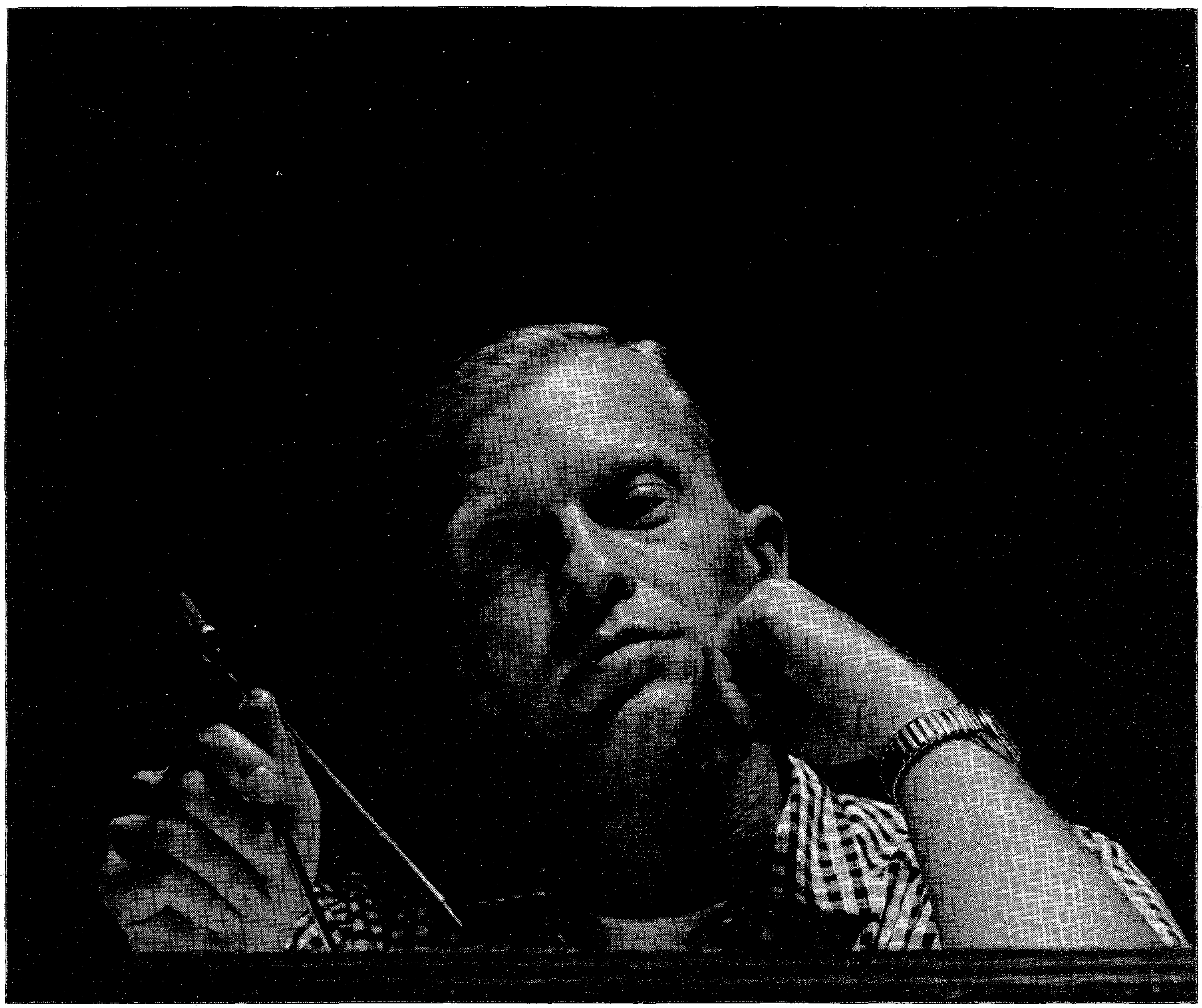
ENGINEERING AND SCIENCE

NOVEMBER/1957

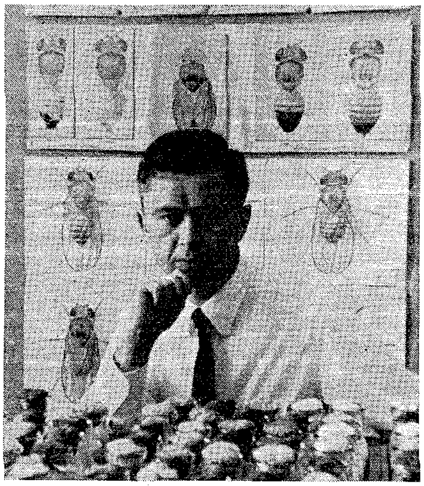
Two wings or four? . . . page 19

PUBLISHED AT THE CALIFORNIA INSTITUTE OF TECHNOLOGY



ENGINEERING AND SCIENCE

IN THIS ISSUE



On our cover this month is Edward B. Lewis, professor of biology, and author of the article on page 19, "Two Wings or Four," describing genetic experiment at Caltech which has provided biologists with a working model for picturing the genetic control of development.

From this working model, Dr. Lewis, developed a four-winged fly—the fruit fly, *Drosophila*, which is such an ideal tool for genetic studies. background of our cover picture. *Drosophila*, you will note, form th They take up the foreground, too, as a matter of fact; each of those bottles contains a family of them (two parents and—after just a few days—their hundreds of offspring).

Dr. Lewis was graduated from the University of Minnesota in 1939, came to Caltech as a teaching fellow and received his PhD here in 1942. After wartime service as a meteorologist with the Air Force in the Pacific he joined the Caltech faculty in 1946.

PICTURE CREDITS

Cover	Nolan Patterson
pps. 22, 23, 24	Thomas W. Harvey
p. 32	William Kaup
p. 44	Edward Hutchings, Jr.

NOVEMBER, 1957 VOLUME XXI NUMBER 2

PUBLISHED AT THE CALIFORNIA INSTITUTE OF TECHNOLOGY

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William R. Schmus '60

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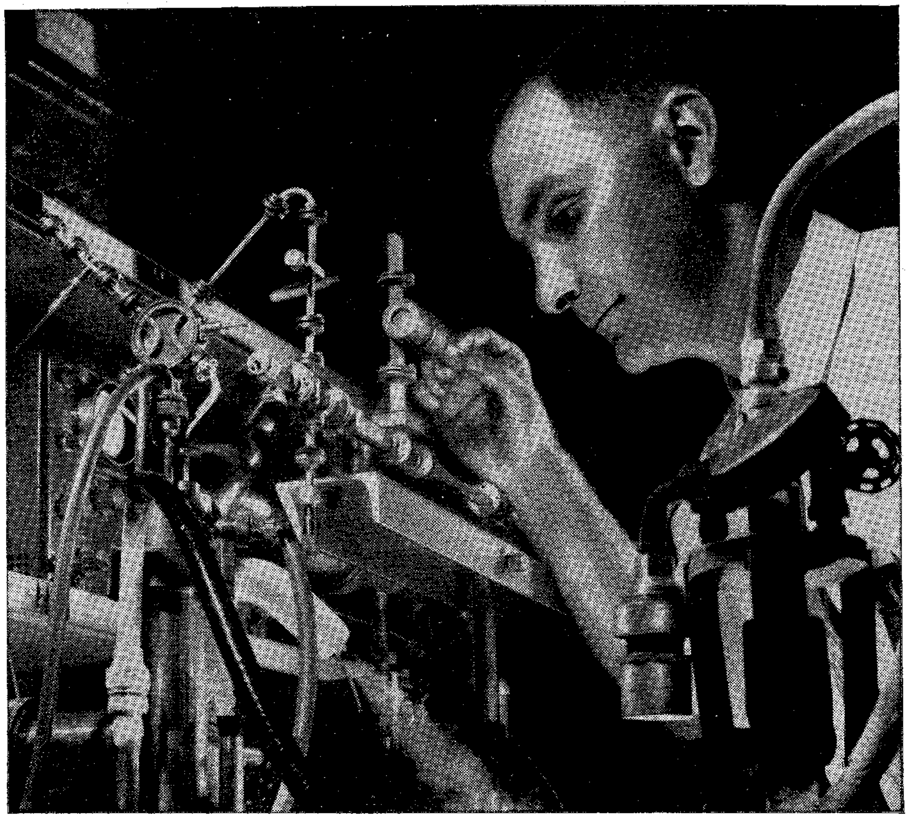


Dr. M. A. Biondi (Massachusetts Institute of Technology, B. S. '44, Ph. D. '49) measuring ultra-microwave transmission through superconductors. This experiment is a joint effort of a group of Westinghouse scientists aimed at obtaining a better understanding of the nature of superconductivity.

Westinghouse Scientists Probe Secrets of Superconductivity, using...

The Coldest Cold

Temperatures within a fraction of a degree of absolute zero are produced routinely by Westinghouse scientists in their search for more knowledge of the important phenomena of superconductivity. These phenomena rank with the nature of nuclear forces as one of the most fundamental problems facing the theoretical physicist. When superconductivity is completely understood, its principles could well revolutionize the electrical and electronic industries.

The basic principles of superconductivity have eluded an explanation since 1911 when the first example of the complete disappearance of electrical resistance in metal was discovered. Today scientists at the Westinghouse Research Laboratories in Pittsburgh, are making significant contributions to the field by their low-temperature research.

Superconductivity occurs in certain metals, alloys and compounds which, below characteristic transition temperatures, completely lose their electrical resistance. While in this superconducting state, they are perfectly diamagnetic, i.e. will completely exclude magnetic flux when placed in a magnetic field.

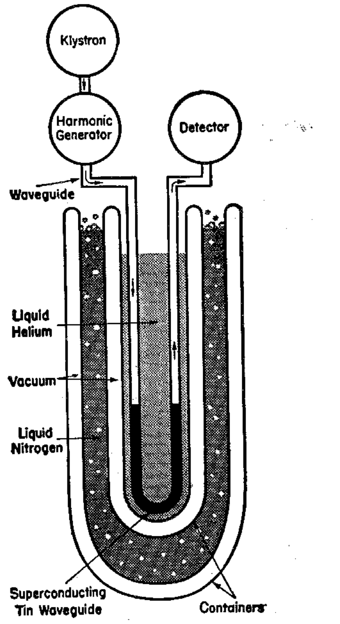
While this fundamental research is being conducted by theoretical physicists in search of knowledge and understanding of first principles, from even the terse description above of superconductivity, the imagination begins to run wild with engineering applications. An electronic computer using superconductivity memory elements will switch 10,000 times faster than conventional computer elements, will store 10 times as much information per unit space as ordinary computers. If the conditions can be fulfilled to make a substance superconductive in temperature regions other than that around absolute zero, design of every electrical or electronic product will be radically changed. Imagine considering the commonest electrical design problem without having to take into account electrical resistance!

While these exciting considerations whet the imagination, they are not the primary object of the low-temperature research going on at Westinghouse. This and many other research projects are being conducted to discover new phenomena and new knowledge of the universe. It is done on the belief that all research is an investment in tomorrow.

To the young, creative engineer this means exciting opportunities for graduate engineers in these exciting fields:

ATOMIC POWER	RADAR
AUTOMATION	SEMICONDUCTORS
JET-AGE METALS	ELECTRONICS
LARGE POWER EQUIPMENT	CHEMISTRY

. . . and dozens of others



Highly simplified diagram of the apparatus used to study the absorption of millimeter wavelength microwaves in superconducting tin waveguide. Studies of this type have shown the existence of a gap in the energy levels of superconductors. These studies have thus provided key information in solving the puzzle of superconductivity.

For more information on Westinghouse research in the field of superconductors and low-temperature studies, or information on job opportunities, write Mr. J. H. Savage, Westinghouse Electric Corp., P.O. Box 2278, Pittsburgh 30, Pa.

Westinghouse

FIRST WITH THE FUTURE

MERCHANT SAIL

by William Armstrong Fairburn and Ethel M. Ritchie

Reviewed by Paul C. Eaton
Dean of Students

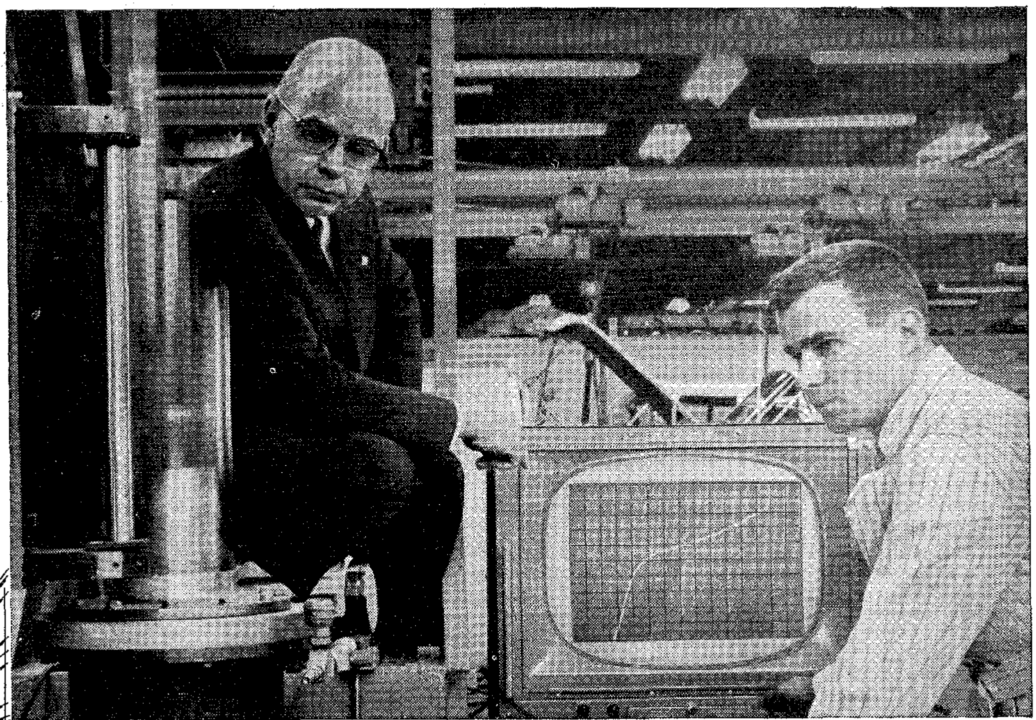
THE HUMANITIES LIBRARY of the California Institute has recently come into possession of a six-volume work entitled *Merchant Sail.* This is the most nearly complete collection of information on the design, building, and operation of American sailing vessels, and of the relation of maritime commerce to the history of the colonies and of the Republic, that has ever been compiled—or perhaps that ever can be compiled.

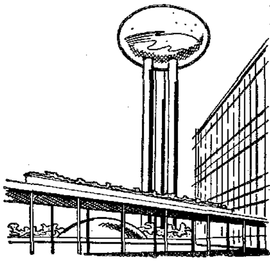
Merchant Sail is the result of a lifetime of research, carried on as the recreation of a busy man, of the late William Armstrong Fairburn (1876-1947), naval architect, marine engineer, and industrial executive. The set has not been offered for public sale but was published and distributed gratis to certain institutions as a public service by the Fairburn Marine Education Foundation, Inc., of Center Lovell, Maine. Its scope, depth, and thoroughness should make it very helpful to students of American history and economics, and invaluable to the maritime historian, amateur or professional.

The chronicle starts with the *Virginia of Sagadahock,* the launching of which into the Kennebec in 1607 was celebrated in Bath this year as the beginning of 350 years of shipbuilding in America. As befits a native of the state of Maine, Mr. Fairburn pays no attention to the claims of Haiti (1495), North Carolina (1526), Florida (1528), South Carolina (1562), Virginia (1585) or any other local "firsts" in shipbuilding, and proceeds from that point to record in Volumes I—III the ups-and-downs of American seaborne commerce from wood to steel, from sail to steam, pretty well down to World War II. Naval construction and operations, as well as the competition of steamships, are also discussed where they have significant relation to wind-driven merchant shipping.

Grand Turk, Great Republic, Shenandoah, Wyoming—all the great names are here. So, too, are *Polly, Gold Hunter, Jere G. Shaw,* and *Transfer No. 6:* pinnaces, brigs, snows, privateers, clippers and their predecessors and successors, barks and barkentines, the coasting schooners from the early pinks to the great six-masters, even the rigged wooden barges which formed the ocean-going

CONTINUED ON PAGE 10





SUSPENSION STORY—Chuck Steger, M.E. '52, probing dynamic properties of new Air Spring developed by Von Polhemus (l.). A nationally recognized authority on suspension systems, Mr. Polhemus directs Structure and Suspension Development Group of GM's Engineering Staff, helps guide Chuck in his professional career.

Because *engineering* is a *profession* at GM -we offer you a career-not a job

ONE REASON engineering standards at General Motors are so high is that General Motors recognizes engineering as a profession. And the men who engineer the many different products made by GM are respected for the profession they practice.

That is why, when you are invited to join GM as an engineer, you don't simply take a job—you start a career.

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You are also actively encouraged to pursue your education towards an advanced degree. For we at General Motors recognize that, in doing so, you will become more valuable to us and the engineering profession.

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And you are also encouraged to take an active role in your community's affairs—because a truly professional man is a good citizen as well as a good engineer.

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Many of the men who will fill the key positions at GM in the future are the young engineers joining GM today. This is not theory, it is fact. For 14 of our 33 Vice-Presidents are engineers, 23 of our 42 Division General Managers are engineers, too.

Today we are looking for young engineers—such as you—who may fill these positions tomorrow. The rewards—both professional and financial—are substantial. If you feel you have the ability, write us. It could be the most important letter of your life.

• • •

GM positions now available in these fields:

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INDUSTRIAL ENGINEERING • METALLURGICAL ENGINEERING
AERONAUTICAL ENGINEERING • CHEMICAL ENGINEERING
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PHYSICS • CHEMISTRY

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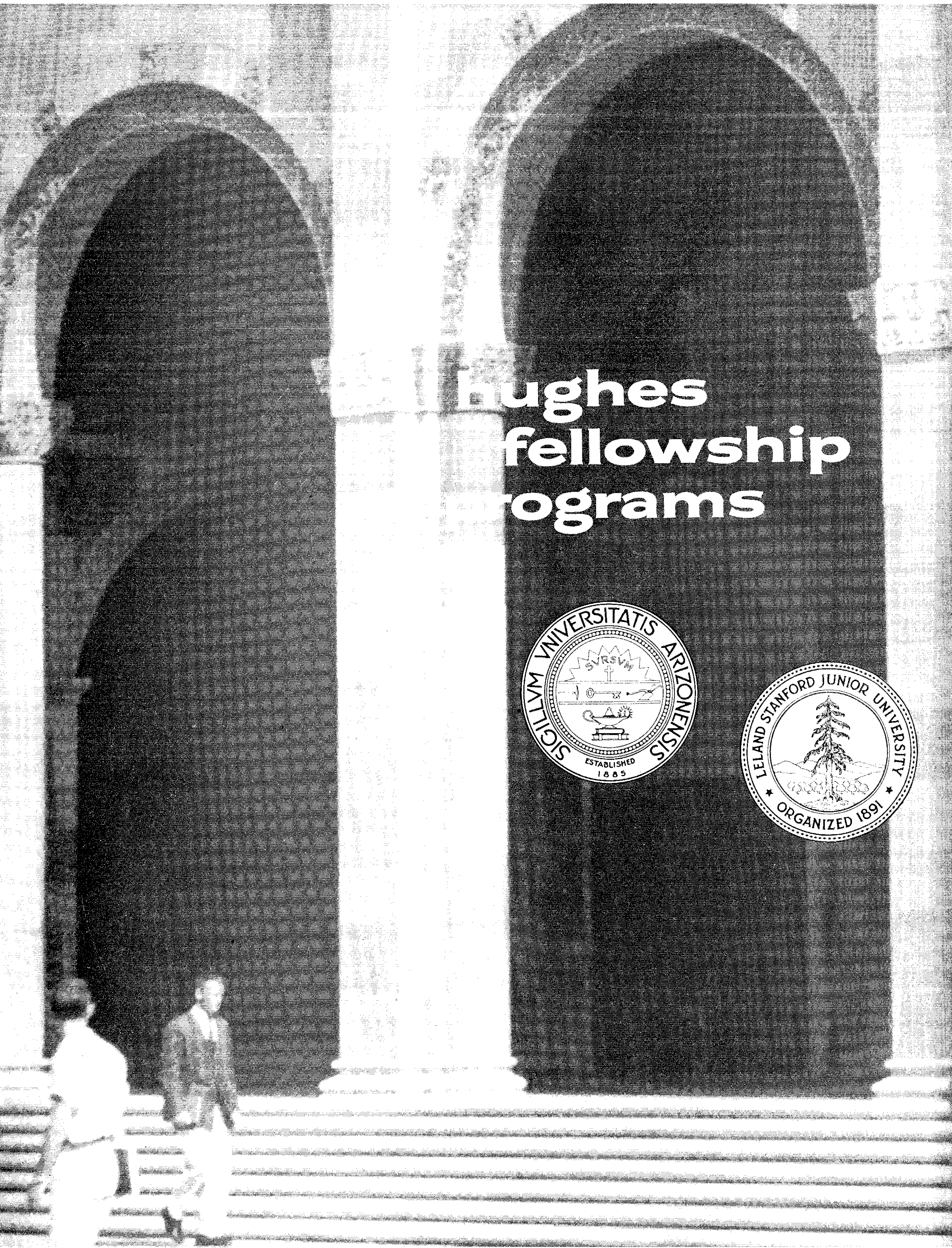
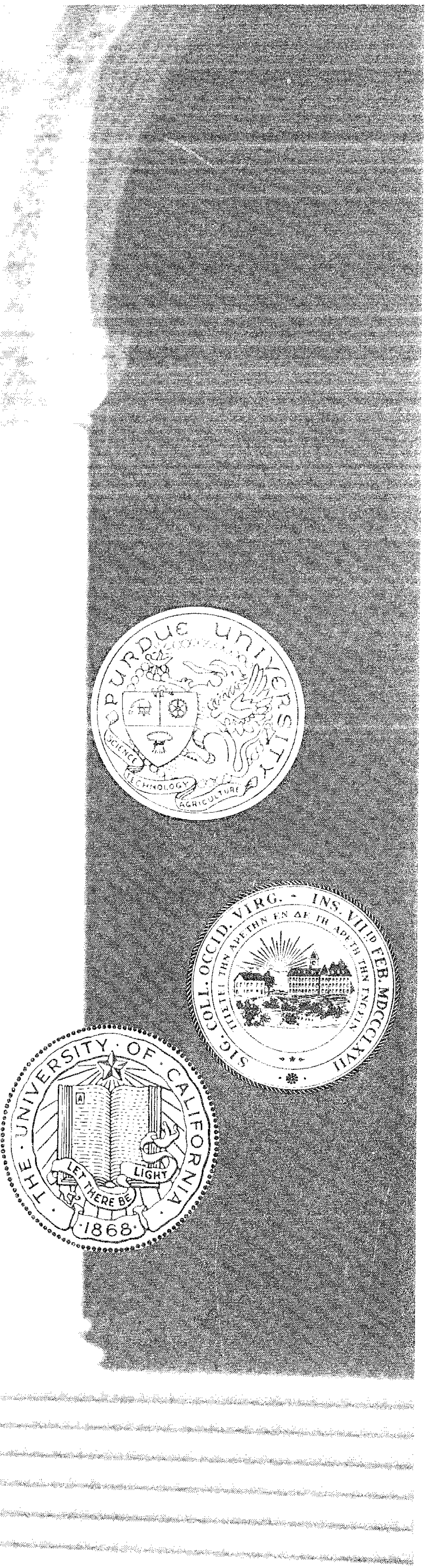
Personnel Staff, Detroit 2, Michigan

hughes fellowship programs

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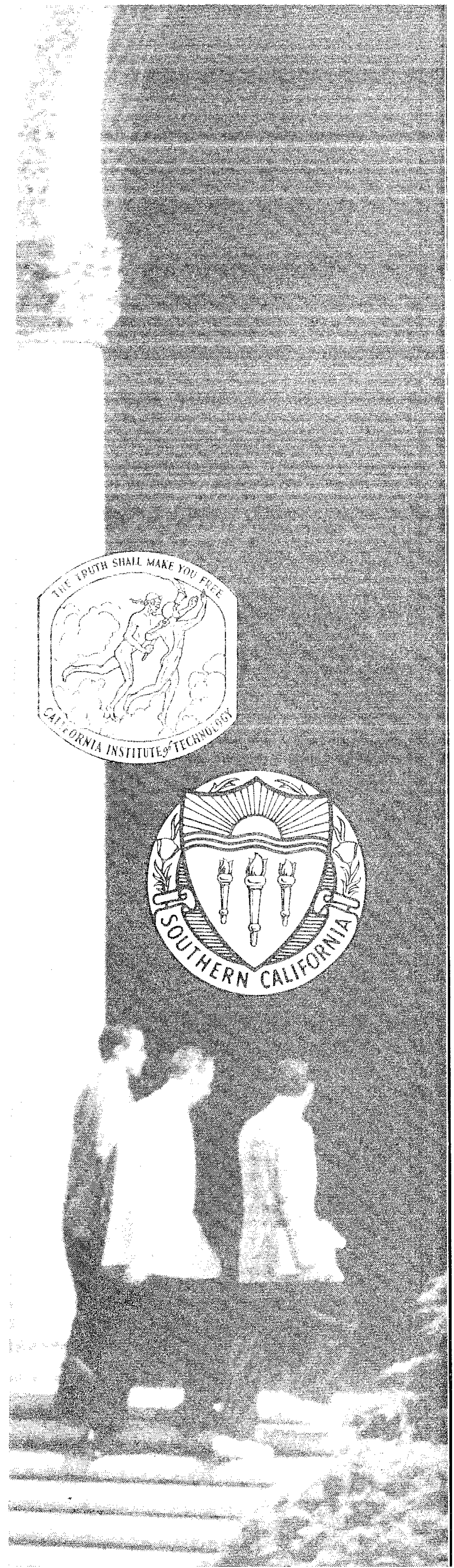
THE UNIVERSITY OF CALIFORNIA
LET THERE BE LIGHT
1868


THE TRUTH SHALL MAKE YOU FREE
CALIFORNIA INSTITUTE of TECHNOLOGY
SOUTHERN CALIFORNIA

tows of the early part of this century. And for each type and trade there are accounts of the supporting skills and activities of designer, master and mate, sailor and supercargo, rigger and adzeman, longshoreman and wharfinger, clerk, banker, lawyer, managing owner, underwriter, crimp, cabin boy, and cook.

Sail under foreign flags

Mr. Fairburn lists the four-masted schooner *Laura Annie Barnes,* launched in 1921, also near the mouth of the Kennebec, as the last commercial sailing vessel built in America, but carries the story of sail under foreign flags down to the Finnish fleet of Capt. Gustaf Erikson, which once included the *Pamir,* lost in the hurricane of September 1957.

Volumes IV - VI are edited by Ethel M. Ritchie of Ojai, California, and deal specifically with the China, Australia, Manila, and India trades (IV), American shipbuilding (V), and an appendix of owners of clipper ships and the records of ships they owned, together with an index by vessels' names of all ships mentioned in the preceding volumes (VI). The final volume also carries an admirable biographical account of Mr. Fairburn, itself a contribution to the record.

Some earlier books, like Capt. Arthur H. Clark's *Clipper Ship Era,* Samuel Eliot Morison's *Maritime History of Massachusetts,* Basil Lubbock's *The Down Easters,* Clifford Ashley's *The Yankee Whaler,* McNairn and MacMullen's *Ships of the Redwood Coast,* dealing with limited areas in the general field, have achieved perhaps a better synthesis of the material and have made more apparent the interrelation of shipping and economic, political, diplomatic, even social developments. Mr. Fairburn's 4,179 pages of fact, dimensions, times, tonnages, narrative and exposition contain the raw material of future studies. Lacking such a collection as this, log books, ledgers, customs house records, and the whole mass of supporting material of this great era in our commercial history could have become even more inaccessible because of dispersion than it already is.

Presumably, those with special knowledge will find errors or omissions in a work as comprehensive as *Merchant Sail.* Great Lakes navigation and the coastwise trade of California and the Northwest, for instance, get little space; while almost every gunk-hole in Maine is heavily, yet not always completely, documented. By and large, however, the work is a major contribution and, fortunately for the non-specialists who make up most of the library's clientele, and who may want to skip the tabulated data, a very readable account of an important phase of the national heritage.

ELASTIC WAVES IN LAYERED MEDIA

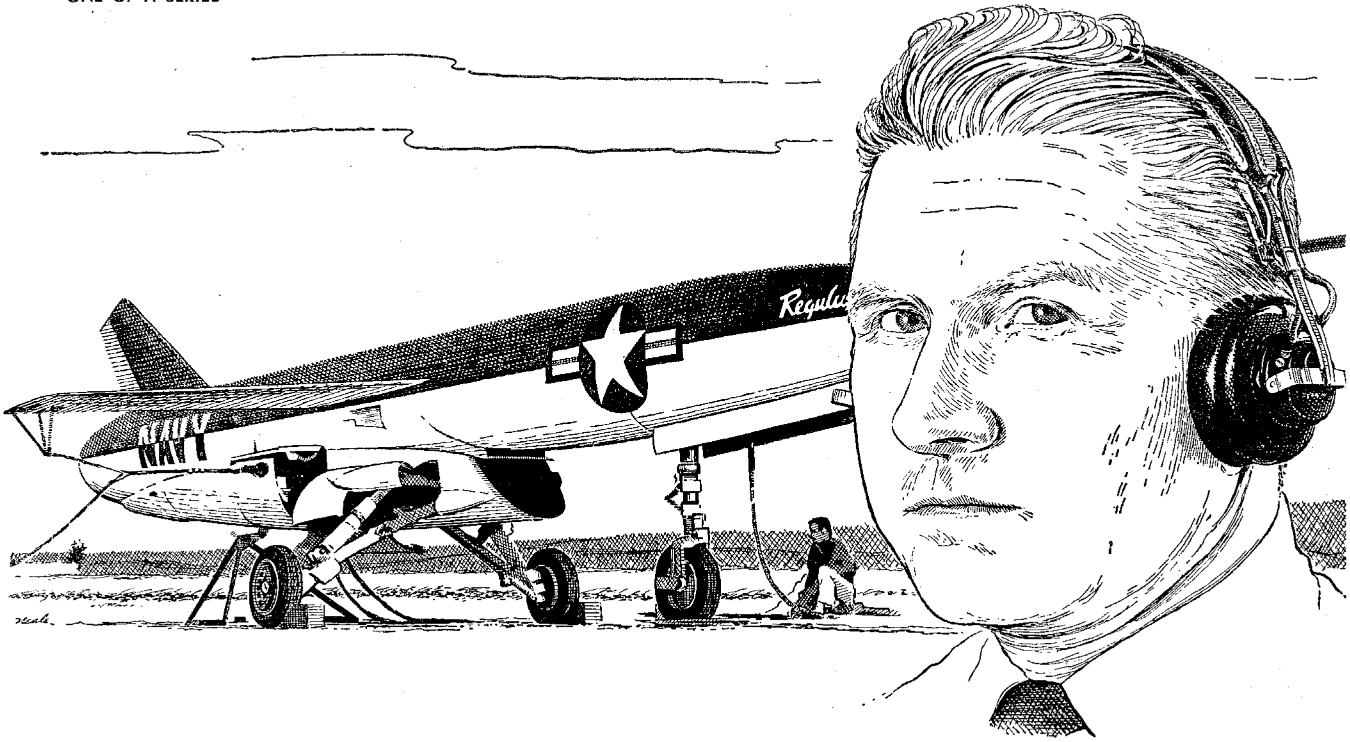
by W. M. Ewing, W. S. Jardetzky and Frank Press
McGraw-Hill, N. Y. $10

ALTHOUGH THE title suggests that this is a highly specialized book, it should appeal to a wide audience. Engineers working on delay lines or wave guides, geophysicists searching for oil, acousticians studying transmission in the ocean or atmosphere, physicists involved with electromagnetic wave propagation or solid friction—all make use of the techniques and results discussed by the authors.

Both experimental and theoretical aspects of the subject are covered on the elementary and advanced level. Perhaps the greatest contribution lies in the bibliography, which lists over 600 entries. The authors have scanned the world literature, including Russian and Japanese work in the field. Even when everything else is outmoded, this summary of the status of the field through 1955 will still be of value.

Frank Press, one of the three authors of this book, is professor of geology, and director of the Seismological Laboratory at Caltech.

A
Vought
Vignette
ONE OF A SERIES



Why the Missile Engineer Never Missed Mail Call

Vought's Regulus II missile took shape just a short walk from the desks of its developers. Engineers handled the new hardware and monitored tests in person — literally flying the big missile on the ground at Dallas. It was a convenient arrangement while it lasted.

Then a big USAF Globemaster landed and taxied to Vought's Experimental Hangar. The missile was winched aboard and airlifted to a desert site for flight tests. By nightfall there was a 1,000-mile rift between Regulus II and home base.

Joe Boston was ready to step into this gap. As Project Assistant for Field Liaison, he'd already equipped Vought's desert crew for extensive flight tests. Now he'd make sure that test data and hardware flowed uninterrupted from the desert to Vought. High-speed feedback of facts on one flight could influence the success of the next.

Mail from the desert poured in to Joe at Vought. From project men at the flight test site came parts for immediate rework and return. From the flight test crew's mobile ground station came rolls of telemetered brush records. From the recoverable Regulus itself, came packets of oscillograph data. And from Field Service — for repair or replacement — an occasional wrench or relay.

Joe served as clearing house and consultant. Flight data was reduced and released to design and support groups. It revealed not only missile performance, but the temperatures and pressures of a strange new environment. When data pointed toward design changes, Joe's time and cost estimates helped specialists reach decisions.

Thanks to Vought's fast overland relay of hardware and data, the records of one flight were decoded and digested in time to improve the next hop. Dividends in performance and reliability were obvious after six flights had been logged by Regulus II.

All six had been flown by one vehicle.

Chance Vought uses comprehensive testing and data analysis to assist the engineer through unexplored problem areas. Test facilities strengthen every phase of the development cycle, and procedures are aimed at feeding data quickly into the engineering process.

BUILDERS OF MILITARY AIRCRAFT
40th ANNIVERSARY
1917 TO 1957

CHANCE VOUGHT AIRCRAFT
INCORPORATED · DALLAS, TEXAS

LETTERS

Beverly Hills, California

Sir:

I was fascinated by the letter in your October issue which gave the statistics on the reunion of the Class of '32. I was particularly interested in Questions 18 and 19 in the questionnaire sent to all class members, which dealt with past and present political convictions of the class.

Question 19, about the present opinions of the class (90.7% Republican) is easy to understand, but the results of Question 18 are rather unusual. In fact, 64% Republican in 1932, at the depth of the depression (or fairly close to it) when graduating scientists and engineers had very poor employment prospects, indicates at best a lack of political awareness in the Class of '32 in '32. As I recall, Mr. Hoover didn't do too well in the election that year.

John Wise '57

Pasadena, California

Sir:

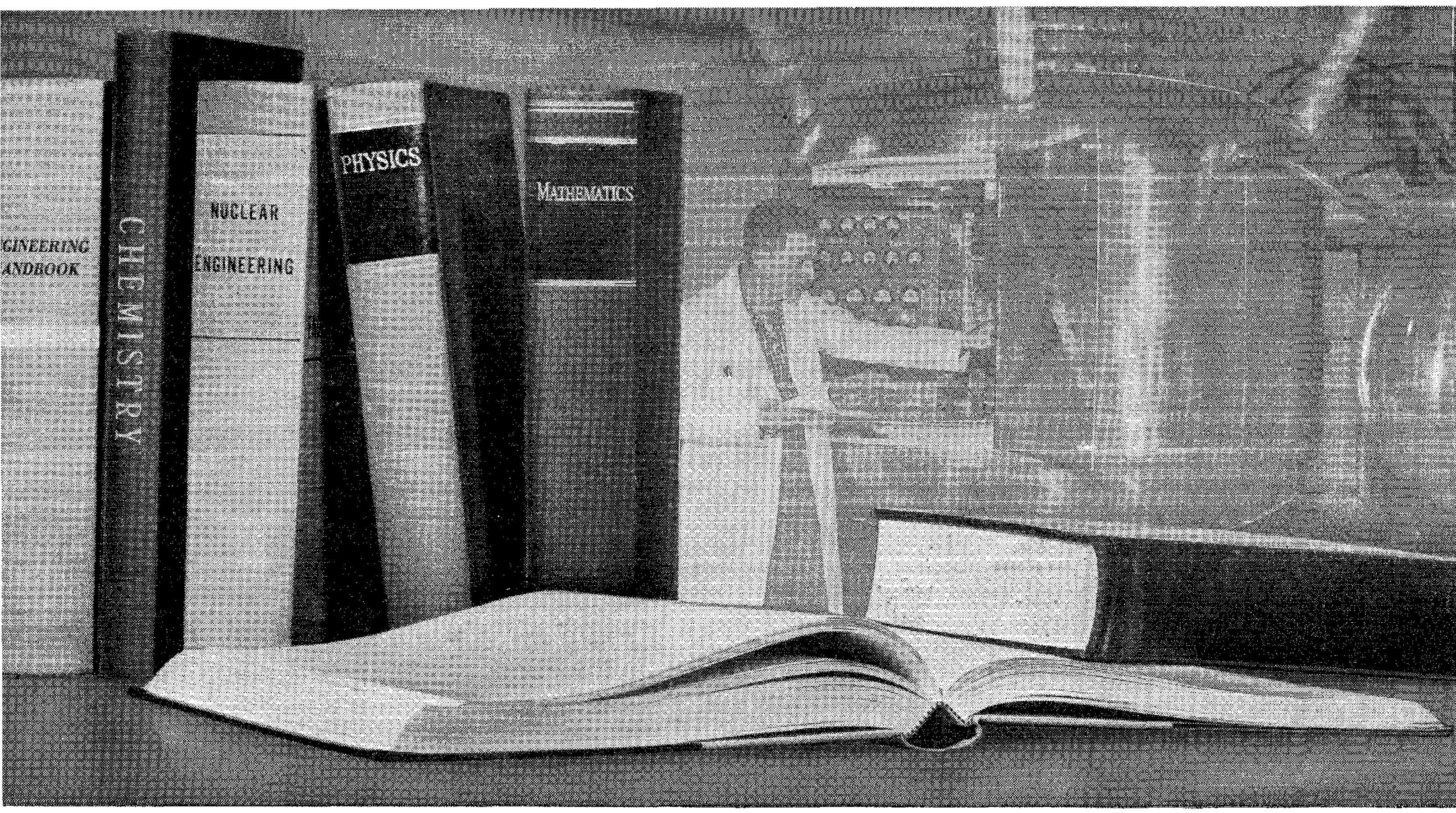
The introduction to your October article, "A New Technique of Education," describes the author, Dr. Simon Ramo, as "a noted scientist."

After recovering from the shock of seeing the editorial kidnapping of a noted engineer, I read the article with great appreciation. It was true to form, Caltech engineering style. Ramo, like all Caltech doctorates in engineering, is not at a disadvantage among scientists but he is first, last and all the time an engineer of whom that profession is proud.

He was granted a B.S. in E.E. degree with Phi Kappa Phi high honors by the University of Utah in 1933 for the completion of a course in Electrical Engineering. At Caltech, he made an outstanding record as graduate student and teaching fellow in Electrical Engineering and in 1936 obtained the distinguished degree Ph.D Magna Cum Laude in Electrical Engineering. His major research program from which we learned much was carried on in the 1,000,000 volt laboratory and his doctorate thesis title was "A Proposed New Standard for High Voltage Measurement."

He is a registered professional engineer, winner in 1941 of an Eta Kappa Nu award for engineering achievement, a Fellow of the American Institute of Electrical Engineers and of the Institute of Radio Engineers, all of which, as well as his writings and inventions, testify to the fact that though he can be properly called a scientist and also a musician of ability, he is by profession an engineer. His onetime professors claim the right to have him known as such.

Royal W. Sorensen
Professor of Electrical Engineering Emeritus


CHEMISTRY
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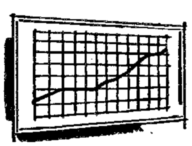
MATHEMATICS

Highlights of

YOUR FUTURE WITH HONEYWELL

Glenn Seidel, Vice President in Charge of Engineering, B.M.E. Minnesota '36

"Here are some of the facts about Honeywell that have most interested the young engineering graduates we talk to."



HONEYWELL IS A GROWTH COMPANY!

A growth company is one in which men move ahead because of opportunity and challenge . . . in which problems are turned into progress . . . and employment, sales and income increase steadily.

Honeywell, world leader in automatic controls, is such a company. For the past 30 years, sales have doubled or tripled every five years ($1.1 million in 1926; $287.9 million in 1956.) Employment has increased from 720 to over 30,000 in the same period and net earnings have climbed from $.4 million to $22.5 million.

The future is even more challenging. Planned diversification puts Honeywell in such new fields as office and factory automation, process control, plastics, atomic energy, electronics, missiles and satellites.

Honeywell has the proven skills to design, engineer and build the equipment required by an increasingly automatic world and to sell its products profitably.

Year	Sales ($000,000)	Net Earnings ($000,000)	Plant Space (Square Ft.) (000)
1926	1.1	.4	158
1931	5.4	.6	200
1936	13.5	3.0	432
1941	24.3	2.6	603
1946	45.9	5.7	1,284
1951	135.2	8.9	2,296
1955	244.5	19.3	3,460
1956	287.9	22.5	5,365

Honeywell's growth in sales!

	Employees				
Year	Total	Hourly	%	Salaried	%
1926	720*	540*	75*	180*	25
1931	1,150	839*	73*	311*	27*
1936	3,139	2,200	70	933	30
1941	4,240	2,859	67	1,381	33
1946	9,474	6,490	68	2,984	32
1951	17,182	10,796	63	6,386	37
1955	25,608	14,853	58	10,755	42
1956	30,353	17,301	57	13,052	43

Honeywell's growth in people!

TWO WINGS OR FOUR?

By turning a two-winged fly into a four-winged one, Caltech geneticists produce a working model for picturing the genetic control of development

by EDWARD B. LEWIS

BY TAMPERING WITH the genes of the tiny *Drosophila* fly we have constructed a four-winged fly at Caltech. Such a fly is really a contradiction in terms. As every school boy (who has had biology) knows, flies have only two wings. How then does a four-winged fly arise—and what is the significance of such a useless creature?

Be assured that the California Institute has not been under contract to develop and produce such monsters. Instead, the four-winged fly was a by-product of some basic studies of the nature of the hereditary material. Perhaps someday knowledge gained from such studies will help prevent the occurrence of similar kinds of monstrosities among human births.

Why do we use the fly in experiments on heredity? To perform such experiments we need to breed large numbers of individuals in a short time in a small space. The *Drosophila* fly admirably fulfills these conditions; a new generation appears every ten days, and a single pair can produce hundreds of offspring in a small culture bottle on an inexpensive food in a few days.

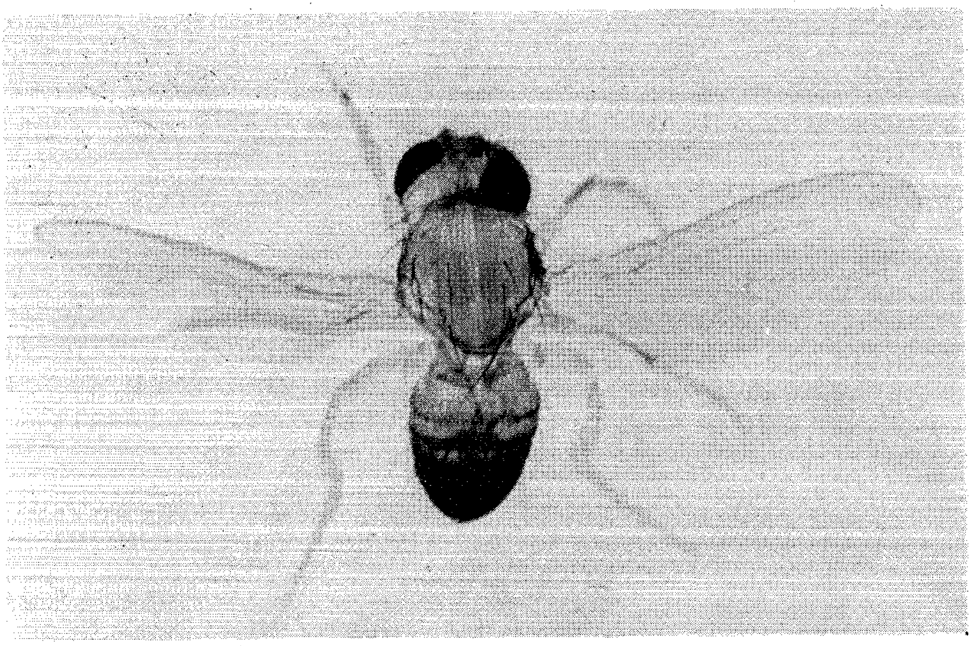
The genetics of this fly is a part of the broad program of genetics that T. H. Morgan and his colleagues initiated at the California Institute in 1928. In fact—in the period from 1910 to 1928—it was Morgan and his group at Columbia University who demonstrated that the genes are arranged in a linear order in the chromosome—much like beads strung on strings.

In 1942, it was discovered at Caltech that there are places in the chromosome where what at first had appeared as a single gene turned out, by finer methods of analysis, to be a cluster of functionally related genes. The genes responsible for the four-winged fly belong to such a cluster—called the "bithorax" cluster.

The normal fly (shown on page 20) has a pair of wings and, behind them, a pair of tiny club-shaped organs—the balancers or halteres. The balancers are thought to provide a gyroscopic action which is used to stabilize the flight of the insect. It is these balancers which are modified into wings in the case of the four-winged flies.

Such flies represent a combination of two extremely rare mutations belonging to the bithorax cluster. The first mutation, a "bithorax" type, was found in 1925 by Professor Curt Stern. It causes an overgrowth of the front half of the haltere so that it resembles the front half of the normal wing.

In 1948, some experiments with x-rays at Caltech produced another kind of mutation that resulted in a



The normal fly has a pair of wings and, behind them, a pair of small club-shaped organs called balancers or halteres.

fly in which the *back* half of the haltere develops an overgrowth resembling the *back* half of the normal wing. This mutant is therefore given the name postbithorax.

We felt that we could best test the validity of these interpretations of the mutant effects by combining the mutants in such a way that both are expressed in the same individual. Then, a fully formed wing should arise in place of the balancer.

To combine the two abnormal mutants required several steps. First, bithorax females were mated to postbithorax males. The offspring of this mating are perfectly normal two-winged flies. They are "carriers," however, of the two mutant genes. These carriers were then allowed to produce offspring which numbered 18,711 flies. Among the 18,711, only three proved to have been cases in which the two mutants were combined together in one and the same chromosome. The final step was to breed together these rare individuals. From this mating, a pure-breeding strain of four-winged flies (shown on page 21) was developed.

The extreme rarity with which the two mutants recombined was expected, since it was already known that these genes are in the same cluster—that is, they are exceedingly close together in the chromosome.

Position of genes

The rule about determining the position of genes can be expressed in another way. If a female inherits a certain genetic defect from her mother, and a quite different defect from her father, the chance that one of her eggs will receive both of these defects depends on how easy it is to get a recombination between the affected genes in the female's maternal and paternal chromosomes. The affected gene in the maternal chromosome must actually be physically recombined with the affected gene in the paternal chromosome by an interchange or "crossover" between these two threadlike structures. The closer the affected genes are to each other, the less often such a crossover occurs. In fact, we use this principle to define the gene: a gene is a unit within which crossovers do not occur.

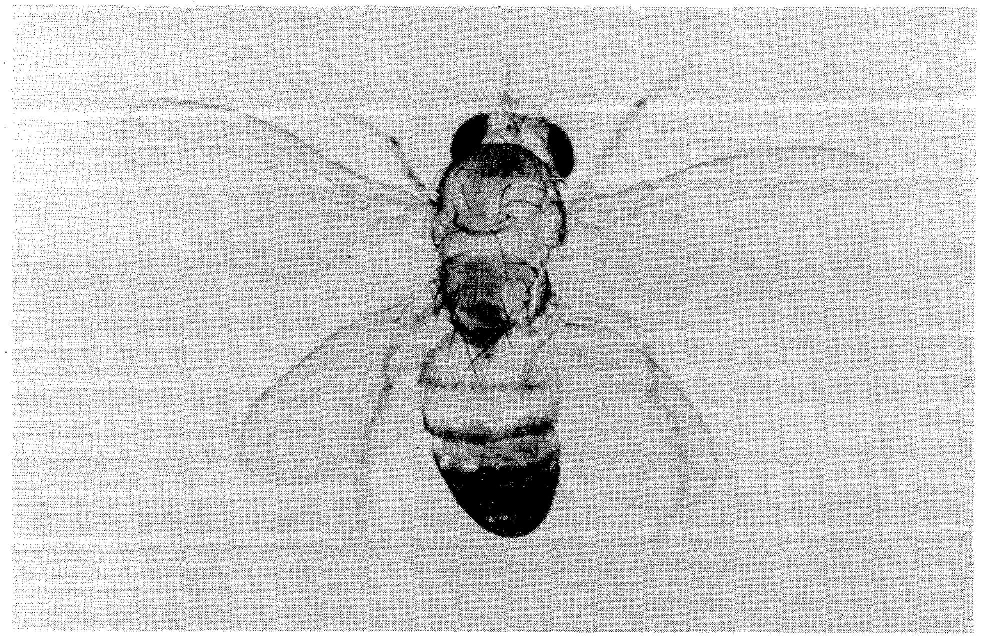
What good is a four-winged fly?

What, if anything, can we learn from a four-winged fly? One thing we hope to learn is how genes affect the development of an organism. We know that the genes are the core of living matter. They provide the information that enables the cells to grow and multiply and develop into the fully formed organism. In other words, they not only account for the transmission of characteristics from the parents to the offspring, but they are also thought to control the whole course of development of the organism from fertilized egg to adult.

In recent years much has been learned about what genes do besides simply making copies of themselves to be handed on from one generation to the next. Thus, each gene seems to control the production of a specific catalyst or enzyme which in turn controls a biochemical reaction. A whole group of investigators in the biology division at Caltech are probing this biochemical aspect of genetics.

Is such a gene-controlled chemistry sufficient to explain how, during its growth and development, an organism acquires its shape and form and elaborate differentiation of parts?

We are not sure of the answer. Instead, as a working hypothesis, we postulate that the development of a living organism is an orderly unfolding in time of many different sequences of biochemical reactions—each ultimately gene-controlled. Curiously, all of the cells of the developing organism seem to contain the same num-



The four-winged fly has fully formed wings in place of the balancers, and a greatly enlarged thorax.

ber and kind of genes. In other words, there appears to be no mechanical sorting out of the genes according to part and function.

If development is to be explained in terms of the action of genes, it becomes necessary to picture it as a gradual and orderly "turning on," so to speak, of systems of genes. The bithorax and postbithorax mutants probably represent part of one such system. Thus, the bithorax cluster is concerned, among other things, with determining whether flies shall have two wings or four wings. We infer this from the fact that, in the presence of the abnormal or mutant genes, bithorax and postbithorax, the normal pathway of development is interfered with and a four-winged fly results.

Now we have good reason to believe that flies evolved from an ancestral type which had four wings. In the evolutionary process, the second pair of wings were reduced to the balancers. From this we speculate that the normal (as opposed to the mutant) bithorax and postbithorax genes must somehow have originated as new genes whose function was to elaborate substances which suppress the potential development of the second pair of wings.

Origin of new genes

Geneticists picture the origin of new genes somewhat as follows: first the "old" gene duplicates; then one of the two identical genes thus formed is free to mutate to a "new" gene having a new function while the old gene is retained to carry out the old function. To be sure, a great many other changes—and perhaps many other new genes besides bithorax and postbithorax—had to arise before the modern fly evolved.

For example, as if to compensate for the reduction of the second pair of wings, the wing-bearing section of the fly underwent an enormous overdevelopment and produced an elaborate pattern of bristles and hairs. The fly shown in the picture above has both wing-bearing sections enormously overdeveloped. This is not surprising, of course, when it is realized that in such a fly there has been no alteration in the systems of genes which are responsible for overdeveloping the wing-bearing region.

What can we infer about the role of the bithorax cluster of genes in normal development? We postulate that, during the course of development of a normal fly, this system of genes is present but effectively inoperative in the wing-bearing section. In the haltere-bearing section, on the other hand, these genes elaborate a series of substances which direct the pathway of that section from wing formation toward haltere formation.

A working model

What determines the essential difference between the wing and haltere-bearing section? We postulate that there is a gradient in the concentration of some chemical substance during the development of the embryo, such that the concentration is relatively much greater in the haltere-forming region than it is in the wing-forming region. It would then be the function of the normal genes of the bithorax cluster to exploit this gradient—to amplify it into an "all-or-none" response. That is, the bithorax cluster would normally be inoperative in the section which ordinarily produces wings, but would be "turned on" (by the presence of greater amounts of the postulated substance) in the section which produces halteres. The normal genes of the bithorax cluster would then elaborate a set of substances which would direct the haltere-forming section to make halteres.

We have a working model for picturing the genetic control of development. Whether it is the correct model or not remains to be seen. In pursuing that model, however, we should make progress in our understanding of the living organism.

THE CAMPUS

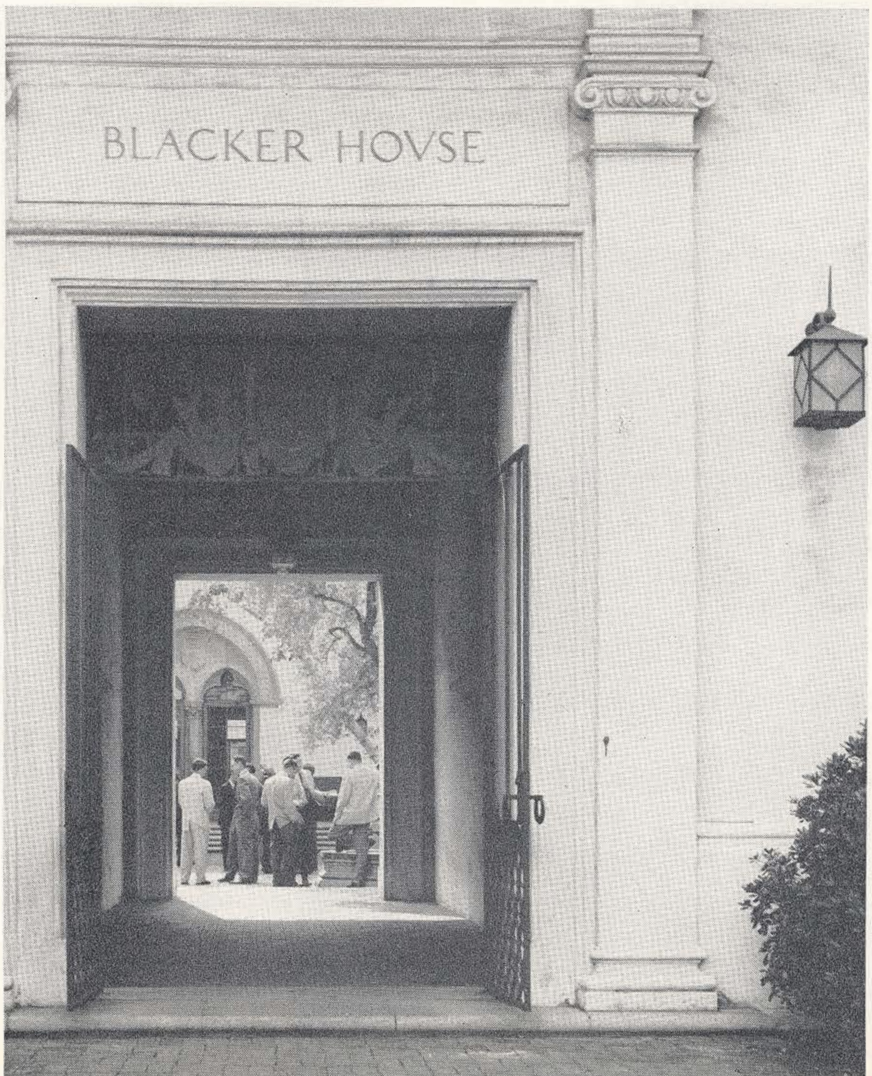
Some samples from a new collection of photographs

by THOMAS W. HARVEY

Left: Throop Hall, oldest building on the campus.

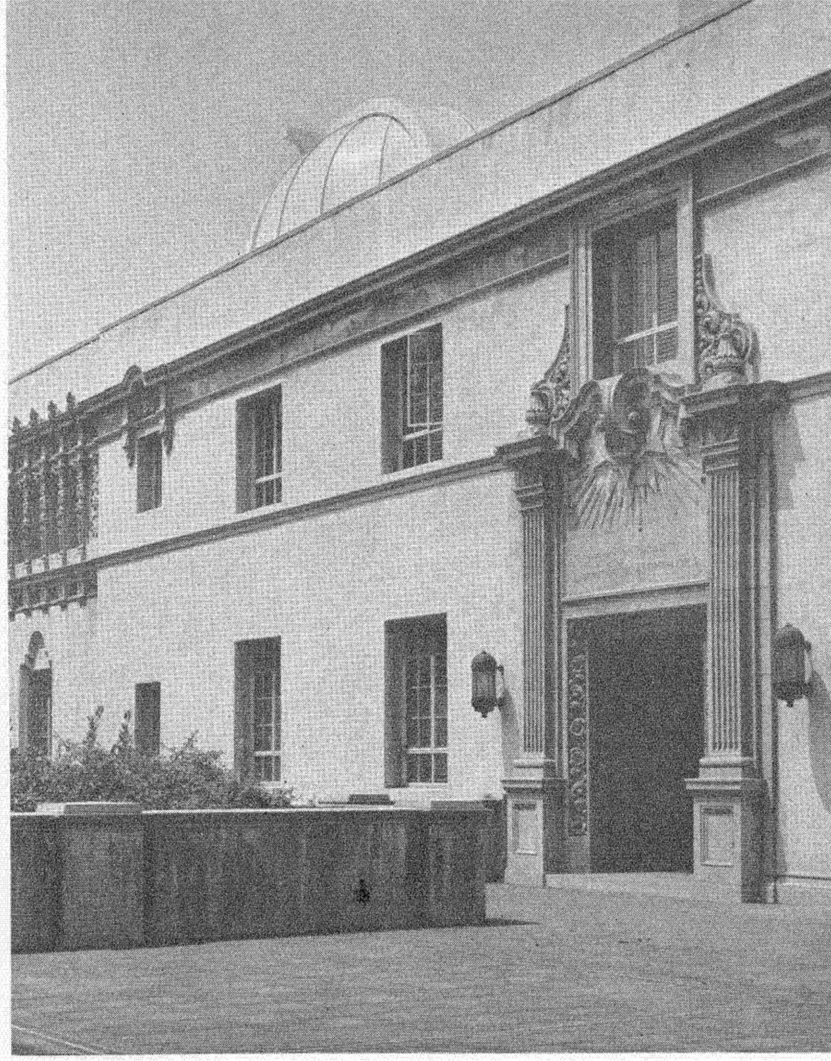
Below: Kerckhoff biology laboratories.

Engineering building, completed in 1950.

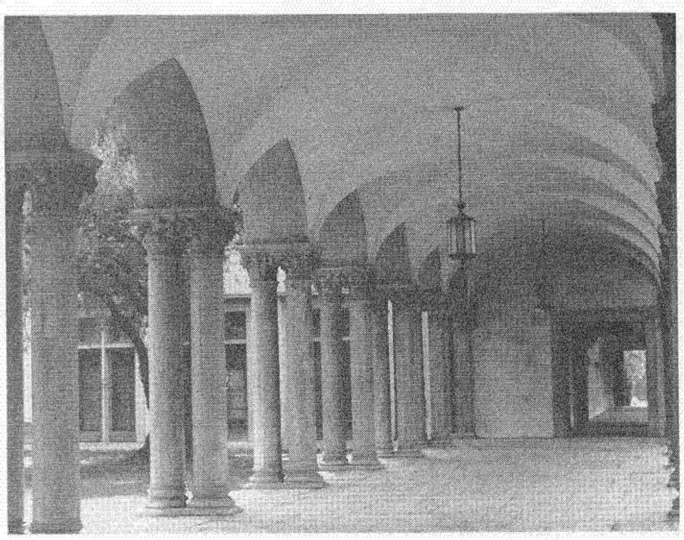


Blacker, one of the four student houses.

Robinson Laboratory of Astrophysics.



Colonnade between Fleming and Ricketts Houses.



Church Laboratory of Chemical Biology, dedicated in 1956.

THE BEST IS NONE TOO GOOD

By 1972 the American people may be sending about 50 percent of their children to college. How will we make room for them? How will we pay the bill? And what quality shall the education be?

by L. A. DuBRIDGE

THE AMERICAN PEOPLE now send 30 percent of their children to college, and the chances are better than even that in 10 years, more or less, the number will be approaching 50 percent. In some of the more prosperous states 50 percent of the high school graduates *now* enter college.

The number of children who reached age 17 and who thus could potentially be applicants for admission to our institutions of higher education was 2,300,000 in 1956; it will be 3,900,000 in 1972—an increase of 70 percent. If the fraction of these who enroll in college continues to increase as in the past, we will have more than doubled college enrollments by that year.

If our present great educational system of 1800 colleges, junior colleges and universities is just adequate for present enrollments (and I hear little complaint about space going to waste!) then we are going to have to build the equivalent of 1800 more colleges by 1972. Double in 15 or 20 years the plant that has taken 300 years to build! The task is staggering; until 1972 it will cost about a billion dollars a year for physical facilities alone.

We now spend 3 billion dollars a year in operating our universities and colleges—about $1,000 per student. It is unlikely that the cost will go down; in fact, to bring faculty salaries to where they should be it must go sharply *up*. Thus we should add a billion dollars a year immediately to the budget, and by 1972 we may need to be spending $1,400 per student, or 8 billion dollars a year for higher education—in addition to a billion a year needed for plant additions.

As President de Kiewiet of the University of Rochester recently remarked in a brilliant paper on the subject, "All this is absurdly too much." "*Or,*" he adds, "*is it?*" He goes on to point out that American industry is spending at the rate of 25 billion dollars a year for new plant facilities. (Southern California alone is spending a billion dollars a year for new plant.) American Telephone and Telegraph spent a billion dollars last year on new telephone equipment. If we can spend that much on helping people talk to each other, might we not spend an equal amount in helping them have something to talk about? Furthermore, 3 billion dollars a year is only 75 cents out of each $100 of Gross National Product. In 1972, 8 billion dollars will be only $1.30 out of each $100 of the projected GNP for that year.

The bill has got to be met. The American people will not tolerate having half their qualified youngsters refused admission to college. The only question is: When shall we pay, and how? Shall we meet the bill soon enough—or too late? Shall we meet it by tuition fees or private gifts or taxes, or by how much of each?

But the quantitative problem is not the most serious one. Americans can scrape up an additional 3 or 4 billion dollars a year by 1972 if they have to. Much more difficult—and more important—than the question

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"The Best Is None Too Good" has been adapted from a talk given at the Conference on Engineering and Scientific Education in Chicago on November 1, 1957.

of how many students are to be educated is the question of what quality shall the education be.

The conclusive test of what the quality of an educational institution *has been* is, of course, the quality of the alumni. If the alumni of 25 years ago appear to have reached, in relatively substantial numbers, positions of high achievement and if they occupy posts of responsibility in government, in industry and in universities, we can then surely conclude that *25 years ago* that institution was doing a fine educational job—or, at least, was attracting exceptionally able students.

A long history of alumni success is the earmark of the great institution. And since greatness has tremendous inertia (it is difficult to achieve but, once established, has a tremendous tendency to persist) we are usually safe in taking past performance, if consistently maintained, as a good measure of present quality or the lack of it.

Now, if the measure of past achievement in a given field is the success of the alumni, then we must ask what are the sources of this success? What factors make for continuing high quality? There are, I think, at least four:

1. Quality of students
2. Quality of faculty
3. Quality of leadership
4. Quality of teaching and research facilities

Each of these factors is worth a brief discussion.

Students—The matter of student quality is not usually given adequate nor adequately candid attention. The blunt fact is that, by any sort of test of intellectual ability ever given, the average quality of students at some institutions is very substantially higher than that found at others. In fact, the upper quartile of students at some colleges may hardly come up to the lower quartile at others.

Now, this is not bad; in fact, it is good and should be encouraged. Top-grade students will get a better education if they are in a place where there is stiff competition; and less able students will also do better if they are not hopelessly outclassed by their colleagues.

Difference in performance

It needs to be realized that in technical subjects like mathematics and physics, which require a high degree of quantitative imagination, the difference in performance between a top student and a mediocre student is really very great. It is far greater than the difference suggested by giving the one a grade of 99 percent and the other 60 percent, for example. It is not a ratio of 5 to 3, but a ratio of 5 to 1, or 10 to 1—or, occasionally, 100 to 1—that we are dealing with.

Trying to accommodate in one class a spectrum of student achievement ranging over a ratio of 10 to 1 presents serious difficulties, to say the least. That means a problem assignment which takes 2 hours for the best student takes 20 hours for the least able student. If we compromise and let the slowest student off with 5 hours of work, the best student may not even bother to solve such easy problems at all. How we attack this difficult problem is one of the prime questions of technical education.

There are some people who will say we need not worry about the outstanding student; he will take care of himself. And they will point to the Thomas Edisons and Charles Ketterings who had very little formal education at all.

But I think this attitude is wrong—very wrong. The future creative leaders of our science and technology should have *the most challenging* opportunities to develop their capacities—intensively and early. You can point to certain great scientists and engineers who are self-taught—but I can point to many, many more who developed under the challenging and understanding encouragement of a great teacher—such as Ernest Rutherford, Niels Bohr, or Robert Millikan, to name but three in the field of physics.

There are so many examples of a great scientist building up a school from which other great scientists have come, that we are forced to the conclusion that—though a few may come through handsomely, even though neglected—we can substantially increase the yield of good technical people if we provide the stimulation, the encouragement and the practical help that a high quality educational center can give. Maybe the most important function of a great center or a great teacher is just to attract the best students and let them stimulate each other. If so, that is a most significant contribution.

Quality and quantity

What shall we do, then, about student quality as enrollments rise? Shall we tighten up the admissions policies of our colleges, cutting off, say, by 1972, the lower half or two-thirds of those who would *now* be admitted—educating only those of ever-higher intellectual capacity?

There are some who advocate this course—and advance in its favor perfectly sound arguments about the importance of quality versus quantity. Others advocate this course to save money.

Neverthless, this extreme measure will not be accepted by the American people, who are determined to have greater, not less, educational opportunities. Nor is this solution, I believe, either practical or desirable—for four reasons:

1. Our selecting and predicting techniques are not nearly good enough to refuse a higher education to half of those who desire it. We would be cutting off many who, because of poor schooling, poor home environment, or other reasons, have made a slow start but may still do very well.

2. In the engineering fields we need men with a variety of skills. And not all the talents we need are necessarily reflected in high academic standing. The old

adage that "the *A* students make the professors and the *C* students make the money" is no longer good statistics, but it still is more than occasionally true.

3. The quantitative shortage of scientists and engineers is sufficiently severe and sufficiently long-term that we should seek to recruit a larger rather than a smaller percentage of students into our engineering schools.

4. Finally, there is no conclusive evidence that under proper conditions rising enrollments in a particular institution necessarily result in declining quality or in lesser opportunities for the gifted student.

What then do we do to keep broad educational opportunity and also to insure the quality of training we need? I would propose:

1. Expand facilities for higher education throughout the country, especially in public institutions, to provide space for the same or slightly larger fraction of the total college-age population as now, and at the same time improve our selection techniques to eliminate the loafers and incompetents.

2. Make more extensive use of the junior college as a means for providing the first two years at low cost for many students—thus delegating to those institutions some of the task of eliminating the unfit and preparing the better ones for upper-division work elsewhere.

3. Provide for all students of outstanding ability, whenever and wherever they appear, special attention, special encouragement and special incentives to go on beyond the routine work of the classroom; and encourage them, when it is appropriate, to transfer to other institutions where more adequate facilities or competition will be found.

4. While many institutions expand their facilities, a few schools around the country should be encouraged in their efforts to select only the most able students and provide them with a supremely challenging program.

We have such schools now—and many of them are facing a difficult dilemma. Shall they expand enrollment and make their excellent facilities available to more students—even at some loss in quality—or shall they put all available resources into higher and higher quality opportunities for a carefully selected few? Or can some, in fact, expand and raise quality also?

The select few

I would not presume to judge what the proper course is for any particular college—except my own. But I do suggest that those who do elect to give high-quality instruction to a select few be given encouragement and support—in spite of the fact that some segments of public opinion will brand such institutions as "undemocratic," a horrible distortion of the meaning of that word.

Faculty—Good scholars are very scarce. You would think, in fact, they would command the highest salaries of anyone in the community. But, instead, their salaries have always been low and, in purchasing power, they have been getting relatively lower as the years go by.

Our colleges and universities are being subsidized by their faculty members who, in the nation as a whole, forego a billion dollars a year in salary because they love to live in a university atmosphere. Now that is very generous and loyal of them—but the universities are courting disaster if they allow this contribution to continue.

Opportunities more remunerating, and in some ways equally rewarding, are available outside the universities for scientists and engineers—especially young ones not yet bitten with the university bug. The quality of our faculties will surely erode away if we do not find ways of keeping a very much larger fraction of these bright young men in the teaching profession.

The seed corn of the future is such a valuable resource that we must promptly begin to adopt more realistic methods of conserving it. The second report of the President's Commission on Education Beyond the High School flatly recommends that average faculty salaries be doubled in the next five to ten years. It is about the most sensible suggestion I have heard.

First-class faculty

To have first-class colleges we *must* have first-rate faculty and there is just no room for further argument on that point. We'll either get first-class talent and pay for it—or we will have second-rate universities. Again the decision rests with the American people.

But this is no easy task. To double the top salary levels of professors in the leading universities means bringing them from the present $10,000-$15,000 salary levels to $20,000-$30,000. Now $20,000 is the annual income on some $500,000 endowment, and $30,000 is the income on $750,000. A group of 100 top professors, then, will require an endowment of $50,000,000 to $75,000,000. Not more than 15 private institutions in the nation have that much endowment to cover *all* expense.

The Ford Foundation recently made munificent gifts totaling $250,000,000 to the accredited private colleges of the country—over 600 in number. This was about equal to one year's salary budget for these institutions. As an endowment, therefore, it provided about a 4 percent salary increase. To *double* the salaries in these same institutions would have taken an endowment gift of 6½ billion dollars! Impossible? Well, at least we must admit it won't be easy and we ought to get to work.

Leadership—The third qualitative criterion in university education is that of leadership: the leadership of the faculty, of the deans and other administrative officers, of the president and the trustees. Someone must set up the ideals which an institution seeks to achieve—and then keep the helm firmly fixed in that direction.

In 1908 a great scientist and scientific leader named George Ellery Hale became a trustee of a private manual training school in Pasadena. He persuaded the other trustees that southern California needed a technical university "second to none" in the nation. Fortunately, he wasn't laughed at, and within two years Throop Polytechnic School had transferred to other schools its 600 elementary and high school students, had retained its best 30 college students, moved them to a new campus and established a policy and a program which led straight to the California Institute of Technology of today. Leadership with vision and with determination brought to reality what in 1908 must have seemed to many to be a hollow boast.

A similar story has been repeated at many institutions. Inspired leadership will attract inspired faculty members; they will attract first-class students; and all together they will attract the necessary funds to make first-class institutions.

I cannot tell you how to manufacture inspired leadership among the trustees, faculty and administration of our colleges. I can only say that without it new goals of high quality cannot be attained.

Dr. Raymond B. Fosdick has said of Dr. Wickliffe Rose, onetime head of the General Education Board—a Rockefeller creation—that his (Rose's) insistent policy in supporting education was expressed in a single phrase: "Make the peaks higher." Where inspired leadership was found—in administration or faculty—he advocated supporting it to the limit; where superb quality was being achieved, he wanted to make it still better.

Make the peaks higher

I believe higher education in America could well adopt Dr. Rose's motto, "Make the peaks higher." This does not prevent making the base broader too— in fact, it requires it. But it brings out the fact that a major function of a broader base is not to take up more space, but to support the higher peaks.

Such a policy is quite contrary to the views held by many educators. There are many who, in fact, advocate the contrary thesis; namely, "leave the peaks alone and fill up the valleys." Their thesis would be to help the weak or so-called "needy" institutions rather than the best ones. This, it is claimed, is "the democratic way."

Now no one could deny for a moment that it is to the national interest to have many good universities, and that it is desirable for every college and university to get a little better. But it is equally important that there be a few institutions—we dare not hope for more than a few —of really superb quality. We must, for the sake of future generations, have a few outstanding leaders, a few institutions that are blazing the trails of the future.

Facilities—A good institution needs adequate facilities. A good faculty needs adequate material support. "Mark Hopkins on one end of a log and a student on the other" is a fine ideal. But as a New York court, passing on the taxability of student and faculty residences, once remarked: "Institutions early learned that a student must live somewhere else than the end of a log. Nor is the other end a suitable residence for the teacher—particularly in northern New York."

Bricks and mortar, steel and concrete are essential elements in a fine technical institution. We must have laboratories for teaching and research libraries where the knowledge of the past is readily accessible to the present; living, dining and recreation facilities conducive to a life of scholarship—these things are essential to students and faculty alike.

Hardheaded businessmen are inclined to criticize universities for making "inefficient use" of space. A classroom, they say, is used only 6 hours a day, 5 days a week, only 9 months a year. Why not 70 hours a week instead of 30? Why not 12 months a year?

Well, why do we use the bedrooms in our houses only 8 hours a day? Why not take turns sleeping and make one bedroom do the work of three? Also, why do automobile assembly lines operate only 40 hours a week—with 6 weeks off every fall to change models?

Machines for men

The answer is, of course, that machines are made for men—not men for machines. Buildings and laboratories are designed to make learning easier, not harder. The time of people—of students, of faculty, of other employees—is far more valuable than the building space they need. It is poor economy to impede the work of a $20,000 professor (in 1965, that is!) for many years for lack of a few thousand dollars' worth of space.

The entire capital cost of a university plant is often no more than 3 to 5 times the operating expenses for a year. And even if classrooms can stand being used 12 months a year, neither the teacher nor the student can.

What I have been saying may be briefly summarized:

1. One brilliant creative scientist or engineer may turn up with more new ideas than 100 ordinary ones. He may, in fact, need the help of the 100 in putting his ideas to use. Hence, while we are educating the 100 we should not fail to find and encourage and give special attention to the *one*.

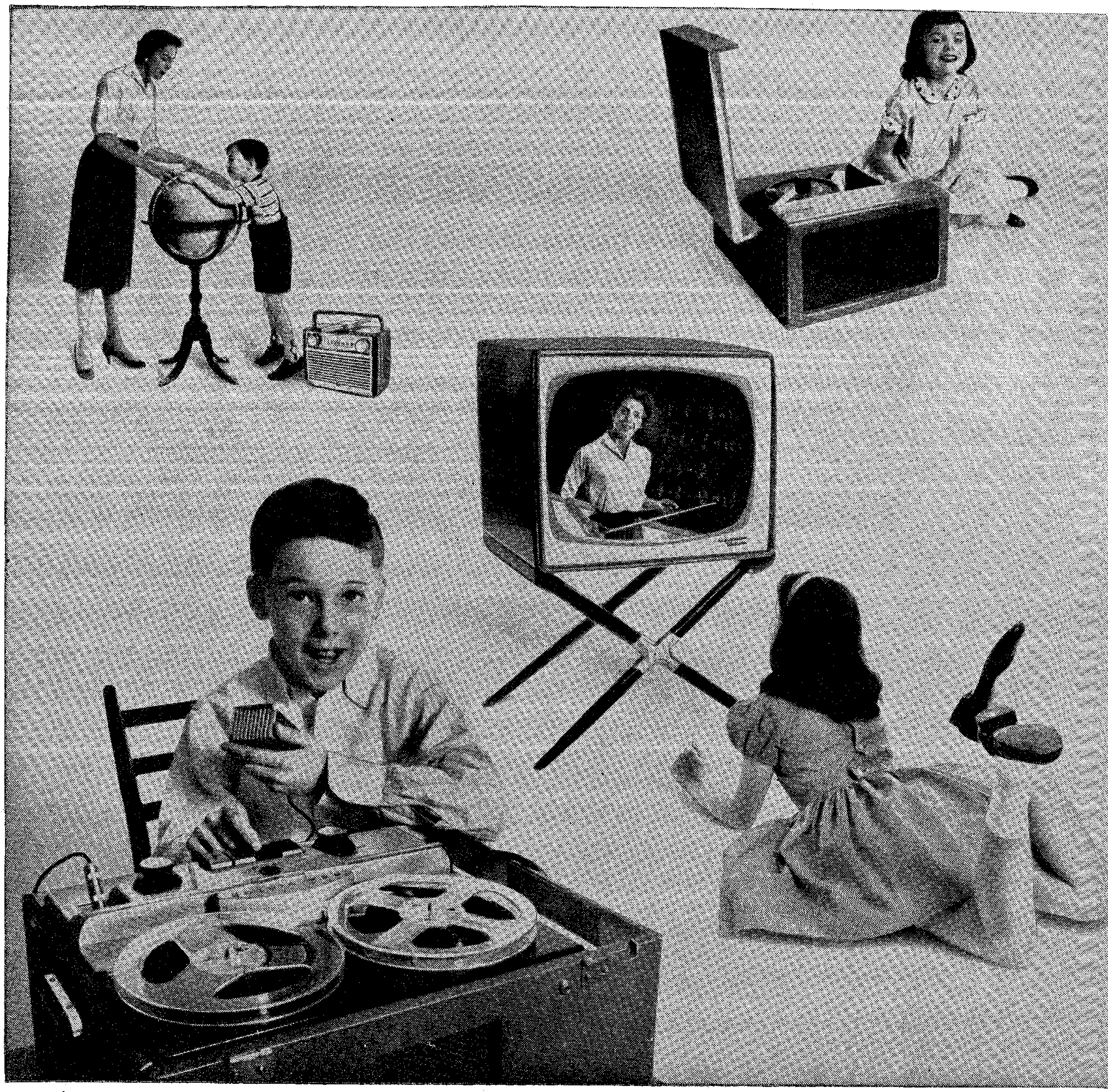
2. Since we cannot always pick out "the one" at an early age, we must provide opportunities for *many*—and we will need the many, too.

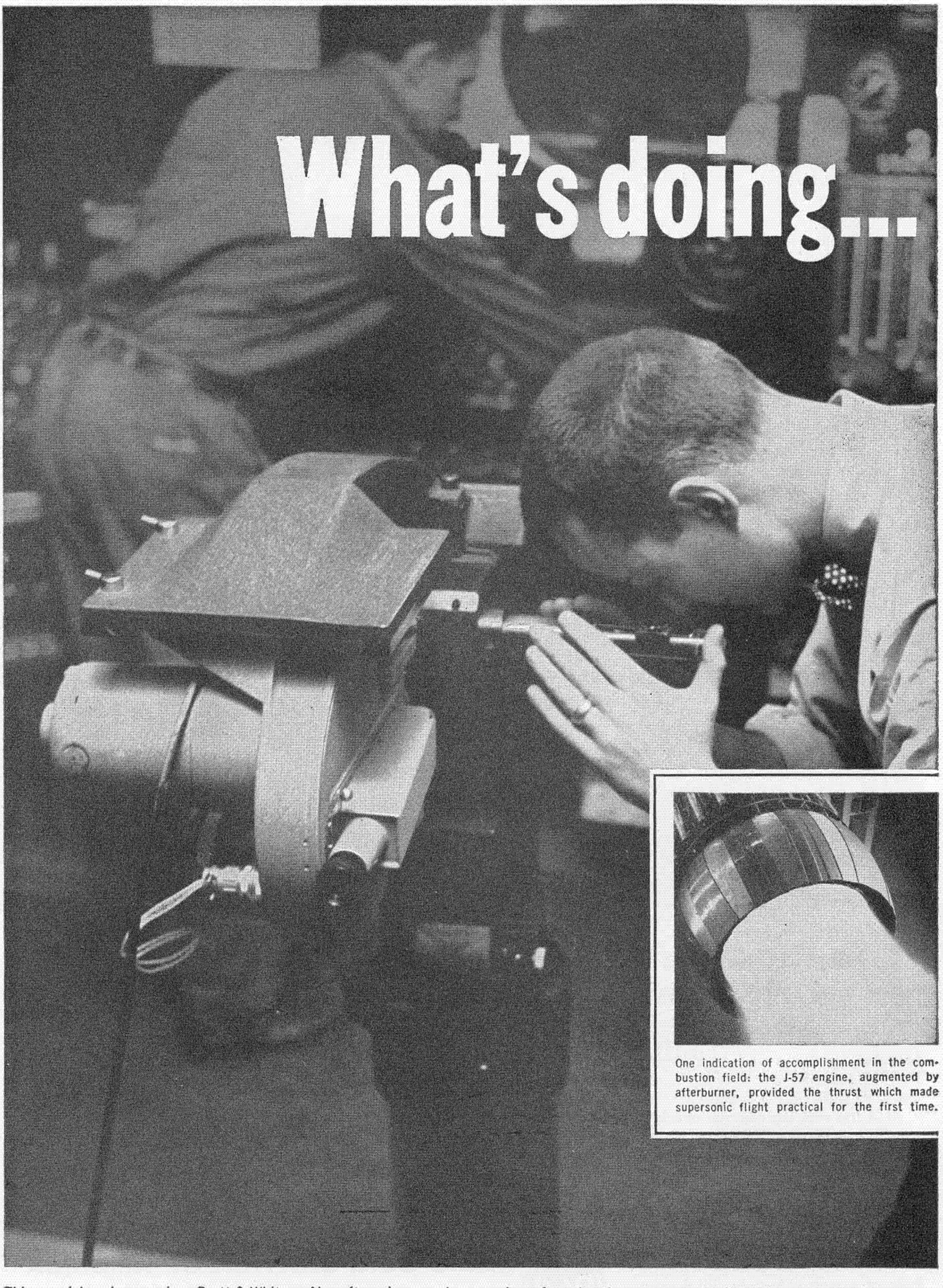
3. Since we can, on the other hand, select some—even if not all—superior students at an early age, there should be a few places where those students can go for especially challenging opportunities.

4. Lest we end up with first-rate students studying under second-rate professors, we must find ways of keeping more first-class professors in the universities.

5. A colossal task faces America in doubling our educational plant and staff during coming years and at the same time improving its quality. We may by 1972 have to spend twice as much for higher education as we do for cigarettes! If we can only make clear to the American people what the task is, I feel sure they will tighten their belts and make the sacrifice.

6. In higher education in America, even the best is none too good.





One indication of accomplishment in the combustion field: the J-57 engine, augmented by afterburner, provided the thrust which made supersonic flight practical for the first time.

This special periscope gives Pratt & Whitney Aircraft engineer a close-up view of combustion process actually taking place within the afterburner of an advanced jet engine on test. What the engineer observes is simultaneously recorded by a high-speed motion picture camera.

at Pratt & Whitney Aircraft in the field of Combustion

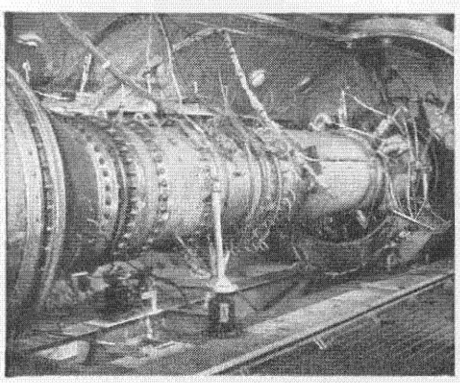
Historically, the process of combustion has excited man's insatiable hunger for knowledge. Since his most primitive attempts to make use of this phenomenon, he has found tremendous fascination in its potentials.

Perhaps at no time in history has that fascination been greater than it is today with respect to the use of combustion principles in the modern aircraft engine.

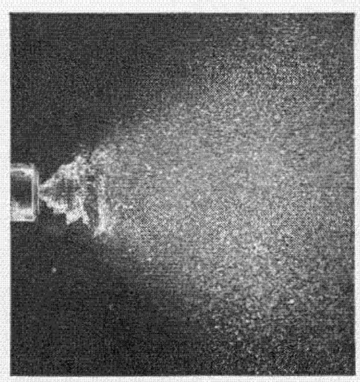
At Pratt & Whitney Aircraft, theorems of many sciences are being applied to the design and development of high heat release rate devices. In spite of the apparent simplicity of a combustion system, the bringing together of fuel and air in proper proportions, the ignition of the mixture, and the rapid mixing of burned and unburned gases involves a most complex series of interrelated events — events ocurring simultaneously in time and space.

Although the combustion engineer draws on many fields of science (including thermodynamics, aerodynamics, fluid mechanics, heat transfer, applied mechanics, metallurgy and chemistry), the design of combustion systems has not yet been reduced to really scientific principles. Therefore, the highly successful performance of engines like the J-57, J-75 and others stands as a tribute to the vision, imagination and pioneering efforts of those at Pratt & Whitney Aircraft engaged in combustion work.

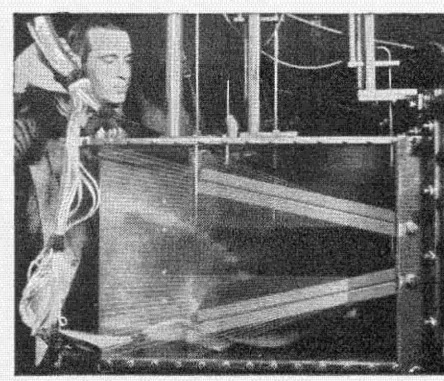
While combustion assignments, themselves, involve a diversity of engineering talent, the field is only one of a broadly diversified engineering program at Pratt & Whitney Aircraft. That program—with other far-reaching activities in the fields of instrumentation, materials problems, mechanical design and aerodynamics — spells out a gratifying future for many of today's engineering students.



Mounting an afterburner in a special high-altitude test chamber in P&WA's Willgoos Turbine Laboratory permits study of a variety of combustion problems which may be encountered during later development stages.



Microflash photo illustrates one continuing problem: design and development of fuel injection systems which properly atomize and distribute under all flight conditions.



Pratt & Whitney Aircraft engineer manipulates probe in exit of two-dimensional research diffuser. Diffuser design for advanced power plants is one of many air flow problems that exist in combustion work.

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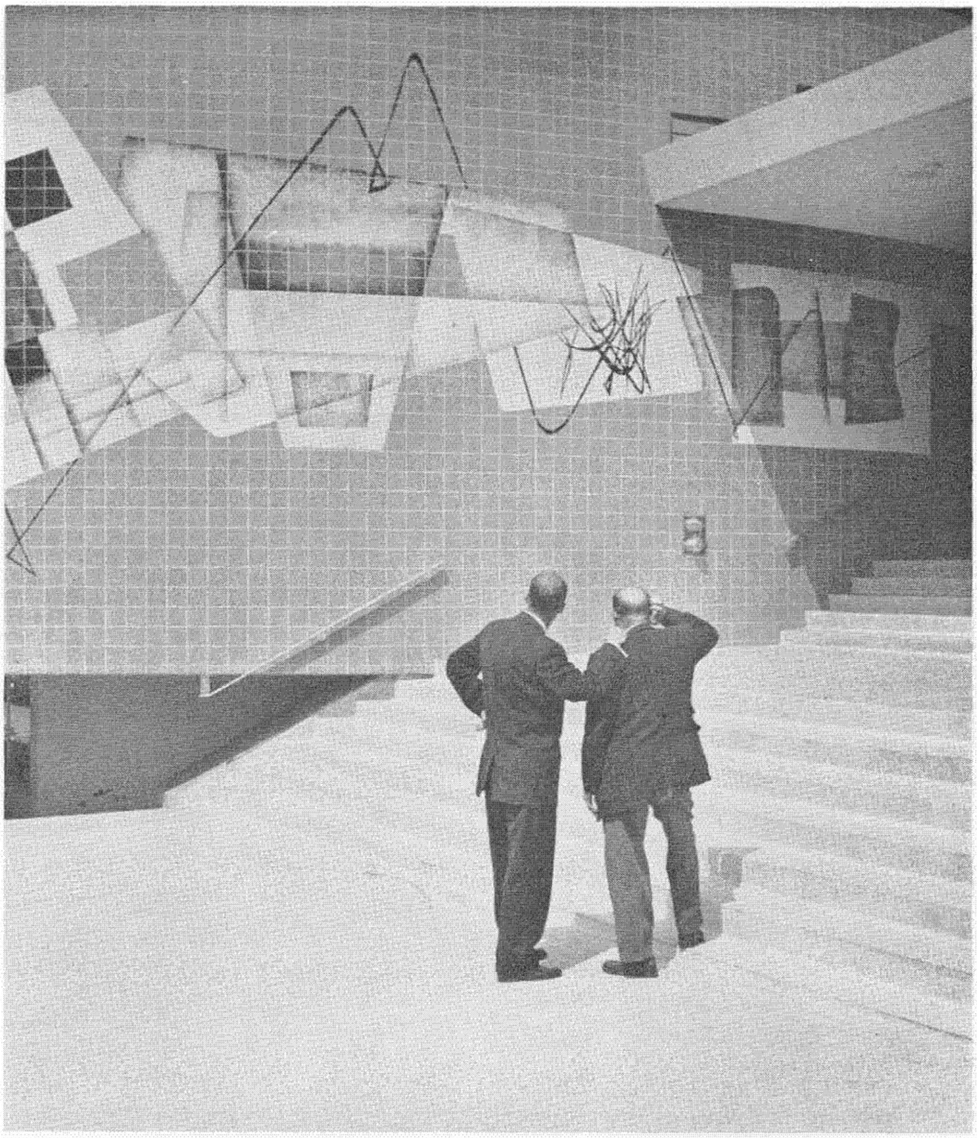

"Connoisseurs"— the Caltech Camera Club's prizewinning photograph.

THE MONTH AT CALTECH

Prizewinner

THE CALTECH CAMERA CLUB, made up of employees and staff members of the Institute, held its annual photographic exhibit on the campus last month. This year's show included the picture which was chosen Print-of-the-Year by the Southern California Council of Camera Clubs. Selected from a total of some 2500 entries, the shot was taken by William Kaup, who worked at Caltech during the war as a member of the visual presentation unit, turning out Air Force manuals dealing with long-range weather forecasting. Kaup, who is now copy chief at the Darwin H. Clark advertising agency in Los Angeles, took the prize with a picture called "Connoisseurs" (above), taken in front of the tile mural at the California State Teachers Association Building in Los Angeles.

Robert Knapp

ROBERT T. KNAPP, professor of hydraulic engineering, died of a coronary attack on November 7. He was 58 years old.

A native of Loveland, Colorado, he was graduated from MIT in 1920 and came to Caltech as an instructor in mechanical engineering in 1922. He received his PhD here in 1929. He was widely known for his work in

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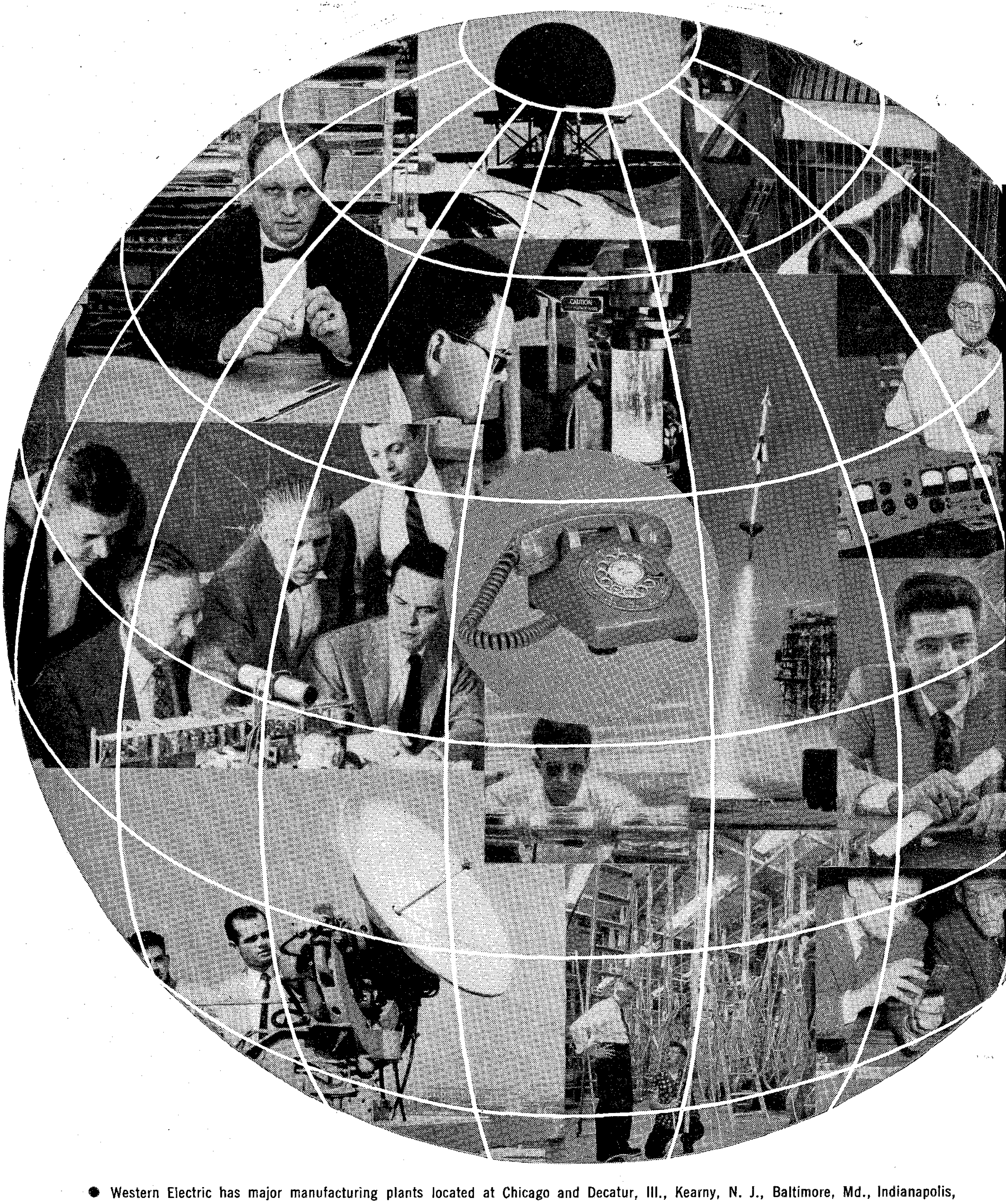


hydro-dynamics and his investigations covered hydrodynamic problems of hydraulic turbines and centrifugal pumps; wave and surge problems of beaches and harbors; the mechanics of cavitation and cavitation damage; and problems of underwater ordnance, soil erosion, drainage and irrigation. The Caltech hydrodynamics laboratory was his concept, and it was developed during the war under his guidance.

In addition to his teaching and research at Caltech, Dr. Knapp served during the war as Official Investigator of the Office of Scientific Research and Development on a study of air and water trajectories of rockets, bombs and torpedoes. He was a consultant to the U.S. Army Ballistic Research Laboratory, Aberdeen Proving Ground, on hydrodynamic problems of fin and spin-stabilized projectiles.

Day Medal

Hugo Benioff, professor of seismology, received the Arthur L. Day Medal of the Geological Society of America at the Society's annual meeting in Atlantic City this month. The medal is awarded in recognition of outstanding contributions to geologic knowledge through the application of physics and chemistry to the solution of geologic problems.

Dr. Benioff has been associated with the Seismological Laboratory since 1924, and he has been a member of the Caltech faculty since 1937, when direction of the Seismo Lab was turned over to the Institute by the Carnegie Institution of Washington.

A graduate of Pomona College in 1921, Dr. Benioff received his PhD from Caltech in 1935. He has been known as an authority on the design of earthquake instruments since 1931, when the first Benioff seismometer was put into service. These instruments are now in operation at many stations in the United States, as well as in Peru, India, South Africa, Australia and Europe.

In his current work as a member of the IGY Technical Panel on Seismology and Gravity, *(E&S—October 1957)*, Dr. Benioff is directing studies in South America with two fused quartz extensometer installations. Measurements of secular strains, made at an adequate number of stations, over a long-enough time interval, may give sufficient information to provide a basis for the prediction of earthquakes.

Tomatoes

Commercial varieties of tomatoes have always been grown most successfully in California and in a narrow geographical band running from the Midwest eastward to New Jersey. These are the principal places in the United States where night temperatures—which are critical to the tomato's flowering and fruit setting—stay within a certain optimum range, around 64 degrees F.

Now, as a result of work done in the Caltech Earhart Plant Research Laboratory, tomatoes of excellent processing quality may soon be grown commercially in areas as far south as Texas. This work was financed by the Campbell Soup Company and was directed by one of the company's plant breeders, Dr. Lester W. Schaible.

Some tomato plants grow in the far north and in the tropics. Their fruit does not compare with the best American varieties in size, flavor and color, but they tolerate night temperatures much lower and higher than ours do. By crossbreeding domestic and foreign strains, the scientists at Caltech produced plants combining the best qualities of the American plants with the temperature tolerance of the others.

The work was begun early in 1956, after a year in which unusually high night temperatures cut the eastern American tomato crop by 80 percent. Upon his arrival at Caltech, Dr. Schaible received from the Philippines the seeds of a native tomato that set small but abundant fruit despite the tropical night temperatures. He planted these and also the seeds of the Rutgers tomato—a standard American variety—and waited for them to flower. By crossbreeding, he produced a fruit whose seeds contained hybrid embryos. When these seeds were planted, they produced hybrid tomatoes—half Philippine, half Rutgers.

Dr. Schaible next inbred the hybrids. The resulting fruit contained seeds which, when planted, produced a second generation of tomato plants that showed all possible re-combinations of characteristics of the original parent plants. Some, like the original Rutgers, bore large fruit abundantly at low temperatures; some, like the original Philippine plants, bore small fruit abundantly at high temperatures; some, like the first generation plants, were hybrid in their product; a few combined the worst characteristics of both parents; and a few combined the best characteristics of both.

Selecting several plants of these last and best strains, Dr. Schaible inbred them for the production of more seeds. These, in turn, produced excellent tomatoes, in abundance, at night temperatures as high as 80 degrees F. The same strains, field tested in the south, have consistently performed as well as their laboratory prototypes.

One tomato plant normally yields enough seeds to plant an entire acre. Thus, within another five years, the field test plants should produce enough seeds so that these extraordinary tomato strains can be grown over many hundreds of acres in warm sections of the country. They may also help to stabilize the yield where tomatoes are grown commercially now.

Long-range consequences may be even more important. Dr. Schaible has shown that in the tomato plant, genes governing temperature tolerance and genes governing fruit size are independently inherited. If this is true of other plants, then the possibilities of developing special strains of food crops—tailored to climatic conditions—may be vastly increased.

HERE WE GO AGAIN

IT'S ABOUT A WEEK before the beginning of school and the student houses are recovering from their summer stupor. Noise in the courtyards, lights in the hallways, disorder in the lounges, are sure signs of returning life. First back are the football players and the summer residents, who lived on campus all through the vacation period. This group really appreciates the solid stoniness of the houses after the wooden emptiness of the Old Dorm.

Soon others return, and the nightly mass excursions to local restaurants begin. Everyone's glad to see at least some of his schoolmates, and conversations are long and lurid with summer experiences. Speculation runs high on one topic: the entering freshmen. What will they be like—neat guys or trolls? Past experience gives the edge to trolls, say the upperclassmen.

Then the freshmen begin to arrive. Of course they're not all neat, and they're not all trolls; they're a tremendously varied group, from all parts of the country and from almost all social classes.

The few days before Freshman Camp present a weird social scene. The upperclassmen are friendly to the point of strain. There's a good reason for this; later each freshman will choose a house, and the houses will choose the freshmen they want. Naturally, each house wants the best of the crop, but in these first days it's hard to judge, so everyone tries to be everyone's friend.

The freshmen react differently to this enforced friendliness. The loud ones get louder, since there's no one to shut them up. Each seems to know a thousand bad jokes, and tells every one of them. There are always a few well-trained upperclass laughers around to prevent embarrassing silences. Most of the under-confident frosh get even more shadowy as they see their aggressive classmates seemingly win the approval of the upperclassmen. Freshman Camp comes as a relief to all concerned.

Up to the mountains go the frosh, a group of faculty members, and a collection of 25 "upperclass leaders." The air is clean, the nights are cold, and there's nothing to do but meet people. This lack of escape is the main advantage of Student Camp. Informality is determinedly enforced, as the faculty members attempt to undo a year's aloofness in two days. While the professors try to prove they're human, the freshmen try to prove they're professors. The upperclassmen just try to be neat.

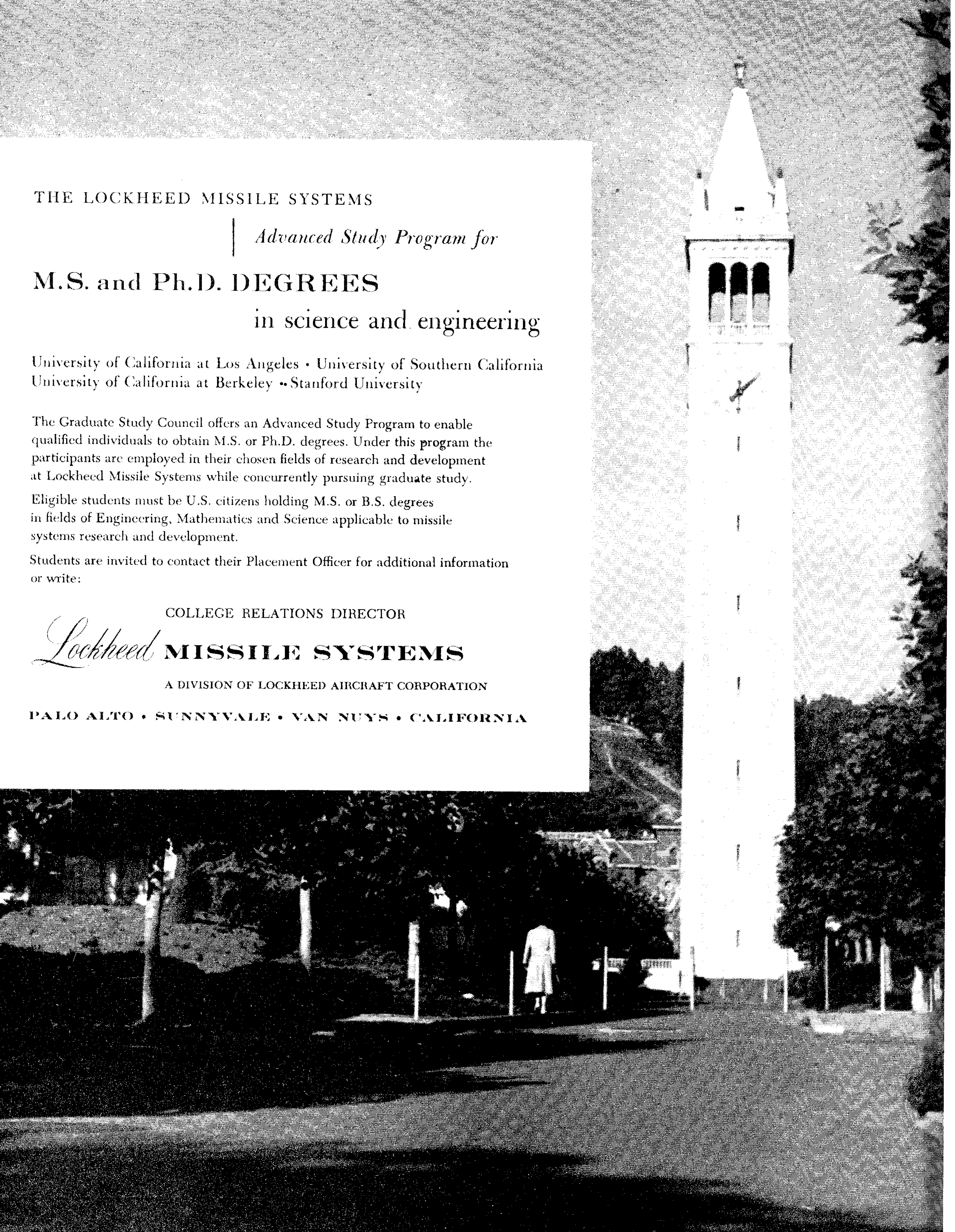
Speeches during the day provide a pleasant break between volleyball games. At night Dr. Feynman plays his bongos and there are more speeches. President DuBridge's talk on "Your $900 Bargain" is the best given and the best received by the frosh, though upperclassmen who remember "Your $750 Bargain," and "Your $600 Bargain," are less enthusiastic.

Meanwhile, the ASCIT board is going through the difficult and self-designated process of choosing first-term freshman class officers. The board members rush about, trying to meet everyone. Naturally they can't, so they concentrate on the people who look good on their "activities sheet," filled out the previous summer. Caltech probably attracts more Math Club presidents than any other school in the country. Math Club presidents don't get chosen. As the final hours of camp approach, the Board is left with about twice as many names as it can use. From this point on, a wrong smile or a misplaced word can eliminate a freshman from the running. At last the new officers are decided upon, announced, and everyone goes home.

Beginning of classes is also the beginning of formal rotation. The freshmen move from house to house, eating lunch and dinner for two days in each. Naturally, there are speeches, but the main influencing work goes on at an individual level—for by this time the houses think they know who's neat and who's not. Groups of upperclassmen form continously around a desirable frosh, while the less-neats and trolls are left alone. The houses really are different, but the desirables seldom get a chance to find this out in the sop of all-surrounding friendliness. It's the less-neats (but not the trolls) who generally go into the house that's best for them. Later, some of the less-neats turn out to be the really-neats.

With rotation over and the freshmen sorted into the various houses, initiation begins. The upperclassmen are no better at sustained meanness than they are at being universally friendly, so the freshmen have to initiate themselves. This they do with water fights and curse-shouting sessions. Finally initiation ends, too, and the freshmen are left alone to mature into upperclassmen. Within a few months they'll be fully ready to greet next year's freshman class with fine fake smiles and misleading information.

—Brad Efron '60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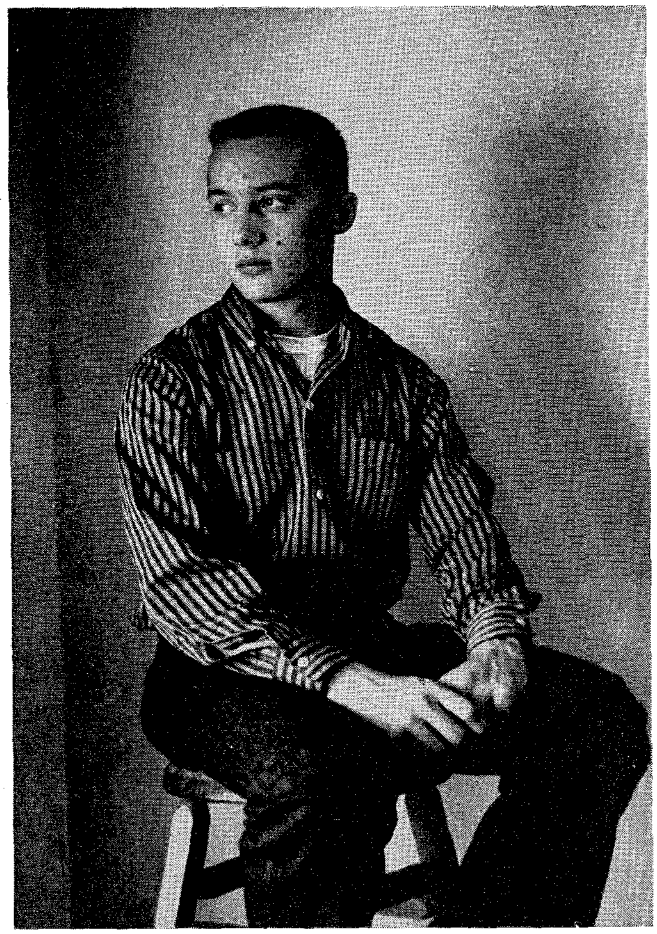
ALUMNI SCHOLAR



Some notes on Robert Poe, fourth winner of the Alumni Association's four-year, full-tuition scholarship

ROBERT POE, a freshman from San Jose, California, is the fourth Caltech student to receive an Alumni Scholarship. The award—a four-year, full-tuition grant, made by the Caltech Alumni Association through contributions to the Alumni Fund—has been given each fall since 1954.

In 1954 Robert Poe was just a freshman in high school, but even then he knew he wanted to come to Caltech. His older brother Bill applied for admission to four colleges that year—including Caltech—and the whole Poe family (with the possible exception of the youngest of the three brothers, who was 2 at the time) spent every waking moment discussing the relative advantages of the four institutions. The more they discussed, the more they were all convinced that Caltech was the best possible choice. Ironically, Bill was turned down by Caltech—at the same time as he was offered scholarship honors by the three other schools. But Bob has been determined to come here ever since.

Bob will be 17 this month. His main interest now is in theoretical physics and mathematics, and his present intention is to pursue his education as far, and for as long, as circumstances permit. His father is a partner in a childrens' wear business in Santa Clara. His brother Bill, now a senior at the University of Chicago, will be going to medical school next year.

At Lincoln High School in San Jose, Bob ranked second in a class of 264, and got A's almost without exception through his high school years. He was active in debate and speech, dramatics, basketball, swimming and wrestling, and he was manager of the varsity football and basketball teams.

At Caltech he not only has an Alumni Scholarship, but two others he won with his writing talents in high school —a $400 scholarship in an essay contest sponsored by the National Safety Council and the American Teamsters Union, and a $100 bond in an essay contest sponsored by the San Jose Real Estate Board. (The subjects of these contests were safe driving and the advantages of home ownership, respectively, and it may be interesting to note that Bob Poe (a) has no driver's license and (b) doesn't own his own home.)

A red-headed, soft-spoken, serious minded young man, Bob Poe is a fine example of the well-rounded freshman Caltech keeps searching for—as you can tell at a glance at this abbreviated list of his recent reading:

Macbeth
Playing the Piano for Pleasure
The Night Life of the Gods
Lucretius—*De Rerum Natura*
MacDougall on Dice and Cards
Collected Poems of T. S. Eliot
Plain Talk to Men Under 21

PERSONALS

1924

E. Dale Barcus, toll service transmission engineer with the Pacific Telephone Company, is now vice chairman of the Los Angeles section of the American Institute of Electrical Engineers.

1925

Thomas P. Simpson is now general manager of manufacturing of the Socony Mobil Oil Company, Inc., in New York. He had been vice president and director of manufacturing for the General Petroleum Corporation in Los Angeles since January, 1955.

1931

Raymond A. Peterson, PhD '35, vice president of the United Geophysical Corporation in Pasadena, writes that "I spend my time between the lab and the field in developing new instruments and techniques for geophysical exploration. Next February will make my 20th year with the company. About our three children: Dianne is a sophomore at Trinity University in San Antonio, Texas; Linda is a senior in high school; and Lowell, 14, has his sights set on Caltech."

1932

James C. Mouzon, PhD, professor of electrical engineering at the University of Michigan, is also a research physicist at the Willow Run laboratories of the University's Engineering Research Institute. The Mouzons have two daughters—Betsy, who is married and lives in Bethesda, Maryland; and Peggy, 16.

E. Bryant Fitch is now director of the Westport (Connecticut) Laboratories of Dorr-Oliver, Inc. He had been serving as research director.

Alvin J. Tickner is head of the guidance and control division at the Naval Ordnance Test Station in Pasadena. He joined NOTS in 1951, after working for three years at Northrop Aircraft on their SNARK missile.

David Y. K. Wong, MS'33, is now an authorized architect in Hong Kong. He writes: "Right after I got my MS in 1933 I was married to Lillian Chung of Los Angeles and we returned to China. My first job was as junior engineer in the Public Works Department in Canton, and in 1935-36 I taught in the College of Engineering at Kwangsi University.

"Just before World War II, I was called to work in the Ministry of Communications in the interior of Free China. For 13 years I stayed in the government service—working on such jobs as the building of the Burma Road, Yunnan-Burma Railway, and the Lend-Lease Airfields for the U.S. Air Force in Kweilin, Liuchou and Lushien. In 1945 I was awarded, along with a few others, a citation and medal from Generalissimo Chiang Kai-Shek for our work in airfield construction. The University of Redlands, from which I graduated in 1931 with a BA, awarded me the Alumni Achievement Award in 1947. Since June, 1949, I have been in Hong Kong, reestablishing myself as a structural engineer.

"Our daughter was graduated from San Francisco State College last year. She is now married and lives in San Francisco. Our son is studying in high school in Hong Kong."

Patrick B. Lyons is now superintendent of Western Electric's manufacturing plant in St. Paul, Minnesota.

Mott Prudames, manager of retail plant and equipment in the domestic marketing operating department of the Socony Mobil Oil Company in New York, writes that "life began at 40 plus when I got married three years ago to Ida Freeman. Then, after living in southern California all our lives, we moved to Riverside, Connecticut. To make things more complete, our son, John Mott, was born in August, 1956—so we are starting out on a family at a time when many of my fellow alumni are well along toward completing the raising of their own. Wouldn't have missed it for the world—even at this late date."

Charles M. Harsh is head of the Human Engineering Branch of the Human Factors Division of the U.S. Navy Electronics Laboratory in San Diego. He was formerly professor of psychology and director of graduate research at Pomona College in Claremont.

1933

Arthur N. Prater, MS, PhD '35, is now vice president of Consolidated Foods Corporation in Los Angeles.

L. Jackson Laslett has returned to the department of physics at Iowa State College after a two-year leave of absence spent at the Midwestern Universities Research Association.

1935

Howard P. Gluckman is in charge of a design group at the L. A. Department of Water and Power, and also teaches engineering at Valley Junior College. The Gluckmans have a daughter who is now married.

1936

Sherwood K. Haynes, PhD, professor of physics at Vanderbilt University in Nashville, Tennessee, is now professor and head of the department of physics and astronomy of Michigan State University in East Lansing. He had been on the Vanderbilt faculty since 1945.

CONTINUED ON PAGE 52

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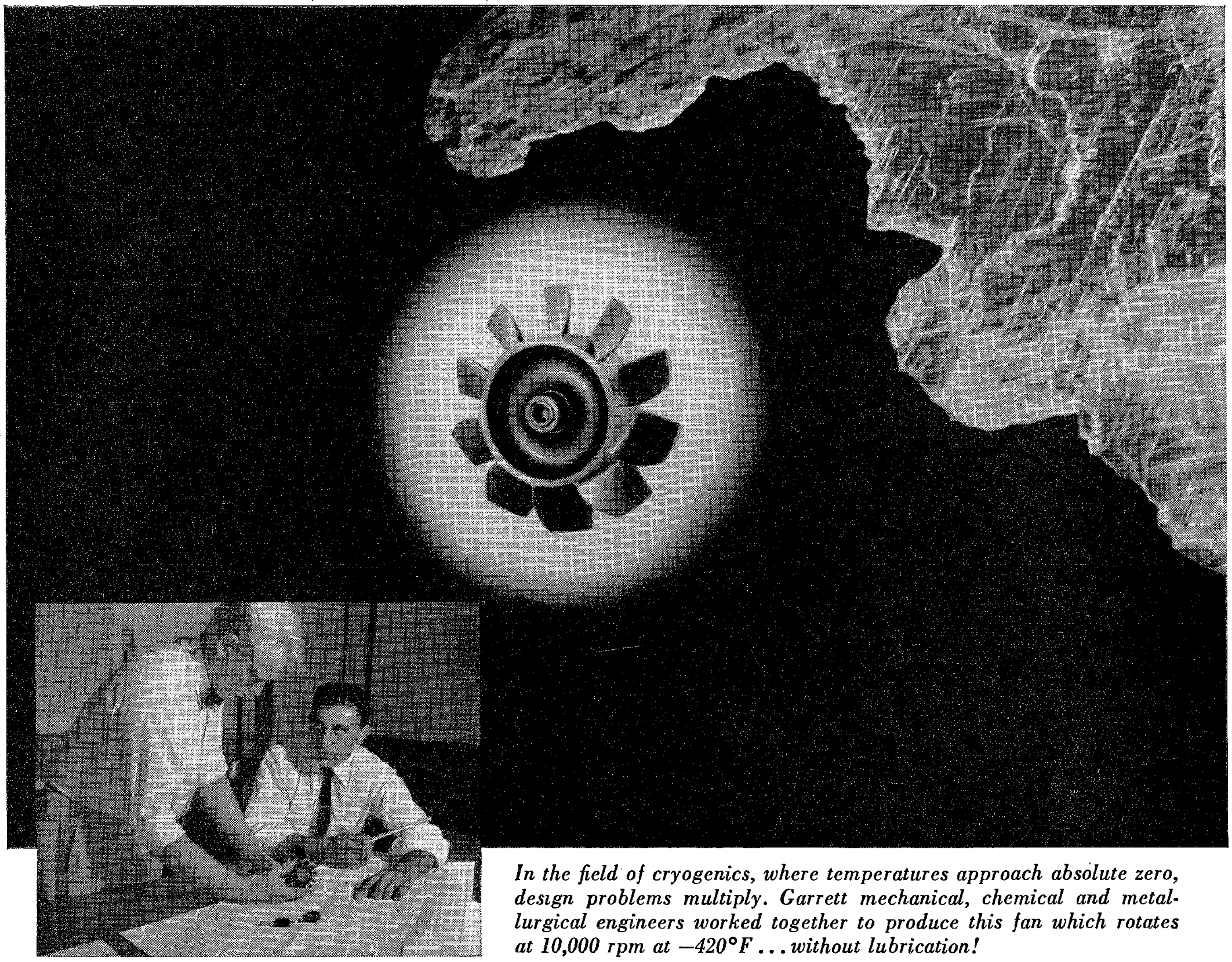

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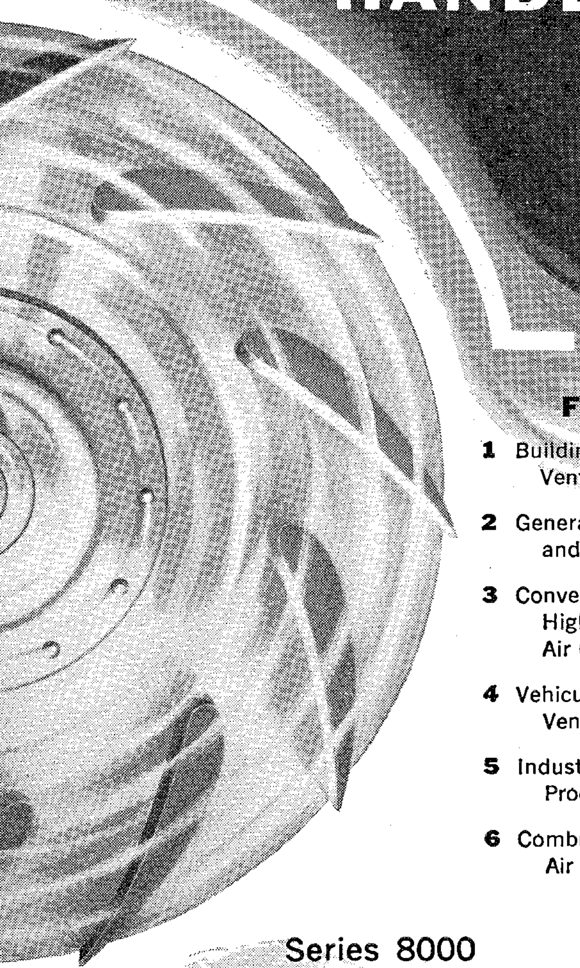

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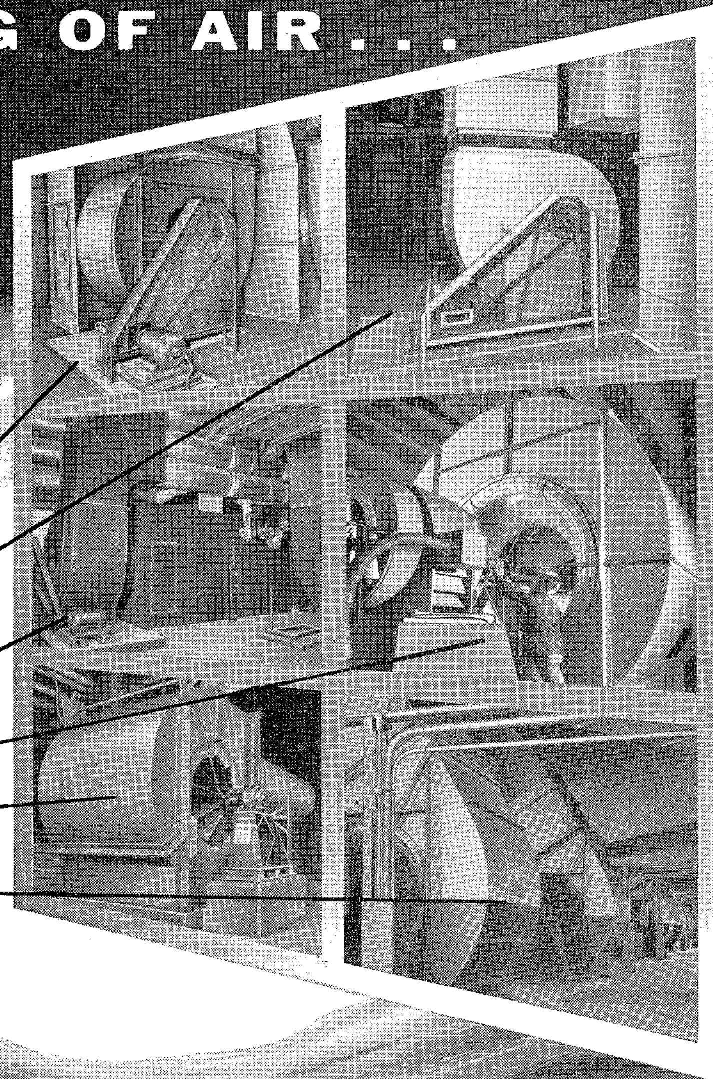

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Personals . . . CONTINUED

1937

John R. Austen is now superintendent of the forge division of the Ingersoll-Rand Corporation plant in Phillipsburg, Pennsylvania. Formerly assistant superintendent of the division, John has been with the company since 1937.

Harold F. Wiley, MS, has been appointed director of the new analytical and control instrument division of the Consolidated Electrodynamics Corporation. The new unit will be housed in the company's main plant facilities in Pasadena. Harold has been director of the company's technical services department for the past four years. He was one of the 13 men who comprised the original working force of Consolidated, and has been with the company since 1937.

1939

George W. Sinclair is now plant manager at the Tucson, Arizona, facility of the Hughes Aircraft Company. He's been with the company since 1949. The Sinclairs have three children—George, 12; Zerilda, 10; and Rowena, 6 months.

John W. Black, formerly associate director of the Hughes guided missile laboratories in Culver City, California, has been named assistant plant manager at the Tucson plant. The Blacks have two sons; Brian, 7, and Kersey, 5.

1940

W. C. House, who was chief engineer of the liquid engine division of the Aerojet-General Corporation in Azusa, California, is now manager of the division. He's worked at Aerojet since 1949.

Harold S. Mickley, MS '41, associate professor of chemical engineering at MIT, became a full professor in July.

1941

William F. Chapin is now chief process engineer at the Fluor Corporation plant in Houston, Texas.

Fred W. Billmeyer, Jr., research chemist in the Du Pont Company's polychemicals department in Wilmington, Delaware, is now a senior research chemist for the company. This is a new classification set up to reward "outstanding performance in execution of research programs."

1942

William L. Rogers is now manager of operations at the Azusa plant of the Aerojet-General Corporation. He's been with Aerojet since 1942 and has been assistant general manager for the past five years.

Carol M. Veronda, head of the engineering department of Sperry Rand's electronic tube division in Gainesville, Florida, writes that "on September 16, our daughter, Cheryl June, arrived. We're very happy to round ont our family with a girl after two fine boys—Bill, now 11 years old, and Chris, 5."

CONTINUED ON PAGE 56

Mars Pencils Sponsors Tomorrow's Designs

Mars Outstanding Design Series—featured in the current advertising of J. S. Staedtler, Inc.—has attracted widespread attention among the users of fine drafting pencils. It has fulfilled our expectation that the men who appreciate the finest working tools are those with a lively creative interest in new designs, new projects, new ideas.

Concerned with unusual projects—*designs of the future*—Mars Outstanding Design Series provides a "showcase" for originality, for interesting work of engineers, architects, and students which so often lies buried. To stimulate you to send in *your* designs, Mars Pencils

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The subject can be almost anything—aviation, space travel, autos, trains, buildings, engineering structures, household items, tools, machines, business equipment, etc. It should be a project that appeals to design-minded readers, be of broad interest, and be attractively presented. Do not submit a design that has been executed. As a matter of fact, the project does not need to have been planned for actual execution. It should, however, be something that is either feasible at present or a logical extension of current trends. It cannot be unrealistic or involve purely hypothetical alterations of natural laws.

There is no deadline for entries but the sooner you send yours in, the greater the probability of its use as one of the subjects in the 1958 Mars Outstanding Design Series.

It Is Simple To Submit a Design For Mars Outstanding Design Series

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If your entry is accepted, we will ask you to send in a sharp photograph of the design, or the design itself, so that we can make a sharp photograph suitable for reproduction—after which it will be returned to your promptly.

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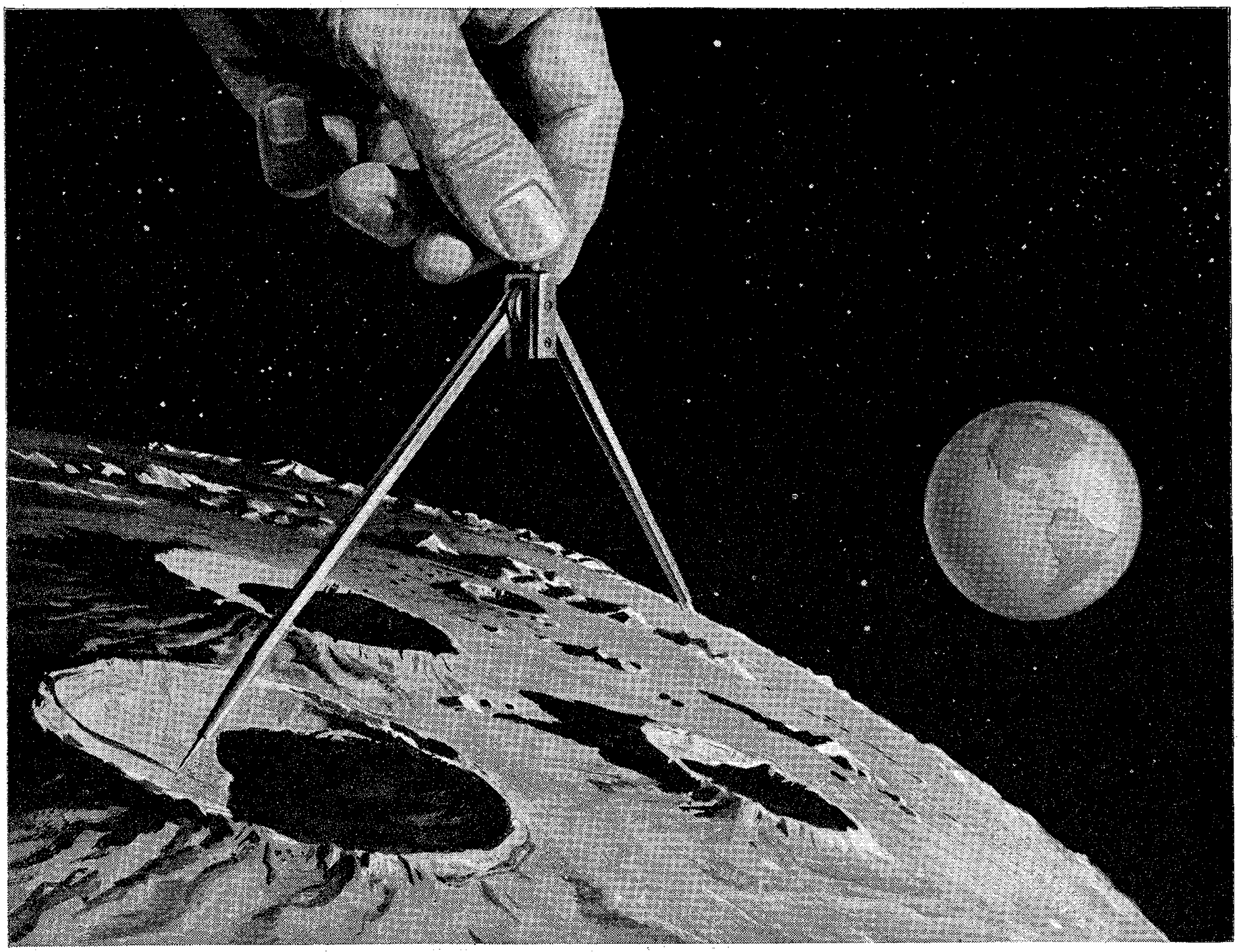

1943

John Cushing, PhD, associate professor of bacteriology at the University of California in Santa Barbara, spent the summer at the Woods Hole Marine Biology Laboratory in Massachusetts on a research grant from the American Philosophical Society. He was also recently appointed a member of an American Association for the Advancement of Science international planning committee for a conference in marine biology to be held in the fall of 1959.

Charles McGee is now doing operations research work in the catalog circulation department of Sears Roebuck & Company in Elmhurst, Illinois. The McGees' fourth child, Joan, arrived in August.

1944

Maurice Rattray, Jr., MS'47, PhD'51, is now associate professor in the Oceanographic Laboratories of the University of Washington in Seattle. The Rattrays have three children—Julie, 3½, Maurice III, 2, and Gordon, 6 months.

Warren H. Amster, MS '47, AE '48, is now a staff member of the guided missile research division of the Ramo-Wooldridge Corporation in Los Angeles. He was formerly a senior associate of the Planning Research Corporation.

William E. Lockwood is now plant manager at the Continental Can Company's manufacturing installation in San Pedro, California. The Lockwoods and their two children live in Long Beach.

Eric Weiss is now staff engineer with the new systems division of Daystrom, Inc., in La Jolla, California. He's responsible for all digital computer activities.

1946

George W. Barton is working at the University of California Radiation Laboratory in Livermore as a chemist in inorganic mass spectroscopy. He writes that he intends to stay as long as possible because he likes the climate, the countryside and his job. The Bartons and their three children—Stephen, 5, Janet, 3, and Peter, 2—are living in Danville.

R. Bruce Foster, MS, is now chief application engineer at the Denver division of the Sundstrand Machine Tool Company. He was formerly chief preliminary design engineer of the rockets division of the Bell Aircraft Corporation in New York.

Harold Comlossy, Jr., project engineer at the Emsco Manufacturing Company in Los Angeles, now has a fourth child, Gail, born on August 20.

1951

Robert E. Smith was discharged from the Army in June after spending two years in Alaska. He's now doing graduate work in biophysics at the School of Medicine at the University of Washington in Seattle.

1955

Gerald E. Hooper is back in the United States after 21 months as communications officer of the 25th Comm. Squadron in Weisbaden, Germany. The Hoopers have a daughter, Sheryl Diane, born on July 19.

1956

Leon M. Keer, graduate student in mechanical engineering at Caltech, announced the arrival of a daughter, Patricia, on August 8.

Donald W. Lewis spent the summer working for the Pure Oil Company at Amarillo, Texas, and has now returned to Northwestern University in Evanston, Illinois, to complete work on his MS in geology.

1957

Ted Lang, back at Caltech and working on his MS, recently won first prize in a satellite essay contest sponsored by the Martin Company of Baltimore, Maryland. His paper, "An Equilibrium Trajectory for a Satellite Powered by Solar Pressure," won a $5,000 cash award for Ted and a $5,000 matching award for Caltech.

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Facts on food colors

What about those headlines on food colors? And the stories that some certified food colors are toxic? Is there anything to the Food and Drug Administration's recent delisting of three previously acceptable colors?

Here are a few facts behind the headlines.

The practice of coloring food is centuries old. Though the early colors were of natural origin, they have been replaced in the coloring of many foods by superior synthetic colors — the certified "coal-tar" colors. The Food and Drug Administration has been certifying a number of these colors for use in food since the early 1900's.

You're probably aware of some of the foods commonly colored today: ice cream, soft drinks, baked goods, candies, processed cheese, gelatin desserts, orange skins, margarine, butter.

Why then have some food colors been "delisted" and why are others being considered for delisting?

The controversy centers on the meaning of a single word in the Federal Food, Drug and Cosmetic Act: "harmless."

The Food and Drug Administration's definition: incapable of producing harm in any quantity or under any circumstances.

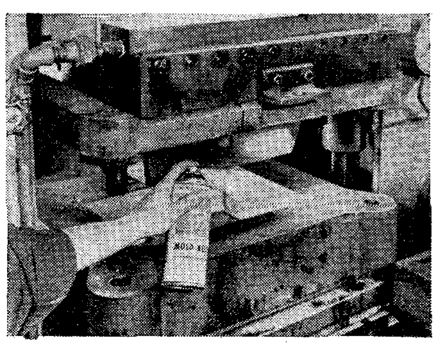
The food color industry's: incapable of producing harm under normal conditions of use.

It is the industry's view that FDA animal tests of certified colors have made use of quantities of color unrelated to — and far in excess of — quantities normally ingested by humans. A newspaper interview quoted the Commissioner of Food and Drugs as saying that he "conceded that three coal-tar dyes recently banned were harmless as used, but explained that their use was [a] technical violation of the law as now worded."

The absolute FDA standard seems to find support in the popular tendency to regard synthetics as inherently inferior to natural products. Yet, many fresh vegetables we eat every day contain small but tolerable quantities of naturally occurring poisons which, if judged as food colors are now being judged, would lead to the elimination of a large part of our vegetable diet.

What the food color industry asks is an amendment to the present law which would clearly grant power to the FDA to set quantitative limits on the use of colors in food. Such limits would safeguard public health, permit maintenance of our food color supply, and encourage research in the field.

Two articles — one supporting the industry's position, the other detailing manufacture and quality control of food colors — have been prepared by Allied's National Aniline Division, the leading food color producer. You can get them by checking the coupon at right.



Aerosol mold release

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There's hardly a more convenient way to dispense liquids than with an aerosol spray.

Ham and eggs: POLY-LEASE *77*, a low-molecular weight polyethylene in a mixed solvent system, supplied in aerosol form. The spray's push, by the way, is from Allied's GENETRON propellants.

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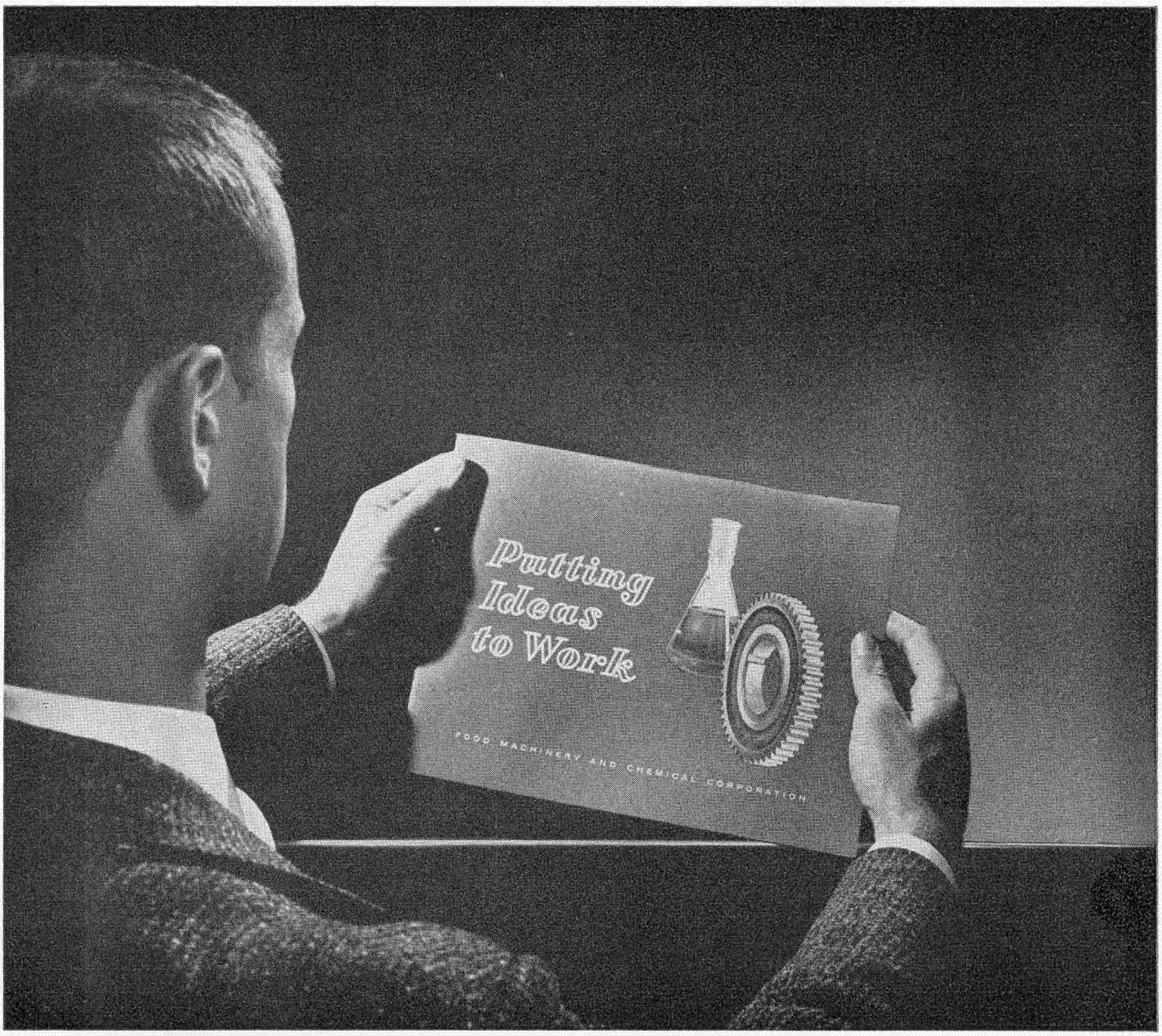
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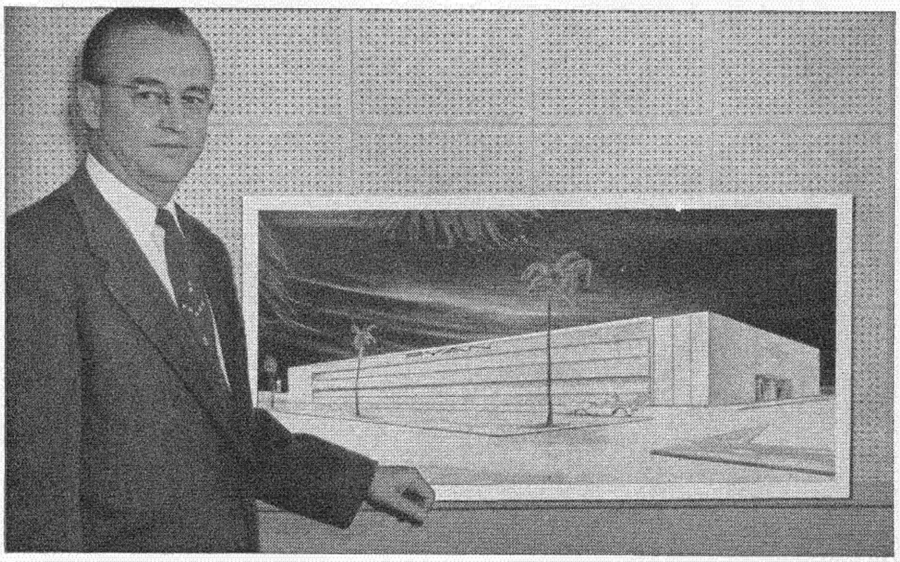
New Engineering Opportunities Created as Ryan Projects Mushroom



FRANK W. FINK, RYAN VICE PRESIDENT AND CHIEF ENGINEER inspects architect's drawing of new Engineering and Research Center.

New Engineering and Research Center To Meet Ryan's Expansion

Construction of a modern two-story, engineering and laboratories building has begun at Ryan, to meet the company's expanding work in Jet VTOL—Automatic Navigation—Jet Drones—Missile Guidance—Jet Metallurgy—Rockets.

The new facility will provide additional quarters for many of the 1000 employees in Ryan's fast-growing engineering division. It will also house complex, new chemical, metallurgical, instrumentation, environmental and autopilot equipment.

With one in six Ryan employees in engineering, this division has tripled in three years. Its mushrooming growth reflects Ryan's increased importance as a research facility in aerodynamics, propulsion and electronics.

RYAN ENGINEER "zooms" straight up in unique rotatable cockpit.

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Ryan's flight simulation laboratory is a prime tool in the test of new aircraft designs. Both the Vertijet and the subsonic, turboprop-driven Vertiplane are put through their paces via earthbound flight test. Ryan leadership in this revolutionary new concept of flight is based upon 2¼ million manhours of VTOL research and development. It is another example of how Ryan builds better.

Ryan Automatic Navigator Guides Global Flight

An advanced system of aerial navigation, designed for high speed, long range flight, has been developed by Ryan electronics engineers, working under sponsorship of the Navy's Bureau of Aeronautics.

Designated AN/APN-67, the new navigator is the lightest, most compact, self-contained electronic navigator in production. Developed to meet military needs, it will also meet commercial jet flight requirements.

The system provides pilots and navigators with continuous information on longitude, ground speed, ground mileage, drift angle and ground track. It is accurate and instantaneous. Requires no computations, ground facilities or wind data.

AUTOMATIC NAVIGATOR guides pilots with single instrument (above).

Ryan has immediate career openings for engineers

Look to the future. Look to Ryan...where you can grow with an aggressive, forward-looking company. You'll find a variety of stimulating projects. Ryan engages in all three elements of modern flight vehicles—airframes, engines to propel them and electronics equipment to guide them.

Send today for Ryan's brochure, "Engineering Opportunities". Mail this coupon to:

Mr. James Kerns, Engineering Personnel
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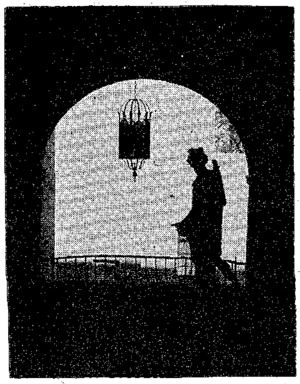
ADDRESS

PHONE NO.

DEGREE SCHOOL

FIELD OF EXPERIENCE OR PREFERENCE



CALTECH CALENDAR

ALUMNI EVENTS

November 15	Homecoming
January 16	Dinner Meeting
February 22	Dinner-Dance
April 12	Annual Seminar
June 11	Annual Meeting
June 28	Annual Picnic

ATHLETIC SCHEDULE

VARSITY SOCCER

November 16—
UCR at Caltech

November 23—
Pomona at Caltech

WATER POLO

November 19—
Long Beach State at Caltech

November 20—
L.A. State at Caltech

VARSITY FOOTBALL

November 15—
Occidental at Caltech (Rose Bowl)

November 23—
La Verne at Caltech

CROSS COUNTRY

November 15—
Pasadena College at Caltech

November 22—
Pomona at Caltech

November 26—
Caltech at Whittier

FRIDAY EVENING DEMONSTRATION LECTURES

Lecture Hall, 201 Bridge, 7:30 P.M.

November 15—
The Anglo-Chinese Opium War of 1841—
Dr. Peter Fay

November 22—
High Voltage Demonstration—
Dr. Gilbert D. McCann

November 29—
Thanksgiving Recess, no lecture

December 6, 1957—
Nuclear Power—
Dr. Harold Lurie

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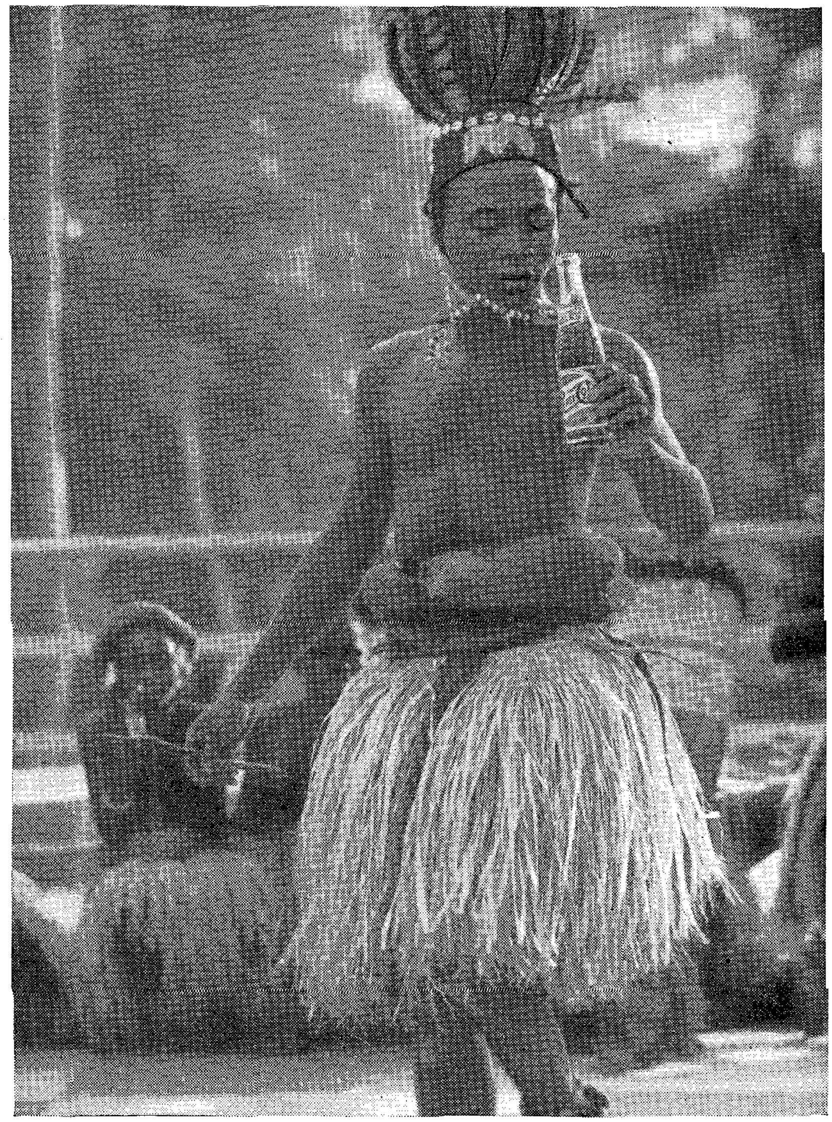
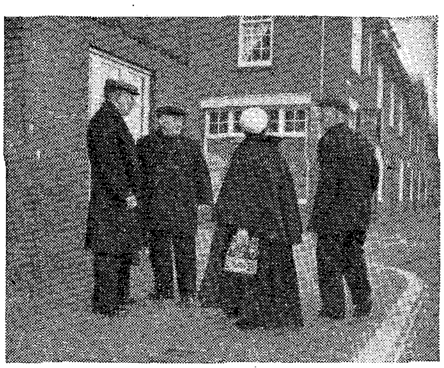
PHOTOGRAPHY AT WORK
No. 30 in a Kodak Series

Pepsi-Cola International Panorama, a magazine of places and people, reaches people around the world, builds recognition for Pepsi-Cola as a product associated with the better, happier side of life.

Photography speaks in every language



What better way to say people take naturally to "Pepsi" whether in Leopoldville or Lichtenstein?



This picture leaves no doubt that Netherlanders are neighborly.

To tell its story in 75 countries, Pepsi-Cola puts pictures to work to add meaning to the product's global billing as "the refreshment of friendship."

To build up an atmosphere of friendliness and understanding in markets around the world, Pepsi-Cola International publishes "Panorama"—and gives the brunt of the job to photography.

Photography knows no language barrier. It is clear to young and old alike—appeals to everyone. With photography, people are real; situations authentic, convincing. This is what makes photography such a powerful salesman.

Large businesses and small can use this powerful salesmanship—can also use photography to cut costs and save time in many other ways. It can help with problems of product design—can watch quality in production. It trains. It cuts office routine. You'll find that it can work for you, too.

EASTMAN KODAK COMPANY, Rochester 4, N. Y.

CAREERS WITH KODAK

With photography and photographic processes becoming increasingly important in the business and industry of tomorrow, there are new and challenging opportunities at Kodak in research, engineering, electronics, design and production. If you are looking for such an interesting opportunity, write for information about careers with Kodak. Address: Business and Technical Personnel Dept., Eastman Kodak Company, Rochester 4, N. Y.

Kodak
TRADE-MARK

One of a series

Interview with General Electric's Hubert W. Gouldthorpe Manager—Engineering Personnel

Your Salary

Although *many* surveys show that salary is not the prime factor contributing to job satisfaction, it is of great importance to students weighing career opportunities. Here, Mr. Gouldthorpe answers some questions frequently asked by college engineering students.

Q. Mr. Gouldthorpe, how do you determine the starting salaries you offer graduating engineers?

A. Well, we try to evaluate the man's potential worth to General Electric. This depends on his qualifications and our need for those qualifications.

Q. How do you evaluate this potential?

A. We do it on the basis of demonstrated scholarship and extra-curricular performance, work experience, and personal qualities as appraised by interviewers, faculty, and other references.

Of course, we're not the only company looking for highly qualified men. We're alert to competition and pay competitive salaries to get the promising engineers we need.

Q. When could I expect my first raise at General Electric?

A. Our primary training programs for engineers, the Engineering Program, Manufacturing Program, and Technical Marketing Program, generally grant raises after you've been with the Company about a year.

Q. Is it an automatic raise?

A. It's automatic only in the sense that your salary is reviewed at that time. Its amount, however, is not the same for everyone. This depends first and foremost on how well you have performed your assignments, but pay changes do reflect trends in over-all salary structure brought on by changes in the cost of living or other factors.

Q. How much is your benefit program worth, as an addition to salary?

A. A great deal. Company benefits can be a surprisingly large part of employee compensation. We figure our total benefit program can be worth as much as 1/6 of your salary, depending on the extent to which you participate in the many programs available at G.E.

Q. Participation in the programs, then, is voluntary?

A. Oh, yes. The medical and life insurance plan, pension plan, and savings and stock bonus plan are all operated on a mutual contribution basis, and you're not obligated to join any of them. But they are such good values that most of our people do participate. They're an excellent way to save and provide personal and family protection.

Q. After you've been with a company like G.E. for a few years, who decides when a raise is given and how much it will be? How high up does this decision have to go?

A. We review professional salaries at least once a year. Under our philosophy of delegating such responsibilities, the decision regarding your raise will be made by one man—the man you report to; subject to the approval of only one other man—his manager.

Q. At present, what salaries do engineers with ten years' experience make?

A. According to a 1956 Survey of the Engineers Joint Council*, engineers with 10 years in the electrical machinery manufacturing industry were earning a median salary of $8100, with salaries ranging up to and beyond $15,000. At General Electric more than two thirds of our 10-year, technical college graduates are earning above this industry median. This is because we provide opportunity for the competent man to develop rapidly toward the bigger job that fits his interests and makes full use of his capabilities. As a natural consequence, more men have reached the higher salaried positions faster, and they are there because of the high value of their contribution.

I hope this answers the question you asked, but I want to emphasize again that the salary *you* will be earning depends on the value of *your* contribution. The effect of such considerations as years of service, industry median salaries, etc., will be insignificant by comparison. It is most important for you to pick a job that will *let* you make the most of your capabilities.

Q. Do you have one salary plan for professional people in engineering and a different one for those in managerial work?

A. No, we don't make such a distinction between these two important kinds of work. We have an integrated salary structure which covers both kinds of jobs, all the way up to the President's. It assures pay in accordance with actual individual contribution, whichever avenue a man may choose to follow.

*** We have a limited number of copies of the Engineers Joint Council report entitled "Professional Income of Engineers—1956." If you would like a copy, write to Engineering Personnel, Bldg. 36, 5th Floor, General Electric Company, Schenectady 5, N. Y.** 959-7

LOOK FOR other interviews discussing: • Advancement in Large Companies • Qualities We Look For in Young Engineers • Personal Development.

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