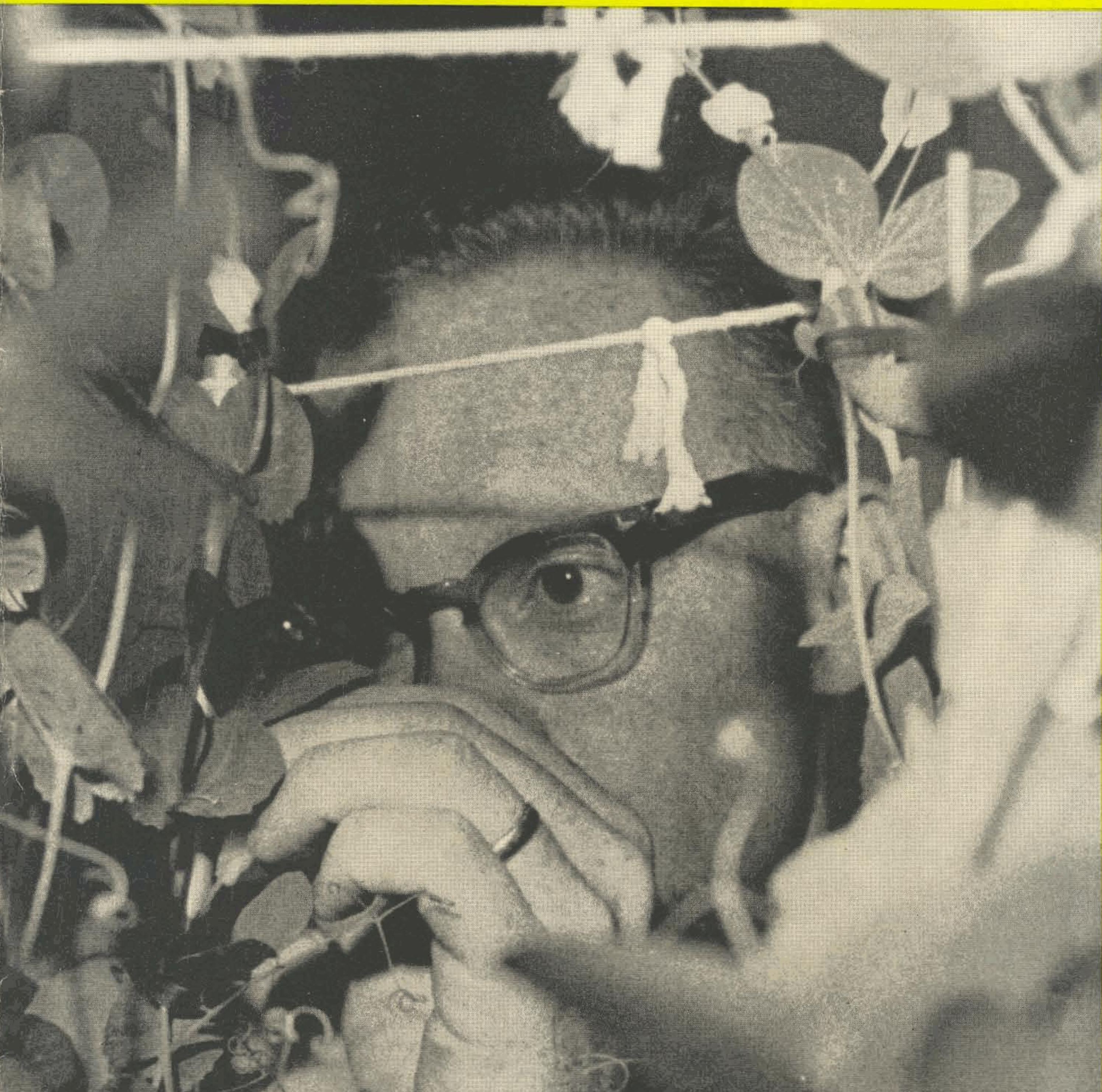
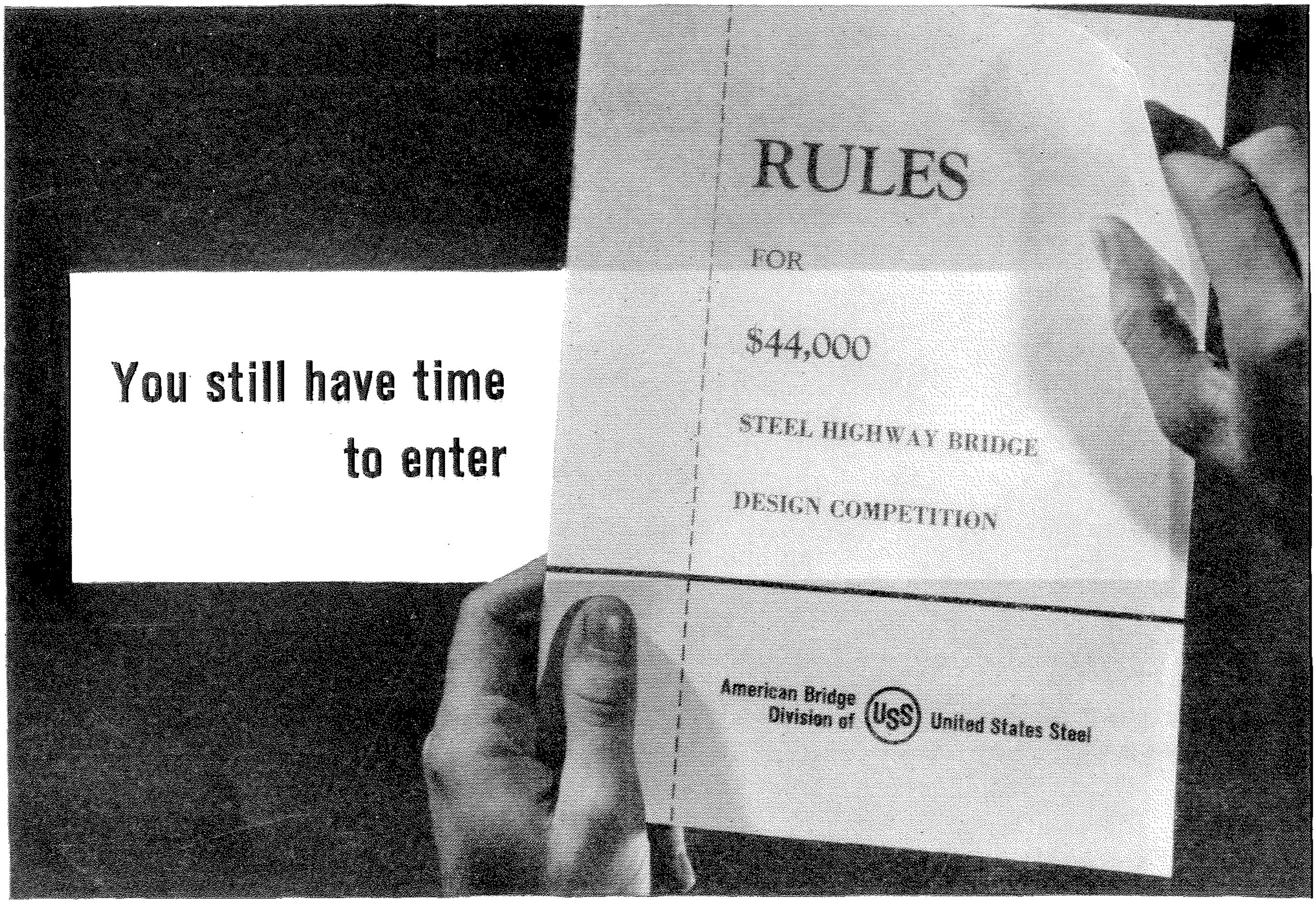
ENGINEERING | AND | SCIENCE

March 1959



Plant research . . . page 18

Published at the California Institute of Technology



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ENGINEERING | AND | SCIENCE

On Our Cover

the eye belongs to James Lockhart, research associate in biology. What he is studying so closely is a pea plant – the subject of his current research in Caltech's Earhart Plant Research Laboratory. The lab, 10 years old this spring, was the first one in the world where plants could be grown under every possible climatic condition, and has attracted biologists from all parts of the globe. For more on Earhart, see page 18.

"Creativity in Science,"

on page 13 of this issue, was first presented as a talk in the creativity series at the Pacific Oaks Friends School in Pasadena. Its author, James Bonner, is professor of biology and acting head of the biology division at Caltech.

"Seven Wonders"

The Reverend Ganse Little, author of "Seven Wonders" on page 23, is not (like most of the other writers for this publication) connected with Caltech. He is pastor of the Pasadena Presbyterian Church. His article appears here at the urging of practically every Caltech civil engineer who heard it when it was given originally as a talk to the American Society of Civil Engineers in Los Angeles last fall.

Picture Credits:

Cover – Graphic Arts
13, 17 – Harry Diamond
18-22 – Graphic Arts
34 – Graphic Arts
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MARCH 1959 VOLUME XXII NUMBER 6

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Published monthly, October through June, at the California Institute of Technology, 1201 East California St., Pasadena, Calif., for the undergraduates, graduate students and alumni of the Institute. Annual subscription $4.50 domestic, $5.50 foreign, single copies 50 cents. Entered as second class matter at the Post Office at Pasadena, California, on September 6, 1939, under act of March 3, 1879. Manuscripts and all other editorial correspondence should be addressed to: The Editor, *Engineering and Science*, California Institute of Technology,

Letters

SIRS:

In his article on "Admissions at Caltech" (*E&S* – January, 1959) Peter M. Miller, assistant director of admissions, makes a passing remark that is so obviously untrue as to demand rebuttal: "The applicants (for Caltech admission) must be male . . . The restriction seems to have had . . . no deleterious effect on the social blooming of the Caltech undergraduate."

Admittedly there are some who do fine socially at Caltech. Many people find that the lack of social competition or hard-to-break-in-to groups at Tech make it an ideal place to "come out of their shells" socially.

Yet, on several counts, the non-coeducational nature of Caltech does lead to "deleterious effects," and creates problems which really ought to concern the Deans (although apparently they choose not to be aware of the problems) and which ought to be explained to prospective freshmen (although usually they are not).

The fact that Tech students have to go to colleges which are anywhere from 7 to 25 miles away in order to find intelligent, college-age girls to associate with makes social life at Caltech into a strictly-weekends affair, and a highly expensive one, too (60 cents for a phone call, for example). The fact that, to the girls they associate with, Tech students are cast in the role of social outsiders tends to make their "social bloom" both frustrating and unrewarding.

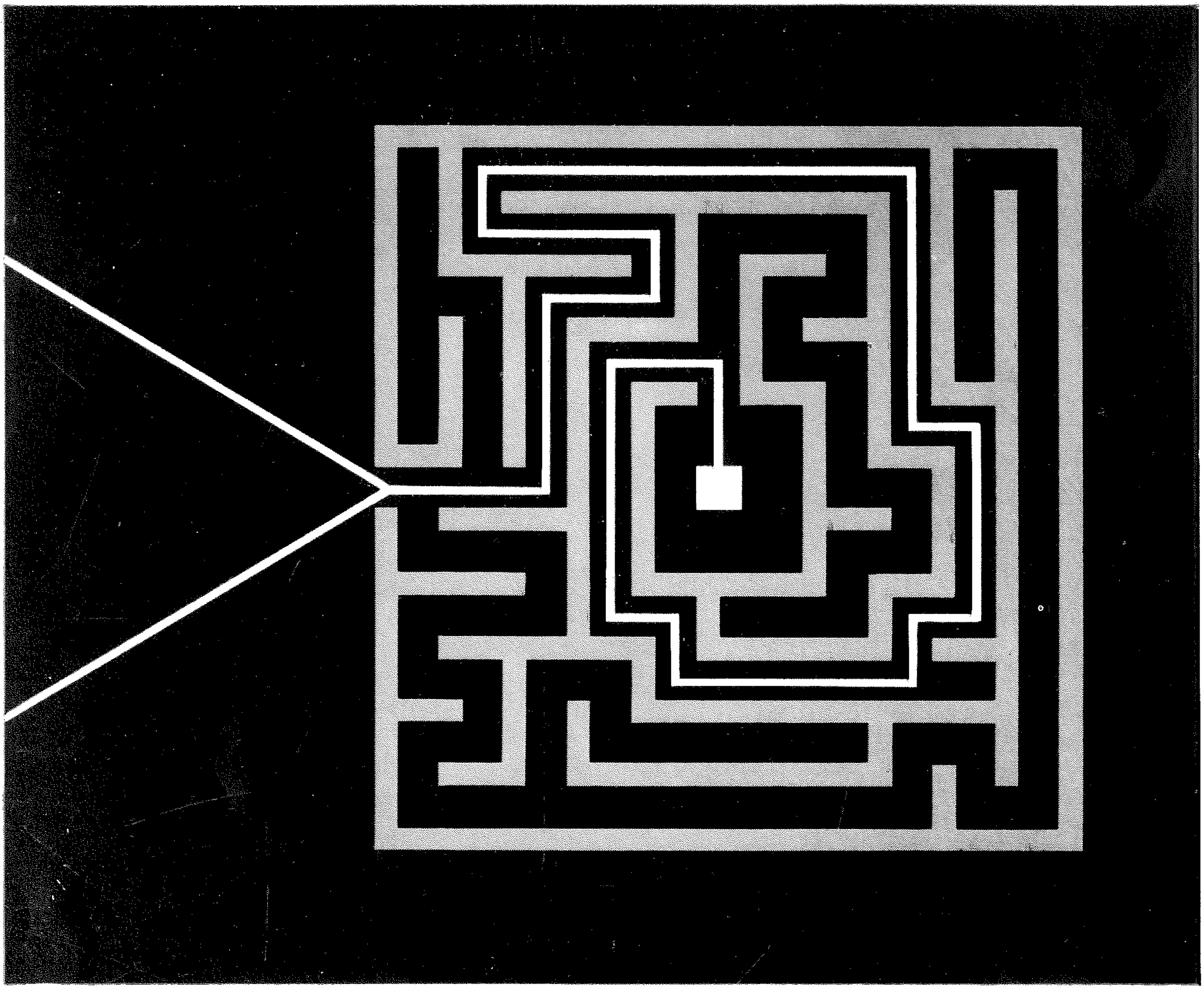
The girls that most Tech students wind up dating leave much to be desired. They are often high-school girls, or girls who cannot make a go of it socially at their own schools.

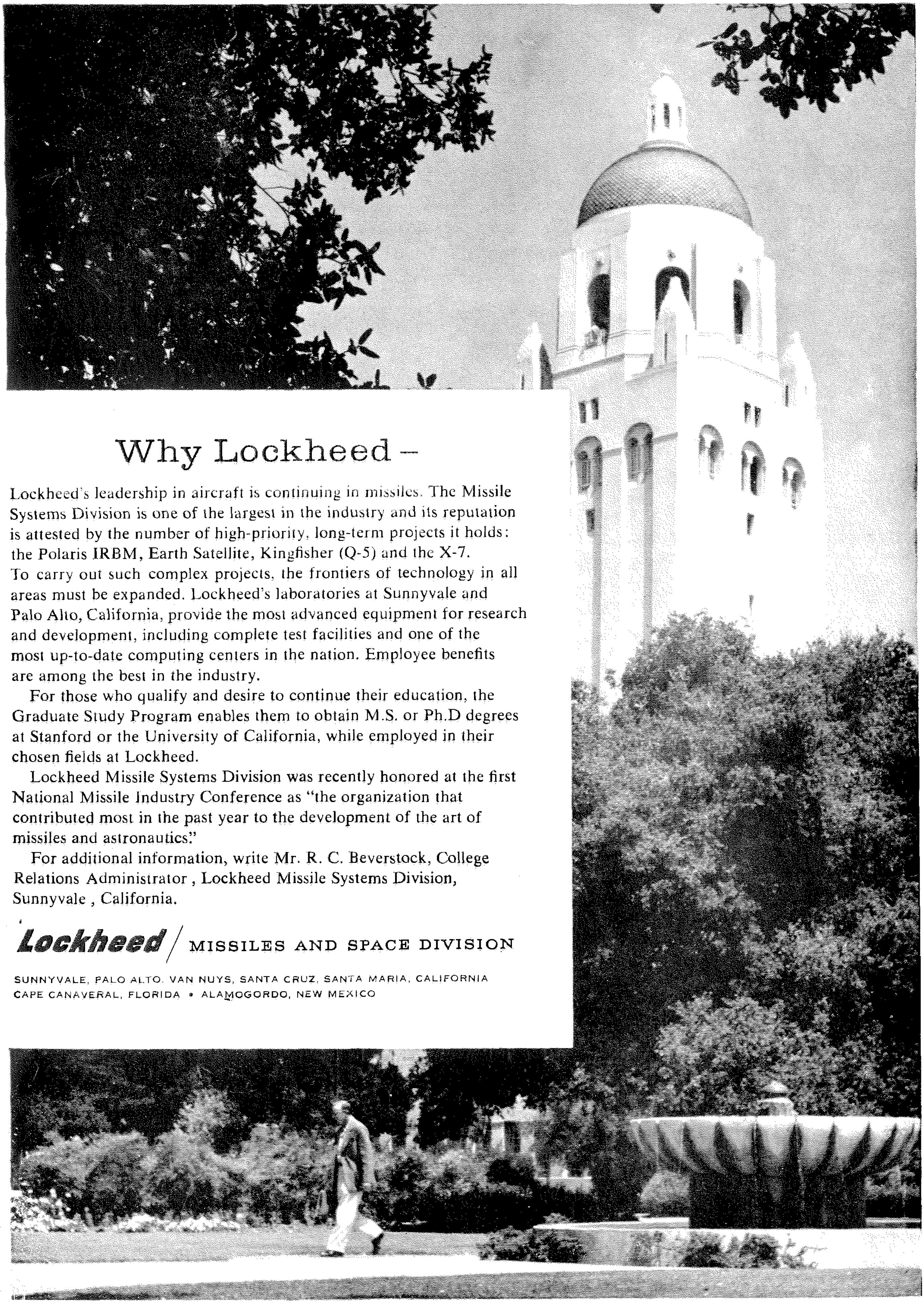
Another major problem is that men who do not have cars (especially freshmen) are limited by transportation problems to attending the three or four "big" events each term.

The truth, which the Deans ought to face, is that a large percentage of Tech students wind up marrying the second or third girl they ever meet. And for most of the rest, undergraduate life at Caltech becomes, not something to look back on with fond memories, but rather something to forget as soon as possible.

Howard Weisberg '60


Westinghouse is the best place for talented engineers





Books

The American High School Today

A First Report to Interested Citizens

by James B. Conant

McGraw-Hill $1.00
(Clothbound . . . $2.75)

Caltech got a preview of James B. Conant's report on American high schools when the distinguished educator and diplomat visited the campus for three days in January as a guest of the Caltech YMCA's Leaders of America program. Now, here is Dr. Conant's complete report, published after a two-year study of high schools in 26 states, financed by a grant from the Carnegie Corporation of New York.

In some hands this report might have turned into another controversial blast at public secondary education in the United States. In Dr. Conant's hands it becomes a defense of the American comprehensive high school, and an impressive list of specific suggestions (21 in all) for improving public secondary education in this country. Because these suggestions are, for the most part, practical, and possible, and irrefutable, the report should get thoughtful consideration from citizens representing *all* points of view on the question of public education.

Education and Freedom

by H. G. Rickover, Vice-Admiral, USN

E. P. Dutton Co., N.Y. $3.50

Reviewed by Paul C. Eaton

Admiral Rickover is already something of a national hero, the popular image of him being that of a stormy petrel furiously buzzing about the heads of conservative and complacent battleship admirals dedicated to resisting the application of nuclear power to ship propulsion, much as the cavalry generals of a generation ago refused to listen to Billy Mitchell's equally furious contention that the airplane was here to stay.

Whatever the nature and the realities of the opposition to Admiral Rickover in the Navy and in the Atomic Energy Commission, the north polar transits of the nuclear-powered submarines, *Nautilus* and *Skate*, have been accomplished and the Shippingport, Pa., central station power plant is a reality. Buzzing which can bring about such results should be heeded, in any field.

In *Education and Freedom* the field is public elementary and secondary education in this country today, and the attack on the status quo is vigorous, well-directed, and all along the line. The book consists of eleven chapters and three appendices. The greater part of the material in the first nine chapters is based upon addresses which the author has delivered before various civilian groups during the past two years.

The general tone of the work is not at all that of the stormy petrel; it is primarily expository, well-documented in contemporary foreign comparisons and historical precedents, and deadly serious. The urgency of his plea for upgrading our educational standards derives in part from his own difficulties in finding competently educated people to staff his assignment in building the first nuclear power plant for naval use. Incidentally, that story is very well told by one of those he did find, Commander E. E. Kintner, USN, in the January 1959 *Atlantic*.

It is possible in the book to identify personal villains, comparable to the battleship admirals and the cavalry generals, but Admiral Rickover does not make the mistake of simplifying the problem to soap-opera good guys versus John Dewey and the National Education Association.

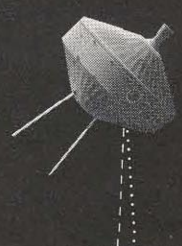
The "Freedom" term in the title means pretty specifically our survival as a nation, as in Thomas Jefferson's dictum: "If a nation expects to be ignorant and free . . . it expects what never was and never will be." Jefferson would have loved Rickover. The first three chapters deal with education as our first line of defense (the battleship admirals wince), lead time and military strength, and pioneering on the frontiers of knowledge.

Chapters five through seven, "Energy Resources and Our Future," "In-

continued on page 44

MAN'S FIRST SPACE COMMUNICATION STATION

On 12 October 1958, an historic event took place. A group of Space Technology Laboratories' engineers at Cape Canaveral, Florida, transmitted radio signals far out into space to the NASA/Air Force Pioneer space probe vehicle. The tiny receiver and transmitter in the Pioneer relayed these same signals to the Space Technology Laboratories' group at Manchester University, England. • This significant experiment promises, like those earlier achievements of Morse, Bell, and Marconi, to pave the way for the use of space vehicles to relay information to and from points on earth. One day the entire world will view televised events as they happen. • Future experiments of *this kind will undoubtedly assist mankind* in his search to understand, use, and benefit from his knowledge of space phenomena. • Scientists and engineers whose interests and abilities enable them to contribute to these developments are invited to join our technical staff.



Space Technology Laboratories, Inc. P.O. BOX 95001, LOS ANGELES 45, CALIFORNIA

The 250′ radio telescope pictured here is operated by a team of British scientists under the direction of Professor *A. C. B. Lovell, University of* Manchester, whose cooperation contributed materially to making this achievement possible.

Creativity in Science

by James Bonner

Discussions of creativity frequently revolve around creativity in art or creativity in literature. We all imagine that we know how to recognize a great creative artist—an artist whose work soars out of and above the imagination. I think we should first ask, in discussing creativity in science, whether there is in fact any comparable creativity in this field. Is the scientist creative? The popular picture of a scientist in our culture runs somewhat as follows: A man in a white laboratory coat grinds away in a logical and inexorable fashion (and dully too) for 20 years, and then suddenly produces nylon or a better mousetrap.

The popular picture of the scientist in our culture might then suggest that scientific work does not grip the emotions, that it is coldly logical, that it is not creative as is the work of the artist. I am prepared, however, to show that this is a misconception. There are many grades and degrees of creativity and innovation in science. The discoveries of which we read in popular magazines are indeed most frequently ones based upon the logical repetitive search for some merely useful material—a new elixir that will magically cure chilblains in mice resident in orbiting space vehicles, and so on. But this is not truly science; it is applied science—and it bears the relation to high-level creative science that the articles in popular magazines bear to creative literature.

Scientific creativity lies much deeper than the repetitive search for a better plastic or the trial and error attempt to find a better desmogger for exhaust pipes. Creative science lies, I believe, in the formulation of relations between facts—the genesis of theories which bring together under one roof observations previously separately housed.

"Creativity in Science" has been adapted from a talk given by Dr. Bonner at Pacific Oaks Friends School in Pasadena.

We all think we know how to recognize a great creative artist, whose work soars above the imagination.

The scientist is confronted by a multitude of facts; he wishes to reduce them to one fact, to formulate a law of nature. This is the urge of a scientist, to find unity in nature. He wishes to find similarities between things not previously recognized as similar. He must create a theory which will unify facts. There are probably many theories which unify a portion of the available facts, but he must imagine one that will unify all. He must reject those theories that he has imagined which will not encompass all facts. It is a hard task. To formulate this theory, to imagine it, is strictly a personal subjective act. It is not done by committees; there is no known and inexorable way to deduce the correct hypothesis in advance; it must first be imagined by some one person.

Think of some of the truly creative figures in science—Darwin, for example. Darwin's creative unifying act was to see relatedness in all creatures, relatedness by evolution. No relatedness between the earth's living things had previously been imagined—merely an almost infinite number of differences.

Or think of Niels Bohr and his atom, imagined strictly ad hoc to relate the thousands and thousands of spectral lines described as miscellaneous facts by physicists for over a hundred years. Each of these new innovations represented a gigantic new concept, personally conceived and brought to test in the same sense that a creative work of art is personally imagined and brought to light.

There is another characteristic of the creative scientific act which may often, although not always, be perceived. This is the fact that it involves discarding what is generally accepted, in pruning away dogma, as a basis for a new and more general unifying concept. Take Darwin again: He had first to discard the accepted fact that each species is individually created by the creator. This is in a sense a unifying concept, and one generally acceptable and accepted in Darwin's time. Before Darwin could proceed to imagine a new and more unifying concept—namely, that species evolve from common ancestors and that creation therefore occurred but once—he had to discard the accepted view. A creative scientist, then, has to have the strength to question what is presently accepted, to turn things topsy-turvy as a part of his creative synthesis.

What I have said about a few major examples of scientific creativity is also true for less spectacular examples. For there is a complete spectrum of creativity, from acts such as those of Darwin and Bohr, down to the man who imagines how to reconcile today's laboratory results with yesterday's different ones. We see creativity in the scientist at work each and every day; some days are merely more creative than others.

Finally, I may note that I assume that the urge to unify, to bring relatedness where none was found before, is a basic urge and drive for the scientific person. I do not know that this is true, but I suspect strongly that it is. I suspect that the desire to unify and understand is a basic part of man's emotional arrangements.

The evolution of a creative scientist

Let us now consider some of the things that may be observed during the process by which a young person emerges as a creative scientist. I will take for my study what happens in the course of graduate education. Each fall we bring into our biology group at Caltech a dozen or so young men and women, all with fresh Bachelor's degrees. These are new graduate students. They have spent four years in college and twelve years in school before college. They are full of facts. They are full of learning. But with rare exceptions they exhibit no evident qualities of the creative scientist. Let us, however, observe them two or three years later. Many of these same young people will be creative scientists. They will be daily formulating and testing new and often highly original concepts. They reveal their work to the world in print and with great assurance. Some will be guiding others along the same path. It is truly a heart-warming process to follow.

Surely these young people were creative in some respect before they entered graduate school, but it had not made itself manifest in any obvious scientific way. One might conclude that all that has been happening in graduate school is that they have been taught—*trained* is a popular word—to use a new art form, that of science.

Finding a subject

But I think that this would be misleading and that the facts go deeper. During the course of graduate education these students have had but few formal courses. They know some new facts, to be sure, but they are not gaining facts at the rate that they did in their undergraduate years. There is, however, one obvious thing that has happened, and that happens to every scientist who becomes a creative practitioner. Let us watch a new graduate student. He browses around; he looks at many subjects; he talks to many people; and suddenly one day he finds a subject which really sends him, one that grips his emotions for reasons he doesn't understand but doesn't think about. He takes hold of this subject; he wants to find out all about it; he reads about it in the literature; he thinks about it; he dreams about it; he works on it.

I have seen some spectacular examples of this in my years as a guider of graduate students. I have seen young men spend one, two, three years in pedestrian work, routinely carrying out token investigations. And I have seen these same young men suddenly find a new subject which really excited them and then blossom out as creative scientists in a period of months. I believe it is safe to say that, unless the potential scientist finds a subject which really grips his emotions, the scientific creativity of the individual does not come to the fore. This is an essential part of the process of becoming a creative, productive scientist.

But the choosing of an appropriate subject of investigation isn't the only thing that has been happening in graduate school. Graduate school is still conducted by apprenticeship; the newcomer is put in close association with a practicing creative scientist; they talk; they make hypotheses; they think up critical tests of hypotheses; the apprentice is actually watching and participating in the creative work of another. There is obvious transfer here and one can mark this in many scientists. The work of the master-scientist-father can be detected years later in the work and mannerisms of the former apprentice son.

Still another thing happens in graduate school.

Graduate school is a very permissive institution. There are no penalties for questions; everyone does it. There is little structure; the apprentice slowly gets to feel that he can question not only his immediate colleagues, but anyone, professors included. Everyone talks; everyone questions; everyone brings forth new unorthodox ideas. At its best, graduate school is a sort of continuous brainstorming session; new ideas continuously pop out and are batted around. And in this connection there is the matter of reward. In graduate school the apprentice scientist is rewarded for his questioning, for his spontaneity, by the approval of his colleagues, by fellowships, and other symbols of material wealth. He is rewarded, perhaps for the first time, for spontaneous unorthodoxy.

Finally, as the graduate student-apprentice progresses toward becoming a creative scientist he receives responsibility—the responsibility to help others along the same path. This appears to me to be a very maturing experience, a step which helps to free the onetime apprentice from his master, to make him independent. This step involves real change from dependency to adulthood, and the challenge to help another is a catalyst which appears to make the great step easier to take.

These are some of the things which I think can be seen happening in graduate school, things that help to determine whether a student becomes a creative scientist or a pedestrian, repetitive investigator. It occurs to one naturally to ask whether we might take the little knowledge that we have of education for creativity in graduate school and apply it in the earlier stages of the educational process – in the undergraduate college years, for example.

The creative scientific act

Let us now pass to another aspect of scientific creativity and consider the creative scientific act itself. How does a scientist have a creative thought? What does he do when he wants to have a new idea? The facts are simple and they are pretty well agreed upon. The creative act follows a definite sequence of steps, which we can outline as follows:

(1) Define the question. This may in itself be a creative act, since to recognize a question which has not been asked before may take great creativity.

(2) Stuff with facts. Once the question has been defined, the potential scientific creator must have all the information that he can get. He may have to do some experiments; he reads the literature; he gets together all the information that he can imagine bears upon the question at issue.

(3) Wait. The scientist may mull the facts over; he may worry; but in principle what he has to do now is wait.

(4) A solution pops out. Perhaps many solutions pop out. Often solutions emerge to consciousness when one is half asleep, or perhaps during a daydream. They may occur when one is talking with others, or they may happen during full but solitary consciousness. The principal point is that creative solutions occur at quite arbitrary and unpredictable times.

(5) Assess the solution. The scientist must now ask himself whether his new creative idea is a useful one or not: Is it good or bad? Does it actually unify everything that is present to be unified?

Steps 1, 2, and 5 above are conscious steps; they are logical. Steps 3 and 4 are not conscious; something is taking place in the preconscious, and here is the nub of the problem of scientific creativity. There are ways to get at what is happening during the waiting period, and at the time the solution pops out. Suggestions as to what is happening are contributed by the study of free association and by the many modifications of the free association process that have been applied to the study of creativity; as for example, in brainstorming, in the psychoanalytic session, the Rorschach and Thematic Apperception tests of psychologists, and in observations of creative people who talk.

The nub of the problem

All of these observations suggest that one and the same individual produces many new arrangements, new constellations, new unorthodox concepts from the same information. They suggest that what is happening during the preconscious interval before a creative solution to a problem emerges is that the facts which have previously been stuffed in to the conscious are taken to the preconscious and there jumbled and rearranged in all possible ways. From time to time one of these rearrangements emerges to consciousness – with greater frequency when certain strictures are removed, as in half sleep or in the brainstorming situation.

We are now in a position to make a formal model of the creative process. We can formulate this model as follows: The scientist who wishes to make a creative solution to a problem must first have a problem and must further possess information on the problem. Next, he must have an objective. The objective is to produce a new symmetry from the component parts of this information. Next, the information is taken into a device, the preconscious of the individual, and there subjected to random rearrangement and recombination. Finally, our unconscious machinery permits the filtered release to consciousness of selected rearrangements.

The key question concerning the nature of the creative act and the creativity of individuals seems to me to lie, if the above model is correct, in what determines which rearrangements come to consciousness. Obviously, the filter process does us a good turn if it serves the objective of only releasing rearrangements that possess some new symmetry, and discards at once all rearrangements that are nonsense and which have no symmetry. But, nonetheless, the filter process is quite evidently a highly untrustworthy instrument; it is wholly subject, because it is unconscious, to unconscious control and to the accompanying opportunities for distortion. The filter process can, for example, quite unbidden, *prohibit from coming* to consciousness creative rearrangements that threaten the security of the individual, that run counter to general opinion, that run counter to long forgotten prohibitions learned in childhood, and so on.

The filtering act would certainly appear to be the most vulnerable, the most unsatisfactory, and the least accessible of the components of creativity. However, I think that we may conclude that, insofar as this part of the creative process is concerned, creativity and spontaneity are closely allied, or perhaps identical. We may conclude, too, that to the extent that we preserve and nurture spontaneous behavior, we minimize *the restricting influences of the filter process* on creativity.

Some case histories

Let us now stand back and look at some selected examples of scientists at work. My examples cover the spectrum from high to very low creativity, but they are selected in a special way. In the first place, they are fictitious, but if they really existed they would all be hard-working, industrious, intelligent and meritorious people, and people who have contributed significantly to science – although with very different degrees of productivity.

My first example is a bubbling, loquacious man of broad interests; he understands any and all subjects, and he can take any problem and contribute really new solutions to it. He is verbal. In conversation on any of a wide variety of matters he will take the subject, grind away inexorably and logically for awhile, and then suddenly he will shift gears and take off in fantasy, producing one new unorthodox concept after another, reassorting all of the facts of the situation into new arrangements, mostly nonuseful.

As he works on a problem, he takes the facts and rearranges them audibly, as it were. We can imagine that we see the preconscious reassortment process at work. Among the many rearrangements produced by this man, he selects consciously with great care and logical skepticism. He discards all but a few. The few that remain are subject to exhaustive testing in every possible way. He is a man of no self-delusion, and his creative ideas, when they are finally passed on to the world at large, are always (thus far) correct. *He is a man with no great measure of personal* investment in his ideas; an idea is not right merely because it is his own. If logic shows that it is wrong or nonuseful, he throws it away; he couldn't care less about it. This man possesses to a high degree the characteristics of a creative, productive person.

My second example is also a man who is bubbling, spontaneous, loquacious and whimsical. He, too, takes a problem and grinds away on it audibly. Here again we imagine that we see and hear the rearranging, reshuffling process at work, the rearrangements coming out as successive fantasies. He is much less rigorous than the preceding individual in the final selection and assessment of his many new and fanciful ideas, and many have proved to be incomplete or even wrong. But his contributions have been tremendous. He, too, has the ability to throw away his own ideas when they are shown by others to be erroneous. Even his mistakes have been useful for the progress of science.

My third example is a quiet man, a lone worker, who does, however, produce creative and quite new ideas. These have reshaped the world of science. But he holds with equal tenacity ideas which appear to be merely capriciously unorthodox. He is a man with *tremendous personal investment in his creative notions*, right or wrong. A questioner of any idea, no matter whether good or bad, becomes at once a personal enemy. This man exemplifies the trait, common to us all, of feeling that his views must be correct because he wants so much to have them be.

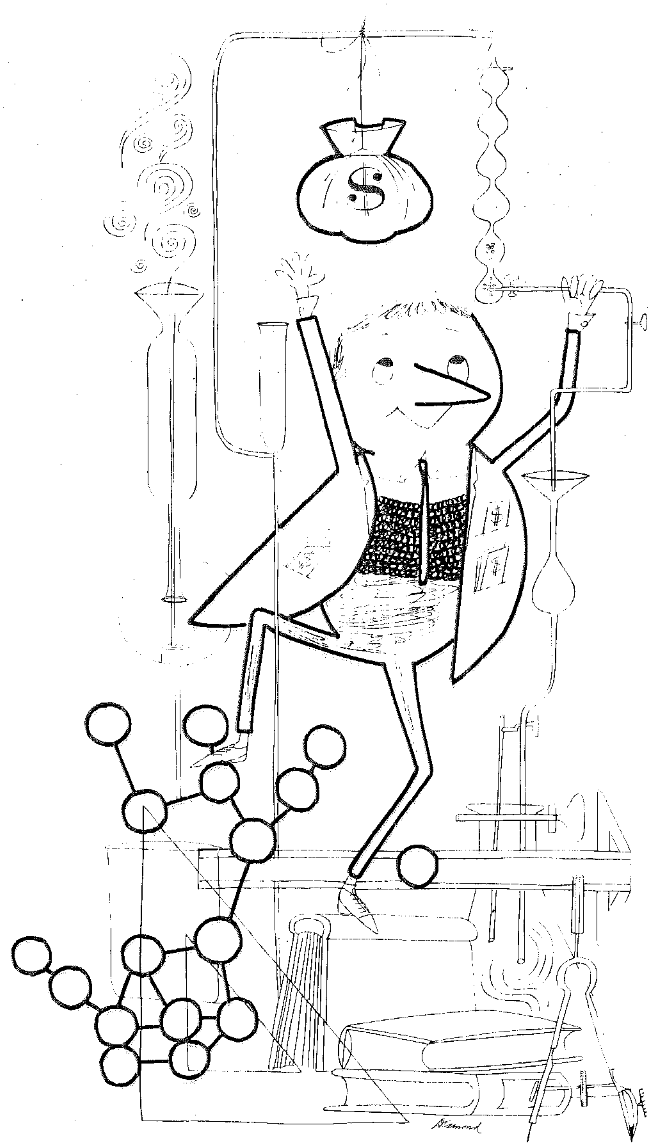
My fourth example is another loquacious bubbler who spouts out a continuous succession of new ideas. But he has, unfortunately, essentially no ability to distinguish logically good new concepts from bad notions. In following up the bad with the good he wastes his effort and, as a result, his scientific impact has been much smaller than it should properly have been.

My next example is a quiet person of tremendous erudition, full of facts, a creative poser of good questions. He poses a question, he gets the facts and then more facts, but the creative rearrangement of these facts into a unified picture does not come. Repeatedly now this has happened. Time and again the facts so laboriously gathered have been unified by others. How frustrating!

My final example is of a hard-working, knowledgeable person, an able experimenter, but with neither the ability to pose new questions nor to solve creatively a problem posed by others. Always a follower, his work is repetitive and tends toward the determination of further significant figures in important constants. He is a useful person, a technician, but not creative. He comes close, perhaps, to the common picture of a scientist in our culture.

Perturbations of the creative process

Let us now turn to some of the troubles implicit in these case histories which beset the creative scientist, and indeed the creative worker generally. We will disregard such obvious matters as the fact that many scientists work under restrictive surroundings for mere money. More pressing are the aspects summarized by Lawrence Kubie in his book, *The Neurotic Distortion of the Creative Process*, and in two articles



Many scientists work under restrictive surroundings for mere money.

in the *American Scientist* (Oct. '53 and Jan. '54).

The first has to do with the goals of the individual scientist. What is the scientist unconsciously trying to achieve by scientific work? I have already pointed out that I assume it to be a human urge and desire to make order, to unify, to simplify, to understand. To a scientist for whom this is the goal, a creative solution to a problem is its own reward. But we know that creative solutions to problems can stand for many other things. To one scientist they may unconsciously stand for material success, to another they may mean acclaim. Or, a creative solution to a scientific problem may represent in symbolic form a way to seek affection, and so on, endlessly.

These are distorted goals. Perhaps one of the commonest symbolic meanings of creative success for the scientist is that of acceptance and adulation. To such a scientist, science represents a route to such success and adulation. Papers submitted to journals represent stepping stones to fame rather than a sharing of creative discovery. And scientists in whom this distorted goal stands high are not highly creative. Such a person has a monkey on his shoulders distorting his creative effort by distorting its goal.

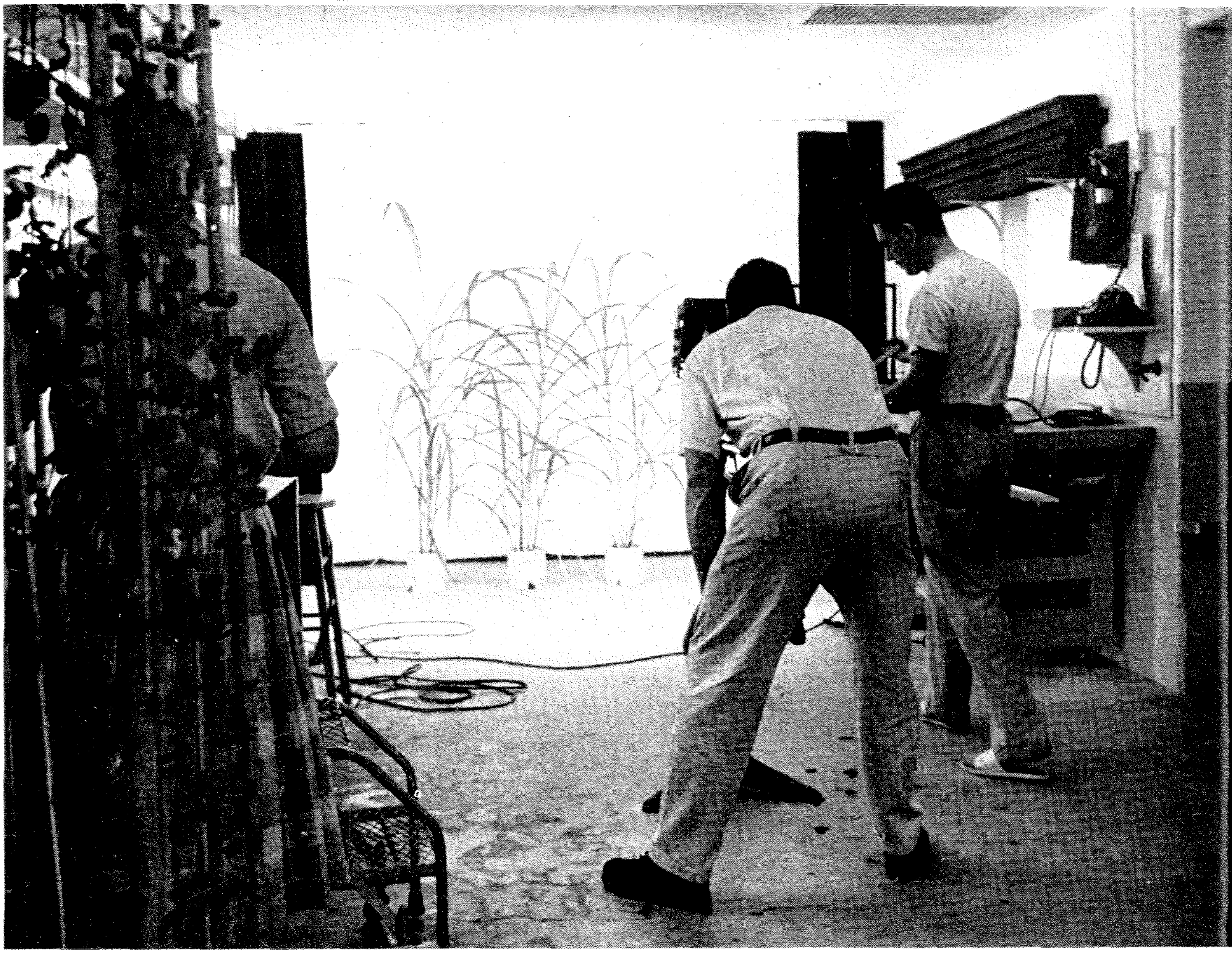
Then there is the matter of problem selection. I have mentioned that a student goes along browsing through the fields of science and all of a sudden finds a subject, a problem, which engrosses him. Obviously this choice has some background, some meaning, just as does career selection in the first place. Perhaps always, the problem selected has its intellectual challenge, but many problems do. Quite probably there are unconscious factors at work in problem selection. The problem has some symbolic meaning. In fact, a great deal of jesting about this matter goes on in biology—how geneticists are people justifying to themselves their own guilty interest in sex, etc., and since this is made as a joke there is probably truth in it.

Creative unorthodoxy

I would note here too the problems associated with the fact that creative thoughts are often held by others to be antisocial, or at least dangerously anti-status-quo, and the sanction which is thereby implied for safe, acceptable, but repetitive work. I think that we can all sense that submissiveness, obedience, acceptance of authority, as the child learns and feels it, can very well have a much wider meaning and significance in later life in relation to creativity. The creative scientist must of necessity allow unorthodox thoughts to come to consciousness. Submissiveness and acceptance of authority is the antithesis of this. And so we should know and understand how to rear children and produce adults in whom creative unorthodoxy has not been dampened by demands for obedience.

These are just a few of the many ways in which unconscious drives can and do prevent or dampen the creative process. And the moral, it seems to me, is twofold: first, that we need much more knowledge of the creative process and the factors that affect it, and wider acceptance of this knowledge. We need to use this knowledge to improve child-rearing procedures, to improve educational processes, and to foster creativity in adults. Just consider college educational procedures with their learning by repetition, their dependence on authority, and the competition between students for grades that depend on acceptance of these procedures. How much more wisdom could we convey in the undergraduate years if we just knew how to use the student's own creative drive in the learning process itself!

The second conclusion, and my final one, is that the creativity of the scientist is beset by many traps and hidden dangers. He needs self-insight and self-awareness to avoid these dangers, and to maximize and free his creativity to keep it turned to the solution of real problems.

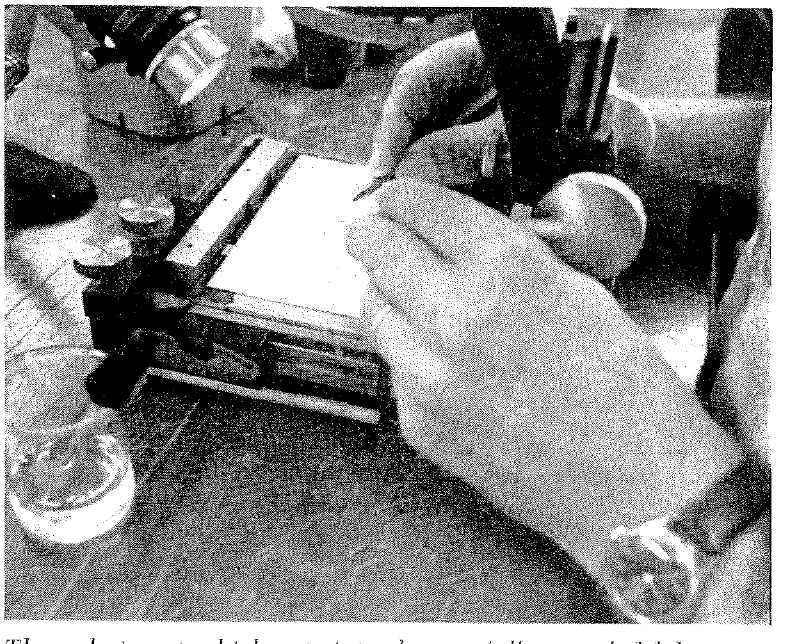


Caltech Research Fellow Harry Highkin, and Kenneth T. Glasziou from Australia, photograph sugar cane plants to record their growth. Current research on the plants may eventually determine why sugar cane suffers a decline in sugar content during the years of its growth.

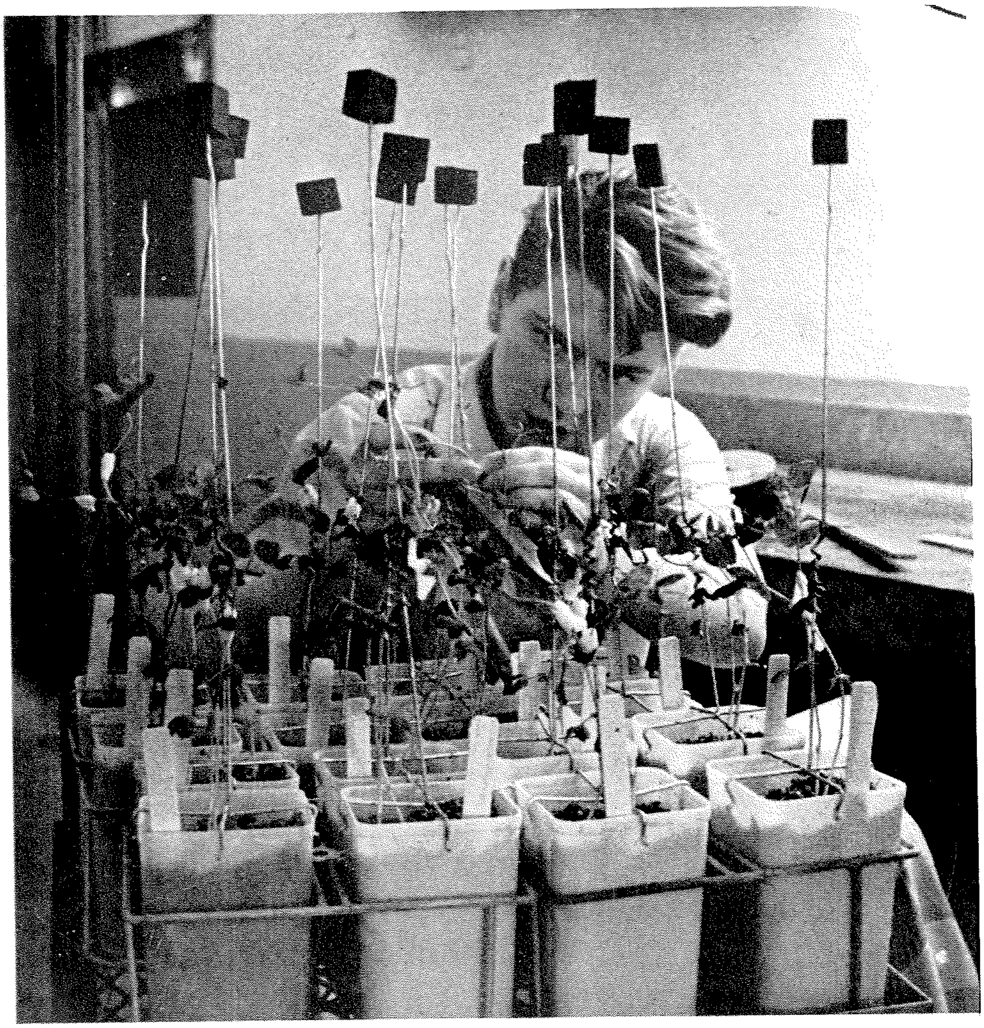
PLANT RESEARCH

Caltech's Earhart Plant Research Laboratory, 10 years old this spring, was the first laboratory in the world where plants could be grown under every possible climatic condition. Here, light, temperature, humidity, wind, rain, fog, or the gas content of the air can be simultaneously and independently controlled. Biologists from all countries are now working in the lab, studying how to match plants to climate, and how to predict ripening, flowering and other phases of the growth cycle. On these pages are some examples of current research in the lab.

Hendrik Ketellapper, from Holland, checks the effect of low temperature on peanut plants. The plant on the left, grown at temperatures below 14°, failed to make chlorophyll and is colorless.



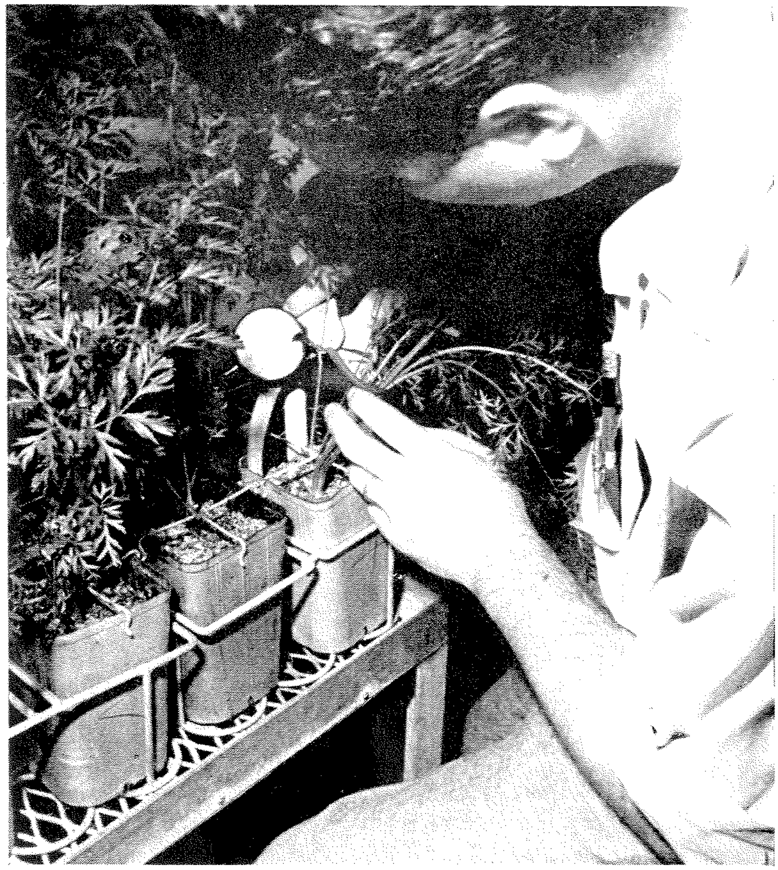
The only insect which gets into the carefully guarded laboratory is there as research material – the willow fly (under the microscope, above), a gall-producing insect which attacks willow trees.



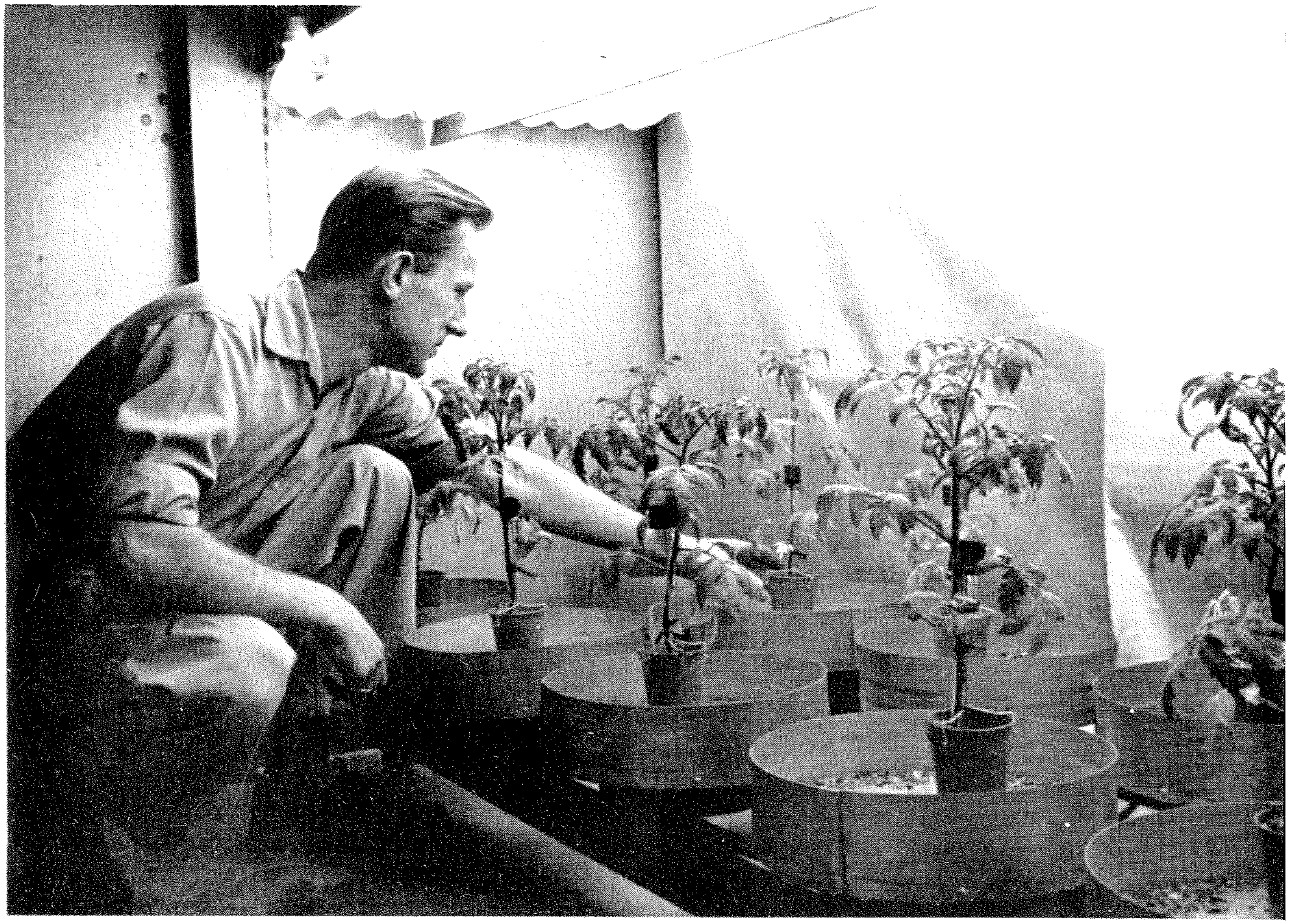
A lab worker grafts old tips onto a young pea plant in a control experiment on senescence. The black tips on the wires are not markers, but simply a protection for lab workers' eyes.

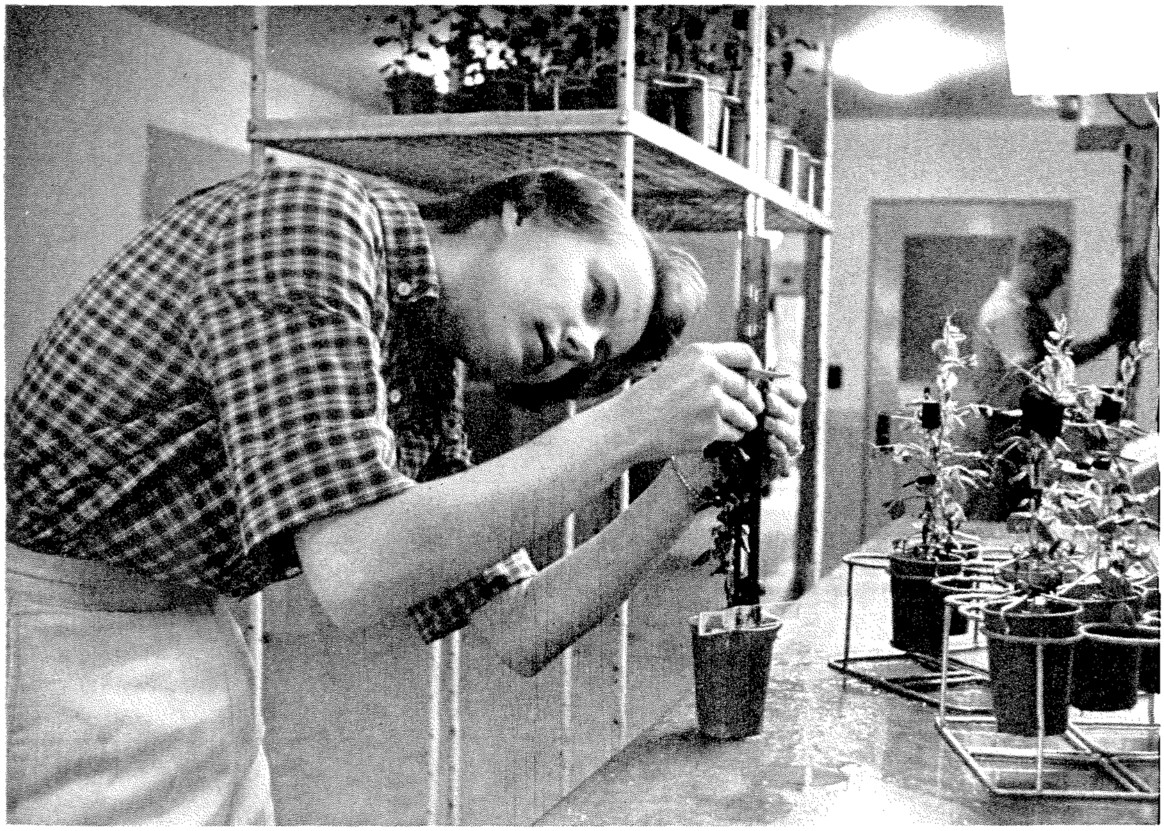
Plants are wheeled from one climatic condition to another on four-foot trucks called research units. There are more than 600 of these in the lab.

Oswaldo Caso, from the University of Buenos Aires, measures the diameter of carrots with a caliper to determine the growth rate. Researchers are attempting to produce an improved type of carrot seed for growth in Argentina.

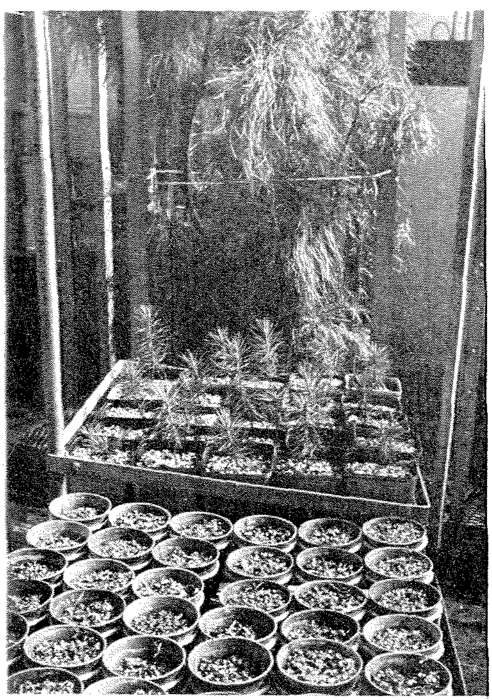


The effect of new light sources is tested on the growth of tomato plants. These plants are six weeks old and have been grown in a low temperature — about 18°.

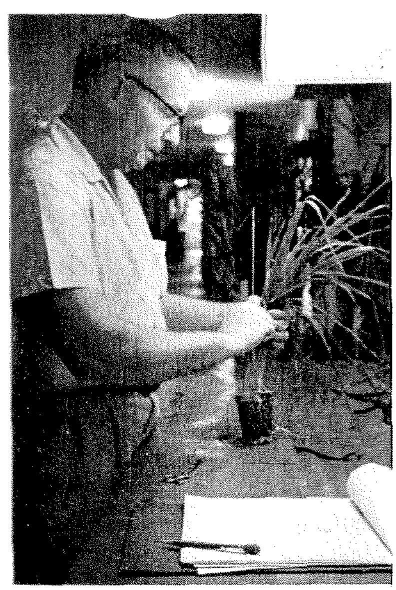




A research aide measures dwarf peas which have been treated with chemical compounds to cure damage caused by high temperatures.



For genetic studies, pines are grown in the lab, from seed to full-sized trees.



All plants are checked regularly for rate of development and growth. Leaves and tillers of barley plant are being counted here.

Seven Wonders

Seven modern wonders of civil engineering — and some of the engineering wonders of Biblical times on which they were based

by The Reverend Ganse Little

In 1955 the American Society of Civil Engineers selected the Seven Modern Wonders of Civil Engineering in the United States of America. These were the Chicago Sewage Disposal System, the Colorado River Aqueduct, the Empire State Building, the Grand Coulee Dam and the Columbia River Basin Development, the Hoover Dam, the Panama Canal and the San Francisco-Oakland Bay Bridge.

All of us, in our day of scientific marvels, may well take a bow, but we should also make a bow to the past in the humility of an Isaac Newton who disclaimed credit in the words, "Remember, I was standing on the shoulders of giants." The seven modern wonders of engineering were superimposed upon the shoulders of the engineering of Bible times.

I am not speaking of the so-called Seven Wonders of the Ancient World (as of 200 B.C., roughly)— the Pyramids, the Hanging Gardens of Babylon, the Phidias Statue of Zeus at Olympia, the Temple of Artemis at Ephesus, the Colossus of Rhodes, the Tomb of Mausolus, and the Pharos of Alexandria.

These were all non-utilitarian projects, and I have purposely chosen to restrict our field of research to, first, useful work (as did the American Society of Civil Engineers in selecting its modern wonders); and second, to those structures and engineering projects which had a definite effect upon Biblical history.

By such restriction we place a very definite limitation upon the magnitude and grandeur of the engineering involved. No aqueduct, for instance, specifically related to Biblical history can compare with the great Roman aqueducts. And so when I refer later to the aqueduct built by Hezekiah in Jerusalem, it isn't much of an aqueduct, judged by Roman or by modern standards, but it was an amazing piece of engineering for those ancient Biblical times.

In the Bible lands and times, as in the twentieth century in our own country, water was the primary concern, challenge, and problem of the civil engineer. How to secure water, how to control it, how to channel it, how to convey it, how to cross it, and how to use it taxed most of his budding genius and grit. Is it not significant that six out of the seven of the *modern* wonders selected by the ASCE in 1955 had to do with water problems?

The Bible lands were truly "a dry and thirsty land where no water is." At the time of the beginning of true history in the Old Testament, the time of Abraham, we find the first thing Abraham undertook when he reached "the Land of Promise" was to dig the well of Beersheba, because while the land was "flowing with milk and honey," it was not flowing with an abundance of water.

Many hundreds of years later, Moses — an engineer of no mean magnitude — was mainly concerned with water problems. In the course of the wilderness wanderings he struck water from "the rock," and water-bearing sandstone is still available in the same locale today to duplicate the "miracle." And his initial success in crossing "the Red Sea" (probably Lake Cardawil, a shallow 45-mile-long lake filled with red reeds) proves him to have been a close observer of wind, weather, and water conditions in the wilderness. He sweetened the bitter waters of Marah by casting in some specie of wood, obviously a primitive method of water purification.

"Seven Wonders" is an adaptation of a talk given by the Reverend Ganse Little, pastor of the Pasadena Presbyterian Church, at a meeting of the American Society of Civil Engineers in Los Angeles.

I. *Sewage Disposal*

But there was little water purification on a major scale in Moses' day, or for many generations thereafter. And there is nothing in the Bible or in Bible times comparable at all to Chicago's sewage disposal system.

Early civil engineers showed far more concern about how to get water *into* the community than how to get waste and refuse out of it. It is true that there were elaborate plumbing and disposal systems in Cretan Knossos (the Palace of Minos) in the Middle Manoan Period – 2200 to 1600 B.C. Mesopotamia in the time of Sargon and the Pharaohs of ancient Egypt provided private and complex systems of plumbing and disposal for the palaces of that day. But even these systems were available only where there was a plentiful water supply, plus the wealth of kings.

Throughout Biblical history and in Bible lands, sewage disposal was practically nonexistent. Jerusalem, for example, had its Valley of Hinnom, used in pre-Israelite times as the place of child sacrifice by fire. Josiah, in order to desecrate it permanently and thus render it unfit for such pagan ritual worship, began to use it as a place for the disposal of the waste, sewage and offal from both city and temple. Aside from bacterial purification, fire was resorted to as the chief reduction agent. Thus, Gehinnom (Valley of Hinnom) became Gehenna, symbol of "Hell" and the worms and fires thereof!

II. *Aqueducts*

As we give merited praise to the Colorado River Aqueduct, it may be well to think back across the centuries to the water tunnel of Hezekiah at Jerusalem. This is not Exhibit A of a great aqueduct system even in that day and time. Roman aqueducts are purported to have delivered 130,000,000 gallons of water per day throughout the Empire at the height of their development, and 90,000,000 gallons per day went into the imperial city of Rome itself.

We also remind ourselves that in the world of his day and time Pontius Pilate would never have been known as the Roman Procurator who passed judgment upon the unknown Galilean, Jesus of Nazareth, but rather as the constructor of a great system of aqueducts and other public works and projects throughout Judea.

But let's look for a moment at the Jerusalem of Hezekiah's day, in the year 705 B.C. Sennacherib is "descending like the wolf on the fold" and the fold is desperately in need of water. Hezekiah and his engineers soon saw that there must be some way of getting water from the spring Gihon – which was in a totally unprotectable site outside the city wall – into a more secluded spot, so that during the anticipated siege water could be brought into the city without too great a sacrifice of life. To answer this problem Hezekiah constructed the Jerusalem water tunnel. It was only 583 yards long, of which 362 yards were dug through a hill. By such means water was brought into a protected area which later became the pool of Siloam of Jesus' day. This tunnel shows the ingenuity and technique of those primitive days when men, equipped only with picks, began excavation from both ends of the project and met in the middle.

Sennacherib was the Assyrian general who, after the conquest of Jerusalem, also laid siege in this same campaign to Lachish, a city 20 miles to the southwest of Jerusalem and one of the great fortifications along the road to Egypt. Lachish itself had a very unique aqueduct system which tunnelled about 70 feet in one direction and then 80 feet in another direction, and from which had been excavated 500,000 cubic feet of solid limestone, all removed without explosives, drills, or cranes!

After this invasion Sennacherib went back to Assyria and 15 years later completed his own great aqueduct at Jerwan, bringing fresh water from the mountains to his capital at Nineveh 30 miles away. Three hundred yards of this aqueduct, 50 feet wide and 5 feet deep, was carried on masonry arches over the valley of a small stream which bisected it.

III. *Structures*

The Empire State Building was selected as one of the seven modern wonders of engineering in this country. There is nothing comparable, of course, in the Bible – unless you count the prehistoric tower of Babel. But there was Solomon's temple, constructed sometime between 973 and 933 B.C.

The thing that impressed me most in my research in this area was the variety of the work and the workers employed. Hiram, King of Tyre, furnished the major portion of the skilled workers in metal and in wood. The Israelites were never truly proficient as metal workers or as carpenters, but they excelled as stone masons. Metal and wood were relatively scarce in the so-called Holy Land, but stone was abundant.

The temple of Solomon was 60 cubits long, 20 cubits wide, and 30 cubits high. If you believe the Old Testament record, Solomon got together 108,000 talents of gold, and 1,017,000 talents of silver to pay for the building of this structure. (The smallest talent, it might be noted, weighed at least 58 pounds!) It took him only seven years to build this beautiful structure. He did it by virtue of pressing into service 30,000 native Israelites, in levies of 10,000 per month, working in the forests of Lebanon under the direction of Hiram's skilled foremen – plus 150,000 Canaanites, as hewers and carriers of stone, under Israelite direction. This was pure slave labor, just as in the pyramid days, and a labor force of this magnitude requires a sizable skilled force of what we would call civil engineers.

The size of the stones used in this operation varied from one to two and a half tons, comparable to the type of construction in the pyramids. Some of them were 25 cubits in length, and we still do not have a complete answer as to how blocks of stone of this size and weight were cut, moved, and placed. Solomon's temple was destroyed at the time of the captivity of the Jews.

IV. *Dams*

The Grand Coulee Dam and the development of the Columbia River Basin was the fourth of the modern wonders in the United States, according to the vote of the ASCE. Again, the Bible cannot enter into competition but we may still marvel at the Lake Moeris Dam of ancient Egypt. This dam is not mentioned in the Bible but it had a profound effect upon Biblical history. Of interest is the fact that somewhere in the period of 2950 to 2750 B.C. – almost 5,000 years ago! – the Egyptians did attempt a huge masonry dam at Sadd-el-Kafara on the Nile. Actually this was to be a double masonry dam proposition with a rubble fill area extending 120 yards in length up and down stream between the two masonry dams. These dams were to be approximately 348 feet long at the top, 265 feet long at the bottom, and 40 feet above the stream bed. The work was never satisfactorily completed because the dams were overtopped in the process of construction by floods – and masonry dams were not attempted again by the Egyptians for many thousands of years.

The Lake Moeris Control Dam, constructed in about 2300 B.C., some 50 miles southwest of Cairo, consisted of two earthen dams. One of these diverted the flood waters from the Nile into the depression which became known as Lake Moeris – an area of 656 square miles, and containing 40,000,000 acre-feet of water when filled, the depression itself being situated about 150 feet below sea level. The second dam was to let the water back out of Lake Moeris downstream into the main channel after the flood waters had subsided.

Such a control system meant that before and after each flood of the Nile both of these dams had to be breached in succession, and then both of them had to be rebuilt. This was a tremendous labor even by the standards of engineers and workmen who were of a race of pyramid builders! This worked well for flood control. But anyone who cut the dam in years of normal flow or of reduced flow and diverted water into Lake Moeris, impounding it there, could thereby create a devastating famine in lower Egypt and adjacent areas.

V. *Mining*

Another of our modern wonders is the Hoover Dam, but instead of talking about more dams, let me expand at this point on mining and the use of metals in Biblical times. According to Genesis, the first child born to Adam and Eve was a boy by the name of Cain. Cain means "smith" or "miner" – a curious name to give a child in the legendary history of a race supposedly composed of farmers, shepherds, and nomads! But one of the descriptions of the Promised Land in the Old Testament is a "land whose stones are iron and out of whose hills thou mayest dig copper."

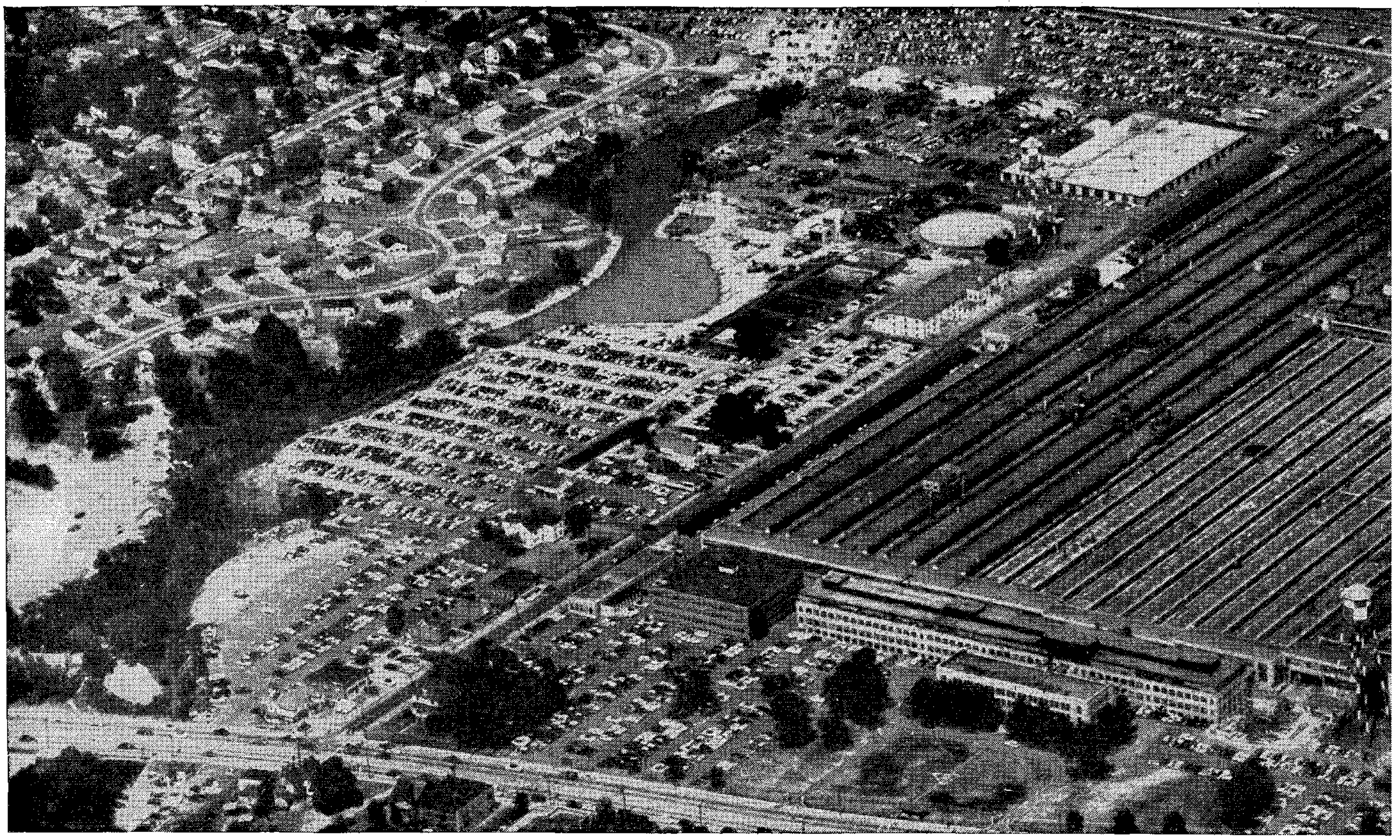
I have already suggested the huge amounts of copper used in the temple of Solomon. Copper utensils and mirrors were also employed in the homes of the wealthy. Copper was used decoratively and protectively on armor, weapons, and chariots. Solomon controlled extensive copper mines at Ezion-Geber. For many years archeologists sought to find the ancient site of Solomon's "Pittsburgh," now known in modern terms as Tell Kheleifah, which is at the head of the Gulf of Aquabah. It was located there for three reasons: first, there was a tremendous draft from the right direction up the Wadi Arabah to run the blast furnaces; second, there were plentiful wells of fresh water; and third, there were date palms for food. At a very early stage of the game these copper mines were under development, and in Solomon's time they were by all odds the greatest single source of his wealth. Equally important products of the copper mines and of the smelting furnaces of Solomon were the six-foot copper saws used to cut some of the huge blocks of stone in the building of the temple.

Copper and iron

In addition to the copper mines at the head of the Gulf of Aquabah, there were the iron mines of Philistia. The Philistines had a monopoly, a stranglehold on the iron mines. Those valuable mines were not located in Israel proper in the days of King Saul. Iron, prior to David's day, was a strictly limited article of supply in Israel. We read that Saul, the first King of Israel, and Jonathan, his son had swords and spears and metal armor, but such equipment was possessed only by a king and a prince, not by the common warrior at all.

You will recall that Saul tried to get David to put on his armor and use his sword when he went out against Goliath. David wisely preferred to fall back upon the simple instrument of destruction with which he was skilled. But it was not a mistake that Goliath of Gath, champion of the Philistines, would have had a full suit of armor and a sword and a spear of iron. He lived in the iron-mining country where all men were thus equipped. In David's boyhood, such farmers in Israel as had the best plowshares made of iron had to take them, or their colters or mattocks, to Philistia to be sharpened. It was no wonder that Israel wanted more than anything else to wrest the iron mines from the control of the Philistines. And when

continued on page 28



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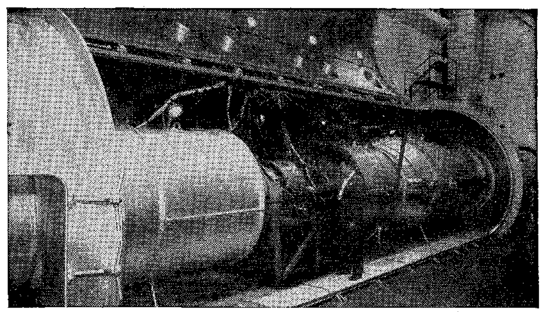
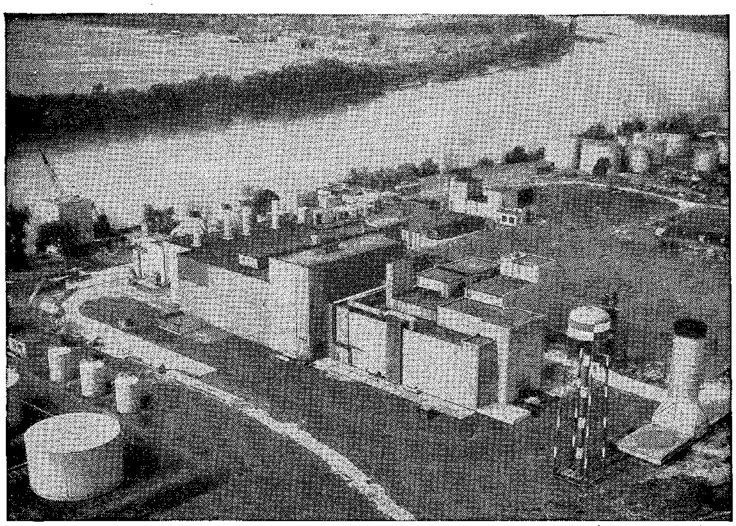
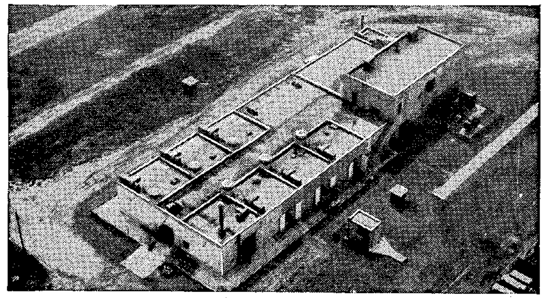


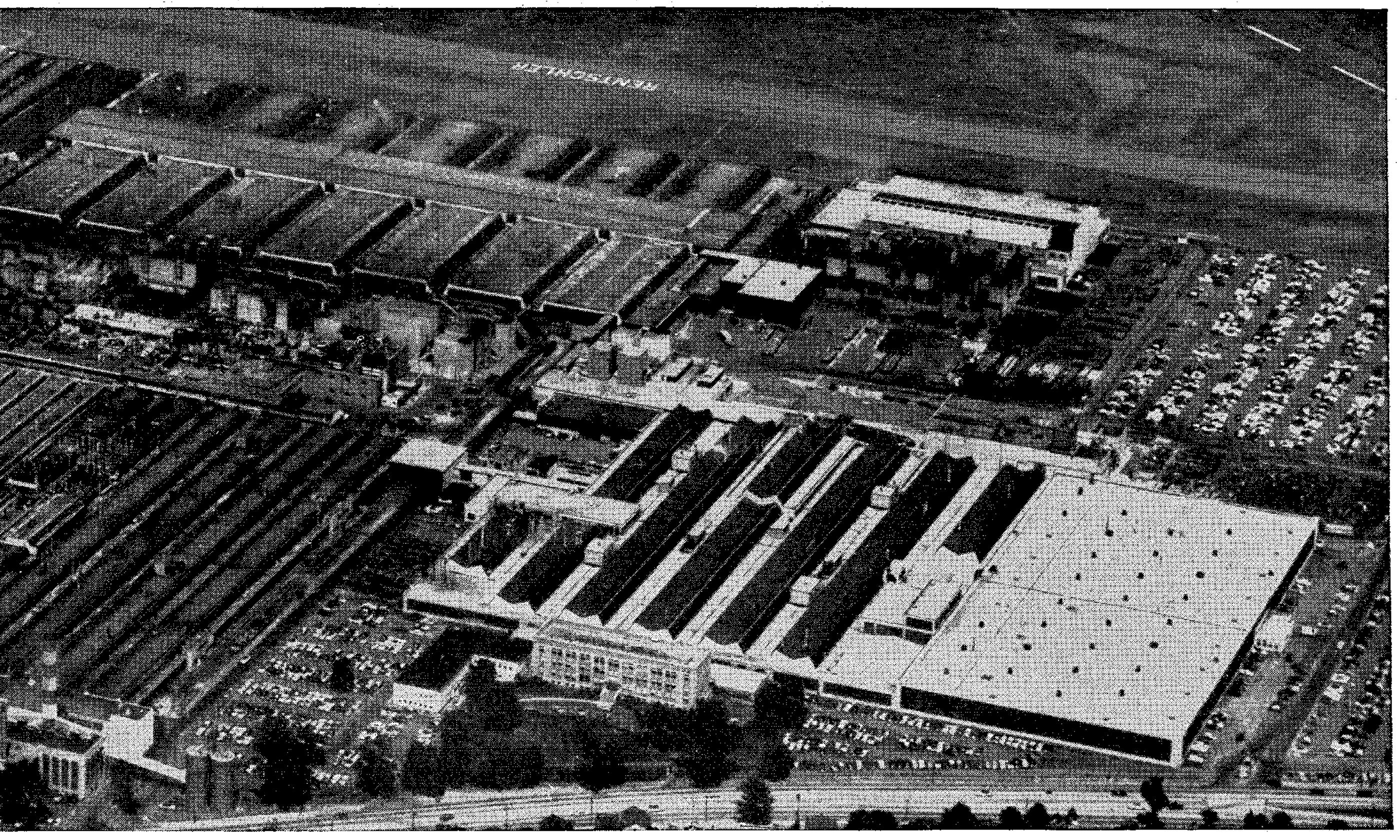
In chambers like this at the Willgoos Turbine Engine Test Facility full-scale engines may be tested in environments which simulate conditions from sea level to 100,000 feet. Mach 3 conditions can also be simulated here.



The Willgoos Turbine Engine Test Facility is the world's most extensive privately owned turbine development laboratory. Designed and built specifically to test full-scale experimental engines and components in environments simulating conditions at extreme altitudes and speeds, it is currently undergoing expansions that will greatly increase its capacity for development testing of the most advanced forms of air breathing systems.



In the new Fuel Systems Laboratory engineers can minutely analyze the effects of extreme environmental conditions on components of fuel systems — conditions such as those encountered in advanced types of flight vehicles operating at high Mach numbers and high altitudes. Fuel for these tests can be supplied at any temperature from $-65°F$ to $+500°F$.



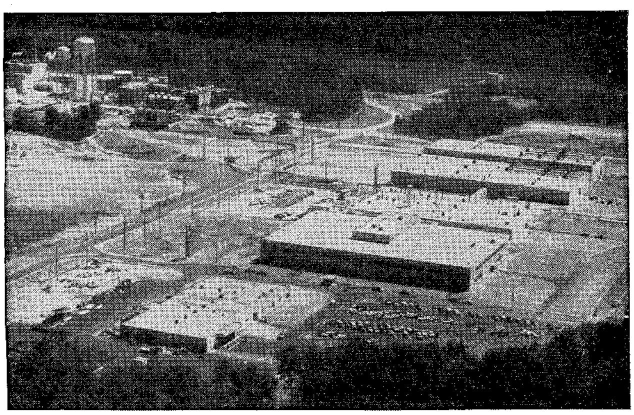
OPERATIONS

Unmatched Engineering Facilities for Developing Advanced Flight Propulsion Systems

Operations at Pratt & Whitney Aircraft are essentially those of an engineering and development organization. As such, an engineering atmosphere dominates the work being done, much of which directly involves laboratory experimentation.

In the past three decades, expansion at Pratt & Whitney Aircraft has been almost tenfold. In recent years, greatest emphasis has been on extending engineering facilities to meet the needs of advanced research and development programs in flight propulsion.

Among the Connecticut P & W A facilities are many that are unequaled in the industry. Thus today, Pratt & Whitney Aircraft is better prepared than ever to continue development of the world's best aircraft powerplants . . . to probe the propulsion future . . . to build and test greatly advanced propulsion systems for coming generations of flight vehicles – in whatever form they take.



The Connecticut Aircraft Nuclear Engine Laboratory, operated by Pratt & Whitney Aircraft, is situated on a 1,200-acre tract near Middletown. The Laboratory was specially built for the development of nuclear flight propulsion systems.

For further information regarding an engineering career at Pratt & Whitney Aircraft, consult your college placement officer or write to Mr. R. P. Azinger, Engineering Department, Pratt & Whitney Aircraft, East Hartford 8, Connecticut.

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David finally reduced Philistia, this was an occasion for proper thanksgiving and rejoicing.

VI. *Irrigation Works*

The Panama Canal is modern wonder number six. Although there is nothing like it in the Bible, the irrigation canals in ancient Canaan were as important to the economy of that day and time. For instance, there was the gigantic Nahrwan Canal of Sargon's time, 400 feet wide, 15 feet deep, 250 miles long, paralleling the left bank of the Tigris River and irrigating an area of an average width of 18 miles!

Egypt, too, had her great canals. Thousands of years ago the Egyptians built a canal detouring the first Cataract of the Nile and opening it throughout its length for shipping. Thousands of years ago they dug a canal connecting the Mediterranean and the Red Sea which, fallen into disrepair through warfare, was reopened by Egypt's conqueror, Darius the Great. It was enlarged to 200 feet in width, 40 feet in depth, and used for more than a thousand years.

But nothing was more needed or more important to an agricultural economy than the irrigation canals in the central Negev of ancient Israel. Because of this series of dams and canals, there flourished an agriculture from the second century B.C. until the seventh century A.D. which made the desert blossom "as the rose," and which modern Israel is now beginning to duplicate.

The irrigation system of such canals was a necessity in an area where the annual rainfall was four inches – which usually fell in a 15-day period. The Israelites conserved this limited annual rainfall by the construction of low rubble masonry dams and cleverly contrived canals, indicating an observation of contour and an ingenuity of surveying that is truly miraculous. In one 50-square-mile area the ruins of 17,000 such dam-canal systems have been uncovered. These dams averaged 100-150 feet in length and between 5 and 6 feet in height. The result was a desert that *did* blossom as the rose and produced barley, wheat, legumes, dates, figs, and grapes, and supported at the height of this agricultural period six cities of between 3,000 and 6,000 population – all on four inches of rainfall a year!

VII. *Wells*

Number seven on the list of modern wonders is the San Francisco-Oakland Bay Bridge. The Bible can offer nothing comparable because bridges were nonexistent in Biblical times. People simply got their feet wet or learned to swim! But we can comment on some of the spectacular wells built in those times.

First, there is Joseph's well at Cairo, which bears the name of a famous Biblical character but is not mentioned in the Bible. It was 297 feet deep, all through solid rock. The upper course went down 165 feet deep with an oblong square of 18 by 24 feet; the remaining course went down the remaining 132 feet with a narrowed dimension of 9 by 15 feet. The access to the first level was by stairs cut out of the solid rock, and at that first level mules were used to operate an endless bucket chain which actually raised the water from the lower level to the first level.

Then there is Jacob's well, in the village of Sychar in Samaria, which is mentioned in both the Old and the New Testament. This was a relatively small engineering feat, but even so it was 9 feet in diameter. Originally it was 105 feet deep, until partial rubble filled it up so that it was only 75 feet deep in 1843. The last several feet of this well had been projected through solid limestone.

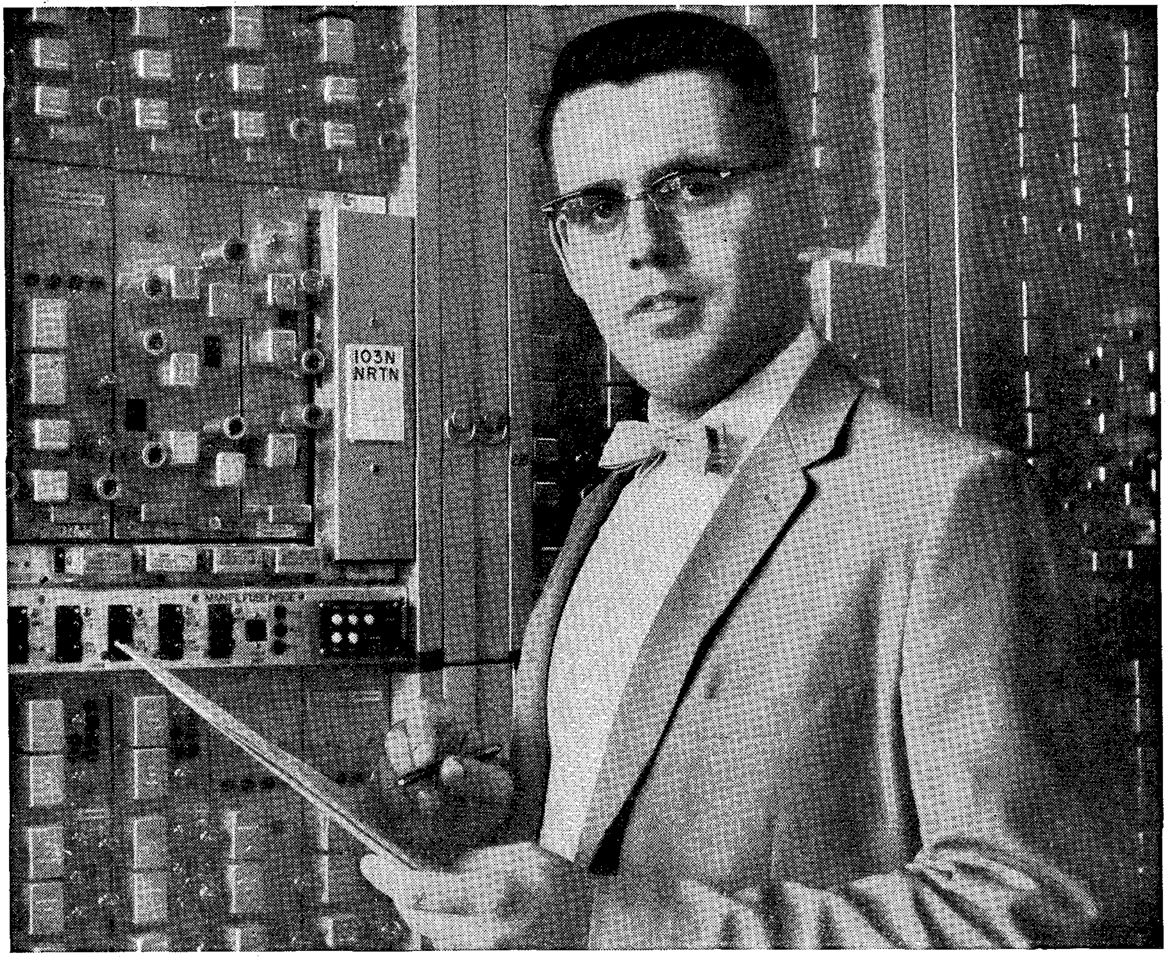
The water of life

While there are many references to wells in the Bible, there are only four wells mentioned by name. One of them is Jacob's well. Another is the well Abraham dug when he first got to the Promised Land, called the well of Beersheba. A third was the well of Bahurim, which has its claim to fame in Biblical history because it was in this well that two of the couriers of David hid from the wrath of Absalom, who, at that time, was trying to overthrow his father in an abortive revolutionary movement. The fourth was the well of Bethlehem. When David was in hiding from the Philistines and also from Saul, he expressed the longing to have "but a drink of the water from the well of Bethlehem," and three of his bodyguards risked their lives to pierce the enemy lines and get this drink for him.

It was at Jacob's well that Jesus held his historic conversation with the woman of Samaria which is preserved for us in one of the most moving and beautiful passages in the Gospel of John. Jesus had been left at the wellside to rest while his disciples went into the little village of Sychar to get something to eat, and while he was there a woman from Samaria (the Jews had no dealings with the Samaritans at all) came to the well to draw water. It would have been unthinkable for a man and a Jew to have asked such a woman for a drink of water, but Jesus did.

There ensues a colloquy which I am sure is familiar to many. Jesus begins to speak to her of "the water of life," and says that if she could come in contact with this water of life, she would not need to come hither again to draw. She replies, "The well is deep and thou hast nothing with which to draw." To find the answer to this problem after the flesh has throughout all the ages been the task of civil engineers who have devised tunnels, aqueducts, wells, canals, and dams.

A Campus-to-Career Case History



"I wanted a job I could grow with—and I've got it"

H. James Cornelius graduated from Swarthmore College in 1954 with a B.S. in Electrical Engineering. He's been "growing" ever since with the Bell Telephone Company of Pennsylvania.

After an initial 44-week inter-departmental training course, Jim was made Facility Engineer in charge of the fast-growing Norristown-Pottstown area. In that capacity, he engineered over half a million dollars' worth of carrier systems and cable facilities between major switching centers in Pennsylvania.

Today, he is one of 50 young engineers from the Bell Telephone Companies chosen to attend a special Operating Engineers Training Program at Bell Laboratories. This 19-month course of study—with full pay—deals with advanced techniques and new concepts in electronics which signal a new era in telephony. It involves both classroom theory and practical laboratory applications.

When Jim and his colleagues return to their companies, they'll review major engineering projects. This will assure the best use of equipment for current engineering, as well as for expected new developments in communications.

"I wanted a job I could *grow* with," says Jim, "and I've got it. I can't think of a better place than the telephone company for an engineering graduate to find a promising future."

Many young men like Jim Cornelius are finding rewarding careers with the Bell Telephone Companies. Look into opportunities for *you*. Talk with the Bell interviewer when he visits your campus. And read the Bell Telephone booklet on file in your Placement Office.

BELL TELEPHONE
COMPANIES

Engineers and Earthquakes

Caltech engineers develop a simple new instrument which should provide valuable information on the effects of strong earthquakes

"Earthquakes, we will grant, can be disastrous, but who's going to sit around and worry about something when you don't know when or where it will happen – or *even if* it will come in your lifetime?"

This is the kind of reasoning behind the apathy of the public toward the dangers of earthquakes to life and property. And this public apathy is evidenced every time a County Grand Jury proposes to reduce earthquake requirements for buildings. As recently as 1955, such proposals were made in Ventura and Marin counties in regard to school buildings.

The proposals were promptly criticized by the Earthquake Engineering Research Institute of California. George W. Housner, Caltech professor of civil engineering and applied mechanics, and president of the E.E.E.I., pointed out that the destructive California earthquakes of 1906, 1925, 1933, 1934, 1940, and 1952 had amply demonstrated the fact that school buildings not designed to resist earthquakes constituted a serious danger to the lives of school children. Buildings designed according to the minimum requirements of the state law, he noted, were safe for occupancy during earthquakes—even though the buildings might suffer minor damage.

Interest in earthquake technology is much greater in Japan than it is in the United States. In addition to regular university research, the Japanese government supports earthquake study institutes at Tokyo and Kyoto. In the United States, the government supports only the work of the limited number of men who are working with the U.S. Coast and Geodetic Survey, collecting data on destructive earthquakes.

One compelling reason for Japan's interest in this research is its memory of the earthquake of 1923 which took more than 100,000 lives. California's last truly disastrous earthquake was that in San Francisco in 1906 – so long ago that it arouses little concern.

In the past a number of potentially destructive earthquakes occurred in California without being near heavily populated areas, but in recent years the growth of California's population accentuates the danger of earthquakes.

Caltech's Engineering Division has recently launched a major program in earthquake research, with the ultimate objective of preventing disasters such as accompanied the 1906 San Francisco and 1933 Long Beach earthquakes.

One of the major stumbling blocks in the study of the effects of strong earthquakes has always been a lack of good data. More information is needed on the effect of ground tremors on different structural designs, and on the part that the particular geological makeup of the surrounding area plays in the effect of an earthquake on a building. With this kind of data, it might, for example, be possible to correlate soil conditions with earthquake damage.

Some of this data can be acquired in laboratories; some can be obtained by studying the effects of blasting on nearby buildings; but much of the required data can only come from direct study of actual earthquakes.

To provide information for engineering studies, the U.S. Coast and Geodetic Survey maintains a number of strong-motion accelerometers to record the

ground motion during strong earthquakes. The table below shows the Pacific Coast strong-motion earthquakes for which there are recorded accelerograms of ground motion sufficiently strong to be of engineering interest.

Earthquake	*Strong-motion accelerometer station*
March 10, 1933	Vernon
October 2, 1933	Vernon
December 30, 1934	El Centro
October 21, 1935	Helena, Montana
September 11, 1938	Ferndale
May 18, 1940	El Centro
February 9, 1941	Ferndale
June 30, 1941	Santa Barbara
October 3, 1941	Ferndale
March 9, 1949	Hollister
April 13, 1949	Seattle, Washington
	Olympia, Washington
July 21, 1952	Taft
March 22, 1957	State Building, San Francisco
	Alexander Building, San Francisco
	Golden Gate Park, San Francisco
	Southern Pacific Building, San Francisco
	Oakland City Hall

The 1957 tremor is particularly valuable for engineering studies since it was the first earthquake that provided good records at more than two strong-motion accelerometer stations in the epicentral region.

One reason earthquake data has been so hard to come by (outside of the infrequency of the earthquakes themselves) has been the prohibitive cost of the instruments used to record the tremors. So, in recent years, Donald E. Hudson, professor of engineering at Caltech, and Prof. George W. Housner have been actively engaged in developing a simplified instrument that could be produced at a low enough cost to permit large numbers of them to be distributed in important areas. The project is sponsored by the National Science Foundation, and the first batch of instruments has been constructed by the Wilmot Engineering Company of Pasadena. A second batch is now being made by the Sprengnether Instrument Company of St. Louis for the U.S. Coast and Geodetic Survey.

The Wilmot Survey Type Strong-Motion Earthquake Recorder, as the one presently designed is called, is an instrument which measures directly one point on the relative velocity response spectrum curves. It lacks the time-recording advantage of the larger, more complex, and expensive accelerometers, but only costs one-fiftieth as much. Whereas the seismographs operated by seismologists are able to measure small, distant quakes, the strong-motion accelerometers and the new instruments are designed to record only earth motions in the immediate vicinity of the epicenter that are strong enough to be of engineering significance.

The instrument itself is essentially a free conical pendulum, with a period of 0.75 second and 10 percent of critical damping, which is capable of swinging in all directions. The pendulum is topped with an inverted smoked water glass. The motions of the earth cause the glass to move against the point of a needle, which etches a pattern into the smoked coating, tracing the motion of the pendulum and indicating the intensity of the earth movement. The glass can then be removed and dipped in lacquer to make the record permanent.

The particular design parameters for the instrument were selected after a careful study of the complete response curves for past earthquakes, and of the dynamic characteristics of typical building structures. The results of the analysis of strong-motion accelerometer data obtained for the San Francisco earthquake of March 22, 1957 were particularly useful in this respect.

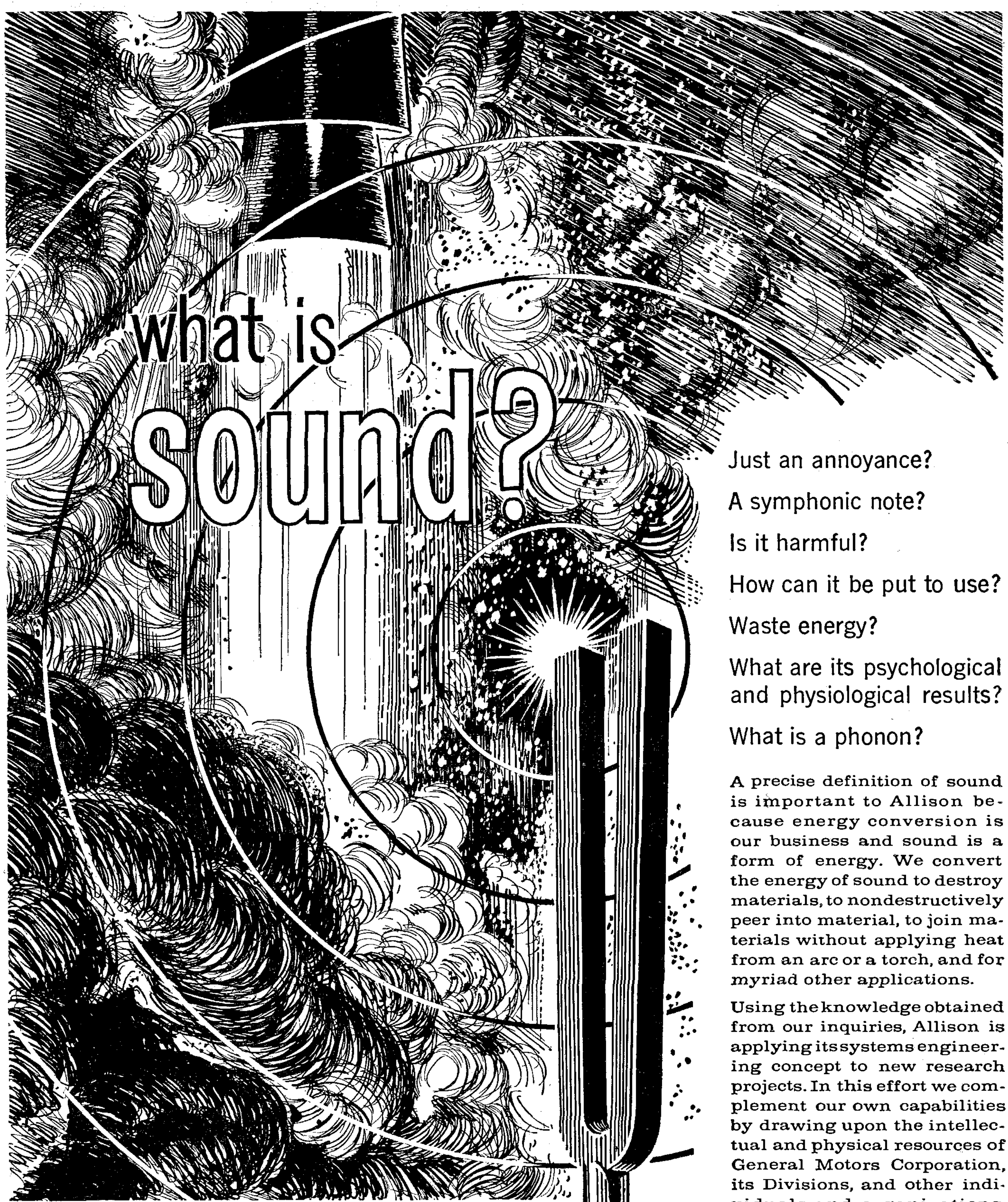
The entire eight-by-twelve-inch instrument weighs eight pounds. Once bolted to a basement floor or to a rock it requires no maintenance.

At a cost of about $100 each, one hundred of these earthquake recorders are now being installed in the Los Angeles and San Francisco metropolitan areas. Dr. Cinna Lomnitz of the University of Chile (Caltech PhD '55) is constructing some of the recorders for use in his country. One of the Caltech instruments is being sent to India to serve as a model. When the strong earthquakes that seismologists anticipate for California do occur, this new instrument program is expected to provide valuable information.

But the engineers who are working to decrease the dangers of earthquakes to life and property realize that they have another problem to overcome — which is to get the results of their work out into practice. Drs. Hudson and Housner are now in India at the University of Roorkee, helping to set up a research laboratory for the study of strong earthquakes and their effects. They report that it will probably be easier to set up the laboratory and to make the studies than to induce the country to make full use of the results.

As noted, our own country is not entirely free of inertia in this respect — even though the larger cities in California do make good use of preventive measures against earthquake damage. But it is better to rely on the adage, "God helps those who help themselves" rather than to rely on the prayer recommended by the author of a booklet published in Naples after the destructive earthquake of 20 March 1730:

The Lord bless you and keep you and show you His face, and have mercy on you, and may He turn His countenance to you and give you peace and health. The Lord bless this house and the occupants in it, and liberate it from the onset of earthquakes.


what is
sound?

Architect's drawing of the new W. M. Keck Engineering Laboratories to be located at San Pasqual and Chester. Construction is scheduled to get under way late this summer.

The Month at Caltech

Engineering Building

The Institute has received a gift of $2,500,000 from the W. M. Keck Foundation and the Superior Oil Company for the construction of a new engineering building. This is the largest gift received to date in Caltech's Development Program, and the largest the Institute has ever received for building purposes.

The new building will be located at the northwest corner of San Pasqual Street and Chester Avenue. A five-story structure, with two floors below ground, its major units will be a laboratory of engineering materials, a laboratory of sanitary engineering, and a laboratory of hydraulics and water resources. It will be named the W. M. Keck Engineering Laboratories. Mr. Keck is founder and Chairman of the Board of the Superior Oil Company.

The new laboratories will provide the Institute with excellent facilities for teaching and advanced research in several rapidly growing fields.

The new engineering materials laboratory will be equipped with an electron accelerator for the study of materials involved in nuclear engineering. It will also provide space for increasing instruction and research in physical metallurgy – particularly with respect to the high-temperature properties of materials, which are of special significance in the development of missiles.

The new laboratory of sanitary engineering will facilitate the investigation of some of southern California's most pressing problems, such as the intrusion of salt water, the need to reuse waste waters in industry, and the disposal of air pollutants and sewage. It will also make possible the chemical, bacterial, and biological analyses of water and liquid wastes.

The new hydraulics and water resources laboratory will include space for a flume, about 120 feet long, to be used in extending the studies of sediment transportation that have gone on at Caltech for 25 years. There will also be space for settling tanks used in studying methods of water purification and the mechanics of water flow in soil. Studies of coastal engineering problems, such as those caused by wave action, will be resumed. This work was interrupted several years ago when outdoor facilities on the campus were razed to make way for permanent buildings.

Construction of the new building should get under way by late summer.

Reflections on Elections

What makes some men run — and what makes others run from running

The rainy season finally came and the crazy hats were pulled out of closets. It got cold, too, so there was snow on the mountains. People went skiing and they went on snow parties, even if they couldn't ski —just to fool around in the white powder. Others weren't fooling around at all. One Monday night, the shortest nomination speeches in history were made, and out of those nominations came a not-suprisingly short list of ASCIT candidates.

Immediately, two questions arose within the student body: Why were so few people running? And why were the candidates who were already in the race running? Of course, the questions had direct bearing on each other, and they both referred back to the age-old, "What do I want out of Caltech?"

In the pre-awareness days, the student house used to put a lot of pressure on its members to carry the house name to a blaze of glory by placing five or six men on the influential ASCIT Board of Directors. Now, however, a completely different concept has arisen. Individualism has crept into the picture. Candidates no longer just *say* that they can do a good job and that they have had experience and that they want to sit on the BOD because they have great ideas on how to spend 15,000 dollars—they *mean* it.

Many candidates admit to having struggled with themselves for months, trying to decide whether to run.

Many of the men running admit to having struggled with themselves for days and weeks and months and years, trying to decide whether to run or not. Then, in a torrent of anguished realization, they *knew*. They knew that they could do the job, that they could furnish the leadership so necessary to student government at Tech, that the experience gained in handling money and people was well worth the time. And they knew that they had decided for themselves. Nobody had high-pressured them into running for the honor of the student houses; this was an individual choice based completely on intelligent rationalization.

Many of these potential leaders did not discover themselves until sometime during the week that ASCIT had decided to keep open for further nominations—but once they had tossed the hat into the ring, their convictions strengthened every day. And then they went around to all the student houses and told the masses why they thought that they were the best for the office and what they thought was wrong with the office and what they were going to do about it and what they thought was wrong with ASCIT policy and what they were going to do about it – and the smell of manure permeated the dining rooms.

The reasons for running were poor; the ideas were even poorer. Nine out of ten blamed the disinterest in school government offices on the "lack of coordination between the students and ASCIT." They cited experience, desire, anything that they could think of to convince the interrupted diners that they were *it*. And many of the rocks of self-realization summed it up in one sentence: "I would appreciate your vote next Tuesday." Maybe that could be rephrased: "I would appreciate winning next Tuesday because that means that you have accepted me and that you like me better than the candidates I'm running against and I would like very much if you liked me better."

But it's not all as basic as that. There are other serious motives. The student may really feel that he can get to know many of the people that he wants to know through an ASCIT office; he may feel that he can actually change a lot of school policies towards things he doesn't like through this office; he may even feel that he will learn about his potentialities and learn to understand people by working with them on the Board and through the Board.

Very few of these dreams ever come true, unfortunately. It's pretty hard to realize your values and understand your fellow officers when any kind of ego-ambition stands in the way; it's harder still when no principles are involved, but only the desire to win —to win elections, to win minor points, to win prestige.

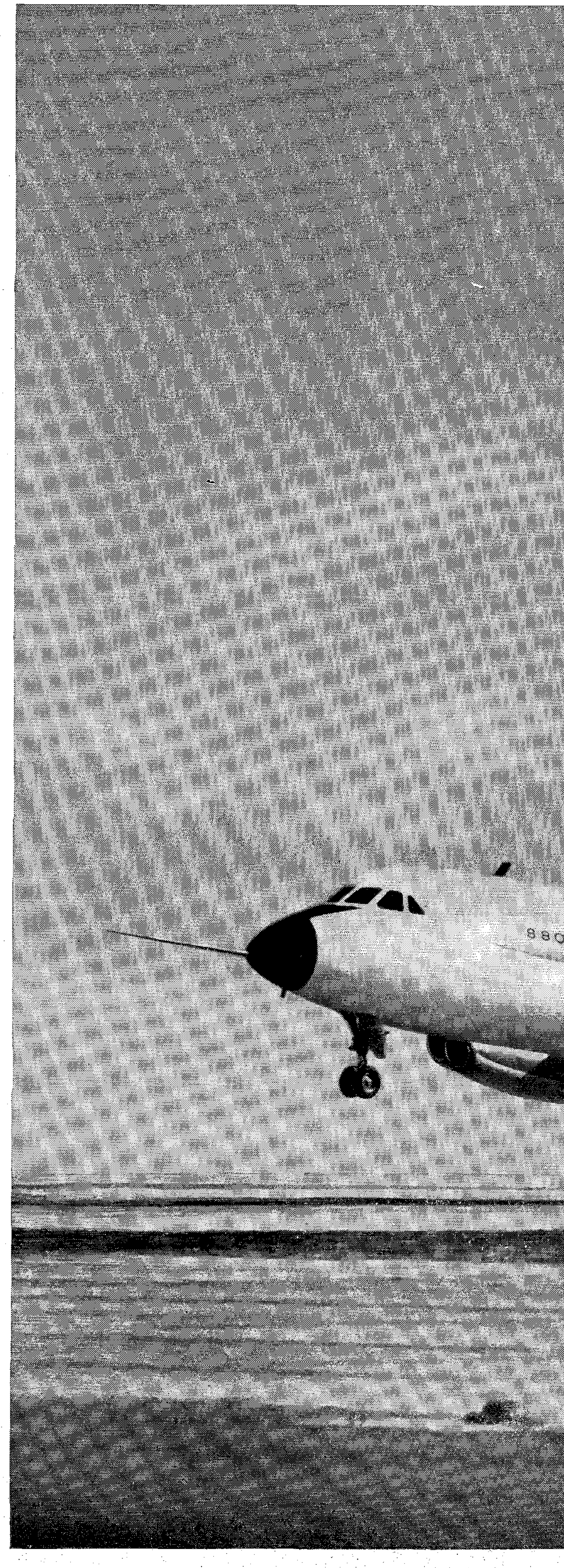
What about those who didn't run? First and foremost, they didn't think they could win and nobody took the time to either talk them into the fact that they *could* win, or to rationalize their "fears." Secondly, they honestly did not want to have anything to do with elections, win or not.

What kind of animal is this out-of-it that has no desire to reach the apex of self-importance? Does he study constantly? Does he have no sense of social prowess? Does he become extremely cynical at any given time? The main reason, essentially, that the almost-candidates were not, was that they considered the BOD a waste of energy; being an officer was simply a security that they did not need.

These are not cynics. They are people who have thought and felt that the way to understanding was not through prestige but through close relationships with students and faculty and the outside world—the kind of relationships that can be achieved without running for office and perhaps burdening themselves with unnecessary responsibilities. Some of these are students who are students and do not include in their goals their name at the top of a piece of ASCIT stationery. Some of these know what it is to govern at Caltech and they realize the ridiculousness of the whole idea.

And when it all comes down to the vote, it doesn't matter who you are or what you are running for—the only thing that counts is how many friends you have and how many friends the other guy has and how long your name is and what letter it starts with and when it's all over and maybe you won, what does it matter when you decide not to run next year?

— Martin Carnoy '60



JANUARY 27, 1959—CONVAIR 880 LIFTS OFF RUNWAY ON MAIDEN FLIGHT, USHERING NEW DIMENSION IN JET-AGE TRAVEL.

Alumni News

Board Nominations

The Board of Directors of the Alumni Association met as a Nominating Committee on February 24, 1959, in accordance with Section 5.01 of the By-Laws. Five vacancies will occur on the Board at the end of the fiscal year (June 1959)—one vacancy to be filled from the present Board, and four members to be elected by the Association. The present members of the Board and their retirement years are:

Frank E. Alderman '30	1960	John E. Fleming '46	1959
Frank C. Bumb '51	1959	Wm. W. Haefliger '50	1960
L. Fort Etter '34	1959	Ralph W. Jones '38	1960
Edward P. Fleischer '43	1959	Francis E. Odell '44	1960
Nick T. Ugrin '34	1959		

The following nominations have been made:

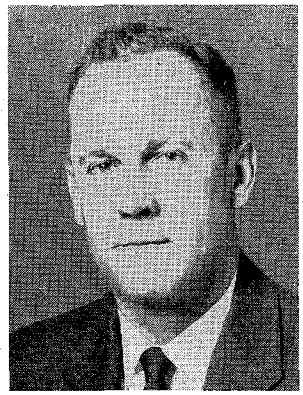
President — Frank C. Bumb '51	(1 year)
Vice President — Ralph W. Jones '38	(1 year)
Secretary — Donald S. Clark '29	(1 year)
Treasurer — George B. Holmes '38	(1 year)
Director — Robert J. Barry '38	(2 years)
Director — Franklin G. Crawford '30	(2 years)
Director — Holley B. Dickinson '36	(2 years)
Director — Frederick W. Drury, Jr. '50	(2 years)

Section 5.01 of the By-Laws provides that the membership may make additional nominations for the four (4) Directors by petition signed by at least twenty-five (25) members in good standing, provided the petition is received by the Secretary not later than April 15. In accordance with Section 5.02 of the By-Laws, if further nominations are not received by April 15, the Secretary casts a unanimous ballot for the members nominated by the Board. Otherwise a letter ballot is required.

Statements about the nominees are presented below.

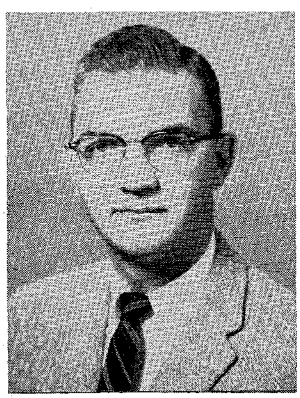
— Donald S. Clark, Secretary

FRANKLIN G. CRAWFORD received his BS in mechanical engineering in 1930 and went to work for the Union Oil Company in Oleum, California. While at Union he served in refinery operations and engineering and research. In 1942 he became associated with The Fluor Corporation, Ltd., as project engineer, and has advanced to his present position of manager of projects. He has been active as a worker for the Alumni Committee in the current Caltech Development Program, and is serving as a Ruling Elder in the Westminster Presbyterian Church in Pasadena.



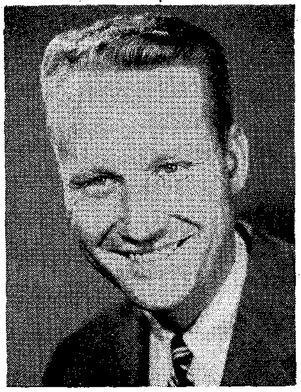
ROBERT J. BARRY received his BS in mechanical engineering in 1938, and then worked progressively for Lane-Wells, Lockheed, Curtiss-Wright, and Goodyear. In 1946 he founded the firm of Barry and Company in Los Angeles. They are consulting management engineers who specialize in business surveys, organization and compensation studies, inventory management, profit planning, and industrial engineering. He is now president of the South Pasadena Community Chest, and is a member of the National Association of Accountants, and the Sales Executives Club of Los Angeles. He is currently serving as chairman of registration and catering for the 1959 Alumni Seminar Day.

HOLLEY B. DICKINSON received his BS in 1936 and his MS in 1937, then went to work for the Lockheed Aircraft Corporation from 1937 to 1948. He joined the Telecomputing Corporation in North Hollywood as an engineer in 1948 and eventually became vice president, treasurer, and director. In 1956 he joined the Consolidated Electrodynamics Corporation in Pasadena as assistant to the president, and was recently appointed director of their Datalab division. He is permanent class secretary for the Class of 1936 and also serves as a team captain for the Alumni Committee on the Caltech Development Program.



FREDERICK W. DRURY, JR., received his BS in civil engineering in 1950, then returned to the U.S. Navy for 28 months as an ASW and Electronics Officer. In late 1952 he joined the Airox Company in Los Angeles as a sales engineer, becoming chief engineer and vice president in 1954. Since 1956 he has been general manager of Admixtures, Inc., in Pasadena, specializing in research, development, production, and sales of admixtures for the concrete industry. He has served as program chairman for the Alumni Winter Dinner Dance and Fall Dinner Meeting, and is 1958-59 chairman of the Alumni Association's Program Committee.

Nominations for Alumni Association President and Vice President



FRANK C. BUMB, who has been nominated as president of the Alumni Association, received his BS in mechanical engineering in 1951 and returned to Caltech for his MS in 1952. He then joined the Consolidated Electrodynamics Corporation in Pasadena as an assistant engineer. Just recently he was named an assistant department manager in the Consolidated Systems Corporation, a subsidiary of Consolidated Electrodynamics. His professional activities include active participation in the American Society of Mechanical Engineering, Sigma Xi, and Tau Beta Pi. He has served the alumni by working on the Seminar Day Program Committee in 1955 and as Alumni Program Chairman in 1956-57. In 1957-58 he was director of all social activities and this year he is serving as athletic council representative. He is also a member of the Board of Directors of the Alumni Association.

RALPH W. JONES, who has been nominated as vice president of the Alumni Association, received his BS in mechanical engineering in 1938 and then worked for the Byron J. Jackson Company in Los Angeles for two years as a design engineer. In 1940 he joined the St. Paul (Minnesota) Engineering and Manufacturing Company as chief engineer, becoming works manager in 1943. Early in 1945 he returned to Caltech to work on wartime projects, then served briefly with the Manhattan District Engineers in the Army, and worked for a year at NOTS. Since 1947 he has been with the management consulting firm of Booz, Allen & Hamilton in Los Angeles and was elected to a partnership in 1952. He served on the Alumni Seminar Program Committee in 1956-57, and was general chairman of the Committee in 1957-58. This year he is serving as director in charge of the Seminar.

STRAIGHT TALK TO ENGINEERS

from Donald W. Douglas, Jr.

President, Douglas Aircraft Company

I've been asked whether non-aeronautical engineers have good prospects for advancement in the aviation industry.

The answer is *yes, definitely!* At Douglas many of our top supervisory people have moved up from other engineering specialties. The complexity of modern aircraft and missiles requires the greatest variety of engineering skills known to industry.

For example, we now have pressing needs for mechanical, structural, electrical and electronics engineers in addition to aerodynamicists, physicists and mathematicians. Whatever your background in the engineering profession may be, there are prime opportunities in the stimulating aircraft and missiles field.

Please write to Mr. C. C. LaVene
Douglas Aircraft Company, Box 600-E
Santa Monica, California

vestment in Human Resources," and "The Education of Our Talented Youth," obviously invite comparison with *The Next Hundred Years*, recently published by three Caltech professors. While there is no direct reference to the latter volume, Rickover comes to pretty much the same conclusions using pretty much the same data. A difference exists in point of view; *Education and Freedom* stresses that action is mandatory.

Anybody can write a book deploring anything. This book explains what is to be deplored, it compares the deplorable with the admirable, and it produces a recommended program for doing something to convert the present deplorable state of American public education to something admirable. Appendix One, "Primer for Parents," is a realistic, do-it-yourself manual. Appendices Two and Three are objective explosions of contemporary Dutch and Russian educational philosophies and the specifics of their application.

In conclusion, this is recommended reading for everybody concerned with education, along with James B. Conant's *The American High School Today,* with which it has many points of congruence, especially with respect to the teaching of foreign languages. Other recommended readings, and readings as a basis for intelligent action, made by Admiral Rickover himself, are *Quackery in the Public Schools,* by Albert Lynd (1953), and *The Restoration of Learning,* by Arthur Bestor (1955).

As Charles van Doren says in the preface, "This is a fine and thoughtful book, and it is probably going to make a lot of people very angry. I think that's a good thing."

Paul C. Eaton, Dean of Students at Caltech is Lt. Comdr., USNR (Ret.). In World War II he served in various units of the Third, Fifth, and Tenth Fleets, principally in anti-submarine operations. In 1947 he had active duty in submarines in the Gulf of Maine, his own backyard, just before joining the staff at Caltech.

Morphologische Forschung

by F. Zwicky

Winterthur, Switzerland . . . $2.20

Written in German, Fritz Zwicky's latest book, *Morphological Research,* is subtitled *Character and Development of Material and Conceptual Relationships.*

Dr. Zwicky, Caltech professor of astrophysics and staff member of the Mount Wilson and Palomar Observatories, defines morphological research as "total research which is concerned with *all* the solutions of any given problem and which evaluates the relative values of all of these solutions."

Dr. Zwicky has already written extensively of applications of the morphological method to problems in jet propulsion and in astronomy – most recently in *Morphological Astronomy,* (1957). In his new book, he discusses the applications of the method to sociological as well as scientific, technical, and military problems.

Personals

1923

Harold A. Barnett resigned as city engineer of the City of San Marino last month after 35 years of service. He hopes to devote more time to his private engineering practice (Barnett, Hopen and Smith) and also plans a trip back to his native Mississippi after an absence of 20 years. Hal will continue as city engineer for Gardena, a job he's held since 1930.

1928

Fred C. Lindvall, PhD, chairman of the division of engineering and aeronautics at Caltech, is one of ten men who have been selected by the staff of the Pacific Missile Range at Point Mugu (and approved by the Chief of the Bureau of Aeronautics in Washington) to act as members of the Pacific Missile Range Advisory Committee. The Committee will advise PMR personnel on the management and conduct of major programs in the defense establishment. Two other Caltech men were chosen as members of the committee; *C. C. Lauritsen,* PhD '29, professor of physics at Caltech; and *William B. McLean,* BS '35, MS '37, PhD '39, technical director of the Naval Ordnance Test Station at China Lake.

George T. Harness, PhD '33, associate dean of the school of engineering at the University of Southern California, has been nominated as a national vice president of the American Institute of Electrical Engineers, which assures his election for a two-year term, starting in August. George has been on the SC faculty since 1946.

Tomizo Suzuki writes from Japan that "after working for the U. S. Army as a civil engineer for seven years, I had to find a new position last spring due to ever changing international relations. I rejoined Hazama-Gumi, Ltd., in March 1958, and came to Miboro, Gifu Prefecture, where the company is building a huge rockfill dam with a sloping core on the Sho River, which empties into the Japan Sea. It is located in the northwestern part of Central Japan amidst rugged mountains where the rain and snow fall abundantly. In this region peculiar customs and culture endure due to long isolation from other parts of the country.

"The height of the Miboro Dam will be about 430 feet when it is completed, and the maximum electric power output will be 215,000 kw. We use up-to-date equipment with the technological assistance of the Guy F. Atkinson Company of South San Francisco. *Richard G. Rofelty,* '29, is the project manager of the company here at Miboro.

"With regard to my family—our

daughter, a graduate of the Aoyama Gakuin University, will be married to a director of a chemical company in Tokyo this month — and my older son, who will graduate from the Law School of the Chuo (Central) University in Tokyo, plans to join the Matsushita Electric Appliance Manufacturing Company after graduation.

"*Howard Nagashi*, '29, MS '31, and his daughter, came to see the dam last May . . . My best regards to professors, friends and acquaintances in and around Pasadena."

1932

Kenneth H. Swart, MS '33, is vice president in charge of engineering as well as a director of the H. C. Smith Oil Tool Company in Compton. He's been with the company for four years. Ken has two sons: Kerry, a UCLA graduate, now at Fort Ord; and Ron, who is 10. Ken has a four-wheel-drive jeep which he uses to explore some of the almost inaccessible parts of the Mojave Desert and of Baja California.

1933

Harold Omsted, MS, chief structural engineer for the L. A. Board of Education, has been elected president of the Structural Engineers Association of Southern California. Other newly-elected officers include *Cydnor M. Biddison*, '40, structural engineer with Hillman & Nowell in Los Angeles, who is treasurer; and *Jack N. Sparling*, '33, vice president and chief engineer of Quinton Engineers, Ltd., in Los Angeles, who is first vice president.

Ammon S. Andes, MS, is now chairman of the department and professor of aeronautical engineering at the University of Kansas in Lawrence, where he has been teaching since 1946. "For the last 8 years I have worked every summer in industry," he writes, "spending last summer at Convair in Pomona, Calif. I also attended the I.A.S. summer meeting in Los Angeles and the American Society of Engineering Education's summer national meeting at Berkeley. I have two daughters; the oldest is now teaching art in Denver, Colorado."

1936

Chauncey W. Watt, Jr., writes from Concord, Mass., that "although we returned to California for two years (1956-57) New England won out after all. Now at Raytheon as corporate director of engineering practices in Waltham, Mass. We love the lakes, rivers, green trees, and fields — and particularly like being able to *see* them, there being no smog here. My only daughter is 12 and in the 7th grade — and is a confirmed New Englander as well."

1937

Stanley Feuer, MS '38, president of the Stanley Feuer Company in Los Angeles, writes that the company celebrated its 10th anniversary last month. "We are mechanical engineers and contractors," Stan writes, "and we specialize in design, sales, and installation of commercial and industrial heating and air conditioning systems. I have also been busy raising a family during the past six years. Margot and I have three boys — Zachary, Joshua and Mark."

1938

Sam Watson, Jr., is now in Abadan, South Iran, and is celebrating his 10th year as a geologist with The Texas Company. In that time he has traveled from Bakersfield, Calif., to Colorado (in uranium mining), to Lewiston, Montana (in oil); to Iran, where he is resident geologist at the Agha Jari Field. The Watsons have two children—Susan, 11, and Sammy, 9.

Howard S. Seifert, PhD, is now special assistant for professional development of Space Technology Laboratories, in Los Angeles. He was formerly a member of the firm's Astrovehicles Laboratory. The Seiferts have three children and live in Playa Del Rey.

Carlton L. Horine is process and project manager with the Collier Carbon and Chemical Corporation (formerly the Brea Chemical Corporation) in Brea, California. The Horines have a son and two daughters — all lively teen-agers.

1939

Warren E. Wilson, dean of the school of engineering at Pratt Institute in Brooklyn, N. Y., has been named chairman of the department of engineering at Harvey Mudd College in Claremont. He takes on his new duties next fall.

Frank E. McCreery is vice president of engineering at the Rohr Aircraft Corporation in Chula Vista. He has three sons — Jim, 4, Bill, 3, and Doug, 2.

Robert H. Widmer is now chief engineer for technical design at Convair, a division of the General Dynamics Corporation, in Fort Worth, Texas. He has been with the company since 1939. He is married and has two children.

Calvin A. Gongwer, MS, is now manager of the new anti-submarine warfare division of the Aerojet-General Corporation in Azusa. He was formerly head of the company's systems and underwater engine divisions.

1944

Robert J. Parks, chief of the department of guidance and electronics at JPL, was named La Canada's "Man of the Year" last month. He received a plaque and honorary membership in the La Canada Kiwanis Club. Bob was given the award for contributions made by his

continued on page 48

group in pioneering electronic developments in missiles and rockets, and for his leadership in the development of the Sergeant guided missile. Bob and his wife and three children live in La Canada.

Leon Trilling, AE '47, PhD '48, associate professor of fluid mechanics at MIT, was a member of the recent U.S. Mission on Engineering Education to the USSR – whose chairman was *Fred Lindvall*, PhD '28, chairman of Caltech's division of civil, electrical and mechanical engineering and aeronautics. Secretary of the Mission was *Newman Hall*, PhD '38, chairman of the mechanical engineering department at Yale.

Dean A. Naldrett, MS '44, died last September 22 of bulbar polio. He was superintendent of the Anchor Bay Schools in New Baltimore, Michigan. Dean is survived by his wife, Ilah, and four children – Sherrel, Phyllis, Alan and Ronald.

1947

Joseph Rosener, Jr., is now the owner of the Empcor Corporation in Burbank, one of the southwest's leading suppliers of etched circuits. Joe will be president and general manager. He had been with the G. M. Giannini Company for the past four years. The Roseners and their three children (ages 6, 4 and 2) live in Pasadena.

1949

Theodore W. Rose is now a senior research engineer at Rocketdyne in Canoga Park. His work involves the development of propellant values for large liquid fuel rocket engines. The Roses have two children – a daughter, 5 and a son, 8.

Samuel R. Hoffman, MS, reports that he is an elementary teacher in the Los Angeles City Schools, and also owner of the Camp Kinneret Day Camp in San Fernando. The Hoffmans have two sons, 5 and 7, and live in Reseda.

Dr. P. N. Leiderman, MS, is now a research psychiatrist and an instructor in psychiatry at Harvard Medical School in Cambridge, Mass. The Leidermans live in Waban, Mass., and have three children – Deborah, 4, Erica, 3, and Joshua, 1.

1951

Richard G. Brewer writes that he was "married in 1954 to Lillian Magidow and we are now four, with Emily almost 2, and Larry, 3. I enjoyed a two-year vacation at the Army Chemical Center as a draftee in 1955-57. I recently completed my PhD at UC in Berkeley. We managed our first family camping trip by going to Sequoia National Forest last summer and this was followed by a hectic cross-country drive to New England where I am employed as an instructor in the Harvard chemistry department."

George J. Smith, MS, PhD '56, geologist with the U. S. Geological Survey in Menlo Park, announced the birth of his first child – a boy, Randall – on December 21.

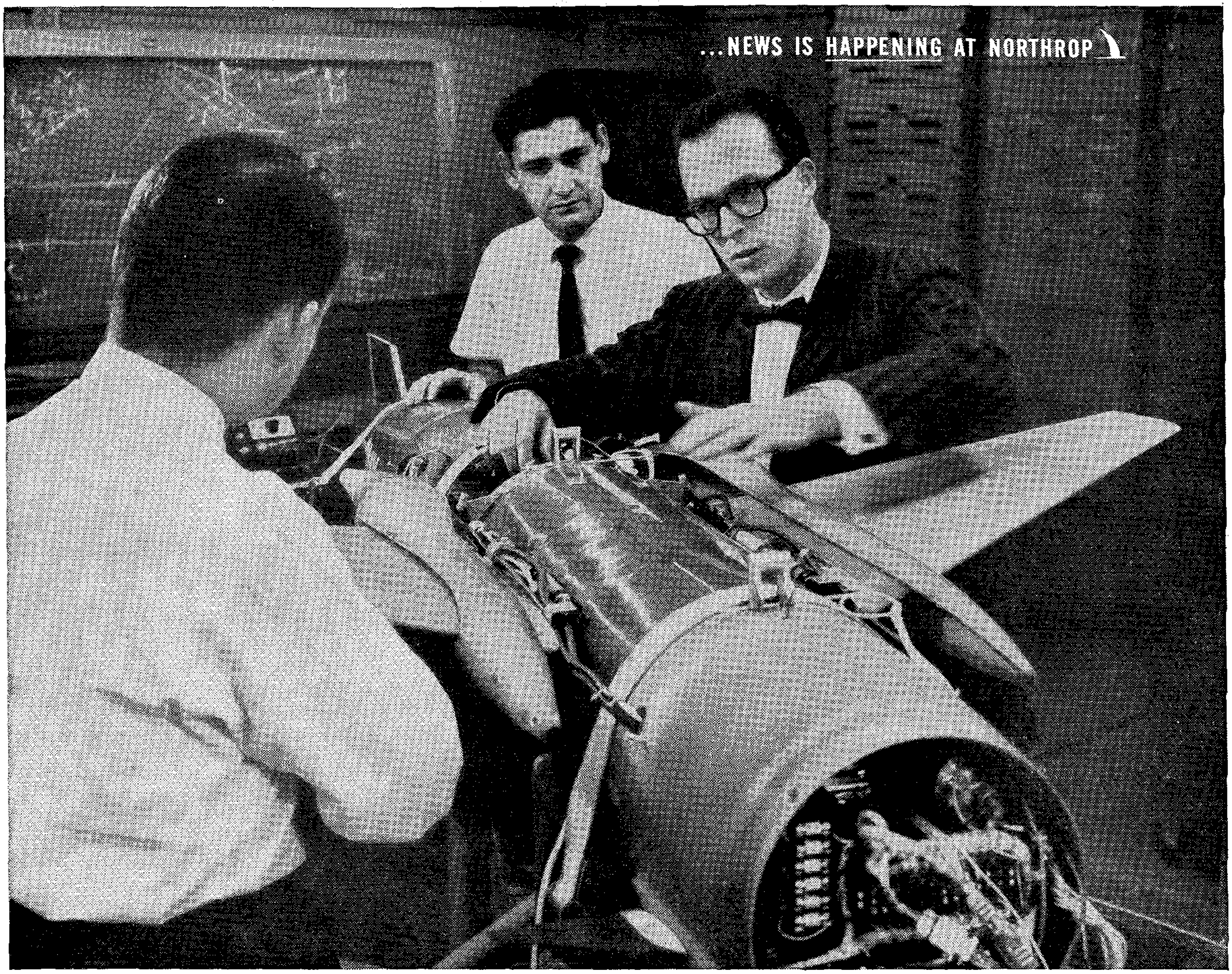
1954

Albert Pitton, resident development engineer at Rocketdyne in Canoga Park, reports an addition to the family – Ann Catherine, born last June. Al is currently working on a rocket engine test stand at Santa Susana. Also seen on the premises, he writes, are *Dean C. Daily*, '51, *Bill Haighler*, '55, and *Dwight L. Dennis*, '56.

1958

Lance Hays, Caltech graduate student, writes that his first child – Deborah Ann – was born on October 12.

Norman T. Ellett was married to Nancy Lee Freeman (Scripps '58) at Wayne, Illinois, in December. The Elletts are now living in Cambridge, Mass., where Norm is going to the Harvard Business School.



Engineer Larry Klivans reviews the results of a computer-simulated ground checkout of Radioplane Division's near-sonic RP-76 rocket-powered target drone. Formerly at Norair Division, Larry came to Radioplane in 1955. At 31, he is Manager of the Division's 140-man Electronic Support Group, is working toward his doctorate at UCLA.

YOUNG ENGINEERS ARE NORTHROP'S NEWSMAKERS!

Northrop Corporation's dynamic and diversified corporate structure creates an ideal work climate for forward-thinking scientists and engineers. Our three autonomous divisions are all in Southern California – are all headed by progressive management eager to examine and try new ideas.

Let's assume that *you* are a man who can qualify for one of our engineering teams – a man who can create history!

YOU'LL EARN what you're worth, get increases as often as you earn them – based on your own individual achievements. Our salary structure is unique in the industry; our vacation policy extra-liberal, as are all of our other fringe benefits.

YOU'LL LEARN while you earn, with no-cost and low-cost education opportunities at leading Southern California institutions – earn advanced degrees and keep abreast of latest technological advances in your own chosen field.

YOU'LL WORK with men who are acknowledged leaders in their fields – men chosen for their own capabilities *and* for skills in guiding and developing the creative talents of younger men. And, these are men who delegate authority, assuring your fair share of credit for engineering triumphs.

YOU'LL BE FLEXIBLE – able to apply your talents to the work you enjoy, in the field best suited to your own inclination and ability. Northrop Corporation and its divisions offer wide diversity, with over 30 operational fields to choose from. All offer challenge aplenty – opportunity unlimited!

RADIOPLANE DIVISION. Creator of the world's *first drone family;* has produced and delivered tens of thousands of drones for all the U.S. Armed Forces. Now developing ultra-advanced target drone systems for weapon evaluation, surveillance drone systems, and missile systems.

NORTRONICS DIVISION. Pioneer in celestial and inertial guidance. Currently exploring infrared applications, airborne digital computers and interplanetary navigation; developing ground support, optical and electro-mechanical, and data-processing equipment.

NORAIR DIVISION. Creator of SAC's intercontinental USAF Snark SM-62. Currently active in programs for the ballistic recovery of orbiting man; flight-testing the USAF T-38 *supersonic trainer;* readying the N-156F NATO-SEATO fighter for flight tests.

NOW WRITE! Get full information on Northrop Corporation and all of its Divisions. Then choose the division that offers *you* the most challenge. To reserve your spot where news is *happening,* write: Engineering & Scientific Personnel Placement Office, Northrop Corporation, P.O. Box 1525, Beverly Hills, California.

Divisions of NORTHROP CORPORATION

Twenty-Second Annual Alumni Seminar

Saturday, April 11, 1959

THEME — THE SPACE AGE

Nationally Famous Evening Speaker

The evening speaker, Major General John B. Medaris, U.S.A., is an outstanding authority in the field of missiles and has been concerned with ordnance phases of the Army since 1926. He is now Commanding General, United States Army, Ordnance Missile Command. His subject will be, "The Exploration of Space."

Special Two-Hour Tours of the Jet Propulsion Laboratory

Tours will be started from the Caltech campus with all persons being transported to and from JPL by bus. Tours will be taken in groups of from 15 to 20 people. A bus carrying 50 persons will leave the campus every 15 minutes, between 8:30 a.m. and 2:15 p.m.

Thirteen Outstanding Lectures

A group of 13 lectures will be given during three periods in the morning, and will be repeated during three periods in the afternoon in order to accommodate those who take the JPL tours.

Alumni outside of southern California who wish to attend the Seminar should write the Alumni Office for reservations.

SEMINAR LECTURES

WHAT WILL SPACE VEHICLES BE MADE OF ?
Pol Duwez, Professor of Mechanical Engineering

New environmental conditions encountered in space flights have created new problems in the field of materials. In addition to the much publicized cone reentry problem, in which extremely high temperatures are generated by aerodynamic heating, other unusual conditions exist in space. The experimental study of materials under such conditions is obviously very difficult since the only laboratory in which the experiments can be performed is space.

CARBON-14 AND SOCIETY
Linus Pauling, Professor of Chemistry

There has been considerable difference of opinion as to the harmful effects of radioactive fallout from testing of nuclear weapons. There is evidence that this fallout will cause leukemia, bone cancer, and other radiation diseases. It may also cause stillbirth, childhood deaths and physical and mental defects at birth. Dr. Pauling will discuss the genetic and physiological effects of Carbon-14, a by-product of nuclear weapons testing.

MESSENGERS FROM SPACE
H. V. Neher, Professor of Physics

Space beyond the earth is not empty. It contains electromagnetic radiations and high-speed particles or nuclei of the atoms, which we call cosmic rays. In addition it contains gas in the form of ionized clouds or plasmas. Such clouds from the sun have pronounced effects on the aurora, the ionosphere and on cosmic rays. They may also be the source of the radiation in the newly discovered Van Allen bands around the earth. Cosmic ray particles are probes that feel out this space and have given considerable information on its properties.

INDIA – GROWING PAINS OF A NEW NATION
Robert A. Huttenback, Lecturer in History
Master of Student Houses

Mr. Huttenback has just returned from India where he spent a year conducting research on a Ford Foundation grant. He will make some observations based on his experiences which will include a discussion of the attitudes behind Indian foreign policy, domestic development and social evolution.

PARTY LINES TO SPACE VEHICLES
Roy W. Gould, Associate Professor of Electrical Engineering

Current techniques for relaying information from satellites to ground stations will be described and a look taken at future systems. The ultimate limitations of communication systems will be discussed – and how these limitations will affect our ability to communicate with space vehicles.

SCOTT FITZGERALD : THE COST OF FAME
Henry Dan Piper, Associate Professor of English

Dr. Piper is completing a book about this well-known American novelist who died forgotten in Hollywood in 1940. Since then, Fitzgerald has been the object of a spectacular revival of interest. This lecture will strip away the aura of myth from Fitzgerald's life and work, and will explain why he has become such a legendary figure in our culture.

CARE AND FEEDING OF SPACEMEN
James A. Lockhart, Research Fellow in Biology

To support human life in a space vehicle or on another planet, we must provide the type of biological cycle prevalent on earth. This requires that the vehicle carry all necessary physical equipment to make available a continuous supply of food and oxygen. Dr. Lockhart will explore such a system.

NEW ORGANS FOR OLD
Elizabeth S. Russell, Research Fellow in Biology

Man has long sought means to replace diseased or defective human tissues or organs. Dr. Russell will discuss her experiments in transplantation of blood-forming tissues in mice as a possible cure for constitutional diseases. She will take a look into the future possibilities of extending transplantation to human organs.

WILL WORLD LEADERSHIP LEAD US TO THE POORHOUSE?
Alan R. Sweezy, Professor of Economics

What is the impact of the budget on the economy? What is the relation between taxes and economic welfare? In what ways and under what conditions does the budget contribute to the danger of inflation? What is the relation between the budget and economic growth? When is it safe to use deficit financing? Is the budget already too large for safety or could we manage to absorb further increases if necessary?

PROPULSION FOR INTERPLANETARY FLIGHT
Frank E. Marble, Professor of Jet Propulsion and Mechanical Engineering

One of the most demanding requirements in the fascinating field of space exploration is that of propelling instrument packages or men over the enormous distances involved. A brief look will be taken at these distances and at the times required for some interplanetary trips. Conventional rockets will be examined to see what sizes are needed for these missions. Some of the novel space-propulsion devices will be discussed, such as ion, plasma, and nuclear propulsion units, to show what part they may play in the future exploration of space.

THE CLOCK PARADOX
H. P. Robertson, Professor of Mathematical Physics

The theory of relativity predicts that a clock in motion loses time in comparison with one at rest. This leads the true believer to the startling conclusion that a traveler to outer space would, on his return to the earth, be younger than his stay-at-home twin; and the heretic to the paradoxical conclusion that, since motion is relative, the earth-bound brother could as cogently deny the rejuvenating effects of travel! Dr. Robertson will discuss the theoretical background and experimental verification of this and related effects. The seminar will, it is hoped, conclude with King John that "This was sometime a paradox, but now the time gives it proof."

NUCLEAR EXPLOSION? CAN YOU BE SURE?
Frank Press, Professor of Geophysics Director of the Seismological Laboratory

Our negotiations with the Russians on the control of nuclear tests depend to an overwhelming extent on the detection of nuclear explosions. The principal methods of detection will be described, and Dr. Press, who made a recent visit to Russia, will discuss Russian capabilities in this field. The probability of future peaceful control will be explored.

WILL THE SPACE PROGRAM EXPLAIN THE EVOLUTION OF OUR SOLAR SYSTEM?
Harrison Brown, Professor of Geochemistry

Using lunar and planetary probes, which are planned in our space program, we can learn a great deal about the origin and evolution of the planets. Dr. Brown will review some of the major problems concerning the solar system, and he will describe the kinds of observations from space vehicles which can help in the solution of these problems.

CALTECH CALENDAR

ALUMNI CALENDAR

April 11	Annual Seminar
June 10	Annual Meeting
June 27	Annual Picnic

ATHLETIC SCHEDULE

Swimming

April 3
U of Arizona at Caltech

April 10
Caltech at Whittier

April 16
Caltech at Redlands

Baseball

April 1
Pomona at Caltech

April 4
San Diego U at Caltech

April 8
Whittier at Caltech

April 11
Caltech at Whittier

April 14
Whittier at Caltech

Track

April 3
Claremont-Harvey Mudd at Caltech

April 11
Caltech at Whittier

April 18
Caltech at Redlands

Tennis

April 2
U of Arizona at Caltech

April 4
Caltech at Redlands

April 11
Caltech at Occidental

April 18
Pomona at Caltech

FRIDAY EVENING DEMONSTRATION LECTURES

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

March 20
Location of Function in the Brain
– Mitchell Glickstein

April 3
Rivers – World's Biggest Earth-movers
– Norman H. Brooks

April 10
Abnormal Molecules of Hemoglobin
– Linus Pauling

April 17
Microwaves
– Roy Gould

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U. S. Navy Electronics Laboratory

One of a series*

Interview with General Electric's Earl G. Abbott Manager—Sales Training

Advancement in a Large Company: How it Works

Where do you find better advancement opportunities—in a large company or a small one? To help you, the college student, resolve that problem, Mr. Abbott answers the following questions concerning advancement opportunities in engineering, *manufacturing* and technical marketing at General Electric.

Q. In a large Company such as General Electric, how can you assure that every man deserving of recognition will get it? Don't some capable people become lost?

A. No, they don't. And it's because of the way G.E. has been organized. By decentralizing into more than a hundred smaller operating departments, we've been able to pinpoint both authority and responsibility. Our products are engineered, manufactured and marketed by many departments comparable to small companies. Since each is completely responsible for its success and profitability, each individual within the department has a defined share of that responsibility. Therefore, outstanding performance is readily recognized.

Q. If that's the case, are opportunities for advancement limited to openings within the department?

A. Not at all. That's one of the advantages of our decentralized organization. It creates small operations that individuals can "get their arms around", and still reserves and enhances the inherent advantages of a large company. Widely diverse opportunities and promotions are available on a Company-wide basis.

Q. But how does a department find the best man, Company-wide?

A. We've developed personnel registers to assure that the best qualified men for the job are not overlooked. The registers contain complete appraisals of professional employees. They enable a manager to make a thorough and objective search of the entire General Electric Company and come up with the man best qualified for the job.

Q. How do advancement opportunities for technical graduates stack-up with those of other graduates?

A. Very well. General Electric is recognized as a Company with outstanding technical skills and facilities. One out of every thirteen employees is a scientist or engineer. And approximately 50 per cent of our Department General Managers have technical back ls.

Q. How about speed ancement? Is G.E. a "young man's company"?

A. Definitely. A majority of all supervisors, managers and outstanding individual contributors working in the engineering function are below the age of forty. We believe that a job should be one for which you are qualified, but above all it should be one that challenges your ability. As you master one job we feel that consideration should be given to moving you to a position of greater responsibility. This is working, for in the professional field, one out of four of our people are in positions of greater responsibility today than they were a year ago.

Q. Some men want to remain in a specialized technical job rather than go into managerial work. How does this affect their advancement?

A. At G.E. there are many paths which lead to higher positions of recognition and prestige. Every man is essentially free to select the course which best fits both his abilities and interests. Furthermore, he may modify that course if his interests change as his career progresses. Along any of these paths he may advance within the Company to very high levels of recognition and salary.

Q. What aids to advancement does General Electric provide?

A. We believe that it's just sound business policy to provide a stimulating climate for personal development. As the individual develops, through his own efforts, the Company benefits from his contributions. General Electric has done much to provide the right kind of opportunity for its employees. Outstanding college graduates are given graduate study aid through the G-E Honors Program and Tuition Refund Program. Technical graduates entering the Engineering, Manufacturing, or Technical Marketing Programs start with on-the-job training and related study as preparation for more responsible positions. Throughout their G-E careers they receive frequent appraisals as a guide for self development. Company-conducted courses are offered again at all levels of the organization. These help professionals gain the increasingly higher levels of education demanded by the complexities of modern business. Our goal is to see every man advance to the full limits of his capabilities.

If you have other questions or want information on our programs for technical graduates, write to E. G. Abbott, Section 959-9, General Electric Co., Schenectady 5, N. Y.

***LOOK FOR other interviews discussing: • *Qualities We Look For in Young Engineers* • Personal Development • Salary.**

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