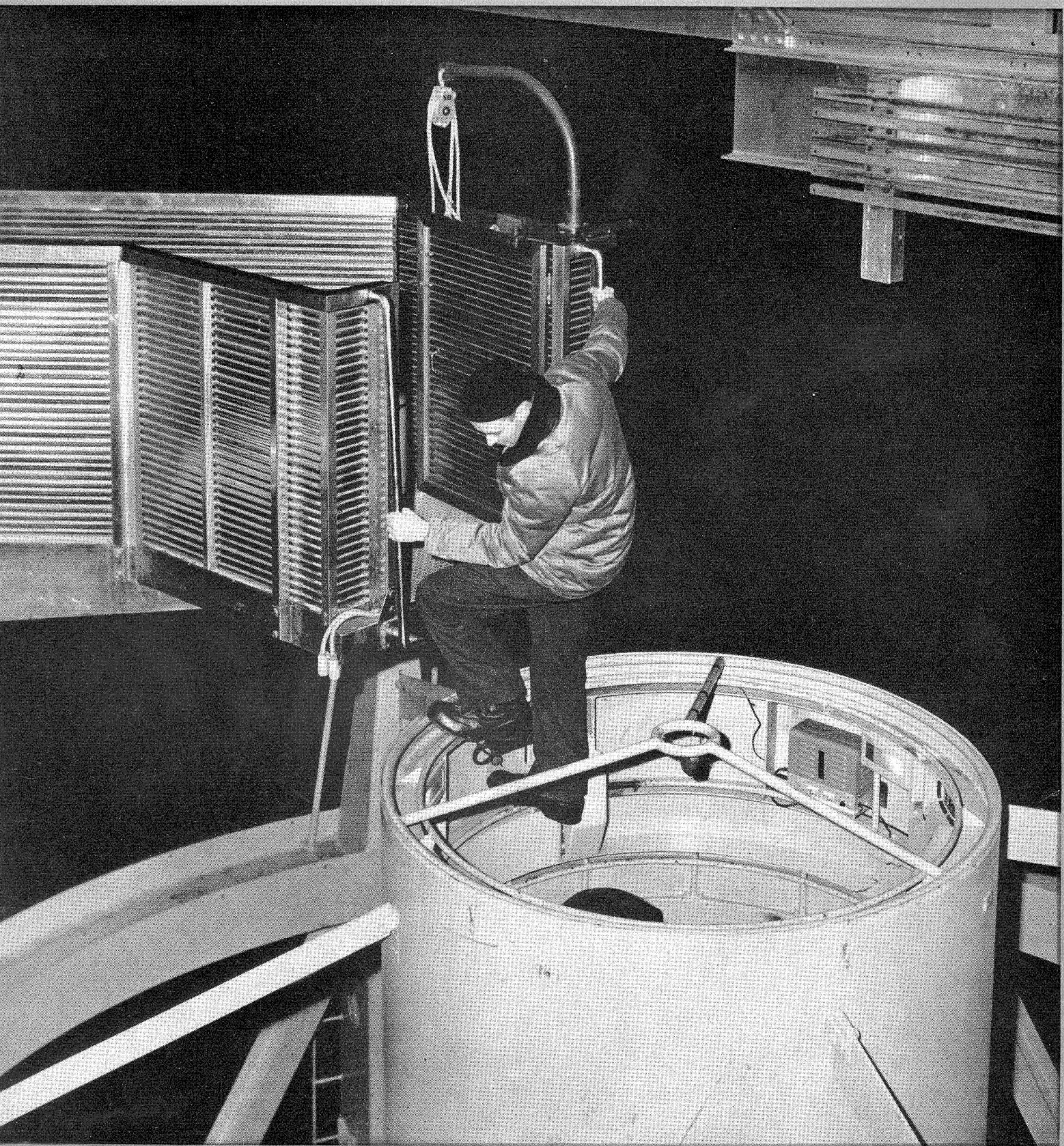
ENGINEERING | AND | SCIENCE

APRIL/1956



Astronomers at work . . . page 13

PUBLISHED AT THE CALIFORNIA INSTITUTE OF TECHNOLOGY

Robert T. Blake, Class of '49

speaks from experience when he says,

"At U.S. Steel, the opportunities are unlimited."

Bob Blake had his first experience in steel mills working there during summer vacations from college. After receiving his B.S. degree in Electrical Engineering, he became an operating trainee in U.S. Steel's Irvin Works. During his training program, his background and versatility were used by the Training Division to develop a training program for Electrical Maintenance employees. By the end of 1951, Mr. Blake had become a Foreman with experience in both Cold Reduction Maintenance and the Galvanizing Department.

Effort is made to have young engineers obtain varied experience before devoting themselves to one field. Mr. Blake feels that, "An engineering graduate has practically no ceiling provided he has the right attitude and is willing."

Promoted again in 1954, Mr. Blake is now Foreman—Electric Shop in Central Maintenance. Supervising a crew of 40 men, he is responsible for electrical construction work, maintenance and crane wiring. Mr. Blake feels he is in "an interesting and challenging field of work." He has found that "U.S. Steel is a highly desirable employer in this most basic of all industries."

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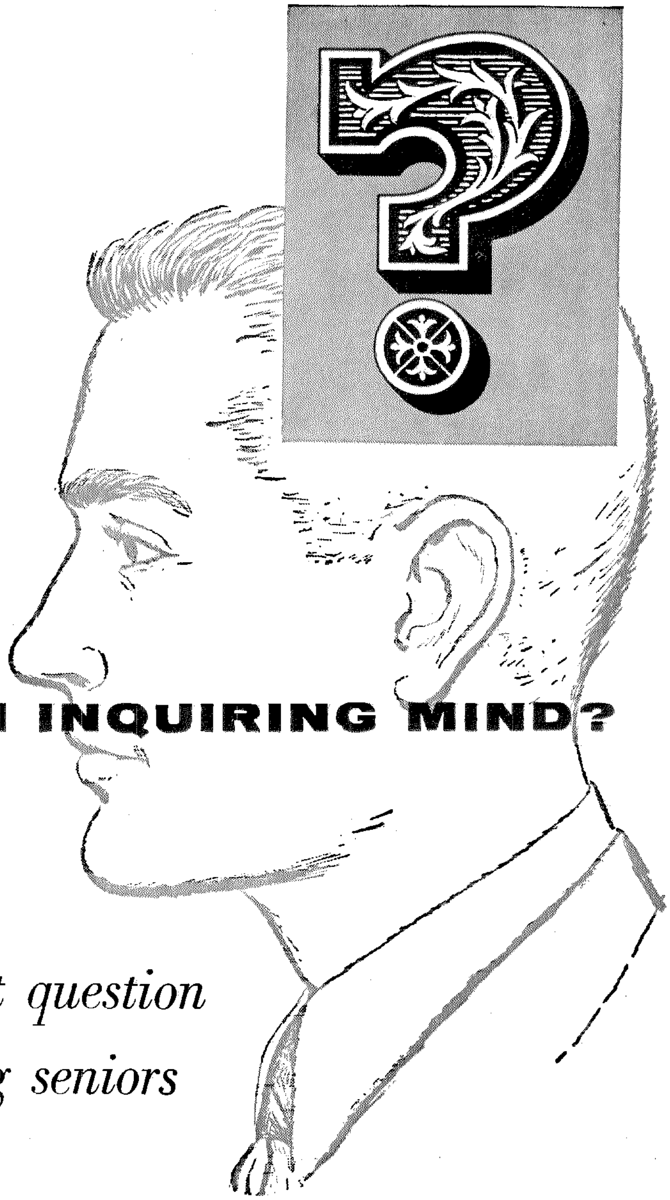
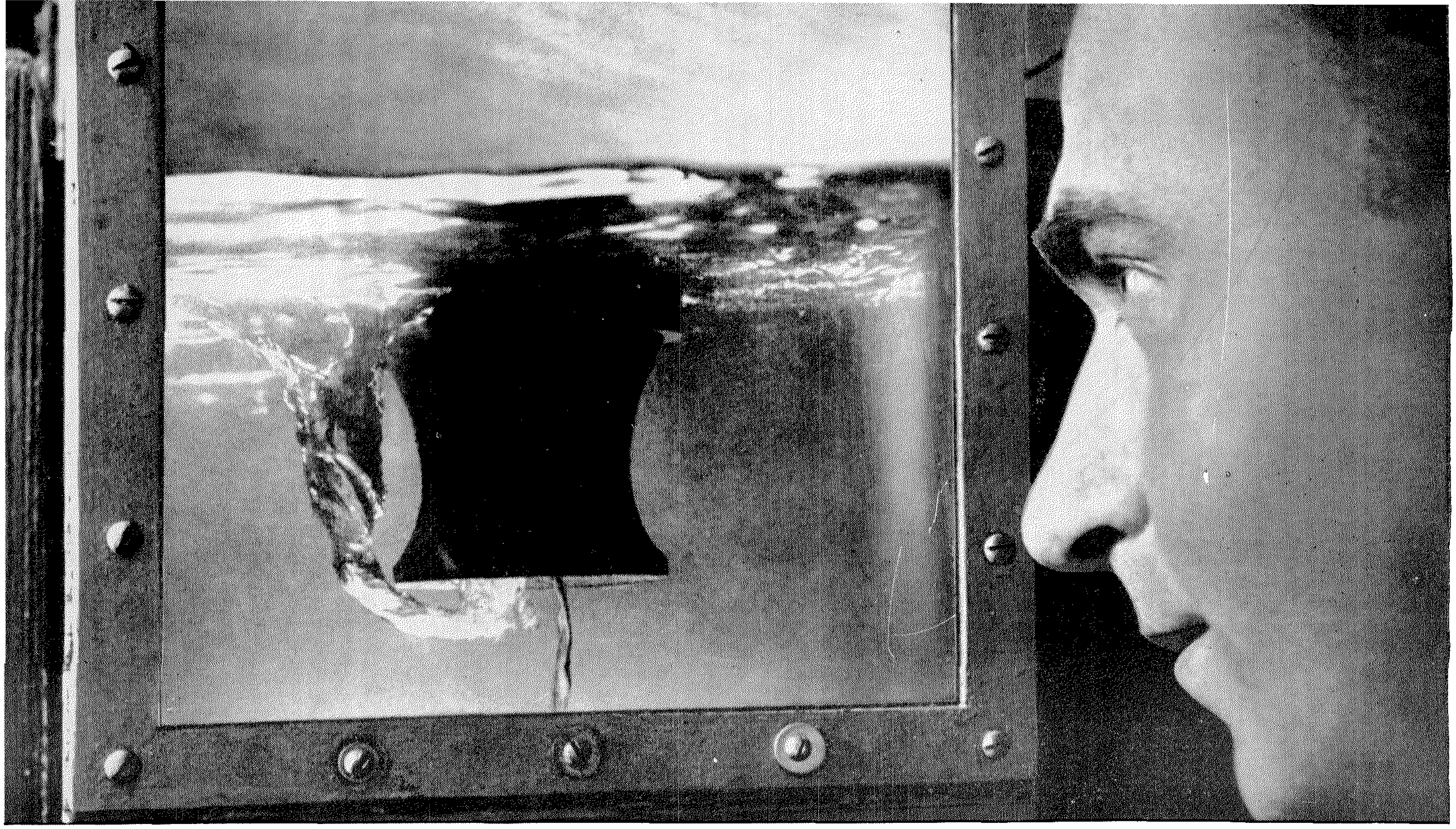
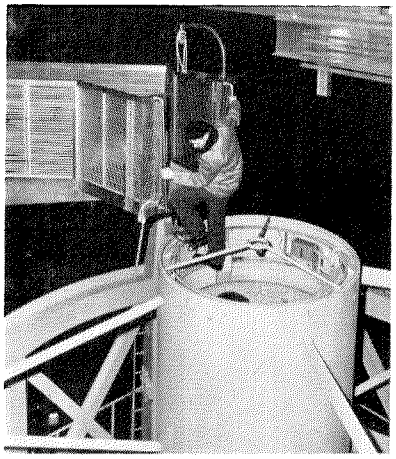




ENGINEERING AND SCIENCE

IN THIS ISSUE



On our cover this month, Dr. William Baum, a member of the Mount Wilson and Palomar Observatories staff, is shown climbing down from the prime-focus elevator at the Palomar Observatory into the observing cage of the 200-inch telescope, where he will put in a night's work.

On pages 13-19 of this issne are some other pictures of astronomers at work at the Palomar Observatory. These are just about the first pictures of this kind that have been taken since the observatory was opened in 1948—and, to all but staff astronomers, they furnish fresh evidence that Palomar is a spectacularly photogenic place.

"Educating Scientists and Engineers" was originally given as a talk by President DuBridge to the Los Angeles Kiwanis Club on March 14. On page 20 is an excerpt from the talk, which provides a sharp evaluation of science and engineering education today.

Sir Charles Galton Darwin, on a visit to Caltech last month, presented "Forecasting the Future" at a physics seminar. His sober, and scarifying, predictions will be found on page 22 of this issue.

Sir Charles, a pioneer in nuclear studies, was director of the National Physics Laboratory in England from 1938 to 1949. He is the grandson of the Darwin who wrote "On the Origin of Species." Now on a lecture tour of New Zealand and Australia under the auspices of London's Royal Society, he was no stranger to Caltech when he visited here last month; he served as a visiting professor at the Institute in 1922.

APRIL, 1956 VOLUME XIX NUMBER 7

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CONTENTS

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Printed in Pasadena PP 6

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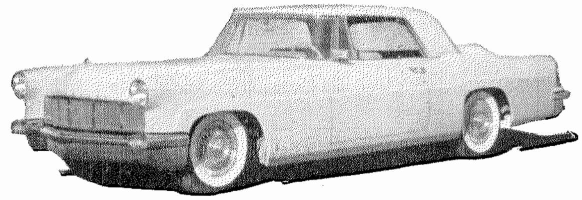

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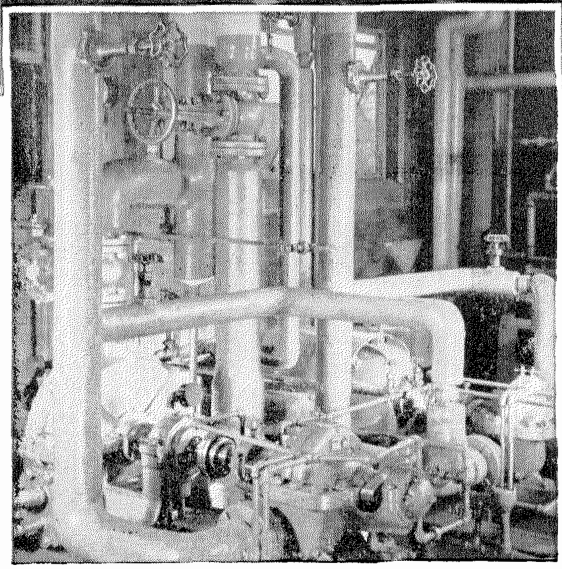

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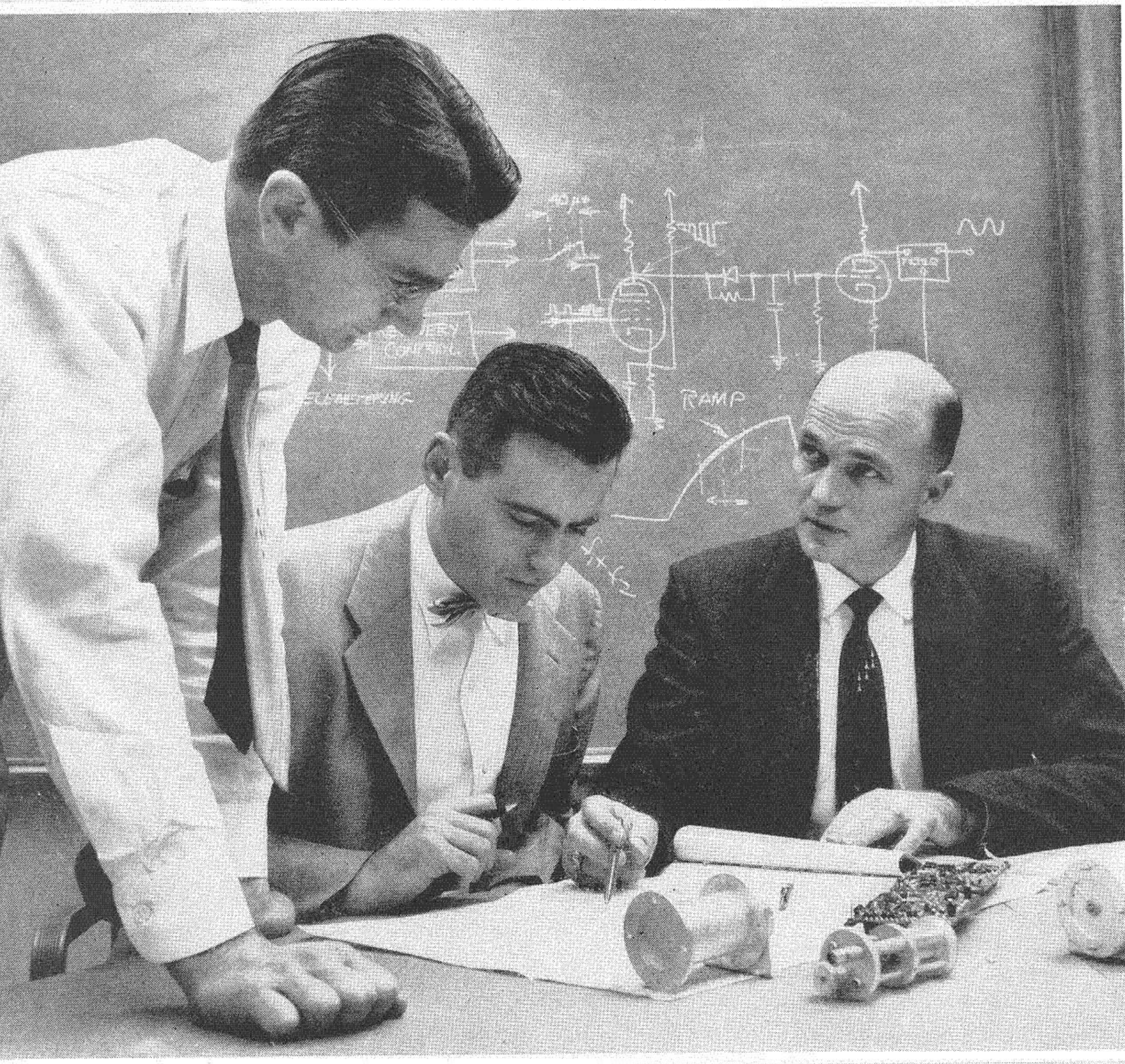
SCIENCE AND ENGINEERING

AT LOCKHEED MISSILE SYSTEMS DIVISION



Charles W. Goedecke, Electronic Design Group Engineer, Emerson M. Hoyt, Electronic Research Specialist, and George L. Larse, head of Electronic Systems Development in the Flight Test Electronics Department, discuss important aspects of new electronic command decoding devices for missile guidance systems.

MISSILE ELECTRONICS

DATA TRANSMISSION LINKS SYSTEMS AND COMPONENTS

The advancement of missile systems technology can be measured to a great extent by increasing demands imposed on the ability of electronic systems and components engineers.

Electronic problems encountered in hypersonic flight, particularly at high ambient temperatures, require creative efforts and coordination of a high order from engineers in fields of radar, guidance, telemetry and instrumentation.

New developments at Lockheed Missile Systems Division offer a wide variety of assignments in the following fields:

Command guidance involving the development and application of radio frequency components, video amplifiers, pulse circuitry, decoding and control devices.

Automatic data processing equipment involving analog-to-digital conversion circuitry; electronic and magnetic storage components; pulse and timing circuitry of all types.

Data transmission and telemetry involving development and application of antennas, transducers, FM oscillators, VHF transmitters and receivers.

Those possessing keen interest in both systems and component development are invited to write.

Lockheed MISSILE SYSTEMS DIVISION *research and engineering staff*

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BOOKS

SPIDER, EGG AND MICROCOSM
by Eugene Kinkead
Alfred A. Knopf, N.Y. $4

SUBTITLED "Three Men and Three Worlds of Science," this book brings together three Profiles originally published in *The New Yorker*. The three men are Dr. Alexander Petrunkevitch, Dr. Alexis Romanoff and Dr. Roman Vishniac; their fields of science, respectively, are arachnology, embryology and microbiology.

Dr. Petrunkevitch, a retired Yale professor of zoology, has spent most of his life collecting and studying spiders; Dr. Romanoff, professor of chemical embryology at Cornell, has put in more than a quarter of a century of constant study of birds' eggs; Dr. Vishniac's consuming interest is in studying and photographing microscopic life.

These are more than colorful portraits of three dedicated men; they are introductions to three generally unfamiliar fields of science — and they are absorbing reading.

FRONTIERS OF ASTRONOMY
by Fred Hoyle
Harper & Brothers, N.Y. $5

FRED HOYLE, one of Britain's most famous young astronomers, is known both for his bold research theories, and for his popular writings on astronomy and physics. A fellow of St. John's College, Cambridge, and professor of mathematics at Cambridge University in England, he has just arrived at Caltech as a lecturer in theoretical cosmology for the next four months.

Applying a combination of modern mathematics and physics to astronomical theories, Hoyle comes up with a shower of ideas. His theme in this book, however, is clearly stated: "the great stage where the Universe acts out its play is one on which the twin roles of coincidence and chance have scarcely any entry. From the vast expanding system of galaxies down to the humblest planet, and to the creatures who live on it, there seems to be a strongly forged chain of cause and effect."

Astronomers are, as a rule, a conservative lot, and many of them don't agree with Hoyle's theories, but he believes obviously that a bold approach to the mysteries of the Universe is far better than a cautious one.

Although most of the book can be enjoyed by the layman, knowledge of nuclear physics and mathematics will prove helpful in understanding some of the more technical chapters. Certainly, *Frontiers of Astronomy* is a creditable successor to Hoyle's first book, *The Nature of the Universe* (*E & S—June, 1951.*)

GUIDED TOUR OF CAMPUS HUMOR
by Max Shulman
Hanover House, Garden City, N.Y. $2.95

Reviewed by Russ Hunter
*Co-editor of Farrago**

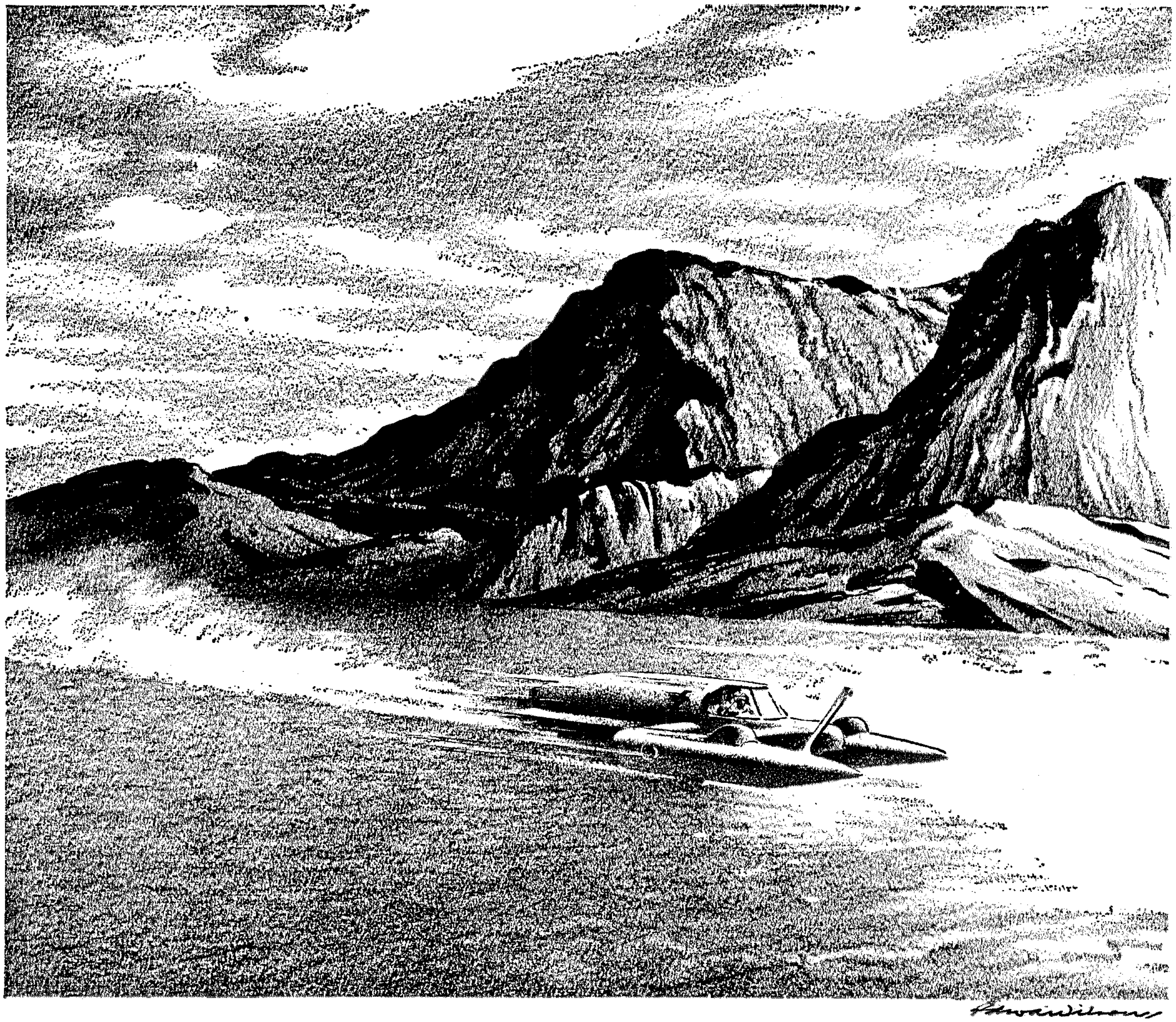
SOME THINGS strike you as uproarious when you read them. In my life I've stumbled on just a few pieces intended to be funny that left me terribly tickled. I can recall a comic book, when very young; *The Man Who Came to Dinner*, the first time I saw it; and now, parts of Shulman's *Guided Tour*.

Max Shulman, author of some very funny books of his own (*Sleep Till Noon, The Feather Merchants*, etc.) has turned editor to cull the best from 65 college humor magazines printed over the last 50 years. The prime reason for laying out your $2.95 for this 50-year slumgullion is to get the short, unclassifiable humorous essays and narratives that are the highest end and the main justification of a campus rag. These little scraps won't ever see the light of day anywhere else. They are on touchy subjects, or they are too topical or too closely connected to the life they are concerned with.

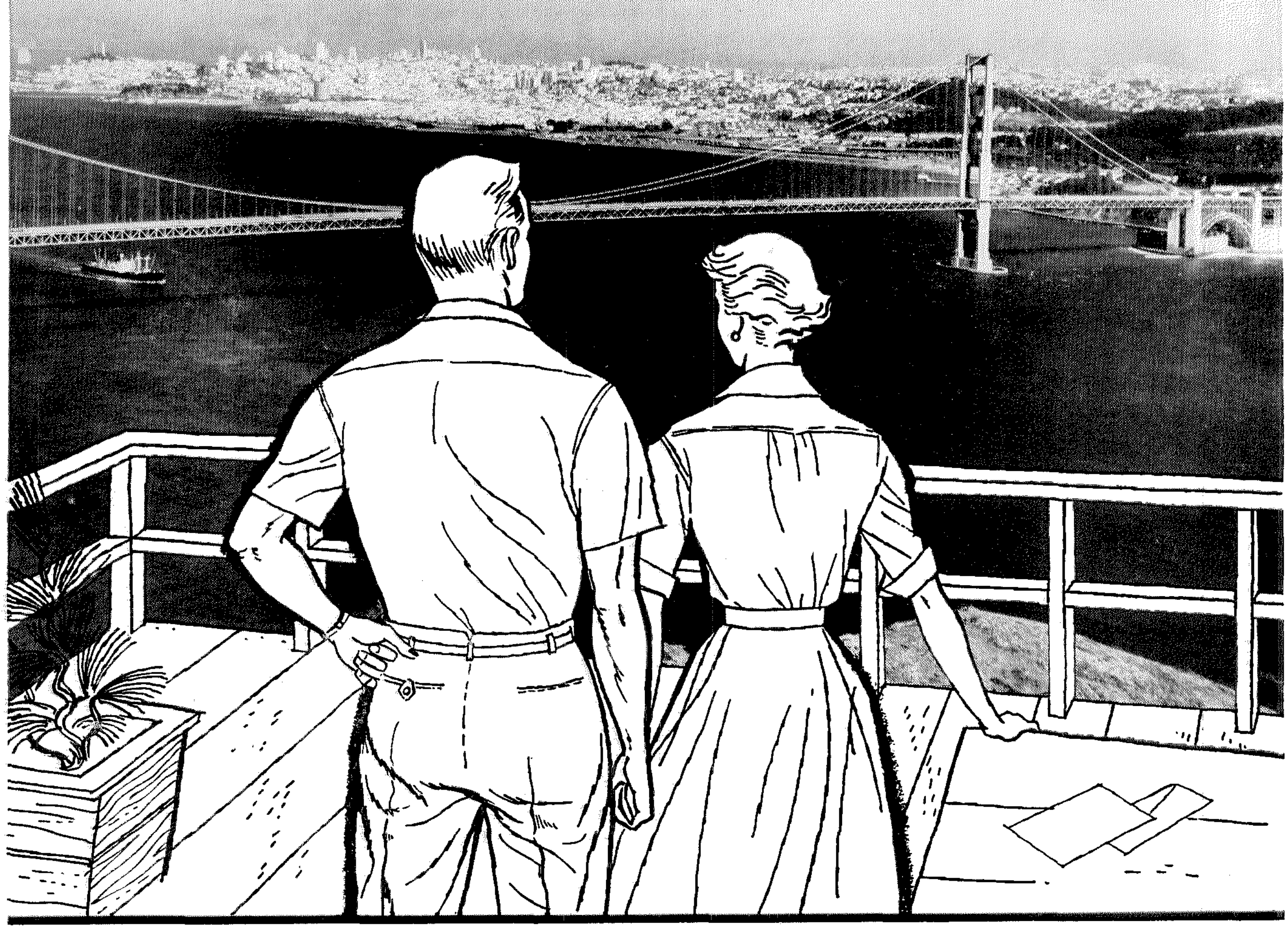
The rest of the book—the jokes, the sly verse, all the miscellaneous fodder of the standard campus humor magazine—is all right for the kiddies who are going through it for the first time. But the over-15 set will not only have "heard this one before"—they will have just read it again in last month's *Reader's Digest.*

The *Guided Tour* is not built for a long session of churning through page after page. Rather, it should be dabbled in so as not to fatigue the funny bone. It's a choice item for plugging up short squiggles of time like those spent in waiting for your wench to put that last touch on her face.

* Caltech's undergraduate literary and humor magazine.



A Career in the Sun



An important advantage of being a Bechtel engineer is that you will live and work in one of the world's most interesting places — San Francisco. There's an excellent choice of diversified homes in the area with outdoor living practical through most of the year, great universities where post-graduate studies can be pursued and an abundance of famous leisure-hour attractions.

Even so, the "where" of a job is never as important as the "what". What kind of work do Bechtel engineers do? They design and build oil refineries and chemical plants, pipe lines, power stations and other large installations for American and foreign industry. In the course of their work they rub shoulders with many of the nation's top engineers and industrial leaders.

Most important, Bechtel provides challenging assignments that put you in close contact with all the latest developments in your own special engineering field. This is the kind of stimulating, thought-provoking work that fills a man with the feeling of accomplishment.

Why not talk with your University's Placement Officer about Bechtel today? For further information write to D. W. Townsend, Bechtel Corporation, 220 Bush Street, San Francisco 4, California.

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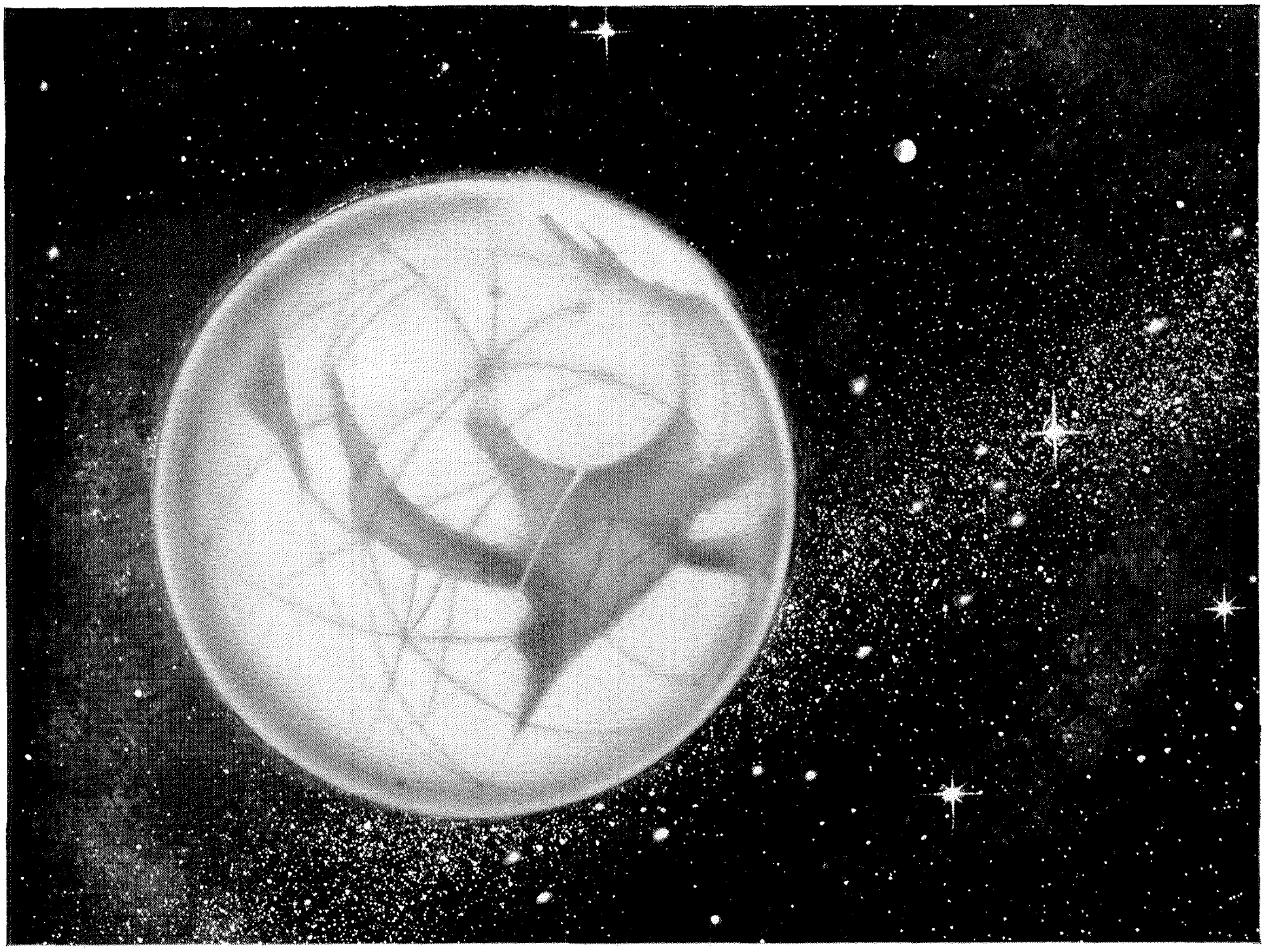
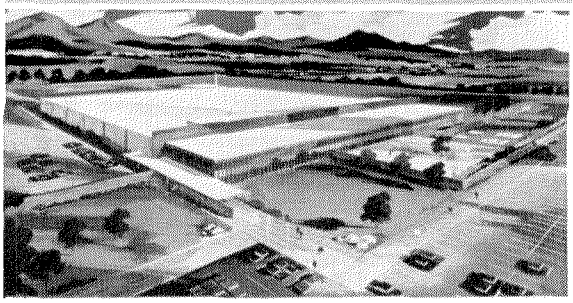
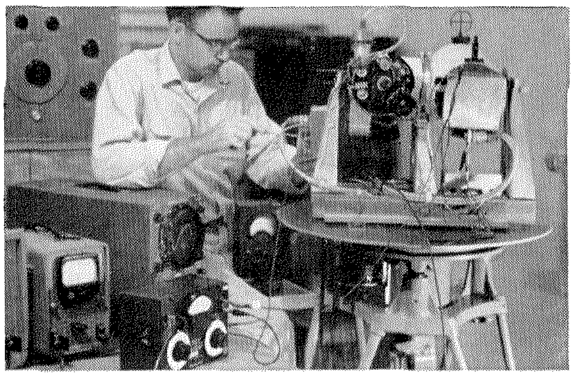


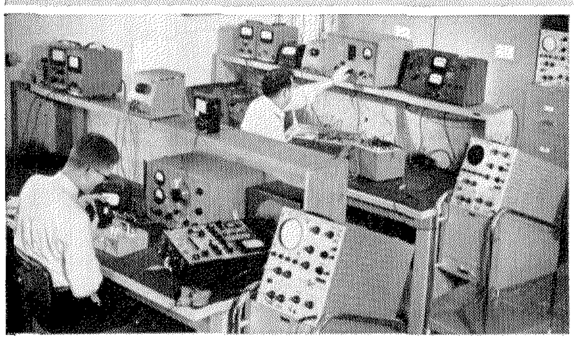
AIRBORNE ELECTRONICS AND WEAPON CONTROL SYSTEMS



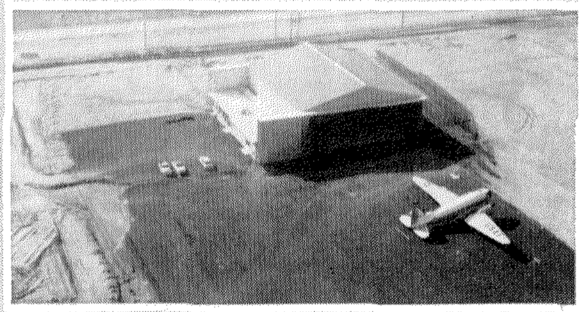
Denver manufacturing plant now under design



Infrared laboratory

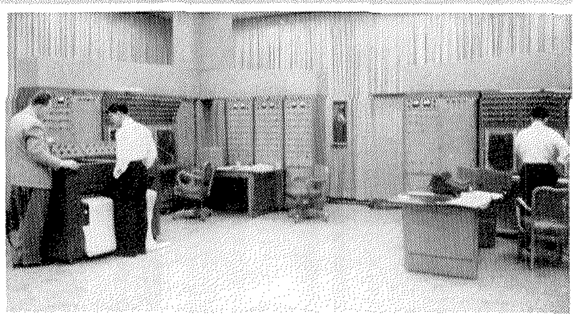


Instrumentation laboratory



Initial unit of flight test facility

Communications pilot line production



Simulators in computing center

At Ramo-Wooldridge today there exists a wide range of projects intended to aid aircraft in navigating to the vicinity of targets, finding the targets, destroying them, and returning safely to base. Work is under way in such fields as infrared and microwave detection, information display, communication and navigation, and analog and digital computing. Some projects are in the laboratory development stage, some in the flight test stage, some in pilot production.

Good progress is being made in the establishment of facilities and operational patterns that are well tailored to the unique requirements of advanced electronic systems work.

Positions are available for scientists and engineers in these fields of current activity:

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Airborne Electronic and Control Systems
Electronic Instrumentation and Test Equipment
Guided Missile Research and Development
Automation and Data Processing
Basic Electronic and Aeronautical Research

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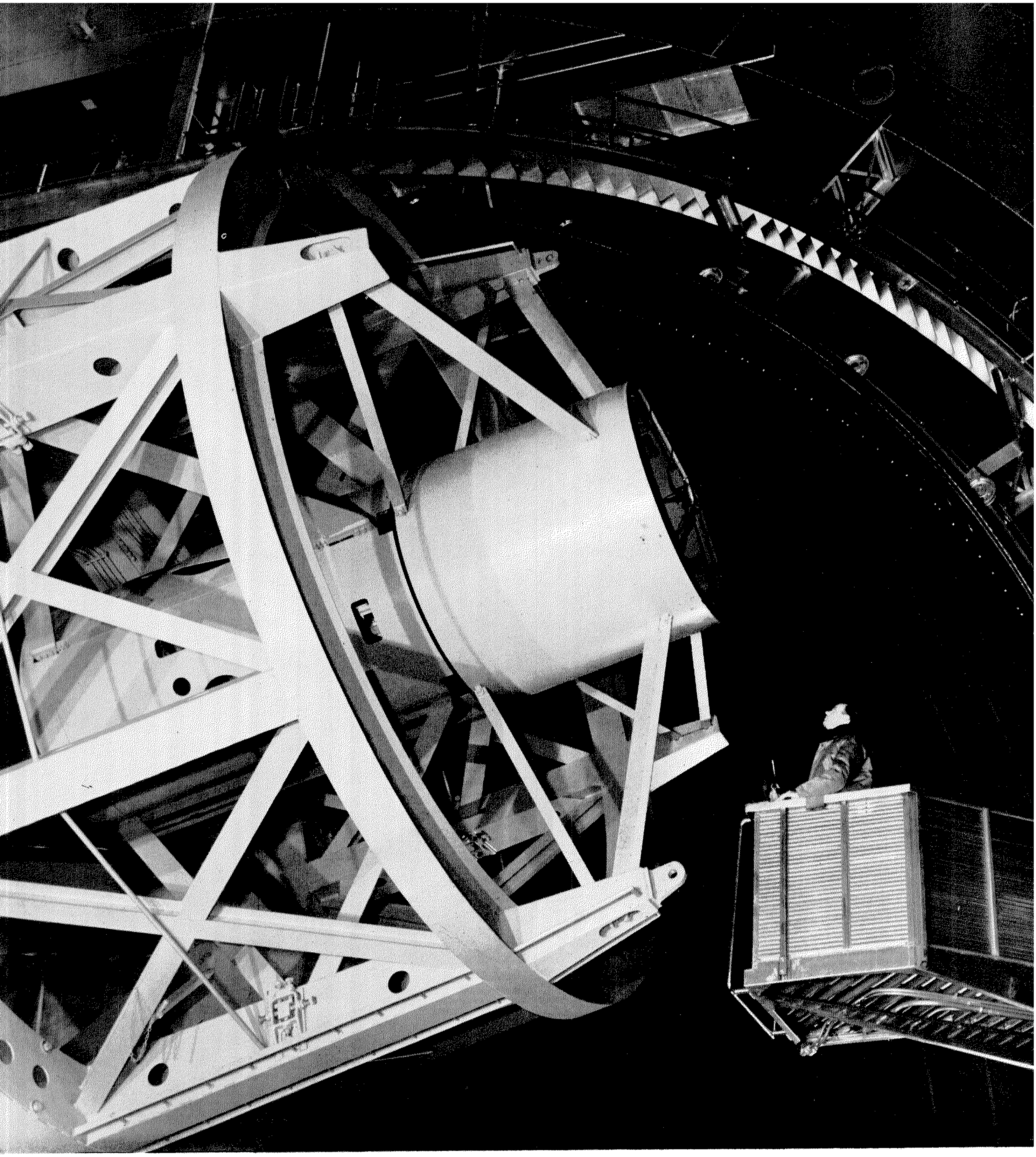
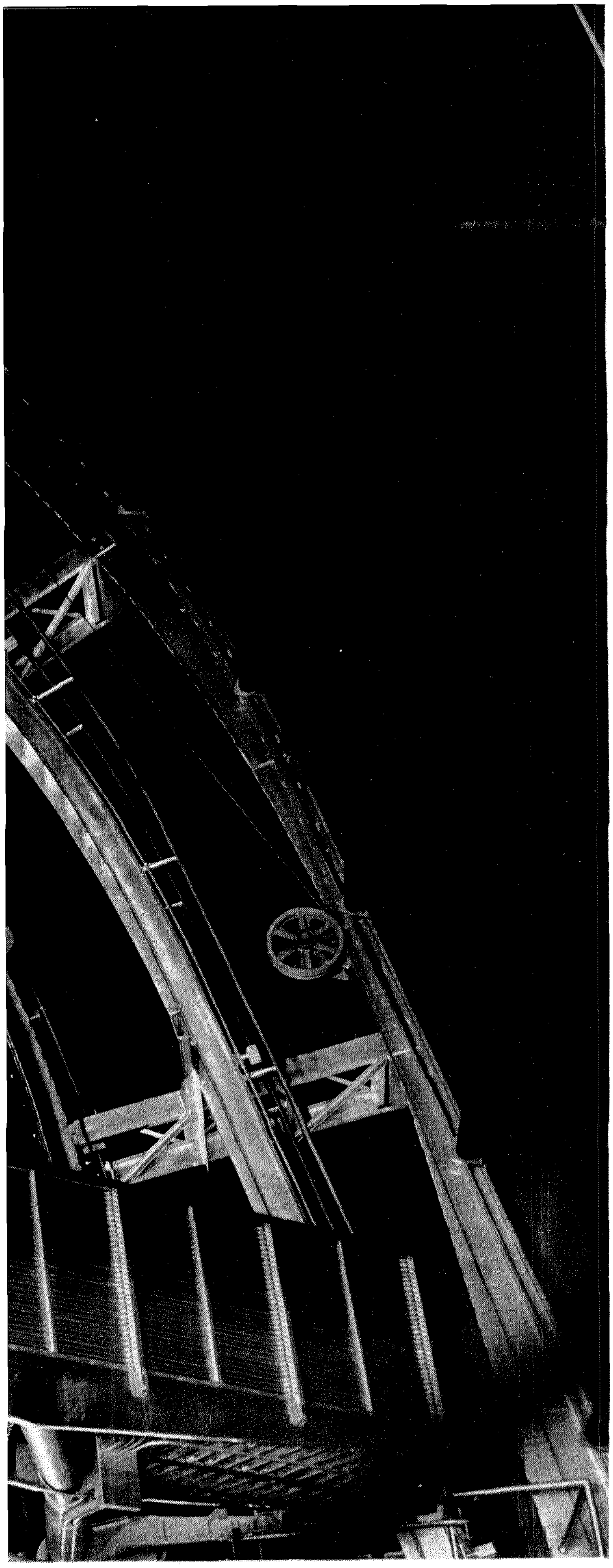
THE PALOMAR OBSERVATORY

A new portfolio of photographs of astronomers at work with the 200-inch telescope

SINCE 1948, when the 200-inch Hale telescope was first put into active operation, only astronomers and observatory workers have been allowed into the observing area at Palomar. Last month, however, staff photographers were permitted to move in, for the first time, to take pictures of some of the activity and equipment inside the huge dome.

The Palomar Observatory is operated jointly by the Carnegie Institution of Washington and the California Institute of Technology. In the eight years that they have been using the 200-inch Palomar telescope, astronomers have learned a good many new things about the vast universe beyond our solar system. The pictures on the following pages give some indication of how these men conduct this absorbing research.

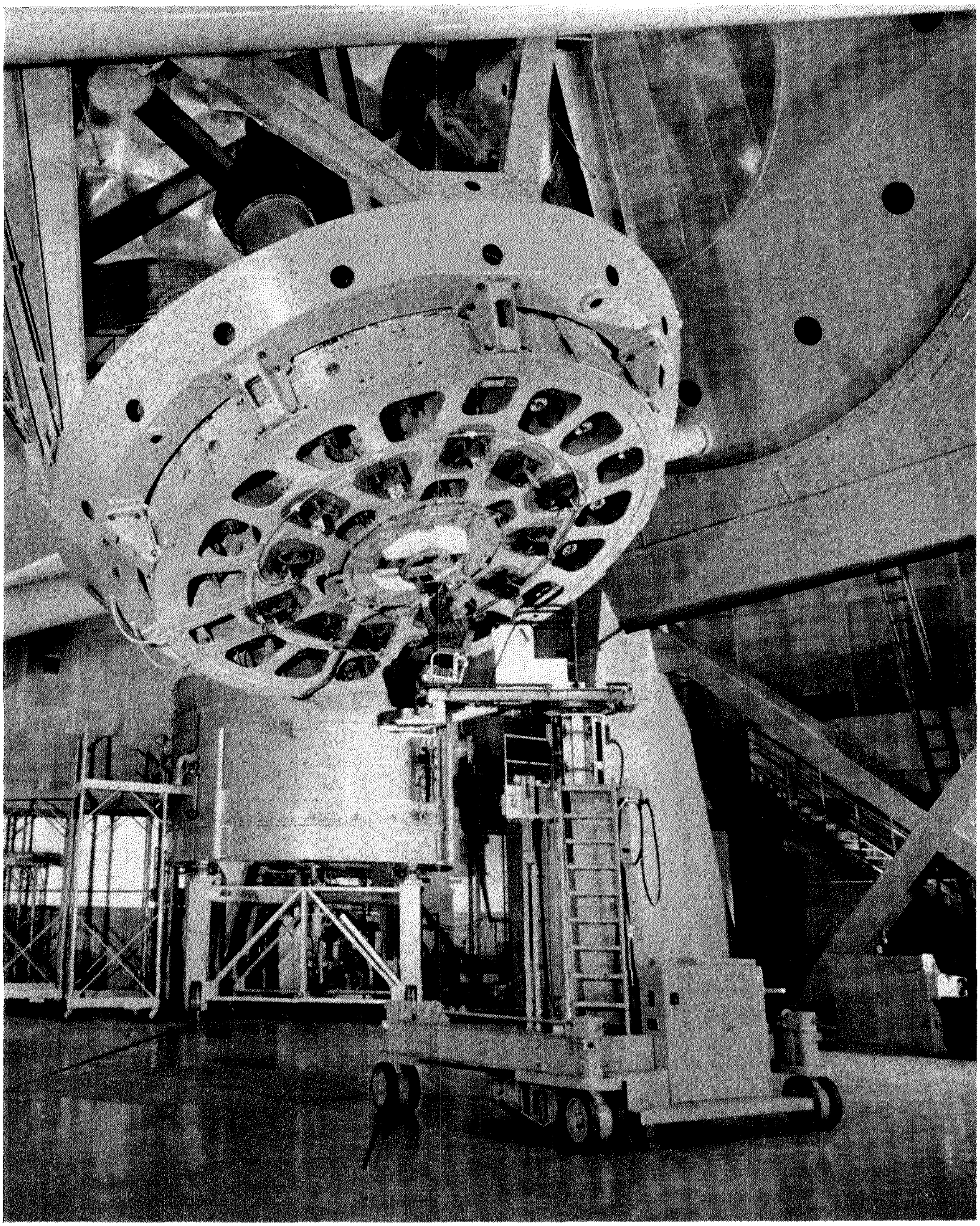




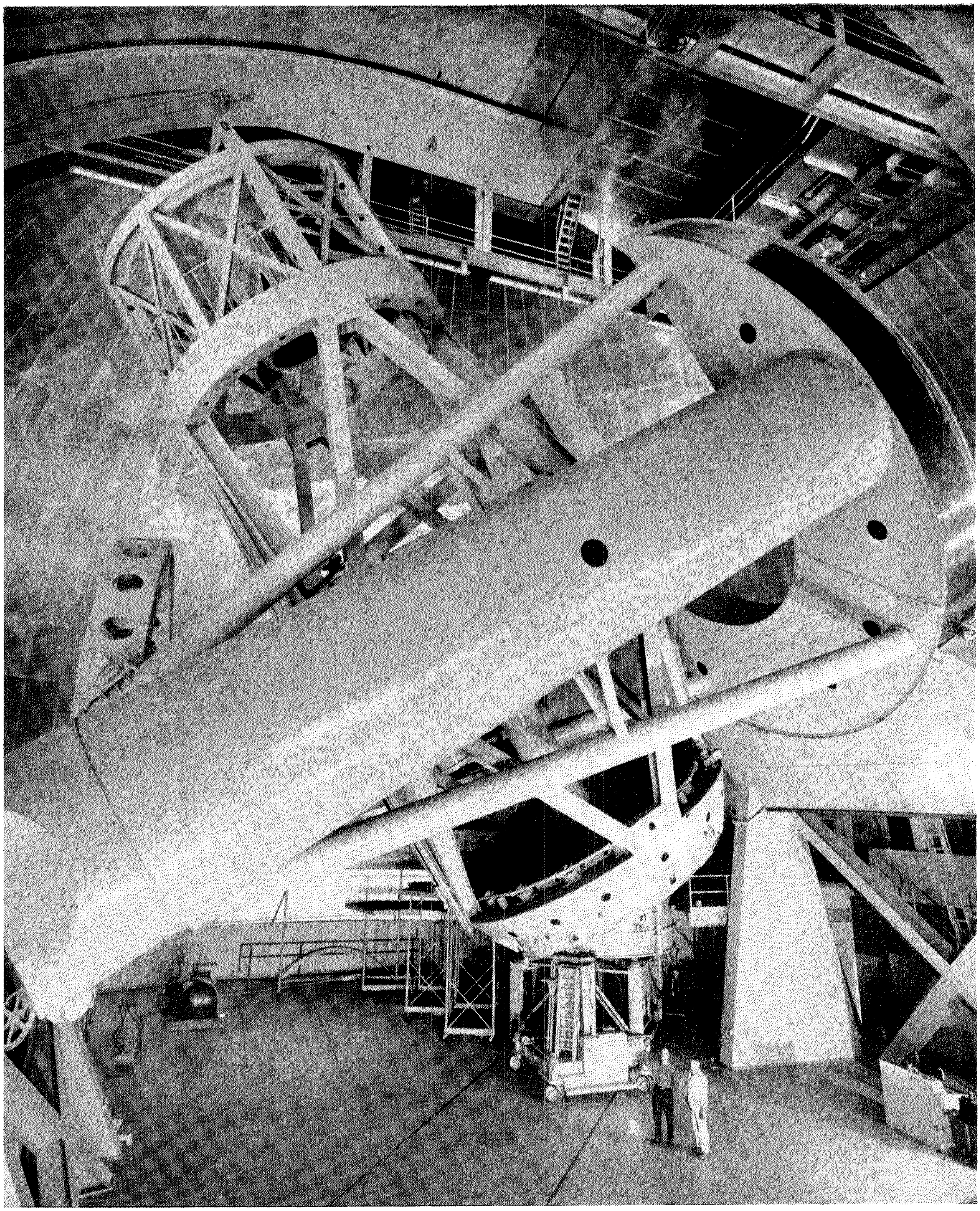
Going Up

The prime focus elevator rides the astronomer to the point where he can step across a 10-inch gap into the observer's cage. Here, at the top of the tube—75 feet above the observatory floor—the astronomer spends the night photographing his particular field of study, armed with enough photographic plates to last the night and plenty of warm clothes to keep out the cold.

At the main control board, the night assistant sets the dials and, with a push of a button, the huge telescope moves into position. Automatically the dome turns to keep its slot in front of the telescope, open to the observer's field of study. Although the Hale weighs 530 tons, a tiny one-twelfth-horsepower motor makes it follow a star.



Besides the prime focus, there are several other types of observation stations. Here the astronomer is at the Cassegrain focus on the underside of the 200-inch mirror. In the chair designed especially for this station, the astronomer is preparing to take photographs.



The 200-inch telescope sits for its latest portrait. At the top of the tube, above, is the prime focus cage, where the astronomer works. On the opposite page is the cage itself, where the astronomer is preparing to take a series of direct photographs. The 200-inch is the only telescope in the world in which an observer actually rides while working.

EDUCATING SCIENTISTS AND ENGINEERS

by L. A. DuBRIDGE

EDUCATION, of course, begins at birth. By the time a youngster starts his schooling, he has learned far more than he will ever learn again in an equal time. He will have learned to speak, to understand, to listen, to remember, to form habits, to have a moderate awareness of what is taking place in the little world that surrounds him.

He has probably even learned to add 2+2. Unfortunately, that is about as much mathematics as he is likely to learn for several years. Because as soon as he learns simple addition, subtraction and the multiplication of small numbers, he begins to hear on all sides about how *hard* mathematics is. Learning the multiplication table does take time, and he soon gets the idea that doing higher mathmatics means just adding and multiplying bigger and bigger numbers. So pretty soon he agrees that math is a tough and boring subject.

What a shame! For higher math has nothing to do with big numbers. Albert Einstein probably had more trouble balancing his check book than most of the rest of us. Algebra, geometry and calculus are exciting adventures into methods of human thought. And the elements of these subjects are not hard. The speedometer on your car is continuously performing a simple operation of differential calculus—measuring the rate at which you are traveling. And the odometer or mileage indicator is doing integral calculus—adding up the distance you have travelled. That's all there is to it! And young people ought to be learning these things at the age of 12 or 14—not waiting until they are sophomores in college.

One of America's most costly illusions is that mathematics is tough and only a few people can do it—and that only a few people *need* to know it. Only a few people *do* need to know Fermat's last theorem. But everyone should know that the energy of an automobile going 60 miles an hour is four times as great as that of one going 30—not just twice as great.

In any case, the first great barrier to producing more and better scientists and engineers is the feeling widely shared by parents, students and many teachers that mathematics—that is, simple quantitative reasoning—is a tough, technical, narrow, specialized subject that should be avoided at all costs.

Over in Soviet Russia every high school *graduate has* had 10 years of math (including calculus) plus 5 years of physics, 5 of biology, 4 of chemistry and a year of astronomy! Now I am not an advocate of doing something just because the Russians do it. But when we note that only 10 percent of all high school graduates in the United States have had any physics and chemistry—and that only 3 percent have gone beyond plane geometry—it is not hard to understand why the Russians produce twice as many engineers as we do—and also why we are not likely to catch up to them very fast. Incidentally, the Russians also awarded 8100 PhD degrees in science in 1954, compared to something like 5000 in the United States—and their PhD degrees are every bit as good as ours, too!

Once an American boy has overcome the barriers to learning a little physics and math in high school he can—if anyone has thought to mention the possibility to him—undertake a college course in science. There are many good engineering and science schools in the country—and they are spending a good deal of time and money trying to tell high school students that they don't have to be long-haired freaks in order to be scientists; that science is fun; and that there are plenty

Some cogent comments on some favorite American illusions —and an indication of how costly these illusions are. An excerpt from a recent speech.

of good jobs open in industry, in government and in education.

This campaign, with the help of the ever higher salaries being offered, is beginning to pay off, and the number of young men of talent who are entering courses in science and engineering is gradually increasing. At Caltech we have 1400 applications for admission next year, and we can accommodate only 180 in the freshman class. Naturally, we will try to pick the very best of the applicants, but all the rest will be admitted at some other school. We do not yet have a shortage of facilities as is the case in medical education.

Now what kind of an education should our budding young engineer seek? There are many possibilities available. First, of course, he will have to find a college which will admit him—that is, whose standards match his talents. There is no use blinking the fact that not all colleges maintain the same standards. They shouldn't—for we need trained talent at all levels. Just because a man doesn't make an All-American football team is no sign he will die of T.B. Everyone fits his physical activities to his strength and ability. It is a good idea to do the same thing in the intellectual field—neither trying to stretch beyond one's reach nor being willing to coast without maximum effort.

That is another great American illusion—that it is all right to talk quite frankly about a boy's physical prowess, or lack of it, but never to admit there are also different degrees of mental skills.

But aside from differing academic levels, there are many choices as to the kind of engineering education that is desired.

Caltech introduced two reforms back in 1921. One was to bring research and teaching together in an attempt to stimulate the development of creative talents. The other was to recognize that engineers needed to be aware of some things outside their special field of study and should give at least a quarter of their time to non-scientific studies—literature, history, economics, philosophy and other humanities and social sciences. This was a great new departure in 1921; it is common practice in most engineering colleges today. The idea that an engineer is necessarily a narrow-minded technician is as dead as the dodo. The modern engineer has had an introduction to the world of art, letters and human beings.

This has led to a curious overswinging of the pendulum of education. After it was admitted that engineers should have some humanities, some began to say that it is better for a boy to take *all* humanities, A number of people are going around the country saying we should go "back to liberal arts"—by which they mean to abandon the study of science.

I was brought up to believe that science was one of the liberal arts and that no one was fully educated unless he knew *something* about the physical world in which he lived.

In any case, the present-day need is for well educated scientists and engineers—men who have mastered their subjects, but who have had an introduction to and acquired an interest in other intellectual pursuits. The dangerous illiterates of modern America are not the narrowly educated scientist, but the hosts of supposedly well educated businessmen, lawyers, politicians and executives who are guiding the devolpment of a modern social, political and economic system without any knowledge of the scientific principles on which the whole of modern industry and technology is based.

FORECASTING THE FUTURE

Every day there are 80,000 more people on the earth. In another 50 years the world population will be four billion —a hungry four billion. And in 100 years?

WE NONE OF US CAN HELP hoping that when anyone undertakes to prophesy the future, the facts will prove him wrong. I share this taste myself, and yet it may appear that I too am starting to prophesy. In fact I am going to try and do something much more modest. Forecasting is the word used for the predictions that the meteorologists make about the probable future weather, and this is the analogy I am going to follow. Through the reports he receives the meteorologist knows better than the rest of us what is happening in other parts of the world, and though he is very conscious that there are a great many things he does not know, with the information and experience that he has, he is in a good position to forecast the *probabilities* of future weather.

The present director of the British Meteorological Office, Sir Graham Sutton, recently wrote an article which describes the situation admirably. In making his forecast the meteorologist is doing the same sort of thing that a player does when he bids his hand at the game of bridge. If he were required to predict what tricks he would take with absolute certainty, he would not get very far; for example, if he had the ace and king of a suit he would only be *absolutely* certain of two tricks if that suit were trumps.

In fact, he does not declare that he will get two tricks, but he makes the estimate that he will probably get say eight or nine tricks. He reckons that this is the probability; he knows that one or two of his strongest cards may possibly fail to win the tricks he expects, but then he knows that this will most likely be compensated by tricks from some of his other cards he was not so confidently counting on. He estimates probabilities, and if he is an experienced player he is usually not far from right in a general way, even though some of his details may be wrong.

That is the sort of prediction that the meteorologist makes about the weather, and it is the sort of prediction that I am going to try and make about the future prospects of the world.

I want to work out this analogy with meteorology rather further. There are two separate branches of that subject, called respectively weather-forecasting and climatology. In forecasting, the meteorologist uses all the detailed knowledge of conditions in the world at the present moment and applies to them the laws of mechanics and also a good deal of personal experience and personal judgment, and from all this he says what things will be like twenty-four hours hence, and he usually gets it fairly right. He also tries to do forty-eight hours, but has a good deal less confidence about that, because as time goes on the things he does not know get proportionately more and more important.

The subject of climatology is quite different. In this there is no forecasting of what things will be like tomorrow, but instead there are general statements such as that this place will be a desert, that place a tropical jungle, while yet another one has a climate which will support good agriculture most of the time. It is much less detailed but a much more general subject, and it is one that must always be in the back of the mind of the forecaster when he makes his predictions.

I am going to try and make a forecast for the fairly close future, say fifty or a hundred years, but before coming to that I must say something about what I call the climatology of my subject, because that really is a deeper part of it. I will begin this by taking a simplified example. Suppose that somewhere in the ocean there is an island that is completely isolated from contacts with other parts of the world. I am told, in a general way, such things as what its climate is, how hot it is, how much rainfall it has, and what the soil is like. I am also told a little about the inhabitants and their state of culture—say that they know about the use of metals, but have only rather inferior food crops.

by
SIR CHARLES DARWIN

With only this information I could say a great deal about the life of the island; for instance, I could make a very fair estimate of the numbers of its population. To do this I should take as my principle that the normal way that any living species of animal survives is by producing too many offspring, of which only a fraction survive. With many lower animals the excess is often enormous, with a million produced of which only one may survive, but the same rule holds for the higher animals, too; the excess production is much less, but it is still there.

The same rule applies to man. The families on the island will mostly each produce several children and the parents will do all they can to keep their children alive and to bring them up. Now, simply to replace the numbers of the two parents, two children would be enough, but most peasant families surely produce more than two children, so that there is a tendency for the population to increase.

What is it that determines the total population then? The whole island will have come under cultivation, and it will be yielding all the food it can. Through the uncertainties of the weather, in some years there will be good harvests and in some years bad, and the peasants will accumulate a certain amount of reserve food against the bad harvests. But sometimes there will be two or three bad years running, and then they will get short of food, and perhaps two or three times in a century there may be four bad years running, and then there will be real famine. It will be these occasional famines that will determine the average number of people on the island.

This is not the sort of thing we see now anywhere in the world, but, for example, it was what used to control the population of India until about a hundred years ago. All this may seem rather obvious, but it is worth noting that we can say with some confidence that one of the most important features in the life of the island will be famines at the rate perhaps of three a century, and it is these famines that will mainly determine the number of people on it.

Now, suppose that the island has settled down into this state, but that its perfect isolation is broken by a ship which is wrecked on its coast and in which there happens to be a cargo of potatoes or some such crop. The new crop will give a much better yield than any of the previous food crops of the island, and it will be gradually adopted by the inhabitants. Every acre of ground will now yield twice as much food as it did previously.

Man is a rather slow breeder, so that the most conspicuous thing first to be noticed is that there is plenty of food for everyone. The bad old days of famines have disappeared and the population starts to increase. The historians of the island will record that it is a Golden Age, with an easy life very different from that of their parents. They will probably have a very human failing; they will forget about the cargo of potatoes, and they will claim how clever the present inhabitants are in overcoming the difficulties of life that used to afflict their ancestors.

This Golden Age will go on for a century or two, while the population increases to double its previous numbers, but at the end of that time the old troubles will begin all over again, because now again the yield of the crops will only be about enough to provide food for the new numbers of the population. There will be the old trouble over occasional successions of bad harvests which will produce famines again, and this will limit the population in the same old way. Something very like this was what happened in Ireland in the 1840's.

I have developed this imaginary example at some length, because it has a most important application to the present condition of the whole world. The world is just now in a highly abnormal condition, as is shown by the consideration of the increasing numbers of humanity. We are living in a Golden Age, which for man may well be the most wonderful Golden Age of all time. The historians have made fairly reliable estimates of the numbers of world population at different periods of history, and these numbers reveal it rather clearly. At the beginning of the Christian era the population of the world was about 350 million. It fluctuated up and down a bit, and by A.D. 1650 it was still only 470 million. But by 1750 it had risen to 700 million, and now it is 2500 million. That is to say that for 1700 years it was fairly constant, and then in 200 years it has suddenly quadrupled itself.

The increase of world population is still going on at a rate of doubling itself in a century, but it is a most menacing thing to think about. Year in year out the increase is at a rate of about one percent, and this means that every day there are 80,000 more people on the earth. That is the daily difference between the number of babies born and the number of people dying. Even those who are not conscious of this fact are unconsciously used to it, and accept it as natural, but it quite obviously cannot go on forever like this, and the most crucial question for us all is how long it *can* go on.

An abnormal state of affairs

This will be the main thing I shall want to discuss, but to see how abnormal the present condition is, I will imagine for a moment that it was the normal condition and I will look at the consequences that would follow. If the population were going to be able to double itself in each century, it would only be two thousand years before it was a million times what it is now, *and two thousand years is only a short time in the* period of human history. As a matter of simple arithmetic, if the population were a million times what it is now, there would be just about standing room on the land surfaces of the earth, but not room for the people to lie down! This would obviously be a fantastically impossible state of affairs, but it illustrates what an abnormal state the world is in just now with its population increasing at this rate.

It is obvious what has produced this present abnormal state of the world. There have been two chief causes. One of them was the discovery of the New World, much of it barely inhabited, which has provided enormous areas for possible expansion, in particular for the white races. The other is the development of science, through which it has been possible for man to find ways of producing a great deal more food, and in particular of transporting it from the places where it is produced to the places where it is needed. The Scientific Revolution, which began about three hundred years ago, must rank as one of the two really great episodes in human history; the only thing comparable with it in importance is the Agricultural Revolution. This happened in about 10,000 B.C., when man learned how to become a food grower instead of merely a food collector.

The climatology of humanity

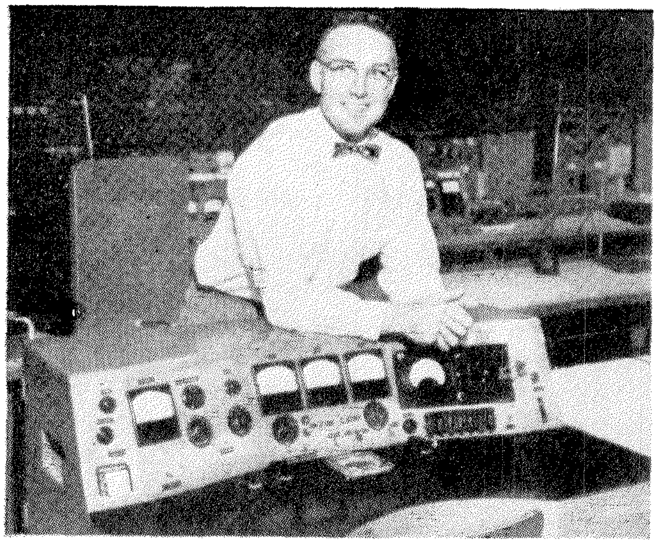
I want to give more consideration to what I have called by analogy the climatology of humanity. As I have shown, the present time is very abnormal, and so present conditions cannot be of much help in this. Are there any deeper principles that can be used? I think there are sufficient of them for us to be able to say a good deal about it. The first point is that the climate—and here I mean the actual climate—of the earth has been fairly constant for something like a thousand million years at least. It is eminently reasonable, then, to expect that we can count on it for say at least one more million years. Here is one constant datum we can use in our estimates.

A second thing is the finite size of the earth, and the fact that its whole surface is now fairly well known. This knowledge, of course, is quite a new thing; even a century ago there were great areas in Africa and South America that were hardly known, and they might have held something quite unexpected. There may, of course, *still* be many things to be discovered; there might possibly be other gold fields like the South African one, or perhaps great ore-fields of other, more practically valuable metals, but we can now be fairly confident that there is not room on the earth for anything, at present unknown, on a scale that would materially alter the possibilities of our ways of life.

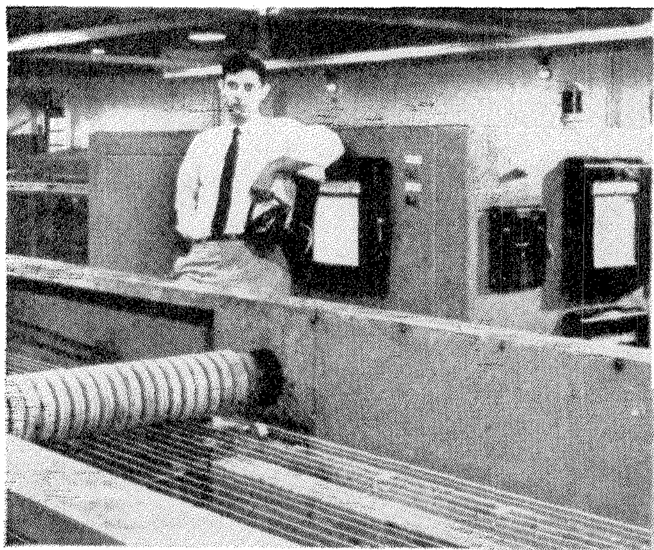
The third principle we can use is much the most important. It is human nature. The characteristics of mankind are conveniently, though only roughly, divided into two parts, which have—as I think, rather clumsily—been called nature and nurture. Nurture signifies the environment in which people grow up and live, and it is, of course, what determines most of their day-to-day behavior. It is thus immensely important in making the short-term forecast, but the conditions of life have varied enormously from century to century, and they will surely continue to do so, and therefore nurture gives little reliable help in estimating what the long-term character of human life will be.

The matter is quite different when we consider nature. Here, as we know from the study of many types of animals heredity plays a predominating part, and so for as long as any of us can really care about—say a hundred thousand years at least—we must accept that man will be just like what he is now, with all his

Young engineers making news at *Western Electric*



Richard C. Shafer, B.S. in mechanical engineering at Lehigh, was one of 16 engineers assigned to one of Western Electric's toughest post-war projects — developing manufacturing techniques for mass-producing *(with great precision!)* the tiny but amazing transistors which are already causing a revolution in electronics.



Paul J. Gebhard, B.S. M.E. at the University of Maryland, was one of a team that helped develop Western's new electroforming process for coating steel telephone wire with copper, lead and brass in one continuous operation. His job: to develop conductor resistance-annealing equipment and electrolyte filtration and circulating systems.

Western Electric's primary job — which goes 'way back to 1882 — is to make good telephone equipment that helps Bell telephone companies provide good service. It's a very big job — and a very important one — which calls for the pooling of varied types of engineering skills.

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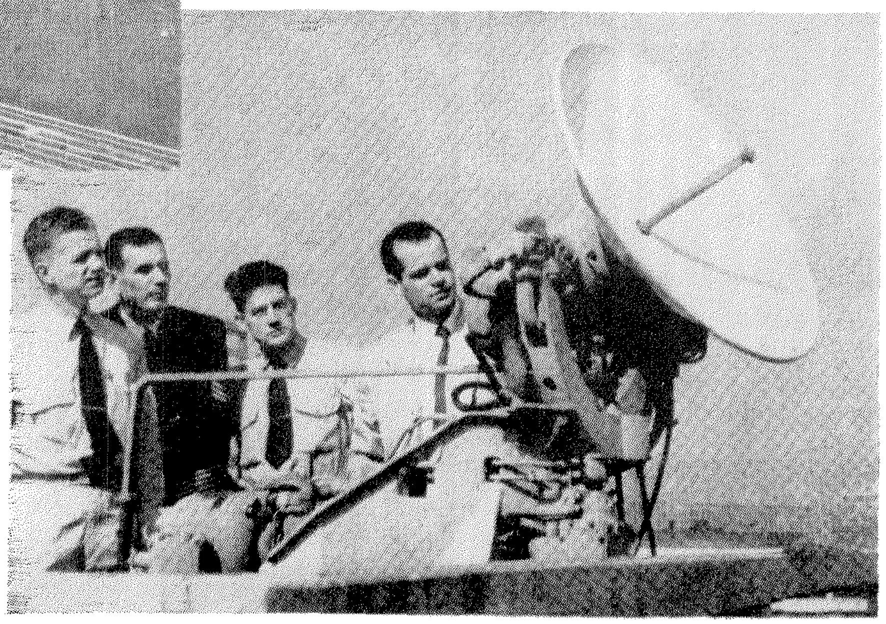
In addition to doing our job as manufacturing unit of the Bell Telephone System, Western Electric is busy producing many types of electronic equipment for the Armed Forces. Here again, young engineers of varied training are doing important work in connection with the manufacture of radar fire control systems, guided missile systems and special military communications systems.



Bobby L. Pettit (at right), an E.E. from Texas A. & M., is one of several hundred members of Western Electric's Field Engineering Force. These F.E.F. men can be found all over the world — working most closely with the Army, Navy and Air Force — advising on the installation, operation and maintenance of complex electronic equipment made by W.E.

virtues and all his defects. There is simply no prospect at all of any millennium in which pure virtue triumphs, because that is not in the nature of the species Homo Sapiens. In so far as heredity determines man's behavior, we can take this as a constant in making our predictions about his destiny.

The most important human characteristics, for my present purpose, are the deepest instincts which human beings have. These are the instincts which are directed towards the perpetuation of the species. One of them is the fear of death, shared by such a vast proportion of humanity that even under the most dreadful catastrophes very few people do actually commit suicide. This instinct serves to help in keeping the individual alive.

Equally important are the instincts serving to reproduce the species. In man and in the higher animals this characteristic falls into two rather separate parts, the sexual instinct and the parental instinct. Among the animals these two instincts suffice to perpetuate the species, and until very recently the same has been true of man. Things have, however, been changed by the developments of methods of birth-control, which have revealed a curious gap in our equipment of instincts.

Most people feel the sexual instinct with a force almost as great as the fear of death, and most people, when they have got children, have a very intense instinct to care for them and bring them up, but a good many people lack the desire to have children in advance; or at any rate, if they have the instinct, it is very much weaker than the other two. The parental instinct seems to be evoked mainly by the presence of the children, and thus it has come about that the sexual instinct can be satisfied without leading to the consequence it ought to have of ensuring the creation of a next generation. This third instinct, coming between the sexual and the parental, may be called the procreative instinct; it is much weaker than the other two, and indeed seems to be absent in a good many people.

Long-range forecast

The really important condition essential for human life was first fully described by Thomas Malthus in 1799, in his celebrated book, *An Essay on Population.* In this he drew attention to the necessity of a balance between the numbers of a population and the food it will require. He pointed out, with numerous examples, that there is a tendency for population to increase in geometrical ratio, whereas the area from which they will derive their food cannot possibly increase in this ratio.

Malthus could not be expected to have foreseen the consequences of the Scientific Revolution, which was going for a time entirely to upset the balance between the two sides of his account. During the 19th century it was possible to take the view that the disasters foretold by him had not occurred and that, therefore, his principles had been proved wrong.

This comfortable view overlooked the fact that all through that century population was, in fact, increasing geometrically, just as he had said, but for a time this was being balanced by the opening up for agriculture of barely inhabited regions in the New World, from which the newly invented railways and steamboats could convey the food to the places where it was needed.

It was the developments of the Scientific Revolution that for a time upset Malthus's balance, but now once again the balance is coming into effect, because we are now very fully conscious of the finiteness of the earth. There are few more regions that can be opened out for agriculture, and once again we have to face the problem of how our rapidly increasing populations are to be fed.

Population and food production

I have noticed that most people, when for the first time they face the population problem, at once think about the possibilities of producing more food. They first think perhaps of the fields we all notice here and there that are not being properly cultivated. Then they may think of improved breeds of plants that will produce two or three crops a year instead of only one. Then there is the possibility of cultivating the ocean. And there is the Chlorella, an alga which might be grown on a sort of moving belt in a factory; it can produce proteins perhaps ten times more efficiently than the garden vegetables do, but unfortunately at a hundred times the cost. Finally with the rapid progress in our knowledge of chemistry, it is not to be excluded that one day the foodstuffs necessary for life will be synthesized in factories from their original elements, carbon, nitrogen, phosphorus and so on.

All these things are possible, and I do not doubt that some of them will be done, but to accomplish them is no help, because of the central point made by Malthus, that there has to be a balance between food production and population numbers. Until population numbers are controlled, it will always continue to be true that, *no matter what food is produced there will be too many mouths asking for it.* New discoveries in the way of food production may make it possible for many more people to keep alive, but what is the advantage of having twenty billion hungry people instead of only three billion?

In the light of these considerations it seems to me that the food problem can be left to look after itself and that all attention must be given to the other side of the balance. Can anything be done about it? Frankly,

CONTINUED ON PAGE 30

INVENIEMUS VIAM AUT FACIEMUS: "We shall find a way or we shall make one."
—Memorial Gate, University of Pennsylvania

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though perhaps for a short term something might be done, in the long run I doubt it. My reason is this. Nature's control of animal populations is a simple, brutal one. In order to survive, every animal produces too many for the next generation, and the excess is killed off in one way or another. It is a method of control of tremendous efficiency, and during most of his history it has also applied to man. To replace a mechanism of this tremendous efficiency it is no use thinking of anything small; the alternative we must offer, if we want to beat nature, must also be tremendous.

The difficulty is even greater than it appears at first sight, because there would be an instability about any alternative scheme deliberately adopted. Thus, suppose some really good solution was found, and was adopted by half the world. For a generation or two this half would prosper. Its numbers would stay constant and the people would not be hungry, but all the time the numbers in the other half of the world would be increasing, so that in the end they would swamp the first half. That is the terrible menace of the matter; there is a strong survival value in being one of those who refuse to limit population.

The most easily imagined solution would be the establishment of some *world-wide* creed prohibiting large families, but when we reflect how many rival religious creeds there already are, all largely subsisting on account of their mutual differences, there seems little hope for any universal creed which would permanently limit population in this way.

It is very much to be hoped that a great deal of thought will be given to this matter on the chance that someone may hit on a solution, but I must repeat that nature's method of limiting population is so brutally tremendous that it can never be replaced by any such triviality as the extension of methods of birth control. It calls for something much more tremendous if there is to be any prospect of success.

Short-range forecast

I have said all I want to say about what by analogy I called climatology, and I will turn to weather forecasting; that is to say, I will attempt to forecast what will happen in the near future of say 50 or 100 years. I would remind you of the description of forecasting that I gave at the start, that it is like declaring a hand at bridge, where one makes a general estimate on incomplete data and one only expects to be right in general and not in detail. The weather forecaster can only do his work by receiving a great deal of information coming from all over the earth, and I need similar information for my forecasting. I have derived this from a fairly wide variety of sources. One of the most useful sources was a book entitled *The Challenge of Man's Future*, by Prof. Harrison Brown of Caltech. As a geochemist his study of the prospects of shortages in the future supply of various minerals led him on to study other shortages facing the world. A second book, *The Future of Energy*, by P. C. Putnam, deals very usefully with a narrower subject, the rate of exhaustion of our present fuel supplies and the various possible alternatives to them. Another very valuable source of information came from attendance at the UNO Conference on Population which was held in Rome in 1954. I may also refer to a book, *World Population and Resources*, recently composed in England by the organization known as P.E.P.

Cautious estimates

As I have already shown, we have been living during the past hundred and fifty years or so in a period of history of quite unique prosperity. Expert demographers estimate that our present two and a half billion population will have become four billion by A.D. 2000 and six billion by A.D. 2050. These estimated increases will be fairly equally distributed among the different races and among the social classes in each. For example, one of the most rapidly increasing groups at present consists of the moderately well-to-do Americans, who are increasing at a rate faster than the peoples of India or Japan. I may say that these estimates should be regarded as cautious ones.

The first thing we may think of which might reduce the numbers is war, but most war is not nearly murderous enough to have any effect. Thus we should count as a really bad war one in which five million people were killed, but this would only set back the population increase for less than three months, and that hardly seems to matter. I doubt if even an atomic war would have any serious influence on the estimate, unless it led to such appalling destruction of both the contestants that the economy of the whole world was so entirely ruined that barbarism and starvation would ensue. There is perhaps some hope that man will be wise enough not to embark on such a war, but anyhow I shall refuse to consider it in my forecast.

Some people may feel that methods of birth control might upset the whole forecast. This is a most important matter, which must be considered. The proponents say a contraceptive may be discovered which would put in our hands the possibility of completely controlling population numbers. It is very possible that such a discovery may be made, and I hope it will, but I do not think it seriously affects the forecast. This is because of the time-scale in human affairs. Even if we already possessed the full knowledge of what I may call the "contraceptive pill," a good deal of time would be taken in building factories to make it on a scale large enough to provide pills for the whole world population and the world-wide distribution would take some arranging; but

there are other more serious troubles which would also have to be overcome.

It is hardly likely that the physiologists could be absolutely confident that such a drastic medicine would have no collateral effect at all, and to verify this, many years of experiment on a smaller scale would be necessary. For example, it would take two or three decades to verify that when the habitual users of the pill did decide to have children, those children would grow up into normal adults. It would be necessary to verify that there were no unforeseen collateral effects, such as a premature aging of the habitual user, or perhaps a special liability to some disease—I may quote as a parallel the liability of people exposed to X-rays to develop cancer a good many years later.

Furthermore there would need to be an enormous educational campaign, and the number of educators would have to be so vast that it would take all of a generation to train them, and therefore two generations for them to produce their results.

On all these counts I think it is safe to say that no large-scale effects could possibly be seen under two generations or so, and therefore the contraceptive pill —which in fact we have not got yet—would have little influence in affecting the forecast for fifty years, though it might for a hundred. But things are unlikely to be even as favorable as this; there are religious doctrines that might prohibit the use of the pill and there is a tremendous stock of unreasoning emotion in such intimate matters that would make a lot of unforeseeable difficulties.

A population of four billion

In the light of these considerations I see no escape from the estimate that by A.D. 2000 the world population will be four billion.

It is time to turn to the other side of the Malthusian account. Malthus only thought of actual food production as the balancing item, but since his day there are a lot of other things to be included which he could not have foreseen—such things as the supply of energy and the metals which are essential for the city life which alone can carry large populations.

First, the agriculturists at the 1954 Rome Conference on Population claimed that a doubling of food production can probably be achieved, but to do so everything has got to be exactly right. There must be no creation of dust bowls by the exhaustion of poor soils, and the stores of artificial fertilizers must not be distributed freely, but must be controlled so that they are only used in the places where they will give the most advantage. I am not competent to discuss this matter, but I do wonder how far this strict control will be possible.

In connection with agriculture I may refer to a thing of the recent past which is at least suggestive. Between 1947 and 1953 the world's agriculture made the most tremendous strides; in these seven years it increased by 8 percent, a truly wonderful performance, which we owe largely to the brilliant work of the scientific agriculturists. *But*—during those seven years the world's population increased not by 8 percent, but by 11 percent, so that the world was hungrier at the end than at the beginning. So, as I have said, I forecast there will be four billion people in fifty years from now, but I forecast that they will be hungrier than the two and a half billion we have now.

Now, to turn to other matters, Malthus needed only to think about agriculture, but we have to consider the provision of a lot of other things, because since his day the enormously increased numbers can only exist by living in large cities, and these demand all sorts of equipment like good roads, railways, water supply, electricity and so on. If some of these things could not be supplied it would be quite impossible to maintain the large numbers we have. So we must add to the right-hand side of Malthus's balance sheet things like energy and metals, and consider whether the supply of these will be adequate to keep us going for the next fifty years.

The prospects for energy

As to energy, as far as we can see the prospects are not too bad. There are only three sources which can provide power in quantities sufficient to be important. They are the "fossil fuels" coal and oil, nuclear energy, and the direct use of sunlight. Notice that water-power is not in the list; this is because the total quantity yielded, if all the rivers of the whole earth were fully exploited, would be only 12 percent or so of even the present energy developed.

At present, of course, practically all the power comes from coal and oil, and it is being used up at an ever-increasing rate. It is not possible to estimate the reserves with any great accuracy because it would be necessary to take some standard of the ease with which the coal can be won; for example, would it ever be worth while to mine a seam only a foot thick? But an estimate very definitely on the optimistic side predicts that the coal will be all gone in 500 years. Since it took some 500 million years to make the coal, it may be said—speaking only very loosely, of course—that we are living on our capital at the rate of a million to one. Is it surprising that we can create wonderful prosperity for a short time? Oil is won much more easily than coal, and it is expected it may at most last for a century.

The prospects for nuclear energy are good, but the construction of nuclear power stations will inevitably take a good many years. It has been estimated that at the end of 30 or 40 years something like a quarter of the power developed in Britain will come from uranium

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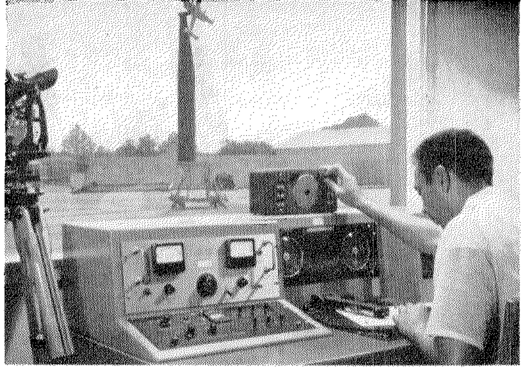
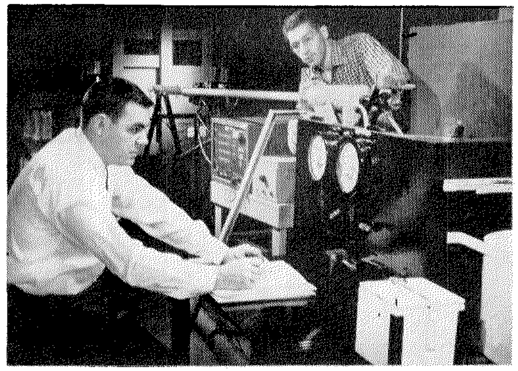
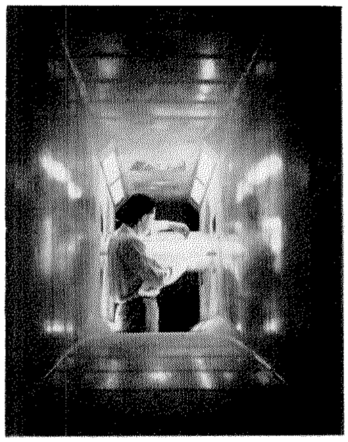


Electronics Research Engineer Irving Alne records radiation antenna pattern on Lockheed's Radar Range. Twenty-two foot plastic tower in background minimizes ground reflections, approximates free space. Pattern integrator, high gain amplifier, square root amplifier and logarithmic amplifier shown in picture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



Mechanical Research Engineer W. M. Watkins (left) directs Research Mechanic Earl Rollo in operating Lockheed's new Hailstone Gun during a test on the effect of hailstones on new types of plastic radome "skin." The gun, which was designed by Watkins and Mechanisms Group Engineer G. W. Louthan, fires up to five hailstones spaced 25 feet apart at speeds ranging from 270 to 500 mph. The hailstones, which are made in the gun, can be varied in size from ⅜" in diameter.

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.

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instead of coal. Even at the present rates of consumption of power this would still mean a very large demand for coal, and as the demand in fact is growing year by year, there seems little prospect of the coal situation improving. Indeed, I would not be surprised if there was going to be a rather awkward period for us in about 50 years, when the expense of winning the remaining coal has increased a good deal, while there are still not enough nuclear power stations.

These difficulties apply specially in Great Britain. In America the situation is much easier in respect to coal. It is being consumed at an almost fantastic rate here, but there would seem to be enough easily mineable coal to last you a century. I have called the rate fantastic, and this can be justified by the following consideration. In the history of the world man has burnt up a very considerable amount of coal in all, but half of this total has been burnt in the United States since 1920.

Favorable prospects

As far as we can judge in these rather early days there is not likely to be any shortage of uranium for many centuries, and there is also always the possibility that the fusion of deuterium into helium may be made to occur slowly instead of, as now, only in the form of a super-bomb. The prospects for the supply of energy are therefore rather favorable, but it must be noticed that it may make very considerable changes in our ways of life. Nuclear power units are likely to have to be very large, and this may mean that there will have to be far fewer small units such as motor-cars. This suggests that in the nuclear age the population will be concentrated in the great cities even more than it is now.

The energy arriving at the earth day by day in the form of sunlight is quite enormous, and if it could be turned into mechanical power it would supply many times over the needs of mankind. A square yard facing the sun receives energy at a rate of about a horse power, but this implies that a great area would be required in order to make any reasonable power station. It may well be that improving techniques will solve this problem, but there is certainly a long way to go. Indeed it is rather humiliating to know that at the present time the most efficient way of collecting solar energy is to plant a row of trees, let them grow, cut them down and burn them.

If the provision of energy is not necessarily going to be a great difficulty, the same cannot be said of many other raw materials, in particular many of the metals, though even the supply of such a common thing as fresh water is going to be a formidable problem. Of course, strictly speaking, the metals, unlike coal, are indestructible; once won they can be used again and again, but in fact there is always some wastage due to wear or to actual loss, and this wastage must be allowed for. There has been the same enormous increase in the extraction of metals as of coal; in fact, of all the metal mined from the earth, half has been dug up in the last 30 years.

The possession of metals in great quantity seems to be essential for industrial development. It would appear likely that there simply is not enough of many of them, such as lead or tin or copper, to permit the underdeveloped countries to become industrialized on a scale at all equivalent to that of the highly developed ones. It is true that substitutes can often be found, but usually they will be inferior; for example, an electric transformer could be made with aluminum wires to replace the copper, but it would be less efficient. The underdeveloped countries which are trying to improve their industrial power are already handicapped in two respects. They lack capital, and they lack engineering experience, and to these difficulties must be added a third, the expected world shortage of constructional materials. So I forecast that at the end of this century industrialization will not have spread very greatly over the less developed parts of the world.

My general conclusion then is that in fifty years the population of the world will be four billion. They will be a rather hungry four billion, busily engaged in straining the resources of the earth to yield enough food, but they will not have succeeded very much in their present ambitions about becoming more industrialized.

I regard the forecast for a century with a great deal more doubt. The demographers forecast six billion for the year 2050, but my own guess is that the world will not have succeeded in yielding enough food for this, and that by then the world will have begun to go back into what I earlier called its normal state, the state in which natural selection operates by producing rather too many people, so that the excess simply cannot survive.

A gloomy picture

I fear this is a gloomy picture, and I ought to say that there are many people who forecast quite the opposite. They are the technological enthusiasts. They claim that whenever a shortage has declared itself the technologists have produced a substitute and that things will go on forever like that. To me they do not seem to appreciate the overwhelming importance and difficulty concerning the population numbers, and that is why I must disagree with them. If they are right and I am wrong the world can look forward longer than I expect to a continuance of the present era of prosperity.

I hope that they will prove right, and that I shall be proved wrong, but I must repeat my opinion that the central problem is that of world-population. I do not see any happy solution of this, but I earnestly hope that if many people face the difficulties, someone may possibly be inspired to find an acceptable solution.

THE MONTH AT CALTECH

Earthquake Protection

REAR ADMIRAL H. ARNOLD KARO, director of the U. S. Coast and Geodetic Survey, conferred early this month with George W. Housner, Caltech professor of civil engineering and applied mechanics, on a plan which would provide structural engineers with valuable new information on how to go about designing earthquake-resistant structures.

The Coast and Geodetic Survey now maintains about 50 scattered instruments in the western states which record "strong ground motions" of earthquakes—and thus show engineers and seismologists how the earth acts in the immediate vicinity of a quake.

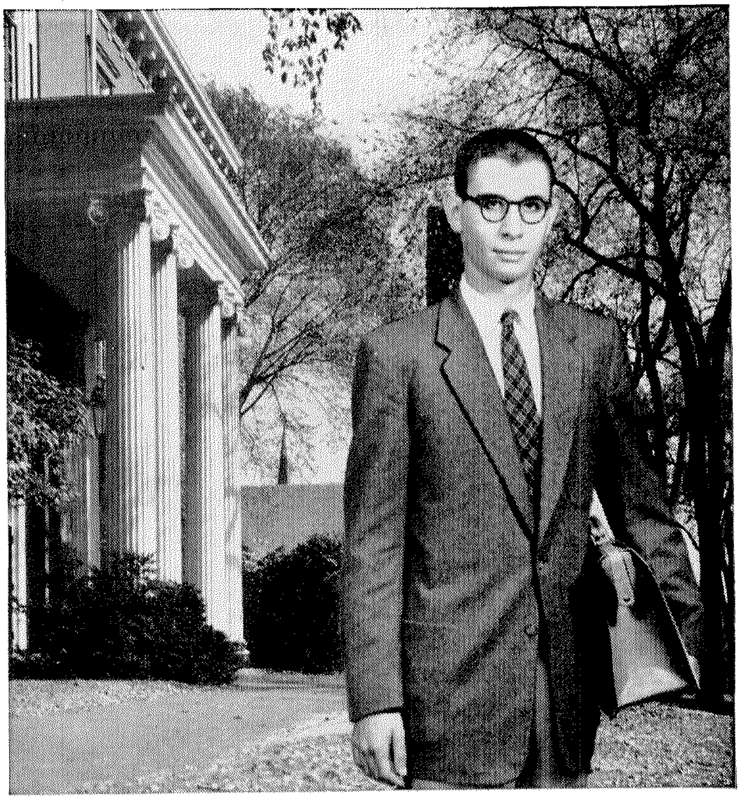
To strengthen the Survey's present program, Dr. Housner has proposed the addition of several hundred more recording instruments. These newly-designed seismographs would cost about $500 apiece, as opposed to the $5,000 cost of the instruments which are now in operation.

This new battery of recording devices, spread over a wider area, would give engineers more basic data on the forces their buildings will have to withstand. The present earthquake protection program of the Coast and Geodetic Survey is being carried on with a $35,000 budget and a staff of only three men. The enlarged program would cost about $140,000, and funds are now being sought from Congress.

Coming and Going

FRED HOYLE, fellow of St. John's College and lecturer in mathematics at Cambridge University, arrived on campus in March to spend four months here as a visiting professor in theoretical cosmology. Mr. Hoyle was at Caltech for short periods in 1953 and in 1954.

GEORGE W. BEADLE, chairman of the Division of Biology, returns the middle of this month from a three-week lecture tour of Pacific Northwest universities and col-



Gaylord E. Moss expects to receive his B.S. in Electrical Engineering from Tufts College in 1957. His interest in electronics was aroused, in part at least, by summer work in Du Pont's Photo Products Plant at Parlin, N. J. But Gaylord's interest in technical work goes much farther back. He received the Bausch and Lomb Science Award at his high-school graduation.

"Gay" Moss wants to know:

At what location would I work for Du Pont?

Clayton B. Hill, Jr., joined Du Pont's Jackson Laboratory at Deepwater, N. J., in 1940 and left for the Air Corps in 1942. After military service he obtained a B.S.Ch.E. from Pennsylvania State University (1949), and returned to Jackson Laboratory. Clayton was assigned to Du Pont's Atomic Energy Division for a period before transferring to the Personnel Division. As a representative of this Division, he currently visits many colleges and universities.

Clayton Hill answers:

Where would you *want* to work, Gay? The choice isn't quite so wide as that reply indicates, but if you have good reason for preferring a given area, and Du Pont has an opening there for which you're qualified, your choice will certainly be considered. We have 69 plants and over 70 research and development laboratories scattered through 26 states. So the odds are pretty fair that you can work in an area you like.

Most of the Du Pont units are situated east of the Mississippi, but some of them are as far west as the Pacific Coast. Right now, new plants are under construction in Michigan and California, providing even wider choice in those two states.

Of course, a man may be transferred after a time. The chemical industry is a growth industry, and transfers are generally associated with progress and promotions.

So you see, Gay, the geography of the United States is pretty much an open book for Du Pont professional men, adding a lot to their interest and enjoyment on the job.

WANT TO KNOW MORE about where you'd work with Du Pont? Send for a free copy of "The Du Pont Company and the College Graduate." This booklet contains a complete listing of plant and laboratory locations, by state, and describes work available. Write to E. I. du Pont de Nemours & Co. (Inc.), 2521 Nemours Building, Wilmington 98, Delaware.

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BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*

Enjoy "Du Pont Cavalcade Theater" on Television leges. Dr. Beadle's trip took him to Reed College, the University of Oregon and Oregon State College, where he delivered the 1956 series of Thomas Condon lectures, sponsored by the Oregon State Board of Higher Education.

MAX DELBRUCK, professor of biology, leaves early in May for Germany, where he will spend the summer teaching at the Botany Institute of the University of Cologne.

JESSE L. GREENSTEIN leaves the middle of this month to spend a month as a visiting professor at the Princeton (N.J.) Observatory.

Wind Tunnel

FRED H. FELBERG, who has served as executive assistant at the Southern California Cooperative Wind Tunnel since 1952, has now been appointed associate director of the project. He succeeds Josiah H. Smith, who has resigned to work in the guided missiles research division of the Ramo-Wooldridge Corporation in Los Angeles.

Mr. Felberg, a Caltech alumnus (BS '42, MS '45), was appointed to the staff of the Cooperative Wind Tunnel in 1943, after working for three years at the 10-foot wind tunnel at Caltech. In 1945 he became CWT's first crew chief with full responsibility for all tunnel operations. After his appointment as executive assistant in 1952, Mr. Felberg was also made coordinator of the modification project at the wind tunnel which is to be completed this year. In addition to his work at the Cooperative Wind Tunnel, Mr. Felberg was a lecturer in aeronautics at Caltech from 1947 to 1955.

Josiah Smith, also a Caltech alumnus (BS '39, MS '40, AE '48), has devoted the last 17 years to wind tunnel design and development. Between his sophomore and junior years at Caltech he worked full time for two years with the Douglas Aircraft Company, where he became familiar with the production control system, airplane fabrication and assembly processes. He was made supervisor of the 10-foot wind tunnel at Caltech in 1939, and later was part of the Caltech team which originally conceived and designed the Cooperative Wind Tunnel, becoming assistant director of the project when it went into active operation in 1945.

ALUMNI NEWS

Alumni Dinner Speaker

Virgil M. Pinkley, editor and publisher of the Los Angeles *Mirror-News*, will be the dinner speaker at the annual banquet and meeting of the Caltech Alumni Association on June 6. The dinner will be held at the Pasadena Elks Club, 400 West Colorado Street.

Mr. Pinkley, who has just returned from a trip to southeastern Asia, will give a newspaperman's view of what is going on in the world today.

After his graduation from the University of Southern California in 1929, Mr. Pinkley went to Europe for the United Press and later to Washington, D.C., where he covered the Treasury and Justice departments. He became European business manager of the United Press in 1938, general European manager in 1943 and vice-president in 1944. He has been publisher and editor of the *Mirror* since 1948.

Alumni Picnic

The annual alumni picnic will be held on Saturday, June 23, at Corriganville, the 2,000-acre movie ranch on Highway 118 about 5 miles west of Chatsworth. Alumni will meet for a picnic in the Robin Hood Lake and Forest area of the ranch, and in the afternoon a rodeo will be held. Aside from these scheduled events, there will be horseback riding, trips in an old stage coach and visits to some of the movie sets used in Western pictures. Complete details will be sent to all alumni early in June—so save the day.

Phoenix Affair

A group of alumni in the Phoenix, Arizona, area met for a buffet dinner on March 19 at the home of Mr. and Mrs. Langdon C. Hedrick. The occasion for the informal gathering was a visit by D. S. Clark '29, secretary of the Alumni Association, who was in town to give a talk to the Phoenix Area Chapter of the American Society for Metals. Don is national vice-president of the society this year. Attending the affair were Mr. and Mrs. Kenneth G. Brown, Jr. '44, Langdon C. Hedrick '47, K. T. Peterson MS '55, Roy T. Richards '17, Paul E. Skoglund '51, W. Clifford Taylor '46 and Mr. Carlton H. Paul '39 and Ralph J. Stone '50.

Chance Vought F7U Cutlass

PERSONALS

1906

Harry H. Canterbury died of a heart attack on February 23 in Paradise, California. Before his retirement in 1954, Harry was in business for himself in Whittier as a consulting engineer. Before that, he had worked as a mechanical engineer for the Lorraine Corporation in Los Angeles.

1918

Robert C. Sticht visited Caltech last month, on the first leg of an eight-month journey around the world. It's a trip the Stichts actually started in 1939 from their home in Australia. That time they got as far as the United States when war broke out; this time they're going all the way. Bob works as a chemical engineer for Commonwealth Fertilizer and Chemicals, Inc., in Victoria, Australia.

1925

Paul E. Noll has been made assistant to the vice-president in charge of sales of the Columbia-Geneva Division of the United States Steel Corporation in San Francisco. He has been director of research and development at the Consolidated Western Steel Division in Los Angeles since 1935.

1926

Burt Beverly, Jr., chief geologist and assistant manager of operations of the American-Arabian Oil Company in Saudi Arabia, is currently in the United States, attending a session on business management at the University of Pittsburgh.

Arthur B. Allyne has been elected a vice-president of the Pacific Northwest Pipeline Corporation in Houston, Texas. Since February, 1955, he has been project engineer for Fish Northwest Constructors, Inc., the company which has been engineering and constructing Pacific Northwest's 1,487-mile pipeline to transport natural gas from New Mexico to the Canadian border.

Art was formerly assistant general manager of the Honolulu Gas Company, Ltd. and Pacific Refiners, Ltd., in the Hawaiian Islands, before he moved back to the mainland to join Pacific Northwest. His two sons are now in the Service.

1933

George H. Anderson, PhD, died on February 23 of a heart attack while on a business trip to New York. He was assistant to the president and industrial consultant for the Dallas, Texas, Power and Light Company, George was formerly associate professor of mining geology at the University of California in Los Angeles. He leaves his wife, two sons and a married daughter.

Louis A. Pipes, PhD '36, professor of engineering at UCLA, presented a paper at the winter general meeting of the American Institute of Electrical Engineers in New York City in January. Louis has been a full professor at UCLA since July, 1951, when he was moved up from associate professor. Before going to UCLA, he worked in research at the Hughes Aircraft Company and at the University of Wisconsin.

1934

Charles V. Newton, president of the Caltech Alumni Association, is still living in Pasadena but now works in Monrovia as plant manager of the Carlson-Sullivan Division of the H. K. Porter Company, Inc., manufacturer of steel tapes.

Ray W. Haskins has moved from Larkspur, California, to San Rafael, where, he writes, "we live on top of a hill overlooking San Francisco Bay. I'm a consulting engineer doing business under the name of 'New Products Research' and I specialize in doing market research jobs for manufacturers having a new technical product to market in the industrial field." The Haskins' have two small sons, Greg and Gary.

1935

Colonel Howard M. McCoy, MS, recently retired from the U. S. Air Force, is now with the Ramo-Wooldridge Corporation in Los Angeles, working in the computer systems division. A recipient of the Bronze Star and the Legion of Merit, Col. McCoy was Air Force representative to the Research and Development Board and director of the Physical Security Equipment Agency.

1937

John L. Sullwold, for the past five years, has been working in sales engineering for the Carrier Corporation in Los Angeles on centrifugal and axial flow air and gas compressors. He has three daughters, 16, 15 and 6 years old.

Robert C. Jones of Berkeley has just celebrated his tenth year with the Shell Development Company's Emeryville Research Center, where he is now a research advisor in the fuels and engine lubricants department.

Claude B. Nolte, vice-president of the Barton Instrument Corporation, was put in charge of manufacturing for the company

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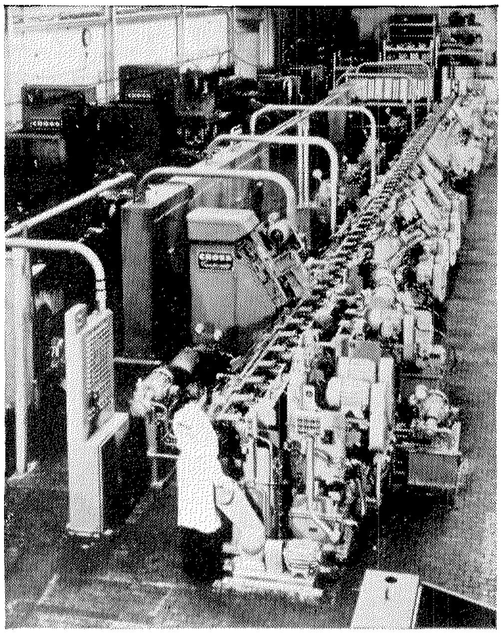
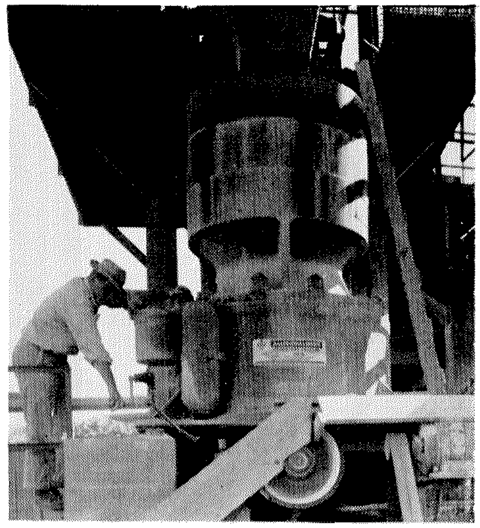


MANUFACTURING — There are 51 Allis-Chalmers motors in this lineup of machine tools designed for high automobile production.



CONSTRUCTION—Crushers like these from Allis-Chalmers process the enormous quantities of aggregate for the booming construction industry.

THERE IS much talk today about growth companies. Allis-Chalmers is one of them, supplying machinery for three basic industries—manufacturing, construction and power.

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. . . for a manufacturing industry that must increase output $3.5 billions by this time next year.

. . . for the construction industry that is destined to spend many billions of dollars on highways in the next ten years.

. . . for the electric power industry that will double its capacity by 1956.

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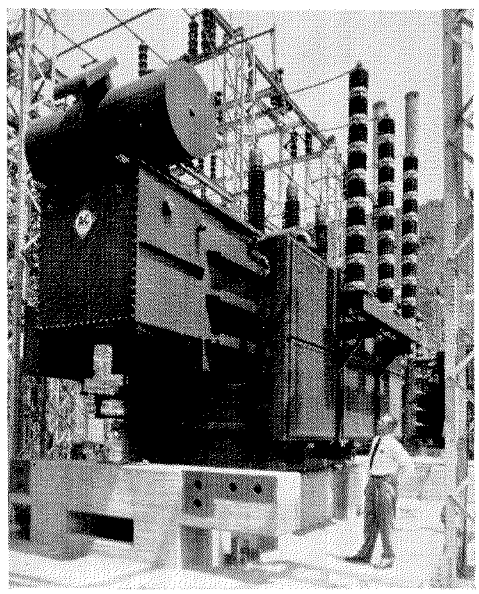
A graduate training course that has been a model for industry since 1904. You have access to many fields of engineering: Electric power, hydraulics, atomic energy, ore processing.

There are many *kinds* of work to try: Design engineering, application, research, manufacturing, sales. Over 90 training stations are available with expert guidance when you want it. Your future is as big as your ability can make it.

Or, if you have decided your field of interest and are well qualified, opportunities exist for direct assignments on our engineering staff.

In any case—learn more about Allis-Chalmers. Ask the A-C manager in your territory, or write direct to Allis-Chalmers, Graduate Training Section, Milwaukee 1, Wisconsin.



POWER GENERATION—Allis-Chalmers is helping meet growing power demand with equipment such as this 150,000 kva transformer.

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Personals . . . CONTINUED

last year. In 1955, also, he was president of the Los Angeles Section of the Instrument Society of America. Claude was married to Martha Mills in Pasadena in 1953 and they have four children, two boys and two girls.

Irving L. Ashkenas, MS '38, MS '39, is now associated with Control Specialists, Inc., an Inglewood firm specializing in automatic control systems and components. He was recently elected vice-president of the three-year old firm.

1938

Frank B. Jewett, Jr. is now vice-president and a member of the board of directors of the Vitro Corporation of America. Before this, Frank spent eight years with General Mills, Inc., in Minneapolis—the last three as managing director of engineering research and development—before joining Vitro in New York. His home is in New Canaan, Conn.

Howard Seifert, PhD., of the Ramo-Wooldridge Corporation, has been reappointed to the subcommittee on rocket engines of the National Advisory Committee for Aeronautics.

Edmond F. Shanahan, who practices patent and trademark law, has opened new offices in the Beverly Hilton Hotel in Beverly Hills, in addition to his office in the Statler Center in downtown Los Angeles.

1940

Leo Davis, MS '42, recently joined the Hughes Aircraft Company in Culver City as a member of the technical staff of the electron tube laboratory. Leo formerly worked for the Aerojet-General Corporation.

1941

John R. White, MS '42, has been district manager for Fenwal, Inc., in Los Angeles since July, 1955. Jack was formerly a designer with the Rand Corporation. He has a nine-month-old son, Jonathan.

1942

John H. Rubel has been with Hughes Aircraft for $9\frac{1}{2}$ years and is now director of the fire control systems laboratories. He is also doing a little teaching at UCLA. The Rubels are living in Brentwood. They have two sons, $11\frac{1}{2}$ and $3\frac{1}{2}$, and expect another addition to the family shortly.

George F. Meyer is now general superintendent of the Warner and Swazey Company in Cleveland, Ohio. In his position George is responsible for the operations of the manufacturing, tools and maintenance divisions at the Cleveland plant. He has been with the company since 1947.

Charles W. Pearson writes that "I moved back to Pasadena two years ago with my

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AND

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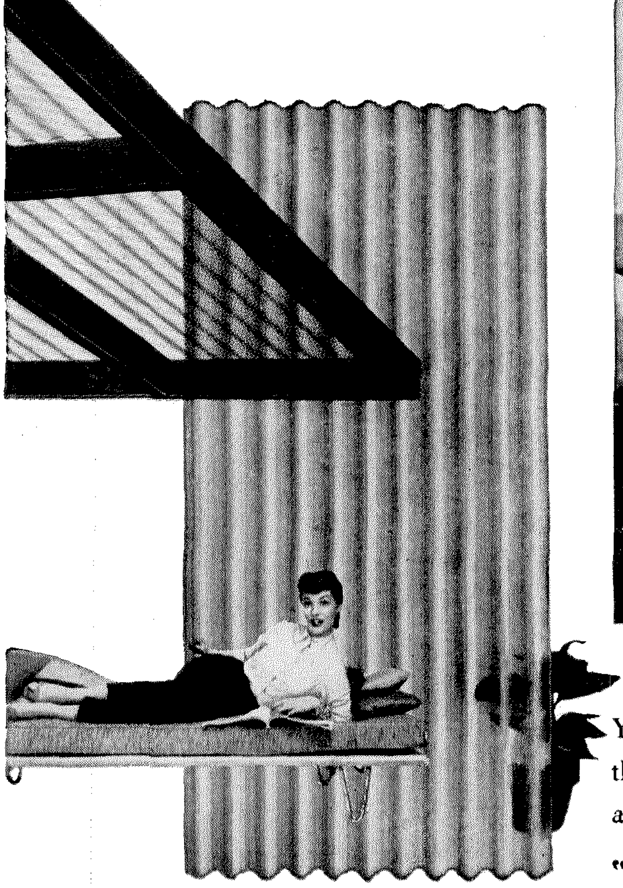

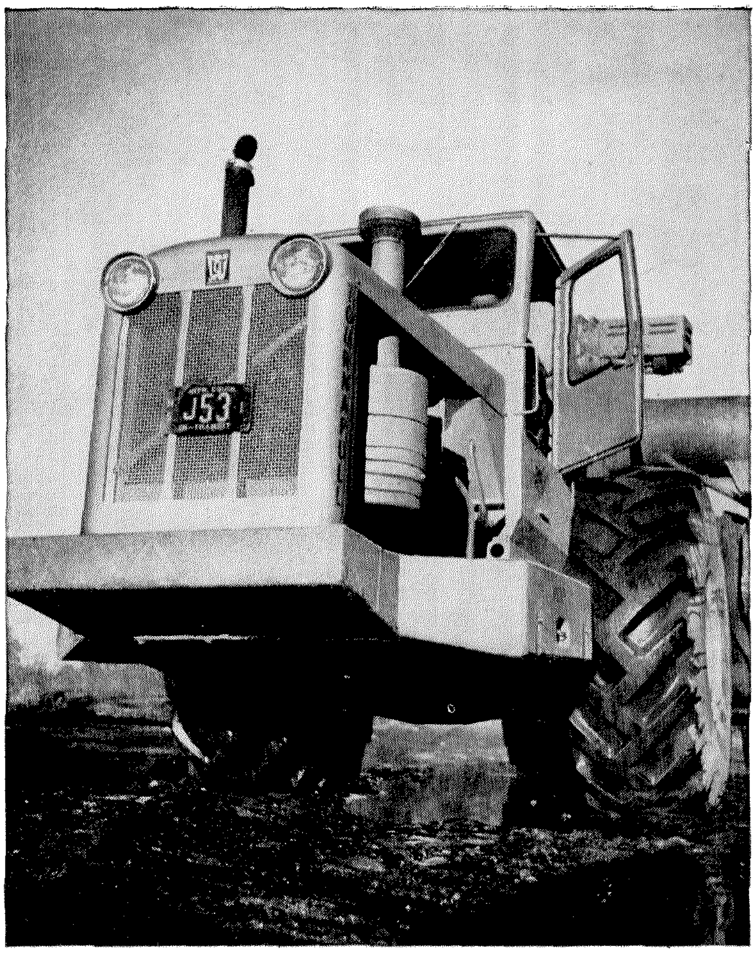

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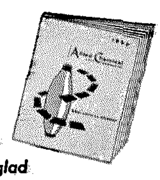


wife, Virginia; son, John; and two daughters, Laura and Hazel." Charles is a sales engineer with the Cannon Electric Company in Los Angeles.

John W. Miles, MS '43, PhD '44, professor of engineering at UCLA, writes that he is a consultant for Ramo-Wooldridge also, and that his current hobby is riding a surfboard at Malibu Beach. He has three daughters—Patricia Marie, 6; Diana Catherine, 2½; and Ann Leslie, born on February 23.

Carter Hunt, who was assistant supervisor of Hiram Walker & Sons in San Francisco, is now at the Peoria, Ill., plant.

1943

John Harrison Laws, MS, is now operating department manager at the Shell Chemical Corporation in Houston. John has been working for Shell since 1952, and recently returned from an overseas assignment.

Robert M. Sherwin, MS '50, ChE '52, has been named plant engineer of the Tacoma plant of the Hooker Electrochemical Company. Bob's been with the company in Tacoma since 1951. He and his wife have two children.

Ralph M. Willits reports that he will have been with General Petroleum for 10 years next October. He's a job engineer at the Torrance refinery in Los Angeles right now, but spent seven months last year in charge of new construction work at the Ferndale, Washington, refinery. He's married and has two daughters—Kathleen, 6 and Kristeen, 3.

David M. Mason, MS '47, PhD '49, who was formerly a research engineer at JPL, is now head of the division of chemical engineering at Stanford University as well as associate professor of chemical engineering. He was married in September, 1953.

Charles P. Strickland has been a sales engineer with the York Corporation's Los Angeles branch since 1947. He was recently honored for the third time by the company for outstanding sales engineering achievement. The Stricklands, and their daughter, Anita, live in Alhambra.

John W. Otvos, PhD, who recently celebrated his 10th year with the Shell Development Company, has now been made assistant head of the chemical physics department at the company's research center in Emeryville. John was formerly assistant head of the spectroscopic department.

Robert M. Sherwin, MS '50, ChE '52, has been made assistant plant engineer of Hooker Electro-chemical at Tacoma, Washington.

1944

Victor Bravo-Ahuja, MS, president of the Monterrey Technological Institute in Mexico, writes that he has been with Monterrey Tec ever since leaving the U. S. He "first began working with the Institute as an assistant professor, then became a full professor in 1945. In 1946 I was named dean of the school of engineering and afterwards, in 1948, general secretary of the Institute. My appointment as president was made effective in May, 1951."

H. Brian Proctor, who is in business for himself as a jobber and manufacturer of furniture frames in Los Angeles, writes that his big news is an addition to the family—twins, Stuart and Suzanne, born last July.

1945

K. Martin Stevenson is working on the technical staff of the Hughes Aircraft Company in Culver City. He was formerly with the Magnavox Company.

John L. Stern has his own business now handling real estate, subdivisions, real estate brokerage, and general and life insurance, in Los Angeles. He writes that with his wife and two children, Debbie, 5, and Johnnie, 3, he visited Europe in 1953.

Donal B. Duncan, PhD '51, has been appointed assistant chief of the guidance section of Autonetics, a division of North American Aviation, Inc., in Los Angeles. This is his sixth year with the company.

Duane T. McRuer, MS '48, was recently elected board chairman of a rapidly growing three-year old firm, Control Specialists, Inc. Located in Inglewood, the firm specializes in automatic control systems and components.

1946

David C. Lincoln, MS '47, is department head of control equipment engineering at Sperry Gyroscope Company. In this position, Dave is responsible for the organization and administration of groups with technical capability in the fields required for drone and missile engineering. He's been with Sperry since 1949.

1947

George Allen Austin died of cancer on January 4 at Claremont. A veteran of the U. S. Army Air Corps, George had been assistant professor of psychology at Claremont Graduate School for the past two years. Previously, he was a lecturer and research associate at Harvard University.

Ernest I. Pritchard, MS, who has been chief of the data analysis department of Caltech's Cooperative Wind Tunnel for the

past two and a half years, was married last April to Marilyn Mangum.

1948

Justin Bloom works as a staff administrator in the experimental physics division of the University of California Radiation Laboratory in Livermore. Justin; his wife, Robbie; and their adopted daughter, Claire, make their home in Livermore. Justin is also president of the Radiation Lab Recreation Association.

John P. Davis, MS, who was formerly with the Hawaiian Broadcasting System, is now a member of the guided missiles division of Hughes Aircraft in Culver City.

1949

Clement J. Savant, Jr., MS '50, PhD '53, professor of electrical engineering at USC, notifies us that he has a new home in Brentwood.

Burton B. Rutkin, MS '50, is traveling in Europe for several months.

William I. Rumer, MS '50, has been appointed head of the analysis and requirements group in the weapons control systems laboratories test equipment section of Hughes Aircraft. Bill has two children, a girl, Kim, 16 months, and a boy, Andy, 3 months old.

1951

Harry T. Brackett, MS, was killed when his test plane crashed in the Mojave Desert near Los Angeles on February 1. He was an experimental test pilot for the Chance Vought Aircraft Company in Houston, Texas. Harry leaves his parents in Sapulpa, Oklahoma, and his wife in Arlington, Virginia.

William A. Kelley, Jr., who has been with the U. S. Army for the past two years, is now in the sales technical service department of the Monsanto Chemical Company's Plastics Division in Springfield, Massachusetts.

Clarence R. Gates, PhD, was appointed a section chief in guidance analysis at JPL in February. He's been with JPL since March 1951, and succeeds *Robert J. Parks*, '44, who is now staff engineer and directs a small staff group which will handle special systems problems. Bob starts his new job this month after a two months leave of absence in Europe.

Edwin E. Pyatt writes that he (1) finished his MS in sanitary engineering at Berkeley in January, 1953; (2) went on active duty with the U. S. Air Force until June, 1955 — his primary duty as commanding officer of a medical squadron at Casablanca, French Morocco, but traveling all over Europe and North Africa on official business as well; (3) from July, 1955, to date, working as a sanitary engineer for Pomeroy and Associates in Pasadena.

1952

Robert C. Perpall writes that "my wife, Doris, and I are living in Pasadena. She is working in the mechanical engineering department at Caltech, and I am on leave of absence from my job at the AiResearch Manufacturing Company while attending Caltech for the fifth year (i.e.—working for my MS in mechanical engineering).

Tucker Carrington, PhD, who has been with the Interior Ballistic Laboratory at Aberdeen Proving Ground in Maryland, was awarded a post doctoral research associateship last month for advanced study at the National Bureau of Standards in Washington, D.C.

George W. Mayle, MS, is an applications specialist in the business systems department of the Magnavox Research Laboratory in West Los Angeles.

1953

Luther W. Eggman, PhD, is now head of research work at the Industrial Nucleonics Corporation in Columbus, Ohio. He's just finished an appointment at Caltech as a research fellow, working with James Bonner, professor of biology, on the biochemistry of water secretion.

1954

Pehr H. Schalin, MS, writes from Linkoping, Sweden, that "after leaving Pasadena on June 25, 1955, we (myself, my wife, and two children, 2½ and 5½) crossed the continent by car, visiting an extremely interesting array of colorful spots —Grand Canyon, Bryce and Zion National Parks, Yellowstone, Niagara, etc. From there the family went on by ship to Oslo and I traveled by plane to Helsinki. In August we all met here in Linkoping. My job at the Saab Aircraft Company is new, as head of the new guided missiles group. Sure could use a JPL here now.

"On the whole, I have to admit we have found more crazy things in this country now than we found when entering the U.S.! For example, this winter, which is colder than for many hundreds of years."

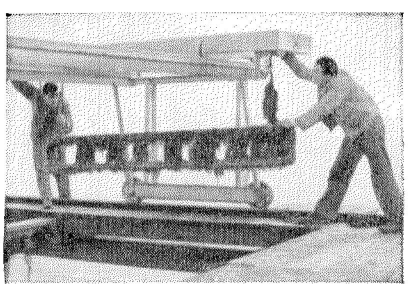
1955

Lt. Frank C. Michel writes from Marana Air Base in Tucson that he "will spend a year training to be an Air Force pilot (courtesy of CIT's AFROTC), then complete two years of active military duty."

Van I. Walkley is now on active duty in the Air Force. He is stationed at McChord Air Force Base in Tacoma, Washington, where he is a 2nd Lt. in the Engineering Section of the 325th Installations Squadron.

Chalon L. Carnahan, who is doing research with the Berkeley Radiation Laboratories, now has a second daughter, Lucia.

How hard can the sea bite? This is no secret to Inco Corrosion Engineers. For over thirty years, they have been collecting data on the corrosive and erosive effects of sea water on many different kinds of metal.



In Inco's "Ocean Test Tube" and associated laboratories, Inco Corrosion Engineers have the facilities and apparatus to study all phases of marine and atmospheric corrosion.

Ocean Laboratory—here at its big Kure Beach, N. C., Testing Station, Inco exposes thousands of metal specimens to the corrosive effects of salt spray, salt air, salt water.

How International Nickel finds out what the wild waves are saying

The sea's a killer of many metals. Some it corrodes or rusts. Some it wears away. Some it destroys by eating up one of the alloying elements. Some it makes so "allergic" to connecting metals that corrosion is speeded up.

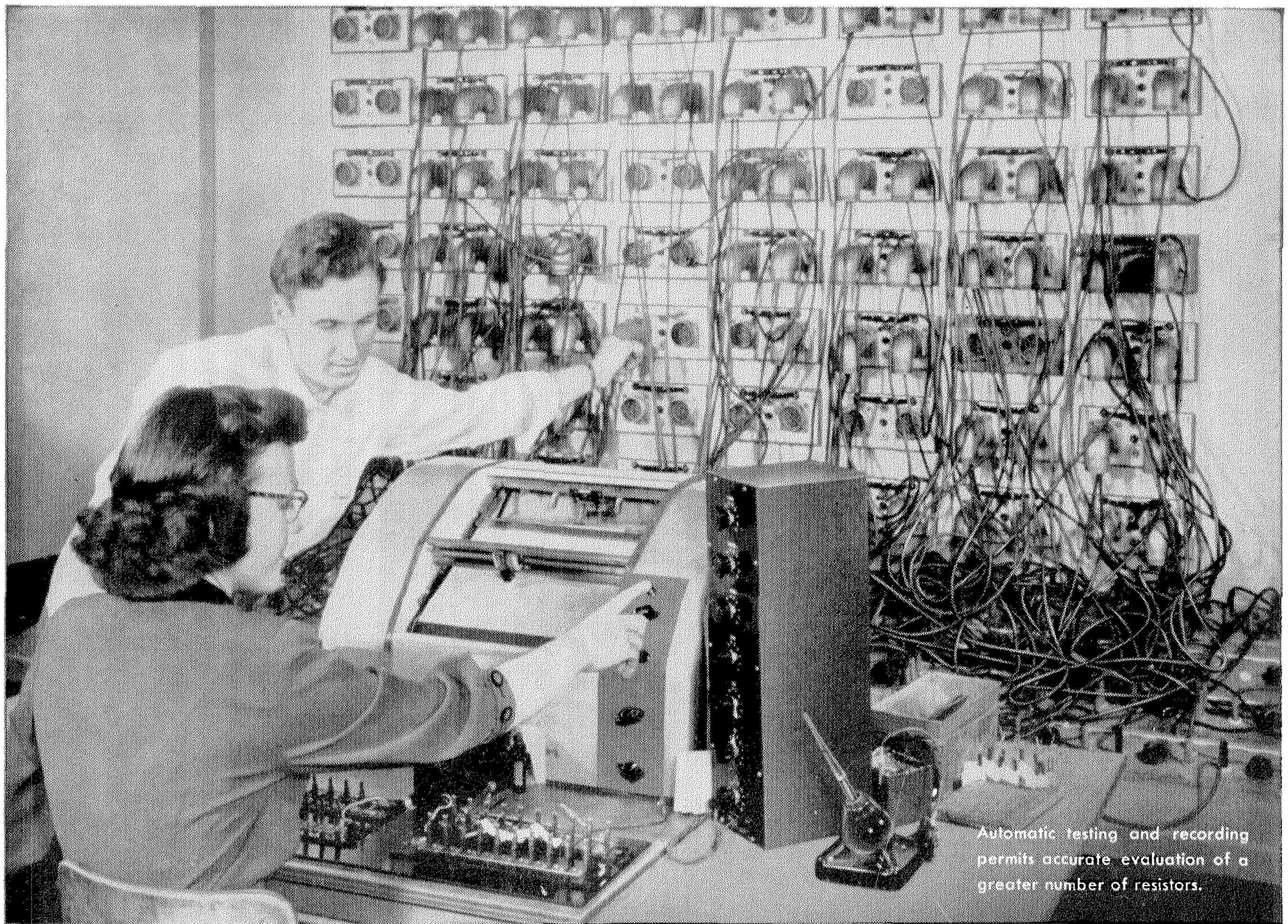
To hunt this killer down, International Nickel has made the ocean into a test tube. At Harbor Island and Kure Beach, North Carolina. Here, Inco Corrosion Engineers study the corrosive effects of salt water, salt spray, salt air, water velocity, marine growths, coupling methods.

To help you plan Inco Nickel into your future, International Nickel Company has collected data from almost a quarter of a million individual tests on the behavior of metals and various other materials under all sorts of corrosive conditions.

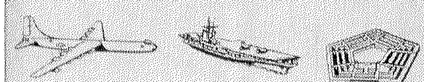
"Corrosion in Action" is an Inco-prepared film in full color. It shows how corrosion acts and how it can be controlled. Prints loaned to engineering classes and student technical societies. Write, The International Nickel Company, Inc., Dept. 126e, New York 5, N. Y.

INCO TRADE MARK **International Nickel**

Producer of Inco Nickel, Nickel Alloys, Copper, Cobalt, Tellurium, Selenium and Platinum, Palladium and Other Precious Metals



Automatic testing and recording permits accurate evaluation of a greater number of resistors.



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JAN and MIL Specifications are basic guideposts for electronic advancement, whether used as engineering reference points or as procurement standards. IRC's dual emphasis on mass production and exacting testing assures highest performance standards at lowest possible cost.

SPECIFIC EXAMPLES

Type BT Insulated Composition Resistors
MIL-R-11A Specification

IRC Power Wire Wound Resistors
MIL-R-26B Specification

Type BW Low Wattage Wire Wounds
JAN-R-184 Specification

Sealed Precision Voltmeter Multipliers
JAN-R-29 Specification

ONLY IRC MAKES SO MANY JAN AND MIL TYPE RESISTORS

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56 different IRC resistors is today's figure—all equivalent to JAN or MIL specifications. Manufacturers of military equipment who must meet these specifications depend on IRC for all their resistor requirements. Offering the widest line of resistors in the industry—138 different types in all—IRC is the logical source of JAN and MIL type units.

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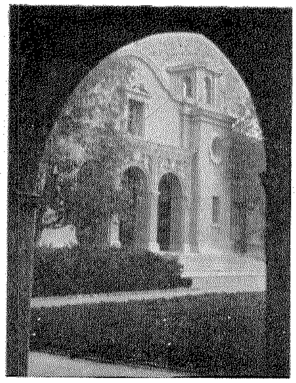

CALTECH CALENDAR

April, 1956

ALUMNI CALENDAR

June 6—Annual Meeting
June 23—Annual Picnic

ATHLETIC SCHEDULE

TENNIS

April 14—Caltech at Pomona-Claremont
April 17—March Field at Caltech
April 19—Pasadena JC at Caltech
May 1—Santa Barbara at Caltech

TRACK

April 14—Caltech at Redlands
April 21—Caltech at Pomona-Claremont
April 28—Caltech at Redlands

SWIMMING

April 13—Caltech at Fullerton JC
April 20—Caltech at Pomona-Claremont
April 26—Redlands at Caltech

BASEBALL

April 14—Redlands at Caltech
April 17—La Verne at Caltech
April 21—Caltech at Occidental
April 28—Whittier at Caltech

FRIDAY EVENING DEMONSTRATION LECTURES

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

April 13—The Structure of Molecules as Determined by the Diffraction of Electrons—
Dr. Verner Schomaker
April 20—Cavitation and Materials Damage
Dr. Albert T. Ellis
April 27—Bio-chemistry and Evolution
Dr. Walter S. McNutt
May 4—Fluorescence in Analytical Chemistry
Dr. Lynne L. Merritt, Jr.
May 11—Radio Astronomy
Dr. John G. Bolton

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