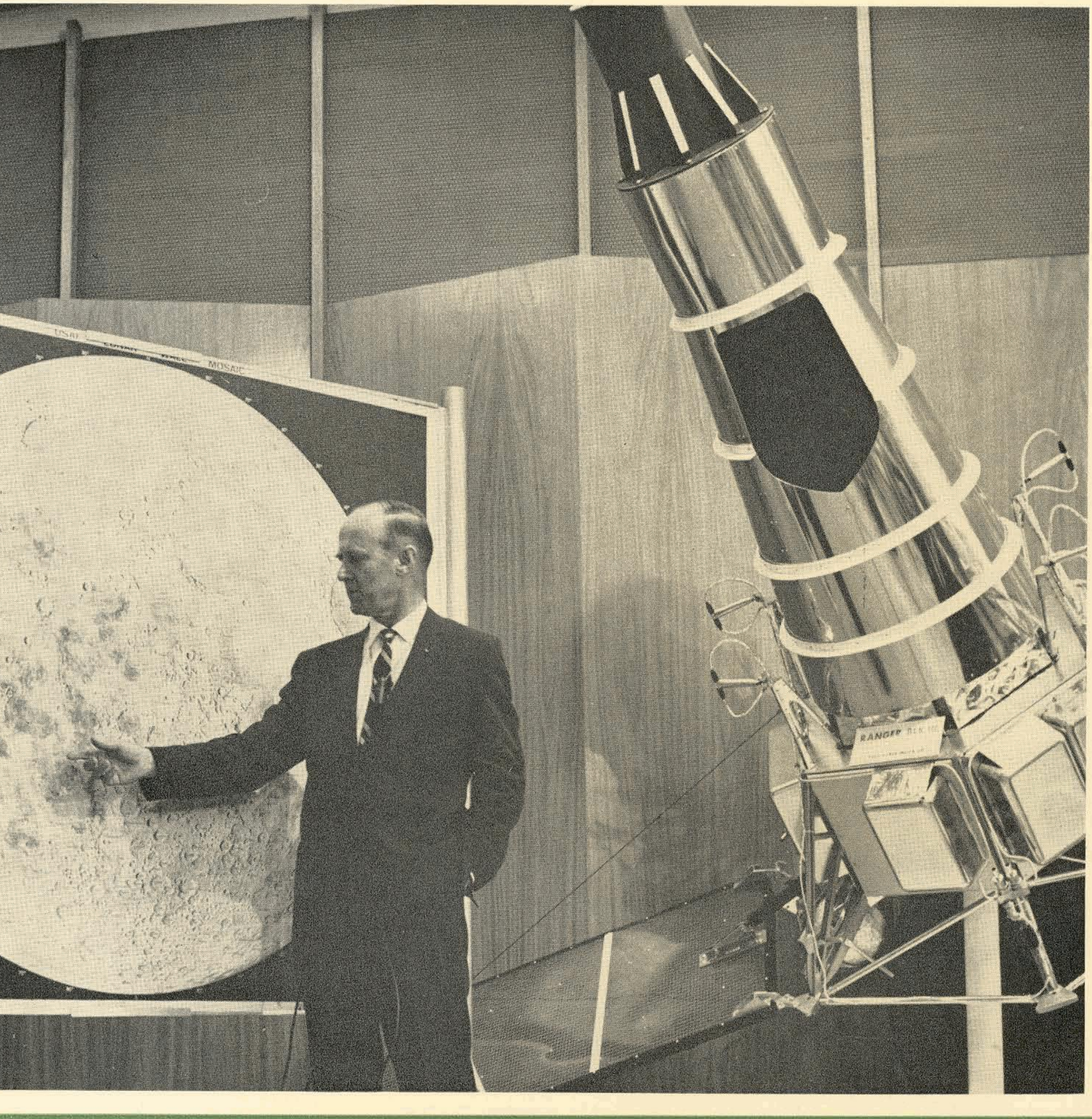
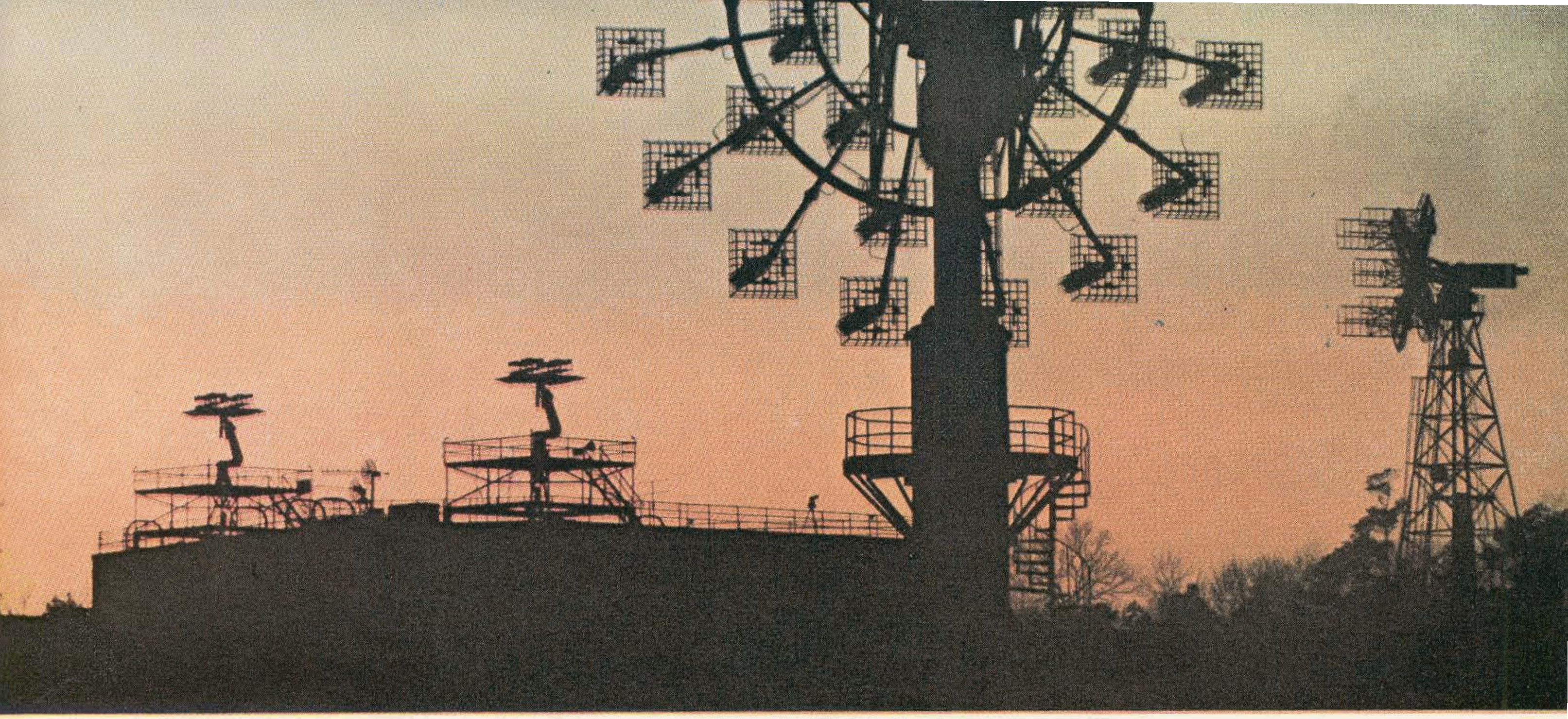
OCTOBER 1964

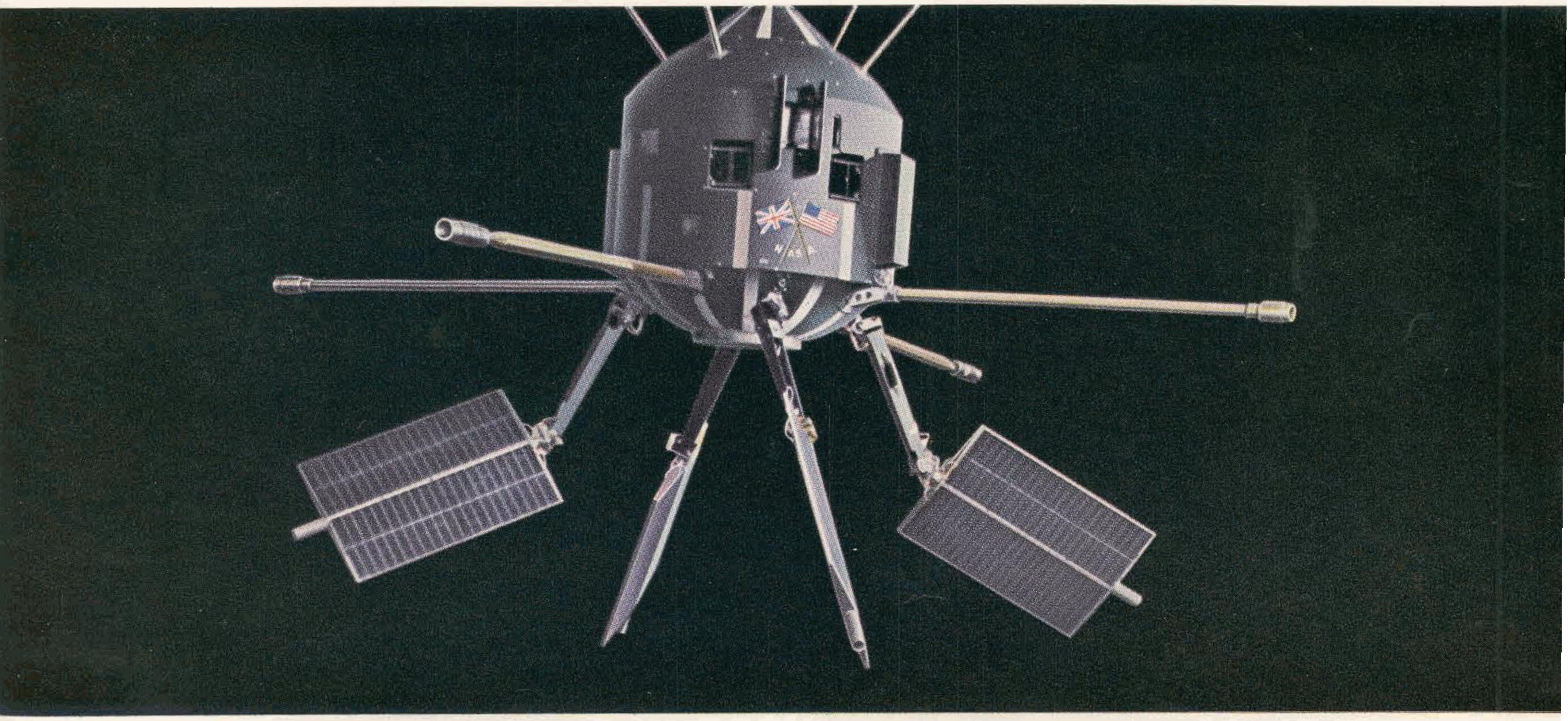
# ENGINEERING AND SCIENCE



PUBLISHED AT THE CALIFORNIA INSTITUTE OF TECHNOLOGY







# APPRENTICE

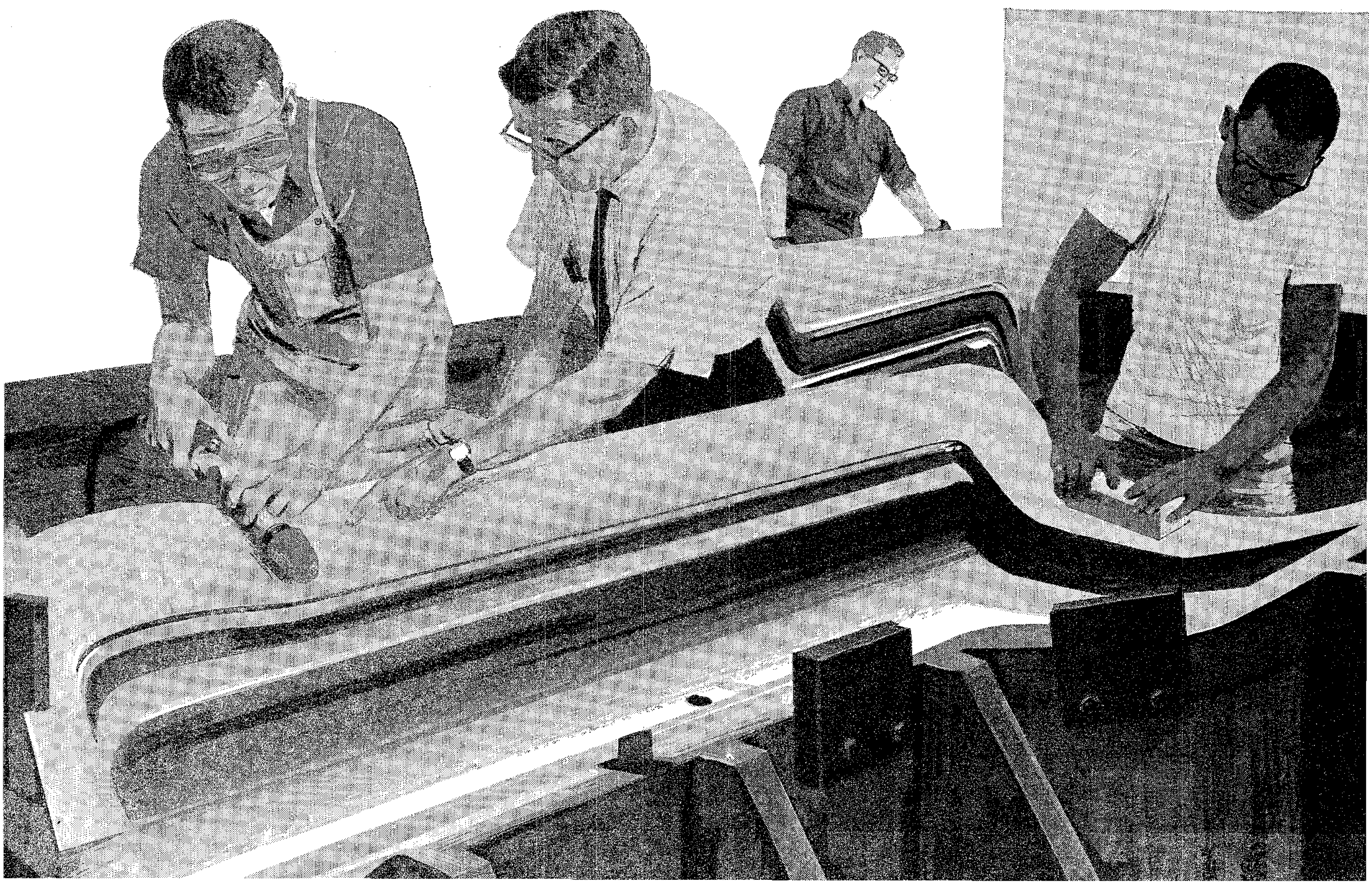
These young men are preparing for important careers with General Motors. Under the GM apprentice plan, they are learning the diemaker's skills. Once they have mastered this craft—and it will take them four years (8,000 hours) of on-the-job training and classroom study—each will be a skilled journeyman, qualified to make the complex dies, jigs and fixtures so vital to modern industry.

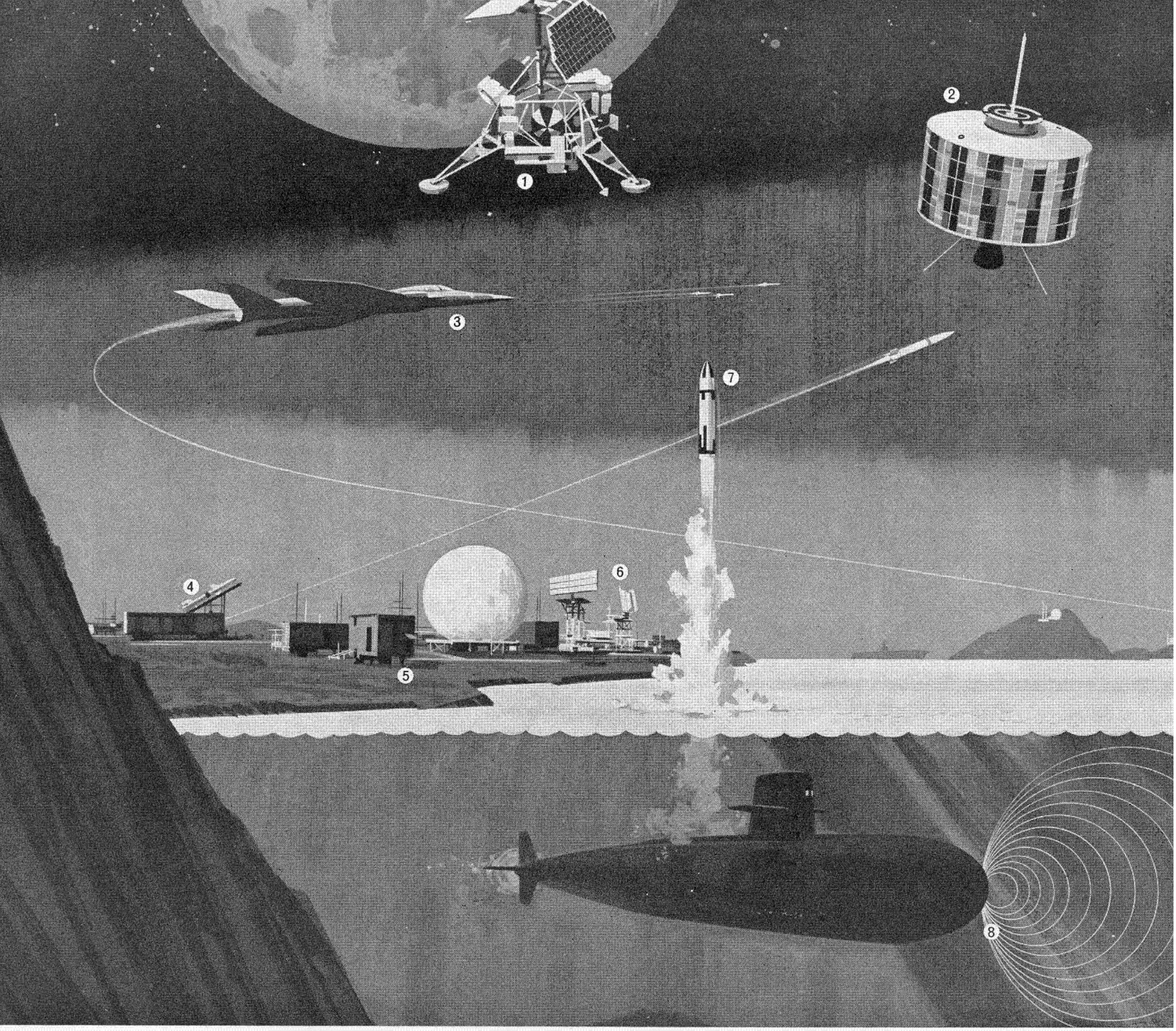
This year, 2,753 General Motors apprentices are being trained for this and other trades—more than 30 in all. They are learning to be pattern makers, pipefitters, bricklayers, toolmakers, diesinkers, electricians and millwrights, to name a few. From the time they start training they are paid good wages on a regular rising scale.

At the conclusion of their four-year courses, apprentices will have gained skills that will serve them well throughout their working careers. They are free, of course, to work anywhere they wish—but most stay with GM. We're glad of that. We need them. Talented people are indispensable to General Motors.

## GENERAL MOTORS IS PEOPLE ...

**Making Better Things For You**






*Opportunities at Hughes for EE's—Physicists—Scientists:*

# from the ocean floor to the moon...and beyond

**Hughes sphere of activity extends from the far reaches of outer space to the bottom of the sea . . .** includes advanced studies, research, design, development and production on projects such as: ① SURVEYOR—unmanned, soft-landing lunar spacecraft for chemical and visual analysis of the moon's surface; ② SYNCOM (Synchronous-orbit Communications Satellite)—provides world-wide communications with only three satellites; ③ F-111B PHOENIX Missile System—an advanced weapon system designed to radically extend the defensive strike capability of supersonic aircraft; ④ Anti-ICBM Defense Systems—designed to locate, intercept and destroy attacking enemy ballistic missiles in flight; ⑤ Air Defense Control Systems—border-to-border control of air defenses from a single command center—combines 3D radar, real-time computer technology and display systems within a flexible communications network; ⑥ 3D Radar—ground and ship-based systems give simultaneous height, range and bearing data—now in service on the nuclear-powered U.S.S. Enterprise; ⑦ POLARIS Guidance System—guidance components for the long-range POLARIS missile; ⑧ Hydrospace—advanced sonar and other anti-submarine warfare systems.

**Other responsible assignments include:** *TAWCS* (Tactical Air Weapons Control Systems), Hard Point defense systems . . . advanced *infrared* systems, associative computers, advanced *communications* systems, *space* materials and devices, parametric *amplifiers* . . . and many others.

**Ph.D. Candidates**

## CAMPUS INTERVIEWS

## November 17, 1964

Learn more about opportunities at Hughes, our educational programs, and the extra benefits Southern California living offers. **For additional information and literature, consult your College Placement Director.** *Or write:*

*Mr. W. K. Walker*
*Research Laboratories*
*Hughes Aircraft Company*
*Malibu, Calif. 90265*

*Creating a new world with electronics*

**HUGHES**

HUGHES AIRCRAFT COMPANY

**U. S. CITIZENSHIP REQUIRED**
An equal opportunity employer.

# ENGINEERING AND SCIENCE

October 1964 Volume XXVIII Number 1



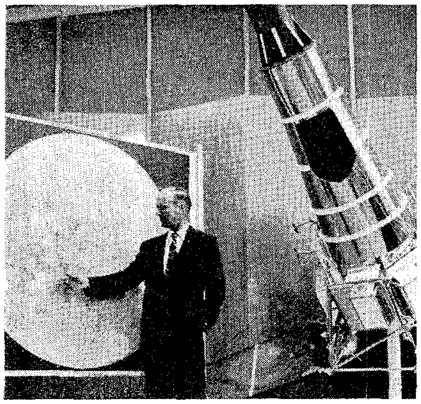
**Picture Credits**

Cover, 10-14 – Jet Propulsion Laboratory
9 – Lick Observatory, University of California

Staff

*Publisher*........Richard C. Armstrong '28
*Editor and Business Manager*........Edward Hutchings, Jr.
*Assistant to the Editor*........Gerda Chambers
*Photographer*........James McClanahan

Published monthly, October through June, at the California Institute of Technology, 1201 East California Blvd., Pasadena, Calif. Annual subscription $4.50 domestic, $5.50 foreign, single copies 50 cents. Second class postage paid at Pasadena, California, under the Act of August 24, 1912.  Manuscripts and all other editorial correspondence should be addressed to: The Editor, *Engineering and Science*, California Institute of Technology. 



*On Our Cover*

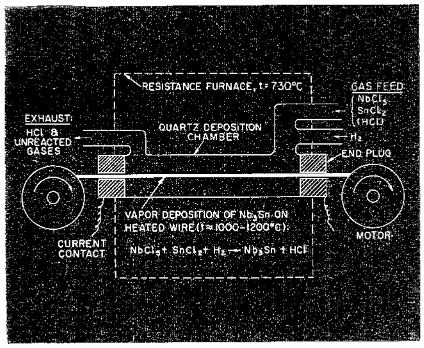
Dr. William H. Pickering, director of Caltech's Jet Propulsion Laboratory, points out the area on the moon that was chosen as the landing spot for Ranger VII. To his left is a full-scale model of the 806-lb. Ranger spacecraft which flew some 240,000 miles to land on the moon on July 28, 1964 – right on the spot that had been selected.

The mission of Ranger VII was to get television pictures of the lunar surface, and to develop some of the required technologies, operational skills, and procedures that will be necessary for the manned lunar landing. The Ranger VII mission, from launch to impact on the moon, was a complete success, transmitting back to earth 4,316 photographs – the first close-up pictures of the moon. The flight took 68 hours and 35 minutes, and all of the pictures were taken in the final 17 minutes and 12 seconds before impact.

The full story of the Ranger VII mission is told on pages 7-14 of this issue by R. J. Parks, assistant director for Lunar and Planetary Projects at the Jet Propulsion Laboratory; and H. M. Schurmeier, JPL's Ranger Project Manager. Mr. Parks received his BS from Caltech in 1944, and Mr. Schurmeier received his BS in 1945, MS in 1948, and AE in 1949.

# Superconductivity at RCA Laboratories

## Vapor Deposition of $Nb_3Sn$




*Apparatus for continuous vapor deposition of niobium stannide on ribbon.*

Very-high-field solenoids capable of generating fields of 100,000 gauss now made with copper winding require about 100 tons of equipment and dissipate more than one megawatt of power as heat. Some superconductors, in particular the compound $Nb_3Sn$, can carry large electric currents with zero power dissipation even at high magnetic fields.[1] Hence, they can be used for the construction of light weight solenoids.

In the past, $Nb_3Sn$ was prepared by metallurgical sintering techniques, which resulted in a porous and extremely brittle material not suitable for widespread use. In 1960, scientists in the Materials Research Laboratory, David Sarnoff Research Center, developed a vapor-phase transport process for preparing this compound for the first time in a dense crystalline state—and *in forms suitable for widespread use in both research and application.* It consists of a simultaneous reduction of gaseous mixed chlorides of niobium and tin by hydrogen at 900 to 1200°C.[2]

Based on this process, an apparatus was developed for continuous coating of refractory metal and ribbon with $Nb_3Sn$. The $Nb_3Sn$ coated ribbon has both electrical and mechanical properties desirable for solenoid construction. It is very thin (typical cross section is 2 x 90 mil, thickness of deposit about 0.3 mil) and hence sufficiently ductile to wrap around diameters as small as ⅜ inch and it can support enormous currents densities: $1 \times 10^6$ amp/cm² at zero field, $3 \times 10^5$ amp/cm² in a transverse DC field of 92,500 gauss and $1.5 \times 10^5$ amp/cm² in a pulsed longitudinal field of 170,000 gauss. By comparison, copper can carry only $1 \times 10^3$ amp/cm² safely. Hence, superconductive solenoids approaching a field of 200,000 gauss appear feasible.

*Reference—*[1]*J. E. Kunzler, et al. Phys. Rev. Letters 6, 89 (1961).*
[2]*J. J. Hanak, "Vapor Deposition of $Nb_3Sn$," Proceedings of AIME Conference on Advanced Electronic Materials, August 1962.*

## Parametric Amplifier

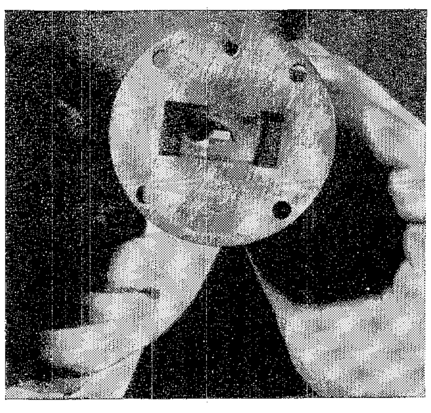
Experiments at RCA Laboratories show that superconducting films exhibit a nonlinear inductance at frequencies extending well into the millimeter-wave range. Frequency conversion was observed in tin films cooled below their critical temperature. Now amplification and oscillation have also been demonstrated. A superconducting "paramp" has been operated at 6 kmc with 11 db of net gain. Parametric oscillations at about the same frequency were also effected.

The superconducting film and the varactor differ markedly in many respects; hence, their circuit needs also differ. A study of the characteristics of superconducting films and parametric device requirements resulted in the concept of the "modified dielectric resonator." The resonator, which was used to demonstrate amplification, consists of a very low-loss, high-permittivity, dielectric cavity modified at one of its boundaries by a superconducting film.

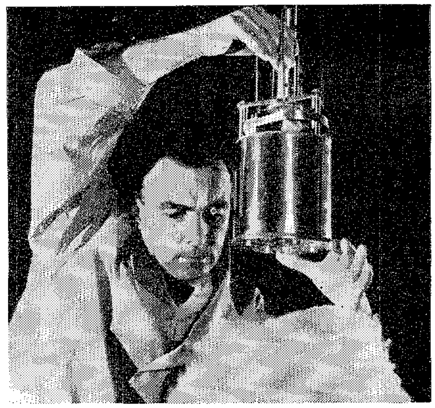
The unit is placed in a waveguide where power is coupled to it with a movable short-circuit. The resonant frequency of the cavity is a function of its dimensions, the permittivity of the dielectric and the impedance of the film.

While it may be premature to speculate on the eventual role of the superconducting "paramp", it should be noted that the device, in principle, offers an outstanding set of features not to be found in the varactor or any other device. First, the frequency limit of superconducting films may extend into the sub-millimeter wave range. Secondly, it is expected that the noise performance of the device can match that of the maser. Furthermore, superconductors can be pumped with considerably lower power and at a lower frequency than either the varactor or the maser. Finally, since one can fabricate large-area films (as compared with lumped varactors), wide-band truly distributed traveling-wave parametric amplification may become possible.

*Reference—A.S. Clorfeine, Applied Phys. Letters 4, No. 7, 131 (1964).*
*A.S. Clorfeine, Proceedings of the IEEE, Vol. 52, No. 7, July 1964.*



## Superconductive Magnet



Recently RCA developed a superconductive magnet believed to be the most powerful in the world, in a practical form that can revolutionize many aspects of solid-state electronics and high-energy physics research.

Success of this magnet and the attainment of zero current degradation using magnetic field stabilization followed research in superconductive degradation phenomena.

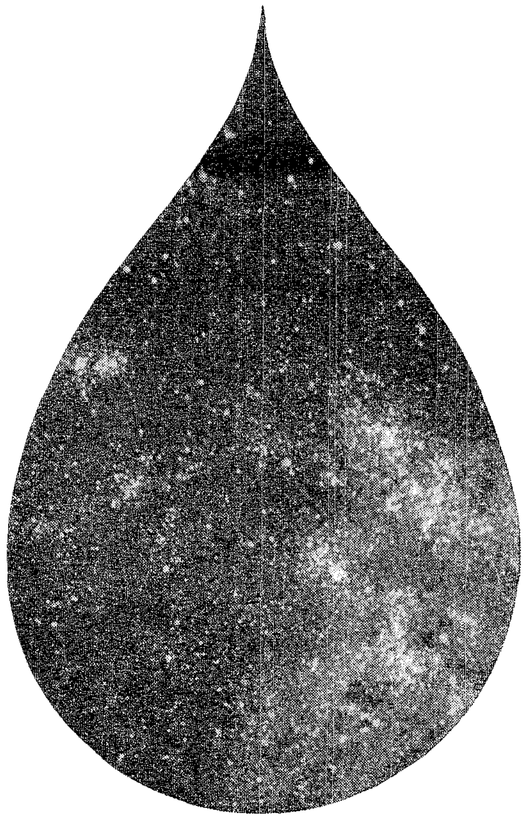
The device generates a magnetic field of 107,000 gauss. When commercially available, it will enable scores of small and medium-sized research laboratories to carry out experiments that now require large multi-million-dollar facilities in order to generate the immense magnetic fields needed for solid-state, atomic, and related areas of research.

Test data obtained under a NASA study contract played a significant part in RCA's development of the 107,000-gauss magnet. The present experimental unit has a bore of one inch, offering for the first time in a superconductive magnet a working area large enough for practical laboratory experiments. The company is continuing its work for NASA, exploring the feasibility of a 150,000-gauss superconductive magnet with a one-foot bore, designed for experiments in space propulsion techniques.

The experimental 107,000-gauss unit was built at the RCA Laboratories by an advanced development group of the RCA Electronic Components and Devices organization.

The experimental RCA magnet weighs 26 pounds and is about the size and shape of a half-gallon paint can. It is made superconductive by immersion in liquid helium and is started with the output of 6-volt storage batteries. By contrast, nonsuperconductive magnets developing similar magnetic fields require almost 1.5 million watts of power and enormous water-cooling systems.

*Reference—Schrader, Freedman, Fakan, Applied Physics Letters, March 15, 1964*
*Schrader, Kolondra, RCA Review, Vol. (25), No. 3, 1964.*





ENGINEERING
AND SCIENCE
*October 1964, Vol. XXVIII, No. 1*

# Ranger to the Moon

*The full story of the successful mission of Ranger VII to take the first close-up pictures of the surface of the moon.*

*by Robert J. Parks and H. M. Schurmeier*

Ranger VII was launched at 11:50:07.873 EST on July 28, 1964. Although it was not known at the time, this launch was destined to become a landmark in space exploration history. It was to break a string of disappointments in lunar exploration that dates back to August 17, 1958, when the first of a series of U.S. lunar space launches, conducted by different organizations under the sponsorship of different government agencies, was attempted.

After a number of these earlier attempts on smaller launch vehicles, it was decided by the National Aeronautics and Space Administration to embark upon a project based on the Atlas-Agena B launch vehicle. To be known as the Ranger Project, this would initiate a big, but inevitable, step in spacecraft design that was made possible by the higher performance Atlas-Agena B. This step—that of attitude stabilization and control—was fundamental to the development of spacecraft that would be capable of efficiently and effectively exploring the moon and the planets. It was important to initiate this step as soon as it was practical; and, although the spacecraft weight permitted by the launch vehicle performance was none too ample, it was decided that the step could and should be taken.

The first two Rangers were not lunar shots. They were to go into elliptical earth orbits to evaluate and test out the new spacecraft design and to perform some scientific measurements on the space environment. The third Ranger was the first to be scheduled as a lunar shot.

These first three Rangers were destined to pay the penalty of pioneering a new launch vehicle; inflight difficulties kept them from achieving their respective mission objectives. As originally planned, a number of military space launches, prior to the first Ranger launch, were scheduled to use this launch vehicle—which was (and still is) a national space booster provided by the military. Because of changes in the schedule and content of the military space program, however, these Ranger launches were among the first for this launch vehicle, which, after this early period, has had a good record.

The next two Rangers were properly injected by the launch vehicle but there were failures in the spacecraft itself. At this point, a thorough review was conducted of the design, fabrication, and quality practices utilized throughout the entire project. Particular emphasis was given to the higher reliability components that had become available since the original design; and to the newly developing experience relating to the performance of components and materials in the space environment.

This review led to a number of changes in detail designs and in fabrication and quality procedures. It also resulted in the deletion of the heat sterilization practice that had been applied to these early Rangers. This latter step was made possible by a series of studies which had determined that even if earth life could survive in the lunar environment, it most probably would remain contained in a very small local area. In addition, there was evidence that heat sterilization actually did reduce the reliability of equipment to a degree greater than was originally expected.

A change in mission, as had been planned for some time, also was implemented at this point in the program. Rangers III through V had intended to land a small package, designed to withstand a rather rough landing (100 to 200 ft/sec impact velocity) on the lunar surface. Beginning with the sixth Ranger, the objective was to obtain high resolution close-up photographs of samples of the lunar surface, particularly areas similar to those of interest to the Manned Lunar Landing Program. As a result, Ranger VI carried, for the very first time, a payload package designed to permit the taking and transmitting to earth of a series of good quality high resolution photographs.

Ranger VI did not obtain lunar photographs, due to a malfunction within this new TV payload package. The rest of the spacecraft worked perfectly, establishing a record in lunar flight precision and providing new data on such items as the mass of the moon and the mass of the earth, which are important both scientifically and for space navigation.

The malfunction in the TV package was determined to have been caused by an unintended (and, to this date, not completely explainable) turn-on of the package during the boost phase, at a time when the spacecraft was subjected to critical electrical arcing pressures. The resultant arcing caused certain circuits in the TV package, including the high voltage circuits in its transmitters, to burn out. As a result, design changes were made on Ranger VII to ensure that the TV package could not be turned on during this critical boost phase.

This was the background at the time of launch of Ranger VII. All of the elements necessary to carry the payload package to the vicinity of the moon, and to point it in the proper direction—including all of those elements necessary to and inherent in the attitude-controlled design concept—had worked perfectly on the previous shot. These same concepts, pioneered by the Rangers, had previously been adapted to — and had made possible — the successful Mariner II Venus probe, which had demonstrated the basic soundness of the approach. (As a result of the experience and developments of both the Ranger and Mariner II, these same concepts have now been further adapted to the forthcoming Mars spacecraft.)

Action had further been taken to preclude the malfunction that had plagued the previous launch. All elements of the project had successfully passed through ground tests. Thus, to the best of our ability to predict, there was no specific reason to expect anything but success. On the other hand, in projects of this nature, one can never be completely sure that all of the weaknesses of the design have been eliminated, or that a "random" failure will not occur, since it is not possible to build equipment of this type that will have a zero failure rate.

## *The Moon and Trajectory Considerations*

In 1609 Galileo described his observations of the moon as follows:

"The prominences there are mainly very similar to our most rugged and steepest mountains, and some of them are seen to to be drawn out in long tracts of hundreds of miles. Others are in more compact groups, and there are also many detached and solitary rocks, precipitous and craggy. But what occur most frequently there are certain ridges, somewhat raised, which surround and enclose plains of different sizes and various shapes but for the most part, circular. In the middle of many of these there is a mountain in sharp relief and some few are filled with a dark substance similar to that of the large spots that are seen with the naked eye; these are the largest ones, and there are a very great number of smaller ones, almost all of them circular."

Galileo first gazed at the moon through a telescope more than 350 years ago. Up to Ranger VII, however, we had seen little more of the detail of the moon's surface than did Galileo. Our modern telescopes are better, but they still stand the same distance from the moon, and on the same platform —the earth. We still peer through the same mantle of atmosphere that hindered Galileo's viewing.

Although the lunar surface conditions still eluded us, we had learned a few facts about the moon. We conclude that the moon has no surface water and no appreciable atmosphere. For all practical purposes, its distance from the sun is the same as the earth's, and so it receives the same amount of heat from the sun. But, due to the lack of atmosphere, the temperature on the moon's surface ranges from 261°F at noon (hotter than boiling water on earth), to −243°F at midnight (more than twice as cold as any place on earth).

Such extremes of temperature, coupled with the lack of atmosphere on the moon, would presumably preclude the existence of any form of life as we know it. Still, the possibility of the existence of so-called sub-life forms must be considered. We cannot predict the action of atoms and molecules at, or just under, the surface of the moon, where they have been under eon-long bombardment by undiluted solar radiation and by cosmic rays. The formation of complex macromolecules may be possible.

Recent studies have made it appear probable that the great craters on the moon are impact craters rather than volcanic craters. Although the great craters appear to be meteoric in origin, this does not imply that no volcanic activity can exist on the moon. On the contrary, there are, for example, rows of craterlets near Copernicus which may be due to volcanic activity. One of the most interesting observations in the past few years was made in a portion of the crater Alphonsus. A temporary haziness was found which lasted long enough for a spectrogram to be obtained, confirming the existence of carbonaceous molecules and some yet unidentified species. So gases do exist, at least for a short time, on the surface of the moon.

One school of thought suggests that the maria, or plains, as well as the centers of many of the old craters, are filled with dust. The thickness of the layer of dust is estimated by the total amount of rock which could have been worn from all of the old crater walls in the highlands. On this basis, a number of 1 kilometer is reached for the maximum dust depth—that is, a little over ½ mile.

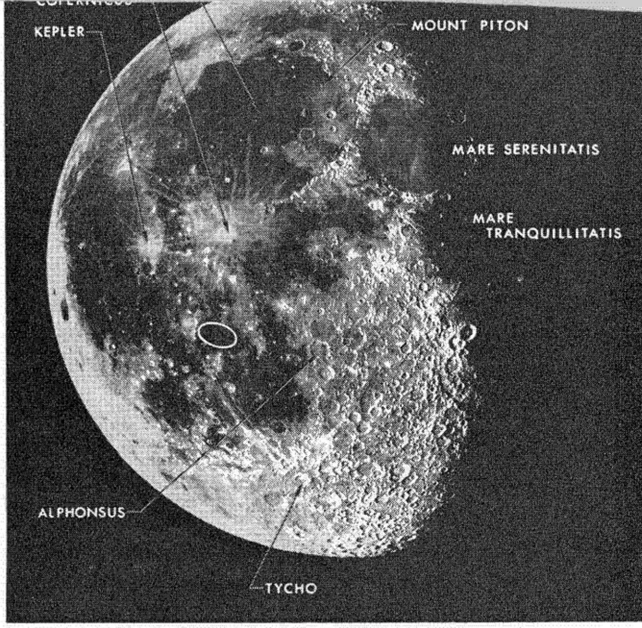
Experiments have indicated that dust, in a vacuum such as on the surface of the moon, would tend to become hard packed. So we can imagine that any deep dust layer on the moon would resemble pumice more than the dust with which we are familiar. Accordingly, there would seem to be little danger of our spacecraft being buried in a half-mile of loose dust. However, there are also the theories of suspended dust, sintered dust, and no dust at all. Thus, the most important task we must accomplish in the first lunar explorations is to determine the exact nature of the moon's surface.

In light of our vast ignorance regarding the nature of the lunar surface—the topography as well as the physical and chemical properties—it was quite natural to look for ways to obtain close-up television photographs of samples of the surface. However, the moon is not an easy object to photograph. Its color and texture and contrast variation are minimum, and it reflects relatively little light.

Thus, the best photographs can be obtained during lunar sunrise or sunset conditions—that is, close to the terminator (the line dividing the sunlight and dark halves of the moon)—where shadow effects are most prominent, and yet where there is still sufficient light to give good photographs.

Estimates of the available light, prior to Ranger VII data, indicated that, in order to be sure of sufficient light for the TV system to obtain good pictures, one should not attempt to go closer than about 20° from the terminator in the sunlight half of the moon. There was, however, considerable uncertainty as to the actual close-up lighting conditions to expect. From the contrast and shadow effects, it would have been better to be able to go even closer to the terminator.

The maria areas—the relatively flat areas which



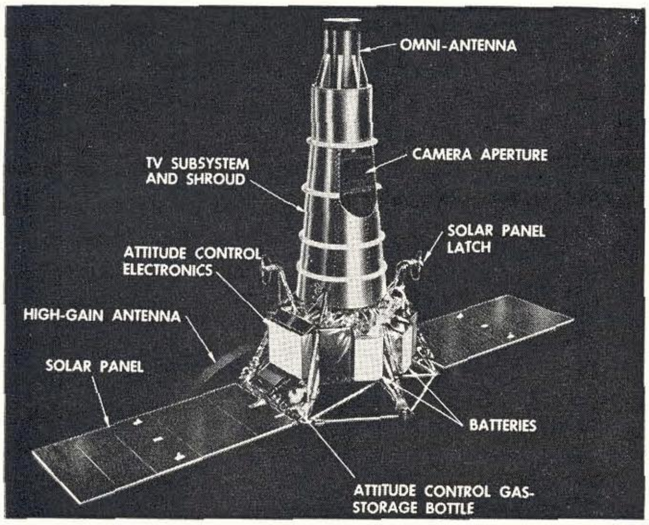

*Some prominent physical features on the east side of the moon. The circled area, which shows where Ranger VII landed, is now officially known as "Mare Cognitum" —the sea that is well known.*

resemble a sea, as their name implies—were the areas selected to be photographed first. This type of lunar terrain has been selected as tentative landing areas for the Manned Lunar Landing, and is also of considerable scientific interest.

The lighting constraint conditions, coupled with such factors as the characteristics of earth-lunar trajectories, and specific design characteristics of the spacecraft, limit the times when launches can be attempted to a one- or two-hour period on each day of a five- or six-day period, once each lunar cycle (approximately once a month). Furthermore, the lighting constraint requirement of taking pictures at a given distance from the terminator requires that the selected target areas change for each of the five or six possible launch days. The practice has been to select, prior to launch, a few possible target areas for each permissible launch day, and then, after launch—when the conditions of the spacecraft and its actual injected trajectory are known—to select one as the actual target area, and to perform the midcourse maneuver accordingly.

## *The Spacecraft*

The Ranger VII spacecraft consists of the power, telecommunications, guidance and control, propulsion, temperature control and pyrotechnics subsystems, plus structure, and the television camera payload. The design provides a fully attitude-stabilized system using solar panel power and providing high-gain directional communication with the earth. In the stowed position, the solar panels fold up along the side of the camera tower and the high-




gain antenna folds under the spacecraft structure. The basic structure is hexagonal in shape with the solar panels hinging from opposite sides of the hexagon. The antenna is hinged from a corner of the hexagon between the solar panels. The camera aperture is on the opposite side away from the high-gain antenna. In the flight configuration the spacecraft has a height of about ten feet, span of about fifteen feet, and weighs just over 800 lbs.

Power is supplied by both batteries and solar panels. The batteries are used whenever the solar panels are not oriented at the sun. The selection is performed automatically by power switching and logic circuitry in the power subsystem.

The telecommunication subsystem consists of the antenna, radio, command, and telemetry subsystems. Two antennas are used. On top of the camera subsystem tower is an omnidirectional antenna which receives the signals transmitted from the earth and which transmits spacecraft data to the earth whenever the high-gain antenna is not oriented at the earth. The high-gain antenna is used to transmit both the spacecraft engineering telemetry and the camera subsystem video signals.

The radio subsystem contains the receiver for two-way doppler and ground commands and the transmitter for sending spacecraft signals back to earth. Phase modulation techniques are used in both the ground commands and the spacecraft telemetry modulation of the transmitter signal.

The command subsystem decodes the subcarrier recovered by the receiver. It provides decoded real-time commands directly to the appropriate subsystem and stored command data to the central computer and sequencer (CC&S) in the guidance and control subsystem.

The telemetry subsystem provides ten channels of 110 separate measurements. Complete spacecraft engineering telemetry is made available to assess the status and performance of the various spacecraft subsystems. The telemetry subsystem is also used to verify the receipt and action upon both real-time and stored commands.

The guidance and control subsystem consists of the CC&S and the guidance and attitude control units. The sequencer stores commands inserted prior to launch, and by radio command, and has a timing system for controlling spacecraft operation in accordance with these commands. The computer provides a velocity increment sensing system to provide midcourse motor shut-off at the prescribed time. Several command sequences are initiated by radio command and then controlled by the CC&S.

The guidance and attitude control subsystem provides the equipment to permit sun and earth acquisition and to attain and maintain specific command attitudes for midcourse and terminal maneuvers. Optical sensors are used to lock onto the sun and earth. Small cold gas jets are used to turn the spacecraft in space. Pitch and yaw turns are used to obtain and maintain sun orientation.

The sun-spacecraft line is defined as the roll axis of the spacecraft. The earth sensor is located on the high-gain antenna hinges. Earth lock is maintained by automatically controlling the roll jets and the antenna hinge-angle servo.

The guidance and attitude control system also contains an inertial attitude reference system. The system is used to attain and maintain a commanded attitude relative to the sun-spacecraft-earth coordinate system for the midcourse or terminal maneuver.

The propulsion system used in the midcourse maneuver is a mono-propellant system using hydrazine. A small quantity of oxidizer is used to initiate the combustion, which is maintained by aluminum oxide pellets acting as a catalyst. The engine can impart a velocity change of from 10 cm/sec. to approximately 60 meter/sec. to the spacecraft.

Spacecraft temperature control is achieved by passive techniques involving the proper selection of surface finishes and controlling the internal heat transfer. Local temperatures are, therefore, dependent upon solar energy absorption, energy absorption from the earth, radiation of energy into space, heat from internal power dissipation, and heat transfer to or from other spacecraft components. Extensive telemetry of temperatures throughout the spacecraft permits a check of temperature-control success for adjustment on subsequent flights.

The television subsystem is mounted on top of the basic hexagonal bus and consists of six cameras, associated control and video circuitry, power system, thermal control system, and transmitters to send the video back to the earth.

Mission reliability is enhanced by providing as much isolation as possible between the wide-angle full-scan cameras and the narrower-angle partial-scan cameras.

### *The Ranger VII Flight*

The first attempt to launch Ranger VII was made on July 27, 1964. This was the first day of the six-day launch period. This first attempt was unsuccessful because difficulties with some of the ground guidance equipment could not be resolved in time to permit the launch during the available launch window.

A successful launch was accomplished at the beginning of the launch window on the following day, July 28, after a very smooth countdown. The launch vehicle, an Atlas D-Agena B, rose vertically then rolled to an azimuth of 97° and followed a programmed pitch maneuver until booster cutoff. During the Atlas sustainer and vernier phases, adjustment in vehicle attitude and engine cutoff times were commanded, as required, by the ground guidance computer, to adjust the attitude and velocity at Atlas vernier engine cutoff.

After the Agena separated from the Atlas and pitched down to a horizontal attitude, the Agena stage ignited and burned until a pre-set velocity increase had been achieved. At this time the Agena-spacecraft combination was coasting in a nearly circular parking orbit in a southeasterly direction at an altitude of 116 miles and traveling 17,400 miles per hour. After coasting in the parking orbit for 20 minutes, determined by the ground guidance computer and transmitted to the Agena during the Atlas vernier phase, a second ignition of the Agena engine occurred. About a minute and a half later, just over the western coast of South Africa, the Agena was cut off, with the Agena-spacecraft combination in a nominal earth-moon transfer orbit and traveling 24,600 miles per hour.

After the injection of the Agena-spacecraft into the lunar trajectory, the spacecraft separated from the Agena and the Agena was given a small retro impulse that was designed to eliminate interference with the spacecraft operation and reduce the chance of the Agena impacting the moon. (Tracking data indicated that the Agena passed the trailing edge of the moon at an altitude of 2,600 miles about three hours after the spacecraft impacted the moon.)

Approximately 60 minutes after launch, the CC&S initiated the sun acquisition sequence, commencing with an order to deploy the solar panels. Explosive pin pullers, holding the solar panels in their launch position, detonated, allowing the spring-loaded solar panels to open and assume their cruise position. After the solar panels were deployed, the CC&S activated the attitude control system. The stabilization and orientation of the spacecraft required for sun acquisition was accomplished in two stages.

During the first stage, gross movements of the spacecraft were reduced by the attitude control system's use of pitch and yaw signals generated by the autopilot's rate gyros. After the spacecraft's movements were dampened and its longitudinal axis was pointing in the general direction of the sun by means of signals from the secondary sun sensors, the second stage began. In this stage, the final pointing of the spacecraft was acomplished by the attitude control system's combining of signals received from its primary sun sensors and from the autopilot's rate gyros.

At the same time that the CC& S ordered sun acquisition, it also ordered the high-gain directional antenna extended. A drive motor extended the antenna to a pre-set hinge angle that was determined before launch.

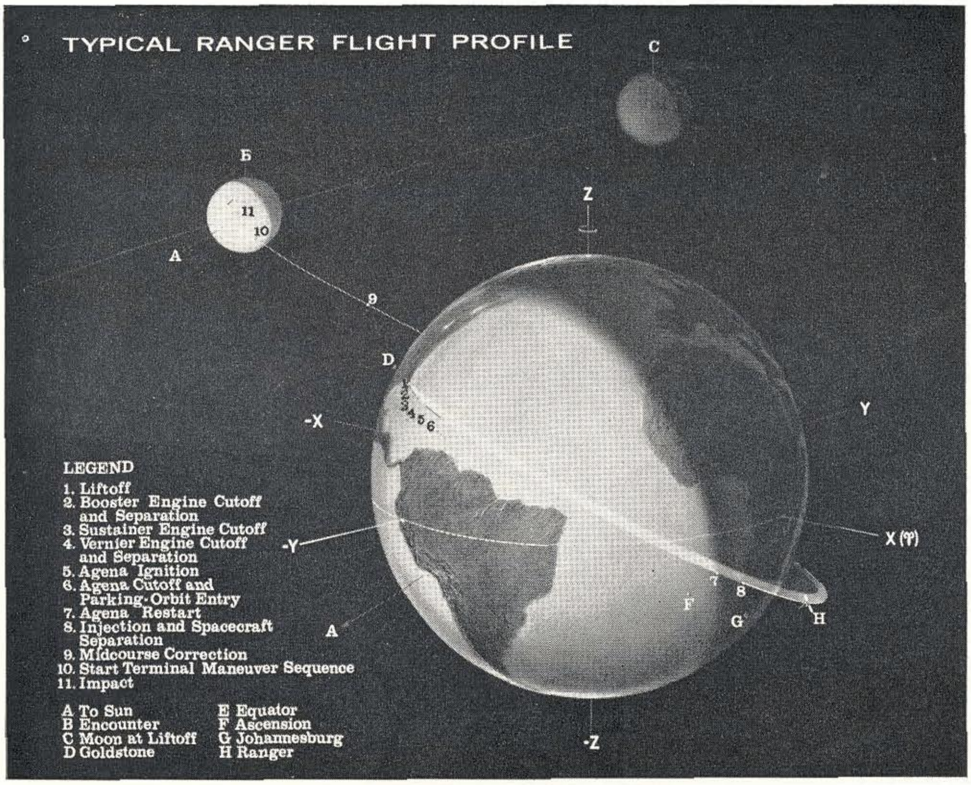
As soon as the spacecraft was locked on the sun, the power system began drawing electric power from the panels.

The next sequence of events commanded by the CC&S was the acquisition of earth by the earth sensor mounted on the high-gain directional antenna. This section was initiated at approximately three and one-half hours after launch. Earth acquisition required 23 minutes out of a maximum total of 30 minutes. To those who were watching the real time telemetered signals for the spacecraft, this seemed like an endless 23 minutes, while waiting to see the indication that the spacecraft in the roll search mode had finally seen and locked on the earth.

With the completion of earth acquisition, the spacecraft was stabilized on three axes – the pitch and yaw, which keep the spacecraft solar panels pointed at the sun; and the roll axis, which keeps the directional antenna pointed toward the earth.

On completion of the earth acquisition sequence, a command was sent from the Woomera, Australia, tracking station to switch the transmitter from the omni-antenna to the high-gain antenna. An increase in signal strength confirmed that the spacecraft had switched to the high-gain antenna and that the earth sensor was locked on the earth. The spacecraft was then in its cruise configuration.

Thirty-one minutes after launch, the Johannesburg, South Africa, station of the Deep Space Instrumentation Facility (DSIF) acquired the space-




craft and from that time until lunar impact continuous communications were maintained by one of the three DSIF stations at Johannesburg, South Africa; Woomera, Australia; and Goldstone, California. Each station has an 85-foot diameter antenna and is equipped to obtain two-way doppler and angle tracking data, to receive telemetry data, and to send commands to the spacecraft as required. The tracking and telemetry data were sent by teletype and telephone lines to the Space Flight Operations Facility (SFOF) at JPL, where they were reduced and analyzed by a group of highly trained specialists, using a large-scale computer system to determine the trajectory of the spacecraft and its performance.

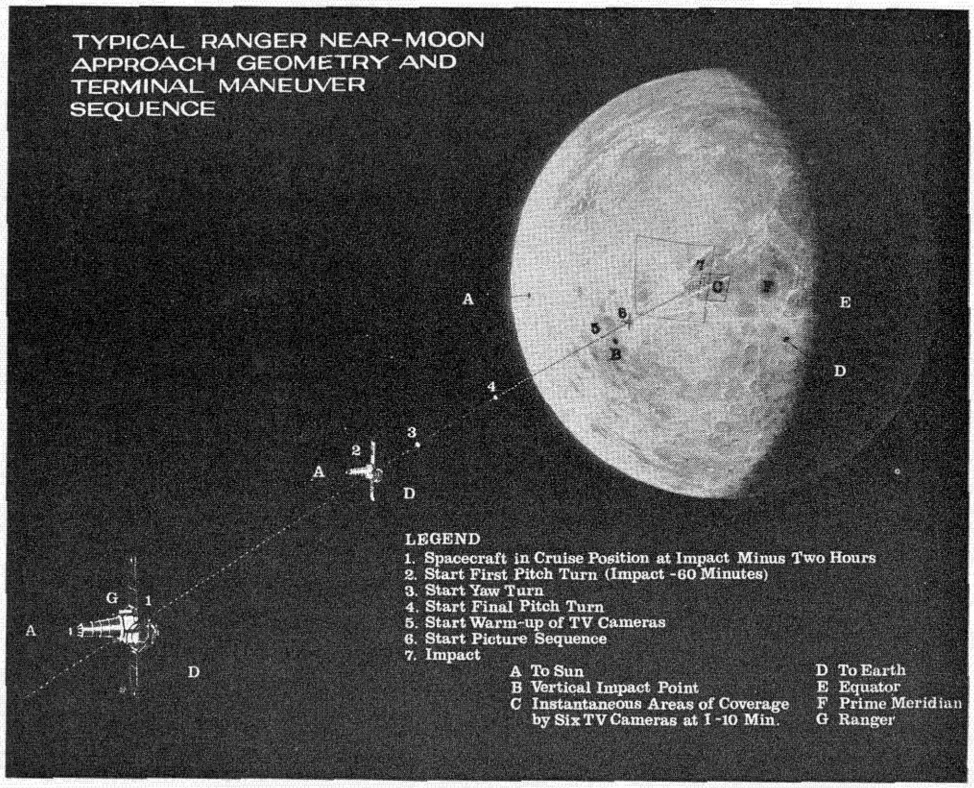
The first few hours of tracking data showed that the spacecraft had been placed on a trajectory that was within its correction capability. The uncorrected trajectory would cause the spacecraft to pass close to the western edge of the moon, then to impact on the back side.

A review of the pre-selected target areas and the spacecraft performance resulted in the primary target for that day being selected. This was the largest rubble-free maria that was the proper distance from the terminator and reasonably close to the equator. The coordinates of the aiming point were 11° south and 21° west. The midcourse maneuver was designed to correct the trajectory to this aiming point. The flight time was also to be adjusted by the midcourse maneuver so that a clock (which had been started at the time of spacecraft separation from the Agena) would turn the full-scan cameras on 17 minutes before the spacecraft would impact the lunar surface. This was done to provide a backup in case the radio command system should fail. The impact time selected was 12:25:30 GMT, July 31, 1964.

The midcourse maneuver was performed about 17 hours after launch when the spacecraft was almost halfway to the moon. This slowed the spacecraft by about 65 miles per hour in its flight to the moon — which essentially permitted the moon to move farther along its orbital path, so that the spacecraft would impact at the desired location at a time that was delayed sufficiently to be compatible with the camera turn-on clock.

The midcourse maneuver commands — roll turn, pitch turn, and velocity increment — were calculated on the computer in the SFOF at JPL and transmitted to the spacecraft from the Goldstone Tracking Station. After verification, by telemetry, that the spacecraft had received the proper commands, an "execute" command was sent to initiate the maneuver at the required time. Since about 97 percent of the velocity increment was in the radial direction toward the earth, the plot of the doppler frequency from the radio tracking gave a good indication that the maneuver had been performed precisely as commanded. The spacecraft proceeded on commands from the CC&S to reacquire the sun, and, a short time later, the earth.

Approximately ten hours after the maneuver,




when sufficient tracking data were available, an orbit was calculated which indicated that the spacecraft would impact very close to the selected aiming point and the specified time. Subsequent computations refined these numbers as more tracking data became available and indicated that the actual impact point was within about six miles of the target point. The actual time of impact was less than 20 seconds different from the selected time.

Studies of the lunar approach geometry indicated that a near-optimum camera alignment existed, with the spacecraft in the sun-oriented attitude, and it was decided not to perform a terminal maneuver. The terminal maneuver was designed to allow the spacecraft to be changed from sun-oriented cruise to any other orientation in case a different attitude would be more optimum for the photography. (The optimum generally aligns the camera axis more nearly with the flight path to minimize the image motion.) On the particular Ranger VII trajectory, one of the cameras (the A camera) already contained the velocity vector within its field of view so that not only was it unnecessary to perform a terminal maneuver, but the impact point would be contained in the entire A-camera sequence.

The cameras turned on exactly as planned and functioned flawlessly, as indeed did the entire spacecraft for the entire flight, until the spacecraft was destroyed on impact with the moon. The video data were recorded on 35mm film and magnetic tape at the Goldstone DSIF station.

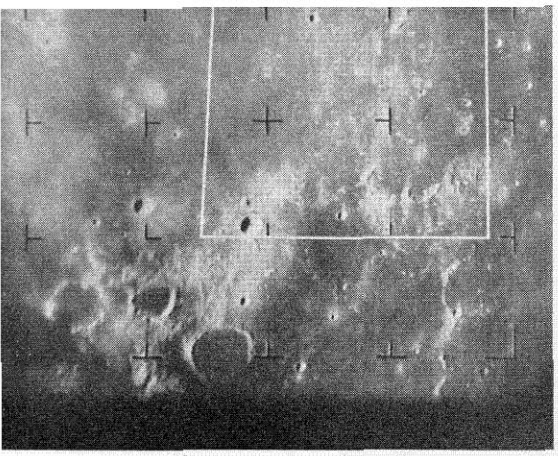
### *Results and Future Plans*

The Ranger VII mission resulted in over 4,300 high quality lunar photos and confirmed the very high degree of lunar flight precision that was initially demonstrated by Ranger VI. Even detailed reviews of the flight records have failed to indicate any evidence of even insignificant malfunctions aboard the spacecraft.

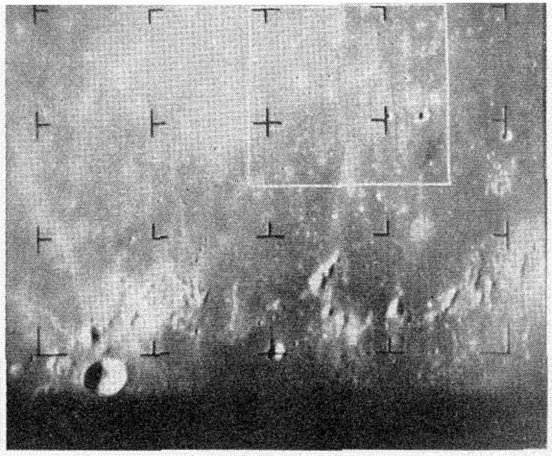
The impact had occurred in a mare region which was well defined but had no name of its own. The International Astronomical Union, at the annual meeting in Hamburg, Germany, adopted the name "Mare Cognitum," in honor of the Ranger VII flight.

At this time an intensive effort is under way to analyze and interpret the large quantity of photographs. This effort is being carried out by the Experimenter team headed by Dr. G. P. Kuiper of the University of Arizona, and his co-investigators: Mr. E. Whitaker of the University of Arizona; Dr. H. Urey of the University of California at San Diego; Dr. E. Shoemaker of the U.S. Geological Survey, Flagstaff, Arizona; and Mr. R. Heacock of JPL.

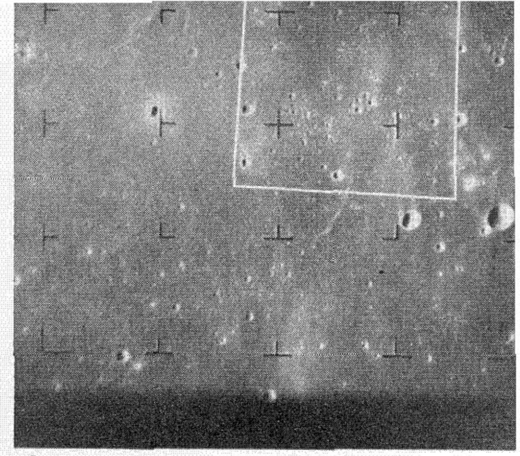
Some very interesting observations have already been made on the basis of the preliminary evaluations of the pictures by the Experimenter team. There appears to be, at least in the areas photographed, almost a complete absence of rocks, boulders, or sharp crevices or fissures of sizes equal to or greater than the resolution of the photos. The reasons for this are not completely clear, but it may



*Photograph taken from an altitude of 477 miles is comparable to the resolution obtainable in photographs from the earth.*



*Photograph taken from altitude of 236 miles, some 2 min. 46 sec. before impact. Each picture covers area marked in preceding picture.*



*Photograph from an altitude of 84.9 miles covers an area 41.04 miles on a side and shows craters as small as 500 ft. in diameter.*

well be due to the long erosion process to which the lunar surface has been subjected. It would not be wind and water erosion as we have on earth, but a "sand-blasting" effect due to high-speed particles from space.

A number of major impact craters like Copernicus, Kepler, and Tycho have very prominent radial features that show up as white rays under full moon illumination. The nature of these rays at resolutions greater than that available from earth-based telescopes has been a subject of considerable speculation. The telescopic observations had shown that these rays contained numerous shallow secondary craters. It was felt by many that these rays also consisted of a white powdery material scattered among a few secondary craters.

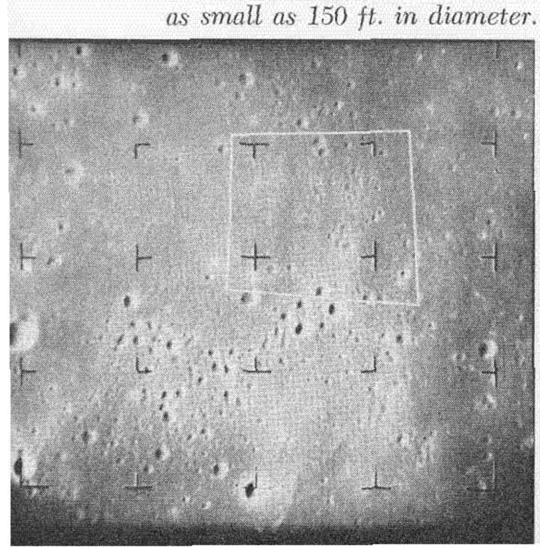
The Ranger VII photos were taken in an area containing faint rays from both of the craters – Copernicus and Tycho. The photos resolved these areas and showed them to consist of numerous small secondary and tertiary craters and apparently not a layer of fine white powder. This is very well shown in the set of nesting A-camera photos shown here. There appears to be a very close correlation between the brightness of a crater ray and the surface density of secondary and tertiary craters.

The highest resolutions obtained are one thousand times better than those from the best earth-based photographs.

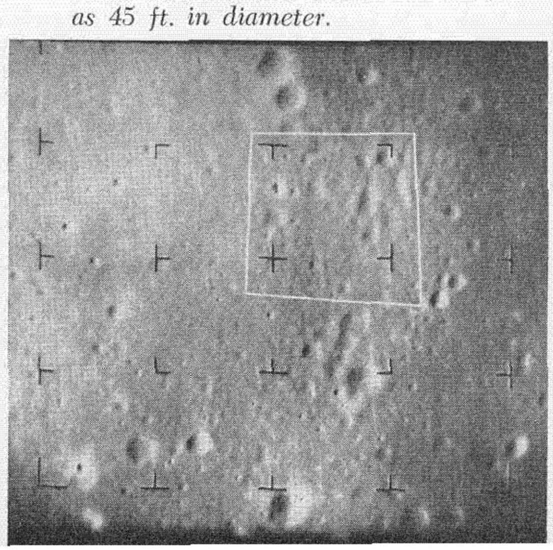
It appears that regions covered by crater rays should be avoided when selecting sites for the landing of instruments or men. A question still to be answered is whether maria that appear smooth and ray-free in telescopic observations are in fact consistently smooth when viewed in detail at resolutions comparable to the Ranger VII photos.

Two more Rangers remain, and these will be launched next year. These spacecraft will be essentially identical to Ranger VII, but the target areas on the moon will be different. If these forthcoming Rangers are as successful as Ranger VII, a great more will be learned about the detailed topography of the moon, and we will be a few steps closer to understanding some of the mysteries, and accomplishing the manned exploration of our closest celestial neighbor.

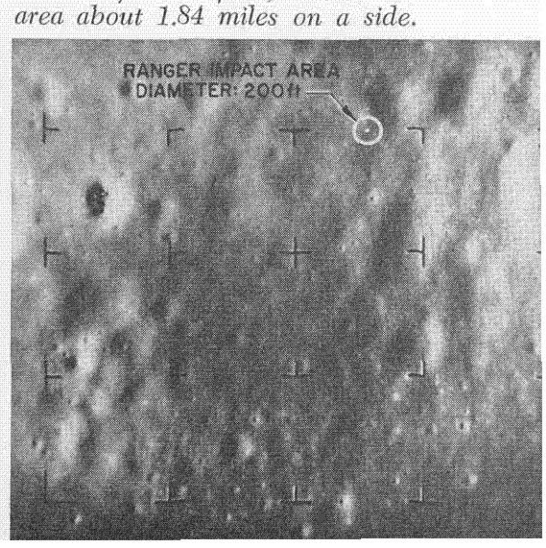
*Photograph taken from an altitude of 33.6 miles shows an area 16.1 miles on a side with craters as small as 150 ft. in diameter.*



*Photograph taken from an altitude of 11.2 miles shows an area 5.47 miles on a side with craters as small as 45 ft. in diameter.*



*Photograph taken from an altitude of 3.7 miles, about 2.5 seconds before impact, shows an area about 1.84 miles on a side.*



# CALTECH'S 1963 ALUMNI SURVEY

## III. *Politics, Community Activities, and Grades*

*by John R. Weir*

It is almost inevitable that the increasing technical complexity of modern living will result in more and more of our alumni achieving positions of influence in business, industrial, and government affairs. Consequently, their economic and political attitudes are of considerable interest.

The sections that follow contain an analysis of responses to survey questions concerning the contemporary political, social, and cultural activities of our alumni. They are in turn followed by comparisons of these activities with the extracurricular activities of the alumni during their college years.

### POLITICAL AFFILIATIONS

U.S. college graduates are predominantly Republican in their political party affiliation, and have been for many years. This was also true for Caltech alumni in 1952, and it still is. According to the current survey, two-thirds of our alumni had parents who voted Republican, a majority consider themselves Republican, and two-thirds favored the Republican candidate in 1960.

| | % Rep. | % Dem. | % Indep. |
|---|---|---|---|
| Parents voted | 65 | 35 | |
| Consider self | 55 | 22 | 23 |
| Favored in 1960 | 64 | 36 | |
| Likely favor in 1964 | 49 | 27 | 24 |

Political party preference is closely correlated with age. Our older alumni are much more frequently Republican than Democratic or Independent. Among those under 30 years of age, four out of ten are Republican. In the 60-and-over age group they have doubled in frequency to eight out of ten. This occurs at the expense of both Democrats and Independents, and leaves the percent of Democrats in the oldest age group at an insignificant 7 percent.

| *Age* | % *Rep.* | % *Dem.* | % *Indep.* |
|---|---|---|---|
| Under 30 | 39 | 32 | 29 |
| 30 - 39 | 53 | 23 | 23 |
| 40 - 49 | 61 | 20 | 19 |
| 50 - 59 | 67 | 13 | 20 |
| 60 and over | 80 | 7 | 13 |

Preference for the Republican Party also varies according to the highest degree obtained. Among alumni with the BS as highest degree, two-thirds are Republican; while those with the PhD are nearly equally Republican, Democratic, and Independent. Postgraduate education seems to reverse the tendency for a college education to make its graduates Republican.

| *Highest Degree* | % *Rep.* | % *Dem.* | % *Indep.* |
|---|---|---|---|
| BS | 68 | 11 | 21 |
| MS | 57 | 15 | 28 |
| PhD | 41 | 29 | 30 |

Undoubtedly, some of this difference is due to the fact that there is a disproportionately large number of young PhD's in our alumni body. But its effect is small, for an analysis in which age was held constant gave essentially the same percents for the different degree levels.

A more important influence seems to be related to attendance at Caltech. By dividing alumni according to where they obtained their degrees, we were able to calculate the following percentages:

| | % *Rep.* | % *Dem.* | % *Indep.* | *Number* |
|---|---|---|---|---|
| BS only (from CIT) | 68 | 11 | 21 | 1,638 |
| BS (CIT) & PhD (CIT) | 46 | 29 | 25 | 264 |
| BS (CIT) and PhD (not CIT) | 39 | 32 | 29 | 347 |
| BS (not CIT) and PhD (CIT) | 36 | 30 | 33 | 608 |

This table suggests that the study required for a Caltech BS degree tends to encourage, and that for a PhD degree to discourage, Republican party affiliation.

There was also a very significant increase in the proportion of Republicans in the higher income brackets.

| Income | % Rep. | % Dem. | % Indep. |
|---|---|---|---|
| 0 - $3,999 | 18 | 30 | 52 |
| $4,000 - $8,999 | 32 | 21 | 47 |
| $9,000 - $12,999 | 54 | 23 | 23 |
| $13,000 - $18,999 | 56 | 22 | 22 |
| $19,000 and over | 66 | 16 | 18 |

Superficially, these changes seem quite reasonable. One might expect that as the alumnus gained a higher income he would come to favor more conservative political and economic ideas. However, when similar analyses were made with age held constant, the correlation disappeared. The differences we see in the table above are due to the fact that there are larger-than-average numbers of young alumni in the lower income brackets, and a high concentration of older alumni in the upper income brackets. In all but the very early and the very late years, approximately 60 percent of our alumni are Republican, 20 percent are Democratic and 20 percent Independent, regardless of income.

## CONSERVATIVE OR LIBERAL?

We were curious about any changes that might have occurred in the political and economic thinking of alumni since graduation. How do their attitudes compare with those reported in 1952?

To answer this question, we repeated a procedure used in the 1952 survey. We defined "conservative" as agreeing with at least three of the following four statements, and "liberal" as any other combination of replies:

*Democracy depends fundamentally on the existence of free business enterprise.*

*The best government is one which governs least.*

*Government planning should be strictly limited, for it almost inevitably results in the loss of essential liberties and freedom.*

*Individual liberty and justice under law are not possible in Socialist countries.*

On the basis of this definition, a majority of our alumni are now liberal (58 percent), whereas in 1952 a majority were conservative (62 percent). Although each of the first three statements had a majority of alumni agreeing with them, only 42 percent agreed with three or all four of them and therefore were identified as "conservative."

*Age.* There are four times as many liberals as there are conservatives in the under-30 age group. If their thinking has changed, it is as likely to have become more liberal as it is to have become more conservative. Among those over 60 there are four times as many conservatives as liberals, and if their thinking has changed it has been in the conservative direction.

*Undergraduate Major.* Alumni with undergraduate majors in civil, electrical, or mechanical engineering are somewhat more conservative than liberal. If their thinking changes, it tends to become more conservative.

On the other hand, alumni with degrees in astronomy, biology, chemistry, mathematics, and physics are somewhat liberal, and become more liberal if their thinking changes.

*Highest Degree.* Among alumni who have the BS as their highest degree, a majority (54 percent) are conservative. Among those with the PhD, almost three-quarters (72 percent) are liberal. Those with the MS are slightly liberal (58 percent).

*Occupational Titles.* Thirty-three different job titles were listed in the questionnaire for the alumnus to indicate his occupational position. There were definite majorities for either the liberal or conservative viewpoint associated with many of the titles. For example, those that were conservative were chief, manager, owner, partner, president, representative, retired, superintendent, and vice-president. Those that were liberal were assistant, assistant professor, associate professor, chairman, dean, director, engineer, group leader, instructor, professor, project leader, project supervisor, scientist, staff member, student.

The concentrations of business and industrial positions in the conservative group, and of educational and research positions in the liberal group are very striking. When compared with business and industry, the relatively greater personal and intellectual freedom provided by the university or research laboratory seems to attract and keep those alumni who prefer change, innovation, and personal freedom, and whose thinking is apt to become more liberal with the passage of time.

## ORGANIZATIONAL MEMBERSHIP

Caltech alumni could hardly be called "joiners." Only 40 percent indicated membership in a recreational or fraternal organization, and only 28 percent belong to civic, patriotic, educational, or political organizations. However, they do belong to business, labor, professional, and scientific organizations; 76 percent indicated they were members of such organizations, and almost a third hold one or more offices or committee memberships.

Two other differences of significant but minor magnitude appear in relation to organizational memberships. Firstly, alumni with the BS as their highest degree are more likely to belong to recreational and fraternal organizations than are those with PhD's, while the PhD's are more likely to belong to professional and scientific organizations than are the BS's. Secondly, alumni with engineering degrees are more likely to belong to recreational and fraternal organizations, while those with degrees in science and mathematics are more likely to belong to professional and scientific organizations.

## CIVIC ACTIVITIES

A section of the questionnaire requested the alumnus to check any of 14 specified civic or community activities he might have engaged in during the preceding year.

Ninety-five percent of the alumni reported participating in one or more of these activities. Forty-two percent were active in five or more, and 10 percent participated in nine or more. Within the latter group, those with BS degrees were most numerous (42 percent), those with PhD's least numerous (28 percent). Alumni with the most education are least active in the kinds of civic and community affairs where their knowledge and abilities should be very valuable.

## CULTURAL ACTIVITIES

Almost all alumni indicated an active interest or participation in one or more of the following cultural activities:

| *During the past year,* | *% checking 1 or 2, or several* |
|---|---|
| Attended a musical event | 86 |
| Visited a museum, art gallery, etc. | 85 |
| Read non-fiction for pleasure | 89 |
| Read classics for pleasure | 50 |
| Attended a lecture on a subject of cultural interest | 70 |

Obviously, Caltech alumni do not fit the stereotype of the narrow-minded scientist with few interests or concerns outside the laboratory. In fact, these figures are about what one would expect from alumni of a liberal arts college.

Again the frequency of participation is related to undergraduate major. Those with degrees in science participated in all these activities more frequently than those with degrees in engineering.

## COMMUNITY ACTIVITIES

We combined the foregoing items in a manner that would identify a group of alumni who are very active and a group who are very inactive in community affairs. This was accomplished by selecting one group of alumni, all of whom had listed five or more civic activities, held membership in three or more organizations, and had cited two or more political, cultural, or philosophical interests (*E & S* – June 1964). The contrasting group was composed of those who listed less than five civic activities, held fewer than three memberships in organizations, and cited no more than one political, cultural, or philosophical interest. The first group, containing 16 percent of the alumni, we will call "Community-Affiliated"; the second group, with 20 percent, will be "Ivory-Tower".

These two groups turn out to be quite different from each other in matters of age, highest degree, income, and occupational field.

*Age.* Participation in community affairs is a function of the middle years. Alumni under 30 are often still students, frequently unmarried, and not yet permanently established in a community. The 30-to-40-year period is the time of social and professional stabilization and the beginning of active participation in community affairs. Participation reaches a maximum in the 40-to-50-year age group. By this time the alumnus is well established in his occupation and in his community. He has both time and opportunity to become actively engaged in his professional organizations and in his community's affairs, and may even have been encouraged to do so by his employer.

| *Age* | *Community Affiliated* | *Ivory Tower* |
|---|---|---|
| % under 30 | 7 | 35 |
| % 30 - 39 | 29 | 28 |
| % 40 - 49 | 39 | 20 |
| % 50 - 59 | 19 | 12 |
| % 60 and over | 6 | 5 |

*Highest Degree.* Community activity also varies by highest degree, at least between the two groups we are discussing here. Alumni with PhD's are found more frequently than those with BS's in the Community-Affiliated group.

| *Highest Degree* | *Community Affiliated* | *Ivory Tower* |
|---|---|---|
| % BS | 31 | 41 |
| % MS | 33 | 37 |
| % PhD | 36 | 22 |

*Income.* The greater the income, the more likely it is that the alumnus will be in the Community-Affiliated group. Here the proportions almost reverse themselves in the transition from low to high income.

| Income | Community Affiliated | Ivory Tower |
|---|---|---|
| % 0 - $4,999 | 2 | 11 |
| % $5,000 - $8,999 | 2 | 10 |
| % $9,000 - $12,999 | 16 | 25 |
| % $13,000 - $18,999 | 35 | 33 |
| % $19,000 - $24,999 | 19 | 12 |
| % $25,000 - $29,999 | 9 | 3 |
| % $30,000 and over | 18 | 5 |

Approximately half of the Community-Affiliated group have yearly incomes above $19,000. Approximately half of the Ivory-Tower group have yearly incomes below $13,000.

*Occupational Field.* Some of the occupational fields in which our alumni are engaged can also be distinguished in terms of community activity. The following occupations had a majority of Community-Affiliated alumni in them: Biochemistry, Business, Chemistry, Civil Engineering, Education, Finance, Geology, Law, Medicine, and Petroleum Engineering. Most of these occupations have an important element of human relations and public service in them. Those with a high majority of Ivory-Tower alumni in them were : Astronomy, Economics, Electrical Engineering, Mathematics, Mechanical Engineering, Military, and Physics. Here the emphasis is toward intellectual and technical pursuits done in relative isolation. In fact, some of these occupations are often referred to as ivory-tower jobs.

*Undergraduate Extracurricular Activities.* The consistent and quite logical differences between the Community-Affiliated and the Ivory-Tower groups raise the question as to whether these groups were different as undergraduates. We've already seen that they majored in different subjects. Were they also different in their amount of participation in extracurricular activities? The answer is yes.

In the questionnaire, we asked the alumnus to indicate whether he had participated in any of eight different kinds of extracurricular activities—varsity sports, other sports, writing, music, speaking, politics, clubs, and societies. We then grouped all those who participated in four or more kinds into a High-Activities group and those who reported no participation in any activity into a Low-Activities group. When these two groups are cross-compared with the Community-Affiliated and Ivory Tower groupings, it is evident that the alumni who are active in community affairs also participated in extracurricular activities in college.

| | Community Affiliated | Ivory Tower |
|---|---|---|
| % Alumni participating in four or more kinds of extracurricular activities | 25 | 15 |
| % in no activities | 8 | 16 |

Alumni in the High-Activities group reported that they value their undergraduate activities highly and would participate in them again if they had it to do over. This was also true for the Community-Affiliated alumni. On the other hand, only a minority of the Low-Activities group think their extracurricular activities were of value after college and only a slight majority would participate again if given another opportunity. While most of the Ivory-Tower group think undergraduate activities have value after college, only two out of three would participate if they had it to do over.

| | % Think ECA of Value after College | % Would Participate Again |
|---|---|---|
| High Activities | 91 | 91 |
| Community-Affiliated | 81 | 81 |
| Ivory-Tower | 93 | 62 |
| Low Activities | 34 | 60 |

From the foregoing we might conclude that the student who is active in student affairs will later on be active in community affairs. The campus leader becomes the community leader.

*Grades.* Alumni in the Community-Affiliated group got higher grades than those in the Ivory-Tower group. In fact, the Ivory-Tower group is somewhat below the distribution of grades for all alumni combined.

| | % Mostly A's | % Mostly B's | % Mostly C's |
|---|---|---|---|
| Community-Affiliated | 32 | 59 | 9 |
| Ivory-Tower | 26 | 62 | 13 |
| Total Alumni | 28 | 59 | 13 |

While the differences are not great they do suggest a positive relationship between the personal characteristics that contribute to earning high grades in college and those that lead to an active social and community life after graduation.

The opposite seems to be true in the case of undergraduate extracurricular activities. Among those participating in four or more kinds of activities there are fewer getting mostly A's than in the total alumni group or in the group that had zero participation. In fact, the zero participation group had fewer "Mostly C's" than the total sample.

| | % Mostly A's | % Mostly B's | % Mostly C's |
|---|---|---|---|
| ECA—four or more | 23 | 64 | 13 |
| ECA—none | 27 | 64 | 9 |
| All alumni | 28 | 59 | 13 |

Perhaps there is a kind of grade penalty for participation in student activities, or perhaps some A students refrain from extra activities in college, but become active in the community later on.

*continued on page 20*

## GRADES: ESTIMATED AND EARNED

In the present survey we asked the alumnus to estimate his four-year over-all grade-point average using a scale of A=4, B=3, C=2, and D=1. This is the scale used by Caltech and most U.S. colleges. In addition, actual earned GPA's were copied from Institute records – before mailing – onto the questionnaires of those alumni who did their undergraduate work at Caltech.

When the estimates from memory are compared with the actual GPA's, it turns out that our alumni have quite good memories. On a scale running from 1.0 to 4.0, one-quarter estimated correctly, another quarter missed by 0.1 grade point and a third quarter missed by 0.2 or 0.3. Only 12 percent over- or underestimated by more than 0.5 GPA.

As might be expected, the magnitude of the errors increased with years out of college. The errors also tended to be in the optimistic direction. This was particularly true for those earning GPAs below 2.5. The median actual GPA for all undergraduates was 2.6, the median estimated was 2.8, and the median error was 0.2. Perhaps the small size of these errors is evidence of the ease with which Caltech alumni usually deal with numbers. Or perhaps it reflects the importance the GPA had for our alumni.

In the 1952 survey we asked alumni to report whether they got mostly A's, B's, C's, or D's during their undergraduate years. When their grades are compared with those in the present survey, the more recent alumni appear to have earned higher grades as undergraduates.

| *Grades Mostly* | % 1963 | % 1952 |
|---|---|---|
| A's | 28 | 22 |
| B's | 59 | 50 |
| C's | 13 | 28 |

During the last decade, the academic ability of our undergraduates has increased, and so has the awarding of higher grades. Consequently, more undergraduates *have* been earning higher grades in recent years.

*Grades and Highest Degree.* Several interesting aspects of grade-point average requirements for admission to advanced work are revealed when comparisons are made between alumni with graduate degrees who attended Caltech as undergraduates and those who did their undergraduate work elsewhere. We used the undergraduate estimated GPA to calculate medians for various combinations of alumni with undergraduate and graduate degrees obtained at Caltech and other institutions. (To do so, we had to assume that the optimistic error of 0.2 for those who did their undergraduate work at Caltech also held for alumni who got their BS's elsewhere. To approximate actual GPA's, it would be necessary to subtract this error from the medians that follow.

MEDIAN ESTIMATED UNDERGRADUATE GPA'S

| *Degree Combination* | *Four-year GPA* |
|---|---|
| Other BS, Caltech PhD | 3.6 |
| Other BS, Caltech MS | 3.4 |
| Other BS, Caltech Engineering | 3.3 |
| Caltech BS, Caltech PhD | 3.2 |
| Caltech BS, Caltech MS | 3.0 |
| Caltech BS, Other PhD | 3.0 |
| Caltech BS, Other MS | 2.8 |
| Caltech BS only | 2.7 |

On the average, a Caltech undergraduate needs a 2.8 to get an MS elsewhere and a 3.0 to get one at Caltech, while an undergraduate coming from elsewhere needs a 3.4 to get an MS from Caltech. This is a difference of 0.6 grade-point.

A similar difference holds for the PhD degree. A Caltech undergraduate needs a 3.0 to get a PhD elsewhere and a 3.2 to get one at Caltech, while an undergraduate from another college needs a 3.6 to get a PhD from Caltech.

One interpretation of these figures is that a 2.6 at Caltech is equal to a 3.2 elsewhere. This may sound familiar to many Caltech undergraduate alumni who have heard it said that a C at Caltech is equal to a B anywhere else. Only 37 percent of Caltech alumni with the BS as their highest degree got 3.0 or above.

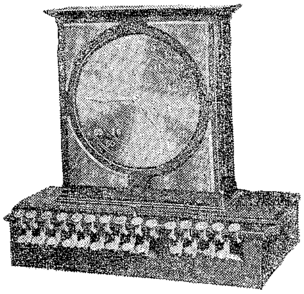
Another interpretation is that Caltech has higher standards of admission to graduate school for those with BS's from elsewhere than it has for its own bachelors. That standard is about 0.4 GPA. This interpretation is further supported by the fact that among all alumni with advanced degrees, those who got their BS's elsewhere had a higher percentage of GPA's above 3.0 (93 percent) than those who got BS's at Caltech (58 percent).

It appears to take mostly A's (3.4) to be accepted at Caltech for graduate work, while our own BS's do graduate work at other schools with mainly B (2.8) averages. When we consider the additional fact that only 14 percent of *all* Caltech BS's got A's, one can only conclude that Caltech grades cannot be equated with grades from other colleges. The price of a high quality student body is high quality competition.

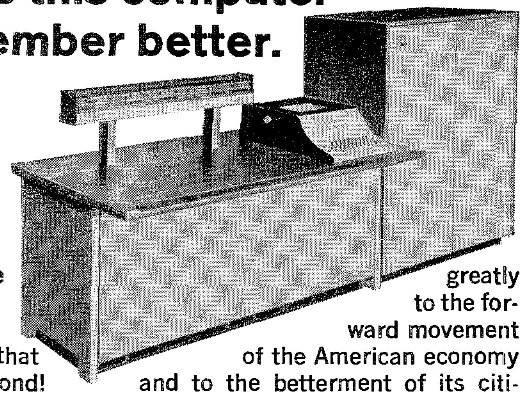
---

*Third in a series of articles in the survey conducted last year by Dr. Weir, associate professor of psychology. In our next issue, Dr. Weir will discuss occupations, income, and achievement.*

# 80 years ago the first cash register helped shopkeepers remember.



# Today NCR's new thin-film rod memory helps this computer remember better.



NCR's job for 80 years has been to make things easier and more profitable for businesses of all kinds and sizes. How? By producing the most complete and efficient line of record keeping and data processing equipment obtainable. We began by marketing the first cash register—*the first automated system for handling sales and cash!* Today NCR continues to make things easier for government, industry, business and banking with a full line of equipment to handle everything from original entry to final report. Latest is a rod memory computer that cycles in billionths of a second!

Equally as important as the development of the total system concept of record keeping are the many *research and development programs* which NCR has in progress. Important advances in encapsulation, photochromism, thin-film and laser technology have contributed greatly to the forward movement of the American economy and to the betterment of its citizens. If you would like to be considered for positions that are now opening for qualified persons at *NCR, write to T. F. Wade, Technical* Placement, NCR, Dayton, Ohio 45409. All correspondence will be treated confidentially. An equal opportunity employer.

**N C R**

BE SURE TO VISIT THE NCR PAVILION AT THE N.Y. WORLD'S FAIR.

THE NATIONAL CASH REGISTER COMPANY ®

# The Summer at Caltech

*Caltech Lecture Series*

Caltech's Friday Evening Demonstration Lectures become the Caltech Lecture Series this year. The talks will be given on Monday evenings in the new 1200-seat Beckman Auditorium. Opening the series on October 12 is Professor Earnest Watson, former dean of the Caltech faculty and professor emeritus of physics, who originated the Demonstration Lectures in the early 1920's. Dean Watson will give his "Liquid Air" demonstration, which has probably been the most popular of all the Institute's public lectures.

The Friday Evening Demonstration Lectures, which grew out of Caltech's freshman and sophomore physics courses, were originally given at the request of local high school teachers who wanted to keep up to date on new developments in the field. To give a broader picture of the research at Caltech, biologists, geologists, engineers, chemists, and others were gradually added to the series.

*Anniversary*

Caltech's Industrial Relations Center celebrated its 25th anniversary on September 17 with a conference in Beckman Auditorium, followed by a dinner at the Biltmore Hotel in Los Angeles.

President L. A. DuBridge gave the welcoming address at the conference and the principal speakers were Dr. Simon Ramo, board vice chairman of Thompson Ramo Wooldridge, Inc., president of the Bunker-Ramo Corporation, and a Caltech trustee; Dr. Mason W. Gross, president of Rutgers University; and J. W. Hull, vice president-operations, Pacific Telephone and Telegraph Company.

At the dinner meeting, the work of the Center was reviewed by Howard G. Vesper, president of the Standard Oil Company of California, Western Operations, Inc., and a graduate of Caltech (1922); Ernest J. Loebbecke, chairman of the board and chief executive officer of the Title Insurance and Trust Company; James F. Davenport, executive vice president of the Southern California Edison Company; and Philip S. Fogg, chairman of the board of Consolidated Electrodynamics Corporation, and vice chairman of the board of the Bell and Howell Company. Speaker of the evening was Lawrence A. Appley, president of the American Management Association.

*Trustees and Associates*

Simon Ramo, vice chairman of the board of directors of Thompson Ramo Wooldridge, and research associate in electrical engineering at Caltech, has been elected to the Institute's Board of Trustees. Dr. Ramo, who received his PhD from Caltech in 1936, is the third alumnus to become a Caltech trustee.

Samuel F. Bowlby, vice president-production of the Shell Oil Company in Los Angeles, succeeds Siman Ramo as president of the California Institute Associates. Added to the Associates' board of directors: J. Stanley Johnson, Caltech '33, MS '34, vice president of the A.S.D. Corporation in Altadena; John R. McMillan, '31, president of the Reserve Oil and Gas Company in Los Angeles; Ruben F. Mettler, '44, MS '47, PhD '49, president of the Space Technology Laboratories in Redondo Beach; Roy L. Ash, president of Litton Industries, Inc., in Beverly Hills; William H. Burgess, president of the Electronic Specialty Company in Los Angeles; and John C. Cosgrove, of Marsh and McLennan, Inc., in Los Angeles.

*continued on page 24*

*Leonard S. Lyon*

Leonard S. Lyon, a trustee of the California Institute of Technology since 1950, died of pneumonia on August 13. He was 68. Senior member of the legal firm of Lyon and Lyon in Los Angeles, he specialized in patent and antitrust cases. Mr. Lyon served as president of the California Institute Research Foundation, a member of the Caltech Associates, a director of the Stanford Research Institute, and an active contributor to the Caltech Development Fund.

*Frederick Hanley Seares*

Frederick Hanley Seares, former assistant director of the Mount Wilson Observatory, died in Honolulu on July 20 at the age of 91.

From 1909 to 1925, Dr. Seares was superintendent of the computing division and editor of publications of the Mount Wilson Observatory. In 1925 he became assistant director and retired in 1940 to become research associate. His most important astronomical work dealt with the precise measurement of the brightness and colors of the stars, and of their distribution in the galaxy. He also contributed to the investigation of the orbits of comets and the measurement of the sun's magnetic field.

*Honors and Awards*

President L. A. DuBridge is the 1964 nominee for "Eminent Membership" in Eta Kappa Nu, the national electrical engineering honor society. The award is made annually to an outstanding American who has made a significant contribution to electrical engineering.

William H. Pickering, director of Caltech's Jet Propulsion Laboratory, was elected president of the International Astronautical Federation at its 15th annual congress in Warsaw, Poland, last month. The election was by acclamation.

Alfred Stern, professor of philosophy and languages at Caltech, has been elected president of the American Philosophical Association, Pacific Division, for 1964-65.

*Changes In Administrative Staff*

HORACE W. BABCOCK is now director of the Mount Wilson and Palomar Observatories. A 1934 graduate of Caltech, he has been a member of the Observatory staff since 1946, and was named associate director in 1963.

IRA C. BECHTOLD has been appointed patent officer of the Institute and executive secretary of its affiliate, the California Institute Research Foundation. A 1930 graduate of Caltech, Mr. Bechtold has been a private consultant for plant location, raw materials evaluation, and process selection, since 1952.

WARREN G. EMERY is now director of physical education and athletics. He came to Caltech as a coach in 1955 and became assistant director in 1963.

JAMES N. EWART is now secretary of the Board of Trustees. He has been at Caltech since 1946, when he came to set up a personnel department, and has served as director of personnel since then.

MAJOR GENERAL ALVIN R. LUEDECKE, USAF (RET.) has been appointed deputy director of the Jet Propulsion Laboratory. He was formerly general manager of the Atomic Energy Commission.

RICHARD MULLIGAN is director of personnel at Caltech after a year as assistant. He came from the University of California at San Diego, where he served as assistant personnel director.

JOHN B. WELDON has been appointed Registrar at Caltech. He was formerly administrative dean for student personnel at Pasadena City College.

## Faculty Changes 1964-1965

PROMOTIONS

*To Professor:*

CLARENCE R. ALLEN — *Geology and Geophysics*
DONALD E. COLES — *Aeronautics*
HAROLD LURIE — *Engineering Science*
J. BEVERLEY OKE — *Astronomy*
C. J. PINGS — *Chemical Engineering*
MAARTEN SCHMIDT — *Astronomy*

*To Associate Professor:*

DON L. ANDERSON — *Geophysics*
PAUL J. BLATZ — *Materials Science*
DAVID BRAVERMAN — *Electrical Engineering*
SUNNEY I. CHAN — *Chemical Physics*
EVERETT C. DADE — *Mathematics*
STEVEN C. FRAUTSCHI — *Physics*
FLOYD B. HUMPHREY — *Electrical Engineering*
STEWART W. SMITH — *Geophysics*
HUGH F. TAYLOR — *Geology*

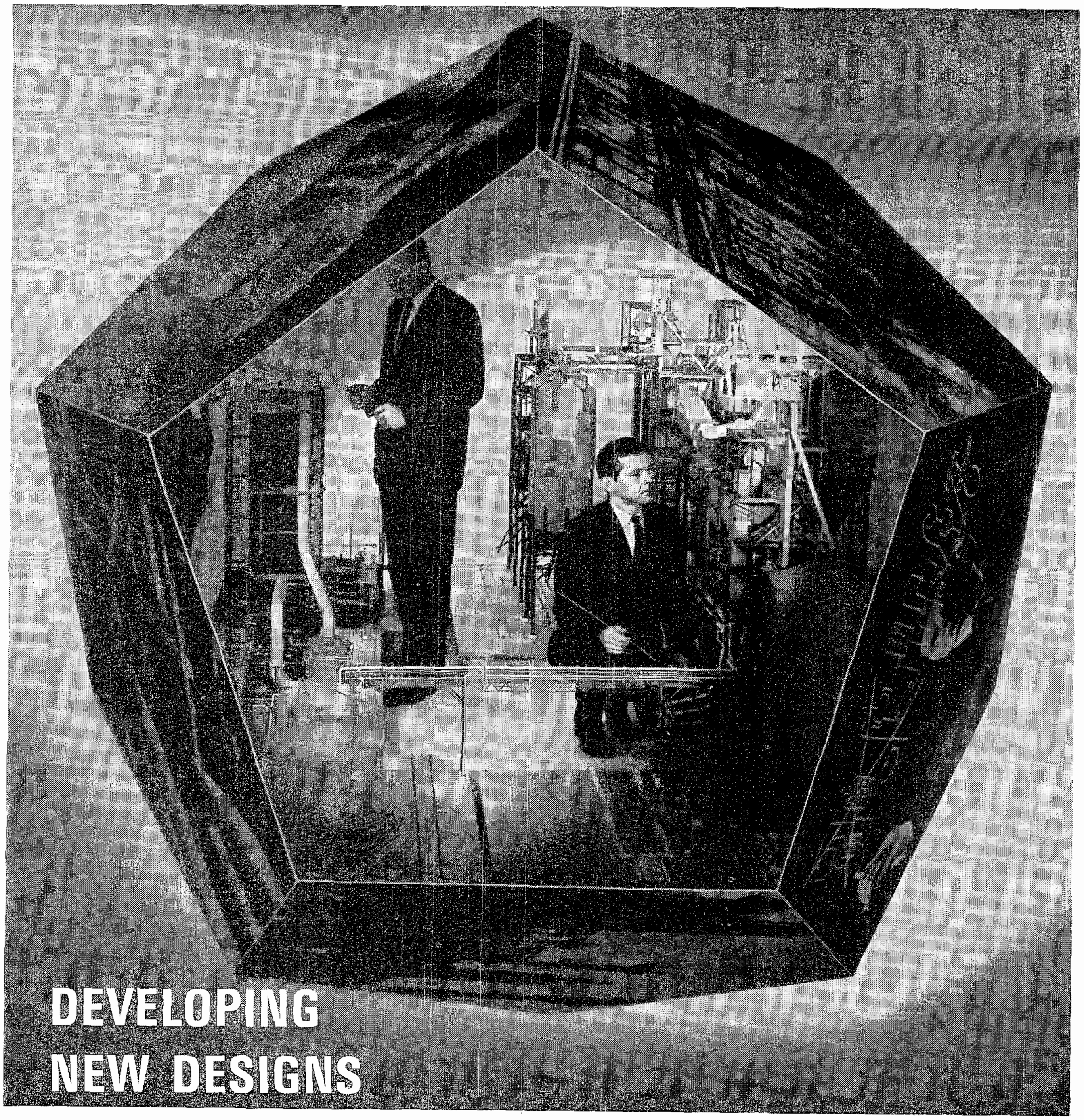
*To Senior Research Fellow:*

ARI BEN-MENAHEM — *Geophysics*
EGBERT KANKELEIT — *Physics*

*To Assistant Professor:*

A. L. GRAM — *Environmental Health Engineering*
ROBERT L. KOVACH — *Planetary Science*

*continued on page 26*




## *Another of your future's many facets at Monsanto*

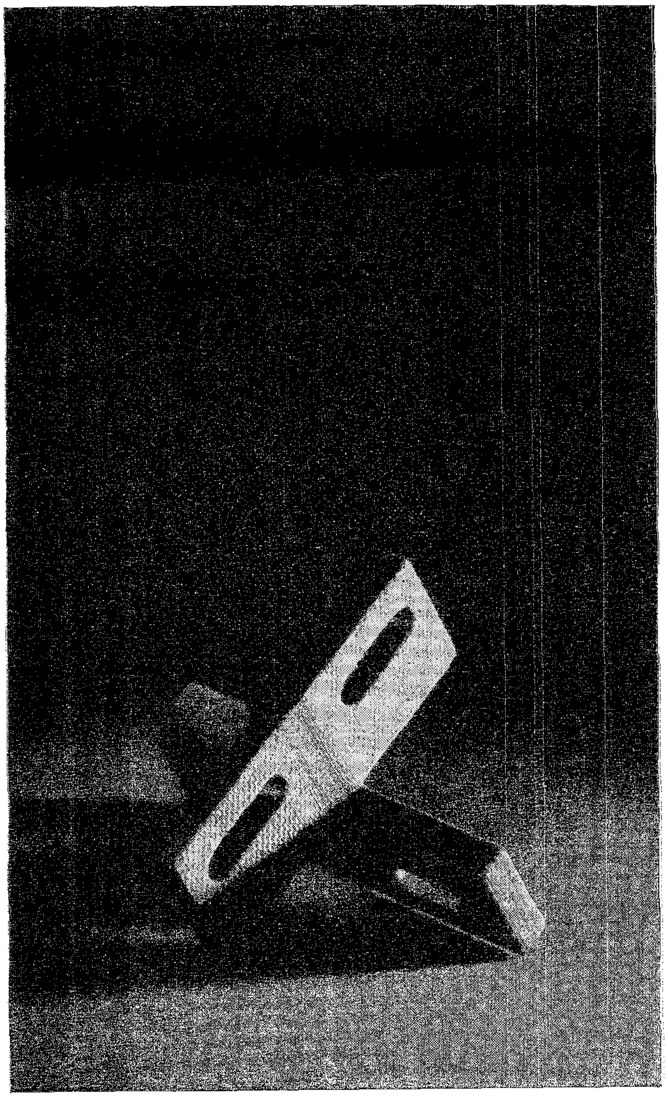
With a company growing as fast as Monsanto (annual sales quadrupled to a hefty $1.2 billion in little more than a decade), design of new plants, equipment and systems has never been so important. Engineers are needed to apply their skills and knowledge . . . in known and unknown areas . . . to help us manufacture the new and improved products that move Monsanto ahead—500 new products in the last 10 years.

*We can show you what this means in terms of increased professional opportunity . . . how Monsanto's continuing expansion affords more and interesting growing room for you.*

See your Placement Director to arrange for an interview when we visit your campus soon. Or write today for our brochure, "Your Future and Monsanto," to Manager, Professional Recruiting, Dept. CM 64, Monsanto, St. Louis, Missouri 63166.

*An Equal Opportunity Employer*

Monsanto ®





# The Summer . . . *continued*

## NEW FACULTY MEMBERS

BORIS AUKSMANN, assistant professor of engineering design, who received his PhD from Caltech in June.

GILES COKELET, assistant professor of chemical engineering, from MIT, where he was assistant professor of chemical engineering. He received his BS in 1957 and his MS in 1958 from Caltech.

GEORGE R. GAVALAS, assistant professor of chemical engineering, from the University of Minnesota, where he received his PhD this year.

WILFRED IWAN, assistant professor of applied mechanics, from the U.S. Air Force Academy in Colorado Springs, where he was associate professor of mechanics. He received his BS in 1957, his MS in 1958, and his PhD in 1961 from Caltech.

DANIEL J. KEVLES, assistant professor of history, from Princeton University, where he received his PhD in 1964.

PHILLIP G. SAFFMAN, professor of fluid mechanics, from King's College, London University, where he was a reader in applied mechanics.

MIKLOS SAJBEN, assistant professor of aeronautics, who received his ScD in magnetohydrodynamics at MIT in June.

THAYER SCUDDER, assistant professor of anthropology, from Harvard University, where he was a research fellow.

ELI STERNBERG, professor of applied mechanics, from Brown University, where he was professor of mechanics.

FELIX STRUMWASSER, associate professor of biology, from the Walter Reed Army Institute of Research in Washington, D.C., where he was research associate in the department of neurophysiology and in the Washington School of Psychiatry.

AMNON YARIV, associate professor of electrical engineering, from the Watkins-Johnson Company in Palo Alto, where he was head of optical systems.

HAROLD ZIRIN, professor of astrophysics, from the High Altitude Observatory at the University of Colorado, where he was research associate. He also served as associate professor of astronomy at the University.

GEORGE ZWEIG, assistant professor of theoretical physics, from a year at the theoretical division of CERN in Switzerland. He received his PhD from Caltech in 1963.

## RESIGNATIONS

EGON T. DEGENS, assistant professor of geology, to the Woods Hole Oceanographic Institution in Massachusetts.

OLIN J. EGGEN, professor of astronomy and staff member of the Mount Wilson and Palomar Observatories, to the Royal Greenwich Observatory in Sussex, England.

ARTHUR ERDÉLYI, professor of mathematics, to the University of Edinburgh, where he will head the department of mathematics.

GEORGE B. LANGDON, assistant professor of history, to Vassar College.

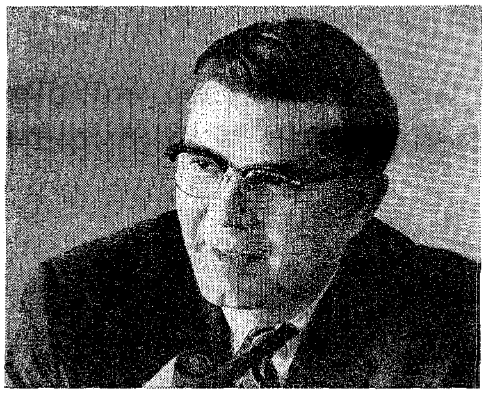
PAUL A. LONGWELL, associate professor of chemical engineering, to the Von Karman Center at Aerojet-General Corporation in Azusa, where he is a member of the corporate staff.

RUDOLPH L. MÖSSBAUER, Nobel Laureate and professor of physics, to the Institute of Technology in Munich, where he holds a chair in experimental physics.

CUSHING STROUT, professor of history, to Cornell University.

# STEP FORWARD WITH FORD MOTOR COMPANY

*An Open Letter to the 1965 College Graduate from Donald N. Frey, Assistant General Manager, Ford Division of Ford Motor Company*



Donald N. Frey was awarded a bachelor's degree in metallurgical engineering by the University of Michigan in 1947 and a doctorate in 1950. One year later, he joined Ford Motor Company as manager of the Metallurgical Department in the Scientific Laboratory. In 1962, Dr. Frey was appointed assistant general manager of the Ford Division with responsibility for all engineering, product planning and purchasing activities. He is 41 years old.

America's automobile industry is in the midst of a challenging era, with prospects of an even more exciting and demanding tempo in the years to come. Ford Motor Company is determined to achieve leadership in all phases of its operation. This leadership promises to bring lasting success to the company, its employes and its stockholders.

It will take people to accomplish this objective. Engineering, finance, styling, marketing, product planning, sales—all require people with the knowledge, judgment and personal drive to avail themselves of the unprecedented opportunities offered by a great industry.

The automobile business is growing. More cars are being bought now than ever before. With increases in population and consumer buying power, even more will be bought in the future. Realizing this, Ford Motor Company seeks to attract college graduates who have the capacity to grow with the company and the market.

Right now, our plans call for employing about a thousand of the best 1965 graduates we can find, with all types of educational backgrounds. We need specialists, but we also need persons with broad liberal-arts training who can handle a wide variety of assignments. Actually, in our company, many graduates grow into jobs totally unrelated to their degrees. They have discovered that Ford offers intellectually challenging opportunities for those with the ability to seize them. We invite you to make the same discovery.

Contact your Placement Office and arrange to see our representative.

Donald N. Frey

Ford

MOTOR COMPANY

The American Road, Dearborn, Michigan

*An Equal Opportunity Employer*

# Personals

1932

R. E. FOSS has been elected president of Sunray DX Oil Company in Tulsa, Okla. Formerly vice president, he has been with the company since 1935.

1933

EVAN G. BOWER, assistant district engineer for operations of the California State Division of Highways, was killed on April 29 when his car struck a taut steel cable stretched between two road graders working on the new U.S. 91 freeway east of Yermo. He was 53. Bower had been with the Division of Highways since 1934, except for three and a half years when he served as Lt. Commander in the U.S. Navy. He is survived by his wife and a brother.

1935

CHARLES M. BLAIR, PhD, has been named vice chancellor for finance and treasurer of Washington University in St. Louis. He was formerly president of the Petrolite Corporation of St. Louis, and had worked for them since earning his doctorate at Caltech. The Blairs live in Ladue, and have two children – Charles Jr., who is a graduate student at Caltech in chemistry; and a daughter, Mrs. J. T. Evans of Abilene, Texas.

RICHARD H. JAHNS, PhD '43, has been named dean of Stanford University's School of Earth Sciences. He will assume his post in July 1965.

Dr. Jahns joined the Caltech faculty in 1946, and became professor of geology in 1949. He left Caltech in 1960 to accept the position of chairman of the Division of Earth Sciences at The Pennsylvania State University. In April 1962 he was also named associate dean of the College of Mineral Industries.

LOUIS T. RADER, MS, PhD, '38, is now vice president and general manager of the industrial electronics division of the General Electric Company. He was formerly president of the Univac division of the Sperry Rand Corporation. This is the third time Rader has worked for G.E. He was with the company from 1937 to 1945, and again from 1947 to 1959.

1936

GLENN R. CARLEY, former head of the weapons planning group at the Naval Ordnance Test Station in Pasadena, has taken a new position with the Secretary of the Navy in the Office of Program Appraisal. In September he started a two-year assignment with the NATO (SACLANT) ASW Research Center in La Spezia, Italy.

1937

RALPH S. BENTON, JR., died in London, England, of a heart attack on July 10. He had been with Ingersoll-Rand, Ltd., since 1937, and had served in the London Sales Department since 1958. During the war he was a salvage officer in the U.S. Navy. He is survived by his wife.

ALBERT H. ZIMMERMAN died on August 11 of peritonitis, after a short illness. He was 50. He was senior plant engineer for the American Pipe and Construction Company in Southgate, California. He is survived by his wife, Betty, and a daughter, Alice, who is a junior at UCLA.

## 1963-1964 CALTECH ALUMNI FUND REPORT

| | Number of Donors | Amount | Corporate Matching | Total |
|---|---|---|---|---|
| Use Where Most Needed: | 1490 | $45,362.72 | $4,227.00 | $49,589.72 |
| Athletic Facilities: | 22 | 463.00 | - 0 - | 463.00 |
| Endowment: | 50 | 2,886.50 | 140.00 | 3,026.50 |
| Faculty Salaries: | 64 | 1,607.32 | 515.00 | 2,122.32 |
| Scholarships: | 71 | 1,800.00 | - 0 - | 1,800.00 |
| Student Loans: | 75 | 2,263.00 | 10.00 | 2,273.00 |
| All Other: | 111 | 4,082.91 | 1,344.04 | 5,426.95 |
| Total: | 1883 | $58,465.45 | $6,236.04 | $64,701.49 |
| Alumni gifts credited to, but not solicited by, Alumni Fund action: | 22 | 24,452.39 | - 0 - | 24,452.39 |
| Grand Total: | 1891* | $82,917.84 | $6,236.04 | $89,153.88 |

*Does not tally due to duplication of donors.

To the nearly 1900 alumni who supported the California Institute of Technology through gifts to the Alumni Fund; *Thank you.*

*—G. Russell Nance and David L. Hanna*
*Co-Directors of the Caltech Alumni Fund 1963-64*

## 1938

ORAN A. GRAYBEAL is now administrative assistant to the president of the Sunray DX Oil Company in Tulsa, Okla. He served as chief reservoir engineer, district production superintendent, and division manager for the Company's Western Division in Los Angeles and Denver prior to his promotion.

## 1939

RICHARD A. FISCHER, acting as secretary for the Class of 1939, reports on the 25th reunion of the class on June 10:

"After somewhat of a hassle the Class of '39 managed an early start on cocktails the afternoon of the Alumni Banquet.

"It seems that it all started with CHARLIE CARSTARPHEN, MS '40, calling CARL PAUL to see if anything special was going to come off for the 25th reunion. Carl called DICK FISCHER and all agreed it would be a great idea to do something. Result: 22 loyal '39 alumni showed up. Some had not seen each other since graduation, some would not have recognized each other if they had . . . how time changes!

"CHARLIE CARSTARPHEN came from Cincinnati, CARL PAUL from Phoenix, HERMAN ENGLANDER from San Diego, FRED HOFF from Sacramento, and the rest from around L. A.

"Everyone looked prosperous. Twenty two reported a total of 61 children and PAUL SMITH and BILL NORTON are both grandfathers. Only BOB KIMBALL and CARL PAUL reported sons at Caltech — Tech must be getting tougher!

"Trying to get statistics on top of a few Martinis can produce errors; however, the latest dope is that DUANE BECK, MS '40, is managing research and development for Hughes Aircraft; PERRY BROWN is vice president of Johnston Pump; CHARLIE CARSTARPHEN is running the food business for Procter & Gamble in Cincinnati; HOWARD CRAFT is a metallurgical consultant at Magnaflux; VIRGIL CRAWFORD runs the materials and processes department at AiResearch; GEORGE CROZIER is engineering things at Lockheed; HERMAN ENGLANDER is project scientist at the Naval Electronic Lab in San Diego; DICK FISCHER is managing outer space and cryogenics at AiResearch; JACK GOODELL is engineering manager for Bechtel; ED GRISWOLD has an underwater business of his own; ANDY HANNON is still successfully operating Hannon Engineering; FRED HOFF is in the vegetable business, directing engineering for Basic Vegetable Produce, Inc. in Sacramento; DAVE HOYT is executive vice president at the O.K. Earl Corporation of architectural engineers and builders; BOB KIMBALL is principal sales engineer for the utility companies at General Electric; DON LAWRIE is pricing administrator at Autonetics (North American Aviation); HAL FISCHER, MS '39, AE '40, is assistant vice chairman of research at UCLA in the department of engineering; CURT LEE is at AiResearch doing some exotic heat transfer engineering; BILL NORTON takes care of the Seafarer Restaurant in Manhattan Beach; HERB STRONG is the technical facilities manager at JPL; CARL PAUL is assistant chief engineer of Garrett's AiResearch division in Phoenix; JIM RITCHEY is manager of industrial engineering at Firestone; PAUL SMITH is manager of marketing analysis for advanced programs at the Douglas Missile and Space Division."

## 1941

FRED W. BILLMEYER, JR, is now professor of chemistry at Rensselaer Polytechnic Institute in Troy, N.Y. His duties include teaching and research in both polymer science and the science of color measurement. From 1945 to 1964 he was in the plastics department of E. I. du

Pont de Nemours and Company in Wilmington, Del. He was also a lecturer in high polymers in the department of chemistry at the University of Delaware from 1951 to 1964. The Billmeyers have three children and live in Schenectady.

## 1942

MELVIN J. SKINNER, a partner in the structural engineering firm of Stacy & Skinner in Los Angeles, died on May 2 at his home in Arcadia, after a lingering illness. He was 44. After graduation from Caltech, he served in the Navy as a Seabee officer in the Admiralty Islands in the South Pacific. In 1946 he joined the Los Angeles firm of Murray Erick Associates and in 1952 he became a partner and the name of the firm was changed to Stacy & Skinner. He is survived by his wife and two sons, Michael and Stephen.

## 1943

J. H. LAWS, MS, is now manager of operations in the industrial chemicals division of the Shell Chemical Company in New York. He was formerly superintendent of the company's Houston plant.

## 1944

WARREN H. AMSTER, MS '47, AE '48, is now senior staff engineer at Aerospace Corporation's El Segundo technical operations.

## 1948

JOHN P. DAVIS, MS, was killed on August 1 when his glider crashed after being caught in a downdraft near Apple Valley. He was 38. He had been director of electronics for Capitol Records since 1960. He was formerly on the technical staff of the air defense laboratories at the Hughes Aircraft Company. He held a commercial pilot's license and was a member of the Sky Roamers Club.

HOWARD B. LEWIS, JR., MS '51, is now director of advanced engineering for the Transducer Division of Consolidated Electrodynamics Corporation in Pasadena. He has been with the company for 12 years.

JAMES C. ELMS, vice president and general manager of Raytheon Company's space and information systems division, received a special award of appreciation from NASA for his work in "reorganizing and managing the Manned Spacecraft Center during the period of its rapid growth from Project Mercury to Gemini and Apollo projects." The Elms' and their three daughters live in Wellesley Hills, Mass., and their son, Chris, is a Caltech sophomore this year.

## 1949

PAUL D. SALTMAN, PhD '53, professor of biochemistry at USC, received an award of $1000 from the university last spring for excellence of teaching. He has been at USC since 1953. He is also a Career Development Awardee of the National Institutes of Health, and has done research in Paris and Copenhagen on human disease at the molecular level, and transport mechanisms in cells.

WILLIAM M. McCARDELL, MS, is now marketing manager for Humble Oil & Refining Company's central region in Tulsa, Okla. He was formerly Chicago area manager, and has been with the company since 1949.

FRED ORDWAY, PhD, consultant in the inorganic solids division of the National Bureau of Standards in Washington, D.C., is now a Fellow of the American Ceramic Society.

JOHN F. WIREN is now director of sales for the guidance and control systems division of Litton Industries in Los Angeles. He joined the company after 14 years with Honeywell, where he was director of marketing for the aeronautical division.

## 1950

WILSON BRADLEY, JR., now president of the Endevco Corporation in Pasadena, and DONALD W. STILLMAN, president of Applied Components, Inc., in Los Angeles, are included in the 1965 edition of *Oustanding Young Men of America,* an annual compilation of about 10,000 young men of outstanding rank throughout the country. Nominations are made by Junior Chamber of Commerce Chapters and College Alumni Associations.

FLOYD B. HUMPHREY and his wife announced the birth of their third child (and third daughter), Nancy, on September 9. Floyd, who had been dividing his time between JPL and Caltech, has now been appointed associate professor of electrical engineering at the Institute.

JAMES R. ALLDER is now manager of the advanced systems section in the electronics division of the Aerospace Corporation in Los Angeles. He has been with the corporation since 1960.

HOWARD E. REINECKE, president of Febco, Inc., in Sun Valley, is the GOP candidate for Congress in the 27th District of L.A. County this fall. He lives in Tujunga, serves on the national and state boards of several trade organizations, including the Water Resources Board of the State Chamber of Commerce.

PAUL H. JACKSON, JR., MS, an engineer with General Dynamics Pomona, died suddenly on July 7. He was 38. He had contracted polio when he was 4 years old, and had spent most of his life in a wheel chair. Despite his handicap, he graduated from the University of Kansas in 1944, and received his MS from Caltech in 1950. He stayed at Caltech for two years as a research engineer in the hypersonic wind tunnel, then joined General Dynamics in 1952.

## 1951

ROBERT J. DIAMOND, PhD, has been promoted from associate to full professor of mathematics in the School of Letters and Science at California State College in Los Angeles. He has been on the faculty there since 1958.

FRANK C. BUMB, JR., MS '52, is included in the 1965 edition of *Outstanding Young Men of America.* He is vice president of engineering at American Concertone, Inc., in Los Angeles.

KENNETH R. BERG is now manager of engineering at Fairchild's Precision Metal Products Division in El Cajon, Calif. He was formerly manager of the systems support activity at the Northrup Corporation in Anaheim.

## 1952

SULLIVAN CAMPBELL, MS, is now assistant vice president in charge of technical planning at the Zerox Corporation in Rochester, N.Y.

DAVID L. HANNA, administration manager at Booz, Allen & Hamilton, Inc., and ROBERT E. STANAWAY, president of Montronics, Inc., in Bozeman, Montana, are two of six Caltech alumni chosen for inclusion in the 1965 edition of *Outstanding Young Men of America.* Selections are made by Junior Chamber of Commerce Chapters and College Alumni Associations of young men who have "distinguished themselves in one or more fields of endeavor to the point of being outstanding."

JAMES N. SHOOLERY, PhD, research chemist at Varian Associates in Palo Alto, is the winner of a $1,000 American Chemical Society Award in Chemical Instrumentation. He pioneered in the development of nuclear magnetic resonance spectroscopy, which is now an indispensable tool in unraveling the structures of steroids, alkaloids, and other organic compounds.

RICHARD R. DICKINSON is now chief process engineer at Texaco's Casper, Wyoming, refinery. He was formerly senior project engineer at Texaco's Rockport, Illinois, refinery. The Dickinsons have two children.

## 1953

KOICHI SADASHIGE, MS, is now group leader of scientific instruments (electron microscopes) design engineering in the broadcast and communications products division of RCA in Camden, N.J. He was formerly senior engineer in the television camera advanced development group. He has been with RCA since he left Caltech.

The Sadashiges have two children – Ernest, 6, and Jacquelene, 9 months.

## 1957

MARTIN C. TANGORA, who is working for his PhD in mathematics at Northwestern University in Evanston, Ill., spent June and July in Paris on his vacation. He was waiting for a break in the traffic there one day when he realized that he knew the man alongside him who was also waiting to cross. It turned out to be BAIRD BRANDOW, who was in Paris attending a scientific congress on nuclear physics at UNESCO. Baird is now in Copenhagen at the Niels Bohr Institute.

CAPT. ROBERT E. AYERS, MS, graduated from the associate course at the U.S. Army Command and General Staff College in Fort Leavenworth, Kansas, in May, and is now assigned to the Office of the Chief of Engineers, Department of the Army, Washington, D.C.

## 1958

ROGER D. SUMNER, MS, has been awarded a Carnegie Institution Fellowship which will enable him to continue to work at the Carnegie Institution's Department of Terrestrial Magnetism in Washington, D.C., on tape-recorded seismologic data he has collected in the Andes since November 1963.

DALE R. SIMPSON, MS, PhD, '60, is now associate professor of geology at Lehigh University in Bethlehem, Pa.

NORMAN T. ELLETT is now organization and general services consultant for George Fry & Associates in Los Angeles. He has served as assistant to the president and manager of cost estimating and pricing for the semiconductor division of Hoffman Electronics Corporation for the past four years.

## 1959

BERNARD M. MALOFSKY is now a research chemist at the Carothers Research Laboratory of the Du Pont Company's textile fibers department near Wilmington, Del.

ANDREW D. BAUER, AE, is now principal scientist for the Ford Motor Company's aeronutronic division in Los Angeles. The Bauers have a five-year-old son, Kenneth.



## PLACEMENT ASSISTANCE TO CALTECH ALUMNI

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

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

(2) To inform you when outstanding opportunities arise.

This service is provided to Alumni by the Institute. A fee or charge is not involved.

If you wish to avail yourself of this service, fill in and mail the following form:

To: Caltech Alumni Placement Service
California Institute of Technology
Pasadena, California 91109

Please send me:

☐ An Application for Placement Assistance

☐ A form to report my field and operation so that I may be notified of any outstanding opportunities.

Name .................................... Degree (s) .......

Address .................................... Year (s) .......

..............................................................

## ALUMNI ASSOCIATION OFFICERS AND DIRECTORS

**PRESIDENT**
Patrick J. Fazio, '53

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

**VICE PRESIDENT**
David L. Hanna, '52

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

James L. Adams, '55
Wm. H. Corcoran, '41
Sidney K. Gally, '41
John L. Mason, '47

John T. McGraw, '38
Richard P. Schuster, Jr., '46
H. M. Worcester, Jr., '40
Peter, V. H. Serrell, '36

## ALUMNI CHAPTER OFFICERS

**NEW YORK CHAPTER**

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

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

**Secretary-Treasurer** — Harry J. Moore, '48
Old Orchard Road, Armonk, N.Y. 10504

**BOSTON CHAPTER**

**Secretary-Treasurer** — Thomas C. Stockebrand, '53
56 Summer Street, West Acton, Mass.

**WASHINGTON, D.C. CHAPTER**

**Chairman** — Willard M. Hanger, '43
4720 Sedgwick St., N.W., Washington, D.C.

**CHICAGO CHAPTER**

**President** — Laurence H. Nobles, '49
Dept. of Geology, Northwestern Univ., Evanston, Ill.

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

**SAN FRANCISCO CHAPTER**

**President** — Edwin P. Schlinger, '52
G.E. Vallecitos Atomic Lab., Pleasanton, Calif.

**Vice-President** — Dallas L. Peck, '51
U.S. Geological Survey, Menlo Park, Calif.

**Secretary-Treasurer** — Thomas G. Taussig, '55
Lawrence Radiation Lab., Univ. of Calif., Berkeley, Calif.

Meetings: 15th Floor, Engineers' Club, 206 Sansome St., San Francisco
Informal luncheons every Thursday at 11:45 A.M.
Contact Mr. Farrar, EX 9-5277, on Thursday morning for reservations.

**SACRAMENTO CHAPTER**

**President** — Dudley E. Bennett, '47
4535 Marble Way, Carmichael, Calif.

**Vice-President** — Harris K. Mauzy, '30
2551 Carson Way, Sacramento 21, Calif.

**Secretary-Treasurer** — William D. Pyle, '49
3920 Dunster Way, Sacramento, Calif. 95825

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

# Personals . . . . *continued*

### 1960

LANNES S. PURNELL received his master's degree in electrical engineering from the University of Colorado in June.

STEPHEN V. STEPHENS is now working on a fellowship for predoctoral research on "Resource-Allocating Decisions in Federal Support of Scientific Research" at the Brookings Center for Advanced Study in Washington, D.C.

DONALD W. ANDERSON has been awarded an NAS-NCR postdoctoral research fellowship to study algebraic topology at Harvard University and at the Mathematics Institute of Oxford University in England.

JOHN C. NICKEL, MS, PhD '64, is acting assistant professor of physics at the University of California, Riverside.

### 1961

MANUEL PANAR, PhD, is now on the staff of the Du Pont Company's central research department, after two years of postdoctoral work at Harvard.

LELAND H. HARTWELL is now doing research on the control of nucleic acid metabolism in animal cells at the Salk Institute for Biological Studies in San Diego, Calif., on an NAS-NRC postdoctoral research fellowship. He received his PhD in June from MIT. The Hartwells have two children.

LAWRENCE D. BROWN is doing research in statistical decision theory at Birkbeck College, London University, England, on an NAS-NRC postdoctoral research fellowship. He received his PhD from Cornell last month.

ELI CHERNOW graduated magna cum laude from Harvard Law School last June and has received a Frederick Sheldon Traveling Fellowship from Harvard. He plans to tour the Far East and Europe.

### 1962

ROBERT L. ROSENFELD, PhD, is now on the staff of the process research and development laboratory of RCA Laboratories at the David Sarnoff Research Center in Princeton, N.J.

JOHN GOLDEN is now working in the applied mathematics group at the David Sarnoff Research Center of the RCA Laboratories in Princeton, N.J. John was married in December, 1962, to Jean Lenhart. He served as assistant instructor of mathematics at Kansas University from 1962 until last June.

### 1964

N. NORBY NIELSEN, PhD, is now assistant professor of civil engineering at the University of Illinois in Urbana.

# ALUMNI ASSOCIATION
# CALIFORNIA INSTITUTE OF TECHNOLOGY

Pasadena, California

## BALANCE SHEET

June 30, 1964

| | | | |
|---|---|---|---|
| **ASSETS** | | | |
| Cash in Bank | | | $ 466.41 |
| Investments: | | | |
| Share in C.I.T. Consolidated Portfolio | | $ 88,372.79 | |
| Deposits in Savings Accounts | | 22,039.36 | 110,412.15 |
| Investment Income Receivable from C.I.T. | | | 4,752.76 |
| Postage Deposit, etc. | | | 29.26 |
| Furniture and Fixtures, at nominal value | | | 1.00 |
| Total Assets | | | $115,661.58 |
| **LIABILITIES, RESERVES AND SURPLUS** | | | |
| Accounts Payable | | | $ 637.25 |
| Deferred Income: | | | |
| Membership Dues for 1964-65 paid in advance | | $ 10,597.50 | |
| Investment Income for 1964-65 from C.I.T. Consolidated Portfolio (earned during 1963-64) | | 4,752.76 | 15,350.26 |
| Life Membership Reserve | | | 63,100.00 |
| Reserve for Directory: | | | |
| Balance, July 1, 1963 | $ 345.52 | | |
| 1963-64 Appropriation | 2,500.00 | $ 2,845.52 | |
| 1963-64 Directory Expense | | 168.13 | 2,677.39 |
| Surplus: | | | |
| Balance, July 1, 1963 | | $ 28,649.35 | |
| Share of Profit on Disposal of Investments of C.I.T. Consolidated Portfolio for 1963-64 | | 5,281.36 | |
| Excess of Expenses over Income for 1963-64 | | ( 34.03) | 33,896.68 |
| Total Liabilities, Reserves and Surplus | | | $115,661.58 |

## STATEMENT OF INCOME AND EXPENSES

For the Year Ended June 30, 1964

| | | |
|---|---|---|
| **INCOME** | | |
| Dues of Annual Members | | $ 17,765.00 |
| Investment Income: | | |
| Share from C.I.T. Consolidated Portfolio | $ 4,362.26 | |
| Interest on Deposits in Savings Accounts | 997.92 | 5,360.18 |
| Annual Seminar | | 6,005.05 |
| Program and Social Functions | | 2,946.60 |
| Miscellaneous | | 59.10 |
| Total Income | | $ 32,135.93 |
| **EXPENSES** | | |
| Subscriptions to Engineering and Science Magazine: | | |
| Annual Members | $ 12,453.00 | |
| Life Members | 3,094.00 | $ 15,547.00 |
| Annual Seminar | | 5,375.35 |
| Program and Social Functions | | 3,259.30 |
| Directory Appropriation | | 2,500.00 |
| Fund Solicitation | | 2,152.33 |
| Administration (Directors' Expenses, Postage, Supplies, etc.) | | 1,939.45 |
| ASCIT Assistance | | 700.00 |
| Membership Committee | | 696.53 |
| Total Expenses | | $ 32,169.96 |
| Excess of Expenses over Income | | $ 34.03 |

### AUDITOR'S REPORT

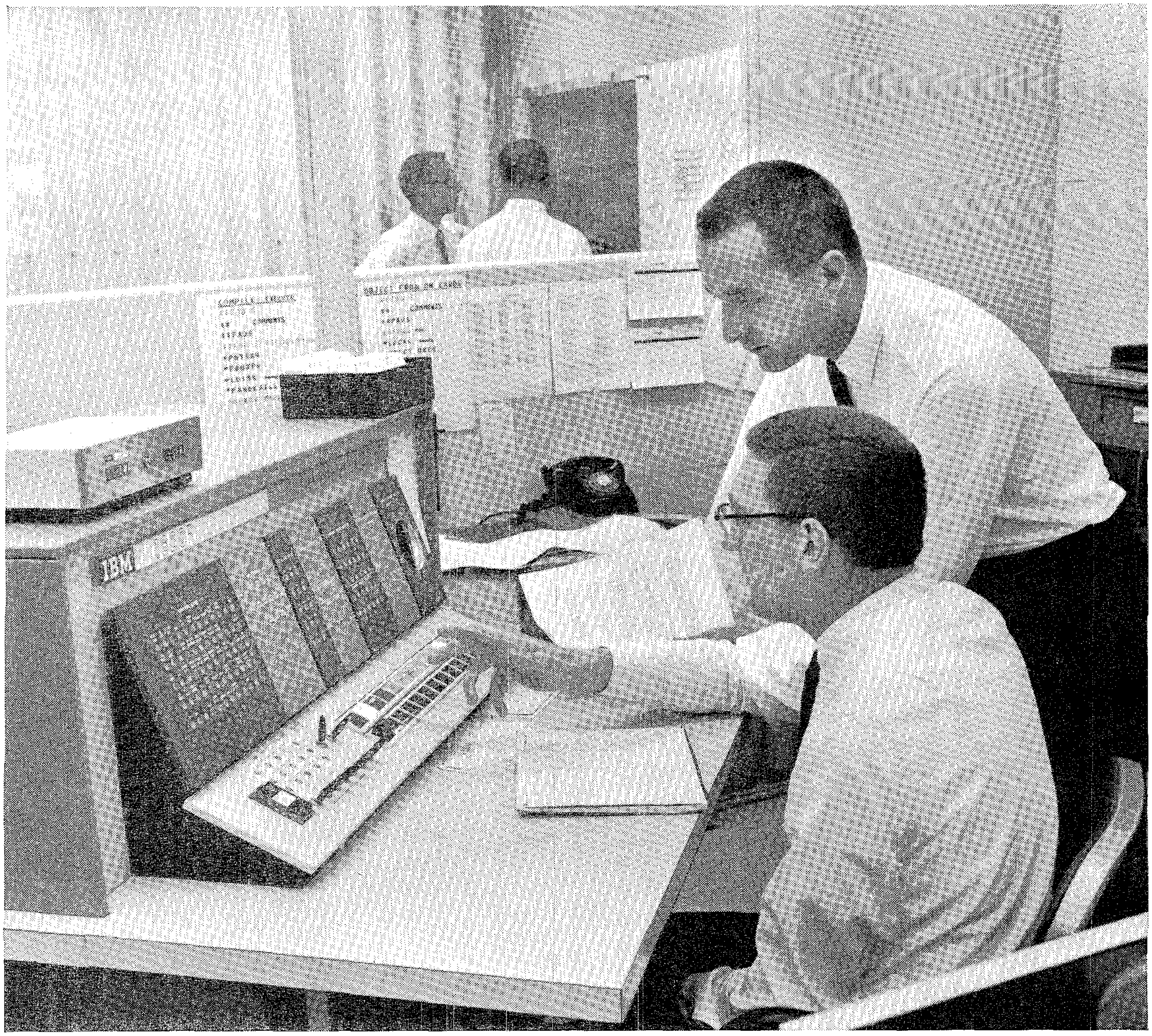
Board of Directors, Alumni Association, California Institute of Technology
Pasadena, California

I have examined the Balance Sheet of the Alumni Association, California Institute of Technology, as of June 30, 1964, and the related Statement of Income and Expenses for the year then ended. My examination was made in accordance with generally accepted auditing standards, and accordingly included such tests of the accounting records and such other auditing procedures as I considered necessary in the circumstances.

In my opinion, the accompanying Balance Sheet and Statement of Income and Expenses present fairly the financial position of the Alumni Association, California Institute of Technology, at June 30, 1964, and the results of its operations for the year then ended, in conformity with generally accepted accounting principles applied on a basis consistent with that of the preceding year.

CALVIN A. AMES, Certified Public Accountant
1602 West Thelborn St., West Covina, California

September 22, 1964




# We give Ch. E.s modern tools and a chance to stick out their necks

Some of our chemical engineers work on fabrics for ladies' coats, some on lunar orbiters, some on raising the hatchability percentage of turkey eggs. The assortment runs on and on too long for easy credibility. The assortment of engineering disciplines that we use besides chemical also gets too long.

We do not deny, however, that sensitized film and paper remain our largest single business. Instead of waning they are waxing. High-order chemical engineering is our secret. This is a nice secret to know. We want to teach it to upcoming chemical engineers endowed with enough mental flexibility to recognize that mathematical model-building which correlates dollars with millionths of an inch of accuracy in superimposing color emulsion layers can be as exciting a practice of their profession as calculating the diameter of pipe with which to feed a still.

In addition to the upcomingness, the flexibility, and the professionalism, one further characteristic can elevate the possessor above a merely good, satisfactory career: a feeling that "the company" *really* means "me" rather than some vague "them," a feeling which on fortunately rare occasions becomes so strong that he is willing to wage a stiff battle for a good idea.

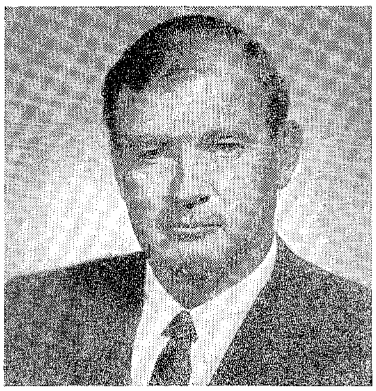
Drop us a note if we interest you.

EASTMAN KODAK COMPANY,
Business and Technical Personnel Department, Rochester, N.Y. 14650
An equal-opportunity employer offering a choice of three communities:
Rochester, N.Y., Kingsport, Tenn., and Longview, Tex.

**Kodak**

# Advancement in a Big Company: How it Works

## An Interview with General Electric's C. K. Rieger, Vice President and Group Executive, Electric Utility Group



C. K. Rieger

■ Charles K. Rieger joined General Electric's Technical Marketing Program after earning a BSEE at the University of Missouri in 1936. Following sales engineering assignments in motor, defense and home laundry operations, he became manager of the Heating Device and Fan Division in 1947. Other Consumer-industry management positions followed. In 1953 he was elected a vice president, one of the youngest men ever named a Company officer. Mr. Rieger became Vice President, Marketing Services in 1959 and was appointed to his present position in 1961. He is responsible for all the operations of some six divisions composed of 23 product operations oriented primarily toward the Electric Utility market.

**Q. How can I be sure of getting the recognition I feel I'm capable of earning in a big company like G.E.?**

A. We learned long ago we couldn't afford to let capable people get lost. That was one of the reasons why G.E. was decentralized into more than a hundred autonomous operating departments. These operations develop, engineer, manufacture and market products much as if they were independent companies. Since each department is responsible for its own success, each man's share of authority and responsibility is pinpointed. Believe me, outstanding performance is recognized, and rewarded.

**Q. Can you tell me what the "promotional ladder" is at General Electric?**

A. We regard each man individually. Whether you join us on a training program or are placed in a specific position opening, you'll first have to prove your ability to handle a job. Once you've done that, you'll be given more responsibility, more difficult projects—work that's important to the success of your organization and your personal development. Your ability will create a "promotional ladder" of your own.

**Q. Will my development be confined to whatever department I start in?**

A. Not at all! Here's where "big company" scope works to broaden your career outlook. Industry, and General Electric particularly, is constantly changing — adapting to market the fruits of research, reorganizing to maintain proper alignment with our customers, creating new operations to handle large projects. All this represents opportunity beyond the limits of any single department.

**Q. Yes, but just how often do these opportunities arise?**

A. To give you some idea, 25 percent of G-E's gross sales last year came from products that were unknown only five or ten years ago. These new products range from electric tooth brushes and silicone rubber compounds to atomic reactors and interplanetary space probes. This changing Company needs men with ambition and energy and talent who aren't afraid of a big job—who welcome the challenge of helping to start new businesses like these. Demonstrate your ability—whether to handle complex technical problems or to manage people, and you won't have long to wait for opportunities to fit your needs.

**Q. How does General Electric help me prepare myself for advancement opportunity?**

A. Programs in Engineering, Manufacturing or Technical Marketing give you valuable on-the-job training. We have Company-conducted courses to improve your professional ability no matter where you begin. Under Tuition Refund or Advanced Degree Programs you can continue your formal education. Throughout your career with General Electric you'll receive frequent appraisals to help your self-development. Your advancement will be largely up to you.

FOR MORE INFORMATION on careers for engineers and scientists at General Electric, write Personalized Career Planning, General Electric, Section 699-11, Schenectady, N. Y. 12305

**GENERAL ELECTRIC**

*An Equal Opportunity Employer*