ENGINEERING | AND | SCIENCE

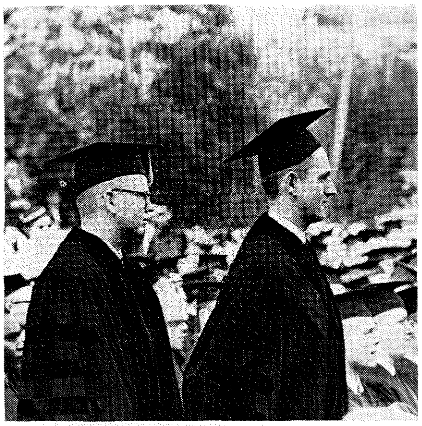
June 1961

Commencement . . . page 9

Published at the California Institute of Technology

ENGINEERING AND SCIENCE

JUNE 1961 *VOLUME XXIV* *NUMBER 9*



On Our Cover
two 1961 graduates at Caltech's 67th commencement. For more about this year's commencement see page 9.

Fritz Zwicky,
professor of astrophysics and staff member of the Mount Wilson and Palomar Observatories, has long been concerned with the conquest of both inner and outer space. Before most men became space-minded, Dr. Zwicky foresaw revolutionary developments in the exploration of space and in rocket development (see page 13).

In his 1958 book, *Rocketry and Space Exploration,* A. G. Haley, president of the American Rocket Society and of the International Astronautical Federation, writes: ". . . Even though the Allies expended a relatively massive effort on rockets during World War II . . . at no time was any serious work conducted on the big ballistic rocket. Rockets were always thought of as supplements to field artillery, to aerial bombs, or to the cannon and machine guns of aircraft by the military services. Neither did anybody (outside of the Germans) foresee that the big rocket would one day change the whole concept of war. The one exception to this conclusion may well be the theoretical work of Fritz Zwicky at Aerojet, 1942-45, when during his morphological study of all rocket uses, he included systems which later proved to parallel the V-1, V-2, ICBM, and indeed systems-concepts still in the 'whispered' stage."

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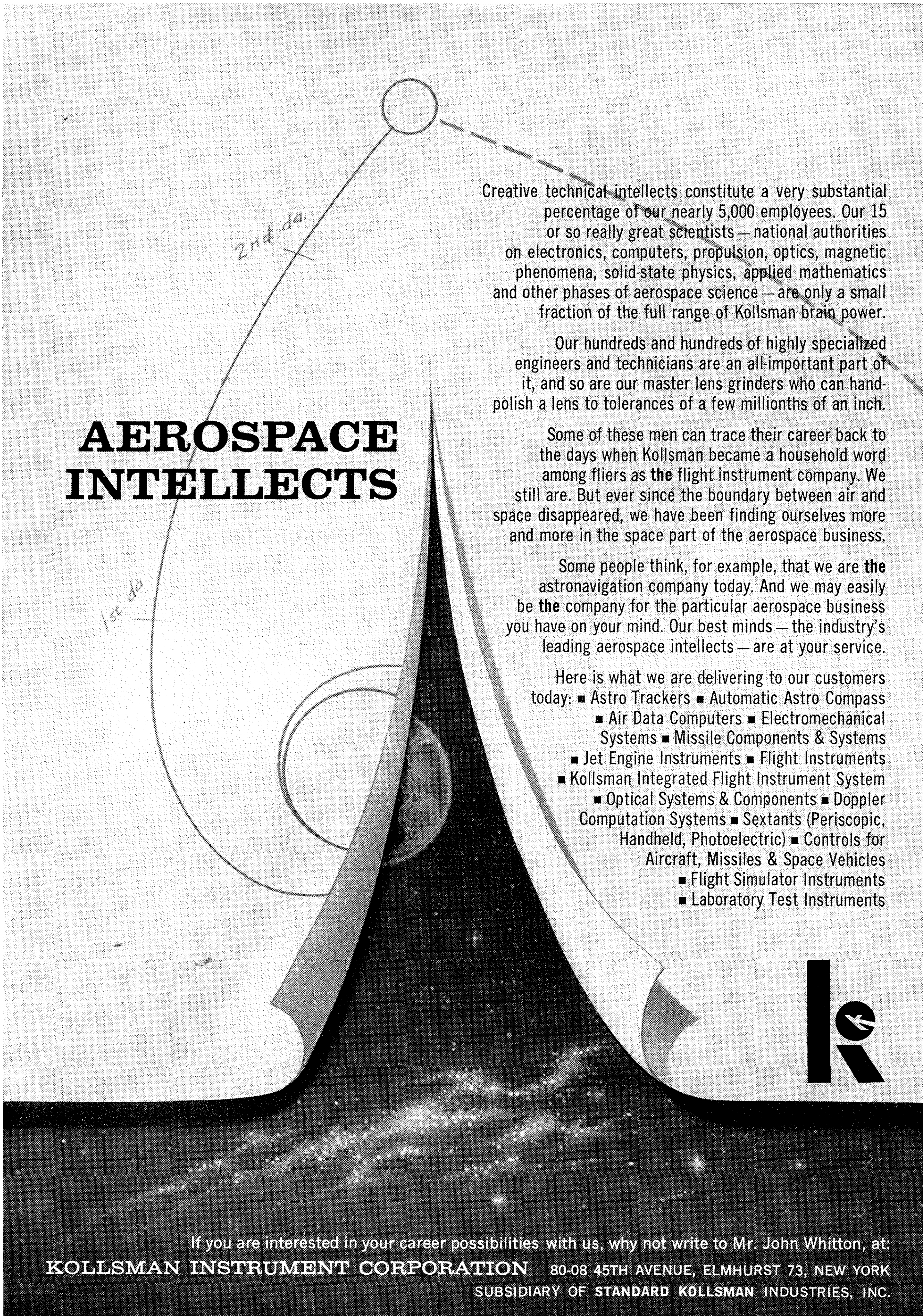
Published monthly, October through June, at the California Institute of Technology, 1201 East California St., Pasadena, Calif. Annual subscription $4.50 domestic, $5.50 foreign, single copies 50 cents. Second class postage paid at Pasadena, California. Manuscripts and all other editorial correspondence should be addressed to: The Editor, *Engineering and Science*, California Institute of Technology.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Creative technical intellects constitute a very substantial percentage of our nearly 5,000 employees. Our 15 or so really great scientists — national authorities on electronics, computers, propulsion, optics, magnetic phenomena, solid-state physics, applied mathematics and other phases of aerospace science — are only a small fraction of the full range of Kollsman brain power.
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ENGINEERING AND SCIENCE
June 1961, Volume XXIV, No. 9

Science, Technology, and Education

by L. A. DuBridge

Science, technology, and education are at once the three great achievements, the three great problems, and the three great opportunities of modern civilization.

They are really not three independent entities, of course; technology grows out of science, and both are unthinkable without education.

One can, however, push the interdependence of these three problem children too far. For example, one of the greatest popular fallacies ever perpetrated by the American people on themselves is the one that the Russians got ahead of us in space because they had smarter, or more, or better educated scientists and engineers than we had. "Therefore," it is said, "their educational system must be better than ours; hence they'll soon surpass us in all fields and we will soon become a second-rate power."

Here, indeed, is a lovely mixture of "sequiturs" and "non sequiturs." It is true that, if our educational system were markedly inferior to theirs, we would be in serious trouble. We would become a second-class power. But it is also true that the Russians' big rockets were not made in the Russian schools — nor does their bigness prove the corresponding smartness of their engineers.

In fact, we know now that for military purposes the smart engineer will design the smallest and simplest rocket — not the biggest — for a given military purpose. Our Minute Man rocket is better than the Atlas precisely because it does the same military mission with smaller weight, smaller thrust, and less cost. *Its* designers are the *smartest* rocket engineers on earth. But have you ever heard anybody stand up and *say* so? No — because we can't yet separate the biggest from the best. We think, somehow, they must be identical.

What really happened in the rocket field was that the American scientists and engineers, considering the problem of delivering a thermonuclear bomb of the size available at the time, concluded that a 300,000- to 400,000-pound-thrust rocket could do the job. So they designed, developed, and built such a rocket. If they had been smarter, would they have built a bigger one? Not at all. If they had been really smart, they would have multistaged it more efficiently, and thus made the first stage smaller.

And the Russians?

They, apparently, were considering a different military problem: either they had a large warhead, wanted to send it farther, or else had some other problem posed to them. They apparently decided they needed a bigger rocket — say 800,000 pounds. So that's what they built. They were smart, too, of course. But they were also lucky. For then along came the space problem — a problem not really considered very important in the United States ten years ago — and the big Russian boosters were a natural for that job.

Were we dumb *not* to start space work back in 1953, say? I don't know. Looking back, it would have been nice if someone had convinced Congress that going into space was important and worth spending a billion dollars or so on a larger rocket to make it possible. If the decision had then been made, the rocket could certainly have been built — as the Russians proved. But the lack of such a decision was *not* attributable to a shortage of scientists and engineers. If anything, it was a shortage of psychologists, or propaganda experts.

More specifically, it was the shortage of a few men who had vision, knowledge, persistence, and persuasiveness to sell to the President, the Congress, and the American people a concept which, in 1953, would have sounded utterly insane — sending a five-ton capsule into space.

Somebody sold that idea to someone in Russia — or else the Russian engineers weren't smart enough to develop a *light* hydrogen bomb, so they had to solve the

"Science, Technology, and Education" has been adapted from a commencement address given by President DuBridge at Union College, Schenectady, New York, on May 29, 1961.

military problem by brute strength and awkwardness. I suspect that is what they did, and that the space venture came as an extra dividend — an unearned run, as they say in baseball.

At the same time, one must concede that the Russians capitalized on this unearned run in a big way, and poured an enormous and well-directed effort into making it pay huge dividends to the glory of the Soviet State.

I say all this to emphasize the point that, to judge a whole educational system, the whole scientific and technical strength of a nation, and even the whole worth of a political system, on the basis of one technical achievement — like a big rocket — is to grossly misunderstand the essential interrelations which exist between education, science, technology, and true national strength.

But what do we mean by true national strength?

I think there is only one sensible meaning to this term; namely, the strength and the ability to use our talents and resources to meet the national goals which we ourselves set.

If this be the definition, then it is obvious that different nations will have different goals and, hence, will give different meanings to the term "national strength." Hence, various nations will develop their talents and resources in different directions.

National goals

In the Soviet State, the national goals are clearly to enhance the power and prestige of the state itself in order to promote the spread of Communism throughout the world. The desires, needs, and aspirations of individual people are secondary to the needs of the state.

In the free world, the priority of goals is reversed. The aspirations of individual people come first; the enhancement of the power and prestige of the state is secondary.

This does not mean that a free people will willfully neglect the essential needs of the state. Quite the contrary. We believe deeply that free peoples can build a basically stronger society than those who live under a dictator. But the purpose of the state will be to protect freedom — not to destroy it; it will be not to impose domination of the state either over its own people or the peoples of other countries.

Now, understanding this contrast between the national goals of a free nation and of a dictatorship is essential to the formulation of our national policies relating to the development and use of our talents and our resources. If we allow ourselves to be led into a mad race to follow and to copy every achievement, every practice, and every policy of the Soviet Union, in the belief that this is the only way to match their strength, then we will, in the process, destroy our own national character; we shall abandon our own national goals; and we might as well organize a Communist state here and now and be done with it.

Obviously we are going to do no such thing. But we would do well to be alert to this danger, else we may drift too far down this road only to find that it is too late to retrace our steps.

All of this has a direct bearing on the subject of science, technology and education. For these three interrelated activities are essential features of our national strength — just as they are essential features of the strength of the Soviet Union. But because of the differences in goals of the two countries, the ways in which we develop our activities in these areas will be vastly different — or at least they should be.

We have heard much since the launching of Sputnik I about the excellence of the Russian educational system and the decadence of our own. But before we begin copying the Russian system we would do well to inquire about the purposes of the two systems.

Educational goals

As I see it, the purpose of the Soviet educational system is two-fold:

1. To indoctrinate its people in the glories of Communism and to shield them from insidious truths about the operation of other social and political systems.
2. To select young people of particular types of talents and to train them in areas which the state believes are essential to its goals and purposes.

I believe the Russians have developed a system which matches these purposes pretty well. Clearly, from time to time, they themselves find defects in the system and change it to meet new needs. But, clearly also, the system has produced those types of scientists, engineers, technicians, and political leaders which they desired. And it has produced men and women well trained in these specialties, and, apparently, has produced them in adequate numbers.

The goal of *our* educational system is quite different; namely, to offer to all our young people the opportunity to develop their own talents and abilities in such ways as will lead them into the types of careers and the kinds of lives which they believe will be most fruitful, most satisfying, and most useful. Thus, we offer not only opportunities to those whose talents lie in scientific and technical fields, but also to those who wish to become bankers, lawyers, political and social scientists, businessmen, housewives — or just good citizens.

How well does our educational system match these goals and these objectives?

No one would maintain that the match is perfect, that our system is ideal and could not be improved. On the contrary, we have far to go to build a system adequate to our needs and our ideals. But the important thing is that, as we change things, we do not abandon our goals but seek only better ways to achieve them.

Wherein have we failed?

We hear much about how we have sacrificed intellectual quality in our pursuit of the goal of developing the "whole child." We did, in fact, up until a few years ago, swing pretty far in this direction. We tended in many cases to put extracurricular recreational and social activities ahead of the classroom, both in our thinking and in our school expenditures — and even in the training of our teachers. Often, too much classroom time was devoted to frills and trivia that were only remotely related to sound intellectual development. Many educationists insisted that methodology was far more important than substance — and many teachers were graduated from college, loaded with methods courses, and with only the slightest understanding of the subjects they expected to teach.

We are now reversing this trend — too slowly perhaps — but we have started. We now realize that while every child, every school, every locality, every school level offers different problems, the goal of intellectual opportunity should be the same for all; that all peripheral activities should lead us closer to and not further from that goal.

We have also tended, in past years, both in our schools and in college, to neglect the highly gifted student. Our nation sorely needs the trained talents of such students. But, even here, we must always keep in mind that our basic purpose is not to train talented men to serve the state — but to give the individual student the opportunity to reach the highest levels to which his own talents and ambition can take him. It is the tenet of a free sociey that when that is done to the maximum extent the nation, too, will be stronger and will prosper.

Science and technology in a free society

This theme of individual opportunity carries over into the realms of science and technology. Shall we educate scientists and engineers primarily to make bigger rockets to enhance the prestige of the nation? Or shall we educate them in order that they may seek and apply new knowledge in any field they select? If we are truly devoted to the ideals of a free society, the answer is self-evident.

We must also ask how, in a free society, we shall set up and organize our scientific enterprises. Shall we do as the Russians have very recently done, and place all science under the rigid control of a powerful agency of the state — an agency which will allocate all funds, determine what scientific projects shall and shall not be pursued, and at what level, and with how many people?

Or shall we continue the policy which has always been followed in America of saying that scientific discovery is the product of the free unfettered minds of individual people, that it shall be the policy of the citizens and their government to encourage the investment of private funds, state funds, corporate funds, and even government funds, in such a way as to provide the best scientists of the nation the opportunities to pursue their investigations into the unknown in whatever directions they believe are most fruitful?

If our goal is to provide the biggest rockets to impress the Hottentots with the glories of our political system, then we should pursue the Soviet plan. But if we believe in free inquiry, and if we believe that the advancement of knowledge on a broad front will, in the long run, do the most to advance the welfare of people everywhere, then we should continue our present policy.

Science in Russia

The Russians have admittedly assigned their best scientists and engineers to work on rocket and space technology. Their achievements in this field have been brilliant. But they have paid a heavy price in the neglecting of research in many key areas of basic science. Not all basic research has been stopped, of course, but the scale, breadth, and depth of their scientific work is grossly inferior to ours — or to that of the British. Count the awards of Nobel prizes in physics, chemistry, and medicine: 61 American scientists have received Nobel awards, and only five Russians.

Witness also the fanfare with which the Russians hurriedly built a 10-billion-electron-volt nuclear accelerator, at very great cost, in order to advertise, for a time, that they had the most powerful nuclear machine in the world. The machine was indeed built — but it has never worked properly and is now almost inactive.

Both the United States and CERN (the cooperative European laboratory in Switzerland, now directed by an American physicist) have in successful operation far more powerful and productive machines. The Russians have not advertised this situation in their international propaganda and, unfortunately, neither have we. We did not build our machine just to beat the Russians; we did it because we believe in the advance of scientific knowledge.

I contend that we should *believe* in freedom and should be proud of the achievements of a free society; that we are justified in using and promoting that freedom because, in the long run (and in the short run too), a free society will contribute most to human welfare throughout the world.

Similar observations apply in discussing the organization and promotion of technology — of applied science. In technology, however, the problem is a little different. Science, as I have said, proceeds most effectively through the method of free inquiry — through projects evolved, pursued, and stimulated by men with ideas. Technology proceeds this way also — in part.

For example, inventive groups throughout the country have developed a myriad of new consumer products, so we have more television sets and refrigerators and automobiles and new food products — and more Metrecal — than all the rest of the world put together. But we have better industrial processes, more advanced communication techniques, and better public health and medical care than the rest of the world, too. These are the products of free technology.

But there are other areas in which technology must be mobilized, directed, and supported by the government — military weapons, space technology, nuclear energy, certain areas of public health, for example. Here again we have not done too badly. I don't believe for a minute that we are behind the Russians in over-all military strength — or even in the specific field of missiles. (As I said before, the biggest rocket booster does not necessarily mean the best military weapon.) Only in space technology have we lagged, for reasons I have already given.

And here I come to one serious defect and criticism of our democratic society — the decision-making process in our government is slow, inefficient, and lacking in courage and imagination. We did not foresee the huge prestige value of space exploration — and, once we did realize it, we were slow in making decisions as to which of many competing lines of endeavor we should pursue and which to abandon.

In both military and space development we have tended to put a small effort on many things, instead of concentrating large efforts on a few essential things. We have trouble in setting priorities among our various national objectives, and, once having set them, we lag in making the essential technical, fiscal, and political decisions to implement our program vigorously. This may all result in making more varied advances on a broad front — but we forego the opportunity of making quick breakthroughs in certain critical areas.

Three choices

What do we do about this? We have three choices: (1) we may say that things are good enough as they are and do nothing; (2) we can abandon our democratic process and put decision-making in the hands of a dictator or a small group of commissars; or (3) we may retain our democratic government, but improve its decision-making processes.

Obviously we shall try to do the latter. But it is not going to be easy. And, since I am not a political scientist, I am not competent to invent a solution. Nevertheless, it is a problem to which I hope the government will devote a serious, extensive, intelligent, and sustained effort in coming years.

We have some terribly important decisions impending just now; not only decisions in politics, international affairs, and national defense. We also face decisions in science, technology, and education.

In education, for example, we as a nation face a major task: how shall we, as rapidly as possible and on an extensive scale, improve the intellectual excellence in our educational system? First, we must recognize that intellectual excellence is our goal — that (according to the National Education Association) — the "central purpose of education, at all levels, is to develop the rational powers of men." There are many things to do to instill this ideal and to achieve it. Can we, at both local and national levels, bring ourselves to make the necessary decisions to give intellectual excellence the primary place in our school programs? We could devote untold billions of dollars a year into doing more of the same things we are now doing. We could also, for a much lower sum, improve the quality of what we do — improve curricular materials and learning aids; challenge students at all levels to really use their full capacities; make the education of teachers a more substantive, more meaningful, and more challenging process.

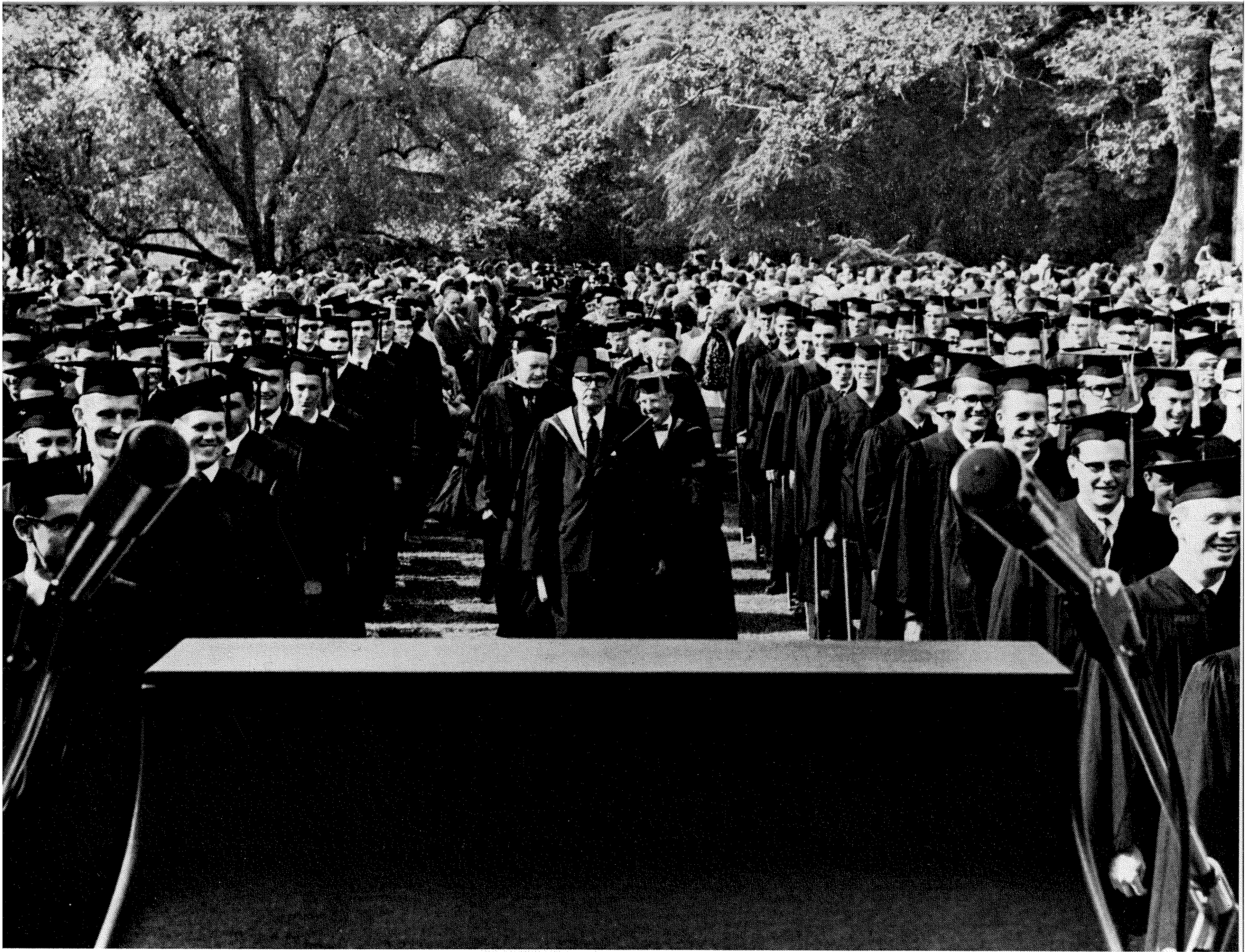
Problems and decisions in science

In science, too, we face problems and decisions. Shall we see to it that free inquiry by free minds continues to be fostered in all fields, and that such inquiry shall command all the financial support it needs — for its own sake? Or shall we let free scientific research be solely the by-product of the difficulties we encounter in the technological fields of industrial production, space technology, or national defense?

But it is in technology that the decision-making machinery of our Federal Government faces its sharpest challenge. Where do the real technical problems lie in the field of national defense? Do we have the courage to concentrate on them and stop the diffusion of our efforts in pursuing a host of marginal or obsolete areas — or by pursuing exotic notions which have the aura of glamor, but little substance of military effectiveness?

In our space program, shall we concentrate effort on pursuing space explorations which have a sound technical base and a useful scientific goal, or shall we let our space program be confined to trying to lift bigger packages into space than the Russians do? Are we interested in space gymnastics or space science? I don't mean that space science won't require big things too. But we must make some decisions on what our goals should be.

These are all problems which may seem remote to the graduating classes of 1961. But many of you will be immersed in these and similar questions very soon; all of you, as citizens, will be immersed in them eventually. They are not problems that are either superficial or temporary; they go to the heart of the problem of the future of a democratic society. How we handle them will be your business for many more years than it will be mine. They are problems that are interesting, exciting, challenging — and terribly, terribly important.



The academic procession at Caltech's 67th annual commencement on June 9.

The Month at Caltech

Commencement 1961

At Caltech's 67th annual commencement on June 9, a total of 365 students received degrees – 135 Bachelors of Science, 145 Masters of Science, 74 Doctors of Philosophy and 12 Engineers. Of the 33 men who graduated with honors, 4 received both academic honor and Student Body Honor Keys: William R. Bauer, Lawrence D. Brown, Clyde S. Zaidins, and Sydney Leibovich.

Student Body Honor Keys were also received by 7 other seniors: Rodney D. Dokken, Joel K. Donnelly, John E. Lohman, Richard S. Norman, Thomas A. Tisch, John A. Todoroff, and Gary O. Walla.

The Frederic W. Hinrichs, Jr., Memorial Award for the year's outstanding senior went to Thomas A. Tisch.

The commencement address was delivered by John L. Burns, president of the Radio Corporation of America. James R. Page, honorary chairman of the

Commencement speaker John L. Burns, president of the Radio Corporation of America, and Caltech President L. A. DuBridge, meet the press before the ceremony.

Caltech Board of Trustees, presided at the ceremonies, and Rev. Mr. John Baker of the Pasadena Neighborhood Church gave the invocation and benediction.

Honors and Awards

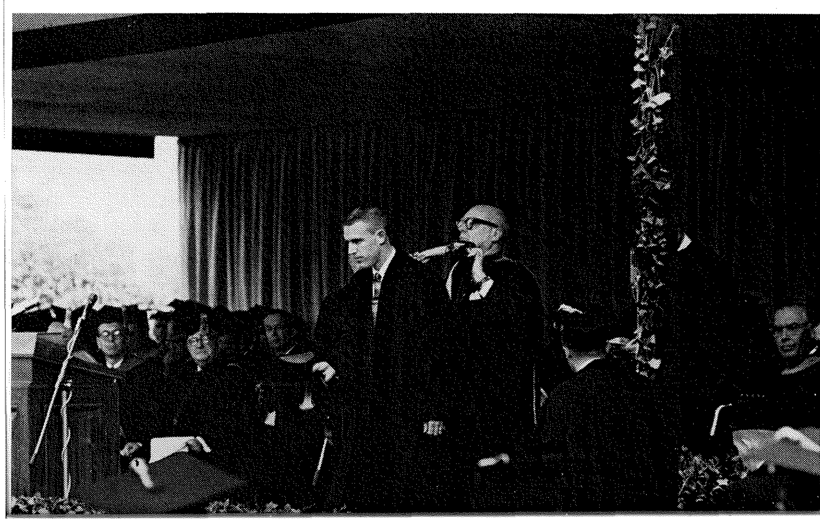
The first Honeywell Award, given by the Minneapolis-Honeywell Regulator Company "for distinguished performance in undergraduate engineering and science" has gone to Michael R. Ruecker, who received his BS from Caltech this month. The award consists of a prize of $200 and an engraved silver tray. In addition, the name of the recipient is engraved on a permanent bronze plaque in the Franklin Thomas Laboratory of Engineering.

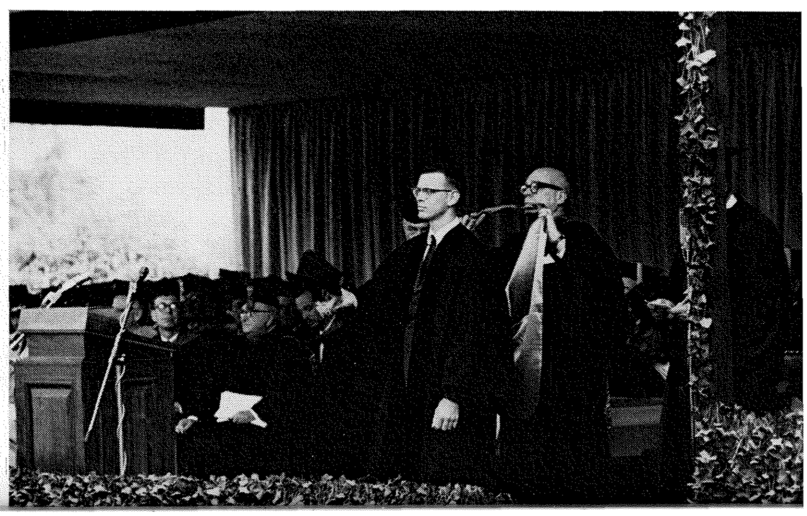
William R. Bauer, who received his BS from Caltech this month, and John H. Arndt, Jr., a junior in chemistry, received 1961 merit awards from *Chemical and Engineering News,* the weekly publication of the American Chemical Society. The awards, consisting of scrolls, were given this year for the first time – for a combination of high marks, extracurricular activities, and "for providing inspiration and encouragement to all students interested in scientific and engineering careers."

Director of Development

Charles Newton, Assistant to the President at Caltech, has also been appointed Director of Development. He will be in charge of the staff that will direct the Institute's fund-raising activities.

Mr. Newton who has been at Caltech since 1948 as assistant to the president, acted as chief staff officer





for the recent development program. A native of Frankfort, Kentucky, he received his PhB Litt. from the University of Chicago in 1933. He worked for a year as a newspaper reporter, then served as senior copy writer and group copy chief for a number of Chicago and New York firms. During the war, he worked at the Massachusetts Institute of Technology Radiation Laboratory, then under the direction of L. A. DuBridge, as group head of special publications and as production manager of a 23-volume series reporting the wartime work of the Laboratory.

New Registrar

Dr. Henry I. Weitzel has been appointed Registrar of the Institute. He takes office July 5. Dr. Weitzel has been serving as research director of the Pasadena City Schools. He succeeds Dr. F. W. Maxstadt, associate professor of electrical engineering, who has been registrar since 1953, and is retiring after 42 years on Caltech's staff.

Dr. Weitzel is a graduate of the University of North Dakota, where he received his BS in 1919 and his MS in 1920. He received his PhD in education and chemistry at the University of Southern California in 1933.

From 1922 to 1924 he taught chemistry and physics at Pasadena High School. He then joined the staff of Pasadena City College, serving as an instructor in applied and industrial chemistry from 1924 to 1928, and then until 1942 served as counselor to engineers, and to science and technology majors.

In 1946 Dr. Weitzel was made dean of student personnel at John Muir College, and in 1951 he became research director of the Pasadena City Schools.

New Trustee

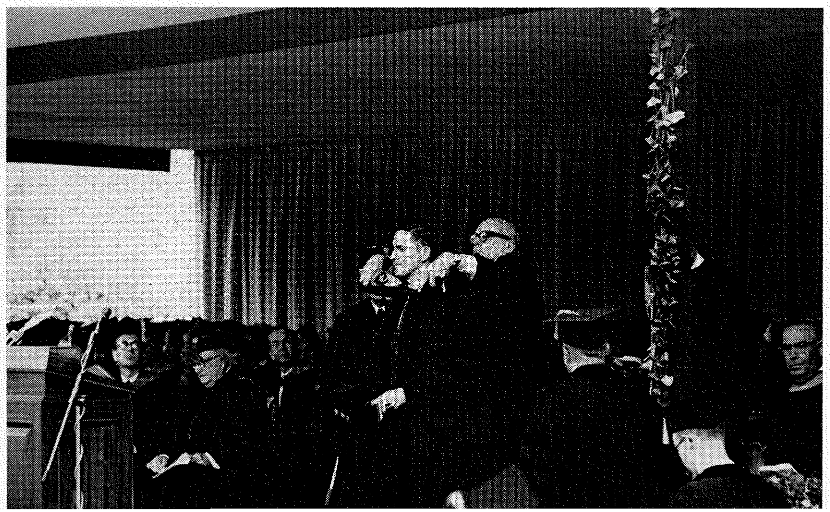
Charles H. Percy, chairman of the board and chief executive officer of the Bell & Howell Company, has been elected to the Caltech Board of Trustees. Mr. Percy is the fifth national trustee named by Caltech in a move to broaden the geographic base of its board membership. Bell & Howell, a Chicago firm, recently acquired the Consolidated Electrodynamics Corpo-

Henry I. Weitzel, Caltech's new registrar.

ration in Pasadena through a merger, and also established the Bell & Howell Research Center here last year.

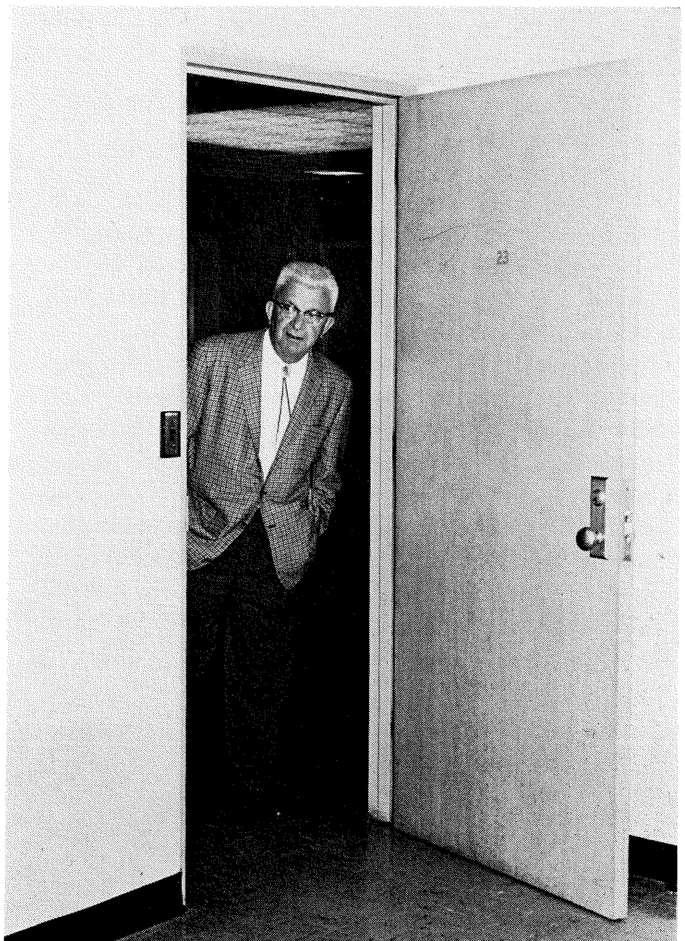
Mr. Percy has been with the company since 1936, when he entered its training program while attending the University of Chicago. He was elected to the board of directors in 1942, and in 1949, at the age of 29, he became president of the company.

In 1949 Mr. Percy was named one of the ten outstanding young men in the United States by the U.S. Junior Chamber of Commerce. He is chairman of the board of the Ford Foundation's Fund for Adult Education, and was chairman of the Republican Platform Committee in 1960. He is a director of the Chase Manhattan Bank in New York, the Harris Trust & Savings Bank in Chicago, and the Burroughs Corporation in Detroit. He is also a trustee of his alma mater, the University of Chicago.



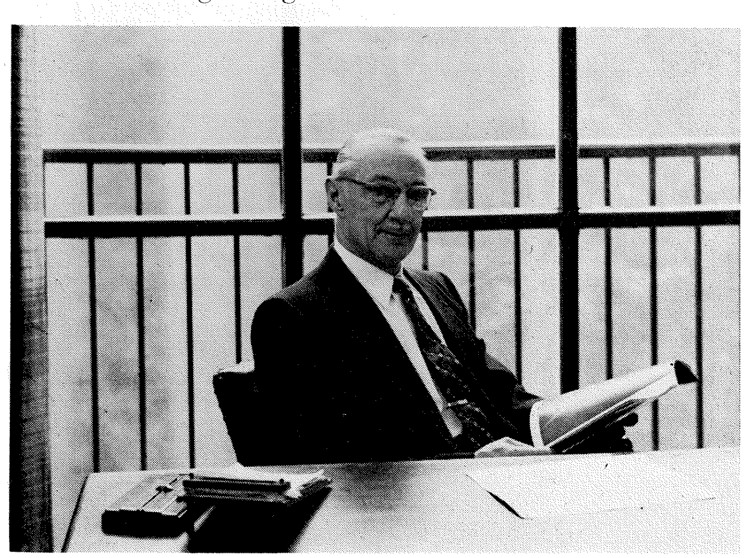
Retiring

Leonora S. Reno, secretary for the geology division, came to work as a substitute in 1926 and stayed on for 35 years. The Geology Club has just named a mountain in Antarctica for her — Mt. Leonora.



Floyd L. Hanes, athletic trainer, is retiring after 38 years on the staff. He was cross country coach from 1934 to 1947 and his squads took top conference honors in 1940-42 and 1945. He also served as track coach from 1943 to 1948.

Francis W. Maxstadt, Registrar of the Institute and associate professor of electrical engineering, retires after 42 years at Caltech. Dr. Maxstadt received his MS (1925) and PhD (1931) degrees from Caltech and has been serving as registrar since 1953.



Ernest G. Anderson, professor of genetics, has been at Caltech for 33 years. Dr. Anderson is known for his research in the field of cytogenetics, particularly in corn, where chromosomal modifications following exposure to atomic and nuclear bomb radiation are proving useful tools for corn improvement.

The March Into Inner and Outer Space

by Fritz Zwicky

Both scientists and laymen frequently inquire why we should want to journey into space. Also, in connection with rocketry, the question is constantly being asked why we let the Russians get ahead of us. Dr. Edward Teller, of H-bomb fame, recently remarked that unimaginative and materialistic thinking in missiles planning led to the loss of the race into space to the Russians.

If many things in the past have gone wrong in the lives of men and in the lives of their communities it is because both small and large scale activities were blundered into without any thought or vision of universal planning.

In our time we have marched into the air age without the benefit of any realistic vision of what was to come. Likewise, radio and radio communication were developed without any planning as to their basic technical and sociological aspects. On the technical side the failure to plan the use of modulation of amplitude, of frequency, of phase, of polarization, and of other parameters of radio waves resulted in a nasty and interminable confusion of channel allocations and led to very costly legal controversies.

The atomic or nuclear age was blundered into with the pitiful result that supposedly enlightened scientists coaxed President Harry S. Truman into using the atomic bomb to wipe out the civilian populations of Hiroshima and Nagasaki. This regrettable action has had the most disastrous influence on the efforts of all men of good will toward the establishment of constructive relations among all races and nations.

We are now at the beginning of the space age. Activities so far hardly indicate that the development of rockets, of propulsive power plants in general, and of the future march into space have been materially directed or even greatly influenced by great men of mature outlook and technical knowledge. In addition we suffer heavily from the blunders of the past. Indeed, the work on rockets started in earnest with World War II, mostly under conditions of military secrecy which carry over to the present day. As a consequence, even the cooperation among free men and free nations has been poisoned. Under the circumstances, major actions by courageous and wise men will be necessary to avoid our continuing to blunder into the space age like unenlightened and selfish idiots.

To achieve cooperation, both a holding action as well as a more effective approach toward large scale planning, education, invention, and construction will be necessary. We are not concerned here with the holding action. Suffice it to say that this action involves a defense against destructive forces and agents of all kinds which threaten our march toward the realization of the freedom and genius of man. We shall here be rather concerned with the more restricted problem of the technical planning for the exploration, ultimate utilization, and colonization of space and the bodies within the solar system.

In this planning we shall include both *inner* and *outer space*. By *outer space* we mean extraterrestrial—interplanetary, interstellar and intergalactic — space. *Inner space* includes both the interior of the earth and the depths of the oceans.

A successful march into the spaces above and below the surface of the earth requires that:

A. The characteristics, material, and phenomenological content of inner and outer space must be clearly visualized and explored.

B. The goals to be reached must be clearly formulated.

C. Practical means must be conceived and constructed which make the journeys into inner space and outer space possible.

D. Finally, the journeys themselves must be undertaken and the spaces penetrated, explored, exploited, or colonized, as the case may be.

The exploration of outer space has been for thousands of years the prerogative of the astronomers. Three great names come to mind in this connection. Aristarchus of Samos (320-250 B.C.) clearly conceived of the sun and of the planets as bodies in space, and he and Hipparchus, around 160-125 B.C. showed the way to survey this space. Giordano Bruno (1548-1600 A.D.) was the first to "break through" the immutable celestial sphere which for the ancients bounded the solar system. Bruno correctly thought of the stars as real bodies in an essentially unlimited space. Finally Knut Lundmark (1889-1958) in 1918 opened up for us the immense spaces beyond the confines of our own Milky Way and first determined the distances to the nearest galaxies, such as the great spiral nebula (Messier 31) in the constellation of Andromeda.

Our knowledge of the true characteristics of inner space — both of the depths of the oceans and the interior of the earth—as yet is meager. Depths of the oceans and profiles of the ocean bottoms are of course well known by now, but much remains to be learned about the various conditions in all depth strata and about all the various occupants in these strata. Still less is known of the interior of the earth, because most of our information has been derived from indirect manifestations originating in the gravitational, magnetic, and electric fields, as well as from analysis of such events as earthquakes and the eruption of volcanoes.

Outer space

The march into outer space started with the climbing of high mountains and with modest ascents in kite balloons and in free balloons. Dirigibles came next, followed by propeller-driven planes and ultimately by jet planes. The record for altitude, curiously enough, was held for more than three decades by the free stratosphere balloons, first used in 1925 by the Swiss professor of physics, Auguste Piccard. The rocket plane (X-15) and the unmanned and manned rocket have only recently topped the altitude records of the stratosphere balloons. These rockets have been successively put in orbits around the earth — and the unmanned rocket into orbits around the sun. (The first predecessor of these space travellers actually was a tiny slug of aluminum oxide and titanium oxide which Mr. J. Cuneo and I propelled into interplanetary space by means of a shaped charge with a coruscative insert, exploded from the nose cone of an Aerobee rocket at Holloman Air Force Base on October 16, 1957, just 12 days after the launching of Sputnik I. This little slug, about one centimeter in diameter, was thus the first manmade object to be propelled permanently away from the earth.)

Our march into inner space, curiously enough, is in a more rudimentary stage than our progress in outer space. Indeed, our diving devices, except for submarines (which do not descend to any considerable depth) are comparable to the stages of the kite balloon and the free balloon in the exploration of the atmosphere. This does not mean, of course, that the accomplishments of Auguste Piccard in the Atlantic and the Mediterranean, and the record dive by his son Jacques to a seven-mile depth to the Challenger Bottom near Guam in the Pacific, do not rate among the most magnificent exploits of all times.

Piccard's achievements are the more amazing since he pioneered both into the stratosphere and into the greatest depths of the ocean. He achieved this as a lone wolf, struggling for over 30 years to find sponsors and to develop the technical means for his bold plans.

Inner space

The penetration of man into the major part of inner space—the interior of the earth—has been slower yet, and has not gone far when we think in terms of the radius of the earth. No vehicles have been developed to propel man through the solid earth. What is more, no one seems to have seriously considered the possibility of such vehicles, except for the terrajet engines I first proposed in 1943.

After what has already been achieved with rockets, the three obvious future tasks are:

1. The construction and operation of more efficient propulsive power plants and of space vehicles.
2. Actual journeys of man to the moon and to the planets.
3. The colonization of the moon and the planets. This may ultimately involve the reconstruction of the whole planetary system—that is, the relocation and modification of the various members of the solar system.

Beyond the propellants and the propulsive power plants of today there lie a number of possibilities. In extrapolation of the conventional chemical propellants, condensed radicals and other fragments of molecules are being worked upon. These "frozen-in" metastable states, such as pseudostable helium hydride propellants, promise to be efficient enough to make single-stage rockets into interplanetary space a distinct possibility. The mastery of nuclear fusion reactions lets us visualize propulsive power plants of even greater efficiency.

Beyond the construction materials available today, work is now in progress to achieve solids of such light weight and superior strength that entirely new vistas open for the construction of space vehicles in the future. For example, "whiskers" and lamellae of microscopic thickness have been grown of many crystals, including iron. These whiskers and lamellae have a strength which is often orders of magnitude greater than that of conventional construction materials.

Actually, as I pointed out many years ago, nothing seems to stand in the way of producing bubbly solids —the bubbles to contain high vacuum or light gases like helium, such that the whole solid is lighter than air and exceedingly strong. Not only can the proverbial magic carpet be made of such spongy materials, but rocket chambers, solid propellant sticks, and vehicles of all kinds can be visualized which are very light—possibly lighter than air.

Engineering aspects

Once these lamellated or bubbly solids become practically available, the engineering of airplanes, rockets, and space ships will take on quite unexpected aspects. For instance, rockets will not have to be lifted away from the earth by conventional propellants, which carry both the fuel and the oxidizers. Indeed, the oxygen of the atmosphere will become available for use in air-breathing engines, which will accelerate space ships, which are floatable in air, around the earth within the atmosphere and bring them to the terminal escape velocity of 11.2 km/sec or more. Air-breathing engines, such as the aeroduct (ramjet) and the rocket pulse, will be particularly useful in this operation. The new materials will make it possible to drive space ships of any dimension off the earth with relatively equal ease. Likewise, soft landings on Mars and Venus or any planet with an atmosphere can be more easily accomplished than with the now conventional rockets.

In this connection it should be mentioned that it is a misnomer to talk about journeys within the solar system as belonging to the realm of astronautics. We should rather place them in the field of helionautics. Astronautics, strictly speaking, will be concerned with voyages to other stars. Remarkably enough, to achieve such feats, we might not even have to leave the earth. It would suffice to accelerate the sun itself to a very high speed and let it drag all its planets with it.

In order to exert the necessary thrust on the sun, nuclear fusion reactions could be ignited locally in the sun's material, causing the ejection of enormously high-speed jets. The necessary nuclear fusion can probably best be ignited through the use of ultrafast particles being shot at the sun. To date there are at least two promising prospects for producing particles of colloidal size with velocities of a thousand kilometers per second or more. Such particles, when impinging on solids, liquids, or dense gases, will generate temperatures of one hundred million degrees Kelvin or higher—quite sufficient to ignite nuclear fusion. The two possibilities for nuclear fusion ignition which I have in mind do not make use of any ideas related to plasmas, and to their constriction and acceleration in electric and magnetic fields.

Needless to say, the achievement of simple methods of nuclear ignition will be of great value in many other fields — power generation in general, efficient and sustained rocket propulsion, submarine and subterranean propulsion, reconstruction of the whole planetary system for the purpose of making thousands of times more living space available than we have now, and innumerable other applications.

Since the moon, however, may be our goal before propellants of the free radical type or the nuclear fusion types become available — and also before we can reasonably hope to achieve the ultra-lightweight-construction materials to which I have alluded — it may be well to direct our attention to some possible operations on this, our nearest conspicuous neighbor in space.

Much work is now being done to prospect the various physico-chemical characteristics of the moon by sending probes and instrumentation to its surface ("The National Program for Lunar and Planetary Exploration," by Albert R. Hibbs—*E&S, May 1961*). I only hope that these projects will succeed before astronauts actually land on the moon, so that the projects do not become antiquated even before they have been completed. In any event, it seems to me that our main concern should be to study and to make ready the means and devices which will allow men to land on the moon, to install themselves rapidly and "live off the land" as soon as possible after their arrival.

The necessary means for sustaining the lives and operations of the astronauts from resources available on the moon are:

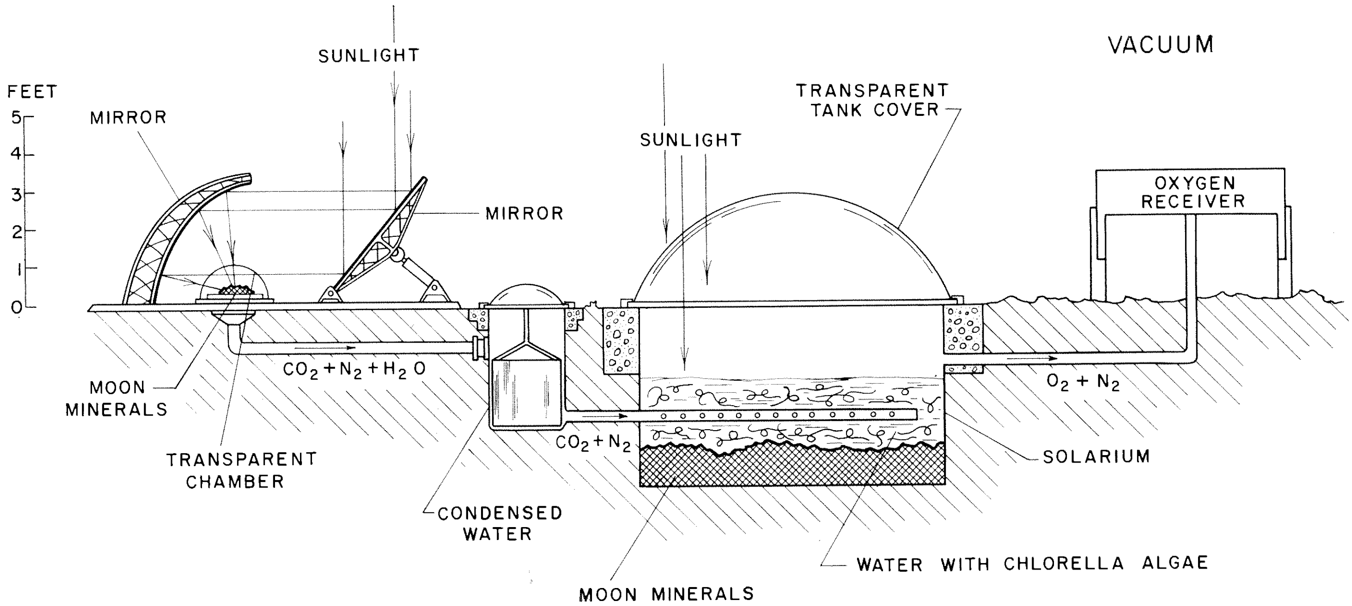
1. Protection against deadly radiations, especially the bursts of high energy particles emitted from solar flares.
2. Oxygen and water.
3. Food.
4. Mechanical and electrical power for operations on the moon.
5. Production of suitable propellants for local rocket hops on the moon and for return trips to the earth.

Solar furnaces

All of these requirements can be satisfied through the use of solar furnaces. The resources with which we propose to work are thus the rocks on the moon and solar power. From astronomical evidence, the rocks on the moon (at least at some moderate depth below the surface) may safely be supposed to contain all of the elements which we know on the earth. "Cooking" of the moon's rocks in the focal spot of a solar furnace will successively produce water vapor, carbon dioxide, and dissociation products of these gases — carbon monoxide, hydrogen, oxygen, and carbon itself.

In a very efficient solar furnace, with temperatures above 4000 degrees Kelvin in the focal spot, almost all chemical compounds will be reduced into the elements, so that elementary magnesium, aluminum, silicon, lithium, beryllium, boron, and others will become available. Furthermore, some of the resulting

An Installation for the Sustenance of Life on the Moon



Sunlight is focused on moon minerals in a vacuum-tight, transparent bell jar by a mirror combination. Water of crystallization (H_2O), carbon dioxide (CO_2), and nitrogen (N_2) are liberated from the minerals through the intense heating and conducted into a watery suspension of chlorella algae in a "lunar garden." Drinking water is also condensed in this container. The algae, with the aid of sunlight, "digest" the carbon dioxide and exude oxygen which—together with nitrogen and some remaining carbon dioxide – is collected in the tank at the right for breathing and other purposes.

products will be ionized and partly-charged particle streams will be ejected, which, in an ion jet generator or magnetohydrodynamic generator, will generate electric currents. Electric current can be conveniently used to decompose the molten rocks of the moon in the focal area electrolytically, and to produce the elementary metals mentioned above, as well as gaseous oxygen, in this indirect way. Gaseous oxygen and food can also be readily obtained through the photodissociation of carbon dioxide in the chlorella "garden" as it is built into the installation shown above.

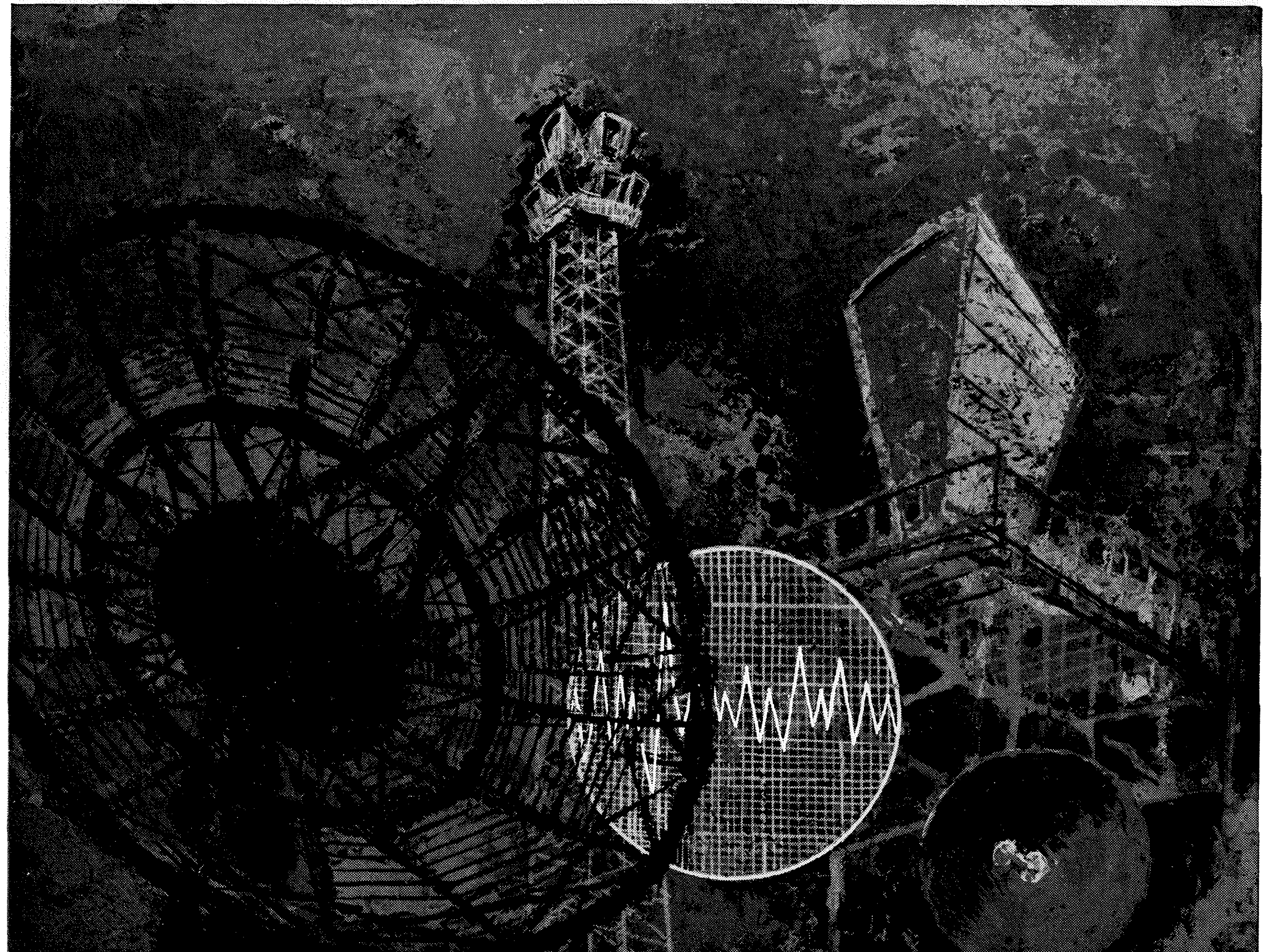
The qualitative and quantitative aspects of these operations have been discussed in another article, ("Some Possible Operations on the Moon" by Fritz Zwicky—*Journal of the American Rocket Society, December 1960*). Suffice it to say here that the requirements for oxygen, nitrogen, water, auxiliary mechanical and electrical power, and eventually for food, can be met with installations of moderate size, using the rocks on the moon as raw materials and the radiation from the sun as the power source.

Another operation involves the production of rocket propellants which are both suitable for powering return vehicles to the earth, and vehicles to be used for hops around the moon itself. Since it will be easy to produce both water and elementary metals such as Li, Na, K, Mg, and Al, in solar furnaces, the natural rocket motors which we should visualize as most natural with these propellants are those of the hybrid type which use a solid fuel and a liquid oxidizer. In fact, in 1944, when I was director of research of the Aerojet Engineering Corporation, I experimented successfully with a hybrid motor which contained a cylinder of aluminum metal, threaded lengthwise, with lithium inserts and water as the oxidizing agents. The water instantaneously reacts with the lithium and generates Li_2O and hydrogen at high pressure and temperature. The aluminum consequently melts and reacts with the water to form Al_2O_3 plus hydrogen gas, which, as a consequence of the high heat of reaction liberated, is expelled as a jet with 2200 meters per second exhaust velocity. This is thus a rocket propulsion system which can be easily produced from the resources available on the moon.

Many scientists have claimed that not too much of scientific value can be gained in the march into space, but I maintain that scores of the most important scientific investigations can only be carried out once we establish ourselves on the moon and other bodies of the solar system.

In the first place, it may prove of vital importance for our views on the evolution of matter in the universe to explore the moon itself for all material constituents, and its magnetic, electric, and gravitational fields.

The features which make the moon an apparently inhospitable place to live – its lack of an atmosphere, its extreme differences in temperature, the absence of bodies of water – are precisely those which the scientist must have to achieve the solution of some rather



burning problems which he cannot yet solve on the earth.

The astronomer and the radio astronomer will be immeasurably aided because of the absence of an atmosphere. In the first place, he need never be bothered by bad weather or, for that matter, care whether it is day or night; he will be able to observe at any and at all times. In the second place, all of the wave length regions of the electromagnetic spectrum, from the shortest gamma rays to the longest radio waves, will arrive from all cosmic sources unimpeded, on the surface of the moon—multiplying the potentiality of the analysis of cosmic bodies and phenomena a hundredfold.

Of the innumerable problems which are much easier of solution on the moon, or which can only be solved there, let us mention two. The first refers to the observation of the Lyman alpha emission line of hydrogen in the spectra of ever more distant galaxies. This type of observation, which is not possible from the earth, and which is exceedingly difficult and expensive from rockets, will give us decisive data on the nature of the universal red shift and no doubt settle once and for all the question of the evolution of our universe, and give us some understanding of its large-scale structure.

The second kind of observation which is not possible from the earth refers to the far infrared range of wave lengths from 1 micron to 1000 microns. Within this range we shall not only be able to see right down to the central nucleus of the Milky Way system; we may expect to see right through the Milky Way in all directions and observe galaxies of whose existence we have no knowledge today. Furthermore, the scanning of the skies in the ultrafar infrared will catch significant and telltale parts of the emission and absorption spectra of all molecules and radicals on planets, the sun, and the stars, as well as in interstellar and in intergalactic space.

Physicists and chemists on the moon

The absence of an atmosphere will allow physicists and chemists to carry out experiments in any desired degree of a vacuum and to produce compounds and materials, which, because of the presence of the gases remaining even in the highest artifically produced vacuum, are not possible on the earth. For instance, the highly controversial problem of what the properties of very pure crystals are can only be solved in a laboratory on the moon.

Most exciting vistas open themselves for biologists, physicians, psychologists, and psychiatrists. To be both serious and humorous—they will want to find out how humans and organisms in general fare in the new surroundings and, particularly, how much of a chance physically and mentally small people have to grow taller and wiser when having to support only one sixth of their weight — and when having the spiritual impetus of pioneering, while their tall and heavyweight comrades back on earth are being cut down to size by the high gravity on the one hand, and the desperately-growing complexities of life on earth on the other hand.

But, joking aside, the chance of exploring entirely new worlds, pioneering in making them habitable, and creating new forms of society, will be the greatest challenge for all great minds. Also, as we have observed during the past two decades, space research is not only important in itself. Our concern with this research has led to the formulation of problems and to results of scientific, technological, and human value which we should not have otherwise achieved. And much more may be expected in the future.

Submarine activity

In submarine activity the big task before us is to build craft which can navigate at will through all parts of the ocean and which will allow us to "reside" in all parts of the ocean, "see" through it, and carry out operations of all sorts, such as mining at the bottom of the sea.

For this we need powered vehicles driven either by wheels and propellers, or better yet by hydrojet engines. Also, for lift we will not only rely on buoyancy but on moving "waterfoils." As a result of my morphological analysis of the totality of jet engines which are activated by chemical propellants I conceived of a number of hydrojet engines in 1943.

The hydrojet engines, which are powered by hydrofuels — chemicals which hydrolyze water — generate hydrogen gas at tremendous pressure and release great heat of reaction, allowing us to build submarine craft which in their way are even more versatile than any type of aircraft or rocket. Indeed, vehicles driven by hydrojet engines can move through the water in all directions, including straight up and down and attain speeds far in excess of one hundred knots. At the same time these vehicles can be made to stagnate at any desired depth, a feat which for analogous heights in the atmosphere is not possible for aerial vehicles, except for helicopters under very restricted circumstances.

The problem of seeing through the ocean and communicating with one another within it is one of the most difficult tasks yet tackled, as all of those scientists know who have grappled with the problem of detecting submarines at great ranges. This task, however, is a great challenge to imaginative investigators and will no doubt be solved in the near future.

With respect to the interior of the earth our outlook and our ultimate goals must be analogous to those formulated for the march into outer space and into the ocean depths. Indeed we shall strive to navigate through the earth, to reside in it wherever we please or find it expedient, and we want to have means of communication from any point of the interior of the earth to all other points. Our first interests obviously

carry over from those of the past, inasmuch as we will want to expand all mining operations and the exploitation of oil as well as deep-lying water resources, including the liberation of water of crystallization in the rocks. Beyond these, many new scientifically, technologically, and militarily important goals beckon. Whether we reach these goals depends largely on our ability to construct vehicles driven by propulsive power plants which can make their way fast through the various parts of the interior of the earth.

In 1943 I conceived of jet engines capable of boring and propelling themselves through the solid earth, and called them terrajet engines. These devices may be powered by chemicals – known as terrafuels – which react with the rocks (or possibly with some water or oil contained between the rocks). At a later stage, when nuclear fusion ignition has been mastered in a general way, terrafuels will provide the ideal driving power for terrajet engines.

Terrafuels are actually more versatile than either ordinary fuels (aerofuels) or hydrofuels. Both of the latter take oxygen from the surrounding medium and bind it chemically more strongly than before by getting oxidized. Terrafuels, however, can do both – reduce the compounds in the surrounding medium or oxidize them further. Indeed, molten lithium will reduce almost any of the minerals of the earth's crust, while liquid fluorine will liberate oxygen from them and fluorinate them instead. Without going into any details of how terrajet engines are actually constructed and operated, I can mention that a pulsating type of terrajet engine (terrapulse) looks the most attractive as a start and that it may be built initially for the purpose of loosening clogged-up oil-bearing strata, for mining in general, and for large-scale underground installations for civilian defense and military offense. (Unfortunately, while we inventors here have talked to deaf ears, the Russians again seem to have taken over our ideas and have already built terrajet engines for military purposes.)

All of the projects which I have described will be eventually realized, I am sure, and much will be gained scientifically, technically, and humanly through our occupation with the problems of the space age. As to who is going to do them first, Khrushchev has squarely challenged us and predicted that he will bury us. So let our veterans who are not yet senile and all of our virile youth take up Khrushchev's challenge and show what free men can accomplish without sacrificing the prerogatives of the human soul.

Personals

1900

Irving C. Harris, Caltech's oldest living alumnus, died on May 13. He received his AB degree when Caltech was known as Throop Institute. A retired engineer, Mr. Harris worked on several major dam projects, including the Shasta, Hoover and Roosevelt dams. He was a member of the Caltech Gnome Club. He leaves his daughter, a grandson and two granddaughters.

1924

G. Harold Hopkins died on April 18 of a cardiac arrest. Before his retirement, he was a project engineer at the Anaheim division of Robertshaw-Fulton Controls. A World War I vet, Harold was past president of the Claremont, California, Rotary, a member of the American Ordnance Association, a registered professional engineer for the State of California, and a Tau Beta Pi.

1926

Johannes A. Van den Akker, PhD '31, senior research associate in the department of physics and mathematics at the Institute of Paper Chemistry in Appleton, Wis., has been invited to be a Fulbright lecturer in physics during the 1961-62 academic year at the University of Manchester, England.

Eugene Kirkeby died on March 27. For many years he had suffered from Parkinson's disease and since about 1936 was unable to work as an engineer. He was an associate in his brother's clothing business in San Luis Obispo.

1942

John H. Rubel has been nominated by President Kennedy to the post of Assistant Secretary of Defense for Research and Development. He was formerly Deputy Director of Defense Research and Engineering.

Jack L. Alford, PhD '50, writes that "two years of working to establish the engineering department in a new selective college – Harvey Mudd – have given me increased respect for the men who built Caltech. Other alumni at Harvey Mudd College include: *Al Focke*, PhD '32; *Bob James*, PhD '46; *Duane Roller*, PhD '29; *Warren Wilson*, MS '39; *Gray Bell*, PhD '57; *Bill Sly*, PhD '55; *Roy Whiteker*, PhD '56; and *Harry Williams*, MS '52, PhD '56."

1947

D. Murray Alexander, MS, has an appointment in the physics department of the recently-established Foothill College, in the Los Altos Hills. The Alexanders have three children, Trish, 12; Dave, 9; and Bev, 4.

Charoen Vadhanapanich, MS '48, is now a captain in the Royal Thai Navy. He writes that "we have a new addition to our family. Our second son is now 8 months old and is called "Pong" as a nickname (this means loud noise in Thai). We had a nice re-union with *Leslie Levin* '45 and his wife when they were in Bangkok."

1949

Gene D. Six, counselor at Pasadena High School, writes of a new addition to his family – Neil, born on June 2, who joins Brian, 6 and Laura, 4.

1950

Almon E. Larsh was one of the four co-discoverers of a new element, 103, at the University of California's Radiation Laboratory in Berkeley. It is the first element discovered by nuclear methods.

John M. Greene, research scientist at the Princeton Physics Laboratory, writes that he has a daughter, Emily. She was born on April 15.

1951

Richard K. Smyth, supervisor of advanced analysis controls at the Autonetics Division of the North American Aviation Corporation, writes that his fifth child, Dawn, arrived on March 27.

1955

Roger De Wiest, MS, associate professor of hydraulics at Princeton University, announces the birth of a third child, Denise.

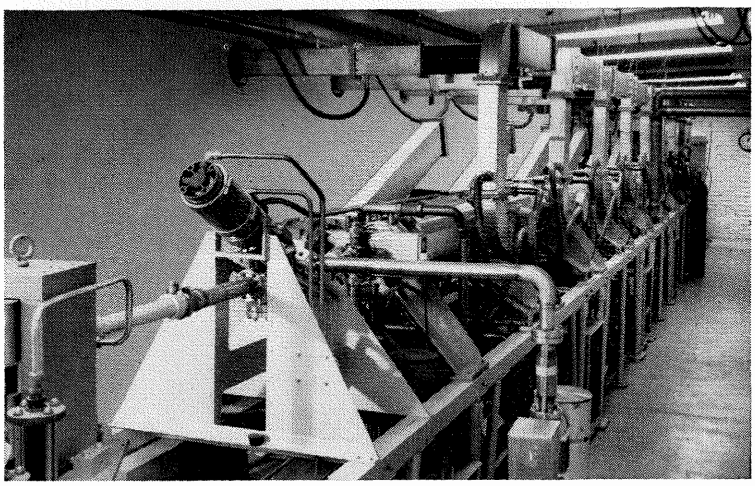
1959

Richard D. Dietz is working for his PhD in astrogeophysics at the High Altitude Observatory at the University of Colorado. He will spend 1961-62 in Italy at the University of Florence on a Fulbright Fellowship.

Martin Conneally, MS, engineer at the General Electric Company in Schenectady, N.Y., announces the birth of a son, Thaddeus, on March 25.

High Voltage Engineering Corporation . . .

"Charged Particles"



Rensselaer Polytechnic Institute — one of the most powerful accelerator neutron sources ever built, this linac will yield up to 10^{14} fast neutrons/sec, or a thermal flux of 10^{12} neutrons/sec/cm^2, with peak energy at 77 Mev, and peak pulse current of 800 ma. Primarily for neutron-time-of-flight and nuclear reactor research, the accelerator will also aid RPI's solid-state and radiation effect studies.

High Energy Linacs

Today's rapid advances in particle accelerator technology are particularly illustrated by the microwave linear electron accelerator (linac). Spurred by experimental requirements for more intense bursts of high-energy electrons and neutrons contained within precise limits of time and space, High Voltage Engineering and Applied Radiation Corporation have sustained intensive development of linacs. The result has been consistent improvement in linac reliability, and a series of record-breaking machines for research.

Two research linacs of considerable sophistication are now being installed at Yale University and Rensselaer Polytechnic Institute physics departments. The Yale machine is a five-section L-band accelerator, producing 28 kw of average radiation power and peak energies of 77 Mev. It will be used in a broad physical research program with emphasis on nuclear cross-section investigations. RPI's accelerator is an unusually powerful neutron physics research tool.

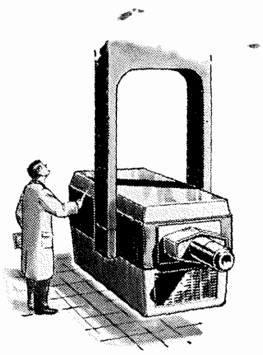
The accelerators of the near-future are exemplified by the machine now being built for the U.S. National Bureau of Standards. This linac, designed to performance specified by the NBS, will produce electron beam peak energies up to 150 Mev. Its 40 kw power output at 100 Mev will be greater than any previously obtained from a linear accelerator and about 100,000 times that obtainable from existing NBS high energy accelerators.

Availability of the intense high energy electron beam — and of secondary radiations such as x-rays, positrons and neutrons — opens up new research areas for NBS scientists. The linac will be used in low temperature chemistry, solid state physics, metallurgical studies, neutron activation analysis, nuclear alignment studies and determination of radiation standards.

Machines of such power were not available previously, and provide the experimenter with many intriguing opportunities.

Applied Radiation

As a powerful source of ionizing radiation, the linac is also a prime candidate for industrial radiation programs where electron penetration above 3 Mev is required. For example, most of the surgical sutures used today (made by Ethicon, Inc., a division of Johnson & Johnson) are electron-beam sterilized in aluminum-foil packages by industrial linacs operating on a two-shift production basis.



Development at High Voltage Engineering and ARCO has led to compact microwave electron accelerators for x-ray inspection and deep-x-ray therapy. High energy x-ray linacs can radiograph through two feet of steel or non-destructively inspect our biggest solid fuel rocket engines. Medical x-ray linacs provide the radiologist with a new precision therapy tool for treating deep-seated malignancies.

If you see the possibilities for accelerators in your research program or have a challenging radiation application, we'd be pleased to receive your inquiry.

High Voltage Engineering
CORPORATION

BURLINGTON, MASSACHUSETTS, U.S.A.

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APPLIED RADIATION CORPORATION

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HIGH VOLTAGE ENGINEERING (EUROPA) N.V.

NICE TALKIN' TO YA, GEORGE

"Hullo . . . George who? . . . George! Old George Sternmeyer! You old son of a *gun!*

"Just fine, George, just fine. Matter of fact I was just gonna call Bob Richman and close the biggest deal of – yeah, Robert *B.* Richman. *I* call him *Bob* . . . Couple hundred grand, boy – lotsa gravy! I'll *really* be livin' in style . . .

"What's new with you, George? Still pushin' a slipstick? Heh, heh, heh . . . How's that? A v.p. . . . Of *Engineering?* . . . Great, boy! . . .

"Wudja say, George? I got a bad connection or some – WHAT? . . . Alumni what? . . . oh . . . yeah . . . sure . . . uh huh. Well, George, you know *me.* Nothin's too good for old Tech I always say. Been givin' to the 'lumni Fund for years an – oh . . . you *do* want more than a dollar, huh? Well, George, you know *me. Nothin's* too good for . . . Development Program? . . . Sure I did, George, I . . . oh . . . you didn't see my name, huh? . . . Funny . . . I was sure I . . .

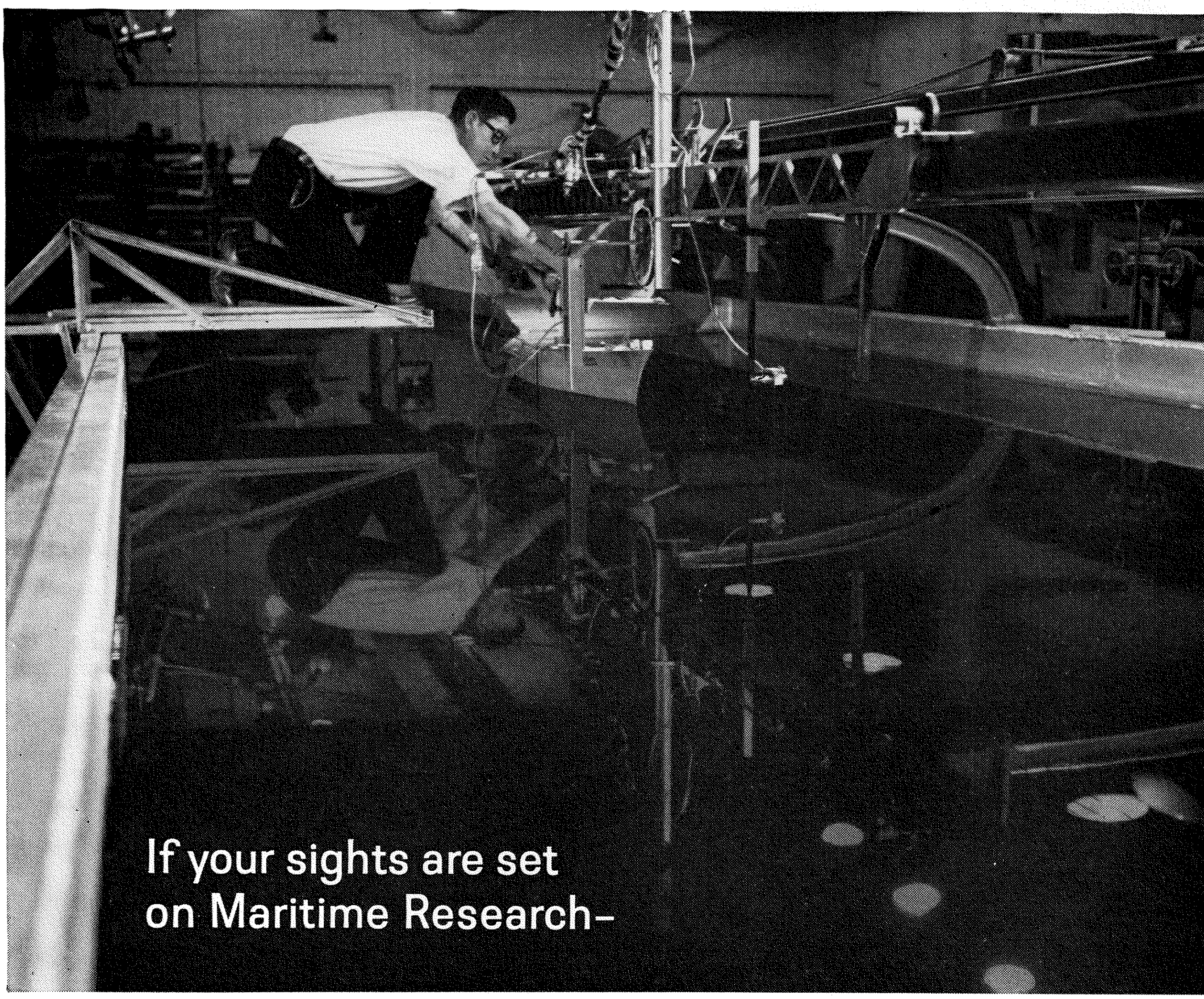
"You're giving *HOW* much? . . . Why that'd pay for a whole night on the . . . Well, sure I know endowment's important but . . . but . . . yeah, but . . .

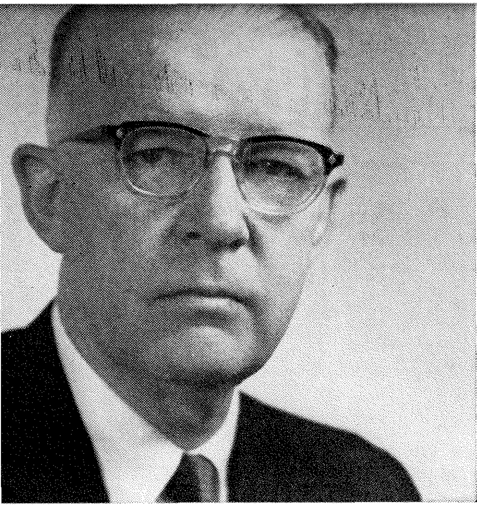
"George, I'll tell you somethin' personal . . . No, that's all right – it's just that Marge needed a new car this year an' the club assessment and that doggone boat . . . oh, a coupla hundred a month countin' everything – but it's worth it. And then there's this recession . . . But, George –

"Tell you what, George – I'm gonna be outta town for a month or so but as soon as I get back I'll give you a call . . . Oh, you'll call *me?* . . . Well, uh . . . September? . . . uh – Fine, George . . . fine.

"Yeah, nice talkin' to ya, George."

THE CALTECH ALUMNI ENDOWMENT FUND STARTS THIS FALL


If your sights are set
on Maritime Research–



One of a series

Interview with General Electric's

Francis J. Boucher

Manager-Manufacturing Personnel Development Service

How Good Is Your Best Job Offer . . .

Q. Mr. Boucher, with all the job interviews a graduating engineer goes through, how can he be reasonably sure he has made the right choice?

A. This is a good question because few seniors have enough work experience in industry, government and educational institutions to allow them to make a fully reasoned choice. However, I think the first step is to be sure that short-term factors like starting salary and location don't outweigh long-range factors like opportunity and professional growth. All of these factors should be evaluated *before making a final commitment.*

Q. But you do feel that starting salary is important?

A. Very much so. If you are married—it may be an even greater consideration. But you should also look beyond starting salary. Find out, for example, if the company you are considering has a good salary administration plan. If there is no way of *formally* appraising your performance and determining your appropriate rewards, you run the risk of becoming dissatisfied or stalemated due to neglect of these important considerations.

Q. What considerations do you feel should be evaluated in reaching a job decision?

A. Let me refer you to a paper written by Dr. L. E. Saline, now Manager of Information Systems in our Defense Systems Department. It is titled "How to Evaluate Job Offers." (Incidentally, you may obtain a copy by writing as directed in the last paragraph.) In it, Dr. Saline proposes six questions—the answers to which should give you much of the information you'll need for an objective job-offer evaluation. He suggests you determine . . .

- to what degree will the work be challenging and satisfying?
- what opportunities are available to further develop abilities?
- what opportunities are there for advancing in the Company (and how dynamic the Company is in the marketplace is an important aspect of this question).
- what salary potentials are possible with respect to the future?
- what about geographical location —now and in the future?
- what effort does the Company make to establish and maintain a professional climate?

There is more to these questions than meets the eye and I think you would enjoy reading Dr. Saline's paper.

Q. What about the openings on defense projects that are listed in the various magazines and newspapers?

A. Presumably, there will always be a need for technical manpower in the defense business. But I want to point out to you that most of these opportunities are for experienced personnel, or personnel with specific additional training received at the graduate level.

Q. How do you feel about training programs? Do they offer any particular advantages over any other offer I might accept?

A. I feel training programs are particularly helpful in easing the transition from an academic to a business environment. Of course they provide formal training designed to add to the individual's basic fund of knowledge. They also provide working experience in a variety of fields and a broad knowledge of the company concerned and its scope of operations. Upon completion, the individual is generally better prepared to decide the direction in which he will pursue his professional career.

General Electric conducts a number of training programs. Those that attract the greatest number of engineers are the Engineering and Science, Manufacturing, and Technical Marketing Programs. Each combines a formal, graduate-level study curriculum, on-the-job experience, and rotating assignments. There is little question in my mind that when an engineer completes the Program of his choice, he is far better prepared to choose his field by interest and by capability. I might also add that because of this, he is more valuable to the Company as an employee.

Q. Then you feel that a training program is the best alternative for a graduating engineer?

A. Not always. Some seniors have already determined the specific field they are best suited for in terms of their own interests and capabilities. In such cases, direct placement into this specific field may be more advantageous. Professional self-development for these employees, as for all General Electric technical employees, is encouraged through a variety of programs including the Company's Tuition Refund Program for work toward advanced degrees, in-plant courses conducted at the graduate level, and others designed to meet individual needs.

Q. For the record, how would you rate a job offer from General Electric?

A. I've tried to get across the need for factual information and a long-range outlook as the keys to any good job evaluation. With respect to the General Electric Company, seniors and placement offices have access to a wide variety of information about the Company, its professional environment and its personnel practices. I think qualified seniors will also discover that General Electric offers professional opportunity second to none—and starting salaries that are competitive with the average offered throughout industry today. From the above, you can see that I would rate a job offer from General Electric very highly.

Want more information about General Electric's training programs? You can get it, together with a copy of Dr. Saline's paper "How to Evaluate Job Offers" by writing to "Personalized Career Planning," General Electric Company, Section 959-15, Schenectady 5, New York.

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