ENGINEERING | AND | SCIENCE

January 1960

Research in progress . . . page 26

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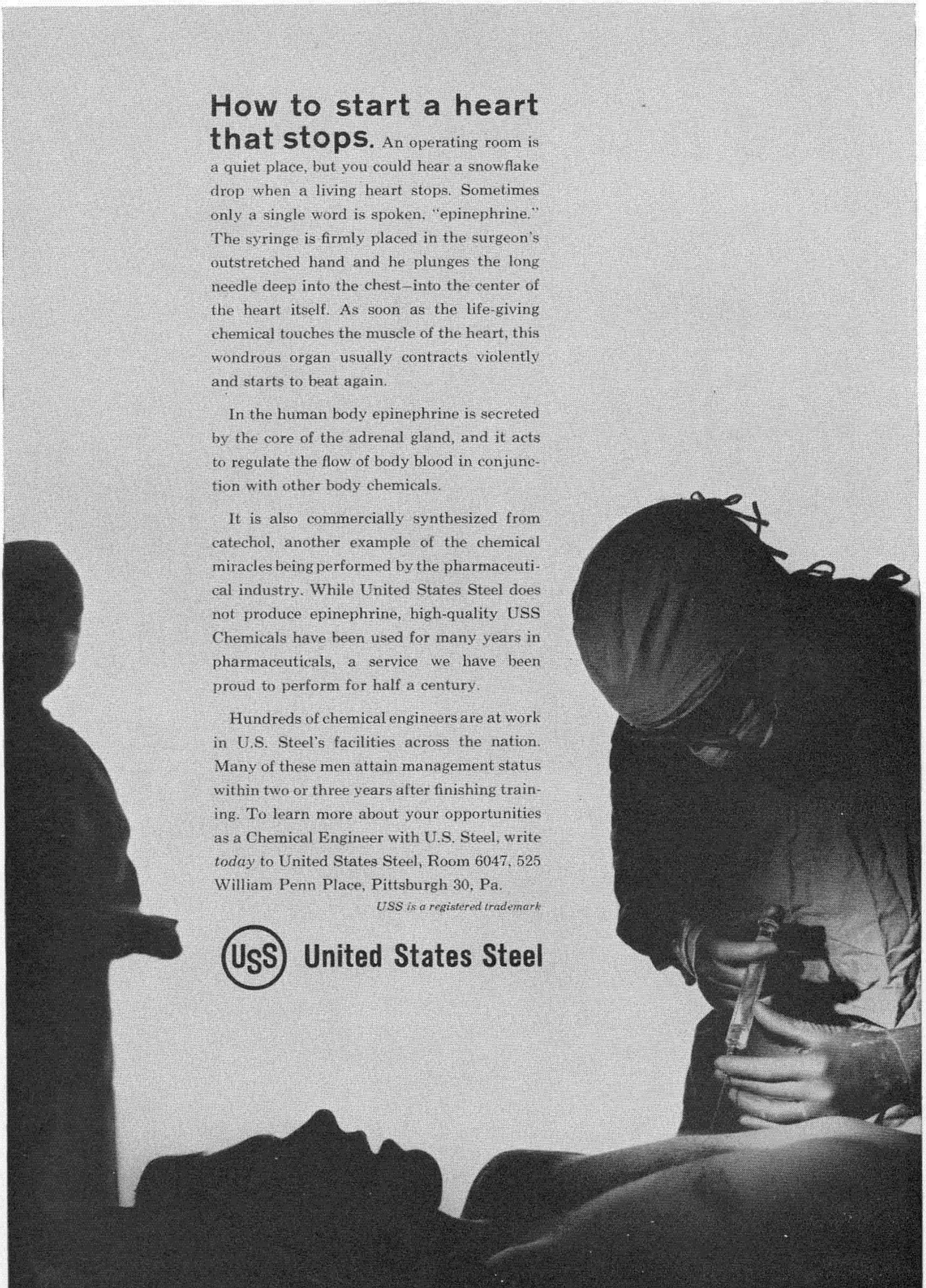
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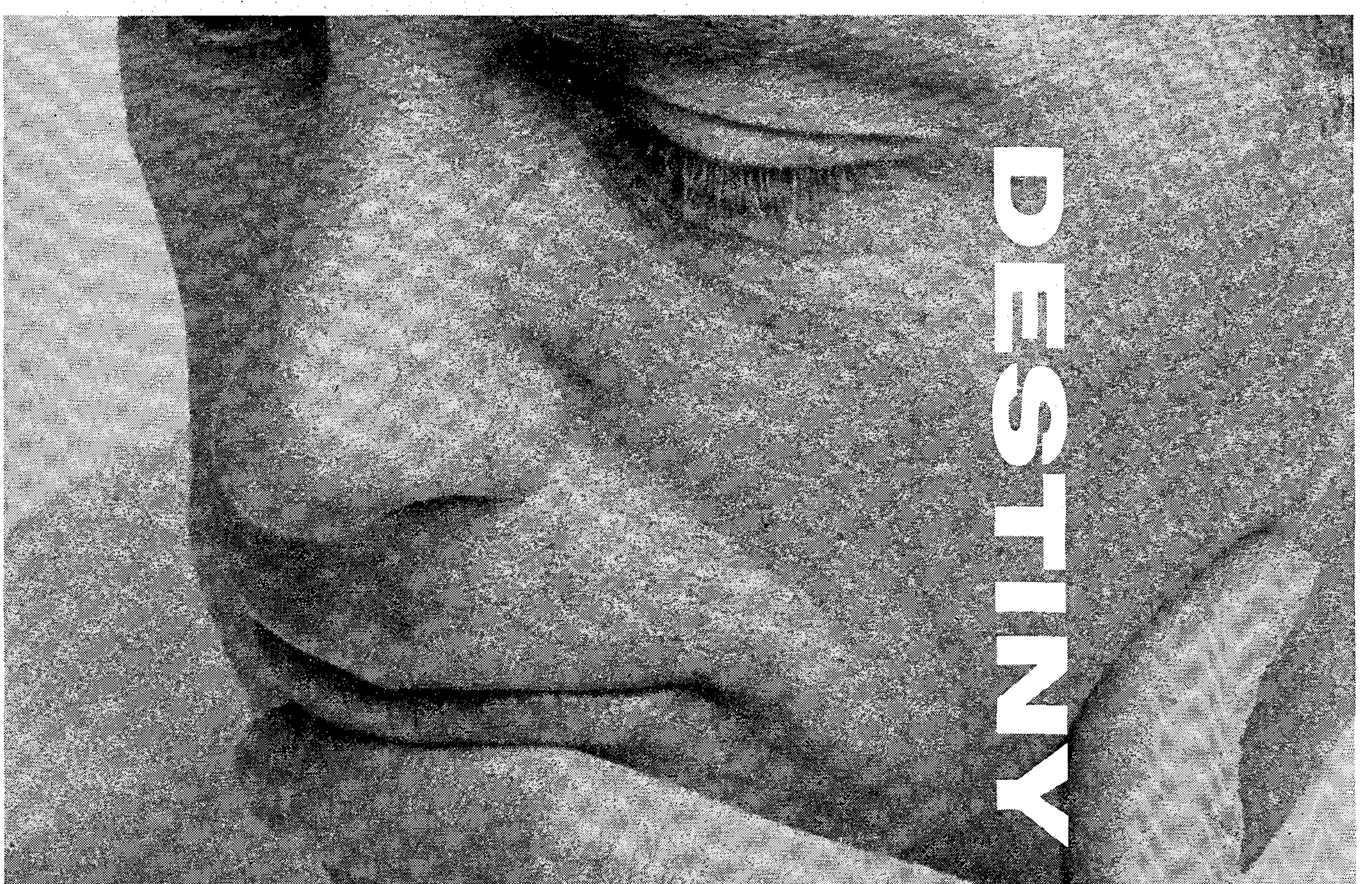
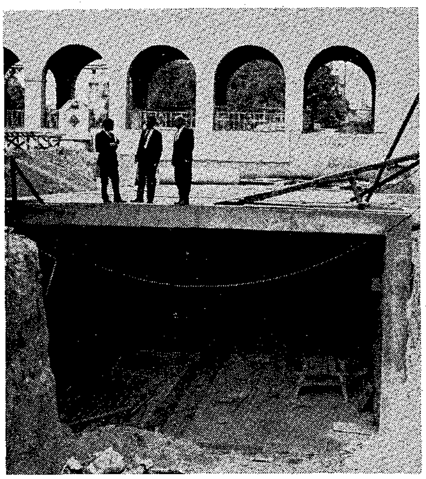

DESTINY

ENGINEERING | AND | SCIENCE

JANUARY 1960 VOLUME XXIII NUMBER 4



On Our Cover

three Caltech physicists check the progress being made on construction of the huge underground vault which will house Caltech's newest and biggest Van de Graaff electrostatic accelerator. The three – who will all work with the new machine – are Thomas Lauritsen, professor of physics; Ward Whaling, associate professor of physics; and William Fowler, professor of physics. For more about the powerful machine which will be used for studies of nuclear reactions, see page 26.

Caltech's Deans

sit for their portraits by Tom and Muriel Harvey in this issue (pps. 15-20). This is the latest in the series of distinguished faculty portraits the Harveys have been presenting in *Engineering and Science* since 1956.

"Cancer and Viruses"

on page 21 was written by Howard Temin, who has been working in Caltech's biology laboratories as a United States Public Health Fellow since 1955, when he received his BA from Swarthmore. His article has been adapted from a Friday Evening Demonstration Lecture he gave at Caltech on November 20, 1959.

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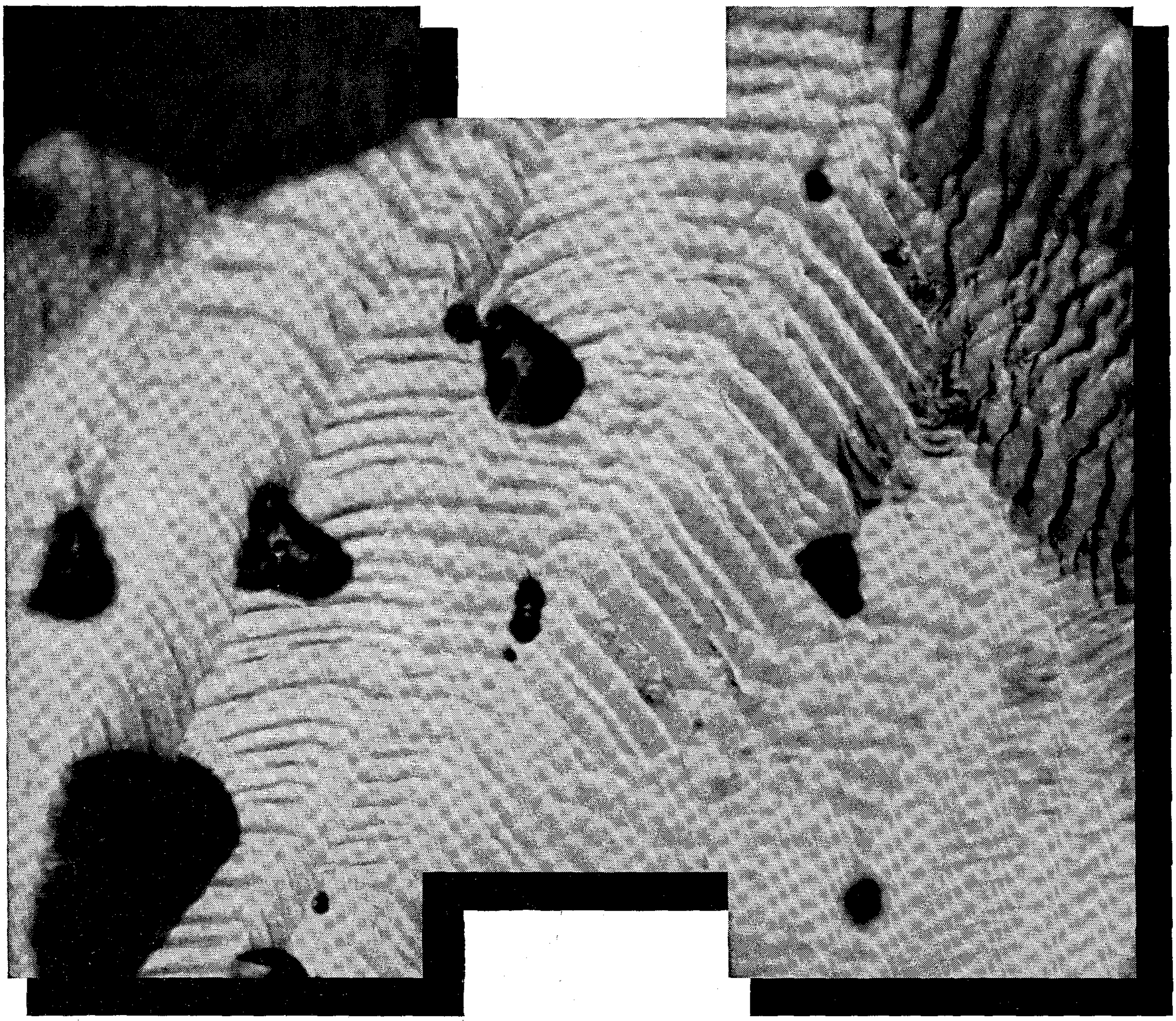
The industry that



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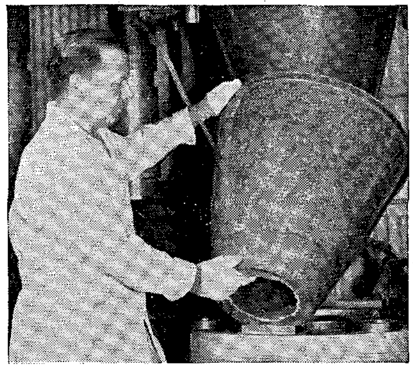

***Exit cones** capable of withstanding temperatures of 6000° F, represent one example of advanced engineering being performed by the Hughes Plastics Laboratory.*

This photomicrograph (at left) of an etched silicon crystal is used in the study of semiconductor materials. Impurities introduced into crystals such as this form junctions for semiconductor devices.

In the fast-growing semiconductor industry, Hughes Products, the commercial activity of Hughes, is leading the field. Its programs include basic research on semiconductor surfaces; alloying and diffusion techniques; and materials characterization studies to determine the electrical effects of imperfections and impurities.

In addition, Hughes Products is developing new semiconductor devices such as parametric amplifiers, high frequency performance diodes, and improved types of silicon transistors. New techniques are being devised for casting silicon into various configurations. Also underway is the development of new intermetallic compounds for use in semiconductor devices.

Other activities of Hughes provide similarly stimulating outlets for creative engineering. The Hughes Research & Development Laboratories are conducting studies in Advanced Airborne Electronics Systems, Space Vehicles, Plastics, Nuclear Electronics, Global and Spatial Communications Systems, Ballistic Missiles... and many more. Hughes in Fullerton is developing radar antennas which position beams in space by electronic rather than mechanical means.

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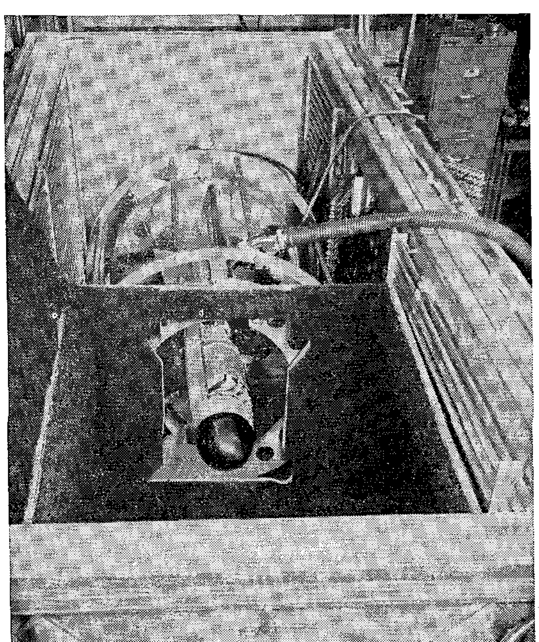


***Falcon air-to-air guided missiles,** shown in an environmental strato chamber are being developed and manufactured by Hughes engineers in Tucson, Arizona.*

Books

The Armchair Science Reader

Edited by Isabel S. Gordon and Sophie Sorkin

Simon & Schuster $7.95

The editors of this smorgasbord of science writing "have tried to assemble an anthology that conveys (the) excitement of science in writings that are a delight to read. It is not primarily to the reader who is already well informed about science, nor yet to the one who wishes to add to his scientific knowledge, that this book is addressed. The reader we have in mind throughout is the one who, first and foremost, enjoys good writing and then is enough of a child of his time to be interested in the way thoughtful men have reckoned with science."

This is a promising concept, and it is nicely realized. The word, "Armchair," in the book's title, seems wisely chosen ("Treasury" might have sounded a little too pretentious, and "Bedside" doesn't seem to be the right location for a science reader) for these "stories and plays that entertain us, accounts of lives that inspire us, poems and essays that give us insight—all drawn from the world of science."

Anthologies, made up as they are of snippets and appetizers, are usually best taken in small portions. However, the *Armchair* editors have tried to organize their material in such a way that, within the six divisions of the book, there is a kind of progression of thought from one selection to the next. This often works out very neatly, and makes it possible to read along consecutively with some satisfaction.

There is a lot of good reading here. The editors (not writers, apparently, or scientists themselves; they seem to have been infected with a continuing interest in this field of literature by Dr. Morris Meister, when he was principal of the Bronx High School of Science) are ladies of taste. Though they have filled their book with familiar names, they haven't cluttered it up with too many familiar selections. (E. M. Forster's short story, "The Machine Stops," is here, but you can't *call* a book a science anthology if you leave that out.)

There are (the book-jacket blurb-writer counted them) 200 items in *The Armchair Science Reader*. Some of the unexpected pleasures among all these would include the radio script of Orson Welles' "Invasion from Mars;" Arthur Compton's account of the first nuclear reaction in Chicago, on December 2, 1942; a Carl Sandburg poem, "In Silent Rooms;" a letter from Thomas H. Huxley to Charles Kingsley; William Beebe's report on his descent in a bathysphere to an ocean depth of 3,000 feet; a scientific detective story by Berton Roueché, from *The New Yorker*, on a 1947 outbreak of smallpox in New York City; a first reaction to the atomic bomb, by John W. Campbell, from the newspaper *PM* in August, 1945.

Space Technology

Edited by Howard Seifert

John Wiley and Sons, Inc. . . . $22.50

This collection of papers by 38 specialists in the field of space technology grew out of a graduate-level course organized in 1957 by a group of scientists and engineers at the Space Technology Laboratories and at the University of California in Los Angeles. The course was designed for engineers about to engage in the burgeoning fields of ballistic and space vehicle development, and it aimed to "provide a thorough exposition of the fundamental principles of very-long-range ballistic missiles, stressing the quantitative relations that are most useful for space flight."

Despite its specialized nature, the resultant course was an overwhelming success. The lectures went on TV in the Los Angeles area, and on kinescope film to other parts of the country. They are now presented in book form.

The material in the book covers five broad areas—ballistics and flight dynamics, propulsion, communication and guidance, man in space, and present and future applications of space technology. The editor of the book

(and chairman of the UCLA course on which the book is based) is Howard S. Seifert (PhD '38), special assistant for professional development at Space Technology Laboratories. Of the 38 authors represented in *Space Technology*, 14 are Caltech alumni or faculty members.

The Ocean of Air

by David I. Blumenstock
Rutgers University Press . . $6.75

A jumbo book that tells the layman just about everything he might ever want to know about the atmosphere – including a physical description, the history of man's observations and studies of the atmosphere, and the influence of the atmosphere on humans (with a no-nonsense section on the possible effect of nuclear weapons). It's an impressive, comprehensive, straightforward job. The author, who worked on the book over a period of more than ten years, is a climatologist and meteorologist who spent a year at Caltech (1944) as a lecturer and research assistant (in climatology). He is now Pacific Area Climatologist for the United States Weather Bureau.

Our Atmosphere

by Theo Loebsack
Pantheon Books, Inc. $5.00

Another book about the atmosphere for the "scientifically interested" reader. Translated from the German, it naturally covers much the same ground as the Blumenstock book, but contains a good deal of colorful information on phenomena not included in that volume. Brightly written and handsomely illustrated.

The Upper Atmosphere

by H. S. W. Massey and R. L. F. Boyd
Philosophical Library $17.50

The authors of this book (Dr. Massey is Quain Professor of Physics and Dr. Boyd is Lecturer in Physics at University College in London) on the upper atmosphere address themselves to a scientifically-trained rather than a scientifically-interested audience. A fair knowledge of mathematics and physics is required to appreciate their account of the studies that have been made of the upper air, the techniques used, and the results obtained. The book covers work in this field up to 1958, and the world-wide program of research into the atmosphere undertaken during the International Geophysical Year.

IGY: Year of Discovery

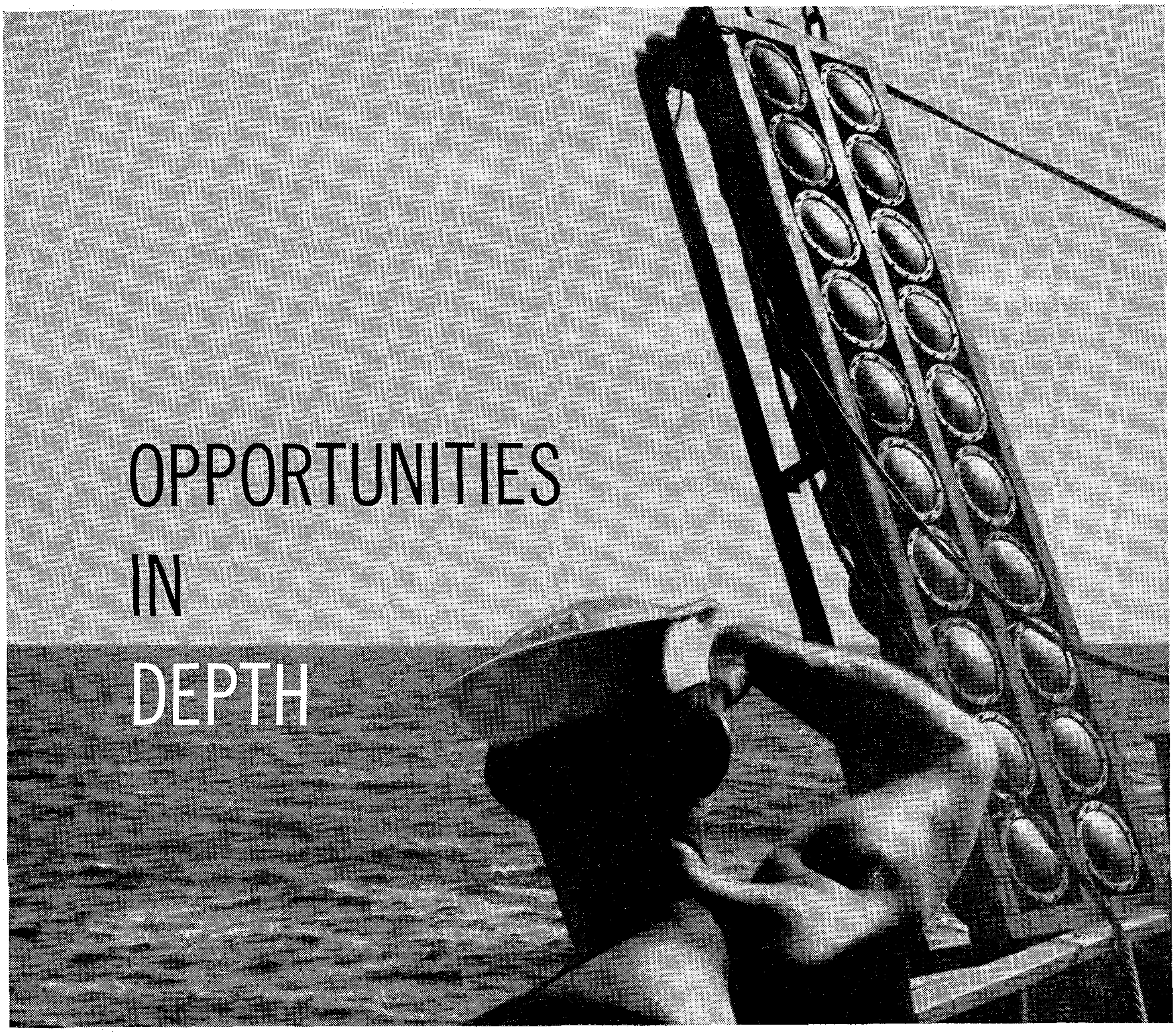
by Sydney Chapman
The University of Michigan Press $4.95

This is a tidy summing-up of the research that went on all over the world during the International Geophysical Year. Professor Chapman, who served as president of the central international committee of scientists that directed the IGY program, gives a lively account of the work, and the presentation of the material makes this an ideal book for all kinds of readers. The book runs only about 112 pages, has an 8-1/2 x 11-inch page size, and is made up of about 40 percent pictures. It is prefaced by a modest, and intriguing, comment of Professor Chapman's: "The time will come when the International Geophysical Year will be viewed as an important but primitive contribution to the exploration of the cosmos."

Inventions, Patents, and Their Management

by Alf K. Berle and L. Sprague de Camp
D. Van Nostrand Company, Inc. $12.50

A guide for inventors. As the authors say: "The theme of this work is that inventing is a business, and he who would work in this field must, to succeed, know its rules and conditions, as in any other business." L. Sprague de Camp, one of the co-authors, received his BS from Caltech in 1930. He has been an instructor with the Inventors Foundation, and was principal of the School of Inventing and Patenting for International Correspondence Schools. He has also had a productive career as a freelance writer, specializing in science fiction, and has turned out almost 30 books to date.



The device about to be submerged is an "underwater sound source". It transmits sound waves beneath the sea and is part of the research equipment developed by Bendix Research Laboratories Division for use in the Bendix program of undersea acoustics research.

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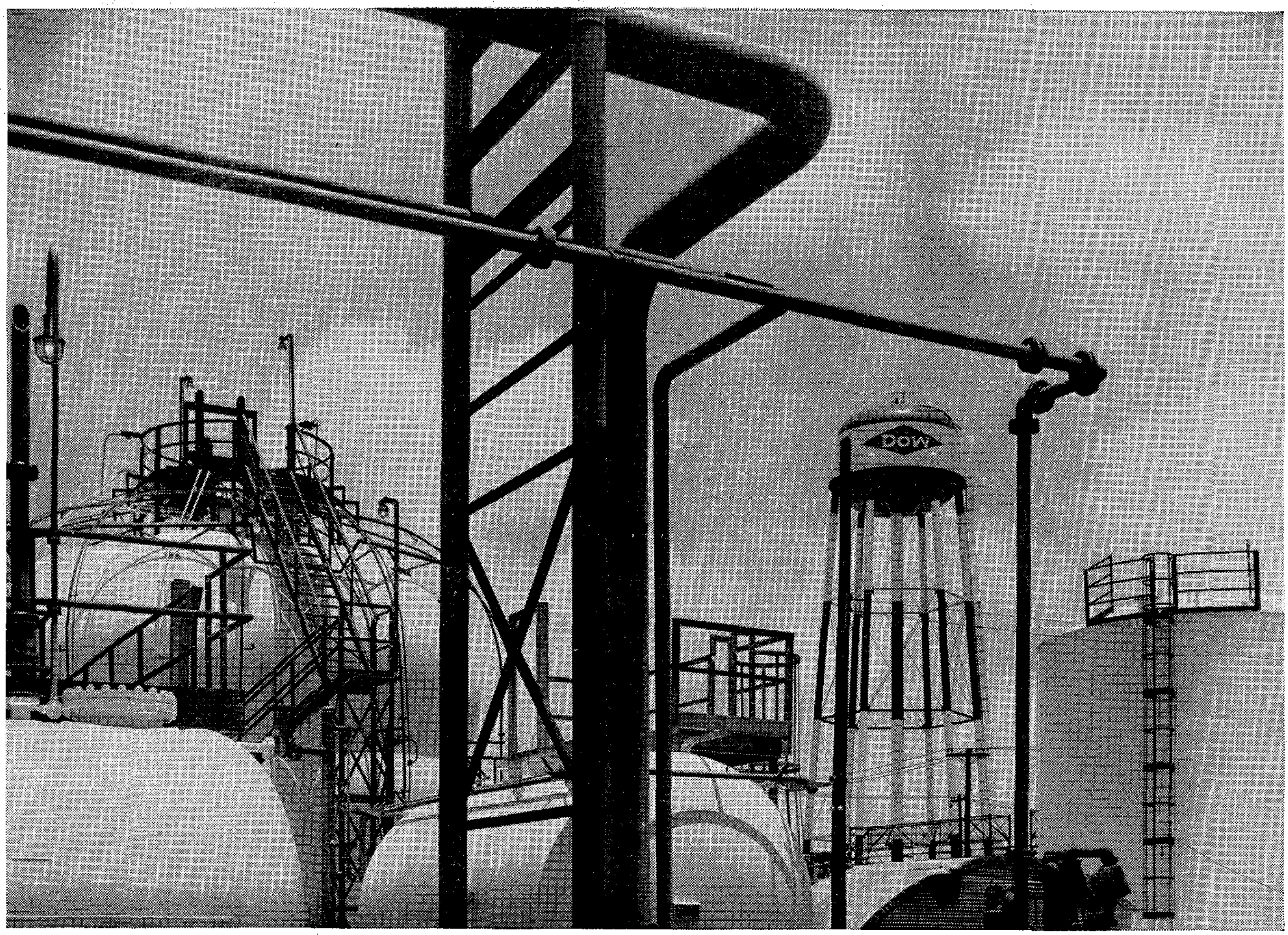
DOW

Galileo...on learning

"Philosophy is written in that great book which ever lies before our eyes—I mean the universe—but we cannot understand it if we do not first learn the language and grasp the symbols in which it is written. This book is written in the mathematical language, and the symbols are triangles, circles, and other geometrical figures, without whose help it is impossible to comprehend a single word of it; without which one wanders in vain through a dark labyrinth." —*Il Saggiatore, 1610*

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Engineering And Science
January 1960, Volume XXIII, No. 4

THE DEANS

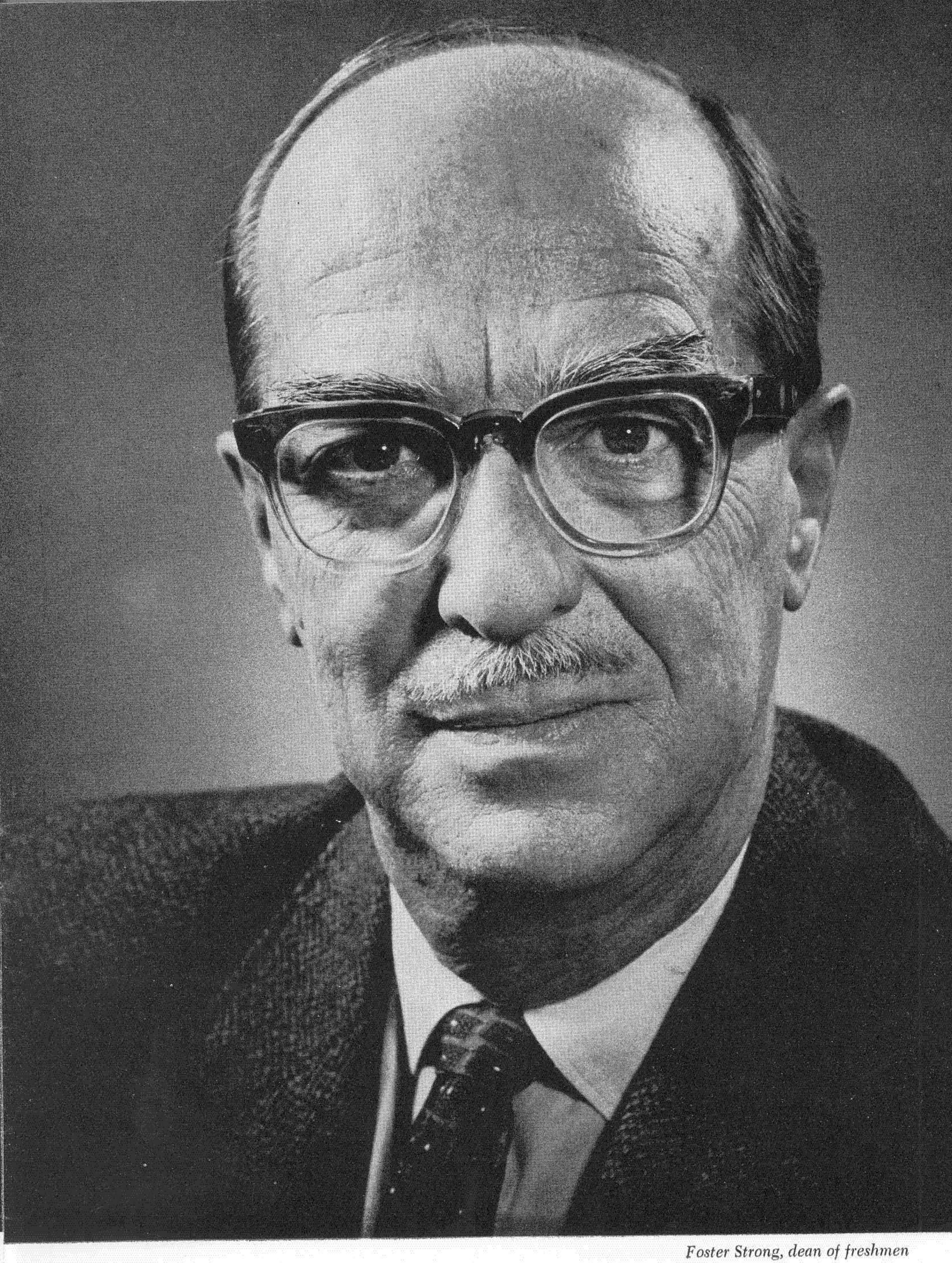
A Portfolio of Portraits by Harvey

Caltech's five deans sit for their portraits on the following pages. The newest dean is George W. Beadle, who became acting dean of the faculty on January 1. He succeeds Earnest C. Watson, who has left the Institute to become scientific attaché to the United States Embassy in India. Like his fellow deans, Dr. Beadle adds administrative duties to an already full schedule. He is professor of biology and chairman of the division of biology at Caltech. L. Winchester Jones, Caltech's dean of admissions, is also director of undergraduate scholarships and associate professor of English. Paul C. Eaton, dean of students, is associate professor of English. Foster Strong, dean of freshmen, is assistant professor of physics. H. F. Bohnenblust, dean of graduate studies, is professor of mathematics.

George W. Beadle, acting dean of the faculty

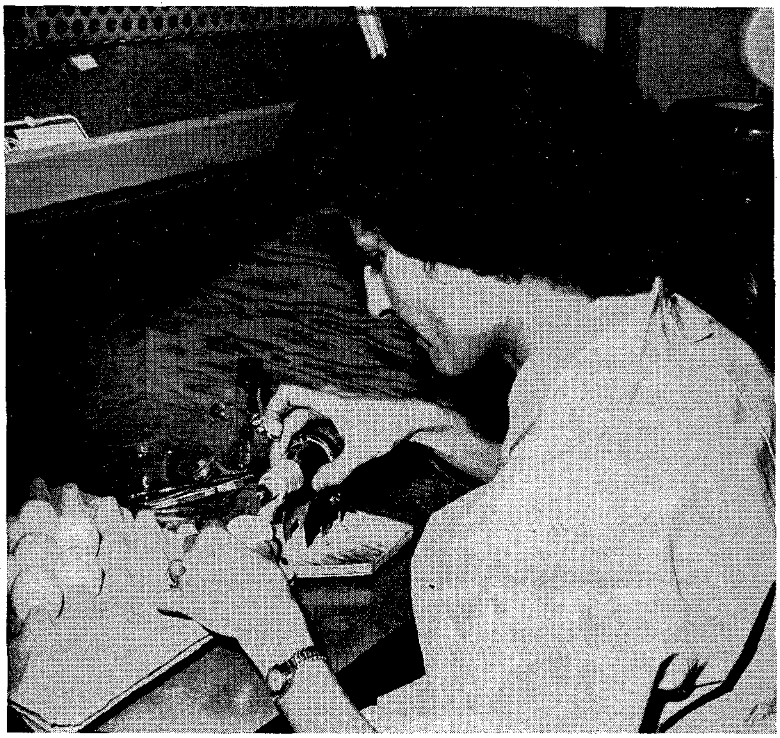
L. Winchester Jones, dean of admissions

Paul C. Eaton, dean of students



Foster Strong, dean of freshmen

Frederic Bohnenblust, dean of graduate studies



In Caltech's biology laboratories, workers infect fertile egg membranes with Rous sarcoma virus to induce tumors.

Cancer and Viruses

by Howard Temin

It is often said that we do not know the cause of cancer but this is not completely correct. We know many *causes* of cancer. What we do not know is how to *prevent* cancer.. To explain, we can first indicate some general causes of cancer in laboratory animals and then see how a better understanding of one of these may be of general importance.

The difficulty in identifying causes of cancer is especially well seen in the case of smoking and cancer. It seems that there is a strong correlation between the occurrence of one type of cancer — lung cancer — and smoking. "Correlation" means that when one event occurs a second is *likely* to occur. Some people have then concluded that this correlation alone is enough to indicate a causal relationship between smoking and cancer. A causal relation means that when A occurs, then *B* occurs. In this case, smoking causes the cancer. However, it is equally possible that some common factor *C* causes both *B* and *A*. Such a situation would give rise to the observation that whenever *A* occurs, *B* occurs — but here *A* would not be a cause of *B*; *C* would be a cause of both *A* and *B*. (It should be added that there is other evidence linking smoking and cancer.)

In working with animals, however, we are able to decide what are causal connections, as opposed to non-causal correlations. We can do this by setting up controlled experiments in which only one factor is changed. In the case of smoking and cancer in people, it may be that only a certain "group" of the population will smoke, and that people in this group are more likely to get cancer than other people. When working with mice or chickens or rabbits, we can either select the animals at random or we can see that they are as similar as possible. By use of these controlled experiments, we find that there are at least three types of causes of cancer: (1) chemical, (2) hormonal, and (3) viral.

Chemical cause of cancer

If we take two groups of mice that are identical genetically and are kept in identical pens and we paint the backs of one group every day with water and the other group with any one of a number of chemicals (for instance, methylcholanthrene), no tumors will develop on the backs of the mice in the first group, but tumors will develop on the backs of those in the second group. In this case, we are able to say that the chemical is causing the cancer; this has been the only variable in the treatment of the two groups of animals.

Hormonal cause

Similarly, we can transplant the ovary of a mouse to its spleen, which means putting the ovary in a different part of the body with a different blood supply. In all cases, this ovary will then develop cancer. We think the cancer develops because of the disturbance of the hormonal relations of the ovary to the pituitary.

Viral cause

The third cause is the virus. If we inject a virus – for instance, the Rous sarcoma virus – into a chicken, the chicken will develop a cancer and usually die. If we take control chickens and inject water or killed viruses, they will not develop cancer. So, we can say in this case that the virus has caused the cancer.

These are laboratory experiments; in each one of these cases we can say that we know a cause of the cancer. However, these causes are not very relevant to naturally occurring cancer, because these particular circumstances do not exist, and still cancers *do* appear.

Knowing that we can cause cancer, we look to see if there can be some common factor. A cancer is a wild, unchecked growth of cells in an organism. This is merely a definition on a cellular level of what a cancer is.

Cancer cells were first normal cells, so we can say that a normal cell gave rise to a cancer cell. Further, we can say that when these cancer cells divide, they give rise to more cancer cells. We can say this because it is possible with transplantable laboratory cancers to take a single cell and start growth in another animal. We can then – speaking broadly – say that the change from a normal cell to a cancer cell is a genetic change; it is something which is inherited. We can then look at the various causes of cancer we have listed to see whether these could have some effect on the inherited part of a cell.

The concept of genetic change is one of the most important concepts in biology. There are several sites where genetic changes can occur. A cell consists of two parts, the cytoplasm and the nucleus. In the nucleus there are bodies called chromosomes. These chromosomes insure that the egg of a mouse gives rise to a mouse, and the egg of a frog to a frog. Genetic change would come about by a change in the number or size of chromosomes.

Chromosomes are divided into regions called "genes;" these genes can change without changing the appearance of the chromosome. This is another site for genetic change – a gene mutation. In addition, there may be other sites for genetic change in the cytoplasm, although less is known about these.

We can now look at the classes of causes for cancer and see how they might operate. Chemicals can cause mutations and they can derange cell division; thus they could alter the genetic sites in a cell in several ways. Or they could operate in what we call "selective" fashions; genetic changes could occur spontaneously (which means that they happen because of something we don't know about) and the chemicals could act as selective agents for the altered cells. Hormone unbalance could act in the same way. And, as far as we knew up to 10 years ago, viruses could only act in a selective fashion, too.

Viruses are small entities which grow in cells and kill them. The viruses we ordinarily think of are those which cause poliomyelitis or influenza. They enter a cell, reproduce in the cell, and produce many progeny viruses while killing the cell. Cancer is a disease in which there is too much growth of cells. A virus which kills cells would appear to have only a very indirect relationship to cancer.

However, our ideas about viruses have changed drastically in the last decade. This change was caused by work with viruses which infect bacteria. Recent work done here at Caltech has extended these ideas and indicated that cancer viruses are different from other animal viruses – that they do not kill cells, but by their presence cause a genetic change in the infected cells.

The Rous sarcoma virus

In 1910, at the Rockefeller Institute, a man named Peyton Rous isolated a virus from a chicken tumor – which means he took the tumor, ground it up, and passed it through a filter that held back cells. (This was in the early days of the work of discovering viruses. Only six viruses had been discovered before this one. The definition of a virus at this time was merely something transmissible that passes through a filter.) Rous took this filtrate and injected it into chickens and got new tumors, and from these new tumors, he could get new virus. For the last 50 years this Rous sarcoma virus, named after its discoverer, has been kept in laboratories.

In order to try to understand how this virus acts, we do not work with chickens, or even with eggs. They are too complicated. We work instead with cells isolated in glass dishes – what we used to call *tissue* culture and now call *cell* culture.

There are two major problems of cell culture. The first is keeping the cells happy and growing; the second is keeping bacteria and molds unhappy and not growing. Once cells are removed from an organism, the elaborate defensive mechanism of an organism is no longer available to them. We substitute a high concentration of antibiotics and work under sterile conditions so as to keep bacteria out. The cells grow attached to the bottom of small glass dishes. The dishes are kept in incubators where the environment is carefully controlled; the cells are kept in a humid atmosphere, at a constant temperature and a constant pH. The cells are fed by a rich medium something like blood. They grow fairly well in such circumstances, but not quite as well as in a chicken. After three or four months in culture, they stop dividing. However, earlier than this, the cells appear to be fairly normal.

A chicken, or any organism, is a group of cells held together by a matrix. To get isolated cells it is necessary to dissolve the matrix. To do this we take pieces of chicken embryos, treat them with trypsin (one of the digestive enzymes) until the cells are separated from each other. The cells are then put in small dishes where we can study them. They form a sparse layer of fibroblastic cells.

We then add virus to these cells, allow the virus to enter the cells, and add an overlay of nutrient medium. At the end of a week, when we look at the culture again, we find areas or foci of altered cells. We know that these foci are caused by the virus, because, if no virus is added, no foci appear. Also, if the amount of virus is increased the number of foci increase proportionately. And, most important of all, the cells of the foci release lots of virus.

Cell changes

Under higher magnification, we find that the cells in the foci look different from the original cells. They are no longer fibroblastic, but are round and refractile. To see if these cells are alive we replate them in another dish. There they grow. If we plate some on cells killed by x-rays, they form small colonies which may descend from one cell and are then called clones.

So we have seen that a virus which causes cancer in chickens alters the appearance of cells in tissue culture, and that these altered cells grow and divide and release more virus which causes cancer in chickens, or alters more cells. At this point we can see that our original ideas about viruses must be modified. Not all viruses kill cells. The growth of some viruses is not incompatible with further division of the infected cells.

As our work has continued, we have discovered another fact about the Rous sarcoma virus. Not all of the foci produced by the virus are alike. Some, instead of being composed of round refractile cells, are composed of long fusiform cells. Virus from the long fusiform cells makes foci of long fusiform cells.

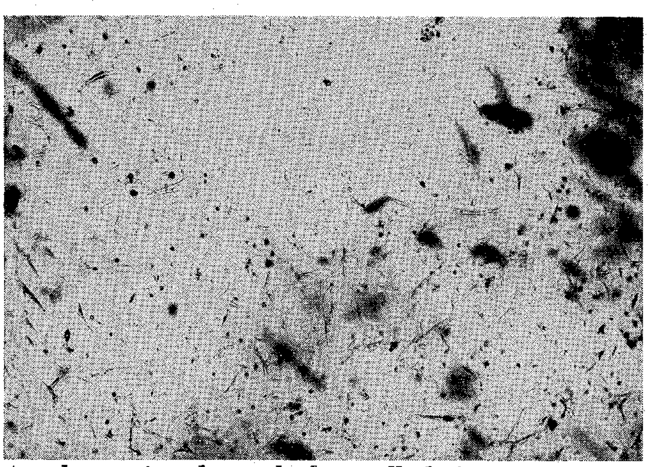
In order to evaluate this observation we must know more things. First, the virus producing foci of long cells is descended from the virus producing round cells — or, in other words, it is a mutant of the round virus.

Genes in viruses

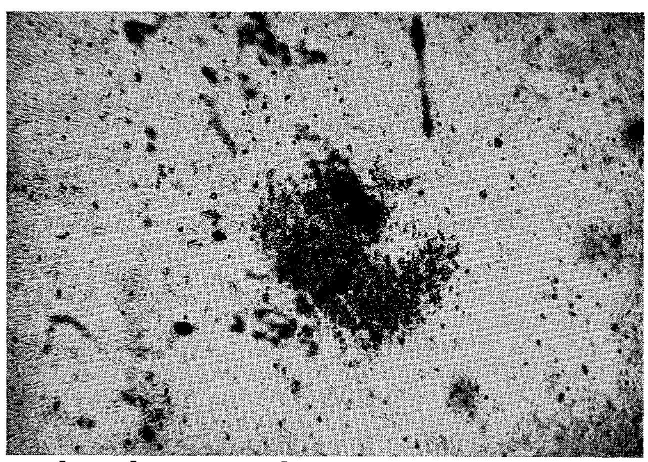
A short digression is perhaps in order. Biologists look upon viruses as organisms in the sense that they have life cycles with genetic continuity. Therefore, we speak of genes in viruses — though perhaps there are only a few — and then we can speak of changes or mutations in these genes.

Second, the virus controls whether an infected cell is round or fusiform. We establish this result by the following experiments. A clone of fibroblastic cells, which are presumed to be identical, can be infected with the two types of viruses and the two types of foci are produced. More directly, if we look at the progeny of an infected cell we find that about one in a thousand or so of these cells has changed spontaneously into another type of cell. This change seems to happen because the virus carried in that cell has mutated.

Genes do not operate in a vacuum. A gene will depend for its expression on what other genes are in the cell, the conditions under which the cell is kept, and so on. Another similarity of the Rous sarcoma virus to a cellular gene is that its expression

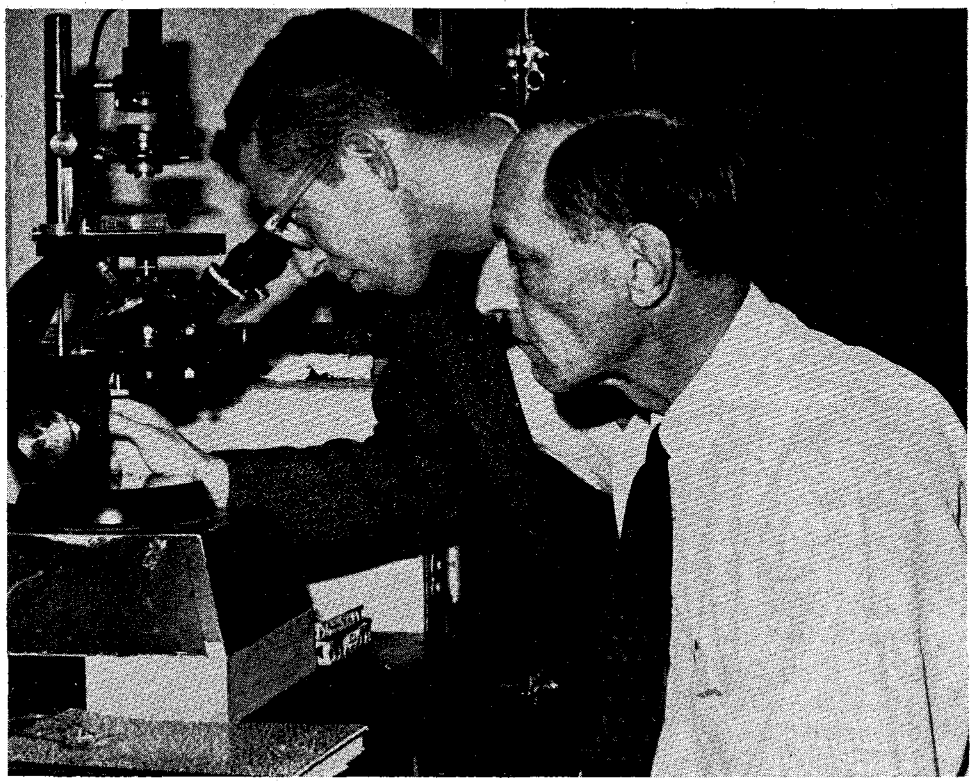


A culture of embryo chicken cells before injection of the Rous sarcoma virus.



Similar culture seven days after infection with virus. A single virus particle initiates the change.

Howard Temin examines infected cells from the iris of a chicken's eye, grown by Boris Ephrussi (seated), visiting professor of biology from the Sorbonne.



is affected by the genome or past history of the rest of the cell. For example, if we take a virus which causes foci of round cells on chicken cells, and place this virus on duck cells, we get foci composed of, not round, but fusiform cells. We can conclude that in a functional sense the virus becomes equivalent to part of the genome of the cell.

There is still one more thing we infer about the virus. When a virus mutates inside the cell, it changes the appearance of that cell and its descendants. Since this change is a rare event, a study of the cells in which the virus has changed enables us to say how many genetic copies of the virus there are in the cell. The answer comes out to be *less than two* on the average. Other experiments show that the inheritance of the virus in a cell is regular, indicating that the previous answer is not due to intracellular selection. The existence of such a small number of genetic units of the virus in the cell, and the regular inheritance of these units, shows that the virus, in some structural sense, as well as the functional sense discussed before, becomes a part of the genome of the cell. Probably it does not attach to a chromosome, and may not even be in the nucleus, but becomes part of the general apparatus of the cell which controls what a cell is.

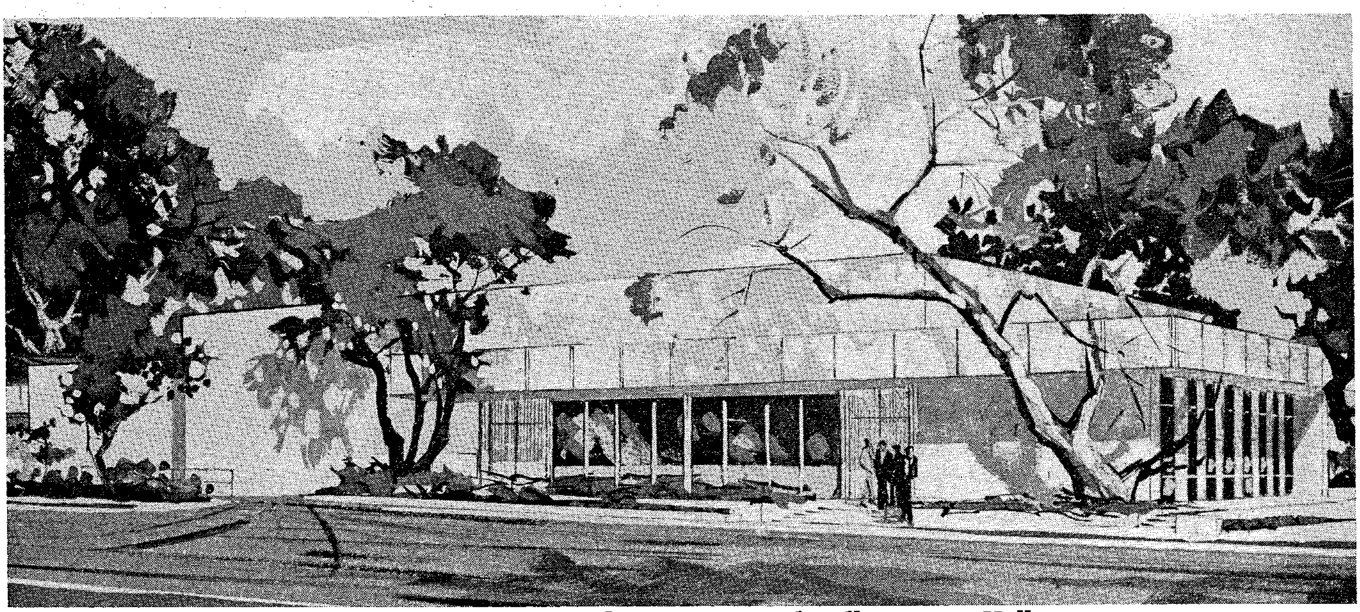
In discussing the causes of cancer then, we can see that, from a functional point of view, there is little difference between chromosomal or gene mutation and infection by the Rous sarcoma virus. Both sets of events cause genetic changes in the cell. There is one difference however. A gene mutation requires a change in some pre-existing structure. The viral infection, as far as we know, introduces a new genetic structure. A gene mutation is a change in something that is inside a cell; a gene that controls formation of one enzyme mutates to something else — it doesn't *form* this enzyme. In the case of the viral infection, the change in the cell is an *addition* of something — not a change in something that is already there. What meaning this difference has is not yet clear. It may be that the virus by its presence affects some pre-existing structure.

Once we know that the virus acts to cause a genetic change in the infected cell, we can ask how this genetic change is related to the production of a tumor. Such studies are now going on in our laboratory.

This work I have been describing has been done with one cancer virus. There are other viruses which cause cancer — but we do not know whether they act in a similar fashion to the Rous sarcoma virus or not.

It could be said further that this work we are doing is all very well, but what all of us are really interested in is people — not chickens. I can only repeat the story of the English gentleman leaving the opera one night who passed a man under a lamppost, looking for something in the gutter. On being informed that the searcher had lost his watch, the first man got down to help, and looked and looked. Finally he asked the searcher if he had dropped his watch right here under the lamppost. "No," the man said, "I *really* dropped it around the corner — but I'm looking for it here because there's so much more light."

We are in the position of the man under the lamppost. What we are primarily interested in is not chicken cancer, but since we have so much light there, we look. Maybe we will find something better than a watch.



Architect's drawing of the new Harry Chandler Dining Hall.

The Month at Caltech

Campus Dining Hall

The Institute has received a gift of $400,000 from the Chandler family of the Los Angeles *Times* for the construction of a new campus dining hall. The building, which will be named the Harry Chandler Dining Hall, is the sixteenth of the eighteen buildings to be financed in Caltech's $19,500,000 Development Program.

The new dining hall will replace the overcrowded campus coffee shop in the 60-year-old Old Dorm. It will have a main room with a seating capacity of 250, and four smaller rooms each seating 30 diners. The building is scheduled to be completed by September, 1960.

Harry Chandler, who was publisher of the Los Angeles *Times*, president of the Times-Mirror Company, and a pioneer southern California civic leader, served as a trustee of Caltech from 1920 until the time of his death in 1944. His son, Norman, now publisher of the *Times* and president of the Times-Mirror Company, is a member of the present Caltech Board of Trustees. Harry Chandler was one of the people who was instrumental in bringing R. A. Millikan from the University of Chicago, to serve as president of Caltech's executive council. He also helped organize the Caltech Associates, an organization of southern California citizens who give financial support to the Institute.

AUFS on Campus

On January 11 the first of four representatives of the American Universities Field Staff came to Caltech to report on political, social and economic conditions in foreign areas. Albert Ravenholt, reporting on the Far East, was on campus from January 11 to January 20. This was his fourth visit to Caltech. He has studied and written about Asian affairs since 1940 and has just returned home from 18 months in the Philippines.

Richard W. Patch, whose field is Latin America, will be on the campus from January 25 to February 2, when he will report on developments in Bolivia and Peru. Lawrence Olson, whose field of interest is Japan, will be at Caltech from February 8 to February 17 to speak on current conditions and problems in that country. Edwin S. Munger, whose field is Africa, will be here from February 22 to March 2, concluding the program for 1960.

All four men are representatives of the AUFS, an organization sponsored by Caltech and 10 other educational institutions in this country, which sends qualified young men to foreign areas to study current conditions, problems, and personalities. Besides reporting regularly by mail, these correspondents visit the campuses of each of their sponsoring institutes every two years to make comprehensive reports in person.

A Powerful New Accelerator for Nuclear Research

The most powerful electrostatic accelerator to be used in Caltech's nuclear research laboratories will be delivered to the campus this spring. Construction is now being completed on a heavily shielded underground vault to house the machine in the new Alfred P. Sloan Laboratory of Mathematics and Physics. The 10,000,000 electron volt tandem accelerator, costing $1,151,400, is being financed by the Office of Naval Research. The new accelerator will be used for studies of nuclear reactions. Scientists study these reactions for clues to the mysteries which govern the structure of the nucleus of the atom.

The new machine joins a team of three lower energy electrostatic accelerators which are now in operation in Caltech's Kellogg Radiation Laboratory. The three existing machines have been used in studies of nuclear reactions in the ten lightest chemical elements (hydrogen, helium, lithium, beryllium, boron, carbon, nitrogen, oxygen, fluorine and neon) and their isotopes.

Heavy nuclei

The new electrostatic accelerator, being more powerful than the other three, will make it possible to study the heavier nuclei, and will also be used for studies of higher energy levels of the light nuclei.

Physicists work with accelerators in order to examine the central core, or nucleus, of the atom. Around this core, electrons rotate like satellites about a planet. The nucleus usually has great stability because the forces binding its parts are the most powerful known. In the nucleus, matter and energy can be interchangeable.

When one nucleus is hit by another one, nuclear reactions result. Sometimes the reaction sparks a release of energy or radiation. Sometimes it results in the transformation of one chemical element into another. Often, both of these things occur.

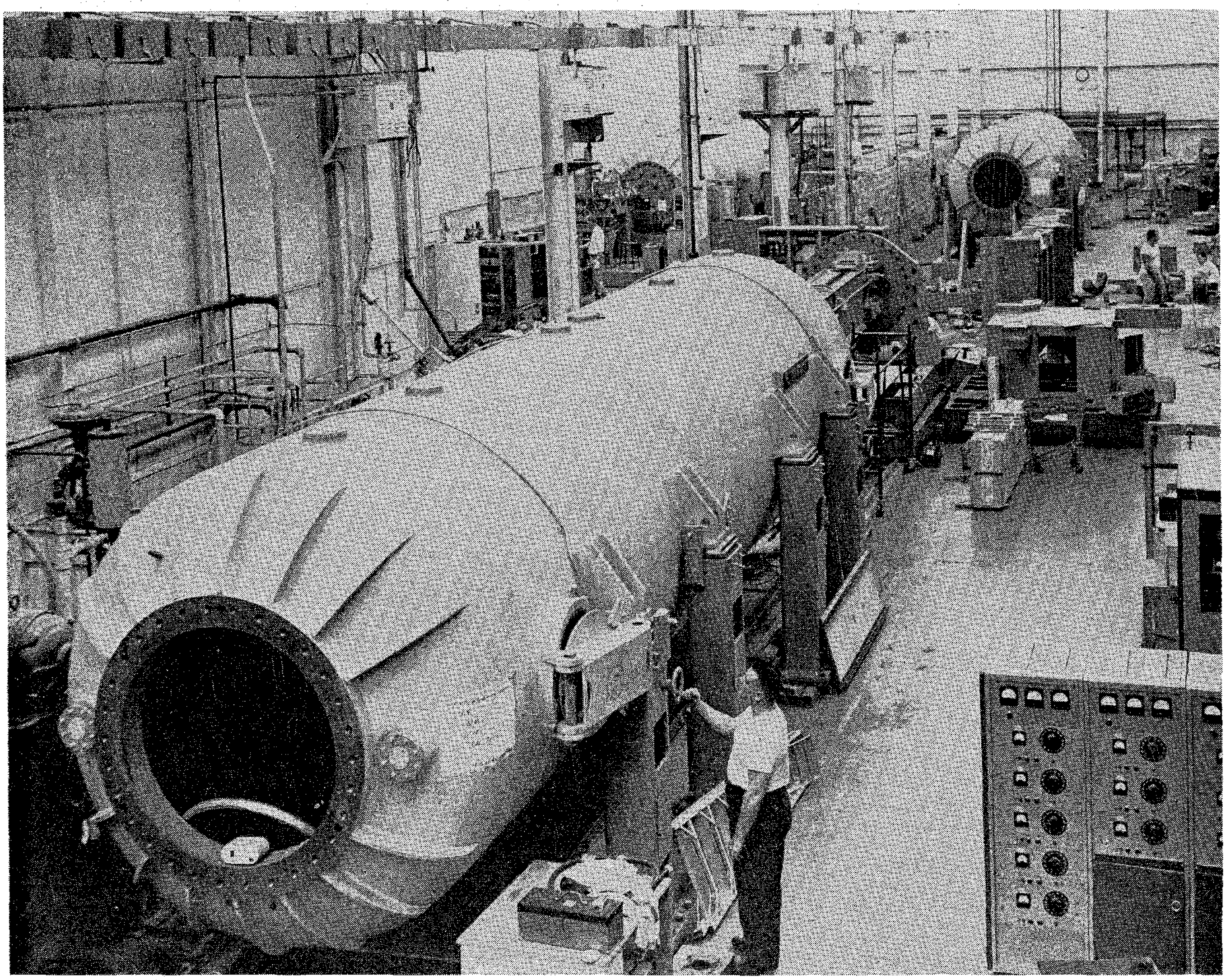
It isn't easy to get two nuclei to collide. Each nucleus carries a positive electrical charge, and because like electrical charges repel each other, nuclei have to be accelerated sufficiently to overcome this electrical barrier before they can run into each other.

Two methods

There are two ways to accelerate nuclei to sufficient speed to overcome their repulsive forces. One way is by heat. The tremendous heat inside stars excites the nuclei and causes them to lose their satellite electrons and dart about at tremendous speeds. Some of them collide and interact.

Another way to accelerate particles is by a machine like an electrostatic accelerator. In this case the target nuclei are held stationary. Nuclei of hydrogen or helium atoms are then accelerated by electric forces and hurled at the stationary target nuclei.

Each nucleus behaves as if it were tuned to a certain pattern of frequencies. It is possible to excite these resonant frequencies by bombarding the nucleus with particles of a certain energy, a different bombarding energy corresponding to each different frequency. By using the electrostatic accelerator, with its beam of variable energy, physicists can excite one after another of the natural frequencies of the target nucleus. Though electrostatic accelerators are not as powerful as cyclotrons or bevatrons, they have a dis-



Caltech's new electrostatic accelerator is now being assembled at the High Voltage Engineering Corporation in Burlington, Mass. It will arrive on campus this spring to be installed in a 120-foot underground vault.

tinct advantage over them because of this beam of continuously variable energy.

Each variety of nucleus has its own characteristic pattern of energy levels. It is important to know these patterns because it is only at their resonance levels that nuclei will interact readily. These interactions include absorbing or giving off energy and combining to form new chemical elements. Determining the pattern of energy levels is a vital part of the work.

Caltech's Kellogg Radiation Laboratory, which has been supported by the Office of Naval Research and the Atomic Energy Commission since 1946, has studied nuclear reactions for a quarter of a century. The earliest work was done with high energy x-rays, and the first electrostatic accelerator was placed in operation in 1939.

In 1942 the laboratory joined the Navy in its war work by designing and developing rockets. Through this work, the China Lake Naval Test Station was located and developed.

Much of the work with electrostatic accelerators has been concerned with the investigation of how stars are born, grow, wane and sometimes explode; how the sun's nuclear fires keep burning; how the nuclei of atoms behave and interact — including how the heavier chemical elements are synthesized from light elements like hydrogen. Findings from these studies are used by nuclear physicists, astronomers, and cosmologists.

Caltech physicists working on these studies include C. C. Lauritsen, one of the nation's pioneer physicists, who started nuclear physics research at Caltech in 1932; his son, Thomas, professor of physics; C. A. Barnes, associate professor of physics; William A. Fowler, professor of physics; R. W. Kavanagh, senior research fellow in physics; Ward Whaling, associate professor of physics; and R. F. Christy, professor of theoretical physics. Some 25 graduate students, working for their PhDs, also join in this research, as do three or four visiting physicists from Europe and Australia.

engineers

Automatic systems developed by instrumentation engineers allow rapid simultaneous recording of data from many information points.

Frequent informal discussions among analytical engineers assure continuous exchange of ideas on related research projects.

Under the close supervision of an engineer, final adjustments are made on a rig for testing an advanced liquid metal system.

and what they do

The field has never been broader
The challenge has never been greater

Engineers at Pratt & Whitney Aircraft today are concerned with the development of all forms of flight propulsion systems—air breathing, rocket, nuclear and other advanced types for propulsion in space. Many of these systems are so entirely new in concept that their design and development, and allied research programs, require technical personnel not previously associated with the development of aircraft engines. Where the company was once primarily interested in graduates with degrees in mechanical and aeronautical engineering, it now also requires men with degrees in electrical, chemical, and nuclear engineering, and in physics, chemistry, and metallurgy.

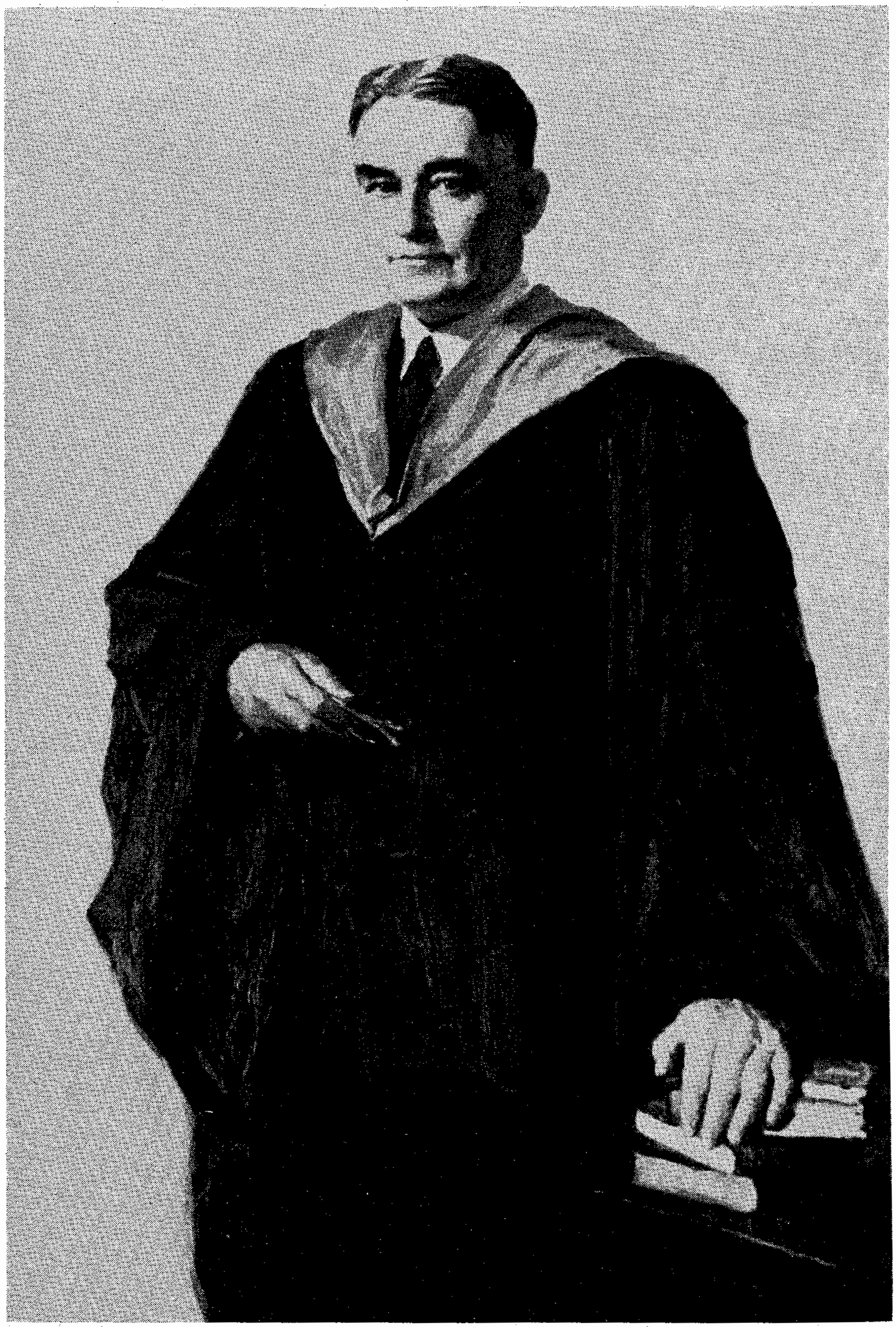
Included in a wide range of engineering activities open to technically trained graduates at all levels are these four basic fields:

ANALYTICAL ENGINEERING Men engaged in this activity are concerned with fundamental investigations in the fields of science or engineering related to the conception of new products. They carry out detailed analyses of advanced flight and space systems and interpret results in terms of practical design applications. They provide basic information which is essential in determining the types of systems that have development potential.

DESIGN ENGINEERING The prime requisite here is an active interest in the application of aerodynamics, thermodynamics, stress analysis, and principles of machine design to the creation of new flight propulsion systems. Men engaged in this activity at P&WA establish the specific performance and structural requirements of the new product and design it as a complete working mechanism.

EXPERIMENTAL ENGINEERING Here men supervise and coordinate fabrication, assembly and laboratory testing of experimental apparatus, system components, and development engines. They devise test rigs and laboratory setups, specify instrumentation and direct execution of the actual test programs. Responsibility in this phase of the development program also includes analysis of test data, reporting of results and recommendations for future effort.

MATERIALS ENGINEERING Men active in this field at P&WA investigate metals, alloys and other materials under various environmental conditions to determine their usefulness as applied to advanced flight propulsion systems. They devise material testing methods and design special test equipment. They are also responsible for the determination of new fabrication techniques and causes of failures or manufacturing difficulties.



Portrait of W. B. Munro by Seymour Thomas hangs in the lounge of the Dabney Hall of the Humanities.

William Bennett Munro

A Memoir by Harvey Eagleson

Best known as a writer and authority on the United States Government and Constitution, William Bennett Munro (1875-1957) was born in Canada. He received his BA and MA degrees from Queens University in Kingston, Ontario. After studying law for two years at the University of Edinburgh, he decided against a legal career and turned instead to teaching the social sciences. He got a second MA and a PhD from Harvard, taught for a few years at Williams College, then returned to Harvard as instructor in government. He came to Caltech after a long (1904-1929) and distinguished career at Harvard in teaching, writing, University administration, and Cambridge and Boston civic affairs. In this excerpt from a book, William Bennett Munro: A Memoir, *to be published by the Institute in February, Harvey Eagleson, professor of English, writes of Munro's years in California, and of his lasting influence on some prominent California educational institutions — most particularly, the California Institute of Technology.*

In the mid-twenties Munro began to spend but half the year at Harvard and the other half year writing in Pasadena, where his wife's parents frequently wintered, and where he also bought a home at 268 Bellefontaine Street. At this time he became acquainted with James A. Blaisdell, president of Pomona College. In the early twenties it had become evident to President Blaisdell that a decision affecting the whole character of Pomona College must be made. The post-World War I growth of population in southern California, and the pressure on the few local colleges for expansion to accommodate the ever growing numbers of young people seeking education, brought up the problem of whether Pomona College was to remain as it was, a small liberal arts college, or lose its identity and character in becoming a private university. The last alternative did not appeal to President Blaisdell. Instead he conceived the plan, unique in American collegiate institutions, of a group of small colleges, each having its own character and identity. He had many talks with several people on this subject, among them Munro, who was much interested in the idea. As a consequence Munro was asked to give the address at the thirty-second Commencement of Pomona College, June 15, 1925. It was entitled "The College at the Crossroads" and proved to be, perhaps, the most important speech of his life.

He said, in part: "In the life of every man there are times when he stands at the crossroads. He comes to the parting of the ways and is in doubt which way to turn. We have all had that experience. But we do not always bear in mind that the same is true of institutions. They also, from time to time, must make some fateful decisions and must choose between perplexing alternatives. Every college sooner or later reaches a point where the paths diverge. One of them leads to expansion, to the surrender of old collegiate ideals, to the transferring of the college into a university. The other alternative, which several American colleges have chosen during the past few years, involves a limitation of numbers, a refusal to grow beyond a certain point, and a consequent restriction of the service which can be rendered to the community.

". . . Shall the college remain a college, with all the intimacy of instruction and fellowship which a simple collegiate status implies, or shall it prepare to go the way that so many of our colleges have gone? —for remember that Yale, Harvard, Princeton, Columbia, all began as small institutions. Or again, is there some third alternative? Is the crossroads a three-way point at which the wayfarer has a choice between more routes than two?

"All other American colleges, on arriving at this point in the past, have chosen to stereotype themselves, to stay small in both numbers and resources, thus narrowing their service to the constituency and losing many valuable friends, or, on the other hand, they have thrown open the gates and, like Dartmouth, for example, have become universities in fact though not in name. In neither case do they seem to be happy about it.

"Here, then, is the opportunity for Pomona to do a great service not only to her own future but to the future of higher education in general. No college is better situated to launch out upon the third alternative, to try the plan of creating two or more academic units joined in a common enterprise. You have here an ideal location, with plenty of land for expansion. You are within easy range of an area which in a very few years will contain more than two million people. You have already a nucleus, a reputation, and what is most important of all, sound traditions already created. It is your task to determine, now that you have arrived at the parting of the ways, whether you will do just as all other colleges have done and are doing, or whether you will do something new, different, and manifestly superior."

A community of colleges

This speech sparked the fuel of President Blaisdell's ideas. In 1925 Claremont College was founded, followed by Scripps College in 1926, and two decades later Claremont Men's College in 1947 and Harvey Mudd College in 1955. Munro took an active part in bringing these ideas to fruition. He became a member of the original Board of Fellows of Claremont College, December 9, 1925, and served on the Board until June 24, 1949. He became a member of the original Board of Trustees of Scripps College in June, 1926, and served until June, 1949, when he became an Honorary Member until the time of his death.

In 1932 Munro became interested in helping to initiate another now successful educational institution in California, the Midland School, a private preparatory school for boys. The Midland School is located at Los Olivos in the country near Santa Barbara. Its educational ideals are those which appealed to Munro — emphasis on teaching and study, little stress on luxurious buildings and quarters. The boys at Midland lead a Spartan life, living in cabins and using equipment largely constructed by themselves, but their record in college and life has been a striking testimony to the excellence of their preparation.

Mr. Paul Squibb, the founder of the school and Headmaster until his retirement in 1952, writes:

"The crisp, definite, vivid lectures of Professor Munro in our Government One course at Harvard made an indelible impression on me and many others.

"In February, 1932, I asked Professor Munro, then at Caltech, to serve as an advisory director of a boarding school for boys that would stress arduous study and frugal living. He assured me there was need for such a school in California and confirmed my notion that depression times were as good as any for such a venture. He said he would be glad to serve on our advisory board and wished me all success in launching the Midland School on a sea that, to most businessmen, looked very stormy indeed.

"As our plans developed, I would stop occasionally at the Institute and report progress and get his reactions. His ideas were always definite, and usually related to the thought that hard work was the only cure for depression in a nation. I suppose he would have said the same for an individual as for a nation.

"Occasionally, in conversation or correspondence over the period from 1932 until his last years, I would raise questions of detail. As I recall, he always avoided answering such questions by turning the thought back to main purposes and objectives. His importance as a member of our advisory board consisted mostly of single-minded emphasis upon two ideals that he admired.

"His name is inscribed on a bronze plaque in our school chapel, and it appears frequently in archives and records, as a very positive influence in the founding and the conduct of Midland School."

The California Institute

In 1925, Dr. George Ellery Hale and Dr. Robert A. Millikan persuaded Munro to give some lectures during the time he was away from Harvard and in Pasadena at the then small and newly named (1920) California Institute of Technology. This Institute had developed from a school of arts and crafts founded in 1891 by the Honorable Amos G. Throop and called Throop Polytechnic. Upon its Board of Trustees was George Ellery Hale, the first Director of the Mount Wilson Observatory. He saw the possibilities of developing in Pasadena a distinguished institution of science and engineering. It was largely through his efforts, backed by certain wealthy and farsighted Pasadenans, and later aided by Dr. Arthur Noyes and Dr. Robert Millikan, that the present Institute came into being.

One of the basic principles in the Institute's educational policy was from the first the inclusion of a large amount of humanistic studies as a supplement to the scientific and engineering subjects. In a report submitted to and accepted by the Trustees of the Institute at their meeting in November, 1926, the statement is made: "The Institute desires, and so soon as funds become available intends, to develop the cultural opportunities of its undergraduate and fifth year students in such a way as to afford them, so far as possible within a five year period, a background of appreciation of all sides of human activity — history, literature, art, economics, the nature sciences — such as a broadly educated scientist or engineer should possess."

Also included in the report is the suggestion by Munro that in order to obtain these ends, "the humanities must have on the campus a home of its own. There must be erected and equipped a Hall of the Liberal Arts (or Hall of the Humanities) devoted exclusively to such studies."

At the same meeting it was "moved by Mr. Robinson, seconded by Mr. Hiram Wadsworth, that Dr. Millikan be authorized on behalf of the Board to negotiate with Dr. Munro with a view to his becoming a regular member of the faculty of the Institute, giving the Institute one-half of his time . . . and to state that if Dr. Munro felt disposed to accept that proposal the Trustees would endeavor through some method not yet determined, to create an endowment for this work of at least $250,000."

A new phase of activity

In the autumn of 1928, the Dabney Hall of Humanities, the gift of Mr. and Mrs. Joseph B. Dabney, was opened with an endowment of $400,000 contributed by other friends of the Institute. The building incorporated in its structure and design many of the ideas of Munro. At that same time Munro left Harvard and came permanently and full time to the Institute as professor of history and member of the Executive Council, the governing body of the Institute with Dr. Millikan as chairman. The Institute had no president during this time, though for all practical purposes Dr. Millikan was the president until his retirement in 1945. With this change Munro entered upon a new phase of activity, less productive in research than the Harvard period, immensely productive in administrative, educational, civic and philanthropic work.

Immediately upon his arrival full time at the California Institute he began to take a vital part in the affairs of the Institute. In 1929 he became the chairman of the highly important Trustee Committee on Buildings and Grounds, remaining in that position until 1953. The enormous amount of time, energy and attention he gave to the complicated detail of academic building and landscaping is testified to by his

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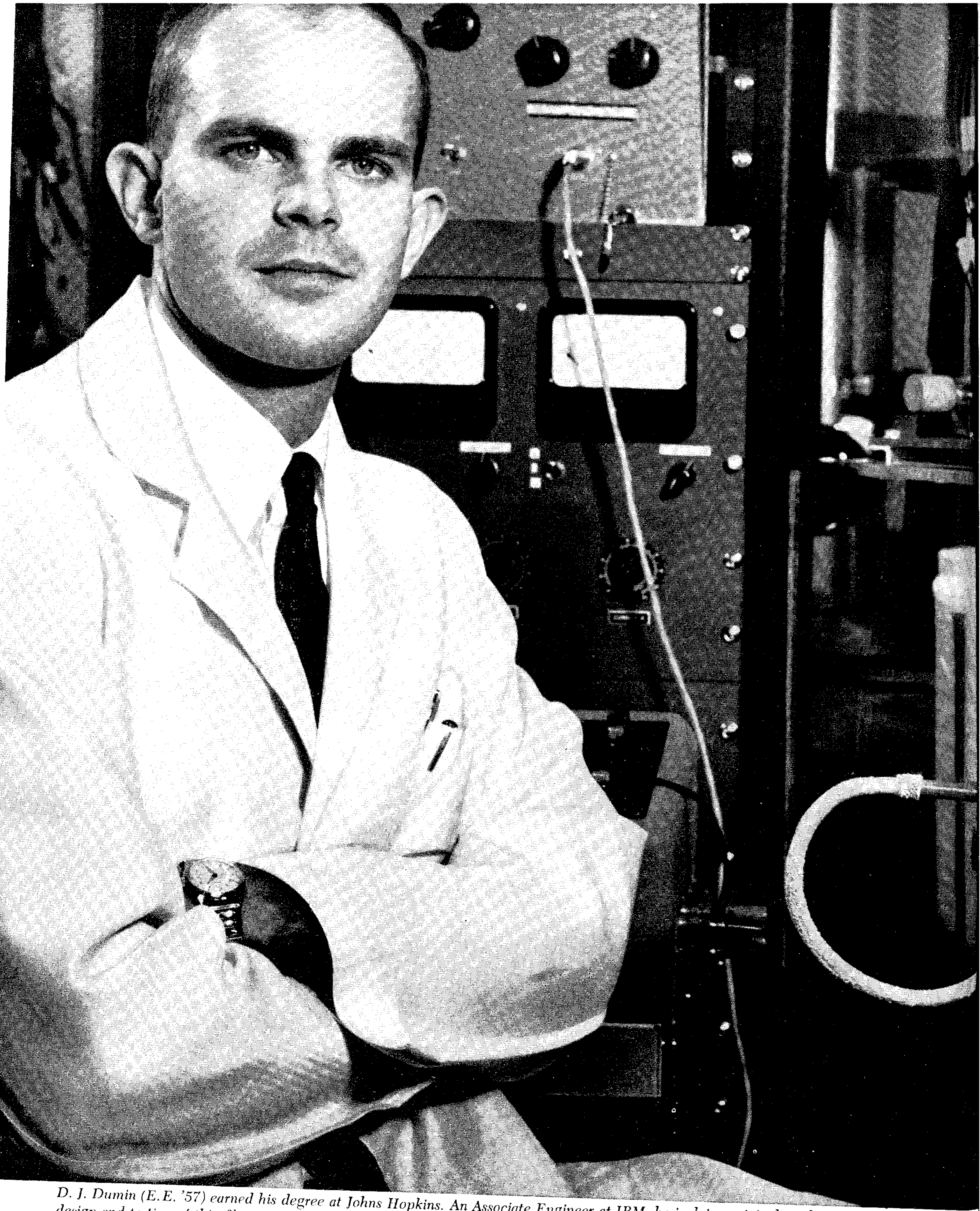


D. J. Dumin (E.E. '57) earned his degree at Johns Hopkins. An Associate Engineer at IBM, he is doing original work in the design and testing of thin film circuits. Two of his ideas in this field have been filed upon for patents.

extended reports to the Trustees and incorporated in their minutes.

His first task as chairman of the committee was the building of four Student Houses which were to change, in large part, the life and character of the Caltech undergraduate. In a report of a special committee (consisting of W. B. Munro, R. A. Millikan, and Arthur A. Noyes) on the Development of Student Life at the Institute, it was stated: "It is the committee's unanimous opinion that the *educational* values and implications to be derived from a system of small-group residence and dining hall would fully justify the extra cost involved." The response of the Trustees to this report was to designate Munro "to represent the Executive Council in the preparation of the plans and in discussions with the architects and builder concerning the proposed dormitories and the Athenaeum."

Harkness Fund

In 1936-37 (the exact date is uncertain) Munro made a suggestion to Dr. Millikan which was to result, monetarily, in the greatest benefit to the humanities at Caltech. Munro had become a friend of Edward S. Harkness during the building of the Student Houses at Harvard which were the gift of Mr. Harkness. Munro told Dr. Millikan that Mr. Harkness had no interest in contributing funds for science, but he might contribute modestly (Munro hoped at the best for $50,000) to the humanities at Caltech. Mr. Harkness was duly approached and replied that he would make his own investigation of the matter. On March 1, 1937, the Institute was informed that Mr. Harkness had set aside $750,000 as endowment for the humanities at the California Institute, the income to be used in addition to that provided already for the humanities, the gift to be given as little publicity as possible and to remain strictly anonymous, which it did until it was designated on the Institute's books as the Edward S. Harkness Fund on July 3, 1948.

In 1940, after the death of Mr. Harkness, Dr. Millikan asked permission of Mrs. Harkness to honor her husband by creating in the Humanities Division the Edward S. Harkness Professor of History and Government with Munro as the first incumbent. The permission was granted, and Munro was made Harkness Professor on December 12, 1940.

On August 13, 1945, Munro retired from active teaching and the Executive Council (it was to go out of existence with the arrival of Lee DuBridge as president of the Institute), and became Professor Emeritus, a member of the Board of Trustees, and Treasurer of the Institute. A year later his portrait by Seymour Thomas was hung in Dabney Hall of the Humanities. On that occasion Mr. James R. Page, then president of the Board of Trustees of the Institute, said: "As the scientists, research men and teachers of the California Institute of Technology approach retiring age it has been the practice of the administration to persuade them to have their portraits painted to be hung in the various buildings in which much of their distinguished research has taken place. In accordance with this custom, as Dr. Munro was reaching this stage in his academic career, the administration tried to get his permission to have his portrait painted. Dr. Munro put up a strong resistance to this and convinced everyone concerned that, although he was ripening, he was far from reaching his maturity. He seemed to think that the change of tense from the Present Indicative to the Past Indicative was more than a change of mood. When he was finally worn down to a point where he made up his mind to retire from a forty-hour week as Professor of History and Government and a member of the Executive Council to become the full time Treasurer of the Institute and a Trustee, which entails one hundred and eighty hours a week, he then consented to have his portrait painted . . ."

On the same occasion Dr. Millikan said: " . . . as a teacher, scholar, writer, financier, businessman, promoter, wise counselor, able administrator, and great humanitarian, William B. Munro rates as one of the most important builders of the California Institute of Technology, and it is hoped that this Seymour Thomas portrait of him will help to keep his spirit and influence alive on this campus throughout the decades and the centuries that lie ahead . . ."

Some tributes

This life of great activity and immense usefulness ended September 4, 1957, when Munro died quietly in his Pasadena home on Bellefontaine Street where he had lived so many years. Some days later a Memorial service conducted by Bishop Francis E. Bloy was held in the garden near his study in which he had done so much of his life work.

Nathan M. Pusey, the President of Harvard, wrote: "All of those who came in contact with Mr. Munro will long remember his thoughtful solicitude for his students and the perceptive mind which he brought to his speciality. Harvard is grateful for having had the benefit of so many of his productive years."

Lee A. DuBridge, President of the California Institute of Technology wrote: "He came to Caltech during its formative period and had a decisive influence on guiding its destinies along the path which has brought it to its present stature as one of the leading scientific institutions of the world. For all of his contributions to the Institute and for all his personal kindness and inspiration to his many friends he will be long remembered."

A Life in the Day of Eric

Seemingly from nowhere, Eric stepped in front of the oncoming Pontiac convertible (he made it a habit to step in front of cars seemingly from nowhere so that they would have as little chance to brake as possible). The Pontiac swerved sharply to the left, but Eric was there first and was caught fully on the hip by the right headlight and then dragged under the wheels for about sixty feet. A woman on the sidewalk screamed and fainted; she wasn't Eric's mother as one would suppose. She didn't even know Eric. It was always unfortunate that these incidents should involve bystanders who had to appear as witnesses later on (those that couldn't get away in time). In any case, Eric dragged himself from under the car and angrily shook the dust and grease from his clothes; he had failed again, and this time it was right after a bad breakfast. Death is hard.

As one descends from the nearest star, let us assume that the landing point on our earth would be the brightest point, the most desirable point. There is such a point, so they say . . . as one descends . . .

The student is smuggled into reality occasionally — leaves the brightest point for dull points and comes back full of new life and energy and worshipping of science as a concept. He may have gone and come back for three years but he never learns and the hope is always there when the dull points of the earth are left behind.

Eric crossed California Street and turned to go back to Arms 155 where he was in the middle of a geology final. He had just caused a brand new Thunderbird to go completely out of control and swerve onto the sidewalk between two palms. Of course, Eric's pencil wasn't even broken. Just three weeks before, on a field trip, he had walked into a poison oak patch and then thrown himself into the Arroyo, hoping to die of exposure. This, he felt, would leave an indelible stain on the geology department's record; however, he had survived. His last attempt before the final was also a failure . . . and the one before the math final . . . and before the physics. Eric even failed to fail the finals; no matter how low his score, the average was lower. Death is hard.

And why doesn't he leave . . . and stop coming back to be beaten and kicked and lifted and kicked again and allowed to survive in order to face it again? Prestige . . . prestige . . . prestige . . . and into the night of society the same name echoes and beckons to its side the innocents . . . unknowingly ushered into a world of numbers from zero to four that determine their glorious fate . . . Oh, but you will look back on those years with a smile; those are the best years — you'll wish for them when you're thirty . . .

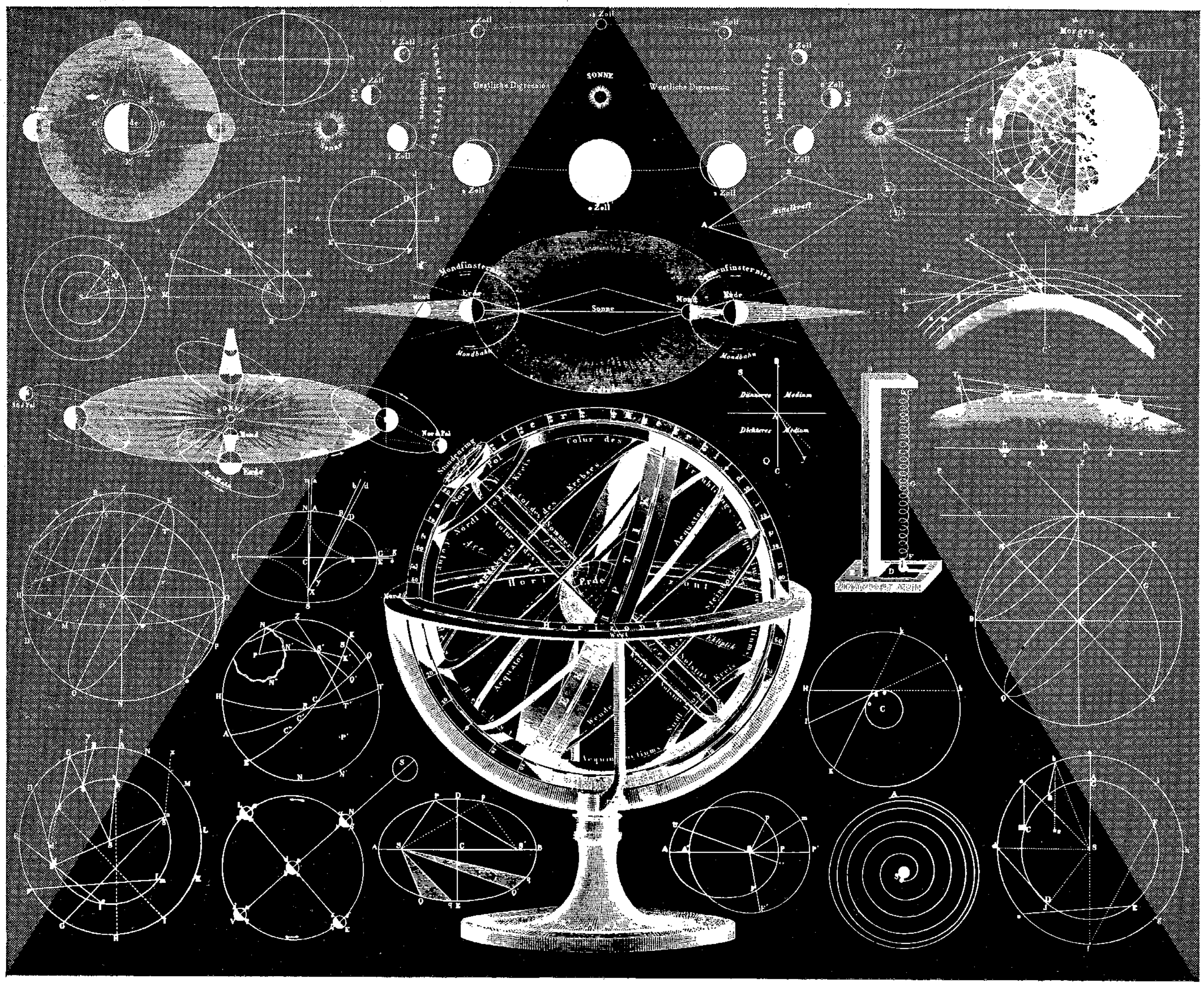
The drug store door pushed open and Eric wearily followed the opening into the cold outside air. He stood for a moment contemplating a large Imperial sedan, but decided rather to return to his room. He had just bought, by pleading extreme insomnia, twelve sleeping pills, which he would take immediately. (There was ham on the menu that night, and horrified at the thought of going through that again, Eric was going to try something radically different.)

Man molds himself in the light of other value systems . . . the brightest light may destroy the fastest . . . and then there is nothing left . . . the path is wrong . . . the systems have failed . . . all that remains is stagnation . . . lethargy . . . fatalism . . . survival from zero to four . . .

Seemingly from nowhere, Eric stepped into his small room on the top floor of the physical plant. He quickly removed his ordinary workaday clothes, revealing a blue uniform underneath. Without the slightest hesitation, he swallowed four of the sleeping pills and fell on to his bed, No ham . . . no ham . . . no turnips, he thought, as he was overcome with heavy sleep . . . Everytime he had gone home they had been so happy to see him; they commended him on his grades even though they didn't exactly know what they meant as far as standing in the class, and so on. And whenever they had friends over, everybody would ooh and ahh at the fact that he was in such a tough school and so famous, and he would feel good for awhile and when he came back he would think that this was a great place after all and he would be happy for a few days and then it would start all over again and he would start stepping in front of cars and throwing himself into the Arroyo and now the sleeping pills.

But Eric knew he couldn't find death . . . it avoided him to prolong the torture; the end never came any nearer . . . zero to four . . . zero to four . . . nothing but survival from zero to four . . . Eric only slept through the ham.

— Martin Carnoy '60



Alumni News

Alumni Development Gifts

With gifts still being received from alumni the world over, the Development Program office announced a tentative alumni total of $962,176 as of the year-end – some $38,000 short of the one million dollar goal announced not quite two years ago.

Participation by alumni, the importance of which cannot be overemphasized, currently stands at 46 percent. It is hoped that many more of the 4,100 men who have not yet contributed will make a gift – no matter how modest – in order that the participation percentage can be substantially increased.

In order to insure a complete roster of alumni donors and to allow time to compute some interesting statistics regarding alumni giving, the Alumni Record will not be published until late February.

In spite of the conclusion of organized activity within the alumni phase of the Development Program, gifts received after the first of the year will continue to be credited to the Alumni Committee. All gifts, large or small, will be most gratefully received.

– *E. Curzon Fager, Jr.*
Associate Director,
Development Program

Winter Dinner Meeting

John Morley, syndicated columnist and war correspondent, will be the speaker at the Alumni Dinner Meeting to be held at the Rodger Young Auditorium in Los Angeles on January 21. Mr. Morley recently returned from his 22nd trip to critical areas in the world and in his talk, "Documented Facts Over Fiction," will tell about his exclusive interview with Boris Pasternak, Russia's Nobel Prize-winning author. He will also discuss "what actually goes on in Russia, what Khrushchev really has in mind, and the significance of Mr. K.'s recent visit to the US."

Mr. Morley, trained as a lawyer, is officially accredited as a correspondent by the U.S. Government, the United Nations, NATO, SEATO and the Baghdad Pact Nations.

Dinner will be served at 7:30 p.m., preceded by cocktails at 6:30. Reservations should be made with the Alumni Office.

– *Ralph B. Pastoriza, Chairman*

New Alumni Directory

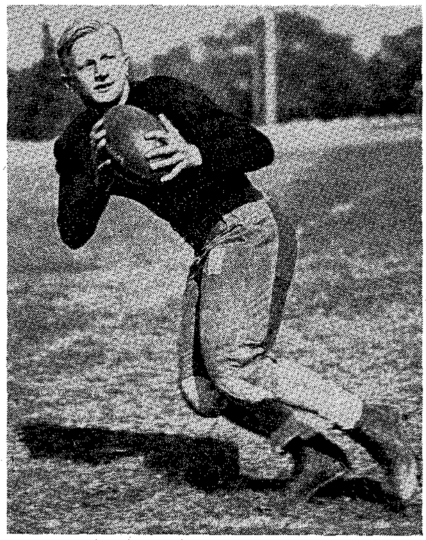
Caltech's new Alumni Directory will be ready for mailing sometime in the early spring. Postcards went out to all alumni everywhere in October and now the information is being compiled from a total of 7,902 people who have received degrees from Caltech.

The Directory will list all names alphabetically, with home and business addresses, degrees and options and will also have carefully compiled geographical and class lists.

Franklin G. Crawford, '30, heads the committee in charge of the Alumni Directory and advises that the book will be available to all paid alumni.

Wallace Johnson — Silver Anniversary All-American

Wallace Johnson '35, president of Up-Right Scaffolds in Berkeley, Calif., was elected last month to *Sports Illustrated*'s annual Silver Anniversary All-America. This is an annual award by the sports magazine to 25 men on the basis of their career success and community service in the intervening 25 years since their senior football season at college. Nomination for the honor is made by each candidate's alma mater, and election is by a panel of eminent judges.

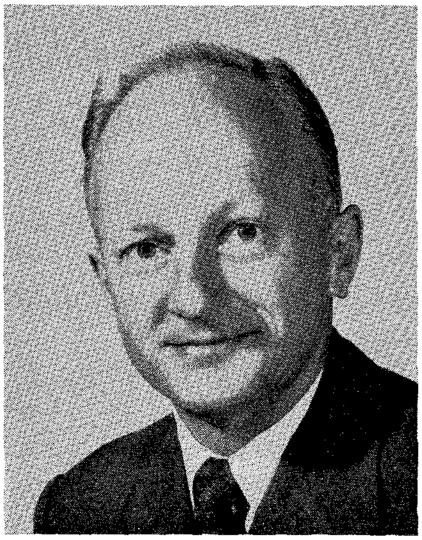


Wallace Johnson – 1935

As a Caltech undergraduate, Wallace Johnson played varsity football in his sophomore, junior and senior years and lettered in both his junior and senior years. He was the lightest man on the squad (134 lbs.), but gave an excellent performance for all of his lightness.

Now president of the Up-Right Scaffolds division of Up-Right, Inc., Johnson started his company in 1946 with an original idea of portable aluminum alloy scaffolds and radio towers. The business is now international.

Johnson lives in Berkeley where he has an active community life – past president of the Rotary Club, deacon in the First Congregational Church, and chairman of the Berkeley-Albany District of the Mt. Diablo Council of the Boy Scouts. He recently served as chairman of a citizen's committee appointed by the school board to study school building needs in Berkeley.



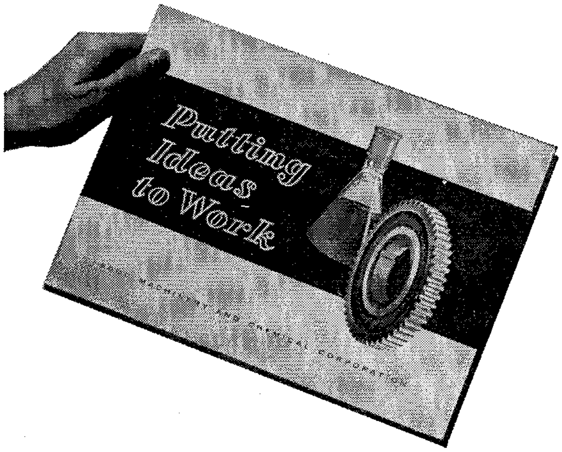
Wallace Johnson – 1960

A REAL CAREER OPPORTUNITY FOR GRADUATES

COMMERCIAL OPERATIONS:

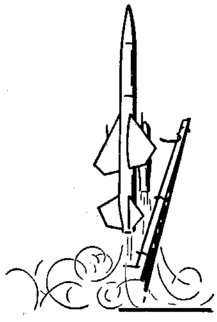
Graduates planning careers in chemical, electrical or mechanical engineering, will be interested in evaluating the opportunities offered by Food Machinery and Chemical Corporation, with headquarters in San Jose, California—a nation-wide organization that puts ideas to work through creative research and practical engineering.

FMC offers career opportunities in these fields: Agricultural Chemicals • Agricultural Equipment • Automotive Servicing Equipment • Food Canning & Freezing Equipment • Defense Materiel • Fire Fighting Equipment • Industrial Chemicals • Materials Handling Equipment • Power Gardening Equipment • Packaging Equipment • Food Packing and Processing Equipment • Petroleum Specialty Equipment • Pumps and Water Systems • Waste Disposal Equipment



DEFENSE OPERATIONS:

FMC's Ordnance Division, located at San Jose, California, produces mobile support equipment for military programs including amphibious tracked vehicles and missile ground support equipment. This fully integrated organization and its well equipped facilities provide coordinated control of each phase of every project from design concept through development and production.



The division possesses complete prototype and quantity production manufacturing facilities along with a wide variety of test equipment and processes, as well as complete testing grounds for tracked vehicles and missile handling equipment. Young graduates employed by FMC have the opportunity of working with men of outstanding engineering talent and leadership in mechanical, structural, electrical, hydraulic, and metallurgical specialties.

This challenging field offers tremendous possibilities for the young engineer. Because of rapid advancements in this sphere of activity, FMC is constantly looking for men with the special capabilities for creative engineering and development.

To acquaint students with the broad scope of career opportunities in FMC's diversified activities, we invite you to write for copies of our brochure, "*Putting Ideas to Work*," which graphically presents FMC's operations and product lines.

Address: **Personnel Administration Department**
P. O. Box 760, San Jose, California,
or Industrial Relations Department
161 East 42nd Street, New York 17, New York

Putting Ideas to Work

FOOD MACHINERY AND CHEMICAL CORPORATION

Personals

1918

William B. Nulsen writes that "I'm still professor of electrical engineering at the University of New Hampshire in Durham – and I still play golf in the 80's."

1925

Michael C. Brunner retired from the Shell Oil Company in 1958 after 2½ years as senior American representative with Royal Dutch Shell in The Hague, Netherlands.

"After returning to the States in February 1958," writes Mike, "I tried a month in the New York office but I decided that the West was the place to live. We bought a place in Corona del Mar in June '58. I was also officially retired from the Army last month as Colonel in the Corps of Engineers. Having retired twice now, it should take."

1928

Dr. Harvey Billig, Jr., medical director of the Billig Clinic in Los Angeles, was recently elected 1960 president of the surgical section of the Los Angeles Medical Society.

1930

J. R. Lester Boyle writes that he's "still doing the same thing I've done for the last 15 years – president and consulting civil engineer with the Boyle engineering offices in Santa Ana, San Diego, and Bakersfield. Our total staff now numbers approximately 110 persons and we work on municipal engineering, water, sewers, dams, highways, etc. We have two boys in college working on engineering courses. My golf handicap is nine and I belong to the Santa Ana Rotary Club and the Santa Ana Country Club. We live in Newport Beach overlooking Newport Harbor. We've been married 24 years now and are enjoying life, working hard, and have indulged in some foreign travel."

1934

Guy O. Miller writes that he is retired and "living on the beautiful Lake of the Ozarks in central Missouri. My present occupations are fishing and whittling, but I am also secretary of the Lake of the Ozarks Yachting Association and a member of the Camdenton, Mo., Rotary Club. During the past year, my wife and I made a trip around the world on the *S.S. President Jackson*, a deluxe cargo boat, in 80 days. I expect to be in Pasadena probably sometime in January to look the place over and make a contribution to the Development Fund."

1935

James B. Stoddard writes that he has been a member of the City Council of Newport Beach since April 1955, and mayor of the city since April 1958. "My term as mayor ends in April 1960," he writes, "and the council term ends in April 1962. The city has a seven-man council, with the mayor chosen by them, from their membership, for a two-year term."

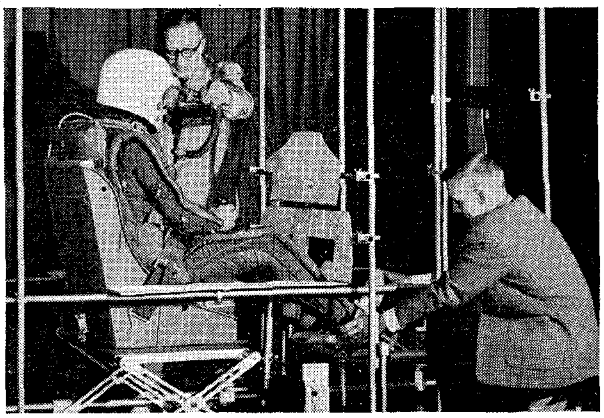
1936

W. E. Swanson is vice president and general manager of the Roberts Construction Company, with headquarters in Lincoln, Nebraska. This year the company is doing heavy and highway construction in the states of Nebraska, Kansas, Wyoming, Colorado and New Mex-

continued on page 46

Where do you want to work?

These 2 answers may shape your future



AT NORTHROP you will be offered a wide diversity of over 30 operational fields from which to choose. You will apply your talents to the work you enjoy – in the fields best suited to your inclinations and ability.

You will work with the newest and most-advanced research and test equipment.

You will work with acknowledged leaders in their fields – men who are chosen for their capabilities and their skills in guiding and developing the talents of younger men. You will like the way they delegate authority and assure you of your fair share of credit for engineering triumphs.

You will earn top salary. Northrop's salary structure is unique in the industry. With this growing company you will receive increases as often as you earn them, and these will be based on your own individual achievements. You will discover, too, that Northrop's vacation and fringe benefits are extra liberal.

And you will continue to learn while you earn at Northrop with no-cost and low-cost education. At leading Southern California institutions, you will earn advanced degrees and keep current with the latest advances in your own chosen field.

IN SOUTHERN CALIFORNIA you will work in the electronic, aircraft/missile center of the world. You will join the outstanding scientists and engineers who continually advance Southern California's dynamic leadership in these fields of the future.

When you work at Northrop you will be able to enjoy your leisure the year around. Close to the beaches and the mountains, you'll enjoy an active life in Southern California's incomparable climate.

Now – as you plan your future, you owe it to yourself to consider these 3 Divisions of Northrop.

NORAIR DIVISION is the creator of the USAF Snark SM-62 missile now operational with SAC. Norair is currently active in programs of space research, flight-testing the USAF-Northrop T-38 Talon trainer and Northrop's N-156F Freedom Fighter.

RADIOPLANE DIVISION, creator of the world's first family of drones, produces and delivers unmanned aircraft for all the U.S. Armed Forces to train men, evaluate weapon systems, and fly surveillance missions. Today Radioplane is readying the recovery system for Project Mercury.

NORTRONICS DIVISION is a leader in inertial and astronertial guidance systems. At Hawthorne, Nortronics explores infrared applications, airborne digital computers, and interplanetary navigation. At Anaheim, Nortronics develops ground support; optical and electromechanical equipment; the most advanced data-processing devices.

Find out more about the young engineers and scientists who are making the news happen at Northrop.

WRITE TODAY for information about Northrop and all of its Divisions.

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Northrop, P.O. Box 1525, Beverly Hills, California

NORTHROP
CORPORATION

NEWS IS HAPPENING AT NORTHROP

Personals . . . *continued*

ico. Wally is also serving this year as vice president and director of the Nebraska Chapter of Associated General Contractors, and he was recently nominated to serve a three-year term as a national director of the A.G.C. of America.

1937

Vernon A. C. Gevecker, MS, who has been serving as assistant dean of the faculty of the University of Missouri's School of Mines and Metallurgy, has now returned to teaching duties as professor of civil engineering.

1938

Donald S. Taylor, PhD, vice president of U.S. Borax & Chemical, was recently appointed president of the U.S. Borax Research Corporation.

Robert C. McMaster, MS, PhD '44, received the annual Deforest Award for outstanding contribution from the Society for Nondestructive Testing, Inc., last month. Bob is professor of welding engineering at Ohio State University.

August V. Segelhorst writes that he "moved from Corona del Mar to Houston, Texas, last May because my firm, the S. R. Bowen Company in Santa Fe Springs, was purchased by Bowen ITCO, Inc., in Houston. Both companies were (and are) manufacturers of oil well fish tools and wire line equipment. I ended up as chief engineer of the combined companies.

"I stopped at a signal last week and noted a Tech sticker on the car alongside. I yelled at the fellow, who turned out to be *Larry Fleming* '37. He has been here for three years with Southwestern Industrial Electronics, but has just quit to go back to southern California (lucky boy). I also saw *John Stick* '35, at the AIME meeting in Dallas recently. He is now in Houston as chief log analyst with the Lane-Wells Company."

Elburt F. Osborn, PhD, dean of the College of Mineral Industries at Penn State, has now been appointed vice president for research at the University. He has been on the Penn State faculty since 1946.

1939

Arthur J. Stosick, PhD, is now assistant to the director of the John Jay Hopkins Laboratory for Pure and Applied Science in San Diego.

James E. LuValle, PhD, is now director of chemical research for the newly-formed physical chemistry laboratory at the Fairchild Camera and Instrument Corporation in Syosset, N.Y. He was formerly projects director at Technical Operations, Inc.

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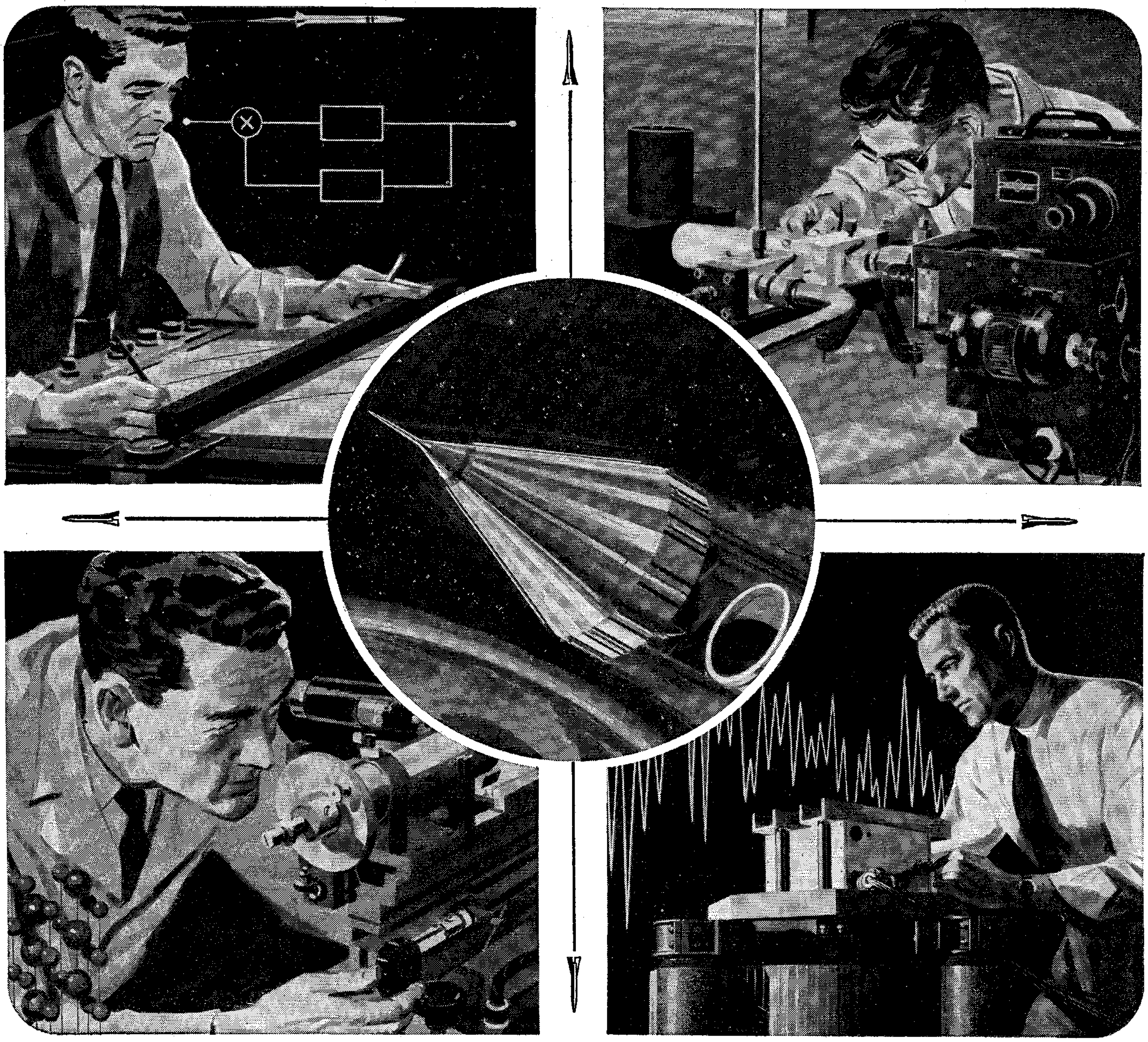

1940

Lt. Col. William W. Stone, Jr., MS '41, is now attending the Army War College at Carlisle Barracks in Pennsylvania. He is taking a ten-month course which prepares selected officers for future assignments to top staff and command positions in the Armed Forces.

Erwin Baumgarten, a staff member of the Operations Evaluation Group of the U.S. Navy, is serving as professor of physical sciences at the Naval War College in Newport, R.I., for the current academic year. Last year he was on the staff of Commander First Fleet in San Diego, as operations analyst.

1941

Lawrence C. Widdoes is vice president and general manager of the Internuclear Company in St. Louis, Mo. The firm specializes in engineering, design and consulting in the atomic power and nuclear energy field.

Reuben P. Snodgrass, MS '42, director of flight research in the aeronautical equipment division of the Sperry Gyroscope Company in Great Neck, L.I., has had a new instrument patented – a navigation aid for piloted aircraft.

1942

Murray L. Lesser is now manager of the research technical staff of the IBM Corporation in Yorktown, N.Y. He has been with IBM since 1954.

Capt. Robert M. Gibbons, AE, writes that he has been Bureau of Aeronautics representative at the El Segundo Division of Douglas Aircraft for the past three years. He leaves the U.S. Naval Service next summer, and his future plans are undetermined.

1943

Edward Brown writes that "I moved to Detroit over a year ago to be director of engineering at Vickers Machinery Division. It was a major change because I've lived in Los Angeles most of my life, and since graduation I've worked in the aircraft industry and related fields. We now have five boys in the family – added another one last year."

1945

Robert E. Phillips, PhD, '53, formerly chief chemist at the California Foundation for Biochemical Research, is now vice president of G. K. Turner Associates in Palo Alto.

1946

James B. Stichka is now plant superintendent of the Richmond fertilizer manufacturing operation of the California Spray-Chemical Corporation. He was formerly in the company's engineering division, supervising design and construction at the Richmond and Kennewick, Wash., fertilizer plants.

Frank H. Lamson-Scribner, Jr., is now with the International Bank for Reconstruction and Development (World Bank) in Washington, D.C.

Stuart R. Bates writes that he received his MS from USC in August, and that he has a son – Ward Jonathan, 2.

1947

Joseph Rosener, Jr., is now vice president and general manager of the Giannini Plasmadyne Company in Santa Ana. The company does research and development in the field of high temperature physics, and manufactures plasma generators. Joe, his wife and three children, live on Lido Island. "We are having a perpetual vacation here," writes Joe, "As sad as we were to leave Pasadena, we must admit that the blue sky and a swim at lunchtime are mighty nice."

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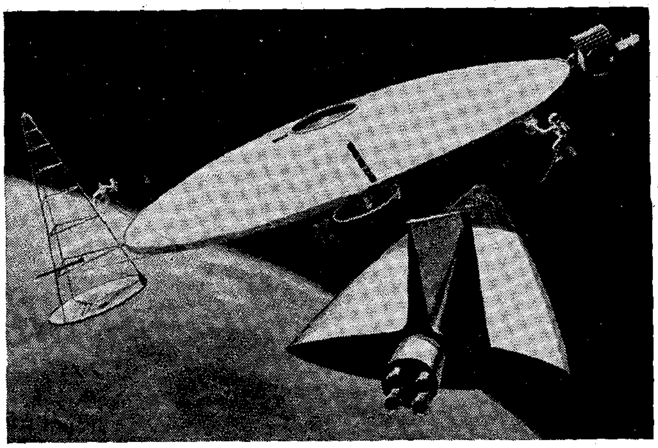
Space-age careers at Boeing



This year, engineering and science alumni will find more challenging and rewarding careers than ever at Boeing. Advanced missile and space-age programs are expanding, and the proportion of engineers and scientists to Boeing's total employment is growing steadily. Boeing programs include the Dyna-Soar boost-glide vehicle, Minuteman solid-propellant ICBM, BOMARC *defense missile system, B-52G missile bomber, KC-135 jet tanker-transport, the Boeing 707 jetliner, and lunar, orbital and interplanetary systems and advanced research projects. A few of the many immediate openings are listed below:*

ADVANCED CONFIGURATION DESIGN — **WICHITA AREA**

M.S. or Ph.D. in A.E. to create configuration of new vehicles proposed by potential military or civilian customers. Creative design of vehicles based on general parameters of missions (payload, performance, etc.). In addition to configuration, special features such as handling payload (i.e., cargo, passengers) and comparison with competitors' proposals are investigated.

INFRARED — **SEATTLE AREA**

Electrical engineer or physicist with advanced degree to set-up and direct an Infrared System Group involved in: (1) Studies and analyses of infrared systems, techniques and phenomena, (2) Definition of models and parametric relationships, and (3) Synthesis of advanced infrared sub-systems (search, track, terminal guidance, mapping, surveillance, and scientific instrumentation) for integration into larger systems.

ELECTRONICS-RELIABILITY — **SEATTLE AREA**

Electrical engineer with B.S. degree minimum (graduate work or equivalent experience desired) to organize and manage reliability programs; to establish requirements, evaluate reliability data and initiate corrective action for missile components and tactical test equipment.

ELECTRONICS-DIGITAL COMPUTER — **SEATTLE AREA**

Engineers with advanced E.E. degree or particularly applicable experience to design and integrate digital computers in advanced military and space programs, involving internal logic design of the computers and the external organization of the associated equipment used in the guidance and control system.

ENGINEERING ANALYSIS & PROGRAMMING — **SEATTLE**

Mathematicians or engineers with B.S. to Ph.D. degrees to work in engineering computing and analysis areas. Analysis positions involve correlation and conversion matrix studies, trajectory simulation programs, error analysis and simulation studies and many others. Computing positions involve programming a wide variety of complex engineering problems to be solved with high-speed electronic data processing machines—digital and analog.

PLASMA PHYSICS — **SEATTLE AREA**

Experimental physicist with Ph.D. in physics for the staff of the Plasma Physics Laboratory, Boeing Scientific Research Laboratories, to conduct studies in the field of Basic Experimental Micro Wave Plasma Physics, Basic Transport Properties of Plasmas and in Theoretical and Experimental Quantum Plasma Physics.

OPERATIONS & WEAPONS SYSTEMS ANALYSIS — **WICHITA**

M.S. or Ph.D. in math, physics, electrical or aeronautical engineering to obtain data on the anticipated operational environment of the devices under study by Advanced Design Staff. Devise analytical models of procedures describing operation of the devices in order to estimate the operational utility of same under study. Studies compare Advanced Design products with other companies and demonstrate anticipated utility to the customer.

ELECTRONICS-TELEMETRY — **SEATTLE AREA**

B.S.E.E. with good knowledge of telemetry systems, transducers, and systems providing inputs into telemetry systems, to work on telemetry systems integration. This requires ability to represent the company in meetings with the customers and associate contractors.

ELECTRO-MAGNETICS — **SEATTLE AREA**

Ph.D. in electrical engineering or physics to direct and participate in the work of a research group engaged in the theoretical and experimental investigation of the propagation and reflection of electro-magnetic waves in the presence of a plasma.

WELDING ENGINEERING — **SEATTLE AREA**

Engineers with degree in Met.E., Mech.E., E.E. or equivalent, to maintain weld equipment, design tools, develop techniques and direct proper use of this equipment, and establish processes for all types of welds used in the unit, including weld settings for qualification programs.

PERFORMANCE & STABILITY & CONTROL ANALYSIS — **SEATTLE AREA**

Aeronautical engineers at B.S. and M.S. level to conduct performance analysis and stability and control analysis. Each field is intimately associated with flight testing and wind tunnel testing. Performance assignments include preparation of sales presentations, operating instructions and preliminary design work in connection with new aircraft; stability and control assignments cover wing and tail design as well as studies concerning detailed control systems.

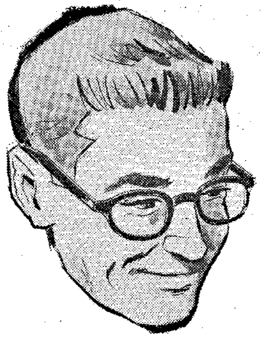
GEOASTROPHYSICS — **SEATTLE AREA**

Theoretical physicists or astronomers with Ph.D. in physics or astronomy on the staff of the Geoastrophysics Laboratory, Boeing Scientific Research Laboratories, to carry out theoretical research studies in the field of Geoastrophysics, particularly in connection with the phenomenology and physics of the planetary system. Excellent snpport is available for research in Solar Physics, Solar Terrestrial relationships and Upper Atmosphere Physics.

Advantages you'll enjoy at Boeing include up-to-the-minute facilities, unexcelled research equipment, insurance and retirement programs, and a company-paid graduate study program (M.A. and Ph.D.) designed to help you get ahead faster.

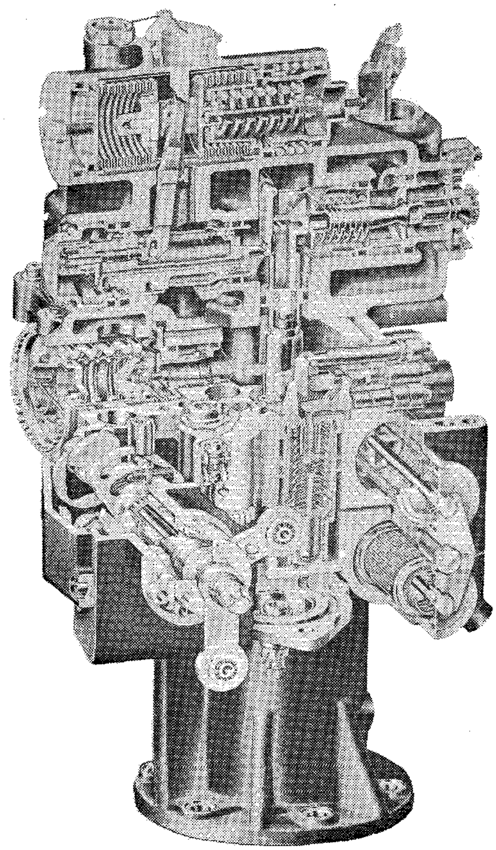
For further information write: Mr. Stanley M. Little, Boeing Airplane Co., P. O. Box 3822 - UCI, Seattle 24, Wash.

BOEING



Student Frank G. analyzes the

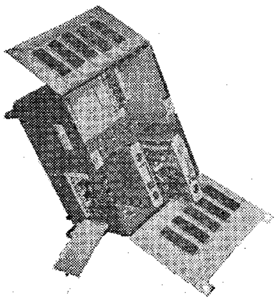
Spectrum of skills built into Hamilton Standard products



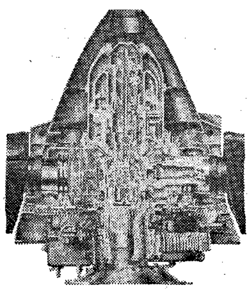
Some engineering specialties that contribute to creating this engine control:

- FLUID DYNAMICS
- HYDRAULICS
- ELECTRONICS
- METALLURGY
- VIBRATION
- MECHANICS
- CONTROL DYNAMICS
- STRESS ANALYSIS
- SERVO MECHANISMS

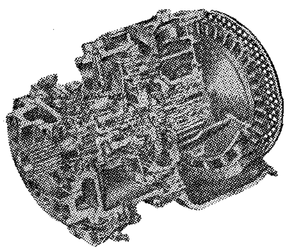
OTHER PRODUCTS DEVELOPED BY THIS INTEGRATION OF VARIED SKILLS:



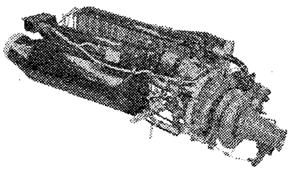
ELECTRONIC FLIGHT CONTROLS



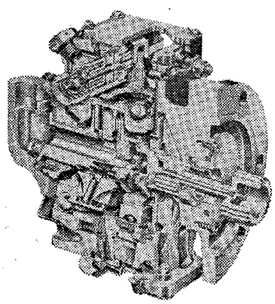
TURBO PROP CONTROLS



JET ENGINE STARTERS



ENVIRONMENTAL CONTROLS



HYDRAULIC PUMPS

MODEL JFC 12-11 FUEL CONTROL is, typically, the result of the Hamilton Standard "task force of talents" concept now producing so many ingenious, space-conquering devices for advanced aircraft, missiles and space vehicles. The unit above is standard equipment on the highly successful Boeing 707 Jet Transport. This lightweight (60 lbs.), complex (about 1200 parts), and sensitive unit delivers 16,000 gallons of fuel in 7 hours—sufficient to drive a car 240,000 miles—the distance to the moon!

Incoming students like Frank G. can use their engineering knowledge immediately at Hamilton Standard by contributing, as members of small design, analysis or project groups to the development of a product. There is virtually no limit to the types of engineering background required at Hamilton Standard, and no limit to the challenging applications that await these talents.

Write to R. J. Harding, Administrator-College Relations, for full color, illustrated brochure:

HAMILTON STANDARD
A DIVISION OF
UNITED AIRCRAFT CORP.
BRADLEY FIELD ROAD, WINDSOR LOCKS, CONN.

Richard C. Gerke, MS, has opened his own office in Pasadena – Richard C. Gerke & Associates, which handles part-time sales work for technical accounts. Dick was formerly with the Vinnell Steel Company in Irwindale, as special products manager.

Carl P. Spaulding is now president of the Datex Corporation in Monrovia. He has been with the company since its establishment as a division of the Giannini Controls Corporation. The Spauldings live in San Marino and have three sons.

1948

William A. Barker, MS, associate professor of physics at St. Louis University, is also a consultant for the Argonne National Laboratories. The Barkers have five children – three girls and two boys.

Raymond V. Adams, PhD, professor of physics at Wayne State University in Detroit, has been acting chairman of the department since the resignation of *J. Earl Thomas, Jr.,* PhD '43, last January. Earl is now director of research and engineering at the semiconductor division of Sylvania Electric Products, Inc., in Woburn, Mass.

Walter P. Eatherly, MS '49, is now assistant director of the research laboratory of the National Carbon Company, a division of the Union Carbide Corporation, at Parma, Ohio. He joined the company in 1956, and is now also working for his PhD at the University of Illinois.

1949

Rolf M. Sinclair writes that "on June 13, 1959 I was married in the Princeton University Chapel to Margaret Lee Andrews. Before our marriage, my wife was a soloist in the Royal Ballet with the stage name of Margaret Lee. Any wandering alumni who saw them at Covent Garden Opera House in London or during their European tours probably saw her in some of the leading roles. We were engaged in London last year, and after the Royal Ballet toured Margaret's native Australia last winter, she left them and came to this country. We are now living in Princeton, where I am working at the University on Project Matterhorn."

1950

Robert C. Howard, MS, PhD '53, writes that, "in 1957 I moved to Santa Ana and the Giannini Controls Corporation where I head up the development of new components and subsystems, do proposal work, and turn fireman as the occasion demands. I'm also a member of the Corporate Engineering staff, which endeavors to guide the long-term activity. We have two daughters, a son, and one on the way. I am learning to fly a hot airplane – the Piper Super Cub. And I've got several patents pending for avionic subsystem concepts."

1951

Woldemar F. von Jaskowsky, MS, writes that "I joined the Giannini Plasmadyne Corporation in Santa Ana in September 1958 as a physicist (senior research scientist). As our company representative, I am engaged in the Boy Scout Science Explorer Program, which stimulates interest in the fields of science and technology, through the joint efforts of the Boy Scouts, the schools, and industry."

1952

Jesse L. Weil writes from Houston, Texas, that "I received my PhD in physics from Columbia University in October 1958, and then traveled for a month in Europe. I sailed back across the Atlantic (from Barcelona to the British West Indies) with a couple of friends in a 37-foot yawl. I am now a research associate at Rice Institute, but expect to spend eight months next year at the University of Hamburg in Germany, helping them to get their new Van de Graff lab well started."

Martin L. Sandell, systems engineer at Consolidated Systems Corporation in Monrovia, recently returned from a trip to Japan, where he installed a mass spectrometer at the Japanese Atomic Energy Institute.

1955

William G. Sly, PhD, assistant professor of chemistry at Harvey Mudd College in Claremont, writes that he's been at the college for two years now, teaching physical chemistry, and enjoying it – despite the difficulties inherent in matching such material to sophs.

Sigmund Redelsheimer, MS, is now aerodynamics group leader in the space group of the advanced design department of the McDonnell Aircraft Corporation in St. Ann, Mo.

1957

Frank E. Goddard, PhD, department chief of aeronautics and propellants at JPL, is now the Lab's representative to the National Aeronautics and Space Administration in Washington, D.C. He's been at JPL since 1949.

1958

Lt. Robert Polansky writes that "I'm still a 2nd Lt. in the Air Force but have changed jobs here at Edwards AFB. I used to work for the Experimental Track Branch but now I'm with the Base Instrumentation Section as an electrical engineer."

IT'S LITERALLY ALL AROUND YOU!

The word *space* commonly represents the outer, airless regions of the universe. But there is quite another kind of "space" close at hand, a kind that will always challenge the genius of man.

This space can easily be measured. It is the space-dimension of cities and the distance between them . . . the kind of space found between mainland and off-shore oil rig, between a tiny, otherwise inaccessible clearing and its supply base, between the site of a mountain crash and a waiting ambulance—above all, Sikorsky is concerned with the precious "spaceway" that currently exists between all earthbound places.

Our engineering efforts are directed toward a variety of VTOL and STOL aircraft configurations. Among earlier Sikorsky designs are some of the most versatile airborne vehicles now in existence; on our boards today are the vehicles that can prove to be tomorrow's most versatile means of transportation.

Here, then, is a space age challenge to be met with the finest and most practical engineering talent. Here, perhaps, is the kind of challenge *you* can meet.

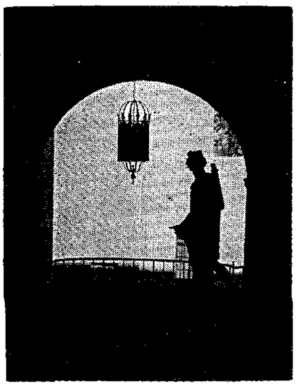
SIKORSKY AIRCRAFT

One of the Divisions of United Aircraft Corporation

STRATFORD, CONNECTICUT

For information about careers with us, please address Mr. Richard L. Auten, Personnel Department.

CALTECH CALENDAR



ALUMNI EVENTS

January 21	Winter Dinner Meeting
March 5	Annual Dinner Dance
May 7	Annual Seminar
June 8	Annual Meeting
June 25	Annual Picnic

ATHLETIC SCHEDULE

BASKETBALL

January 26
Caltech at Whittier

January 30
Caltech at Redlands

February 2
UC Riverside at Caltech

February 6
Pomona at Caltech

February 9
Cal Western at Caltech

February 12
Claremont-Harvey Mudd at Caltech

FRIDAY EVENING DEMONSTRATION LECTURES

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

January 29
Plant Growth Hormones
– Anton Lang

February 5
The Silent Witness
(A Study of Physical Evidence in Accident Analysis)
– Dino Morelli

February 12
Molecular Diseases and Protein Puzzles
– Richard Jones

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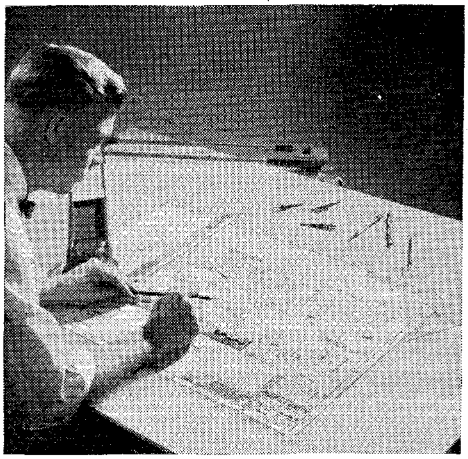
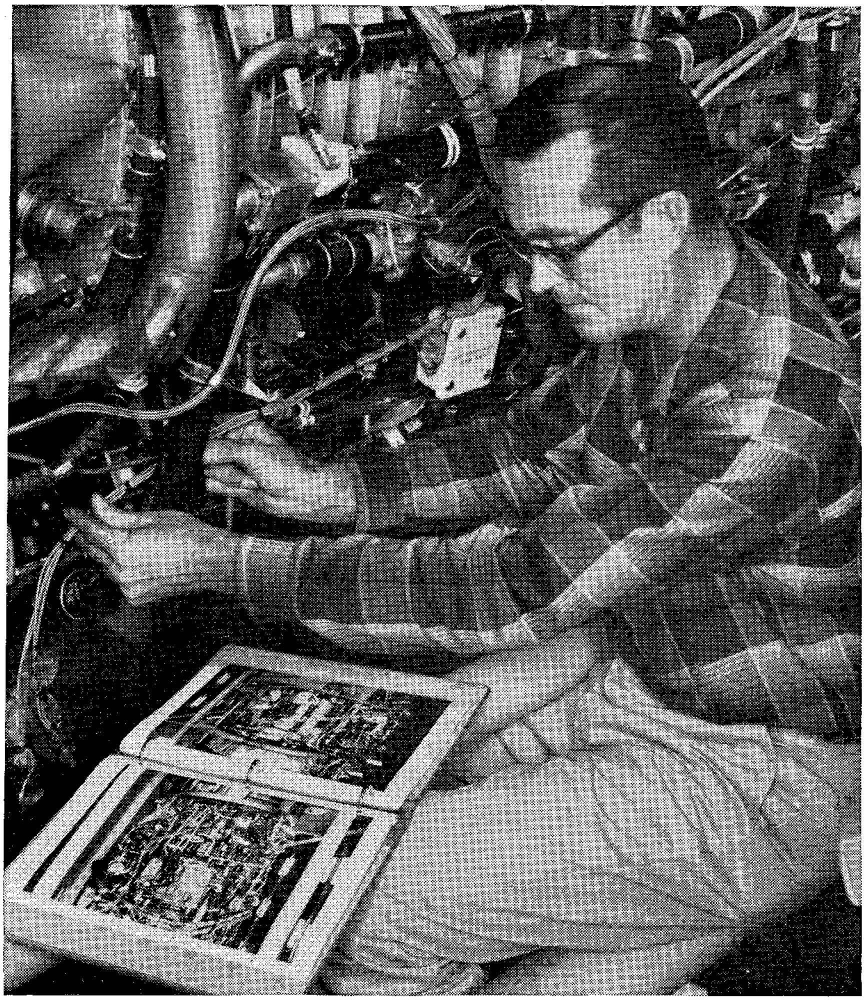


Photographs of parts, assemblies and models help both speed and accuracy in drafting.



At Rohr Aircraft photography provides accurate instructions for the intricate assembly of an 880 jet engine.