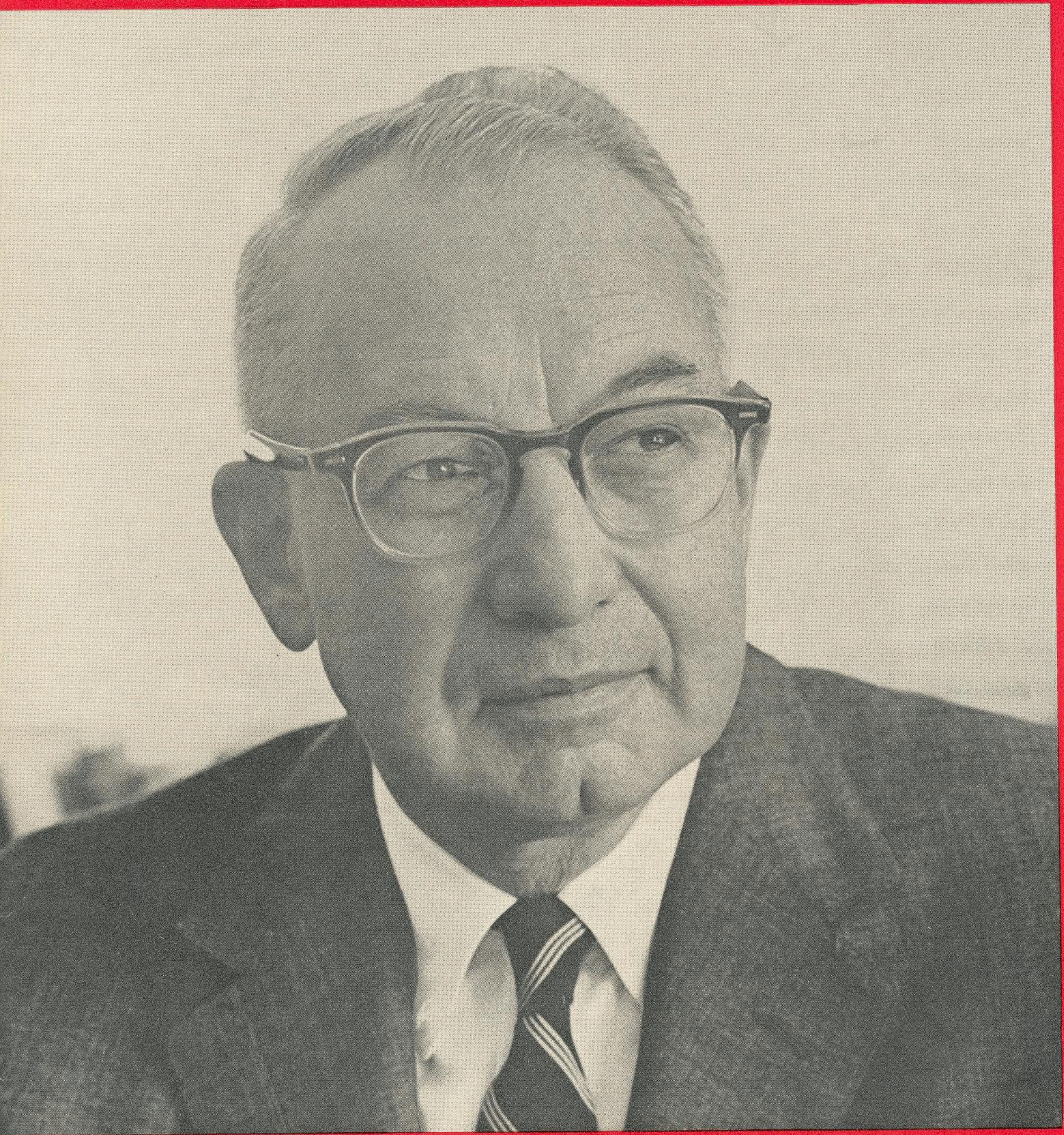
# ENGINEERING | AND | SCIENCE

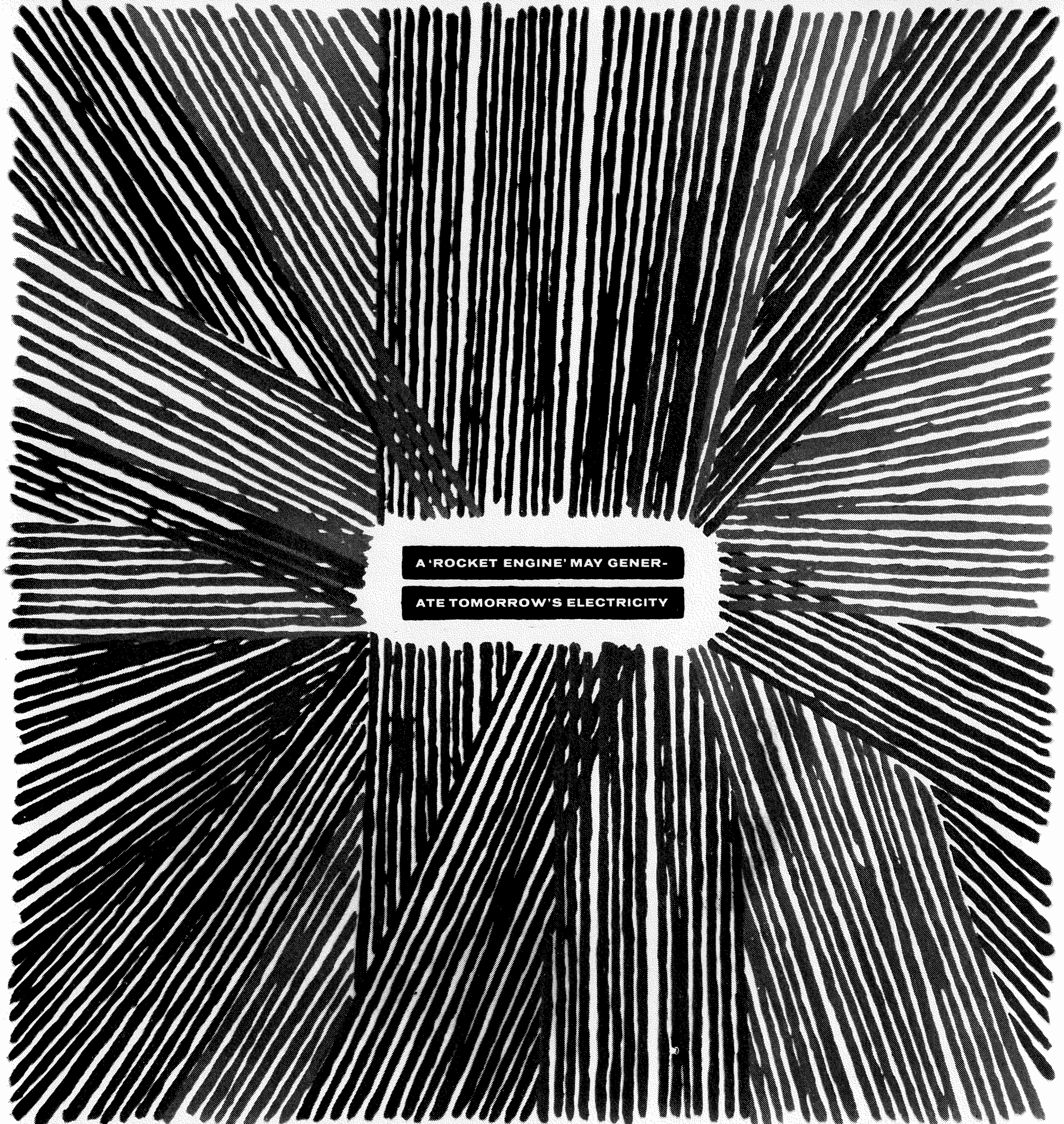
December 1961



Provost . . . page 12

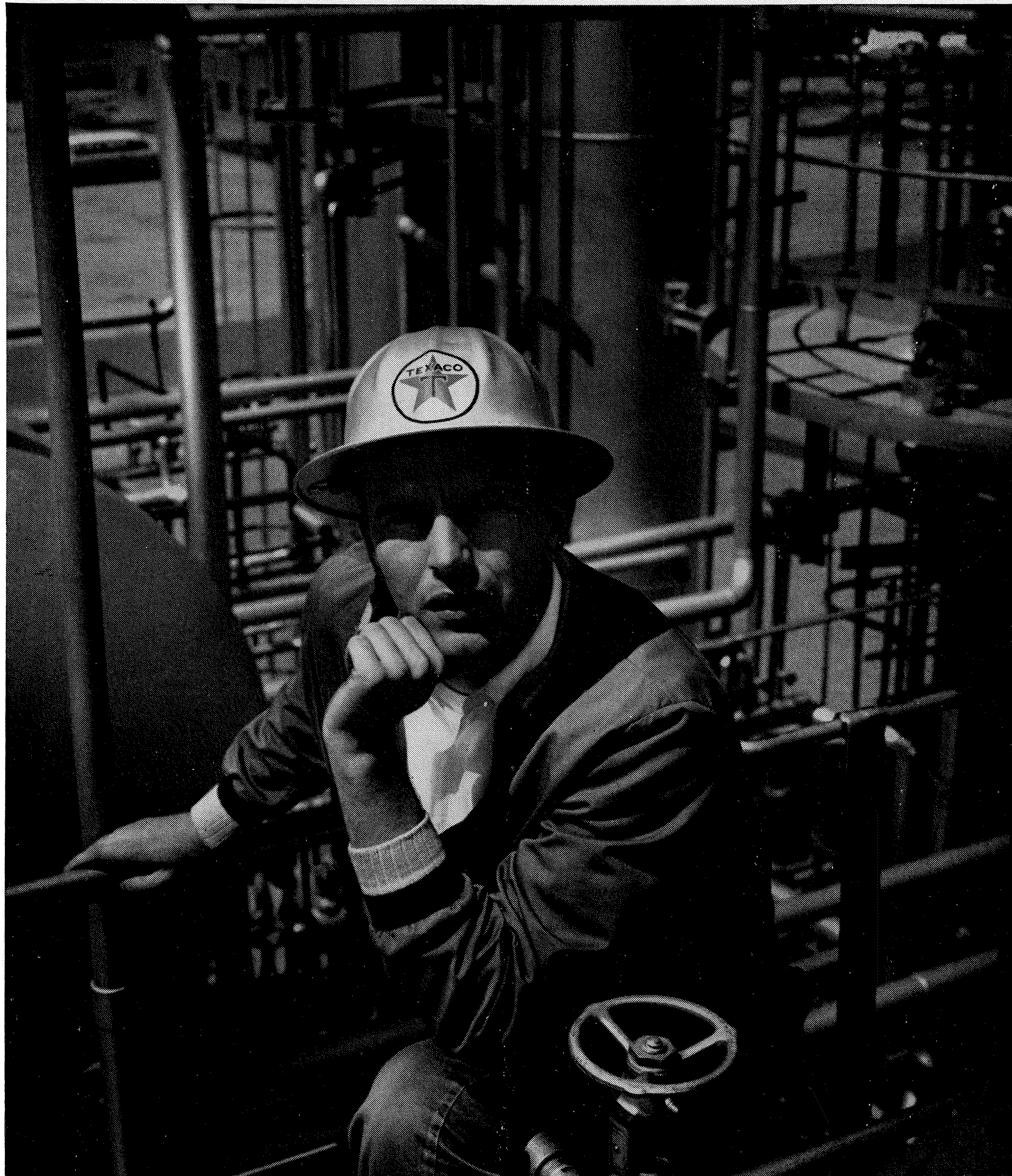
*Published at the California Institute of Technology*

Westinghouse puts the future in your hands




Today's electricity is produced in some of the biggest, most ingenious and precise equipment ever built. One part . . . the turbine . . . is as big as a locomotive, revolves at the speed of sound, is so hot it glows a cherry red, and its parts fit together like a fine watch. That's today's best method, and it's gone about as far as it can go. And so Westinghouse, which builds this equipment, is experimenting with completely new methods of producing electricity. Some of them are rather exotic. One method produces electricity by shooting a stream of gas between a set of magnets. Sounds simple, but this is like handling the roaring exhaust of a rocket. The gas travels 2,000 miles an hour at 5,000 degrees F. This method is magnetohydrodynamics. Called MHD for short. It is a jawbreaker of a problem. But Westinghouse and other companies are nearing a solution. A Westinghouse MHD generator has produced electricity for 52 minutes. That's five times as long as any other has ever run. If MHD "works," we will be in a new world of electric power. Problems like this and other problems face talented scientists and engineers at Westinghouse. For information about a career with Westinghouse, an equal opportunity employer, see our representative when he visits your campus or write: L. H. Noggle, Westinghouse Educational Department, Pittsburgh 21, Pennsylvania.

You can be sure . . . if it's **Westinghouse**


TEXACO

ENGINEERING | AND | SCIENCE

*On Our Cover*

Robert F. Bacher, chairman of the division of physics, mathematics and astronomy at Caltech, who has been named first provost of the Institute. For more news about the new provost, and his duties, see page 12.

*Science: A Liberating Art,*

on page 9, has been transcribed from a talk given by President DuBridge at his alma mater, Cornell College, in Mount Vernon, Iowa, at the inauguration of Arland F. Christ-Janer as president on November 20, 1961.

*Renato Dulbecco,*

professor of biology at Caltech, has been a member of the faculty since 1949. In 1952 he developed a new technique for studying those viruses which attack animal tissue. From his technique scientists were able to isolate, for the first time, genetically pure strains of three types of polio virus. Now, using virtually the same technique, he and his co-workers are studying the relationship between viruses and cancer. His report on page 15, "A New Approach to Cancer Research," has been adapted from an address given on November 13 at a dinner meeting of Caltech's Industrial Relations Center in Los Angeles.

*How To Ride a Wave,*

on page 20, was written by Graham Berry, assistant director of Caltech's News Bureau. Mr. Berry was science editor of the Los Angeles *Times* before he came to Caltech in 1958.

*DECEMBER 1961 VOLUME XXV NUMBER 3*



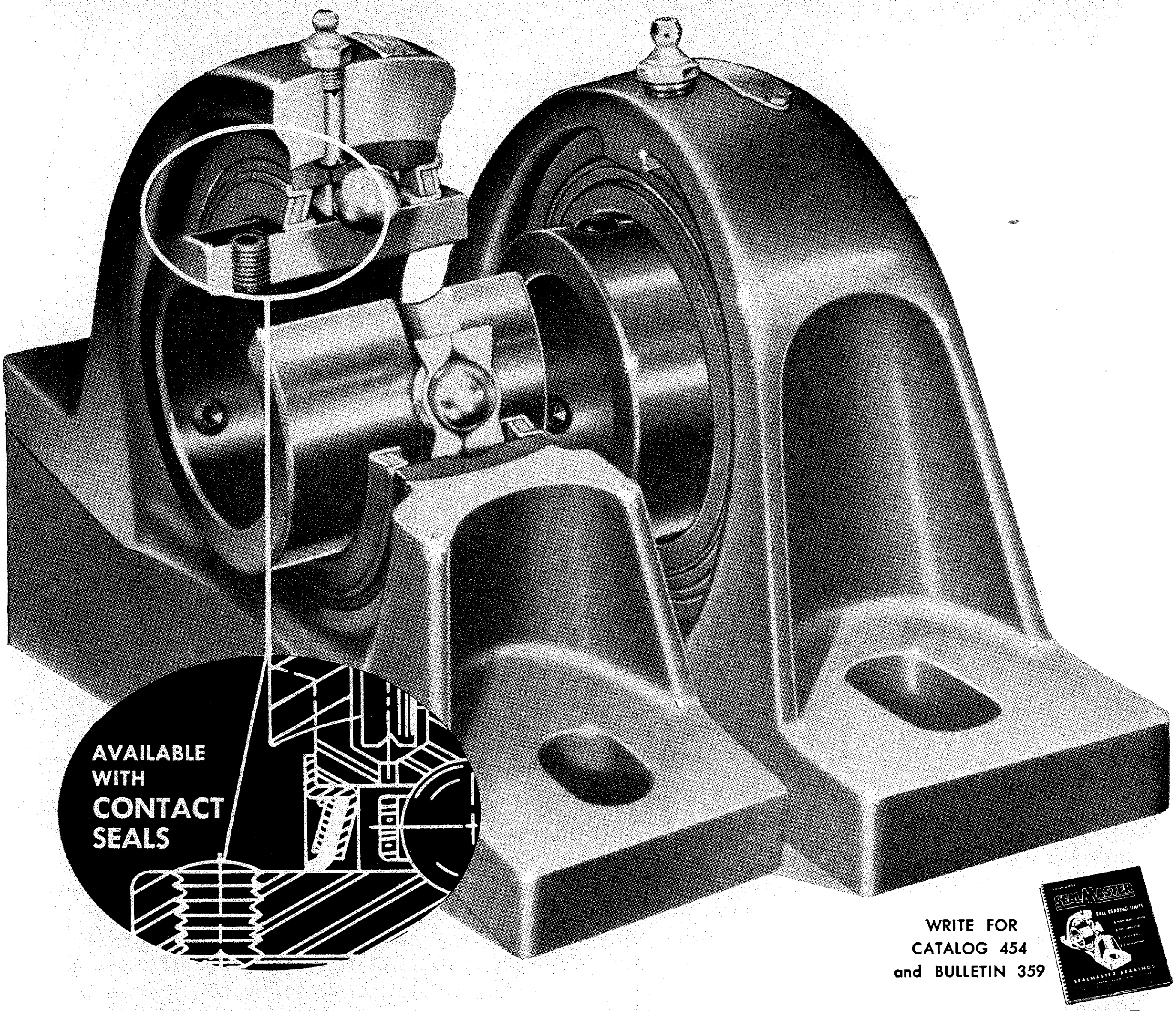
*STAFF*

*Publisher*........Richard C. Armstrong '28
*Editor and Business Manager*........Edward Hutchings, Jr.
*Assistant to the Editor*........Gerda Chambers
*Student News*........Lance Taylor '62
Roger Noll '62
*Photographer*........James McClanahan

Published monthly, October through June, at the California Institute of Technology, 1201 East California St., Pasadena, Calif. Annual subscription $4.50 domestic, $5.50 foreign, single copies 50 cents. Second class postage paid at Pasadena, California.  Manuscripts and all other editorial correspondence should be addressed to: The Editor, *Engineering and Science*, California Institute of Technology. 

INSIDE or OUT there is only one...

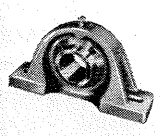
# SEALMASTER®



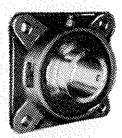

WRITE FOR CATALOG 454 and BULLETIN 359

## AVAILABLE IN QUALITY UNITS TO MEET EVERY REQUIREMENT

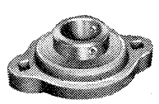
SEALMASTER® BALL BEARING UNITS



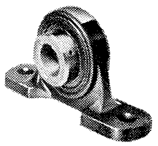
Normal-Standard Medium Duty PILLOW BLOCKS



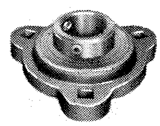
Standard Medium Duty FLANGE UNITS



LFT FLANGE UNIT



LP PILLOW BLOCK



LF FLANGE UNIT

SEALMASTER BEARINGS A Division of STEPHENS-ADAMSON MFG. CO 49 Ridgeway Avenue, Aurora, Illinois
PLANTS IN: LOS ANGELES, CALIFORNIA • CLARKSDALE, MISSISSIPPI • BELLEVILLE, ONTARIO • MEXICO CITY, D. F.

# Books

## *Genetics and Evolution*

*Selected papers of A. H. Sturtevant*
*Selected and edited by E. B. Lewis, with a foreword by G. W. Beadle.*

*W. H. Freeman & Co. . . . $7.50*

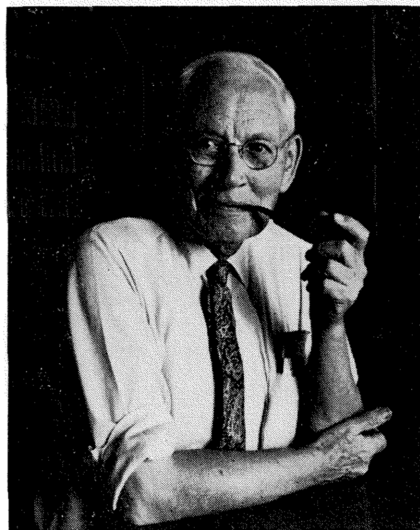
*Reviewed by Ray D. Owen, professor of biology; acting chairman of the division of biology.*

It is a curious fact that contributions in science often acquire anonymity at a rate, and to a degree, that is positively correlated with their importance. They are speedily incorporated into the "principles" sections of textbooks, where they are told and retold in successive editions and texts. As impersonal principles they need not be identified with persons, and because they are told in texts few students need to seek them out in their original sources.

As these sources retreat in time they become less accessible; it becomes harder to find them even if one chooses to look. They develop ramifications as their significance becomes apparent in various contexts. The original is screened by an army of extenders and consolidators, closer in time to the current student, and involved with more narrowly-defined and more easily-encompassed subareas penetrated by the ramifying original.

There are several such elements in modern genetics. The genes can be deduced from genetic data to be arranged in a linear array on the chromosomes, each gene in a particular position on a particular chromosome. Sometimes this order may be changed; for example by an "inversion," in which a whole segment of a chromosome, a whole block of genes, is broken out of the linear array, rotated through 180 degrees, and reincorporated in inverted sequence.

The existence of such inversions can be deduced from their action as suppressors of crossing-over in individuals carrying the two gene-orders on the two respective chromosomes of that pair, and can be confirmed by breeding data. They show unusual behavior in transmission through the female germ line; they pose complex problems for natural populations; they can


*A. H. Sturtevant*

be used to trace relationships among species in evolution. Sometimes, during the development of an individual, areas of mosaic tissue appear different in chromosomal and genic constitution from the remainder of that individual's body. Sex mosaics of this sort are currently coming to prominent attention in the medical genetics of man; they have been known for a long time in Drosophila.

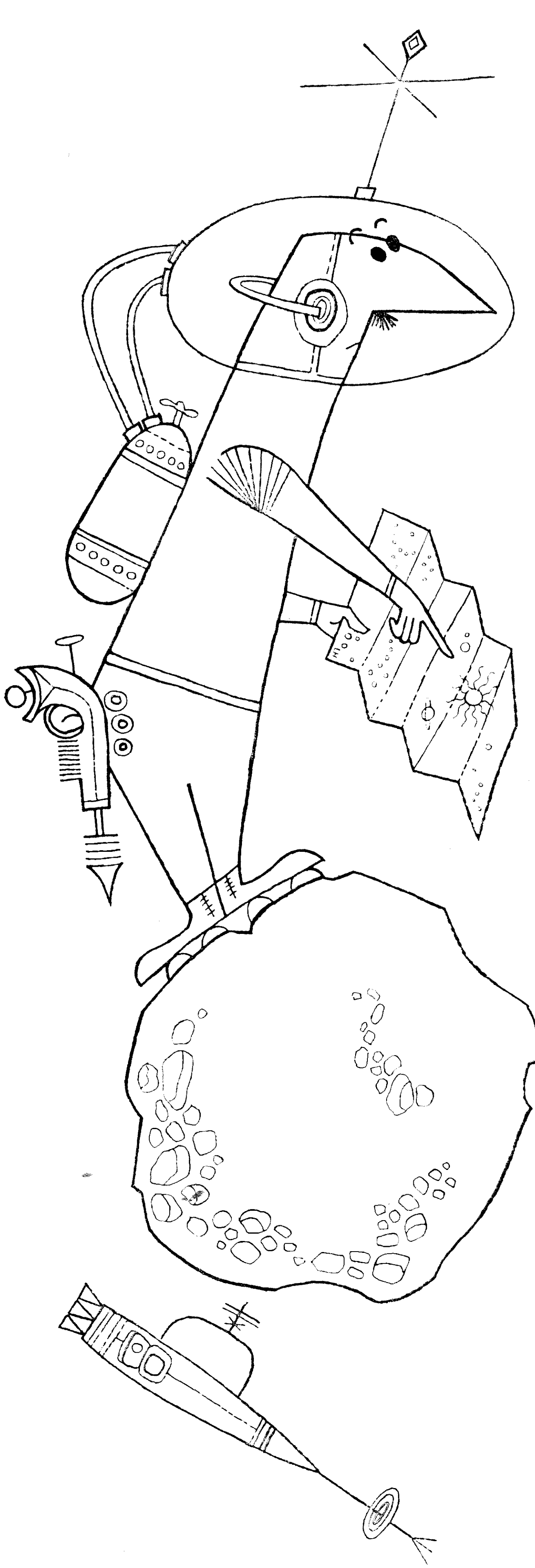
From the behavior of a gene in mosaic tissue one can deduce whether the gene is limited in its effects to the cells in which it exists, or whether it has impact upon, or is dependent upon, the action of genes in other tissues. Clear observations in this category were the forerunners of modern developments in the field of biochemical genetics. Some aspects of development show "maternal effects," dependent upon genes possessed by the mother even though the developing individual may himself not have them. There are maternal effects on sex determination in hybrids. Particular genes may cause inter-sexuality.

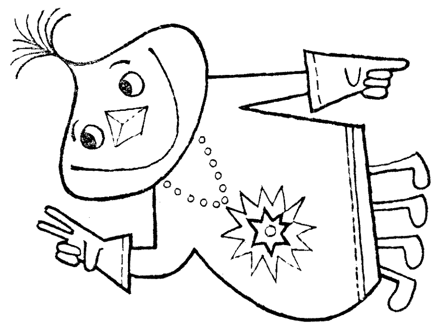
We commonly think of genes in pairs, but numerous alternative forms exist for many genes in populations—and these "multiple allelomorphs" provide tools for studying the ultrastructure of genes. The effect of a gene may be dependent on what other genes are near it on the chromosome—the phenomenon of "position effect." Particular genes may affect mutation rates for other genes. Genetic changes are the raw material for evolution, and understanding the processes of evolution is dependent upon understanding and studying the consequences of many precise principles of genetics. Several of these principles appear at the population level, and offer complex interesting problems—for example, sexual selection and selection in social insects.

All of the above contributions, and others, were the work primarily of one quiet man who is retiring from the Caltech faculty, at the age of 70, at the end of the current academic year. This book is a reprinting of 33 of his contributions, about a quarter of his total output over the period from 1913 to the present. The book is a tribute to A. H. Sturtevant. It is an impersonal record of contributions by a most remarkable man. It makes accessible, to be studied afresh, many of the most important milestones of the history of genetics. The author's 1961 notes, which follow most of the papers, give this book a strong sense of history.

Especially with Beadle's foreword and Lewis's introduction, the book should communicate some of the sense of excitement of scientific discovery experienced by a person working in an active and enthusiastic group in which things are breaking fast, and in which "group discussion, argument, and speculation were so frequent that it was next to impossible to determine who had what ideas;" in which a list of the names of the people involved is a list of giants, to be accepted reverently, but which in those days included one who "often dropped in to take part in the discussions and to help himself to one of the bananas that were kept in constant supply as 'fly food'."

But this book is more than a tribute to Sturtevant, and more than a history; it is a book to be studied and referred to again and again. Its values, concepts, and content are as current today as they were when they first appeared, and assuredly the clear conciseness, the incisive penetration, the dignity, simplicity, and insight of Sturtevant's original thought and presentation have not been improved upon by the retelling that has been done by others in the interval.





ENGINEERING AND SCIENCE
*December 1961, Volume XXV, No. 3*

# SCIENCE: A LIBERATING ART

*by L. A. DuBridge*

As an undergraduate at Cornell College — all of 40 years ago — it did not seem strange to me that I was going to a liberal arts college to major in a science. Quite a few of us were doing it and, as far as I can recall, we were regarded as no different from the students majoring in English or economics, or music or philosophy. We used to kid each other on our strange tastes, of course. But it was only many years later that I began to read about how some people believed that the scientists lived in one world and the liberal arts majors in another one. And then, just a few years ago, I began to hear some people suggesting that the world of science was an evil, materialistic, inhuman sort of world, and that only in the liberal arts did men think beautiful thoughts and have generous impulses and learn how to get along with other people.

Well, all this was news to me. And it still is! I have always thought the sciences were a part of the liberal arts; that the natural sciences, the social studies, the humanities, and the fine arts were all included in the term "liberal arts"—and that each of these fields was an essential part of our culture, and of a liberal education.

When the human mind is seeking to learn, it doesn't make much difference what subject is being examined at the moment. The same attitudes of open-mindedness, of curiosity, of thoughtfulness, of concentration, are necessary whether we seek to understand history or philosophy or physics. We must learn a different vocabulary to master each of these fields, of course—for each subject must have names for its ideas, its concepts, for the facts and phenomena with which it deals. The musician talks of counterpoint, the physicist of quantum theory, the philosopher of empiricism, the poet of hexameters, the geologist of seismicity — and the student must, sooner or later, learn what these words mean, what ideas or concepts or things they represent.

It is perfectly true that, as one delves further and further into any subject, the number of new words and phrases he must use becomes very great, for he is dealing with more and more ideas, more complex relationships, more varied phenomena. That's what knowledge is — the mastery of new ideas. When two musicians, for example, get into a detailed discussion of their subject, their conversation is wholly incomprehensible to anyone who is not a musical scholar. The same is true for two philosophers, economists, or literary scholars — just as much as it is for biologists or chemists or physicists. The language barriers between different scholarly fields are truly imposing and they get more and more insurmountable the more knowledge grows, and the more special branches develop. It has been suggested that eventually this proliferation of scholarly specialties will result in every scholar having his own little field of knowledge about which he can converse with no one but himself. That's a gross exaggeration, of course; scholars are much too talkative and too gregarious to ever allow themselves to get into that situation. There will always be at least *two* in each field!

Language barriers are terrible things, whether they bar communications between nations, or between scholarly disciplines.

However, the language barrier is not peculiar to the relation between science and non-science. The artist and the musician have vocabularies just as different from each other as they are from those of the biologist, the physicist, the chemist, or the economist. Language problems pervade the whole field of knowledge — in all subjects — so let's not let anybody persuade us that language barriers provide the excuse for driving a wedge just between the sciences and the humanities, or that a gulf exists there which is not to be found elsewhere. The gulf is everywhere and constitutes the challenging problem of the world of the scholar — of the whole world of the intellect. And that means for the whole world itself.

But it is not a hopeless problem. Highly specialized scholars in any field will always have their special language. They must have it, or else they cannot talk or think in precise terms about their subject. Though it is regrettable when groups of specialized scholars get isolated from each other, it constitutes no danger of great or imminent calamity.

But there is another danger that does exist. If not just small special fields, but whole broad areas of knowledge, become isolated from each other and thus become isolated from the everyday world of men — then we could be in trouble.

We see a dramatic example of this sort of thing in the Soviet Union today. There, not by the will of the scholars or teachers, but by force of the state, the young student, and the adult, too, lives in a frightening condition of intellectual isolation. He is not allowed to learn anything like a history of the western world. He can have no contact with modern economic thought except that which follows a particular line. Social studies, current affairs, and much of western literature are closed books in his educational career and in his daily reading. It is frightening that such a situation can exist. It is unbelievable that in these days of rapid communications and transportation it can persist. Yet there it is—a vast nation in ignorance; and, in its ignorance, following an unscrupulous group of leaders who may well lead the civilized world to the brink of destruction.

We are fortunate that in this country we need not submit to enforced ignorance. But that does not mean that ignorance does not exist. Far from it. We may have self-imposed ignorance, ignorance which we drift into through laziness, or neglect, or misunderstanding.

Our bulwark against serious doses of such "ignorance by neglect" is our free educational system. From kindergarten through the PhD, and even beyond, an American boy or girl can now proceed as far as his talents will take him. Opportunities are not yet fully equalized, we must admit. Geographical, racial, and other inequities still exist. But, by and large, we have an educational system open to all subjects and to all students on a scale undreamed of in any other age — and even today in any other country.

Surely we are immune from widespread ignorance.

But are we?

Are our high school and college graduates really getting a worthy education? Are they emerging from school with a comprehension of the basic ideas and the basic language of each field of knowledge — of literature, history, social studies, physical, and biological sciences?

Is it possible that many high school graduates are closed off from further learning because they can't really read — or because they haven't really learned to *want* to read?

Have the vistas of history, the history of men and of ideas, been opened up to students in their school years? Or have such vistas been forever sealed off from them because they think history means only memorizing the dates of wars and the names of kings?

Are the great ideas of science forever closed because mathematics was too hard and too dull, chemistry too smelly, and biology too messy?

I am not trying to condemn our whole educational system. I abhor such sweeping indictments. And I can say at once that the answers to these questions I have been raising are, in many places and for many people, wholly favorable. Our young people who are brightest and who are going to our best schools and colleges are receiving a superb education. And it is getting better every year.

But we have a long way to go. The thirst for knowledge is not really very widespread. The ability to follow the meaning of current national and world affairs is not really possessed by many people.

We have had a serious jolt in the past dozen years. Because of many events that have transpired through advances in science and technology — atomic weapons, automation, and space exploration, to name but three —we have suddenly become aware of the fact that, as a nation, we are vastly illiterate in scientific fields. The Sputnik events rammed this lesson down our throats — but it was evident long before 1957. It is not just that people did not know about nuclear fission and radioactivity; about electronic computers and transistors; about gravity and the moon and planets and stars. The trouble was that they had no basis on which to begin to learn about them. The language was utterly strange. The simplest ideas of force, energy, radiation, and gravitation were quite unfamiliar. People always thought such technical things were too difficult, and of no importance anyway.

Suddenly, we found that the whole world was unexpectedly being changed by these "unimportant" technical ideas. Suddenly congressmen were voting billions of dollars for atomic energy, when they and their constituents often had no idea what the words meant. They then voted more billions for space exploration, with no possibility of knowing why we are going there, or what we intend to do, except that somehow they feel we must "keep ahead of the Russians."

So, indeed, we found that in one huge area of human knowledge millions of Americans were just as ignorant as though the study of science had been forbidden in our schools. "Ignorance by neglect" had grown upon us in a big way—and without our being aware of it.

It is no accident that this ignorance grew up during the period between the world wars when many voices were loudly proclaiming that there was too much emphasis on science, that technical subjects had no place in a liberal arts curriculum, and that trigonometry and physics were much too difficult subjects to inflict on high school students. Not every school and not every college believed such nonsense.

But still ignorance grew to such an extent that, by 1940, scientific illiteracy was a very widespread disease. And it has been a costly disease indeed, as we can see from the public confusion and misunderstandings which have arisen since World War II.

First came the era of secrecy and suspicion. The United States had invented some miraculous new war weapons — radar, proximity fuses, sonar, and atomic bombs. If any other nation now showed up with any of these devices, it was at once concluded either (a) that foreign spies had stolen the secrets from us, or (b) that American traitors had given the secrets away. Charges and countercharges were hurled; every scientist who had engaged in war work was investigated — not to determine whether he had done a good job, but to determine whether he or his wife, or his family, had any "questionable" friends. And who was a questionable friend? Well, he was someone who, in turn, had a questionable friend. There was no limit to suspicions — and hence to fear. And the healthy development of science was seriously impaired.

All this happened because too few people understood the nature of science. Too few understood that it was often true that scientists in different parts of the world, interested in similar problems, came upon identical solutions; that the only true secrets involved were secrets of nature, secrets which nature gladly gave up to any inquiring mind, regardless of race, creed, color, or nationality.

Then, years later, came the hysteria engendered by Sputnik. The Russians, it seems, decided to develop and make (for reasons best known to themselves) an 800,000-pound-thrust rocket. The Americans, for perfectly sound military and economic reasons, decided a 350,000-pound thrust was what we needed. Suddenly the Russians decided to use one of their big military rockets to orbit a satellite. We in the United States were giving our attention to making more useful military weapons.

If the Russians purposely launched Sputnik to persuade us to stop making military weapons, they almost succeeded. The clamor for bigger rockets to get bigger loads into space was deafening. What were the loads to *do* in space? "Never mind, just *get* there — at any cost!" "Why can't we do it faster?" "Obviously, our scientists must be incompetent"—though it is engineers, *not* scientists, who make rockets. "If our scientists are incompetent, our schools must be no good."

And so the hullabaloo mounted—and it hasn't abated yet. "We must get a man into orbit; we must get a man to the moon." Why? Just to beat the Russians?

Well, no scientist gives that answer. The scientist goes into space to conduct scientific research. And that's all! He would like to get his instruments to the moon first, of course. But he knows that no great calamity will befall if the Russians find out whether there is any magnesium carbonate on the moon before we do.

So we have the complete paradox. Our confusion about space is not because the scientists are incompetent; they are busily engaged in all sorts of valuable space research enterprises. It's not because the engineers are incompetent; they built the kind of rockets which the United States clearly needed. And, in 1956, you could find hardly anyone in the United States who felt that our most urgent need was for an earth satellite. And the scientists, engineers, and military people were right. We didn't need such a satellite for any urgent scientific, engineering, or military purposes. The only people who were negligent were the propaganda experts. Why didn't *they* say we needed a satellite for propaganda purposes?

Probably because they had never studied any science and didn't know what an earth satellite was — or that it was possible.

And why did Sputnik have such an enormous propaganda impact?

Because, to a nation—indeed, to a world—illiterate in science, its significance was grossly exaggerated and misinterpreted. And people naturally concluded that a nation that could make such a miraculous device — something they had never *heard* of — must be a nation of supermen.

Illiteracy, ignorance by neglect, can lead to strange things—sometimes to frightening things.

Fortunately, a democracy often muddles through. Space science is on a more sensible basis now, though still suffering from unduly large propaganda overtones. The military have returned to working on miltary weapons — almost.

And our schools? Well, even though they had nothing whatever to do with Sputnik, we are now busily improving our schools anyway. For whatever reason, *that* at least is a good thing.

And the results are beginning to show. Our freshmen at Caltech now turn up with high school credits not only in trigonometry, but even (about 40 percent of them) in calculus. Our freshman chemistry course went out of date several years ago; the present one is more like what our sophomore and junior courses *combined* were like then. A similar situation exists in physics, and also, praise be, in English.

Our freshmen are very highly selected, of course. But a change in the schools has come, and it is spreading.

Liberal arts courses in college, I predict, will also soon return to a balance between all of the liberal arts — not just the non-scientific ones.

But I would be missing the most important reason why I think this is good if I left the impression that the only function of teaching science to everyone is to help people understand the technical basis of modern society — the technical facts of industry, transportation, communication, and of modern war.

There is much more to it. Science is one of the truly *liberating* arts. It frees the mind of ignorance of the world we live in. It expands our horizons, letting us see man in his true perspective in a colossal universe. It helps men understand the nature of learning, the process of attaining understanding. And, as one appreciates the process by which men's minds acquire understanding, one better appreciates men's minds — and better appreciates *men.*

*Robert F. Bacher, Provost of the California Institute of Technology.*

# The Month at Caltech

### *Caltech's First Provost*

Robert F. Bacher has been appointed Caltech's first provost. This is a new position created by the Institute's board of trustees.

Dr. Bacher has served as professor of physics and chairman of the Institute's division of physics, mathematics and astronomy since 1949. He will assume his new post in September 1962.

The purpose of his new position, according to President DuBridge, is "to create a closer link between the faculty, the administration, and the trustees in order to increase the effectiveness of the Institute in the development and improvement of its academic program."

As provost, Dr. Bacher will:

1. Serve as principal academic officer to assist the president in carrying out his responsibilities for the development and operation of the Institute's program.
2. Assume the duties now handled by the dean of the faculty, which post will be discontinued.
3. Serve as acting president in case of the absence or disability of the president.
4. Work closely with the chairman and other elected officers of the faculty in providing better communication among faculty members, and between faculty members and the administration, for the purpose of improving mutual understanding and expediting action on academic matters.
5. Take responsibility for the development, in collaboration with faculty members, of proposals for improvement of Institute academic practices and policies, and for making recommendations to the president and the board of trustees when administrative action is appropriate.
6. Carry on such other consultation, studies, discussions, and activities which he and the president believe are to the benefit of the Institute.

Dr. Bacher is a graduate of the University of Michigan (BS 1926, PhD 1930). He first came to Caltech as a National Research Council Fellow in 1930, and subsequently did research and teaching at MIT, Michigan, Columbia, and Cornell. During World War II, he worked first at the Radiation Laboratory at MIT, then at the Los Alamos Laboratory, where he headed the experimental physics division from 1943 to 1944 and the bomb physics division from 1944 to 1945. He was awarded the President's Medal for Merit in 1946.

Dr. Bacher was the first scientist member of the Atomic Energy Commission, on which he served from 1946 to 1949. He was a member of the President's Science Advisory Committee from 1957 to 1960, and was one of three U.S. delegates to the Geneva technical conference on nuclear test cessation in 1958. He is currently a member of the Naval Research Advisory Committee and is consultant to the President's Science Advisory Committee, the Department of Defense, and the Atomic Energy Commission.

Because Dr. Bacher had already asked for and been granted a scholarly leave for the second and third terms of the academic year 1961-62, his appointment as provost will become effective on September 1, 1962. Dean William N. Lacey will retain the title and duties of dean of the faculty until that time.

## *Eastman Professor*

James Bonner, professor of biology, has been appointed George Eastman Visiting Professor at Oxford University for the academic year 1963-64.

The Eastman Professorship was established in 1929 by George Eastman, founder of the Eastman Kodak Company, to send senior American scholars to Oxford for one year. In the past, this visiting professorship has gone to such men as Felix Frankfurter, Arthur Holly Compton, Herbert Spencer Jennings, Simon Flexner, Linus Pauling, Wallace Notestein, Donald A. Stauffer, Roger S. Loomis, Harold C. Urey, George F. Kennan and George W. Beadle.

## *National Science Foundation Grant*

Caltech's W. M. Keck Laboratory of Hydraulics and Water Resources has received two grants totalling $129,300 from the National Science Foundation for research work in the field of mechanics of sediment-laden streams $45,000), and for the construction of a unique tilting flume ($84,300). This research is directed jointly by Vito A. Vanoni, professsor of hydraulics, and Norman H. Brooks, associate professor of civil engineering.

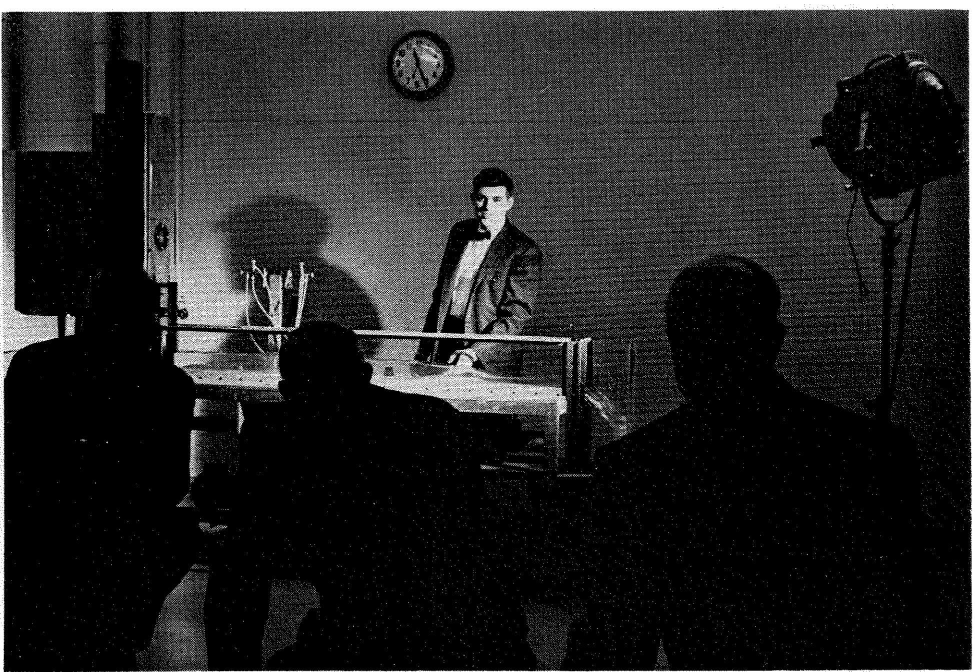
Basically, a laboratory flume is a tool for making a flow of water with an open surface. The fluid mechanics of the flow of clear water may be studied, or sand or other material may be added for sedimentation studies. The new 130-foot flume will be used first to study the transportation of sediment by flowing water. Engineers have learned how to control the flow of water, but have not yet solved many of the complex problems caused by the moving and shifting of mud and silt in rivers. Because of the increased importance of careful and efficient utilization of water resources, Caltech engineers feel that the new flume will be an indispensable research tool.

Valuable studies can also be made of sediment deposits, and of flow pattern over or through such structures as spillways, chutes, or weirs. Miniatures of these structures can be introduced anywhere in the flume and the pattern of flow downstream can be easily studied.

The new flume, to be ready for use early in 1963, will be housed in the longest room at Caltech, the 197-foot sub-basement hydraulics laboratory. The maximum weight of sand and water that will be supported by the flume is about 20 tons.

Research on sedimentation has been going on at Caltech for over 25 years, with smaller flumes, and research reports on flowing streams have been sent to hydraulics laboratories and universities in more than 30 nations. In addition to the general problems of the fluid dynamics of streams, more specific problems have been studied, such as the depositing of silt behind dams on the Colorado River, and the swift stream erosion in northeastern Mississippi.

Construction of the long flume was not possible until the W. M. Keck Laboratory of Hydraulics and Water resources was built. Here, a special area was set aside for the big flume, which Caltech engineers expect will be the most versatile in the world.



*The California Institute of Technology's board of trustees, on a campus tour, watch a demonstration by Norman H. Brooks, associate professor of civil engineering, in the W. M. Keck Laboratory of Hydraulics and Water Resources.*

*Caltech's National Board of Trustees — November 6, 1961*

*W. Keck Chandler Watson*
*Valentine Green Hahn Ingersoll Von Hagen Banks Morton Crandall Mudd*
*Dubridge Braun Fluor Lyon Beckman Volk Vesper McCollum Williams*
*Barber McDuffie Minckler Page Ruddock O'Melveny Percy*
*(Not present: C. Jones, T. Jones, Jorgensen, Stuart, Winnett)*

## *First Meeting*

Caltech's national board of trustees held its first meeting on the campus on November 6. A group of national trustees was elected to the board last spring to broaden the geographic base of its membership.

The trustees made a campus tour in the morning, held a business meeting after lunch, heard reports from the Institute's division chairmen, then attended a reception at the President's house, and a dinner at the Athenaeum.

Robert L. Minckler is the new chairman of the board. His election followed the retirement of Albert B. Ruddock, who has been a member of the board since 1938 and has served as chairman since 1954. Mr. Ruddock will continue on the board as an honorary member.

Two other men have been named honorary members of the board — William C. McDuffie, who has been on the board since 1933, and has been vice president since 1946; and P. G. Winnett, who has been a board member since 1939.

A new member of the board, William M. Keck, Jr., was elected to replace Howard B. Keck, who has resigned.

## *Indian Institute of Technology*

Caltech has joined with eight other American colleges and universities to assist in the development of a technological institute in India. The school will be known as the Indian Institute of Technology, and will be established in Kanpur, a major industrial city on the Ganges, about 250 miles southeast of New Delhi. The project parallels technological institutes in India which have been sponsored by other governments, including Russia.

Joining Caltech in the project are MIT, Princeton, the University of California, Carnegie Tech, Ohio State, Purdue, the University of Michigan, and the Case Institute of Technology. The institute was formed at the request of the Government of India and the U.S. International Cooperation Administration.

India will build the classrooms, laboratories, and dormitories for the new institute, and the American institutions will supply key faculty members and help set up the curriculum. Donald Hudson, professor of mechanical engineering, is Caltech's representative on the planning committee.

# A New Approach to Cancer Research

*by Renato Dulbecco*

Since their discovery, half a century ago, viruses have been investigated with ever-increasing interest. They have yielded a wealth of information about the organization and the dynamics of life, yet they have not given away all their secrets. Viruses are to biology what atoms are to physics—the smallest units capable of autonomous and stable existence. Like atoms, viruses can be broken down further into elementary components, the study of which reveals the most intimate secrets of life.

Viruses can be obtained in pure state, and as such are kept in vials in refrigerators and freezers in laboratories all over the world. These pure viruses are made up of very tiny particles, which are as lifeless and inert as a pure substance on the shelf of the chemistry laboratory. However, when the virus particles come in contact with a living cell, an interaction takes place between the two, in which the virus becomes very much alive. In the living cell one of the elementary constituents of the virus, chemically known as nucleic acid, enters a frantic process of reproduction. In this process the nucleic acid of the virus undergoes the essential life processes that occur in all cells during their growth; thus the reproduction of a virus in the cell recapitulates the basic phenomena of life in their most simplified form.

Virus reproduction is an effective and fascinating model for an experimental study of life for several reasons—the relative simplicity of the processes, compared to those of the cells of the body; the possibility of causing a very large number of virus particles to develop their life cycle at the same time; and the possibility of using precise methods of investigation. For these reasons the study of viruses has attracted many scientists of different backgrounds, including chemists, physicists, geneticists, mathematicians, and physiologists. Each one of them looks at viruses from his own highly specialized angle, and from the various fragments of information that every specialist contributes comes an ever-increasing knowledge of life.

The penetration of a virus particle into a living cell, a process which we call infection, is never inconsequential. In many cases the virus multiplies at a terrific speed, increasing between a thousand to a millionfold in a short time, and eventually killing the cell. In other cases the cell is not killed but modified. This event is of great biological interest because it gives a tool for studying cellular modifications, which occur constantly in organisms and are the main factor in many normal and pathological processes.

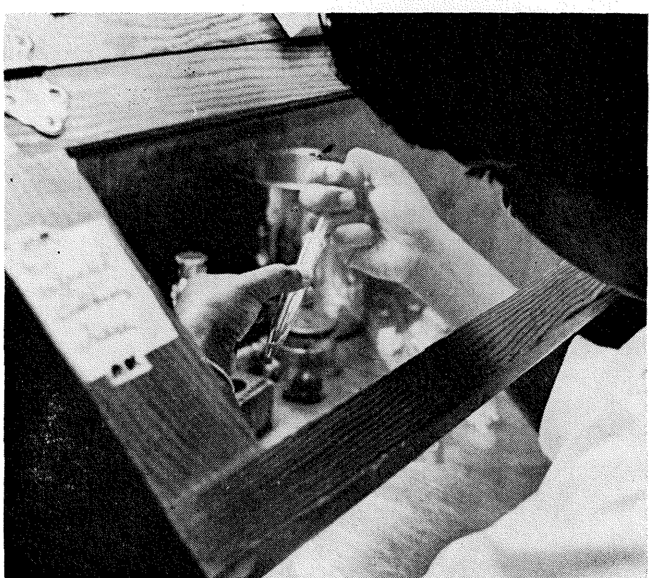
One possible modification of cells infected by virus is their transformation into cancer cells. We can visualize this process in the following way: A single particle of virus enters the body of an animal, interacts with one cell, and transforms it. The transformed cell now becomes released from the restraints that normally control the growth of the body cells and starts to grow and multiply relentlessly, giving rise to a large, ever-growing cell population, which is the cancer. Not all viruses do this, but only those of a special class, which are defined as tumor-producing or cancer-producing viruses.

At Caltech we have been interested for many years in the basic aspects of virus replication. In this framework, cancer-producing viruses have been studied for several years; however, only recently has an intensive effort been concentrated in this area. The interest in these viruses rose considerably two years ago, due to the discovery, at the National Institutes of Health, of a virus called polyoma, which is able to produce cancer in mice and hamsters. In examining the properties of this new virus we soon found that it was possible to develop a satisfactory system for following and measuring its multiplication. When this was found we set to work in an effort to learn how the virus causes cancerization. We had no practical question in mind when we started, but as the project developed, findings of practical significance were discovered — a not uncommon occurrence in science.

One main aspect of this work was that we did not take the traditional approach in cancer research and use animals; we used tissue cultures exclusively. These are cultures of cells derived from animals or embyros. The cells are grown in test tubes, bottles, or special plastic dishes, and they are maintained in properly outfitted incubators, where the cells find conditions very closely resembling those existing in the body.

This approach involves a specialized and delicate technology, but allows a study of the events following virus infection far more direct than would be possible with experimental animals. Furthermore, this approach extends the range of investigations beyond the usual limits of experimentation; for instance, it makes it possible to carry out experiments with human material.

This unconventional approach was made possible by one of the first results obtained in our work. We discovered that, by allowing the polyoma virus to interact with cells deriving from mouse or hamster embryos in plastic dishes, some cells became transformed into cancer cells, and gave rise to a growth which—in spite of the artificial conditions used—acquired all the characters of cancerous growth as we know it in the body. When cells from this growth were injected into an animal of the same strain as that



*A research assistant transfers cultures of cells that have been made cancerous by interaction with polyoma virus.*

from which the culture was obtained, the cells grew and gave rise to a conventional cancer; but cells of the same culture which had not been exposed to the virus never grew in the animal. This success provided an ideal experimental system which enabled us to carry out all the phases of our work with cell cultures in test tubes and plastic dishes.

Among the results of theoretical significance which were obtained by using this system we found that, although the virus interacts with most cells in a culture, it causes the transformation of only a small proportion of them—about one in a thousand. We also found that the transformation into a cancer cell, if it happens, occurs very shortly after the infection of the cell by the virus. These results indicate that a normal cell is transformed into a cancer cell by virus only when a very special type of virus-cell interaction occurs, and that this interaction causes the immediate and total transformation of the cell.

By using our system we were able to study the cancer cells very shortly after they were formed. The initial results of this study showed that the cancer cells always differ from the normal cells in certain characteristic properties of the cell surface. These surface changes were discovered by studying the spontaneous movement of the cells on a glass slide and by observing how strongly the cells adhere to the slide.

## *A most intriguing problem*

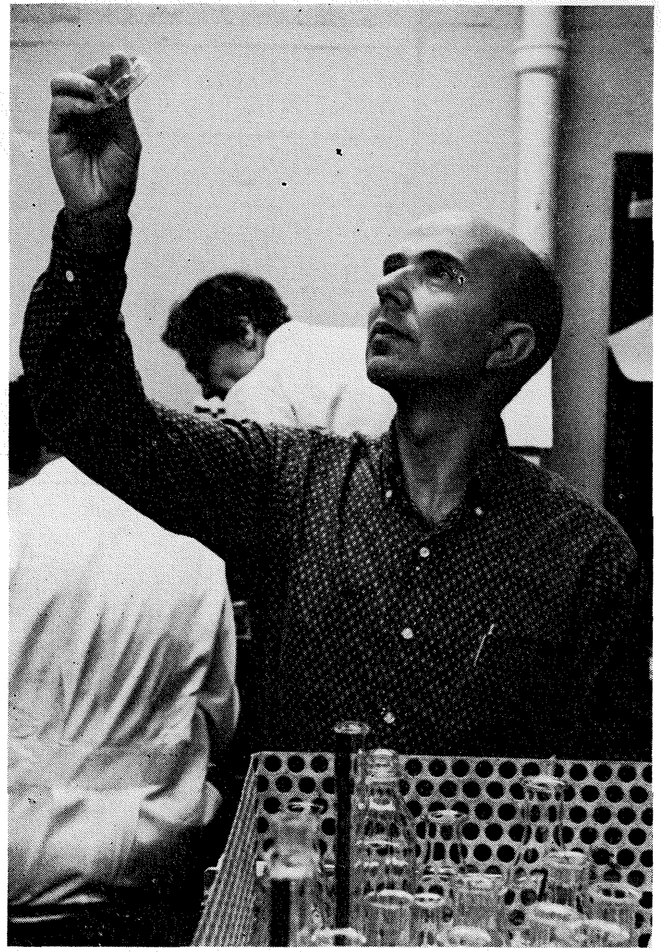
We do not yet know the chemical reasons for these changes, but we are in the process of investigating them. What meaning these surface changes may have for the cancerous transformation of cells is a most intriguing problem. Due to the great significance of the surface for the function of the cell, the surface changes may cause the abnormal behavior of the cancer cells in the body, and may therefore hold the secret of the main difference betwen a normal cell and a cancer cell. However, the surface changes may only be a consequence of some other key change. In any case, these changes are at the present moment of great interest to us as a marker of the action of the virus.

A very interesting finding emerged when we tried to find out what had happened to the particles of polyoma virus that had caused the cancerous transformation of the cells. We were expecting to find the virus growing in the cancer cells, but were surprised to discover that the cancer cells were free of the polyoma virus in its usual form. This showed that cells made cancerous by the virus continue to be cancerous even in the absence of the infectious form of the virus.

To try to understand the fate of the virus in the cancer cells, we made numerous attempts to find a number of the elementary components of the virus in the cells, but the results were consistently negative.

The fate of the virus in the cancer cells is still shrouded in mystery, and with it the basic mechanism of the transformation of the normal cells into cancer cells. The results obtained so far in the study of this problem have reduced to two the number of possibilities as to the fate of the virus. Either the virus-transformed cells contain a small fragment of the virus—for instance, a fragment of its nucleic acid—which would not be recognizable by the means now available, or they do not contain any trace of the virus. These alternate possibilities are being actively investigated, since solving these problems would greatly contribute to our understanding of what is cancer.

These findings have significant bearing on the possible role of viruses in human cancer. This is an important medical problem, because if human cancer is due to a small number of viruses, the prevention of the disease, if not its cure, might be feasible with our present means. Although this problem has been studied a great deal in the past, no clear answer has been given, and it is still unknown whether human cancer is caused by viruses. Our results suggest that two difficulties may be responsible for the inconclusiveness of the results, and they suggest new approaches to avoid these difficulties. One difficulty is the impossibility of making adequate experiments by following the conventional approach; the other is the previous lack of knowledge about certain properties of cancer-producing viruses.


*Dr. Renato Dulbecco examines a culture of cells infected with polyoma virus.*

### *Cancer experiments on man*

Traditionally, to determine whether a cancer of an animal was caused by a virus, extracts of the cancer were tested by inoculation into animals of the same species, where the virus would elicit the formation of the cancer. In the case of human cancers, tests by inoculation into man are impossible. Extracts of human cancers have been inoculated into the usual experimental animals, such as mice and hamsters, and viruses have from time to time been isolated, but these viruses were characteristic of the experimental animal inoculated. There is every reason to believe that these were contaminant viruses present in a latent state in the animal itself, rather than viruses derived from the human cancer. It is most likely that, to reveal a human tumor-producing virus, experiments will have to be conducted by using man as the experimental animal. This seemingly insuperable difficulty may now be easily circumvented by using cultures of human cells. On the basis of the results obtained with polyoma virus, a test based on the production of cancerous growth in these cultures in plastic dishes would have the same significance as if the cancer had been produced in a human being.

The second difficulty derives from the unrecognized possibility that the virus causing the cancer may not be found in the cancer cells themselves. The traditional procedures of searching for a cancer virus in the cancer itself may therefore fail, even if experiments are carried out with human cells. The results obtained with polyoma virus suggest a different approach. The polyoma virus is found, as a seemingly harmless virus, in many healthy mice—most of which never develop cancer. When tested under proper conditions, however, the carcinogenic capacity of the virus can be easily revealed.

Considering the situation in man, we know that many viruses can be found in healthy individuals. Some of these viruses are not definitely associated with any disease. Among these a cancer virus may well be hidden; such a virus may cause cancer in a few of the individuals infected, and may disappear later from the cancer cells themselves. These considerations suggest that viruses commonly found in normal individuals should be studied for their possible carcinogenic activity in cultures of human cells. If any is found that can produce the cancerous transformation of the cells, its connection with known human cancers could be studied epidemiologically.

We hope that these ideas will contribute to the clarification of the relationship between virus and cancer, and that in this way research conducted to serve the interest of science will end up also serving the needs of man.

# How to Ride a Wave

*by Graham Berry*

With a streamlined piece of metal in a water tunnel, Caltech engineers have resolved a problem that has puzzled scientists for years – a problem in physics that any reasonably bright young dolphin solves without so much as cracking a textbook.

These streamlined mammals are able to ride the bow waves of ships, apparently indefinitely, without having to wiggle a flipper. Nearly or completely submerged, they move along at the speed of the ship, not having to exert any energy themselves. Mere people can't do it. What laws of physics do the dolphins use?

For years only the dolphins knew the answer, while physicists and naturalists debated the issue with equations, diagrams, experiments and articles in scientific journals. There have been some lively disagreements over the relationships of the forces involved: weight versus buoyancy, and drag versus thrust.

A group of Caltech engineers decided to try and resolve these differences, once and for all. They spent a few hours one Saturday in the Hydrodynamics Laboratory setting up and observing a small metal simulation of a dolphin. The model, which actually was the model of a torpedo used in earlier Navy experiments, was attached to a force balance, which sensitively measures the lift, drag, and tendency of the test model to upset.

The investigating team consisted of Allan J. Acosta, associate professor of mechanical engineering; Taras Kiceniuk, group leader in the Hydrodynamics Laboratory, and Byrne Perry, associate professor of civil engineering from Stanford University.

The streamlined metal "dolphin," about one foot long and two inches in diameter, was suspended in the water at depths ranging from a little more than one inch to nearly six inches. In nature the dolphin moves through the water. In the test the model remained stationary and the water moved past it. The purpose of the experiment was to determine whether the drag force acting on the model would be reduced when the model was located in the forward part of the wave. If the force was reduced, it would demonstrate that the dolphin also might obtain similar assistance from a wave.

A level stream of water flowing past the "dolphin" produced some lift and considerable drag. The water flow was accelerated to about five miles an hour, at which speed it produced a standing wave in the water tunnel. The "dolphin" produced much more drag and also more lift when riding in the trough of the wave.

The model was moved into the forward slope of the wave and tilted at an angle corresponding with the wave's slope. In this position and at depths ranging from nearly two inches to four inches – while the model was entirely submerged – forward thrust was detected! This thrust was sufficient to be effective only with a very streamlined and slick body, like that of the dolphin.

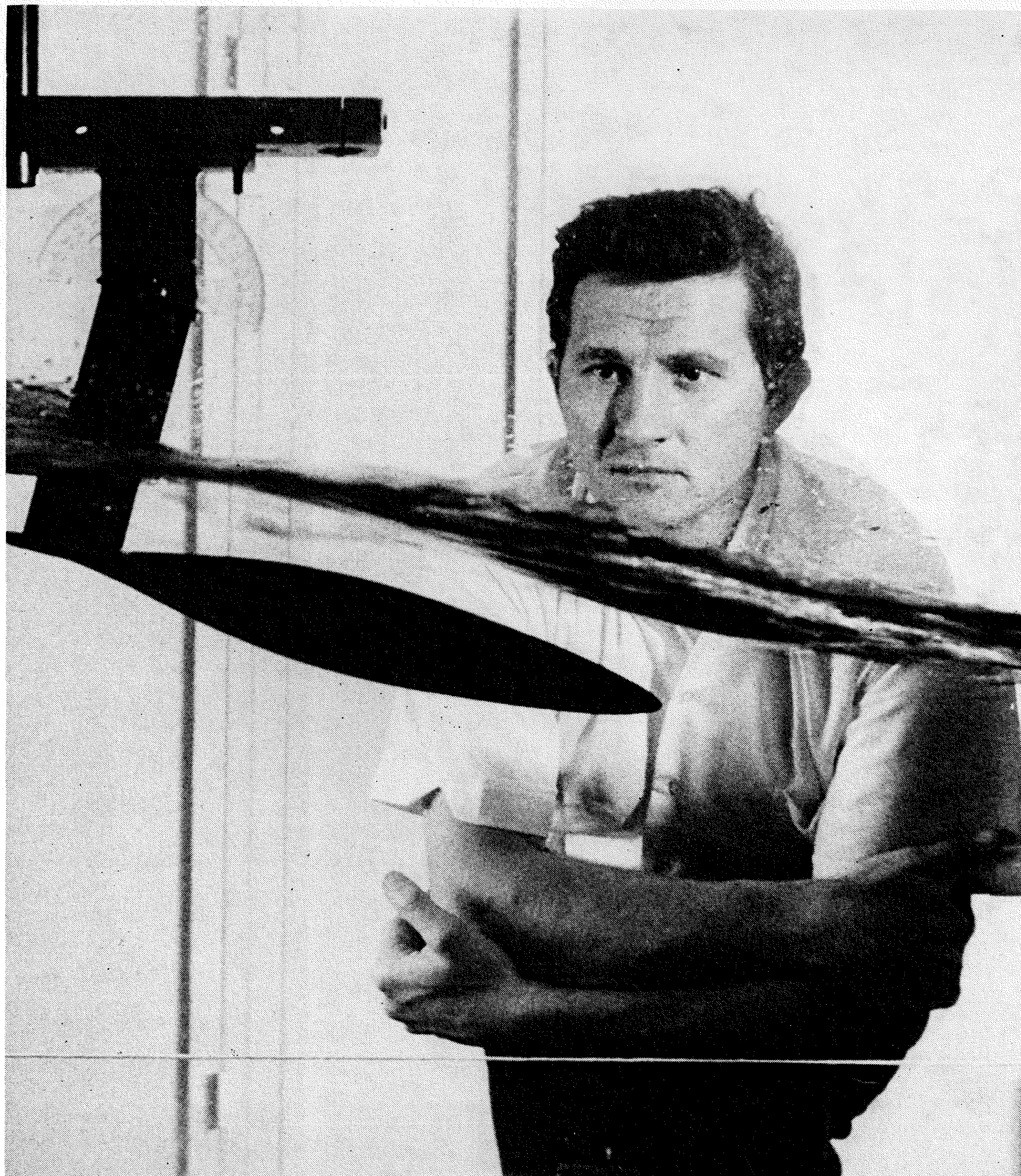
This, then, appeared to be the secret of the dolphin's ability to free-load rides on the bow waves of vessels. His propulsion may be likened to that of a surf rider who is constantly "falling" down the slope of an advancing wave and who will move forward as long as he holds his planing position on the wave's slope.

According to Kiceniuk, the dolphin's forward thrust is produced by the fact that the buoyant force is not directly upward, as it would be if there were no waves, but is tilted forward, being at right angles to the forward slope of the wave. "The mere existence of the measured forward-acting thrust on the test body in a wave demonstrates that a rigid body with turbulent flow can perform the wave-riding trick," he says.

The Caltech experiment appears to substantiate a mathematical analysis of the problem which was developed some time ago by a Caltech alumnus, Wallace D. Hayes (BS '41, AE '43, PhD '47), now professor of aeronautical engineering at Princeton University.

Wave-riding may be a skill that must be learned, says Kiceniuk. Young dolphins probably do it by watching their elders, and follow up the observations by practice. They learn to do it by "feel," just as a child learns how to ride the breakers at the beach or to ride a bicycle. They use their kinesthetic senses instead of mathematical equations.

Free-riding in this manner is believed to be a common practice in nature.

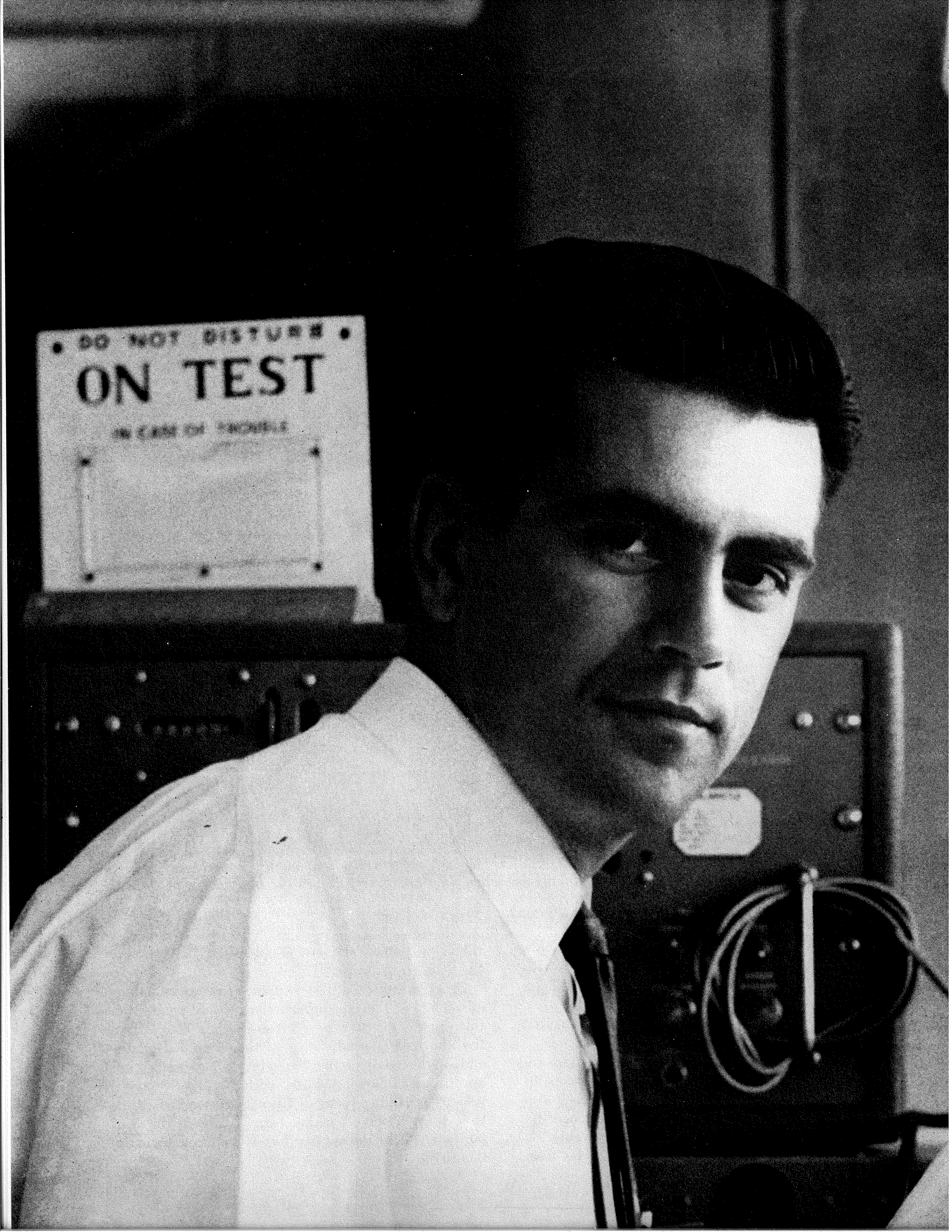


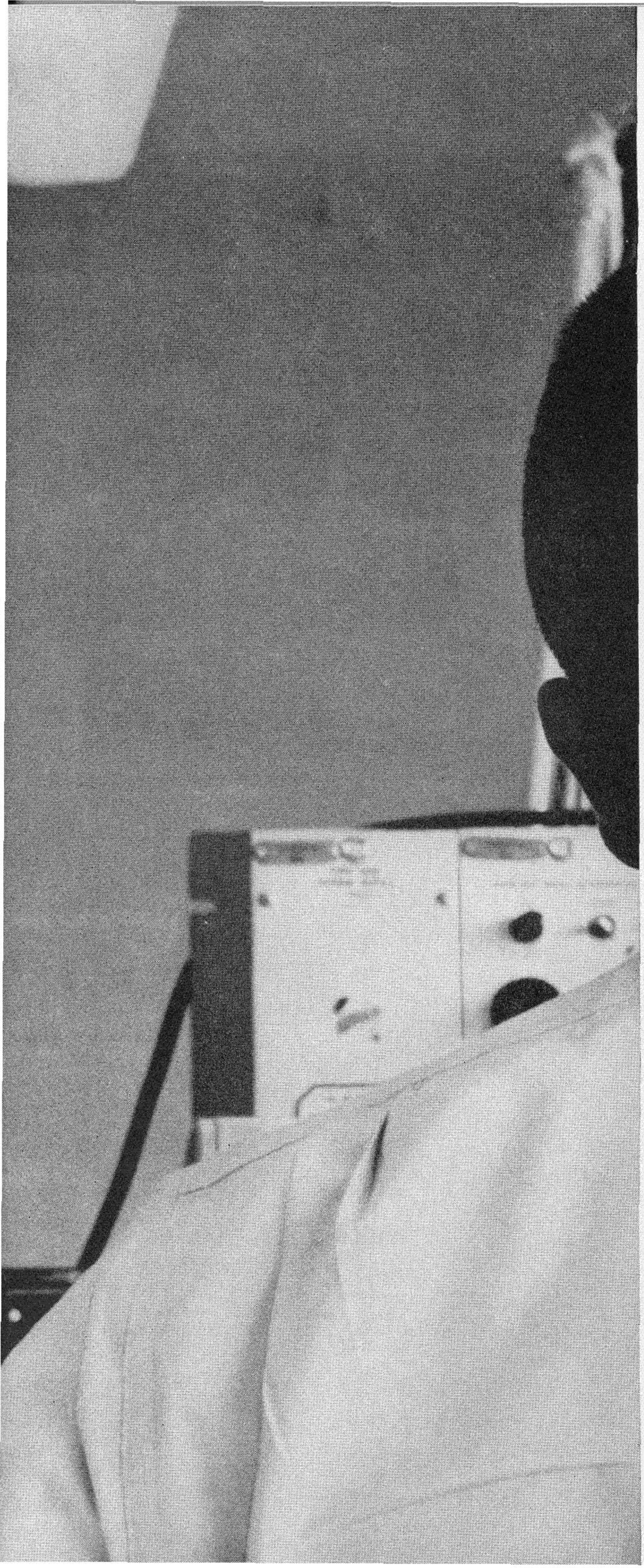
*With a metal model, Taras Kiceniuk, group leader in Caltech's Hydrodynamics Laboratory, tries to find out what laws of physics dolphins use when they take free rides on the bow waves of ships.*

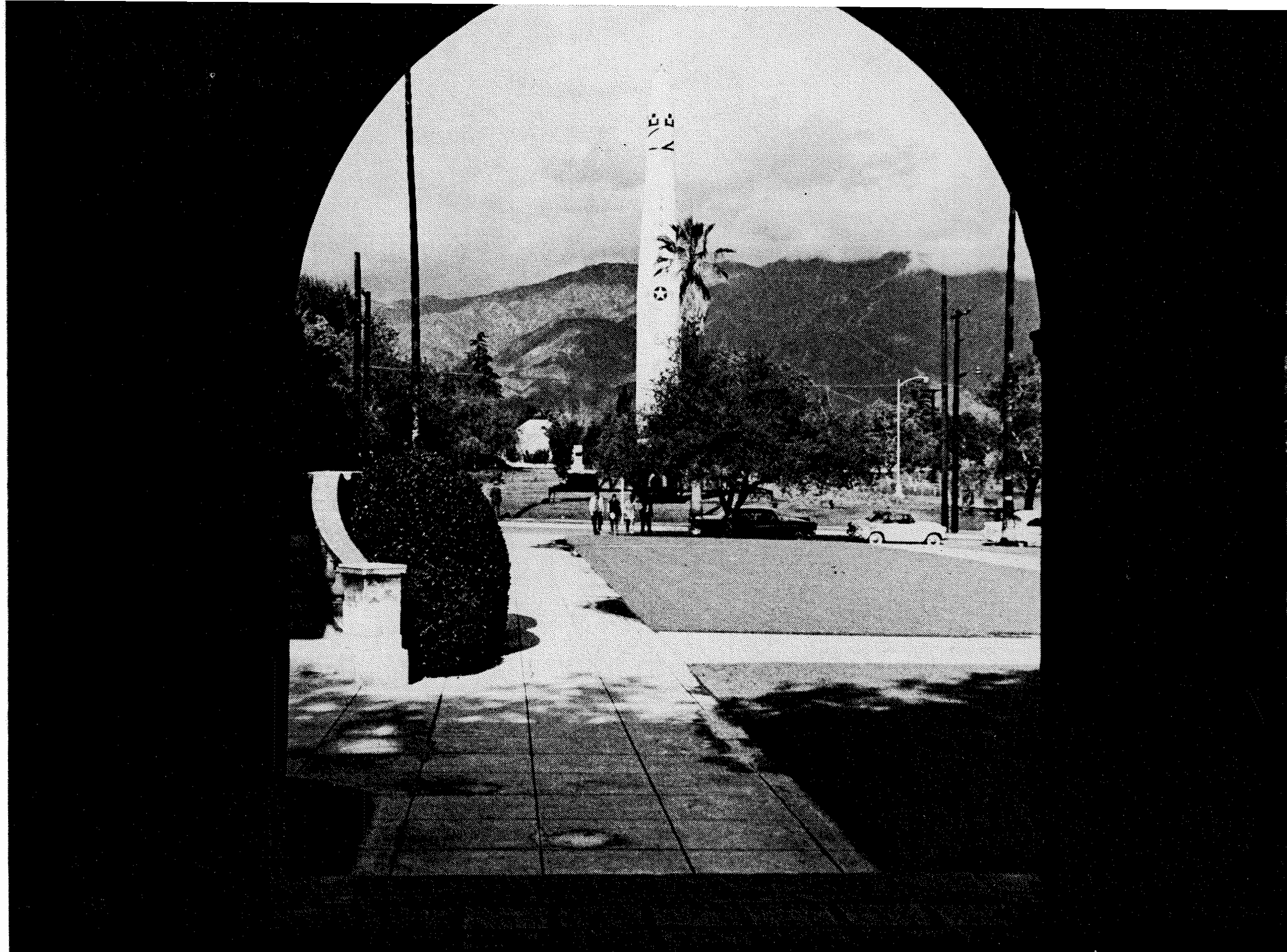
"It has been suggested that dolphins and porpoises migrate long distances by riding the ocean waves that are created by the winds," Kiceniuk says. "Whales should be capable of learning this art, too, but they probably haven't ever done it because they are too large for most natural waves."

The bow waves of ships are evidences of pressure fields created in the water by large moving objects. In the same way that dolphins ride the waves, they also may ride the pressure fields. Pressure fields may be created by another dolphin, or even, conceivably, by a submerged submarine. A pilot fish may be free-riding a shark's pressure field when he precedes the shark on its forays.

Other creatures are known to free-ride by taking advantage of flow disturbances which are created for them in the air. It is why geese fly in a "V." All but the lead bird take advantage of the air spilled off the end of the wing of the bird ahead. This spilled air approaches following birds with a slight upward velocity, enabling them to fly with less effort. Birds have been observed taking turns flying in the lead position, where the most effort is required to maintain flight.

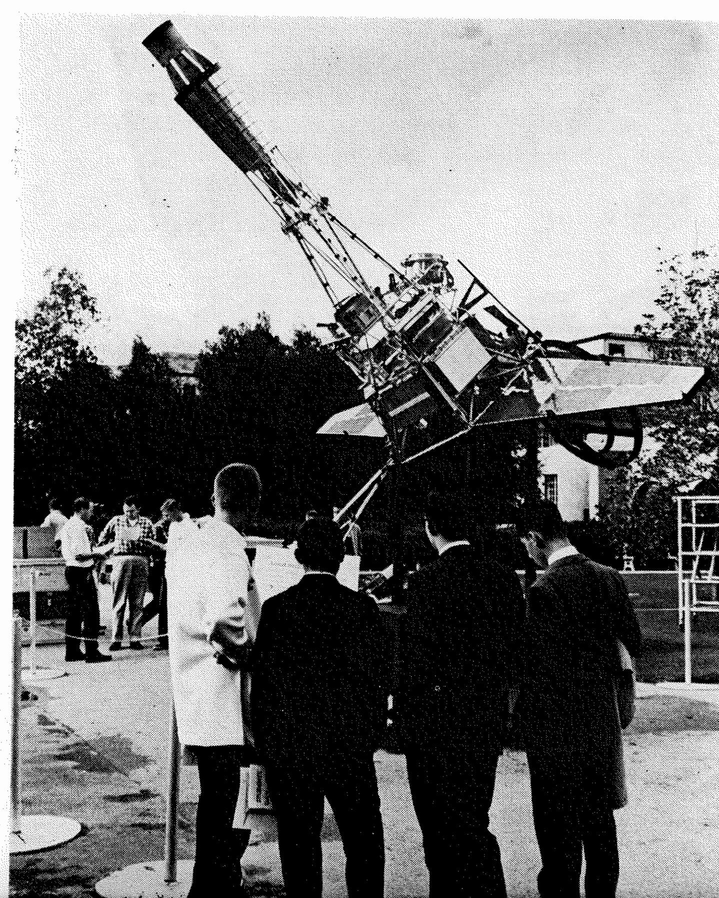

DO NOT DISTURB
ON TEST





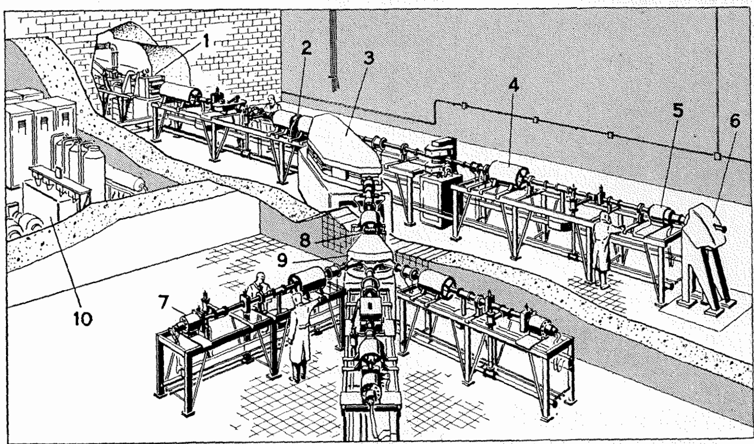
# Students' Day

Over 1,000 southern California high school students from 225 schools came to the campus on December 2 for the most elaborate Students' Day on record. Each department seemed pledged to outdo the others in impressing the visitors with the wonder and excitement of science during the morning tour of the campus, and President DuBridge spoke to the students after lunch (below), but what won the day was the Ranger spacecraft (right) set up in front of Throop Hall by Caltech's Jet Propulsion Laboratory, and the giant Thor rocket (above) on display in the parking lot next to the Keck Engineering Laboratories.



*High Voltage Engineering Corporation . . .*

# "CHARGED PARTICLES"




Typical high power electron beam analyzing and deflecting system for 10 to 80-Mev, 30 kw linac

1. Linac
2. Positron Target
3. Deflecting Magnet System and Energy-Defining Slits
4. Focusing Lens
5. Neutron Target
6. Terminating Magnet
7. Targets (3)
8. Monoenergetic Gamma Target
9. Switching Magnet
10. Equipment Room

The main features of this analyzing system are: (a) the beam can be delivered to any of three different experimental areas, focused to a small spot or spread out over a large area to facilitate target cooling; (b) net energy dispersion of the beam after deflection is negligible. This means that maximum beam of the desired energy is available because particles of varying energies move along the same center line into target regions; (c) in the deflecting magnet system there is a large energy dispersion at a collimator, which selects the required energy spectrum with a precision of 0.1 per cent or better; (d) the part of the electron beam discarded at this collimator or elsewhere in the system produces x-rays, the major portion of which are directed away from experimental areas; (e) the system can be converted to handle positrons produced in a shower target close to the entrance of the deflecting magnet system.

## High Power Linacs

In a recent discussion of *High Energy Linacs,* we indicated that the power of the new accelerators, plus better energy resolution opens up intriguing possibilities for the experimental physicist. One of these possibilities involves production of a monoenergetic gamma-ray beam, with adjustable energy, heretofore just a dream.

Positron annihilation in flight in a thin target produces such a gamma-ray beam. The linac electron beam is used to produce positrons in a wide energy spectrum in a shower target. These particles are energy-analyzed in a deflecting magnet before they impinge upon the annihilation target. Energy selection of the gamma rays is accomplished by varying the magnetic field of the deflecting magnet. The conversion factor is small, so it is essential to have an intense electron beam. It is not essential, however, to have a high degree of beam-energy homogeneity.

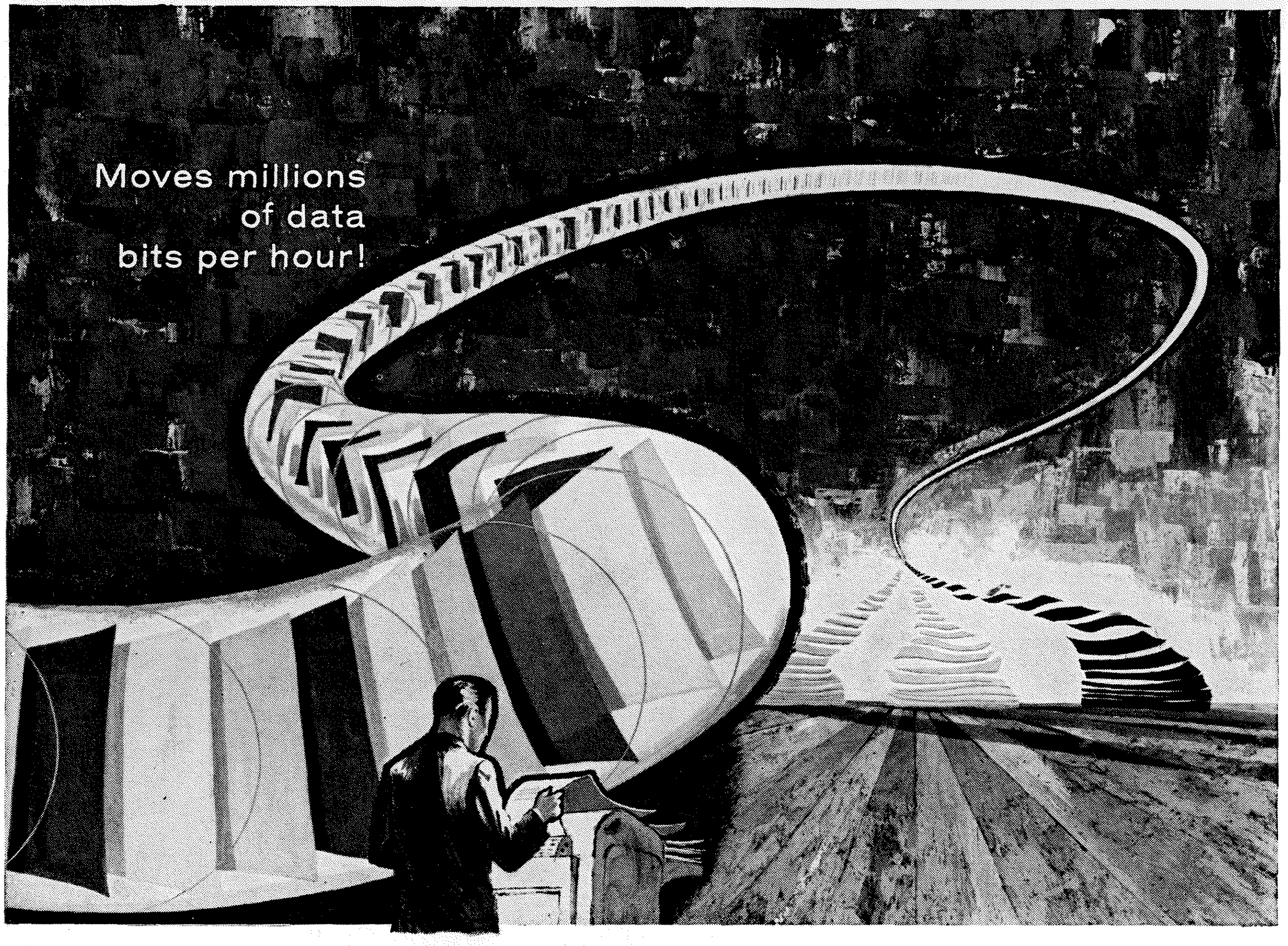
An experiment in which beam-energy homogeneity is important is the spectroscopic study of inelastically-scattered electrons from nuclei. Magnetic spectrometers for this kind of experiment can be built with a resolution of better than 0.1 per cent, and the electron beam must be analyzed to this accuracy before it impinges upon the scattering target.

## Hot Electron Beams

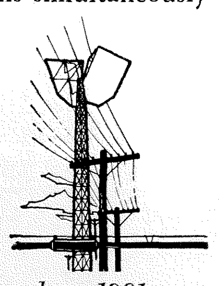
The high accuracy and power called for in these experiments requires considerable beam-handling ingenuity. The problems may be illustrated: A typical high-energy linac will put 45 kw of high-energy electrons on a one-half centimeter square — this equals 180 kw/cm$^2$, enough to vaporize any known material in a few seconds. To make such a system fail-safe requires precisely-protected beam slits and electron scattering devices, and specially cooled vacuum chambers, in addition to the analyzing and collimating equipment. The situation is complicated by an x-ray background which prohibits use of organic materials for coil insulation and vacuum gasketing.

The beam analyzing and deflecting system is an increasingly complex and important part of the linac experimental facility. An inadequate system will greatly reduce the accelerator's research utility. Fortunately, High Voltage Engineering has had years of experience designing and building extremely accurate, magnetic analyzing systems to guaranteed specifications.

**HIGH VOLTAGE ENGINEERING CORPORATION**
BURLINGTON, MASSACHUSETTS, U.S.A.
•
**APPLIED RADIATION CORPORATION**
•
**HIGH VOLTAGE ENGINEERING (EUROPA) N.V.**


Moves millions
of data
bits per hour!





# Personals

### *1919*

*Lloyd W. Kraemer,* retired owner and manager of the Ace Hardware Store in Pasadena, died on January 21 of cerebral arteriosclerosis. He had owned and managed his retail store for 25 years. He leaves his wife and sister.

### *1921*

*Charles F. Quirmbach,* associate engineer with the Public Utilities Commission of the State of California, died very suddenly of a coronary occlusion on October 8. He leaves his wife; son, *Charles F. Quirmbach, Jr.,* BS '49; and four grandchildren.

### *1923*

*Douglas A. Stromsoe* has retired as president of the Southern Pipe division of U. S. Industries, Inc. in Azusa. He joined the company in 1932.

### *1926*

*Mark Serrurier,* president of the Moviola Manufacturing Company in Pasadena, announces the engagement of his daughter, Linda—a graduate of Oregon State University—to Lt. John R. Velthoen, U.S.A.F.

### *1931*

*Alvin C. Tutschulte,* assistant district manager for the Tidewater Oil Company's Coastal District with headquarters at Ventura, Calif., died on October 7 after an operation for a malignant brain tumor. Carl was a member of the board of directors of the Caltech Alumni Association in 1949-51. He leaves his wife, two daughters, and a son.

### *1932*

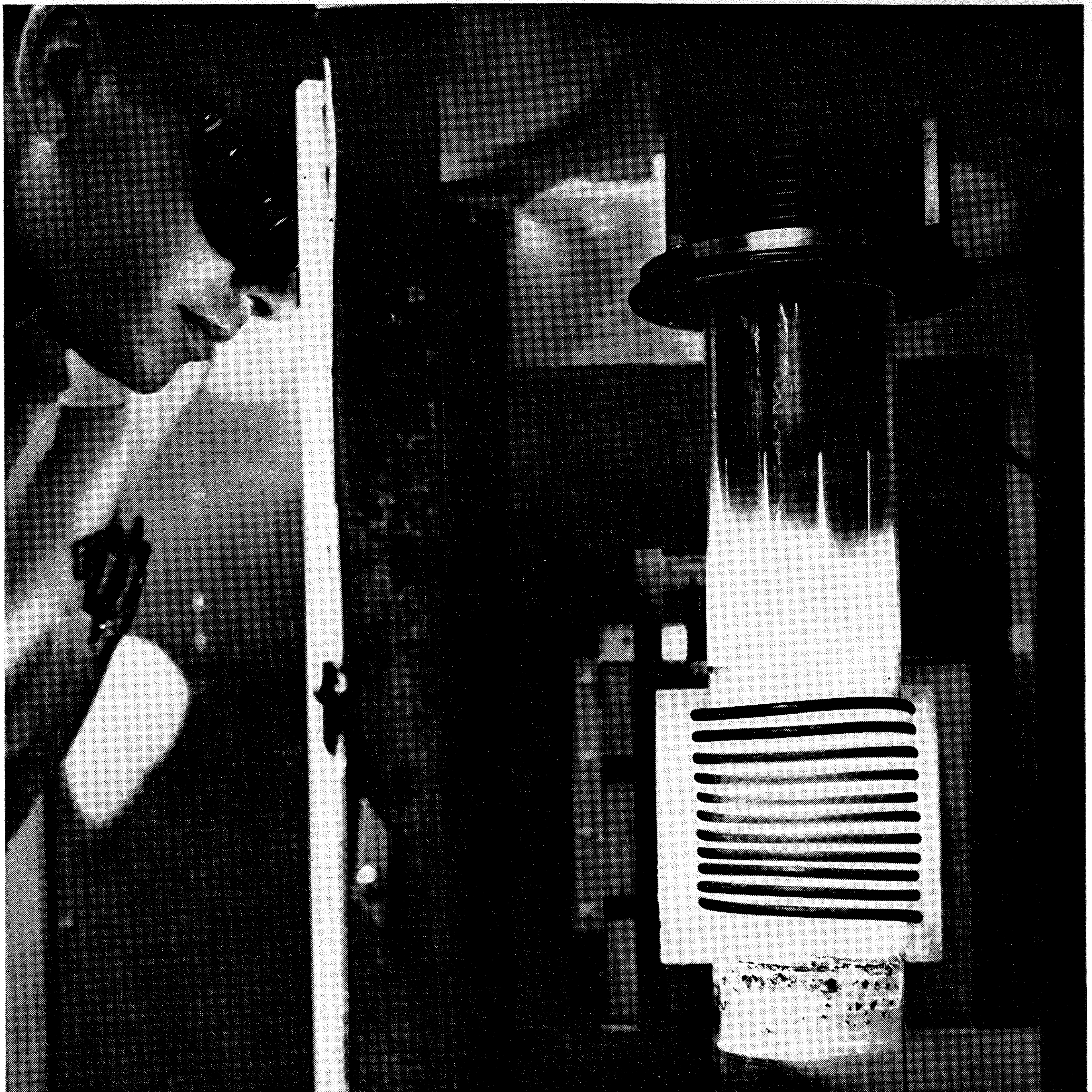
*William J. Thomas,* chief chemist in the coated fabrics department of the Firestone Tire & Rubber Company of California, celebrated 25 years of service with Firestone this fall. The Thomases have three children: Ed, 11; Dorothy, 10; and Bob, 3.

*William Saylor,* chief mechanical engineer at the Norden Division of United Aircraft in Costa Mesa, had a narrow escape on September 26. He was driving on the Santa Ana Freeway near the Tustin turnoff when his car was hit from the rear by a drunken driver who was possibly traveling as fast as 100 miles an hour. The two cars went up the embankment at terrific speed and Bill was thrown into the passenger's side of his car. He managed to steer the vehicle enough to avoid a large light standard and almost got it back on the freeway again, but the car turned over and skidded on its side for over 300 yards before coming to rest in the center dividing strip. The other car ended up in an orange grove. Its passengers apparently only received serious cuts and bruises. Bill's car was demolished, but he escaped without a scratch.

### *1937*

*William R. Cato,* owner of the William R. Cato Automobile Agency, died on October 4 when his plane crashed into San Francisco Bay. The airport was obscured by overcast and he was making an instrument landing when he hit the bay. Bill was an aviation enthusiast and chairman of the aviation committee of the Woodland Chamber of Commerce. His business was established in Woodland in 1945. He leaves his wife, a daughter, his father, and a sister.

*continued on page 30*



*1938*

*Samuel E. Watson, Jr.*, geologist with the Iranian Oil Exploration and Production Company, in Iran, a subsidiary of The Texas Company, writes that he has "spent four years as reservoir research geologist in the Iranian oil fields. Fantastic geology and oil production here—an average well is 25,000 barrels per day. Our first home leave of 3 months meant a tour of Europe. This time we have round-the-world tickets and will see part of the Far East.

"My family now consists of Susie, 14, and Sammy, age 12."

*George T. Rudkin*, PhD '42, is now an associate member of the Institute for Cancer Research in Philadelphia. He was formerly research associate. He is currently investigating the chemistry of genes with the giant chromosomes of the salivary glands of fruit fly larvae. He has been with the Institute since 1946. The Rudkins have four children.

*1939*

*Col. Robert F. Fulton*, MS, (USAF Ret.) died on August 31 after a brief illness at the Elmendorf Air Force Base Hospital in Anchorage, Alaska. He was 56.

He had served in the North African-Mediterranean Theater in World War II, and in the Philippines. From 1944 to 1948 he was stationed in Washington and received the Legion of Merit for his duty as a staff weather officer at the Air Transport Command headquarters.

After duty as base commander at Elmendorf AFB and as chief of staff for the Fourth Air Force at Hamilton AFB in California, he retired in 1958 to become assistant director of the Logistics Missile Division of the North American Aviation Company in Downey, Calif. He returned to Alaska a year ago to make his home there. He is survived by his wife, two sons and five daughters.

*1940*

*Sheldon Crane* is one of the four partners in a growing firm called Del Monte Technical Associates in Monterey, Calif. Two of the other partners are Caltech alumni, too—*Glynn H. Lockwood*, BS '46 and *Max L. Panzer*, BS '44, MS '45, PhD '48. *Mitchell L. Cotton*, BS '48, associate professor of electronics at the U.S. Naval Postgraduate School, is a consultant on the staff.

DTA was formed in 1960 as a consulting service to industry. Their main field of approach is advanced system concepts applied in the development of complex electro-optical assemblies for automatic reduction of missile and satellite photographic data.

*1944*

*George G. Bennett*, MS, died of a heart attack on October 23 at Greensboro, N.C. He was an executive with the J. H. Biggar Furniture Company in Pasadena. He is survived by his wife and a son, George, Jr.

*1945*

*Joseph F. Hook* writes that "I'm now a member of the senior staff of the National Engineering Science Company in Pasadena. This company is practically a Caltech alumni association chapter. I am concentrating on seismic wave propagation studies. As a company, we specialize in solving unusually difficult or advanced problems in applying scientific concepts to engineering problems."

*Charles E. Lamar* is now president of the Southern Pipe division of U.S. Industries, Inc., in Azusa. He succeeds *Douglas A. Stromsoe*, BS '23, who has retired. Charles has been with Southern Pipe since 1951.

*1947*

*Col. Bernard Marschner*, MS, AE '48,

*continued on page 32*

PhD '54, is now professor and head of the department of aeronautics at the U.S. Air Force Academy in Colorado.

*Fernand de Percin*, MS, is now associate program director for physical sciences facilities at the Office of Institutional Programs of the National Science Foundation in Washington, D.C. He was formerly with the office of the chief of research and development in the Army Research Office.

### *1948*

*Arthur N. Cox* writes that he's "still group leader at the Los Alamos Scientific Laboratory. We now have two young boys—the latest one born on October 2."

*Paul B. MacCready*, MS, PhD '52, president of the Atmospheric Research Group of Altadena, has been awarded a research grant by the National Science Foundation for his assistance in the testing of a new instrument for measuring the size and distribution of water drops in clouds. He is taking the instrument to the Puy de Dome mountain-top observatory in southern France, for a series of tests conducted by research scientists from many countries.

### *1949*

*Lt. Col. Richard T. Batson*, MS, has received the Army Commendation Medal for outstanding performance of duty during his recent assignment with the Blast and Shock division of the Defense Atomic Support Agency in Washington, D.C.

### *1950*

*Franklin Page, Jr.*, PhD, president of DuPaCo., Inc., in Arcadia, died on November 16 after being hit by a car. He was returning on foot from a Little League meeting. Frank was well known in Arcadia for his work with the Boy Scouts, Little League, and the youth program at the Arcadia Presbyterian Church.

### *1953*

*Pierre J. Marien*, MS, was married to Monique Deval on September 5 in Ghent, Belgium.

### *1955*

*Hsung-Cheng Hsieh*, MS, has been appointed associate professor of electrical engineering at the State University of Iowa. After receiving his PhD from the University of California, he held a teaching post at the University of Wichita before going to Iowa.

### *1959*

*Donald B. Owings* received his MS in chemical engineering from Stanford University recently and is now on the staff of the research and development division of Du Pont's Polychemicals Department at the Experimental Station near Wilmington, Del.

*Anthony J. Iorillo*, MS '60, has just returned from a year in Italy on a Fiat-Fulbright grant at the Politecnico di Torino. He writes that most applicants for these grants are liberal arts students, so the commission is always looking for good applicants from the sciences and engineering. Tony is now working on the flight-control system for the "DYNA-SOAR" at the aeronautical division of Minneapolis-Honeywell in Minneapolis.

### *1960*

*John W. Porter*, MS, is working for his PhD at the Guggenheim Jet Propulsion Center at Caltech on a Guggenheim Fellowship this year.

*Henry H. Dearman*, PhD, is a research chemist in the diffusion and dyeing research group at the Chemstrand Research Center in Durham, N.C.



## Caltech Varsity Game Scores

| | | | | |
|---|---|---|---|---|
| **Football** | | | | |
| October 28 | Southern Calif. College | 8 | Caltech | 28 |
| November 4 | UC Riverside | 43 | Caltech | 8 |
| November 10 | Occidental | 47 | Caltech | 8 |
| November 18 | Claremont-Harvey Mudd | 60 | Caltech | 8 |
| **Water Polo** | | | | |
| October 27 | Redlands | 7 | Caltech | 7 |
| October 31 | Occidental | 20 | Caltech | 1 |
| November 3 | Claremont-Harvey Mudd | 9 | Caltech | 4 |
| November 7 | Pomona | 15 | Caltech | 5 |
| November 10 | El Camino | 15 | Caltech | 7 |
| November 14 | Redlands | 5 | Caltech | 8 |
| November 17 | Occidental | 13 | Caltech | 9 |
| **Cross Country** | | | | |
| October 27 | Whittier | 15 | Caltech | 42 |
| November 3 | Pomona | 15 | Caltech | 40 |
| November 14 | Claremont-Harvey Mudd | 28 | Caltech | 28 |
| | Pasadena Col. | 33 | Caltech | 23 |
| **Soccer** | | | | |
| October 28 | Redlands | 2 | Caltech | 12 |
| November 4 | Pomona | 2 | Caltech | 1 |
| November 11 | Biola | 1 | Caltech | 6 |
| November 18 | UC Riverside | 0 | Caltech | 4 |

# NO WAY OUT

"Yes, Miss Johnson? . . . Speak up, girl, speak up.

"*George* Sternmeyer? In the outer office? What's he want? What did he say? . . . *Nothing?* You mean he just walked in and handed you his card? . . . Good grief!

"Well, there's no way out now . . . better show him in and—oh, have some aspirin ready when he leaves. I think I'm going to have a migraine.

"Well, well, *well!* What a *pleasant* surprise! Sure is good to *see* ya, George. Heh, heh, heh. Sit down here, fella–make yourself comfortable . . . Smoke? Heh, heh.

"You don't look so well, George. All this work been gettin' to ya, huh? . . . Whyn't ya *say* something, George?

"What's this? Oh . . . a gift card . . . my name . . . heh, heh. Tell you what, George. I'll be big about it. You can have the picture I gave last month *and* some money. O.K.? . . . I figure about five bucks ought to cov—*that* was a funny noise, George. O.K. ten dollars . . . For heaven's sake! You sick or something? Your face looks kind of weird. George! DOWN, BOY! DOWN! *Twenty*-five bucks, George, Twenty-five b—— LOOK OUT! Take it easy there! . . . look out for the lamp! *Fifty,* George. *FIFTY WHOLE DOLLARS!*

"That's better, George. Take it easy, boy. Whew! That's it, sit down here. Easy now . . . there . . . Boy. You had me scared there for a minute. Terrible thing to see a grown man go to pieces like that . . .

"Now. Ink's still wet—don't smear it . . . there you go. Feeling better now?

"You know it must be a great thrill to call on our old classmates. When you turn this money into the Fund it must make you feel real good. Boy!

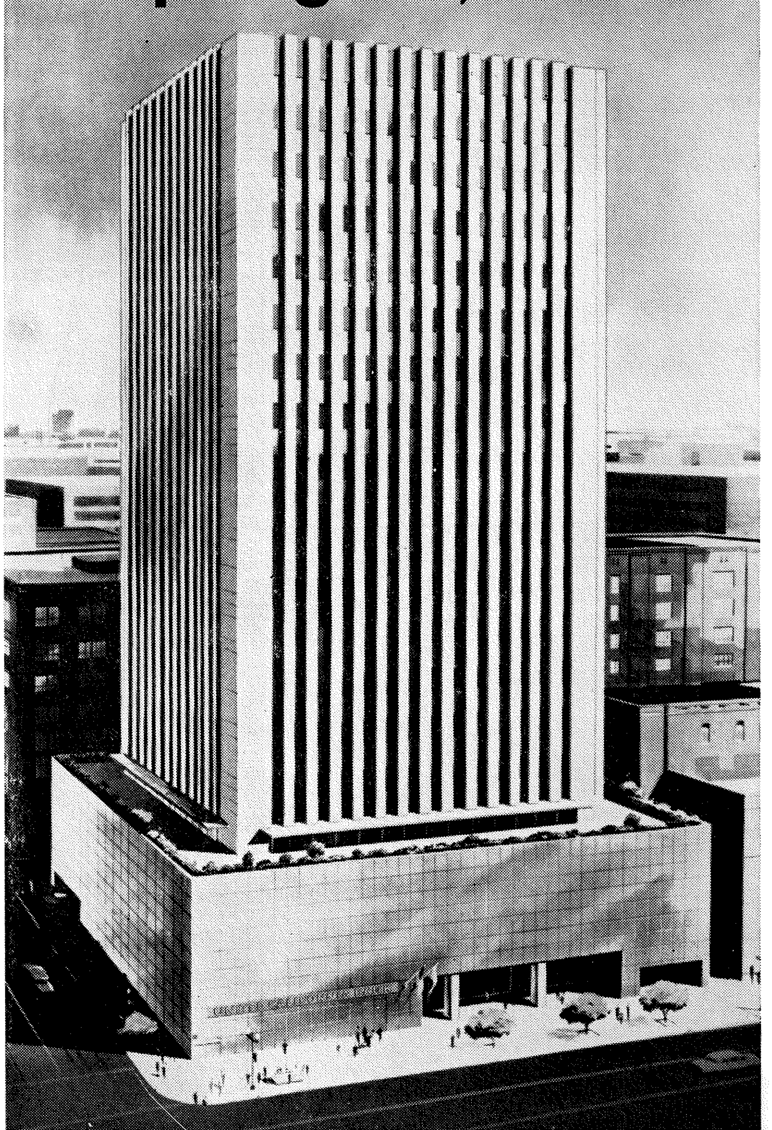
"Ya know? I wish *my* job was as easy as calling on—George? You O.K.? George?

"Poor guy—he must be overcome with my generosity."

MONEY CARRIES GERMS. PLAY IT SAFE. GIVE IT TO THE ALUMNI FUND

# Spring St., L.A. *like* Wall St., N.Y.C.

## *knows the soundest investment in valves*


New headquarters of UNITED CALIFORNIA BANK
Los Angeles

*Architect:* CLAUD BEELMAN & ASSOCIATES; *Mechanical Engineer:* JOHN C. FREEMAN; *Mechanical Contractor:* MEHRING & HANSON CO.; *General Contractor:* C. L. PECK CONSTRUCTION AND REALTY CO. . . . all of Los Angeles

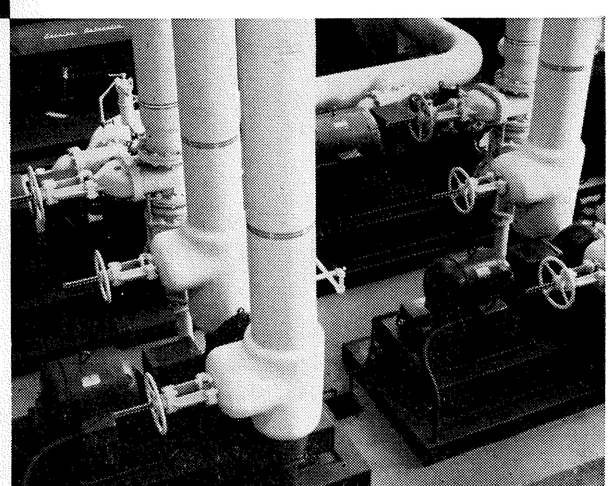
### Again, JENKINS VALVES are the bankers' choice

Taller, perhaps, but there's no *finer* bank building in New York than the new Head Office of United California Bank on Spring Street in Los Angeles' financial area. Headquarters for 122 offices in California, this 370,000 sq. ft. building is an outstanding example of the excitingly modern architecture and superb engineering and construction which draws many building experts to Southern California for a "look-see."

There's an expected "California difference" in the design and decor of this bank. But a significant fact is that, like so many of the great bank buildings in New York and other cities, the valves that control the piping systems bear the same *"Diamond and Signature"* trademark.

Obviously, California bankers and their architects and engineers agree with their contemporaries everywhere about the soundest investment in valves. To assure a building-lifetime of trouble-free, economical valve service, they call for JENKINS.

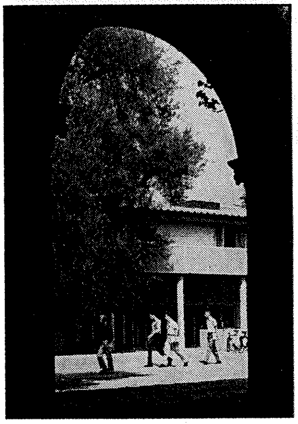
Why should *you* settle for less . . . especially when Jenkins Valves *cost no more* than other good valves? Specify "Jenkins Valves," for almost a century *the standard of quality*. Jenkins Bros., 100 Park Avenue, New York 17, N. Y.


Jenkins Valves control all service lines in the plumbing, heating and air conditioning system

**JENKINS**
MOST TRUSTED TRADEMARK IN THE VALVE WORLD
**VALVES**
JENKINS SINCE 1864
*Jenkins Bros*

AVAILABLE FROM LEADING DISTRIBUTORS EVERYWHERE

# CALTECH CALENDAR



## ALUMNI EVENTS

| | |
|---|---|
| January 25 | Winter Dinner Meeting |
| March 3 | Annual Dinner Dance |
| May 19 | Annual Alumni Seminar |

## ATHLETIC SCHEDULE

### Basketball

December 15
Naval Training Center at NTC

December 15
Cal Western at Cal Western

January 5
Caltech at Upland College

January 6
UC Riverside at Caltech

January 9
Pomona at Caltech

January 13
Caltech at Whittier

January 16
Biola at Caltech

January 19
Caltech at Claremont-H. Mudd

## FRIDAY EVENING DEMONSTRATION LECTURES

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

December 8
Development Genetics of a Bacterial Virus
—Robert Edgar

December 15
How Fossils are Used in Age-Dating of Rocks
—Arthur Boucot



## ALUMNI ASSOCIATION OFFICERS

**PRESIDENT**
Holley B. Dickinson, '36

**SECRETARY**
Donald S. Clark, '29

**VICE-PRESIDENT**
William L. Holladay, '24

**TREASURER**
John R. Fee, '51

**BOARD OF DIRECTORS**
John D. Gee, '53
Howard B. Lewis, Jr., '48
Claude B. Nolte, '37
Wiliam H. Saylor, '32
Peter V. H. Serrell, '36
William H. Simons, '49
Charles P. Strickland, '43

## ALUMNI CHAPTER OFFICERS

**NEW YORK CHAPTER**

**President** — Victor Wouk, '40
Electronic Energy Conversion Corp.
342 Madison Ave., New York 17, N.Y.

**Vice-President** — Bruno H. Pilorz, '44
75 Echo Lane, Larchmont, N.Y.

**Secretary-Treasurer** — Harry J. Moore, '48
IBM Corp., 590 Madison Avenue, New York 22, N.Y.

**WASHINGTON, D.C. CHAPTER**

**Chairman** — Major Lothrop Mittenthal, '48
3420 Livingston St., N. W. Washington 15, D.C.

**Secretary** — Willard M. Hanger, '43
2727 29th St., N. W., Washington 8, D.C.

**SAN FRANCISCO CHAPTER**

**President** — James A. Ibers, '51
Shell Development Co., Emeryville

**Vice-President** — Lee A. Henderson, '54
Weld Rite Company, Oakland

**Secretary-Treasurer** — Edwin P. Schlinger, '52
Scott-Buttner Electric Co., Inc., Mountain View

Meetings: Fraternity Club, 345 Bush St., San Francisco
Informal luncheons every Thursday

**CHICAGO CHAPTER**

**President** — Laurence H. Nobles, '49
Department of Geology, Northwestern University
Evanston, Illinois

**Vice-President** — Philip E. Smith, '39
Eastman Kodak Company, 1712 Prairie Ave.
Chicago, Illinois

**SACRAMENTO CHAPTER**

**President** — George Langsner, '31
Division of Highways, State of California

**Vice-President** — G. Donald Meixner, Jr., '46
Dept. of Water Resources, State of California

**Secretary-Treasurer** — John Ritter, '35
Division of Highways, State of California

Meetings: University Club, 1319 "K" Street
Luncheon first Friday of each month
Visiting alumni cordially invited—no reservation

**SAN DIEGO CHAPTER**

**Chairman** — Maurice B. Ross, '24
3040 Udal Street

**Secretary** — Frank J. Dore, '45
Astronautics Div., Convair

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

# Kodak beyond the snapshot . . .

(random notes)

## Light as air

Both beakers contain the same quantity of applesauce. The picture should interest the millions who face the problem of avoiding more calories than their doctors say are good for them while enjoying the delight of good eating.

The one on the right contains only two additional ingredients: 1% of a certain type of monoglyceride fat we distill for the food industry and 1000% of air. Both added ingredients are harmless as applesauce itself.

One adds the monoglyceride, warms, and whips. If the result is a bit too airy for the common taste, one can either use more strongly flavored applesauce, freeze while mixing (as in making ice cream), or both.

It doesn't have to be applesauce. We have made the idea work just as well with bananas, tomato juice, etc.

Mind you, expect no applesauce from us. We offer no foods in family-sized quantities. We work closely, however, with companies that do.

## THIS paper

"My husband sells oscillograph paper. Competition is fierce. He comes home beat every night."

Few overhearing her would know what the poor soul is talking about, yet she speaks the truth. Oscillographs probably outnumber pickle barrels in this country at present. Oscillographers are correspondingly numerous. Methods that one sect of oscillographers prefers above all else another sect can't see for dirt. One sect prefers automatic oscillogram processors. Paper manufacturers like us find their favor worth competing for. Therefore we announce a new advance in media for their use.

An advance in the old art of paper-making came first. Then new emulsions were devised to work properly with the new base. Then proper processing chemicals were devised for the new emulsions. Then the combination was extensively proved out under practical conditions of use by parties interested only in end-results and hardly at all in the how and why.

They found that THIS paper dries thoroughly at high processor speeds without creases, doesn't crack or distort, isn't fussy about how long it sits around *before* use, and gives trace lines that stand out black as the ace of spades.

"THIS" won't do for a trademark. We call it Kodak Ektaline Paper. Kodak Ektaline Chemicals come as liquids. The stabilization principle used in the automatic oscillogram processors came from Kodak, too.

## Smart hardware

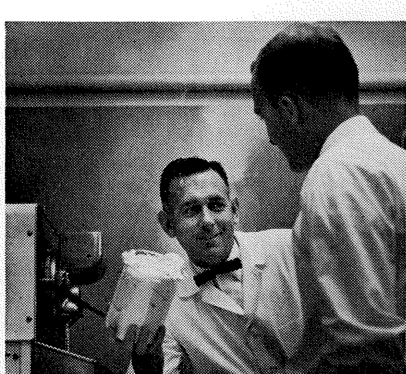
Alarm prevails over the nation's bill for research unwittingly repeated. We have an answer. Even the hardware is all built. It uses little chips of film 16mm by 32mm, which are never touched by human hands.

Each of the millions of chips carries both a) language the machines can use in classifying information to almost any depth of detail and b) microreproduction of documents, photographs, manuscripts, drawings, or whatever for the human user to examine with his natural-born eyes as soon as the machine has "remembered" it and restored it to size.

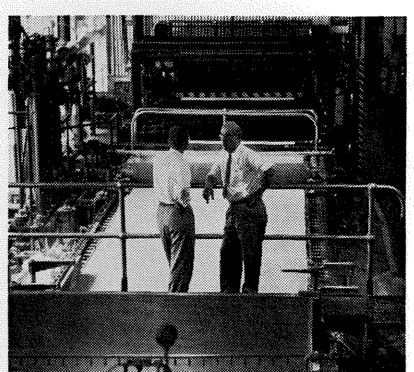
The machines search very fast. They further save searching time because of the incredible information-packing density and copying speed of photography. It is practical for the machinery to duplicate each complete chip for every pertinent sub-classification. The sub-classifications can therefore be made so fine that each contains relatively few chips for the machinery to zip through.

This is called the Minicard System. It can occupy legions upon legions of creative minds with very sharply relevant information from the whole recorded past while the stroke of genius is patiently awaited.

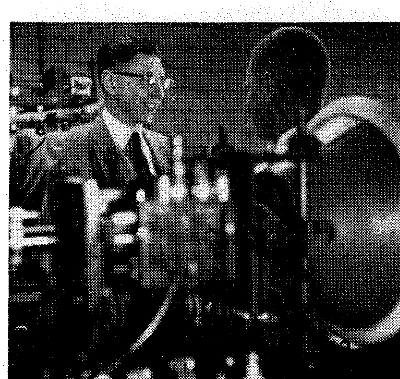
**Note:** Whether you work for us or not, photography in some form will probably have a part in your work as years go on. Now or later, feel free to ask for Kodak literature or help on anything photographic.



FOOD TECHNOLOGY NEEDS GOOD PEOPLE



ADVANCED PAPER-MAKING NEEDS GOOD PEOPLE



INFORMATION RETRIEVAL NEEDS GOOD PEOPLE

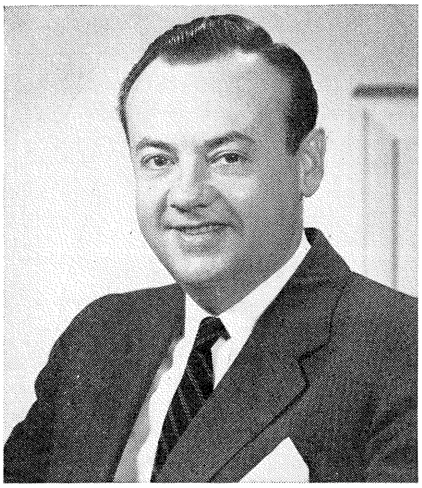
From solvents to slide projectors, plenty of lively careers are to be made with Kodak in research, engineering, production, marketing. *Address*:

**EASTMAN KODAK COMPANY**
Business and Technical Personnel Department
Rochester 4, N.Y.

Kodak
TRADE MARK

One of a series . . .

## Interview with General Electric's Dr. J. H. Hollomon
## Manager—General Engineering Laboratory



# Society Has New Needs and Wants—Plan Your Career Accordingly

**DR. HOLLOMON** is responsible for General Electric's centralized, advanced engineering activities. He is also an adjunct professor of metallurgy at RPI, serves in advisory posts for four universities, and is a member of the Technical Assistance panel of President Kennedy's Scientific Advisory Committee. Long interested in emphasizing new areas of opportunity for engineers and scientists, the following highlights some of Dr. Hollomon's opinions.

**Q. Dr. Hollomon, what characterizes the new needs and wants of society?**

A. There are four significant changes in recent times that characterize these needs and wants.

1. The increases in the number of people who live in cities: the accompanying need is for adequate control of air pollution, elimination of transportation bottlenecks, slum clearance, and adequate water resources.

2. The shift in our economy from agriculture and manufacturing to "services": today less than half our working population produces the food and goods for the remainder. Education, health, and recreation are new needs. They require a new information technology to eliminate the drudgery of routine mental tasks as our electrical technology eliminated routine physical drudgery.

3. The continued need for national defense and for arms reduction: the majority of our technical resources is concerned with research and development for military purposes. But increasingly, we must look to new technical means for detection and control.

4. The arising expectations of the peoples of the newly developing nations: here the "haves" of our society must provide the industry and the tools for the "have-nots" of the new countries if they are to share the advantages of modern technology. It is now clearly recognized by all that Western technology is capable of furnishing the material goods of modern life to the billions of people of the world rather than only to the millions in the West.

We see in these new wants, prospects for General Electric's future growth and contribution.

**Q. Could you give us some examples?**

A. We are investigating techniques for the control and measurement of air and water pollution which will be applicable not only to cities, but to individual households. We have developed, for example, new methods of purifying salt water and specific techniques for determining impurities in polluted air. General Electric is increasing its international business by furnishing power generating and transportation equipment for Africa, South America, and Southern Asia.

We are looking for other products that would be helpful to these areas to develop their economy and to improve their way of life. We can develop new information systems, new ways of storing and retrieving information, or handling it in computers. We can design new devices that do some of the thinking functions of men, that will make education more effective and perhaps contribute substantially to reducing the cost of medical treatment. We can design new devices for more efficient "paper handling" in the service industries.

**Q. If I want to be a part of this new activity, how should I plan my career?**

A. First of all, recognize that the meeting of needs and wants of society with products and services is most important and satisfying work. Today this activity requires not only knowledge of science and technology but also of economics, sociology and the best of the past as learned from the liberal arts. To do the engineering involved requires, at least for young men, the most varied experience possible. This means working at a number of different jobs involving different science and technology and different products. This kind of experience for engineers is one of the best means of learning how to conceive and design—how to be able to meet the changing requirements of the times.

For scientists, look to those new fields in biology, biophysics, information, and power generation that afford the most challenge in understanding the world in which we live.

But above all else, the science explosion of the last several decades means that the tools you will use as an engineer or as a scientist and the knowledge involved will change during your lifetime. Thus, you must be in a position to continue your education, either on your own or in courses at universities or in special courses sponsored by the company for which you work.

**Q. Does General Electric offer these advantages to a young scientist or engineer?**

A. General Electric is a large diversified company in which young men have the opportunity of working on a variety of problems with experienced people at the forefront of science and technology. There are a number of laboratories where research and advanced development is and has been traditional. The Company offers incentives for graduate studies, as well as a number of educational programs with expert and experienced teachers. Talk to your placement officers and members of your faculty. I hope you will plan to meet our representative when he visits the campus.

A recent address by Dr. Hollomon entitled "Engineering's Great Challenge — the 1960's," will be of interest to most Juniors, Seniors, and Graduate Students. It's available by addressing your request to: Dr. J. H. Hollomon, Section 699-2, General Electric Company, Schenectady 5, N.Y.

**GENERAL ELECTRIC**

*All applicants will receive consideration for employment without regard to race, creed, color, or national origin.*