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ENGINEERING AND SCIENCE

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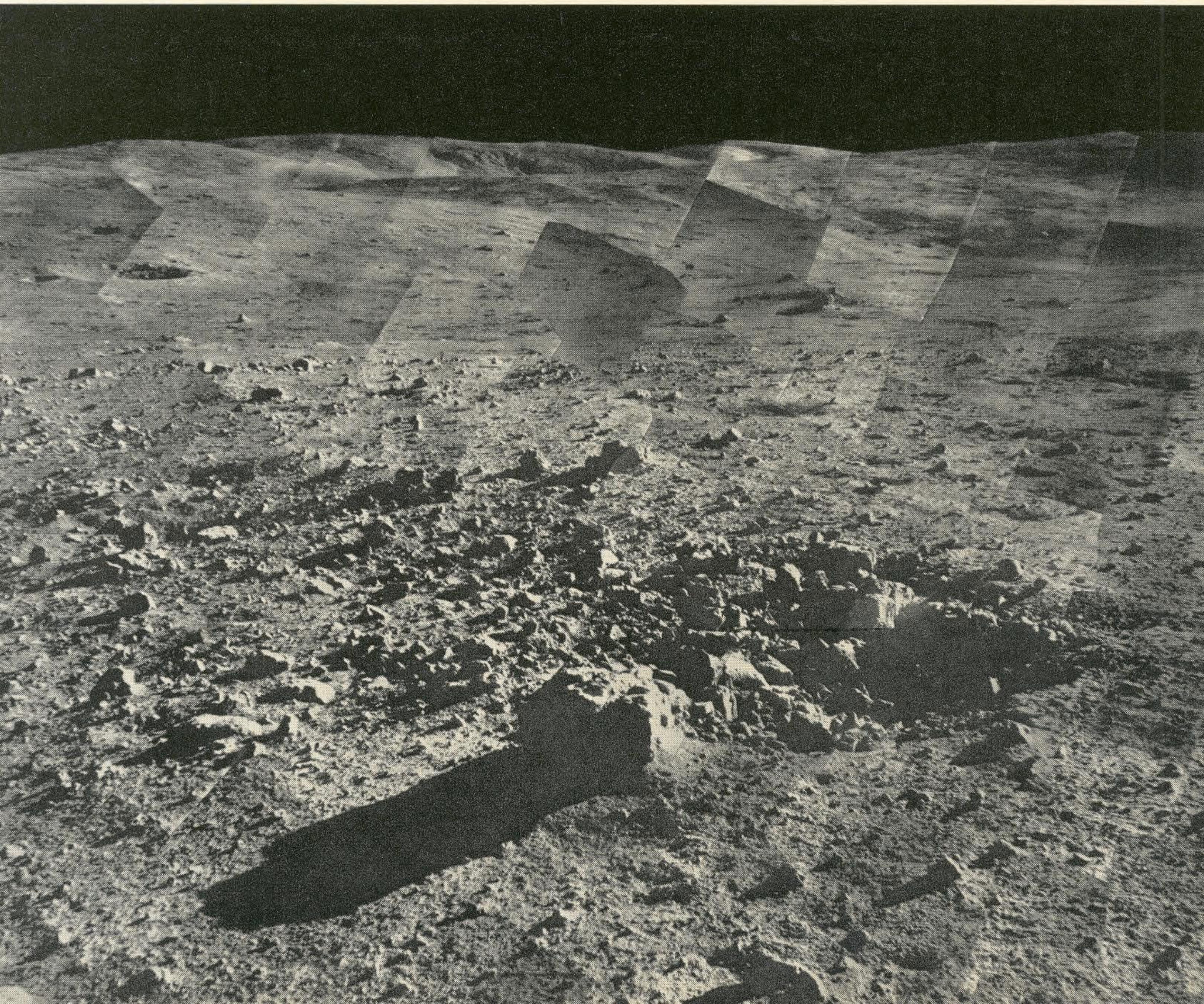
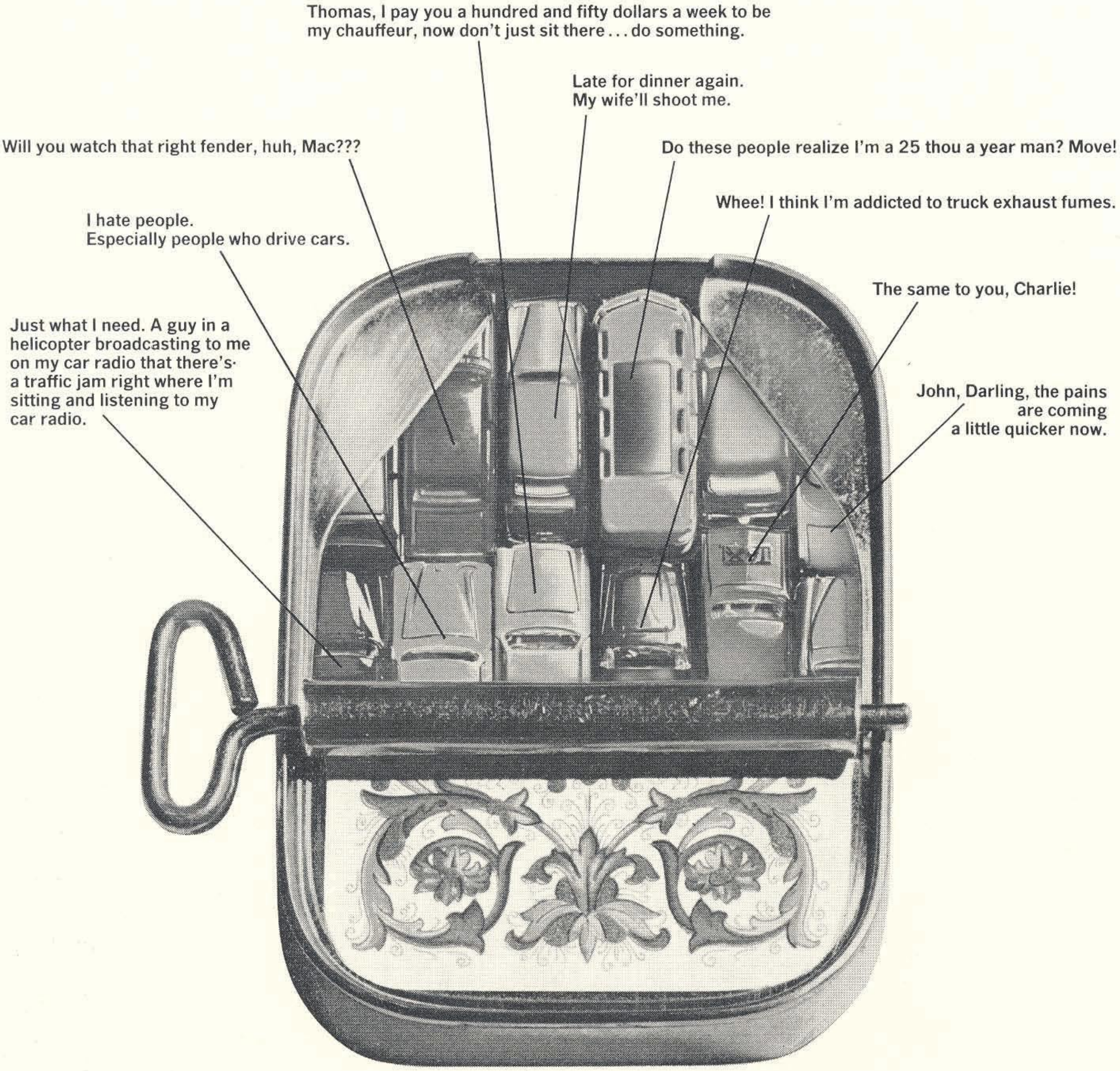
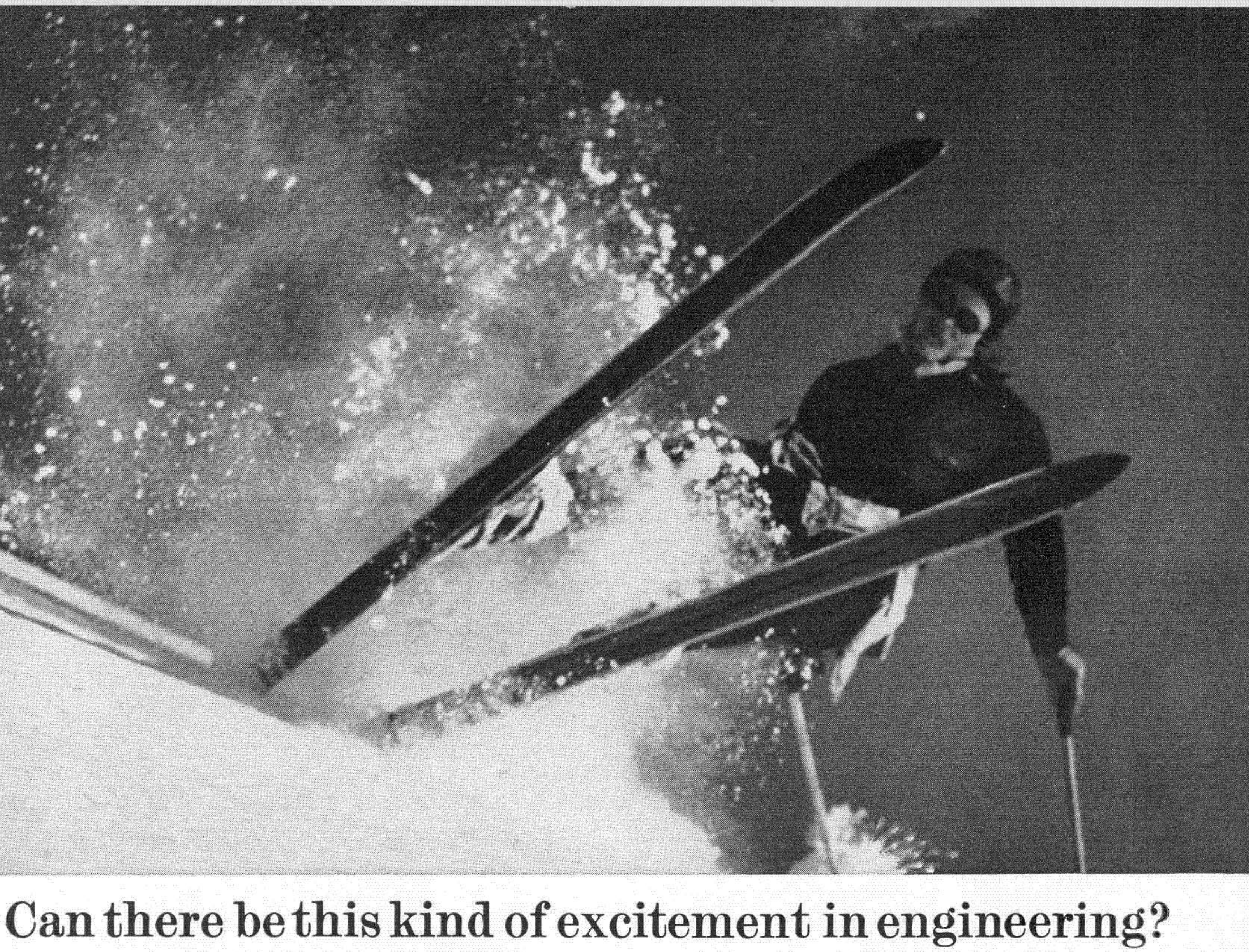
February 1968




Thomas, I pay you a hundred and fifty dollars a week to be my chauffeur, now don't just sit there . . . do something.
Late for dinner again. My wife'll shoot me.
Will you watch that right fender, huh, Mac???
Do these people realize I'm a 25 thou a year man? Move!
Whee! I think I'm addicted to truck exhaust fumes.
I hate people. Especially people who drive cars.
The same to you, Charlie!
Just what I need. A guy in a helicopter broadcasting to me on my car radio that there's a traffic jam right where I'm sitting and listening to my car radio.
John, Darling, the pains are coming a little quicker now.



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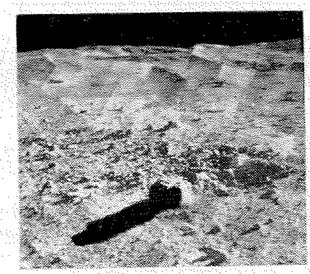
ENGINEERING AND SCIENCE

FEBRUARY 1968 / VOLUME XXXI / NUMBER 5



ON THE COVER
This remarkably detailed picture of the moon, compiled from photos taken by Surveyor VII on January 10, is a startling reminder of how far we have come since Caltech's Jet Propulsion Laboratory developed Explorer I for launch on February 1, 1958—and ushered in the space age in America. The tenth anniversary of that event was celebrated at Caltech this month (page 24). A man who helped set the stage for that success—Frank J. Malina—tells (page 9) of pre-Explorer research at Caltech.

PICTURE CREDITS:
Cover—Jet Propulsion Laboratory; 14-17, 24, 25—James McClanahan

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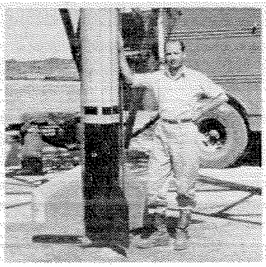
IN THIS ISSUE



ROCKET PIONEERS

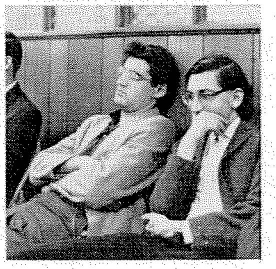
Frank Malina recalls the early days of rocket research in the article starting on page 9. Now an artist living in Paris, Malina has not lost his interest in aeronautics. He is deputy director of the International Academy of Astronautics and chairman of the Lunar International Laboratory Committee in Stockholm, an organization devoted to the study of technical problems related to the construction of a research laboratory on the moon.

SCIENCE AND THE RISING SUN

Roy Lockheimer has been a student of Japanese affairs since his undergraduate days at Tufts University. Doctoral research took him to Japan in 1962, during which time he served as an exchange research fellow at Keio University and as a columnist for the *Japan Times*. Since 1966 he has been a member of the American Universities Field Staff, an organization sponsored by 12 colleges (Caltech is a founding member) that has representatives throughout the world to study and report on current conditions. The article on pages 20-23 was adapted from a lecture given in Beckman Auditorium on January 29 and from a talk presented by the author at a Caltech conference last October. It will also appear in a forthcoming AUFS publication.

CHEMICAL GAMESMANSHIP

George Hammond, Arthur Amos Noyes Professor of Chemistry, is acting director of Caltech's division of chemistry and chemical engineering (page 24). His current research is reviewed on pages 14-15.



THREE DAYS IN THE "GHETTO"

Caltech senior Michael Meo is an astronomy major with a growing interest in earthly affairs. He is quick to volunteer his energies to a worthy cause, although his greatest asset is his ability to effectively criticize the cause he supports—such as the ghetto program he describes on pages 16-17. Our intrepid reporter is shown at the far left absorbing information on the ghetto at a briefing session.

31st ANNUAL ALUMNI SEMINAR

May 4, 1968

An outstanding program of lectures
to be given by:

Mrs. J. L. Agresti, Graduate Student in Biology

Dr. J. F. Benton, Associate Professor of History

Dr. M. Delbrück, Professor of Biology

Dr. P. W. Fay, Associate Professor of History

Dr. C. R. Gates, Manager of Voyager Mission Operations Systems Division

Dr. J. L. Greenstein, Profesor of Astrophysics and Staff Member, Mount Wilson and Palomar Observatories, Owens Valley Radio Obesrvatory; Executive Officer for Astronomy

Dr. P. C. Jennings, Assistant Professor of Applied Mechanics

Dr. D. J. Kevles, Assistant Professor of History

Dr. R. F. Scott, Professor of Civil Engineering

Dr. F. H. Shair, Assistant Professor of Chemical Engineering

Dr. H. D. Smith, Professor of English and Chairman of the Division of Humanities and Social Sciences

Dr. G. J. Wasserburg, Professor of Geology and Geophysics

special lecture for all attendees by

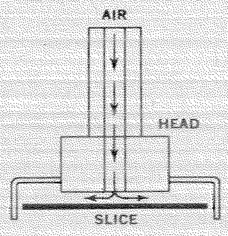
Dr. Paul D. Saltman, Provost
Revelle College, University of California,
San Diego

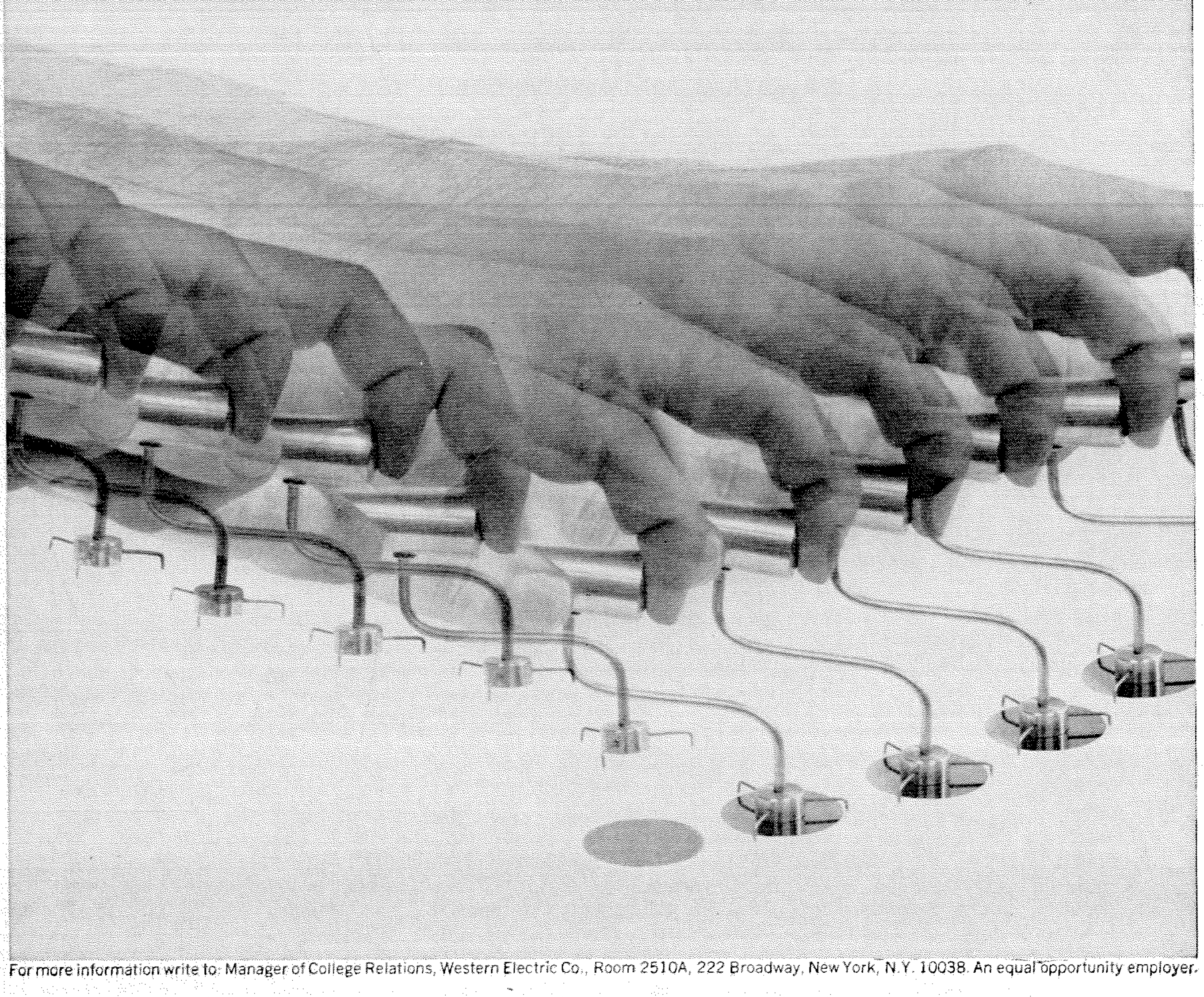
The day will end with a social hour and dinner at the Huntington-Sheraton Hotel

guest speaker

Mr. Thornton A. Wilson,
Executive Vice President
The Boeing Company

Complete program and registration form will be mailed in April


AIR
HEAD
SLICE



BOOKS

The Cassiopeia Affair

by Chloe Zerwick & Harrison Brown

Doubleday & Co. $4.50

A Caltech geochemist and political scientist has combined efforts with a writer friend to produce a unique literary mixture. *The Cassiopeia Affair* is a scientifically based, historical novel—the history of the future, that is. Set in the "late 1900's," the story deals with the intriguing possibility of life on another planet outside our solar system. A group of American scientists engaged in a government-sponsored project of "listening" for signals from other celestial bodies does, in fact, get a message from somewhere out in space near Cassiopeia 3579. How this shattering discovery affects both international relations and the personal lives of the people most closely involved is the substance of the novel.

Harrison Brown, whose previous writings have revealed his ability to describe both clearly and lyrically the excitement of science, has contributed these literary qualities to this novel. And, from personal experience with many of the situations and settings in the book (radio-telescope listening posts, the inner offices of government leaders in Washington, and the international gatherings of representatives of science and government), Dr. Brown is able to give credibility and authenticity to this story which lifts it out of the category of ordinary science fiction.

The writing, the characters, and the dialogue are sometimes uneven, but this is still a fast-moving, suspenseful story.

The Great Monkey Trial

by L. Sprague de Camp '30

Doubleday & Co. $6.95

"In this book I have tried to tell the story of the Scopes evolution trial of 1925, at Dayton, Tennessee, as truthfully as possible."

And—Mr. de Camp should have added— as thoroughly as possible. His research has been so extensive, in fact, that *The Great Monkey Trial* runs to more than 500 pages, containing everything that anyone will ever want to know about the Scopes trial—and then some. (For example, this is the way Mr. de Camp introduces John Scopes: "John Thomas Scopes, twenty-four, was a tall, slim, gangling, round-shouldered, freckled, blue-eyed youth with wavy blond hair, a high forehead, a long nose, and irregular features.")

Mr. de Camp handles this mass of material with great skill—which is not at all surprising when you consider that he is the author of about 40 books, ranging from science fiction to popular works on technology and archeology. His book is not just good reading; it should stand as the last word on this world-famous trial. After years in which our impressions and beliefs about the case have been variously colored by the biased reporting of H. L. Mencken, or the rousing dramatics of *Inherit the Wind,* Mr. de Camp has finally put the great monkey trial into true perspective.

The Star Lovers

by Robert S. Richardson

The Macmillan Company $7.50

Robert S. Richardson, a staff member of the Mount Wilson and Palomar Observatories for 25 years, retired several years ago to do free-lance writing. Today he is one of the most skillful, and prolific, writers in the field of popular astronomy.

The star lovers of Dr. Richardson's latest book are 16 famous astronomers whose lives span four centuries. They are not, as Dr. Richardson explains, "the sixteen greatest astronomers the world has known," but "men whose personality and work especially interested me. No apology is offered for omission of the numerous names that 'ought' to have been included."

Easy to read and seasoned with humorous glimpses into the personal lives of the astronomers, *The Star Lovers* neatly conveys the challenge and excitement of astronomy to the amateur. Explanations of the astronomers' achievements are written in such a way as to be comprehensible to laymen and acceptable to scientists.

The book begins in 1546 with the life of Tycho Brahe, a Dane who became one of the world's greatest observational astronomers prior to the invention of the telescope. It goes on to such colorful figures as Isaac Newton; Edmund Halley, who predicted the return of the comet that bears his name; John Goodricke, who during his 22 years of life observed the variable star Algol; Heinrich Samuel Schwabe, whose discovery of the 11-year sunspot cycle in the middle of the 19th century showed the world that the science of astronomy was not exhausted; Lady Huggins, a pioneer in celestial photography; and Albert Einstein.

The book ends with the stories of two men who were colleagues of Dr. Richardson's at the Mount Wilson and Palomar Observatories—Seth Nicholson, who discovered four satellites of Jupiter; and Walter Baade, whose research showed that the universe was twice the size it was then thought to be.

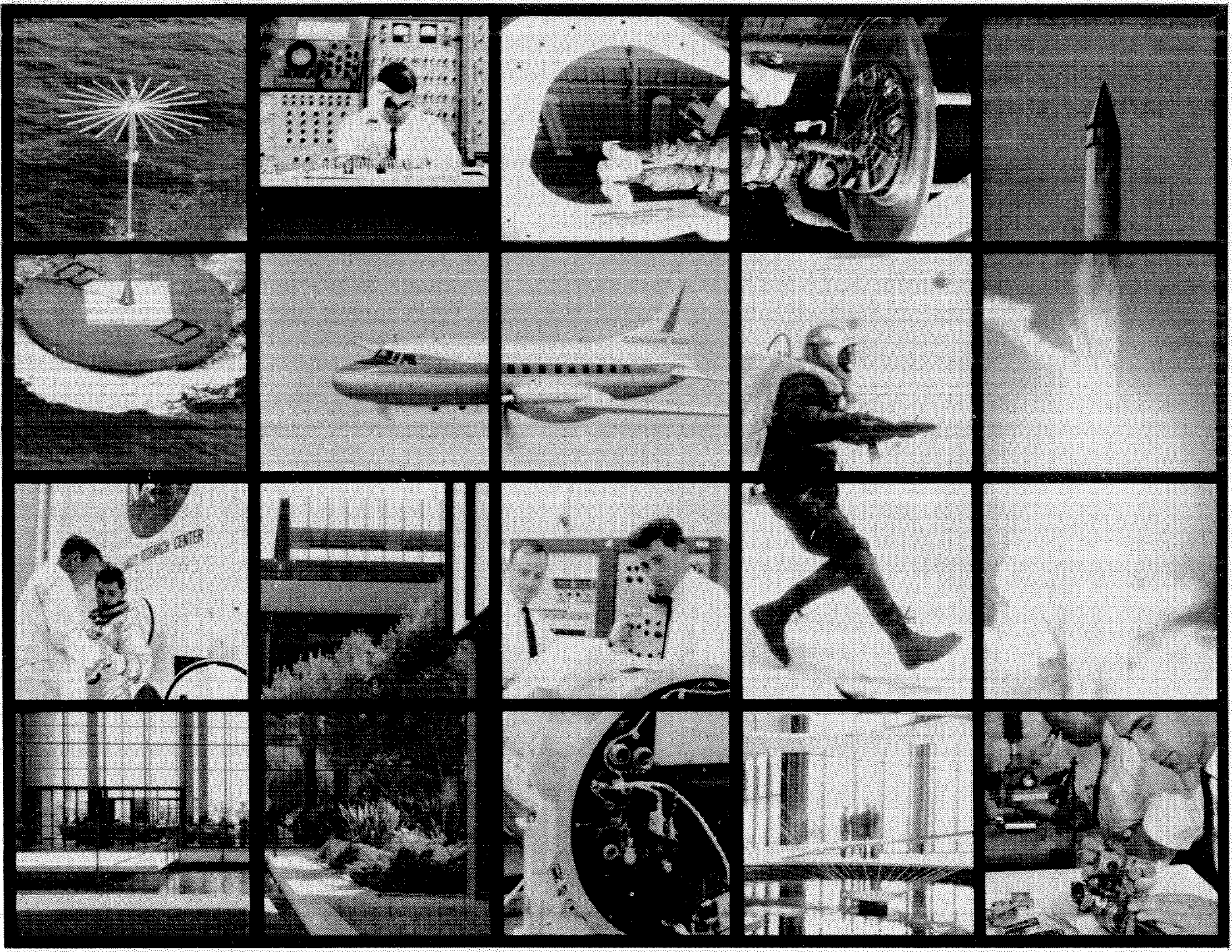
LETTERS

Pasadena

EDITORS

In my article, "Nuclear Power and Nuclear Proliferation," in the January issue of *Engineering and Science*, there was one editorial change which seemed to be misleading. The article began: "The materials necessary for nuclear bombs are spreading throughout the world. This will, of course, lead to an increase in the number of nations which have nuclear weapons." The text originally read: "The nuclear materials which are necessary for producing nuclear bombs are becoming widespread throughout the world. There is the danger that this diffusion of the essential bomb materials will lead to an increase in the number of nations which have nuclear weapons."

MILTON S. PLESSET



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E&S
February 1968, Vol XXXI, No 5

The Rocket Pioneers

Memoirs of the infant days of rocketry at Caltech

by Frank J. Malina

My interest in space exploration was first aroused when I read Jules Verne's *De la Terre à la Lune* in the Czech language as a boy of 12 in Czechoslovakia where my family lived from 1920 to 1925. On our return to Texas I followed reports on rocket work which appeared from time to time in popular magazines. In 1933 I wrote the following paragraph for a technical English course at Texas A. & M. College:

> *Can man do what he can imagine?*—Now that man has conquered travel through the air his imagination has turned to interplanetary travel. Many prominent scientists of today say that travel through space to the Moon or to Mars is impossible. Others say, "What man can imagine, he can do." Many difficulties present themselves to interplanetary travel. The great distance separating the heavenly bodies would require machines of tremendous speeds, if the distances are to be traversed during the lifetime of one man. Upon arrival at one of these planets the traveler would require breathing apparatus, for the astronomers do not believe the atmosphere on these planets will support human life as our atmosphere does. If a machine left the earth, its return would be practically impossible, and those on the earth would never know if the machine reached its destination.

In 1934 I received a scholarship to study mechanical engineering at the California Institute of Technology. Before the end of my first year there I began part-time work as a member of the crew of the GALCIT (Guggenheim Aeronautical Laboratory, California Institute of Technology) ten-foot wind tunnel. This led to my appointment in 1935 as a graduate assistant in GALCIT.

The Guggenheim laboratory at this time, a few years after its founding, was recognized as one of the world centers of aeronautical instruction and research. Under the leadership of Theodore von Kármán, GALCIT specialized in aerodynamics, fluid mechanics, and structures. Von Kármán's senior staff included Clark B. Millikan, Ernest E. Sechler, and Arthur L. Klein. The laboratory was already carrying out studies on the problems of high-speed flight, and the limits of the propeller-engine propulsion system for aircraft were beginning to be clearly recognized.

In 1935-36 William W. Jenney and I conducted experiments with model propellers in the wind tunnel for our master's theses. My mind turned more and more to the possibilities of rocket propulsion while we analyzed the characteristics of propellers.

In March 1935 at one of the weekly GALCIT seminars, William Bollay, then a graduate assistant under von Kármán, reviewed the possibilities of a rocket-powered aircraft based upon a paper published in December 1934 by Eugen Sänger, who was then working in Vienna. The following October Bollay gave a lecture on the subject before the Institute of the Aeronautical Sciences in Los Angeles.

Local newspapers reported on Bollay's lecture, which resulted in attracting to GALCIT two rocket enthusiasts—John W. Parsons and Edward S. Forman. Parsons was a self-trained chemist who, although he lacked the discipline of a formal higher education, had an uninhibited, fruitful imagination. He loved poetry and the exotic aspects of life. Forman, a skilled mechanic, had been working for some time with Parsons on powder rockets. They wanted to build a liquid-propellant rocket motor but found that they lacked adequate technical and financial resources for the task. They hoped to find help at Caltech. They were sent to me, and that was the beginning of the story which led to the establishment of the Jet Propulsion Laboratory.

After discussion with Bollay, Parsons, and Forman, I prepared in February 1936 a program to design a high-altitude sounding rocket to be propelled by either a solid- or liquid-propellant rocket engine.

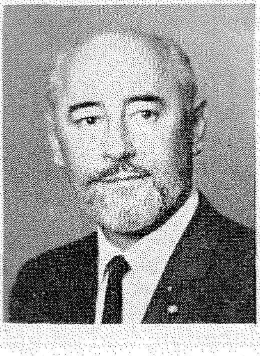
We reviewed the literature published by the first generation of space flight pioneers—Ziolkowsky, Goddard, Esnault-Pelterie, and Oberth. In scientific circles this literature was generally regarded as science fiction, primarily because the gap between the experimental demonstration of rocket-engine capabilities and the actual requirements of rocket propulsion for space flight was so fantastically great. This negative attitude extended to rocket propulsion itself, in spite of the fact that Goddard realistically faced the situation by deciding to apply this type of propulsion to a vehicle for carrying instruments to altitudes in excess of those that can be reached by balloons—an application for an engine of much more modest performance.

We concluded from our review of the existing information on rocket-engine design, including the results of the experiments of the American Rocket Society, that it was not possible to design an engine to meet specified performance requirements for a sounding rocket to surpass the altitudes attainable with balloons. After much argument, we decided that until someone could design a workable engine with a reasonable specific impulse there was no point in devoting effort to the design of the rocket shell, propellant supply, stabilizer, launching method, and payload parachute.

We therefore set as our initial program the following: (a) theoretical studies of the thermodynamical problems of the reaction principle and of the flight performance requirements of a sounding rocket; and (b) elementary experiments of liquid- and solid-propellant rocket engines to determine the problems to be met in making accurate static tests. This approach was in the spirit of von Kármán's teaching. He always stressed the importance of getting as clear an understanding as possible of the fundamental physical principles of a problem before initiating experiments in a purely empirical manner, which can be very expensive in both time and money.

Parsons and Forman were not too pleased with an austere program that did not include at least the launching of model rockets. They could not resist the temptation of firing some models with black powder motors during the next three years. Their attitude is symptomatic of the anxiety of pioneers of new technological developments. In order to obtain support for their dreams, they are under pressure to demonstrate them before they can be technically accomplished. Thus there were during this period attempts to make rocket flights which were doomed to be disappointing and which made support even more difficult to obtain.

The undertaking we had set for ourselves required, at a minimum, informal permission from Caltech and from the Guggenheim lab-



Frank Malina's supporting role in the drama of early rocket research at Caltech, as well as his part in the founding of JPL and the Aerojet-General Corp., is fairly well known. Less well known, however, is his enthusiasm for art and music. In the early fifties, with success in the field of aeronautics assured, Malina proceeded to achieve international recognition in the field of kinetic art—a unique combination of art and science in which paintings are luminous and mobile and controlled by electricity. He has lived in Paris since 1953, and his paintings have been exhibited throughout Europe and the United States. He is currently editor of *Leonardo*, an international journal of the contemporary artist, which he founded.

"The Rocket Pioneers" has been adapted from a paper prepared for the First International Symposium on the History of Astronautics held in Belgrade, Yugoslavia, in September 1967.

oratory before we could begin. In March I proposed to Clark Millikan that I continue my studies leading to a doctorate and that my thesis be devoted to studies of the problems of rocket propulsion and of sounding rocket flight performance. He was, however, dubious about the future of rocket propulsion and suggested I should, instead, take one of many engineering positions available in the aircraft industry at that time. His advice was no doubt also influenced by the fact that GALCIT was not then carrying out any research on aircraft power plants. Later he supported our work.

I knew that my hopes rested finally with von Kármán. Only much later did I learn that back in the 1920's in Germany he had given a sympathetic hearing to discussions of the possibilities of rocket propulsion and that in 1927 he had included in his lectures in Japan a reference to the problems needing solution before space flight became possible. He was at this time studying the aerodynamics of aircraft at high speeds and was well aware of the need for a propulsion system which would surmount the limitations of the engine-propeller combination.

After considering my proposals for a few days, von Kármán agreed to them and gave permission for Parsons and Forman to work with me, even though they were neither students nor on the staff at Caltech. This decision was typical of his unorthodox attitude within the academic world. He pointed out, however, that he could not find funds.

During the next three years we received no pay for our work, and during the first year we bought equipment—some secondhand—with whatever money we could pool together. Most of our work was done on weekends or at night.

We began our experiments with the construction of an uncooled rocket motor similar in design to one that had been previously tried by the American Rocket Society. For propellants we chose gaseous oxygen and methyl alcohol.

Our work in the spring of 1936 attracted to our group two GALCIT graduate students, A.M.O. Smith and Hsue Shen Tsien. Smith was working on his master's degree in aeronautics; Tsien, who became one of the outstanding pupils of von Kármán, was working on his doctorate. Smith and I began a theoretical analysis of flight performance of a sounding rocket, while Tsien and I began studies of the thermodynamic problems of the rocket motor.

The work of our group had the benefit of advice from von Kármán, Clark Millikan, and other GALCIT staff members. We realized from the start that rocket research would require the ideas of many brains in many fields of applied science.

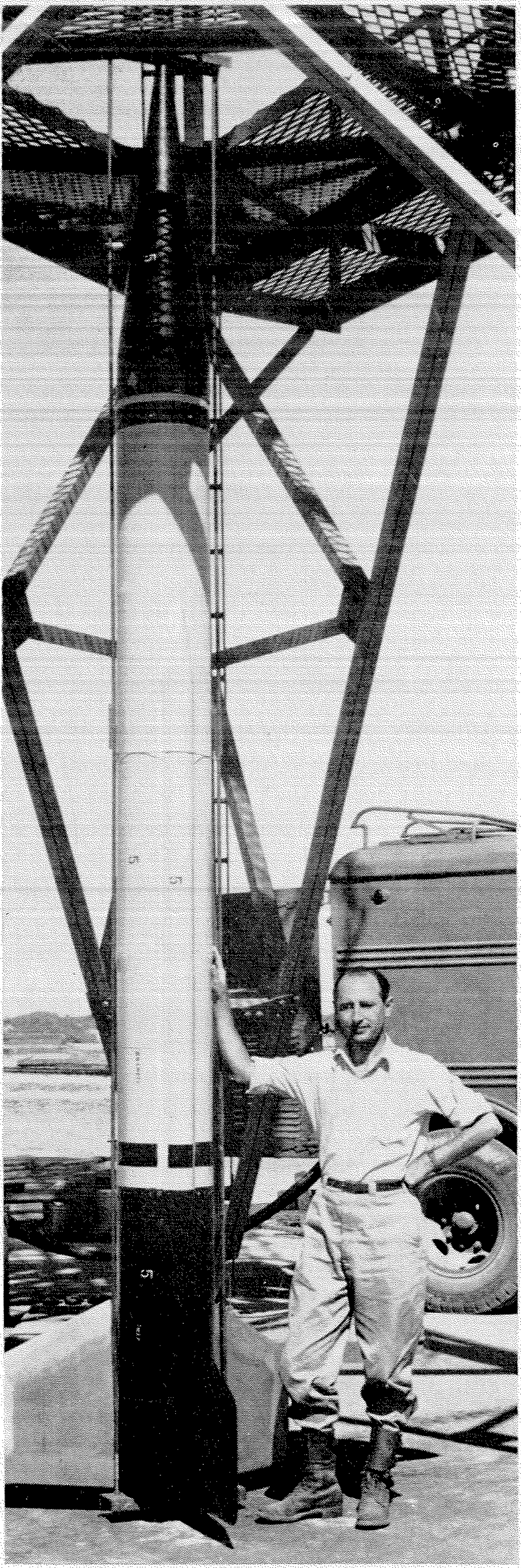
I was very fortunate at this time to enter von Kármán's inner circle of associates because he needed someone to prepare illustrations for the textbook *Mathematical Methods in Engineering* which he was writing with Maurice A. Biot. Bollay had been assisting von Kármán with the manuscript of the book, and when he left for Harvard University, I inherited his job as "caretaker" of the manuscript.

Thereafter I worked with von Kármán on many projects until his death in 1963. In a way he became my second father. We worked so closely during the formative years of the Jet Propulsion Laboratory that it is not always possible to separate the contribution either of us made to technical and organizational developments during the period 1939 to 1944.

It is necessary to point out, however, that during the period of the GALCIT Rocket Research Project the initiative rested with our group, and it fell to me to hold it together.

The group heard with excitement in 1936 that Robert H. Goddard would come to Caltech in August to visit Robert Millikan. Millikan was a member of a committee appointed by the Daniel and Florence Guggenheim Foundation to advise on the support given by the foundation to Goddard for the development of a sounding rocket. Millikan arranged for me to have a short discussion with Goddard on August 28, during which I told him of our hopes and research plans. I also arranged to visit him at Roswell, New Mexico, the next month, when I was going for a holiday to my parents' home in Brenham, Texas.

Both Dr. and Mrs. Goddard received me cordially. My day with him consisted of a tour of his shop (where I was *not* shown any components of his sounding rocket), a drive to his launching range to see his launching tower and 2,000-lb.-thrust static test stand, and a general discussion during and after lunch. He did not wish to give any technical details of his



Frank Malina with the Wac Corporal at White Sands, New Mexico, in November 1945.

current work beyond that which he had published in his 1936 Smithsonian Institution report, with which I was already familiar. This report was of a very general nature and of limited usefulness to serious students.

The impression I obtained was that Goddard felt that rockets were his private preserve, so that any others working on them took on the aspect of intruders. He did not appear to realize that in other countries there were men who had arrived, independently of him, at the same basic ideas for rocket propulsion, as so frequently happens in technology.

Von Kármán in his autobiography *The Wind and Beyond* writes:

> I believe Goddard became bitter in his later years because he had no real success with rockets, while Aerojet-General Corporation and other organizations were making an industry out of them. There is no direct line from Goddard to present-day rocketry. He is on a branch that died. He was an inventive man and had a good scientific foundation, but he was not a creator of science, and he took himself too seriously. If he had taken others into his confidence, I think he would have developed workable high-altitude rockets and his achievements would have been greater than they were. But not listening to, or communicating with, other qualified people hindered his accomplishments.

With this background to the relations between Goddard and the project, a summary of his effect on our work can be made. This appears needed, for erroneous impressions exist as to his influence on rocket research at Caltech.

As I pointed out earlier, the stimulus leading to the formation of the GALCIT Rocket Research Project was Sänger's work in Vienna. Like Goddard, our group at first believed that the most promising practical application of rocket propulsion would be a sounding rocket for research of the upper atmosphere, which was of interest at Caltech in connection with cosmic ray studies and with meteorology requirements. Actually it did not turn out this way, for the first application of rocket power we successfully made was in assisting the takeoff of aircraft.

Our group studied and repeated some of Goddard's work with smokeless powder, impulse-type motors, which he reported on in his Smithsonian report of 1919. Work on this type of solid-propellant rocket motor was, however, dropped by the group in 1939 in favor of developing one of constant-pressure, constant-thrust type. Goddard's smokeless powder rocket engine did, however, find application in armament rockets during World War II.

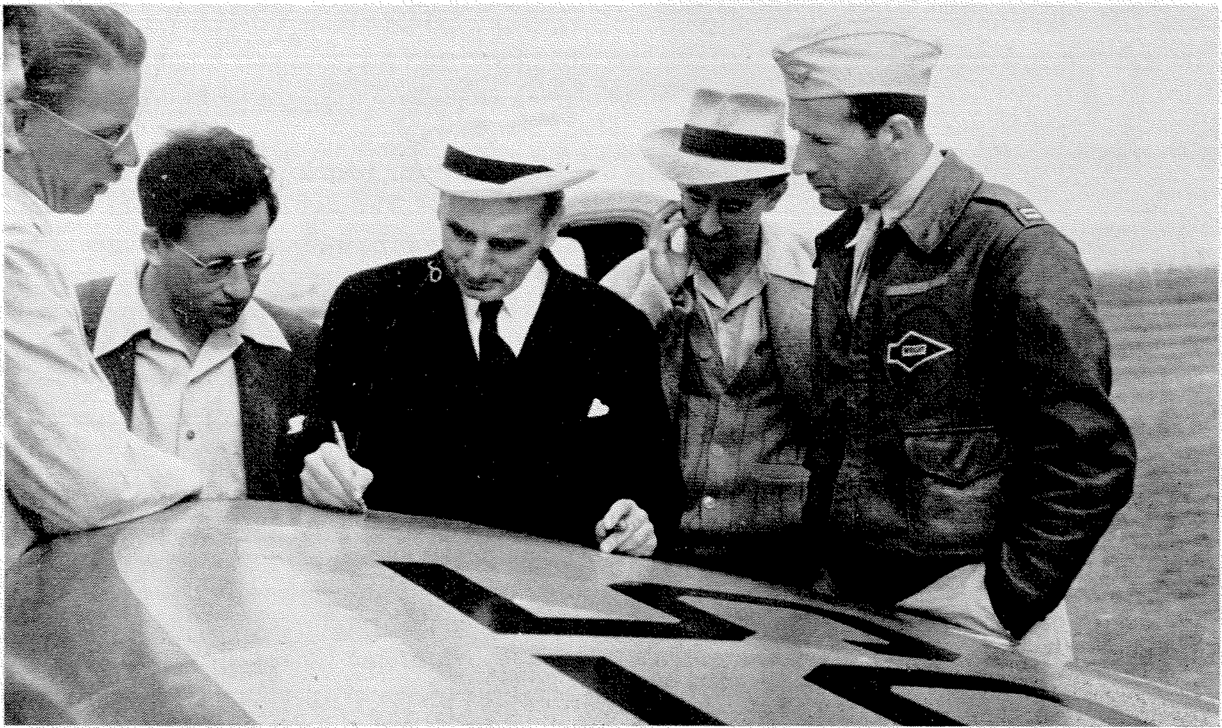
There is no doubt that had Goddard been willing to cooperate with our Caltech group his many years of experience would have had a strong influence on our work. As it happened, our group independently initiated the development of different liquid and solid propellants from those that Goddard studied. Finally in 1944 when I initiated the construction of the Wac Corporal sounding rocket at the Jet Propulsion Laboratory, it bore little technical relation to Goddard's sounding rocket of 1936, about which we still did not have any detailed information.

On October 29, 1936, the first try of the portable test equipment was made for the gaseous oxygen-methyl alcohol rocket motor in the area of the Arroyo Seco back of Devil's Gate Dam on the western edge of Pasadena—a stone's throw from the present-day Jet Propulsion Laboratory. I learned several years later from Clarence N. Hickman that he and Goddard had conducted smokeless-powder armament rocket experiments at this same location during World War I.

In November, I wrote home as follows:

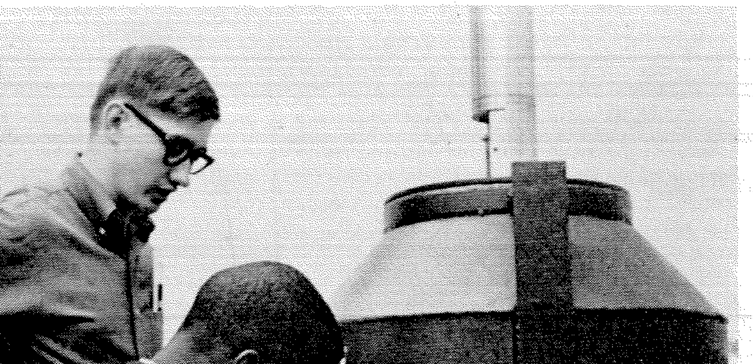
> This has been a very busy week. We made our first test on the rocket motor yesterday. It is almost inconceivable how much there is to be done and thought of to make as simple a test as we made. We have been thinking about it for about six months now, although we had to get all the equipment together in two days, not by choice, but because there are classes, and hours in the wind tunnel to be spent. Friday we drove back and forth to Los Angeles picking up pressure tanks, fittings and instruments. Saturday morning at 3:30 a.m. we felt the setup was along far enough to go home and snatch three hours of sleep. At 9 a.m. an Institute truck took our heaviest parts to the Arroyo, about three miles above the Rose Bowl, where we found an ideal location. Besides Parsons and me, there were two students working in the N.Y.A. working for us. It was 1 p.m. before all our holes were dug, sandbags filled, and equipment checked. By then Carlos Wood and Rockefeller had arrived with two of the box type movie cameras for recording the action of the motor. Bill Bollay and his wife also came to watch from behind the dump.
>
> Very many things happened that will teach us what to do next time. The most excitement took place on the last "shot" when the oxygen hose for some reason ignited and swung around on the ground, 40 feet from us. We all tore out across the country wondering if our check valves would work. Unfortunately Carlos and Rocky had to leave just before this "shot" so that we have no record on film of what happened. As a whole the test was successful.

continued on page 30



The GALCIT rocket research group makes final plans for the first jet-assisted takeoff test flight in 1941. From left: Clark Millikan, Martin Summerfield, Theodore von Kármán, Frank Malina and pilot Homer Boushey.

CHEMICAL GAMESMANSHIP



James King Jr., JPL research group supervisor, uses a Geiger counter to check the radaition level around a cobalt-60 gamma ray source. This equipment is used in experiments at JPL done by chemistry graduate student Thomas Penner (upper left).

Caltech scientists are engaged in a kind of scientific gamesmanship in an effort to find out how radiation produces chemical changes in materials.

The research is being done by George S. Hammond, Arthur Amos Noyes Professor of Chemistry and acting chairman of the division of chemistry and chemical engineering, along with other members of his research group. They are taking what is already known about photochemistry—the study of chemical changes produced by light—and applying it to elucidate the fundamental mechanisms of chemical changes initiated by high-energy radiation such as gamma rays.

Gamma rays, which are a very energetic form of x-rays, and light rays are both beams of energy in tiny units called photons. The energy of each gamma photon is much greater than the energies of photons in visible or ultraviolet light. High-energy gamma rays move easily through matter, but when an interaction with a molecule of matter does occur, the molecule literally explodes and ejects high-energy electrons. Most of the chemical changes are not caused directly by these primary interactions but by secondary effects. The electrons produced in the blowup excite other molecules, producing excited states similar to those formed by absorption of light.

The photochemistry of some substances is well known; these substances are used as excitation monitors in the radiochemical experi-

Caltech chemists use what they know about photochemistry to find out more about the fundamental mechanisms of chemical changes initiated by high-energy radiation.

ments. These chemical detectors are put into a system in small amounts, and samples are then irradiated with gamma rays. Excited states of solvent molecules are produced which transfer energy to the test molecules which act as energy scavengers. Analysis is performed to show the extent to which the scavengers have reacted by paths already familiar from photochemical studies. Finally, the results are read backwards to tell the investigator about the forms of excitation deposited along the track of the gamma ray.

Last year John King, now a chemist in the Chevron Research Laboratory in Richmond, California, did work using an organic material called TMO (tetramethyloxetanone) as a scavenger. TMO undergoes an especially simple photochemical reaction in which it falls apart to give two simpler substances, acetone and tetramethylketene. However, decomposition occurs only from excited singlet states of TMO, not from the related triplet excited states. By measuring the yields of the decomposition products from TMO in benzene solutions, Dr. King was able to make the first accurate measurement of the yield of transferable singlet excitations in the gamma radiolysis of benzene.

Sometimes the game turns out to be more complicated than anticipated. At the present time Thomas Penner, a graduate fellow, is studying the gamma-induced reactions of CHD (1,3-cyclohexadiene). The photochemical behavior of CHD has been previously studied carefully by other members of Dr. Hammond's research group, so it seemed easy to use the substance as an energy scavenger. Irradiation of benzene solutions of CHD led to formation of the familiar photoproducts—along with other unexpected products. Apparently the scavenger is catching and using two kinds of excitations. At this stage in their research Dr. Hammond and Mr. Penner believe that the nonphotochemical products arise from positive ions, but still more experiments with scavengers for ions will be required to confirm their suspicions.

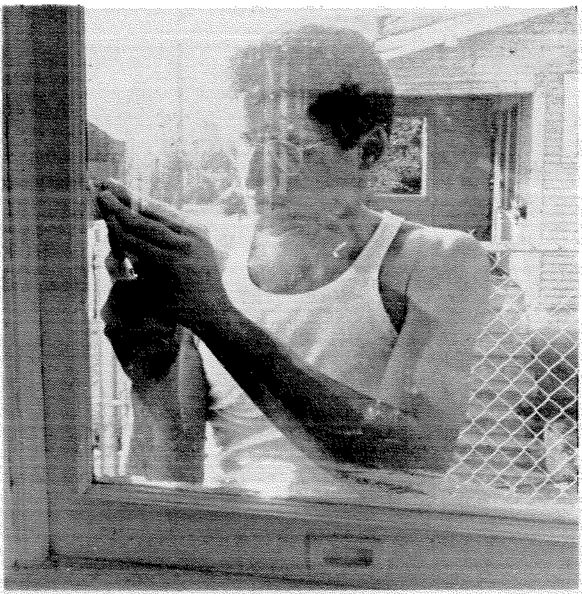
Radiation is constantly showered on the earth from the sun, from cosmic rays, and from other natural sources. This radiation bath causes many chemical changes in materials. The consequences range from the life-sustaining storage of light energy by green plants to death from acute radiation sickness in animals.

The Caltech experiments might lead to development of chemical mechanisms for protection against chemical damage from radiation in nonliving materials. In living things, however, the physiological toxicity problems and the dynamic activity within the living system that moves foreign materials around would have to be observed carefully.

The experiments are carried out using the cobalt-60 gamma source at the Jet Propulsion Laboratory and supported by a contract from the Air Force Office of Scientific Research.

THREE DAYS IN THE "GHETTO"

by Michael Meo



The author does his share toward rehabilitating the Westside Study Center headquarters in Pasadena.

A briefing session, attended by participants, prepares Caltech students for "the actualities of ghetto life."

No domestic question has the importance today of the Negro problem—yet few issues are less easily resolved by means of the traditional Caltech method of equation and slide rule. In order to give Caltech students a first-hand acquaintance with the actualities of ghetto life, the Caltech YMCA sponsored a program last month in which 20 students lived and worked in northwest Pasadena for three days, sleeping in the homes of Negro hosts at night and participating in social work during the day. The major focus of the program to those participating was in the area of communication, and the reactions of the students varied according to either the enhancement or frustration they experienced in this area.

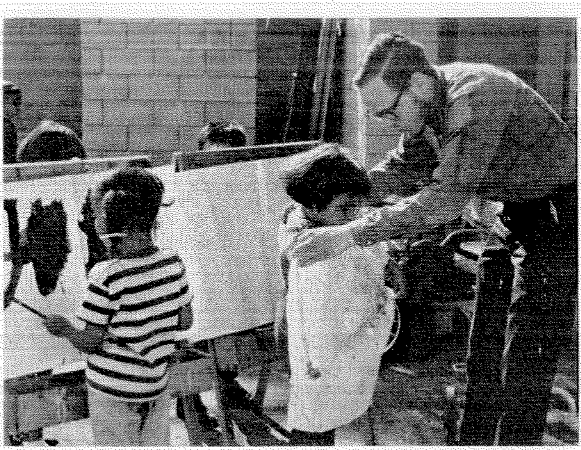
The living-in was "Phase Three" of the Y project, "The Urban Ghetto: Blight and Promise," that has already sponsored a visit to the campus by United States Senator Thomas Kuchel and the stay on campus of a dozen or so articulate Negroes who lived in the student houses for three days. The Westside Study Center, a community social service organization run by Pasadena Negroes, was co-sponsor with the YMCA of "Phase Three." A keynote present in both organization and execution of the project was informality—informal assignments, informal requirements of the host.

Because of an unfortunate stress on the word "ghetto," the view many students had received of the Pasadena ghetto before they entered the program was usually considerably different from the reality they encountered. Some expected to see rats biting children, but they did not; few "ghetto facts to make an honest man shudder" came to light. Indeed, most of the homes to which the Caltech students were assigned were middle class; I slept one night in a home which had a swimming pool.

If the aim of the project was limited to showing liberal-minded Caltech students (for they were the only kind who participated) that Negroes are people who are just as kind, generous, and friendly as white people, then it succeeded overwhelmingly. The students' reception, in spite of the fact that one Caltech participant was beaten up as he walked along Fair Oaks Avenue the final afternoon of the program, was extremely hospitable. After only one day in the ghetto, students commented on the large number of blacks who uncritically accepted them as comrades, joked and laughed with them. After three days at a Head Start program center, one Caltech student half-seriously boasted that he was an "old hand" around the place. What was true where the students worked was even more true where they slept. Almost every family invited its guest to return some day, and many mothers described their guest as "one of the family." No participants had any reservations in their praise of this aspect of the program.

The superficial acceptance among ghetto

A Caltech senior reports on his brief exposure to ghetto life in Pasadena



Warren Burton, assigned to work in a Head Start Center for three days, now volunteers every week.

residents made some students overly optimistic about their experiences. Relief that they were not ignored, resented, or viewed with suspicion (as had been predicted they might), made many students feel that their ability to communicate with and understand black people and their problems was greatly heightened. One of the participating students likened his experiences with the Negro problem to a three-stage development. When he came to Caltech he was in *ignorance;* when the Negro tutors spoke to him last term about life in the ghetto, he *conceived* the magnitude of the problem; finally, after spending 72 hours in the Pasadena ghetto, he reached the level of *understanding.* Negro hosts and co-workers, however, doubted the validity of such sweeping statements.

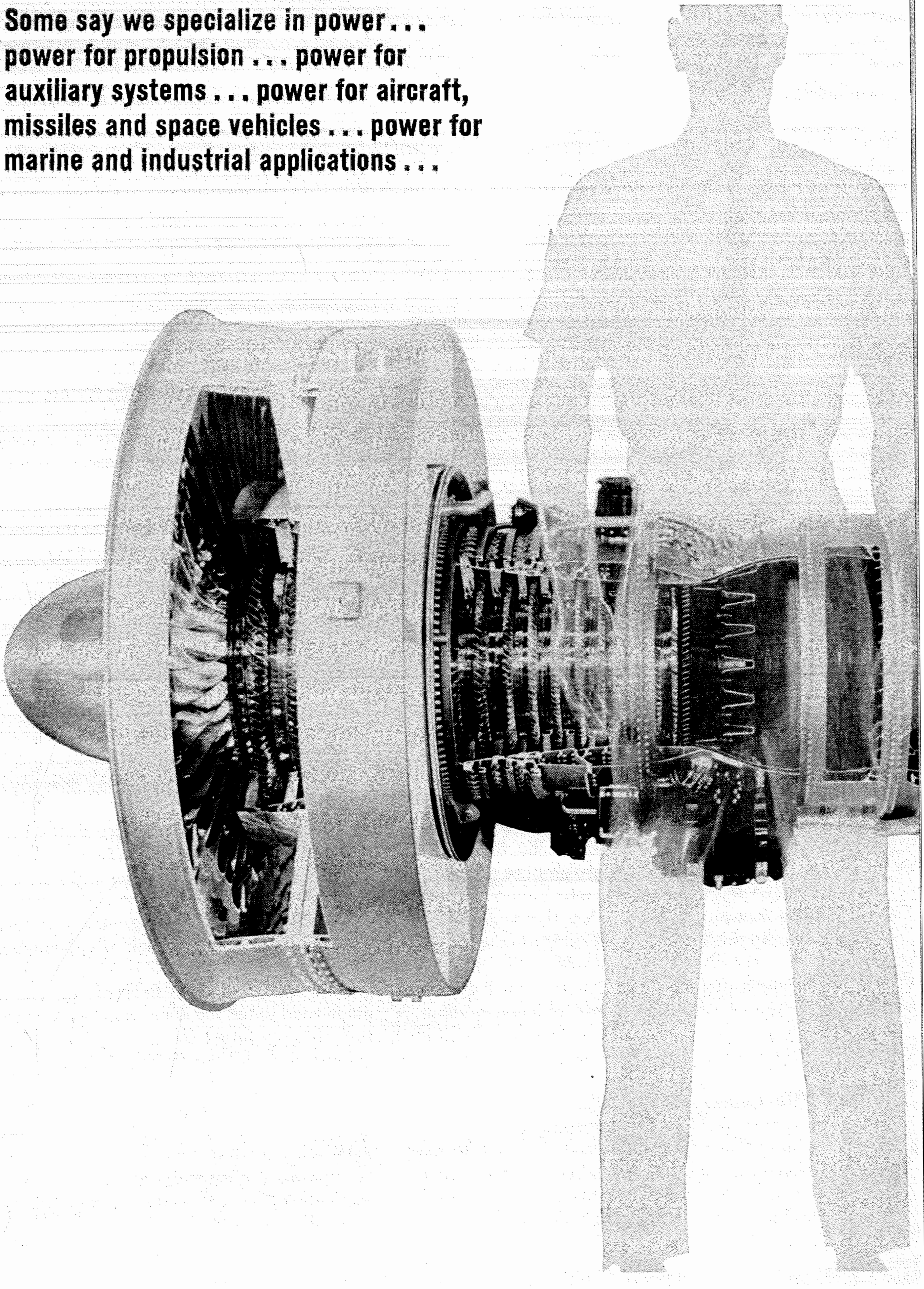
In contrast to the roseate visions of some of the Caltech students, many Westside Study Center personnel had pessimistic apprehensions about the white man's approach to the Negro problem. And on other occasions a more open and puzzling hostility manifested itself. One way for the students to deal with this hostility was to join it. Once the Caltech students had found that the Pasadena Negroes would readily work and laugh with them, they usually made little effort to probe further. Some of those who did probe more deeply were willing to accept a one-sided view of the problem and to repeat what I call the black "party line."

To explain the term, consider that it is an Establishment "party line" that only hoodlums and criminals were responsible for the riots in American cities recently. Such a one-sided view is disproved by the fact that there were 65 race riots last summer alone and the fact that riots have been breaking out for the last three years. Most intelligent men reject such a formulation of the story. I call a black "party line" an explanation of current history that has similar oversimplification and bald disregard of contradictory evidence, but tends to shift the blame on the whites. An example of the black "line" is the allegation that every major American city is a concentration camp, and that the mayor and the police chief are the keepers; yet such is the feeling of a number of Caltech students after listening and watching for three days in the northwest of Pasadena.

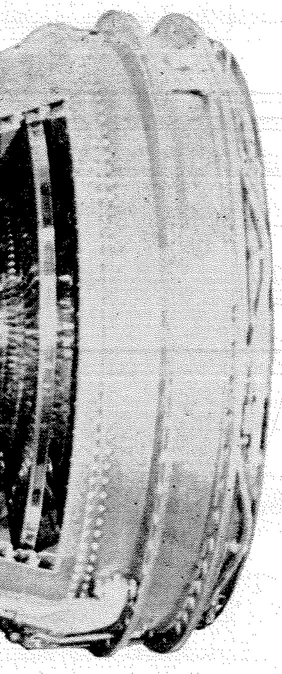
Another example is the tendency of black men to overemphasize their disadvantages. One boy whose father had an MA and whose grandparents had only finished the eighth grade tried to tell me about his disadvantage. But my own father has only a BS and my grandparents did not finish grammar school.

If the YMCA program had as its goal the appreciation by its participants of the psychic as well as the socioeconomic distance between the black and white communities, it had partial success; if it intended to foster real communication it was, to a great extent, only superficially successful.

Some say we specialize in power . . . power for propulsion . . . power for auxiliary systems . . . power for aircraft, missiles and space vehicles . . . power for marine and industrial applications . . .



...they're right. And wrong.



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Science and the Rising Sun

by F. Roy Lockheimer

*Creative science in Japan needs cultivating —
a specialist in Far Eastern affairs tells why.*

Japan is the only Asian country to have industrialized successfully, and it has done so extremely well. Japan today is first in the production of ships, second in the production of automobiles, third in the production of steel in the world, and will very shortly, I predict, become the fourth nation to launch its own satellites with its own rockets. All of this adds up to the somewhat startling fact that Japan is today the third most significant industrial unit in the world. That is quite a development in less than 100 years.

In nearly every aspect of its national life, Japan was a well-developed society in the middle of the 19th century—perhaps more developed than some underdeveloped countries are today. Every field of endeavor that existed in the West flourished in Japan before 1868 except science and its ensuing technology. In the mid-19th century, however, after 250 years of almost complete seclusion, Japan was abruptly shaken out of its isolation by an expansionist West whose source of strength stemmed from a rich scientific tradition that was unknown in Japan. At the same time, internal tension had brought the country close to dangerous strife at the highest levels of government. The old regime was weak, near the point of collapse.

Yet, within 15 years after the appearance of Perry's ships, Japan had not only set its house in order, but it had also launched a wildly successful program of nation-building along Western lines. *Fukoku kyōhei* ("rich country, strong army") became a national password, and priorities were adjusted accordingly. If the country was to become a Western-style power, then Western science would have to be imported just as it was. While Japan possessed an artistic and philosophical basis for exchanging ideas with the West at all levels, it had no basis for a scientific exchange and thus no possibility for adaptations and modifications to lead to new approaches.

Even before the government was stabilized and had begun introducing Western science into the nation, almost 100 Japanese had been abroad for foreign study. Although this number may not appear large, its significance becomes clearer when it is realized that as a general rule foreign travel was prohibited. The government itself sponsored study abroad for the first time in 1862 and by 1868 had sent 47 students abroad for study in France, Great Britain, the Netherlands, Russia, and the U.S.

Time was not wasted on "frills." Whatever was needed to make the nation prosperous and strong received emphasis: medicine, gunnery, engineering, general science, agriculture, manufacturing, and commerce. By 1912, more than 65 percent of all the students who had gone abroad for study under sponsorship of the Ministry of Education had specialized in the "hard" areas of the basic and applied sciences, especially the latter. (The only other major emphasis was on legal studies—encouraged to help make Japan strong and independent.)

The government was dedicated to strengthening the country as rapidly as possible. If desired results could not be obtained at home with native talent, or if study abroad proved inadequate, then what was needed could be imported—not only foreign teachers, but foreign technology, patents, licenses, and publications. All was done at great expense, but with spectacular results. The goal of developing Japanese science was certainly a long-range one, but for reasons of expediency rather short-range measures were adopted—with the result that even today Japan is without a strong creative tradition in basic science. There comes a time when the price of foreign technology becomes too high.

JAPAN ADAPTS TO WESTERN SCIENCE

Japan was able to receive Western science, and adapt it to its purposes, because by the mid-1800's existing conditions were quite conducive to the development of science. The country had a flourishing culture based on a settled agricultural economy, with educational institutions, communications, a bureaucracy, and a tradition of scholarly discourse, as well as some preliminary accumulation of scientific knowledge by individual scholars who had limited contact with Western scientific publications. It was also a national entity—a state. Japan possessed large cities and a developing national economy. The country was not divided by differences in language or culture; on the contrary, the insularity of the Japanese islands had engendered strong feelings of unique identity among the people. The tradition of centralized government and bureaucracy was a valuable legacy, as was a well-developed national system of education.

No matter how well endowed a country may be in the prerequisites for science, its society may not respond favorably—or even with monumental inertia—to the introduction of scientific concepts. But once science is broadly introduced and well received within a society, then social change is bound to occur. Japan's experience is testimony to this process.

Japan's natural insularity made the Japanese suspicious of foreigners, but it also made them very curious about the outside world. Even before the 16th century they had shown great interest in Chinese cultural achievements, many of which they adapted to their own use. Acceptance of foreign ideas, therefore, was not a new aspect of Japanese history by the 19th century. Informed Japanese could understand that their country did not have all the answers, that there was much to be learned from the outside world.

The Japanese are keenly competitive, success-minded, goal-oriented people. Causes, conditions, and circumstances change, and when they do, Japanese values change with them. If the majority of the Japanese were antiforeign when Perry attempted to end their isolation, in less than 15 years those same Japanese were reaching with enthusiasm for Western ways. Three generations later, another majority of Japanese were convinced that their nation was invincible and that they would fight to the last rather than surrender, but after a few short and painful years, they surrendered in all meekness, submitting to defeat and occupation at foreign hands. Why? Part of the explanation in both cases for this amazing change in national attitudes is that national circumstances had changed; therefore, so did national goals. The Japanese drive for success was not altered; they simply adjusted to new goals, which now seemed proper against the background of their new environment.

Japan's value system, with its situational ethic and goal orientation, allowed the nation an extraordinary receptivity to science after 1850, much in the same way that it allowed the population to behave with dignity and cooperation while under the occupation of a formerly detested enemy after 1946.

But it is one thing to recognize national needs and quite another to respond quickly to fulfill those needs, even with a high degree of national receptivity to foreign concepts. Leadership is required. This leadership was undertaken by the Japanese government, beginning a tradition of governmental initiative and bureaucratic influence in the sciences that has continued to the present.

THREE PERIODS OF SCIENTIFIC GROWTH

A broad view of the development of science and technology in Japan over the past century shows three main periods of growth: (1) 1868 to the outbreak of World War I, 1914; (2) the interwar period, 1918-1937; (3) the period after World War II, 1945 to the present.

The first period saw the establishment of many of the basic educational institutions that had the responsibility of training native scientists. The University of Tokyo was founded in 1877, then reorganized and combined with the college of technology in 1886 as Tokyo

Imperial University. The government-sponsored ordinance which defined the character of the Imperial University stated the school's purpose clearly: "The aim . . . shall be to teach and study such sciences and practical arts as meet the demands of the State." Other imperial universities were established in Kyoto, Sendai, and Fukuoka. As early as 1884, an astronomical observatory was established at the University of Tokyo.

The first steps taken by the government toward the development of native science and technology were more internal ones, however. A ministry of engineering was established in 1870, and under its aegis the building of railways and lighthouses, the erection of telegraphic services, and the development of modern techniques in mine and factory management were all implemented.

NATIONAL POWER—FIRST PRIORITY

During the second major period of Japan's development of science from 1914 to 1937, tremendously significant advances were made in heavy industry and its supporting technology, again with the building of national power receiving first priority. Electricity, gas, chemicals, ceramics, metals, machinery—all employing the most recent improvements in technology and in methods of mass production—made large strides forward. But, faced with the prime responsibility of expanding national power, Japanese science during the interwar years did not have time to keep up with foreign scientific developments.

The interruption in scientific communication caused by the outbreak of World War I made the Japanese realize how dependent their science was on foreign sources of information. Japanese attention was drawn to the task of creating an independent foundation for scientific research, again largely under government initiative and direction. Although concern was expressed at the time about the need to develop a better foundation for basic science, it is probably fair to say that the *raison d'etre* of the new research institutes was to serve industrial and military technology.

With the launching of its program of aggression on China in 1937, Japan's science and technology were mobilized for war. Basic science, the investigation of phenomena for the advancement of knowledge without necessarily seeking practical applications, never was given a chance to take root in Japanese soil. The brief period of promise after World War I, when there was a slight opportunity for the development of independent science in Japan, went unfulfilled. Within three generations, science in Japan had progressed from magic to a foundation for national development—only to suffer an almost disastrous blow from the distorted influence and increasing isolation brought on by the military adventures that eventually led to defeat in World War II.

Japanese science did not grow during World War II. Some important technological innovations were made to meet wartime requirements, but, duplicating the experience of World War I and with very much increased gravity, Japan was cut off from worldwide scientific developments.

Defeat in war brought Japan under military occupation for almost seven years, during which time significant change was wrought in the organization of national science and technology. In the early days of the occupation, scientific research in Japan almost came to a halt. Any investigation that had military implications was naturally prohibited, especially studies concerning atomic energy. Interestingly enough, Japanese investigation of the effects of atomic bombings was not entirely prohibited. Gradually, as the occupation developed more confidence in itself and in the Japanese, the resumption of research was permitted, and in some cases even encouraged.

ADVICE TO DEMOCRATIZE

One of the recommendations made by American scientific advisory missions to the occupation authorities was to discourage the Japanese tendency to organize science and scientists on a hierarchical basis. As a result, the occupation encouraged the democratization of the Japanese scientific world on all fronts. The establishment of the Science Council of Japan (SCJ) in 1949 was a direct result of this occupation policy. The primary aim of the SCJ was to mobilize professional talent in all fields to advise the government in the development of science and technology, research utilization, research training, scientific administration, and the infusion of science into industrial and national life. Unfortunately, drastic changes occured in the Asian political setting in 1949, and, as a consequence, relations between the government and the occupation authorities on one side, and the SCJ on the other, became increasingly strained. Japanese science since that time has been heavily political through the efforts of various groups.

SCIENCE FOR WAR AND PEACE

The shibboleth of politically oriented Japanese scientists is peace, and consequently all research becomes divided into two categories: peace and war. This extreme sensitivity to possible military applications of scientific research —both a legacy from wartime experience and a requirement of postwar conformity to an anti-military posture—has caused, for example, serious delays in the development of Japanese space science. Research in rocketry may be permissible, the reasoning goes, but since guidance systems help to turn observation rockets into war missiles, guidance systems had better be avoided. Research on guidance systems was not emphasized for a long time at the University of Tokyo, and, perhaps as a consequence, the university has yet to achieve success in orbiting a scientific satellite.

During 1966 and 1967, the University launched three Lambda rockets, somewhat similar to the American Scout rocket. The primary design purpose of the Lambda was probably not to launch a satellite, but there was some possibility that it could, so the Japanese decided to see if it would work. The Lambda Rockets were launched from Uchinoura, the most important space base in Japan, which is run by the University of Tokyo. The Ministry for Science and Technology has yet another base in Tanegashima, and there is a military base on the island of Niijima off Tokyo. This points up the division in rocket research sponsored by the government, by education, and by the military. The scientists who engage in rocket research for the military do not participate in the space research activities being carried out at the University of Tokyo, primarily because the university wants to develop rockets only for peaceful purposes.

If the politicizing of science and the hypersensitivity of certain scientists to alleged schemes of the military to control research activity are unhappy conditions that evolved out of the occupation period, the increased participation and greater mobility of Japanese scientists are decidedly happy results. Although the occupation wrought these changes in attitudes as well as others in scientific education, in the organization of research institutes and scientific societies, and in the direction of international scientific exchange, the foundation of science in Japan went unaltered.

Government initiative and the importation of foreign technology remain the basic keystones of science in Japan. Creative science has yet to come to full bloom. Like other nations, Japan cannot escape the influence of its history. The old master-apprentice relationships, the custom of secret techniques, the prestige of the national over the private universities, the tendency to departmentalize and equalize research, the consciousness of a hierarchy and mutual exclusiveness among researchers in universities and in industry, the fear of military applications—all of these factors have worked both to impair scientific cooperation and to hinder the development of creative scientific traditions.

THE LESSON TO BE LEARNED

After a century of development in the sciences, the problems of basic science and the development of its creative aspects are beginning to be given national recognition in Japan. The country is groping for the establishment of a national science policy. Such a program might go a long way in replacing jealousy, suspicion, rivalry, and shortsightedness with scientific cooperation.

The most important lesson that can be drawn from the Japanese experience is that no matter how much effort is spent on building scientific traditions swiftly, there is neither a shortcut nor a substitute for the development of a nationally based, cooperatively organized, research foundation for the stimulation of creative, basic science. Science through government initiative and foreign technology, and science for national power, may offer significant encouragement for the growth of native scientific traditions, but creative science does not appear to flourish until scientific research is supported for its own sake, without any immediate thought of practical applications.

THE MONTH AT CALTECH

EXPLORER'S BIRTHDAY

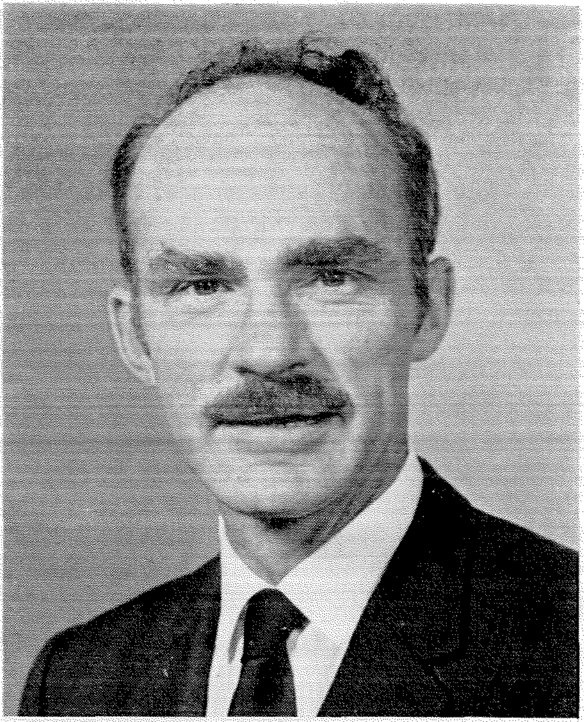
More than 200 prominent physicists, space executives, and military officials gathered in Caltech's Beckman Auditorium on February 1 for a two-day symposium celebrating the tenth anniversary of the launching of Explorer I—and the beginning of the space age in American science.

Speakers at the Explorer Anniversary Symposium included James A. Van Allen, head of the University of Iowa's physics and astronomy department, who verified the radiation belts discovered by Explorer I; Lt. Gen. Austin W. Betts, chief of research and development, U.S. Army; John Findlay, chairman of the lunar and planetary missions advisory board of NASA; and Joseph Kaplan, UCLA professor of physics, who was U.S. Chairman of the International Geophysical Year when the first Explorer was launched.

Following the first day of the symposium, Lee A. DuBridge, president of Caltech, and William H. Pickering, director of Jet Propulsion Laboratory, were hosts at an anniversary banquet at the Huntington-Sheraton Hotel.

Explorer I, developed at JPL, was launched at 3:55 a.m. on February 1, 1958, following a hectic 80-day period after the Soviets launched Sputnik I. The satellite was carried into orbit by the Jupiter C rocket and its Redstone first stage, designed and built by an Army Ballistic Missile Agency team led by Wernher von Braun.

Dr. von Braun was a special guest at the celebration along with Maj. Gen. John B. Medaris, retired former head of the Army Ballistic Missile Agency; Lt. Gen. John H. Hinrichs, retired Army chief of ordnance; and Col. Frank Borman, one of the first U.S. astronauts and a Caltech alumnus.



George S. Hammond

ACTING CHAIRMAN IN CHEMISTRY

George S. Hammond, who has been Arthur Amos Noyes Professor of Chemistry at Caltech since 1964, became acting chairman of the division of chemistry and chemical engineering on February 1. He will serve for a 14-month period while John D. Roberts, division chairman since 1963, takes a temporary leave to devote more time to research and writing.

Dr. Hammond's appointment, which was to have been effective July 1, was rescheduled when Dr. Roberts broke his leg in a skiing accident on December 20.

Dr. Hammond has been on the Caltech faculty since 1956. He is distinguished for his research in photochemistry and believes that the field may ultimately lead to development of new methods for the harvest, storage, and transfer of energy. He is a consultant for a number of government agencies and industry and is also known as an innovator in chemical education.

HONORS AND AWARDS

Pol Duwez, Caltech professor of materials science, delivered the American Society for Metals' Edward De Mille Campbell Invitational Lecture for 1967 in recognition of his outstanding ability in metallurgical science and engineering.

John R. McMillan, president of the Reserve Oil and Gas Company, has been elected president of the California Institute Associates. He succeeds Samuel F. Bowlby, a retired petroleum executive, who has held the office since 1964. Also elected were William Burgess and Franklin Donnell, vice presidents; John R. White, secretary; Preston Hotchkis, treasurer; and Theodore Combs, assistant secretary-assistant treasurer. Newly elected board members are Mrs. Anna Bing Arnold, Francis D. Frost Jr., and W. Morton Jacobs.

Allan R. Sandage, staff member of the Mount Wilson and Palomar Observatories, has been awarded the David Rittenhouse Silver Medal for his work with quasars and in the field of cosmology. The medal was presented to Dr. Sandage in Philadelphia by the Rittenhouse Society, the second oldest astronomical society in the United States.

Hans W. Liepmann, Caltech professor of aeronautics, has been named as the first Dryden Research Lecturer by the American Institute of Aeronautics and Astronautics.

APPOINTMENTS

Rear Admiral John E. Clark, USN (Ret.), has been named deputy director of the Jet Propulsion Laboratory. Concluding a distinguished naval career, Admiral Clark retired last September. He was commandant of the 12th Naval District, with headquarters in San Francisco. He will assume his new duties at JPL on February 19.

Royal H. Tyson has been appointed campus architect for Caltech. Mr. Tyson came to Caltech from Stanford University where he has served as principal campus planner for the past seven years. He is president of the National Association of University Architects.

STAR STUDY GRANT

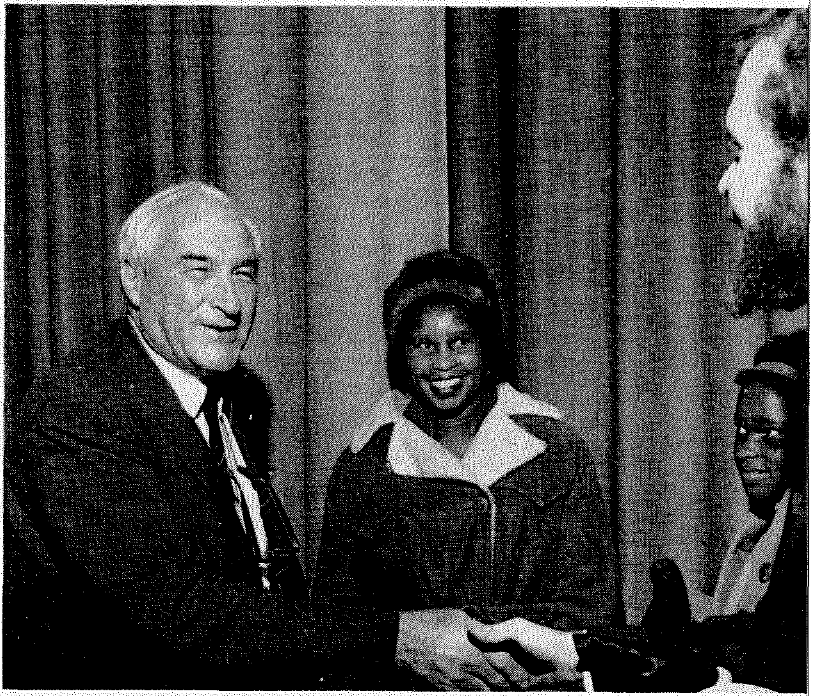
Caltech has received a $200,000 grant from the National Science Foundation for continuing research on how stars and other cosmic objects generate energy and synthesize chemical elements. The research is under the direction of William A. Fowler, professor of physics.

Additional studies involving detailed analysis of materials found in meteorites will be conducted under Gerald Wasserburg, professor of geology and geophysics.

EDWIN BUCHMAN 1904-1968

Edwin Raphael Buchman, Caltech research associate in organic chemistry, died on February 6 at the age of 63. He had been at Caltech since 1937. Before coming to the Institute, he had done research at Columbia University and was responsible, with two colleagues, for synthesizing vitamin B-1. At Caltech he continued his work on vitamin B-1 with James Bonner. During World War II he helped direct an anti-malaria research project here. He also did exploratory work on the problem of the synthesis of cyclobutadiene. During the past 15 years he was involved largely in mathematics research, specializing in very large prime numbers.

A memorial service for Dr. Buchman was held in Caltech's Dabney Hall lounge on February 12. Dr. Bonner, John Roberts, and Max Delbrück, who were colleagues of Dr. Buckman's during his years at Caltech, spoke about his life and his work.



L.S.B. LEAKEY, world-renowned archeologist from Kenya, after his lecture at Caltech on January 26, received *the special tribal greeting of the Kikuyus of* Kenya from Wairimu Bowman, wife of Caltech research fellow Dave Bowman (right) and their daughter, Patricia Njeri. Dr. Leakey is a tribal member.

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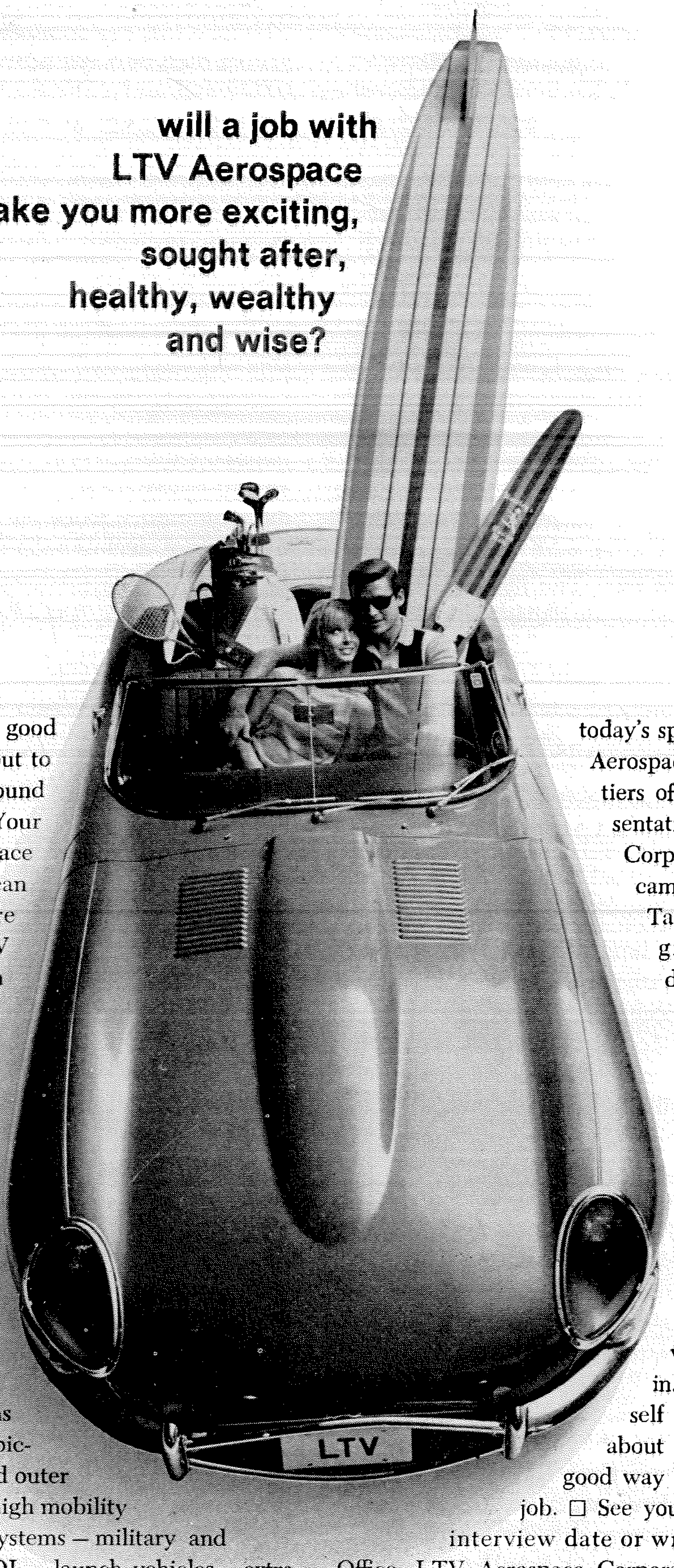

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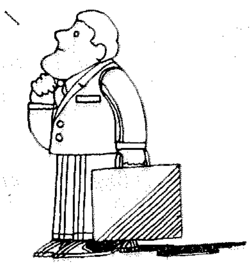
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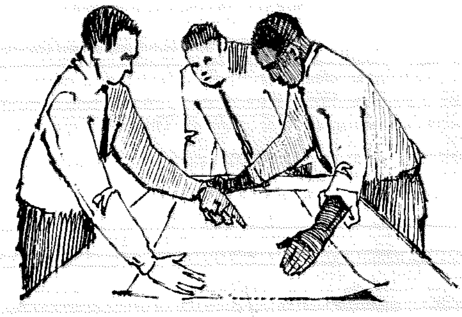

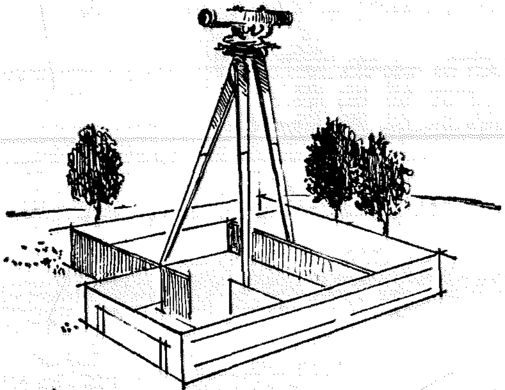

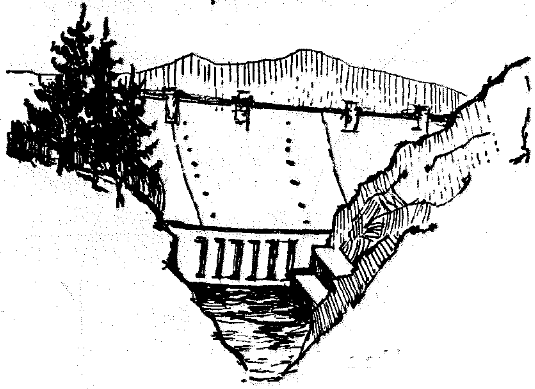

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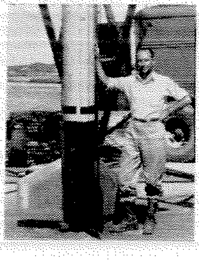


A number of tests were made with this transportable experimental set-up; the last one on January 16, 1937, when the motor ran for 44 seconds at a chamber pressure of 75 lbs. per square inch.

In March 1937 Smith and I completed our analysis of the flight performance of a constant-thrust sounding rocket. The results were so encouraging that our project obtained from von Kármán the continued moral support of GALCIT. We were authorized to conduct small-scale rocket motor tests in the laboratory. This permitted us to reduce the time we wasted putting up and down the transportable equipment we had used in the Arroyo Seco. Von Kármán also asked me to give a report on the results of our first year's work at the GALCIT seminar at the end of April.

The unexpected result of the seminar was the offer of the first financial support for our project. Weld Arnold, then an assistant in the astrophysical laboratory at Caltech, came to me and said that in return for his being permitted to work with our group as a photographer he would make a contribution of $1,000. His offer was accepted with alacrity, for our project was destitute.

This enabled Parsons and me to give up our effort to write an anti-war novel with a plot, of course, revolving around the work of a group of rocket engineers. We had hoped to sell it for a large sum to a Hollywood studio as a basis for a movie script to support the work of the project! This was of some relief to me, for I could then spend less time in Parson's house, where he was accumulating tetranitromethane in his kitchen.

Arnold, who commuted the five miles between Glendale and Caltech by bicycle, brought the first $100 for our project in one dollar and five dollar bills in a bundle wrapped in newspaper. We never learned how he had accumulated them. When I placed the bundle on Clark Millikan's desk with the question, "How do we open a fund at Caltech for our project?" he was flabbergasted.

What has been called the original GALCIT rocket research group was now complete. It consisted of Parsons, Forman, Smith, Tsien, Arnold, and myself. In June 1937 studies made by the group up to that time, including Bollay's paper of 1935, were collected together into what our group called its "bible."

When von Kármán gave the group permission to make small-scale experiments of rocket motors at GALCIT, we decided to mount a motor and propellant supply on a bob of a 50-foot ballistic pendulum, using the deflection of the pendulum to measure thrust. The pendulum was suspended from the third floor of the laboratory with the bob in the basement. It was planned to make tests with various oxidizer-fuel combinations.

We selected the combination of methyl alcohol and nitrogen dioxide for our initial try. Our first mishap occurred when Smith and I were trying to get a quantity of the nitrogen dioxide from a cylinder that we had placed on the lawn in front of Caltech's Gates Chemistry Laboratory. The valve on the cylinder jammed, causing a fountain of the corrosive liquid to erupt all over the lawn. This left a brown patch there for several weeks, to the irritation of the gardener.

When we finally tried an experiment with the motor on the pendulum, there was a misfire. The result was that a cloud of NO_2-alcohol mixture permeated most of GALCIT, leaving behind a thin layer of rust on much of the permanent equipment of the laboratory. We were told to move our apparatus outside the building at once. We also were thereafter known at Caltech as the "Suicide Squad."

We remounted the pendulum in the open from the roof of the building and obtained a limited amount of useful information. We made the first, or one of the first, experiments in America with a rocket motor using a storable liquid oxidizer. On the basis of this experience with nitrogen dioxide, Parsons later developed red-fuming nitric acid as a storable oxidizer which is still being used today.

Although rocket research unavoidably involves experimentation of a dangerous nature, to my knowledge no one has suffered a fatal injury up to the present day at JPL. Unfortunately, Parson's familiarity with explosives led to contempt, and in 1952, when moving his Pasadena home laboratory to Mexico, he dropped a fulminate of mercury cap which exploded and killed him. It was a great loss. His work was of great significance in the history of the development of American rocket technology, both as regards storable liquid propellants and composite solid propellants.

During this period Tsien and I continued our theoretical studies of the thermodynamic characteristics of a rocket motor. To check our results, steps were taken to design and construct a test stand for a small rocket motor burning gaseous oxygen and ethylene gas. Von Kármán reviewed our plans and agreed that we could build the apparatus on a platform on the eastern side of GALCIT. In 1939 this apparatus exploded. I escaped serious injury only because von Kármán had called me to bring him a typewriter at his home. Parsons and Forman were shaken up but unhurt.

"Arnold, who commuted between Glendale and Caltech by bicycle, brought the first $100 for our project in one dollar and five dollar bills wrapped in newspaper."

Smith made simple experiments to determine the material from which we should make the exhaust nozzle of the motor. He describes these experiments as follows in a recent letter to me:

> Sometime, perhaps in the 1937-38 school year, perhaps before [it was in the spring of 1938], we began investigation of materials—ceramics, metals, carborundum, etc. I developed a standard simple test. I would use the largest tip (No. 10, I believe) on an oxy-acetylene torch and play it over a specimen for one minute. Some super refractories spalled and popped like a pan of popcorn and some just melted. You obtained a ½" cube of molybdenum and I tested that. It did not melt, but when I removed the neutral protecting atmosphere of the torch, before my very eyes I watched it literally go up in smoke. While cooling, it

> dwindled from about a ½″ cube to a ¼″ cube giving off a dense white smoke. As part of this phase you and I visited the Vitrefax Corporation in Huntington Park to get help from them about super refractories. One important refractory was forcefully brought to our attention. We watched them make mullite and saw large graphite electrodes working unscathed in large pots of boiling super refractory. This opened our eyes to the possibilities of graphite. It tested well under the torch. Later, shortly before I left Caltech in June 1938, I happened to try the torch on a ½″ x 2″ x 12″ long piece of copper bar stock. The torch could not hurt this piece at all and this test opened our eyes to the possibilities of massive copper for resisting heat.

The first combustion chamber liner and exhaust nozzle of the motor were made of electrode graphite. Later the exhaust nozzle was made of copper. An experiment made in May 1938 at 300 lbs. per square inch chamber pressure for a period of one minute showed that the graphite had withstood the temperature, and the exhaust nozzle throat, which was 0.138 inches in diameter, suffered only an enlargement of 0.015 inch. The motor delivered a thrust of the order of five pounds.

"The word 'rocket' was still in such bad repute in serious scientific circles that it was felt advisable to drop the use of the word."

In the winter of 1938, Tsien and I also extended Smith's and my study of the performance of a sounding rocket to the case of propulsion by successive impulses from a constant-volume solid-propellant rocket engine. We had reviewed Goddard's 1919 paper on "A Method of Reaching Extreme Altitudes" and decided to find a mathematical solution for the flight calculation problem, which Goddard had not carried out. We did this in spite of the difficult practical problem of devising a reloading mechanism for such a rocket engine, for at that time no propulsion method could be discounted.

Parsons and Forman built a smokeless powder constant-volume combustion rocket motor similar to the one tested by Goddard. With it they extended Goddard's results. To my knowledge, no practical solution has ever been found for a long-duration solid-propellant rocket engine using the impulse technique.

The negative conclusions we reached as regards the practicability of devising an impulse-system rocket engine for long-duration propulsion made us turn to the study of the possibility of developing a composite solid propellant which would burn in a combustion chamber in cigarette fashion. Parsons decided first to try extending the burning time of the black powder pyrotechnic sky rocket. He finally constructed a modified black powder 12-second, 28-lb.-thrust rocket unit in 1941.

During the summer of 1938, Smith began working in the engineering department of the Douglas Aircraft Co., where he is still employed. Arnold left Caltech for New York and completely vanished as far as we were concerned. It was not until 1959 that I learned that he was a member of the board of trustees of the University of Nevada. We then corresponded until his death in 1962. Tsien was able to devote less time to the work of the project, as he was completing his doctorate under von Kármán. I struggled on with Parsons and Forman, little suspecting that in the next few months the project would become a full-fledged GALCIT activity supported financially by the federal government.

We also had less time to devote to rocket research, for we had to support ourselves. Parsons and Forman took part-time jobs with the Halifax Powder Co. in the California Mojave Desert, and I began to do some work on problems of wind erosion of soil with von Kármán for the Soil Conservation Service of the U.S. Department of Agriculture.

From the beginning the work of the group on rocket research at GALCIT attracted the attention of newspapers and popular scientific journals. Since our work was not then classified as "secret," we were not averse to discussing with journalists our plans and results. There were times that we were abashed by the sensational interpretations given of our work, for we tended to be, if anything, too conservative in our estimates of its implications.

The fact that our work was having a real impact in America came from two sources. In May 1938 von Kármán had received an inkling that the U.S. Army Air Corps was getting interested in rocket propulsion.

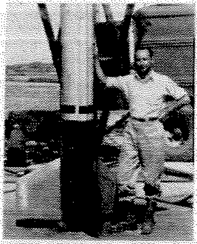
"In 1944 I proposed a jet propulsion section at Caltech. It was decided that it would be premature. Instead, von Kármán and I founded JPL."

Then in August 1938 Ruben Fleet, the president of the Consolidated Aircraft Co. of San Diego, California, approached GALCIT for information on the possibility of using rockets for assisting the takeoff of large aircraft, especially flying boats. I went to San Diego to discuss the matter and prepared a report entitled "The Rocket Motor and its Application as an Auxiliary to the Power Plants of Conventional Aircraft." I concluded that the rocket engine was particularly adaptable for assisting the takeoff of aircraft, ascending to operating altitude, and reaching high speeds. The Consolidated Aircraft Co. appears to have been the first American commercial organization to recognize the potential importance of rocket-assisted aircraft takeoff. It was not, however, until 1943 that liquid-propellant rocket engines, constructed by the Aerojet-General Corporation, were tested in a Consolidated Aircraft flying boat on San Diego Bay.

In October 1938 a senior officer of the U.S. Army Ordnance Division paid a visit to Caltech and informed our group that on the basis of the Army's experience with rockets he thought there was little possibility of using them for military purposes!

I had learned during the year of the REP-Hirsch International Astronautical Prize, which was administered by the Astronautics Committee of the Société Astronomique de France. The prize was named for the French astronautical pioneer Robert Esnault-Pelterie (REP) and the banker rocket-enthusiast of Paris, André-Louis Hirsch.

The money contributed by Arnold was rapidly being used up. In the hope of augmenting the funds of the project, I decided to enter the competition by sending a paper on some of my work. I did not learn until 1946 that the prize had been



PIONEER continued

awarded to me in 1939. The outbreak of World War II in Europe had prevented the Astronautics Committee from notifying me. In 1958 Andrew G. Haley, then president of the International Astronautical Federation, arranged for the medal to be presented to me by André-Louis Hirsch at the IXth International Astronautical Congress at Amsterdam. The prize was then worth a fraction of its former value.

In December 1938 I was informed by von Kármán, Robert Millikan, and Max Mason that I was to go to Washington, D.C., to give expert information to the National Academy of Sciences Committee on Army Air Corps Research.

One of the subjects on which General H. A. Arnold, then Commanding General of the Army Air Corps, asked the Academy to give advice was the possible use of rockets for the assisted takeoff of heavily loaded aircraft. I prepared a report which contained the following parts: (1) Fundamental concepts, (2) Classification of types of jet propulsors, (3) Possible applications of jet propulsion in connection with heavier-than-air craft, (4) Present state of development of jet propulsion, and (5) Research program for developing jet propulsion.

The word "rocket" was still in such bad repute in "serious" scientific circles at this time that it was felt advisable by von Kármán and myself to follow the precedent of the Air Corps of dropping the use of the word. It did not return to our vocabulary until several years later, by which time the word "jet" had become part of the name of our laboratory (JPL) and of the Aerojet-General Corporation.

I presented my report to the committee on December 28, 1938, and shortly thereafter the Academy accepted von Kármán's offer to study with our GALCIT rocket research group the problem of the assisted takeoff of aircraft on the basis of available information, and to prepare a proposal for a research program. A sum of $1,000 was provided for this work.

Parsons and Forman were delighted when I returned from Washington with the news that the work we had done during the past three years was to be rewarded by being given government financial support and that von Kármán would join us as director of the program. We could even expect to be paid for doing our rocket research!

Thus in 1939 the GALCIT Rocket Research Project became the Air Corps Jet Propulsion Research Project. In 1944 I prepared a proposal for the creation of a section of jet propulsion within the division of engineering at Caltech. It was decided that it would be premature to do so. Instead, von Kármán and I founded JPL.

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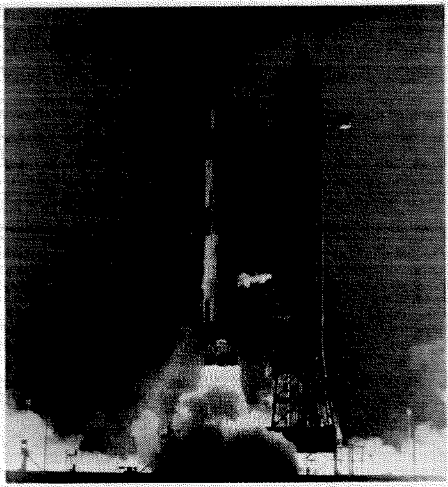

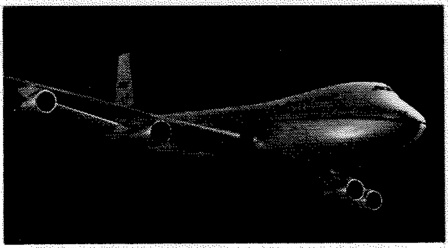

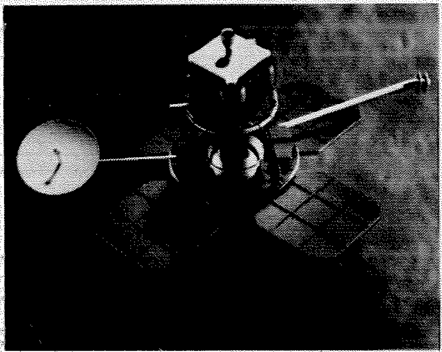

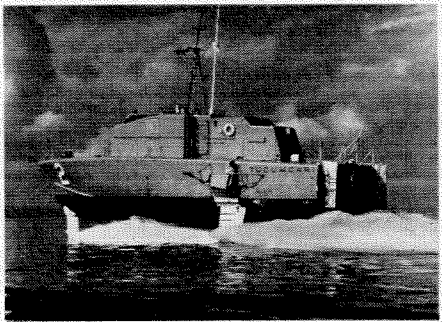

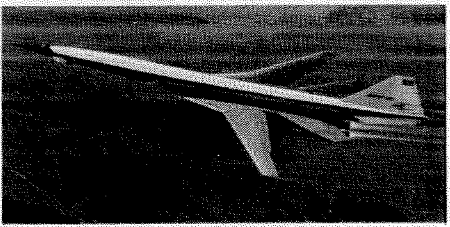

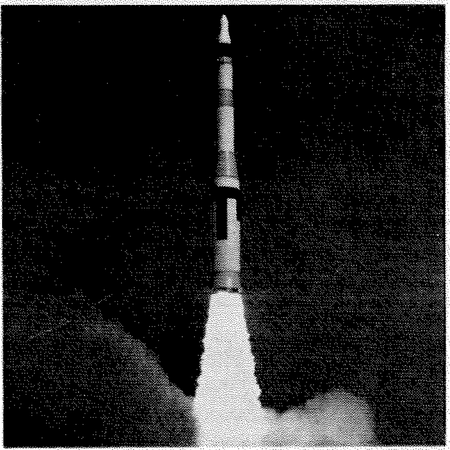

USAF SRAM. New U.S. Air Force short-range attack missile, now being designed and developed by Boeing, is a supersonic air-to-ground missile with nuclear capability. Boeing also will serve as system integration and test contractor.

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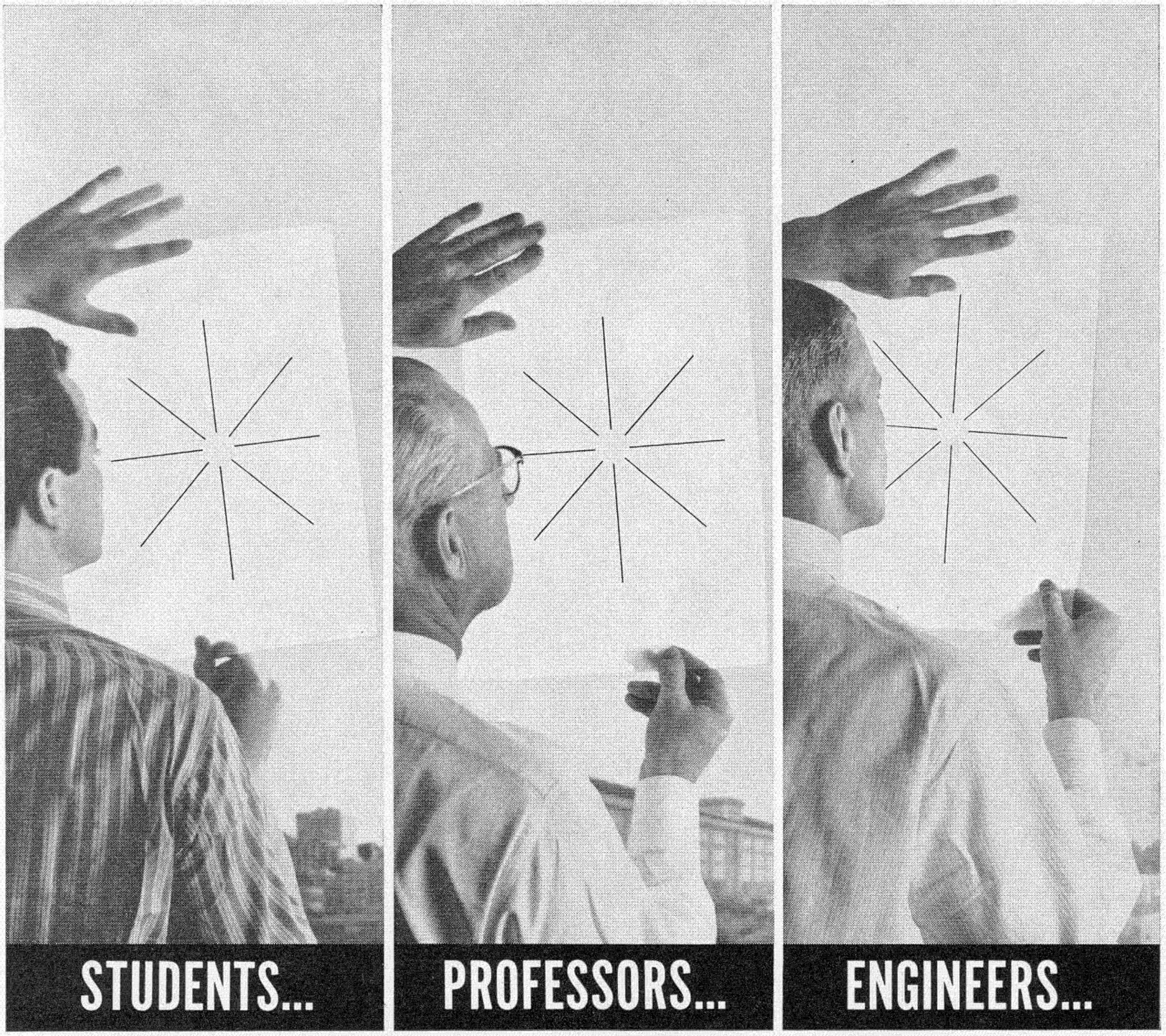
Meetings. University Club 1319 "K" St.
Luncheon first Friday of each month at noon
Visiting alumni cordially invited—no reservation.



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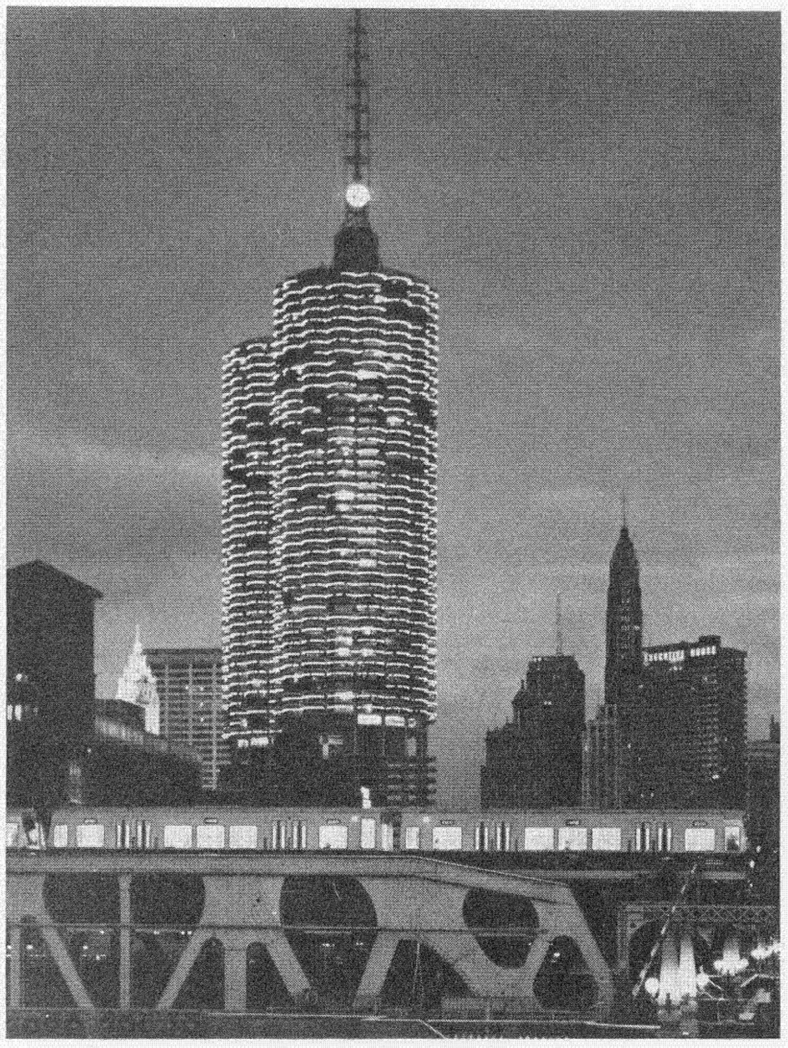

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