn't distort in quenching. They said yes—if the steel were uniform from lot to lot in analysis and hardenability.

TIMKEN® steel quality control solved the distortion problem

The roll maker switched to 52100 steel made by the Timken Company. He found the steel was uniform from lot to lot, heat to heat, year in and year out. Result: he was able to standardize heat-treating practice. Distortion was practically eliminated.

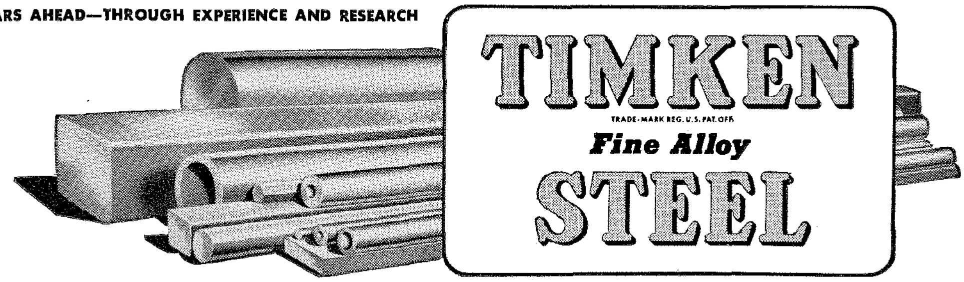
The Timken Company constantly solves steel problems like this one by furnishing steels to the most exacting specifications. Timken Company metallurgists are specialists in fine alloy steels. And they use the most modern quality control methods to assure uniformity, time after time after time.

Want to learn more about steel or job opportunities?

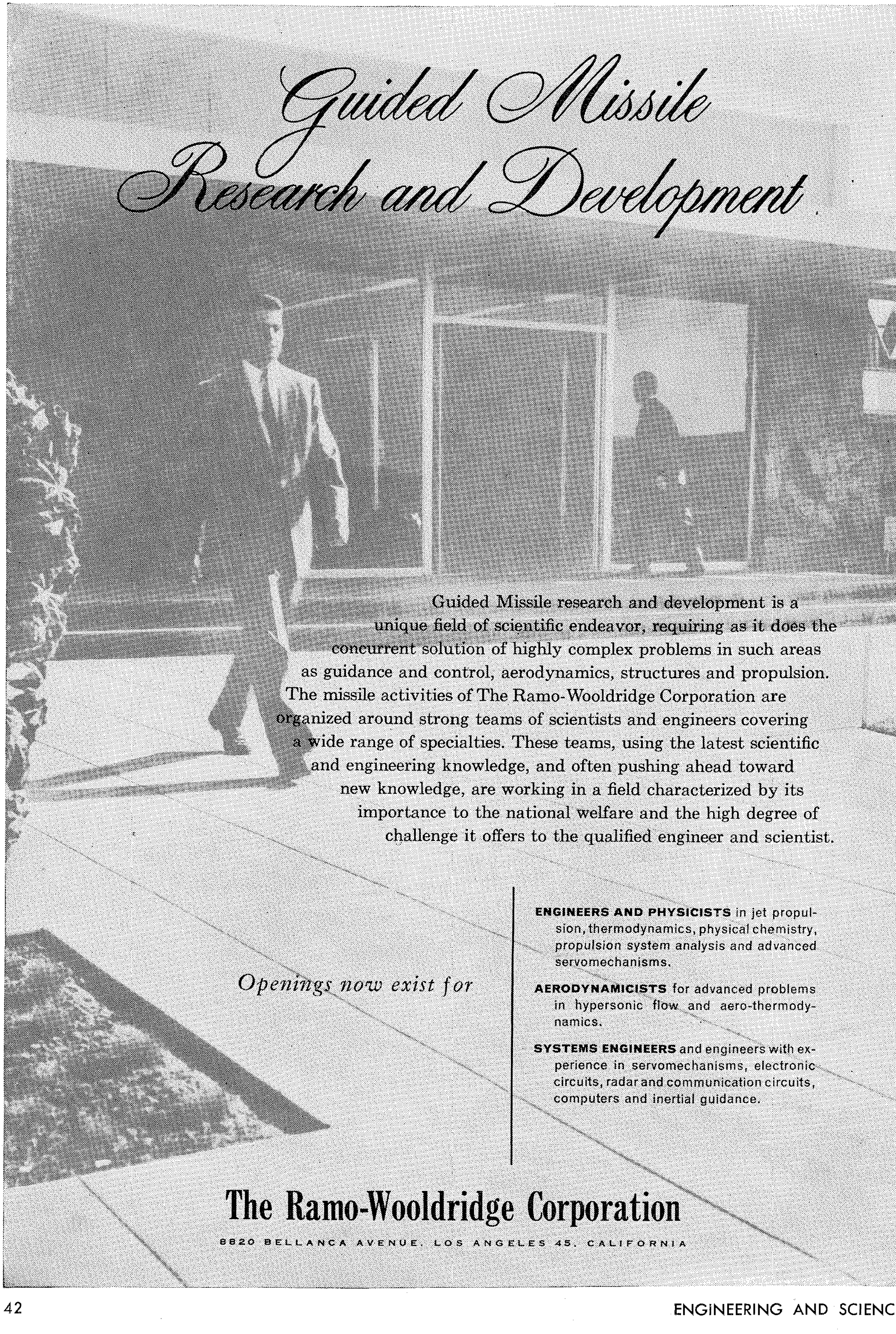


Some of the engineering problems you'll face after graduation will involve steel applications. For help in learning more about steel, write for your free copy of "The Story of Timken Alloy Steel Quality." And for more information about the excellent job opportunities at the Timken Company, send for a copy of "This is Timken". Address: The Timken Roller Bearing Company, Canton 6, Ohio.

YEARS AHEAD—THROUGH EXPERIENCE AND RESEARCH



SPECIALISTS IN FINE ALLOY STEELS, GRAPHITIC TOOL STEELS AND SEAMLESS TUBING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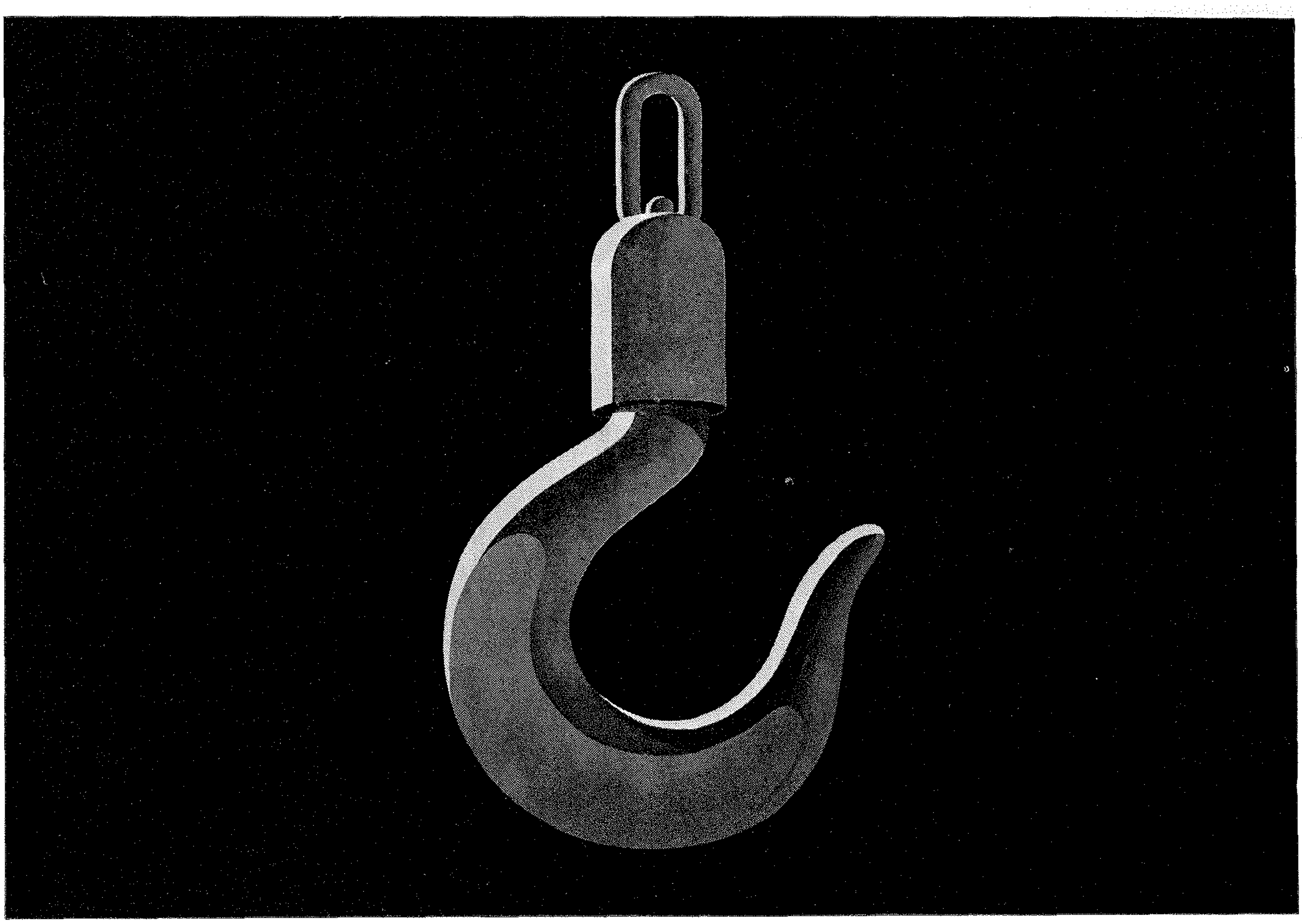

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Hoists lift steel beams for buildings and bridges, raise and lower drills and casing for deep-driven oil wells, lift a bucket of cold water from a country well or a ladle of molten metal in a mill . . . lighten load-lifting chores for machinists and miners, loggers and longshoremen, farmers and factory workers.

HOW MANY KINDS?

Consider the many kinds of hoists in use today . . . reeved with rope, cable, chain . . . powered pneumatically, manually, electrically . . . engineered with gears, pulleys, pistons, ratchets.

Think how many millions of plans, sketches, models and mock-ups have contributed to their evolution. The eyes of a myriad of inventors, engineers and draftsmen have appraised them. The hands of countless patternmakers, tool and die makers, machinists and other craftsmen have shaped them.

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HEADQUARTERS FOR TECHNICAL AND BUSINESS INFORMATION

PERSONALS

1917

J. Calvin Brown, attorney, has been elected to serve as chairman of the board of the Engineers Club of Los Angeles. *A. M. Zarem,* MS '40 and *Thomas F. Edson,* '29, were elected as directors. Abe Zarem is manager of the Southern California Division of the Stanford Research Institute and Tom Edson is a consulting engineer.

1921

Chester A. Boggs has joined the technical staff of the Radar Division of the Hughes Research and Development Laboratories at Culver City. He was formerly a design engineer with the Western Geophysical Company.

1923

George T. McKee, director of architecture and engineering for the Oakland Public Schools, died of lung cancer on July 3, after an illness of seven months. George had been with the school system since 1936. He is survived by his wife, two sons, a daughter and two grandchildren.

1925

Thomas P. Simpson, vice-president and director of manufacturing of the General Petroleum Corporation, celebrated 30 years of oil company service last month.

1928

Moe W. Gewertz is a senior bridge engineer with the California Division of Highways, currently functioning as resident manager of the San Mateo-Hayward and Dumbarton toll bridges.

1935

Nathan Karp is home from the hospital after a seven week bout with meningitis—and doing fine. He has his own office as a consultant in structural engineering in San Francisco.

1938

Sylvan B. Walton, MS, has been teaching engineering at San Jose State College for the past eight years, specializing in heating, ventilating, refrigeration and industrial instrumentation.

Howard Seifert, PhD, is now a senior staff member of Ramo-Wooldridge. He has also accepted an appointment at UCLA as visiting professor of engineering and will divide his time between the two positions. Before joining Ramo-Wooldridge in 1954, Howard was with the Caltech Jet Propulsion Lab for 12 years.

1940

Robert B. Young, who has been chief engineer at Aerojet's Azusa liquid engine division since 1951, has been appointed as resident manager of the Company's new liquid rocket plant in Sacramento.

1941

Newell T. Partch reports a third addition to his family—a daughter, Vicky—

Personals . . . CONTINUED

which makes a total of three daughters from 10 years down to 2 months. He is vice-president and factory manager of Up-Right Scaffolds, Berkeley, Calif.

Ebenezer Vey, MS '42, has been appointed a full professor of civil engineering at the Illinois Institute of Technology in Chicago.

Reuben Snodgrass, MS '42, is the engineering department head for flight research at the Sperry Gyroscope Company in Long Island, New York. A recent paper of his, "A Flight Investigation of the Performance of Low-Ceiling Visibility Measuring Equipment," appeared in the *Aeronautical Engineering Review* for May, 1955.

1942

Wayne MacRostie is nearing the end of his sixth year in Sacramento, where he has been engaged in hydraulic engineering work for the State of California. Most recently Wayne has been supervising engineering studies aimed at providing a basis for settlement of water rights along the Sacramento River and in the Sacramento-San Joaquin Delta. The three MacRostie boys are now 2, 6, and 9.

1943

Robert M. Benson has formed a new company of his own, in Santa Monica, called Inertial Instruments, Inc. As president, he will direct its activities in the mass flowmeter field. Boh was formerly vice-president of Gyromechanisms, Inc.

Alexander C. Ridland, who was lead test engineer in the turbine lab at Convair, has now joined Solar Aircraft as an experimental engineer.

1946

Robert E. Stephenson, MS, formerly a research engineer at the University of Utah, has joined the staff of the Guided Missile Division, Hughes Research and Development, at Culver City, California.

1948

Frederick C. Roop, PhD, has been appointed head of the applied mechanics section in physics of Standard Oil of Indiana. He joined the company in 1948 as an assistant project engineer and became a senior project engineer prior to his new appointment.

David B. Willmer, MS, reports that he recently bought an Eichler home in Walnut Creek, California, and is working in San Francisco for the engineering department of the Standard Oil Company as a project engineer.

George P. Steck, MS, writes that he finished his PhD in statistics at the University of California in Berkeley last May and is working for the Sandia Corporation in Albuquerque, New Mexico. George is married and has two sons, aged one and three.

Alfred Paul Fay was married in June to Mary Consuelo Oseguera of Altadena. They are living in Santa Monica.

1949

Douglas Brown and his wife announced the birth of their second child, Kyle Warren, in September. Doug is working in Los Angeles where he is in charge of foundation investigations for the Bridge Department of the California Division of Highways. The Browns are living in Van Nuys.

Irving L. Krumholtz writes that he is "still with the central engineering division of Fibreboard Products, Inc., in Antioch, California, and rusticating with my wife and three rapidly growing daughters in Concord. We are occasionally visited by the *James A. Harders*, '48, and other Caltech classmates or friends."

Donald Petersen, PhD '55, joined the Dow Chemical Company in August as a chemist.

Lloyd P. Geldart writes about life in Trinidad, where he is working for the Dominion Oil Company, Ltd.: "Have been here for three years in Port-of-Spain as chief geophysicist. Trinidad is ideal for foreign service—no language barrier, lovely homes, inexpensive servants, food of fair quality, although a restricted choice compared with the U.S. Almost everyone has a sail or power boat, lots of fishing, golf, tennis, parties. Have a month's vacation with the family every year, and last year returned to Los Angeles with stops in Venezuela, Colombia, Panama and Mexico City.

"Trinidad is cross-roads of air travel and we have many visitors en route to Rio, Buenos Aires, Europe, U.S., Venezuela, Colombia, etc. Tobago, of Robinson Crusoe fame, is 25 miles off shore and a wonderful place to spend long weekends. Grenada and Barbadoes are also near by and are frequented by those who have tired of Tobago." (Everybody ready to catch the next boat?)

Henry A. Long, MS '50, has joined the Solar Aircraft Company as a controls engineer. Henry, his wife, and two children make their home in San Diego.

1950

Henry Shapiro, MS '51, ME '52, announced the birth of a son, Richard Murray, on June 9, 1955. The Shapiros are living in Los Angeles.

James O. McCaldin, MS '51, PhD '54, is working for General Motors in Detroit as a senior research engineer.

Jerry O. Matthews, who graduated from the USC Medical School in June, is now interning at the Orange County General Hospital. Jerry and his wife have a baby girl, Julie Ellen, born on June 25, 1955.

Walter John received his PhD in nuclear physics from the University of California and is now an instructor in the depart-

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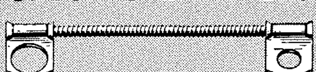

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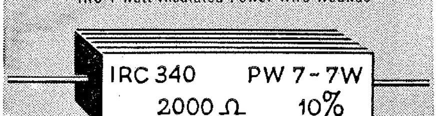

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1951

Robert John Kurland, who received his PhD at Harvard, has been granted a post-doctoral research associateship by the National Bureau of Standards and is conducting a study of free radicals and other unstable molecular species using microwave and other spectroscopic techniques.

Richard A. Hoppin, PhD, is now an associate professor at the State University of Iowa. He has been with Iowa State since 1951.

Richard Smyth reports a third addition to his family; Ernest Paul, who was born in October. Rich is with North American Aviation now. On the family's vacation last summer, he piloted their Bonanza to New York and back.

James A. Ibers has joined the Shell Development Company in Emeryville, California, as a chemist. During the last academic year, he was a United States National Science Foundation Postdoctoral Fellow in Chemistry at the Commonwealth Scientific Industrial Research Organization in Melbourne, Australia.

Stephen Pardee, MS '52, says he "is now firmly enclosed in the protective web of the U.S. Army. Mary Jo and I are living in Falls Church, Virginia (just outside Washington, D.C.) and are looking forward to seeing *Dallas Peck,* (BS '51, MS '53), plus family, who are going to be in this area 'til next summer."

1952

Gerald D. Fasman, PhD, has just returned from four years in England, Switzerland and Israel where he did post doctorate research. He is currently at the hospital of the Children's Cancer Foundation, a Harvard research group in Boston.

Michael J. Callaghan and *Richard Dickinson* have both completed Officer Candidate School at Newport, R.I., and are now ensigns in the USNR. They are stationed at the Naval Air Station in Jacksonville, Florida, attending Aviation Ground Officer's School. They report that *William Harris,* BS '49, was also in the same class and is now back in California.

1953

Kim Hamberger is at the University of Oklahoma studying for an MS in geological engineering, after spending some time with the Phillips Petroleum seismograph crew and two years in the 549th Army Engineers in San Francisco and Alaska.

Carl G. Sauer, Jr., who is in electronics research at the Jet Propulsion Lab, was married to Eileen Holtan in May at Glendale.

Lawrence Davidson Starr, now a graduate student at MIT, was married in June to Irma Kushner, in Newton, Mass.

George B. Cook, Jr. is now a Reserve Ensign in the Navy.

1954

Paul Concus is now a member of the staff at the Advanced Electronics Laboratory, Hughes Research & Development, Culver City, California. Other Tech grads who have recently joined Hughes include: *Walter W. Lee, Jr.,* '54, *J. Philip Wade,* '55, *Lewis Ellmore,* '55, and *Walter L. Whirry,* '55, all members of the Systems Division. *Arthur E. Miller, Jr.,* MS '55, is employed in the Guided Missile Division.

1955

Charles St. Clair is working for an MS in geology and instructing beginners in the geology labs at the University of Arizona.

John W. Brookbank, PhD, is an assistant professor of zoology at the University of Florida in Gainesville.

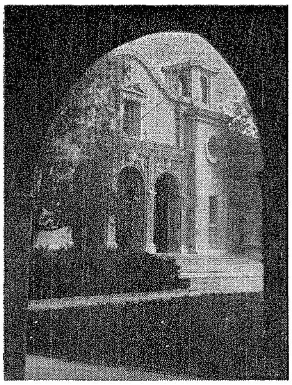
Joseph D. Mandell, PhD, is doing a year's work on bacterial viruses at the Carnegie Institute in Cold Spring Harbor

John W. McKee, PhD, is working on aircraft nuclear propulsion at Douglas Aircraft.

Ernest Dzendolet is working in experimental psychology at Brown University.

William Lindley writes that "*Don Taylor* was married right after graduation and both he and his wife are working at the University of California Radiation Lab and living in Concord. *John Weisner* has moved to Livermore and is with the Lab. *Roy W. Paul* is in the same group that I am and is living in Berkeley. *Alva Yano* is living with Roy and working here, also. *Horace Furumoto* is the sole casualty—his Air Force orders came and now he's in Wyoming."

Oreste Lombardy, Carl Bowin, and *Robert Meade* are all taking graduate work in geology this year. Oreste spent the summer studying saline deposits in the Saline Valley, California,—in preparation for his Master's thesis, which he is working on at the New Mexico Institute of Mining and Metallurgy. Carl, now at Northwestern University, spent the summer as a field assistant for the Texas Company. Bob also did field work last summer (subsurface) for the Shell Oil Company, before starting at UCLA this fall.



CALTECH CALENDAR

November, 1955

ALUMNI CALENDAR

January 12 — Winter Dinner Meeting

February 4 — Dinner Dance, Oakmont Country Club

April 7 — Annual Alumni Seminar Day

June 6 — Annual Meeting

June 23 — Annual Picnic

CALTECH ATHLETIC SCHEDULE

Nov. 22, 4:15 p.m.
CROSS COUNTRY
Nazarenes at Caltech

Nov. 23, 3 p.m.
SOCCER
Caltech at UCLA

Dec. 1, 2, 3
BASKETBALL
Tournament — Caltech at Redlands

FRIDAY EVENING DEMONSTRATION LECTURES

Lecture Hall, 201 Bridge, 7:30 p.m.

November 18—
Lightning and Atmospheric Electricity—Dr. Gilbert McCann

November 25—
Thanksgiving recess

December 2—
The Chemistry of Enzymes—Dr. Carl Niemann

December 9—
Tumors and Viruses—Dr. Harry Rubin

December 16—
Floods—Dr. Norman Brooks