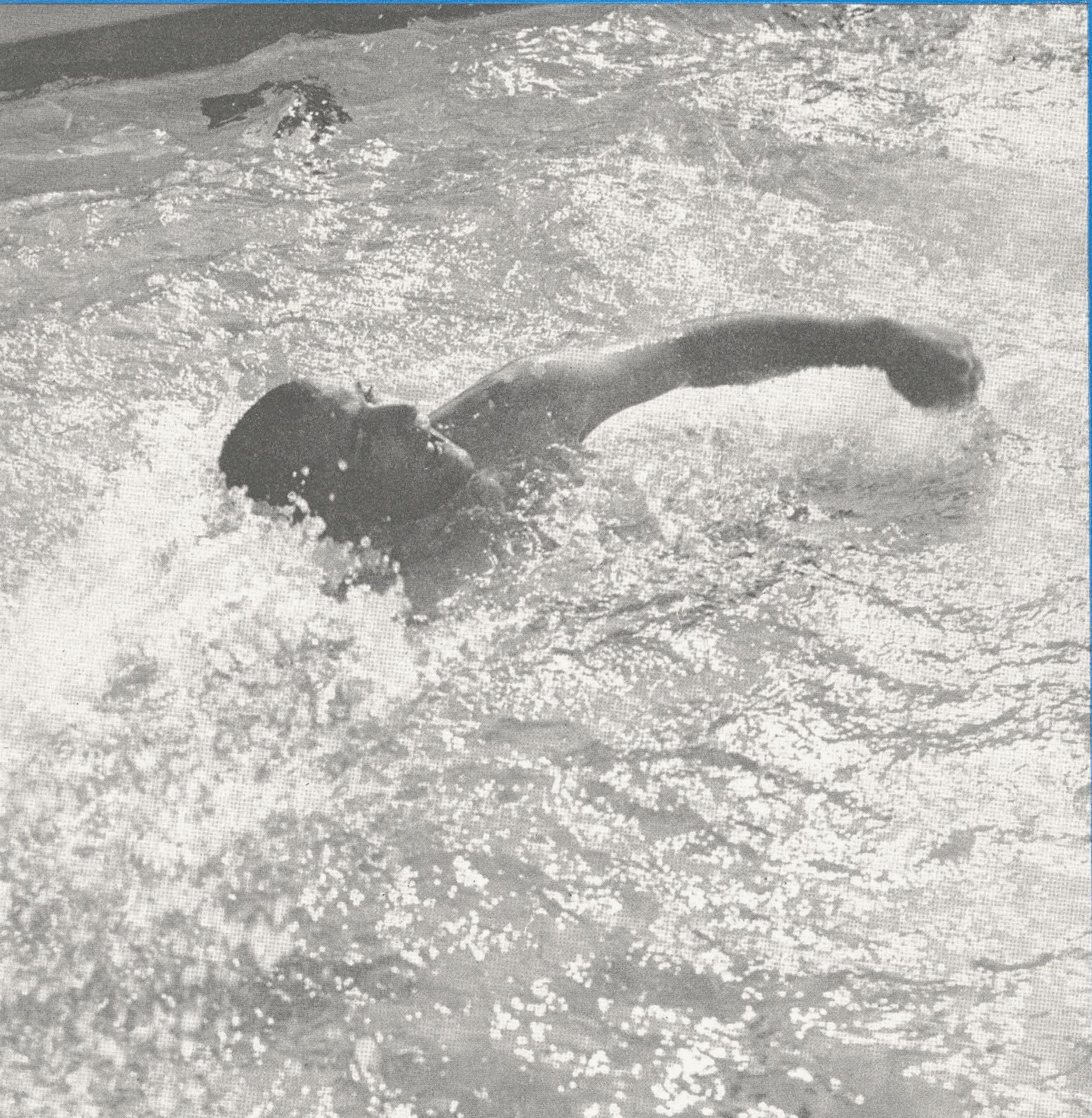
ENGINEERING | AND | SCIENCE

APRIL/1955



Alumni Swimming Pool . . . page 20

PUBLISHED AT THE CALIFORNIA INSTITUTE OF TECHNOLOGY

John F. Holt, class of '47

speaks from experience when he says . . .

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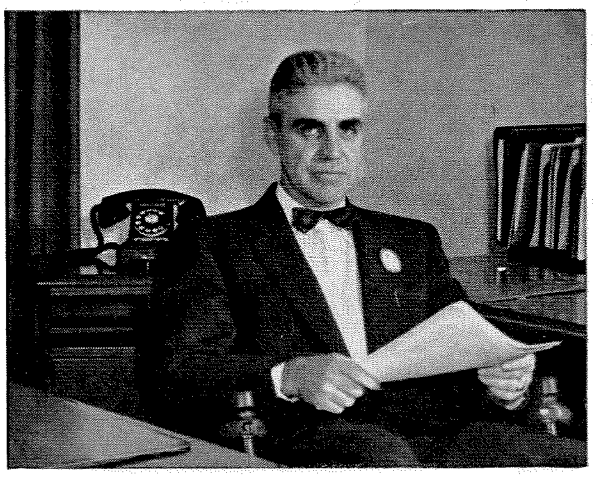

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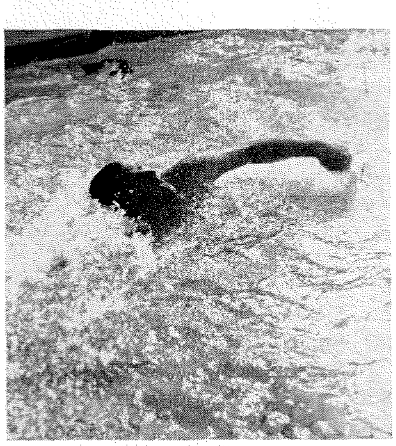
ENGINEERING AND SCIENCE

IN THIS ISSUE



This month's cover shows a Caltech undergraduate wallowing in the recently completed Alumni Swimming Pool, which is to be formally dedicated on Alumni Seminar Day, April 16. You'll find other pictures of the new pool on pages 20 and 21 of this issue.

"Portrait of a Scientist" on page 11 is a warm tribute to one distinguished man—Linus Pauling, Chairman of Caltech's Division of Chemistry and Chemical Engineering—by another—George W. Beadle, Chairman of Caltech's Division of the Biological Sciences. . . . "Some Like it Cold" (p. 13) is a report by Dr. Dan Campbell, Caltech Professor of Immunochemistry, on studies of Arctic animals, and their bearing on problems of human survival under Arctic conditions . . . On page 28, another entry in the E & S Science Writing Contest, by Frank Salisbury, who receives his PhD from Caltech in June in Biology. A plant physiologist who is also interested in plant ecology, Salisbury describes himself as "a sort of ecological physiologist—which, it seems to me, is exactly what a person ought to be to wonder about life on Mars." That's just what Salisbury does wonder about in his article on page 28—in a pretty provocative way, too. Frank Salisbury is teaching at Pomona this year, and has accepted a job teaching plant physiology at Colorado A & M next year.

PICTURE CREDITS

Cover	Walter Girdner
p. 11	Nolan Patterson
p. 12	Richard Hartt
p. 18	Ben Olender, Pasadena Star-News
pps. 20, 21	Walter Girdner, Charles Kassler III
p. 23	Mt. Wilson and Palomar Observatories Photo

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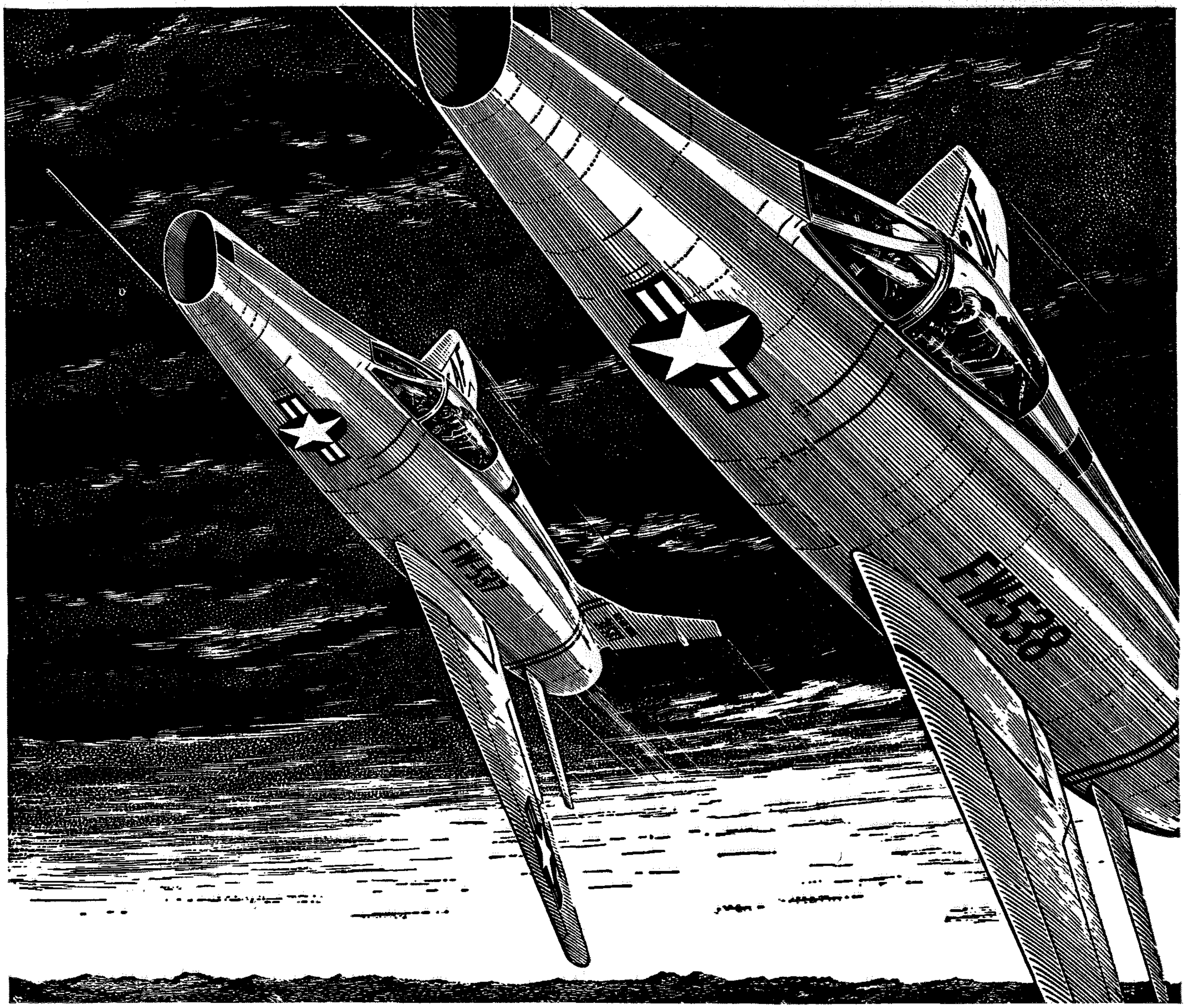

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ENGINEERING AHEAD FOR A BETTER TOMORROW

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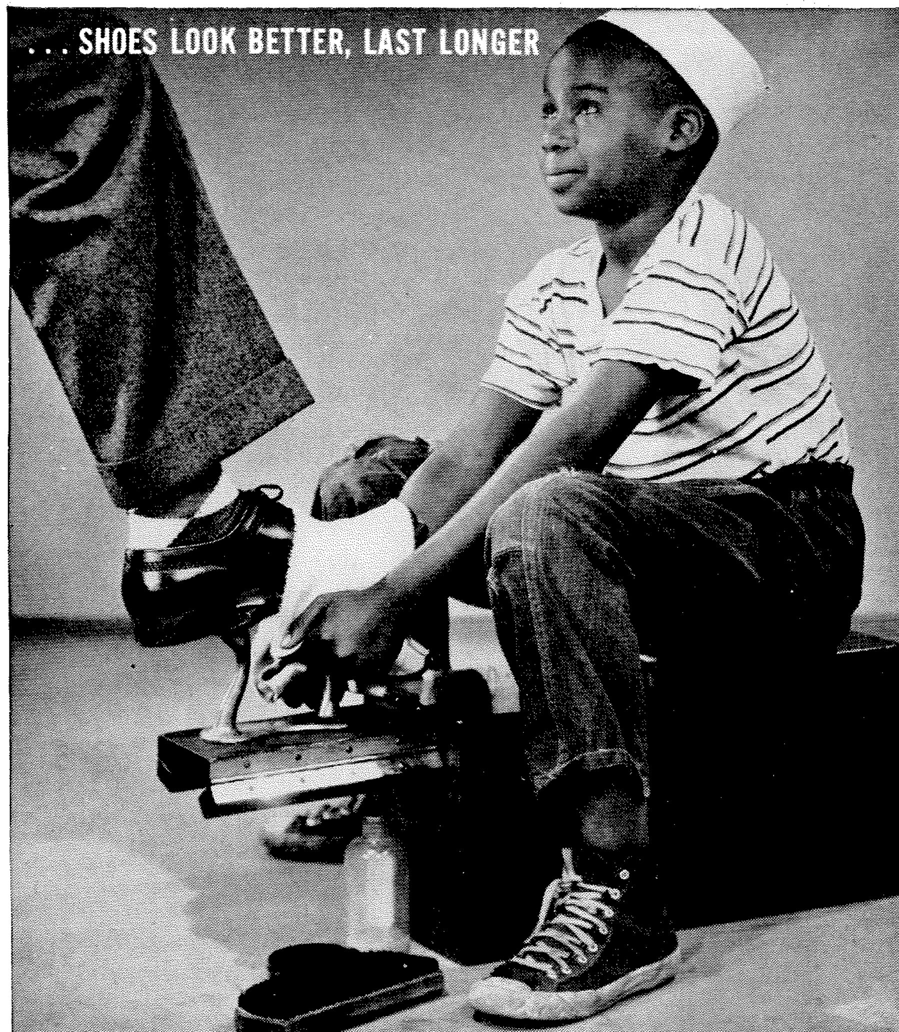

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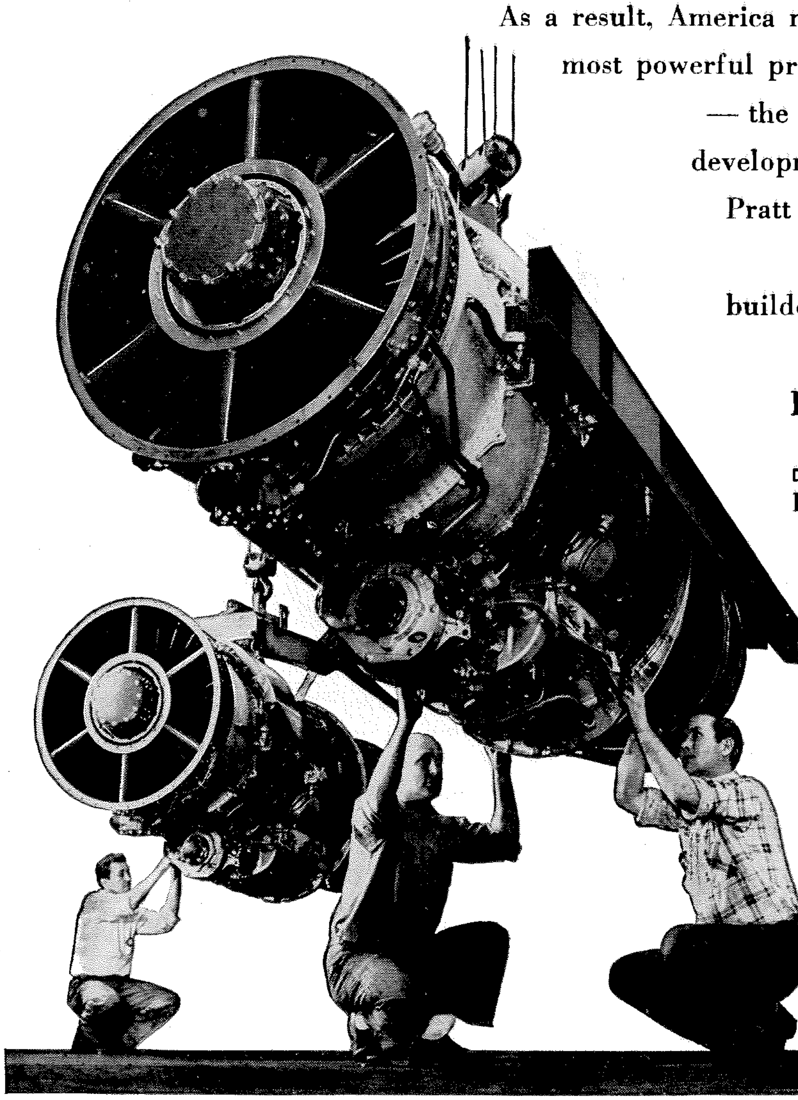
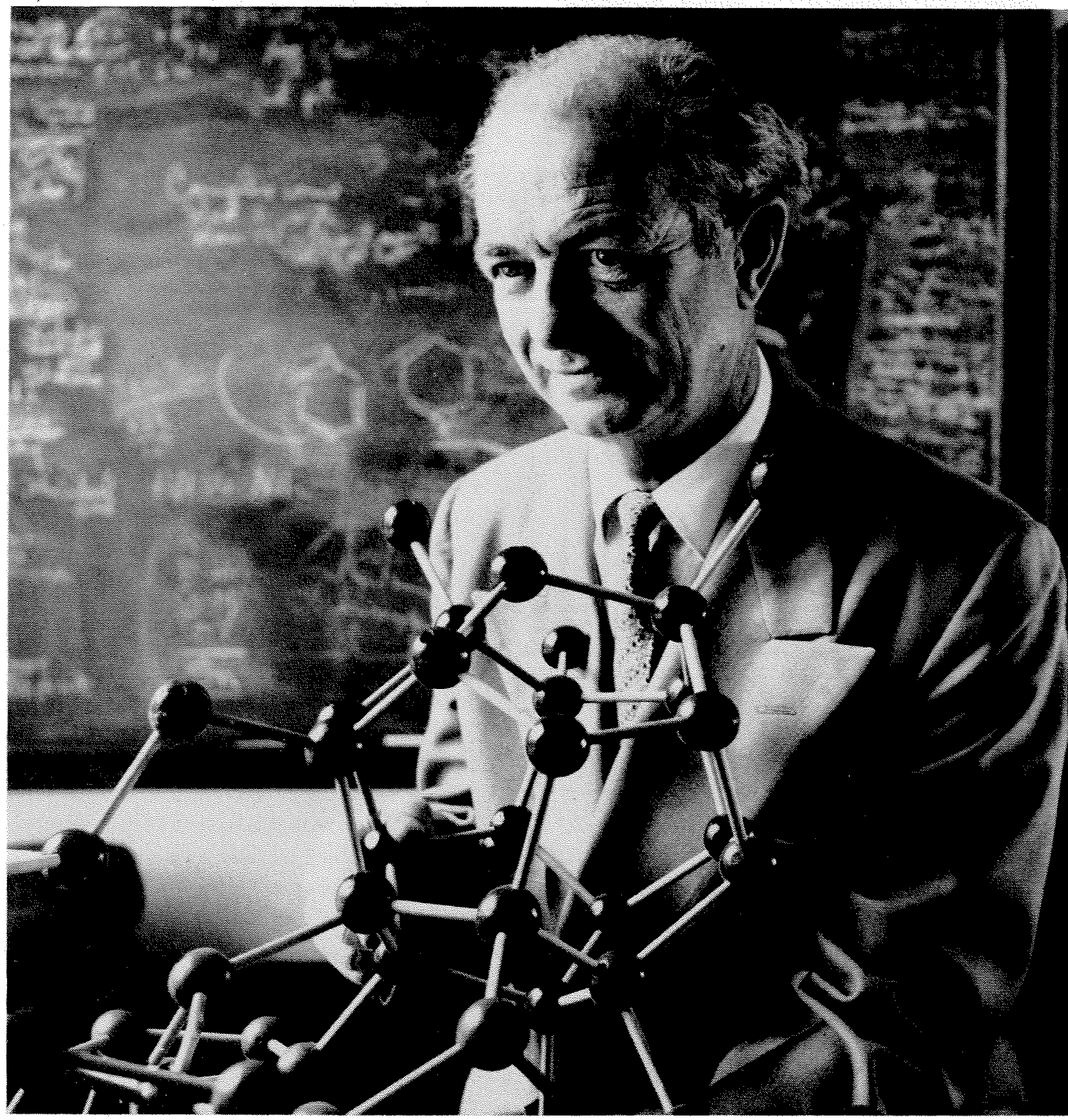


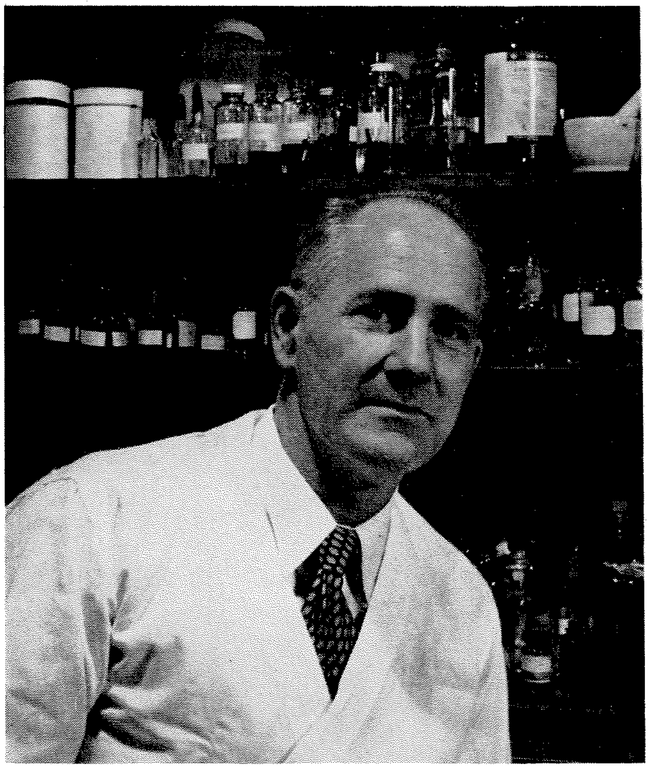


PORTRAIT OF A SCIENTIST

A tribute to Linus Pauling

by GEORGE W. BEADLE

WE HEAR A LOT about science and scientists these days. By some, scientists are believed to be peculiar people. Actually, scientists are merely people who work at science. And I want to emphasize the "people" part of the definition. Scientists *are* people. They obviously have special aptitudes, special interests, and a special kind of ambition. But otherwise, like new cars, they come in all varieties—all sizes, all shapes, all colors, all creeds, and all behavioral patterns. And, if an observation of a colleague of mine is correct, they end up with an equally wide range of spouses. In looking over a group of wives at a Caltech faculty party, he was heard to say, half to himself:



Portrait of another scientist—George W. Beadle, Professor of Biology, Chairman of Caltech's Division of Biology, President of the American Association for the Advancement of Science, and author of this article. "Portrait of a Scientist" has been adapted from a talk given by Dr. Beadle at the National Nephrosis Foundation Dinner in Beverly Hills, on March 25, 1955.

"You know, I believe professors marry a pretty random sample of women."

Scientists, like other scholars, are trained to be receptive to new ideas and to look at them objectively. Being human, they don't always achieve this ideal, to be sure, but their success in science does depend on freedom of inquiry. Follow the lead wherever it may take you. Search for the truth by every method you can devise. And don't be distracted. These are the credos of the scientist. That's why he is so insistent on his right to intellectual freedom—academic freedom, if he is in a university.

Maximum advance in science depends on free exchange of ideas. It is obvious that the chance of correctly fitting together the small bits of knowledge that are the component parts of a big advance will be greatest when the largest possible number of competent workers have access to all the small bits.

This is why so many scientists worry so much about our security system. They are afraid it will be so tight that, in addition to preventing a potential enemy from finding out what we're doing in those sciences applicable to military uses, it will seriously slow down our own progress by retarding internal exchange of scientific information.

The area of science that is subjected to "classification"—that is, available only to persons holding appropriate security clearances—should be reduced to an absolute minimum. A great many scientists believe we have already gone too far, especially in the classification of basic science. They would confine classification largely to phases of science dealing uniquely with military technology.

In addition to requiring that persons working with classified information be cleared, there has been a widespread trend towards requiring loyalty checks of persons working for government or receiving government support, even though they have nothing to do with classified information. The argument sounds convincing enough. "We don't want disloyal persons supported by government, do we?" Of course we don't. We all agree. The difficulty comes when we try to define loyalty. Too often a disloyal person is one who happens to disagree in an entirely defensible way with the then popular political and social views.

What does this have to do with science? A great deal. To take an example, the U. S. Public Health Service has in the recent past been following the practice of denying or terminating grants to universities in cases in which there was evidence of disloyalty on the part of the principal investigators. In the PHS practice, the reason for denial or cancellation is not given in individual cases. There is no statement of the charges, no mechanism for re-examination of evidence for errors, and no possibility of appeal. The practice is so inexcusably bad that there now seems to be real hope that it will soon be discontinued.

The National Science Foundation has a much more reasonable policy. It holds that it is the responsibility of the universities to which research grants are made to determine whom they shall have on their faculties. NSF inquires into the merits of the research and the professional competence of the scientists who do it, but it does not withhold grants for security or loyalty reasons unless an investigator has been convicted, through due process, of a crime involving the security of the nation. This is a sensible policy and one that can be administered fairly and objectively.

Universities do not wish to protect persons who are a threat to the security of the nation—it's the last thing in the world they want to do. But neither do they want their faculty members deprived of an opportunity to contribute to the nation's welfare on the basis of unsupported evidence of disloyalty or as a result of malicious backyard gossip. Universities have excellent records of doing responsible jobs in selecting faculty members of competence and good character. Society has a right to be, and should be, proud of them.

There is no way of determining how many competent and loyal persons are now prevented by unreasonable security and loyalty clearance policies from using their talents to maximum advantage. In science it is surely a large number. The public hears only about the big-name cases. But for every one of these there are dozens or hundreds of less-well-known persons about whom there is allegedly derogatory information, but about whose loyalty there would be no reasonable doubt if the information were competently and fairly evaluated.

There is another aspect of security-loyalty investigation policies about which I want to add a word. This is the misuse of such investigations for political purposes. The so-called game of numbers in which one political party finds it advantageous to boast that it has been responsible for the dismissal of more security and loyalty risks than has its rivals, is a game so dangerous to the survival of the principles of fair play and justice in our society that it should be stopped at once. It is gratifying that Mr. Harry P. Cain of the Subversive Activities Control Board has recently publicly recommended this and other much needed reforms. Those who know his previous record will realize that his present views represent a marked change of heart. Few people are in a better position than he to know the facts.

A contagious disease

A most unfortunate consequence of over-classification of scientific information, inadequate or poorly administered security clearance systems, misuse of loyalty checks, and failure to divorce these matters from politics, is the spread of suspicion and mistrust among us. This loss of faith in the honesty, integrity and character of our fellow men is a dangerous and contagious disease that weakens us at a time when it is so terribly important that we be strong.

The disease is not confined to science. It affects all of society and includes science only because science and scientists are a part of society. That is why I have insisted so strongly that scientists are people. They have the same hopes and aspirations—the same apprehensions and fears—as do other intelligent members of society. They want no special privileges. The intellectual freedom of science is no different in principle from any other kind of intellectual freedom. It is a counterpart of freedom of speech, of freedom of the press and of freedom of religion. None of these freedoms should be a freedom divorced from responsibility. No sensible person would claim otherwise.

But this is enough on science and scientists in general. There's much I've left unsaid. I'd like to discuss the question of whether by itself science is good or bad. (I think it is neither, although society, including scientists, can surely use it for good or for evil.) I've skipped the important question of whether or not scientists should have special responsibilities in determining how society is to use science (I believe they should have in so far as they have special ability and special knowledge—but no further.)

What I want to do now is to discuss a subject of much more immediate interest—a particular scientist.

We all know Linus Pauling is a great scientist—we've been told so many times. But do we all know *why* he is? I'm not going to try to give you all the reasons but I'd like to talk about some of them.

If we were to set out to construct a scientist like Linus Pauling, what kind of a set of directions would we follow?

The ingredients of greatness

Well, first, we'd have to start with outstanding intellectual equipment. We can't make it—we'd have to see that it was inherited. Then we'd add a superior training. A trained intellect is no good unless it has interest, so we'd add that. We'd make it a passionate and dedicated interest and we'd direct it toward chemistry. Greatness in science requires discrimination and good judgment—the ability to distinguish the important from the trivial. We must also have originality and imagination—the ability to see the problem as it has never been seen before and, from the new viewpoint, see the way to the solution. There must be a touch of intuition too, along with the creative ability essential to see how the big picture can be built up from the little pieces. Finally, we'd want to put in a good-sized piece of industry, for a scientist cannot become great without work. It may not be physical work, which is easy, but mental work, which is much more difficult. A successful academic scientist has to have ambition and drive—the ability to generate his own steam—for there is no one to tell him what to do or when he should do it.

But whatever are the ingredients of greatness in science, there can be no doubt that Linus Pauling has them.

What has he done with all his talent and his time? Plenty, I assure you. I'll mention a very few of his accomplishments.

For one thing he has spent a lot of time looking at the insides of molecules—figuratively, of course, since with even the most modern electron microscope most molecules are too small to be seen. He has studied the atoms that make up molecules—and the chemical bonds that hold them together. His book, *The Nature of the Chemical Bond*, is a classic. And even though he wrote it many years ago, it is still widely used as a standard reference.

His investigations of ways in which atoms are put together to make molecules and crystals were made with relatively simple molecules and crystals. Gradually the methods developed were extended to larger and more complex molecules—even to those out of which living things are built.

To a layman this may seem pretty far removed from the world he knows. But I assure you it is not. Pauling's work not only digs right down to the heart of theoretical chemistry but what he has accomplished is also of tremendous importance to all of us in practical ways.

Let me explain with examples. Everyone knows the importance to man of metals and their alloys. The preparation of alloys has been and still is largely an art, not a science. Metallurgists have found useful alloys by mixing metals in different combinations and in varying proportions. If they were fortunate, they got a good alloy. The theory of the structure of alloys was extremely complex mathematically until Pauling put his talents to simplifying it. His success in doing this has gone a long way toward making a true science of metallurgy.

Or to get still closer to home, it has been known for a long long time that our bodies are made of a great variety of molecules, many of them so large that a single one of them may contain thousands of atoms—perhaps in some cases as many as a million.

One category of these large molecules consists of proteins. Proteins come in thousands of varieties. Egg white is one. Each of us is unique partly because each of us has a combination of kinds of proteins slightly different from that of other individuals of our species. Proteins serve many important functions. One kind makes up the fibers of our muscles and its properties are responsible for movement by means of muscle activity. Another is essential in the oxygen-carrying mechanism of red blood cells. Others play an essential role in immunity to disease. Many of them serve as catalysts—enzymes—that regulate the chemical reactions that make up our life processes.

Molecular structures of proteins

Pauling's laboratory was the first to work out what we now believe to be correct molecular structures of proteins. This is an achievement that by itself has greatness for both chemistry and biology.

On the basis of his knowledge of proteins, Pauling was the first to suggest that one of the hereditary anemias of man results from an alteration of hemoglobin molecules—the molecules that give red blood color to our blood and that are involved in oxygen transport. By now there have been found more than half a dozen hereditary anemias, all having the same type of explanation. They are "molecular diseases" in the sense that their primary cause lies in modifications of a specific known molecule of the body.

In response to many infections, we build antibodies in our blood—proteins of specific kinds that incapacitate disease-producing organisms or molecules. The nature of this inactivation, so important in our defense against disease, has become clearer as a result of Pauling's work and that of his associates.

And finally, to get as close as science can get to the purpose of our meeting tonight, I want to mention Pauling's collaboration with the late Thomas Addis, with Addis' student Richard W. Lippman, and with others who have been interested in the workings of that marvelously complex and efficient organ, the human kidney. In this, Pauling has abundantly demonstrated how a knowledge of molecules and their interactions can contribute to a better understanding of the science and practice of medicine.

That's a pretty inadequate account of a small part of what Pauling has contributed to science. I hope it has been sufficient to give you an understanding of why he is a great scientist.

The human side

Linus Pauling is a wonderful example of my thesis that scientists are human. If you know him, you know that a scientist doesn't have to be a recluse who shuts himself up in a dark lab and forgets the rest of the world. You will know that a scientist can be a friendly person with a fine sense of humor, a genuine interest in other people, and a deep concern about problems outside of science. As I said before, scientists come in all types. In addition to inheriting and acquiring that unique combination of qualities that make him great as a scientist, Linus Pauling possesses an array of additional traits that make him an all-around "great guy." And those of you who have been privileged to know his good wife Ava Helen, know he didn't make a random choice when he won her hand.

I want to close by saying I regard it a great privilege to know and to be associated with Linus Pauling. I respect him as a great scientist and an outstanding scholar. I deeply appreciate him as an understanding colleague and as a true friend. And I admire the courage with which he stands by his convictions even at times when his views may not meet with popular favor.

I am proud to belong to the faculty of an institution with the foresight to see his greatness and the wisdom to give its development full freedom. I am proud that Caltech has a president who knows the true meaning of academic freedom and who has the courage to speak and act accordingly. I contrast our good fortune with the lot of a certain few of our sister universities whose presidents belie by their acts the fine-sounding words of their public utterances. I am grateful for a Board of Trustees that has not succumbed to the disease of mistrust and suspicion that could so easily undermine their faith in the wisdom of academic freedom and the rightness of liberal decency.

NOTES FROM AROUND THE WORLD

by LINUS PAULING

LINUS PAULING, chairman of Caltech's Division of Chemistry and Chemical Engineering, returned last month from a three-month trip around the world with Mrs. Pauling. The trip began in December, when the Paulings flew to Stockholm, where Dr. Pauling received the Nobel Prize in Chemistry for 1954.

The Paulings spent two weeks in Sweden and Norway, a week in Israel, six weeks in India, a few days in Thailand, and three weeks in Japan.

In Israel they visited the Weizmann Research Institute, Hebrew University in Jerusalem, the Technion (Institute of Technology) in Haifa, and the potash plant at Sodom on the Dead Sea. They spent Christmas Eve in Bethlehem—the customary complications in crossing the border from Israel to Jordan having been simplified somewhat to make this pilgrimage possible.

In India the Paulings were the guests of the Indian Government and the Indian Science Congress Association. Dr. Pauling gave three addresses at the Congress, which was held in Baroda during the first week of January. He and Mrs. Pauling also visited several of the leading Indian universities and research institutes, including the new National Physical Laboratory in New Delhi, the National Chemical Laboratory in Poona, the National Road Research Institute in New Delhi, and the National Glass and Ceramics Research Institute in Calcutta.

During their three weeks in Japan the Paulings visited Tokyo University, Kyoto University, Osaka University, and a number of industrial plants. In Tokyo and Kyoto, Dr. Pauling gave public lectures, which were translated into Japanese, on the subject of the hemoglobin molecule in health and disease. The lectures were sponsored by the Asahi Press, publishers of a leading Japanese newspaper.

Although Dr. Pauling delivered more than fifty lectures on his trip, he and Mrs. Pauling still found time to see such sights as the Taj Mahal, the caves at Ajanta and Ellora, Elephanta, the burning ghats and temples in Benares, and the temples at Nara, Japan.

Some of Dr. Pauling's own notes and observations on the trip follow:

THE NOBEL CEREMONY in Stockholm was very impressive; I think that it must be one of the most impressive ceremonies held in the modern world.

The ceremonies began on Thursday, December 9, with a reception held by His Excellency the Royal High Chamberlain of Sweden, who is President of the Nobel Foundation. This was followed by a formal dinner held by the Secretary of the Swedish Academy.

On Friday the Nobel awards were made, by King Gustav Adolph, in the Concert Hall in Stockholm. Following this ceremony there was the Nobel Dinner in the Gold Room of the Stockholm City Hall. A toast to the Nobel Laureates was proposed by the King. Each of the Laureates made a speech of appreciation. The guests then moved to the Blue Room, where a torchlight procession was held by the university students of Sweden. I had the honor of having been selected by the Nobel Laureates to give the response to the students for the whole group (page 17).

On Saturday afternoon I presented my Nobel lecture. In the evening we were guests of the King and Queen at dinner in the royal palace.

The visit to Stockholm ended with a large reception held in the American Embassy, on Monday.

Sweden is an impressive country. Sweden has a policy of making no alliances in peacetime and of remaining neutral in wars. Sweden has not been in a war for 140 years. The feeling of the Swedes is that they do not wish to risk the destruction of their country for no good purpose. The Swedish refusal to join NATO does not mean that the Swedes are pro-Russian: I think that they are to be classed among the non-extremist nations, together with India. Many Japanese, probably the majority, would also like to see Japan in this class.

The unwillingness of the Swedes to become involved in foreign entanglements expresses itself in many ways. I was made aware of one of these, when I stated that I should like to leave some of my Nobel Prize money in Swedish investments—it seemed only proper to me that I should do this, since the Nobel Foundation is a Swedish Foundation. I was told, however, that it is against the law for me to do this—that the only way in which it might be done would be with special permission of the Swedish government. The reason is that the Swedes do not want to have some other country interfering in Swedish affairs in order to protect the investments of its nationals.

A visit with Nehru

Of the men whom I met on this trip I was most impressed by Premier Nehru of India. My wife and I had dinner with him, and heard him give three public addresses. Although he is the head of a great nation, he did not read his speeches from a manuscript, but spoke without notes. It was evident that he had thought deeply about the problem that he was discussing, so deeply that it was not necessary for him to refresh his memory with notes or to use a manuscript in order to express his opinions accurately. He gave me the impression of having great mental powers, excellent judgment, and complete sincerity. In my opinion Nehru is one of the greatest men in the world, and I think that future historians may well give him a major share of the credit for avoiding a third world war.

Nehru said that India's approach to peace is a positive, constructive approach, not a passive, negative, neutral approach. He expressed himself as being disturbed by the kind of strong language that statesmen now use. He said that if you seek peace you cannot go far in your search through warlike methods: you must be peaceful in your approach. He said that various countries, including also the Soviet Union, are obviously interested in finding ways out of the tangle of the Formosa problem and other problems, and in finding some way for a peaceful solution through conferences and diplomatic approaches.

Nehru said that both Britain and India are proud of the way in which the problem of the freedom of India was settled. This peaceful settlement of the problem has changed the hostility of the two peoples into friendship.

A similar peaceful solution of the Pondicherry problem was also reached. The French withdrew from Pondicherry, which is now a part of India. This action has resulted in increased good relations between France and India.

The situation between Portugal and India is an unpleasant one, but Nehru has stated that India has no intention of using force in resolving it.

Nehru feels strongly that Red China should be admitted to the United Nations. He has pointed out that it is very odd for the United Nations not to recognize the existence of this major country, Red China. He has said that it is unreal to have a so-called representative of China in the United Nations who has nothing to do with the real China.

The Indian Government and people seem to be making great progress in improving conditions in India. I could see how rapid the progress is in science and technology. My wife and I visited some of the villages, and found the villagers to show great enthusiasm for the village improvement projects. In one village that we visited, which can be reached only by bullock cart or jeep (we traveled by jeep), the villagers had just completed construction of a small town meeting place, the first community project that they had ever carried out. They will be reimbursed by the Government for half of the cost of this building. They took advantage of our visit to ask my wife to lay the cornerstone of a schoolhouse—the first school in this village. In addition to the Government of India and local private agencies, such as the Mrs. Ghandi Fund, the Ford Foundation has been making significant contributions to the program of village improvement. I found that the Indian people were deeply appreciative of the efforts of the Ford Foundation in their behalf.

Politics in Japan

The occurrence of national elections during our stay in Japan provided the opportunity for us to obtain a deeper insight into the feelings of the Japanese people about political questions than we had had before. The nature of the Japanese Government is determined by the membership of the House of Representatives. The four leading parties are the Liberals, the Democrats, the Right Socialists and the Left Socialists. The Liberals got 26 percent of the seats, the Democrats 40 percent, and the two Socialist parties, which are closely similar in their policies, 34 percent.

The two principal questions determining the balloting were the attitude toward Russia and Red China and the question of rearmament of Japan. All of the parties except the Liberals included in their platforms a promise to resume normal diplomatic relations with Russia and to develop trade with Russia and Red China. The 74 percent majority for these parties reflects the popular support of this proposal.

ADVICE TO STUDENTS

Response by Linus Pauling, as spokesman for all Nobel Laureates, to the university students of Sweden, holding a torchlight procession in the Blue Room of the Stockholm City Hall, on December 10, 1954.

Young men and women:

On behalf of my colleagues, as well as myself, I thank you for your kind demonstration of friendship and respect.

I am reminded of my own students in California. They are much like you—I have observed that students, young people, are much the same all over the world—and that scientists are the same. There is a world-wide brotherhood of youth and science.

Perhaps, as one of the older generation, I should preach a little sermon to you, but I do not propose to do so. I shall, instead, give you a word of advice about how to behave toward your elders.

When an old and distinguished person speaks to you, listen to him carefully and with respect—*but do not believe him. Never put your trust in anything but your own intellect.* Your elder, no matter whether he has gray hair or has lost his hair, no matter whether he is a Nobel Laureate, *may be wrong.* The world progresses, year by year, century by century, as the members of the younger generation find out what was *wrong* among the things that their elders said. So you must *always* be skeptical—*always think for yourself.*

There are, of course, exceptional circumstances: when you are taking an examination, it is smart to answer the questions not by saying what you think is right, but rather what you think the professor thinks is right. Arrhenius discovered that there is danger in being too original in one's Doctor's thesis.

You will have some great problems to solve—the greatest of all is the problem of war and peace. I believe that this problem has been solved, by the hydrogen bomb—that there will never again be a world war—the knowledge that a world war would mean world-wide destruction, perhaps the end of civilization, will surely now lead to permanent peace.

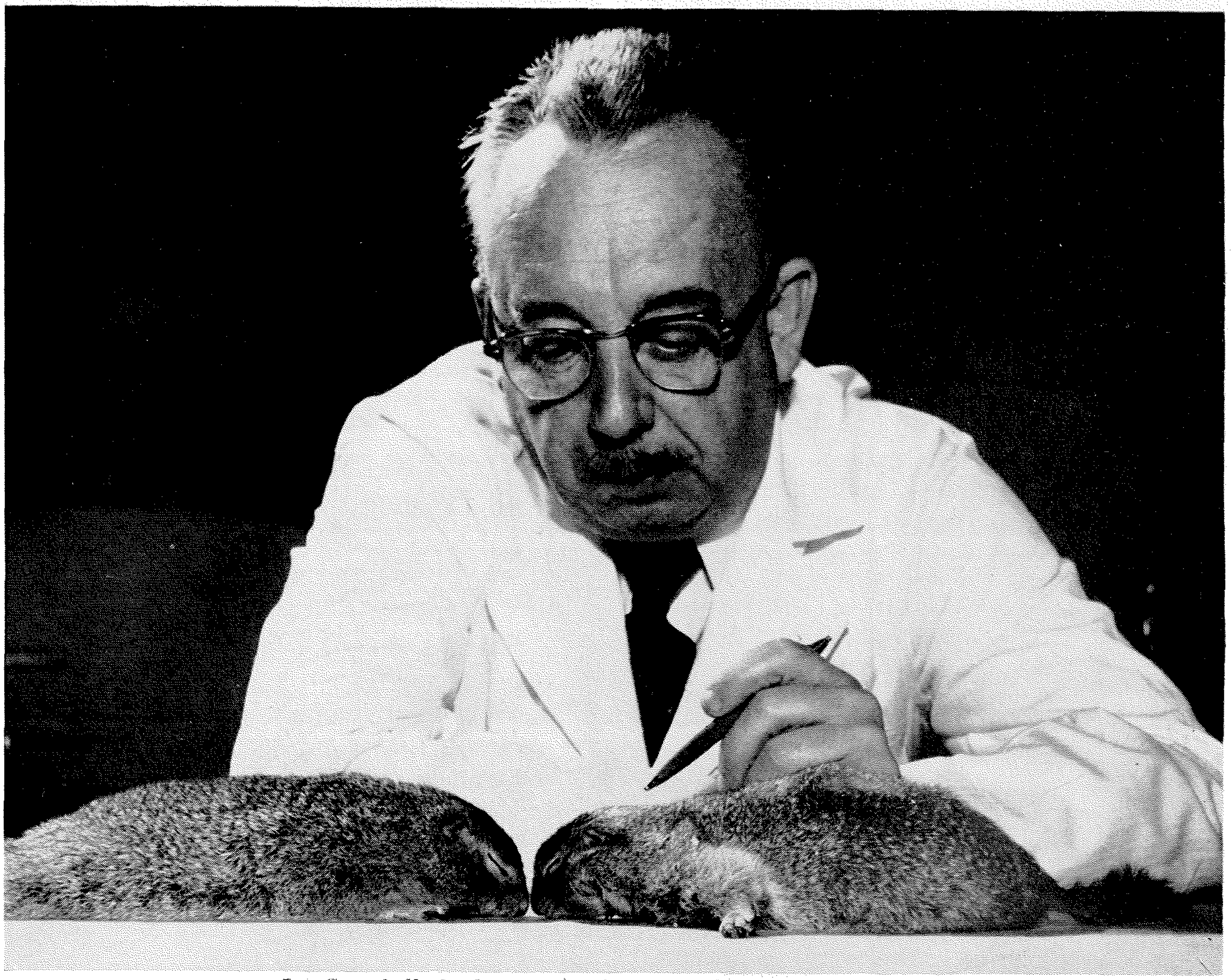
But it is *your* generation that will have the job of working out the means of preventing disaster, by developing safeguards against paranoiac demagogues who might make nations rabid; *you* will have this great job to do—and I am confident that you can do it.

This popular support is the result of the rather poor economic situation in Japan, where there is considerable unemployment. The condition was expressed by a speaker before the American-Japan Society in Tokyo in the words: "While Americans can be expected to defend their prosperous way of life, many Japanese do not know when their next meal is coming."

The other question, that of rearmament, is one about which many of the Japanese people whom I met have strong feelings. Although the Japanese constitution does not permit rearmament, a significant amount of rearmament has been brought about in Japan. Many people consider that this action is unconstitutional, and a move has been made to amend the constitution, which would require a two-thirds vote of the House of Representatives. The Liberals and Democrats supported this move, but it has been blocked by the vote of the people, since more than one third of the elected representatives (the two Socialist parties) are opposed to it.

The caliber of the scientific and technical people in Japan is very high. The quality of work done is excellent, but Japanese scientists are handicapped by lack of financial support in the universities, which is a result of the poor economic condition of the country as a whole.

The universities, which are supported by the national Government, do not have large enough budgets to meet the need for higher education in Japan. During our stay there the entrance examinations were held. About ten times as many students took the examinations as could be admitted. Several professors spoke to me about their concern over the fact that a large number of thoroughly qualified students had to be denied admission to the universities. The same problem was discussed in the letters columns and on the editorial pages of the newspapers. The interest of Japanese people in science is indicated by the fact that at each of my lectures in Japan, held in auditoriums with 400 to 600 seats, hundreds of people were turned away, and overcrowding in the auditorium was so great in two cases as to cause some of the seats to be broken because of pressure from people trying to force their way in.



Dr. Campbell checks on two hibernating Arctic ground squirrels

SOME LIKE IT COLD

By studying how Arctic animals adapt themselves to cold, we are making a start towards solving problems dealing with man's survival in the Arctic.

by DAN H. CAMPBELL

ABOUT EIGHT YEARS AGO the Office of Naval Research initiated a program to stimulate research in the Arctic and on Arctic problems, by supplying facilities at Point Barrow, Alaska. Groups from several universities immediately became interested and began a variety of investigations which included everything from abstinence and acclimatization to zoography. From modest facilities which consisted of two small Quonset huts, and a few test tubes and thermometers in 1947, the equipment developed into a modern laboratory which comfortably accommodated about thirty research workers and contained all of the essential supplies, apparatus and services for biological, physical and chemical research.

Caltech became one of the early participants in this program when I was given a grant by the ONR to investigate possible changes that might occur in the chemical and physical properties of blood and in the immunity responses of animals and man under conditions of Arctic stress. The first trip to the Point Barrow laboratory was made early in 1948. Naval Air Transport supplied transportation as far as Kodiak Island, and then it was necessary to "hitch-hike" plane rides to Fairbanks. At this point, a Navy contract commercial plane supplied transportation to Point Barrow. The air route "through" the Brooks mountain range via Anaktuvuk Pass was extremely spectacular but rather disturbing, owing to the closeness of canyon walls.

Getting under way

The crowded quarters and lack of supplies at the laboratory prevented any significant research accomplishments during this initial period of orientation. However, a clear idea was obtained with regard to laboratory needs and the problems that could be studied under these conditions.

One of the most interesting problems involved the chemical and physiological changes which occur in the common Arctic ground squirrel during its active and hibernating states. These animals have a remarkable mechanism which enables them to survive the long Arctic winters by going into a state of "suspended animation." When the winter sets in, they enter their burrows and go to sleep. The body temperature falls to about 0°C, and is maintained at this point until spring. Some observers have stated that if the body temperature falls much lower, a hibernating animal will partially awaken and shiver until the body temperature rises to around 0°C, then immediately go back to sleep.

The mechanism of hibernation

To date, no information has been obtained as to the factors involved in regulating the mechanism of hibernation. If the mechanism is determined, one can speculate on the possibility of application to humans during surgery, for instance. However, during the next few years in which research was carried on at Point Barrow, several interesting facts came to light regarding the physiology and blood chemistry of these animals.

For example, it was found that the circulation of blood was practically nil and heart beats could hardly be detected, even with a stethoscope. Respiration was so shallow and at such long intervals (one or two times a minute) as to be almost non-existent. As might be expected, metabolism apparently reached an extremely low rate. Animals which had been immunized during the pre-hibernation period contained circulating antibody protein when they came out of hibernation. Such proteins as appear as a result of immunization (vaccination) usually disappear within a few weeks after the last immunization "shot."

Another interesting finding was that the normal blood coagulation mechanism was drastically changed, so that, instead of clotting within a few minutes after removal from the body, it took many hours, and in some cases failed to clot completely even after standing for several days. An analysis of serums for their plasma protein composition showed that the total concentration increased during hibernation and that relative concentrations of the various components changed. Also new protein components appeared which were not present in serum taken from active animals.

"Cold stress"

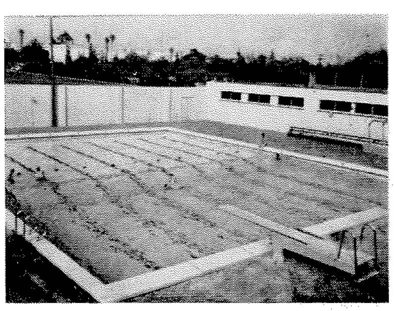
Because of the rigors of Arctic conditions, it was impossible to carry on a sustained program, so that after the second year research was done intermittently at intervals of several months, and finally moved entirely to the Caltech campus. These studies during the past few years have concentrated on the effect of "cold stress" on the common laboratory rabbit with respect to changes in blood chemistry, antibody response to immunization, and the rate of formation and decay of blood plasma proteins.

Normal young rabbits have been placed in cold rooms at about 32°F and their "coats" removed gradually over a period of about a week by shaving off their fur. After about a month under these conditions it was found that such rabbits were active and healthy and gained more weight than a control group maintained under normal conditions.

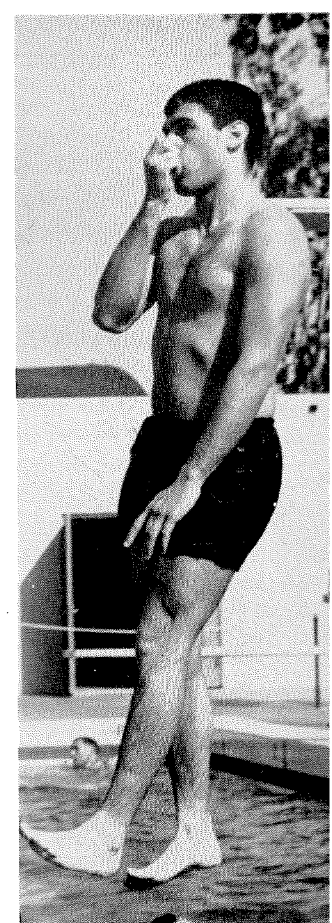
One of the most significant findings was that the blood of animals subjected to the "cold stress" clotted at a much slower rate than that of normal animals. This finding suggests that studies should also be made on humans under Arctic conditions, since blood clotting is of great importance in maintenance of a normal physiological state as well as in guarding against severe hemorrhage following injuries or surgery. It was also found that when blood was removed from "cold" rabbits, plasma was restored at a normal rate, but red blood cell restoration was much slower than in normal animals.

Adaptation and survival

A great deal of folklore has been written about the behavior and physiological state of animals and humans under Arctic conditions, but sound scientific investigation of these problems has hardly been touched. It is obvious that with the increase in interest and activity in Arctic regions as a possible battle ground, or as a part in global transportation routes and perhaps as a new source of natural resources, the problems of adaptation and survival become more important. If we knew why birds are able to stand barefooted on a cake of Arctic ice in sub-zero weather or how Arctic squirrels are able to turn off their body heat and go to sleep when the going gets tough, we should be a long way towards the solution of problems dealing with survival in the Arctic.

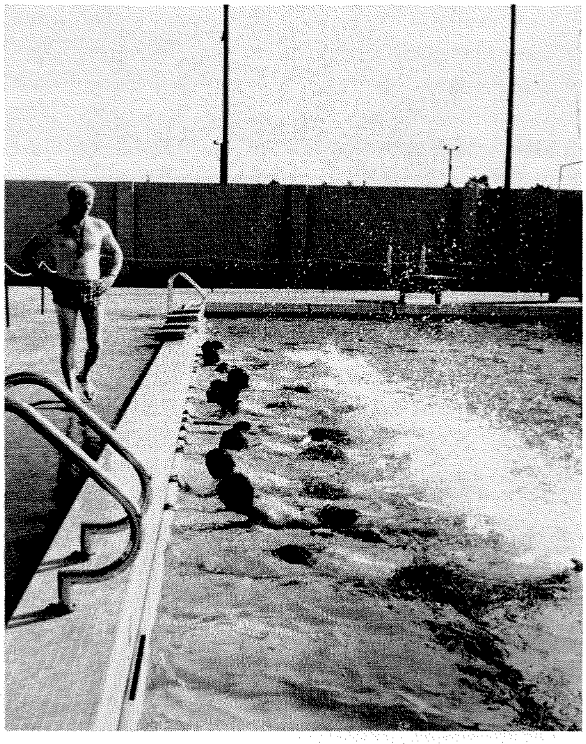


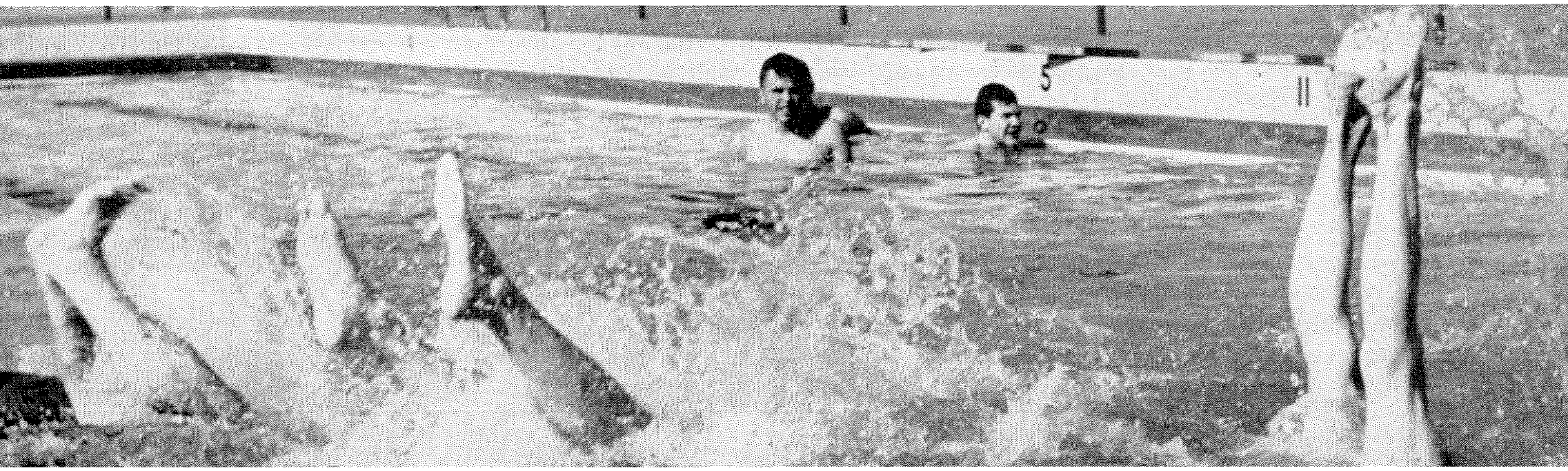
THE ALUMNI SWIMMING POOL



CALTECH ALUMNI will have their first opportunity to swim in the new Alumni Pool on Seminar Day, April 16, when the $150,000 pool is officially dedicated. Undergraduates are already putting the pool to good use, as the pictures on these pages indicate.

The pool measures 60 by 75 feet, and varies in depth from 3 feet to 12 and a half feet. It holds 288,000 gallons of water, heated to a constant 78°, has night lighting, two low (1 meter) diving boards and one high (3 meter) board.





THE SOPHOMORE: HALF A MAN

THE SOPHOMORE laughed a little bit to himself as he gazed through his window at the horrible mess in the courtyard below. In the center of the jumbled heap were two beds, piled high with clothing, linens, spreads, and what have you. Around the outside his eyes picked out a chest of drawers, a dozen or so pairs of shoes, several desks, countless books, an alarm clock, some chairs, some wastebaskets, and some lamps —and he was sure there was more, though he couldn't make it out from his window.

Ditch Day had come early this year, he thought. Probably the seniors had planned to take their traditional day off very early in third term this year, in the hope that the lowerclassmen would be caught off guard. They had been off guard—for about a half an hour; then the usual sadistic practices had begun.

Ditch Day was a funny tradition, he mused; at least part of it seemed a little strange to him. Sure, it was natural enough for the seniors to all take the same day off every year, to ditch their classes and head for the beach. But it wasn't quite clear to the Sophomore why the other guys had to go and make such a mess of everything as their part of the tradition.

He wondered how Ditch Day had developed historically. When had the first jealous freshman stacked a senior's room while the senior was taking his ditch? Why had it become the proper thing to do, to use Ditch Day as a day of revenge? What the Sophomore really would like to do was, instead of going around stacking the seniors' rooms, to take off for the beach with them. Sort of an All-School Ditch Day instead of just for the seniors.

Still, it wasn't that he hadn't enjoyed his part in the sadism. He had helped fill the oil drum with water in the former ASCIT president's room, and had helped empty a dozen vacuum cleaner bags full of dust onto the floor of another unlucky senior. It certainly was a good way to blow off steam.

He was a little bit jealous of the guys in Fleming who had dreamed up the neatest stunt in years. He hadn't actually seen it, but from what he had heard, they had rotated one senior's room through ninety degrees! The bed and desk and chair were propped up on the wall. Paintings and wall decorations were now on the floor and ceiling. The floor lamp had been set on its side, and even the light switch had been transplanted. The door even had been taken off its regular hinges and hinged at the top (or bottom, he forgot which). You could just walk into the room (so he had heard) and lie down on the floor, and it looked like you were standing up. It had really been an inspired job.

Third term certainly had arrived. The sun was shining every day, almost, and the smog wasn't usually enough even to irritate your eyes. The air was getting hot, and the classrooms were getting warmer and the classes drowsier. It was always hard for the Sophomore to stay attentive through two or three hours of classes in the mornings, but it was impossible now—and that was a sure sign of spring. Another sign was the slowly increasing number of wet spots on the concrete, where premature waterfights, forerunners of the full-scale wars of the next few weeks, had spent themselves.

Probably the best sign of all was the faint shade of brown that was beginning to show on the faces of the undergrads. Almost everyone had been to the beach a few times now. There was a bright red face at the dinner table almost every night, sported often by one of those confident "I-never-burn-I-only-tan" people who characteristically end up burning brightest of all.

The Sophomore stepped back from the window and looked around his room, which was not quite the shambles that the courtyard was, but was hardly a model of good housekeeping. He noticed the house social program that was pinned up on the wall next to the door, and reminded himself to get on the stick and get some girls lined up for the fabulous round of third-term parties.

It's April already, he thought with a start. April of my sophomore year. Two more months and my college days are half over! What was going to be next? He sympathized with the seniors, who were thinking two more months and it's all over, all of it—except for the ones for whom grad school might provide a short-term extension of their college life. But he'd just left high school a few months ago, it seemed like, and now college was half gone. If a high-school graduate is a boy and a college graduate is a man, then I'm half a man now, he smiled to himself. Half a man. What will I be like in two more years? he wondered sleepily.

Hey, he thought, snapping out of it, if I'm going to Little Corona tomorrow I'd better knock off that calculus homework.

The last thing he wanted to do! He wanted to go down to the courtyard and sit and talk, or read a magazine in the lounge, or call up his girl, or just sack out, or something—anything except that homework.

Serves me right for wanting to get an education, he thought with a forced grimness. He sat down at his desk and pulled down his book, and then stopped to gaze out the window at the evening sky one last time.

Two years and I'll be a man, he thought again. Let's make 'em good years.

Resignedly he started in on the hated homework.

—Marty Tangora '57

A biologist examines the direct evidence that life does exist on Mars—and comes to an intriguing conclusion.

by FRANK SALISBURY

THE INHABITANTS OF MARS

ARE THERE MARTIANS? Are there entities on the planet Mars which, according to our standards, possess life? Certainly, of all the objects which an asstronomer may directly observe with his telescope, Mars is the only one with an environment even remotely enough related to our own to possess life at all as we know it. Mercury is as hot as a furnace on one side and as cold as space on the other. Venus has no water, and its surface is probably subjected to constant sand blasting. The planets beyond Mars are frozen wastes with atmospheres containing large amounts of astringent gases such as ammonia and methane. Most of the satellites of the solar system planets have no atmospheres (nor does Mercury), and beyond the solar system the suns the astronomer sees appear only as points of light, and planets which might support life can only be inferred.

If there are Martians, what are they like? Are they extremely small and simple, comparable to earthly bacteria, algae or lichens? Or do they possess reflective intelligence, comparable to that of man? Certainly, the only way to obtain answers to such questions would be to build a rocket ship and fly to Mars. Since this isn't being done at present, everyone is left to his own speculations.

Speculation can be lots of fun, both to read and to indulge in. As a framework for logical speculation about the possibilities and characteristics of Martian life, one should have all the known facts regarding the Martian environment. But first, to see whether or not any speculation at all is warranted, let us examine the direct evidence that life *does* exist on Mars.

The direct evidence for life on Mars is easily seen even with a small telescope. When it is winter in the southern hemisphere of Mars, the planet appears as a reddish disc with a brilliant white polar cap covering the south pole (the top pole, as the inverted image appears in the telescope). Some rather faint brownish markings extend irregularly from the polar cap to, and slightly beyond, the Martian equator. As spring arrives in the Martian southern hemisphere, the polar cap begins to recede, and the brownish areas begin to become bluish-green, and finally, in summer, after the polar cap has completely disappeared, these areas are quite green. In the fall the areas become brown again, and the cap begins to appear. The colors involved in these changes are strongly reminiscent of the changes seen in earthly vegetation as the seasons succeed one another. The colored areas are not static from year to year, but change in both size and shape. Observation in the summer of 1954 revealed a fairly large area which had not previously been seen.

In the spring the markings first become green in the area nearest to the polar cap, and the greening then progresses away from the pole and toward the equator, rather than from the equator toward the pole as on earth. This striking fact implies that the melting of the polar cap is a direct cause of the change of color in the markings, rather than merely coincident with it, both phenomena being the result of the general increase in temperature.

All of the above features have been photographed, and their reality is accepted by everyone. Of a more controversial nature, however, are the so-called Martian canals. Since 1877, when the Italian observer, Giovanni Schiaparelli, published a map of Mars showing the planet covered by a network of fine lines (which he called *canali*, probably for want of a better term), many observers have confirmed his observation and many others, equally well trained, have denied that such markings exist.

Professor Percival Lowell has been, perhaps, the greatest champion of the canals. To detect the canals, it is said that the "seeing" must be exactly right; that is, that the air above the observatory must be perfectly clear and still. To obtain these conditions, Lowell established the Lowell Observatory in Arizona, around the turn of the century. After many years of patient observation by him and his co-workers, a map was published showing 700 canals on the surface of Mars. Many of the canals were double lines, and often at the intersection of two such sets of canals there would be a small green area, which Lowell called an oasis.

Lowell gradually developed an extensive hypothesis relating the canals to intelligent life. The oases were said to be Martian cities, surrounded by farms, and the canals, which varied in width from a few to many miles, were actually farms located along Martian waterways extending from the polar cap to the equator and beyond. Lowell reported that the canals, as well as the other areas, became green in the spring, starting at the pole and working toward the equator.

The problem of the canals

Few people nowadays agree with the theories of Lowell. Although the canals have been seen by many people and some of the major ones seem to be present on some of the best photographs of the planet, no one claims to have seen all 700 described by Lowell. Fairly plausible explanations have been advanced to account for them on some basis other than that of intelligent life. Some consider them to be optical illusions. Others suggest that they mark boundaries between unlike areas. Certainly the problem of the canals is far from solved. Perhaps the strongest evidence against the sort of civilization proposed by Lowell is found in the description of the Martian environment given below.

Whatever the significance of the canals, the facts concerning the green areas are well established and are very difficult to interpret under any other hypothesis except that they represent life—probably vegetation. No one has been able to think of a chemical which would change color, as do the green areas, with slight increases in relative humidity. Dean B. McLaughlin, astronomy professor at the University of Michigan, suggests that the areas consist of volcanic dust, which is green because of the lack of oxygen, and are blown around and made more visible each spring as the Martian winds increase. (Shades of the March Winds!)

This would account for the changes in size and shape, and windrows of volcanic dust might account for the canals; but why should the areas turn brown in the fall, and why should the greening progress from the poles towards the equator in the spring? Furthermore, astronomers often see clouds of yellow dust from the red and yellow deserts blowing across the face of the planet. If the green areas consist of green volcanic dust, why isn't it seen blowing across the planet and why hasn't the yellow dust covered the green areas? The best hypothesis still seems to be that the green areas consist of Martian vegetation, able to "grow through" the yellow dust which is often deposited upon it.

Life like ours?

Could the Martian environment support a type of life akin to our own? The Martian soil probably would be suitable. Dr. Gerald P. Kuiper of the University of Chicago concludes from spectral studies that the red deserts consist of igneous rock, possibly felsitic, or something similar. (The red color was long thought to be due to large amounts of iron oxide, but Kuiper's studies failed to bear this out.) This rock, as well as most other related materials, would be a perfectly suitable substrate for plant growth.

The atmosphere, however, is much more critical than the soil for life as we know it. The polar caps are almost certainly ice (rather than frozen carbon dioxide—dry ice—as has been suggested), although they may be only a few millimeters thick. Clouds are occasionally seen in the atmosphere, and they have the spectral characteristics typical of earthly clouds consisting of minute particles of ice. Indeed, the thin haze which covers the planet almost all of the time may consist of fine ice crystals, which would give the Martian sky a brilliant white appearance—making the sun almost invisible. As the morning twilight zone crosses the planet, a narrow white line can be observed which disappears as soon as it is in the direct rays of the sun. This is probably frost on the surface of the planet.

All of these facts indicate that water must be present, but, so far, no vapor has been detected in the Martian atmosphere. Because of the large amounts of water in our own atmosphere, the problem of observing water in the atmosphere of Mars is very difficult. None the less, our methods are sensitive enough to show clearly that the atmosphere of Mars, by our standards, is very dry. So dry indeed, that liquid water must exist, if at all, only in areas immediately adjacent to melting ice crystals.

Carbon dioxide does occur in the atmosphere of Mars. There is probably about twice as much above the surface of Mars as there is above the surface of the earth at sea level. Oxygen, on the other hand, has never been detected in the Martian atmosphere. Once more, we are limited by the methods available, but the most optimistic upper limit set by astronomers for the amount of oxygen present is still far too low to support animal life as we know it on earth. This one fact throws into very serious doubt all the inferences of Lowell about intelligent animal life.

The total amount of atmosphere on Mars can be roughly estimated, and carbon dioxide, the only gas so far detected, is not present in nearly large enough quan-

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tities to account for the total amount of gas. Argon must be present, as it is produced in fairly large amounts from the radioactive decay of an isotope of potassium. The principal gas is thought to be nitrogen, but no method is known by which this assumption could be directly tested. A fair estimate of the composition of the Martian atmosphere would be: 0.3% CO_2, 4.0% A, and about 96% N_2. The atmospheric pressure is probably equal to about .10 to .20 atmospheres as measured on earth.

The average maximum temperature on Mars seems to be from 0° C. to about 16° C. In the green areas, near the equator and in the Martian summer, the temperature may reach 30° C. in the middle of the day. The night temperature may drop as low as —100° C., and is always very much below freezing.

A factor of great importance in consideration of life on Mars is the ultra-violet radiation which strikes the surface of the planet. The ice-crystal haze and the carbon dioxide and nitrogen of the atmosphere allow most of the ultra-violet light from the sun to reach the surface. On earth the ozone layer of the upper atmosphere is the primary agent which filters out this ultra-violet radiation, but ozone has not been found on Mars.

The Martian environment

Thus the Martian environment can be summed up as follows: The atmosphere contains considerable carbon dioxide (0.3% compared to 0.03% in our atmosphere) and nitrogen, but very little water or oxygen. The temperature has a great daily variation from far below zero to somewhat above freezing. Because of low atmospheric pressure, a dry atmosphere, and a normally frigid temperature, water does not commonly exist as a liquid, but only as a solid or a gas. Ultra-violet radiation strikes the surface almost with undiminished intensity. There are seasonal variations in climate and rather frequent storms of yellow dust. Mars is an extremely cold, extremely dry desert.

Nothing exactly comparable to this environment occurs on earth. Of course our atmosphere differs greatly in composition from that of Mars, and only small amounts of radiation strike the earth. Even temperature and moisture conditions are not duplicated on earth. On earth, where it is very dry, it is also very hot, and where it is very cold, it is also very wet, at least for part of the year. Yet in spite of the striking differences between the environments of the two planets, conditions on Mars more nearly approach conditions on earth than do the conditions found on any of the other planets.

Could earthly vegetation survive in an environment like that of Mars? On Mars most of the familiar plants would perish immediately. Astronomers, however, have considered the possibility that lichens might survive the Martian climate. Lichens are a sort of symbolic "double plant," consisting of an alga (which photosynthesizes) and a fungus, which seems to help in water storage) with their cells in intimate contact. They are the little green, brown, or reddish patches seen on rocks. They are found in the coldest, driest, and highest places on earth. Assuming that Martian plants contain less than half as much water as plants on earth, and taking into account the total amount of water on Mars, it has been estimated that Martian plants, from their area on the planet and their water content alone, could be at most a fraction of a millimeter high. The patches of lichens seen on rocks are often less than a millimeter thick. The infra-red reflection spectrum of the green areas on Mars is nearly the same as the infra-red reflection spectrum of earthly lichens. The spectrum, however, is lacking in detail in both cases, probably because of lack of water, and certainly no definite conclusions can be drawn from such data.

Martian plants

In the opinion of this author, there are two striking differences between lichens as we know them on earth and the green areas of Mars. First, the completeness of cover of the grass areas is hard to reconcile with the lichen growth habit. For an area to appear green, the cover must be very nearly complete, as in our forests. In our deserts, a distant hill may appear barren, although a fair percentage (perhaps 30 percent) of its area may be covered by plants. There are lichens in the desert, but their detection requires careful examination; they are never a conspicuous part of the landscape. In the far north they do form a complete cover, but during at least a part of the year they have a super-abundant supply of liquid water, a circumstance far different from conditions on Mars.

Second, the rate of change of size, shape, and color of the Martian green areas is many times greater than would be expected if these areas consisted of lichens like those found on earth. The thin, flat type of earthly lichens (those which fit the calculated size range of Martian plants) is extremely slow-growing. Erosion can be estimated from the line of lichens on a rock above the soil level, for the lichens may extend their area only a fraction of an inch in a century. Of course some earthly lichens grow more rapidly than this, but they occur only in moist places, as on the trees of a rain forest or on the soggy tundra of the north. Lichens do change color as their moisture content changes (becoming brown in summer as they dry), but it would seem unlikely that the slight change in relative humidity which seems to cause the color changes on Mars would be sufficient to bring about such a color change in earthly lichens.

On earth, the continuance of life is absolutely dependent upon oxygen. There are organisms that are able to live in the absence of oxygen, but if all life on earth consisted of such organisms, the processes of decay could never be complete. Dead organisms would pile up until essential nutrients such as carbon were no longer avail-

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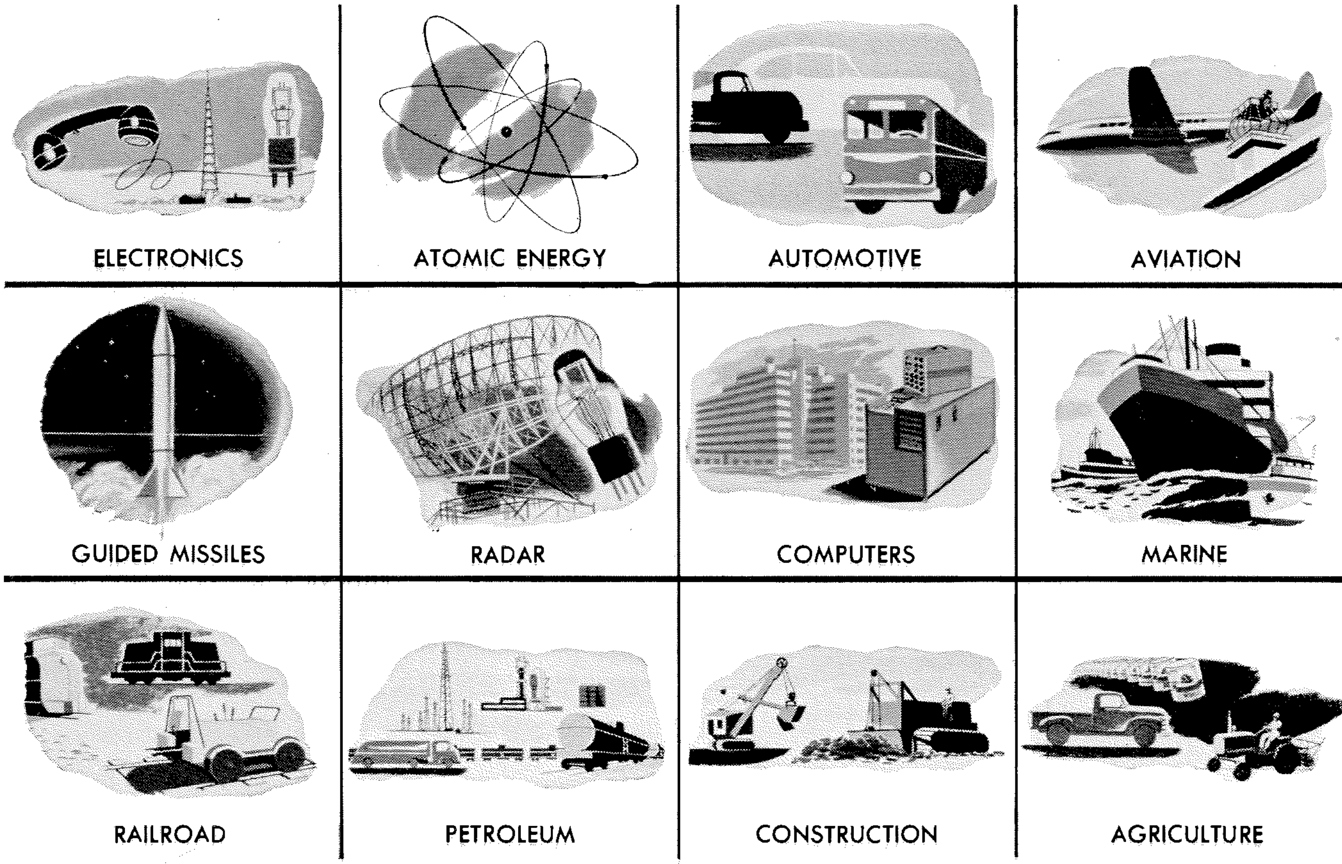

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It encourages and promotes freedom of ideas. Keeps engineering ingenuity flexible and adaptable. In short, gives full vent to an engineer's creative ability . . .

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able but were all contained in these dead remains, and then life would stop. Decay is an oxidation reaction, and although various stages of it take place in the absence of oxygen, oxygen must ultimately be present or the process will come to a halt. Thus it is highly short-sighted to suggest that Martian plants live by an anaerobic metabolism. Most plants on earth, including lichens, require oxygen, as do virtually all animals.

Dr. Hubertus Strughold, head of the department of Space Medicine at Randolph Field, Texas, in a recent book, *The Green and Red Planet,* suggests that the key to this problem is the "internal atmosphere" found within the plant body. Oxygen produced in photosynthesis would be trapped in the inner spaces and used in respiration. It is, however, rather difficult to imagine how an internal atmosphere could contain one gas (oxygen) without allowing its escape and yet allow another gas to enter (carbon dioxide). Certainly the plants on earth from which this model was taken have no such mechanism. Nor does the "internal atmosphere hypothesis" explain how the decay organisms might obtain oxygen.

Perhaps the most serious problem of all concerns the ultra-violet light striking the surface of Mars. This type of radiation, at such high intensty, would probably be fatal to most things living on earth, at least after an extended period of time.

Lichens could be subjected to an artificial Martian environment in the laboratory to see if they could survive the rigors of Mars. It would seem, however, to the present author, that even in the absence of such tests, we might be quite certain that earthly lichens transplanted to Mars could not produce the effects described above. Indeed, they would probably not survive for long.

A new type of life?

The conclusion of this discussion, then, is that earthly vegetation—even lichens—could not survive the Martian climate, let alone flourish and expand in the manner described by many careful observers such as Lowell. Certainly the oft-painted picture of Martian lichens struggling for existence on a dying planet does not seem to convey a true representation of the Martian green areas.

Hence, since speculation is free, we may be justified in postulating an entirely new type of life. We might assume, in our Martian biochemistry, that nitrogen instead of oxygen plays the active role in energy transfer. Various soil bacteria on earth oxidize nitrogen from ammonia to nitrite and then to nitrate, and derive energy from so doing. Martian biochemistry would certainly involve the many compounds of carbon, as does our biochemistry, for there is ample carbon in the atmosphere (CO_2). Martian photosynthesis might use red and blue absorbing pigments (which appear green, as does chlorophyll), but it might involve the formation of carbon-nitrogen bonds as well as carbon-carbon bonds. The medium of reaction might be water, as it is on earth, or it might be some other compound which remains liquid at much lower temperatures (a sort of protoplasmic anti-freeze—synthesized by the "plants" themselves).

The fact that the areas become green in the Martian spring nearest to the melting polar cap indicates that water is of distinct importance to the Martian vegetation, but it may act in a limiting way as a growth regulator rather than as a primary solvent. In our oceans, when some disturbance in the current brings water from depths, the concentration of critical elements such as phosphorus and nitrogen may be increased, and the result is a rapid growth of the sea flora and fauna. Perhaps, in an analogous manner, the slight increase in relative humidity of the Martian atmosphere, caused by melting (or subliming) of the polar cap, provides the few molecules of water required by the Martian vegetation to flourish in the Martian spring.

Perhaps the compounds involved in Martian biochemistry are relatively stable to ultra-violet radiation, or they are protected by screening pigments on the surface of the organisms. Indeed, important reactions may occur through absorption of ultra-violet radiation, such as the production on earth of vitamin D from certain sterols.

No precedents

Our knowledge of biochemistry rests upon the study of earthly enzymes produced under earthly conditions, and hence there are no real precedents known to us for a synthesis of a new biochemistry. One might consider a biochemistry with the oxidation and reduction of sulfur as its basis, or perhaps manganese is responsible for certain phases of energy transfer in Martian protoplasm. On earth this element is lethal in doses larger than trace amounts, but such trace amounts are essential for life!

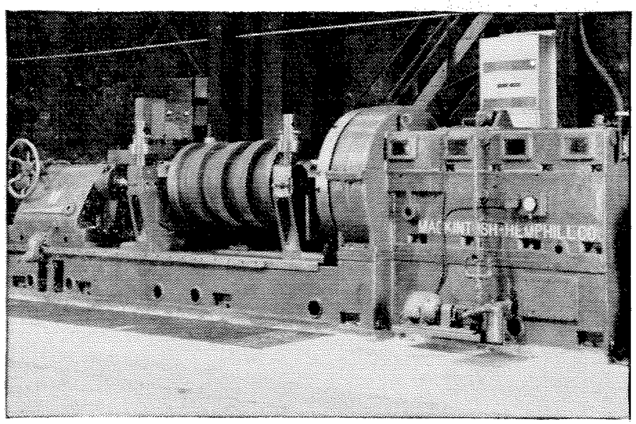
The idea of water as a growth regulator rather than a primary solvent has some rather interesting implications. The calculation of the size of Martian plants based on their water content would no longer be valid. Plants much larger than one millimeter might be found, and animal-like organisms having locomotion would not be out of the question. They might obtain "vitamin H_2O" from the plants! Even intelligence is conceivable, and Lowell's canals could have some of the significance which he tried to attach to them.

Whatever sort of life exists on Mars, it must have an ecology. There must be numerous like and unlike individuals, struggling for existence with each other and with their environment. The complete cover would certainly seem to indicate this. Probably all ecological niches are filled and natural selection operates in full force.

Seasonal and secular cycles in the Martian vegetation may be observed from earth. A biochemist studying the inhabitants of Mars would also study their life cycles, and a bio-geochemist would study elemental cycles. If

Another page for **YOUR BEARING NOTEBOOK**

How to carry 35-ton loads in a roll-neck lathe



The engineers who designed this roll-neck lathe were faced with three problems. 1) To build a lathe that would cut finishing time as much as 75%; 2) To build a lathe that would give great accuracy and 3) To provide great load-carrying capacity as well. Their answer was this electronically-controlled mill roll lathe. To carry the 35-ton loads with a maximum runout of .0003 and still do the job quickly, they specified Timken® tapered roller bearings.

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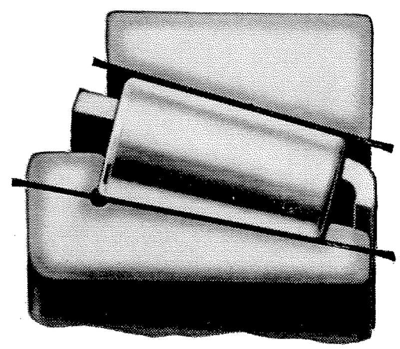
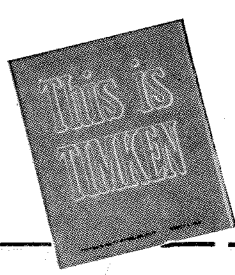
This cross-section of a Timken tapered roller bearing illustrates one reason why Timken bearings do such a good job under heavy load conditions. Notice that there is full line contact between the rollers and races. It's this full line contact that distributes the load over a wider area, gives Timken bearings their extra load-carrying capacity.



Want to learn more about bearings or job opportunities?



Some of the engineering problems you'll face after graduation will involve bearing applications. For help in learning more about bearings, write for the 270-page General Information Manual on Timken bearings. And for information about the excellent job opportunities at the Timken Company, write for a copy of "This Is Timken". The Timken Roller Bearing Company, Canton 6, O.

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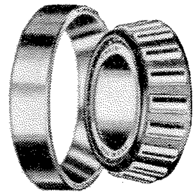
TAPERED ROLLER BEARINGS



NOT JUST A BALL ○ NOT JUST A ROLLER ▭ THE TIMKEN TAPERED ROLLER ▭ BEARING TAKES RADIAL AND THRUST LOADS OR ANY COMBINATION carbon and nitrogen are fixed in photosynthesis, some other processes must ultimately free them to the atmosphere. Again it is tempting to think of animal-like forms occupying a position between the autotrophic "plants" which are able to live on minerals from soil and atmosphere and the organisms of decay which finally release these minerals from the Martian biosphere. On earth food chains become very complex. How complex are they on Mars?

Plant succession must be a Martian phenomenon as well as an earthly one. Some forms must be more adept at surviving on the undisturbed Martian red deserts than others. Indeed, the deserts may be sparsely covered with vegetation, as our own deserts are. Some of these forms may, by their reaction upon the environment, modify conditions so that other species are able to move in. The invaders then probably crowd out the pioneers, as they do on earth. Eventually a climax is reached in which no other Martian species is able to compete with the existing ones, and the resulting environment is quite different from the original bare red desert. The color and insulating quality of the climax vegetation result in significantly higher temperatures. A soil has formed in equilibrium with the climate of the region. When disasters such as severe yellow dust storms wipe out a climax population, a secondary succession must take place.

Species distribution is probably correlated with latitude, topography, etc. Plant (or animal) communities probably result from the control of certain dominants and the association of species having common environmental requirements.

And what effect would intelligence have upon all this?

It is intriguing to a biologist to think of life on Mars. Would the ecological and physiological principles worked out on earth today apply there? An earthly biologist likes to think of things such as plant succession, photosynthesis, and natural selection as fundamental principles of life. Yet they have only been studied under one general set of conditions, those of earth, and their universal nature can only be inferred. It would be a most striking evidence that they are indeed of a fundamental nature if such principles were found to apply to the inhabitants of Mars as well as to the inhabitants of earth. Astronomer, geologist, chemist, and physicist would all like to test their theories on another world, but what could surpass the enthusiasm of the biologist if he were given a chance to examine the inhabitants of the red planet in their native habitat?

THE MONTH AT CALTECH

Fisher Award

DR. ERNEST H. SWIFT, Caltech Professor of Analytical Chemistry, received the $1,000 Fisher Award in Analytical Chemistry at the spring meeting of the American Chemical Society in Cincinnati on April 2.

The award, which was announced last fall *(E&S—October '54)*, is sponsored by the Fisher Scientific Company of Pittsburgh, and is given annually "to recognize and encourage outstanding contributions to the science of analytical chemistry, pure or applied—carried out in the United States or Canada."

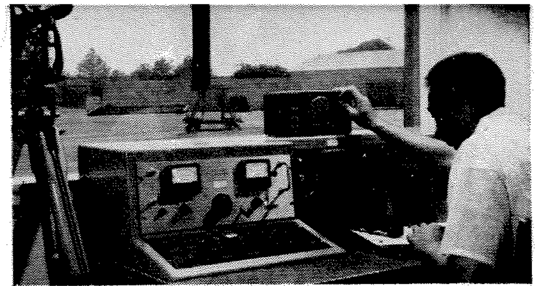
A member of the Caltech faculty for 35 years, Professor Swift is recognized as one of the greatest living analytical chemists and the world's leading authority on the use of physico-chemical principals for chemical analysis.

An official investigator for the Office of Scientific Research and Development during World War II, Dr. Swift worked on problems related to the identification of chemical warfare agents and their detection in the field. He also helped develop a comprehensive system of chemical analysis for use by Army chemical laboratories in the field. More recently he has pioneered in the development of coulometric analysis—the use of an electric current to detect and measure chemical elements—and is recognized as the foremost authority in this field.

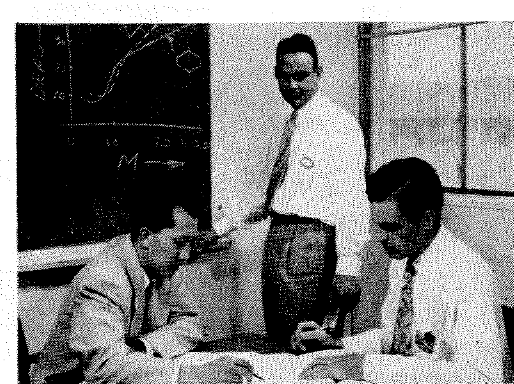
Dr. Swift received the BS degree from the University of Virginia in 1918 and the MS and PhD at Caltech. He joined the Caltech faculty as an instructor in 1920 and was named Professor of Analytical Chemsitry in 1943.

Honors from France

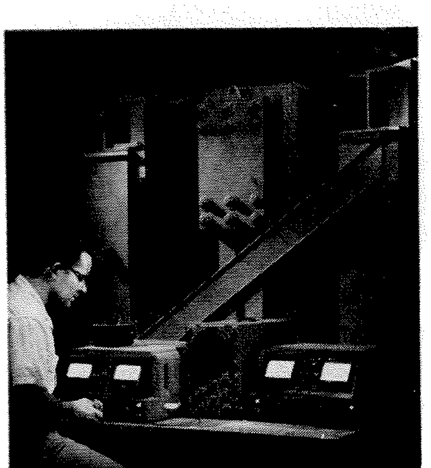
THE REPUBLIC OF FRANCE has awarded two new honors to Dr. Theodore von Karman, Caltech Professor of Aeronautics Emeritus. For many years a corresponding member of the French Academy of Sciences, Dr. von Karman has now been elected a full foreign member of the Academy. He is one of only 14 non-French scientists so honored. He has also



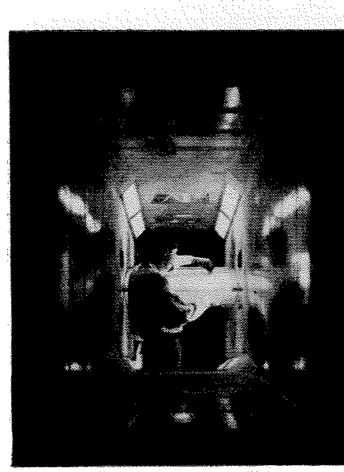
Electronics Research Engineer Irving Alne records radiation antenna patterns on Lockheed's Radar Range. Twenty-two foot plastic tower in background minimizes ground reflections, approximates free space. Pattern integrator, high gain amplifier, square root amplifier and logarithmic amplifier shown in picture are of Lockheed design.



Jim Hong, Aerodynamics Division head, discusses results of high speed wind tunnel research on drag of straight and delta wing plan forms with Richard Heppe, Aerodynamics Department head (standing), and Aerodynamicist Ronald Richmond (seated right). In addition to its own tunnel, Lockheed is one of the principal shareholders in the Southern California Cooperative Wind Tunnel. It is now being modified for operation at supersonic Mach numbers.



Research Engineer Russell Lowe measures dynamic strain applied by Lockheed's 500,000 lb. Force Fatigue Machine on test specimen of integrally-stiffened Super Constellation skin. The Fatigue Machine gives Structures Department engineers a significant advantage in simulating effect of flight loads on a structure. Among other Lockheed structures facilities are the only shimmy tower in private industry and largest drop test tower in the nation.



C. H. Fish, design engineer assigned to Lockheed's Icing Research Tunnel, measures impingement limits of ice on C-130 wing section. The tunnel has a temperature range of −40°F. to +150°F. and maximum speed of more than 270 mph. It is the only icing research tunnel in private industry.

Advanced facilities speed Lockheed engineering progress

Lockheed's unmatched research and production facilities help make possible *diversified* activities in virtually all phases of aviation, military and commercial.

They enable engineers to test advanced ideas which would remain only a conversation topic in firms lacking Lockheed's facilities. They help give designers full rein to their imagination. They make better planes — and better careers.

Engineering students interested in more information on Lockheed's advanced facilities are invited to write E. W. Des Lauriers, Lockheed Student Information Service, Burbank, California.

Lockheed AIRCRAFT CORPORATION

BURBANK **California**

been elevated to the highest rank of the French Legion of Honor—that of commander. He was made an officer of the Legion in 1947.

Dr. von Karman has been chairman of the Advisory Group for Aeronautical Research and Development (AGARD) of NATO since 1951 and chairman of the Scientific Advisory Board to the Chief of Staff, U.S. Air Force, since 1944. Now in Pasadena, he plans to return to his AGARD duties in Paris in mid-April.

NSF Fellowships

TWENTY-FOUR Caltech students have been selected by the National Science Foundation in Washington to receive graduate fellowships in the natural sciences for the 1955-56 academic year. Six of the fellows are now Caltech seniors and 18 are graduate students here. Sixteen of the 24 plan to continue their work at Caltech.

They were chosen on the basis of ability as determined by scores in fellowship examinations for scientific aptitude and achievement, academic record, and recommendations.

The awards are made by the Foundation to encourage students with scientific aptitude to continue in advanced studies in preparation for careers in scientific research and teaching. Pre-doctoral fellowships carry stipends of $1,400 for the first year, $1,600 for intermediate years, and $1,800 for the terminal year of graduate study. Post-doctoral fellowships carry a stipend of $3,400. All awards include additional allowances for dependents, tuition, and other normal expenses.

Caltech seniors selected for NSF fellowships are *John P. Andelin, Jr., Charles J. Brokaw, John J. Domingo, John L. Honsaker, Thomas W. Noonan, and Richard J. Piccolini.*

Graduate students awarded fellowships to continue their graduate work are *Thomas H. Applewhite, Albert T. Bottini, Jon Mathews, John S. Mathis, Matthew S. Meselson, William B. Nichols, W. Barclay Ray, Willard V. Rusch, Ronald L. Shreve, Charles M. Steinberg, Walter R. Thorson, William G. Tifft, Hal R. Waite,* and *William G. Woods.*

Post-doctoral fellowships for advanced study and research were awarded to *Gary Felsenfeld, Edwin J. Furshpan, Donald L. Glusker,* and *Robert J. Metzenberg, Jr.*

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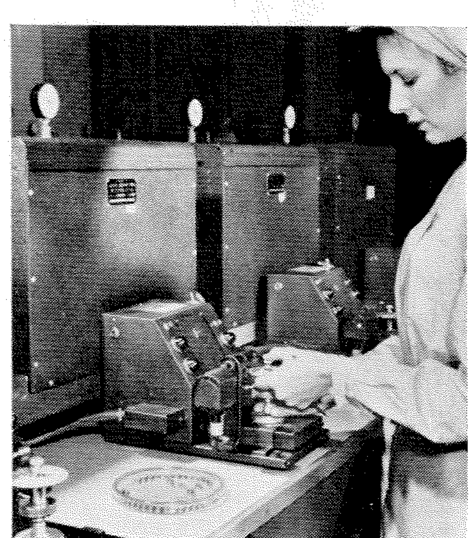
NOTHING ROLLS LIKE A BALL



Automatic gram-centimeter torque tester measures starting torque characteristics of New Departure instrument ball bearings. Like many of the ultra-precise devices used in bearing manufacture, this torque tester was largely developed by New Departure.

ALUMNI NEWS

Dinner Speaker

R. L. MINCKLER, president of the General Petroleum Corporation of Los Angeles, will be the dinner speaker at the annual banquet and meeting of the Caltech Alumni Association to be held on June 8 at the Pasadena Elks Club, 400 West Colorado St.

Mr. Minckler's talk on "Progress in Management," will deal with the accelation in the rate of economic progress—and the part business management has played in this progress.

R. L. Minckler joined General Petroleum in 1924. A graduate of the University of Washington, majoring in business administration, he worked as a purser for a trans-Pacific steamship line for a time, then came to southern California in 1921 as a cost accountant for the Southern California Edison Co. He progressed through various phases of accounting at General Petroleum and, ten years after joining the company, was made assistant to the president.

During World War II Mr. Minckler served as Director of Petroleum Supply of the Petroleum Administration for War, with headquarters in Washington. Returning to General Petroleum in 1945, he was elected a vice-president in 1947, and became president of the organization in 1948.

Mr. Minckler is a director of the Western Oil and Gas Association, a director of the American Petroleum Institute, a member of the National Industrial Conference Board, a director of the American Management Association, and a member of the Board of Governors of the Pacific Oil Institute.

He is also a Trustee of the California Institute of Technology and of Stanford University (where he is a consulting professor of business management), a director of the California State Chamber of Commerce, the All-Year Club of Southern California, and the Welfare Federation of the Los Angeles area.

DEEP SEA MONSTERS AT THE PICNIC

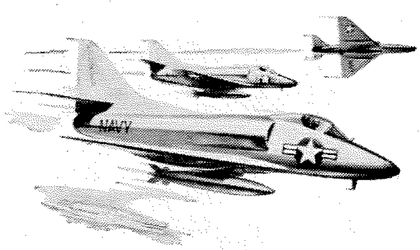
At the Annual Picnic, children from 6 to 60 will thrill to the antics of Frankie and Floyd, trained porpoises that jump high out of the water to take their food from the feeder's hand. They will stand hypnotized as a deep-sea diver descends to the bottom of the Oceanarium floor to hand-feed giant sea turtles, eels and many other fish.

Save Saturday, June 25, for your visit to this fascinating watery zoo and for an organized picnic with your fellow alums, family and friends at the Marineland of the Pacific, Palos Verdes. The day's events will entertain and please the entire family, and costs will be low—you may bring your own lunch, nature provides a lovely seaside setting, and we get special group rates to the Oceanarium.

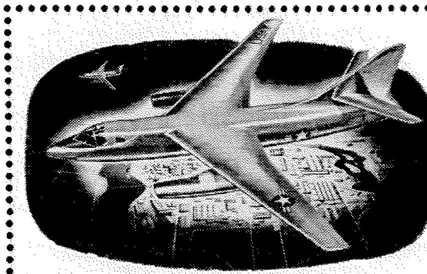
See you there!

Edward P. Fleischer, '43
Chairman, Picnic Committee

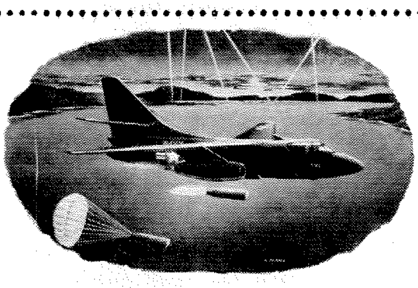
F4D, "SKYRAY"— only carrier plane to hold official world's speed record



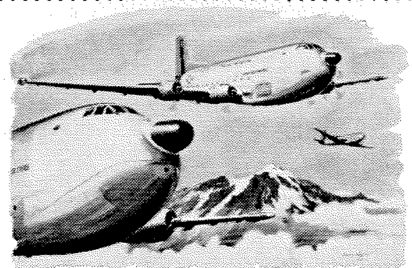
A4D, "SKYHAWK"— smallest, lightest atom-bomb carrier



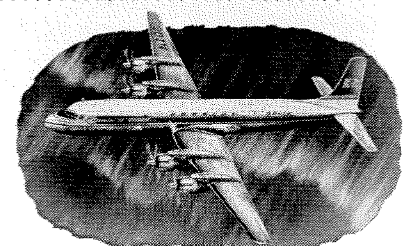
RB-66 — speedy, versatile jet bomber



A3D, "SKYWARRIOR"— largest carrier-based bomber



C-124, "GLOBEMASTER"— world's largest production transport



DC-7 "SEVEN SEAS"— America's finest, fastest airliner

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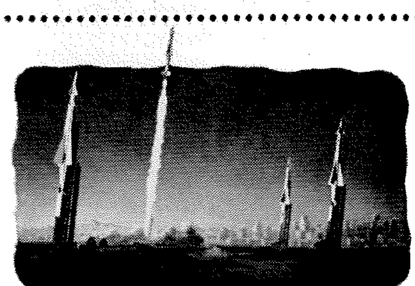
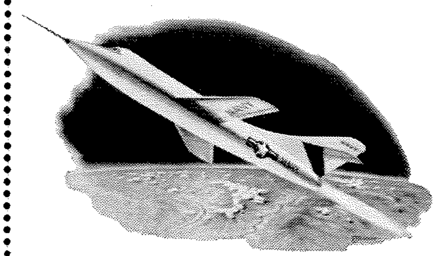


"NIKE"— supersonic missile selected to protect our cities



D558-2, "SKYROCKET"— first airplane to fly twice the speed of sound

At DOUGLAS you'll be joining a company in which the three top executive officers are engineers...you'll be associated with men who have designed the key airplanes and missiles on the American scene today! Nothing increases an engineer's ability faster than working with other engineers of top calibre.

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PERSONALS

1924

Douglas Tellwright, vice president of public relations at the Pacific Telephone and Telegraph Company in San Francisco, has been appointed campaign chairman for the 1955 United Bay Area Crusade. Doug says: "Geographically the campaign covers San Francisco, Oakland, Berkeley, Richmond, Marin County, San Mateo County, and parts of Contra Consta County." The United Crusade raises money to meet the needs of the Community Chest, Red Cross, and many national health agencies.

1925

Tracy Atherton claims the reason he left Los Angeles in 1951 was because he couldn't stand the smog and traffic any longer. He is now in Sacramento, working as a topographic engineer in the State Engineer's Office — his work being concerned mostly with California's cooperative mapping program with the U.S. Geological Survey.

1926

W. Leroy Dixon has been named president of the Western States Chemical Corporation in San Francisco.

1927

Gustaf W. Hammar, PhD, who had been senior supervising physicist in the Navy Ordnance Division of the Eastman Kodak Company in Rochester, New York, died last August after a long illness. Dr. Hammar directed a scientific group on a variety of Navy problems at the NOD, and was responsible for the development of Ektron Detectors, special devices which detect certain infra-red rays. Before joining Kodak in 1946, Dr. Hammar was head of the physics department at the University of Idaho, a position he had held for 16 years.

1928

Frank Noel is enjoying the smog-free, congestion-free life, abundant water supply, skiing, camping, and the other virtues of Redding, California, where he is a District Right of Way Engineer with the Division of Highways. Frank's daughter Phyllis entered the University of California on a scholarship last fall, and son Tom is now a high school sophomore.

1932

Robert W. Wilson, PhD '36, Associate Professor of Zoology at the University of Kansas, in Lawrence, Kansas, has been appointed president of the Society of Vertebrate Paleontology for a one-year term. The society, the only one of its kind, has an international membership of more than 400. Bob, in addition to his teaching duties at Kansas U., is associate curator of vertebrate paleontology in the Museum of Natural History.

Frederick W. Bowden spent last summer

PERSONALS . . . CONTINUED

in the East as a member of the General Electric Professors' Conference. Fred, who is head of the electrical engineering department at California State Poly. College, in San Luis Obispo, reports the following news of another alumnus: "While in Schenectady I had a long visit with *J. D. Cobine*, PhD '34. He is still doing research on arcs—and has also bought a farm, on which he is planting a 'forest'."

Joshua L. Soske, PhD '35, writes: "In reporting my activities for the past year, the following seems to cover the situation.

"1. Continued job as Associate Professor of Geophysics, and Director of the Henry Salvatori Laboratory of Geophysics at Stanford University.

"2. During the summer of '54 I was in charge of an engineering job investigating foundation conditions for a new rail crossing of the Great Salt Lake. This work employed the use of the seismograph and offshore techniques, and was done for the Southern Pacific Railroad."

1933

Ferdinand E. Strauss is working for the General Electric Company in Oakland, California, as manager of the Industry Control Department, Oakland Operations. He has a high-school-age daughter now, but he's taking up skiing to see if he's as young as he feels. The Strausses live in Piedmont.

Thomas Terrill is operating the General Petroleum Bulk Plant in Orland, California.

Louis H. Goss has been the city engineer and Director of Public Works for South San Francisco since 1953.

1934

Bryant Myers, an ME turned rancher, reports: "I am operating a 1000-acre ranch in the Santa Ynez Valley, raising beans and alfalfa—and feed the alfalfa to our own feeder cattle in a feed lot here on the ranch. My family is now six: three boys and a baby girl, Linda, born a year ago. All of us are enjoying the country life and I am trying hard to make it pay. Best wishes to all."

1935

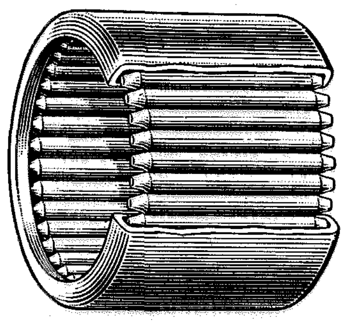
Robert P. Jones, who is assistant superintendent of the Telephone and Telegraph Division of Standard Oil of California, reports that he attends the Caltech weekly alumni lunch in San Francisco fairly often, and wishes that more grads would turn out. Bob has two boys, Bob Jr. and Chris.

1939

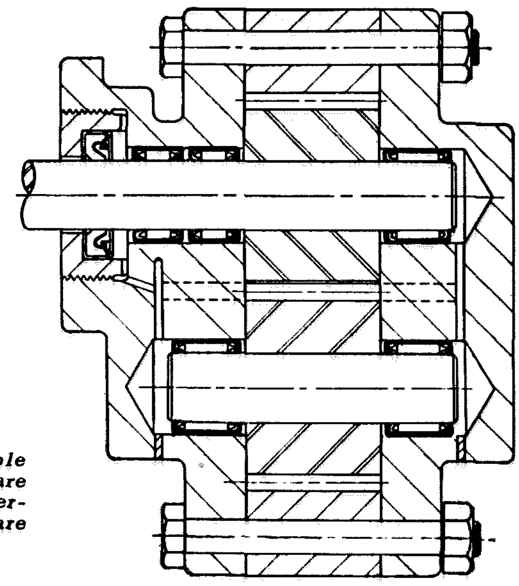
David H. Scott writes from Perth, West Autsralia: "Left my post as head of the Gravity Department at the Texas Company in Houston to take up the position as exploration superintendent of West Australian Petroleum, Pty., Ltd., in Australia. This company is under the American

The Torrington Needle Bearing

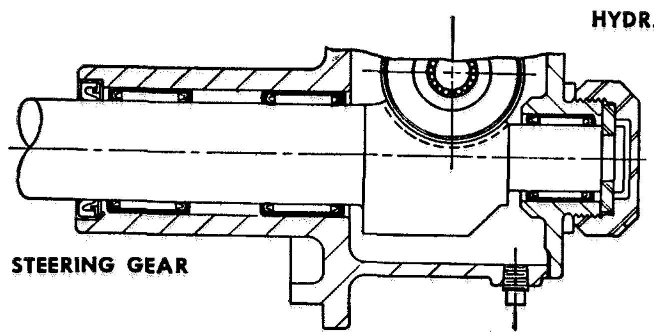
proper housing design is essential to proper performance



Needle Bearings require simple housings. If the housing bores are held to proper size, accurate operation and high radial capacity are assured.



HYDRAULIC PUMP



STEERING GEAR

The Torrington Needle Bearing offers many design and operational advantages for a great variety of products and equipment. For example, a Needle Bearing has greater rated radial load capacity in relation to its outside diameter than any other type of anti-friction bearing. It is extremely light in weight. And it is easy to install and lubricate.

Housing Maintains Bearing Roundness

The housing is an essential part of the Needle Bearing assembly. Care should be taken to provide a straight, round housing bore to the recommended tolerances.

The thin, surface-hardened outer shell of the Needle Bearing acts as the outer race surface as well as a retainer for the rolls. This shell assumes the shape of the housing into which it is pressed. Consequently, the housing bore should be round, and the housing so designed that it will carry the radial load imposed on the bearing without distortion.

Housing Material Determines Bore Size

The specified housing bore dimensions for any given material should be maintained in order to give the proper running clearance between the needle rollers and the shaft, and to assure sufficient press fit to locate the bearing firmly.

When designing housings of materials that are soft or of low tensile strength, allowance should be made for the plastic flow of the material when the bearing is pressed into place. Bore dimensions in such cases should be less than standard. Needle Bearings can be pressed directly into phenolic or rubber compounds, although metal inserts are recommended.

The new Needle Bearing catalog will be sent on request.

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PERSONALS . . . CONTINUED

Overseas Division of California-Texas Oil, and the offices are situated in Perth. There is quite a prospective oil boom in progress in Australia, and rather extensive exploration is being planned for the future.

"Perth, the capital of West Australia, is a beautiful city, laid out on the banks of the Swan River. This is the first river I've seen that doesn't look and act like a river, but instead is more like a series of curving bays and inlets. The local rose gardens rival those of Pasadena in beauty. The Australian people are kind and generous and very partial to Americans.

"The Australian bush, which begins immediately on the outskirts of the city, is wild and beautiful, and much of the flora and fauna are peculiar to this country. We have found out that there are really three kinds of kangaroos. The Big Boomer, the largest one, is red, and bounds about with great leaps in the uninhabited areas. The Big Grey is also a large one, and the Wallaby is a smaller version of the large grey kangaroo.

"We've seen emus (which can be described as a sort of ostrich) and their eggs, which the natives consider good eating, would make an omelet for 12 men. The koala bears are just like their pictures, with big kind eyes and patent-leather noses, and they are found in eucalyptus groves all over the country."

1941

James J. Vonk, MS, passed the California State Bar exam last fall, and was admitted to the practice of law in January 1955. Jim, who has been employed by the State Compensation Insurance Fund, in San Francisco, since his separation from the Navy in 1945, will soon be transferred to their legal department. He started originally in the engineering department.

1942

Robert F. Hall was recently appointed manager of manufacturing engineering for the Link Aviation Company in Binghamton, N.Y. Bob has been production manager of this division for the past four years.

1943

Walter F. Rhoades, MS, has been named vice-president and general manager of the DeSoto Paint & Varnish Company of Garland, Texas. He was previously clinical director of the Pacific Paint & Varnish Company of Berkeley.

1944

Clarence J. Woodard, formerly sales manager of the Rucker Company in Oakland, has now been appointed vice president in charge of sales and engineering.

1946

Carroll Webber sends in one brief sentence about his recent activities, as follows: "Carroll Webber is learning to weld."


RW
Communications

James A. Lewis has taken military leave from "Librascope" and is on active duty in the Navy. Jim holds the rank of lieutenant and is attached to the 4th Marines as Naval Liaison Gunnery Officer.

1947

Harold Comlossy, Jr. was recently appointed field representative for the Guardian Life Insurance Company, in Los Angeles. Harold was formerly employed by Baker Oil Tools, Inc.

Jeptha A. Wade, Jr. goes on record as saying that he thinks San Jose is big enough to support an alumni meeting once in awhile, and wonders if any other alumni in the area would be interested. He's living in San Jose with his family (two boys and a girl) and is manager of new business for the California Water Service Company.

1949

Byron C. Karzas, engineer with the North Shore Gas Company in Evanston, Illinois, has become a family man, with a daughter one year old.

Herman S. Dichter, MS, is now a member of the technical staff of the Guided Missile Division, Hughes Research and Development Laboratoes. Previously, he worked for the Bulova Research and Development Labs.

1950

Donald Barrie has been with Kaiser Engineers in Oakland, California, ever since graduation, and is now resident engineer in charge of construction on various projects.

Daniel Markoff and *Donald Royce* are batching together in San Francisco, where Dan is district engineer for the Electro Rust-Proofing Corporation, and Don is a production engineer for Varian Associates. Says Dan: "We occasionally see *Windsor Soule* who is attending grad school at Berkeley, and *Jim Blom* and his wife. Jim has his PhD in geology and may be referred to as Pvt. Dr. James Blom, because he is presently playing soldier at the Presidio in San Francisco."

C. James Blom elaborates a bit on the above report of his activities, writing the following: "The years of preparation are drawing to a close (I'll be sprung from the Army in June) and I'll actually be a productive member of society. That is, I hope to be; as yet the job isn't at all certain except that it will be geological. What *is* certain is the coming addition to the family in June. That will make Olly and me to three. I haven't been made president of anything . . . but the Army made me a corporal, if that's worth anything. It isn't."

Robert Duff Clark, MS, until recently employed as a development engineer in the Research Department of Union Oil Com-

EYE-EXAM for a BATTLESHIP

Western Electric field engineers supervise installation of complex electronic equipment made for Armed Forces

Marco Polo had nothing on Western Electric's field engineers. They travel the world to advise on use, installation and maintenance of the electronic equipment we produce for the Armed Forces . . . like radar bombing systems, anti-aircraft fire control systems, and the Nike guided missile control system.

Western Electric is called upon to make these things because of its vast experience with highly complex electronic equipment as the manufacturing unit of the Bell System. It's a job that presents an unending challenge to our engineering staff.

Western product and development engineers are responsible for turning out some 50,000 different items annually for the Bell System – everything from tiny transistors to giant bays of electronic switching equipment. Shown is one stage of transistor manufacture.

Western Electric

MANUFACTURING AND SUPPLY UNIT OF THE BELL SYSTEM

PERSONALS . . . CONTINUED

pany of California, has joined Page Oil Tools, Inc., as Chief Engineer. The company is located in Long Beach.

1952

Douglas C. Alverson enlisted in the Army last October, after more than two years with the U.S. Geological Survey. After his basic training he was re-assigned to the Army Language School at the Presidio of Monterey, California, and is now spending a year learning Russian.

David C. Hanna was mustered out of the Army (after service in Korea) in time to spend last Christmas at home in San Diego. In January Dave and his father flew to the British Isles, met Dave's sister who had been teaching in Europe, and the three took off to do a lot of sight-seeing in England, Scotland, and Ireland. Last we heard, Dave had bought himself a British car (a Rover) and was getting in some skiing in Austria before returning to his former job in New York with the Anaconda Wire & Cable Co.

Leon L. Vickman is in the Guided Missile Research and Development Division of Hughes Aircraft at Culver City, California. As staff assistant to the project services section head, Leon is directly responsible for the routine administration of the film, editorial, and script groups of the Guided Missile Division.

1954

Edward Gauss was married on April 2 to Virginia Robbins in Ambler, Pennsylvania. The wedding party included three other members of the class of '54, now attending Harvard's grad school: *Jerry Mitchell* was best man, and *Mark Cher* and *Will Richards* were ushers. Both Ed and his wife are in the grad school at the University of Colorado and had to cut the honeymoon short to return to preliminary exams. Ed writes that in April "*Popular Science* will carry my article on 'A Geiger Counter You Can Make' and *Radio and TV News* will run my article on a gadget for UHF."

Gregory A. Loew, MS, joined the electrical engineering department at Stanford University last September, and is presently working on a research project concerned with noise in microwave devices, while studying for his PhD.

Allan Conrad and Mardene Lubin of Pasadena were married in January.

1922—Roll-out of a Boeing-built fighter

1954—Roll-out of America's first jet transport, the Boeing 707

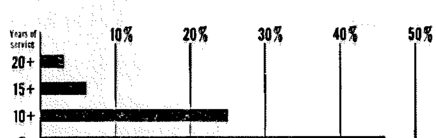
Progress is a Boeing-career hallmark

From the earliest days of aviation, Boeing engineers have produced an impressive number of trend-creating "firsts"—including the 707, America's first jet transport, shown above.

Boeing's 38-year history of Research, Design and Production progress has continuously opened up new career opportunities for engineers. Today Boeing employs more engineers than even at the peak of World War II.

At Boeing you'd work with engineers who developed: The world's first all-metal, 3-mile-a-minute commercial transport. The first pressurized airliner. The first effective four-engine bomber (the B-17). Today's fastest operational bomber (the six-jet B-47). The even more advanced B-52 eight-jet global bomber, and the 707, America's first jet transport. Boeing engineers continue to design "years ahead," doing research on nuclear-powered aircraft. They are also developing a new Air Force defense weapons system, based on the Boeing F-99 Bomarc pilotless interceptor. These long-range programs project Boeing progress far into the future.

One measure of the satisfaction of Boeing careers is given in the chart below. It shows that 46% of Boeing engineers have been with the company for five or more years; 25% for 10 or more years, and 6% for 15 or more years.



Here are other advantages: Boeing promotes from within and holds regular merit reviews to assure individual recognition. Engineers are encouraged to take graduate studies while working and are reimbursed for all tuition expense.

Of technical graduates at Boeing, 28% hold Mechanical Engineering degrees, 24% Electrical, 19% Aeronautical, and 9% Civil. The remainder is comprised of other engineering graduates, physicists and mathematicians.

For further Boeing career information consult your Placement Office, or write:

JOHN C. SANDERS, Staff Engineer — Personnel
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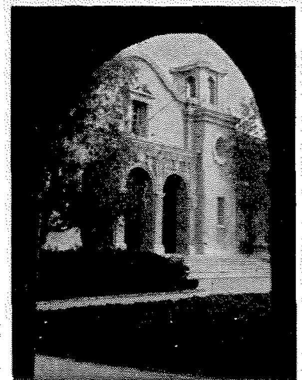

CALTECH CALENDAR

April, 1955

ALUMNI CALENDAR

April 16	Seminar Day
June 8	Annual Meeting
June 25	Annual Picnic

ATHLETIC SCHEDULE

VARSITY BASEBALL

April 16—
Caltech at Redlands

April 23—
Caltech at Pomona

April 30—
Occidental at Caltech

VARSITY TRACK

April 16—
Redlands at Caltech

April 23—
Pomona at Caltech

April 30—
Conference at Oxy

SWIMMING

April 15—
Caltech at Redlands

April 20—
Whititer at Caltech

April 29—
Occidenta lat Caltech

May 6—
Pomona at Caltech

May 14—
Conference at Caltech

VARSITY TENNIS

April 16—
Caltech at Redlands

April 23—
Pomona at Caltech

April 30—
Whittier at Caltech

May 7—
Occidental at Caltech

May 13, 14—
Conference at Pomona

FRIDAY EVENING DEMONSTRATION LECTURES

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

April 22—
The Production of Nuclear Power—
Dr. Milton Plesset

April 29—
Radio Astronomy—
Dr. Jesse Greenstein

May 6—
Dollars from Rocks in Southern California—
Dr Thane McCulloh

May 13—
The Nature of Sound—
Dr. Earnest C. Watson

Necklace of Linde Star Rubies and Diamonds worn at the Coronation of H. M. Queen Elizabeth II.

Man-made gems perfect as nature's finest—

created with the aid of photography's keen eye

Linde Air Products Company measures rare elements as close as 2 parts in a million with the spectrograph to produce star sapphires and star rubies more nearly perfect than natural gems.

Wartime instruments called for millions of synthetic jewel bearings. But supplies from Europe were shut off. So at Uncle Sam's request, Linde, a division of Union Carbide and Carbon Corporation, undertook to create sapphires and rubies—with photography filling a role in the intricate technology.

Postwar, Linde went even further. Using the spectrograph, a photographic instrument so sensitive it can measure the chemical content of celestial bodies, they found just the right trace of rare element to create a deep silky star within the stone and thus achieved the fabulous Linde "Stars"—man-made counterparts of one of nature's rarest gems.

This is the way photography is working in small companies and large, in laboratories, on production lines, in offices and drafting rooms. It is saving time, reducing error, cutting costs, improving production for all kinds of business and industry.

Graduates in the physical sciences and in engineering find photography an increasingly valuable tool in their new occupations. Its expanding use has created many challenging opportunities at Kodak, especially in the development of chemical processes and the design of precision mechanical-electronic equipment. If you are a recent graduate or a qualified returning serviceman, and are interested in these opportunities, write to Business & Technical Personnel Dept., Eastman Kodak Company, Rochester 4, N. Y.

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Engineering & Science
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How will you help to sharpen radar's "eyes"?

Exact range and accuracy of the radar antennas shown here are classified. But this can be told—the radio energy transmitted can light fluorescent lamps 100 feet away.

Progress in radar, as in the entire field of electronics, has been rapid. At General Electric much credit for these advances belongs to engineers who are recent college graduates. Take, for example, E. B. Carrillo, EE, Pratt Institute, '49, responsible for manufacture of servo- and time-sharing systems, and G. G. Wilson, EE, N. Y. U., '48, in charge of design and development of remote control equipment.

The work of these young men typifies GE's emphasis on young, creative engineers from such fields as electrical, mechanical, metallurgical and aeronautical engineering, and from the scientific fields of physics and chemistry. Like other graduates, Carrillo and Wilson were able to increase their engineering awareness in the after-graduation G-E program of technical assignments. In this program, the engineer selects the fields, the locations himself. And at G.E. you will be able to make real contributions early in your career in activities ranging from plastics to large electrical apparatus, electronics to jet propulsion, automation components to atomic power.

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