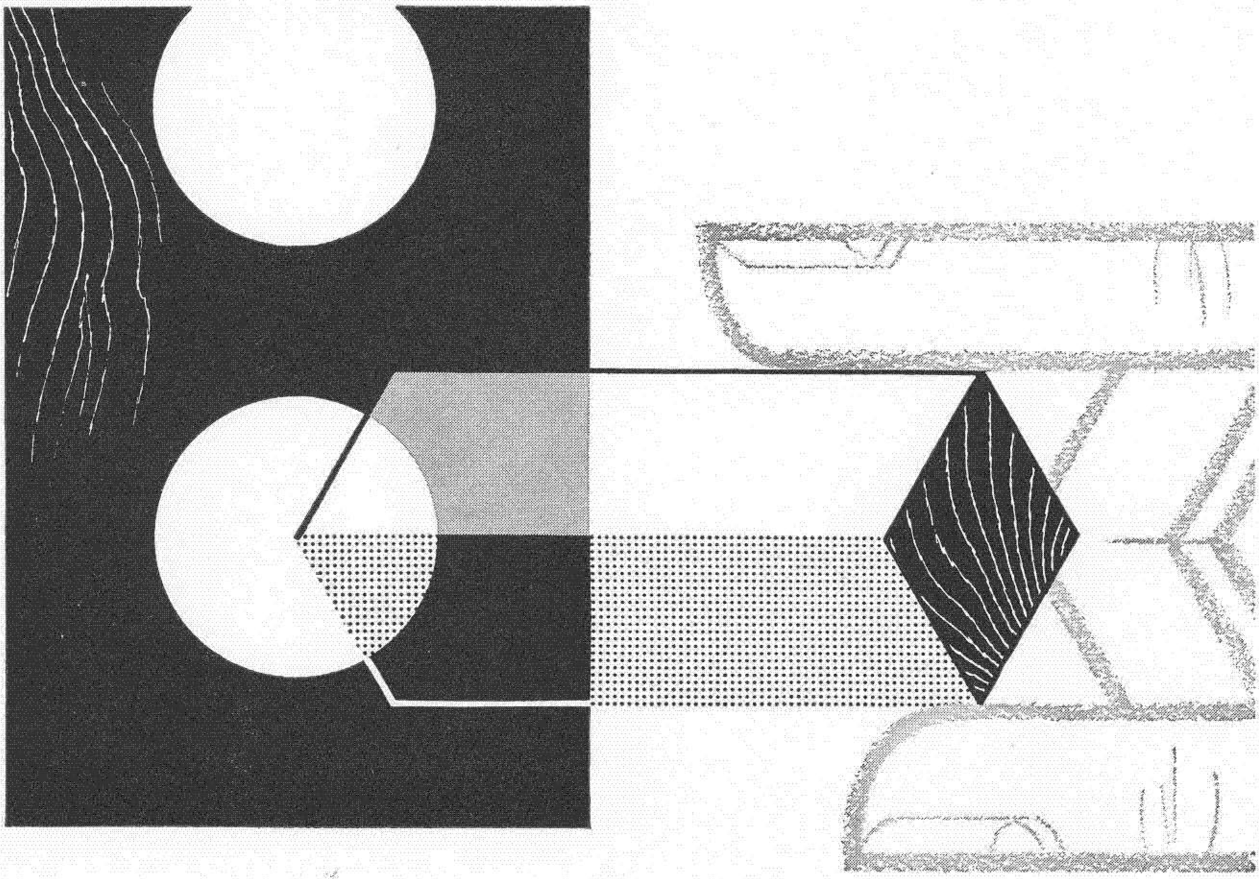
ENGINEERING | AND | SCIENCE

MARCH/1956

PUBLISHED AT THE CALIFORNIA INSTITUTE OF TECHNOLOGY



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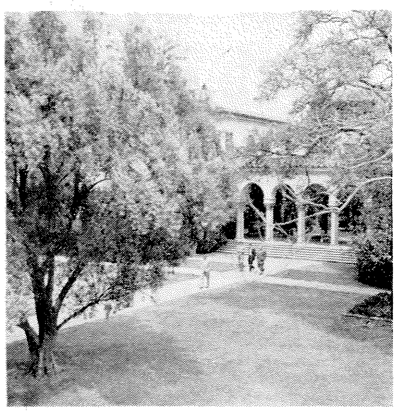
ENGINEERING AND SCIENCE

IN THIS ISSUE



On our cover this month is a rare view of the Olive Walk, taken from the upper reaches of the student houses, looking toward the Athenaeum. What else is rare about this view is that we're running it on our cover at all. Unlike most college publications, ours usually bypasses campus views in favor of scientists and engineers as cover subjects. Here, then, to show what a well-rounded publication this is, is a campus view—and a reminder that we still have a full complement of natural beauty in these parts.

President DuBridge's article on page 13 of this issue, "Things We Do Not Know," has been adapted from a talk given on February 10 to the Los Angeles Rotary Club.

Margaret and Geoffrey Burbidge, who wrote "Cosmical Alchemy" on page 17, are at Caltech this year—she as a research fellow at the Kellogg Radiation Laboratory, and he as a Carnegie Fellow of the Mount Wilson and Palomar Observatories.

An observational astronomer, Mrs. Burbidge got her PhD from the University of London in 1943, has served as assistant director and acting director of the Observatory there. A theoretical astrophysicist, Dr. Burbidge got his PhD in applied mathematics from the University of London in 1951. The Burbidges began a collaboration with Dr. W. A. Fowler last year (when he was a Fulbright professor at Cambridge University) on research which is now continuing at Caltech — and which the Burbidges describe in their article.

PICTURE CREDITS

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BOOKS

ELECTRONS, WAVES AND MESSAGES

by John R. Pierce
Hanover House, Garden City, N.Y. $5

Reviewed by Robert V. Langmuir
Associate Professor of Electrical Engineering

JOHN R. PIERCE, who received all his degrees at Caltech (BS '33, MS '34, PhD '36) has written a clear and simple book about modern electronics. It is written for the intelligent and interested layman at about the level of the *Scientific American.*

After an introductory section on simple mathematics, Newton's laws of motion, and electric and magnetic fields, he treats simple electron optics, microwave tubes and Maxwell's equations. All this is presented in a beautifully clear fashion and can be easily understood by anyone with some technical training, I am not so sure that it can be understood easily by a person untrained in any scientific discipline.

For non-scientific people there is something basically boring about most introductory discussions of Newton's laws of motion which do not use the calculus. One of the reasons for this is that Newton's laws are often used as a language or tool for further discussion of physical phenomena.

I suspect that this part of the book will be somewhat difficult, and possibly dull, for a layman. Certainly the study of languages was dull for me when I was in college, and physics was very exciting. As a result, I specialized in physics. Other students, who had the reverse reactions to these courses, studied further in languages and never touched science again.

To make Newton's laws interesting to such language majors was a very difficult thing. I hope that Dr. Pierce has succeeded, although I am not sure that he has. He has, however, done a far better job than I have ever seen anywhere else. I cannot think of a better textbook for that one required science course in a liberal arts curriculum.

Once the basic foundations are laid, Pierce discusses microwave systems, noise and information theory. The applications of information theory to the English language and to music are fascinating, and should be studied carefully by all who are interested in these subjects.

In the discussion of microwave tubes Pierce gives the case history of a research project—namely, his own work during the past ten years. He manages to convey the curious feeling that attends much good research; the very poor understanding that accompanies successful "pushing back the frontiers of knowledge," and how simple it all seems a few years later. I particularly liked the lack of unjustified philosophizing on scientific matters and his deep suspicion of all analogies.

This book can be heartily recommended to all Caltech graduates in all fields. It would be very interesting to find out how many of the wives of Caltech graduates can read, understand and enjoy this fine book about science for the layman.

On p. 8, an extract from the book.

QUOTE: An extract from "Electrons, Waves and Messages" by John R. Pierce*

LITERATE AND CURIOUS men of every age have thought and read and learned about matters outside of their immediate physical needs and experience. What they have thought and read and learned about has varied from age to age, as both the tasks of everyday life and the aspirations that go beyond these tasks have changed. Sometimes men have been concerned with religion, sometimes with mathematics and philosophy, sometimes with exploration, trade and conquest, sometimes with the theory and practice of government, sometimes with ancient learning, sometimes with the arts.

In different times, in different cultures, these matters have engaged the atttention of the unusually able and intelligent men. When some of the best thought and best effort of a culture is spent in political philosophy, or in classical learning, or in art, the cultured man is the man who is acquainted with, and whose thought reflects, political philosophy, or classical learning, or art.

One can scarcely deny that the most effective thinking of our age, and a great deal of its energy and enterprise, go into science, and especially into the sort of science which guides an immensely complicated technology in doing new things and in doing old things cheaper and better. This prodigious technology in turn supports science with a lavishness unprecedented in any former age.

It is not only true that the world about us would astound a man of a much earlier age. It would astound a man of fifty years ago almost as much. He could not help being astounded by electric power, washing machines, dishwashers, freezers, highways, automobiles, radio, television, airplanes, rockets, nuclear energy. The widespread good living, the rarity of servants, the diminution of great luxury would astound him as much. If he looked more deeply, the growth of science — both in knowledge, in magnitude of effort, and in monetary reward and public recognition as well—would astound him.

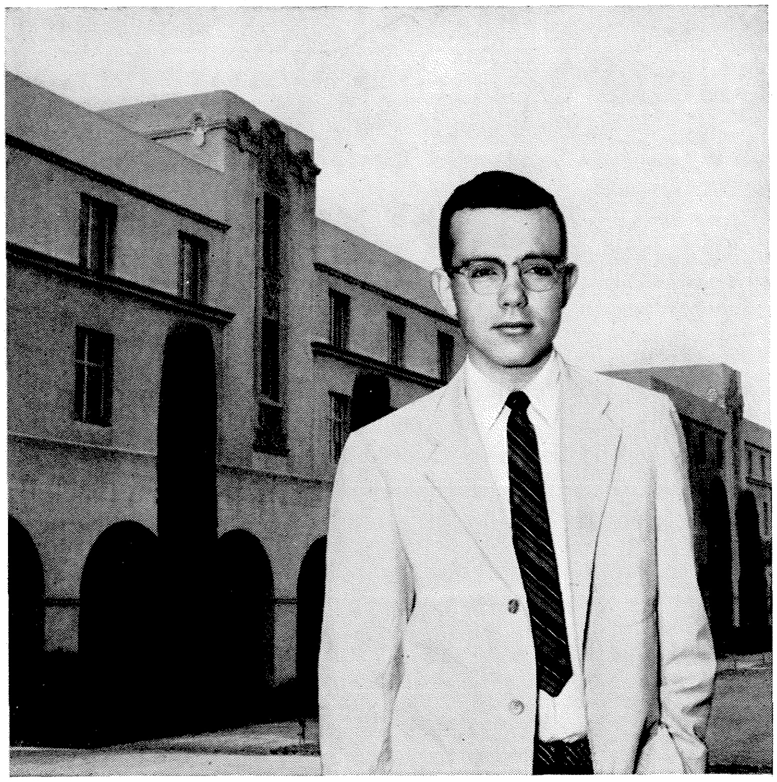
The world of fifty years ago had writers, poets, painters, musicians, philosophers, politicians, and governments. No doubt all of these have changed of recent years. It is clear, however, that the great, the characteristic, the significant changes have been in science and technology and in the way the world is divided into countries and governed. We might even argue that the tremendous political upheavals of our age are primarily a consequence of a revolution in science and technology. Whether or not we go this far, it is clear that science and technology, together with political change and turmoil, are the outstanding features of our culture. Many would put science and technology first.

One cannot be in tune with his age without understanding something of science, and yet this does not seem to have dawned on many people who consider themselves educated or, indeed, on professional educators.

The very things that enable a man to understand something of our culture — mathematics, physics, chemistry — are pared away from the curricula of grade schools, high schools, and colleges, to be replaced by generalizations and surveys. Men who profess to be educated flee frantically from the most significant feature of their culture and seek culture in almost any place but where it is to be found. It sometimes seems to me that writing, painting, and music have become weak, ineffective, and discouraged by seeking nourishment in the decaying remains of the past and ignoring the vigorous thought and achievement of the present.

Suppose we do grant that our science and technology are the great and important contributions of our era, the first things that men should know about when they look beyond the tasks and problems of the day and want to partake in some measure of the spirit and achievement of the times. Is it not hopeless to try to understand a science and technology so multifarious that no scientist can grasp all the details of more than a tiny fraction of it? I believe the answer to be no.

In the past there was less technology to understand. However, in the past technology was empirical art. The understanding of those who had mastered its skills and rules did not go beyond those skills and rules themselves. It seems to me that the outstanding feature of modern technology is that skill, rule of thumb, art, are rapidly being replaced or explained by science, by understanding. Engineering education, which waxes brilliantly while much of education flourishes dubiously, is continually being freed from detailed art and special knowledge to make way for more physics and mathematics, for more and wider fundamental understanding. The engineers who are graduated today are far better educated than I was twenty years ago. Their education is tougher, they learn more that is fundamental and broadly important, and they spend less time on special rules and tedious art. Engineering by handbook is not enough in the modern world. Handbooks last scarcely long enough to become familiar before they are outmoded. An engineer must understand and think to keep up with his art.

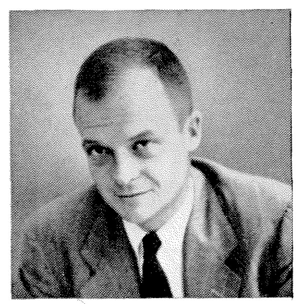


John Young asks:

How does research differ from development work at Du Pont?

John E. Young is working toward his B.S. in chemistry from California Institute of Technology this June. He has maintained honor standing in classwork while serving on the school newspaper, in the debating society, and as treasurer of the student body. John is interested in chemical research and development.

John Aaron answers:



John B. Aaron worked for Du Pont as a summer laboratory assistant even before he graduated from Princeton with a B.S. in 1940. After military service he obtained an M.S.Ch.E. from M.I.T. and returned to Du Pont in 1947. Over the years he has had many opportunities to observe Du Pont research and development work. Today John is process and methods supervisor at the Philadelphia Plant of Du Pont's Fabrics and Finishes Department.

Well, John, it's hard to define the difference in a way that will satisfy everybody, because one always finds a lot of overlapping between research and development work. But most people agree that there are differences, especially in time sequence. Research work comes first, because one of its main objectives is to establish or discover new scientific facts that will supply the foundation for new industrial developments. In other words, research men seek new knowledge about matter, generally working with small quantities of it.

Development work comes later, and Du Pont has two main types. First, there is *new process* development. Here scientists and engineers modify, streamline, and augment the findings of research so that new chemical products can be profitably made on a large scale—or existing products can be made by newer and more efficient methods. Pilot-plant and semi-works operations are usually included under this heading.

Second, an important kind of development work is directed toward improvement of *existing processes and products.* Here the men study how to obtain yield increases, utilize by-products, increase outputs, and solve sales service problems as they arise. This may require considerable research, and that brings us back to the overlapping I previously mentioned.

There are genuine differences, John, but a good deal of similarity, too—especially in the constant need for imagination and creative effort. I think you'll find that research and development work are equally challenging and rewarding at Du Pont.

WANT TO KNOW MORE *about working with Du Pont? Send for a free copy of "Chemical Engineers at Du Pont," a booklet that tells you about pioneering work being done in chemical engineering—in research, process development, production and sales. Write to E. I. du Pont de Nemours & Co. (Inc.), 2521 Nemours Bldg., Wilmington 98, Delaware.*

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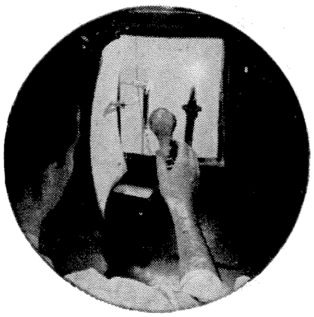
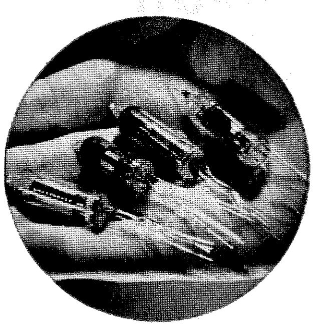
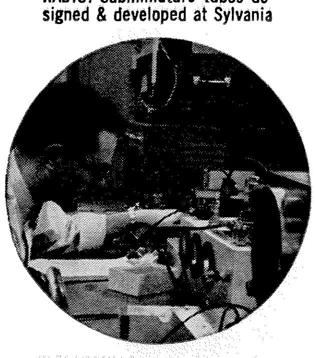


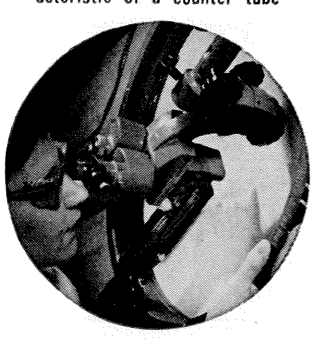
LIGHTING: Testing bulb light transmittance photometrically



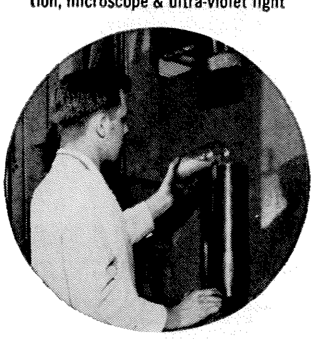
RADIO: Subminiature tubes designed & developed at Sylvania



ELECTRONICS: Testing the characteristic of a counter tube



TELEVISION: Color screen inspection, microscope & ultra-violet light



ATOMIC ENERGY & RESEARCH: Compacting powders on new presses

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THINGS WE DO NOT KNOW

They may be the most important things about a university. Some comments on education and research

by L. A. DuBRIDGE

MANY PEOPLE ASSUME that the main business of a university is to deal with things that we know; that the main business of a professor is to know a lot. But some of the most important and exciting things about a university are the things we *don't* know; or possibly the things about which we know only a little and would like to know a little more. This suggests the basic truth—often forgotten—that the most valuable professor is not necessarily the one who knows the most (certainly not the one who *thinks* he knows the most) but the one who has the most consuming desire to know more.

And so it is that the most important thing about Caltech is that it contains a lot of people who realize how little they know about the physical world and are willing to spend their lives learning a little bit more.

Many an able scientist has worked all his life on things he didn't know—making slow but steady progress, yet never running onto anything earth-shaking. Others, through good luck or exceptional insight, or both, make many spectacular advances. But they never know ahead of time what their discoveries will be. That is the difficulty about exploring the unknown. It really *is* unknown; you just don't know what you will find—if anything. What we do know is but a tiny island in a vast sea of ignorance.

The ancient Greeks used to think that one could learn everything there was to know about the world by just sitting in a chair and thinking. So that is what they did. They thought up some pretty good ideas, too; but they also invented some real cock-eyed ones! And the trouble is, they did not know how to tell which were the good ideas and which were the bad. Not until Galileo came along 1500 years later and started doing *experiments* did anyone find out which Greek theories were right and which were wrong. Today we know that experiment and theory must go hand in hand in our quest for understanding the physical world.

With this introduction, let us look at some of the things going on at Caltech. Down in the basement of the Norman Bridge Laboratory of Physics we find Dr. Carl Anderson hard at work. Thirty years ago he was a student at Caltech and began working with Dr. Robert A. Millikan in his search for knowledge about cosmic rays. A few years later Dr. Anderson, in his cosmic ray pictures, identified a new kind of particle—called a positron or positive electron. It was a breathtaking discovery which earned him a Nobel prize. He has been taking pictures of the tracks of cosmic ray particles ever since and he and others have discovered several other kinds of new particles, too—mesons and V particles and K particles—and they have learned a great deal about their properties.

However, there is far more here that we don't know than we ever suspected. There is a whole array of new particles (we counted up 15 the other day) whose existence was quite unsuspected a few years ago and whose role in the scheme of things is still quite mysterious. Most of these particles are found in cosmic rays but they do not come in to the earth from outer space; they are created in our atmosphere or in the apparatus itself by other primary particles which do come in from outside. How are all these particles created? Still more puzzling—what happens to them?

Some of them exist for only a millionth of a millionth of a second and then they are gone. Where? We know about some of them; they simply blow up into other particles or vanish into radiation.

Some of these particles—mesons—clearly have some terribly important part to play in holding nuclei together. But just how? They do not have any real existence in nuclei. Yet they can be knocked out of nuclei!

To find out more about these questions, Dr. Robert F. Bacher and his colleagues have built a synchrotron in the big building where the 200-inch mirror for the Palomar telescope was ground and polished. This machine has been making half-billion-volt X rays; it will soon be boosted up to a billion. Such high-energy X rays are pretty good at knocking mesons out of protons.

The atomic nucleus

Now the proton—the nucleus of hydrogen—is the one particle that we used to think was a permanent elementary thing. Yet any number of mesons can be knocked out of it—leaving a neutron behind which promptly converts itself back into a proton! A mysterious process, indeed, in which energy is being converted into matter.

There are thousands of unknowns there. Maybe some day we will be able to learn how the atomic nucleus is put together. Right now all we know is how to make it fly apart. Just that knowledge will soon be the basis for a new power industry. But there is so much *more* to learn.

Even the astronomers are becoming nuclear physicists these days. We know that the sun is a kind of continuously operating H-bomb—deriving its energy from nuclear processes which, on a small scale, we can observe in the laboratory. Hence, we can hope some day to know more exactly what goes on in the sun and in the stars. Some of the stars are very different from the sun—are kept warm by a very different set of nuclear processes. Is the sun a sort of second or third generation star, descended from other types? Or are the other types descendants from stars like the sun? What is the evolutionary history of the stars? A quantitative study of the nuclear reactions which go on in stellar interiors—a long and very complex series of nuclear transmutations—is revealing the actual figures from which calculations can be made which will reveal the true story. Dr. W. A. Fowler and two visitors from England, Dr. and Mrs. G. R. Burbidge (*see page 17*), are making exciting progress on this problem.

Let us now cross the campus and look into the biology building. We have, as a matter of fact, just completed a new building there—the Norman W. Church Laboratory of Chemical Biology. In this laboratory, members of our Division of Biology join with the members of our Division of Chemistry for a joint attack on a whole series of unknown questions concerning the chemistry of living materials.

One of the most important living materials and one of the most interesting is that group of mysterious particles called viruses. A few short years ago almost everything about viruses was unknown. All that was known was that they were substances which caused diseases in plants and animals—but were too small to be seen in the most powerful microscope, and even too small to be filtered out in the finest filter. Nevertheless, ways were found for studying these viruses and the electron miscroscope now makes it possible to actually see them. There are many, many kinds of viruses—some shaped like cylinders, some like spheres, some like tiny hair-like snakes, some like tadpoles. These little objects constitute a kind of transition state between inanimate and animate matter. Each virus particle is actually a rather simple system made up of a few very complicated molecules. The virus substance can be crystallized, stored away, and kept in a bottle on a shelf for years like any other chemical. However, when the substance is put into the proper environment—the right living cell—the molecules suddenly come alive and begin to multiply.

Some types of viruses live only on bacteria and in living on them destroy them. Many of these are friendly viruses which could conceivably provide us with powerful tools for fighting diseases caused by bacteria. Other viruses, however, such as that of poliomyelitis, attack the nerve cells of animals; they may destroy them and therefore cause serious disease. We have an active virology laboratory at Caltech and in the new Norman Church building a suite of rooms has been provided with the finest equipment for virus research.

A few years ago Dr. Renato Dulbecco and his colleagues discovered a completely new technique for studying animal viruses—a technique which now enables them to make 100 experiments in the time and at the cost for a single experiment a few years ago. As a result, information is now being rapidly collected on how these creatures behave, what substances they live on, and how they grow and multiply.

Viruses and genetics

As with more complicated organisms, each generation of viruses inherits the characteristics of its parents, but there are frequent mutations and new genetic strains develop. The study of the genetics of the viruses has a double value: (1) It sometimes happens that a new strain will be developed which is relatively harmless and yet it will cause the animal tissue to develop antibodies which will kill the other harmful strains; thus vaccines against harmful viruses may be developed. (2) At the same time the virus, being a simple creature, has simpler genetic properties than, say, human beings and hence we can learn much more about the mechanics of the inheritance process.

As a physicist, I have never understood the complex subject of inheritance. All I know is that the unit of all inheritance, the gene itself, is also one of these particles that lie at the transition zone between the living and the dead. Like the virus, it is also a large and complex molecule, and in recent years important progress has been made in learning about the structure of the molecule. The extraordinary thing about these gene molecules and the virus molecules is that, when placed in the proper environment, each can serve as templates or molds to form or build up other molecules just like themselves. This suggests that the basic process of reproduction in all living things is that of complex molecules serving as a pattern to form, out of surrounding material, other molecules precisely like the originals.

Yes, biology is a fascinating and important subject —full of interesting unknowns.

But let us turn to our laboratory of geology.

The research worker in geology is usually thought of as a person equipped with a pair of high boots and a hammer who hikes into the mountains to bring back interesting rocks—especially rocks which might contain gold or uranium.

Well, of course, geology does deal largely with the earth's crust—which is largely rock—and so depends heavily on detailed exploration of the earth's surface. But new tools and techniques have been added in recent years—the tools of the nuclear physicist and of the isotope chemist, for example.

A primary interest of the geologist is the history of the earth—how it was formed, how the mountains and seas came into being, something about the rise and fall of various forms of life which have left their fossil remains—and also the processes now going on, such as volcanic activity, changing climate, the building of coral islands in the sea.

The earth

There are lots of things we don't know about the earth. We do not even know the answer to such a simple question as whether the earth as a whole is getting cooler or warmer. Of course, we know as we go down deep in a mine or an oil well that the temperature rises, which means that heat is flowing up to the surface and escaping into space. In the old days, this was regarded as quite adequate evidence that the earth is cooling off. But with the discovery of radioactivity it was realized that there was a source of heat in the earth—uranium, radium and other radioactive materials are slowly decaying, losing a part of their mass, which is transformed into heat. It turns out that quite a lot of heat is generated in this way. We still do not know whether the rate of heat generation is greater than the rate of loss—that is, whether we are getting hotter or colder.

Modern chemistry has provided a new tool for learning something of the temperature history of fossil shells as found, for example, in sedimentary rocks. It turns out that the ratio of abundance of the two isotopes of oxygen—O^{16} and O^{18}—contained in most living material depends on the temperature at which the material was formed. Thus we are able to determine the temperatures which existed hundreds of millions of years ago. We already know from examining the animals in the La Brea tar pits that less than 100,000 years ago southern California was both wetter and hotter than it is now. As yet, however, there is no decisive evidence that the earth two billion years ago was either much hotter or much colder than now.

It has been recently determined from the ratios of lead isotopes in meteorites and materials of the earth's crust that the earth is just about 4½ billion years old —that is, it has been solidified in its present form for that long. The astronomers now believe that the universe is only about 5 billion years old—so if the earth did much cooling off after it was formed it must have done it pretty rapidly!

Hotter or colder?

Actually, since the half-life of uranium is only about a billion years, there was much more of it on the earth 4½ billion years ago than now. So the earth might have been formed cold—then been slowly heated up for a billion or two years by the uranium and then gradually cooled off as the uranium disintegrated. We don't know whether we have already passed, or not yet reached, the maximum temperature. Professor Harrison Brown is directing a group of geochemists in the attack on such problems.

The Division of Geological Sciences is also the place where they study earthquakes. (Our Seismological Laboratory is, in fact, one of the best equipped—probably *the* best equipped—in the world.) Earthquakes are interesting to southern Californians for obvious reasons. For example, over in the Engineering Division our structural engineers apply synthetic earthquake-vibration patterns to simple model structures—like buildings and bridges. They can then tell you how to design a building so that it will not fail in a severe earthquake. That's one thing they *do* know.

But earthquakes are interesting geological tools, too. Seismologists are very much pleased when a quake occurs for these disturbances serve as probes to explore the interior of the earth. Indeed most of what we know about the earth—down below the 4 or 5 miles you can go with an oil well—has been learned from earthquakes, either natural ones or man-made ones. The waves from an earthquake which occurs, say, in Borneo will travel clear through the center of the earth and come out in Pasadena. In fact, a whole series of waves will bounce off various discontinuities in the earth, be reflected back from the surface and give rise to the most complex patterns of wiggles on a seismological instrument. Dr. Beno Gutenberg and his colleagues have learned how to sort out these wiggles and can tell which ones are waves which came through—or bounced off—the earth's core.

Other earthquake waves travel along the surface through the earth's crust—and from the speed with which they travel, the way in which they are reflected, and the differences in travel time between waves of different frequencies one can learn a great deal about the structure of the earth's crust, about the formations which are inaccessible under the bottom of the sea and about the structure of the roots of the mountain ranges.

There are, of course, two kinds of research which go on at Caltech: pure research, which is the discovery of new knowledge about nature; and applied research, which is the application of this knowledge to develop devices or techniques of practical use to men. Many people think of Caltech as the home of pure research—the search for knowledge for its own sake. We are indeed glad to have and even to promote this reputation, for we are proud of the achievements in pure research of the Institute over the many years since Dr. Millikan's pioneering work here, beginning in 1921.

Practical matters

However, it is very unfair to a large segment of our campus to pretend that there is no work of a practical nature under way—no attempt to apply the knowledge of science to things that are beneficial and directly useful. Our Engineering Division makes it its business to carry on research in the various fields of engineering and to apply scientific knowledge to the development of such things as chemical processes, design of machinery, the study and development of metals and alloys, the study of the behavior of turbines and pumps with an eye to improving their effectiveness and efficiency, studies in the best design for various types of structures—including the work I have already mentioned in earthquake resistant structures—a study of high-speed aerodynamics with an eye to the design of supersonic airplanes and guided missiles, and the study of materials useful in the structure of aircraft and of jet engines.

Some of the first wind-tunnel tests on large models of aircraft ever made in the United States were made in the old wind tunnel of the Guggenheim Aeronautics Laboratory at Caltech in the late twenties, and these tests plus the succeeding wind-tunnel work which went on there in the early thirties did much to build and strengthen the aircraft industry of southern California. The modern wind tunnels at Caltech, instead of operating at speeds of 180 miles an hour, operate at speeds of from five to ten times the speed of sound. There is even one small experimental wind tunnel using helium instead of air which for short periods can attain speeds of twenty times the speed of sound.

The work done in the High Voltage Laboratory by the electrical engineers on the problem of the transmission of electric power over great distances resulted in the development of high voltage transmission techniques which made possible bringing electric power from the High Sierras and from the Colorado River to Los Angeles.

In the Hydrodynamics Laboratory there are water tunnels which serve for water-borne craft and undersea craft the same function that wind tunnels serve for aircraft.

Throughout all the engineering departments there is work going on which has made possible the design and building of more effective equipment, machinery and devices now being manufactured by American industry.

But it is not only in engineering that work of practical importance is done. An able biochemist, Dr. A. J. Haagen-Smit, a few years ago began to get curious about the chemical nature of the Los Angeles smog. Up to that time, it was actually unknown what particular chemical materials were responsible for the objectionable effects of smog, such as eye irritation, the cracking of rubber and damage to plants. Some thought the irritating substance was black smoke; others thought it was sulfuric acid formed from sulfur and others thought it was fumes from synthetic rubber plants. Actually, the irritating substances turned out to be materials formed in the air by the action of sunshine on the vapors of unburned oil and gasoline and the oxides of nitrogen. The oxides of nitrogen, it turns out, are formed in any combustion process. The raw gasoline and oil vapors are emitted into the air in a variety of ways — through evaporation of gasoline from tanks, from filling stations and from cars, as well as through the emission of unburned hydrocarbons from the exhausts of cars, from the stacks of oil-burning fires of many kinds. The problem of eliminating smog, then, is the problem of stopping the emission into the air of hydrocarbons and of the oxides of nitrogen. To reduce by a large amount the emission of either of these types of substances is not an easy problem; but whether it is easy or not, that is the problem which we must solve if air pollution in Los Angeles is to be reduced.

Research and education

There are, of course, many other things of interest that are happening on the Caltech campus. The field of the unknown is a vast one and the attacks on it are going forward on many different fronts.

Nevertheless, I should like to emphasize that, with all the research going on, Caltech is primarily an educational institution. Our major function is to select young men who have exceptional talents in the fields of science and engineering; to assist them in developing their talents to the maximum degree; and to help them prepare themselves for careers of exceptional usefulness in extending the bounds of scientific knowledge, or in applying such knowledge to the satisfaction of human needs, or in becoming teachers to carry on the education of the next generation. Since a large fraction of our students will be going into research, development and engineering work, it is obviously necessary that their professors be actively engaged in such work. Our research work therefore is an inherent part of our educational program and vice versa. At Caltech education and research are not two unrelated activities but they are heads and tails of the same coin.

COSMICAL ALCHEMY

Combined research from four fields of science—physics, astrophysics, astronomy and geochemistry—leads to a new theory of the synthesis of the elements in stars

by MARGARET and GEOFFREY BURBIDGE

FOR MANY YEARS physicists and astronomers have speculated on the origin of the chemical elements. In every case they have tried to understand the conditions under which all of the elements could be built up out of the fundamental building blocks, which are protons, neutrons and electromagnetic radiation. In the last three or four years many ideas have come from staff members or visitors at Caltech. These suggest that the element-building processes have gone on, and are continuously going on, in the interiors of stars.

It has been known since the classical work of Hans Bethe in 1938 that the energy radiated by stars is released in the stellar core by the conversion of hydrogen into helium through the carbon cycle or the proton-proton cycle. From 1950 to 1952 R. N. Hall, E. J. Woodbury, and A. W. Schardt, working as graduate students in the Kellogg Radiation Laboratory under Drs. W. A. Fowler and C. C. Lauritsen, made measurements on the carbon cycle reaction probabilities at low energies and experimentally confirmed Bethe's ideas.

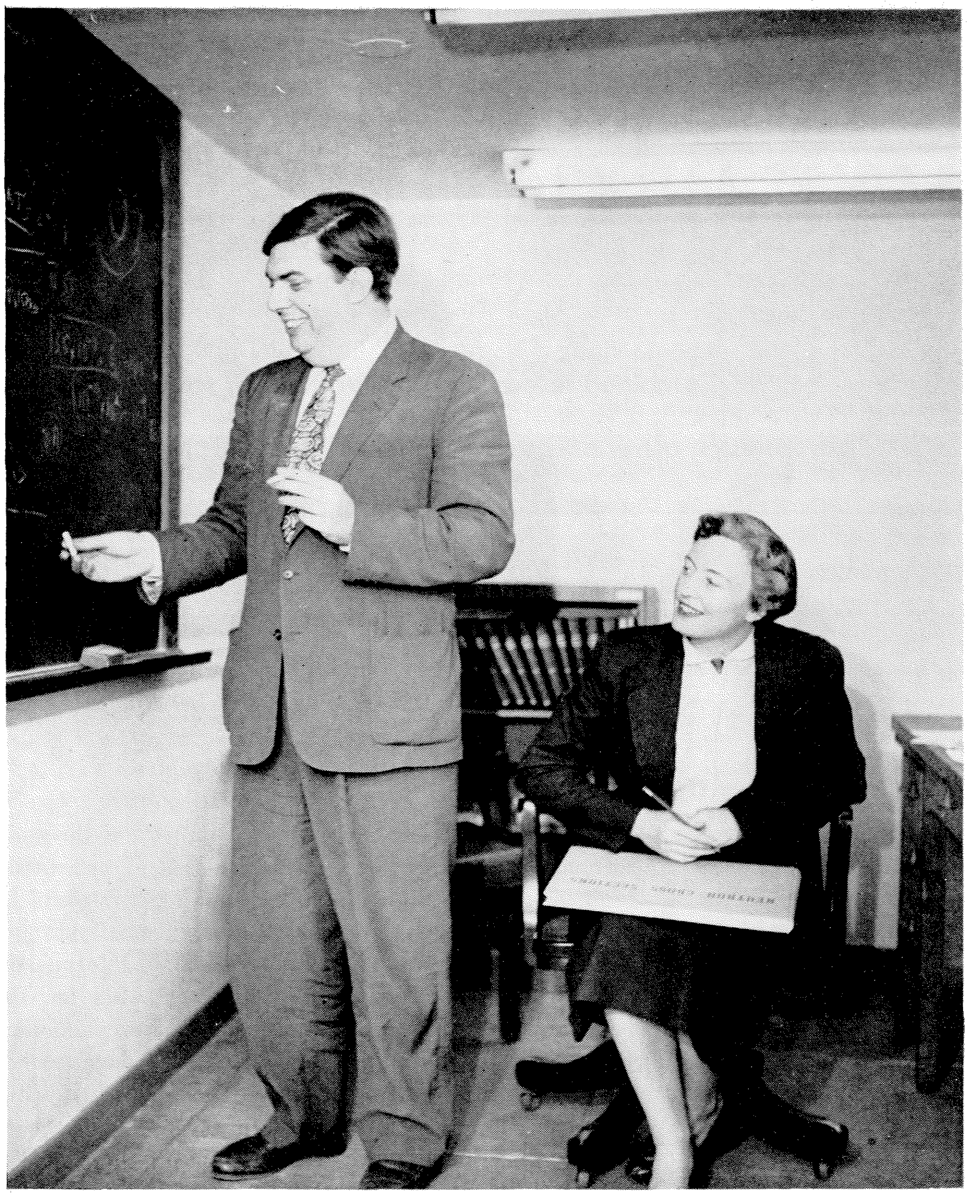
Until recently, reactions producing elements heavier than helium were not considered to be possible in stars. However, in 1949 Dr. Alvin Tollestrup, now assistant professor of physics in Caltech's Synchrotron Laboratory, investigated, with Fowler and Lauritsen, the properties of beryllium 8, an isotope of beryllium of mass approximately eight times that of the proton or neutron, which does not exist in nature and is therefore presumably unstable but which can be produced momentarily in the laboratory. He showed that the beryllium 8 was indeed unstable but broke up into two helium 4 nuclei (alpha-particles) with the release of only 100 kilo-electron volts of energy.

This result laid the groundwork for Dr. E. E. Salpeter of Cornell University, on a visit to Caltech in the summer of 1951, to show theoretically that if sufficiently high temperatures (about 100 million degrees) could be reached in the helium cores of stars, a small but not negligible amount of beryllium 8 would be formed in equilibrium with the helium. Before breaking up, the beryllium 8 has a chance to capture another alpha-particle to produce a stable carbon 12 nucleus. Then further alpha-particles would be captured by the carbon to produce, successively, oxygen, neon, magnesium and silicon.

Since beryllium 8 exists only for a very short time it cannot be bombarded in the laboratory as can stable nuclei. However, at the present time an experiment is underway in the Kellogg Radiation Laboratory in which the break-up of an excited carbon 12 into beryllium 8 and an alpha-particle and thus eventually into three alpha-particles is observed. This indicates, by the general laws concerning the reversibility of physical reactions that the process by which alpha-particles form carbon 12 will take place in stars under appropriate conditions. It appears, therefore, that some of the lightest and most abundant elements can be produced by helium reactions.

To build the rest of the light elements, like fluorine, sodium and aluminum, we need to suppose that the carbon, oxygen and other light elements will interact with protons and alpha-particles. The consequences of such activity have been worked out by Fred Hoyle, Fellow of St. John's College, Cambridge — when he was visiting professor at Caltech in 1953 — and by W. A. Fowler—when he was visiting Cambridge as Fulbright professor in 1954-55—with Margaret and Geoffrey Burbidge at the Cavendish Laboratory, University of Cambridge.

It may be asked at this stage whether there is any



Margaret and Geoffrey Burbidge, from Cavendish Laboratory at the University of Cambridge, England, are at Caltech this year to continue their work with Dr. W. A. Fowler on the astrophysical processes by which elements are produced in stars.

observational evidence that there are stars which have central temperatures hot enough for such reactions to take place. Recent work on the evolution of the stars suggests that the red giant stars, which are colossal nuclear furnaces, and which have diameters many times larger than that of the sun, but whose surface temperatures are cooler than the sun's, do have conditions near their centers which are suitable.

Now, in order to build elements heavier than those already mentioned, more complicated processes have to be introduced. Hoyle has suggested that the elements from silicon right up to titanium may be built by the interactions of charged nuclei, like helium and carbon. However, it is almost certain that this is not the whole story.

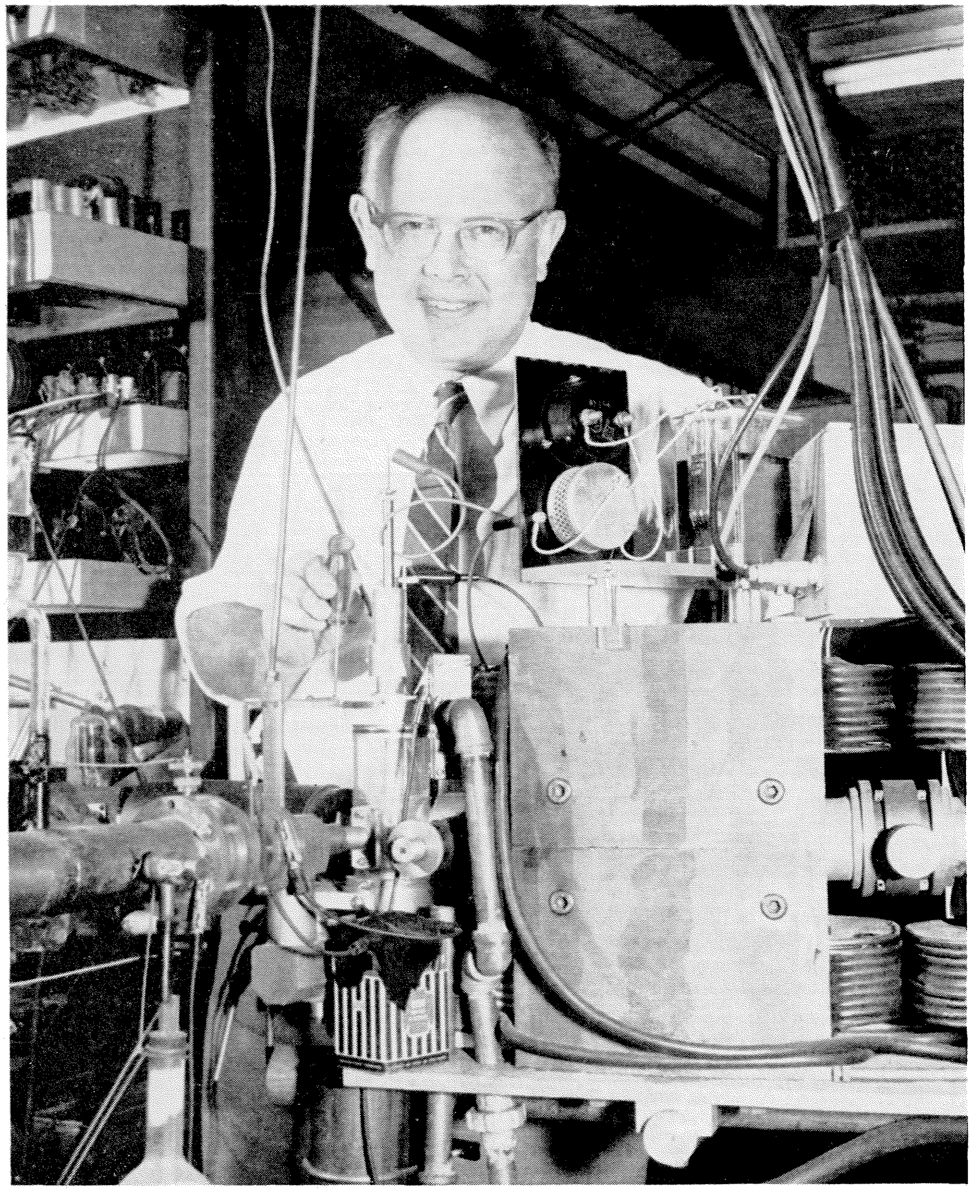
In this connection, a very important step forward was made by Dr. A. G. W. Cameron of the Chalk River Atomic Energy Establishment in Canada, who suggested that if a carbon 13 nucleus captures an alpha-particle, the end product would be an oxygen nucleus together with a neutron. Thus, if this process goes on inside red giant stars, a source of neutrons will be produced.

These neutrons will very rapidly reach equilibrium with the hot gas in the star's interior and then they will be captured by the other elements. If a number of successive capture processes take place on the same nucleus, we can easily see that we shall build heavier and heavier elements. There are some measurements of the probabilities of capture of neutrons by different nuclei, and it is possible to calculate what will be the relative numbers of nuclei of different kinds which are produced by such a process.

Such a calculation suggests that maybe not enough neutrons are produced by Cameron's process to build the elements to the required levels, and Fowler and the Burbidges have therefore suggested, as an alternative, a similar process in which a neon 21 nucleus interacts with a helium nucleus, giving a magnesium 24 nucleus and a neutron.

Under suitable conditions this process will provide

W. A. Fowler, professor of physics, at the observation station of the two-million-volt accelerator in the Kellogg Radiation Laboratory. Evidence for the formation of carbon from three helium nuclei has recently been found with this equipment.



more neutrons than that described by Cameron. So neutron sources of this sort may arise inside stars which have already built either the light elements up to neon or silicon, or in stars which already contain iron and the elements near to it in the periodic table. If the stars have only got the light elements, these then will capture all of the neutrons, and the intermediate elements between neon and titanium will be built.

Calculations by Fowler and the Burbidges suggest that a large proportion of the elements in this region of the periodic table will be built by this process, though some may also be built by the charged particle reactions described by Hoyle. If, on the other hand, the star already contains the metals in its core, these will capture all of the neutrons and the very heavy elements from nickel to lead will be built up.

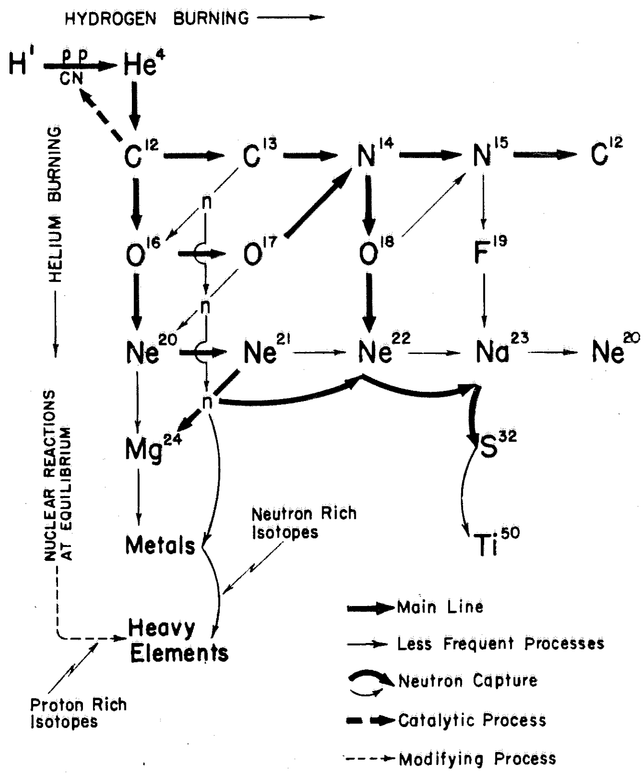
When the cosmical abundances of all of the elements are collected together and plotted on a curve of relative numbers of atoms against their atomic weight, as has been done, for example, by Dr. Harrison Brown, Caltech professor of geochemistry, this curve shows a large peak for the atoms in the metallic group, with the maximum at iron.

This peak cannot be explained by any of the processes described so far. To explain it, Fred Hoyle has suggested that the star contracts again and so its temperature and density rapidly increase. When a temperature of about five billion degrees is attained the nuclei reach equilibrium, one with another, and calculations made by Hoyle suggest that most of the matter in the core of the star will be transmuted into atoms of iron and other elements close to it, so that in fact the central region of the star is simply an iron ball.

More detailed calculations along these lines are now being made at Caltech. In the diagram at the top of page 20, the various reactions which have been described by Fowler and the Burbidges are shown schematically.

Thus the various steps of this argument suggest that the majority of the elements between hydrogen and lead can be processed over very long times in the interiors

Synthesis of the Elements in Stars



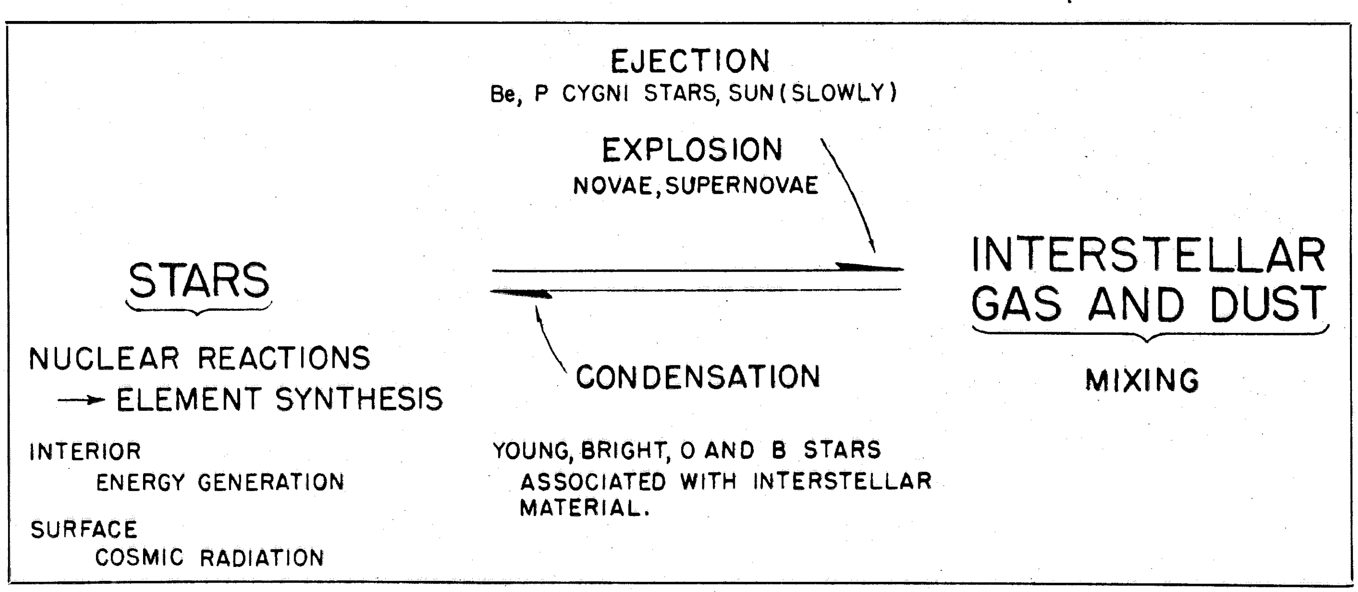
of stars. Observational evidence in support of this type of theory has been found by astronomers who have analyzed the spectra of stars of different brightnesses, masses and ages, and they find evidence in them of differences in chemical composition. Much of the work along these lines has been carried out by Dr. and Mrs. Martin Schwarzschild of Princeton and Dr. L. H. Aller of the University of Michigan—when they were visiting the Mt. Wilson Observatory—by Dr. Jesse L. Greenstein and Dr. Paul Merrill of Mt. Wilson and Palomar and Caltech, by the Burbidges and Dr. W. P. Bidelman —when they were working at the McDonald Observatory, and the Universities of Chicago and Texas—and by others.

Some stars show large amounts of carbon, and the ratio of the numbers of carbon 12 and carbon 13 atoms in them is different from the ratio in normal stars, suggesting that the processes involving the building of carbon have been going on in there. Greenstein has made contributions on this subject, and also on the abundance of lithium and beryllium in the sun, which are of importance in considering the depth to which the surface material of the sun is stirred up and mixed inward by convection currents.

Other stars in the red giant stage show apparently large abundances of the very heavy elements, suggesting that in them the neutron capture processes are going on. The discovery of technetium in some of these stars by Merrill is an extremely good pointer in this direction. This element is unstable and has a half-life against decay of about 200,000 years. It has been produced in the laboratory by bombarding molybdenum with neutrons from a nuclear pile. Thus when it is found in stars this is a good indication that it is being produced in their interiors by neutron bombardment and that it is traveling to the surface in a time which will be less than 200,000 years. Also, some of the older stars appear to have proportionately less of the metals and heavy elements than younger stars.

No adequate theory has yet been proposed to account for the production of the elements heavier than lead and up to uranium. The difficulty here arises through the decay properties and short decay times of some of these nuclei, but it remains a challenging problem for the future. The very light elements, deuterium (which is the heavy isotope of hydrogen), lithium, beryllium and

How Elements Are Produced in Stars and Distributed in Space



Jesse L. Greenstein, professor of astrophysics, working with a comparator, in which the spectra of two different stars are seen at once, presenting a comparison of the strength of lines of different elements.

boron cannot be built in the interiors of stars, as they are unstable at temperatures of only a few million degrees and will frequently tend to be broken up.

To overcome this difficulty Fowler and the Burbidges have proposed that these elements are built on the surfaces of stars, where in some cases peculiar conditions of magnetic fields, etc. exist which allow ions to be accelerated by giant betatron effects, so that they can gain enough energy to interact with the other material which is only at a few thousand degrees, and in the resulting collisions produce these elements.

To conclude, we can indicate schematically what conditions are demanded for this kind of cosmical alchemy. The diagram at the left shows how the interchange of material between stars and the interstellar medium may take place.

We believe that our galaxy was, about five billion years ago, a large turbulent whirling sphere of hydrogen gas. Within this sphere stars began to condense out of hydrogen, and the sphere began to flatten, forming the disk which we see today. Probably a number of very large stars formed, and, because they were so massive, they had a comparatively short lifetime during which a proportion of them built some of the elements by the processes described above. Then, possibly through gigantic supernova explosions, the material was blown out from them, and it formed part of the gas out of which the second generation stars were formed.

These stars may now be those which we observe to have low abundances of the metals. However, some of these stars also may have become unstable and blown off some of their material. Thus third generation stars may have formed. The majority of the stars which we can study are comparatively near to the sun. These stars are considered to have the normal "cosmical abundances" of the elements and thus may be third generation stars. However, on the basis of a theory of this sort, we would expect that the chemical composition of the stars would be related to their age and to their evolutionary tracks in time.

R. R. MARTEL

Professor of Structural Engineering

R. R. MARTEL, Caltech professor of structural engineering, has had a long and successful career, both as a teacher of civil engineering and as a consultant in the fields of bridge design and the design of flood control structures and reservoirs. He is nationally known as an authority on the design of structures to resist earthquakes.

When a man has such a distinguished record and reputation, it is usually interesting to know something about how he got his start, and what it was that led him into a career that has proved to be so impressive.

Martel has a simple explanation. He was a high school senior, and not at all sure what field he wanted to get into, when he happened to see a surveyor at work one day. It was the first surveyor he had ever seen, and this carefree character was wearing a slouch hat, gloves and boots; he was working out in the open air; and he was operating a fascinating-looking instrument. All in all he looked like a man living a good life. Then and there Martel decided that it was the life for him. He went into civil engineering.

If this story seems regrettably short on inspirational values for the oncoming generation of civil engineers, let them merely consider the fact that Martel has never regretted this seemingly chance choice for a single instant; he's *still* living that good life.

R.R. (for Romeo Raoul) Martel was born in Iberville, Quebec, in 1890. His father, a farmer, soon moved the family to the United States, however, and when Romeo was six months old they settled in Pawtucket, Rhode Island, where the elder Martel went into the real estate and insurance business.

In 1908 Romeo entered Brown University (where his freshman English instructor, a young man teaching his first class, was George R. MacMinn, now professor emeritus of English at Caltech). After graduation Martel taught civil engineering for a year at Rhode Island State College, then at Mechanics Institute in Rochester, New York, for another year. In 1915 he went to work as assistant engineer for the Sayles Finishing Plants, a string of cotton mills scattered through Rhode Island. In 1918, several months after he had taken a job with the Atchison, Topeka and Santa Fe Railroad in Amarillo, Texas, he was offered a teaching position at Caltech. This offer was, to put it mildly, something of a surprise.

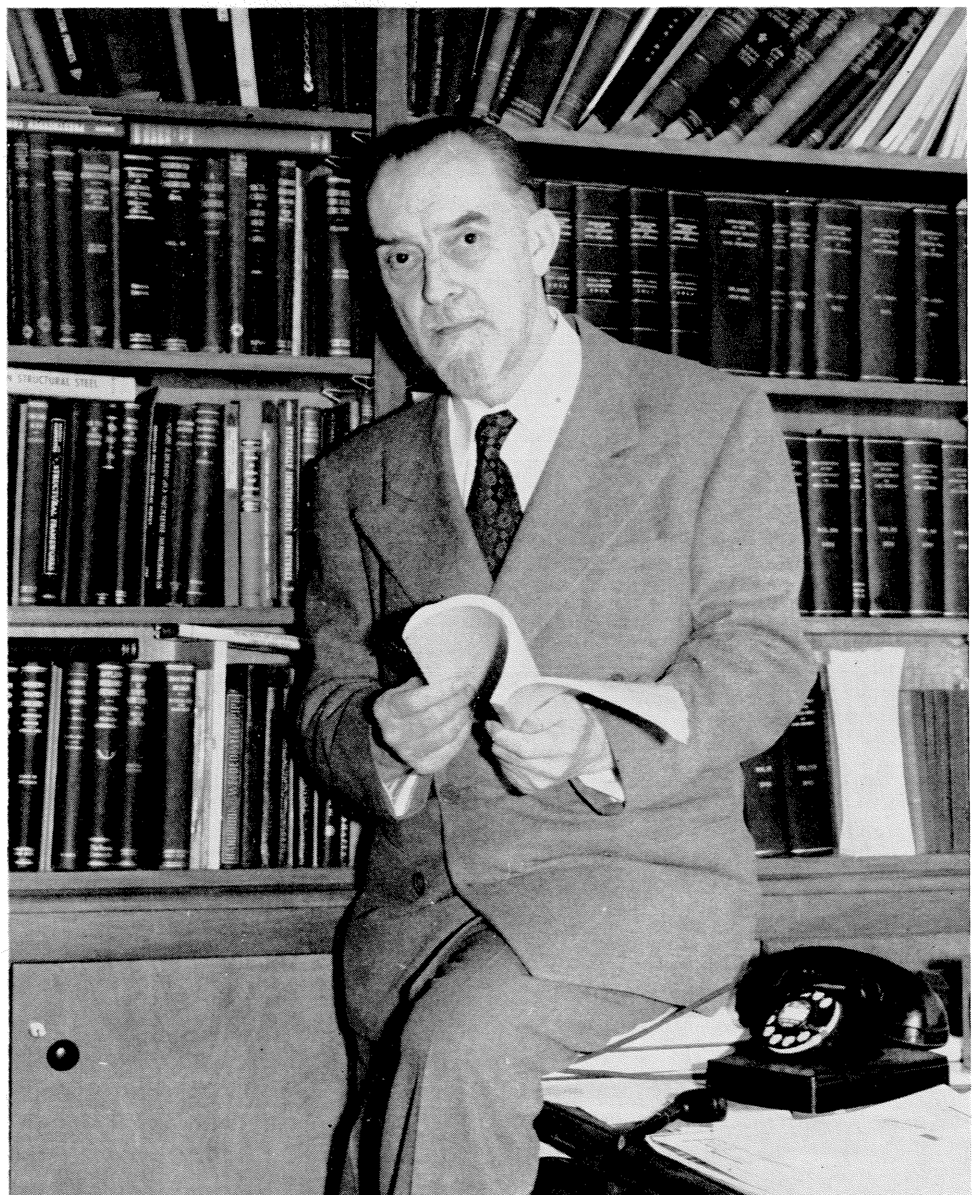
While working in Amarillo, Martel had, at intervals, applied for jobs at a number of schools in which he thought he would like to teach. Most of these applications had brought no response at all, but here, after some months, was a reply from Caltech—and a brisk, no-nonsense reply at that. In substance, it said, "How long will it take you to get here?"

It was some time later that Martel pieced together the story of his hiring. His application had gone to Franklin Thomas, who was the Institute's civil engineering department at that time. In his lifetime, Thomas was notorious for never throwing anything away, so he slipped the Martel application into a pile on his desk. As World War I was ending, it became apparent that the Institute was going to be flooded with new students, and Thomas plowed into his stack of applications to find a fast addition to the civil engineering staff. It is Martel's contention, to this day, that he got the job because he was the closest man to Pasadena in the stack.

Nevertheless, he welcomed the job, and, shortly afterwards, was married to Mildred Pray, a high-school classmate from Rhode Island.

In 1918 the Institute was confined to Throop Hall, and the civil engineering department occupied the space now taken up by the Alumni Office. There was a strict no-smoking edict in those days, so the faculty often found it necessary to take surreptitious cigarette breaks out in the orange grove in back of Throop Hall—finishing off with a healthful fresh orange as they hurried back to class. Most of the faculty brought their lunch every day and ate together under the trees in Tournament Park.

In 1921 Franklin Thomas, a Pasadena City director at the time, recommended Martel as a consultant on the



R. R. Martel, authority on the design of structures to resist earthquakes.

construction of the city's San Rafael bridge. It was the beginning of a distinguished career for Martel. He has been a consultant on bridges for the cities of Pasadena and Glendale, the State of California, the Southern Fuel Company and the Southern Counties Gas Company.

He has consulted on the design of flood control structures and reservoirs for the U. S. Army Engineers in Los Angeles, and for the cities of Glendale, Burbank and Riverside.

And he has been a consultant on the seismic provisions of such buildings as the Southern California Edison offices in Los Angeles, the First Trust Building in Pasadena, the Fruit Growers Exchange in Los Angeles, the Glendale Power House, the Bridge Auditorium in Pomona and most of the buildings on the Caltech campus.

Martel was one of the first engineers to become interested in the field of earthquake-resistant structures—and very possibly the first of all to go into this field with a serious and continuing interest. Characteristically, he gives the credit to Robert A. Millikan for pushing him into it.

After the destructive Santa Barbara earthquake of 1925, which was California's first big quake since the San Francisco one of 1906, R. A. Millikan—then chairman of Caltech's Executive Council—formed a group of engineers, seismologists, architects and businessmen to work on the problems of earthquake-resistant construction. Martel was the Caltech representative on the committee.

The work of this organization received little attention from the public at large until the Long Beach earthquake of 1933 reminded southern Californians that earthquake-resistant construction could be a personal matter. Building codes were adopted in nearly all southern California cities—and not only adopted but enforced. New buildings were *required* to meet specific standards to make them better able to withstand any future quakes. The 1941 earthquake in El Centro showed how well these new buildings stood up; again, in Tehachapi in 1952, buildings which had been constructed under the new codes came through remarkably well.

Martel has been serving on building code committees since the late twenties—for the city of Pasadena, the American Standards Association, the Structural Engineers Association, the State Division of Architecture and the State Chamber of Commerce among others. In this work he has been responsible for a number of refinements for taller buildings in southern California, and he has helped to bring about a better approximation to the pattern of forces that act on a building in an earthquake. At Caltech today Martel and his colleagues continue to study these forces by analyzing the response of structures to recorded earthquake ground motion, using a special analog computer constructed in the engineering laboratories.

Earthquake-resistant construction

Since 1947 Martel has served on the Advisory Committee of Engineering Seismology. Originally set up by the U. S. Coast and Geodetic Survey to advise it on such problems as how to make seismic measurements and what instruments to use, the committee gathered such a mass of data on engineering seismology that its services were eventually extended far beyond an advisory capacity. In 1952 the 13 members of the committee (which include Dr. George Housner, Caltech professor of civil engineering and applied mechanics, as well as Martel) set up the independent, non-profit Earthquake Engineering Research Institute. This organization bridges the gap between the science of seismology and actual building design and construction, collecting, compiling, correlating and distributing seismic data, and promoting research with the specific objective of developing safe and economically feasible methods of earthquake construction and design.

In 1926 Martel was the delegate of the Southern California Council on Earthquake Protection to the 3rd Pan-Pacific Science Congress in Tokyo, and again, in 1929, to the World Engineering Congress there.

As usual, Martel made his mark here too. Last summer, George Housner and Donald Hudson, Caltech professor of mechanical engineering, on a tour of Japan, were entertained at dinner by the Japanese engineering society. The speeches after dinner were in Japanese, so Hudson and Housner were unable to pick up much useful information from them. In fact, they were able to understand only three words all evening—"Martel-san," which was repeated over and over again, and finally the surprising phrase, "Indian suit."

Tracking down an interpreter later on, they discovered that the speakers had first of all discussed the memorable visits to Tokyo of the famous Professor Martel. Then, Dr. Tachu Naito, the well-known structural engineer and architect, had described one of Martel's memorable contributions to Japanese culture: Prior to his 1929 visit, it seems, Martel had written to see what kind of present he could bring from the United States to Dr. Naito's small son and that was the way in which young Naito happened to become the first Japanese to own an American Indian outfit, complete with feathered headdress.

When Martel came to Caltech as a civil engineering instructor in 1918, he didn't confine his teaching to civil engineering subjects by any means; in fact, he taught algebra, trigonometery and just about anything else that came along. Over the years, however, he worked into different aspects of structures (steel, wood and reinforced concrete) and this then became his teaching field.

He is no longer the only teacher in the family; his son Hardy is now an assistant professor of electrical engineering at Caltech. Hardy Cross Martel (named after an engineering instructor Martel studied under at Brown University — now the distinguished Professor Hardy Cross of Yale University) now has a son of his own. Hardy was graduated from Caltech (a rare feat for a faculty member's son) in 1949, received his MS from MIT in 1950 and is now completing the requirements for his PhD at Caltech. His sister Nancy works on the San Francisco *Chronicle*.

The man who came to dinner

Working in a field which is of such concern to southern Californians, Romeo Martel has, of course, been called upon often to speak at dinners and banquets. One of these occasions, however, stands out in his memory above all the others.

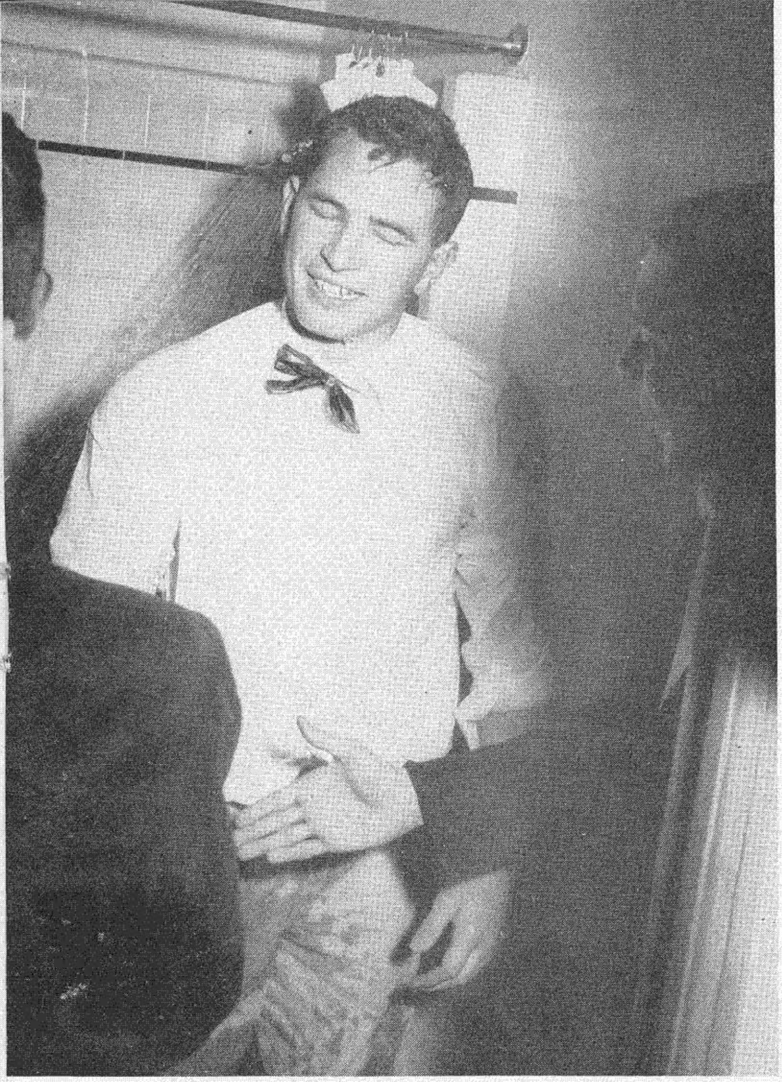
Martel had agreed to speak at a large, formal affair at a Los Angeles banquet hall. His speech prepared, he arrived at the dinner in good time.

"Professor Martel," he said, introducing himself.

"Ah!" said his hosts, greeting him warmly, "Professor Mar*tel*!" And they seated him at the speakers' table.

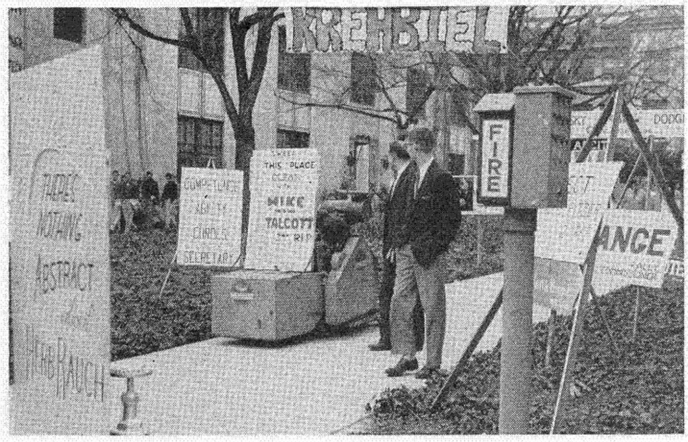
As he sat listening to the other speakers after dinner, Martel found their talks increasingly obtuse. Slowly he came to the realization that he was at the wrong banquet.

There was a moment of panic; then reason set in again and he relaxed and enjoyed what was left of the evening. At the end of the affair, puffing on a fine banquet cigar, he thanked his hosts for a delightful evening and disappeared into the night—one speech ahead of the game.



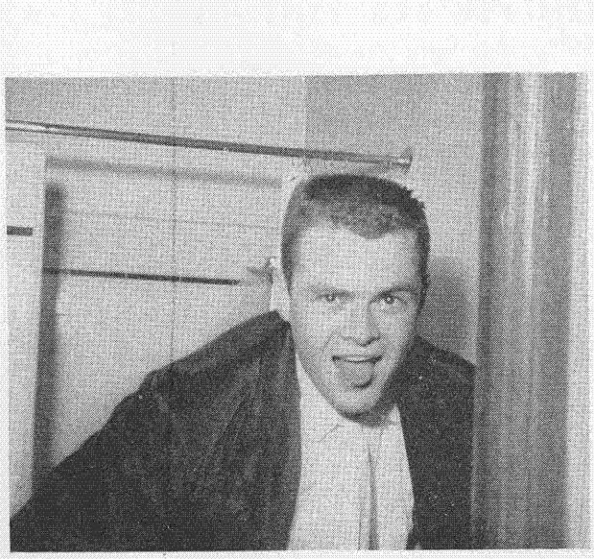
Where all successful candidates wind up

STUDENT ELECTIONS



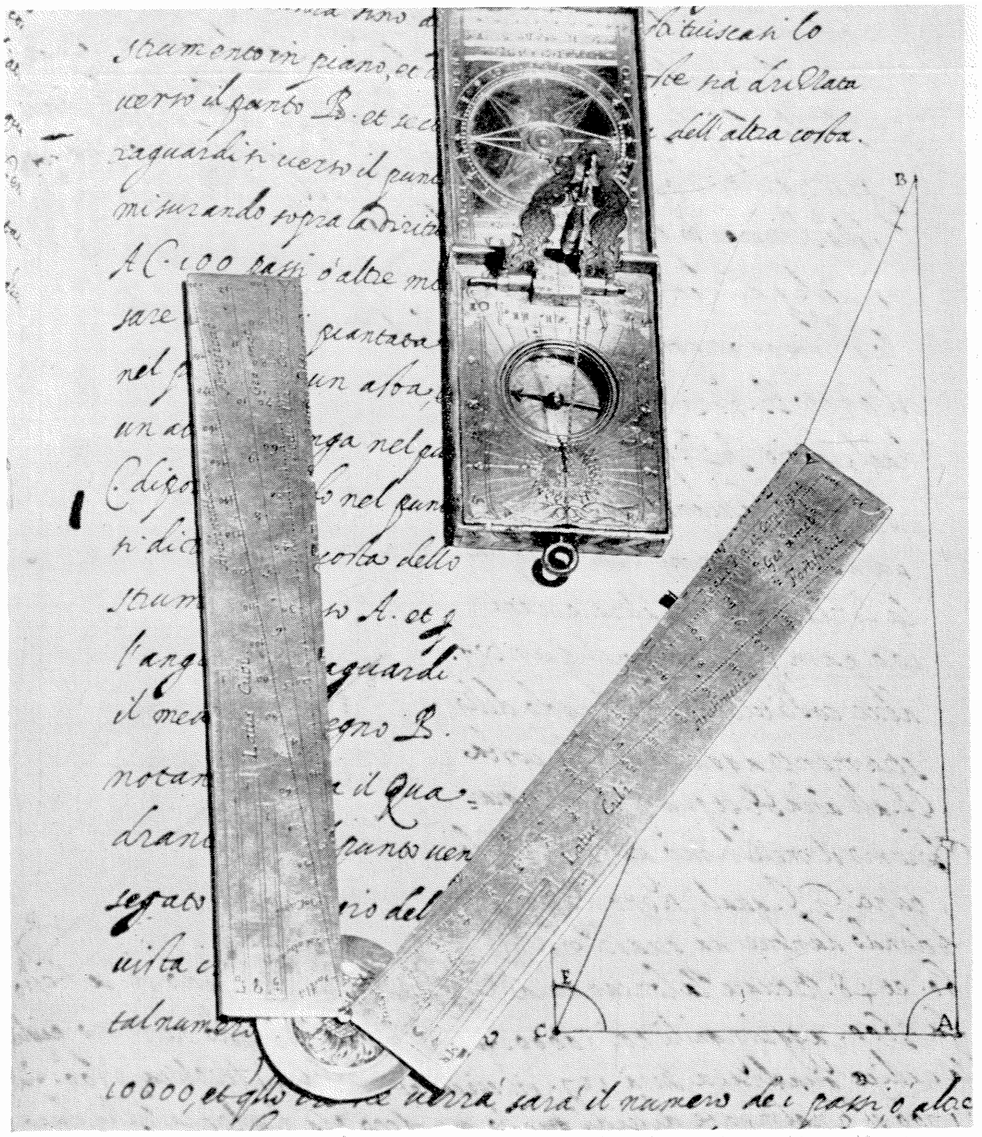
Sidewalk campaign

Campaign speech



Informal portraits of the new student body president, Craig Elliott (left), and vice-president, Reuben B. Moulton (right)

THE MONTH AT CALTECH



Galileo manuscript describes rare instruments already in Caltech's collection.

Rare Books

A COLLECTION of 300 rare scientific books, including first editions of Galileo, Copernicus and Kepler, were formally presented to Caltech last month by a trustee of the Institute. Purchased from Dr. Giampaolo Rocco of Florence, Italy, some of the books are still in their original bindings, handsome and sturdy after hundreds of years of use.

The books were added to the impressive library already started by Ernest C. Watson, dean of the Caltech faculty, and the late Drs. Edwin P. Hubble and George Ellery Hale. These combined collections now make the finest library on the early history of astronomy on the West Coast.

Among the rarest books in the new collection is Galileo's treatise on his first invention, a geometrical and military compass, a device resembling a modern sector. Published in Padua in 1606, this was Galileo's earliest printed work; only eight copies of it are known to exist today. The collection also contains a manuscript of this work, bound together with the manuscript of Galileo's first work on mechanics.

Another first edition, dated 1543, is *De Revolutionibus Orbium Coelestium*, written by the great Polish astronomer, Copernicus. In this volume, he expands on his theory that the earth moves around the sun, which upset all previous conclusions that the earth was the center of the universe. The rare 1566 and 1617 editions of this work are also in the collection.

One of the handsomest editions in the collection is Kepler's *Rudolphin Tables*, which contains a large world map regarded as the most elaborate and authoritative of its day.

MIT at Caltech

PRESIDENT JAMES R. KILLIAN, vice-president and provost J. A. Stratton and eight other administrative officers and department heads of the Massachusetts Institute of Technology will visit the campus this month to discuss mutual educational problems with Caltech staff members.

The MIT group starts its visit with a trip to Palomar Observatory on March 18. In the party will be Caltech President L. A. DuBridge, members of the board of

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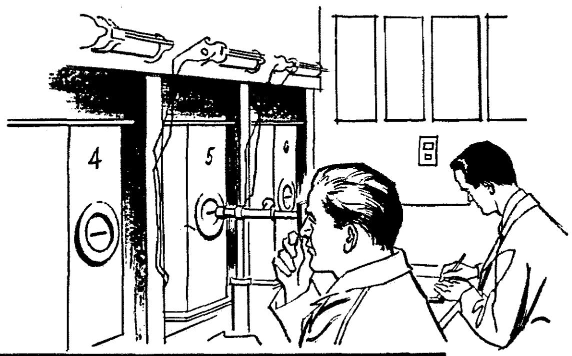
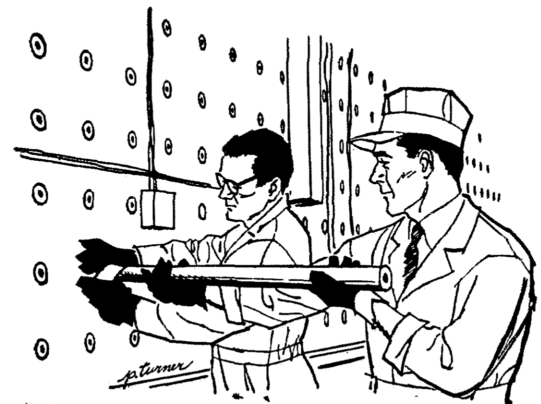
College graduates develop their skills...

growing with UNION CARBIDE



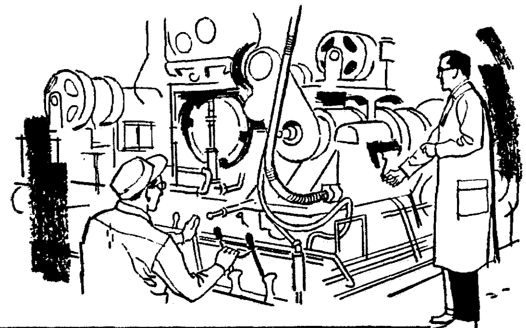
IN TITANIUM RESEARCH...

"After graduating in 1951 with an M.S. in metallurgical engineering, I joined the Metals Research Laboratories of Electro Metallurgical Company. Some of my research in corrosion behavior and notch sensitivity resulted in a patent for a stainless steel. In 1954 I was promoted to Section Leader, supervising research projects in titanium and other reactive metals."



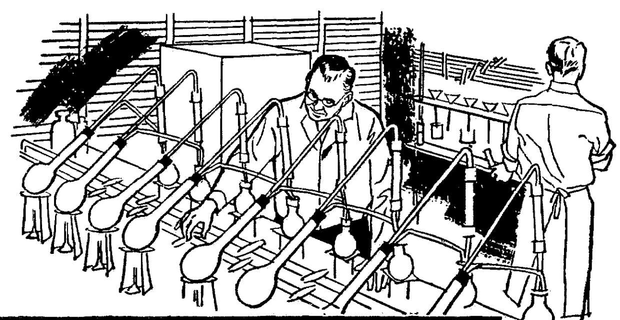
IN ATOMIC ENERGY...

"I graduated in '51 with a B.S. in physics and mathematics. Because of my interest in atomic energy I joined Union Carbide Nuclear Company at Oak Ridge in April, 1954. By November of that year I was classified as a Junior Physicist. I now supervise the operation of mass spectrometers used to analyze radioisotopes produced in atomic reactors here at Oak Ridge."



IN QUALITY CONTROL...

"I'm an electrical engineer, Class of '51. I started in Works Engineering at a National Carbon Company plant. A year later I transferred to a location where Works Engineering covered three plants, and soon became Engineer on important development projects. I was recently promoted to Assistant Head of the Product and Process Control Laboratory at one of the plants."



IN METALLURGICAL CONTROL...

"I'm a metallurgical engineer, Class of '49. I started at Haynes Stellite Company as a Development Engineer in high-temperature alloys, and in 1953 became Shift Foreman in the Metallurgical Control Department. Recently I was promoted to General Foreman, responsible for the Chemical, Spectographic, Material Release, and X-Ray Departments and the Test Laboratory."

THEY ARE KEY MEN WITH A FUTURE...

If you are interested in a future in production, development, research, engineering, or technical sales, check the opportunities with any Division of Union Carbide. Get in touch with your college placement officer, or write directly to:

UCC DIVISIONS INCLUDE...

- Bakelite Company • Carbide and Carbon Chemicals Company
- Electro Metallurgical Company • Haynes Stellite Company
- Linde Air Products Company • National Carbon Company
- Silicones Division • Union Carbide Nuclear Company

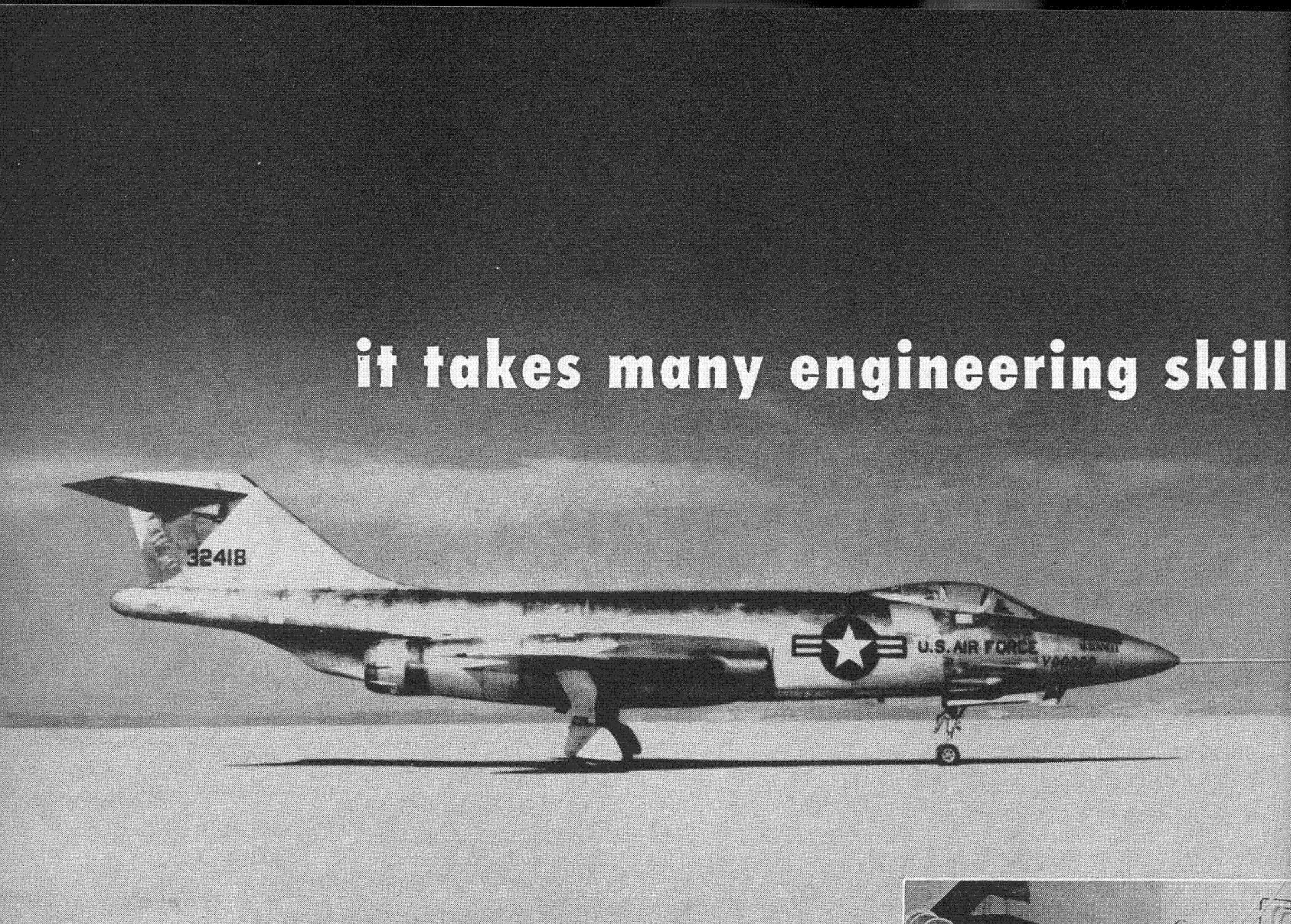
UNION CARBIDE

AND CARBON CORPORATION

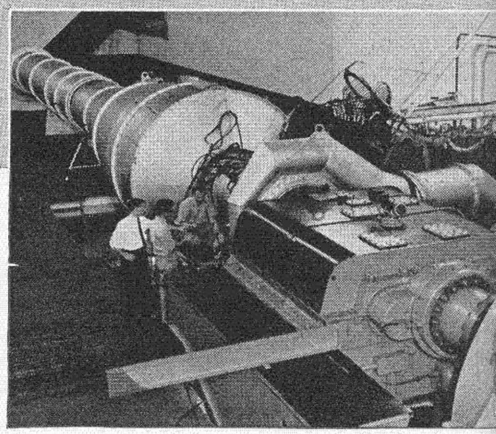
UCC

Industrial Relations Department, Room 406
30 East 42nd Street, New York 17, N. Y.

it takes many engineering skills



McDonnell "Voodoo", *the most powerful jet fighter ever built in America.*



J-57 POWERED AIRCRAFT

MILITARY

F-100	F8U
F-101	A3D
F-102	B-52
F4D	KC-135

COMMERCIAL

Boeing 707

Douglas DC-8

MECHANICAL ENGINEERS are concerned with many phases including experimental testing and development, mechanical design, stress and vibration analysis, combustion research, heat transfer and nuclear reactor development.

AERONAUTICAL ENGINEERS work on innumerable internal and external airflow problems concerned with design, development and testing of aircraft powerplants. Some who specialize in analytical engineering forecast engine-airplane combinations a decade in advance of design.

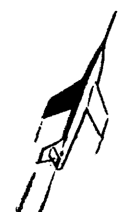
ELECTRICAL ENGINEERS directly contribute their specialized skills to the analysis and development of controls, systems and special instrumentation. An example is the "Plottomat" which automatically integrates and plots pressures, temperatures and air angles in performance testing.

to create the top aircraft engines

An aircraft powerplant is such a complex machine
that its design and development
require the greatest variety of engineering skills.
Pratt & Whitney Aircraft's engineering team
has consistently produced
the world's best aircraft engines.

The best planes are always designed
around the best engines. Eight of the most
important new military planes are powered by
Pratt & Whitney Aircraft J-57 turbojets.
The first two jet transports in the United States
will use J-57s. Further, no less than
76 percent of the world's commercial air transports
are powered by other Pratt & Whitney Aircraft powerplants.

Such an enviable record can only be built
on a policy which encourages, recognizes and
rewards individual engineering achievement.



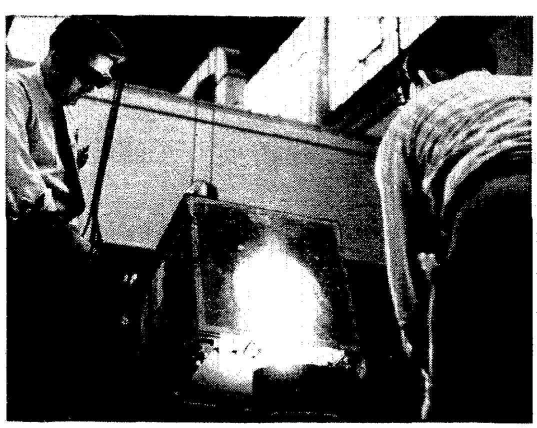
PRATT & WHITNEY AIRCRAFT

Division of United Aircraft Corporation

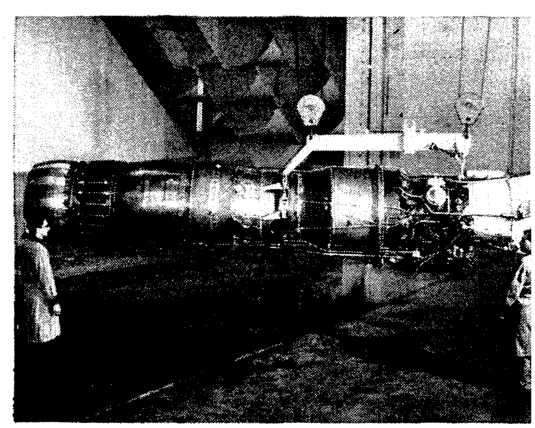
EAST HARTFORD 8, CONNECTICUT

World's foremost designer and builder of aircraft engines

CHEMICAL ENGINEERS, too, play an important role. They investigate the chemical aspects of heat-producing and heat-transferring materials. This includes the determination of phase and equilibrium diagrams and extensive analytical studies.



METALLURGISTS investigate and develop high temperature materials to provide greater strength at elevated temperatures and higher strength-weight ratios. Development of superior materials with greater corrosion resistance is of major importance, especially in nuclear reactors.



WORLD'S MOST POWERFUL production aircraft engine. This J-57 turbojet is in the 10,000-pound thrust class with considerably more power with afterburner.

trustees, division heads and deans of Caltech, who will accompany the group to the observatory and from there to Warner Hot Springs for the night. The following day the whole group will take a tour through the desert. With Dr. George Beadle, chairman of the Division of Biology, as chairman, the formal meetings will begin on March 20 at Caltech.

During the three days of meetings, discussions will include the future complexion of engineering education, fiscal problems and government contracts, methods of improving the quality of science and mathematics instruction in secondary schools, new educational experiments at Caltech and MIT, graduate school problems and the handling of students of exceptional intellectual capacity.

Pasadena '76

PRESIDENT DuBRIDGE accepted appointment last month to a new committee set up by the Pasadena Chamber of Commerce to study the economic and cultural growth of this area and make a report which will provide a background for planning for the next 20 years.

The four-man committee, known as Pasadena '76, also includes industrial designer Henry Dreyfuss as chairman; Philip S. Fogg, president of Consolidated Aerodynamics Corp.; and Walter S. Young, superintendent of Bullock's Pasadena.

Travelogue

EARNEST A. WATSON, dean of the faculty, took a leave of absence from the Institute this month to make an extensive tour of the Middle East with Mrs. Watson —he to do research on the contributions of the area to the history of science, she to collect material for a book on the Crusades and the Middle Ages.

The Watsons, who left Pasadena on March 6, are not due back until school opens in the fall, and a run-through of their itinerary indicates that there is little of the Middle East they intend to miss.

After flying direct from New York to Cairo they go on to Alexandria, then up the Nile to Luxor and Aswan. Back in Cairo, they join a group of about 20, in a chartered plane, to travel to such spots as Petra—the rose-red desert city that commanded the caravan trade for centuries — and other old caravan cities, Damascus, Palmyra, Bagdad and Babylon.

Moving east to Iran, they stop at Kermanshah, Hamadan, Tehran, Isfahan, Shiraz and Persepolis, the old Persian capital destroyed by Alexander the Great. After visits to Saudi Arabia and some of the oil developments, as well as Ur of the Chaldees, the Watsons leave the chartered plane to do some traveling on their own—including Nishapur and the tomb of Omar Khayyam, and Maragha, Persia's once-great capital of science.

From Beirut the Watsons will tour the Crusaders' country by car, move on to Cyprus, Ankara, Istanbul, Izmir and down the coast of Asia Minor. To cover the islands off the coast they will either take an Istanbul-Antioch freighter or hire their own fishing boat out of Rhodes.

Through Crete, Athens, Thessaly and Thrace they will then use Sicily as a base to cover the centers in Italy and Sicily where Archimedes and Pythagoras lived and early Greek science flourished. Finally, by way of Madrid and Lisbon, this itinerary includes—home.

Pauling's Peregrinations

LINUS PAULING, chairman of Caltech's Division of Chemistry and Chemical Engineering, starts late this month on an extensive lecture tour which will take him as far north as the University of Manitoba (where he will give the annual Merck Lecture to the faculty of medicine) and as far east as Amherst College, Massachusetts.

In between, he will lecture at the State University of Iowa, Iowa State College, the American Psychiatric Association in Chicago (where a symposium will be held on the recent progress in genetics and its implications in psychiatric theory), the University of Kansas, and Yale University (where he will lecture by invitation from the Yale Law School Forum).

Dr. Pauling will spend the month of April as a visiting professor at the University of Illinois.

Sir Charles Darwin

SIR CHARLES GALTON DARWIN, one of the world's leading physicists, visited Caltech this month to address two physics seminars. On March 8 he spoke on "The Discovery of Atomic Number"; on March 9 his subject was "Forecasting the Future."

Sir Charles, 68, was a pioneer in nuclear studies, and from 1938 to 1949 he was director of the National Physics Laboratory in England. He is the grandson of the Darwin who wrote *The Origin of Species*. His father was Sir George Darwin, a distinguished astronomer, and his godfather was Sir Francis Galton, the celebrated geneticist. He has written two popular science books: *The New Conception of Matter*, which was published in 1931, and *The Next Million Years*, which appeared in 1952.

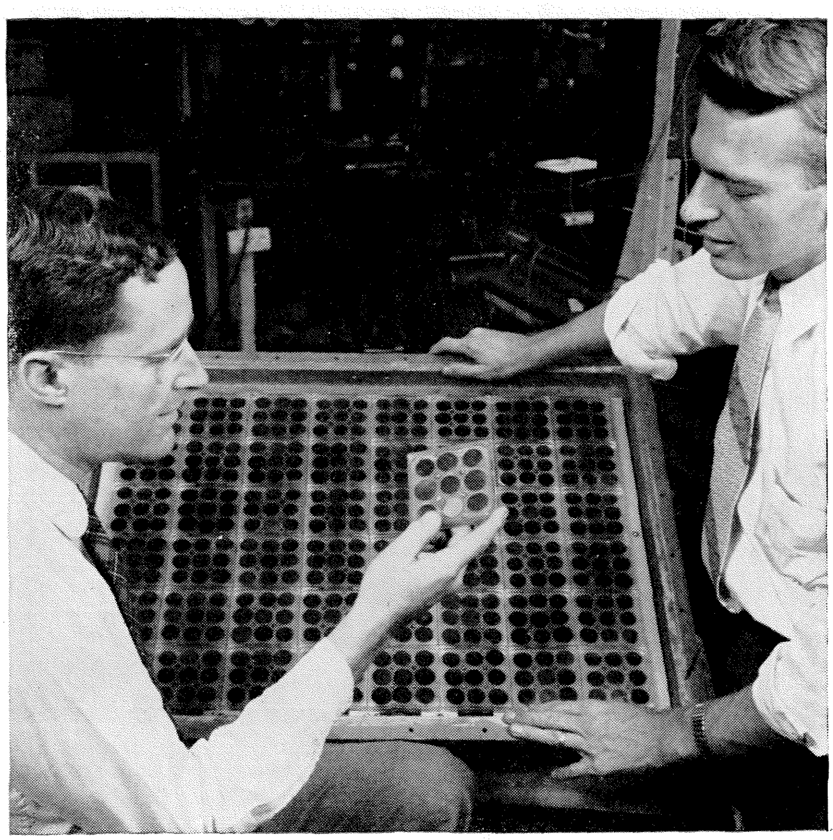
Polio Grants

THE NATIONAL FOUNDATION for Infantile Paralysis last month announced grants to Caltech of $40,509 for research by Renato Dulbecco, professor of biology, and $32,126 for Linus Pauling, professor of chem-

CONTINUED ON PAGE 34

How the Bell Solar Battery Converts Sunlight into Electricity

Another example of the pioneering opportunities for engineers at Bell Telephone Laboratories



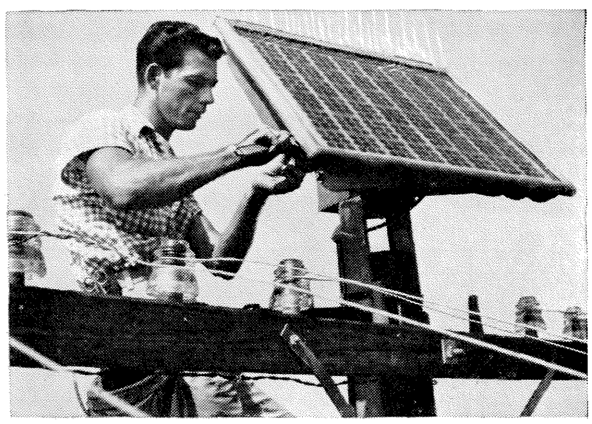
In a career with Bell Telephone Laboratories, young engineers and scientists can expect to take part in pioneering radically new developments in the field of communications. One such development is the Bell Solar Battery.

Like the transistor, the Bell Solar Battery was invented by Bell System scientists. Indeed, it was the study of semiconductors which revealed the fact that sunlight could induce the movement of electrons in silicon and thus create electric current.

The basic unit of the Bell Solar Battery is a thin disc compounded of two kinds of treated silicon. The body of the disc is silicon with a trace of arsenic to provide negative potential. Into this body boron is diffused, to a depth of less than 1/10,000 of an inch, providing positive potential. The junction of these layers of treated silicon is the "*p-n*" junction. Equilibrium between the *p* and *n* regions is upset when the disc is exposed to sunlight, which jolts electrons free, and causes them to move across the *p-n* junction. The charges pass through contacts, and current — though a small amount — flows.

In the past year, the efficiency of the Bell Solar Battery has been increased from 6 to 11%. Right now, in Americus, Georgia, the battery is being used experimentally to power a rural telephone system. And more widespread application is in the offing.

The Bell Solar Battery is one of many developments underway in the Bell System to improve America's telephone service. The special role of Bell Telephone Laboratories in forwarding the exciting search for tomorrow's better telephone service is creating many fine career opportunities for young scientists and engineers. Your placement officer can give you more information about careers with Bell Telephone Laboratories, and also with Bell Telephone Operating Companies, Western Electric and Sandia Corporation.



The Bell Solar Battery consists of 432 silicon discs wired together. It is mounted on telephone poles to catch prevailing sunlight, and on a sunny day can produce 10 watts. Excess energy is fed into storage batteries, to be used at night or in bad weather.

BELL TELEPHONE SYSTEM

At David Sarnoff Research Center, Princeton, N. J., RCA tests one of loudspeakers used in new high fidelity "Victrola" phonographs.

istry and chairman of the Division of Chemistry and Chemical Engineering.

Dr. Dulbecco, whose technique for studying animal viruses has made it possible to isolate genetically pure strains of polio viruses, will continue research to determine the properties of the polio virus. Dr. Pauling's research, financed by the new grant, will be to ascertain what viruses are made of and how they are formed.

NSF Grants

THE NATIONAL SCIENCE FOUNDATION recently announced research grants of $3,240,500 to 164 institutions and individuals. At Caltech, Herschel K. Mitchell, professor of biology, received a three-year grant of $18,000 to study the nature of phospholipids, a derivative of phosphoric acid. And Renato Dulbecco received a grant of $15,000 for one year of study on the virus host complex formed by animal viruses and their host cells.

Honor Guest

RAY OWEN, professor of biology, left for England late last month to attend an international conference on immunological tolerance sponsored by the Royal Society in London. Dr. Owen made the first discovery of naturally occurring tolerance to foreign cells in cattle twins more than a decade ago. As an honor guest at the conference, he was given a full morning to discuss results from his long-time research on red blood cell antigens and changes that occur in the antibody-forming mechanism when embryonic or new-born mammals and chicks are exposed to red cells from another individual of the same species, or exposed to red cells of a different species.

Earthquake Advice

ON, OF ALL THINGS, the Edgar Bergen Hour, Dr. Charles Richter, professor of seismology, provided radio listeners with a good deal of valuable information about earthquakes on February 19. Though readers of this publication may already be familiar with much of this information, they can still benefit from Dr. Richter's advice on what to do when caught in an earthquake.

"I always fall back on the saying of an eminent geologist, Bailey Willis," he said. "'Stand still and count 30. After that it doesn't matter what you do.'"

Boeing engineers find rewarding jobs in Wichita, Seattle

This model of a supersonic airplane design was dropped at extreme altitude from a B-47 Stratojet. Telemetered data revealed the characteristics of its supersonic flight to destruction at the earth's surface. This is just one example of Boeing-Wichita's continuing development of advanced aircraft and associated system components.

At Wichita research and development programs are expanding rapidly. Laboratory space has been quadrupled and many other new engineering facilities have been added to keep pace with increasing emphasis on technical development. At both of the company's plants, Seattle and Wichita, the increased scope and magnitude of this development effort is creating additional and excellent career opportunities for all types of engineers.

This means that if you are an electrical engineer, a mechanical engineer, a civil or an aeronautical engineer or a physicist or mathematician with an advanced degree, there is a real challenge for you in one of Boeing's design research or production engineering programs. You would work in a tight-knit team where there is plenty of room for self-expression and recognition.

Boeing engineers are working now on future airplanes and missiles that will maintain the standard of technical superiority established by the B-47 medium bomber, the B-52 intercontinental bomber, the BOMARC IM-99 pilotless interceptor, the 707 jet transport and the KC-135 jet tanker-transport.

Recognition of professional growth is coupled with career stability at Boeing — twice as many engineers are now employed by the company as at the peak of World War II. They enjoy a most liberal retirement plan. How would *you* like a satisfying, creative job with the pick of the engineering profession? There may be one waiting for you in the progressive communities of Wichita or Seattle.

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

JOHN C. SANDERS, Staff Engineer—Personnel
Boeing Airplane Company, Seattle 14, Wash.

RAYMOND J. B. HOFFMAN, Admin. Engineer
Boeing Airplane Company, Wichita, Kansas

BOEING

Aviation leadership since 1916

SEATTLE, WASHINGTON WICHITA, KANSAS

ALUMNI NEWS

Board Nominations

THE BOARD OF DIRECTORS of the Alumni Association met as a nominating committee on February 28, 1956, in accordance with Section 3.04 of the By-Laws. Five vacancies will occur on the Board at the end of the current fiscal year, one vacancy to be filled from the present Board and four members to be elected by the Association. Present members of the Board and the years in which their terms of office expire are:

R. H. Bungay '30........1957	R. H. Jahns '35........1957
H. C. Carter '49..........1956	W. F. Nash, Jr. '38, 1956
Philip Cravitz '29......1956	C. V. Newton '34....1956
W.R.Donahue,Jr.'34, 1957	R. W. Stenzel '21......1957
C. P. Strickland '43........1956	

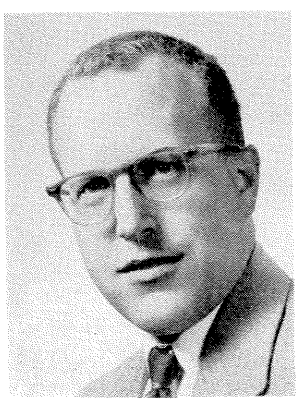
The four members of the Association nominated by the Directors are:

John R. Fee '51	Chester Lindsay '35
Edward Fleischer '43	John E. Osborn '39

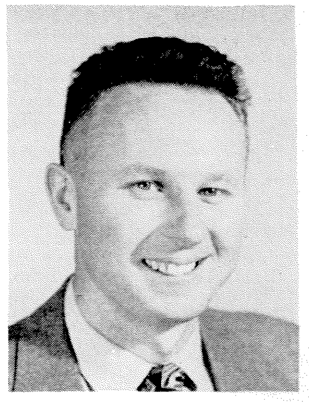
Section 3.04 of the By-Laws provides that the membership may make additional nominations by petition, signed by at least ten (10) regular members in good standing, provided the petition is received by the Secretary not later than April 15. In accordance with Section 3.05 of the By-Laws, if further nominations are not received by April 15, the Secretary casts a unanimous ballot for the members nominated by the Board. Otherwise a letter ballot is required.

Statements about the nominees of the Directors are presented below.

—Donald S. Clark, Secretary.

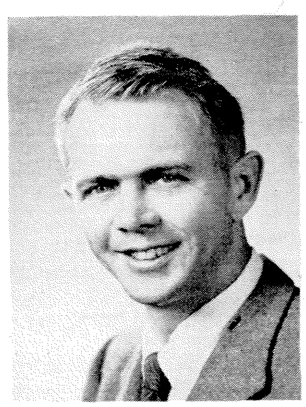


JOHN R. FEE received his BS in civil engineering in 1951. Prior to that he was a captain in the U. S. Army during World War II, and he received a BS in business (accounting) from the University of Kansas in 1947. Since leaving Caltech, he has been a civil engineer with James M. Montgomery, a consulting engineering corporation in Pasadena; and in 1955 he became secretary of that corporation. He has served the alumni as permanent secretary of the class of 1951, as a member of the Seminar Day Committee in 1954, as chairman of the Annual Meeting in 1955, and as Alumni Program Chairman.

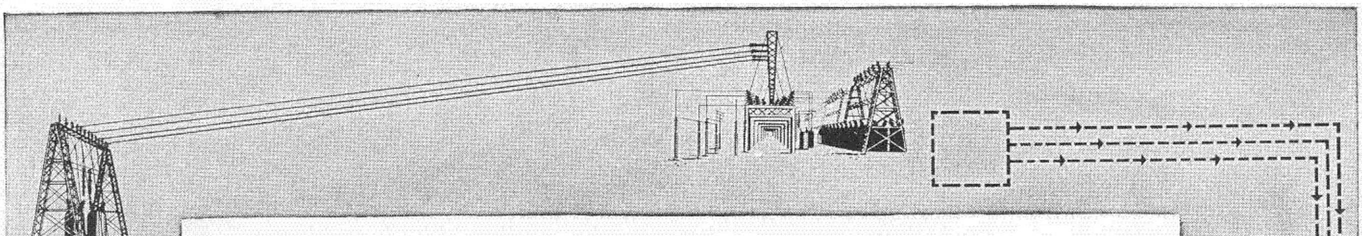


EDWARD P. FLEISCHER received his BS in chemical engineering in 1943 and joined the Standard Oil Company as an engineer at the El Segundo Refinery before entering the Navy. After a tour of the Pacific in electronic maintenance work, he left the Navy in 1946, and spent three years in elevator sales and construction in Los Angeles. He then took graduate work in business administration at Stanford and received his MBA in 1951. He went to work in the engineering department of the Consolidated Electrodynamics Corporation in Pasadena in that same year, and has been serving as staff assistant to the president since 1953.

CHESTER W. LINDSAY received his BS in chemistry in 1935 and went to work as a quality control chemist in the Los Angeles Vegetable Oil Refinery of Swift and Company. In 1938 he became chief chemist for the Maui Pineapple Company in Hawaii, and in 1946 returned to California to be production manager for the Exchange Orange Products Company—part of the Sunkist Growers Organization—in Ontario. This year he is serving as chairman of the Alumni Seminar Day.



JOHN E. OSBORN, who was student body president when he was an undergraduate, received his BS in civil engineering in 1939. After three years in the Navy C.B.'s he joined his father in the Osborn Company, contracting excavating, grading and paving in and around Pasadena (including most of the paving on the Caltech campus, incidentally). He has been active in civic and trade associations, and belongs to the Pasadena Rotary Club, is on the local YMCA board, and recently served as president of the Southern California Asphalt Plant Association.



The Importance of Cable Engineering and Design

Cable engineering is concerned with the design and use of wires and cables to direct the flow of electrical energy from its source to the point of utilization. It is generally more economical to generate electric power in relatively large blocks at strategically located power plants and to transmit it over relatively long distances than to generate in small quantities where it is used.

There are, therefore, two general types of wires and cables used in the electrical industry:

(a) those used for power transmission, usually at voltages above 22 kilovolts,

(b) those used for power distribution at lower voltages.

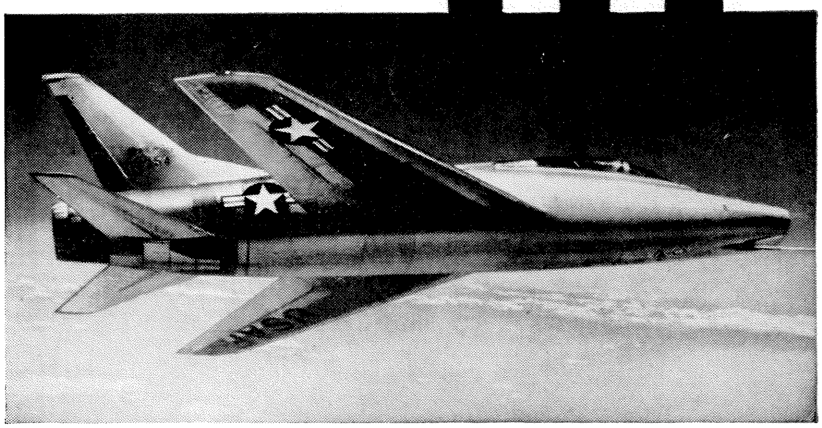
Cables used for power transmission are generally single conductors with no insulation. They are supported on insulators above ground at such separations or spacings that the air provides the required insulation. For power distribution, on the other hand, where the space occupied by the power line is important, insulated cables are used. This discussion deals with the design and use of insulated wires and cables for power distribution systems.

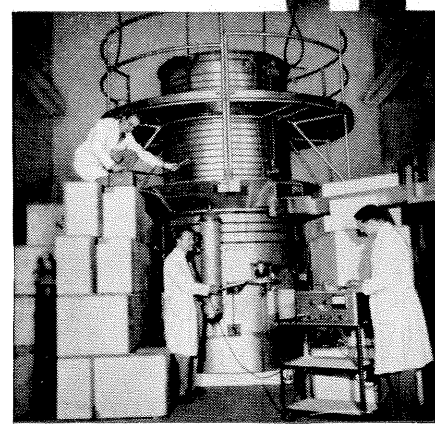
Insulated distribution cables carry power from the transformer stations along the transmission lines to its point of ultimate utilization. The voltages at which power is distributed vary from about 15 kilovolts to 115 volts used in individual homes. The higher voltages are used for the distribution of relatively large amounts of power from the transformer stations to substations nearer the points of utilization, such as industrial plants, where it is transformed to low or utilization voltages, either alternating or direct current. Large quantities of electric power are distributed in this way and the value of the distribution equipment required is great. The value of the insulated conductors, including those for both portable or stationary installations, probably exceeds that of any other single item used in power distribution. The design and operation of insulated conductors and distribution systems are of great public and commercial importance. The primary function of insulated cable engineering and design is to provide safe, adequate, reliable and pleasant appearing distribution systems. Electric power is so extensively used in modern life that interruptions to it are serious. The failure of electrical power in an industrial plant throws people out of work and reduces production.

The appearance or sightliness of cables installed overhead in a community is important and is attained chiefly by installing such cables with a small and uniform sag from pole to pole.

Watch for the appearance of advertisements in this series in a forthcoming issue. Reprints of this advertisement and subsequent ones, relating to the uses of insulated wire and cable, will be sent on request without obligation.

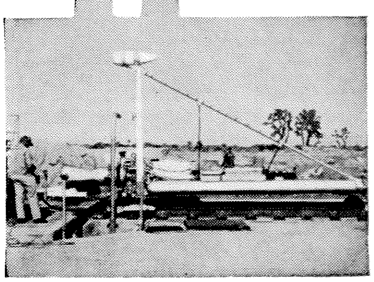
NORTH AMERICAN HAS BUILT MORE AIRPLANES THAN ANY OTHER COMPANY IN THE WORLD





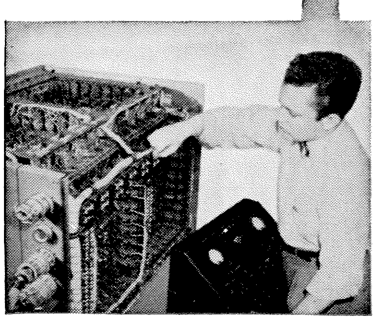
At North American—

DIVERSITY CREATES OPPORTUNITY



Graduates, undergraduates — A North American representative will be on your campus soon. He will give you complete details on the hundreds of openings these expanding fields create: AIRCRAFT: the Korea-famed F-86 SABRE JET, the record-smashing F-100 SUPER SABRE, and Airborne Vehicles of the Future. GUIDED MISSILES: the SM-64 NAVAHO Intercontinental Guided Missile. ELECTRO-MECHANICAL CONTROLS: fire controls, automatic navigation systems, flight control computers — for aircraft and missiles. ENGINES: lightweight, high-thrust rocket engines for the NAVAHO and for other missile programs. ATOMIC ENERGY: the development of nuclear reactors for research, medicine and power.

North American engineers work in top-level teams, share in a liberal Patent Award Program, a highly successful Suggestion Award Plan and many other unexcelled job benefits.



See the North American Representative at your school . . . or write:

Mr. Stevenson, Dept. 56-CM
Engineer Personnel Office
North American Aviation
Los Angeles 45, California

Mr. Kimbark, Dept. 9120-CM
Engineer Personnel Office
North American's Missile & Control Departments
Downey, California

Mr. Pappin, Dept. 56-CM
Engineer Personnel Office
North American's Columbus Division
Columbus 16, Ohio

ENGINEERING AHEAD FOR A BETTER TOMORROW

NORTH AMERICAN AVIATION, INC.

PERSONALS

1896

Diantha May Haynes, a member of the first college graduating class of Caltech (then Throop Institute) died on February 15. One of only three women graduates of the Institute, Miss Haynes received her BA in 1896 and would have celebrated the 60th anniversary of her graduation this year. Her 50th and 55th anniversaries were each celebrated at the annual meetings of the Alumni Association.

A native Kansan, Miss Haynes came to California in 1892 after attending preparatory school at Buchtel College in Akron, Ohio. She taught in California schools for 38 years, 27 of which were spent at Redondo Union High School. Miss Haynes was chairman of the science department at the time of her retirement in 1938 and her greatest pride was that out of her many students, 24 were graduated from Caltech.

1900

Nathan A. Bowers, Ex '09, was given an "Oscar" for outstanding achievement in heavy engineering construction, at the first annual award dinner of the Beavers, a newly formed organization of the construction industry. Held at the Statler Hotel in Los Angeles, on January 27, the meeting was attended by over 1,000 representative engineers and builders. Nate is a consulting engineer at the Tree Ring Laboratories in Atherton, California.

1920

Paul D. Barton has just been made director of engineering of the Sun Oil Company in Philadelphia, Pa. A registered professional engineer, Paul has been with Sun Oil since 1934. He is living now in Phoenixville, Pa., where he is a director of the Community Chest, on the board of trustees of the Phoenixville Hospital and is currently serving his third six-year term on the East Pikeland Township School board of directors. Board president for the past seven years, he has also been elected president of the Phoenixville Area Jointure School Board.

1921

Ernest H. Mintie writes that his business, (E. H. Mintie Company, Filtration Engineers) has recently moved into enlarged and improved quarters at 1919 Raymond Avenue, Los Angeles. Ernie's two sons are in the organization and his family now consists of 5 children and 8 grandchildren.

1923

Loren E. Blakeley, consulting civil and sanitation engineer, is now a partner in the firm of Finley's Color Laboratory in Montebello, California. Loren continues to be a consultant in the field of water supply as well.

1926

Domenick J. Pompeo, who has been with the Shell Development Company in Emeryville, California, since 1928 — the year the company was formed—was recently selected by the Instrument Society of America as the outstanding engineer in the Bay Area for 1955. He's head of Shell's instrumentation department.

Henry P. Henderson writes that he is "happy to be on the job again after suffering a heart attack in September—and I'm 25 pounds lighter, too. The San Francisco Chapter luncheons every Thursday at the Fraternity Club have from two to a dozen Techman out every week. Bob Stirton '30, Harry Farrar '27, Bob Jones '25, Howard Fisher '27, Jules Mayer '40, Harry Sigworth '44, Manley Edwards '26, and I make up the regulars." Henry is district engineer for the Worthington Pump and Machine Company in San Mateo.

1928

Edwin W. Templin has been elected chairman of the Pacific Coast Section of the Society of Motion Picture and Television Engineers, which has about 1600 members in the Los Angeles area. Ed is supervisor of electronic development for Westrex, the Western Electric Company subsidiary which provides sound recording equipment for use with motion pictures.

1929

Alfred E. Towne, who was formerly chief engineer of KPIX, resigned recently to form A. E. Towne Associates, Inc. His new company, composed of radio and television consulting engineers, specializes in FCC applications and proof of performance, and has offices in San Francisco. The Townes are living in Belmont and have a daughter 18 and a son 16.

1930

Harland Moss writes that he has returned to the faculty of Loyola University in Los Angeles after an absence of 12 years in industrial work.

Personals . . . CONTINUED

Roscoe Downs reports that he is project manager for the contractors for a $40,000,000 dam and hydroelectric power project on the Gediz River about 75 miles east of Izmir in Turkey. The project is located in the area of Ancient Greece (Aeloia, Ionia, Lydia, Phrygia, Caria, etc.) and the scene of much early Christian history. Although the Downs' live fairly comfortably, Roscoe admits that "accommodations and food are not what we Americans are used to, and our travel is very carefully planned and held to a minimum because traveling in Turkey is not as easy and pleasant as the travel folders would have you think."

1932

Thomas W. Bell, MS '33, division petroleum engineer of the Texas Company's Pacific Coast Division, has become assistant division manager of the producing department in Los Angeles. Tom has been with the Texas Company since 1934, lives in Glendale with his wife and two children, Tom, Jr. and Virginia.

1933

William C. Pauly, who was listed as a *Lost Alumni* in the December *E & S*, is in Barbarton, Ohio, working as plant engineer at the Barbarton Works of the Babcock and Wilcox Company. *Orin S. Shoemaker* '34, of Pasadena, writes that "Bill has been with the company since 1934. He started with them (as I did) on the Boulder Dam project. I saw him about two years ago on one of my trips east, and I'll bet that a vote would put him in top position on the list of those of '33 who have changed the least."

1935

Paul F. Genachte, PhD, has been appointed acting director of the atomic energy division of the Chase Manhattan Bank in New York. Before joining the bank in 1954, Paul spent about 20 years in public utility work in Belgium and Mexico.

Russel L. Maycock, Ex '35, is now with the Shell Chemical Corporation in Houston, Texas.

1936

Verne Peugh is manager of the San Francisco office of Peter Kiewit Sons' Company, Contractors. Verne's been with the firm for six years.

Raymond H. F. Boothe, MS '37, has joined the technical staff of Ramo-Wooldridge in Los Angeles. Ray had been with the State Division of Architecture as a senior structural engineer for seven years before this.

Louis G. Dunn, MS '37, MS 38, PhD '40, has been elected vice-president of the Ramo-Wooldridge Corporation. He joined the company in 1954 to direct missile research activities, and will continue in this capacity.

Sydney U. Barnes writes from Mogadisco, Somalia, that "after the conclusion of my contract in Spain for De Golyer and MacNaughton, I returned to the U.S. and secured a contract with the Sinclair Somal Corporation to conduct a geological plane-table survey of this country. Although only 2° north of the equator, it is surprisingly cool here (about 90°) because of the continual winds. The country is barren, with typical desert vegetation, and occasionally there are tribal disputes over water in which casualties are suffered. However, they do not bother foreigners. About 95 percent of the Somalis are nomads.

"My son was born December 22, 1955 in Madrid, Spain, and my family is living there now."

1937

Christopher Dykes, MS '37, MS '38, has been practising as an advising aeronautical engineer in London, England, since 1951. He writes that "the work enables me to do a great deal of traveling and I've visited North America a total of six times since 1952 and am planning another trip of one month, including New York, Montreal, Cleveland, St. Louis, San Diego and Pasadena. I am currently retained by various firms in the U. S., Britain and Canada, advising them on future trends, mainly on aeronautical development." Chris and his wife have a 7-year-old daughter, Sarah, and a 20-month-old son, Andrew.

1938

L. Bruce Kelly joined the Underwater Engines Division of the Aerojet General Corporation in Azusa last summer as a senior mechanical engineer, after being with the U. S. Naval Ordnance Test Station in Pasadena for 9½ years. During his years with NOTS he served as head of the applied research branch, head of the propellants branch, and head of the components branch.

Stanley T. Wolfberg, who has been general manager of Squires, Inc., has left the retail business to return to industrial engineering as a management consultant for Benjamin Borchardt & Associates in Los Angeles.

1939

Paul L. Smith will be moving to Tulsa in April to work as chief of operations of the analysis group in the engineering department of the Douglas Aircraft Company there. Paul has been with the Santa Monica division of Douglas for 17 years.

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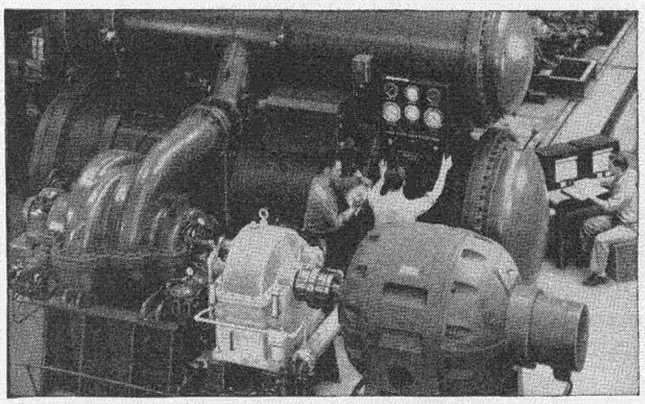

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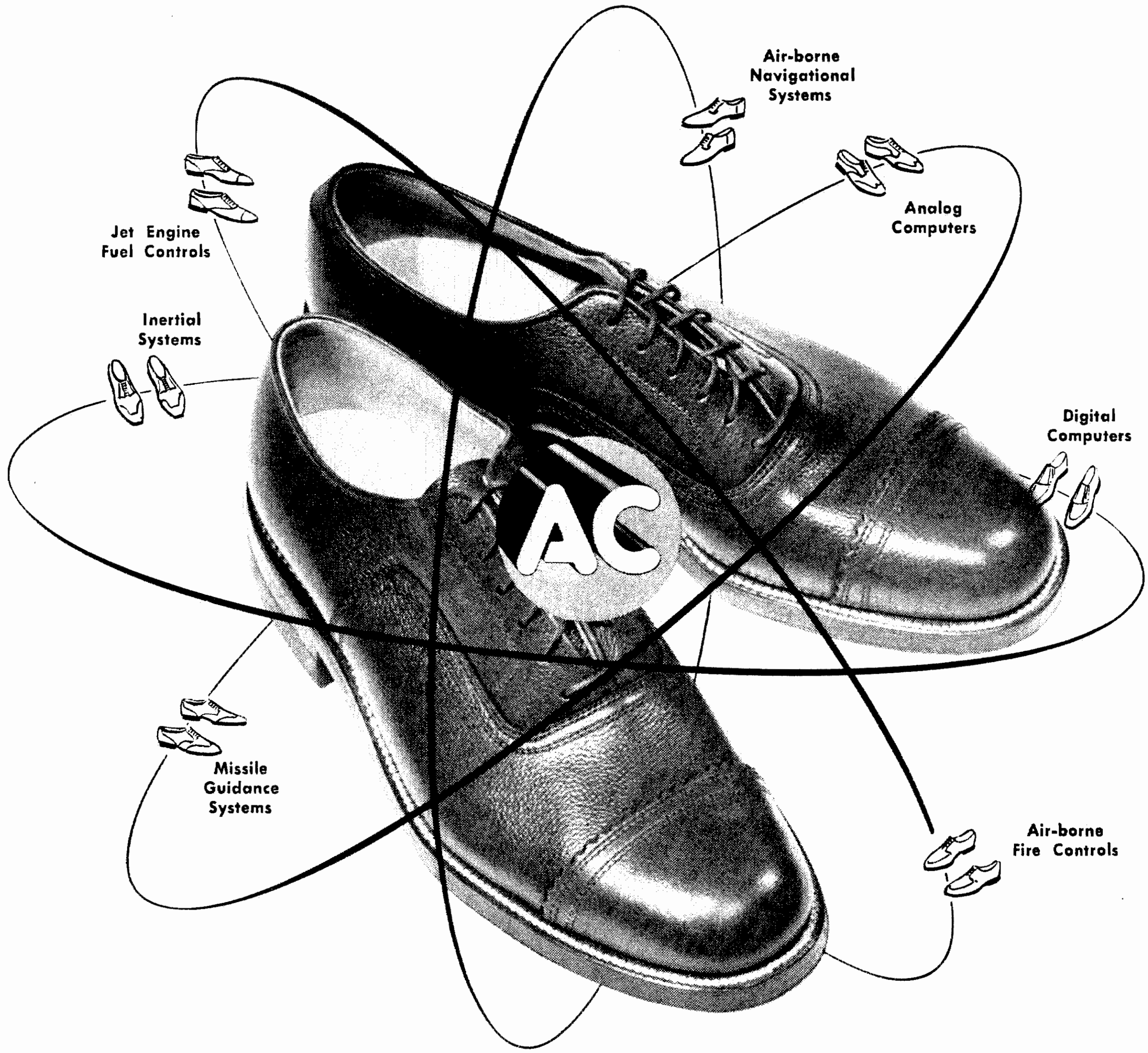

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Personals . . . CONTINUED

He has three children—Sue, 15, Stephen, 13, and Charles, 9.

Andrew L. Hannon, president of Hannon Engineering, Inc., in Los Angeles, has been elected president of the L.A. chapter of the National Electrical Contractors Association.

John Norton Wilson, PhD, writes from Oakland that he "returned in August, '54 from a year in Amsterdam at the Shell Laboratories there to the same job as before at Shell Development Company in the catalysis and surface chemistry department. Visited a number of laboratories in England and on the continent, and saw something of France, Spain, Italy and the Low Countries as well as Britain during sojourn abroad. Life since then has been busy but less replete with novel experiences."

1940

Harold E. Heywood, Jr., MS, is now works manager of the National Supply Company in Gainesville, Texas. Hal has been with the company since 1940, when he was appointed assistant chief engineer at the Toledo plant.

Gerald P. Foster, former president of the Caltech Alumni Association (1953-4), has been named chief of the services section, Systems Division, of the Consolidated Electrodynamics Corporation of Pasadena.

William T. Kluge is now in Japan representing the North American Aviation Company as a consultant technician at the Mitsubishi Aircraft Company. Bill, his wife, and three sons (Clifford, 7½, David, 6, and Steven, 4), will be in Japan for a year.

Harrison A. Storms, PhD '41, chief technical engineer at North American Aviation in Los Angeles, has been appointed to the aerodynamics committee of the National Advisory Committee for Aeronautics.

1941

Frederick W. Thiele, project engineer with North American Aviation, writes that he has just built a new home overlooking the Sound in Seattle after moving there recently.

Donald E. Dawson is supervisor of mechanical research in the research section of the Los Angeles Division of North American Aviation, Inc. He reports that heads of the research section are *L. P. Spalding*, '36, chief research engineer; and *Robert R. Jannssen*, '40, assistant chief research engineer. Don lives in Manhattan Beach with his wife, Judy, and two children, Terry, 11, and Claire, 9.

Norman F. Svendsen, MS '42, reports that, in 1955, he and his wife "took a trip around the world—via a Norwegian

freighter, banana boat and Nile steamer, with a safari in a newly purchased Volkswagen about Europe. We were traveling about 11 months and visited the Philippines, Indonesia, Malay, Siam, Burma, Africa, India and the Near East. After Europe, we took a freighter from London to Panama, then down from Costa Rica to Los Angeles."

1944

Neil S. Estrada, MS, is with a paint company in or near San Francisco and lives in Palo Alto, reports a friend of his, John R. Macarthur, of Chula Vista.

Cornelius Steeling writes briefly of his recent accomplishments: "(1) made a European trip in the summer of 1953, (2) climbed the Matterhorn in Switzerland, (3) finished PhD in organic chemistry at UCLA, (4) now a member of the board of directors of the American Civil Liberties Union."

Bert H. Golding, MS '48, is working with the Arabian American Oil Company in Dhahran, Saudi Arabia. Bert's wife and three boys are in Washington, D.C., until housing becomes available in Arabia.

Charles B. Miller is now the mechanical engineer for Southern Pacific Pipelines, Inc. in Los Angeles.

1946

Richard C. Warner writes that he has been made chief draftsman for the California State Division of Highways in Eureka: has just finished building his home: and has a frogman suit and air tank to explore the ocean possibilities of northern California.

1947

Arthur S. Bolles writes that he "had a two-month vacation in the U. S. this summer with my wife, son, 3½, and daughter, 2½, and returned to Saudi Arabia via the Pacific. We made several stops, including Tokyo, where I was best man at the wedding of my brother Ralph, who was stationed there in the U. S. Armed Forces. I am at present employed as a pipeline engineer and am in my 8th year with Arabian American Oil Company in Saudi. My wife, by the way, is a cousin of *James R. Wilcox* '50, but we met in Arabia in 1948."

1948

Reed A. Gray, PhD, won the first award of $1,000 in the 1955 Glycerin Research awards while working in the microbiological research department of Merck and Company, Inc., in Rahway, New Jersey.

George William Boutelle has been appointed director of sales of AMF Atomics, Inc., a subsidiary of the American Machine and Foundry Company. George has been with AMF since January, 1955 and was formerly with the Bulova Watch Company as assistant to the vice-president in charge of sales.

George R. Schull, MS, writes that the principal news in his life is that he's getting married in March. On their honeymoon, George and his wife will fly their Bonanza to Mexico.

Mihran S. Agbabian, MS, received his PhD in 1951 at the University of California at Berkeley, and joined the Ralph M. Parsons Company of Los Angeles after four years with the Bechtel Corporation in San Francisco. Mike is now assistant head of the structural department of the architect-engineering division. He's married to Elizabeth Apkarian, formerly of Beirut, Lebanon.

1949

Sidney G. Gibbins has completed work for his PhD in organic chemistry at the University of Washington and is now on the staff of the Du Pont electrochemicals research laboratory in Wilmington, Delaware.

Gaelen Felt, MS, PhD '51, has been named acting commander of Task Group 7.1 at the Los Alamos Scientific Laboratory which will conduct a new series of experiments after May 1. Gaelen has been at Los Alamos since 1946 when he was discharged from the Army and stayed on in a civilian capacity.

Mehmet A. Turkkan, MS, died in February, 1955 while serving as a Lieutenant Engineer in the Jet Engine division of the Turkish Air Force.

Lowell G. Wayne, PhD, is 1956 chairman of the Los Angeles branch of the Federation of American Scientists. Another officer of the Association is *John Drake*, '42, MS '43, secretary. Lowell is the Industrial Health Engineer at the University of California in Los Angeles.

1950

William T. Staats, Jr., is now working as a design engineer for Weston Hydraulics, a subsidiary of the Borg-Warner Corporation. A son, Donald, was born on Bill's birthday last August.

John P. Moffat, Jr., has been appointed as assistant director of quality control of the Consolidated Electrodynamics Corporation in Pasadena. John has been with the company since 1952.

Harry F. Clark, Jr., who is with the All-States Engineering Company in Cincinnati, was married last July 15th to Dora Dean Furnish of New Port, Kentucky. Harry flies his own four passenger plane.

1951

Robert E. Covey, MS '52, is now in charge

Personals . . . CONTINUED

of the Caltech Jet Propulsion Lab's 20-inch supersonic wind tunnel. He's been with JPL since his graduation. He and his wife, Joyce, became parents for the first time last July when their son, Alan Reed, was born.

Julius Hermann, MS, who is working for the Stratos Division of the Fairchild Engine and Airplane Corporation in Bay Shore, New York, was married on February 4 to Roberta Shapiro of Newark.

1952

Berni J. Alder, PhD, is in the theoretical physics division at the Radiation Laboratory in Livermore. He spent a year (1954-55) in Europe as a Guggenheim Fellow before working in this new position.

1953

Gerald H. Ross writes that he is still with the McCullock Motors Corporation in Los Angeles as chief engineer of the electrical vehicle division and with the aid of *Takeo Asakawa*, BS '53, who started with the company last December, we are designing and building small industrial tractors, inter plant personnel carriers and golf course vehicles.

Warren E. Mathews, PhD, has been head of the advanced planning staff in the Weapon Systems Development Laboratories of the Hughes Aircraft Company in Los Angeles, for almost a year. He has three daughters, Carol, 5, Peggy, 2, and Gail, ten months old.

1954

Roland S. Miller, MS, worked at Quinton Engineers, Ltd. until last December when he was drafted into the Navy. He is now a seaman recruit in San Diego.

1955

Jerry A. Orr, MS, is working with Rocketdyne, a division of North American Aviation.

Stanley F. Parkill, writes that he has "been uprooted from the civilian pleasantries of the southern California bon vie and am now a Naval officer candidate at Newport, R.I., where it rains, snows, fogs, and where all southern Californians have permanent colds."

Thomas Trilling has been at Hughes Aircraft since June, working part-time and is attending graduate school at USC, also part-time, working for a master's degree in electrical engineering, under the Co-operative Fellowship Program.

NINETEENTH ANNUAL ALUMNI SEMINAR - SATURDAY, APRIL 7, 1956

8:30-9:15 A.M.—REGISTRATION

Dabney Hall of the Humanities

MORNING PROGRAM

9:30-10:30 A.M.

One of the following:

A. CALIFORNIA FAULTS AND EARTHQUAKES

Clarence R. Allen, Assistant Professor of Geology

San Francisco, Long Beach, and, most recently, Lower California have experienced violent and destructive earthquakes. Geologists and seismologists relate these crustal movements to an extremely complex local fault structure. Strain release studies and field observations have recently shed light on the mechanics of faulting and now allow limited predictions of future seismic activity.

B. METABOLIC STRATAGEMS WHICH STAY TIME'S ARROW

George Laties, Senior Research Fellow in Biology

The living state, representing as it does a high degree of organization, and reflecting in its myriad forms a vast store of chemical energy, is by all reasonable considerations a highly unlikely state. In the biological world, means have been evolved whereby evanescent uphill scrambles may be made in the face of a constant tendency for the stuff of which living organisms are made to run downhill to a final low energy state incompatible with life. Such means, powered by solar energy, are remarkably similar in the lowliest micro-organism and in man.

10:20-10:50 A.M.—COFFEE TIME

Served in the patio between Arms and Mudd

10:50-11:40 A.M.—

One of the following:

A. DICKENS, THACKERAY, AND GEORGE ELIOT; or How to Tell a Good Novel From a Bad One

Harvey Eagleson, Professor of English

Professor Eagleson is known and admired by all of us. His stimulating and entertaining approach to any facet of English literature makes his lectures memorable. This discussion is concerned with establishing standards by which one may judge the worth of a novel, using the authors named as illustrations.

B. COMPUTERS: APPLICATIONS AND IMPLICATIONS

Gilbert D. McCann, Professor of Electrical Engineering

The development of large scale computers and their applications in technology and business are progressing at a rapid rate. New principles of instrumentation and logical design permit machines with extremely high computational speeds which are capable of handling very complex analyses and data processing problems. This advance opens up completely new concepts in science, engineering, business administration, and manufacturing. In addition it requires new points of view in research and the training of technical personnel.

11:55-12:45 P.M.—

One of the following:

A. WHY THE EARTH SATELLITE?

William H. Pickering, Director, Jet Propulsion Laboratory

Why do we bother to launch an earth satellite into space? This magnificent technical achievement, due to become a reality during the coming International Geophysical Year, has ample justification in the scientific observations which will be made by instruments carried by the satellite. Dr. Pickering is a member of the National Academy of Sciences Committee in charge of the satellite, and will discuss the scientific aspects of the satellite program and the problems to be overcome.

B. MUSCOVITE MAKE-BELIEVE

Heinz E. Ellersieck, Assistant Professor of History

During the centuries of oppressive and arbitrary rule under the Tsars the Russian people developed many interesting techniques for physical and psychological survival. Under the even more oppressive rule of the Soviets the same methods continue to serve. Unfortunately, however, along with the all-pervading deceptiveness there is a great deal of self-deception. This enables Soviet Man to maintain his self-respect under abominable conditions. It also makes him extremely dangerous. Dr. Ellersieck, from his wide knowledge of Russian political history, will comment on these problems.

1:00-2:00 P.M.—LUNCH—Student Houses

AFTERNOON PROGRAM

2:15-3:45 P.M.

STARS AS NUCLEAR FURNACES—A SYMPOSIUM

Nuclear Physics and Astrophysics have recently combined forces to produce a new approach to the fascinating questions of the formation of the elements and the origin of the universe. By integrating their viewpoints and drawing on experiment and theory in several fields of science, the participants in this symposium make a novel and important contribution to the Alumni Seminar.

Speakers:

W. A. Fowler, Professor of Physics

J. L. Greenstein, Professor of Astrophysics and Staff Member, Mt. Wilson and Palomar Observatories

Fred Hoyle, Senior Research Fellow in Astrophysics and Lecturer in Mathematics, St. John's College, Cambridge

Chairman: *A. M. Zarem '40*

3:45 P.M.—COFFEE TIME

Served in patio between Arms and Mudd

OTHER EVENTS

Open from 2:00 to 4:00 P.M.

Synchrotron
Solar Furnace
200-inch Model Telescope
Geology Museum

Athletic Events, Tournament Park:
Track Meet—Varsity & Frosh —Whittier
Tennis—Frosh—Whittier
Baseball—Frosh—Whittier

EVENING PROGRAM

Dinner Hour: 6:30 P.M. (Bar opens 5:30)

Elks Club, 400 W. Colorado Street, Pasadena
Dress—Informal

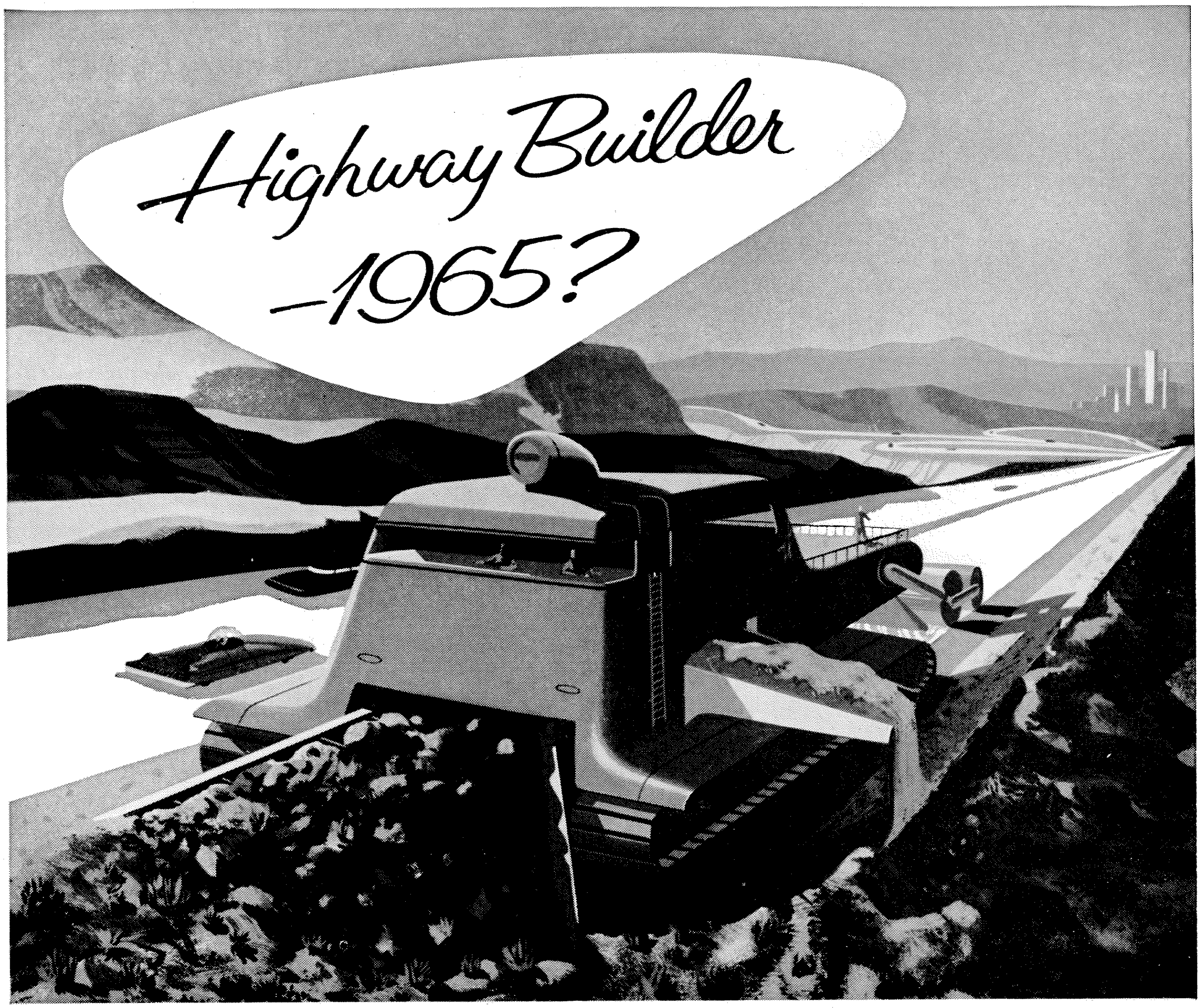
AFTER DINNER:

Introductions by C. W. Lindsay '35, General Chairman, Alumni Seminar Day. Remarks by Dr. Lee A. DuBridge, President, California Institute of Technology.

Guest Speaker—MR. PAUL G. HOFFMAN
His Subject—"FREE ASIA IN THE BALANCE"

Mr. Hoffman is Chairman of the Board, Studebaker-Packard Corporation, and serves as a Director of several other organizations. He has previously been President and Director of The Ford Foundation and Administrator of the Economic Cooperation Administration. Mr. Hoffman is the author of several books on international affairs.

NEW DEPARTURES OF TOMORROW



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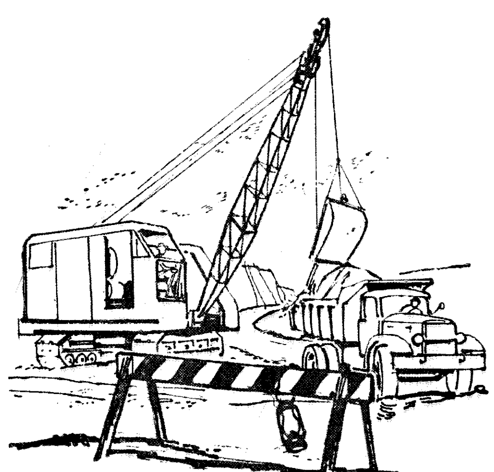

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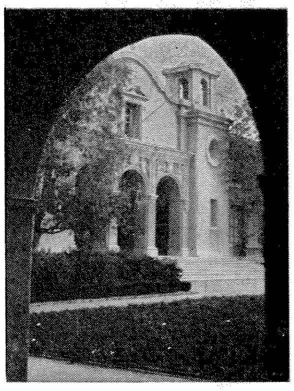

CALTECH CALENDAR

March, 1956

ALUMNI CALENDAR

April 7 Seminar Day

June 6 Annual Meeting

June 23 Annual Picnic

ATHLETIC SCHEDULE

TENNIS

Apr. 3—Pendleton Marines at Caltech

TRACK

Mar. 27—March Field at Caltech

Apr. 7—Whittier at Caltech

SWIMMING

Apr. 2—Santa Monica CC at Caltech

Apr. 6—Caltech at Occidental

BASEBALL

Mar. 21—Caltech at San Diego State

Mar. 22-23—Caltech at Marine Recruit Depot (San Diego)

Mar. 26—Caltech at Cal Baptist (Covina)

Mar. 30—Pomona at Caltech

Mar. 31—Caltech at Westmount (Santa Barbara)

FRIDAY EVENING DEMONSTRATION LECTURES

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

March 16—The Origin of Life—
Dr. Norman Horowitz

March 30—Microwaves, Past and Future—
Dr. Roy Gould

April 6—Use of X-Rays in Determining Atom Structure—
Mr. Robert Nathan

April 13—The Structure of Molecules as Determined by the Diffraction of Electrons—
Dr. Verner Schomaker

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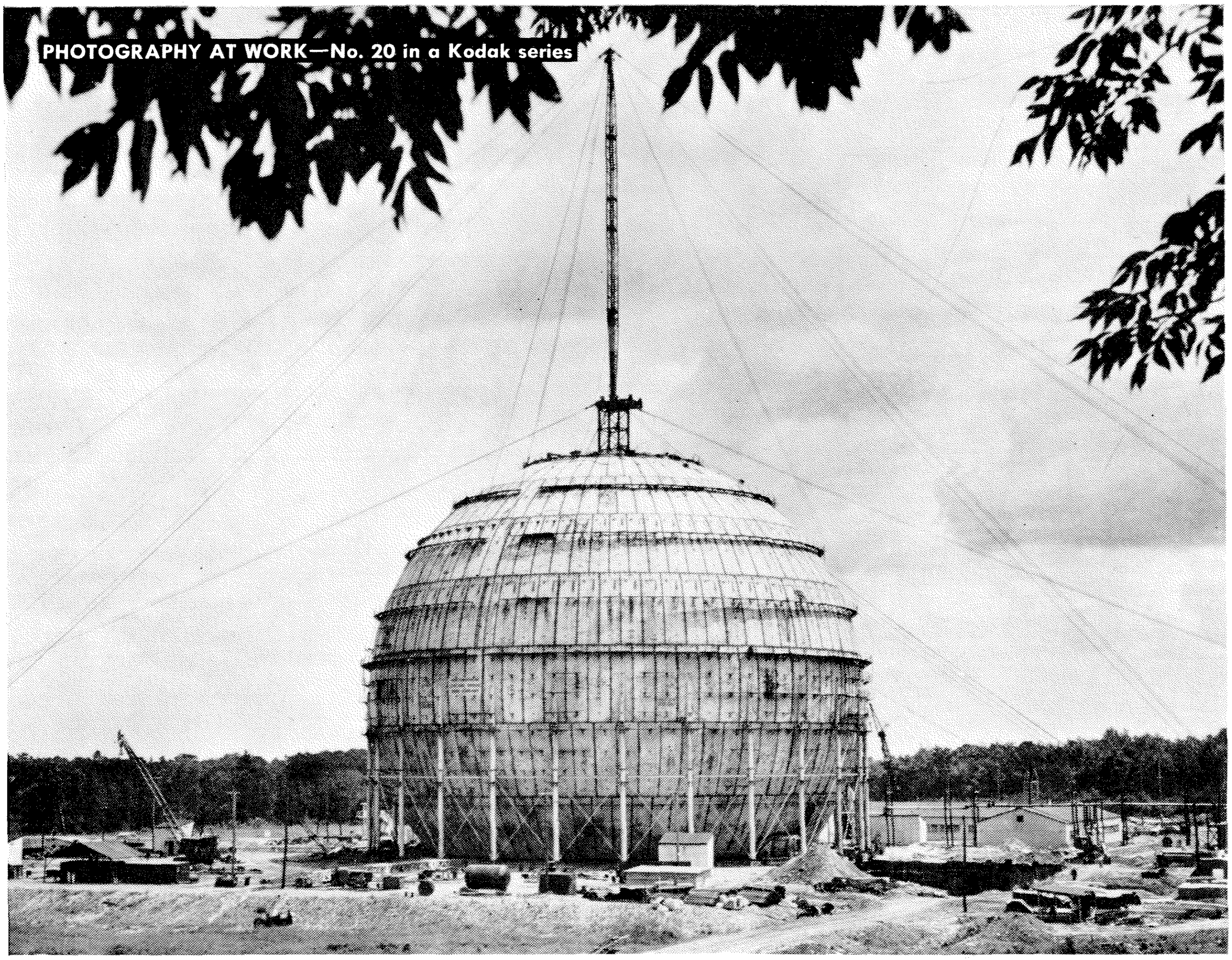
Consolidated Vultee Aircraft Corp., San Diego

Program Chairman Herman S. Englander '39
U. S. Navy Electronics Laboratory



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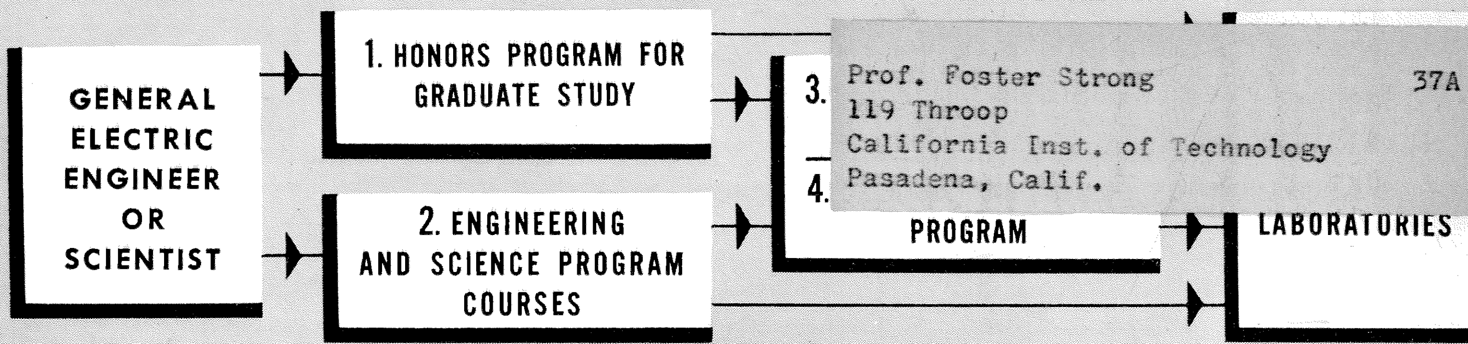

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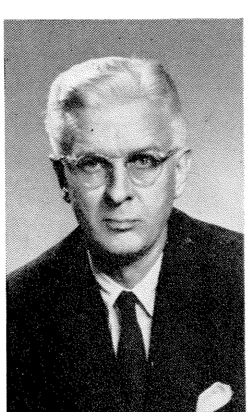

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Industrial progress hinges on the engineers' ability to apply amazingly complex technology to the problem of creating new goods and services. It is vital that the engineer at G.E. be given every opportunity for self-development in his chosen field, and so the far-reaching educational programs described on this page are designed to satisfy three specific needs.

The Team Approach

The team approach to complex technical projects is extremely important in industry today. It brings together competent men with a wide variety of training and experience to blend their abilities in the solution of problems. To be prepared to work as a member of a team, the engineer must develop appreciation and understanding of the work and contribution of the other members. Recognition of this need is the basis of teaching philosophy all through the programs.

Importance of Supporting Sciences

Many of the problems facing engineers in modern industry are not found in the principal engineering sciences, but have shifted into areas which have been thought of as supporting sciences. An engineer working principally in aerodynamics, for example, may find the main roadblocks in his work are the limitations of the materials which are available. By working closely with experts in the field, the engineer must in fact influence the development of new and better materials.

Broad Technical Backgrounds

The solid core of industry's engineering effort is a body of men thoroughly grounded in the fundamentals of basic science. With the explosive increase in technology, the engineer and scientist need to keep abreast of all allied areas. G-E advanced-study programs give this opportunity.