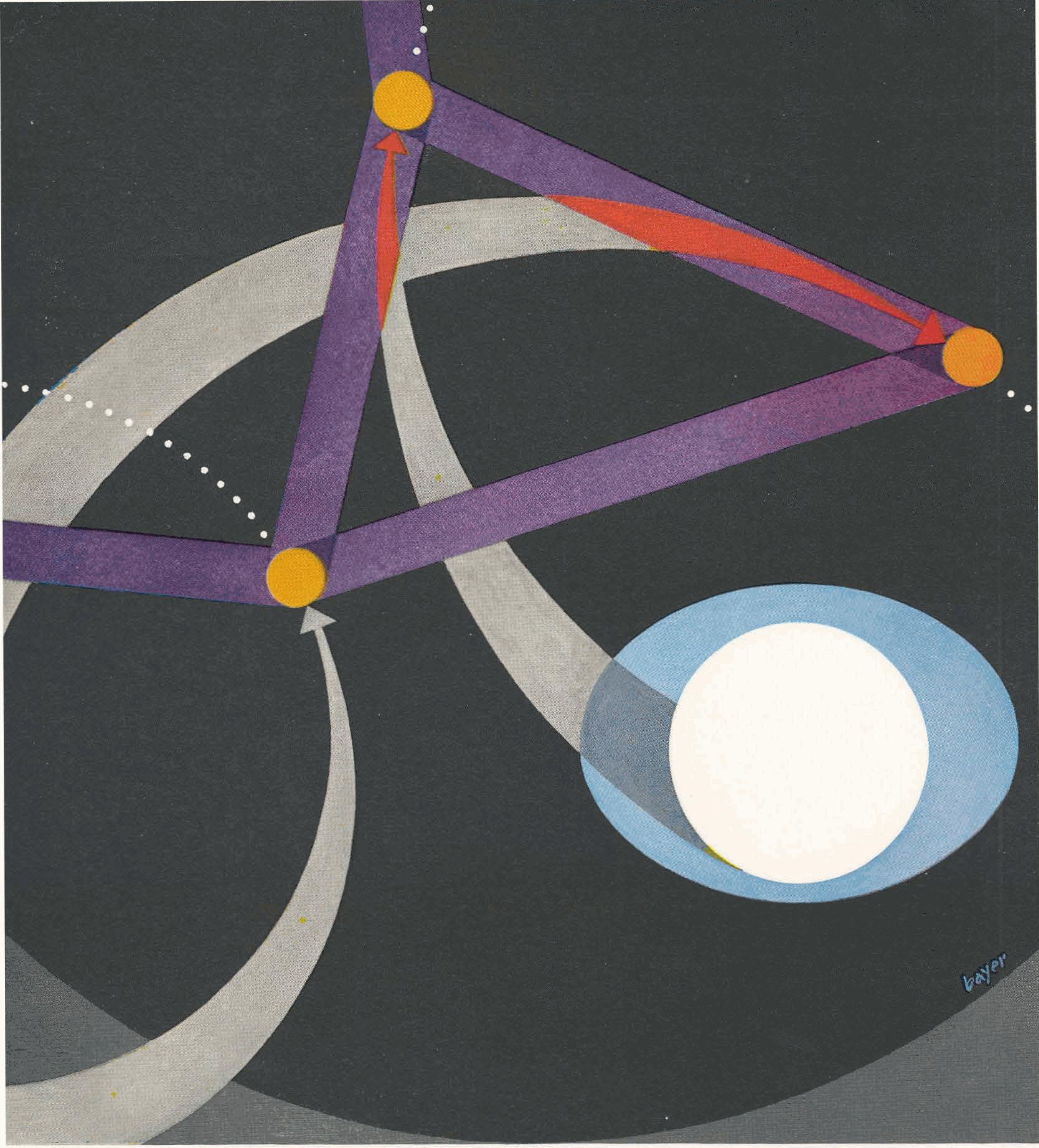
ENGINEERING | AND | SCIENCE

April 1963

Published at the California Institute of Technology



Westinghouse developments will send words and pictures millions of miles from spacecraft to spacecraft

A beam of modulated light extending into the ultraviolet will some day carry messages, even TV pictures, from one spacecraft to another, or from a spacecraft to a satellite, across the vastness of outer space. This beam will travel 50 million miles with a single watt of transmitted power. It will be so concentrated that interception or jamming will be virtually impossible. A transmitter about the size of a hatbox will send messages farther than a conventional radio transmitter as big as a steamer trunk. How soon will it be ready? Westinghouse has already demonstrated its feasibility in the laboratory.

Learn more about the diverse and challenging space age research and development projects at Westinghouse, an equal opportunity employer. Talk with the Westinghouse representative when he visits your campus, or write L. H. Noggle, Westinghouse Educational Department, Ardmore Boulevard and Brinton Road, Pittsburgh 21, Pa. You can be sure . . . if it's Westinghouse.

INNOVATOR

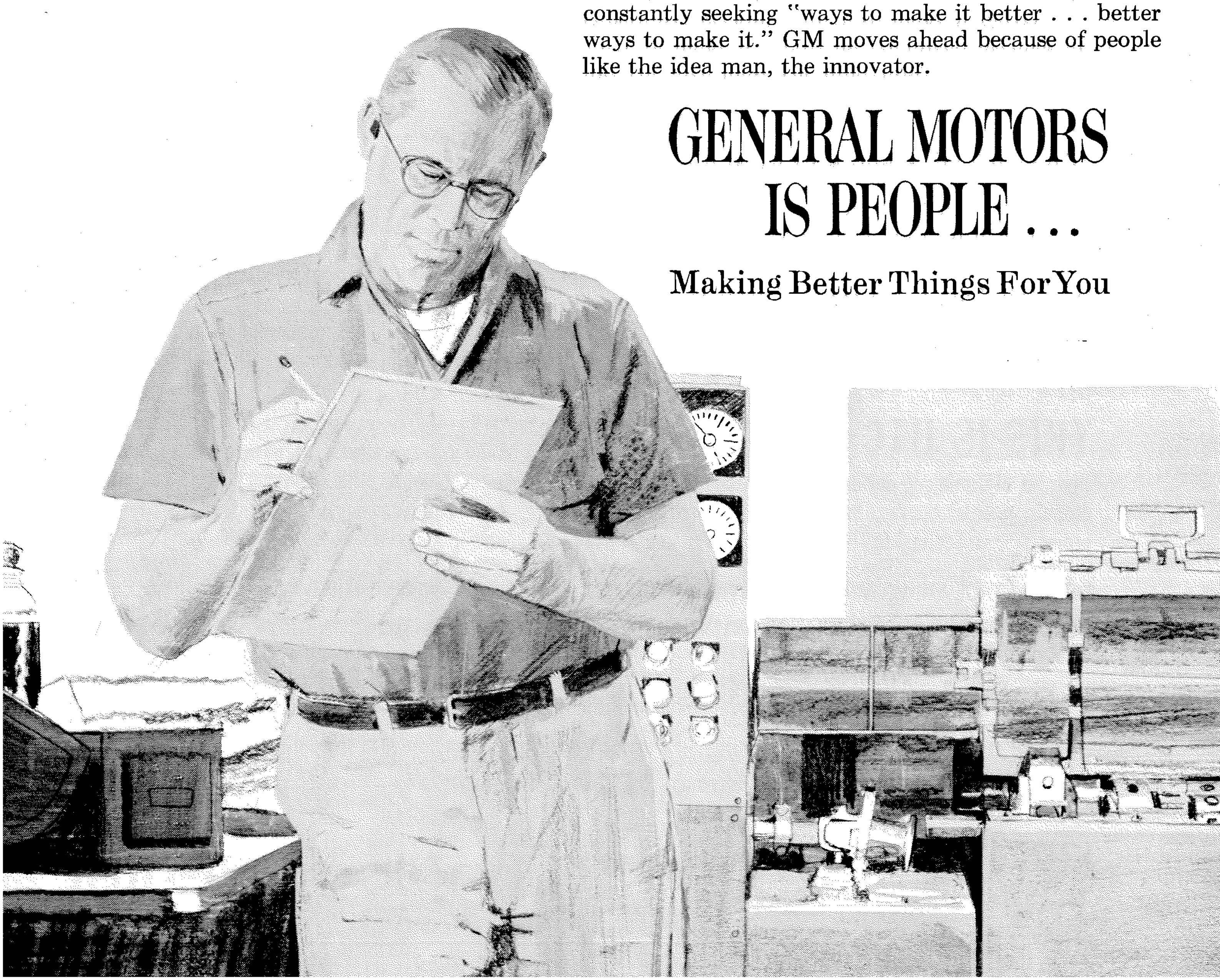
Idea man. A man who knows it pays to think. He's a General Motors employe who works at his job, thinks at his job. He never stops looking for ways to help make it safer and for ways to improve products and processes.

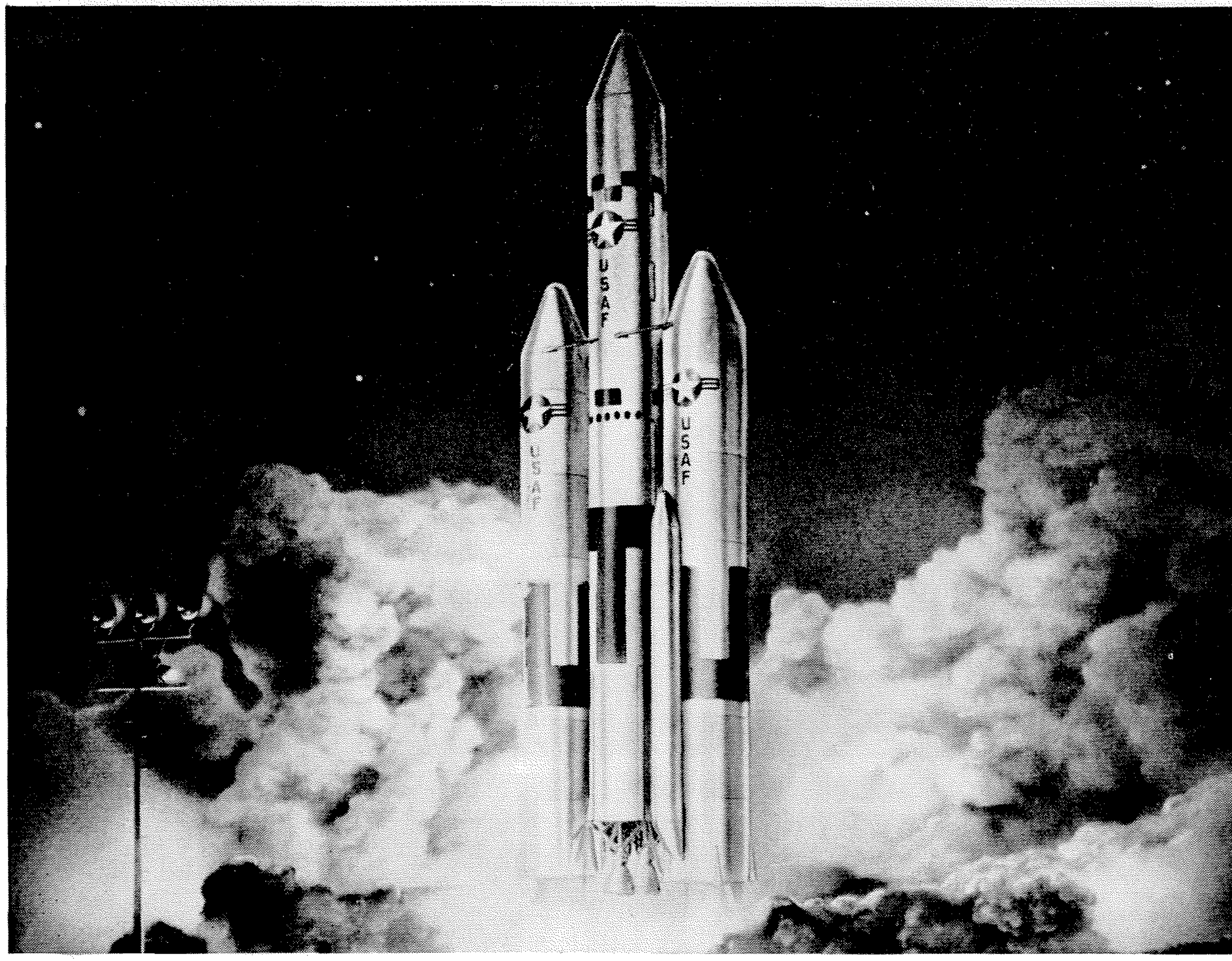
Last year General Motors awarded over $6,750,000 under the GM Employe Suggestion Plan to people like him for more than 188,000 on-the-job suggestions. Since 1942 GM has adopted more than a million employe suggestions and has happily paid out more than $48,000,000 in suggestion awards.

At GM, you'll find the idea man in office and plant. Alert, interested, aggressive . . . he doesn't wait for "George" to suggest it, *he suggests it himself*. He is constantly seeking "ways to make it better . . . better ways to make it." GM moves ahead because of people like the idea man, the innovator.

GENERAL MOTORS IS PEOPLE . . .

Making Better Things For You





THIS IS TITAN III United Technology Center is now at work on development of the first or solid booster stage for the Air Force Titan III. UTC's huge segmented solid propellant rocket motors, each 120 inches in diameter and producing more than a million pounds of thrust, will blast the Standardized Space Launch Vehicle from its launch pad. Titan III, with all stages assembled, will stand more than 100 feet tall on the pad, and will be utilized to put multi-ton payloads into orbit.

THIS IS UTC Graduates planning careers for the Space Age will do well to talk with UTC. This young and dynamic division of United Aircraft is one of America's fastest-growing aerospace organizations. In UTC's unique professional atmosphere, you'll move ahead faster, team up with scientists preeminent in rocket propulsion, enjoy the facilities of UTC's Research and Engineering Center and sprawling test site. Here are a few of the projects . . . in addition to Titan III . . . underway to challenge your imagination and scientific skills.

UPPER-STAGE LIQUID MOTORS • HYBRID ROCKETS • FILAMENT-WOUND MOTOR CASINGS • ABLATION-COOLED THRUST CHAMBERS • VARIABLE-THRUST CONTROL SYSTEMS • THRUST VECTOR CONTROL SYSTEMS

And that's not all. United Technology Center is located in the heart of the beautiful San Francisco Bay Area. Glamorous San Francisco, skiing, sailing, and the scenic wonders of the High Sierra are within easy reach.

Pick up that pen. Drop a line to UTC. Tell us your engineering specialty. You'll be glad you did.

For information, contact Jay W. Waste, Department 26E, P. O. Box 358, Sunnyvale.

DIVISION OF UNITED AIRCRAFT CORPORATION

UTC

United Technology Center

(Formerly United Technology Corporation)

An Equal Opportunity Employer

ENGINEERING | AND | SCIENCE

APRIL 1963 VOLUME XXVI NUMBER 7

On Our Cover

is a picture of explosions set off in the Mojave Desert by Caltech geophysicists. By studying the reflective wave patterns generated by these explosions, C. Hewett Dix, professor of geophysics, has found some interesting data that might offer an explanation of how mountains are built ("Mountain Building," page 7).

In a miniature bus outfitted as a laboratory, Dr. Dix and his team work with electronic equipment including a radio transmitter and receiver for communicating with a radio system at the shot site. Recorders pick up the reflected shot waves, which travel at about 20,000 feet a second through the ground. Their patterns indicate the presence of discontinuities at various depths down to 22 miles or more.

Jesse L. Greenstein,

professor of astrophysics and member of the staff of the Mount Wilson and Palomar Observatories, is the author of "Radio 'Stars' – Explosions in Space" on page 9. Dr. Greenstein is a graduate of Harvard University where he also received his AM and PhD. From 1940 to 1948 he was a member of the staff of Yerkes Observatory. He joined the Caltech faculty in 1948 and organized the graduate school in astrophysics in connection with the Mount Wilson and Palomar Observatories.

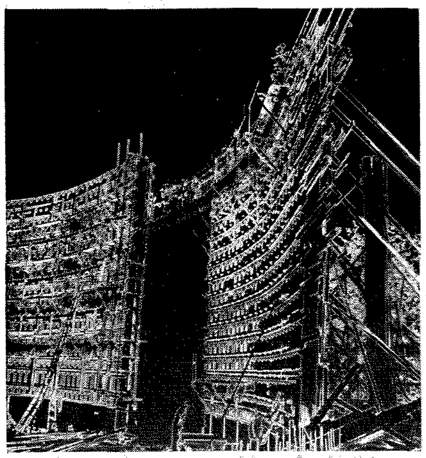
Picture Credits:

Cover – Alexander Goetz, Jr.
13 (top), 16, 21 – James McClanahan
13 – (lower right) Harvey
14 – Joe Munroe

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 St., 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.



E & S Cover, March 1963

Letters

Los Angeles

EDITOR:

Just how did your photographer achieve the effect he got in that March cover picture of the Beckman Auditorium?

R. FISHER '43

In answer to the question concerning the techniques employed in the March cover, our procedures were as follows:

1) A normal Rolleiflex negative (2¼ by 2¼) was projected onto Kodalith film, an extremely high contrast film normally used for photographic charts, graphs, etc.

2) The resultant high-contrast positive was then contact-printed onto a Kodak Commercial film, a thick-emulsion, blue-sensitive copy film.

This film was solarized during development, a process wherein the film is exposed to a carefully controlled amount of white light midway during the development cycles. This results in very fine lines being formed wherever there are adjacent light and dark areas.

3) Since we felt that white lines on black would be more dramatic, the solarized negative was contact-printed onto Kodak Fine Grain Positive film, a thin-emulsion copy film well suited for preserving the fine lines produced during the solarization process.

4) A print was then made from this "negative"—well, "film"—to the proper size for the magazine cover.

DOUG STEWART
Graphic Arts, Caltech

Arcadia, California

EDITOR:

Individualism, one of the most precious heritages bestowed upon the men of the Institute, is in jeopardy and I believe my classmates and all other members of the Caltech alumni should be so informed.

Permit me to go back to the January 1961 issue of *Engineering and Science* which contained the unbelievable details of The Great Rose Bowl Hoax performed by "the Fourteen" on the unsuspecting members of the Washington card (rooting) section. Here is clear-cut evidence of brilliant collective individualism.

Recently, the March 8, 1963, issue of *Life* magazine contained a short article illustrating the first U.S. participation in a new Spring fad organized at Caltech by the Piano Reduction Study Group. More evidence of individualism plus team work.

While I have no argument opposing free publicity in a national magazine with the circulation enjoyed by *Life*, there is no excuse for some uninformed writer to refer to the MEN of Caltech as "boys". Not only once, but twice in the same article there is failure to distinguish between infantilism and individualism. This requires a rebuttal.

I challenge my fellow alumni to stand and fight for the basic principles of our heritage and clarify once and for all the public misconception confusing collective individualism with group conformity.

I also challenge "the Fourteen" and the members of the "Piano Reduction Study Group" to reorganize as a unit to represent the entire alumni in our common defense.

Furthermore, while defending our individualism, I challenge this honorable group to go one step further: Make public their collective ideas for solutions to some of the World's most pressing problems . . . i.e.:

"How to peacefully remove Castro and restore freedom and individual dignity to the people of Cuba . . ."

"How to peacefully take down the Berlin wall and prevent duplication of the act in the future . . ."

"How to cope peacefully with the Communist philosophy and bring about its self-destruction, primarily in Latin America . . ."

"How to achieve higher standards of ethics in U. S. private enterprise, before it is too late . . ."

Etc., etc.

Arise, gentlemen, and join me in spirit, strength and brotherhood in defense of our honor and dignity as citizens of the U. S. and members of the alumni of the California Institute of Technology. Hear ye . . . hear ye . . . ! !

FRIEND F. BAKER, JR., '40

Books

Alumni Books

THE ANCIENT ENGINEERS
by L. Sprague de Camp
Doubleday *$4.95*

L. Sprague de Camp, who got his BS in mechanical engineering from Caltech in 1930, has been a free-lance writer, except for the war years, since 1938. *The Ancient Engineers* is his 38th book. Of the other 37, there are 3 listed as historical fiction, 12 science fiction, 11 fantasy, 7 non-fiction, and 4 juvenile. *The Ancient Engineers* belongs in the non-fiction category and is the story of invention and technology from Egyptian times up to the Renaissance. As anyone who has read any of his previous books knows, Mr. de Camp is a tireless researcher and a voracious collector of miscellaneous facts. *The Ancient Engineers* is loaded with them.

MATRIX METHODS FOR ENGINEERING
by Louis A. Pipes
Prentice-Hall, Inc. *$13*

Louis A. Pipes, BS '33, MS '34, PhD '35 at Caltech, and professor of engineering at UCLA, has based his book on a course of lectures on matrix calculus and its application to a representative group of physical problems, delivered by him over the last 15 years to engineering students at UCLA. It is "the first book in English that develops matrix algebra and calculus ab initio, and traces the applications of these techniques to engineering problems in dynamics, electric circuit theory, elasticity, the theory of vibrations and their related fields."

Science Paperbacks

Doubleday Natural History Library:

How to Make a Telescope
by Jean Texereau $1.45

Back of History (revised edition)
by William Howells $1.45

Animal Behavior
by John Paul Scott $1.45

Snakes in Fact and Fiction
by James A. Oliver $1.25

A Guide to Bird Watching
by Joseph J. Hickey $1.25

Doubleday Science Study Series:

Lady Luck: The Theory of Probability
by Warren Weaver $1.45

ENGINEERING AND SCIENCE
April 1963, Volume XXVI, No. 7

MOUNTAIN-BUILDING

by Graham Berry

The processes of mountain-building and the mechanism by which ocean basins maintain their integrity are among the great interests and mysteries of geology. Now, C. Hewitt Dix, professor of geophysics at Caltech, has found some data which could offer an explanation of how the great ocean basins remain virtually unchanged for billions of years and how mountains and high plateaus may be formed by being "pumped up" hydraulically by the high-pressure intrusion of molten rock beneath them.

The theory is based on reflected wave patterns obtained by Dr. Dix with sensitive depth-sounding equipment on a Mojave Desert upland at the edge of the San Bernardino Mountains. The waves, generated by explosions, were reflections off deep subterranean layers.

Their patterns indicate the presence of groups of discontinuities in the earth's crust under the highland at various depths down to 22 miles and perhaps below. The most natural conclusion is that the discontinuities mark the presence of subterranean sills, horizontal layers of rock that were originally intruded as molten material into preexisting rock.

The mechanism of sill formation is at least partially understood. Molten rock rises from great depths under high pressure through a near-vertical fissure, which it forces open in seeking an outlet. The molten material will rise vertically to a level where the vertical pressure on the surrounding rocks is not great enough to prevent the fluid from cracking the rock. The fluid then spreads out in a horizontal or vertical crack, forming a fluid layer which will extend in some cases for great distances, depending upon the amount of fluid available. This material later will solidify to form a sill.

As mountains and plateaus are eroded away, their weight is lessened. According to Dr. Dix, this would result in a vertical pressure reduction to invite the intrusion of a sill. The higher the mountains, the more the wearing away, the more the unloading, and the more favorable the setting for sill formation and further mountain uplift. If such intrusions are several hundred feet thick, as indicated by the seismic data, they could have a hydraulic lifting action on the mountain or plateau above them.

The proposed mechanism for mountain-building can be turned around to suggest a major reason for the permanence of the great ocean basins. The growing load of sediments brought down by the rivers from the eroding continents maintains pressures that prevent sills from forming to lift the ocean floor.

Another weight factor could be the increase in the amount of water in the oceans over the geologic ages. There is good evidence that the amount of water in the oceans has increased in the past billion years.

During great glacial periods, the sea levels are lowered because the glacial ice is formed of ocean water and this water becomes locked up in ice on the land. This unloading of the oceans would permit the formation of sills even under the oceans for geologically short periods of time. These sills in their fluid form may be necessary to explain some of the large horizontal displacements of the ocean floor that appear to have occurred in the eastern Pacific. The evidence for these displacements comes from measuring the amounts of magnetism in the rocks of the ocean floor. This work is largely that of the Scripps Institution of Oceanography.

The areas involved in these shifts are large;

so is the amount of shifting. The crust under the ocean is known to be thin. It seems almost necessary that shifting of blocks of the ocean floor under these circumstances requires some sort of "lubrication." And a horizontal fluid sheet which later will form a solid sill seems to be the most likely setting for the shift.

The major evidence for Dr. Dix's theory is the groups of discontinuities he has found under the Mojave Desert upland. The main groups are at depths of 7, 12, 16, and 20 to 22 miles, with the reflecting signals being strongest from the group at 16 miles. The discontinuities at the greater depths must be nearly plane and nearly horizontal; otherwise it is difficult to account for the strength of the reflected signals from them.

Reflection records, like the one below, indicate that one sill is approximately 2,500 feet thick. One would expect that a sill of this thickness would extend for many miles under the Mojave region, according to Dr. Dix, and it could be expected to have a lifting action on any highlands and mountains above it.

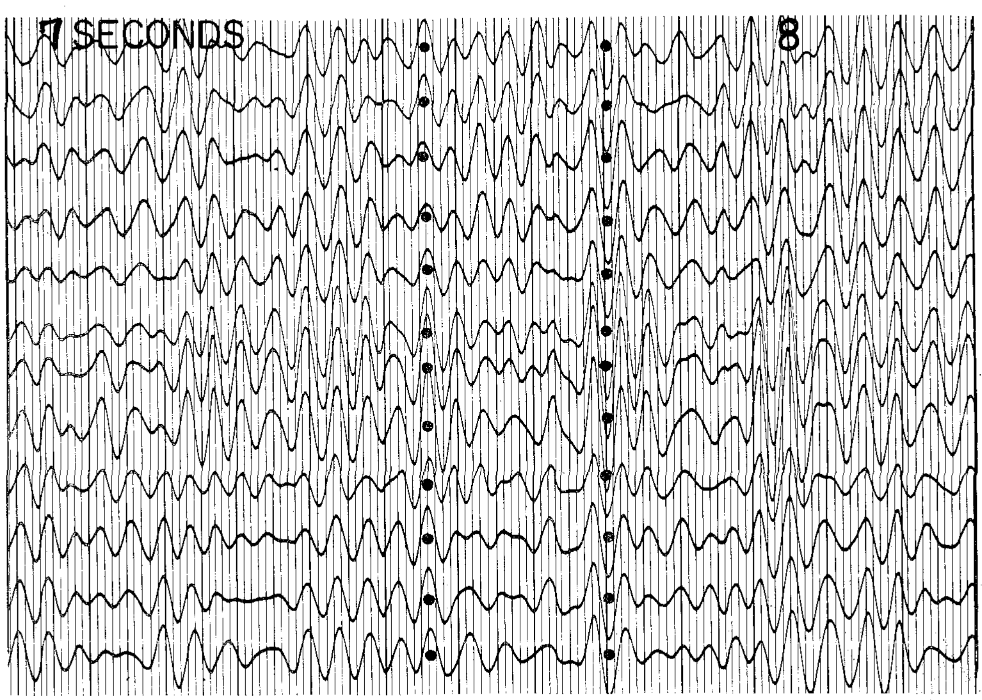
The records require careful interpretation, since the seismic waves will reflect off any discontinuity, such as shallower sills. Reflections which bounced back and forth several times between shallow discontinuities before being recorded may seem to come from deeper discontinuities because of the time intervals involved. The sounding technique is similar in principle to that used by seismic prospectors looking for oil.

The Mojave Desert soundings were taken some 40 miles east of Victorville and near Lucerne in dry lake country. Detecting equipment was located at various distances from each shot, most of the time within five to seven miles of it and occasionally as near as one mile and as far as 15 miles. The detectors were sensitive geophones that were buried a few inches deep to reduce surface noises such as wind. About a dozen pairs of geophones were set out for each shot and were spaced at intervals along a 2,000-foot path approximately in line with or across the line from each shot.

The geophones were linked by wires to recorders in a miniature bus outfitted as a laboratory. The electronic equipment included a radio transmitter and receiver for communicating with a radio system at the shot site. The shots were detonated and recorded individually. To time each shot with the necessary accuracy of five thousandths of a second, its dynamite cap was wired to release, at the instant of detonation, an electric surge that was radioed to recorders in the bus.

The recorders, one receiving data on photosensitive paper and the other on a magnetic drum, also picked up from the geophones the reflected shot waves, which traveled at about 20,000 feet a second through the ground, reflecting off discontinuities at different depths.

Dr. Dix plans other expeditions to record a series of shots in mountains in an attempt to learn more about the discontinuities and to obtain more evidence that they are sills which may have hydraulically "pumped up" the mountains.



Part of a reflection record. The shot is about 6 miles west of the line of detectors, and the line of receivers is about 2,000 feet long. The rows of dots are two reflection events. The earlier one on the left corresponds to the trough of the second, suggesting that they are reflections from the top and bottom of one sill about 2,500 feet thick.

Radio "Stars"—Explosions In Space

by Jesse L. Greenstein

The field of radio astronomy has had an extremely rapid growth. First, weak signals from our own Milky Way Galaxy were detected with instruments of low resolving power; then refined and sophisticated devices of high resolving power began to locate radio sources at various points in the sky. The first of these sources to be identified was a galaxy 500 million light years distant. The entire northern sky has now been mapped by the group under Martin Ryle at Cambridge University, and catalogs of a thousand such sources have been prepared. Various workers at the Caltech Radio Observatory (notably Tom Matthews, Per Maltby, and Alan Moffett) have been responsible for great improvement in determining the accuracy of the positions of these sources, and — collaborating with optical astronomers — in identifying the sources with optical objects.

Three years ago there was considerable surprise when, for the first time, accurate positions, combined with accurate measurements of the apparent angular diameter of some of the radio sources, indicated that a few extremely small objects had been found. Radio galaxies had been characteristically several minutes of arc in angular diameter, but these new objects were less than a few *seconds* of arc in diameter.

Refined work at radio observatories at Caltech, in Manchester, England, and in Australia revealed that these objects were probably less than a second of arc in diameter. Sophisticated interferometers were used in this research, which showed that relatively simple and inexpensive antennae, separated by distances that were extremely large compared to the wavelength used, could provide better positions and angular resolution than any very large, single, steerable paraboloid that can now be built.

A further surprise came from the failure of Tom Matthews at Caltech to find an obvious identification on photographs of these objects that had been located accurately by radio techniques. Within the accuracy of the positions given, which had become increasingly accurate with time, there was no galaxy or group of galaxies, no emission nebula, no remnant of an exploding supernova to be found. Instead, only relatively faint stars were seen on the photograph.

The first of these to be recognized, 3C48, caused a flurry of excitement two years ago when spectra taken with the 200-inch Hale reflector by Allan Sandage, Guido Munch, and myself, showed no recognizable features. To spectroscopists, this was a direct insult, since in no other objects except supernovae are there lines of unknown origin.

These radio stars produced theoretical excitement also. Analysis by Matthews and Sandage of their brightness, measured photoelectrically at several different wavelengths, gave colors unlike those of other stars. Their distribution of energy with wavelength had no resemblance to the light emitted by heated gases or solids, the so-called black-body distribution. In fact, the synchrotron emission process that produced the radio frequency energy of distant radio galaxies seemed to produce the light of these stars. Very high-energy electrons were present, spiralling around magnetic lines of force and emitting what is called synchrotron radiation. Synchrotron radiation has a distribution with wavelength that is easy to distinguish.

3C48 was the first of these radio stars to be investigated spectroscopically, and Maarten Schmidt followed up the study of these small radio sources last year with even more baffling results than had been obtained on 3C48. In two more sources, whose continuous spectra were probably caused by synchrotron radiation, weak emission lines were seen which again could not be identified.

I studied 3C48 extensively on long-exposure spectrograms taken at Palomar. The mystery seemed to be partially solved, but the solution was tantalizingly incomplete. Three weak, broad, emission lines were at approximately the right wavelengths to be ionized helium and five-times-ionized oxygen. But other observed lines did not fit; and, if helium and oxygen were present, lines were missing that should have been present.

Consequently, although with some hesitation, I developed an elaborate theory which ended up with 40 pages of manuscript, approximately 100 equations, and a suggested explanation. The hypothesis was that 3C48 was the remnant of an old supernova. After hundreds of thousands of years the exploding gases would long ago have vanished into interstellar space, but a star of high density would remain, with unusual composition, high surface temperature, and a source of energy in radioactive decay of some of the elements synthesized in the explosion. Sandage had found near 3C48 and one other object faint wisps of what might be gas clouds too faint for spectroscopy (possibly the remnants of the explosion, according to my hypothesis). This beautiful fantasy neared publication — not proven, and not quite acceptable.

Three puzzles

Fortunately, circumstances and nature intervened. In two other radio stars the emission lines detected by Maarten Schmidt were not at the same wavelengths as in 3C48. If these radio stars were really stars, they constituted a group of three strange objects, all of which contained different lines largely of unknown spectroscopic origin. One puzzle is bad enough. Three similar puzzles with all different features was too much.

Nature, by a freakish accident, had one kind surprise left for us which led to the correct interpretation. One of the recently discovered radio stars, 3C273, is located far enough south to be observable by radio astronomers using the new 210-foot dish in Australia. They found that the object was occulted by the moon on several occasions. From the change in brightness as the moon hid the radio source, and later as the radio source reappeared from behind the moon's rim, they were able to obtain an extremely accurate position and to prove that the radio source was double, and small. One component is only a few seconds or less in diameter, and separated by about 20 seconds of arc from a larger object.

Maarten Schmidt, studying a 200-inch photograph, found a thirteenth-magnitude star with a faint wisp nearby, a jet of nebulosity. The star and the jet agreed almost precisely, within one second of arc, with the positions given by the Australian radio astronomers. When Schmidt obtained the first spectrum of 3C273 it showed a bluish continuum — possibly, in part, of synchrotron origin — on which was superposed a set of rather broad but regularly-spaced emission lines. They looked so much like the harmonic series of lines produced by hydrogen that it seemed plausible that they were produced by some atom resembling hydrogen. The wavelengths, however, disagreed with those of the hydrogen lines. Schmidt and I attempted to explain them as an element with a single electron left near its ionized nucleus, and therefore having the regular simple spacing of the hydrogen series.

This effort proved to be vain. The only rational solution was that, if it was a hydrogen-like atom, it was hydrogen itself. The wavelengths, however, were 16 percent larger than those of hydrogen. The decisive point was an observation by J. B. Oke, with an infrared photoelectric scanner. Oke found a single strong emission line in the near infrared, at wavelength 7560 Angstroms. The infrared line proved, in fact, to be H-alpha, the first line of the hydrogen spectrum, which is normally at 6563 Angstroms but is here shifted to a 16-percent-longer wavelength, just as were the lines observed by Schmidt.

Another line in the spectrum of 3C273 was then identified as a shifted forbidden line of doubly-ionized oxygen. (Forbidden lines are certain weak lines emitted in a gas at low density.) But at the very violet edge of the spectrum, near the absorption produced by the ozone layers of the earth's atmosphere, one additional line remained. Subtracting 16 percent from the measured wavelength, we obtained the true wavelength as 2800 Angstroms.

This rang an immediate bell. The ultraviolet spectrum of the sun had been observed from rockets years ago by scientists at the Naval Research Laboratory who were pioneers in the ultraviolet spectroscopy of astronomical objects. They found a strong, double, emission line at 2800 Angstroms, the strongest atomic transition in ionized magnesium.

Two possibilities

That a normal star could have a velocity of 48,000 km/sec and show hydrogen and ionized magnesium emission seemed improbable indeed. Normally, stellar velocities are a few tens of kilometers per second. The possibilities remained that we had (1) an extraordinary new kind of star, producing a very large red shift — a shift of lines of the spectrum toward the red end, indicating that objects are rushing away from our stellar system — caused by the action of an intense gravitational pull on light, or (2) a galaxy.

3C273 now had a spectrum that could be explained. It was a simple spectrum and hydrogen was dominant. But its lines did not fit those which I had suspected were in 3C48. Moreover, the existence of a strong line at 2800 Angstroms suggested that I should see whether the strongest line in 3C48, located at 3832 Angstroms, could possibly be the same element with a different red shift. This suggested a red shift of 37 percent. Trying 37 percent red shift on the other lines of my spectrum gave the final answer to the puzzle. Unwillingness to accept the implausible and improbable had made me unwilling to imagine so large a red shift. But now all the strong lines in the spectrum were identifiable. They turned out to be forbidden lines of ionized neon and oxygen. Hydrogen, if present, is weak, unlike 3C273.

The actual red shift of 3C48 turned out to be about 37 percent. If the red shift is due to recession, this is a speed of 110,000 kilometers per second. It is the second largest red shift known, surpassed only by the very faint radio galaxy 3C295, identified by Rudolph Minkowski. Based on current estimates of the size of the universe, a red shift of 37 percent corresponds to a distance of about 5 billion light years; 3C273 is at a distance of approximately 2 billion light years.

The brightest objects

The radio stars, if they are distant galaxies, are enormously luminous. From the observed red shift and apparent brightness, they have approximately the same intrinsic luminosity — about 100 times greater than that of our own galaxy. This is far greater than the luminosity of any other known galaxy. Even in searching over clusters of galaxies which form a large sample of the objects in the universe, the brightest objects found remain approximately 30 times fainter than the two radio stars 3C48 and 3C273.

The interpretation of these two objects as very luminous galaxies involves difficulties and problems. They had first been recognized by radio and optical means as "stars" from their small angular diameter. But the small angular size, at these enormous distances, is not small *linear* size. For example, one second of arc, the upper limit of the size of the apparently stellar image of 3C48, corresponds to 25,000 light years. Since 3C273 is double, the angular separation between the star and the jet corresponds to 150 thousand light years. The faint wisps originally interpreted as remnants of a stellar explosion in our own galaxy are objects of truly galactic dimensions. But they still do not look like normal galaxies.

Is it possible that we are wrong and that they could be stars with an enormous red shift? Obviously, velocities of 110,000 kilometers per second are impossible for stars bound to our own galaxy, in which the maximum speed is about 300 kilometers a second. However, a very interesting state of very dense matter involving both general relativity and nuclear physics might occur in a star of very high density. The possibility exists that red shifts may be caused by the gravitational pull on light, as was predicted by Einstein. In the sun, the Einstein shift is less than a kilometer a second. If we could increase this effect of gravity, the red shifts might become large.

Physicists have found that it might be possible for massive small objects to be stable; a star could weigh more than the sun and have a radius of only 10 kilometers (while our sun is 700,000 km in radius). The density would then be about 10 billion tons per cubic inch. For such an object the gravitational red shift would give a recession velocity of about 61 percent the velocity of light.

I fear, however, that astronomical objections to the interpretation as superdense stars are too serious. The thickness of a gas cloud around the star would be needed to produce the emission lines. If it were more than a few kilometers thick, the gravitational red shift would vary inside the cloud and the emission lines would be broadened. Since the lines are relatively narrow, the actual thickness of the emitting gaseous envelope works out to be only a fraction of a kilometer. From the theory of emission lines in hot gases, it proves absolutely impossible to produce an observable emission line in so small a volume. In fact, the emission produced is so weak that these objects would have to lie inside the solar system. Thus, for the present, we must regretfully abandon the hope of finding these extremely dense stars.

An exciting result

We are left then with the still very exciting result that two stars — 3C273, studied by Schmidt and by Oke; and 3C48, studied photometrically by Sandage and Matthews, and spectroscopically by myself — are galaxies of enormous brightness, at very great distances.

Future prospects opened by this discovery are most exciting. We have learned how to find objects of greater luminosity and distance than the most luminous galaxies known till now. If an object like 3C48 could be found at a distance three times greater, it would still be detectable by the radio astronomers who are making surveys of the entire sky. It would emit enough radio noise to have its diameter measured and its position accurately determined by the sophisticated interferometer techniques at the Caltech Radio Observatory. It would be easily photographable and its spectrum could be observed at Palomar.

A red shift of 37 percent is far below the maximum observable for such objects. At three times the red shift of 3C48, the strong ionized magnesium line at 2800 Angstroms, originally in the far ultraviolet, would have moved to 6000 Angstroms, near the red sensitivity limit of photographic plates. It might be followed even further with a photoelectric scanner for the near infrared such as was used by Oke.

If objects still further could be found, we might lose the magnesium emission line found in 3C48 and 3C273 into the unobservable infrared. But we could hope to find, at a much larger shift, the strongest resonance line of hydrogen, Lyman-alpha, which could then be a very strong emission feature at the ultraviolet end of our spectrum. Consequently, if nature provides us with similar enormously bright galaxies, we may be able to trace them very nearly to the horizon of the universe, when the apparent velocity approaches that of light.

The story of the radio "stars," which are very luminous galaxies, is just at its beginning. I have attempted to give our first results, but many important theoretical problems remain. For example, the continuous radiation emitted is not that of the stars in a distant galaxy but it is almost certainly the synchrotron emission of electrons in magnetic fields within that galaxy. The process requires electrons of energies up to 100 billion electron volts moving in magnetic fields near 1/1000 of a gauss.

The masses of gas involved in producing the emission lines, and possibly part of the continuous spectrum, lie in the range between one million and one billion solar masses. The extraordinarily high luminosity cannot be maintained very long. It is almost certain that we are viewing the end-product of a violent explosion of unknown origin which occurred not many hundreds of thousands of years ago, in the time frame of reference of these galaxies. The objects that we are viewing are now long dead, because of the long light-travel time. Schmidt's discovery of an isolated jet in 3C273 at a distance of over 150 thousand light years from its galaxy, requires a duration of the explosive phase of that order of magnitude even if the jet was expelled at nearly the velocity of light.

Recent speculations by Hoyle and Fowler concern the possible brief existence of stars weighing a hundred million times as much as the sun. They have imagined that a star of such enormous mass begins to form out of gas near the center of a galaxy. It is too massive to be permanently stable. There is controversy concerning difficult points in general relativity and neutrino physics as to whether these objects can be stable at all. Some think that they would disrupt before collecting such enormous masses. However, relativistic effects and the production of positron-electron pairs might make stability possible. After a short time, the end product of these large stars would be a collapse and an enormous explosion, which might result in the phenomenon we have here observed.

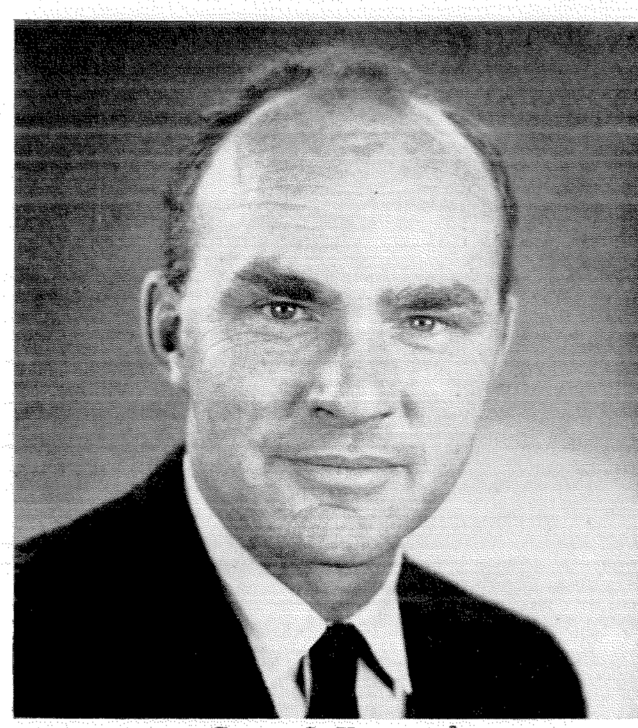
The jet and the wisps of gas near 3C48 seem to have been blown out nearly at the velocity of light in some initial explosion. The entire galaxy of stars is now invisible, submerged by synchrotron emission from high-energy electrons and magnetic fields which may be the result of such an explosion. In another hundred thousand years the visible remnants of the explosion will fade, leaving only the optical galaxy, possibly profoundly disturbed by this event. It is possible, but far from certain, that we will then have a typical large radio source such as those that have been recently studied at Caltech.

With or without any theory of their origin, it is obvious that the radio "stars" are a valuable tool for cosmology, and one of the most dramatic events in the evolution and life of a galaxy.

Another fascinating facet of this new observation is that we can study now, for the first time, emission lines from the far ultraviolet, which would be unobservable without these large red shifts. One may hope that ultimately they will be observed in nearer galaxies from outside our atmosphere. But it is interesting to note that these two radio stars are too faint to be observable by the first few generations of orbiting astronomical observatories. The magnesium lines had been seen, before this, only in spectra of the sun observed from rockets. One line recognized in 3C48 proved to be a special type of "auroral" forbidden line of quadruply-ionized neon, which cannot be observed in the laboratory or in any astronomical object.

Earthbound astronomy, radio and optical, has shown that it is still very much alive. The universe always is and always will be full of the unexpected.

The Month at Caltech



George S. Hammond

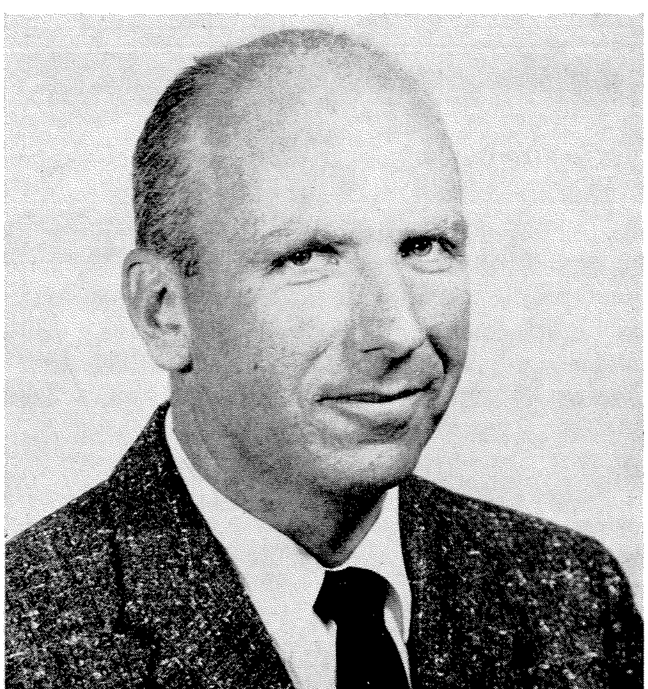
National Academy of Sciences

Three Caltech scientists were elected members of the National Academy of Sciences at its 100th annual meeting held this month in Washington.

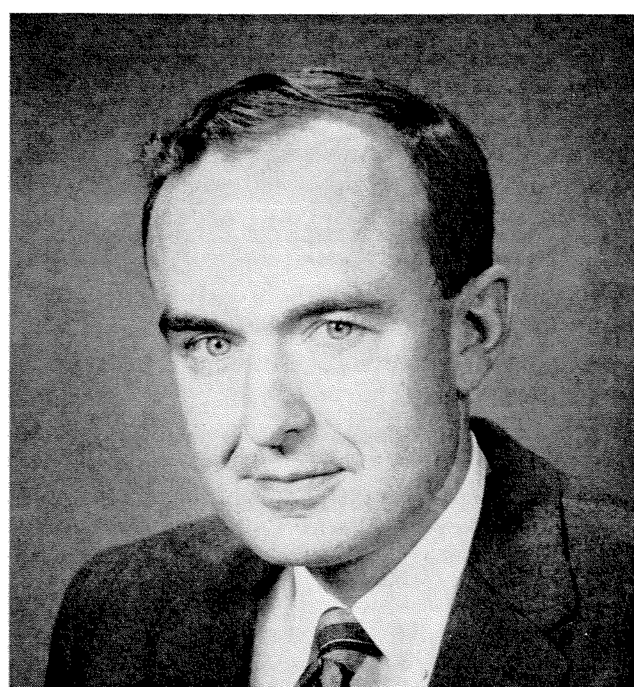
They are Dr. George S. Hammond, professor of organic chemistry; Dr. Leon Knopoff, professor of geophysics; and Dr. Allan R. Sandage, staff member of the Mount Wilson and Palomar Observatories.

Election to the Academy is in recognition of outstanding achievement in scientific research. Caltech, now with 34 Academy members, has the highest percentage of members of any university faculty.

George Hammond, who received the American Chemical Society Award in Petroleum Chemistry in 1961, is considered to be one of the world's leading investigators in physical organic chemistry. He is especially interested in the chem-



Leon Knopoff



Allan R. Sandage

ical changes that occur in some molecules as the result of energy being transferred to them by other molecules that have absorbed energy from light. He also does research on reactions that occur when one molecule is added to another. His earlier work produced new insight into the action of oxidation inhibitors. Dr. Hammond is the author of a new textbook, *Organic Chemistry*, with D. J. Cram, and is also co-author of *Analytical Organic Chemistry*.

Dr. Hammond was graduated from Bates College in 1943 and received his MS and PhD degrees from Harvard University. His academic experience includes teaching and research at Iowa State College and the University of Illinois. He came to Caltech in 1956.

Leon Knopoff has contributed much to the understanding of waves in the earth and has done significant research on the mechanism of earthquakes, and on the composition of the earth's crust, mantle, and core. His mathematical models of earthquakes have represented major advances in seismology.

A native of Los Angeles and a Caltech alumnus, Dr. Knopoff got his BS degree at Caltech in electrical engineering in 1944, then received his MS and PhD degrees in physics. He is a professor of geophysics on the faculties of both Caltech and UCLA.

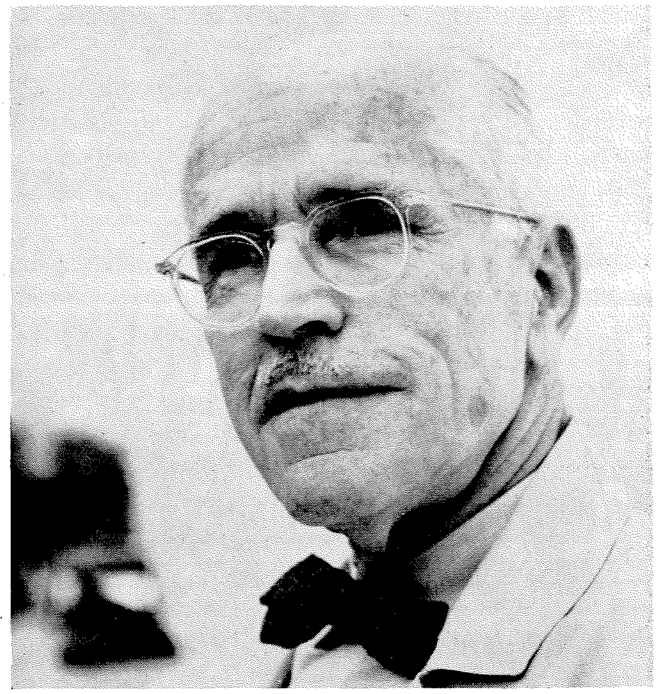
Allan Sandage has made important contributions on the evolution of stars, star clusters, galaxies, and the universe. He has done important work on developing cosmic yardsticks for measuring the immense distances beyond the Milky Way Galaxy. He is also interested in the rates of recession of galaxies and has found evidence that the universe is slowing down. He put together the *Hubble Atlas of Galaxies*, which represents a rich source for future studies of galaxies.

Dr. Sandage was graduated from the University of Illinois in 1948 and received his PhD at Caltech in 1953. He joined the Mount Wilson and Palomar Observatories staff in that year, and has received several awards for his work.

Richard Chace Tolman Medal

Ernest H. Swift, professor of analytical chemistry and former chairman of the division of chemistry and chemical engineering, has been awarded the 1962 Richard Chace Tolman medal by the southern California section of the American Chemical Society.

Dr. Swift, who has been a member of the Caltech faculty for 44 years, received the medal



Ernest H. Swift

"in recognition of his research contributions to analytical chemistry, leadership and interest in the development of analytical procedures, and his long and continued interest in teaching as well as for his service to the local and national chemical community, the American Chemical Society and the nation."

This is the third year the section has awarded the medal, named for the late Dr. Tolman, professor of physical chemistry and mathematical physics at Caltech.

NASA Grant

The Institute has received a grant of $268,900 from the National Aeronautics and Space Administration to support the training of 15 full-time graduate students in space-related sciences and technology. The purpose of the grant is to "help achieve the long-range objectives of the national space program and meet the nation's future needs for highly trained scientists and engineers."

The grant takes effect in September. Each graduate student chosen for the training program will receive $2,400 for 12 months of training plus an allowance for dependents up to $1,000 per year. The recipient is assured three years of graduate study provided he maintains a satisfactory record.

Eighty-eight colleges and universities have been selected to receive these training grants from NASA for the academic year 1963-64, with a total of approximately 800 graduate students participating in the program.

continued on page 16

William C. McDuffie

William C. McDuffie, a Caltech trustee for 30 years, died on April 10 of a stroke. He was 76.

Mr. McDuffie, a prominent oil and aviation executive, started in the oil business as a roustabout in 1907 and by 1921 was in charge of production for the Shell Oil Company when they brought in the first well on Signal Hill. More recently Mr. McDuffie was an independent oil producer and chairman of the boards of Mohawk Petroleum Corporation, Northrop Aircraft, and the Wilmington Gas Company.

He served as a trustee at Caltech from 1933 to 1961 and since then he has been an honorary trustee of the Institute.

"His passing is a tragic loss to the entire Southern California community," said President DuBridge, "and a great personal loss to the trustees, administration, and faculty of the California Institute of Technology.

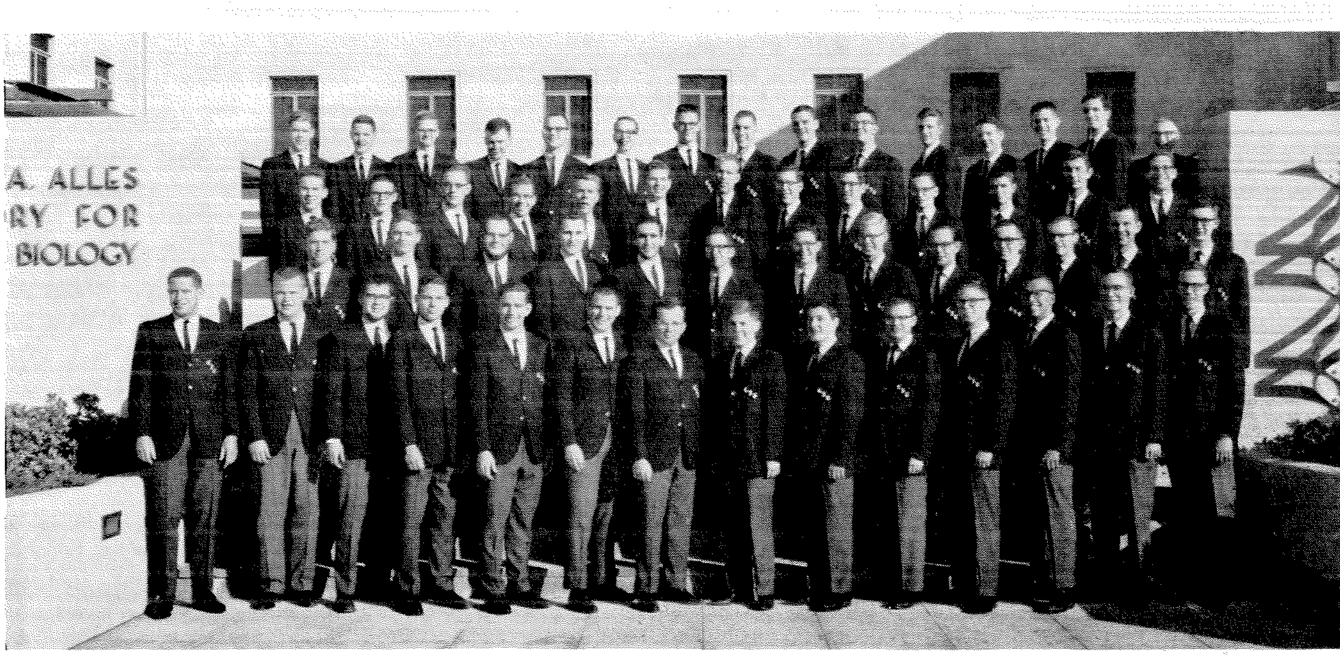
"No one better understood and supported the aims and ideals of Caltech or was a warmer friend to all. His loss is an irreparable one."

Spring Concert

Caltech's Glee Club of 55 men (below), directed by Olaf M. Frodsham, will give their annual spring concert on May 11 at 8:15 p.m., at the Marshall Junior High School, 990 North Allen Ave., in Pasadena. They will have as guests the Pomona College Women's Glee Club, who will sing several numbers with the Caltech Club.

Now in their 47th concert season, Caltech's Glee Clubs have gained a reputation as leaders in the field of male choral singing. Mr. Frodsham, who is in his tenth year as director of the Glee Clubs, is associate professor of music at Occidental College, and organist and choirmaster at St. Mathias Church in Los Angeles.

Tickets to the Glee Club spring concert are available at the Caltech Bookstore, and in the News Bureau. They will also be on sale on Alumni Seminar Day, May 4, on the campus. Student tickets are $1, adults $1.50. Proceeds will be used to support choral musical activities at Pomona and Caltech.



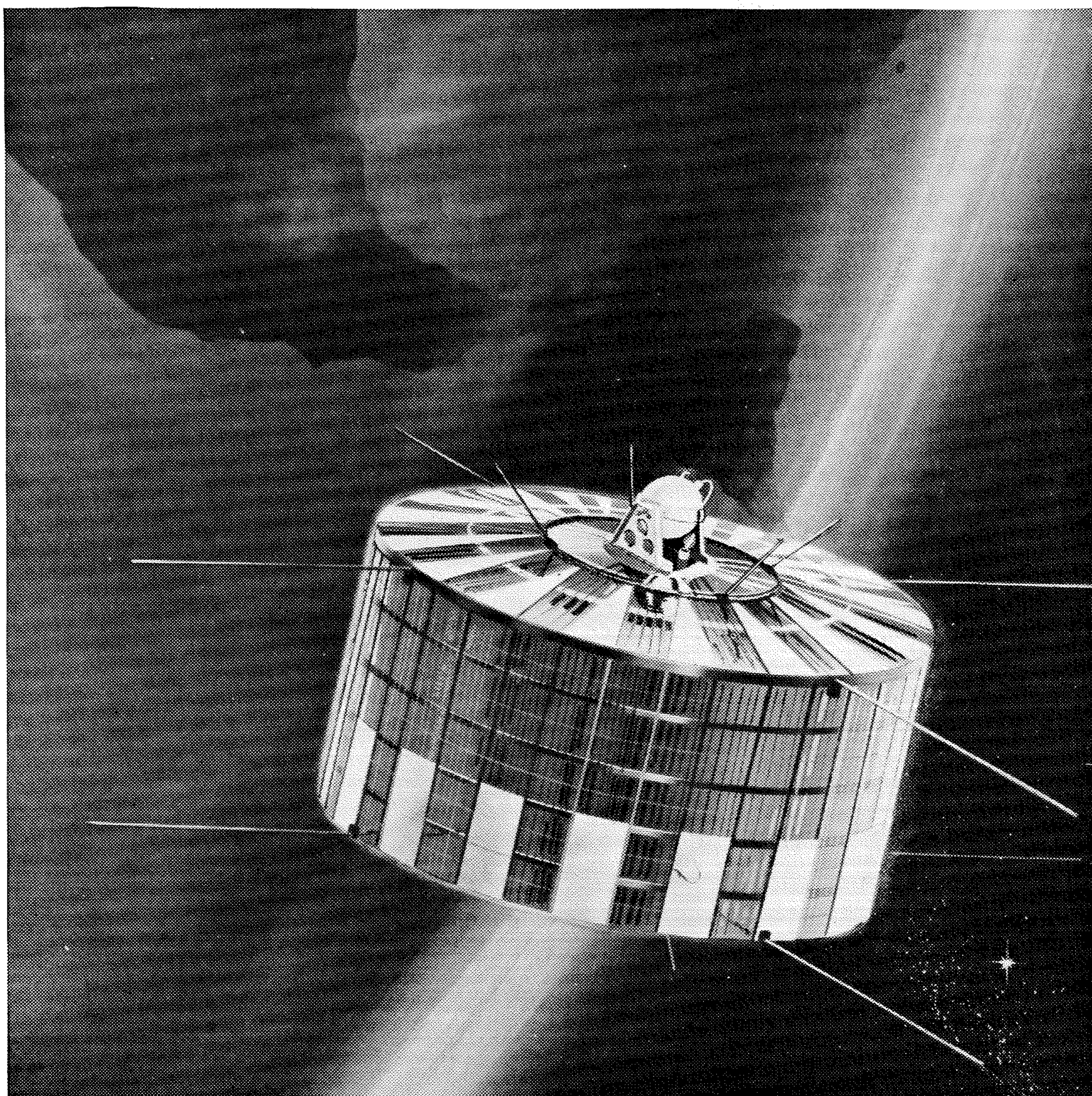


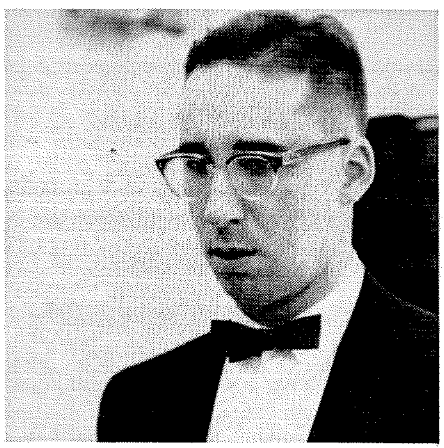
Illustration Courtesy The Martin Company

How long've you been out of school?

Since '52. Purdue. Then two years in the Navy and a year for my Masters at Caltech.

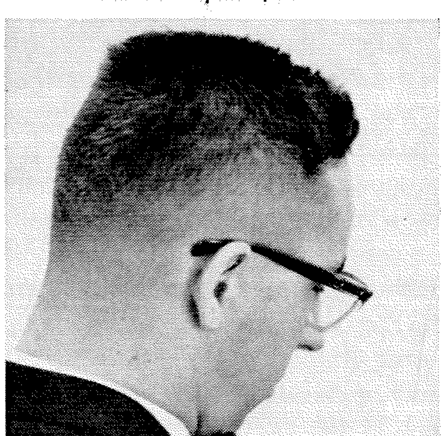
I came to Jet Propulsion Laboratory right after that. '55. I like it very much. It's a nice atmosphere for engineers to work in. There's a lot of work, a lot of hard work. But interesting.

And because we're operated by Caltech, we can work closely with some of the top scientific minds in the country. I think that makes a difference. We have a lot of freedom within our individual disciplines, too.

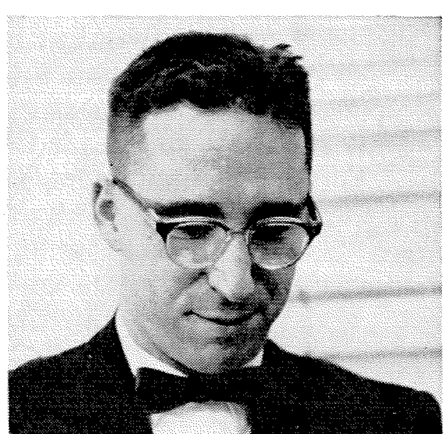


I'm an Engineering Group Supervisor. Our group is among those responsible for communications with spacecraft designed by JPL to go to the moon and planets.

Among other things, we want to find out what the moon is made of, and if there's life on other planets. Contributing to space exploration is a challenging vocation.



We've excellent facilities here. One of the largest technical libraries, for example. There are at least two support people for every scientist and engineer at JPL. And they're all great to work with.



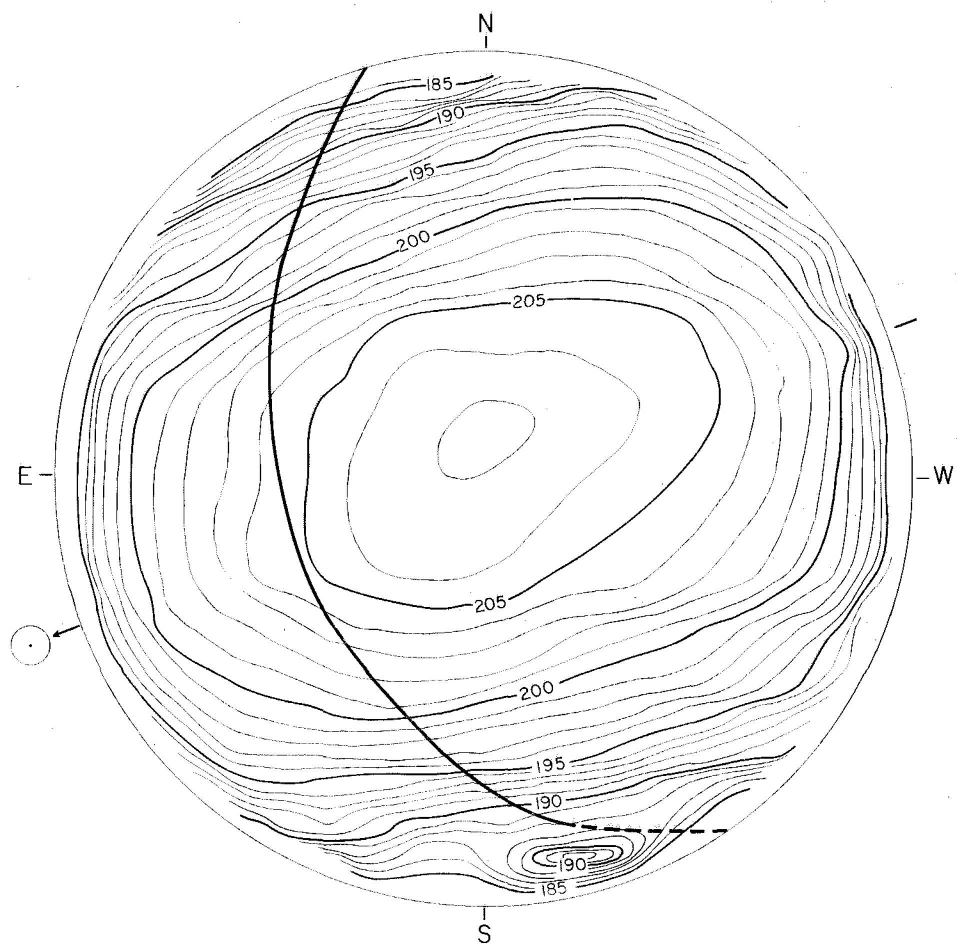
I bought a home close by. Only 20 minutes from coffee cup to coffee cup. My wife likes that. The kids like where we are, too. We like hiking and there are excellent trails minutes from our house.

You've just been chatting with Dick Mathison, JPL engineer. He likes his work. He likes where he works. Would you like to share in the challenging and important work he does? Maybe you can...why not write to JPL and see.

jpl "Research and development for America's lunar, planetary and interplanetary exploration programs."

JET PROPULSION LABORATORY

Operated by California Institute of Technology for the National Aeronautics & Space Administration
4800 Oak Grove Drive, Pasadena, California
Attention: Personnel Department 103
"An equal opportunity employer"



Temperature contour map of Venus, December 15, 1962

VENUS OBSERVED

The most detailed observations yet reported of the upper atmosphere of Venus have just been disclosed by Caltech investigators. Bruce Murray and Robert L. Wildey, research fellows in space science, and Senior Engineer James A. Westphal scanned the planet Venus with a heat-sensitive detector fitted to the 200-inch telescope on Palomar Mountain. The observations were made on four successive nights before, during, and after Mariner II flew by Venus last December 14. They showed that:

1. A storm region was clearly visible on one weather map (above), near the southern tip of the planet. It was about 1,000 miles across, similar in size to many storms in the earth's atmosphere, and the temperature in the region was about 5° Kelvin (10°F) hotter than in the surrounding atmosphere. Although the storm region was clearly defined on only one night, it disturbed the temperature distribution in the southern hemisphere on all four nights of observation. No similar disturbances were noted elsewhere on the planetary disk.

2. The temperature of the upper atmosphere was the same on the planet's dark side as on the sunny side (the sun is the small circle on the left in the drawing above), indicating a surprisingly efficient distribution of the sun's energy that falls on the sunlit side.

3. The apparent temperature of the atmosphere is about 205°K in the central region of the planetary disk and grows gradually colder toward the "top" and "bottom" of the disk. (Top and bottom refer to the direction perpendicular to the plane of the planet's orbit around the sun.) The maximum difference in temperature is about 20°K.

In general, the overall temperatures found were not too different from those observed by other workers using less sensitive instruments. The measurements made by the Caltech group, however, are the first ones to map in detail the atmospheric temperatures across the planetary disk.

The fact that temperature similarities are not bulls-eye-shaped but tend to stretch across the middle of the planet like a semi-squashed bull's-eye, coupled with the finding that the investigators detected no temperature differences between day and night, could most easily be explained by a modest rotation of the planet. However, there also may be other more complicated explanations of the temperature distribution.

For instance, the mode of rotation suggested by these data may be inconsistent with the recent interpretations of radar observations, which indicate a very slow reverse rotation.

Whether Venus rotates on its axis more than once every time it makes one complete orbit around the sun every 225 days has long been a puzzle to astronomers. The planet is blanketed with a dense cloud cover that shows no tell-tale surface markings to give a clue as to its rotation rate.

Measuring device

The Caltech team scanned the planet's upper atmosphere with an infrared radiation measuring instrument designed and built by Westphal. The device is 20 to 50 times more sensitive than any previous one devised for measuring temperatures of comparatively "cold" celestial bodies.

Linked with the 200-inch telescope, the instrument measured the temperature of segments of the planet's atmosphere as small as 260 miles in diameter. Up to 30 scans were made horizontally across the planet, from top to bottom, on four successive nights, Dec. 13, 14, 15, and 16, in the early morning hours just before sunrise.

Those dates coincided with the Mariner II fly-by observations so that the Caltech group could correlate their findings with those of the Venus space probe. Venus was in a favorable position for such observations. It was comparatively nearby (about 36,000,000 miles away). Also, about a quarter of its disk was illuminated by the sun, which made it possible to get temperature readings of the light and dark areas of the planet's atmosphere.

The unique crystal detector (which also recently showed that the dark side of the moon is much colder, 270° F. and below, than previously supposed) "sees" heat waves through a "wavelength window" in the earth's atmosphere that admits infrared radiation whose wavelengths are about 20 times longer than those of visible light.

The tremendous light-gathering power of the 200-inch Hale mirror collects and focuses the longer infrared waves just as it does light waves. Instead of being focused onto a photographic plate, as light waves are, the infrared waves are filtered and focused onto the special crystal detector.

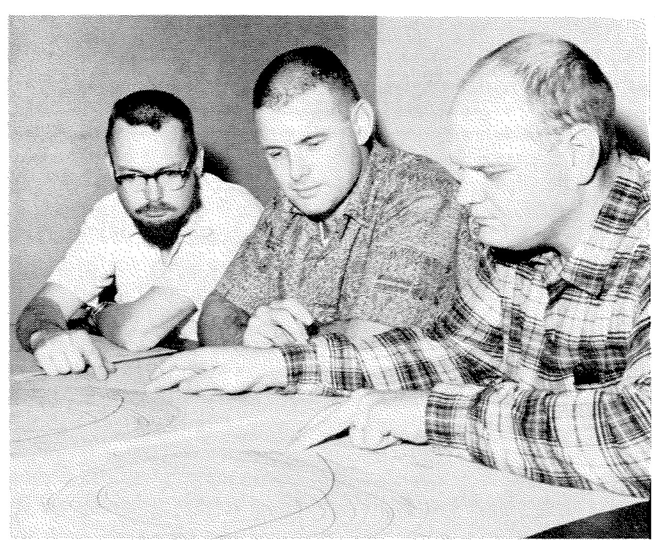
The crystal is of germanium. Scattered through it are mercury atoms which, when struck by heat radiation, give up electrons. The more intense the incoming radiation, the greater the number of electrons that are given off. The varying number of electrons causes a slight voltage fluctuation in the crystal. These variations, calibrated to indicate temperature, are amplified about one million times and recorded.

Sensitivity control

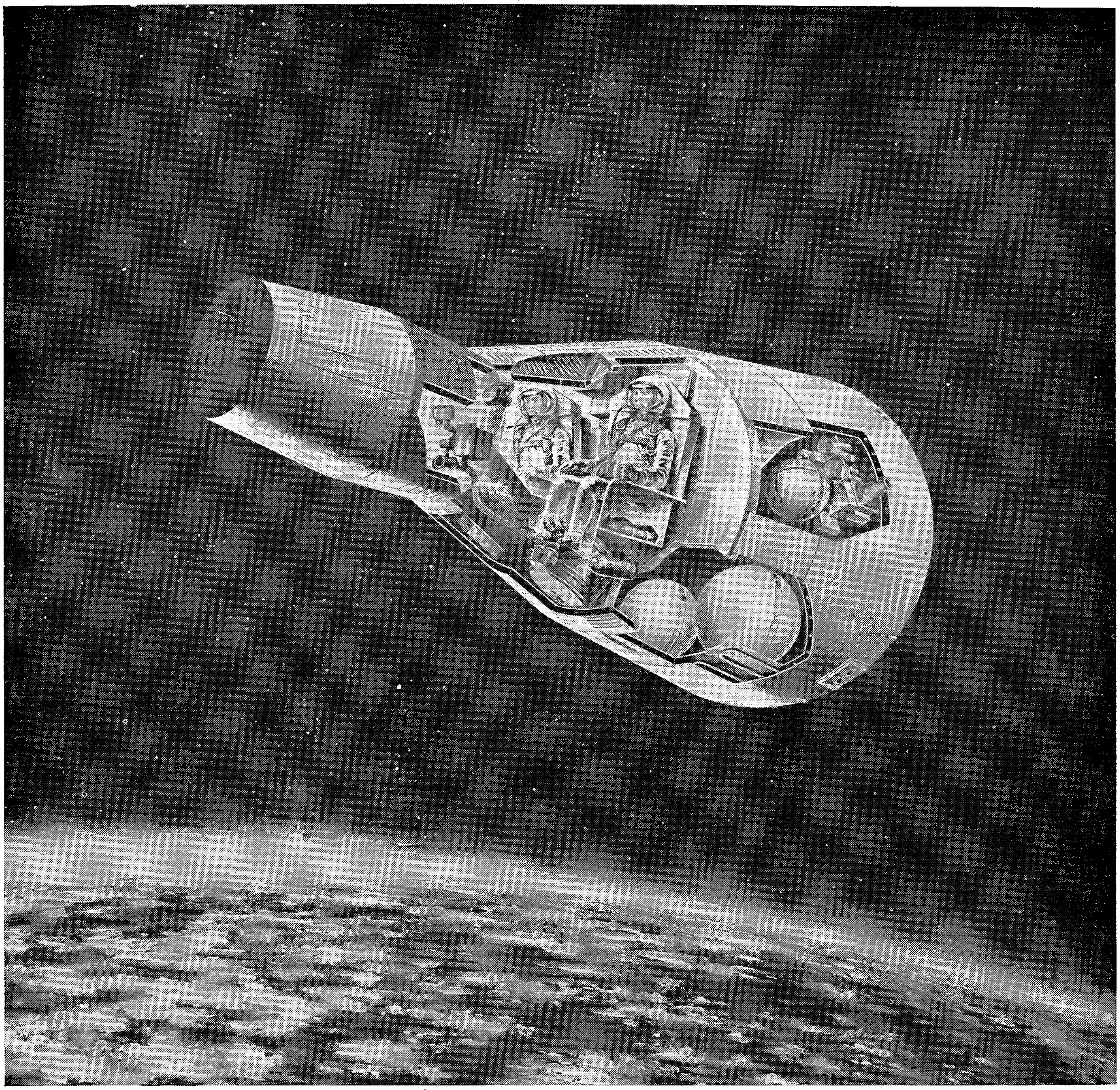
So that the crystal will be as sensitive as possible, it is maintained in a container cooled with liquid hydrogen, lowering its temperature to about 423° below zero (F.) Liquid hydrogen also cools radiation shields around the crystal. The shields reduce background noise from "hot" surroundings on earth.

The observing is done with a double beam system that looks at the spot whose temperature is to be taken and at the same time compares its radiation with that emanating from a nearby spot in the sky. Only the difference in radiation between the two beams is amplified.

This research is sponsored by the Caltech Division of Geological Sciences with the support of the National Science Foundation and the National Aeronautics and Space Administration.



Senior Engineer James A. Westphal and Research Fellows Bruce Murray and Robert L. Wildey study light-temperature contour maps of Venus.



Twenty-Sixth Annual Alumni Seminar

Saturday, May 4, 1963

Dinner and Evening Program

Huntington-Sheraton Hotel, Pasadena

"HIGHER EDUCATION – CHANGE AT THE TOP" – ROBERT L. MINCKLER

Robert L. Minckler, chairman of Caltech's Board of Trustees and retired president of the General Petroleum Corporation, is a consulting professor of business management at the Stanford University Graduate School of Business, and president of the Los Angeles World Affairs Council. He has served as president and director of the Western Oil and Gas Association and as a director of the American Petroleum Institute. During World War II he was Director of Petroleum Supply for the Petroleum Administration for War, developing a program to meet both military and civilian needs. He has also served as a vice president and director of the California Chamber of Commerce.

Special Exhibits

JPL model of the Mariner II – Open House, Winnett Student Center – Book Store (open all day) – "Clouds of Venus," a film about the Mariner II flight.

Outstanding Lecture Program

Three morning and three afternoon periods, each with four simultaneous lectures. Each lecture will be given once in the morning and once in the afternoon.

Alumni outside of southern California who wish to attend the Seminar should write the Alumni Office for reservations.

Seminar Lectures

GOLD MINERS, BOOM TOWNS AND GHOSTS
9:30 A.M. and 2:15 P.M.
Rodman W. Paul, Professor of History

Are ghost towns the only survivors of the great gold and silver rushes that pioneered the Far West? How does a writer discover why some boom towns lasted for only a hectic moment while others have become permanent and prosperous cities? Professor Paul discusses the enduring versus the transitory features of this dramatic phase of early western history.

THE SEARCH FOR EXTRATERRESTRIAL LIFE
9:30 A.M. and 2:15 P.M.
Norman H. Horowitz, Professor of Biology

Rocket exploration of the nearest planets, Venus and Mars, began in the fall of 1962. The search for extraterrestrial life is an important and exciting objective. Dr. Horowitz weighs the evidence for life on Venus and Mars, and describes "Gulliver," a life-detection device designed to operate under Martian conditions.

ENGINEERS AND POLITICS
9:30 A.M. and 2:15 P.M.
Frederick C. Lindvall, Professor of Electrical and Mechanical Engineering; Chairman, Division of Engineering and Applied Science.

Engineers carry out society's plans. Should they participate more in making them? Why are there so few engineers in our national councils in this technical era? Dr. Lindvall examines the engineer's role and his training for it, both in the United States and in underdeveloped nations.

DOES YOUR TAP WATER FOAM?
9:30 A.M. and 2:15 P.M.
William R. Samples, Assistant Professor of Civil Engineering

Some of the water you drink has been renovated by man. While purification removes contaminants, in many parts of the U. S. minute quantities of certain detergents remain to cause foaming. Since this could occur locally under special conditions, Dr. Samples will discuss the need for, and problems of, waste water reclamation in southern California and will demonstrate foaming and its elimination.

MINITALK AND MEGATHREAT
10:45 A.M. and 3:15 P.M.
Albert R. Hibbs, Chief, Arms Control Study Group, JPL

Dr. Hibbs probes three basic questions that underlie our struggle to halt the arms race.

1. Can bargaining with the Russians enhance our national security?
2. Can we advance our national interest through international negotiations?
3. When nations are measured by their military power, what is the role of talk?

THE WORLD NUTRITION PROBLEM– A SCIENTIFIC VIEW
10:45 A.M. and 3:15 P.M.
Henry Borsook, Professor of Biochemistry

Half of the world's population is malnourished – that is, diseased for lack of essential nutrients. These are the substances that the body needs in small quantity but cannot make for itself. They occur naturally in foods, but most of them can now be produced industrially to great advantage. If industry and science join hands with agriculture, Dr. Borsook believes that the world's nutrition problem can be solved.

WHAT WE LEARNED FROM MARINER II
10:45 A.M. and 3:15 P.M.
Leverett Davis, Jr., Professor of Theoretical Physics

The Venus probe is yielding new information about high-energy charged particles, cosmic dust, the mass of Venus, and the appearance of the planet at long wavelengths. Dr. Davis will discuss the scientific implications of some of the preliminary results. In addition, he will briefly review the history of the mission and present slides of the spacecraft, its trajectory, and the scientific data it obtained.

IF HANNIBAL COULD DO IT NOW
10:45 A.M. and 3:15 P.M.
W. Barclay Kamb, Professor of Geology

A crossing of the Alps, formerly a frightening ordeal, nowadays is a fascinating and instructive experience as seen through the eyes of the scientist or engineer. The great barrier to travel and communication has been mastered by modern technology in ingenious ways; at the same time an incredible story of upheaval within the earth has been deciphered – a story that to the discerning eye is plainly written in the magnificent Alpine landscape.

PENNIES, POWER AND POLARIS
11:45 A.M. and 4:15 P.M.
David C. Elliot, Professor of History

The common market is a great new force. It is changing world perspectives by shifting the centers of power, and it is bringing new politics to old nations. Professor Elliot reviews the economic, political, and military implications of the common market for the outside world.

THE SWITCHBOARD OF LIFE
11:45 A.M. and 4:15 P.M.
James Bonner, Professor of Biology

The cells of a creature contain all of the information required for its development. A cell does not use all of its information, however. A switchboard mechanism within the cell connects the required information and disconnects the rest. Professor Bonner describes this genetic programming and his methods of investigation.

DEATH OF A STAR
11:45 A.M. and 4:15 P.M.
Jesse L. Greenstein, Professor of Astrophysics

Hydrogen fuel is consumed as stars release nuclear energy. After all the hydrogen has been exhausted, stellar evolution can proceed on any of several paths. Some stars condense to form compact, high-density bodies known as white dwarfs that cool toward invisibility over billions of years. Dr. Greenstein discusses recent observations that shed new light on the cosmic process.

PHOTON FOOTBALL
11:45 A.M. and 4:15 P.M.
George S. Hammond, Professor of Organic Chemistry

Quanta of energy may be rapidly passed from one molecule to another like a ball in play. Dr. Hammond shows that this transfer of excitation, after absorption of light, is an essential step in many photochemical reactions.

Personals

1922

HOWARD G. VESPER, president and director of the Standard Oil Company of California, Western Operations, Inc., has joined the executive committee and advisory board of the Northern California region of the National Conference of Christians and Jews.

1926

ALPHEUS M. BALL has been appointed chairman of the Munitions Task Group for a special quality assurance study just launched by the Army Materiel Command, with the aid of the National Security Industrial Association. He holds the position of manager of quality assurance in the Chemical Propulsion Division of the Hercules Powder Company's Explosives Department in Wilmington, Delaware.

The Army's study is a six-month project by some 90 quality control experts.

1927

CHARLES A. BRADLEY, JR., died on March 2 in Corning, N.Y. He had just returned from a vacation when he was admitted to the hospital on March 1.

Dr. Bradley had been with Corning Glass Works since 1936 and had recently been named manager of Project Analysis in the Technical Staffs Division.

1933

BRIG. GEN. JOHN C. MONNING has been promoted to the rank of major general by confirmation of the United States Senate on February 28. He is commanding general of the 311th Logistical Command, U.S. Army Reserve, the largest headquarters type command in the U.S. Army. In civilian life, General Monning is general manager of the Los Angeles City Building and Safety Department.

1935

ALAN BEERBOWER, research associate at the Esso Research and Engineering Company in Linden, N.J., has been with the company for 27 years. He joined Esso after receiving his MS from Columbia University in 1936. The Beerbowers have one married daughter, Marjorie.

ALBERT O. DEKKER, PhD '40, has been appointed manager of the Propellant Research Division at the Aerojet-General Corporation in Sacramento.

KENNETH S. PITZER, president of Rice University, has received Dickinson College's Priestley Memorial Award for 1963 for "distinguished contributions to mankind through chemistry" and also for his interest in the education of young scientists. The award is a portrait medallion of Joseph Priestley, the discoverer of oxygen, and $1,000.

1937

JAMES W. DAILY, MS, PhD '45, professor of hydraulics and research at MIT, is now a Fellow in the American Society of Mechanical Engineers. He supervises the MIT Hydrodynamics Laboratory, and was responsible for the formulation of a pioneer curriculum in civil engineering.

1938

SAMUEL E. WATSON, JR., has been in the Iranian oil fields for the past 6 years as a resident geologist, special projects geologist, and lately as a reservoir research geologist. On May 20 he will transfer to the head office in Tehran as senior exploitation geologist. The Watsons and their two children spend their six weeks annual leave traveling in Europe and the Far East.

ROBERT C. MCMASTER, MS, PhD '44, professor of welding engineering at Ohio State, has received an Alumni Award for Distinguished Teaching with a $1,000 grant from Ohio State. He has been on the faculty since 1955.

1940

HAROLD S. MICKLEY, MS '41, was appointed Ford Professor of Engineering at MIT last year, and this year is serving as chairman of the faculty. He has been at MIT since 1942, when he started studying for a PhD which he received in 1946. While at Caltech he earned part of his tuition by writing science fiction under pseudonyms. The Mickleys live in Belmont, Mass., with their two sons, Steven, 17, and Richard, 14.

1941

H. GUYFORD STEVER, PhD, was elected to the board of directors of the Simplex Wire & Cable Company in Boston at their annual meeting last month. He is head of the departments of mechanical engineering and naval architecture & marine engineering, and also serves as professor of aeronautics and astronautics at MIT.

1944

KNOX T. MILLSAPS, PhD, chief scientist for the U.S. Air Force's Office of Aerospace Research, joined the faculty of the University of Florida as research professor of aerospace engineering on April 1.

1948

MAJOR HOWARD W. GREEN is now at the Air Force Special Weapons Center at Kirtland AFB in New Mexico and expects to transfer to Norton AFB in California in July. He writes that he plans to spend four or five years more in the service and then retire in California. The Greens and their three children, Miriam, 13, Debbie, 10, and Douglas, 8, have a mutual hobby of trailer travel in their 30-foot Airstream.

1949

JOSEPH F. BURKHOLDER is now a civil engineer in the investigations, planning and reports unit of the United States section of the International Boundary and Water Commission, United States and Mexico. He acts as assistant to Principal Engineer William E. Walker.

1952

GORDON E. ZIMA, MS, PhD '56, is now on the staff of the chemistry department of the University of California's Lawrence Radiation Laboratory in Livermore. The Zimas and their three children live in Danville.

HENRY L. RICHTER, JR., PhD '56, has been named manager of the advanced systems development operation at Electro-Optical Systems, Inc., in Pasadena. This is a new post which entails directing the company's efforts in hardware systems for military and space applications.

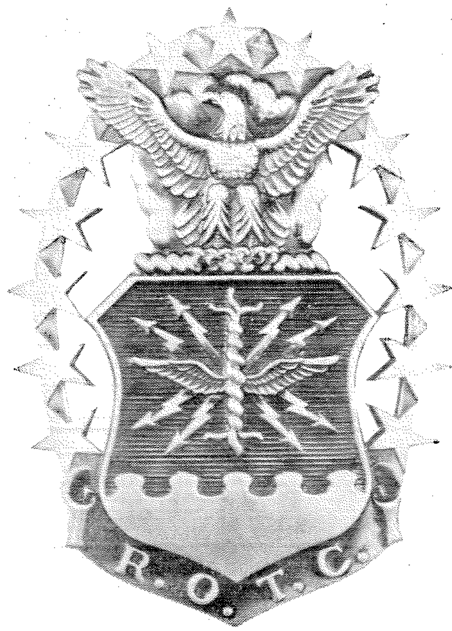
1956

DR. ALAN POISNER was married on July 15, 1962, to Roselle Burstein in New York. The Poisners are now in London, where Alan is working for a year at the National Institute for Medical Research.

1957

CHARLES H. ANDERSON has joined the research staff of RCA Laboratories at the David Sarnoff research Center in Princeton, New Jersey. Since June 1961 he has been on the staff of Harvard University as a research assistant and instructor in physics.

DOUGLAS G. RITCHIE is now a mechanical engineer at Wiancko Engineering in Pasadena. He is currently working on the design and testing of a DC-DC gas damped accelerometer capable of operating at cryogenic temperatures in a high nuclear radiation environment. He is also working on pressure transducer design for use in various space programs.



Missed A.F.R.O.T.C.?

Go A.F.O.T.S!

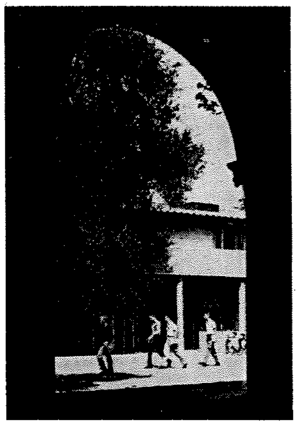
These letters stand for Air Force Officer Training School—a three-month course for those who realize they want to become Air Force officers, but don't have enough school time left to enroll in AFROTC.

We prefer our officers to start their training as freshmen, so we can commission them directly upon graduation. But right now we're accepting applications for another fine way to become an Air Force officer—OTS. We can't guarantee that this program will still be open a year or so from now.

As an Air Force officer, you'll be a leader on the Aerospace Team, serving your country while you get a flying headstart on the technology of the future. The U.S. Air Force sponsors one of the world's most advanced research and development programs—and you can be part of it.

If you're within 210 days of graduation, get more information on OTS from the Professor of Air Science.

U.S. Air Force



CALTECH CALENDAR

ALUMNI EVENTS

May 4 Annual Alumni Seminar

ATHLETIC SCHEDULE

Baseball

May 1
La Verne at Caltech

May 4
Pomona at Pomona

Swimming

May 1
All-Conference Prelim. & Frosh Diving at Caltech

May 2
All-Conference Diving at Caltech

May 3
All-Conference Finals at Caltech

Track

May 1
All-Conference Heats at Occidental

May 3
All-Conference Finals at Occidental

FRIDAY EVENING DEMONSTRATION LECTURES

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

May 3
Ferromagnetism in Ultra-thin Films
—Charles H. Wilts

May 10
International Student Exchange: Scholarship Opportunities
—Horace N. Gilbert

May 17
Nucleolus
—Max L. Birnstiel

May 24
Exploding Stars
—Robert P. Kraft

May 31
Stars in Their Courses
—Olin J. Eggen

ALUMNI ASSOCIATION OFFICERS

PRESIDENT
William L. Holladay, '24

SECRETARY
Donald S. Clark, '29

VICE-PRESIDENT
Peter V. H. Serrell, '36

TREASURER
John R. Fee, '51

BOARD OF DIRECTORS

Robert Boykin, '34
Patrick J. Fazio, '53
G. Russell Nance, '38
Richard W. Powell, '40
William H. Saylor, '32
William H. Simons, '49
Charles P. Strickland, '43

ALUMNI CHAPTER OFFICERS

NEW YORK CHAPTER

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

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

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

WASHINGTON, D. C. CHAPTER

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

Secretary Cmdr. Joseph B. Deodati, '46
7933 Deepwell Dr., Bethesda, Maryland

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.
University of California, Berkeley, Calif.

BOSTON CHAPTER

President Robert C. Kausen, '56
163 Oakley Rd., Belmont 78, Mass.

Vice-President Thomas C. Stockebrand, '53
10 Bulkely Rd., Littleton, Mass.

Secretary Alan L. Helgesson, '55
345 South Rd., Bedford, Mass.

Treasurer Charles K. Daniels, '59
8 Cutler Farm Rd., Lexington, Mass.

CHICAGO CHAPTER

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

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

SACRAMENTO CHAPTER

President Joe A. Dobrowolski, '49
P.O. Box 1952, Sacramento 9, Calif.

Vice-President Dudley A. Bennett, '47
4535 Marble Way, Carmichael, Calif.

Secretary-Treasurer Harris K. Mauzy, '30
2551 Carson Way
Sacramento 21, Calif.

SAN DIEGO CHAPTER

Chairman Maurice B. Ross, '24
3040 Udal Street

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

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

An interview with General Electric's W. Scott Hill

One of a series . . .

Manager—Engineering Recruiting

How to Make the Most of Your First Five Years

MR. HILL has managerial responsibility for General Electric's college recruiting activities for engineers, scientists, PhD's and technicians for the engineering function of the Company. Long active in technical personnel development within General Electric, he also serves as vice president of the Engineers' Council for Professional Development, board member of the Engineering Manpower Commission, director of the Engineering Societies Personnel Service and as an officer or member of a variety of technical societies.

Q. Mr. Hill, I've heard that my first five years in industry may be the most critical of my career. Do you agree?

A. Definitely. It is during this stage that you'll be sharpening your career objectives, broadening your knowledge and experience, finding your place in professional practice and developing work and study habits that you may follow throughout your career. It's a period fraught with challenge and opportunity—and possible pitfalls.

Recognizing the importance of this period, the Engineers' Council for Professional Development has published an excellent kit of material for young engineers. It is titled "Your First 5 Years." I would strongly recommend you obtain a copy.*

Q. What can I do to make best use of these important years?

A. First of all, be sure that the company you join provides ample opportunity for professional development during this critical phase of your career.

Then, develop a planned, organized personal development program—tailored to your own strengths, weaknesses and aspirations—to make the most of these opportunities. This, of course, calls for a critical self appraisal, and periodic reappraisals. You will find an extremely useful guide for this purpose in the "First 5 Years" kit I just mentioned.

Q. How does General Electric encourage self development during this period?

A. In many ways. Because we recognize professional self-development as a never-ending process, we encourage technical employees to continue their education not only during their early years but throughout their careers.

We do this through a variety of programs and incentives. General Electric's Tuition Refund Program, for example, provides up to 100% reimbursement for tuition and fees incurred for graduate study. Another enables the selected graduate with proper qualifications to obtain a master's degree, tuition free, while earning up to 75% of his full-time salary. These programs are supplemented by a wide range of technical and nontechnical in-plant courses conducted at the graduate level by recognized Company experts.

Frequent personal appraisals and encouragement for participation in professional societies are still other ways in which G.E. assists professional employees to develop their full potential.

Q. What about training programs? Just how valuable are they to the young engineer?

A. Quite valuable, generally. But there are exceptions. Many seniors and graduate students, for example, already have clearly defined career goals and professional interests and demonstrated abilities in a specific field. In such cases, direct placement in a specific position may be the better alternative.

Training programs, on the other hand, provide the opportunity to gain valuable on-the-job experience in several fields while broadening your base of knowledge through related course study. This kind of training enables you to bring your career objectives into sharp focus and provides a solid foundation for your development, whether your interests tend toward specialization or management. This is particularly true in a highly diversified company like General Electric where young technical graduates are exposed to many facets of engineering and to a variety of product areas.

Q. What types of training programs does your company offer, Mr. Hill?

A. General Electric conducts a number of them. Those attracting the majority of technical graduates are the Engineering and Science, Technical Marketing and Manufacturing Training Programs. Each includes on-the-job experience on full-time rotating assignments supplemented by a formal study curriculum.

Q. You mentioned professional societies. Do you feel there is any advantage in joining early in your career?

A. I do indeed. In fact, I would recommend you join a student chapter on your campus now if you haven't already done so.

Professional societies offer the young engineer many opportunities to expand his fund of knowledge through association with leaders in his profession, to gain recognition in his field, and to make a real contribution to his profession. Because General Electric benefits directly, the Company often helps defray expenses incurred by professional employees engaged in the activities of these organizations.

Q. Is there anything I can do now to better prepare myself for the transition from college campus to industry?

A. There are many things, naturally, most of which you are already doing in the course of your education.

But there is one important area you may be overlooking. I would suggest you recognize now that your job—whatever it is—is going to be made easier by the ability to communicate . . . effectively. Learn to sell yourself and your ideas. Our own experience at General Electric—and industry-wide surveys as well—indicates that the lack of this ability can be one of the major shortcomings of young technical graduates.

******The kit "Your First 5 Years," published by the Engineers' Council for Professional Development, normally sells for $2.00. While our limited supply lasts, however, you may obtain a copy by simply writing General Electric Company, Section 699-04, Schenectady, New York.*

(An equal opportunity employer.)

Progress Is Our Most Important Product

GENERAL ELECTRIC