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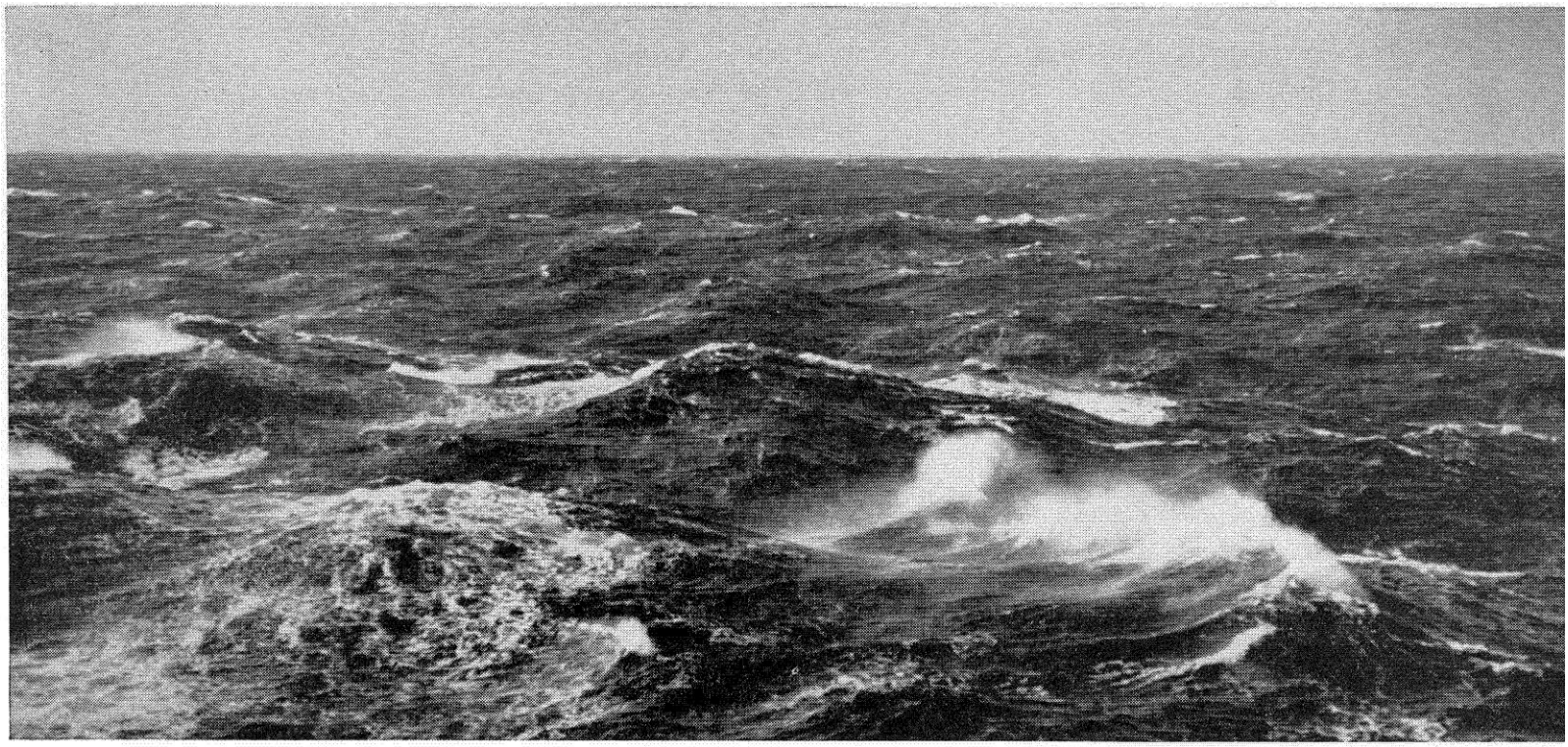

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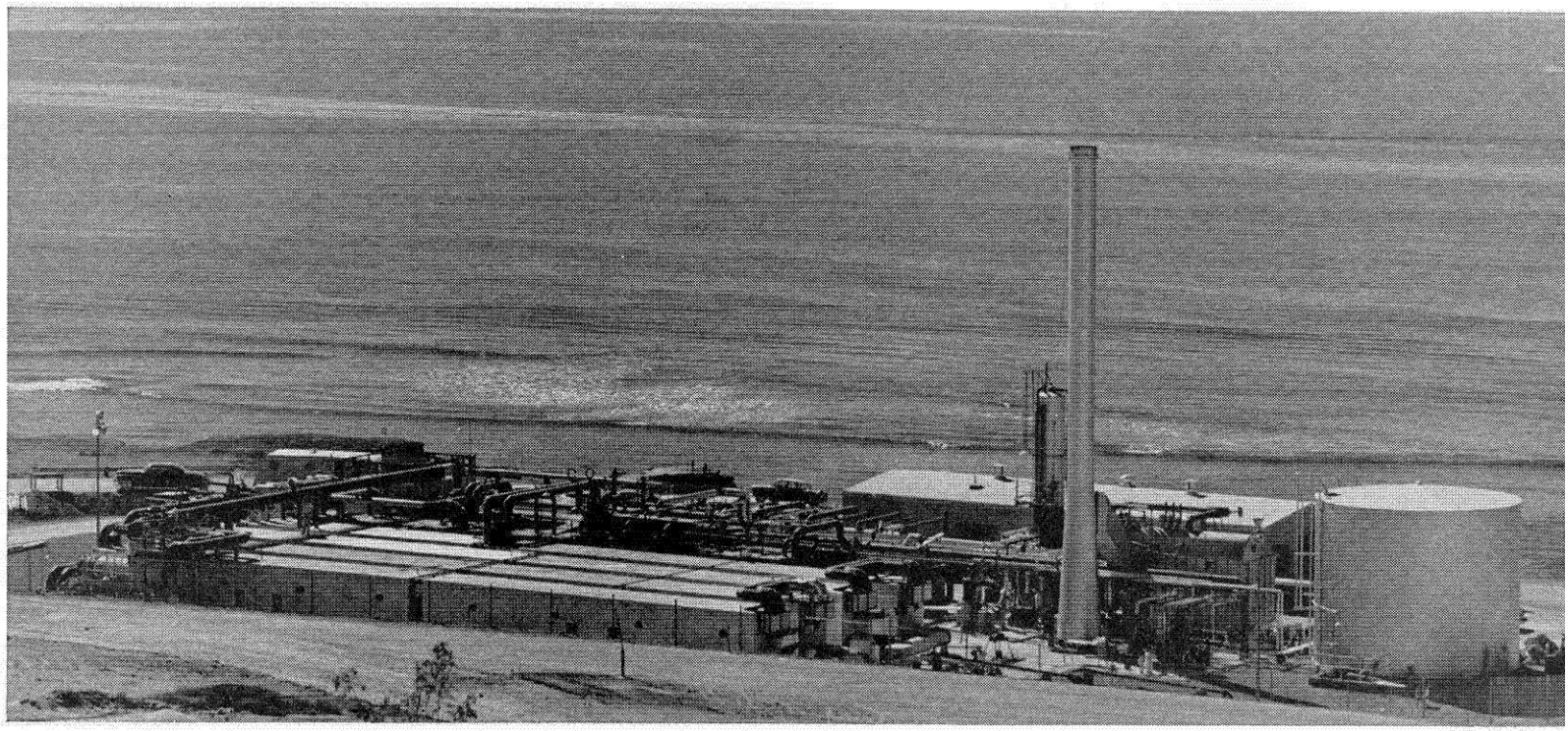

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ENGINEERING AND SCIENCE

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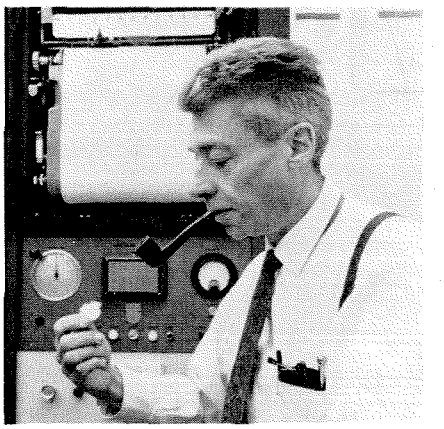

On Our Cover

Pol Duwez, professor of materials science, prepares to run an electron diffraction analysis of an unusual alloy made with a technique developed in collaboration with Ronald Willens, assistant professor of materials science. Five years ago, when Dr. Willens was still a graduate student, the two men began trying to find a way to cool molten materials so fast that the normal crystallization processes might be bypassed, leading to room-temperature material with high-temperature atomic structure. Their success has led to many new structural forms for alloys, including one that they call a "metallic glass." The story is on page 15.

Rodman W. Paul,

professor of history, has had nearly 20 years on the Caltech faculty to watch the steady improvement in the quality of students in his classes and in the humanities program designed to keep pace with them. In "The Humanities at Caltech" on page 11, he describes the undergraduate of today and the significant changes devised by the humanities division to provide an ample intellectual diet for this bright young man.

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Books

Day of Trinity *by Lansing Lamont*
Atheneum Publishers $6.95

Hiroshima Plus 20
by The New York Times
Delacorte Press $5.00

Science: U.S.A. *by William Gilman*
The Viking Press $7.50

Reviewed by Daniel J. Kevles, assistant professor of history

Near Alamagordo, New Mexico, in the dark before morning of July 16, 1945, a lone tower jutted 103 feet into the air from the wasted desert floor. In a sheet metal shack at the top, "the gadget," as the Los Alamos scientists called the nuclear device, rested amidst a tangle of wires. Outside a ten-thousand-yard radius from the tower, hundreds of men waited, tense, nervous, apprehensive.

It had been a long night of waiting. The spatter of rain had pushed the test back to the last possible moment before dawn. But now Samuel Allison, clutching a microphone in the South-10,000 bunker, had begun the countdown. A few feet away, 24-year-old Donald Hornig, fixing his gaze on the instrument panel, nervously fingered the stop switch that would shut down the entire operation at the slightest sign of malfunction. J. Robert Oppenheimer, standing in the doorway, seemed to totter on the verge of nervous collapse. Hundreds of miles to the east at Oak Ridge, a team of psychiatrists, poised, ready, if the test failed, to rush to the aid of the jittery scientists. At minus ten seconds a gong sounded over the public address system. Allison's voice rose to a scream. "Zero!"

"A pinprick of a brilliant light punctured the darkness, spurted upward in a flaming jet, then spilled into a dazzling cloche of fire that bleached the desert to a ghastly white. It was precisely 5:29:45 A.M."

That was Trinity, the first man-made nuclear explosion, as Lansing Lamont describes it in his vividly written, absorbingly detailed book. Many volumes have been written about the events surrounding that weird morning of terror and exhilaration, but none has captured the intense human drama of the Los Alamos effort as expressively or poignantly as *Day of Trinity*. Rather than the technical story of the bomb, this is the personal history, month by month, week by week, day by day, and, finally, hour by hour, of that small group of people who sweated through the years of the Manhattan Project.

Hundreds of scientists, gone mysteriously from their campuses, came to Los Alamos, the ramshackle settlement some 35 miles north of Albuquerque. They chafed under security restrictions, rasped against jerry-built housing, and endured not only the military but each other. Above all they lived in an air of almost unremitting tension.

Each met the strain in his own way. There was Richard P. Feynman, as likely to play the bongos as he was unlikely to wear socks, who happily figured out the combinations of safes containing classified documents, unlocked them, and left notes that read, "Guess Who?" There was Edward Teller, moody, apt to spend his leisure in long walks, driving his neighbors to distraction by rhapsodizing on the piano at odd hours of the night. There was Robert Oppenheimer, the tough-minded administrator, the man of luminously brilliant eyes, relaxing over the poetry of John Donne.

Whatever the diversions, no one ever forgot the business at hand. Major General Leslie R. Groves, responsible for the expenditure of two billion dollars, warned his aides that if the bomb failed, "each of you can look forward to a lifetime of testifying before Congressional investigating committees."

There was no time for misgivings. Convinced that the United States had to be first with the bomb, consumed by the sheer scientific and technical challenge, the scientists raced ahead. They celebrated wildly the night after the test. But at the moment of Trinity, after the first exhilarating thrill of success, many of them were sharply sobered by what they had wrought. Through Oppenheimer's mind flashed a line from the Bhagavad-Gita: 'I am become Death,/ The shatterer of worlds." Kenneth T. Bainbridge, with a different kind of eloquence, turned to Oppenheimer and said, "Now we're *all* sons of bitches."

Sixteen days after Trinity, Turner Catledge, assistant managing editor of *The New York Times*, got word to appear in an old apartment building in downtown Washington the next day. At that Washington meeting he was given the information that would break on *The Times'* pages four days later in the story of Hiroshima. Now, 20 years later, *The Times* has prepared a collection of eight retrospective essays on the impact of the bomb. The pieces in *Hiroshima Plus 20*, all interesting and some first-rate, range from Hanson Baldwin's analysis of the decision to drop the bomb, through A. M. Rosenthal's description of contemporary Hiroshima, to W. H. Auden's perception of the bomb and man's consciousness.

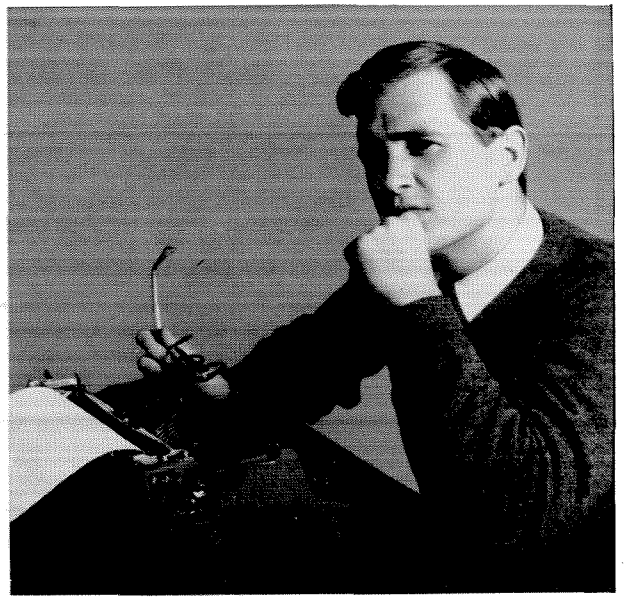
Perhaps the most provocative of the essays is Richard H. Rovere's "The Bomb and International Politics." The threat of nuclear war hovering over the world has colored the deliberations of diplomats since August 6, 1945. It has tempered the traditional pursuit of national interests, Rovere argues. The ultimate sanction of diplomacy, as international politics has implied over the last 20 years, is no longer total war. Mr. Rovere inclines to the view that "the bomb and its diplomatic consequences have had, by and large, a stabilizing effect on our time." We have been living, he suggests, in a *pax atomica*.

Apart from a new age of diplomacy, the bomb ushered in a munificent age for science in the United States. Today the federal government spends yearly some fifteen billion dollars for research and development. Through it all, the scientist has emerged from the laboratory to enter the highest councils of government. But, as John W. Finney writes in *Hiroshima Plus 20*, "inevitably, the increasing dependence upon federal support has had a corrupting influence upon the scientific community in diverting its attention from just the pursuit of scientific truth. Increasingly in recent years, the scientific community has become another vested and vocal interest in the body politic . . ."

Many thoughtful Americans have come to share Mr. Finney's disturbing view. A rush of books is emerging, analyzing the scientific enterprise, criticizing it, sometimes with affection and wonder, at times with hostility and puzzlement. William Gilman's *Science: U.S.A.*, a discursive survey of industrial, academic, and government science since the war, hurls rocks at the entire establishment.

Put simply, Mr. Gilman's is a wide-ranging book that ranges much too widely. It is replete with accusations and innuendoes with almost no substance or proof. "Isn't it disturbing," he writes, "that a congressional committee abandoned the idea of hiring scientific consultants – it could find no unbiased ones in that field." But we are left in the dark, wondering what committee, what circumstances. *Science: U.S.A.* does provide a sense of the breadth and scope of the contemporary scientific enterprise. But it flatly fails to illuminate the issues that concern so many Americans. "What path for science?" Mr. Gilman asks. "Will this elite keep its house clean? Will government have to control it completely? . . . Will the public rise against it . . .?" These are critical questions indeed. But *Science: U.S.A.* is of no help in finding the answers.

Engineers & Scientists



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Note first that Sylvania employs the small group form of organization—within its nationwide complex of research and development groups, manufacturing plants and world-wide field engineering operation. This makes swift individual progress and development possible within a wide choice of current in-house projects.

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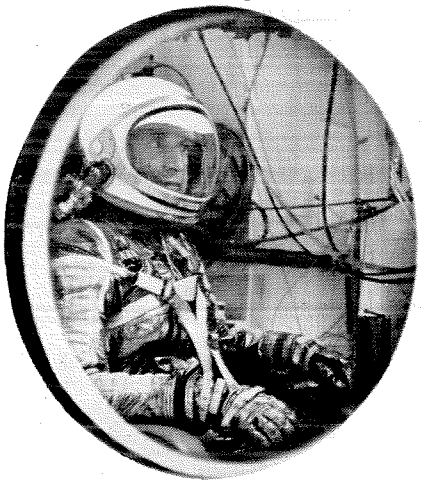

The product lines at AiResearch, Los Angeles Division, are environmental systems, flight information and controls systems, heat transfer systems, secondary power generator systems for missiles and space, electrical systems, and specialized industrial systems.

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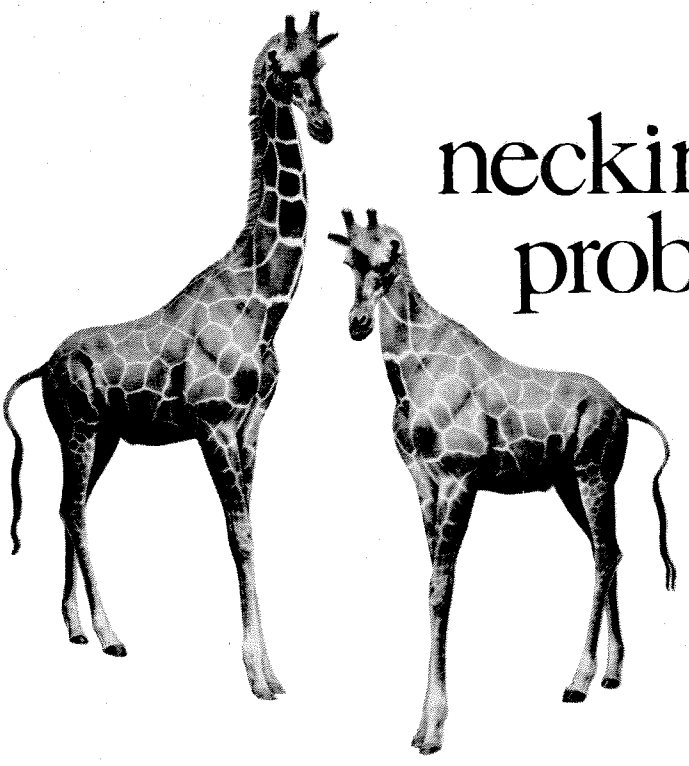

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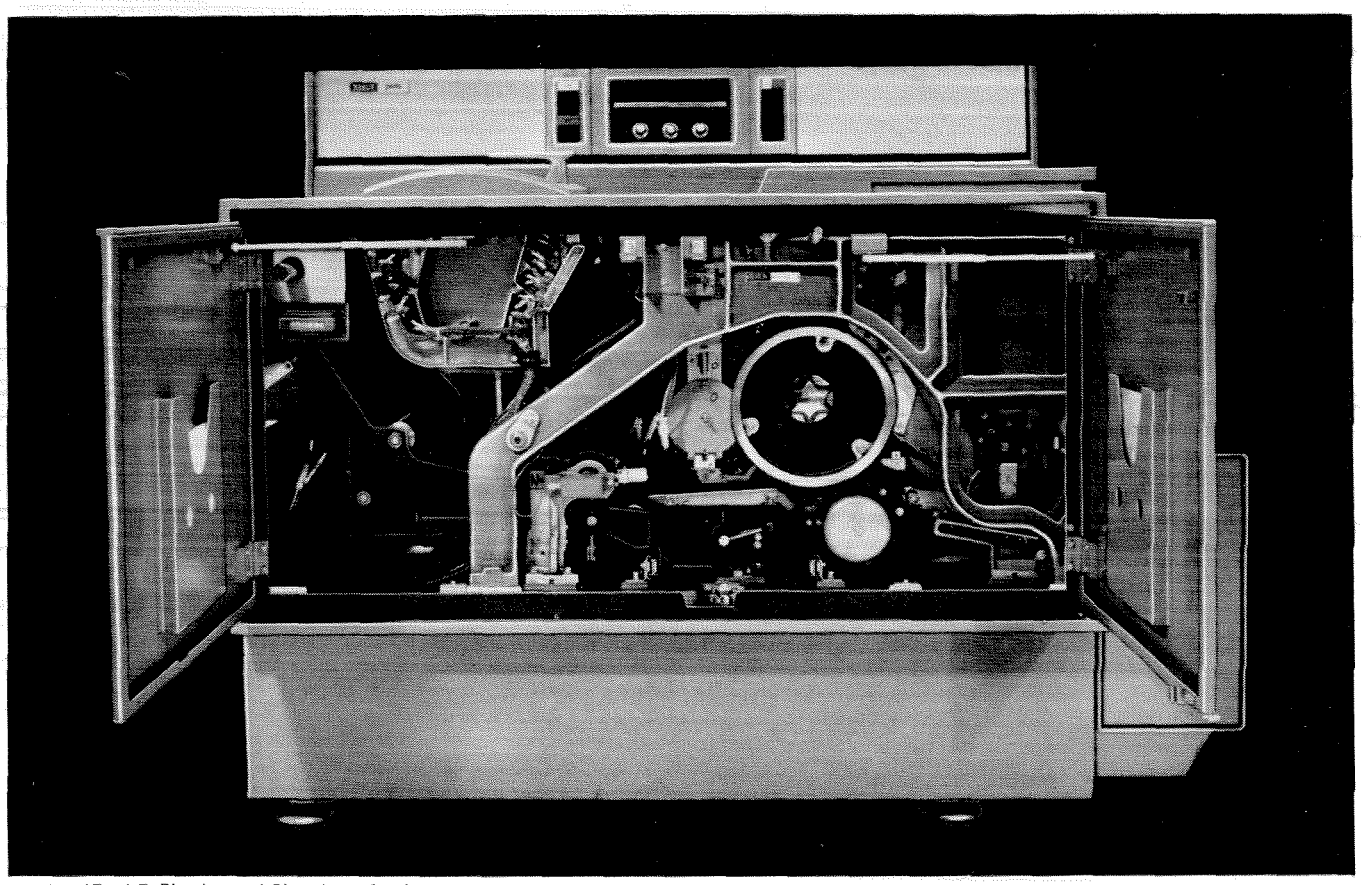

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ENGINEERING
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January 1966, Vol. XXIX, No. 4

THE HUMANITIES AT CALTECH

by Rodman W. Paul

Not everyone who comes to our campus is aware that Caltech has a curious habit of insisting that an educated scientist must have some experience in humane fields of learning. A few months ago my wife and I were present at the annual reception given by President and Mrs. DuBridge for new members of the faculty and research staffs. We met a new couple, and my wife politely made conversation with the wife in this new pair. The other lady announced that her husband was dedicating his life to scientific research, and had come to Caltech for that purpose. Then she asked: "And what does your husband do?"

"He is a historian."

"A histologist? You mean biology?"

"No, he's a *historian.*"

"But what does a historian do at Caltech?"

"He teaches."

"Teaches! Whom does he teach?"

"Students."

"*Students!* I thought Caltech was a research institution."

She was partly right. Caltech is three things simultaneously: an institution devoted to basic research in science; a large graduate school with 750 PhD candidates and several hundred postdoctoral students; and a small undergradute college with about 700 students.

All three of these activities occupy the same small campus, share the same buildings, and draw their faculty and research staffs from pretty much the same pool of talent, although there are some people, like the husband in this newcomer family, who are so exclusively in research that they never see a student, and indeed would be terrified if suddenly they had to face a freshman. Conversely, there are some people who have grown away from research and have gradually become teachers or administrators exclusively.

But we in the humanities find that most of our thinking revolves about the young undergraduates. I have been here since 1947, nearly 20 years. In that time the central fact of my teaching life has been the steady improvement in the quality of our students. I haven't had a dumb student in years. The performance in our classes has made all of us sharply aware that our modern students are brighter, more alert, better educated, and better motivated than even the quite adequate boys that we had 20 years ago. I can illustrate statistically what is happening by citing a couple of figures from the Admissions Office. Our admission procedure is of course based primarily on the students' showing in science and math, but it has been our experience that, as they have improved in science and math, so have they improved in all subjects. The only entrance examinations they take that apply directly to the humanities are the verbal part of the Scholastic Aptitude Test and the English examination.

Back in 1951, when our records with the College Entrance Examination Board begin, the mean score of entering freshmen in the verbal aptitude exam was 578; today it is 688. That score of 688 puts our freshmen in the 97th percentile of all scores nationally. Back in 1951, the mean score of entering

"The Humanities at Caltech" has been adapted from a talk given by Dr. Paul, professor of history, to visiting high school teachers on Students' Day at Caltech, December 4, 1965.

freshmen in the English exam was 565; today it is 671, which puts our freshmen in the 92nd percentile of all scores nationally.

A study that is now in process in our Admissions Office suggests that our entering freshmen are higher in verbal aptitude than the freshmen at some of the most famous privately endowed liberal arts colleges in the country. Most of the colleges whose students have higher verbal aptitudes than ours are women's colleges or at least co-ed. I would not dare to speculate about what this means for the future of our nation.

The Caltech boy today

The Caltech boy as we see him today is sincere, eager, and young. Socially he is sometimes younger than most of his chronological age group. He has disciplined his mind into an effective instrument. He writes extremely well. Although he is less sophisticated in matters of politics, literature, and social issues than the best students at good liberal arts colleges, he catches on quickly. He is fun to teach — because he is responsive and rewarding.

Because these boys are so good, they deserve the very best. Anything less would be a breach of faith with the boys themselves, and with the parents and high schools that have sent the boys here.

Since we do feel this way about our job, we have been constantly striving to improve our work in the humanities courses, including both the courses that the boys are required to take and those that they may elect. (I should perhaps explain that a boy spends between 20 and 25 percent of his time in courses offered by our division.) Statistically I can give you a rough measure of the extent of change in the humanities by comparing the Caltech catalog published in 1947, the year that brought me to Caltech, with the current catalog. In the autumn of 1947 we had a humanities faculty of 25; today we have 45. In 1947 we offered a total of 42 courses; today we offer 80. And yet our undergraduate student body has changed very little in size. The additional men and courses represent our attempt to give the student a wider choice and richer offerings.

We are an expensive division to maintain. One of the several traditions that I found here when I came was that we do nearly all our teaching in relatively small classes — the average would be about 20 students per class. Obviously, this makes for a high cost per student. Another tradition is that nearly all of our teaching is done by the regular, full-time humanities faculty. We have no teaching assistants, and only 6 of the 45 humanities teachers this year are instructors who are still doing graduate work on the side.

This means that from the moment a freshman enrolls in History 1 and English 1, he finds himself in a relatively small class that is taught by someone who knows his subject and wants to teach it. What is more, another tradition that I found when I came here was that of good teaching. As classroom performers our humanities staff has always won high marks from its student audiences. Perhaps this is why, through the years, the humanities teachers have been especially close to the students in relationships outside of the class. It is a common experience to find the boys coming to one of their humanities teachers for advice on all sorts of questions that have nothing to do with classes. Like the Ancient Mariner, the worried freshman or sophomore stoppeth his English or history teacher to talk about himself (his favorite subject), or some scheme he has dreamt up, or the war in Asia, or his shy uncertainties about girls.

Still one more tradition that I found well established when I came here in 1947 was that the core of the humanities program was literature and history, with some economics. We offered a few other courses in those days, such as philosophy and psychology, but the variety was not great once you got outside literature and history. Today we still think that literature and history are central to man's ability to understand himself, because they represent the accumulated wisdom and the accumulated esthetic sense that make up modern culture. And we have always appreciated the significance of economics.

Division name change

But we have been aware also that it is possible to study modern society by processes of formal analysis based on the social and political sciences. Most of our new courses have been created in order to give the students a chance to learn more about politics, economics, social change, and personality. On December 6 the faculty voted its approval of a recommendation to change the name of our division to the Division of the Humanities *and Social Sciences*. On January 10 the proposal was approved by the Institute's board of trustees. This change symbolizes in part what has already happened to the content of our courses, and in part what we confidently expect is going to happen during the next few years.

Let me outline very briefly the more important of these changes that have been taking place within the humanities division. All of these have been conceived, debated, and brought into actuality during the 15 years since the present chairman of the division, Hallett Smith, took office.

The first, in point of time, has had to do with the field of public affairs. The inspiration for action here came from Caltech's senior scientists. During the Second World War, and during the crucial decisions over nuclear weapons immediately after the war, our senior scientists – such as President DuBridge, Charles Lauritsen, Robert Bacher, and the late Richard Tolman and H. P. Robertson – became deeply disturbed over the increasing necessity for scientists to deal with questions of broad public policy. The old cloistered atmosphere of prewar science was gone forever. Our scientists felt that the education we offered our science students should be enlarged to include both formal instruction in public affairs and chances for voluntary participation in discussion groups, seminars, and research projects dealing with this vast area of governmental policy and public problems.

Today all of our seniors attend a formal lecture once a week on some major aspect of public affairs. This is a required course. In recent years the stress in it has been on foreign policy. On an elective basis, any upperclassman can enroll in courses that deal with such subjects as arms control and military security, American foreign policy, modern warfare, contemporary Africa, southeast Asia (including India and Pakistan), and the Russian economy. Outside of class any student can go to our admirable Public Affairs Room, where he will find daily newspapers and magazines from all over the world, current documents of particular importance, and carefully arranged visual exhibits that are timed to coincide with, and reinforce, the lectures in our required course in public affairs. Thanks to a grant from the Carnegie Corporation, distinguished visitors are constantly being brought to the campus to give lectures and hold seminars on big questions that concern our nation or some foreign country.

A start on the social sciences

In providing opportunities for bright young men to mature in fields related to public affairs, we have gone far. I don't think anyone could complain about the intellectual diet now available in that sector. In the social sciences, on the other hand, we are only just well started. Recently we have added an anthropologist, a cultural geographer, and another economist. At the moment we are in the market for a political scientist, and we will probably seek still another economist, more political scientists, another psychologist, and another anthropologist or a sociologist.

We are tending to link up our developing efforts in the social sciences with our recently established work in public affairs. Thus, our cultural geographer and our anthropologist are both African specialists, and we expect to specify that some of the additional social scientists likewise have their geographical specialty in Africa, so that we can focus our strength instead of scattering it thinly.

Experiments with the fine arts

All this talk of public policy and social science does not mean that we are forgetting our original dedication to fields that are more clearly "humane." Let me cite our modest but very fruitful experiments with music and the fine arts. In both instances we face the very practical problem that there isn't room in the course schedule for much formal instruction in those two fields, however much we may wish to the contrary. Accordingly, we have worked out a combination of formal courses and voluntary participation. The cultural resources of the Pasadena area are such that we have succeeded in borrowing the part-time services of an excellent teacher of music and an equally good man in fine arts. Each of these offers a course and is winning an enthusiastic response from a small group of students. But beyond that we put up, in the humanities building, small traveling art exhibits that are open to all who wish to see them. We have a regular concert series in the humanities building, mostly of chamber music, and there are big concerts of all kinds in the handsome new Beckman Auditorium. In addition, we have a large record collection in the humanities library. Any boy can check out records just as he checks out books. Finally, there is a "musicale" room in which good listening equipment is available for any boy who doesn't own his own.

In the field of music, the student response has been great. There seems to be a definite correlation between possession of a scientific or mathematical mind and enthusiasm for music. This has been reinforced very strongly by the current craze for hi-fi equipment. Even boys on scholarships seem to find the money to buy parts for hi-fi sets. Even the boys who are in academic difficulty seem to find time to assemble the hi-fi sets. Each designs and builds his own set and is fully convinced of the superiority of his machine over that of any of his neighbors. The worst of it is that they turn up their equipment full blast in order to drown out competition. Mozart competes with classical New Orleans jazz.

Less of a novelty, but at least as important, has been our determination to strengthen those three fields that traditionally have formed the central concern of the humanities division: namely, literature, history, and economics. After months of de-

bate, the faculty and the trustees finally took a most important step last winter when they voted that, for the first time in its history, Caltech would start granting undergraduate degrees in non-scientific fields. The only fields authorized so far are these three. We hope to add government – political science – within a few years, as a fourth field. At the moment we have neither the manpower nor the library resources to justify a major in government.

Too young to be sure

Behind this very significant change lies our formal recognition of a condition that has bothered us increasingly for a number of years. We know that our students are exceedingly bright and that they are easily capable of doing distinguished work in fields outside of science. But we also see mournful proof each winter that some boys commit themselves to science when they are too young to be sure of the wisdom of their choice. Suppose a boy who comes here to be a physicist discovers that college science is quite different from high school science and that what is really appealing is history or economics. In the past such students have had little alternative but to transfer to some other university, or else drag out an unenthusiastic career here at Caltech. Either solution involves wasted time, frustration, and a good deal of emotional strain.

Henceforth another alternative will be open to such students. They can remain here but major in a non-scientific field. The number of students choosing to so major will always be small. After all, the justification for Caltech is its distinction in science. We will continue to admit primarily upon the basis of an applicant's aptitude for science or engineering. But we will now give the boys a chance to change their minds after they get here. We believe deeply that these boys are too good to be wasted in frustration or lost purpose.

Establishing majors in the humanities is making it necessary for us to enlarge our teaching staff in the three fields of English, history, and economics, but we are using the additional manpower in ways that will benefit the whole student body, not just the very small number who will specialize in our disciplines. Our plan is to have the new hands teach in the basic courses as well as in the small, advanced ones. For example, this year we are beginning an experiment in freshman instruction. Our instructors have always complained that they have an inadequate number of class hours in which to do justice to their subject, and that the students don't have time to read deeply enough. This year, at the end of the first term, each freshman, as he finished English 1 and History 1, was required to choose between those two subjects for the remainder of the year. All of the time formerly divided between the two fields is being combined for the remaining two-thirds of the year, so that a boy will study either English or history, but not both. We are thus deliberately sacrificing breadth in order to make possible depth. We think it is important also to leave the choice to the student. Today's college student is a person who wants to have a say in the determination of his career, even if sometimes he makes mistakes.

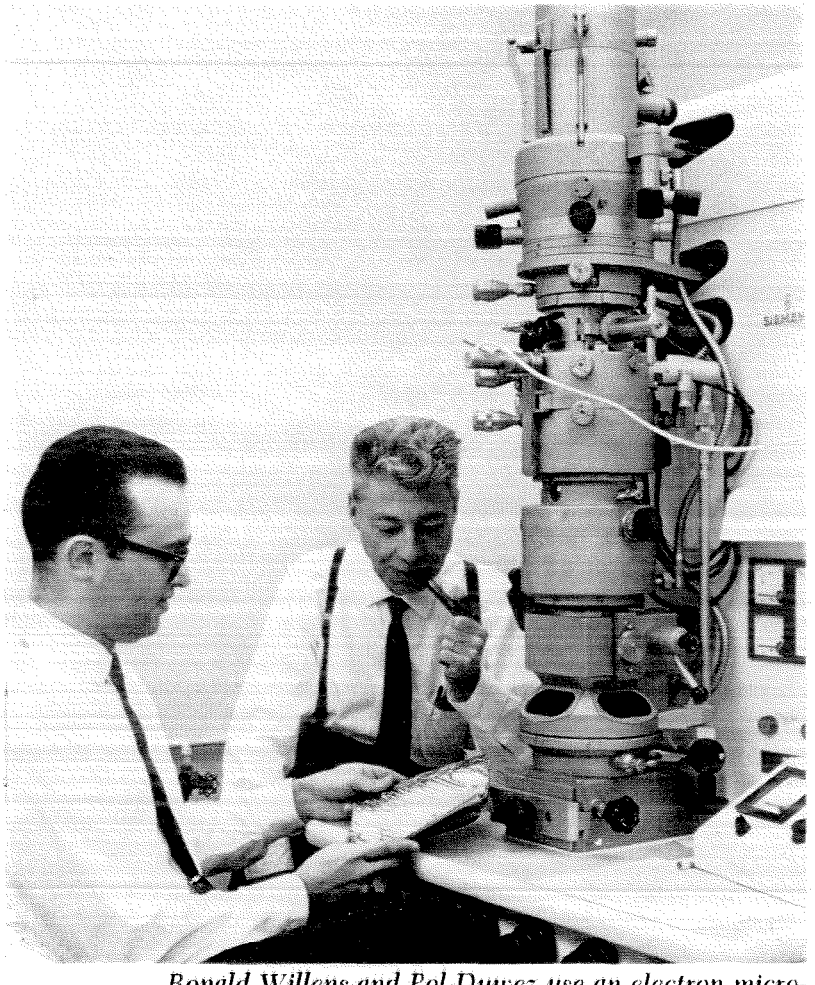
At the sophomore level we are trying another experiment. Hitherto we have required all sophomores to take a survey course in American history. The only exception has been that for years we have run a totally separate class for 15 honor students, the brightest boys in the sophomore class. This year we are proposing a different scheme. We have greatly increased the number of upperclass elective courses in American history, and we have offered 70 of the brightest of last year's freshmen the option of stepping directly into these advanced electives, instead of going through the regular survey course routine. Virtually every one of the 70 accepted this new option with eagerness, even though traditionally the sophomore survey has been a well-liked course. The one doubt I had about this plan was that the morale of the 130 students who would be left in the survey course might be poor, but the three men teaching the survey course say this has not been the case. The explanation is partly good teaching in the present survey course, and partly the fact that the three men running the course have had the wisdom to raise the whole level of the survey course coincidentally with the inauguration of the new elective scheme.

Challenge and responsibility

There are other innovations that I could describe, but I think I have said enough to demonstrate that the humanities division is not lethargic. Indeed, we are doing so much all at once that I'm sure we will find, presently, that some of our departures are mistakes. But it is better for us to risk a moderate degree of error than to sit here complacently. There are two compelling forces that are driving us forward. One is the challenge of teaching the brightest and most rewarding young minds in America. The other is the responsibility for preparing these young men to live in an incredibly difficult world. This is not an easy assignment, but it is one in which we will succeed if the nation's high schools will continue to send us the fine young men who now fill our classrooms.

Rapid Cooling: A Way to Make Unusual Alloys

"Freezing" molten mixtures very fast can produce new materials with some unexpected properties



Ronald Willens and Pol Duwez use an electron microscope to check the structure of alloys made with the rapid cooling technique.

A new technique for metallurgical research, developed at Caltech, is producing some remarkable new alloys. By cooling molten material so fast that it doesn't have time to crystallize normally, Pol Duwez, professor of materials science, and Ronald Willens, assistant professor of materials science, can create thin foils of materials with some very unexpected properties.

The latest in a series of new alloys is a "metallic glass," composed of palladium and silicon. It doesn't have a crystal structure, but still has metallic properties. For example, this amorphous substance has electrical resistivity that is nearly constant over a temperature range from a fraction of a degree to about 375° K. Moreover, it can be made ferromagnetic with the addition of a small amount of iron, cobalt, or nickel. Crystalline alloys, too, that have been rapidly cooled often turn out to have properties markedly different from those they would have if cooled slowly. For example, a gold-germanium alloy obtained by rapid cooling is superconducting at 1.6° K, although neither constituent nor the alloy itself is superconducting normally. Another new alloy, a high-temperature phase of tungsten carbide, was found to be superconducting at 10° K, although it too would not normally be.

While it is true that amorphous alloys with metallic properties had been produced previously by vacuum deposition of the components on a target maintained at liquid helium temperature, they were

stable only at quite low temperatures. The palladium-silicon glass is stable indefinitely at temperatures up to about 200°C. When heated, it changes to what is probably a transition crystalline phase at about 300°C.

Analysis of structure

That the alloy is truly amorphous has been shown with electron microscope photographs. The photographs, which have an effective resolution of about 30 angstroms for metallurgical work, do not show any discrete crystals; the interatomic distances involved in crystal formation make it unlikely that any could exist and not be seen. Also, electron and x-ray diffraction patterns confirm the electron microscope observations.

The amorphous palladium-silicon is perhaps an extreme example of the possibilities of rapid cooling; crystalline alloys with unusual structures are also of great interest. Moreover, they are much more likely to result from rapid cooling. Amorphous structures are generally the most unstable form and are much more difficult to produce. The crystalline alloys fall into two general classes. In one, the solubility of one metal in another can be greatly increased; in the other, new intermediate crystal phases, impossible to produce through normal equilibrium cooling techniques, can be made. Both may be quite stable at the relatively low level of room temperatures.

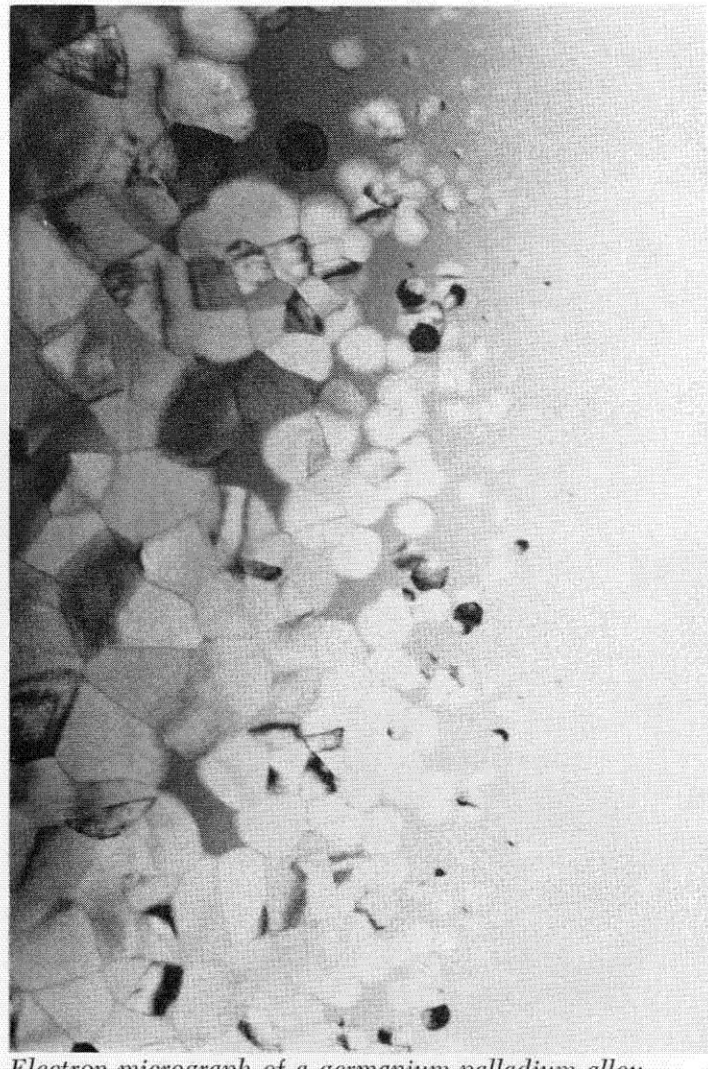
Rapid cooling technique

Two different techniques are being used for rapid cooling; they are dubbed the "gun" and the "piston and anvil" methods. The object is the same for both of them — to cool the molten material so quickly that the unoriented atoms in the liquid state are "frozen" in position, or are at least frozen into some unusual crystal structure. The method of cooling is to force the molten material to spread over a relatively cool surface very fast (on the order of a few thousandths of a second). The surface absorbs heat from the liquid, cooling it at a rate of more than several million degrees per second. However, because the liquid must be spread very thinly to achieve such high rates of cooling, the size of the foil that can be made with this process is limited.

The gun technique uses a shock tube to impart high velocity to a drop of molten material which is "shot" downward onto a curved copper strip. The drop impacts at a glancing angle, acquiring a radial acceleration that spreads it out on the copper. For lower quenching temperatures, the copper strip can be submerged in liquid nitrogen. The foil produced is about one centimeter wide and three or four centimeters long. Thickness may vary from about one-tenth to several microns. However, the thickness is not uniform, which limits the extent of tests that can be performed on the foil. Tests such as yield strength and tensile strength cannot be made.

The piston and anvil method does produce uniformly thick foils (about 45 microns thick). In this case the liquid is spread over two flat, heat-absorbing surfaces by the force of their impact, which occurs just as a drop falls between them. The action is initiated as the falling drop is sensed photoelectrically.

The range of possibilities of this technique is very broad. With the equipment now able to achieve temperatures of about 4000°C, rapid cooling of nearly any compound is possible. The work has been supported by the Atomic Energy Commission.



Electron micrograph of a germanium-palladium alloy, showing the transition from amorphous (right) to crystalline material. The left side is thicker, so it cooled more slowly and crystallized. Magnification: 54,000.

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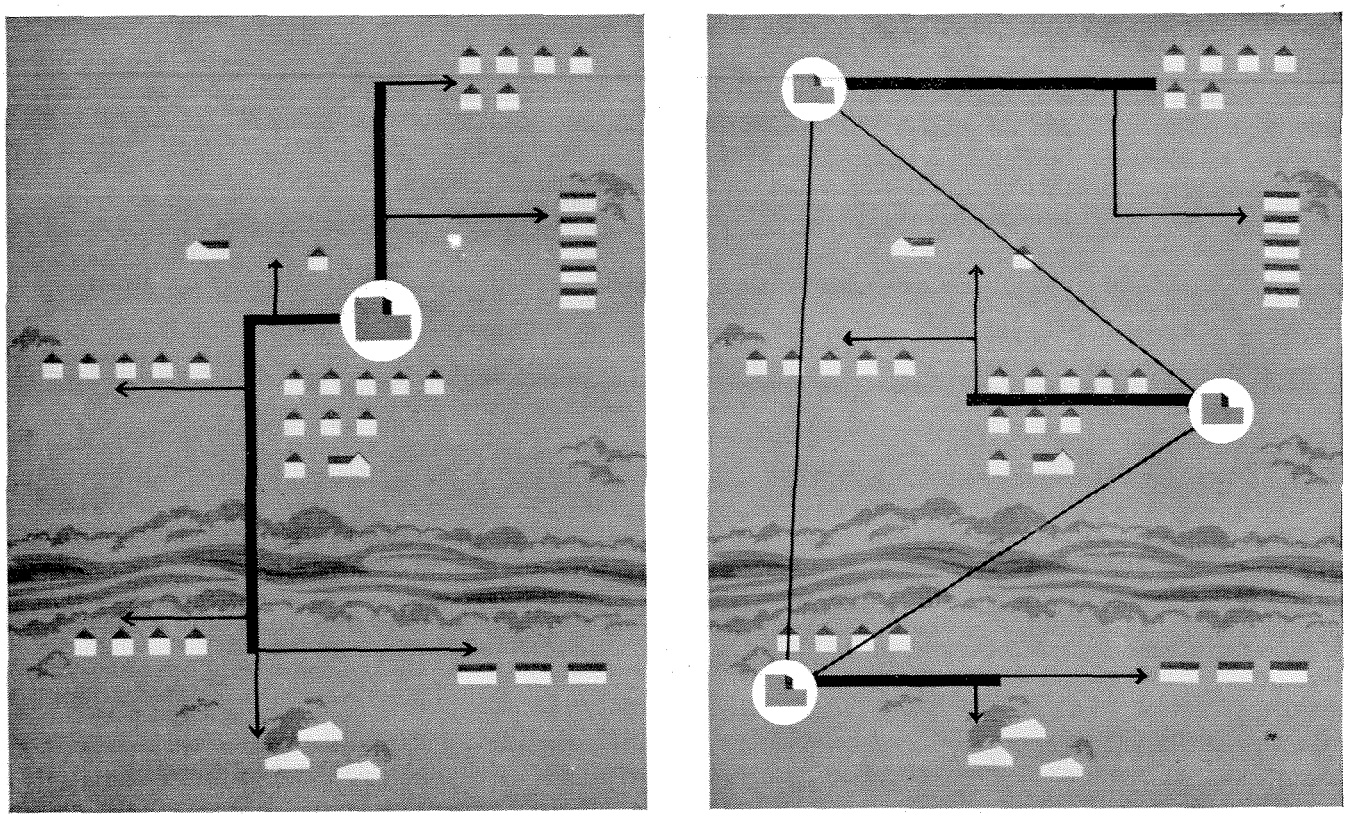
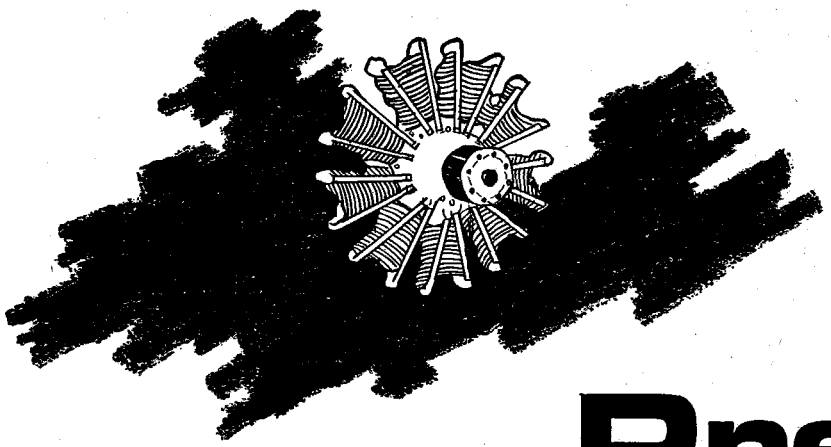


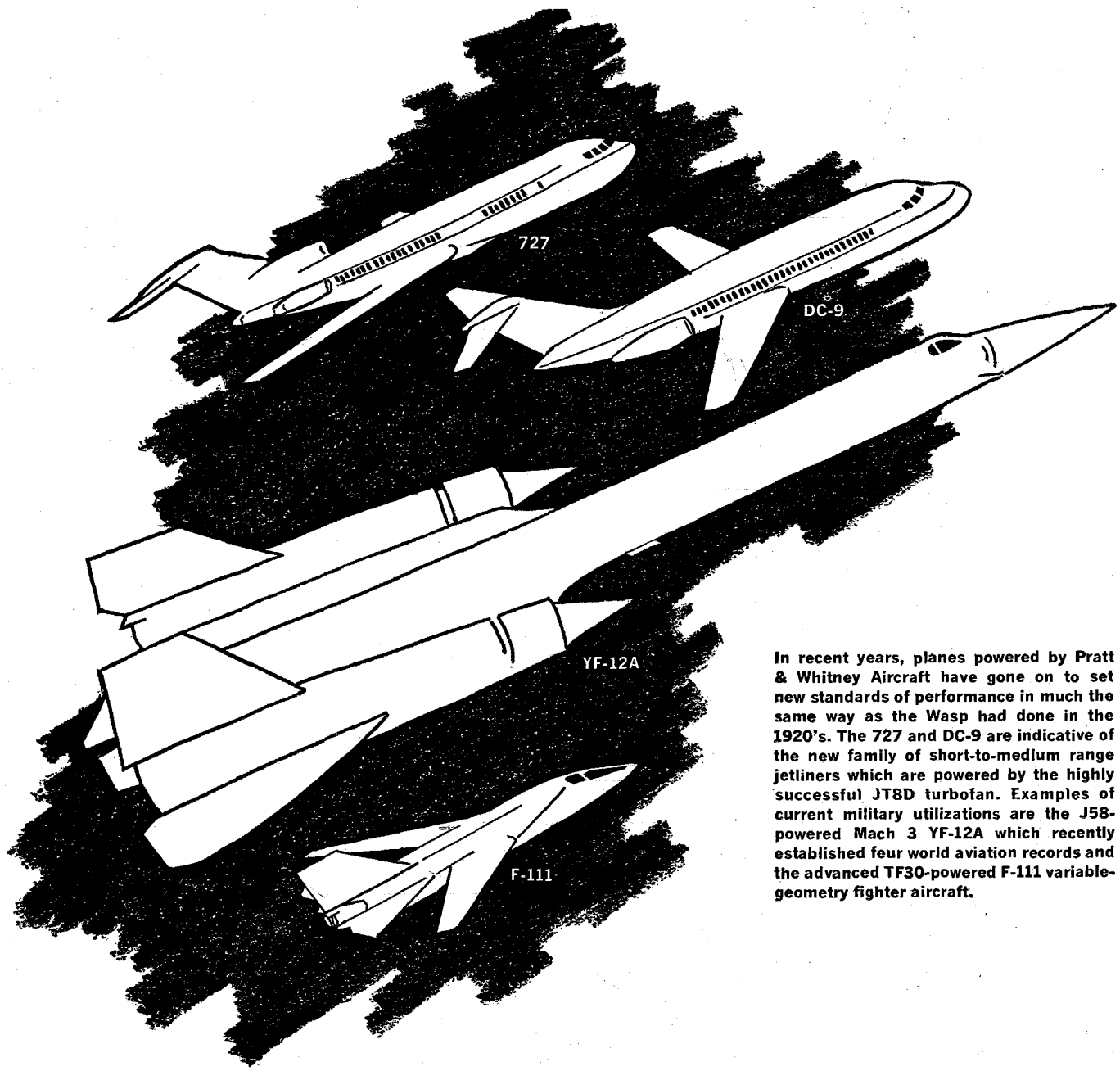
This? In this hypothetical geographical area, communications could be supplied with one large telephone switching office and a network of cables (left), or with three smaller offices and a different network (right). Many other combinations of offices and cable networks might be possible. This situation, although hypothetical, is typical of the complex telephone engineering problems that are being solved with the aid of computer programs designed at Bell Laboratories. **Or this?**

Past



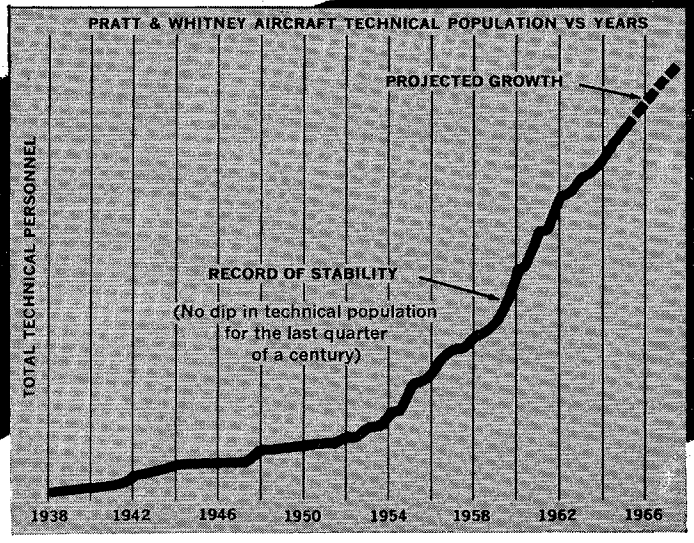
The Company's first engine, the Wasp, took to the air on May 5, 1926. Within a year the Wasp set its first world record and went on to smash existing records and set standards for both land and seaplanes for years to come, carrying airframes and pilots higher, farther, and faster than they had ever gone before.

Present



In recent years, planes powered by Pratt & Whitney Aircraft have gone on to set new standards of performance in much the same way as the Wasp had done in the 1920's. The 727 and DC-9 are indicative of the new family of short-to-medium range jetliners which are powered by the highly successful JT8D turbofan. Examples of current military utilizations are the J58-powered Mach 3 YF-12A which recently established feur world aviation records and the advanced TF30-powered F-111 variable-geometry fighter aircraft.

Your and the Future



Take a look at the above chart; then a good long look at Pratt & Whitney Aircraft—where technical careers offer exciting growth, continuing challenge, and lasting stability—where engineers and scientists are recognized as the major reason for the Company's continued success.

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CLARK BLANCHARD MILLIKAN

(1903-1966)

Clark B. Millikan, professor of aeronautics and director of Caltech's Graduate Aeronautical Laboratories, died of a heart attack at the Huntington Hospital in Pasadena on January 2. He was 62 years old.

A graduate of Yale University in 1924, he received his PhD in physics and mathematics at Caltech in 1928. He joined the Caltech faculty the same year, became full professor of aeronautics in 1940, and in 1949 was appointed director of the Guggenheim Aeronautical Laboratory. His title was changed in 1961 to director of the Graduate Aeronautical Laboratories. He was a member of the executive committee of the Institute from 1945 to 1947, and had been chairman of the Institute's Jet Propulsion Laboratory committee since 1949.

A pioneer in the development of multi-engine, high-altitude airplanes, jet propulsion, and guided missiles, Clark Millikan's scientific contributions began with his development of the large wind tunnels at Caltech and the associated Southern California Cooperative Wind Tunnel in Pasadena, which Caltech operated for five major aircraft companies. This was one of the first uses of wind tunnels as a detailed engineering development tool for the development of aircraft, and under Clark Millikan's direction these facilities were carried to a high state of effectiveness. The Caltech wind tunnels helped solve design problems for more than 600 types of aircraft, including virtually all of America's military aircraft, and several military missiles in World War II.

Clark Millikan's further contributions are represented by the large-scale engineering activities

which grew out of the research in the aeronautics department at Caltech in the area of rockets and guided missiles. This work during World War II led to the establishment of the Jet Propulsion Laboratory, the Aerojet-General Corporation, and to many other related activities in the modern guided missile and space industry.

For his work for the Air Force, Army, and Navy in aeronautics and ballistic missiles during World War II, he received the U.S. Presidential Medal for Merit and the British government's King's Medal for Service in the Cause of Freedom.

He was a member of the Air Force Scientific Advisory Board, and also of the Scientific Advisory Committee of the Army Ballistic Research Laboratory. He was an honorary fellow of the American Institute of Aeronautics, of which organization he was president in 1937, and was a fellow of the Royal Aeronautical Society of Great Britain, the American Academy of Arts and Sciences, and the American Physical Society.

He was elected to the National Academy of Sciences in 1964 and was a founding member of its offspring, the National Academy of Engineering.

In accordance with the wishes of the Millikan family, contributions to Caltech in memory of Dr. Millikan are being placed in a special fund to be known as the Clark B. Millikan Scholarship, to assist worthy students in their education.

A memorial service for Clark Millikan was held in Beckman Auditorium on January 6. Some excerpts from the tributes to him on that occasion follow.

THE SCIENTIST

by William Zisch, President, Aerojet-General Corporation

We are this afternoon memorializing a man of achievement, a man beloved among his colleagues, a man devoted to his family, a man dedicated to his country.

Clark Blanchard Millikan did great honor to his father, also world renowned. To what greater achievement can one aspire?

Seldom does the occasion occur where one has such an opportunity. Yes, but there is more—his constancy and loyal support of another of distinction, the late Theodore von Karman.

Clark's modesty could not conceal his name from being synonymous with GALCIT and all it means to each of us. His continuing encouragement and tireless efforts developed many of today's leaders in the field of aeronautics, rocketry, missiles, and space science, in industry and in the Armed Forces, in addition to academic institutions.

It is clear to me his life was guided and inspired by the principle: "What is excellent is enduring."

Our country today benefits from the fact that the first college course in rocket propulsion in the United States was taught by a man guided by the star of excellence.

The breadth and depth of his interests, activities, and talents were not restricted to the laboratory alone. Thus his inspiration and leadership in his many associations were enhanced. He was sought after as a member of corporate boards of directors in industry. He chaired many important committees dealing with the protection of our country. His vitality was limitless. His unselfish giving of himself was an inspiration.

THE FRIEND

by Philip W. Pillsbury, Yale, 1924

From Clark's favorite restaurant, Mory's in New Haven, at Yale, friends sent this message today:

"Members of the Yale class of 1924 gathered here mourn deeply the death of our beloved classmate, Clark Millikan. We honor the unaffected greatness of mind, heart, and soul which brought him the highest professional distinction and the admiration and affection of all who knew him, regardless of age, culture, and nationality. We share with all you members of his family, colleagues, and friends poignant loss and profound pride in unforgettable memory."

Clark Millikan, we salute you. You have enriched the lives of every one of us with whom you have come in contact. You have taught us your principles of life: real wisdom, humor, affection, critical ability, and judgment—a rich legacy to inherit.

THE MAN

by Lee A. DuBridge, President, Caltech

Clark Millikan was a man of many talents and many interests. He was also possessed of unbounded energy which enabled him to enter into a multiplicity of activities with zeal and enthusiasm.

Clark's distinguished father, Robert A. Millikan, the physicist, used to enjoy telling of an incident which took place about the end of World War II. A stranger, on being introduced to Robert Millikan, exclaimed:

"Oh, are you *the* Dr. Millikan?"

Being used to such questions, Robert Millikan smiled modestly. But the stranger continued:

"*You* are the great aeronautical engineer?"

Dr. Millikan's smile became a proud grin.

"Oh, no," said he, "that is my son."

Clark *was* a famous aeronautical engineer. He devoted a full 40 years of his life to the effective pursuit of his beloved profession. He was honored all over the world for his many achievements. For most

men there would have been time and energy left for no other pursuits at all.

But not so for Clark!

He also found time to be a skilled musician, a sportsman, a scholar, a devoted teacher, a well-informed citizen active in many civic organizations, a leading light in many circles in Washington, a husband and father, a great and valued member of the Caltech faculty, and a fine companion and friend to many, many people.

I first met Clark when I came to Caltech as a research fellow in 1926. He was then a graduate student in physics and mathematics, devoting a good share of his time to Professor Harry Bateman's courses in hydrodynamics and aerodynamics—courses generally regarded as the most demanding in time, energy, and in mathematical skill of any ever given at the Institute. But in them Clark was a bright star.

He enjoyed, too, his studies and his personal friendships with such men as Richard Tolman, Paul Epstein, Eric Temple Bell, and later with a host of Caltech faculty members. Most of all, Clark became attached, after his arrival in 1928, to Theodore von Karman, with whom he worked intimately for over 20 years.

Yet, even in those student days he found time for much besides study: for learning to fly (and taking his friends on some hair-raising stunt flights); for helping Albert Merrill build an airplane; for extended trips into the desert which he loved; for playing tennis—and bridge and poker; for music; and for reading—reading—reading.

Professor Clinton Judy, then professor of English, used to conduct a literary discussion group regularly at his home near the campus. Clark was one of the privileged few to be admitted to this select group. And he was one of the most active participants. Literature, both ancient and ultramodern, philosophy, history, the most abstruse ideas in economics and political science—all he discussed avidly and with deep perception. Such discussions were often continued through the week around the lunch table in the old faculty club. There I often listened with amazement to discussions far beyond my comprehension. I was just a physicist. Clark was that, too—and an erudite scholar in many other fields besides.

Music was one of his most intense lifelong loves. I do not know when Clark's musical activities began. I do know he was a member of the Yale Glee Club, and he never lost his joy in singing. Many an informal party and Sunset Club outing which I have attended in recent years was enlivened by his fine singing—and there was *no* song that he did not know, no matter how many verses it contained. I know, too, that when he was a graduate student he was already an accomplished pianist, and was still at that time taking piano lessons and playing at every opportunity.

His athletic activities were always close to his heart, too. He was a star track man at Yale. He played tennis and badminton, was a sailing enthusiast, and an inveterate swimmer. When the Caltech Alumni Swimming Pool was opened in 1954, he became its most faithful user, swimming for a half-hour before lunch every day, until he later built his own swimming pool at his home. All of these activities—musical, sports, literary, travel—which he enjoyed as a student, he continued throughout his life.

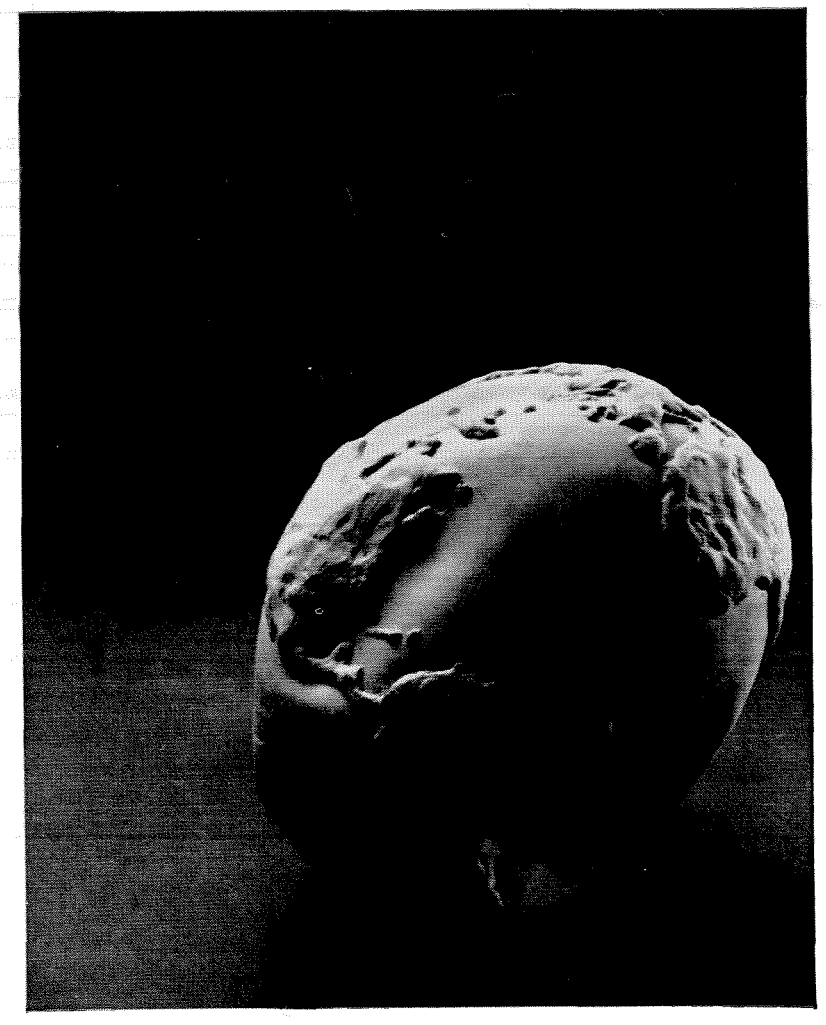
Clark will always be remembered primarily, of course, as a great scientist-engineer. He was honored by election to the National Academy of Sciences and was a founding member of the National Academy of Engineering. He was adviser to the highest levels of government, a pioneer in aeronautics and in space, a founder and the guiding spirit for many years of the Caltech Jet Propulsion Laboratory and of the Aerojet Corporation.

Yet, to most of us he will be remembered as a friend—congenial, gay, ebullient, untiring. If he had a fault, it was that he would never admit that he was tired or sick or needed a rest. Just last week, as he lay helplessly in his hospital bed, he muttered unhappily, "I guess I am just a lazy bum."

Like all men, he had his tragedies, his disappointments, his frustrations. But he knew that life was worth living—that joy came in work, in service, in friendship, in love. During recent months he must have known that the illness he suffered would never leave him. Had he spared himself, he might have lived a little longer. But that was not in his makeup. He would not even admit to his friends that anything was wrong. Life was to be lived, and it was to be lived intensely, devotedly, and with joy. He could not have tolerated being an invalid.

He will be sorely missed in many circles—in the Sunset Club, at the Lost Angels' Camp in the Bohemian Grove, among his wide circle of friends. He will be missed greatly at Caltech where, for far longer than any other person, he participated in and guided the activities of one of the world's great aeronautical centers. His kindly wisdom will be missed on the campus and in many other quarters. Most of all, he will be missed by his own family, to whom our sympathies go in full measure.

He will be missed—but not forgotten. His memory will live forever in the hearts of his students, his colleagues, in the annals of the institution to which he devoted his life.



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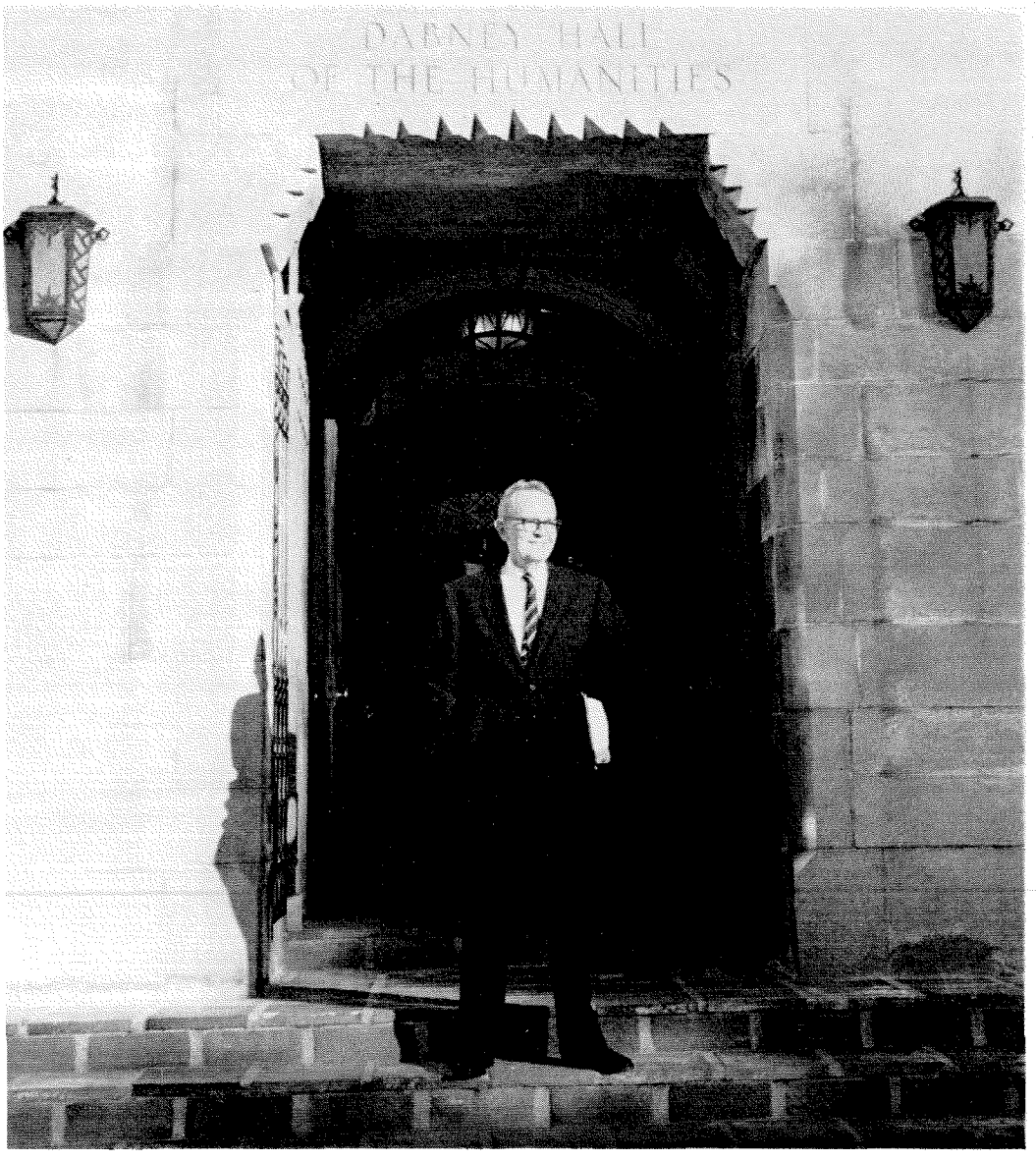
February 2, 3



The Month at Caltech

Professor Emeritus

Roger F. Stanton, professor of English, became professor emeritus this month after 40 years as a member of the Caltech faculty.

Dr. Stanton came to the Institute in 1925 as an instructor in English after receiving degrees from Colgate University and Princeton. He returned to Princeton in 1929 to get his PhD and resumed teaching at Caltech in 1931.

From 1949 to 1963 Dr. Stanton served as director of Institute libraries. Although the appointment was originally "just for a year," his extended service as director involved him deeply in plans for the new R. A. Millikan Memorial Library, to which he gave much time and study.

Dr. Stanton's love of music and the theater has been expressed in numerous contributions to Caltech and the community. For many years he was co-director of Caltech undergraduate plays, an actor at the Pasadena Community Playhouse, and a member of the board of directors of the Coleman Chamber Music Association.

"Roger Stanton, in his forty years' service on the Caltech faculty," says Hallett Smith, chairman of the humanities division, "has exhibited the versatility and the grace under pressure which the humanists of the Renaissance recommended as the highest virtues. As a teacher and counsellor of students, as administrator of student loans, as director of Institute libraries, he has made valuable contributions to many different areas of Caltech education. His colleagues in the humanities division will miss his daily presence in Dabney, but congratulate him on his well-earned leisure and his distinction as Professor Emeritus."

And Social Sciences

The *Division of the Humanities and Social Sciences* became the official title of the division of humanities on January 10 when Caltech's board of trustees approved the name change voted by the faculty at their December 6 meeting.

The division, which is offering undergraduate degrees this year for the first time in the Institute's 74-year history, proposed the new name in order to more accurately describe the fields it covers.

Honorary Doctorate

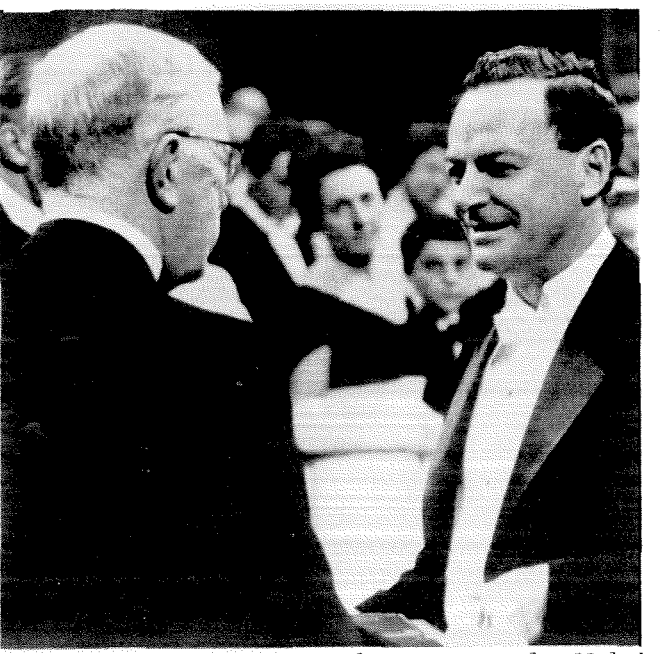
Max Delbruck, Caltech professor of biology, received an honorary doctorate from the University of Copenhagen on November 25 at the commemoration of Neils Bohr's 80th birthday anniversary. Four other former associates of Dr. Bohr were honored at the ceremonies.

Dr. Delbruck's citation acknowledged "the great significance your researches have had for the development of modern virology," and the "new and deeper meaning to virus research, first and foremost through the development of precise quantitative methods."

A photograph of the occasion (below) was obtained by Morens Westergaard, Gosney Research Fellow in Biology at Caltech last year and now at the Carlsberg Laboratory in Copenhagen. It was sent to Dr. Delbruck with the following caption:

"Professor Max Delbruck of Caltech, known as a staunch anti-royalist, yesterday refused to shake hands with His Majesty King Frederik the Ninth of Denmark at a reception at the Copenhagen University. The distinguished scholar ostentatiously kept both hands behind his back, ignoring the friendly, outstretched hand of the king. Embarrassment and sadness are reflected in the faces of Professors Heisenberg and Rosenfeld standing nearby."

King Frederik of Denmark congratulates Max Delbruck on his award at ceremonies in Copenhagen.



King Gustav Adolf of Sweden presents the Nobel award to R. P. Feynman at ceremonies in Stockholm.

Feynman Dinner

The Caltech faculty honored its newest Nobel Prizewinner on January 7 with a dinner at the Athenaeum. Richard P. Feynman, Richard Chace Tolman Professor of Theoretical Physics at Caltech, who was co-winner of the 1965 prize in physics, had just returned from Sweden, where he received the award at ceremonies on December 10. At the faculty dinner he regaled his Caltech colleagues with an account of the perils and protocol that come along with a Nobel award.

Earthquake Study

An extensive program of earthquake research, costing an estimated $137 million for a 10-year period, has been proposed by a panel of 14 prominent earth scientists.

The ad hoc committee, organized at the request of President Johnson by the Office of Science and Technology following the Alaskan quake of 1964, includes among its members George W. Housner, Caltech professor of civil engineering and applied

continued on page 30

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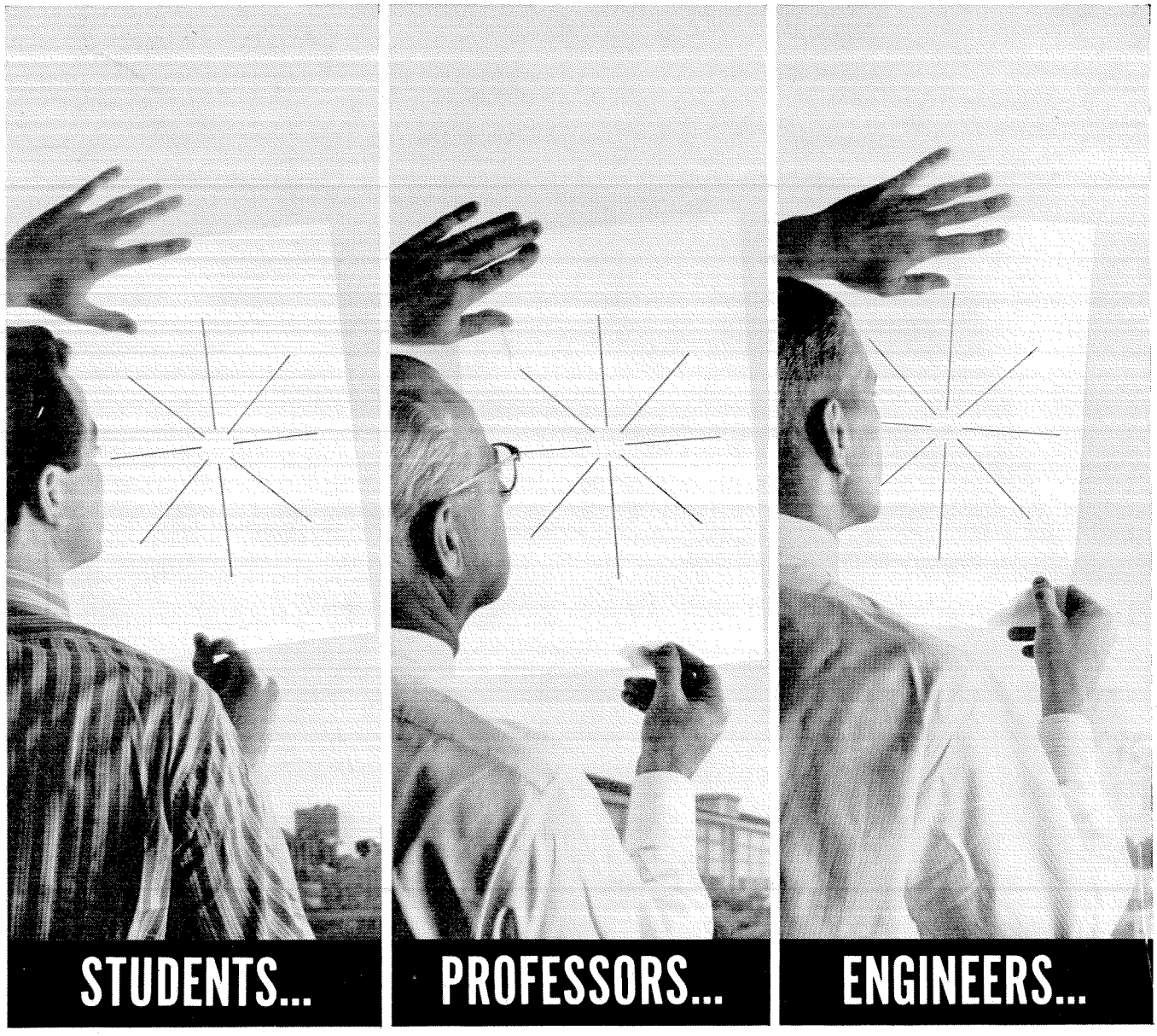

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mechanics, and Hugo Benioff, professor of seismology, emeritus. The panel is headed by Frank Press of MIT, former director of Caltech's Seismological Laboratory.

Their report, which offers hope of predicting major earthquakes hours, days, or weeks in advance of their occurrences, and of greatly reducing casualties and property damage, is a detailed scientific plan calling for:

1. Extensive geological and geophysical surveys of fault zones.
2. Laboratory and theoretical studies of mechanisms of fracture and creep of rocks under realistic pressures and temperatures.
3. Research in prediction theory as applied to geophysical phenomena.
4. Augmented research in earthquake engineering.
5. The development, installation, and operation of new instruments for monitoring earthquake faults. Clusters of these instruments, some to be placed in holes 10,000 feet deep and located along major fault systems in the California-Nevada area and in Alaska, will register stresses, strains, and tilts in earth strata, and changes in gravitational, electrical and magnetic fields.

The projected program is now being studied by various government agencies — the Army Engineers, the Geological Survey, the Coast and Geodetic Survey, the new Environmental Science Service Administration, and the National Science Foundation.

Earthquake Engineering

George Housner is chairman of another earthquake study group — The Committee on Earthquake Engineering Research — of 12 distinguished U.S. engineers chosen by the National Academy of Engineering to make a year's study and report on earthquake engineering research. Other Caltech members are Donald E. Hudson, professor of mechanical engineering and applied mechanics, and Ronald F. Scott, associate professor of civil engineering. Formed in reaction to the costly 1964 earthquakes in Alaska and Niigata, Japan (damages $350 million and $1 billion), the committee has been asked to report on the present state of knowledge on the subject, to propose a 10-year research program, and to make specific recommendations for methods of furthering the development and dissemination of knowledge in the field.

Conference on Invertebrates

An international conference on the nervous systems of invertebrates, sponsored by Caltech and the National Institutes of Health, was held on campus January 10-12. More than 30 world authorities on the subject attended the sessions.

C.A.G. Wiersma, Caltech professor of biology, who was organizer of the conference, said the sessions were planned to stress the necessity of studying invertebrate nervous systems at all levels of development and complexity, not only to obtain insight into how they function, but also to explore the value of such studies in learning more about the nervous systems of mammals.

Fifty Years at Caltech

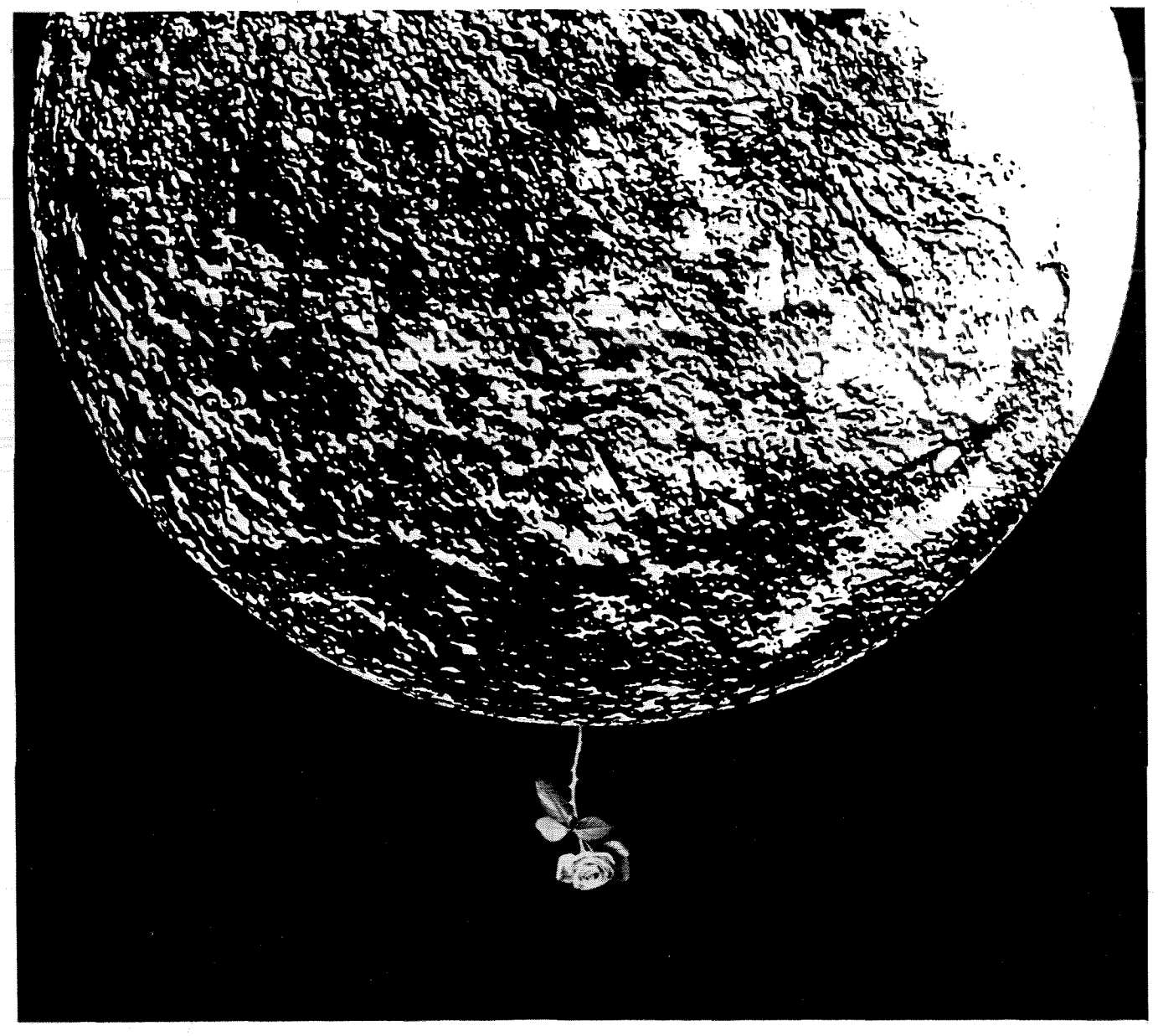
The 50th anniversary of the Caltech YMCA will be celebrated on February 25 in Beckman Auditorium. The program includes songs by the Caltech Glee Club; an illustrated history of the Caltech Y by its executive secretary, Wes Hershey; a dramatic musical by Kent Clark, professor of English; and a talk by President DuBridge.

Staff Changes

Ivan F. Betts, who has served as assistant treasurer of Caltech since 1962, has been elected treasurer of the Institute by the board of trustees. He will continue to be responsible for the administration of Caltech's investment properties and for trust and estate property matters.

Lee Stockford, sales administrator and instructor in employment psychology, is the newly appointed assistant director of management development at Caltech's Industrial Relations Center. Stockford has taught at the University of Southern California, Occidental College, Los Angeles State College, and San Francisco State College. He also has served as corporate industrial relations advisor for the Lockheed Aircraft Corporation.

Ethel H. Rogers, administrative assistant to the director of physical plant operations and Caltech's longest employed non-academic staff member, retired this month after 36 years with the Institute. Mrs. Rogers was secretary to William B. Munro of the humanities division when she first came to Caltech in 1929. She also was the first secretary of the Caltech Management Club.



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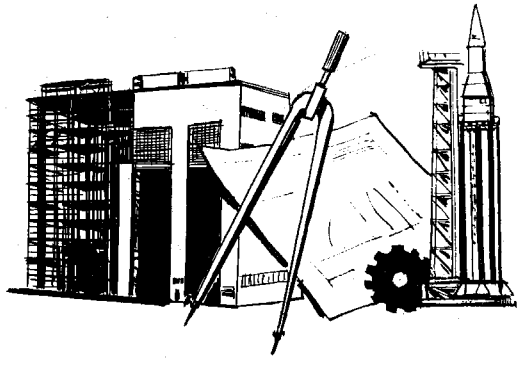

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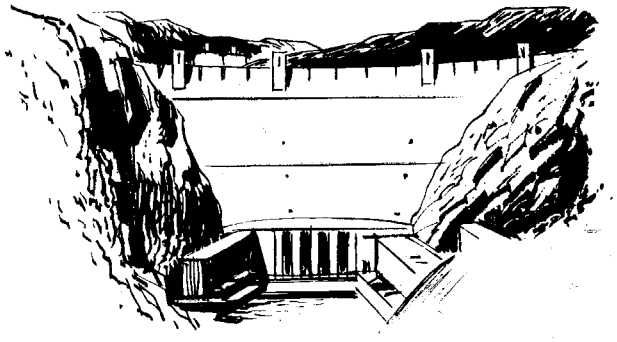

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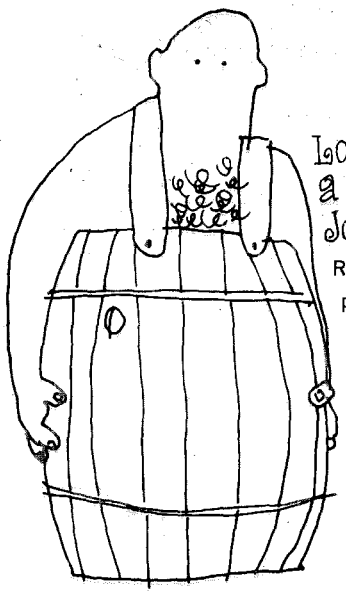

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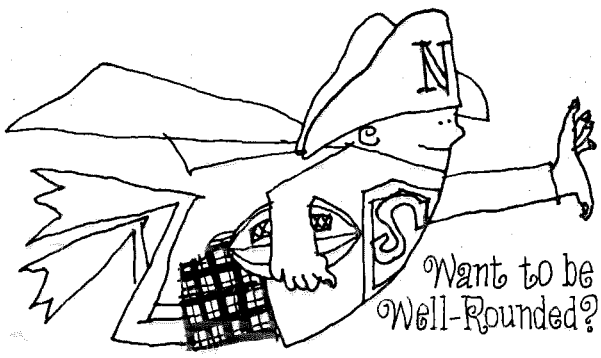

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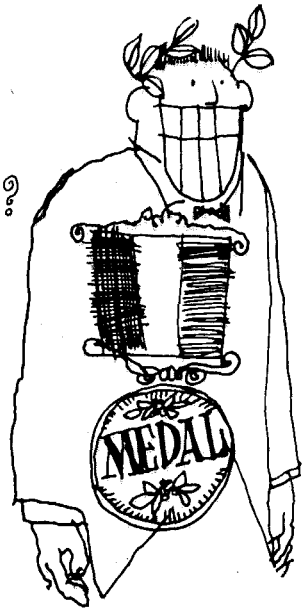

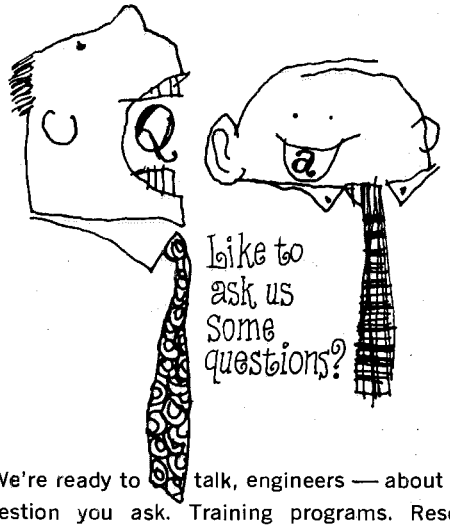

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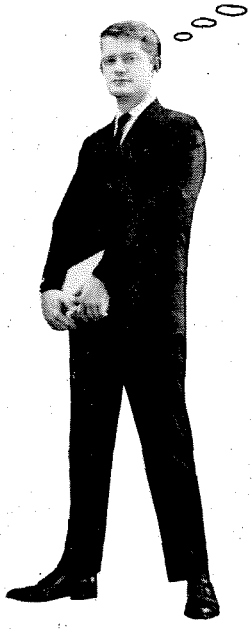

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Personals

1922

HOWARD G. VESPER, vice president of the Standard Oil Company of California and a member of Caltech's board of trustees, has been appointed by President Johnson to the general advisory committee for the AEC.

1927

HALLAM E. MENDENHALL, PhD, retired from the Bell Telephone Laboratories last April after 36 years of service with the Bell System. He was executive assistant to the assistant vice president in charge of university relations. Mendenhall joined Bell in 1928 and for 22 years specialized in research and development of vacuum tubes. After 1950 he was concerned with the Laboratories' educational programs. He and his wife, Elizabeth, live in Summit, N.J. A daughter Althea (wife of KENNETH M. HATCH, MS '53) lives in Florence, Oregon; a daughter Mrs. Harry G. Spencer is in Winchester, Oregon; and his son, Edward, is in Houston.

1929

V. LYMAN HOLDAWAY, MS '30, recently celebrated his 35th year of service with the Bell Telephone Laboratories. He is currently an engineer in the company's optical device department in Murray Hill, N.J., and is a member of a group engaged in development of gas lasers. In his early years with Bell, Holdaway worked on the development of electron tubes for radio transmitters and public address systems. Later he was concerned with cold cathode tubes for telephone plants, and more recently with gas tubes for the protection of repeatered submarine cable systems.

1930

JOHN S. MURRAY has been elected president of the Standard Felt Division of the Victoreen Instrument Co. in Alhambra. Murray joined Standard Felt in 1934 as a chemist. When the firm was acquired by Victoreen in 1959, he became executive vice president and general manager of Standard Felt. In 1964 he was named vice president and a director of Victoreen.

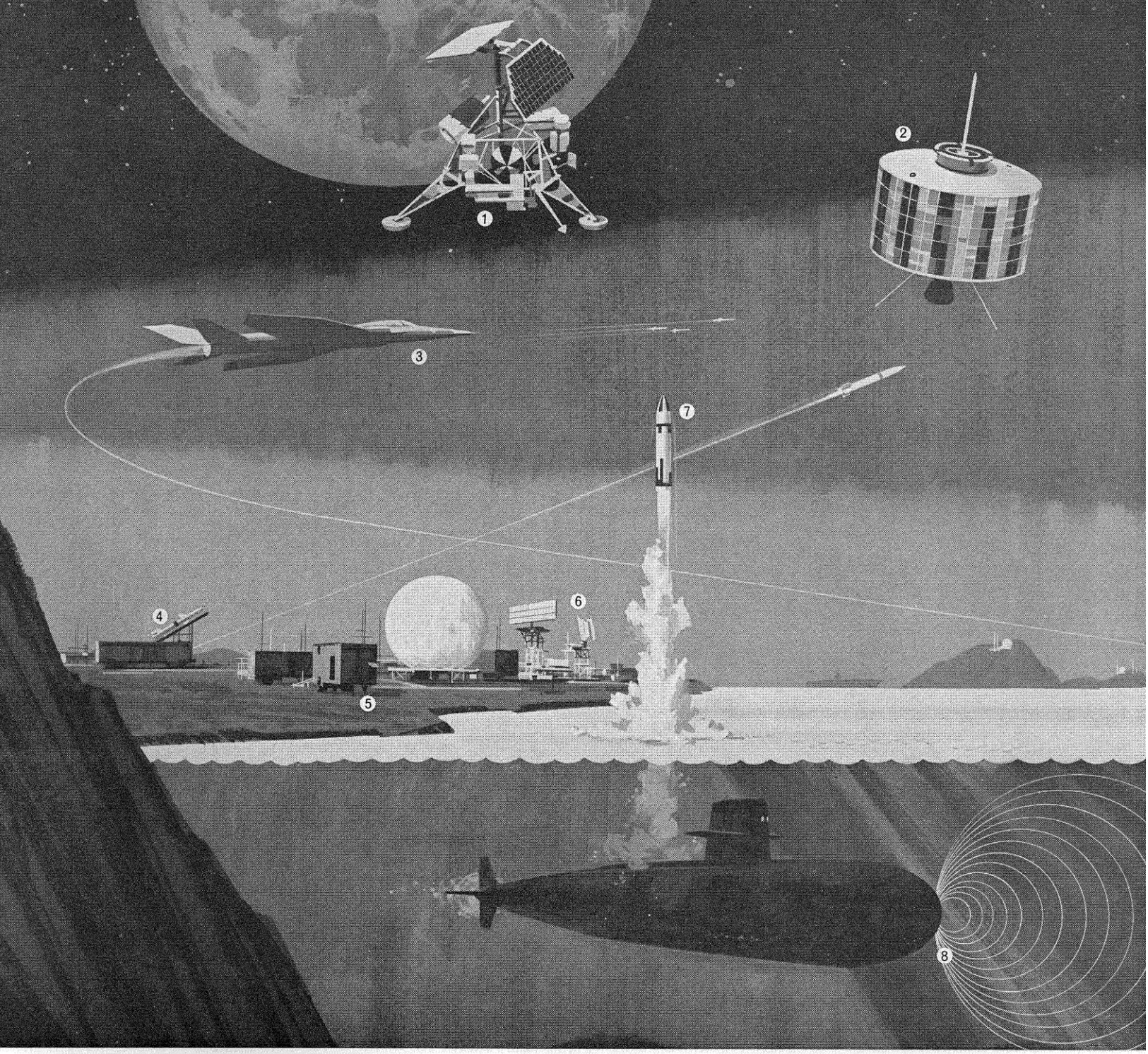
1932

SAMUEL A. GUIBERSON writes that he has been an independent oil operator since selling The Guiberson Corp. to Dresser Industries several years ago. His headquarters are in Dallas, Texas, but he is currently working in Taft, Calif.

1938

MUNSON W. DOWD, MS '46, took part in ceremonies dedicating a memorial library to his father, the late MUNSON J. DOWD '18, at the Imperial Irrigation District's new headquarters in El Centro, Calif., on Oct. 12. Munson presented a picture of his father to the IID and made a speech of thanks for the commendatory resolution voted by the Assembly of the State of California on February 10, 1965, honoring his father's service to the people of Imperial Valley and California. Copies of the resolution were presented to members of the family at the ceremonies by Assemblyman Victor V. Veysey '36. Munson J., who died just 12 days after the resolution was passed (*E&S*, March 1965), was a pioneering engineer for the IID. His books and papers were presented to the new memorial library by his wife, Neva White Dowd, as a contribution to the historical records of irrigation.

JOHN K. MINASIAN, MS '44, consulting structural engineer with an office in Pasadena, is currently acting assistant chairman of the engineering division of California State College at Los Angeles, and vice president of the State of California Board of Registration for Civil and Professional Engineers. Minasian, who has specialized in tower construction for 15



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February 17 and 18, 1966

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years, has been involved in the design of 80 towers, including the Space Needle in Seattle, launch towers for Atlas and Saturn missiles at Cape Kennedy, two television towers on Mt. Wilson, and restoration of the twin towers at the Santa Barbara Mission.

1948

EDWARD A. NORTH has been named computer operations supervisor of S.C. Johnson & Son, Inc. of Racine, Wis. He has been with the company since 1948 and has been programming supervisor for the last several years.

1953

SHELDON RUBIN, MS '54, PhD '56, has been appointed senior staff engineer for the engineering sciences subdivision of the Aerospace Corporation's applied mechanics division in El Segundo. The division provides specialized assistance to a broad range of company programs, including Gemini launch vehicles, Titan III, and defense communications satellites. Rubin joined Aerospace in 1962 as a member of the dynamics section of the solid mechanics department, and was manager of its advanced studies section just prior to his new appointment.

1956

JAN L. ARPS has been elected president of the G.E.M. Corporation of Dallas, a subsidiary of D. R. McCord and Associates, Inc., which provides management and financial assistance to new, small, technically-oriented companies. He is also president of the Arps Corporation, a patent holding company in Dallas.

1957

FRANK BORMAN, MS, recently returned from a two-week, all-expense-paid, round-the-world flight. Borman is a lieutenant colonel in the U.S. Air Force.

1959

ROBERT ROY BLANDFORD, PhD '64, was married to Mary Jane Corbett on December 18, at the Church of St. Thomas More in New York City. Bob is with the department of meteorology and oceanography at New York University.

1961

WILLIAM C. RIPKA has completed requirements for his PhD in organic chemistry at the University of Illinois in Urbana and has joined the research staff of the Du Pont Company's central research department at the experimental station near Wilmington, Del.

ALUMNI EVENTS

The Caltech Glee Club, making an Eastern tour, will be in New York and New Jersey March 20-27.

Details in February *E&S*.

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SAN FRANCISCO CHAPTER

President — Edwin P. Schlinger, '52, G. E. Vallecitos Atomic Lab., Pleasanton, Calif.

Vice-President — Dallas L. Peck, '51, U.S. Geological Survey, Menlo Park, Calif.

Secretary-Treasurer — Thomas G. Taussig, '55, Lawrence Radiation Lab., Univ. of Calif., Berkeley, Calif.

Meetings: 15th Floor, Engineers' Club, 206 Sansome St., San Francisco
Informal luncheons every Thursday at 11:45 A.M.
Contact Mr. Farrar, EX 9-5277, on Thursday morning for reservations.

SACRAMENTO CHAPTER

President — Harris K. Mauzy, '30, 2551 Carson Way, Sacramento, Calif. 95821

Vice-President — Frederick J. Groat, '24, 877 - 53rd St., Sacramento, Calif. 95819

Secretary-Treasurer — William D. Pyle, '49, 3920 Dunster Way, Sacramento, Calif. 95825

Meetings: University Club, 1319 "K" St.
Luncheon first Friday of each month at noon.
Visiting alumni cordially invited—no reservations.

Kodak

wants two kinds of mechanical engineers:

1. burning with ambition to reach manager's status as soon as possible

- **College grade-point average on the high side in technical subjects**

Secretly admitted to self at certain point in undergraduate career that the scholar's way of life is for other people *but smart enough to have kept secret from the professors who are, after all, scholars.* Diploma in, secret out.

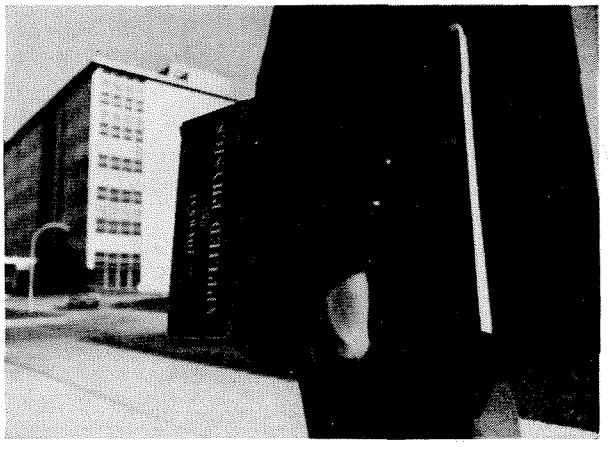
- **Seeks prosperous, highly diversified employer**

Competitive personality who wants to play on a strong, long-lasting team in the big leagues.

- **Unafraid of choices and changes**

With a mechanical engineering background, we might find him adept at keeping a troupe of welders happy on a new petrochemical project, or designing a new type of machine for the lithographic industry, or organizing a small laser-manufacturing department, or operating a large magnetic tape plant, or profitably piloting one of the world's major industrial corporations.

2. able to hold a manager's job in time but sure he wouldn't like it



- **College grade-point average on the high side in technical subjects**

Why not? The subjects were intrinsically interesting, and most of the professors proved to have a clear understanding of them.

- **Seeks prosperous, highly diversified employer**

To practice modern mechanical engineering—this is not 1936—one needs scope, contacts, and resources.

- **Unafraid of choices and changes**

With a mechanical engineering background, he might choose to take a high leap over the interdisciplinary wall into solid state physics, pull some excessively generalized equations out of a journal that others on the circulation list quickly glance at and pass along. Six months later he may have a new composition of matter on board a ship bucking the solar wind to Mars.

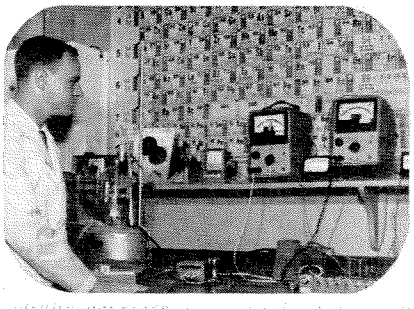
What is said here about mechanical engineers is equally applicable to chemical engineers and electrical engineers. Our expansion rate now demands technical people who, at the one extreme, are still fresh from the classroom with its benefits and, at the other, have had ten years of practice in their professions and are now ready to select a lifetime employer. We offer a choice of three communities: Rochester, N. Y., Kingsport, Tenn., and Longview, Tex. We earnestly solicit serious and honest self-descriptions addressed to:

EASTMAN KODAK COMPANY

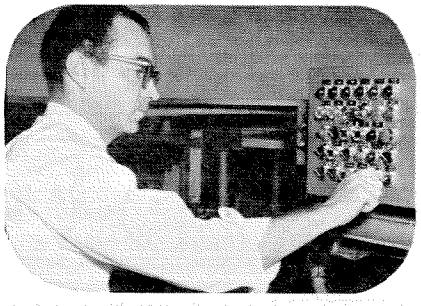
Business and Technical Personnel Department/Rochester, N. Y. 14650

An equal-opportunity employer.

ONE RESULT of product innovation is G.E.'s modern manufacturing facility in Brockport, N. Y.



OUTPUT VOLTAGES from nickel-cadmium cells are examined by engineer John Bliven, BSEE, Union College '63 on assignment at G.E.'s Battery Business Section.



PRODUCT RELIABILITY of electric slicing knife components is the responsibility of Mike Reynolds, BSME, New Mexico State, a recent Manufacturing Training Program graduate.

PRICE AND DELIVERY information on nickel-cadmium batteries is supplied by Bob Cook, BSME, Univ. of Florida '65 on a Technical Marketing Program assignment in Gainesville.

A PREVIEW OF YOUR CAREER AT GENERAL ELECTRIC:

Creating New Growth Businesses

At our Brockport, N. Y., plant, the new business of manufacturing cordless slicing knives is **rush.** So is that of the rechargeable-battery supplier, our two-year-old plant at Gainesville, Fla., which has just doubled its working area. Its sealed, nickel-cadmium batteries, in hundreds of shapes, sizes and ratings, are meeting growing customer demands in the consumer, defense, and aerospace industries—with applications from power tools to satellites. At General Electric, new ventures are a way of life. In both their formative and growth stages, these ventures call on the skills and enthusiasms of experts in more than 120 product departments—in engineering, manufacturing and technical marketing. To define your career interest at General Electric, talk with your placement officer, or write us now. Section 699-15, Schenectady, N. Y. An Equal Opportunity Employer.

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