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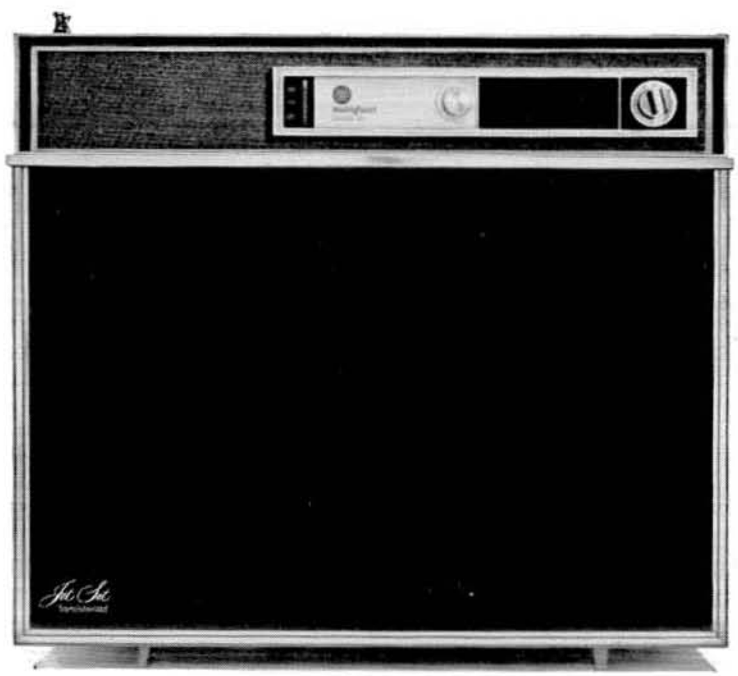

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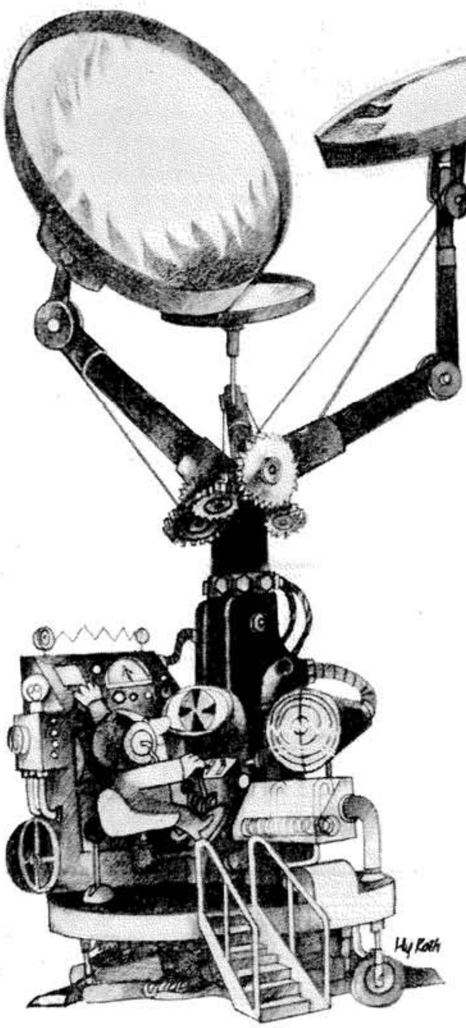

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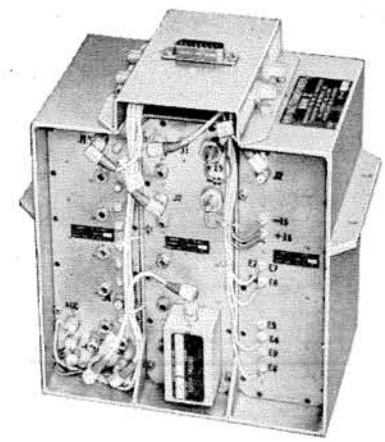

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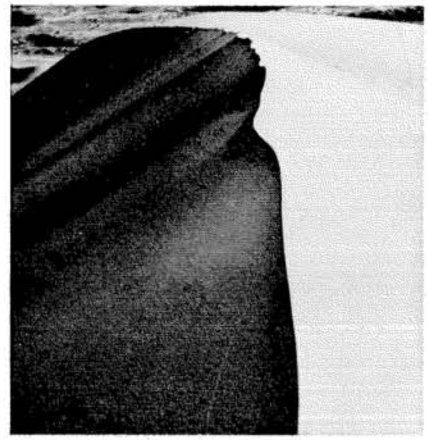

On Our Cover

is the crest of a sand dune near Kelso in the Mojave Desert. The very sharp crest indicates that wind has recently blown from the right. When the wind direction changes, the edge will be quickly dulled. The dunes of southern California constitute a unique research resource for Robert P. Sharp, professor of geology and chairman of Caltech's geology division. Pictures from his collection illustrating other features of dunes are in "When the Desert Winds Blow" on pages 14 and 15.

Jesse L. Greenstein,

professor of astrophysics at Caltech and staff member of the Mt. Wilson and Palomar Observatories, was the subject of an interview with British science writer Gerald Leach on the British Broadcasting Corporation's Third Programme on October 19, 1965. This spirited radio interview—one of a BBC series on "Some Scientific Americans"—appears, in large part, in "The Study of Immensity" on page 8.

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Books *by faculty and alumni*

The Molecular Biology of Development

by James Bonner
Oxford University Press $3.50

A book for biologists who want to learn about those portions of molecular biology which pertain to the study of development, and for molecular biologists who want to consider some of the ways in which the insight of modern biology may be applied to developmental matters.

Dr. Bonner, professor of biology at Caltech, wrote the book during his recent tenure of the Eastman Visiting Professorship.

Quantum Mechanics and Path Integrals

by R. P. Feynman and A. R. Hibbs
McGraw-Hill $12.50

Reviewed by Jon Mathews, associate professor of theoretical physics.

In the vigorously active and competitive world of contemporary physics, very few ideas or techniques remain for long the property of their creator. Ideas in this area are rarely patented, and inventors can usually hope only that their contribution will not be totally submerged in the avalanche of papers that follows each new idea. The path integral concept, developed originally by Feynman as a graduate student some 25 years ago, is an exception. It has been left for Feynman, now Tolman Professor of Theoretical Physics at Caltech, with the assistance of A. R. Hibbs, a former student of his now at the Jet Propulsion Laboratory, to present in this book the first systematic discussion of path integrals in quantum mechanics.

According to the dust jacket, the book is intended as a supplement for first-year graduate courses in quantum mechanics, as an introduction to path integrals for physicists already familiar with quantum mechanics, and as a source book for Feynman's contributions in this area. The validity of the second and third purposes is beyond question; the writing combines clarity, informality, and physical insight with admirable effect. However, it is a rare first-year graduate student who has acquired sufficient feeling for quantum mechanics and quantum statistics for the elegance of Feynman's reformulation to come through.

The situation is reminiscent of the introduction of the Feynman lectures to the freshmen and sophomores at Caltech. Arguments were made, before and after the changeover, that the material could not be fully comprehended by lower division undergraduates. Nevertheless, the experiment was successful. Only the passage of time can tell whether the path integral approach to quantum mechanics, which is set forth so elegantly by Feynman and Hibbs in this book, will similarly affect the teaching of quantum mechanics at the graduate level.

The Machinery of Life

by Dean E. Wooldridge, PhD '36
McGraw-Hill $7.95

Reviewed by G. D. McCann, professor of electrical engineering and director of the Booth Computing Center.

Dean Wooldridge is a research associate in engineering at Caltech and a director of TRW, Inc. During the past few years he has become intensely interested in the examination of the life sciences from the viewpoint of a physicist. His first book, *The Machinery of the Brain* (McGraw-Hill, 1963), dealt with explanations of the functional properties of the brain and nervous system. This book is concerned primarily with the structure of living organisms in terms of successively more complex building blocks. Wooldridge takes a viewpoint that this structure can be understood as a logical extension of the physical laws of the inorganic atoms and molecules.

Starting with the prehistoric geophysical state of the earth, which provided the environment for the origins of the "pre-life" organisms, he develops in a relatively clear and precise manner the detailed steps that scientific research indicates were necessary for the evolution of primitive life and the higher living systems leading to man.

This is a semi-popular book, and yet it contains a remarkably thorough treatment of the amino acid-protein and the nucleonic acid structures, together with their roles in the formation and functioning of living organisms.

This description of the physically known properties of extremely complex chains of molecules supports his thesis that, as man understands life in physical terms, life loses its mystical properties. Admittedly, however, our knowledge of the living organisms is not yet sufficiently complete to explain the more comprehensive, larger, living systems or more complete animals, to the extent that we can have the conviction that the complex functions and behavior properties of man can also be explained in such physical terms.

The Uncommon Man in American Business

by Wallace J. S. Johnson, '35
The Devin-Adair Co. $3.50

Reviewed by Theodore C. Combs, '27

Wallace Johnson is president and founder of Up-Right, Inc., a successful scaffolding business. He also is mayor of Berkeley, California. In this book he philosophizes and reminisces about the role of the uncommon man in business, of whom he is, indeed, one.

To Johnson's man, freedom is for adventure, not for security. He succeeds by being enterprising, inventive, honest, responsible, and deeply appreciative of the values of his fellow man.

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One might wish that uncommon men, Wallace Johnson stye, were commoner—and that more men might use his do-it-yourself kit, *The Uncommon Man in American Business*.

Thermodynamics of Multicomponent Systems

by Bruce H. Sage
Reinhold $18.50

A text for advanced study of the thermodynamics of multicomponent systems. The development, based on the work of J. W. Gibbs, is thorough and rigorous. Starting from the basic scientific concepts, the subject is treated in sufficient depth so as to show the engineering applications. Many illustrative examples are discussed, and a wealth of valuable numerical information is given. Dr. Sage is professor of chemical engineering at Caltech and has been associated with the Institute since 1934. He is the holder of many honors and awards, including the Medal of Merit, U.S. Department of Defense.

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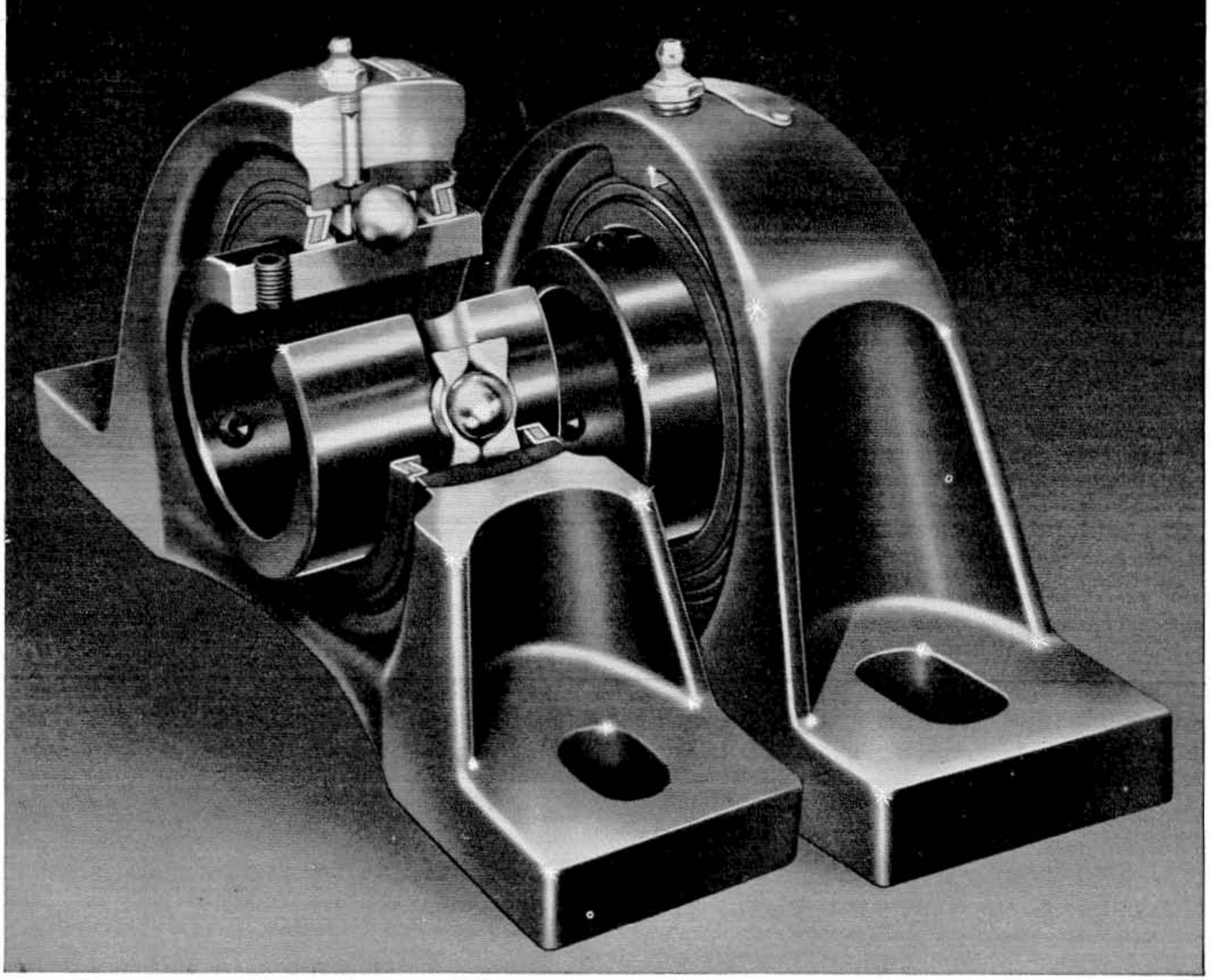

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THE STUDY OF IMMENSITY

A non-scientific interview between Jesse L. Greenstein, professor of astrophysics and staff member of the Mt. Wilson and Palomar Observatories, and British science writer Gerald Leach. Adapted from a BBC Third Programme broadcast on October 19, 1965.

LEACH: I went to see Dr. Jesse Greenstein because I'd heard that he was one of the most gifted talkers on the whole American continent. The reports were correct. We sat in the living room of his house in Pasadena, and we talked all morning. In those few hours he managed to convey more deeply than I have ever heard before a real sense of the total involvement of doing science: a personal tie with the objects one studies that is perhaps unique to science. To put it bluntly, Dr. Greenstein *knows* stars, and feels for them, as other people know other people.

Yet I was not concerned just in asking him about *what* astronomers have found. I wanted to know what it is like to do astronomy. How does the study of immensity affect one's personal values? How does one arrive at the great speculative ideas from which astronomy advances? And so, to start our conversation, I asked him how it feels to work in a subject that is exploding intellectually probably faster than any science has ever exploded before.

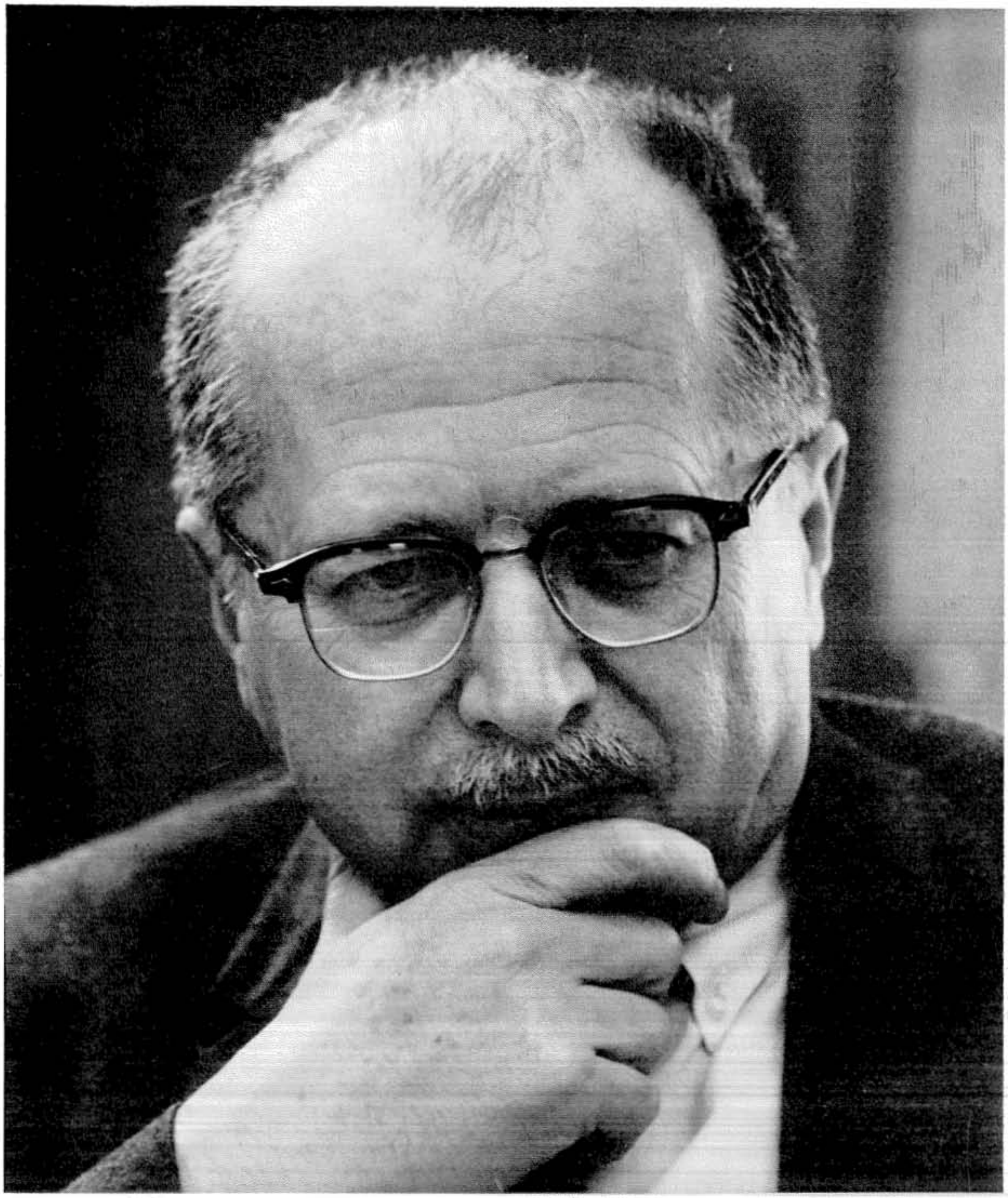
GREENSTEIN: It's a very happy time to be alive. And it really is viewed by most of us as an opportunity to share the great and explosive pleasure of novelty and change. I think the stimulation of a new discovery, the realization that not everything is known, that one doesn't need to go over the old ground again and again, push one into free imagination and create the pleasure of the work.

LEACH: I'd like to talk to you about quasars, which are only about two or three years old now. What is the current situation?

GREENSTEIN: Enormous ignorance, alleviated by splashes of light. What we think we find is a large group, almost 100 objects, of an extraordinary class. They are extremely luminous in both radio frequencies and in light, and very much brighter than our own galaxy.

LEACH: What are the current ideas on how this enormous amount of energy is produced?

GREENSTEIN: Well, the facts seem to indicate that what we see is not really the source of the energy. So we leave the great speculators to speculate about what is going on inside what we see. What we see is a gas cloud, not very massive—perhaps a million times as heavy as the sun—very small, hot, and pouring out energy at this enormous rate. The mystery is that under no conceivable circumstance could this gas cloud be the only thing that is producing energy. If you take its temperature and measure its total heat content and let it turn into light in the most efficient way, it could last only a few years before it would fade. It must be replenished. And so several of us invented an invisible object—perhaps forever invisible—a thing much smaller than a light year, buried in this gas cloud, and producing energy, and we call it Object X. We have good reason to know that it has produced energy for at least some hundreds of



years, because the brightest of these objects has been observed photographically on old plates taken at random over almost 80 years now. These plates show that the light has varied in a rough 10-year cycle. But it hasn't changed systematically.

LEACH: But this Object X must be a very extraordinary object.

GREENSTEIN: Yes, and that's where I find myself, surrounded by good friends—physicists and astrophysicists—of great intellectual depth who have had a wonderful time thinking what Object X might be. They listen respectfully to the very few facts we have, and then they go on enormous branching paths of speculation. I don't mean to sound cynical or contemptuous, because these are brilliant men and brilliant ideas. I think the main thing that I draw my pleasure from is that we have forced brilliant people to extreme solutions. There is no easy way out of this problem.

LEACH: Probably more than in any other science, such crazy speculative ideas have been produced in the last two years that this is almost becoming like a game.

GREENSTEIN: Well, all good science is a game of free intellectual play. Fortunately we have enough boundary conditions so that the play is not completely a game without rules.

These are not extraordinarily speculative ideas; I think the existence of the universe is an extraordinary fact. The existence of quasars is not more extraordinary. One theory, proposed by Yuval Ne'eman, who was visiting Caltech last year, holds that instead of a gravitational collapse, or a superstar, we are seeing little bits of the universe before it started to expand. The bits were so dense that they never started expansion, and maintained themselves in quasi-stable form for 10 or 15 billion years.

LEACH: This is an idea about as far out as one can get.

GREENSTEIN: Yes, but you make it sound a lot stranger than you need to. If you say the universe exists and there was a big bang 15 billion years ago, you've made so extraordinary a statement that the simple and quantitative statement that parts could have been stabilized for billions of years is not relatively extraordinary. If you believe in the universe's existence, you have enough mystery.

LEACH: The thing that fascinates me is that you astronomers can make such strange, speculative statements, which may turn out to be wrong, but the community of astronomers doesn't laugh at you for being wrong.

GREENSTEIN: Well, when you make your statement based on limited information—and in astronomy we are certainly always living with a minimum amount of information—you have an operative, temporary, partial truth. Then you make an interpretation on the basis of even fairly well-established fact. You are quite privileged to be wrong a very large majority of the time. It is the intellectual free play of new ideas that provides the stimulus for theoretical people and for other experimentalists to check these ideas. You are privileged in theoretical work to build up an enormous world picture in which there is never any contact with an observable fact, but it's risky. I really feel that the novelty and depth of your fantasy and theory are what are important. Since the world is so difficult to know and since we are always finding such new and strange things in it, it is the duty of the theoretical person to break free from the apparent fact with which he might conceivably be so limited that he could not think of something new.

LEACH: And you would go so far as to call this a fantasy?

GREENSTEIN: I call it fantasy at first, certainly. The word fantasy or intuition in science means that you create a possible imaginary world, and then you look at the real world to see if there is any point of contact.

LEACH: Which is the difference between science and the arts.

GREENSTEIN: Yes, except that if it is a fantasy in the arts, it has to have some human relevance; no matter how abstract the painting, either the painter or some viewers must be able to feel that there was some action or feeling.

LEACH: There's a much more tenuous anchoring back to earth as it were?

GREENSTEIN: Oh, yes. Now, when a good astrophysicist makes a theory which is fantastic, he does not set out in a few paragraphs a word picture of a world, but he makes a mathematical model. This mathematical model, following the rules of normal mathematics and logic, is internally consistent. It must be consistent; otherwise it is no theory. Ultimately, it reaches a certain prediction, which may be merely a new way of viewing an old fact.

LEACH: Doesn't it ever surprise you that an idea based on mathematics and obviously internally consistent should be consistent with the real world of today?

GREENSTEIN: Yes, the existence of mathematical pattern in the real world seems to me implausible and almost immoral. Since Newton's time, the world has fit first into a geometrical and then later an algebraic picture; now the more tenuous theory of fields, group theory, and more and more abstract parts of mathematics become part of the model.

Whether or not the reality behind the appearance has anything to do with the mathematical model is somewhat irrelevant, just as long as the input is the real world, the output is the observable real world, and the connection between is a consistent mathematical structure. There are many alternative structures.

LEACH: This is a pragmatic view? As long as it works, it works.

GREENSTEIN: Not really. If the Lord is a mathematician is a reasonable question; it was said that he was, but it seems clearly rather arrogant. If so, he is a better and more applied mathematician than the real ones that we have. But this oddity, that the natural world seems to have some logic which we can understand in part, is a permanent mystery of science.

LEACH: Yet it could be said that one only finds those irregularities that one is looking for.

GREENSTEIN: That's also true. Could we believe in the existence of a self-contradictory, nonlogical, random universe? Could we know it?

LEACH: An idea I've always had is that our mathematics, our whole search in nature, is based on a faith in order and regularity.

GREENSTEIN: Yes.

LEACH: There could be an intelligent race who didn't put order so high but put irregularity higher—and then they would search for randomness. Would they get a different universe?

GREENSTEIN: Well, they certainly would have found quantum theory before they found billiard-ball Newtonian mechanics. The real world of atoms and nuclei is a quantum world, which is a randomness world, in a sense. Imagine a world composed not of discrete human beings with hard frames walking on earth, but of highly organized collections of marine organisms floating in the sea. There, shape does not count, gravity does not count, solidity does not count; what counts is the exchange of, say, food between the liquid medium outside you and the liquid medium inside you. You are a wave of organization rather than a hard-shelled animal. I wonder if science for such people wouldn't have been different, just as art would be very different for those living in the darkness of the seas where sight is not an important sense. It would be a very odd universe, although the mathematics of patterns would be the same—with an increased emphasis on randomness.

LEACH: Do you see the universe as a great piece of clockwork?

GREENSTEIN: No and yes—I can't say—I can't answer really sensibly. It certainly isn't a simple bunch of solid bodies going around each other according to the laws of Newton. Life has changed that a great deal.

LEACH: Astronomy in the last 30 or 40 years has changed this, and you have helped change it. Your work with others on the evolution of matter in stars—the nuclear reactions and so forth, which build the elements from simple hydrogen right on to the heavy elements—this in a kind of way is a piece of clockwork.

GREENSTEIN: Well, it is different clockwork. The clockwork of the 16th through 19th centuries was that of classical mechanics, matter in motion. Now it is the clockwork of atoms and nuclei—which is a lot vaguer clockwork—and instead of balls of dirt like the earth going around the sun, we concentrate on what goes on in the sun. The sun is not a simple mechanism that we can describe by the laws of mechanics; they are relevant, but more important laws are those of thermodynamics. The life of the universe is the destruction of matter, the production of energy, and its conversion into light. The sun and other stars, hot balls of gas, are the fundamental entities of the universe. I hate to hear you call it clockwork; it is more like a swarm of radiant, flying balls of fire than cold planets are, so the word clockwork irritates. But it is still, of course, clockwork.

LEACH: Just now, you put a sense of purpose into the sun and universe; you said its object was to produce energy.

GREENSTEIN: We look at everything through the eyes of the use of energy by man, I guess. But I also feel that the life of a star is as romantic as the life of an individual. It isn't as various or complicated, just bigger. But it is beautiful; it has the glamour of contrasts, of light contrasted with the cold of interstellar space. But meaning, purpose, goal—certainly not.

LEACH: Astronomers throw off phrases like "4,000 million years old" or "energies millions of times our own sun" very casually. Do you really feel so casual yourself?

GREENSTEIN: No. It is easy to hide behind big numbers, but more important to try to feel what they really represent. That, I think, is one of the pleasures of being a scientist—having a visual, imaginative grasp of the range of physical conditions in which matter can find itself. If you really feel what these things mean, if you try to imagine the conditions in space, the incredible emptiness of things, you get a genuine emotional reaction. It is nothing that you can feel dispassionately; if you do, you are losing half the pleasure of being a scientist.

LEACH: Do you find you can imagine them at all?

GREENSTEIN: Well, I try hard, but a billion or a million is an absolutely meaningless concept. I think all you can do is try to extrapolate them within the limitations of the human senses. The heartbeat of our galaxy, a single rotation, might be viewed as something like the earth turning on its axis—a day. But that's 200 million years for a galactic day. Our whole galaxy has turned only 50 times on its axis since it was formed. That's graphic; our young giant spiral pinwheel turning only 50 times since the beginning of all the stars in our system. But each turn is 200 million years, and no one can visualize, feel, what that means. Stars live and die in a tenth of that time; the brighter stars of our own galaxy, if you took a photograph, would come and go. In fact, the only analogy for the very brightest objects is something like a St. Catherine's wheel, a firework that spins rapidly; you see all the sparks, and every spark lasts a tiny fraction of a turn; the spark is a star.

LEACH: The whole life of a star?

GREENSTEIN: The whole life of a star. Such short-lived stars clearly never had planets with intelligent living things developed on them; the older stars may well have done so, but these young ones do not. But the whole life of even quite a reasonable star is often a small fraction of a galactic day—as brief as the life of a butterfly.

LEACH: The enormous expansion in our view of the universe has only taken place in the last 40 years.

GREENSTEIN: The enormous scale of things has been found just in the last few decades. Within a human life, the possibility of understanding each new discovery has strained our fantasy more. At a certain point you might say, "Well, give up, become numb; the whole thing is inhuman." But you can't, because you have to keep yourself placed in it; you have to keep responding to it as a scientist, not only emotionally. I feel very small compared to the earth; the fact that the sun and the space to the stars are a lot bigger than the earth doesn't make me feel any more inferior. I'm looking at the sun; it isn't looking at me. This human, anthropocentric pride has to persist if you're going to be a scientist.

LEACH: But I think a lot of people who aren't scientists do blank off at these enormous distances.

GREENSTEIN: Escape is a nice refuge, but this is clearly impossible. Human beings have had to face the realities of the world philosophically and emotionally. What one has to do is to try to absorb the real material universe as much as possible and try to take a proper attitude towards it. What this proper attitude is, each person must find for himself.

LEACH: When you are on top of Palomar Mountain at night—"sitting up with the universe" as you've described it—looking at the stars, you don't see them as cold, rational things at all. Do you see stars as important as men?

GREENSTEIN: I would say very often that to me an important new concept (which in an experimental subject would be a new particle) is as exciting as, say, another human being. Of course, there's much more in the realm of values in people. But the significance of discovery and the excitement of novelty—which I'm sure exist in the arts also—is so great that if I find an exciting individual object I respond to it as much as to new people. If it is a significant step forward in scientific knowledge —maybe not revolutionary, but part of the accumulation—this strange new thing which permits one step forward in human knowledge is to me really emotionally significant. I guess I must really feel as if it contributes to my well-being. I think most people who work in science find it that way or they would not work—at least in the abstract and speculative sciences. People who want to work for people are engineers or moralists. This is a different kind of response.

LEACH: Do you find yourself very cut off from non-scientists and non-astronomers? I don't mean in your personal, everyday life— I mean, you spend your life sitting on Palomar Mountain looking at these enormous scales and sizes and distances; can you communicate this to your wife or to others?

GREENSTEIN: Well, I certainly hope so. I hope I'd be able to communicate both what I have found and what it means to anybody. If you can't do it, you probably don't understand it; if you can't say it clearly, it is your fault, not theirs. People are quite stupid since they don't know much about science, but on the other hand, people are very fine and do know a great deal. If you cannot clarify the story by some analogy, which may be loose—though not incorrect scientifically—but which is humanly valid, it is your responsibility and not theirs.

LEACH: This is the tragedy of many scientists. I can think of no other people who really cannot communicate to their wives what they are doing.

GREENSTEIN: Well, the scientists are people first; many became scientists because they could not communicate. Many people evade the world by hiding behind science. It is quite true that there are parts of science which are incommunicable; I do not think that modern mathematics, or the advancing front of high energy physics, or even molecular biology are genuinely communicable. But if you cannot give people the feeling of what is going on in these subjects, it is because you are unable to and not because the people are too stupid.

"Seeing a star at night is a very small sight indeed compared to seeing it with eye of the mind."

LEACH: Do you think the beauty and adventure, particularly of astronomy, have got across to most people and changed their views?

GREENSTEIN: Oh, I think so . . . I think so . . . I think we have been very fortunate in the number of astronomers who have been able to communicate well, who can write and talk well, and who have felt the public need to tell their story. I think we are much luckier than the other sciences in that way, because the story of being so small in a universe that is so large and old is a story that most people like to hear—even if it hurts them.

LEACH: And we can, after all, all see stars, even if we can't all see atoms.

GREENSTEIN: That's true, but seeing a star at night is a very small sight indeed compared to seeing it with the eye of the mind.

LEACH: I am trying to get behind your use of the word "creation," which is obviously something you use technically, in terms of the evolution of the universe, and this also goes with our whole conversation about clockwork. I want to know whether you see the creation as something that comes entirely out of physics, out of fields and particles, or whether there's an extra something.

GREENSTEIN: A very good, difficult, horrible question. In the beginning the Lord created, and I don't know very much more than that. I don't know enough about deep theoretical physics to have confidence that sometime it will be possible to show that the universe must be. That I do not really know, and I don't know that anybody knows.

LEACH: Can't one accept that it just *is*?

GREENSTEIN: That is not enough because the universe runs downhill. Because of our continuous work with finite time spans and beginnings and one-way evolution, most astronomers think more in terms of some mystery before physics began than do most physicists, who don't have to worry about it. Physicists say, "the universe is, and here are the laws." This strangeness of the finiteness in time of everything we know in our own galaxy—and that is all I can really talk about—is such that I guess most of us unconsciously accept the idea of a beginning. That this almost occupational disease of acceptance of a mystery before "our" world began must lead to God, in the sense of a personal god, is a little difficult to accept. It just leaves an enormous, early step of mystery, and there are many people who think along such lines. You can imagine all kinds of weird things. The total energy of the universe is zero, and this is practically true. Things fluctuate, and if nothingness fluctuates, positive and negative energies adding up to zero might separate in some unknown way. But I am spilling words that don't mean anything. One must say that zero is the total of everything.

LEACH: And zero split into plus and minus . . .

GREENSTEIN: . . . in the beginning of the world.

LEACH: Do you yourself believe in God?

GREENSTEIN: Probably not. Probably not in the conventional sense. I have what I guess would be described as a vague theistic kind of feeling of the drive from material evolution into the emergence of some kind of value. To me, however, this does not necessarily involve a personal god, or a revealed god, or a revealed religion. It involves very largely an ethical concept, and I wonder whether there is any relation between ethics and religion now. I doubt it for myself.

LEACH: Do you think it unfair that the public should always come to astronomers and ask them theological questions?

GREENSTEIN: Yes, I think it is extremely unfair. I think they should ask these questions of themselves because the interesting questions of theology, it seems to me, are those that affect your own belief in your own significance, in your own value and responsibility, and in the contribution that your existence has made to something you feel external to yourself and permanent. We are not really the intellectual or spiritual masters of the universe. We can't hold that position; we haven't been able to for a long time. Once you give this up, once you really de-center yourself, the rest of knowledge seems to me just to increase the beauty and wonder of human existence and accomplishment. If there are intelligences billions of years more advanced than ours somewhere, then it is our problem to do the same thing, to become the same. In other words, it seems to me that the typical human love for perfection is only given greater strength by a knowledge of the vastness of the universe and the infinite possibilities of evolution. That everything must come to an end is always a dim and lurking and very depressing kind of thought, just as death is richly behind every human value. But to me, the complexity and variety enrich my experience rather than diminish it.

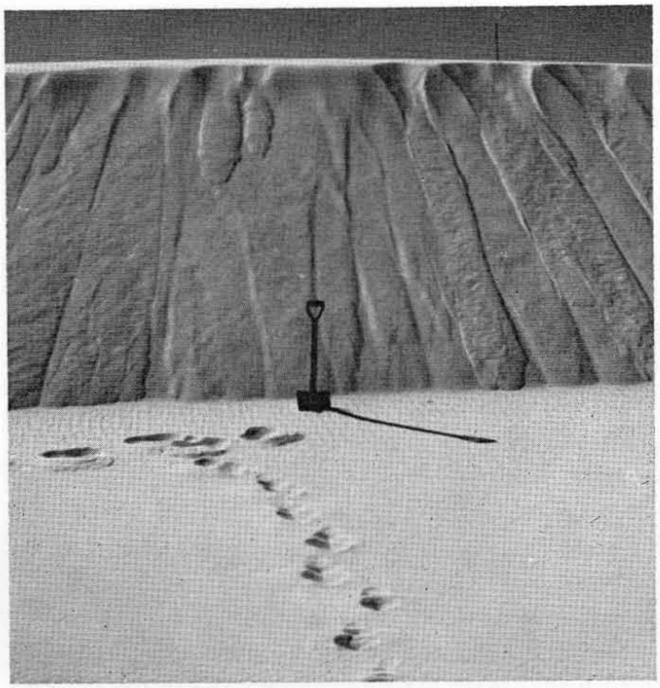
Robert P. Sharp makes notes during a field trip to the Kelso Dunes.

When the Desert Winds Blow

For the past 15 years Robert P. Sharp, professor of geology and chairman of Caltech's geology division, has been conducting a "weekend research project" among the sand dunes of southern California. As a geomorphologist—one who studies the evolution of land forms—he is interested in the mechanisms by which the dunes form and move as sand is nudged and carried by the winds. Among the kinds of information that he thinks dunes may be able to provide are records of the possible migration of the geographic and magnetic poles during the earth's history (which would change the prevailing wind patterns and, hence, be reflected in the orientation of fossil dunes) and the rates of erosion on Mars, where wind may be the major eroding agent.

But sand dunes are attractive to Dr. Sharp for another reason—their great beauty. The pictures on these pages illustrate some of the features he has been studying and the stark beauty of the dune country as well.

Aerial view of a dune complex west of the Salton Sea shows the typical barchan (crescent) form of dunes, but also shows how those forms are distorted when faster-moving dunes overtake slower ones. The wind is from the left.



Sand is blown along the relatively gentle windward slope of a dune and accumulates on the lee slope. Eventually it "slumps" on the lee side in little slides like these.

Both types of ripples here were developed under the same wind conditions. The barchan-like ripples occur in material having the consistency of fine gravel; the others are in sand.

It takes very little to start a dune growing—just something to begin sand accumulation. Once begun, however, the dune will move from its original site and may grow to impressive size, like this one in the Kelso Dunes.

The Energy of a Chemical Reaction

Caltech chemists have made the first direct measurement of the minimum energy required for a chemical reaction, and it is expected to have far-reaching effects on chemical research. Aron Kuppermann, professor of chemical physics, directed the research, which was sponsored by the Atomic Energy Commission. He points out that the measurement will make it possible to gain new insight into chemical reactions, their rates, and the energies required for them. It may also make it possible to learn, at last, if bi-molecular chemical reactions can be described by the laws of classical mechanics or if it is necessary to use quantum mechanics.

Graduate student John M. White, working on his doctoral thesis under Dr. Kuppermann's direction, made the measurement. He showed that 0.33 of an electron volt of energy is required to initiate one of the simplest chemical reactions—that of splitting a hydrogen molecule and linking a deuterium atom with one of the hydrogens. If less than that amount of energy is applied, the reaction will not occur.

The chemical reaction was energized by light from a 200-watt mercury lamp. The light—in the ultraviolet spectrum—was made monochromatic, to standardize the photon energy, by a diffraction grating. Change in the angular orientation of the grating permitted the wavelength (and, consequently, the energy) to be varied.

The light beam was shone on a glass vessel containing a mixture of hydrogen gas and deuterium iodide (molecules made up of one atom of deuterium and one of iodine). The photons kicked apart the deuterium and iodine atoms but did not affect the linked hydrogens. The iodines, being heavy, moved sluggishly, while the deuteriums moved much more quickly.

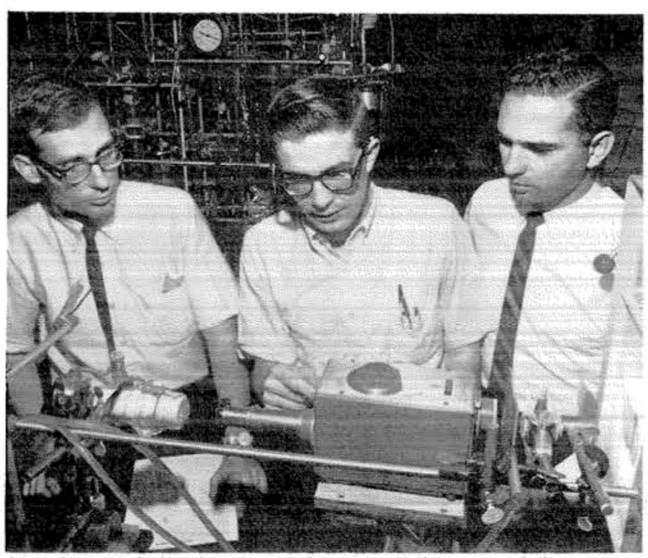
When a sufficiently energetic deuterium atom strikes a hydrogen molecule, it can split off one of the hydrogens and stick to the other one, forming a molecule of deuterium hydride. The freed hydrogen atoms later combine into other molecules, and the freed iodine atoms combine into pairs.

As the gases were irradiated, their chemical composition gradually changed. At the end of an hour or more the contents of the reaction vessel were examined in a mass spectrometer—built by Samuel Epstein, professor of geochemistry at Caltech, especially to analyze very small amounts of deuterium hydride in hydrogen.

The experiment was repeated with light of increasing wavelength (decreasing energy) until no deuterium hydride was formed. This provided a direct measurement of the minimum energy required for the reaction to occur.

Donald R. Davis, a National Science Foundation postdoctoral fellow and part-time instructor at Caltech, is now carrying on the research with Dr. Kuppermann. He is using a much more powerful light source—a 5,000-watt xenon high-pressure lamp similar to those in the projectors in drive-in theaters. This intense light, 25 times more powerful than the one used earlier, will provide a greater number of reaction events per time of exposure, thus permitting an even more precise figure for the minimum energy of the reaction. Minimum energies also will be measured for more complex chemical reactions.

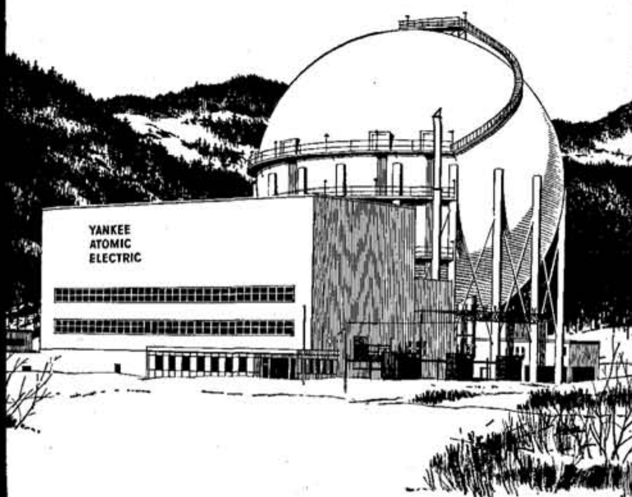
This new technique should make it possible to resolve a major question in chemistry: How does the probability of a reaction between two molecules depend on the energy with which they collide?



Dr. Donald R. Davis, John M. White, and Dr. Aron Kuppermann find the minimum energy of a chemical reaction by decreasing the energy of light shining on a glass vessel until no reaction occurs.

ATOMIC POWER

A fifth step forward. Stone & Webster engineers participated in the first nuclear reaction at Stagg Field, Chicago back in 1940 — engineered the first commercial nuclear power plant at Shippingport, Pennsylvania and are now constructing the fifth Stone & Webster designed nuclear station, Connecticut Yankee at Haddam Neck. This new plant incorporates a unique design concept, a reinforced concrete pressure vessel for reactor containment.



COMPUTER TECHNIQUES

Striking a heat balance. At Stone & Webster computer techniques do not stop with the use of computers to simulate the operations of proposed plants. Stone & Webster is constantly pioneering new computer applications. For example, Stone & Webster engineers developed a program to produce the world's first computer-drawn and calculated heat balances.

EHV

A Stone & Webster first. Extra High Voltage (EHV) transmission has moved out of the "laboratory". Stone & Webster is designing and building a 350 mile, 500 kv system for Virginia Electric and Power Company. This is the first commercial system at this voltage to be built in this country and it is the first system designed to bring low cost power generated at distant coal fields to urban load centers.

RICHARD W. SUTTON

1900-1966

Richard M. Sutton, Caltech professor of physics and director of relations with secondary schools, died on March 29 of a heart attack at the Huntington Memorial Hospital in Pasadena. He was 66 years old. At a memorial service for Dr. Sutton, held in Dabney Hall on April 1, President DuBridge delivered a tribute—printed here in part—to his colleague and friend.

Richard Sutton was born in Denver, Colorado, on January 23, 1900. He received his bachelor's degree at Haverford College in 1922 and then served as instructor in physics at Miami University in Ohio for three years. While at Miami, Dick met a lovely physical education student named Grace Leeds, and they were married in 1924. They then came to Pasadena where Dick pursued his graduate studies. He received his PhD in physics at Caltech in 1929 and stayed on as a research fellow for two years.

In 1931 Dick went back to his alma mater—Haverford College—where he taught physics continuously during the next 25 years. He was chairman of the department during his last 12 years there. After two years as professor of physics at Case Institute of Technology in Cleveland, Ohio, he returned to Caltech as professor of physics and director of relations with secondary schools.

During his 25 years at Haverford College Dick Sutton became famous as one of the leading physics teachers in the country. Many of his students went on to successful careers. But Dick became chiefly noted for extraordinary imagination and ingenuity in designing lecture and laboratory experiments illustrating basic principles and phenomena in physics. His *Demonstration Experiments in Physics* has been a handbook for physics teachers since 1938.

Dick's work in science—indeed Dick's whole life—was based on his keen interest in students, his love of people, on his ingenuity, his exceptionally keen powers of observation, and his wide range of interests. He continually surprised his friends, and even his family, by the many interests which he pursued with care, with diligence, and with imagination. He was a student of history, especially of the southwestern part of the United States. He made an extensive study of the explorations of the Grand Canyon. He studied the life of General Fremont and other major figures in the history of California and the West. He made a hobby of genealogy and compiled the genealogies of many important figures in the early colonial history of the United States.

Dick was a lover of music. He played the piano and the flute, and he loved to sing. In recent years he became interested in art and used to go out sketching and doing pastels and water colors.

His interests were so many that he was never idle. His sons told me that once while they were climbing in the Grand Tetons they were caught in a storm and had to take refuge in a small cave. Rather than sitting idly while waiting out the storm, Dick used the walls of the cave as a blackboard and gave his sons an elementary lesson in trigonometry.

Dick was brought up as a Quaker, and this is what attracted him to Haverford—a school of Quaker tradition. He was a minister and elder of the Friends Meeting of Haverford and in recent years a trustee of Haverford College. The Quaker tradition was evident in the firm, quiet integrity of his character.

We shall all miss Dick as a companion, as a friend, as an interesting, interested, and loyal member of the Caltech community.

Picture yourself as a Western Electric engineer. What might you be doing?

As a MANUFACTURING ENGINEER you'd work closely with Bell Telephone Laboratory engineers on the latest concepts in communications systems. It would be your job to work out production techniques for these systems, which might mean developing special tools, machines, or test equipment. You would have the opportunity of guiding products from their final development to the point where they roll off the production line.

As an INDUSTRIAL ENGINEER your work would be more closely related to the search for new ideas to reduce the cost of currently manufactured products, to improve their quality or make the job easier. Many of the Industrial Engineer's problems relate to human engineering as well as to operations research and the establishment of wage incentive rates.

As a SYSTEMS EQUIPMENT ENGINEER you'd really know how a communications system operates, because you'd have built it on paper before it was manufactured and installed. After one of your systems had been installed, you'd be held accountable for its performance and compatibility with existing systems.

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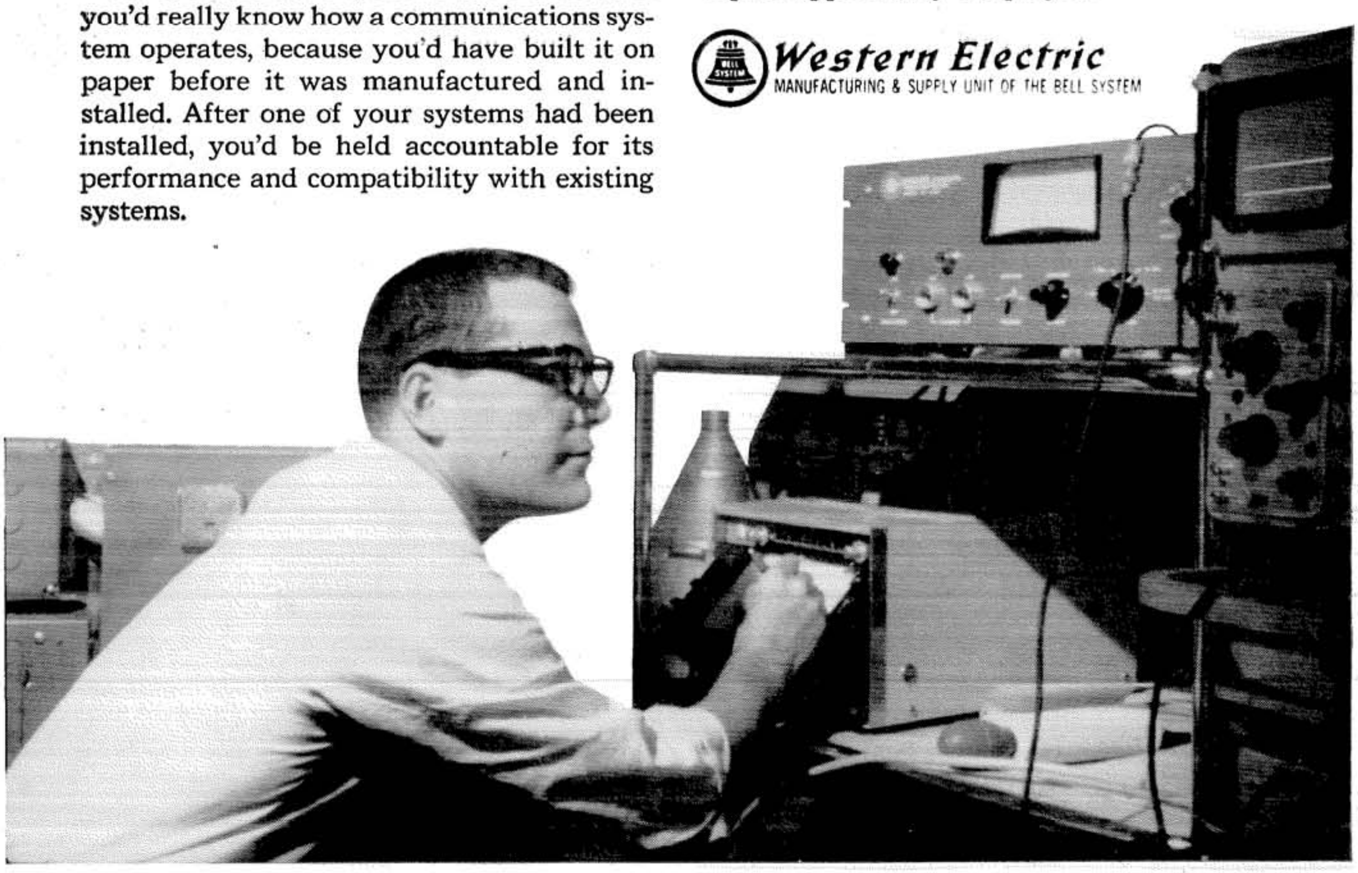
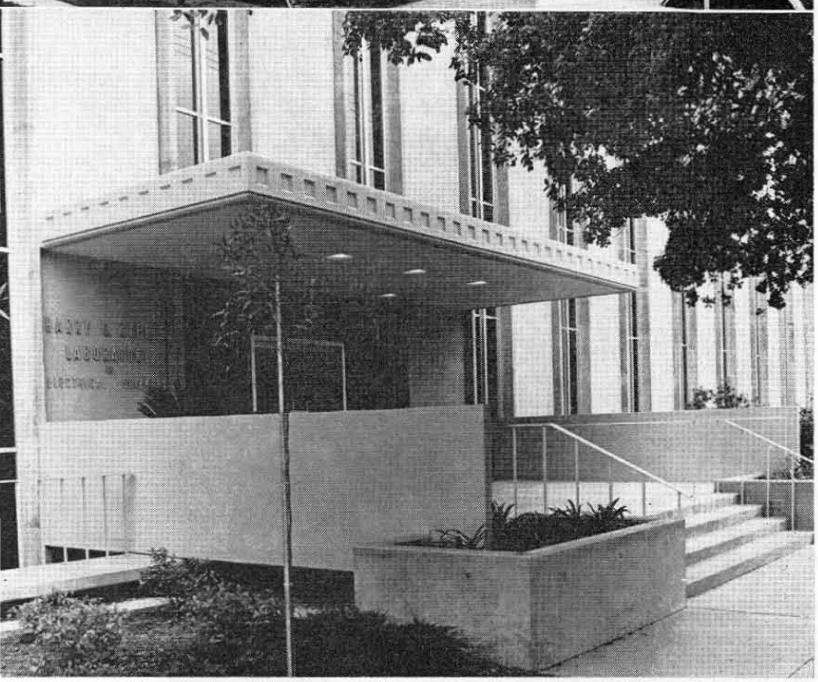




Caltech's Harry G. Steele Laboratory of Electrical Sciences was dedicated on April 4. The five-floor building, to be used primarily for physical and systems research, was made possible by a gift from the Harry G. Steele Foundation of Pasadena, and was named in honor of the late president of U.S. Electrical Motors.

The Month at Caltech

Honors and Awards

Jesse W. M. DuMond, Caltech professor of physics, emeritus, has been awarded the degree of doctor of honor by the University of Uppsala, Sweden—an award which has been given to only one other man in the past 10 years.

In announcing the selection of Dr. DuMond, the university wrote him ". . . we hope that we, in this way, may show something of our deep appreciation of your distinguished scientific contributions within such wide domains in physics."

Dr. DuMond is internationally known as one of the guardians of the universal constants—the natural yardsticks of science, including the pull of gravity, the quantity of electricity an electron carries, a formula for measuring units of angular momentum, and the speed of light. These foundations for the mathematical frameworks of science and engineering are continually re-evaluated by Dr. DuMond as new scientific discoveries are made.

Murray Gell-Mann, Caltech professor of theoretical physics, has been awarded the Ernest Orlando Lawrence Memorial Award for 1966, given by the Atomic Energy Commission for recent contributions in the field of atomic energy. One of five scientists who will be honored at ceremonies in Washington, D.C., on April 27, Dr. Gell-Mann is cited for his "contributions of the highest significance to the theory of elementary particles and for the exceptional stimulus he has provided to experimental and theoretical work in the field of physics."

The Lawrence Award was established by the AEC in 1959 in honor of the late E. O. Lawrence, inventor of the cyclotron and director of the radiation laboratory at the University of California at Berkeley. Five scientists are named each year to receive the award. In 1962 it was given to Richard P. Feynman, Richard Chace Tolman Professor of Theoretical Physics at Caltech.

Ray D. Owen, Caltech professor of biology and chairman of the division of biology, and William E. Zisch, president of the Aerojet-General Corporation and a member of the Caltech board of trustees, received honorary degrees from the University of the Pacific in Stockton, California, last month.

Dr. Owen was honored for his excellence as a teacher and administrator, and for his pioneering work in biology; Mr. Zisch was cited for his examples of hard work, application of talents, and the wise use of creative abilities in helping meet the challenge of space exploration.

Fritz Zwicky, Caltech professor of astrophysics and staff member of the Mount Wilson and Palomar Observatories, has been elected to serve on the Scientific-Legal Liaison Committee of the International Academy of Astronautics—a group of 15 scientists from Europe and the United States organized to study the scientific, technological, and human problems involved in space exploration and to prepare recommendations for the establishment of an international code of procedures.

Feynman Fellowship

A new graduate student award, to be called the Richard P. Feynman Fellowship in honor of Caltech's 1965 Nobel prizewinner, has been made possible by a gift of $175,000 to the Institute from H. Dudley Wright, former chairman of the board of Endevco in Pasadena. The fellowship will be awarded to students, preferably in theoretical physics, "who best represent the standards exemplified by the man whose name it bears."

Mr. Wright, a close friend of Dr. Feynman, now lives in Switzerland, where he has begun publication of an electronics magazine, *Orbit*.

New Trustees

Two new members were elected to the Caltech board of trustees at the March 7 meeting: Chester F. Carlson, a patent lawyer, inventor of xerography, and consultant to the Xerox Corporation of Rochester, New York; and Louis E. Nohl, owner of the Rancho Santiago de Santa Ana near Olive, California, and a retired business executive.

Chester Carlson was born in Seattle, Washington, in 1906. He attended Riverside Junior College in California and received his BS in physics from Caltech in 1930. Moving to New York City, he worked during the day in the patent office of an electronics firm, attended evening law classes, and at night began experimenting on a new method of duplicating. Although he completed the basic work on the xerox process in 1938, it took him until 1944 to convince an organization of its potential, until 1947 to sell the commercial rights, and until 1960 to see his invention become a widely recognized success.

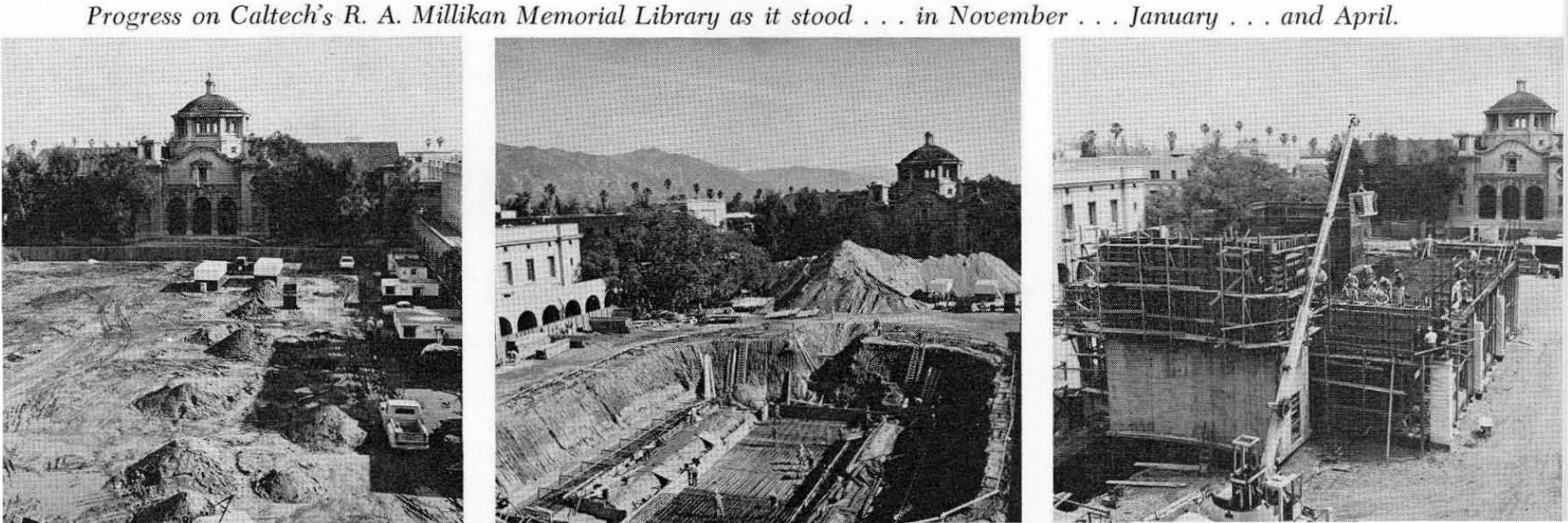
Louis Nohl was born in 1897 in Santa Fe, New Mexico. After attending the University of New Mexico and serving with the U.S. Army in France during World War I, he completed his education at Columbia University, where he received a BS degree in business administration in 1921. He became associated with the Bankers Trust Company of New York and was executive vice president when he left, 21 years later, to become executive vice president and director of the Elliott Company in Pittsburgh, Pennsylvania, manufacturers of electrical equipment for submarines. In 1944, after two years with Elliott, he moved to California.

Dedication in Israel

Paco A. Lagerstrom, Caltech professor of aeronautics, recently took part in the dedication of a

continued on page 26

Progress on Caltech's R. A. Millikan Memorial Library as it stood . . . in November . . . January . . . and April.



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building, at Tel Aviv University in Israel, named for the late Saul Kaplun, a Caltech alumnus known for his research in aeronautics, fluid dynamics, and applied mathematics. Dr. Lagerstrom, who was Dr. Kaplun's teacher and colleague, gave the dedicatory address.

When Dr. Kaplun died of a heart attack in 1964, he was a senior research fellow in aeronautics at Caltech and had earned his BS, MS, AE, and PhD degrees at the Institute. Through gifts from his father, Morris Kaplun of New York, the Saul Kaplun Institute for Applied Mathematics and Space Physics at Tel Aviv University was made possible.

It's a Plane

The Aero Association of Caltech is now official and airborne. The signing of incorporation papers and the purchase, this month, of a two-passenger 1965 Cessna 150 Trainer are the culmination of many months of groundwork—including the drawing up of by-laws and procedures, making legal arrangements, raising money, and negotiating for a suitable aircraft.

While not part of the academic program of the Institute, the new flying club is a recognized student activity and has the support of the administration, particularly of the department of aeronautics. Peter Lissaman, assistant professor of aeronautics, is faculty advisor. With the help of alumni, trustees, friends, and industry, the association succeeded in obtaining funds to pay more than half the cost of the Cessna.

The flying group is open to students, faculty, and employees of Caltech for a $100 membership fee, to be refunded on termination of membership.

"Assuming the certainty that some Caltech students are going to fly, someplace, somehow," says Dave Cartwright, graduate student in chemical physics and president of the AACIT, "our purpose is to provide the opportunity to fly more safely, to use better equipment, to give serious and detailed flight training, and to provide more available flying time for less money."

The plane is based at Brackett Field in LaVerne, where flight training and other technical cooperation will be supervised by Howard and Iris Critchell, administrators of the Harvey Mudd Flying Club.

But the association isn't planning to stop at flying or training, or with the acquisition of a single plane. Already there are plans to build an experimental glider designed by Dr. Lissaman. His design is not aimed at contest flying, but uses advanced and unconventional techniques to produce an extremely simple, cheap, and lightweight craft for fun flying.

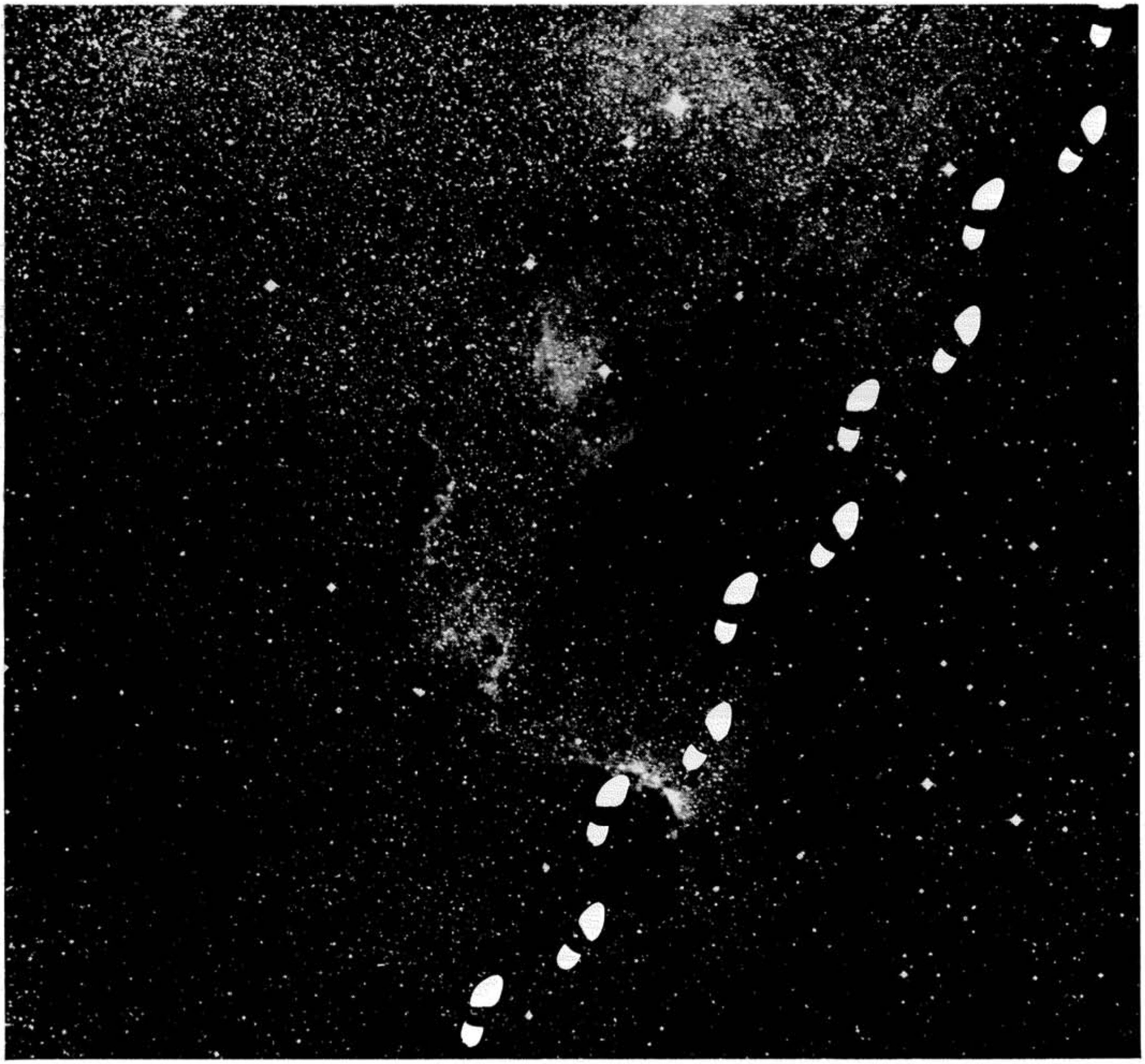
The Aero Association's Cessna gets a checkover.

Leader of America

Saul Alinsky, nationally known organizer of self-help programs for ghetto communities and a self-styled professional radical, will be on campus May 11-13, as a Y-sponsored Leader of America. Mr. Alinsky, who has worked in slum areas for more than 27 years and who is an outspoken critic of the federal anti-poverty program, operates on the conviction that the only way to fight povetry is with leadership from within the stricken neighborhood itself. In California alone he has founded more than 30 community projects, mostly for Mexican-Americans. At Caltech he will meet informally with groups of students and faculty and will give a major address in Beckman Auditorium on Wednesday evening, May 11.

Seeing Stars

An educational and demonstration planetarium was presented to Caltech this month as a gift from the Hughes Aircraft Company. The Musser Copernican Planetarium, installed in the Robinson Laboratory of Astrophysics, is a compact, 7½-foot-tall, 700-pound machine which projects onto a screen planets and star fields that can be made to rotate at controlled rates. The location of these images in relation to each other at any given time or season can be simulated, and the rotations of the planets and their satellites can be observed on an accelerated time scale.



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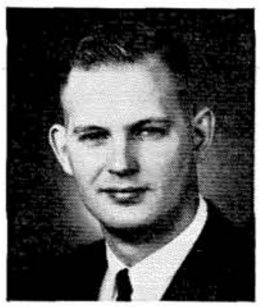

David Tenniswood
B.S., Michigan State Univ.
M.S., Michigan State Univ.

Opportunity comes early at Ford Motor Company. Graduates who join us are often surprised at how quickly they receive personal assignments involving major responsibilities. This chance to demonstrate individual skills contrasts sharply with the experience of many young people entering the business world for the first time. At Ford Motor Company, for example, a graduate may initiate a project and carry it through to its final development. One who knows is David Tenniswood, of our research staff.

Dave joined Ford Motor Company in July, 1961. Assigned to our steering and controls section, he helped develop a revolutionary steering system that will facilitate driving in future Ford-built cars. Currently a design engineer working on suspension design and analysis, Dave has been impressed by the extent to which management encourages personal initiative among recent graduates like himself. Here, management looks immediately to young engineers, like Dave, for fresh concepts that reflect their academic training and special abilities. Moreover, when the idea is accepted for development, the initiator is frequently given the opportunity to see the job through—from drawing board to production line!

The experience of Dave Tenniswood is not unusual. Ford Motor Company believes that early incentive is fundamental to individual growth and a successful career. If you are interested in a job that challenges your abilities and rewards enterprise, we urge you to contact our representative when he visits your campus.

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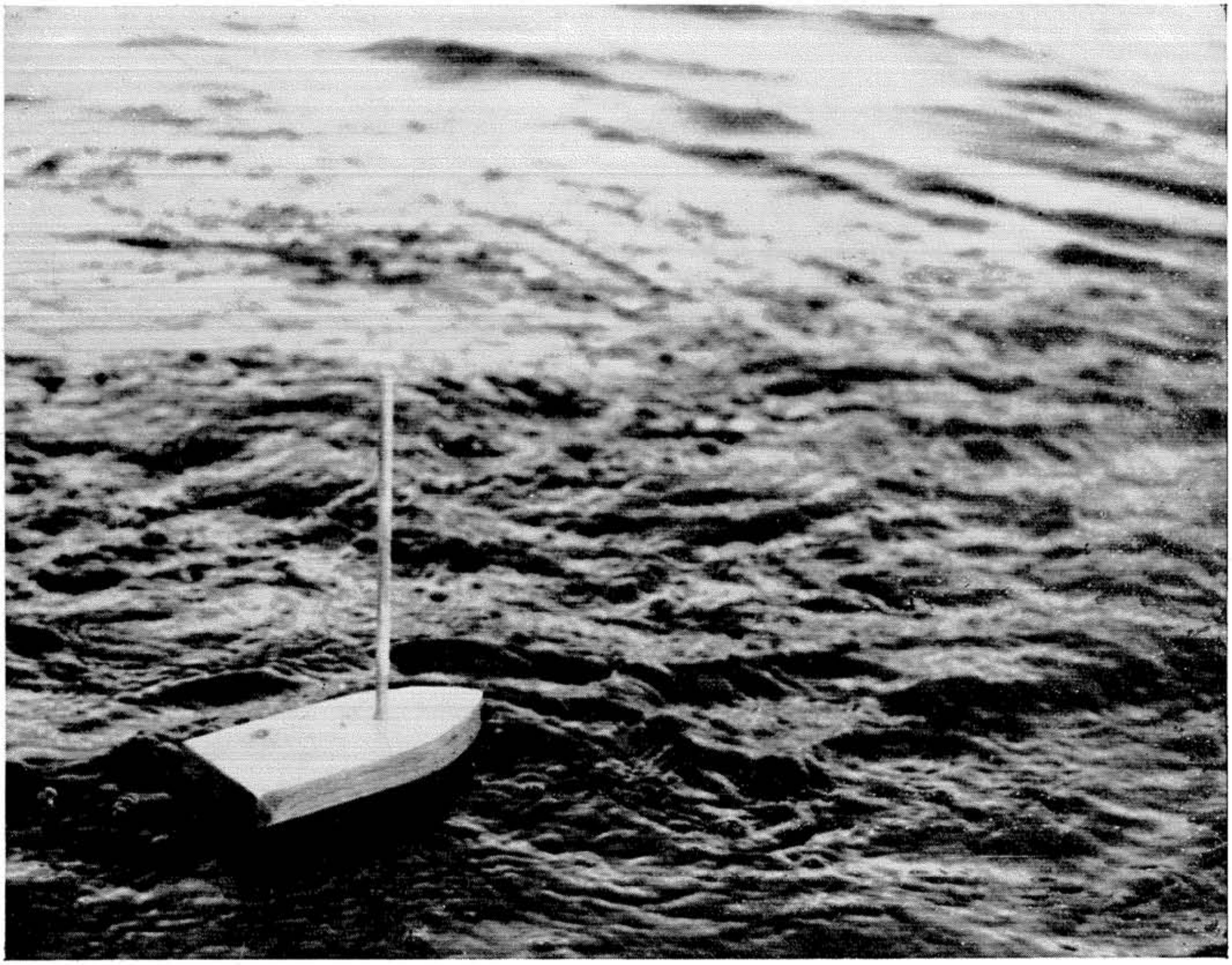

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Twenty-Ninth Annual Alumni Seminar

Saturday, May 7, 1966

Dinner and Evening Program

Huntington-Sheraton Hotel, Pasadena

THE CRISIS IN OUR CITIES

John A. McCone

Mr. McCone was graduated from the University of California in engineering. He has had a long business career in the fabrication, design, and construction field. In addition to the executive positions he has held, he has served as a member of the President's Air Policy Commission, a special deputy to the Secretary of Defense, Under Secretary of the Air Force, Chairman of the Atomic Energy Commission, and Director of the Central Intelligence Agency. His most recent contribution to public service was as Chairman of the Governor's Commission on the Los Angeles Riots.

Special Panel Discussion

Beckman Auditorium, 11:45 A.M.

AIR, WATER, AND PEOPLE

President Lee A. DuBridge, Moderator
Arie J. Haagen-Smit, Professor of Biology
James J. Morgan, Asso. Prof. of Environmental Health Engineering
Thayer Scudder, Assistant Professor of Anthropolgy

The panel will consider the technologies of two important environmental problems of southern California and the role the public plays in both creating and solving them.

Seminar Lectures

FERTILITY CONTROL
9:30 A.M. and 3:15 P.M.
Albert Tyler, Professor of Biology

How do sperm and egg recognize each other? How do they distinguish between species? How do they unite? How does the egg exclude all but one sperm? How does fertilization initiate the development of a new individual—turning-on of protein synthesis and of the genes? These basic problems will be discussed with reference to the quantitative and qualitative control of fertility in man and lower animals.

LIQUIDS—ORDERED CHAOS
9:30 A.M. and 3:15 P.M.
Cornelius J. Pings, Professor of Chemical Engineering

Molecular configurations in liquids have some of the characteristics of both a highly ordered solid and completely random gas. The complexities of this ordered chaos have so far defied concerted scientific effort to produce a satisfactory general theory for the behavior of liquids. However, significant progress has been made on this problem in recent years, and a number of molecular-level experiments are being carried out to test the veracity of the new theories.

THE CREAKING SAN ANDREAS
9:30 A.M. and 2:15 P.M.
James N. Brune, Associate Professor of Geophysics

Portable seismographs were utilized to record microearthquake activity along the San Andreas fault of southern and central California. Quiet areas and extremely active areas were found along the trace of the fault from Hollister to the Salton Sea. These data are being studied to relate microearthquake activity to past major earthquakes and to stress conditions. Methods of predicting sites and possibly for predicting times for earthquakes related to the San Andreas fault complex might result from these studies.

MARS: CAN IT SUPPORT LIFE?
9:30 A.M. and 2:15 P.M.
Norman H. Horowitz, Professor of Biology,
Chief of the Bioscience Section JPL

The Mariner IV results and other recent observations show the Martian environment to be an extremely hostile one by terrestrial standards. Nevertheless, present evidence does not exclude the possibility that Mars is the abode of lower forms of life. In fact, some observations suggest seasonal biological activity on the planet. The discovery of even simple organisms on Mars would be an event of major significance.

SOVIET AND U.S. EFFORTS TO EXPLORE OUR NEAREST PLANETARY NEIGHBORS
10:45 A.M. and 3:15 P.M.
Bruce C. Murray, Associate Professor of Planetary Science

The Soviets have maintained a much larger program than the U.S., but have only gradually overcome technical difficulties. The modest U.S. program achieved early success by means of unusually reliable spacecraft, but the over-all scope of the program remains small. Comparisons will be made of size, complexity of payloads, number of launches, and results achieved.

MAN AND HIS COMPUTER
10:45 A.M. and 3:15 P.M.
Frederick B. Thompson, Professor of Philosophy and Applied Science

A development of great significance is taking place in the use patterns of computers. We are learning to communicate directly with the computer in languages and media which are natural to us and efficient for the problems in which we may be interested. Large data bases and great computing capabilities are now at our fingertips. Such systems will be illustrated, in particular systems now being readied for use at Caltech.

IT KEEPS ME HUMBLE
10:45 A.M. and 4:15 P.M.
J. Kent Clark, Professor of English

This informal discussion of the writer's trade might be subtitled, "How to be Happy, Though a Novelist." It recounts one man's experiences with the attractions, frustrations, and built-in lunacies of a masochistic but highly educational profession.

QUANTUM ENGINEERING
10:45 A.M. and 4:15 P.M.
James E. Mercereau, Research Associate in Physics, Manager Cryogenic Devices Dept. Ford Scientific Lab.

Nature's techniques for control of electron current in atoms are now directly accessible to the electronic engineer for the design of macroscopic devices. Experiments on superconductivity leading to this realization and its subsequent development will be discussed.

THE RINGS OF DNA
2:15 A.M. and 4:15 P.M.
Jerome Vinograd, Professor of Chemistry and Biology

The long "linear" molecule that contains the information of inheritance has recently been found to be arranged in the form of rings in various microorganisms and viruses. These rings are now known to occur as single rings, intertwined double rings, and as twisted intertwined double rings. The chemical properties and the biological significance of these topologically interesting materials will be discussed.

THE EXCITING LASER
2:15 A.M. and 4:15 P.M.
Nicholas George, Associate Professor of Electrical Engineering

An exciting field of research and technology has grown out of the invention of the laser. This field of quantum electronics will be reviewed briefly. A detailed account will be given of current research in high resolution photography for holograms and turbulence effects in optical communication links.

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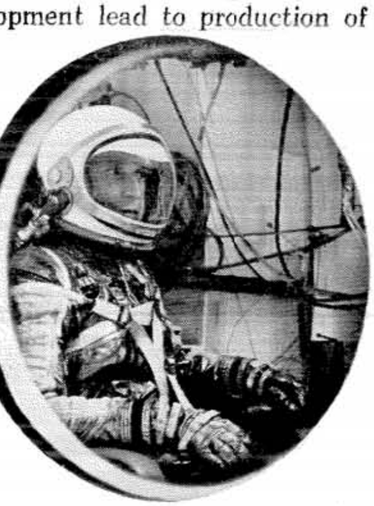

The product lines at AiResearch, Los Angeles Division, are environmental systems, flight information and controls systems, heat transfer systems, secondary power generator systems for missiles and space, electrical systems, and specialized industrial systems.

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Personals

1921

ALBERT L. RAYMOND, MS '23, PhD '25, has retired as senior vice president and director of research and development of G. D. Searle & Co. of Chicago, after 30 years with the firm. He will continue his business career as a consultant. Raymond was with the Rockefeller Institute in New York City for 11 years before going with Searle.

1922

FRANCIS L. HOPPER retired recently from the Bell Telephone Laboratories in Winston-Salem, N.C., where he was head of the electromechanical and guided missile department. In his 42 years with the Bell System, he has been involved with radar, sonar, and Navy fire control systems, as well as with guided missiles. Hopper and his wife plan to remain in North Carolina.

1923

CHARLES P. WALKER died on March 4 at the age of 66 of lung cancer. He was city councilman of Manhattan Beach, Calif., his home for the past 34 years. He had served three terms as mayor of the city; he was a past president of the League of California Cities; and he had recently been appointed by Governor Brown to the State Advisory Board of Scenic Highways. He was also a member of the County Tax Appeals Board. In 1961 Walker received the American Society of Public Administration award for distinguished service in public affairs. He is survived by his wife, Marjorie, a son, Charles, and two grandchildren.

1924

WARREN P. BAXTER, MS '26, PhD '28, died on February 22 in Pasadena. A native of Canada, he had been a resident of Pasadena for 45 years. He leaves his wife, Elizabeth, a son, John W., of Pasadena, and four grandchildren.

1927

JOHN H. MAXSON, MS '28, PhD '31, geologist and authority on the formation of the Grand Canyon, died on March 17 of a heart attack in Denver, Colo. He was 59 years old. Maxson was a Caltech faculty member from 1931 to 1946. In 1947 he became a consultant for petroleum companies in Denver, and later he established the Aerial Exploration Co. there to do photo geology. He was author of several pamphlets on the origin of the Grand Canyon and Death Valley. Maxson was buried at the cemetery in Grand Canyon National Park. He is survived by his wife, Helen Ward, and three daughters: Mrs. Frank Gerhardt of Garden Grove, Calif.; Marilyn, of San Francisco; and Patricia, a student at the University of Colorado.

1931

PAUL M. TERRY died suddenly of a heart attack on January 31. He was 60. Until his retirement in 1962 he was head of the construction division of C. F. Braun & Co. of Alhambra, Calif. Since then he had been living in Easton, Md., working as a watercolor artist. He leaves his wife, Millicent, a daughter, Phyllis Maize, and a son, Stephen.

1937

HAROLD L. LEVINTON, MS, died on January 18 at the age of 56. He had been involved in property management in the Los Angeles area since 1947. From 1938 to 1947 he was an electrical engineer with the Bonneville Dam Power Administration in Oregon, and before that time he was with the Metropolitan Water District in southern California. He is survived by his wife, Irene, and a daughter, Mrs. Sharon Mansker of Northridge, Calif.

1940

ERWIN BAUMGARTEN has been named director of the Institute of Naval Studies of the Center for Naval Analyses in Arlington, Va., a private research organization managed by The Franklin Institute of Philadelphia. Baumgarten has been associated with the center since 1952. In his new capacity as head of INS, he will be in charge of delineating and analyzing basic problems in strategy, technology, and geopolitics for the Navy.

FRANK W. DESSEL JR., MS '43, has recently been elected president of the San Marino, Calif., Chamber of Commerce. Dessel has owned and operated the San Marino Pharmacy for 15 years.

1941

H. GUYFORD STEVER, PhD, president of the Carnegie Institute of Technology in Pittsburgh, Pa., was elected to the board of the United Aircraft Corporation last month. Dr. Stever is also chairman of the scientific advisory board to the Air Force Chief of Staff.

1942

GEORGE P. SUTTON, MS '43, who has been director of Long Range Planning at North American Aviation, Inc., since 1960, has recently been appointed executive director, engineering, of Rocketdyne—North American's division in Canoga Park, Calif. An associate of North American for 19 years, Sutton returned to the company in 1960 after a year's leave of absence to accept an appointment as chief scientist of the advanced research project agency of the Department of Defense. The Suttons and their two daughters live in Encino.

1944

F. OTIS BOOTH JR. was married on March 25 to Mrs. Thomas Evans Brittingham III of Bel-Air, Calif. Booth is operations director of *The Los Angeles Times*, and great grandson of the founder of *The Times*, the late Harrison Gray Otis.

1945

WARREN M. MARSHALL III, BS '48, has been appointed chief exploitation engineer in the production department of the Shell Oil Company's New Orleans exploration and production area. Marshall has been with Shell in southern California, New York City, The Netherlands, New Mexico, and Venezuela since he joined the company in 1948. He has been in New Orleans since 1963. Marshall and his wife, Carol, have a son and two daughters.

1946

DOUGLAS W. HEGE, MS, has been named vice president, marketing, of Rocketdyne, a division of North American Aviation, Inc., in Canoga Park, Calif. He has served as director of marketing since March 1965, and before that, as manager of advanced projects and marketing for the liquid rocket division. Since Hege joined North American in 1947, he has been associated with the development of the Navaho, Redstone, Thor, and Jupiter missile rocket engines, as well as with the Atlas propulsion system. The Heges have two sons.

CARROLL WEBBER JR. is associate professor of math at East Carolina College in Greenville, N.C., where his wife is doing graduate work in linguistics. He writes that he is trying to classify applied recursive functions . . . also that his daughters, Alice, 15, and Eleanor, 9, "are bookworms like their parents."

1949

WARREN E. DANIELSON, MS '50, PhD '52, is executive director of the transmission division at Bell Telephone Laboratories in Holmdel, N.J., responsible for the digital transmission, submarine cable, and exchange transmission laboratories. Prior to his new appointment, he was director of Bell's military research laboratory in Whippany, N.J. Danielson joined Bell in 1952. He and his wife, Evelyn, have a daughter, Connalie Susan, and a son, Richard Warren.

M. KENT WILSON, PhD, chairman of the chemistry department of Tufts University in Medford, Mass., since 1956, will become administrator of chemical research grants at the National Science Foundation on July 1 this year.

1950

JOHN T. MOSICH has joined the Aerospace Corporation as assistant director of the space vehicles office in the system planning division. He has been with the Space/Aerojet-General Corporations for 10 years, and prior to that was district engineer with C. F. Braun and Co.

1952

JAMES K. LA FLEUR is president of a newly-formed company, Industrial Cryogenics, Inc., of Hermosa Beach, Calif., an engineering firm specializing in the field of low temperature processes. Before forming the new organization, he was president of the LaFleur Corporation, and of Kemsco, Inc., both companies he helped establish. LaFleur holds more than 60 patents related to closed cycle helium gas turbines for production of low temperature refrigeration.

1953

GILBERT E. STEGALL, MS, who is with the U.S. Weather Bureau in Asheville, N.C., has recently been appointed chief of the climatic operations branch at the National Weather Records Center there. Until his transfer to Asheville in 1963, he was in the Weather Records Processing Center in Kansas City, Mo.

1955

ALLEN E. FUHS, MS, PhD '58, a member of the plasma research laboratory of Aerospace Corporation in Los Angeles, has published a book, *Instrumentation for High Speed Plasma Flow*, on behalf of the advisory group for aerospace research and development, NATO. Fuhs, who has worked in plasma research at Aerospace since 1960, did a portion of his work on the book during a year at the University of Colorado, where he was visiting fellow of the Joint Institute for Laboratory Astrophysics.

1956

JOHN F. KENNEDY, MS, PhD '60 associate professor in the hydraulics department of MIT, will become director of the Institute of Hydraulic Research of the University of Iowa in Iowa City, and a professor in the department of mechanics and hydraulics, effective July 1. Formerly a research fellow in civil engineering at Caltech, Kennedy has been at MIT since 1961. He is married and has four children.

1957

THOMAS C. HAYS, MS '58, was recently elected a member of the board of directors of the Andrew Jergens Company of Cincinnati, Ohio, where he is a product manager in marketing. Hays and his wife, Mary Ann, have two sons.

1959

ROBERT P. HANGEBRAUCK, a research engineer with the U.S. Public Health Service in Cincinnati, Ohio, is chief of the combustion research unit in the engineering research and development section of the division of air pollution. The Hangebrauck's have a three-year-old daughter and a two-year-old son.

1960

MEREDITH C. GOURDINE, PhD, is president of Gourdine Systems, Inc., of Livingston, N.J., a two-year-old company set up to develop the idea of using electrogasdynamics for large-scale power generators. If successful, the EGD concept, now in the experimental stage, would eliminate the use of boilers and steam turbine generators in power plants and substitute the relatively cheaper EGD method of producing electricity directly from burning oil or coal. The Foster Wheeler Corp. holds an exclusive license to develop the Gourdine idea.

Alumni News

Wine Tasting—1966

The second annual alumni wine tasting on April 2 drew more than 200 Caltech alumni and friends to the Athenaeum to sip, savor, and listen to a lecture on wine. The wineries and distributors that furnished the wines brought supplies that outlasted the people. Six sherries were selected for tasting before the lecture, and twenty-seven table wines were available after.

J. Harold Wayland, Caltech professor of engineering sciences, gave a short introductory talk on French wine culture, and Denny Caldwell, manager of the beverage department at Hines Grocery and the man responsible for arranging the event, gave a lecture on wineries, the wine-making process, and characteristics and varieties of wine grapes.

PLACEMENT ASSISTANCE TO CALTECH ALUMNI

There are two ways in which the Placement Service may be of assistance to you:

(1) To help you seek new employment or a change of employment.

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This service is provided to Alumni by the Institute. A fee or charge is not involved.
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Informal luncheons every Thursday at 11:45 A.M.
Contact Mr. Farrar, EX 9-5277, on Thursday morning for reservations.

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University of Rochester Library Tower as seen by the famed photographer Ansel Adams

Have your cake and eat it

Suggestion to Ch.E.s, M.E.s, and other engineers:

The University of Rochester has long committed itself to the pursuit of academic excellence and long ago attained success in that quest. Likewise, with a somewhat different conception of higher education, has the Rochester Institute of Technology earned high regard. The two institutions are quite unrelated to each other or to us, except that their fortunate presence in Rochester provides opportunity for those who join us with fresh baccalaureates to proceed right on course with the next formal stage of professional or business preparation. In Kingsport arrangements are offered by the University of Tennessee Graduate School and East Tennessee State University.

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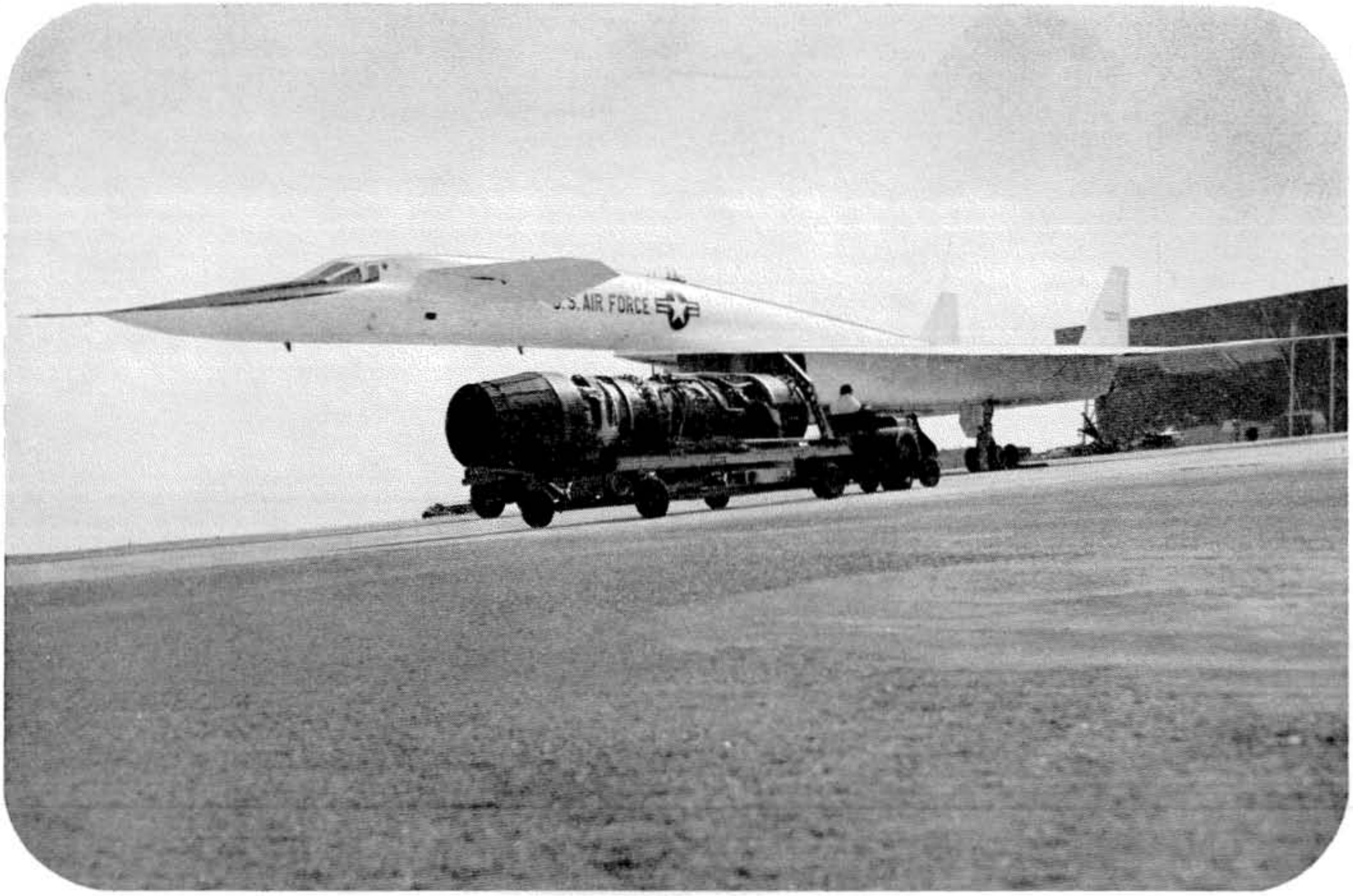
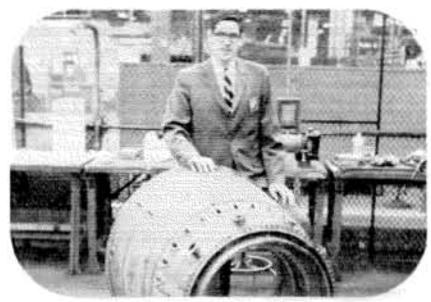


SIX G-E J93 ENGINES push USAF XB-70 to MACH 3.

JACK WADDEY, Auburn U., 1965, translates customer requirements into aircraft electrical systems on a Technical Marketing Program assignment at Specialty Control Dept.

PAUL HENRY is assigned to design and analysis of compressor components for G.E.'s Large Jet Engine Dept. He holds a BSME from the University of Cincinnati, 1964.



ANDY O'KEEFE, Villanova U., BSEE, 1965, Manufacturing Training Program, works on fabrications for large jet engines at LJED, Evendale, Ohio.

A PREVIEW OF YOUR CAREER AT GENERAL ELECTRIC

Achieving Thrust for Mach 3

When the North American Aviation XB-70 established a milestone by achieving Mach 3 flight, it was powered by six General Electric J93 jet engines. That flight was the high point of two decades of G-E leadership in jet power that began when America's first jet plane was flown in 1942. In addition to the 30,000-pound thrust J93's, the XB-70 carries a unique, 240-kva electrical system that supplies all on-board power needs—designed by G-E engineers. The challenge of advanced flight propulsion promises even more opportunity at G.E. GETF39 engines will help the new USAF C-5A fly more payload than any other aircraft in the world; the Mach 3 GE4/J5 is designed to deliver 50,000-pound thrust for a U.S. Supersonic Transport (SST). General Electric's involvement in jet power since the beginning of propellerless flight has made us one of the world's leading suppliers of these prime movers. This is typical of the fast-paced technical challenge you'll find in any of G.E.'s 120 decentralized product operations. To define your career interest at General Electric, talk with your placement officer, or write us now. Section 699-16, Schenectady, N.Y. 12305. An Equal Opportunity Employer.

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