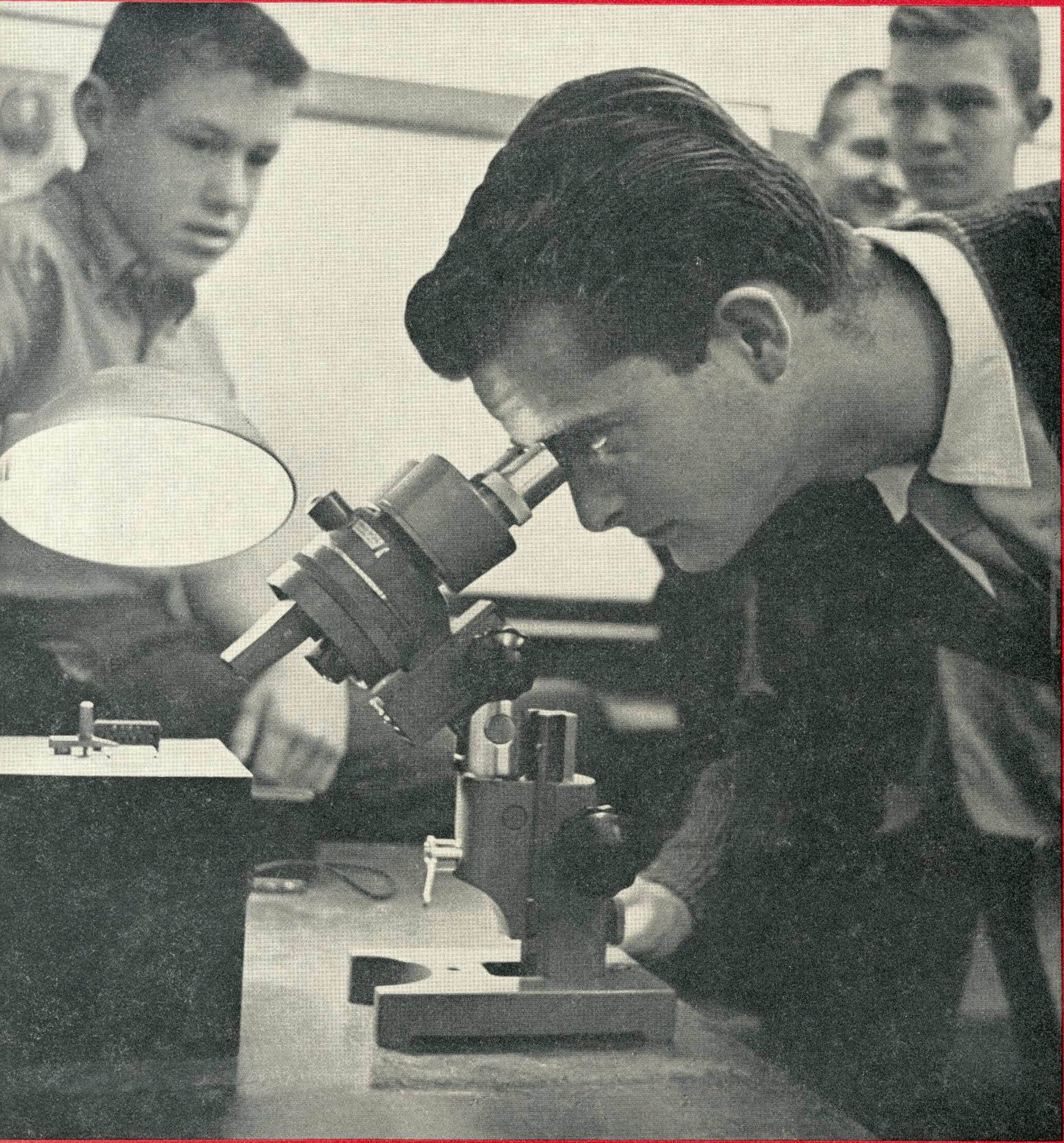
ENGINEERING | AND | SCIENCE

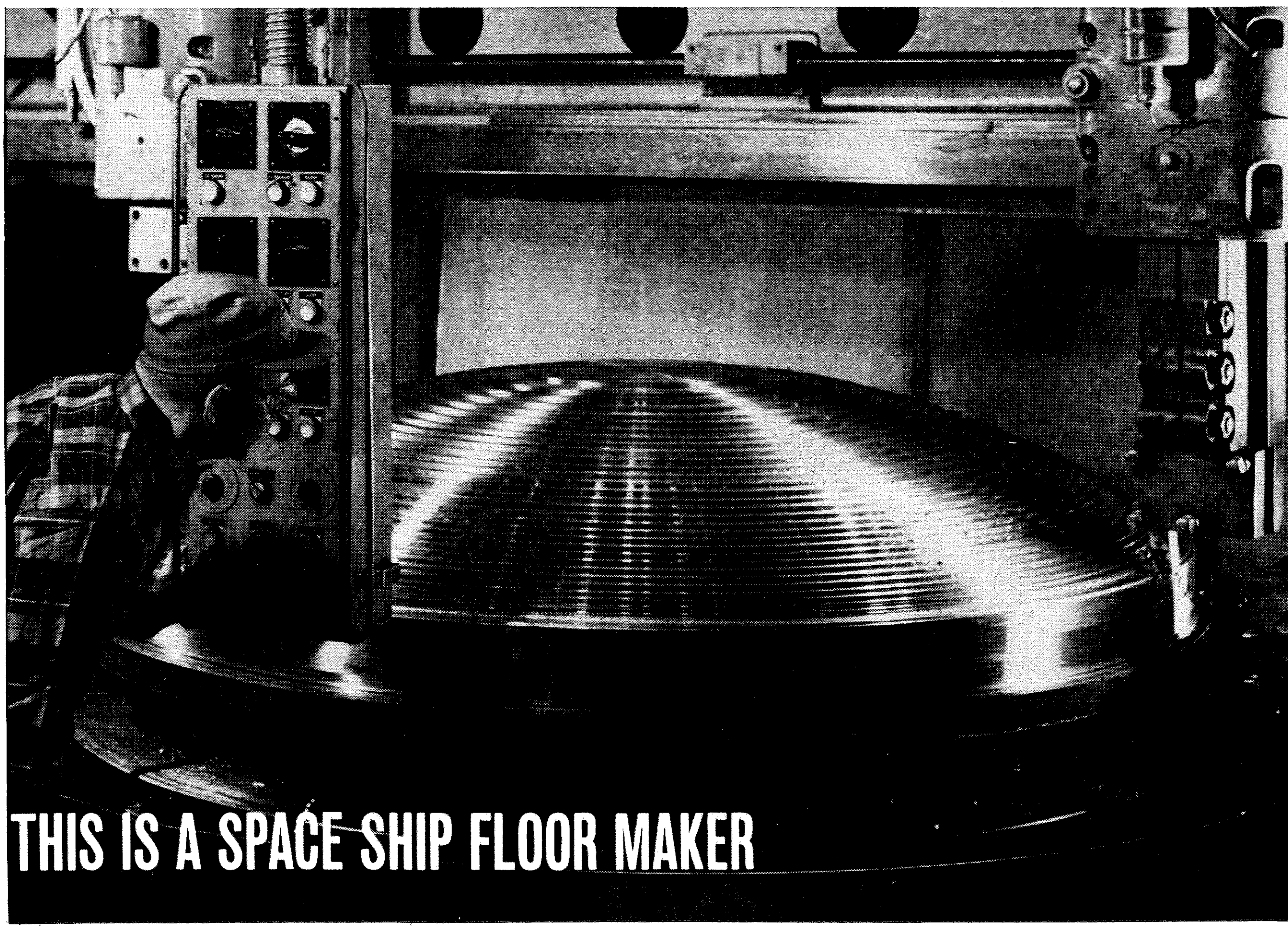
December 1960



Students' Day . . . Page 18

Published at the California Institute of Technology

Sometime within the next several years, the first American will soar into orbit around the earth. He will be sealed in a small, cone-shaped space capsule mounted atop an Atlas missile. The missile will climb 100 miles in less than six minutes, where the capsule will disengage and go into orbit. The man will be alone in space.



The vehicle for this historic voyage is already in production under the auspices of the National Aeronautics and Space Administration's "Project Mercury." One of the methods of heat protection is a beryllium heat sink, forged on two giant steel dies. Both dies are USS Quality Steel Forgings. The top die (shown being rough-machined on one of our vertical boring mills) will be convex, 20 inches thick and will weigh 26,520 pounds. The bottom die, concave and 18 inches thick, weighs 27,700 pounds. Both are 92 inches in diameter.

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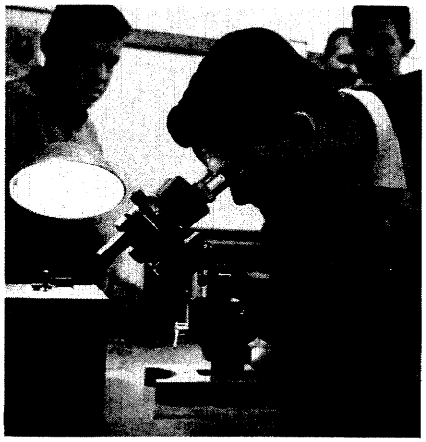
DECEMBER 1960 VOLUME XXIV NUMBER 3



On Our Cover

a high school student peers into a microscope at an amazing new invention; for a closer look at it, see page 18. This young man is one of 11 students and teachers from 240 high schools in Southern California who visited the campus on Students' Day – an annual December event at Caltech.

Many phases of current research at the Institute were represented in the 85 Students' Day exhibits and lectures this year. You'll find a sampling of the exhibits on page 18, and one of the best of the lectures is reproduced on page 20 – a down-to-earth account of "Cosmic Rays – Past, Present, and Future" by Victor Neher, professor of physics and a specialist in this field.

Frank Press

professor of geophysics and director of Caltech's Seismological Laboratory, writes on the scientific aspects of the nuclear test ban talks conducted at Geneva on page 26. As chairman of the U.S. delegation to the Information Exchange Group of the Conference on the Discontinuance of Nuclear Weapons Tests in 1960, and as a staff member of the U.S. delegation in 1958 and 1959, Dr. Press is able to make a reasonable estimate of the progress we have made in these conferences with the Russians.

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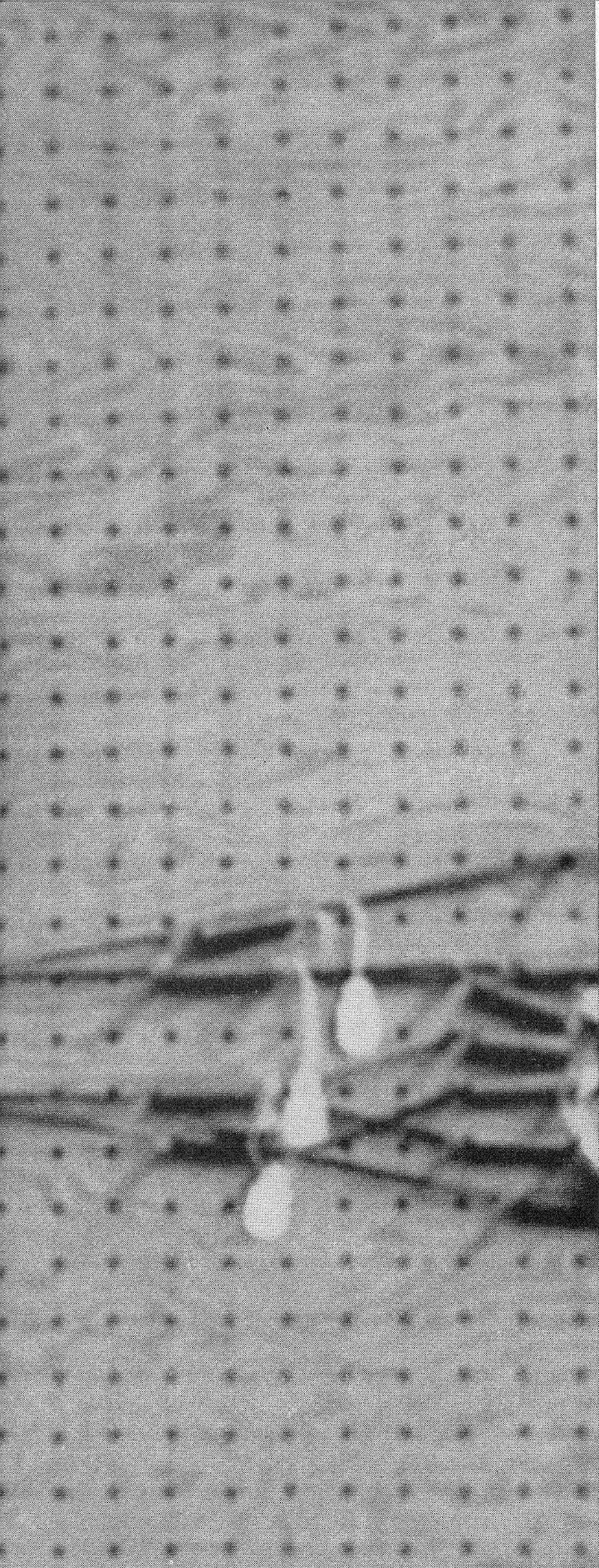

Edward H. Sussenguth, Jr. (B.A., Harvard '54; M.S. in E.E., MIT '59) is investigating the theoretical requirements of an automated design system for advanced cryotron-circuit computers.

HE WORKS WITH A NEW DIMENSION IN COMPUTER DESIGN

Thin film cryotrons may make possible computers of small size and truly prodigious speeds.

The speeds of today's computers are limited mainly by device switching times. Speeds of cryotron computers would be limited mainly by signal propagation times between devices.

Automation of Logical Circuits. Edward Sussenguth is studying methods of design which will reduce the distance between devices to a minimum. He hopes to work these methods into a completely automatic design system.

Ultimately, then, the systems designer would specify his needs in terms of Boolean equations and feed them into a computer. The computer would (a) design the logical circuits specified by the equations, (b) translate the logical circuits into statements describing the interconnections, (c) from the interconnections, position the devices in an optimal fashion, (d) from this configuration, print out the masks to be used in the evaporation process by which these circuits are made.

This is a big order, but Edward Sussenguth and his colleagues have already made significant progress. Their work may well have a profound effect on computer systems in the coming years.

Orientation: the future. One of the exciting things about computer development is this orientation towards the future. If a man wants to match his personal growth with the growth of computer systems, his future can be virtually unlimited. This is true of all the fields associated with computer systems—research, development, manufacturing, programming, marketing. The IBM representative will be glad to discuss any one of these fields with you. Your placement office can make an appointment. Or you may write, outlining your background and interests, to:

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Books

The Intelligent Man's Guide to Science (2 vols.)

by Isaac Asimov

Basic Books *$15*

The Intelligent Man's Guide to Science is a rarity – an outline of science written so that it will inform the layman and, at the same time, retain the respect of the scientist. Of course, even two jumbo volumes (Volume I on The Physical Sciences, Volume II on The Biological Sciences) do not provide enough space to contain the whole history of, and recent discoveries in, all the major fields of science. But that's what the redoubtable Mr. Asimov has tried to crowd in here, and his book lives up to its title admirably; it is a comprehensive, readable – and even absorbing – *guide* to science.

Isaac Asimov is associate professor of biochemistry at Boston University, though he is probably even better known as one of the best of the contemporary science fiction writers. The book has an introduction by G. W. Beadle, professor of biology and acting dean of the faculty at Caltech. And it should be noted that *The Intelligent Man's Guide* is a particularly impressive physical specimen too – the text set in large, handsome type, and the two outsized volumes stoutly boxed.

The Major Achievements of Science

by A. E. E. McKenzie

Volume I *$5.50*
Volume II *$3.50*

Cambridge University Press

Mr. McKenzie, of Cambridge University, has also produced an outline of science – but with a difference. He directs his book first to the student, then to the general reader. And the book is not so much an outline of science, or even a history of science, as it is a history of scientific ideas, with secondary emphasis on biographical accounts of outstanding scientists. ("If it is right," says Mr. McKenzie, "that one of the main tasks of the educator is to bring youth face to face with greatness, science should be presented not only historically but biographically. In these egalitarian days, when it is thought almost unethical to work harder and to achieve more than the next man, it is well that youth should be reminded that the greatest scientific achievements have been the fruits of intense toil and self-sacrifice. Most of us, moreover, are far more interested in people than in ideas.")

Most of the chapters in Mr. McKenzie's book are devoted to outlining the development of various fundamental scientific theories – the Copernican theory, the circulation of the blood, the pressure of air, atomic theory, the conservation and dissipation of energy, relativity, cosmogony. But there is also considerable material here on the interaction of science with philosophy, religion, social change and so on.

Originally, Mr. McKenzie intended to add to each chapter of his book a series of extracts from original books and papers in which scientists gave their own accounts of their theories and discoveries. But the book got too unwieldy, and these accounts now make up a companion volume to the first.

The Autobiography of Science

edited by Forest Ray Moulton and Justus J. Schifferes

Doubleday *$5.95*

This large economy-size anthology of key passages from the master works of science presents "the life story of science in the original words of the men who made it." A first edition of the book appeared in 1945, but this second edition now runs all the way from the story of creation in Genesis, to Harrison Brown on the population explosion, and Willy Ley and Wernher von Braun on the exploration of Mars.

As the authors say, "there are six ways to read this book: as a storybook, a history book, a textbook, a reference book, a source book, or a chronicle." Most of all, they hope it will serve as an introduction to the history of science. It makes a good one.

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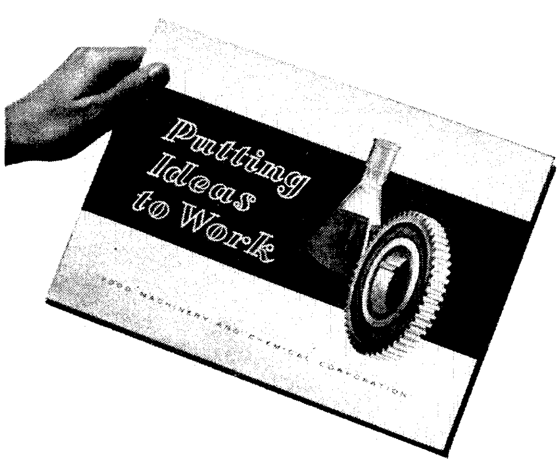

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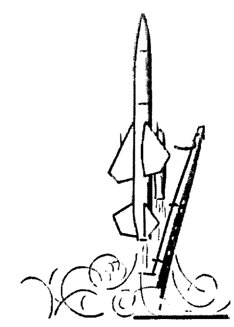

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Scientific Progress, the Universities, and the Federal Government

The White House, on November 20, released a report of the President's Science Advisory Committee on "Scientific Progress, the Universities, and the Federal Government." The report was drafted by the Committee's 14-man Panel on Basic Research and Graduate Education, after long study of the present relationship between the Federal Government and the universities.

The quotations from this report, and the comments on it that follow have been prepared by George W. Beadle, acting dean of the faculty and professor of biology at Caltech, who is a member of the President's Science Advisory Committee, and of its Panel on Basic Research and Graduate Education.

Why should the Federal Government continue to appropriate larger and larger sums for the support of academic research and manpower training in the sciences and engineering? In the words of the President's Committee:

> Both the security and the general welfare of the American people urgently require continued, rapid, and sustained growth in the strength of American science. Other reports of qualified bodies, and earlier reports of this Committee, have argued in detail the reasons which make this growth vital to us all. We believe that most Americans are in favor of more and better science. In a general way Americans recognize that scientific understanding is at once highly valuable in its own right and quite indispensable for the sustained progress of a modern industrialized society. We are proud of our great accomplishments, and we become concerned whenever it appears that our scientific effort in any field may be second-best. Most of all we have learned to recognize that the defense and advancement of freedom require excellence in science and in technology.
>
> But our acceptance of these quite modern ideas does not mean that we understand fully their consequences for our policy and practice. American science in the next generation must, quite literally, double and redouble in size and strength. This means more scientists, better trained, with finer facilities. Many forces contribute to this urgent need for growth. Our population is rapidly increasing, so that there are more and more young people to be taught, and we have nothing like the number of qualified teachers we need even now. Science itself is expanding so fast that our efforts would have to be much increased, if we were only to keep up with its general international momentum. The training of scientists takes longer than it used to, and the facilities needed in a modern laboratory are usually much more complex and expensive than those that were needed only a few years ago. Science and technology today have steadily growing mutual impact, so that the practical man has need of the closest and most immediate access to new results in basic science. Thus both science and scientists must be more and more widely diffused throughout our society. We need more men doing more things, with more support, in

more places. And each of these requirements is bettter measured by multiplication than by addition. It is the simple truth that if this country is to safeguard its freedom and harvest the great opportunities of the next generation of science, the level of its scientific investment must be multiplied and multiplied again.

Yet the right word is *investment*. What this country spends on excellence in the sciences is not money gone with the wind. It is money that brings us handsome returns, and of many kinds. In immediate economic terms the proposition is clear enough: what we have done in science has brought our society riches many times greater than what science costs us, and this will be true as far in the future as we can see. In economic terms, indeed, scientific investment has quite extraordinary power. Ordinary capital investment puts savings to work on labor-saving machinery that is already known and understood; the increased wealth produced is what separates the developed modern society from helpless poverty. But scientific and technological investments are still more powerful tools, since they invest in the discovery of what we do not yet understand. We are only just at the beginning of the use of scientific investment in this large sense, and the returns it can bring in are literally incalculable. Simply in terms of economic self-interest our proper course is to increase our investment in science just as fast as we can, to a limit not yet in sight.

But we should not emphasize only the material returns of scientific investment. Science yields a return also in the quality and humanity of our civilization. Science is not merely an inducement to progress, it is an affirmation of man's respect for nature and a way to the fulfillment of some of his highest capacities. Science is enriching, but at its best it is much more: it is enlarging to the spirit. This higher value is one we should never leave out of account in our desire to reassure ourselves that science "pays." Indeed any shortsighted calculation of return-on-investment is likely to be self-defeating. Scientific progress does not occur in any neatly predictable way; nor can we be sure ahead of time which research project is likely to have particular consequences for our prosperity or security. Moreover scientific discovery is not easy, and many experiments fail. Nothing could be more unwise than an effort to assign priorities or judge results in basic research on any narrow basis of immediate gain. It is the advance of science as a whole on which we must rely, for material as well as other returns.

Much of this basic argument for the strengthening of American science applies equally to other fields of learning. While this report centers on the needs of science, we repudiate emphatically any notion that scientific research and scientific education are the only kinds of learning that matter to America. The responsibility of this Committee is limited to scientific matters, but obviously a high civilization must not limit its efforts to science alone. Even in the interests of science itself it is essential to give full value and support to the other great branches of man's artistic, literary, and scholarly activity. The advancement of science must not be accomplished by the impoverishment of anything else, and the life of the mind in our society has needs which are not limited by the particular concerns which belong to this Committee and this report.

We do not, in this report, attempt to consider what direct responsibility and interest the government has for strengthening basic research and graduate education outside the sciences. This is a subject which deserves careful attention, but it is beyond our mission. What we can say, however, is what earlier reports of this Committee have regularly emphasized, that neither the government nor the universities should conduct the support of scientific work in such a way as to weaken the capacity of American education to meet its responsibilities in other areas. *The costs of scientific progress must not be paid by diverting resources from other great fields of study which have their own urgent need for growth.* (Italics added.)

Thus, after pointing out that ". . . the process of graduate education and the process of basic research *belong together* at every possible level" and stating the ways in which government can best provide the needed support, we find the following:

But when all these things have been said, the first and greatest of responsibilities comes back to the Federal Government. No matter how many diverse elements of our society may join in their support (and the more the better), basic research and graduate education are in the end, by their very nature, a problem for the nation as a whole, and so for the national government. There is not one physics for California and another for Texas. A first-rate program in Massachusetts or Connecticut must not be limited to New Englanders. Science flourishes by honorable rivalry, but not by any effort to consider only narrow or local interests. Both basic research and graduate education must be supported in terms of the welfare of society as a whole. It is in this large sense that the role of the Federal Government is inevitably central.

The truth is as simple as it is important: *Whether the quantity and quality of basic research and graduate education in the United States will be adequate or inadequate depends* *primarily upon the government of the United States. From this responsibility the Federal Government has no escape. Either it will find the policies — and the resources — which permit our universities to flourish and their duties to be adequately discharged — or no one will.*

The Institute's part

What is the situation at Caltech? Without substantial help from the government both our research in science and engineering and our educational accomplishments would be far less than they are today. Omitting the 50 million dollar annual expenditure at JPL, which is government-owned and Caltech-operated, some 43 percent of the 1960-61 academic budget of 12 million dollars comes from government sources. And this is not high as other strong academic institutions go. The extent of such support will almost surely increase in the future, for, as the Committee says, there is simply no other source of funds of the magnitude required to meet the needs of future years.

Dependence and control

The question is often raised, is it wise for a private institution like Caltech to become so dependent on government? What if the funds should be suddenly cut off or drastically reduced? Clearly we'd be in a bad way. But this will not and cannot happen short of a complete economic collapse of the nation. And in that case all institutions, private and state, would collapse too. The dependence is mutual. No longer can a modern nation remain economically strong and free without supporting academic research and education in a big way. So long as Caltech remains strong, sensible, and effective, we as an institution will continue to receive support.

What about control? ". . . the hand that controls the purse . . ." Government support comes from many agencies and for many purposes. Most of us believe that this is as it should be, for that is a part of our insurance against control. The government is not a monolithic giant capable of acting in unison in all its parts. A second part of our protection against control is our private support. This we must continue to have in some reasonable proportion to government support. Our own resources from foundations, individuals and industry is of the greatest importance to our freedom. Properly used, a part of this support can serve as a kind of "independence fund." If the policies of a given granting agency become unreasonable and unacceptable, we use such funds in refusing to be controlled. The fact is the Institute has several times done just this — with the full support of the Board of Trustees. If we are right and our principles are sound, we will not lose. Furthermore if we act sensibly as a part of a very large community of academic institutions, private, municipal and state, we are just too large and important a part of society ever to have to submit to control by government in any undesirable way.

On this point of control, the President's Committee has this to say:

> Perhaps the most important single task of the universities is to see to it that their own standards of freedom and excellence are maintained in a period of growing connection with government. While we do not share the notion that government money is necessarily subversive of university freedoms, it is obvious that large-scale Federal spending, like any other form of patronage, has its hazards. In the record of the last fifteen years, there is much more ground for hope than for fear, but occasionally government action has distorted the direction of research or unwisely discriminated against particular scientists on irrelevant grounds. It is to the credit of the government that such cases have been the exception, not the rule, and we commend the good sense which has led the Administration to oppose discriminatory and useless affidavits of disbelief as a condition for fellowship aid.
>
> But the first and greatest responsibility for keeping our universities free and self-reliant rests with the universities themselves — with their faculties, their administrators, and their trustees. What they do not defend, others will not find it easy even to understand, while when they are staunch in their principles and vigilant in their practices, the record suggests that neither the Federal Government nor any other source of support is an overwhelming threat to them. Courage and vigilance are essential, but there is no ground for a timid mistrust of government in and of itself. The right concept is that of partnership, with each partner respecting the rights and responsibilities of the other. For this there is need for a constant effort of communication and understanding, and we repeat that the first responsibility here rests with university people.

Faculty salaries

There are many — a decreasing number, I hope — faculty members who believe it unwise, immoral or both for a part of a faculty member's salary to be paid from a government contract or grant. In this we must learn a new way of life, for it is clear that in more and more ways and to a greater and greater extent faculty salaries will come from government funds.

Here is what the Committee says:

> And there is more to it than money and time for research. The really great scientific faculty cannot be the servant of other men — it has to be secure in its own freedom and responsibility.

Too many university administrators suppose that faculties can be bought and managed like baseball teams. It is not so. Universities need brave trustees and strong administrators, but in the end they are what their faculties make them. That the United States today has a number of first-rate faculties is our greatest single scientific asset. To sustain them and to provide the conditions for the growth of more is the greatest single task of American university administrators.

In placing first and central responsibility upon the universities here, we do not mean to underestimate the importance of what government does or does not do – quite the contrary. In our judgment the general pattern of Federal support for science has so far developed with very little regard for the problem of building strong faculties, and we think it urgent that careful thought be given to changes in policy that may help the universities discharge this great responsibility. The basic difficulty at present is that most Federal funds are tied to specific research projects in a way which makes it hard for universities, in making long-term appointments, to rely in any way on Federal funds. This difficulty is compounded in some agencies by policies which discourage the use of Federal money to pay the salaries of senior faculty people. We believe that these practices and policies need to be revised in the light of the proposition that nothing is more clearly in the general interest of the Federal Government than a rapid increase in the quality and quantity of the nation's teaching scientists.

We do not venture to prescribe the ways in which the government and the universities can best serve their common interest at this sensitive and highly important point. Experience is a powerful teacher, and so far we have no knowledge of what can happen when the government and the university become jointly concerned with strengthening the ranks of senior scientists in our universities. There are many instruments that can be used here. At one extreme is the relatively simple practice of paying an appropriate share of the salaries of all faculty members engaged in a federally-supported project; we think that this policy should in general be adopted as an interim measure, even though it often has the disadvantage of perpetuating the misleading distinction between "teaching" and "research." At the other extreme is the method, now used in Great Britain, of large general grants for all purposes to all universities; we doubt if any such pattern could or should be accepted here. In between are such devices as the training grant, which can often be used for professional salaries, and the so-called "institutional" grant, in which broadly inclusive support is offered for a relatively large sector – say "biological science" – over a relatively long period of time. We believe that the government and the universities should take energetic measures to put into effect programs in this middle ground, with the specific objective of making Federal money not simply a reinforcement of scientists already holding tenure, but a stimulus and a support in the appointment of more such men. We repeat that in the general interest a rapid increase in the number of such permanent professorial scientists is needed.

We recognize that many university scientists are strongly opposed to the use of Federal funds for senior faculty salaries. Obviously we do not share their belief, but we do agree with them on one important point – the need for avoiding situations in which a professor becomes partly or wholly responsible for raising his own salary. If a university makes permanent professorial appointments in reliance upon particular Federal project support, and rejects any residual responsibility for financing the appointment if Federal funds should fail, a most unsatisfactory sort of "second-class citizenry" is created, and we are firmly against this sort of thing. A variant of this same abuse is the practice of permitting extra pay to faculty members from grants or contracts, during the regular academic year. It seems to us fundamental to the spirit of a university that a man's salary from the university itself should not be supplemented by extra term-time payments for work that is properly part of his professorial responsibilities. (Summer compensation for research work is a separate matter, since most academic appointments plainly leave the summer months free for other activities at additional compensation.) Just as a professor should not be responsible for obtaining the funds to pay his regular salary, so also there should be no bonus payment for "landing a contract."

But in our judgment the possibility of abuse is not a good argument against action. We are convinced that when a university is firm in accepting institutional responsibility for payment of all senior salaries, and protects its staff from improper pressures or incentives, it can and should seek Federal support for salaries as for other needed elements in basic research and graduate education.

It is today a widespread practice for faculty members in science and engineering to be paid from government funds during two or three months of the summer – 22 percent or 33 percent over and above the regular stipend. And it has just been announced by the National Institutes of Health that substantial funds are now available to add faculty members in colleges and universities in "health-related" areas, their full annual salaries to be paid from this source.

The Caltech plan for faculty salaries

The President's Committee endorses the payment of summer salaries from grants and contracts, largely, I believe, as a matter of practical expedience. I am a dissenter on this point, for I believe this is a compromise with the principle that there "... should be no bonus for landing a contract." A summer salary not otherwise available is a bonus, in a sense determined by the faculty member himself. I believe the Caltech policy provides a proper way of arranging for partial support of faculty salaries. This policy provides that every faculty member has the option of being reimbursed on a twelve-month basis, with one month provided for vacation. Some reasonable fraction of the total stipend, as determined by the fraction of time spent on supported research, may be charged to the grant or contract. The total annual salary is guaranteed by the Institute, in return for a commitment to spend eleven months in recognized scholarly activity, whether this is supported by outside funds or not, and whether it is done at the Institute or elsewhere on the basis of leave-of-absence with salary. Thus the individual faculty member is rewarded for what he does and not merely for his success in "landing a contract." He may be paid from outside funds for a proper fraction of his time spent in grant- or contract-supported research, without reference to the way that part of his time is distributed through the eleven months. He does not then need to rationalize what he does during the three summer months. "Is it all right to attend a Science Teachers Institute, supervise graduate students, work on that book or try out an idea in an area not covered by the grant?" I fear that under the alternative policy of summer salaries from grants such rationalization is sometimes pushed to the very brink of illegality or immorality.

The Institute policy has the great additional advantage that the faculty member doing scholarly work in an area in which grant or contract support is unavailable is not penalized financially as compared with his colleague in more favored areas.

Most people will readily agree that our policy is right in principle. At the same time they may point out that it is not possible in their own institutions because there are so many faculty members outside science and engineering that available funds will not support such a plan. They therefore choose to continue living on a double standard of faculty salaries.

There is a real danger that competition will force the Institute to give up a fair an ddesirable policy, for obviously our policy is a more expensive one. If we were to revert to the more general practice, we could more easily increase salaries in the sciences and engineering to meet outside competition for faculty members in greatest demand by other institutions. With a given income available for faculty salaries such a change would obviously mean a redistribution of salary funds — more for those in grant-favored areas, less for others. I sincerely hope we will resist pressure to do this. If we are all convinced our policy is sound and right, we can resist. At the present time our 1959-60 average faculty salary is the second highest among academic institutions of the nation, *after adjustment to a nine months basis (AAUP Bulletin, Summer 1960).* The annual take-home salary is of course 22 percent higher for everyone. I do not mean to suggest that this standing is reason for complacency. The substantial increases effective for 1960-61 are tangible evidence that every effort is being made to improve our competitive position. If we are to maintain top excellence in quality of faculty, we must do everything possible to achieve and hold a top position in salaries. And we can, if we will, do this without compromising a policy that is right and fair to all.

The overhead bugaboo

There is one highly undesirable way in which government — and other — granting agencies may unknowingly do great harm to colleges and universities. This is through continuing to think in terms of "purchase of services" — of getting the most return for the dollar. Thus funds are often restricted in such a way that certain direct costs and none or only a part of the indirect costs of research are reimbursed.

Since the full costs, direct and indirect, must be met by the recipients of such grants, the deficit must be made up by a redistribution of available funds. Thus by increasing research activities in science through grants that do not meet full costs, other activities are often robbed in the process. Unfortunately faculty members who do research do not always fully appreciate this. Their first loyalty often is to their science, not to an institution — and it can be argued that this is as it should be. As a consequence they are inclined to say, "Indirect costs are not my problem. They belong to the business office." They may fail to recognize that the indirect costs of added research may have to be met at the cost of needed faculty salary increases.

Fortunately, at the Institute most faculty members understand the indirect cost problem. Those who do not agree with the Committee's recommendation:

> We repeat the recommendation of an earlier report that "Government departments and agencies concerned should uniformly modify the grant and contract provisions to permit universities and non-profit research institutions to charge full cost of research performed for the government — including overhead — and to amortize capital expenditures as an allowable cost."

may find it worth while to read a recent article by Norman Kaplan in *Science*, **132**, 400, 1960) and a reply by President DuBridge *(Science* **132**, *1746, 1960).*

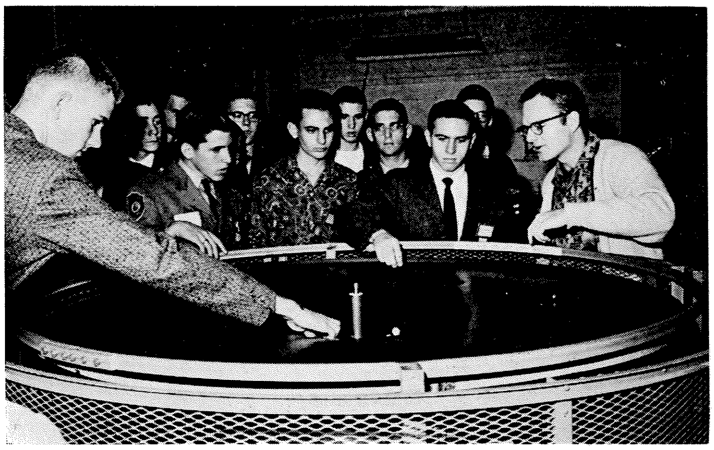
The Month at Caltech

The Alfred P. Sloan Laboratory of Mathematics and Physics, which houses Caltech's new 12,000,000-volt tandem accelerator, was officially dedicated this month. Here, with the accelerator – President DuBridge; Rear Admiral Rawson Bennett II, Chief of Naval Research; Dr. James R. Killian, chairman of the corporation of MIT; and Alfred P. Sloan, president of the Sloan Foundation, which financed the new building.

A crew of photographers invaded the campus last month to film a typical day at the Institute for a U. S. Information Agency movie on "Higher Education in the United States" which will be shown abroad. Here photographers move in on Hallet Smith, chairman of the division of humanities, lecturing on the Shakespearean theater.

Archibald MacLeish (right) poet, playwright, and Harvard lecturer, in an unscheduled seminar with Hallett Smith, head of the humanities division at Caltech, and other faculty members, during his three-day stay on campus as one of the YMCA's Leaders of America.

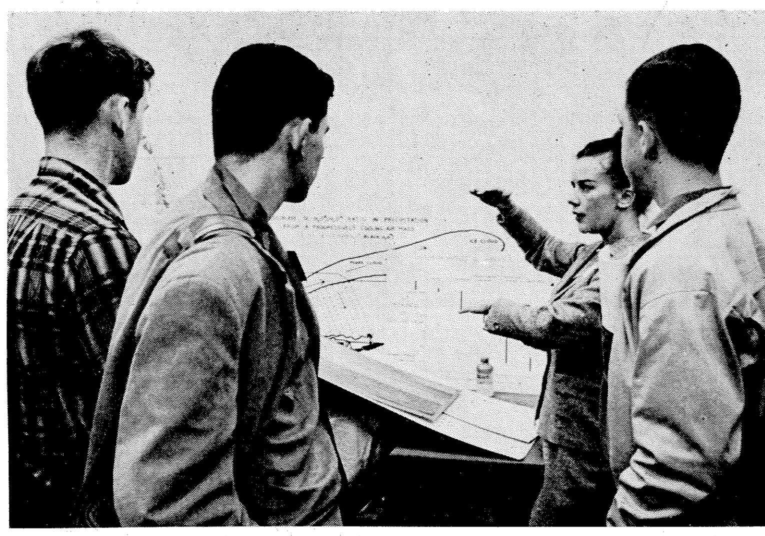
1960 Nobel Prizewinner Donald Glaser (PhD '50) made a flying visit to the Caltech campus this month on his way to Stockholm to claim his half of the prize. Here, physics professors, plus acting dean of the faculty Beadle, turn out to greet him and his brand-new bride — Professors Sands, Lauritsen, Bacher, Feynman. Cowan, the Glasers, Smythe, Beadle, DuMond, Walker, Neher, King, Anderson, and Leighton.



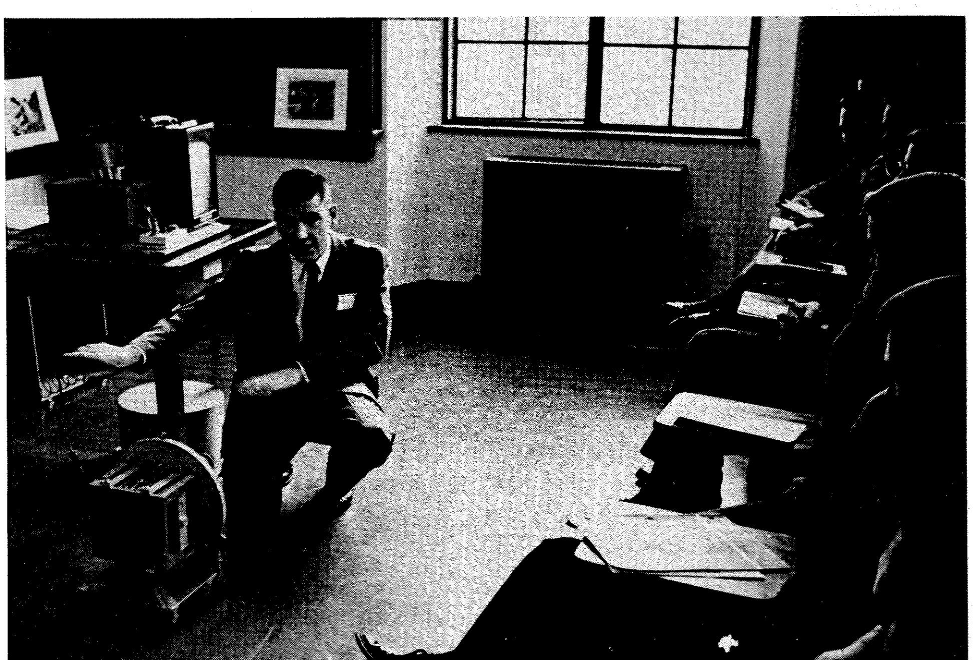
Spherical balls rolling on a specially contoured surface exhibit the orbital behavior of a small satellite or space ship in this analog computer which simulates the earth-moon system. The center depression represents the earth.

Students' Day

Some sample exhibits set up for the eleventh annual Students' Day on December 3 when more than 1,000 high school students and teachers from all over southern California visited the Caltech campus.



In Caltech's geochemistry laboratory, Irene Goddard, analytical chemist, demonstrates to students how studies of the oxygen isotopes in ice reveal the temperatures of past eras, the flow of glaciers, and their age.



Graduate student Stewart Smith shows how seismic waves are recorded with the portable seismograph used in the study of local earthquakes.

The World's Smallest Motor

Ever since *Engineering and Science* ran his article on micro-miniaturization, "There's Plenty of Room at the Bottom," (February 1960) Richard P. Feynman, Caltech professor of physics, has been besieged by inventors of miniature motors. This, Feynman brought on himself, for he had ended his article by saying: "It is my intention to offer a prize of $1,000 to the first guy . . . who makes a . . . rotating electric motor which can be controlled from the outside and, not counting the lead-in wires, is only 1/64th inch cubed."

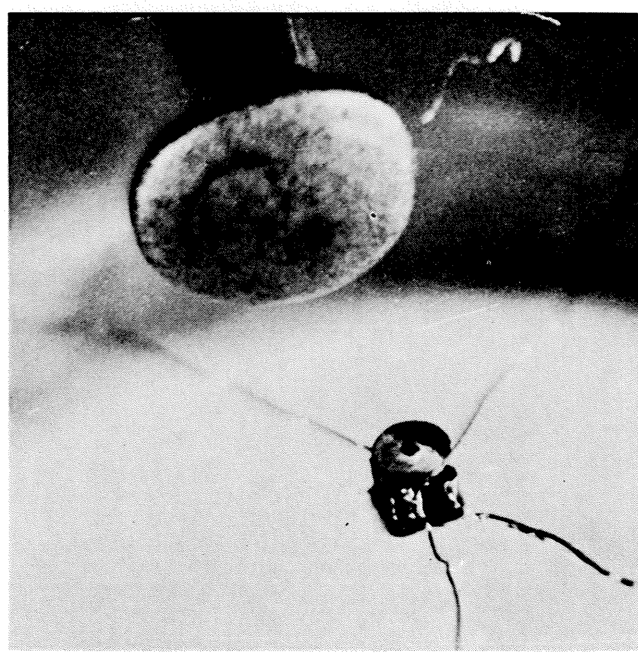
So – after that it was a rare day when Feynman was not interrupted in his lab by someone eager to show him what usually turned out to be a *very* large small motor.

Last month, when William McLellan (Caltech '50) walked into Feynman's lab with *his* small motor, it looked like the same old story, because McLellan was carrying his invention in a big grocery carton.

O.K., said Feynman wearily, he'd look at the thing – but there was no money in it for anybody. It had been his *intention* to set up a prize, but he never got around to doing it.

That was all right with McLellan. It was the challenge that had set him to work on the problem anyway. Then he took a microscope out of the grocery carton and let Feynman look in it to see the motor he had built.

It had taken McLellan 2½ months of lunch hours to make it, at Electro-Optical Systems in Pasadena, where he is a senior engineer. The motor was 1/64th of an inch cubed in size, or about as big as a speck in your eye. It weighed 250 micrograms, had 13 parts, was built with the aid of a microscope, a watchmaker's lathe, and a toothpick, and it could be controlled from the outside. As Feynman watched, McLellan set the rotor going.



The McLellan micromotor, photographed under a microscope. The huge object above it is a pinhead.

William McLellan shows Students' Day visitors scale model of his motor 100 times larger than the original.

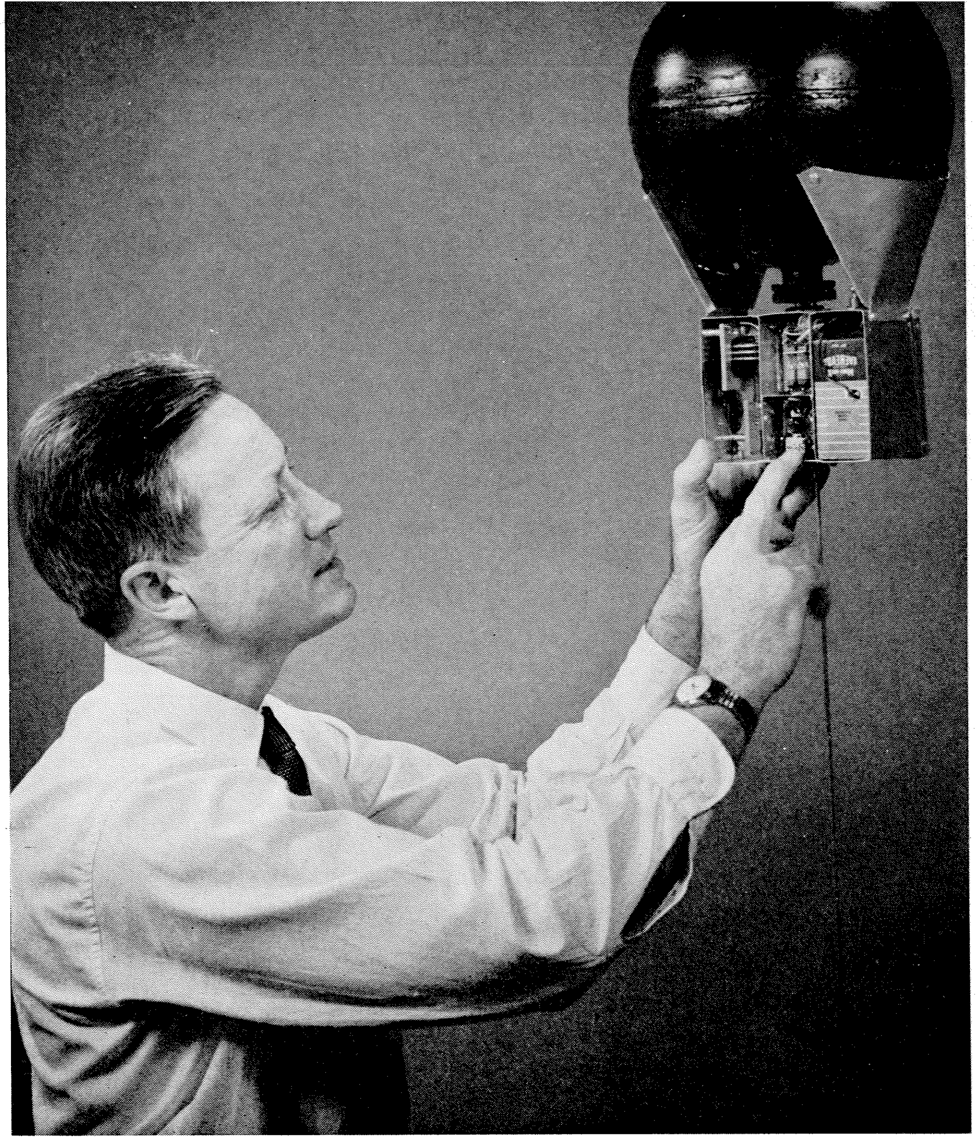
Feynman and McLellan spent the better part of the afternoon operating the motor. It was after he got home that night that Feynman's conscience began to bother him, After all, the motor was *exactly* what he had asked for.

"So," he says, "I sent the guy a check for a thousand bucks."

Elated as he is over the little motor, Feynman is now having worried thoughts about a *second* prize that he offered in his *E&S* article – another $1,000 "to the first guy who can take the information on the page of a book and put it in an area 1/25,000 smaller in linear scale in such a manner that it can be read by an electron microscope."

Daily, he expects to meet the man who has accomplished this spectacular feat. And, daily, the thought haunts him – because, in the meantime, Feynman has been married, bought a house and, what with one thing and another, hasn't *got* another spare $1,000.

This, then, is a public appeal by *Engineering and Science*, to all inventors who are now at work trying to write small and collect the Second Feynman Prize – TAKE YOUR TIME! WORK SLOWLY! RELAX!



Victor Neher, professor of physics, with the ionization chamber for measuring cosmic rays which is carried up to high altitudes by balloons. The chambers are used mainly in Polar regions, where cosmic rays are most intense.

Cosmic Rays —Past, Present, and Future

by H. V. Neher

I am sure that few of those individuals, in the years before the first World War, who concerned themselves with that mysterious phenomenon later to be called cosmic rays, ever thought that their infant would develop into the adolescent that we know today. I say adolescent because there is every indication that our knowledge of this aspect of nature still has decided growing pains and one may reliably predict that a fully matured understanding will not come for a good many years. After all, our present knowledge has developed only very slowly and it has taken 50 years to arrive where we are today.

Let us first get our thinking straight as to what cosmic rays are. To do this, let us tell you what goes on right here on the Caltech campus, in a small building called the cosmic ray shack, just south of the Guggenheim Aeronautical Laboratory. Set up in there is a so-called cloud chamber big enough to walk into. It measures five feet tall, five feet wide, and two feet deep. Inside this space are a number of iron plates to absorb the particles, and a gas which can be expanded to make visible the tracks left behind by cosmic ray particles. Eugene Cowan, associate professor of physics, whose child this is, has taken some most extraordinary photographs of what goes on in this chamber. Sometimes simple events take place. At other times some very complicated situations develop.

None of us is aware, from any tingling or feelings, that cosmic rays are constantly passing through our

"Cosmic Rays" is a transcript of a talk given to high school students and teachers visiting the Caltech campus on Students' Day, December 3, 1960.

bodies. Perhaps this is best, for, if we could see the showers of particles that continually bombard us from above, we might not always be in such a tranquil state of mind. It would not be comforting to look overhead and see a skyrocket type of burst over our heads and then see these particles come out the other side of our bodies. It may console us a bit to realize that all during our lives and our ancestors' lives, from time immemorial, this bombardment has gone on.

The inability of our senses to detect directly the incidence of different kinds of radiation is one aspect of modern science to which students must become accustomed. When the dentist takes an X-ray photograph of your teeth, you feel nothing. Yet each set of X-rays so taken constitutes an appreciable fraction of the maximum total dosage during your lifetime.

Several days ago one of my graduate students and I were calibrating one of the instruments we hope to send into space, using a strong cobalt-60 source of gamma rays. You could carry this piece of cobalt around in your pocket and hardly be aware of its weight, but were you to do this for any length of time you would most surely suffer ill effects. Naturally, no sane person would carry such a source of radiation around with him, but it behooves all of us to be aware of these dangers and to believe the instruments that tell us that which our five senses do not reveal.

Going up

To continue our story about cosmic rays, we might imagine that this room and the people in it are earthbound no longer but are free to move wherever we wish, at will. Starting, then, here in Pasadena, let us head straight upward. Before leaving we note the rate at which a cosmic ray detector, known as an ionization chamber, goes off, indicating the intensity of cosmic rays in our room. At 10,000-ft. elevation we pause to observe the conditions within and without our room. We note first that cosmic rays have increased in intensity about four times. An observer on the roof tells us that we are on about the same level as the distant mountains and that he can discern the City Hall of Pasadena through the thick pall of smog directly below.

Next we pause at the 25,000-ft. level. Here we find that cosmic rays have increased 30-fold over what they were at sea level. Imagining that our room is a huge cloud chamber, we look up and see almost a continuous rain of particles coming down upon us. Not all of them come through the ceiling above, but as we go up, more and more of them come in through the side walls. Reinforced concrete is an excellent generator of new particles and reveals that few of these came here from outer space, but that more than 95 percent of them have been generated in the atmosphere above us, or in the walls or ceiling of our room. They are therefore called secondary particles and they consist chiefly of so-called mesons (mu-mesons to be exact) that are created by the primary particles. They live a short time (a few microseconds on the average). But in that time they go sufficiently far for some to penetrate to sea level and even many feet into the earth.

At this 25,000-ft. altitude each of us is being hit by some 2,000 particles per second, most of which go right on through and down into the atmosphere below. Our observer outside, in looking through the pressure window, informs us that the only signs of life here are a few military aircraft, although some civilian craft may be seen far below as they are letting down to land at, or are gaining altitude after taking off from, the Los Angeles International Airport.

Cosmic ray intensity at 60,000 feet

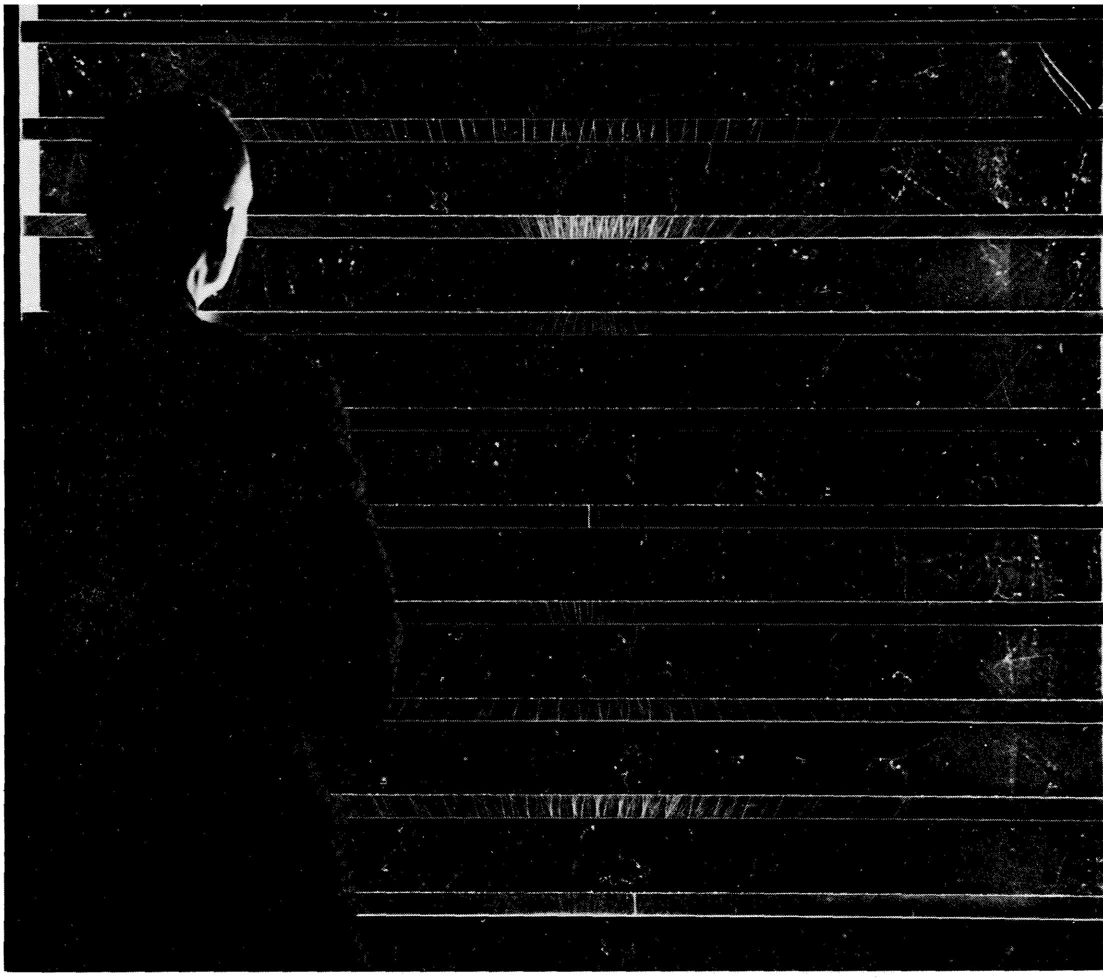
Continuing our journey upward we next pause at 60,000 ft. Here we note that cosmic ray intensity has climbed to 100 times that at sea level. Our ionization chamber is now discharging very rapidly and our room is pretty well filled with charged particles coming from almost every direction, except from below. With some study we learn that something like two-thirds of the particles passing through our room are still secondary particles that have been formed by the primaries colliding with the nuclei of the atoms composing the atmosphere above us. Some – in fact, an appreciable number – of these events occur as the primaries strike the nuclei of atoms composing the concrete and iron in the walls of our room.

Our observer outside informs me that at this altitude the sky is getting dark and there is no sign of life. "Wait a minute," he says. "There goes something in the distance. It's headed straight up. Ah yes, it must be that X-15 from Edwards Air Force Base."

We pause next at 100,000 feet. The air pressure here is only 1 percent of that at sea level. Surprisingly, the cosmic ray intensity is less here than it was at 60,000 feet. We also find, with some experimentation, that most of the particles here are primaries. We conclude, then, that the reason the number of particles is greater at 60,000 feet than it is here is because each primary particle, in striking the nuclei of the air atoms, forms several charged particles. Thus there is a buildup of numbers, or intensity, as the radiation passes downward through the atmosphere, reaching a maximum at about 60,000 feet. Then absorption begins to play a dominant role and there is a rapid decrease from there on down.

While we are at this altitude, let us find out what we can about the primaries. We use photographic emulsions, cloud chambers, and various kinds of counters in our experiments. Also we use the knowledge we have about mathematics and physics.

We find that many of these particles go through a foot of lead or more and that they leave tracks in our photographic emulsions and cloud chambers. After considerable analysis we learn the following facts:



Eugene Cowan, associate professor of physics, watches events taking place in his 5'x5'x2' cloud chamber.

1. Most of the particles are high-speed protons. We note with considerable interest that protons are the nuclei of hydrogen atoms, which make up 90 percent of the matter in the universe. And, in fact, we find that 84 percent of cosmic ray particles are protons.
2. We also find alpha-particles or the nuclei of helium atoms. In fact, some 15 percent of the primaries are identified as helium nuclei and we remember that astronomers tell us that helium makes up some 10 percent of the mass of the universe.
3. We find heavier nuclei in much the same proportion as they exist in the sun and in meteorites, up to and including iron nuclei.
4. These nuclei of the common atoms are the things we see shooting through our cloud chamber in all directions, and the things which are passing through us, here at 100,000 feet above Pasadena. It takes a little experimentation and knowledge of physics to learn that they are really going at great speeds. In fact, they might be called celestial bullets traveling at speeds very close to the velocity of light – i.e. nearly 186,000 miles a second.

   It is better to talk about the energy of these particles rather than their speed. We soon become accustomed to talking about their energy in terms of electron volts, or the energy these electrically charged particles would gain in being accelerated by an electric field where the change in potential was so many volts. Thus we may speak of a particle with 1000 electron volts (ev) of energy – meaning that, if it has a single electric charge (i.e., a charge corresponding to a single electron), its energy is definite and equal to what it would have by going between two metal plates with a difference of potential of 1000 volts.

   When we try to express the energy of our cosmic ray particles in terms of electron volts we must go higher than our national debt. In fact, we find them having energies all the way from a hundred million electron volts to a billion billion electron volts.
5. The numbers of these particles at the 100,000-ft. level is such that through each cubic centimeter of volume there will pass something like five particles per second. This would give you about a maximum recommended dose of radiation if you were to stay at this altitude for years.

As we continue our journey upward the sky becomes completely dark except for the stars and the nearest star, our sun. Below, the earth is bright in the sunlight, and the distant horizon is beginning to take on a noticeable curvature. The intensity of cosmic rays has dropped a bit from what it was at 100,000 feet, but beyond the 100,000-ft. mark – and on out to a million feet from the surface of the earth – there is not much change.

As our distance from the earth becomes 400 to 500 miles, we find that our cosmic ray detector indicates an increase of radiation and we realize we are entering the inner Van Allen radiation belt. We realize also that we are fortunate in having chosen to go up at the latitude of Pasadena, because we will pass through only the northern fringes of this belt and hence will not receive a lethal exposure to charged particles. Had we gone up from the equator, we would have passed directly through this band, and might not have survived – depending, of course, on how long we took to go through. This band is several thousand miles thick and consists of high energy protons and electrons. The walls of our room will stop most of them, but their numbers are such that if only a small fraction got through the walls, the effects would be disastrous. Furthermore, the high energy electrons striking the walls on the outside would give rise to X-rays and these *would* penetrate the walls and give us all a heavy exposure.

The protons in this inner Van Allen belt, we are told, come from the bombardment of the atmosphere of the earth by cosmic ray particles, which eject upward high speed neutrons resulting from nuclear collisions in the atmosphere. These neutrons do not live very long but change into high speed protons and electrons. These charged particles then become trapped in the earth's magnetic field and remain for long periods of time.

Continuing our journey, we note that at about 2000 miles out the radiation drops slightly; then, when we are out 4000 to 5000 miles, the radiation begins to increase again. We realize we are passing into the outer radiation belt. Inside our room with its heavy concrete walls, few of the electrons that exist in this band will penetrate. We will again find X-rays in our room, however, generated by the impact of these electrons on the outside of the walls. We should not linger long here, but continue outward.

At about 10 earth radii, or at about 40,000 miles out, we come to the outer boundary of the outer radiation zone. The reading of our cosmic ray detector drops down to a low value and we interpret this as meaning that we are now detecting cosmic rays only. The intensity is about what we measured over Pasadena when we were at an altitude of 30,000 to 40,000 feet.

As we continue outward no changes in the cosmic ray detector occur and we are getting bored by the monotony of the situation.

But what is this? What has gone wrong with our ionization chamber? It is counting a hundred, a thousand times more than normal. We had better get back to earth fast, where we have the protection of the earth's magnetic field, which turns away low energy particles; and the protection of the earth's blanket of air, which absorbs the effects of most of the particles that get through the earth's magnetic field.

Back here on earth we learn that, while we were out there, a very intense bright spot occurred on the sun which not only gave out a burst of ultraviolet light, but also generated a burst of high energy protons which reached the earth in a matter of minutes after leaving the sun. We also learn that this was one of the smaller solar flares, which caused only slight disruptions of radio communications on the earth. Even so, the intensity of protons was such that, had we stayed out there for a few days, we would have had a lethal dose of radiation. Had this been a really big solar flare, a few hours exposure would have been sufficient.

The walls of our room would have stopped many of these solar protons, but many of them would have been energetic enough to go through, and in fact to go through any reasonable thickness of shielding material which a rocket ship might have for lining the walls of its living quarters.

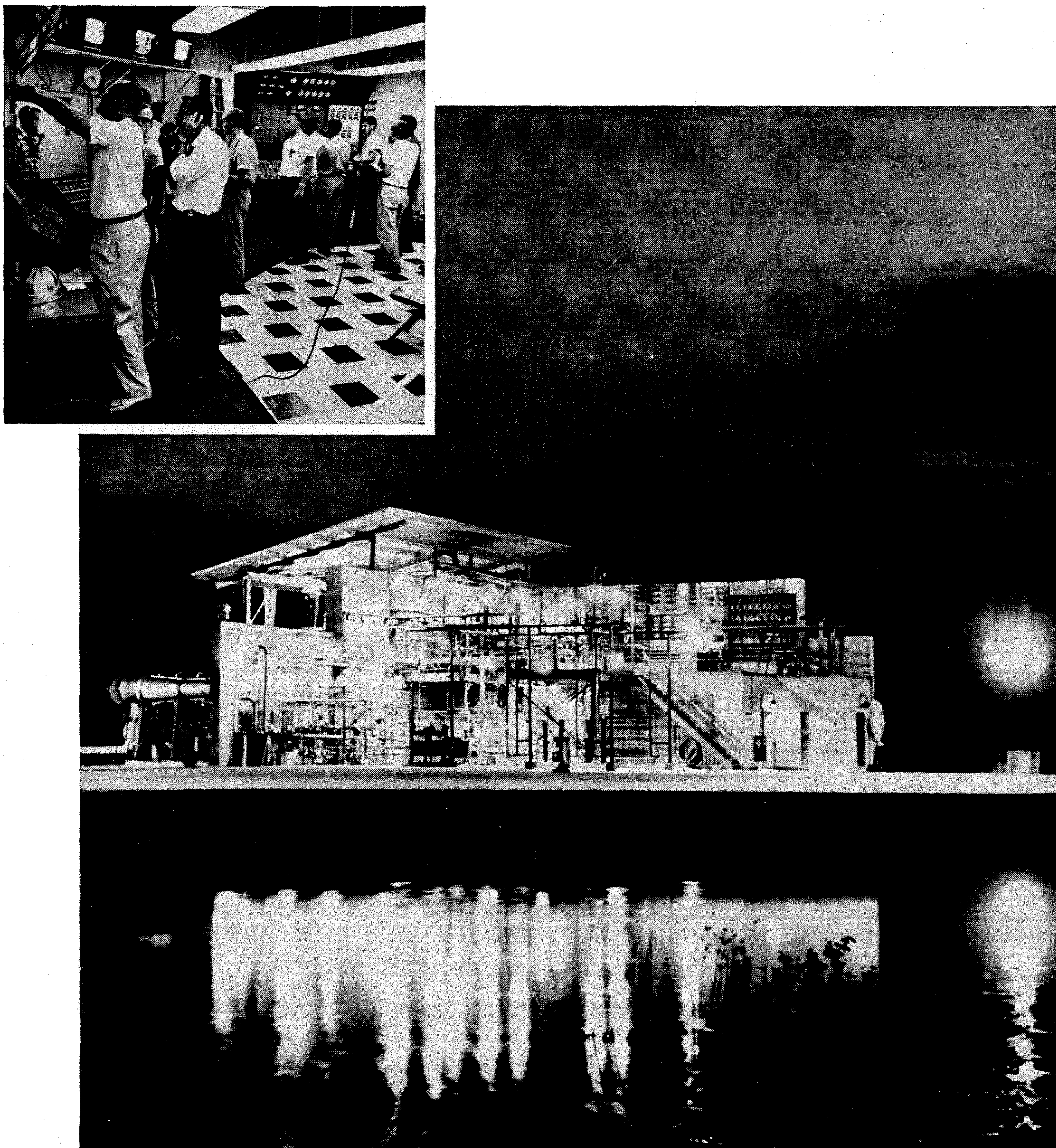
Solar bursts and astronauts

Will these solar bursts be damaging to the astronauts of the future? The answer is yes – unless by chance no solar outbursts occur while the space ship is out in space. So far this year 11 such bursts have occurred. The sun is now becoming more quiescent and will continue to do so for the next 3 or 4 years. There will be these sporadic bursts, however, that will, on the average, become less frequent. If I were to be the man in space I would certainly prefer to go in 1964 rather than in 1961. 1965 might still be a good year, but by 1966 the sun will start to become active again and the chances of a safe journey to the moon and back will be very much decreased. By 1975 the sun will again be quiet.

Because of the dangers of these radiations in space, which are unpredictable as of now, experimentation in space can best be done by automatic apparatus – leaving the astronaut home. There is much to be learned about the conditions in space, including what causes cosmic rays to change by at least a factor of five during a solar cycle. I am sure that, in the years to come, many new things will be discovered about the environment in interplanetary space so that we may become more aware of the nature of the universe in which we live.

I see that we have all gotten back from our journey safely. I hope none of you is any the worse for having taken this imaginative trip out into our solar system.

What would YOU do as an engineer a



Development testing of liquid hydrogen-fueled rockets is carried out in specially built test stands like this at Pratt & Whitney Aircraft's Florida Research and Development Center. Every phase of an experimental engine test may be controlled by engineers from a remote blockhouse (inset), with closed-circuit television providing a means for visual observation.

'ratt & Whitney Aircraft?

Regardless of your specialty, you would work in a favorable engineering atmosphere.

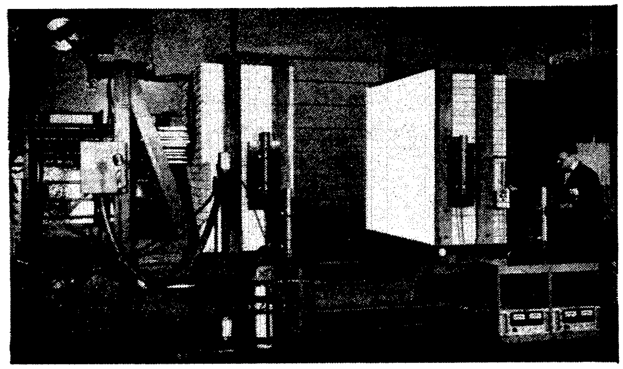
Back in 1925, when Pratt & Whitney Aircraft was designing and developing the first of its family of history-making powerplants, an attitude was born—a recognition that *engineering excellence* was the key to success.

That attitude, that recognition of the prime importance of technical superiority is still predominant at P&WA today.

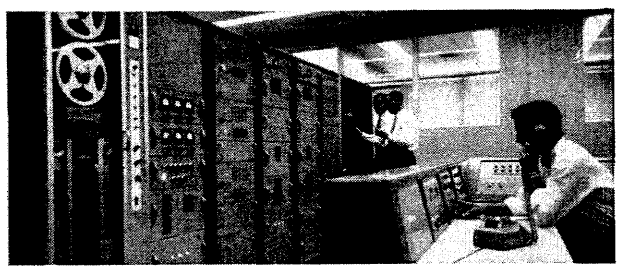
The field, of course, is broader now, the challenge greater. No longer are the company's requirements confined to graduates with degrees in mechanical and aeronautical engineering. Pratt & Whitney Aircraft today is concerned with the development of all forms of flight propulsion systems for the aerospace medium—air breathing, rocket, nuclear and other advanced types. Some are entirely new in concept. To carry out analytical, design, experimental or materials engineering assignments, men with degrees in mechanical, aeronautical, electrical, chemical and nuclear engineering are needed, along with those holding degrees in physics, chemistry and metallurgy.

Specifically, what would *you* do?—*your own engineering talent* provides the best answer. And Pratt & Whitney Aircraft provides the atmosphere in which that talent can flourish.

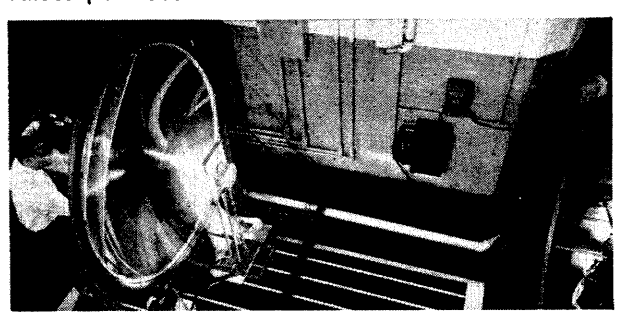
For further information regarding an engineering career at Pratt & Whitney Aircraft, consult your college placement officer or write to Mr. R. P. Azinger, Engineering Department, Pratt & Whitney Aircraft, East Hartford 8, Connecticut.



At P&WA's Connecticut Aircraft Nuclear Engine Laboratory (CANEL) many technical talents are focused on the development of nuclear propulsion systems for future air and space vehicles. With this live mock-up of a reactor, nuclear scientists and engineers can determine critical mass, material reactivity coefficients, control effectiveness and other reactor parameters.



Representative of electronic aids functioning for P&WA engineers is this on-site data recording center which can provide automatically recorded and computed data simultaneously with the testing of an engine. This equipment is capable of recording 1,200 different values per second.



Studies of solar energy collection and liquid and vapor power cycles typify P&WA's research in advanced space auxiliary power systems. Analytical and Experimental Engineers work together in such programs to establish and test basic concepts.

PRATT & WHITNEY AIRCRAFT

Division of United Aircraft Corporation

CONNECTICUT OPERATIONS — East Hartford

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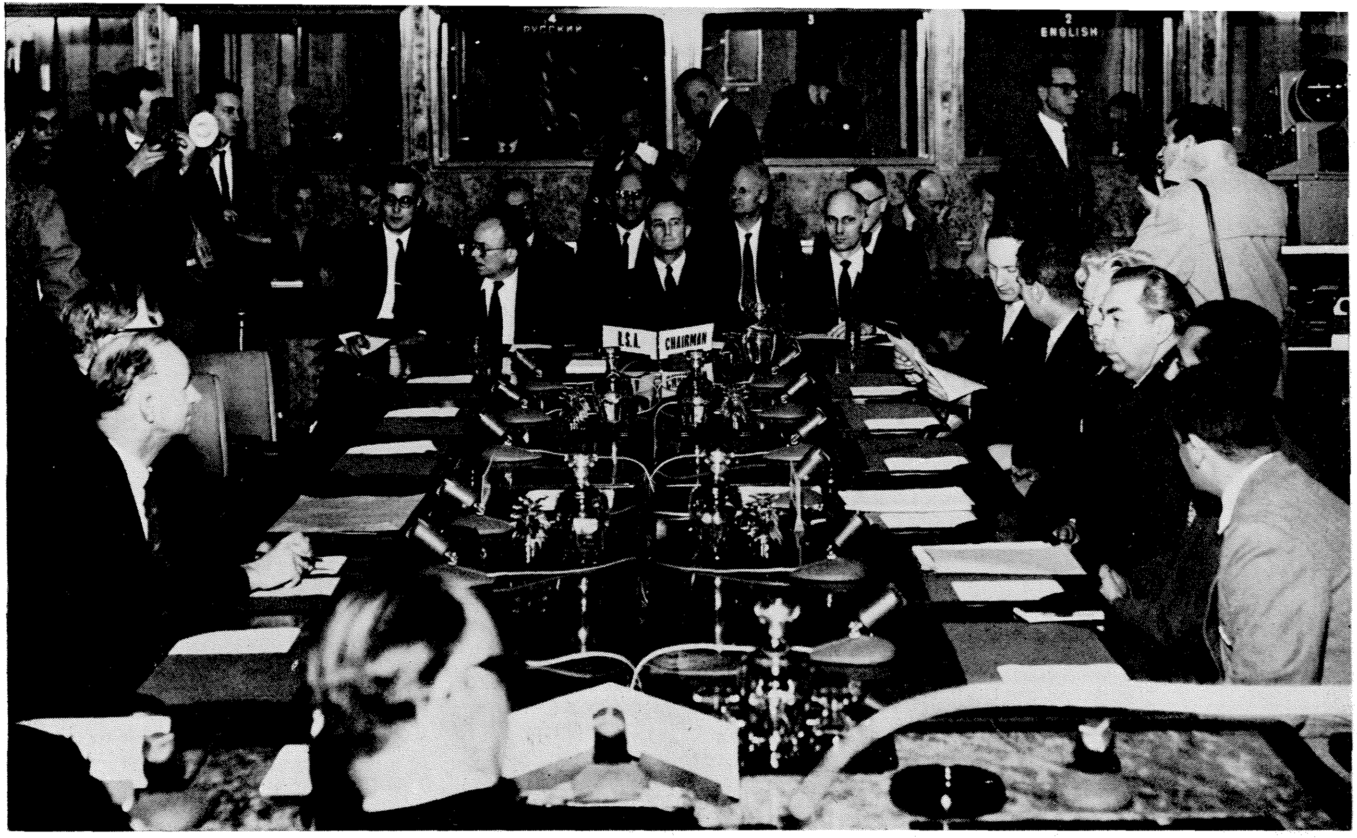

U.S. delegation (center) at the Geneva Conference (1959). First row: Professor Wolfgang Panofsky (Stanford), Dr. James Fisk (Bell Labs), Dr. Carl Romney (USAF). Second row: Dr. Harold Brown (Livermore Laboratory), Prof. Frank Press (Caltech), Prof. A. Turkevitch (U. of Chicago), Prof. Hans Bethe (Cornell), Prof. J. Tukey (Princeton). USSR delegation is at right, U.K. delegation (not seated) at left.

Scientific Aspects of

The Nuclear Test Ban

by Frank Press

The negotiations for a nuclear test cessation have been going on between the East and the West since 1958. These negotiations have been unique in many respects, particularly in that scientists initiated the talks in an attempt to lay a scientific foundation on which the diplomats could then build.

Now, there are many pitfalls in putting scientists from East and West together in a room and telling them to behave like scientists, knowing full well that the ultimate decisions must be based on non-scientific questions. But this is a long story in itself and I won't go into it. However, the use of scientists was a new concept in international negotiations, and many of us were unfamiliar with the role that we had to play, of being scientists and yet being cognizant at the same time of the political implications of any positions that were taken.

The nuclear test cessation treaty is now partially written, and a number of articles have been agreed upon by the East and West. Such issues as the concept of "on-site" inspections (field investigation of suspicious events), the immunities and privileges of the monitors, and the makeup of the inspection and monitoring teams have been settled.

The remaining articles are some of the most difficult ones, and they are still being negotiated. One of the most important of these deals with the number of inspections that will be permitted each year. Of course, this is one of the crucial aspects of any monitoring agreement, and if the Russians insist on no more than two or three inspections a year, I don't see how we can make any progress toward a successful treaty.

At the present time, the proposed monitoring system would be able to deal with underground nuclear

continued on page 28

explosions of somewhere between 5 and 20 kilotons. The bombs that were used during the war were about 20 kilotons. Smaller explosions are not now identifiable as suspicious events. Explosions in the atmosphere offer no major problems. Explosions in outer space are feasible, and of uncertain use. It is questionable whether they can be detected, and it is difficult to gage their significance as a factor in a test cessation treaty.

The decoupling method

A major problem has recently been posed for this treaty – namely, the possibilities of exploding nuclear devices in large cavities. This is known as the decoupling method, or the "muffling method." It is interesting to me that the greatest improvement in detection and the greatest degradation in detection were made by investigators of the same organization – the RAND Corporation. They have recently shown us how to improve our monitoring capability from 20 kilotons down to about 5; and yet they have also discovered how to hide these explosions in large cavities.

The possibility of decoupled explosions is something we have to live with. The decoupling theory has recently received experimental verification in tests involving small chemical explosions. Now, one doesn't go around blithely shooting explosions in large cavities. For one thing, it is expensive. It might cost anywhere from $5 million to $20 million to dig one of these holes. Furthermore, it will take something like two years to excavate a hole large enough for a 5-kiloton explosion. Such an excavation is a major effort, involving a lot of men and equipment. It is the sort of thing that could be difficult to hide from intelligence agents.

The present technology limits us to holes in salt (where they can be dug by using hot-water solutions), but I think it is quite possible that ways will be found at not too much greater expense to dig these holes in other rocks; and if a nation is willing to spend enough money, it might even be able to make a hole in granite. This has not been fully studied. There is a whole new technology of excavating underground cavities which now must be explored in order to anticipate the possibility of clandestine testing. Unfortunately, we must realize that if a nation wanted to conduct clandestine tests by means of shooting in large cavities, it probably could succeed so far as the present technology is concerned. It is not an easy job, but it is one that is quite feasible.

Now, recognizing the difficulties of detecting small explosions, Prime Minister McMillan and President Eisenhower made a very sensible proposal. They suggested that we enter into a treaty with the Russians for explosions of 20 kilotons and larger, with an appropriate number of monitoring posts, inspections, and so on, and that we enter into a moratorium with the Russians for the smaller shots. The moratorium might last about two years – the exact length is another political question. During the moratorium, both sides would conduct a joint research program in an attempt to find ways to improve detection so that the smaller explosions which are now not detectable can be brought into the treaty. This is a very reasonable approach, and it seems to me to be the only way out of a very difficult situation. Admittedly there is a risk in going into this treaty – but there are also some returns.

The treaty represents a first step in opening the countries of the world to inspection – a small step indeed, but one which is preliminary to progress in disarmament. It would give us experience in implementing controls under a treaty organization to see if further disarmament proposals are feasible. Of great importance is the hope that the treaty would inhibit the development of nuclear weapons by other countries.

A controlled monitoring system

After the moratorium research program is completed we will be in a better position to specify the monitoring system needed to provide adequate control. If political restrictions on the number of stations and the number of inspections, and the use of unmanned stations, are not excessive, a feasible monitoring system might deter clandestine tests. Then again, it might not – and it would be risky for us to enter into a treaty. It is dangerous to anticipate the results of research and to predict the outcome of the political-scientific deliberation that determines what detection capability represents an acceptable risk.

There is not, by any means, unanimous support in this country of the proposed moratorium. Many Americans who have made tremendous contributions to our national security see pitfalls in such a moratorium. It will diminish our security by inhibiting development of those weapons needed to improve our defense.

Where do we stand now? During May of this year, we met with the Russian scientists to discuss the moratorium research proposal and many of us were surprised. The Russian scientists supported the moratorium research program and agreed in principle to participate. They even said that they would allow us to use nuclear explosions during the research program even though they would not conduct any nuclear explosions themselves. They placed certain restrictions, however, on the use of nuclear explosions – some of which were reasonable. They insisted on the privilege of examining each nuclear device in detail – opening it before it was detonated – in order to

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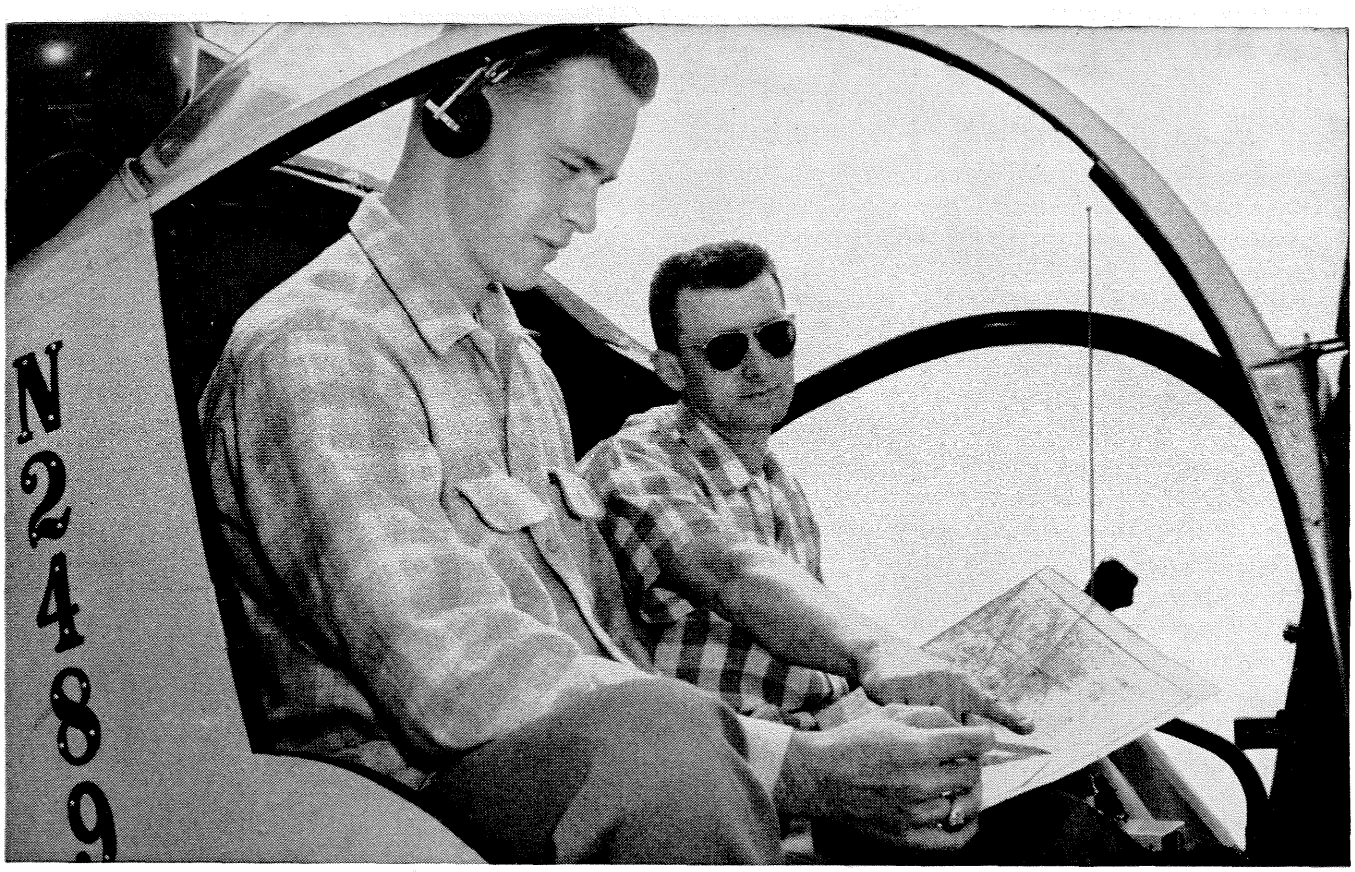


Telephone engineer Bill Pigott, left, and helicopter pilot plan aerial exploration for microwave tower sites.

"I ENGINEERED MICROWAVE TOWER LOCATIONS ON MY FIRST ASSIGNMENT"

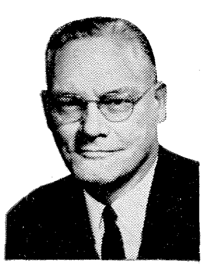
When Bill Pigott knocked on the door of Pacific Telephone, he had two big assets. One was an electrical engineering degree from Seattle University. The other was a craving to jump right into vital engineering problems.

It was not long before Bill was exploring Washington's rugged Cascade Range in a helicopter to find sites for microwave relay towers—part of a multimillion dollar telephone construction job. Today, it's considerable satisfaction to him to see these towers spanning the mountains, knowing that his planning helped put them there.

Other important assignments followed: engineering maritime radio systems, SAGE systems—figuring engineering costs for Air Force Titan missile bases.

"Our people respect a man's engineering training—you really get a chance to show what you've got on the ball," Bill says. "I was up to my neck in tough engineering problems right from the start."

If you want a job where you put your training to work from the day you hang up your hat—you'll want to visit your Placement Office for literature and additional information.



"Our number one aim is to have in all management jobs the most vital, intelligent, positive and imaginative men we can possibly find."

FREDERICK R. KAPPEL, *President*
American Telephone & Telegraph Co.

BELL TELEPHONE COMPANIES

make sure that we were not developing weapons under the subterfuge of a research program to improve detection. I think this is a legitimate request on their part, and I think that this is something which eventually could be agreed upon, subject to Congressional approval.

The Russians also insisted on the privilege of participating in the planning of the experiments. They wanted to be real partners in this study – and we would have been delighted to have had them as partners.

A more difficult problem arose when they said that they would not countenance any decoupling tests during the research program. They frankly admitted that their position was not a scientific one but a moral one. It was immoral, they argued, to try to find better ways to hide nuclear explosions. We attempted to point out to them that there would always be a cloud of uncertainty over the treaty until we could resolve the decoupling problem – or, at least, until we completely understood its implications. Without some decoupling tests we could make no progress in attaining these goals.

It is difficult to predict how this will go – whether the Russians will be adamant on this question, or whether it is negotiable. I, for one, do not see how we can agree to a moratorium research program without some decoupling tests.

A nuclear test cessation treaty

I believe that if there is going to be any progress toward disarmament, the first step is a nuclear test cessation treaty along the lines of the McMillan-Eisenhower proposal. A major impediment is the number of inspections. The Soviets are very leery of inspectors on their territory, as we all know. They have placed, essentially, a political strait jacket on all progress in the sense that they are limiting us, for political reasons, to an inadequate number of inspections.

It is quite impossible to feel secure with a treaty that allows too few inspections. This follows because of the large number of natural events – perhaps in the hundreds each year – which are inseparable from explosions. For all of these suspicious events, the Soviets propose to allow us only several field inspections each year. Clearly, the chances for violation are very large under this circumstance. The fact that we are asking for a few tens of inspections is in itself a concession, because we are not asking to inspect every single suspicious event (which is what we would like to do) but only a very small percentage.

This is not something that is readily negotiable. It is not the case that the geometric mean between both points of view – or the arithmetic mean – will leave us with proper safeguards. After the research program, we will be in a better position to set the number of monitoring stations and annual inspections that are *really* necessary.

Another indication of the strait jacket that the Russians are putting on us by their obstinate desire to keep their country closed is the following.

There is only one suggestion now on the books that might provide some security against decoupled shots. This is the suggestion made by Professor Hans Bethe. He proposed that we increase the number of monitoring posts by setting up unmanned stations – instruments which telemeter their information without requiring local personnel. With a network having an instrument spacing of a few hundred kilometers, decoupled shots would be detected and might be identified as suspicious events. This is a sound proposal but, in the present framework of the negotiations, it is not admissible because of the Soviet position.

I think another impediment is the fact that there is no solid American position on this question. The President is in the difficult situation of receiving conflicting recommendations from his advisors. This does not make for a very strong American position at Geneva.

Resuming nuclear testing

There is increasing pressure in the U.S. to resume testing, not only for the development of weapons but also to get on with our own research program to improve detection. Very soon we are going to have to face up to this question. The Russians now have a moratorium which is not policed. Like an Irish wake, they would like this to go on forever, because they have everything they want and they give nothing in return. They have slowed development on weapons needed for our security. We cannot be certain that they have given up testing, although there is no direct evidence that they have detonated nuclear explosions during the negotiations.

Sooner or later, we are going to have to take stock and put a time limit on the negotiations for the treaty. We must make a reasonable attempt at negotiations, however, for abrupt test resumption could be embarrassing to us and might bring censure from many of the nations of the world. I hope that if we resume testing independently it is only after a yeoman's effort in Geneva to reach a treaty with reasonably adequate safeguards. It may require a summit conference devoted to this one problem. Difficult though such a treaty may be to realize, I think this is the easiest of the disarmament questions before us.

We are now actually engaged in our research program to improve detection. The U.S. Government is presently spending some tens of millions of dollars each year to improve detection techniques. This is all unclassified research, and much of it is being con-

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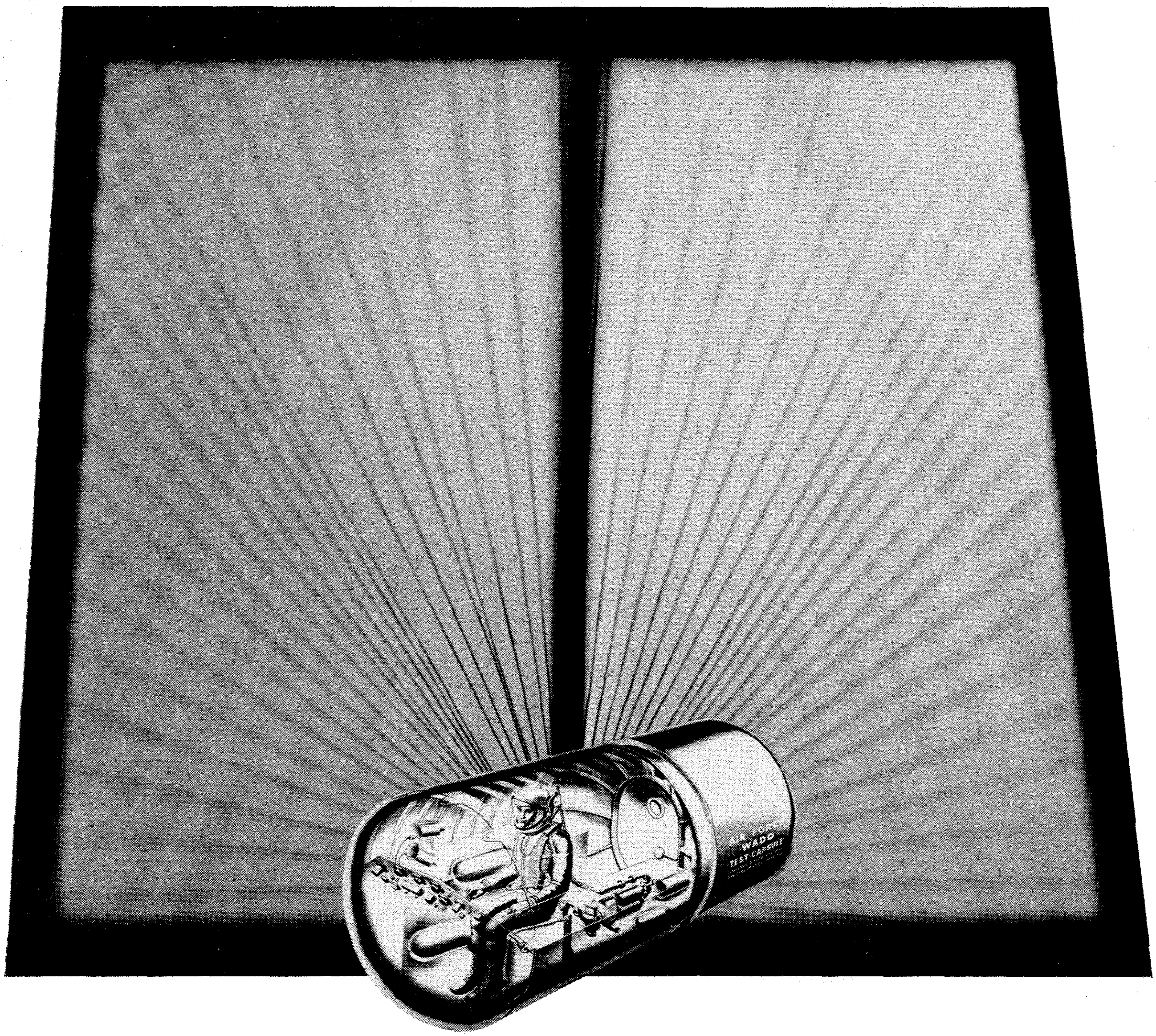
OUT OF THE LABORATORY



Bringing space down to earth... this laboratory space capsule is designed to measure man's physiological and psychological limits and test life support systems under simulated space flight conditions. Now scientists will be able to study, simultaneously, the space flight stresses of high altitude, acceleration, heat and isolation.

Developed and being built by Garrett's AiResearch divisions for the U.S. Air Force's Wright Air Development Division, this ground test space capsule is an example of Garrett's research leadership in life support and secondary power systems for space vehicles for long duration flight at zero gravity. Development of these life support systems utilizing cryogenic gases and efficient turbine drive secondary power systems using solar or nuclear energy are opening up vast new worlds of exploration and career achievement for engineers in the space age.

A world leader in the development and manufacture of major systems and components for aircraft and missiles as well as advanced flight vehicles, The Garrett Corporation provides an orientation program lasting a period of months for the newly graduated engineer, working on assignments with experienced engineers in laboratory, preliminary design and development projects.

Should you be interested in a career with The Garrett Corporation, write to Mr. G. D. Bradley in Los Angeles.

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OTHER DIVISIONS AND SUBSIDIARIES: AIRSUPPLY-AERO ENGINEERING • AIRESEARCH AVIATION SERVICE • GARRETT SUPPLY • AIR CRUISERS AIRESEARCH INDUSTRIAL • GARRETT MANUFACTURING LIMITED • MARWEDEL • GARRETT INTERNATIONAL S.A. • GARRETT (JAPAN) LIMITED ducted in the universities. Nuclear explosions have not yet occurred. We hope to conduct these jointly with the Russians as part of a moratorium research program, if such cooperation is possible. Otherwise we may have to go it alone. I think that this program is something we really can be proud of; it shows the world that we are working to make a treaty possible.

Let me give you some examples of the projects that are now under way. A typical monitoring post of the kind that will be spread throughout the world has been completed and placed in operation. We can evaluate its capability. It is a post which is quite large; it includes an area of many square miles, with tens of seismographs within the area, and a large technical staff. A number of similar stations will be built soon. These are the treaty-type stations which were accepted by both sides in 1958.

In addition, the government has just funded an improved station which incorporates the advances that have been made since 1958. This improved station will have many more detectors, improved instruments, computing machines, and, possibly, digital seismographs. It will include all of the sophisticated analytical and instrumental advances that have recently been made.

Caltech's program, for example, is to make a digital seismograph for processing directly by a computer. We are also interested in making extremely sensitive seismographs by finding optimal spectral bands to record in. We are studying the long waves of earthquakes and explosions in the hope that these long waves may be a new diagnostic feature which distinguishes earthquakes from explosions. It may interest you to know that these wavelengths are of the order of 100 km-lengths which are long compared to most discontinuities on the earth's surface.

The Bell Telephone Laboratories have taken up the problem of depth of focus. If we can precisely determine the depth of focus of an earthquake, most earthquakes will be eliminated as suspicious events since they typically occur at depths greater than those at which explosions are likely to occur.

Stanford University, together with the University of California, is studying the aftershocks of earthquakes. One feature of an earthquake is that very often there is another one at the same place within a few days. A nuclear explosion is not likely to be followed by an aftershock. These groups are gathering more precise statistics on aftershocks of earthquakes.

Some firms drawn from the oil industry are engaged

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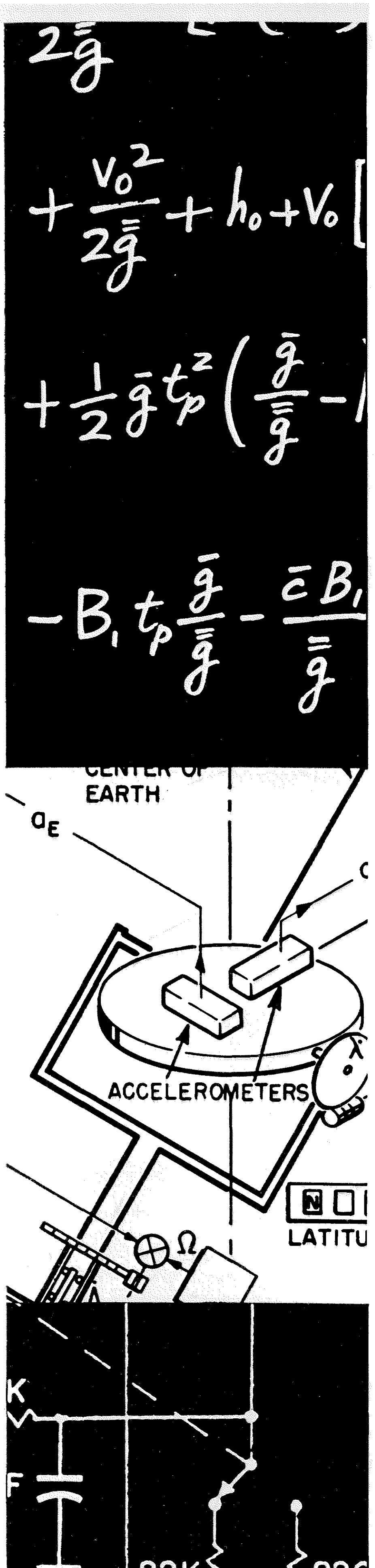
in such problems as how to locate a decoupling hole at a depth of a thousand feet. What measurements can be made at the surface to locate one of these holes? These are difficult problems as is the following one: If a certain number of inspections are allowed per year, what will the inspectors look for? Any violator will make sure that the surface is smoothed over again, that any evidence is removed. These inspectors must now find a way to locate fission products at a depth of a thousand feet in a hole that may be a hundred feet in diameter. This is not an easy job.

The Scripps Institute of Oceanography at La Jolla, and Columbia University in New York are making deep-sea seismographs. This may seem like a strange thing, but scientists at Columbia have shown that the bottom of the ocean is one of the quietest places to put an instrument; the noise is very low, and with a low noise-level, a more sensitive seismograph can be built to detect smaller explosions.

One of the most interesting aspects of the research program to me is what we call the "giveaway" program. The U.S. Government is essentially going to re-equip the seismograph stations of the world. This is perhaps the greatest single act of progress that geophysics has seen. It is like giving away one hundred 100-inch telescopes to observatories all over the world, or giving 100 cyclotrons to 100 universities all over the world. I hope you do not think me bizarre if I say that if all else fails, and the negotiations blow up, at least we will have greatly improved world research in geophysics. Now the government doesn't give money away without reason, and their support of the "giveaway" programs is in the interest of improving seismic research all over the world. It may turn out that a researcher in some remote country, stimulated by this new equipment, will come up with a significant improvement.

I think this shows the firm intention of the U.S. to go ahead and try to improve the technology so that a treaty is possible. Two years from now, we will have completed much of our research program, and we will have learned a great deal. I don't know how much better off we will be insofar as detection of explosions is concerned. I think that, no matter what happens at the end of two years, the final problem, again, will be in the hands of the diplomats. However we will be better able to advise our diplomats about the state of affairs, so that the final diplomatic decision will rest on a more secure scientific foundation than is now possible.


U.S. ARMY



The TOP name in missile inertial guidance—AC THE ELECTRONICS DIVISION OF GENERAL MOTORS, is seeking top talent

AC has immediate, permanent positions in Milwaukee, Los Angeles, Boston and Flint. If you have a BS, MS or PhD degree in EE, Physics, Math or ME, you may qualify for one of the positions.

You can find challenge and opportunity for advancement at AC where you will work on such inertial guidance projects as MACE, THOR, POLARIS, the ultra-sophisticated TITAN system and complex Bombing Navigation Systems, and even manned space vehicle guidance.

AC and GM will assist your career progress through graduate study at universities in nearby locations. In addition, you will have the opportunity to take exclusive on-the-job course work on the advanced state of the art.

These training programs are now available in Milwaukee:

ENGINEERING PROGRAM—For engineers whose career aim is design and development of inertial guidance equipment. All Junior Engineers will enter this six-month training program with formalized, half-day classroom instruction. This instruction will be in conjunction with rotating job assignments of two-month duration. These assignments, in Manufacturing, Reliability and Engineering areas, will provide a smooth transition from academic learning to career development.

FIELD SERVICE PROGRAM—Formalized two to four month classroom training on missile inertial systems and bombing navigation systems. After completion of training program, assignments will be made to domestic and foreign sites.

Contact your placement officer regarding GM interviews.

* * * * *

Technical Honorary Society Program Chairman: If your society would be interested in a technical presentation on inertial guidance, we would like to work with you to plan such a presentation. Contact Mr. R. E. Allen, AC Spark Plug, Milwaukee 1, Wisconsin.

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Personals

1926

Domenick J. Pompeo, who retired last June after 32 years with the Shell Oil Company, died of cancer on September 20. Domenick was founder and head of the Shell instrumentation department at Emeryville, and was responsible for the development of nearly 100 devices – from a recording retractometer to a reflux ratio controller. He is survived by his wife, Cora.

1929

Charles M. Wolfe, MS, PhD '32, is now head of the transducer engineering department of Borg-Warner Controls in Santa Ana. He was formerly a research specialist at United Electrodynamics.

1934

Milton U. Clauser, MS '35, PhD '37, is president of the newly-formed Clauser Technology Corporation, in Torrance. The company will engage in the development and production of electronic equipment and instruments "for the missile age." He was formerly vice president and director of research at Space Technology Laboratories, a subsidiary of the Ramo-Wooldridge Corporation.

1935

Charles F. Thomas has been appointed manager of marketing and planning for The Radio Corporation of America's major defense systems organization in Moorestown, N.J. He joins RCA after 25 years with the Lockheed Aircraft Corporation, where he has been serving as director of military sales since 1952.

1940

Fred Brose has been made production manager of the Datex Corporation in Monrovia. He was formerly assistant operations manager, and has been with the company since 1957. Fred is married and has three daughters and a son.

1941

Fred W. Billmeyer, Jr., senior research chemist at the Du Pont Experimental Station near Wilmington, Del., is on leave this year to conduct a course in high polymer technology at MIT. Fred has been with Du Pont since 1945.

1942

Howard C. Hall is resident manager of Crown Zellerbach's pulp and paper mill in St. Helens, Oregon. He has been with the company since 1947.

William L. Rogers is now vice president of Aerojet-General's Azusa plant. He has been vice president of Azusa Operations for the past two years and will now have responsibility for all service functions and operating activities at the plant.

1943

Oscar D. Terrell has been made manager of purchasing at the Knolls Atomic Power Laboratory in Schenectady, New York. KAPL is operated by General Electric for the U. S. Atomic Energy Commission. The Terrells and their three sons live in Schenectady, New York.

Ralph Willits is now chief project engineer of the engineering design section at the Socony Mobile Oil Company's Ferndale, Washington, refinery. He was formerly with the engineering department of General Petroleum in Torrance, California, and moved to Washington last June when General Petroleum was integrated into the parent company. The Willits' and their two daughters (10 and 7) have been enjoying the water-skiing and fishing in their new location.

1945

William F. Gulley is now assistant regional manager of the western division of the Rockwell Manufacturing Company. He will continue to live in San Francisco where he was formerly district manager for Rockwell. He has been with the company for 13 years.

Franklin Sproles Edwards, MS, died on October 19, at Starkville, Miss., of a stroke suffered the day before. He was 47 years old. He had been at Mississippi State University since 1941, and had served as head of the aeronautical engineering department there since 1947.

1947

Robert G. Hawthorne has been promoted to senior research engineer at the Union Oil Company of California's Research Center in Brea.

Manfred Eimer, MS '48, PhD '53, has been appointed to the newly-created position of deputy division chief in the reorganization of the Space Sciences Division of Caltech's Jet Propulsion Laboratory.

Justin L. Bloom is now project engineer of the Advanced SNAP Programs (Systems for Nuclear Auxiliary Power) in the nuclear division of The Martin Company in Baltimore. He has been chief of the materials management branch of the San Francisco Operations

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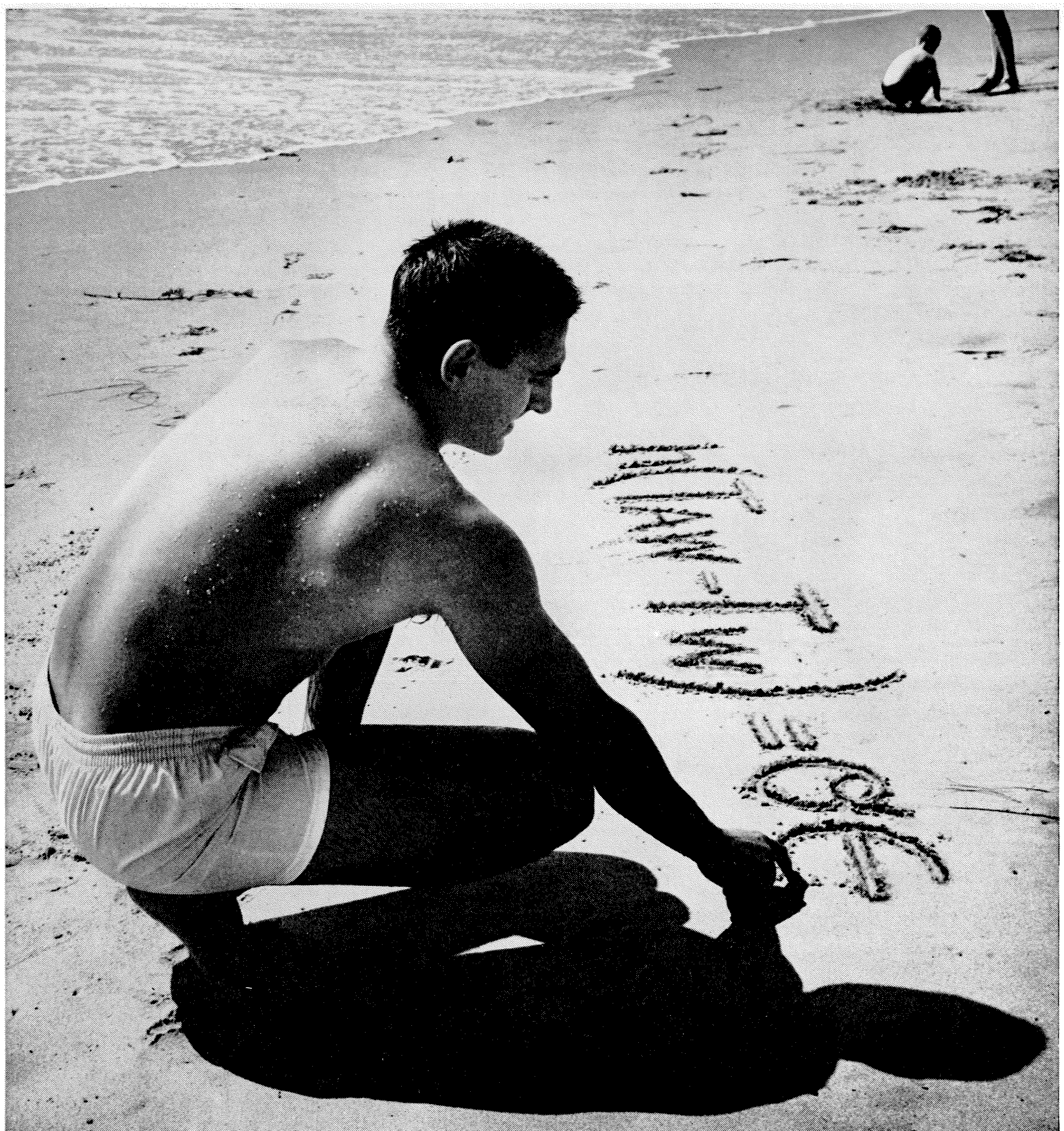

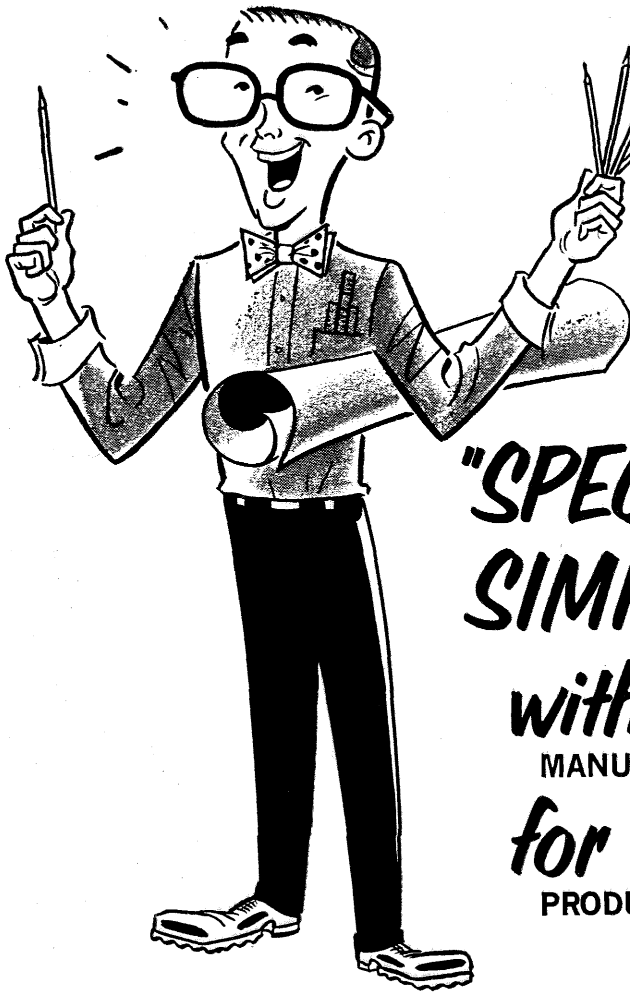

Personals . . . *continued*

Office of the U.S. Atomic Energy Commission for the past four years. The Blooms have a daughter and a son.

1949

Thomas H. Wakeman is now manager of plate, structural and bar sales at the Kaiser Steel Corporation's Oakland, California, office. He joined the company's sales division in 1950 and has been mid-continent sales manager since 1954. The Wakemans have two children.

Virgil J. Berry, Jr., MS, PhD, '51, is director of the petroleum engineering research division at the Sinclair Research Laboratories, Inc., in Tulsa, Okla. He was formerly research group supervisor at the Pan American Petroleum Corporation in Tulsa.

1950

Worthie Doyle, PhD, formerly a staff member at the Lincoln Laboratories in Lexington, Massachusetts, is now at Aeronutronics in Newport Beach, California.

J. Robert Holmes, MS, has been appointed manager of reliability engineering at the Owego facility of IBM's Federal Systems Division in Vestal, N.Y. He has been with the company since 1951 and was formerly manager of reliability evaluation.

Dean A. Rains, MS '51, PhD '54, is now manager of the systems design branch of the United Technology Corporation in Sunnyvale, Calif.

Donald J. Gimpel, MS, has been appointed vice president in charge of engineering at the Arnoux Corporation in Los Angeles. Before joining Arnoux in 1958, he was director of the computer systems department of Panellit, Inc.

1951

William V. Wright, PhD '55, is now a vice president of Electro-Optical Systems, Inc., in Pasadena. He will continue in his present position as manager of the company's solid state division. He came to Electro-Optical in 1957 from Pacific Semiconductors, Inc., where he was program director of semiconductor materials.

1952

Raymond L. Heacock, MS '53, now chief of the space instruments section in the Space Sciences Division at Caltech's Jet Propulsion Laboratory, will be responsible for scientific instrumentation on spacecraft. He has been in the computer group at JPL since 1953.

John C. Porter, Jr., MS '58, formerly a staff engineer on assignment to NASA headquarters in Washington, is now

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NEW MIRRO ALUMINUM ROLLING MILL

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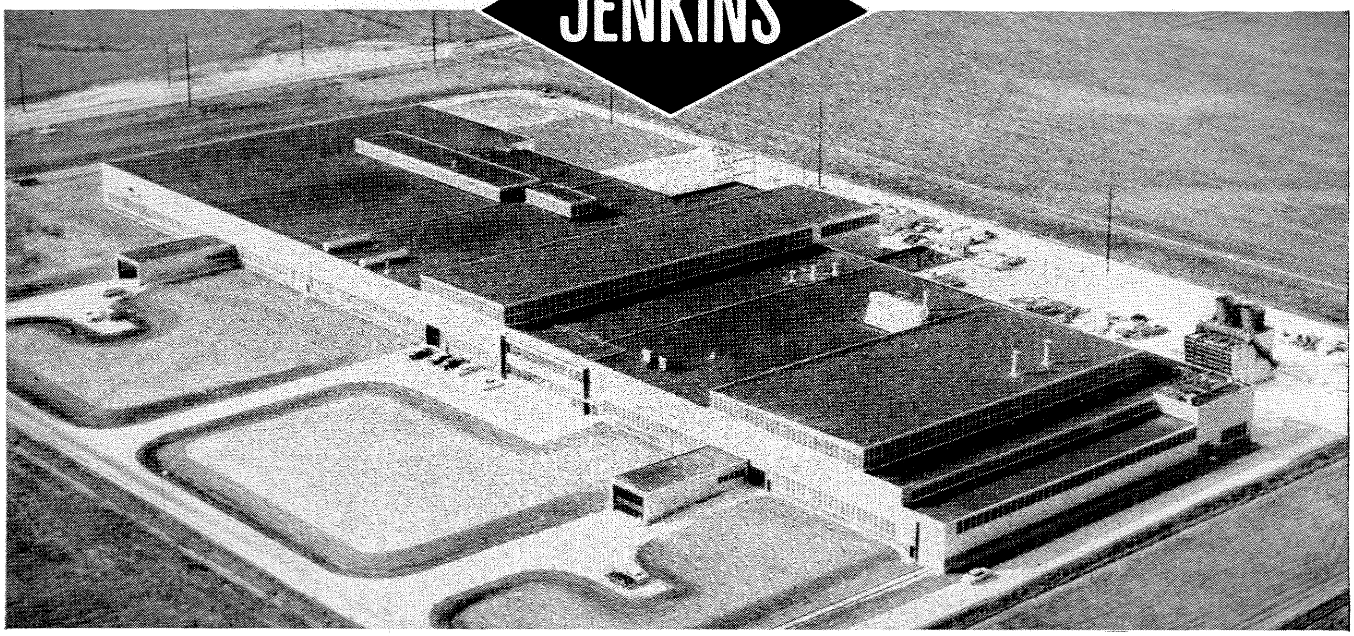

Consulting Engineers and Contractors: Klug & Smith Co., Milwaukee, Wis. • **Mechanical Contractor:** Paul S. Grunau Company, Milwaukee, Wis.

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There are over 15 miles of piping in this huge new mill that can produce 60,000,000 pounds of aluminum foil and sheets a year. But there will be no valve problems . . . no avoidable valve maintenance and replacement expense on these lines. Mirro made sure of that by installing Jenkins Valves throughout the system.

There's no point in gambling with valve problems when you can have the known reliability and trouble-saving quality of Jenkins Valves, without paying extra for the protection. Jenkins Bros., 100 Park Avenue, New York 17.

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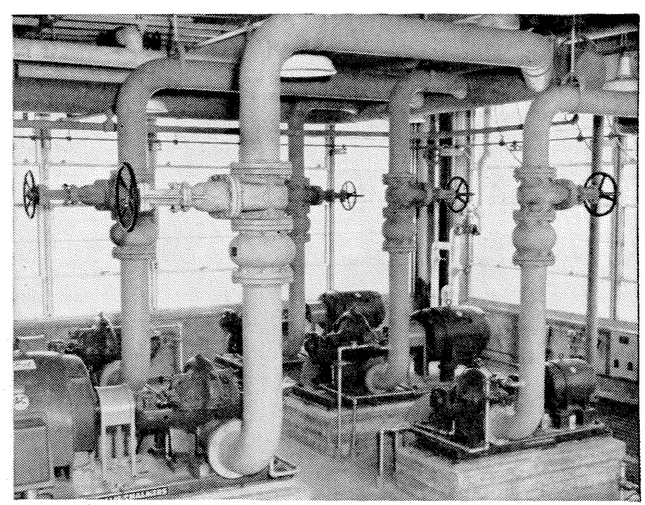

Jenkins Bronze and Iron Valves on lines in pump house for water cooling tower

JENKINS VALVES

LOOK FOR THE JENKINS DIAMOND ®

JENKINS SINCE 1864 Jenkins Bros

chief of the research analysis section of the Space Sciences Division at Caltech's Jet Propulsion Laboratory.

Henry L. Richter, Jr., PhD '56, has joined the staff of Electro-Optical Systems, Inc., in Pasadena. He will manage the company's newly-formed advanced electronics and information systems division. He was formerly chief of the space instruments section of the Space Sciences Division at Caltech's Jet Propulsion Laboratory.

1953

M. Edmund Ellion, PhD, is president of Dynamics Science Corporation, a subsidiary of Marshall Industries in South Pasadena. He was formerly project engineer at the Given Manufacturing Company in Pasadena.

James T. LaTourrette has joined the staff of the General Electric Research Laboratory in Schenectady, New York. After receiving his MS and PhD from Harvard, he studied at Bonn University in Germany and, prior to joining General Electric, he served as a lecturer at Harvard University. The LaTourettes and their two children are living in Scotia, New York.

Carl A. Rambow, MS '58, received his PhD from the University of Wisconsin last June, and is now working for the California Research Corporation in La Habra. The Rambows have three children – Michael, 3; David, 2; and Barbara, born last September.

William A. Acerre writes from Costa Rica that "after several months as a consultant for the Venezuelan Government Ministry of Mines and Hydrocarbons, we finally made it to Costa Rica. Since the engineering field is almost a closed corporation here and the obstacles for a graduate from other than the University of Costa Rica are substantial, a new career is in order. For the present, I am seriously considering raising pigs. Not pig iron, but the kind of pig that walks around on four feet and grunts. They also eat a lot – however, I think that they leave a good profit and that's what I like."

1955

Delano Brouillete, MS '56, will head a newly-formed servomechanism group at the Datex Corporation in Monrovia. He was formerly senior engineer at Librascope, Inc., in Glendale.

Saul Feldman, PhD, is now a principal scientist in the fluid physics division of Electro-Optical Systems, Inc., in Pasadena. Before that, he was principal research scientist at the AVCO-Everett Research Laboratory in Massachusetts

James R. Bowden, MS, research group leader in Continental Oil Company's research and development department at Ponca City, Okla., is at MIT on a Sloan Fellowship.

John J. Merrill, MS '56, has been promoted from instructor in physics to assistant professor at the Harvey Mudd College in Claremont.

Stanley L. Grotch, MS '56, is now an engineer in the chemical engineering department of the Shell Development Company's Emeryville research center.

1958

Nathaniel Grossman writes that he is working for his PhD in mathematics at the Institute of Technology of the University of Minnesota and has been teaching for the past two years. He has received the NSF Cooperative Graduate Fellowship for the coming year so that now he can devote full time to research and credit-gathering.

ALUMNI DIRECTORY SUPPLEMENT

A supplement to the 1960 Alumni Directory will be ready for distribution sometime after the first of January, 1961. This supplement will list the names and addresses of those who received degrees in June, 1960. Copies of this supplement will be sent automatically to Association members who received degrees in 1960. Other Association members may secure a copy of this supplement by filling in the form below and sending it to the Alumni Office.

Please send the 1960 Supplement of the 1960 Alumni Directory to:

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Facts about chemical job assignments that can influence your future career

Do you know the number of different kinds of jobs in the chemical business? It's one of the biggest factors favoring a career in chemistry! Chemists and chemical engineers may find their spots in research, development, analysis, testing, production, technical service, management, or sales.

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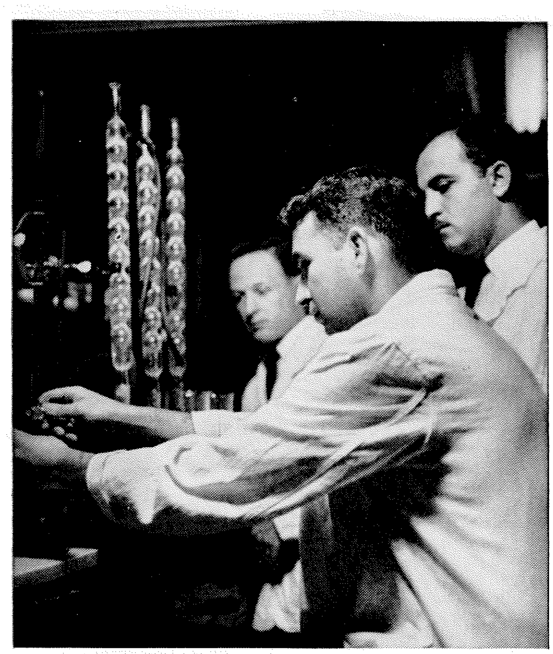
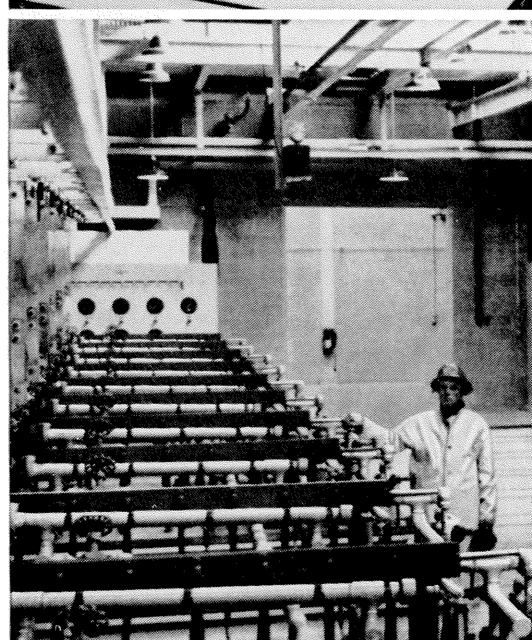
Ask our interviewer about career opportunities at Allied when he next visits your campus. Your placement office can give you the date and supply you with a copy of "Your Future in Allied Chemical." Allied Chemical Corporation, Dept. 126-R3, 61 Broadway, New York 6, N. Y.





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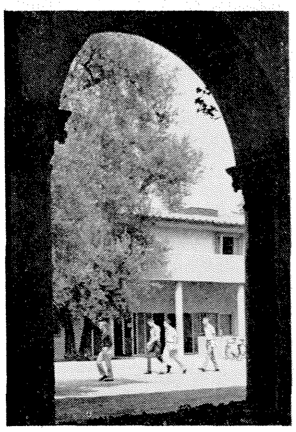

ALUMNI EVENTS

January	Winter Dinner Meeting
March 4	Annual Dinner Dance
May 6	Annual Seminar
June 7	Annual Meeting

ATHLETIC SCHEDULE

December 1-January 2
Christmas Vacation

Basketball

January 4
Caltech at UC Riverside

January 10
Redlands at Caltech

January 13
Caltech at Pomona

January 17
Orange Coast at Caltech

FRIDAY EVENING DEMONSTRATION LECTURES

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

January 6
Advanced Propulsion Concepts for Spacecraft
– Stanford S. Penner

January 13
The Geography of Earthquakes
– Charles Richter

January 20
India
– Robert Huttenback

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Informal luncheons every Thursday

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State of California, Dept. of Natural Water Resources
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Visiting alumni cordially invited—no reservation

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If your sights are set  on astro-electronics–

Photo from screen of RCA's TV Imagery Simulator. This device permits electronics to enhance photographs to aid interpreters. It was used in the design of TIROS I, developed for the National Aeronautics and Space Administration by RCA, to simulate photographs which could be obtained from 400 miles in space.

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Outer space presents vast new challenges to the engineer—especially in electronics. And photography becomes one of his valuable tools. Orbiting satellites send messages to be recorded from the oscilloscope tube. X-rays and film allow him to check the internal integrity of sealed components. Even intricate circuits can be printed and miniaturized by photographic methods.

There's hardly a field on which you can set your sights where photography does not play a part in improving the product, simplifying work and routine. It saves time and costs in research, on the production line, in quality control, in the engineering and sales departments, in the office.

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TRADE MARK

One of a series

Interview with
General Electric's Byron A. Case
Manager—Employee Compensation Service

Your Salary at General Electric

Several surveys indicate that salary is not the primary contributor to job satisfaction. Nevertheless, salary considerations will certainly play a big part in your evaluation of career opportunities. Perhaps an insight into the salary policies of a large employer of engineers like General Electric will help you focus your personal salary objectives.

Salary—a most individual and personal aspect of your job—is difficult to discuss in general terms. While recognizing this, Mr. Case has tried answering as directly as possible some of your questions concerning salary:

Q Mr. Case, what starting salary does your company pay graduate engineers?

A Well, you know as well as I that graduates' starting salaries are greatly influenced by the current demand for engineering talent. This demand establishes a range of "going rates" for engineering graduates which is no doubt widely known on your campus. Because General Electric seeks outstanding men, G-E starting salaries for these candidates lie in the upper part of the range of "going rates." And within General Electric's range of starting salaries, each candidate's ability and potential are carefully evaluated to determine his individual starting salary.

Q How do you go about evaluating my ability and potential value to your company?

A We evaluate each individual in the light of information available to us: type of degree; demonstrated scholarship; extra-curricular contributions; work experience; and personal qualities as appraised by interviewers and faculty members. These considerations determine where within G.E.'s current salary range the engineer's starting salary will be established.

Q When could I expect my first salary increase from General Electric and how much would it be?

A Whether a man is recruited for a specific job or for one of the principal training programs for engineers—the Engineering and Science Program, the Manufacturing Training Program, or the Technical Marketing Program—his individual performance and salary are reviewed at least once a year.

For engineers one year out of college, our recent experience indicates a first-year salary increase between 6 and 15 percent. This percentage spread reflects the individual's job performance and his demonstrated capacity to do more difficult work. So you see, salary adjustments reflect individual performance even at the earliest stages of professional development. And this emphasis on performance increases as experience and general competence increase.

Q How much can I expect to be making after five years with General Electric?

A As I just mentioned, ability has a sharply increasing influence on your salary, so you have a great deal of personal control over the answer to your question.

It may be helpful to look at the current salaries of all General Electric technical-college graduates who received their bachelor's degrees in 1954 (and now have five years' experience). Their current median salary, reflecting both merit and economic changes, is about 70 percent above the 1954 median starting rate. Current salaries for outstanding engineers from this class are more than double the 1954 median starting rates and, in some cases, are three or four times as great.

Q What kinds of benefit programs does your company offer, Mr. Case?

A Since I must be brief, I shall merely outline the many General Electric employee benefit programs. These include a liberal pension plan, insurance plans, an emergency aid plan, employee discounts, and educational assistance programs.

The General Electric Insurance Plan has been widely hailed as a "pace setter" in American industry. In addition to helping employees and their families meet ordinary medical expenses, the Plan also affords protection against the expenses of "catastrophic" accidents and illnesses which can wipe out personal savings and put a family deeply in debt. Additional coverages include life insurance, accidental death insurance, and maternity benefits.

Our newest plan is the Savings and Security Program which permits employees to invest up to six percent of their earnings in U.S. Savings Bonds or in combinations of Bonds and General Electric stock. These savings are supplemented by a Company Proportionate Payment equal to *50 percent* of the employee's investment, subject to a prescribed holding period.

If you would like a reprint of an informative article entitled, "How to Evaluate Job Offers" by Dr. L. E. Saline, write to Section 959-14, General Electric Co., Schenectady 5, New York.

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