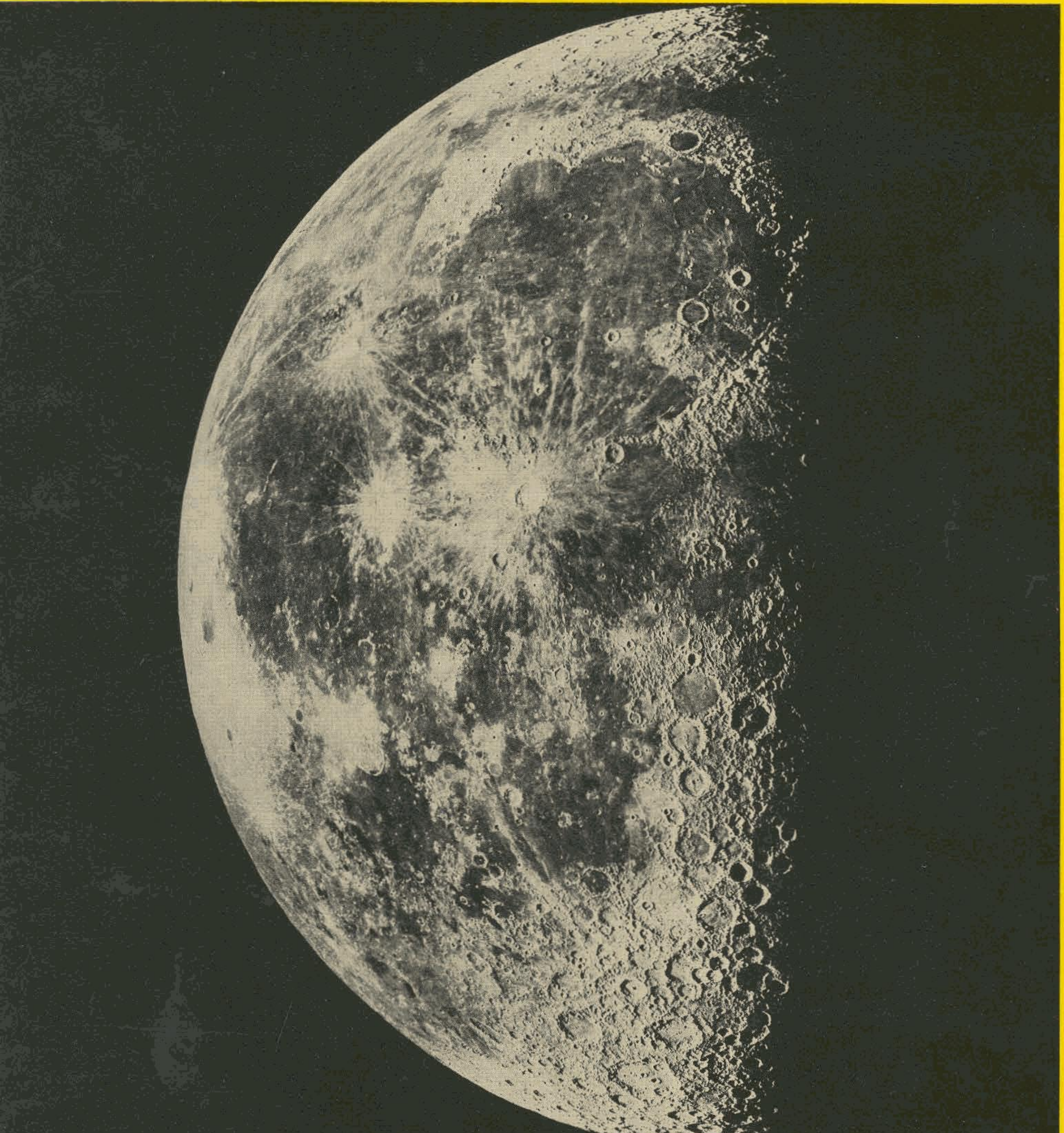
ENGINEERING | AND | SCIENCE

June 1960

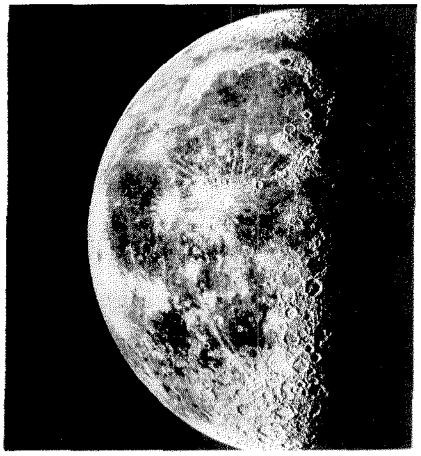


A new look at the moon . . . page 7

Published at the California Institute of Technology

ENGINEERING | AND | SCIENCE

JUNE 1960 *VOLUME XXIII* *NUMBER 9*



On Our Cover

is a composite photograph of the moon, made up of several pictures taken with the 100-inch telescope on Mount Wilson showing the moon at last quarter. In his article on page 7, "A New Look at the Moon," Albert R. Hibbs, chief of the Space Scientists Division at Caltech's Jet Propulsion Laboratory and an alumnus of Caltech, discusses what we now know about the moon from studies of some amazing pictures taken with the Mount Wilson and Palomar telescopes.

Donald E. Hudson,

professor of mechanical engineering at Caltech, is the author of "Hunting Big Earthquakes in India" on page 16. In September 1958, he took a leave of absence to spend six months at the University of Roorkee to help set up the Earthquake Engineering School there. As part of a cooperative research program between Caltech's Earthquake Engineering Research Laboratory and Roorkee, he also shared earthquake research information with practicing engineers in India.

Since India is a land of big earthquakes, it was the ideal place to set up some of the unique strong-motion earthquake recorders designed at Caltech in cooperation with the U.S. Coast and Geodetic Survey. Records of future Himalayan earthquakes made with these small instruments should interest structural engineers all over the world.

Photo Credits:

Cover, pps 8-11 – Mount Wilson and Palomar Observatories
pps 13-15 – J. W. McClanahan

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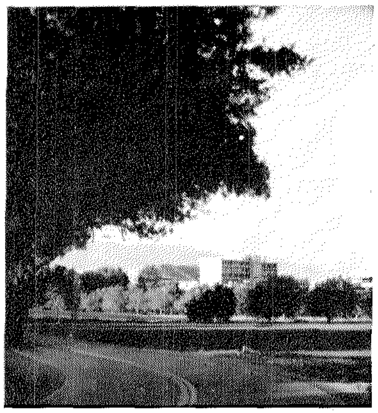
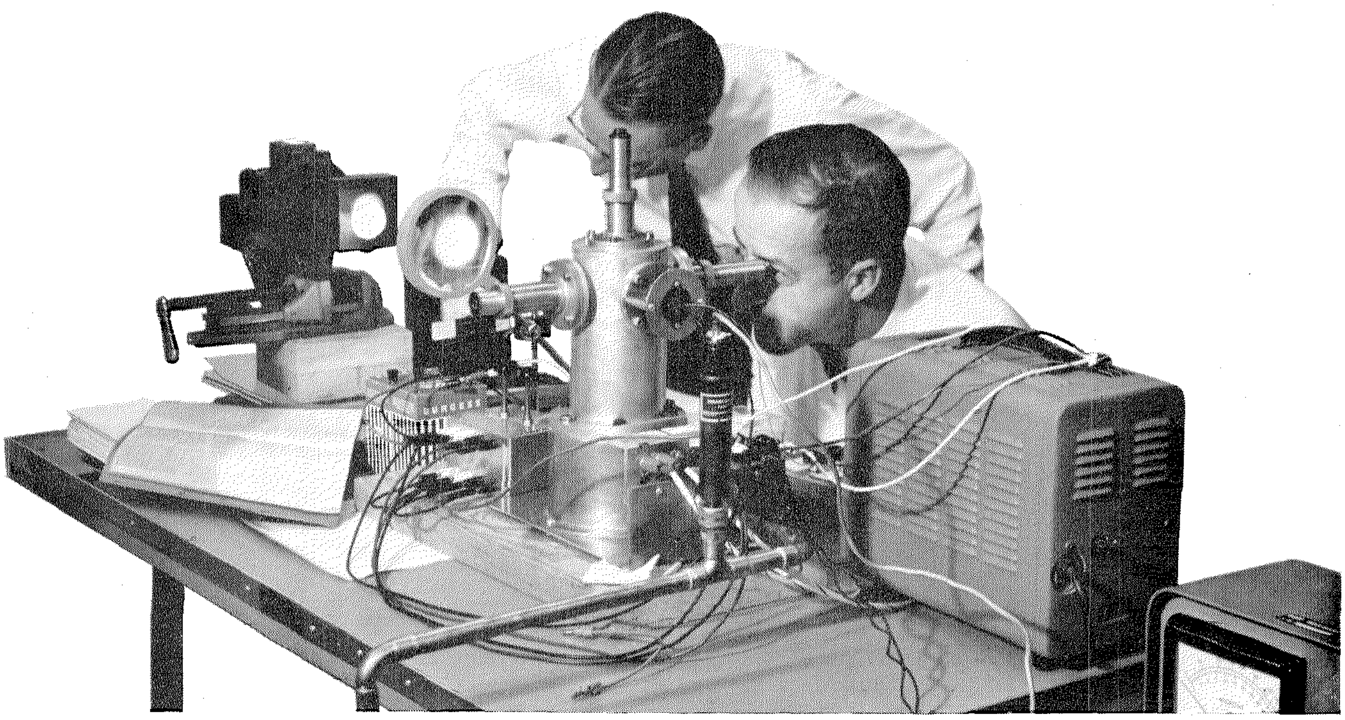
Published monthly, October through June, at the California Institute of Technology, 1201 East California St., Pasadena, Calif. Annual subscription $4.50 domestic, $5.50 foreign, single copies 50 cents. Second class postage paid at Pasadena, California. Manuscripts and all other editorial correspondence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





An electron device permits scientists to study the behavior of charged dust particles held in suspension.

Gilbert Lewis...on practical aims

"The scientist is a practical man and his are practical aims. He does not seek the *ultimate* but the *proximate*. He does not speak of the last analysis but rather of the next approximation. His are not those beautiful structures so delicately designed that a single flaw may cause the collapse of the whole. The scientist builds slowly and with a gross but solid kind of masonry. If dissatisfied with any of his work, even if it be near the very foundations, he can replace that part without damage to the remainder. On the whole, he is satisfied with his work, for while science may never be wholly right it certainly is never wholly wrong; and it seems to be improving from decade to decade.

"The theory that there is an ultimate truth, although very generally held by mankind, does not seem useful to science except in the sense of a horizon toward which we may proceed, rather than a point which may be reached."—*The Anatomy of Science, 1926.*

ENGINEERING AND SCIENCE
June 1960, Volume XXIII, No. 9

A New Look at the Moon

by Albert R. Hibbs

Galileo did not invent the telescope.

This may come as no surprise to you, dear reader, but it did to me. In gathering information for this article, I was checking the date on which Galileo (I thought) invented the telescope. I discovered he did not invent it at all. Instead, someone in Beligum or someone in Holland (the records are not very conclusive) was the first to discover that, if you held one lens in front of another and then looked through them both, distant objects would appear closer.

This happened in the very early 1600's. In the year 1609, Galileo, visiting Venice, heard of this discovery. On his return home he tried it for himself.

Galileo then developed his Galilean telescope and used it to observe the planets. He discovered that the planet Venus, when viewed from the earth, changes phase in a manner that could only be understood if the sun were the center of the solar system.

Twenty years later, on the basis of the observations he had made with the telescope, as well as arguments similar to those first presented by Copernicus, Galileo wrote his "Dialogues Concerning the Two Chief World Systems." The two systems discussed in this dialogue were the Copernican and the Ptolemaic systems, the first of which had the sun as the center of the solar system and the second of which put the earth in this special position.

For writing this dialogue, Galileo was sentenced to prison for the rest of his life. His arguments ran contrary to the metaphysical doctrines of the Church.

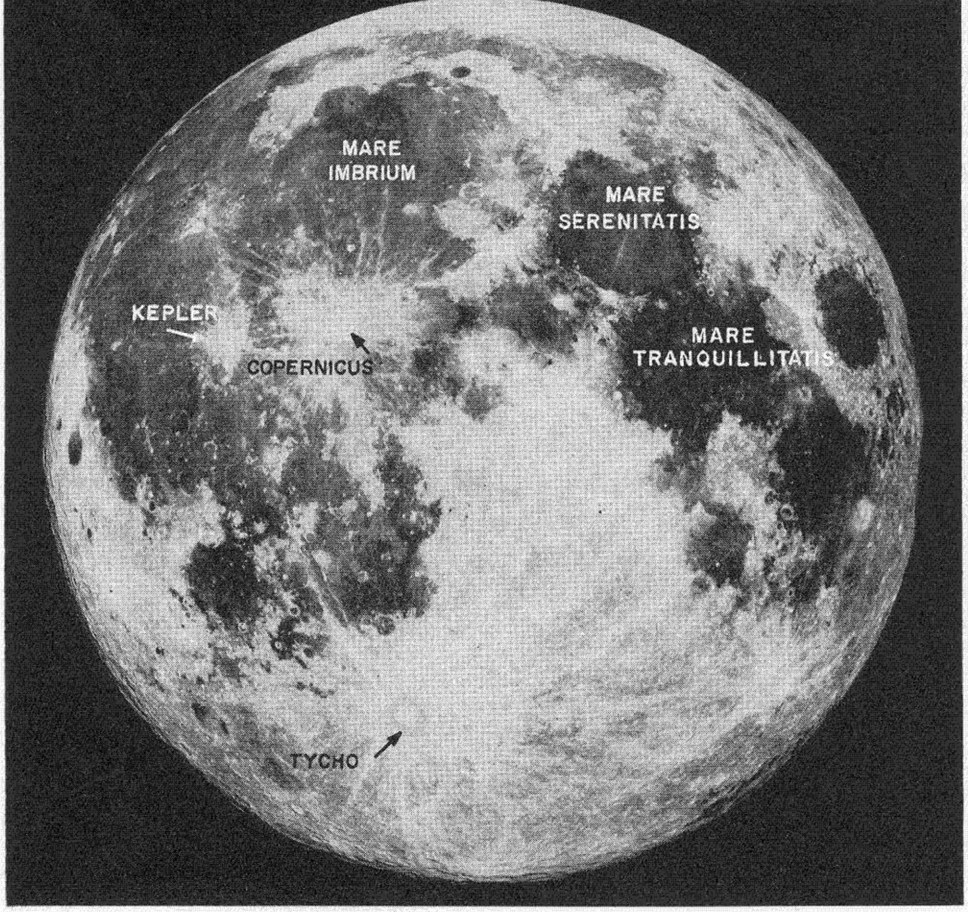
In the translation of this dialogue by Stillman Drake, Galileo described his observations of the moon as follows:

> "The prominences there are mainly very similar to our most rugged and steepest mountains, and some of them are seen to 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 (I shall use this word because no more descriptive one occurs to me), 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 rather 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."

A little more than 300 years later, the 14th edition of the *Encyclopaedia Britannica* describes the surface of the moon as follows:

> "The most striking formations on the moon are the craters, which are of all sizes up to a hundred miles or more in diameter and are scattered over the surface with a great profusion, frequently overlapping. These craters in appearance closely resemble the volcanic craters on earth, and it is possible that they may have a similar origin. They have, however, often so large a diameter compared with height that the analogy may not be so close as it first appears. A typical crater has a surrounding ring rising to anything up to 20,000 feet above the general level. The floor of the crater may be higher or lower than the outside level. Often, there may be a central peak or peaks within the crater. The darker areas which are not so much covered by craters have been considered to be seas of lava which have spread over the moon's surface at a later date than that of the formation of most of the craters."

As you can see, there is very little difference in the



The full moon. The craters (Tycho, Copernicus and Kepler) are surrounded by rays, probably resulting from explosive impacts of meteorites.

two descriptions, which is not surprising, since neither the moon nor our observational techniques have changed much during the intervening 300 years. We are still as far away from the moon as Galileo was. The one outstanding difference in the two descriptions is that the *Encylopaedia Britannica* indulges in a little speculation, whereas Galileo restricted himself to the things he could see.

In between Galileo and the 14th edition of the *Encylopaedia Britannica*, the geologist, G. K. Gilbert, delivered an outstanding paper at an 1893 meeting of the Philosophical Society of Washington, D.C. On the basis of excellent arguments, Gilbert concluded that the features of the surface of the moon have resulted principally from collisions of objects with the surface. Even the maria, he reasoned, are the result of such collisions, and, in fact, Gilbert believed that there were no volcanoes at all on the moon.

Gilbert based his conclusions not only on his extensive experience as a geologist but also on a lengthy series of observations of the moon at the Naval Observatory in Washington which he undertook a year before his paper was presented.

He was in Washington on a mission that is familiar to many of us. Gilbert at this time was Chief Geologist of the National Survey. During 1892, Congress was cutting back funds of the Survey, and Gilbert was supposedly lobbying for more money. (In the annals of the Survey, this time period is recorded as "The Disaster," when half of the personnel was laid off.) Nevertheless, Gilbert found time to spend many nights at the Observatory, looking at the moon.

Gilbert wrote to a friend on this occasion, "I am a little daft on the subject of the Moon, being troubled by a new idea as to its craters, and I have haunted the Observatory for three evenings in which I have netted but one hour of observation. Clouds and congressmen are about equally obstructive."

The congressmen, on their part, were not silent. During debate in the House of Representatives, one of them said, "So useless has the Survey become that one of its most distinguished members has no better way to employ his time than to sit up all night gaping at the moon."

From Gilbert's "gaping" came what remains to this day one of the most impressive discussions of the lunar surface features and their origins. Gilbert's idea that almost all of the craters are due to meteor impacts is now generally accepted, although the mechanism he suggested for this process does not appear to be equally valid. He suggested that the earth was surrounded by a ring of moonlets, just as Saturn is surrounded by a ring of rocks. These moonlets were supposed to have crashed into the moon one by one as variations in their orbits brought them near the moon. This would have resulted in a preponderance of craters near the lunar equator, which of course is not the case.

Gilbert felt that the moonlet theory was necessary to explain the fact that most craters appeared circular. He reasoned that meteorites striking the moon from random directions — not necessarily vertically — would often leave oval-shaped craters. Thus, he suggested moonlets in orbits around the earth, which would approach the moon at relatively slow speeds and then be drawn to the moon's surface by the moon's gravity, striking it nearly vertically.

Nowadays we do not feel that Gilbert needed to have gone to all of this trouble. A body impacting at high speed does not scoop out a trench, but simply explodes. The resulting depression will be a circular crater centered at the point of impact, regardless of the angle of flight of the impacting body.

After Gilbert's paper appeared in print, it was remarked that the majority of astronomers explained the craters of the moon by volcanic eruption — that is, by an essentially geological process; whereas a considerable number of geologists are inclined to explain them as an impact of falling bodies upon the moon — that is, by an essentially astronomical process.

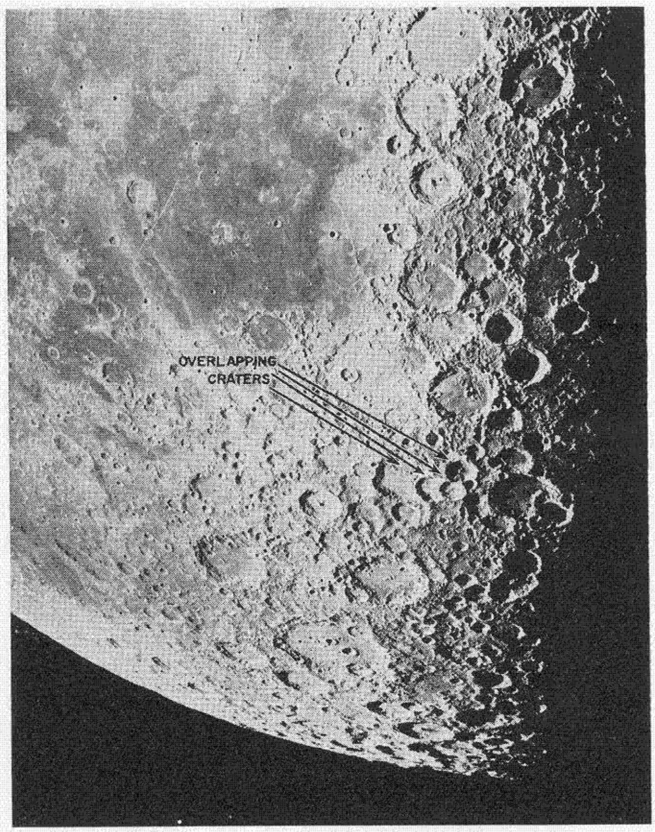
The full moon (opposite page) displays some of the signs which led Gilbert to conclude that the craters were the results of impacts. Although the topography is not apparent in the flat lighting of the full moon, the rays around many of the craters stand out quite sharply. For example, the long rays of Tycho (the crater in the southern hemisphere which looks like the navel on a navel orange) radiate out from it to a great distance, apparently going all the way to the invisible hemisphere. Perhaps when we get a *good* picture of the back side of the moon we will see the rays of Tycho stretching across it. Looking at the crater Copernicus, north of the equator, toward the west, you can almost hear the "splat" of the crashing meteorite.

The craters are named after astronomers and philosophers of the Renaissance and before — Tycho, Copernicus, Kepler, Eratosthenes, Aristotle, Ptolemy, and so on. The large dark areas are called "seas" or "oceans," and some of them are called "bays." Latin names are used, such as Mare Serenitatis, Mare Tranquillitatis, Mare Imbrium.

The rumor that the watery nomenclature of the moon's surface was introduced by an ambitious admiral anxious to establish a roles-and-mission position for the U.S. Navy's space program is absolutely untrue. These names were given hundreds of years ago, when early astronomers thought that perhaps the moon might actually have water on its surface.

Today, on the basis of careful observations (for example, when the moon passes in front of a star, we measure how rapidly the starlight is dimmed by any lunar "atmosphere") we have determined that not only does the moon possess no water but that it has no appreciable atmosphere. In fact, the atmosphere of the moon is a better vacuum than any we can produce in most of our laboratories.

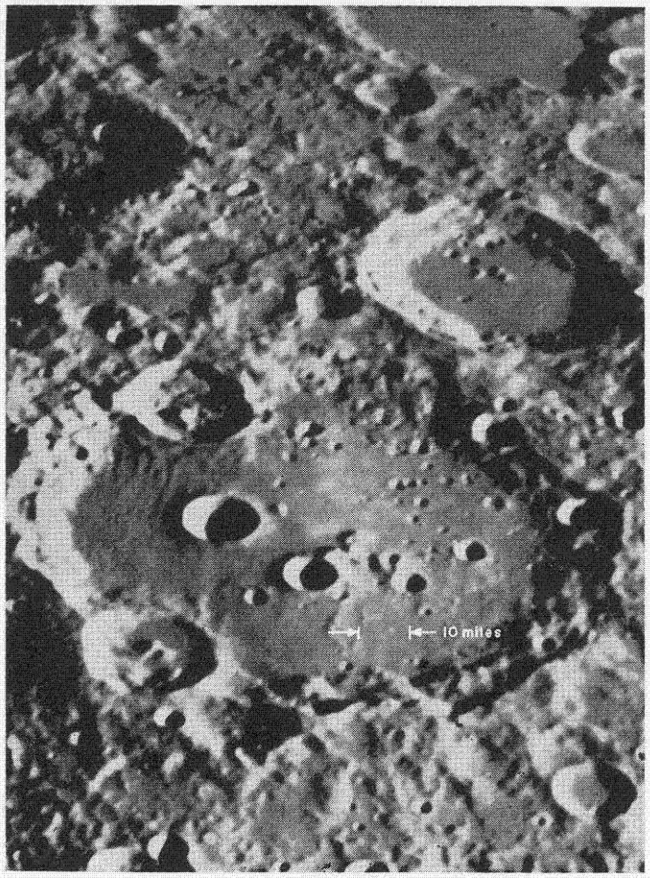
The absence of a lunar atmosphere is important in determining the objectives of lunar exploration. The formation process of the solar system must have ended billions of years ago. The planets and all their satellites, including the earth's satellite, the moon, were probably built up by the accumulation of smaller hunks of rock. Today, very few of these original hunks of rock are left. But still, a meteorite occasionally comes into the atmosphere — and on even rarer occasions a meteorite comes in that is big enough to reach the surface of the earth and to be picked up. Very infrequently — maybe once every hundred thousand years — a meteorite hits the earth that is big enough to make a crater almost a mile across, such as the one near Winslow, Arizona. But most of the bombardment was over billions of years ago.



The southern portion of the moon during the last quarter. The rugged appearance of the craters is accentuated by the shadow detail near the sunset line — or terminator. Many series of overlapping craters can be picked out. The relative overlap is a measure of relative age.

After the formative bombardment ceased, the mountain-building processes on the earth, aided and encouraged by the erosion due to the earth's watery atmosphere, has so continuously changed the appearance of the earth's surface that no record of its early formation persists. But on the moon the record remains. It is very likely that the surface of the moon will show us the history of the solar system's formation.

In the photograph above we get a closer look at the southern portion of the moon. Sunset is approaching along the right-hand edge, and near the shadow line (the "terminator") the topography of the moon stands out clearly. Numerous craters are visible in the southern region. In fact, close inspection shows that the surface is covered with them, one on top of the other. This region is called the "highlands" to



The crater Clavius, whose walls have apparently been eroded from their original rugged shape and whose central section is filled with the debris from this erosion process. This central plain is marked with the impacts of later meteorites.

differentiate it from the smoother, dark plains called the "seas."

A little more than halfway down the terminator you can see a series of four overlapping craters extending from the terminator off to the west. The overlap indicates the relative ages of the various craters. The newer crater cuts into the walls of the older crater. At least, this seems a sensible way to distinguish relative ages of craters. Fortunately, nowhere on the moon do we find a ring of craters with each one overlapping the one in front of it, like a ring of elephants each holding onto the other's tail. Such a situation would defeat the logic of the relative age idea.

A close look at these craters reveals one interesting detail. The older craters appear to have the least rugged walls. Ruggedness seems to be a characteristic of young craters. Other examples can be found in this area and other areas of the moon, showing this same relationship. Some craters can be found whose walls are almost nonexistent, as if they had been worn away to almost nothing. These worn-down craters are in most cases filled with some sort of smooth material in their central section, whereas the newer rugged craters are often found to have an extremely rugged central section with a central peak.

Certainly, there is a very strong suggestion that some sort of erosion process has been operating on the moon, gradually changing the appearance of the surface markings. This process must be quite different from the erosion we are familiar with on the earth.

Professor Thomas Gold, now at Cornell University, has suggested one possibility for such an erosion process. He points out that several processes are available for the creation of dust and the wearing away of the rock's surface, such as the impact of meteorites and dust particles (micrometeorites), high-energy solar radiation (which never reaches the surface of the earth, since it is absorbed in the earth's atmosphere), and violent temperature changes between the lunar night and day. What is required is a process to move the dust from the peaks and sides of the crater rims to the flat areas at lower altitudes.

Professor Gold suggests that high-energy solar radiation can electrostatically charge small areas of the lunar surface. In particular, particles of dust will acquire charge and be electrostatically repelled from the surface. They will hop about with a greater tendency to hop downhill than uphill. This process may seem slow compared with the processes of wind or water erosion on the earth. Surely, a hopping dust particle would take a long time to travel 100 or 200 kilometers from a crater in the highlands to one of the maria. However, these particles on the moon have had five billion years to hop. So they could have travelled quite a distance.

Professor Gold has reported that some preliminary experiments carried out in a vacuum chamber with dust particles illuminated by ultraviolet light have shown that such a process actually does occur.

On the basis of these arguments, he suggests that the maria, as well as the centers of many of the old craters, are not filled with lava, but rather with dust. He computes the thickness of the layer of dust which must have formed in the maria by estimating the total amount of rock which has been removed from all of the old worn-down crater walls in the highlands. On this basis, he reaches a number of one kilometer for the maximum dust depth – that is, a little over one-half mile.

It should be pointed out that, although this material may have been dust at some time in its past history as it was moving from a higher spot to a lower spot, once it has settled in its final resting place it probably does not behave very much like the dust we are familiar with on earth. After all, our intuitive experience with dust is gained in an environment where the dust is mixed with air. "Dustiness" is more a property of the air lubrication between particles than it is of the particles themselves. In a vacuum, dust tends to become hard packed. Thus, we can imagine that any deep dust layer on the moon would have the physical properties resembling pumice more than the pile of dust we are familiar with on earth.

Unfortunately, it is not possible to resolve the controversies on the nature of the lunar surface – the controversies between volcanoes and impacts or between lava and dust – by looking through our largest telescopes. The photograph on the opposite page was taken with the 200-inch telescope at Palomar at high magnification. The smallest detail that can be seen in this picture (one of the small crater pits inside the large crater Clavius) is almost a mile across. Details smaller than that are simply unresolved.

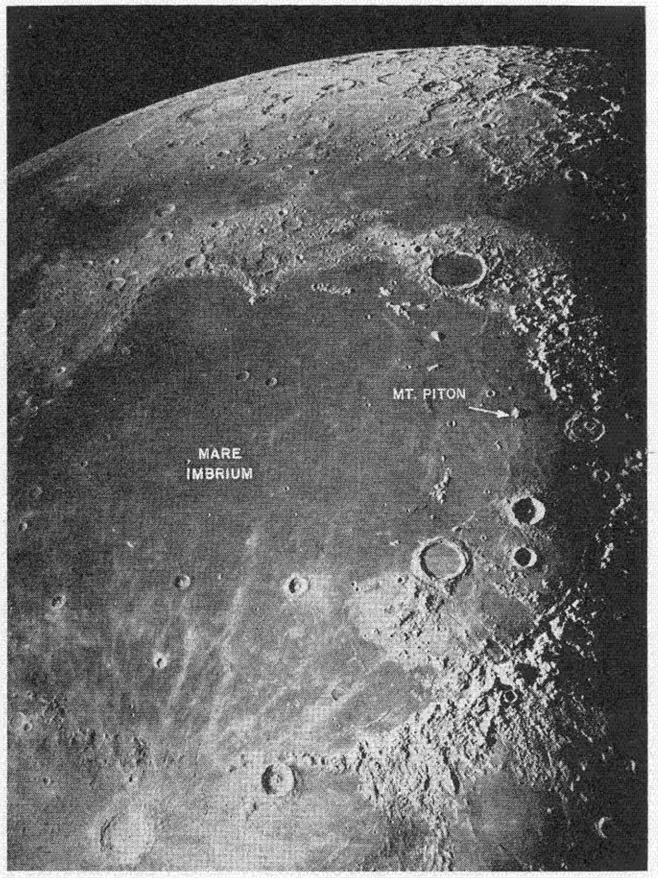
The material filling the crater Clavius might be as smooth as it appears, or it might be composed of rocks 100 or so feet in diameter. Looking out from under our blanket of atmosphere here on the surface of earth, we cannot tell the difference. The turbulence of the atmosphere through which we look – the turbulence that makes the stars twinkle so beautifully – unfortunately makes the details of the moon twinkle also. In this twinkling, the resolution is lost.

As a matter of fact, better pictures can often be obtained with a telescope of much smaller diameter. A telescope of 30- to 40-inches diameter is often considered better for lunar photography than one of 100 inches or more. The diameter of a telescope does not affect its power to magnify, but rather its power to gather light, its power to see farther out into the universe to the far-distant, faint objects. On an astronomical scale, the moon is neither far nor faint.

The photograph at the right shows the Mare Imbrium – the right eye of the face of the Man in the Moon – as the sun is beginning to set on its eastern edge. This is one of the level plains which Gold supposes is filled up with dust. Standing out of the plain near the shadow line is a peak that appears as jagged as a hound's tooth – Mt. Piton. This is one of the prominences which Galileo described as "very similar to our most rugged and steepest mountains." Literally, how rugged and how steep is Mt. Piton? It is possible to measure heights on the moon with surprising accuracy. Relative heights of 50 to 100 feet can be determined with a technique known to the ancient Egyptians – the measuring of shadow lengths. When an object stands out against a flat surface, the length of the shadow it casts is proportional to its height. If we know the angle of the sun to the surface, we can determine height.

For a peak such as Mt. Piton standing out of a nearly level plain, this technique is well applicable.

Over the last few months, Professor Zdenek Kopal, at Manchester, England, working in cooperation with astronomers at Pic du Midi in France, has applied this method systematically to many craters and mountains on the moon's surface. In particular, he made a rough contour map which shows how Mt. Piton would look to a moon explorer standing on the surface a few miles from its base. It is a high but gentle hill rising to about 7000 feet, and stretching out more than 70,000 feet (about 13 miles). The top is so nearly level that it would be difficult to choose the highest



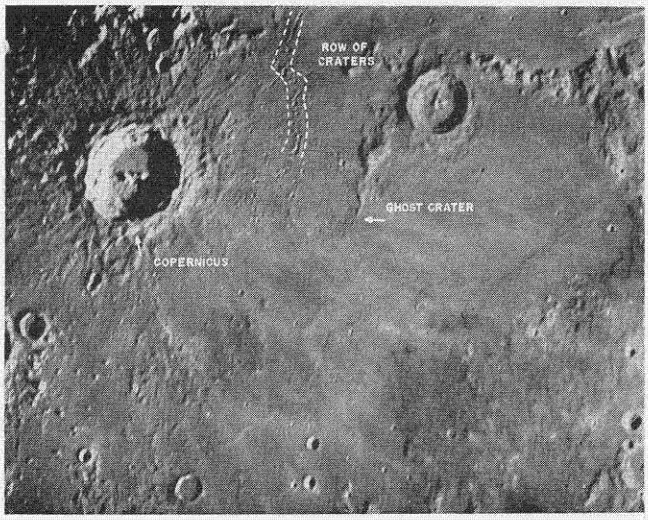
The Mare Imbrium, with sunset on its eastern edge. Near the sunset line, Mt. Piton stands out as a jagged peak, casting a long shadow to the east.

point. Certainly, from this point of view it looks quite different from the rugged mountain it appears to be in the photograph above.

Although the moon appears to be bright when we look at it in the dark, star-studded sky, it is actually made of rather dark rock. It reflects less than one-tenth of the light which it receives from the sun. The earth, on the other hand, with its clouds and oceans, reflects almost four-tenths of the light it receives. Thus, a space traveler flying away from the earth-moon system and looking back at them out of his porthole would see the earth as a much more brilliant object than the moon.

The dark color is almost the only thing we know about the surface rock of the moon. We know the average density of the moon, since we can measure both its diameter and its mass (the mass measurement comes from a measurement of the effect of the moon's gravity on the motion of the earth). The average density of the moon is less than that of the earth and is similar to the density of the crustal rock of the earth. Thus, we might guess that the moon lacks the comparatively large fraction of iron which we believe makes up the core of the earth and accounts for its greater density.

Unfortunately, we cannot make any unambiguous deductions about the lunar material from the density



The crater Copernicus and its smaller neighbor Aristosthenes, taken with the 200-inch telescope. To the right of Copernicus lies a group of small craters running almost in a straight line.

measurement alone. Not only are granite and basalt on the earth's crust similar in density to that of the moon, but the stony meteorites also have this same general density. One of the most important measurements which we can make in the early stages of lunar exploration will be a measurement to determine the chemical nature of the crustal rock.

We know even less about the interior of the moon than we do about the surface. Of course, this fact is true of the earth also, so it comes as no surprise. However, there are some features of the surface which allow us to make a few deductions about the nature of its interior. For example, there are no "strike-slip faults" visible on the moon. These are the faults of earthquakes where the slippage of the earth is horizontal rather than vertical. The San Andreas fault – responsible for the great San Francisco earthquake and for numerous shocks since – is such a fault on earth. Over many millions of years, the horizontal displacement can build up to several miles, perhaps hundreds of miles.

On the surface of the moon there are so many linear and circular features that we should easily see evidence of such a fault, and yet no such evidence exists on any portion of the visible face of the moon.

Although horizontal motion has apparently not occurred, some geologists feel that vertical faults are present on the moon. Along the eastern edge of Mare Imbrium, for example, a chain of mountains cut by several valleys radiates outwards generally from the center of the Mare. These valleys may be the result of vertical sliding.

A close-up (above) of the crater Copernicus, taken with the 200-inch telescope, shows another feature commonly held up as evidence for faulting and perhaps even volcanism sometime in the moon's past. To the right and above the crater there is a curved line of several small crater pits in a row. It is hard to imagine that these craters could have been the results of random impacts of meteorites striking the surface. Random impacts just would not line up so neatly. Instead, it is suggested that a crack was opened here on the moon's surface (perhaps by the impact which caused the crater Copernicus) and volcanic gases trapped beneath the surface bubbled out through this crack. The crater pits remaining are the result of these bubbling gas streams.

Another peculiar feature shows up in this photograph. Just below the row of craters is a faint circular mark – a "ghost" crater. Gold, in his study of lunar surface erosion has pointed out several examples of such ghost craters which he believes have been covered up to the brim with the dusty debris from higher regions on the moon's surface.

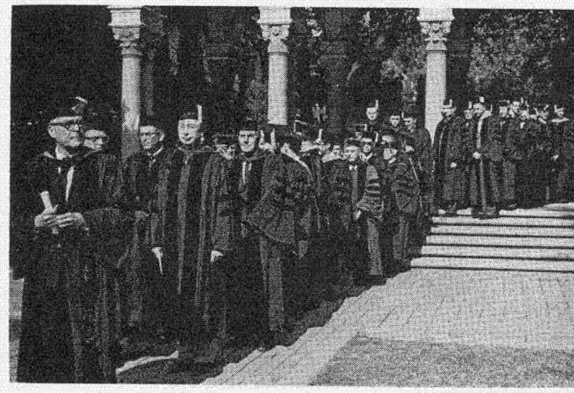
The question of faulting on the moon's surface – either vertical or horizontal – is closely related to the question of the moon's temperature history. If the moon was at one time quite hot and has since cooled then we would expect that the interior is shrinking and the crustal surface must wrinkle to accommodate the shrinking interior. This would result in the strike-slip faults which are remarkable by their absence. This appears to imply that the moon has not undergone any significant cooling since the formation of its surface.

If, on the other hand, the moon is steadily heating up, then the interior is expanding and the surface is stretching to accommodate it. This would result in vertical faults as chunks of the surface fall into the cracks left by the stretching skin. Perhaps this is what has happened. But, if so, then we can argue towards another conclusion. If large pools of lava were available below the surface at some time in the past – available for release by the impact of large meteorites, as is suggested by the lava school of thought – then these pools of lava must be available today, because the moon has not been cooling. Here, again, we are led to an important measurement for the early lunar exploration program – the temperature gradient of the moon's surface.

Coming up – a really new look

Today, our new look at the moon has little more visual evidence than that which was available to Galileo 350 years ago. Perhaps our increased knowledge of geophysics has made some of this visual evidence more understandable to us, but for many of the controversies and uncertainties we must wait until our instruments land on the surface for a *really* new look at the moon.

Now we can hope that the wait will be a short one. We can hope that in less than one percent of the time between Galileo and now we will have solved many of these ancient mysteries – and very likely will open up twice as many new ones.



The Month at Caltech

Commencement

At Caltech's 66th annual commencement on June 10, a total of 352 students received degrees – 145 Bachelors of Science, 134 Masters of Science, 65 Doctors of Philosophy, and 8 Engineers. A total of 42 students graduated with honor.

The Frederic W. Hinrichs, Jr., Memorial Award for the year's most outstanding senior went to Leroy E. Hood.

The commencement address was delivered by Barnaby C. Keeney, president of Brown University in Providence, Rhode Island. Dr. Keeney, a graduate of the University of North Carolina, received his MS in 1937 and his PhD in 1939 from Harvard University. He served as an instructor of history at Harvard until he entered the Army in 1942. In 1946 he became assistant professor of history at Brown. He was appointed Dean of the College in 1953, and president in 1955.

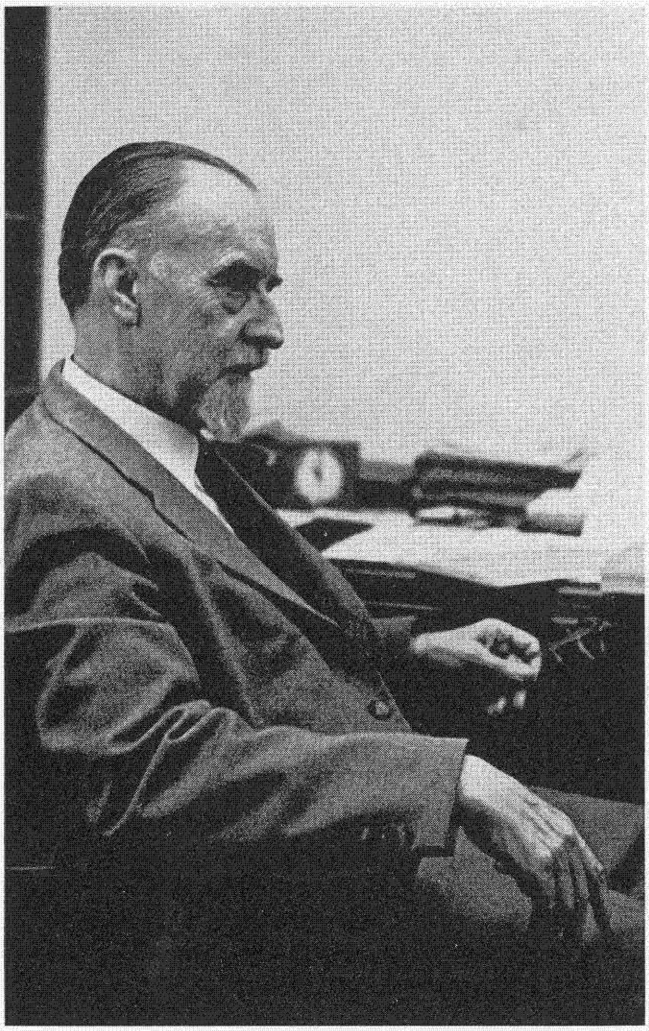
Retirement

Retiring this month: R. R. Martel, Caltech professor of structural engineering; and Rudolph L. Minkowski, staff member of the Mount Wilson and Palomar Observatories.

Romeo R. Martel has been a member of the Caltech faculty for 42 years. A native of Iberville, Quebec, Dr. Martel graduated from Brown University in 1912. He taught civil engineering for a year at Rhode Island State College, then at Mechanics Institute in Rochester, New York, for another year. In 1918 he was working for the Atchison Topeka and Santa Fe Railroad in Amarillo, Texas, when he was asked to teach at Caltech.

In 1921 Dr. Martel served as a consultant on the construction of Pasadena's San Rafael bridge. He went on to be consultant on bridges for the cities of Pasadena and Glendale, the State of California, the Southern Fuel Company, and the Southern Counties Gas Company.

He has been consultant for the design of flood control structures and reservoirs for the U.S. Army Engineers in Los Angeles, and for the cities of Glendale, Burbank, and Riverside. He has served on the Advisory Committee of Engineering Seismology since 1947. In 1952 the 13 original members of the committee set up the independent, non-profit Earthquake



R. R. Martel, professor of structural engineering.

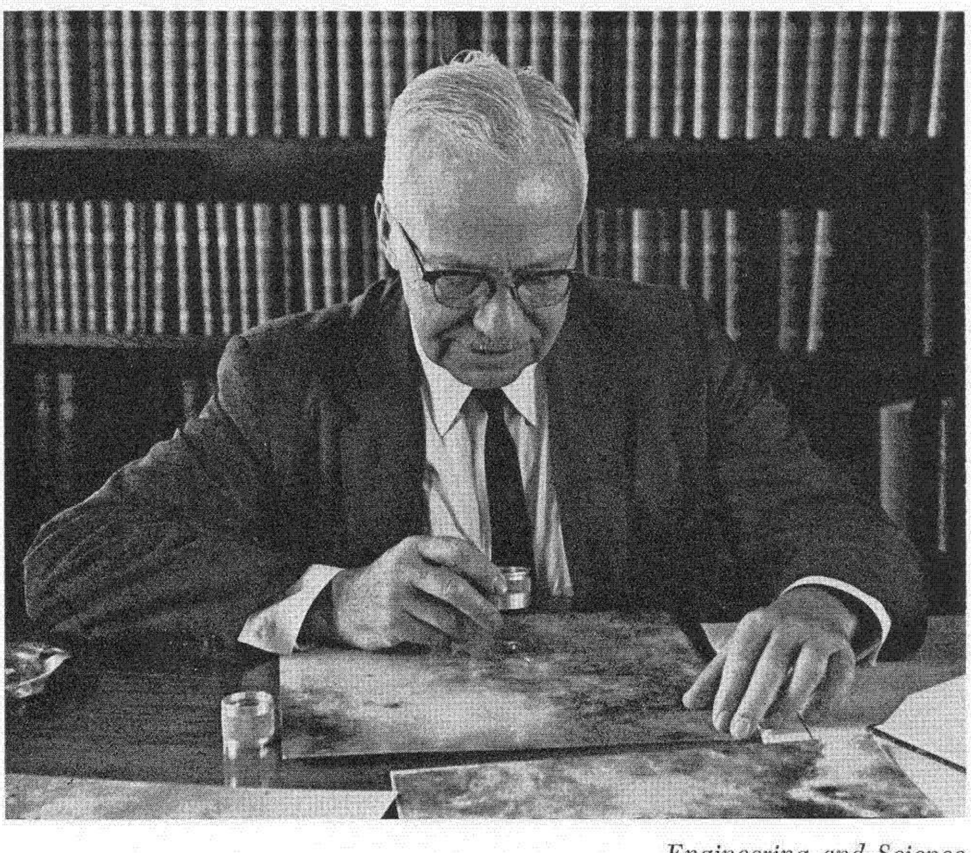
Engineering Research Institute which promotes research with the specific objectives of developing safe and economically feasible methods of earthquake construction and design. Dr. Martel is also a life member of the American Society of Civil Engineers.

Rudolph L. Minkowski has been a staff member of the Mount Wilson and Palomar Observatories for 25 years. On the eve of his retirement Dr. Minkowski has made one of the greatest discoveries of his career. Using Palomar's 200-inch Hale telescope, he has photographed a celestial object that is about six billion light years away – the most distant object ever identified.

The new find is exciting to astronomers because it may have an important impact on current cosmological theory. The object is a galaxy, or a pair of galaxies in collision, and it is receding from the earth at nearly half the speed of light. The rate of recession (90,000 miles a second) is the fastest ever measured.

The speed is determined by photographing a spectrum of the object – a significant scientific accomplishment in itself, since it is immensely difficult to obtain spectra at such a distance because of the night sky's own spectrum which veils spectra of faint, distant objects.

The discovery was made through Dr. Minkowski's skilled use of the telescope, and through radio signals pinpointed by astronomers at the Caltech Radio Observatory in Owens Valley.



Rudolph L. Minkowski, staff member of the Mount Wilson and Palomar Observatories.

How to Raise $1,000,000

At the annual meeting of the Caltech Alumni Association, held in Los Angeles on June 8, Frank Bumb '51, retiring president of the Alumni Association, and chairman of the Alumni Steering Committee for the Caltech Development Program, announced that the alumni phase of the Development Program had just passed its goal of $1,000,000.

"Enthusiastic response was received to a last minute letter," he said, "indicating that less than $9,000 remained to reach the $1,000,000 alumni goal. A shower of good wishes, pledges, and additional contributions – more than enough to reach and exceed the goal – were received. More than $1,005,400 has now been recorded from 3,575 alumni.

"For the past 28 months Caltech alumni everywhere have looked forward to the day when just such an announcement would be made. Those who had a part in this remarkable achievement should be justly proud of their combined accomplishment."

The campaign gets underway

When their $1,000,000 goal was first established, at the start of the Institute's $16,000,000 Development Campaign, the alumni set up a steering committee, headed by Simon Ramo, PhD '36, executive vice president of Thompson Ramo Wooldridge, Inc. Officers of the Alumni Association served as Dr. Ramo's committee, and this group was responsible for the overall planning of the alumni campaign.

A full-time staff was also necessary to carry out the plans of the Steering Committee, and to help stimulate and advise regional committeemen and prospective donors.

A geographical breakdown of Caltech alumni revealed that there were 33 groups of alumni throughout the United States, each containing at least 30 men. These were called divisions. Chairmen were enlisted for each division, and each chairman formed his own steering committee, with one member of each committee responsible for a particular phase of the program.

The advance gift phase was one of the most important in the program, and division chairmen and the committee responsible for the recruitment of workers began calling on alumni to help solicit those alumni who might be able to make larger than average gifts.

By early October, 1958, the advance gift phase had recorded $132,000 from 130 alumni – more than $1,000 per contribution.

On October 7, the general solicitation was launched with a conference telephone call to 400 alumni campaign workers in the 33 division areas across the country. In the month of October alone, the totals increased by $84,000 and 310 donors. By the end of 1958 the grand totals were $475,000 received from 1,238 donors. With the program officially only three months old, almost half the money had been pledged.

By commencement of 1959 the major part of the personal solicitations were completed, and 2,792 alumni had contributed $810,000.

In the months that followed these figures grew more slowly, but then many alumni, whose original gifts had been in the form of cash, began to give a second or even a third time. So, by the end of 1959 only $40,000 was needed to reach the goal. By April 1960 the gap was only $9,000, and it was decided to send one final letter to all alumni, to let them know where things stood. More than 125 men responded with $14,000 in contributions.

An impressive performance

The Caltech alumni goal is impressive on a number of counts. Almost 47 percent of the alumni contributed. As alumni participation goes, in fund-raising campaigns, this is unusually high. A comparison with Carnegie Tech, for example, shows that – at the end of a 22-month period – Carnegie had an alumni participation percentage of 30; at a comparable point in the Caltech campaign the alumni participation was 45.7 percent.

The average gift from Caltech alumni is $280. This does not include three large gifts of over $100,000. Early in the campaign the Alumni Steering Committee agreed that gifts of $100,000 or more would not be counted toward the $1,000,000 goal until the end of the drive.

Now, then, is the time to count these gifts. They amount to $1,300,000. This means that Caltech alumni throughout the world have contributed $2,305,400.

Hunting Big Earthquakes in India

by Donald E. Hudson

For the past four years, the Earthquake Engineering Research Laboratory of Caltech's Division of Engineering has been engaged in a cooperative research program with the University of Roorkee, in Northern India, on problems of earthquake-resistant design of structures. Several staff members have visited back and forth between the two schools, and plans are now under way for an expansion of this joint venture.

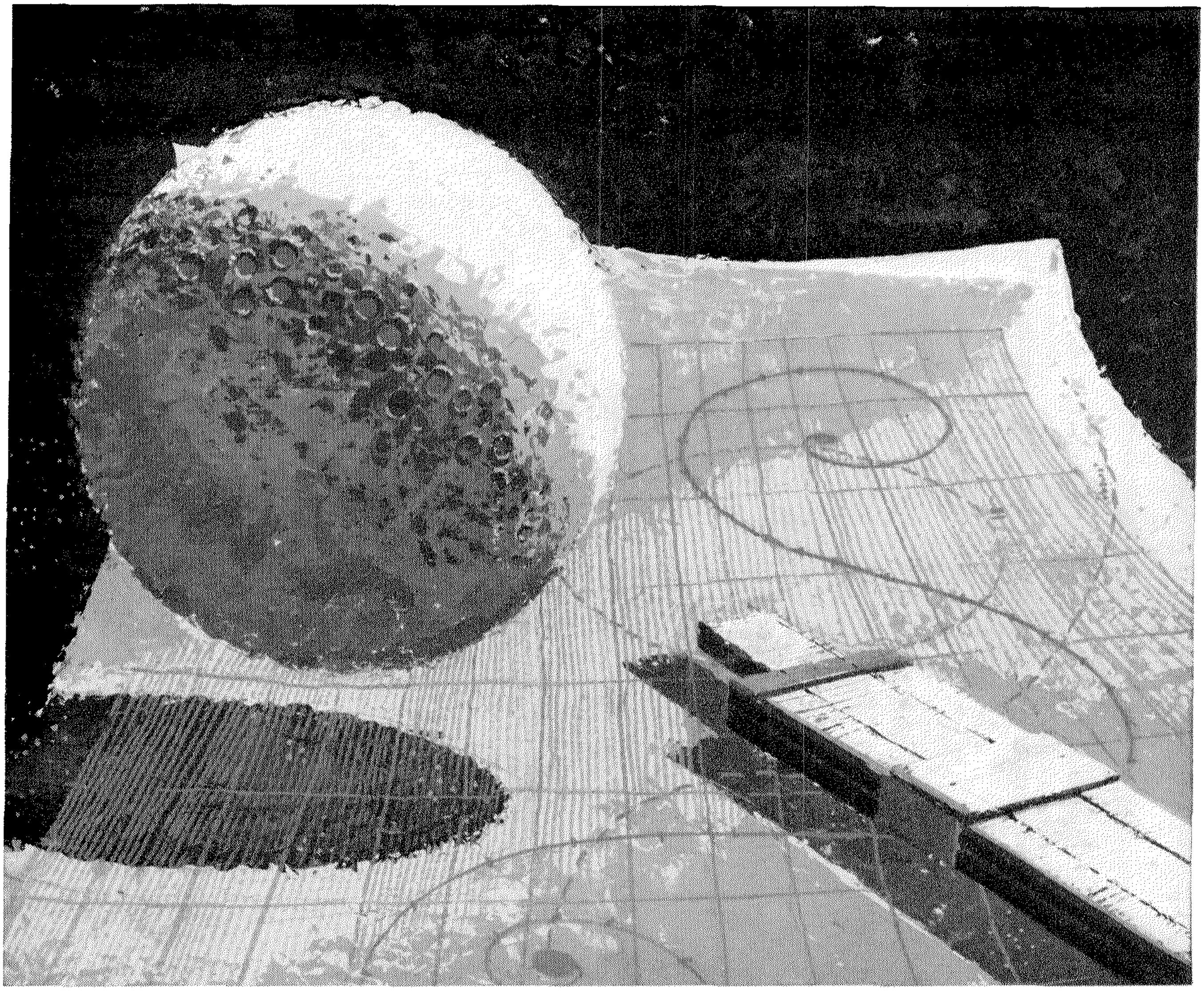
Why do we have to go so far out of our way to find earthquakes? Aren't we satisfied with our own California variety? Oddly enough, it turns out that our California earthquakes are neither big enough nor frequent enough to satisfy us. In this respect, the engineer is in a rather different position from the seismologist or the geophysicist. These scientists can collect much basic data for their studies by measuring small earthquakes at far distant points with sensitive instruments. It is only in the near vicinity of large earthquakes, however, that serious structural damage can occur, and at present the means for studying these large quakes from the standpoint of earthquake-resistant structural design are very limited. The measurements obtained by seismologists, even if their instruments can be adjusted to record the relatively large ground motions associated with damaging quakes, do not give the complete data needed by the engineer. We have records from only a few large earthquakes that show how ground acceleration varies with time. This information is essential for the structural engineer, and, for the future development of this field it is important to get many more such records.

The Himalayan regions of Northern India are subject to large earthquakes, and there are many similarities between Indian earthquakes and our California variety. So, by measuring and studying large Indian earthquakes, we hope to get information that will be of engineering significance for all of the other seismic regions of the world. A network of strong-motion earthquake recorders in Northern India similar to that operated in California by the United States Coast and Geodetic Survey would multiply by several times the rate at which the basic data for earthquake-resistant design could be obtained.

Although India has a tradition of pioneer work in seismology, Indian engineers have only recently become interested in the structural damage aspect of the problem. The development of the country will require the construction of many engineering works in Northern India. Many large multi-purpose irrigation and power projects are being built now, and these projects call for the location of large dams, buildings, and oil refineries, in the highly seismic regions of the Himalayas. There is considerable interest in establishing studies in this field, and we have received the utmost cooperation from the Government of India in pursuing this work.

Earthquakes are associated with the same deformation processes in the earth's crust that are responsible for mountain building, and the largest and most frequent earthquakes are associated with the largest and youngest mountains. Data from past earthquakes have shown that more large earthquakes have occurred in the Himalayan regions than in the California-Pacific Coast area. During the past 50 years there have been some 18 earthquakes of Gutenberg-Richter magnitude 7 or over in the Himalayas, but only 8 such earthquakes in the California region. Data on smaller, but still potentially destructive, earthquakes in India is incomplete, because of the limited network of seismolo-

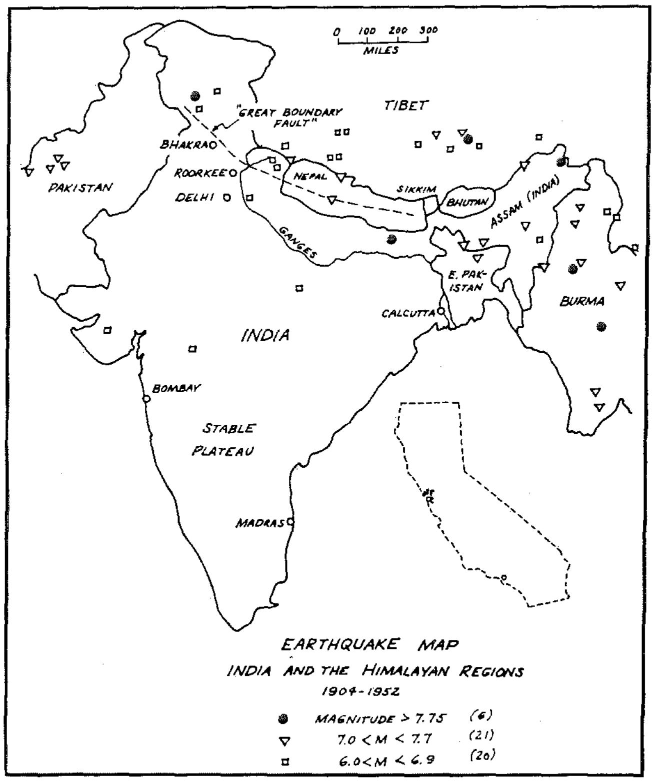
continued on page 18



gical stations. There is every reason to believe that a correspondingly large number of much smaller earthquakes is also occurring.

The general picture of the distribution of Himalayan earthquakes is shown below. The line marked "Great Boundary Fault" is the region of major geological disturbance at the edge of the high Himalayas, and a center of seismic activity. For the past 50 years the eastern end of the arc in Assam has been the most active, and this is reflected in the fact that the headquarters of the seismological department of the Government of India is located there. In 1950 one of the greatest earthquakes in history occurred just on the border of Assam and China. Whole mountains were rearranged, and the resulting topographical changes so disrupted the river systems that floods are still taking a heavy toll each year. Oil has been discovered in the Assam region, and now an oil refinery is being constructed there. The design of various refinery structures which will resist earthquake forces has been a major consideration in the planning of this installation.

The other end of the Himalayan arc in Kashmir has also been visited by very large earthquakes. One of the most notable quakes of all time occurred in 1905 very close to the site of Bhakra Dam, which, when it is completed next year, will be the world's highest gravity dam. Earthquake-resistant design techniques developed by the United States Bureau of Reclamation were used in the planning of this dam.



Map showing locations of major Indian earthquakes for the past 50 years. Insert map of California shows the scale.

At present there are in this whole vast region only three strong-motion seismographs of the type needed for structural engineering data, whereas there should be hundreds. This compares with some 70 such instruments installed in California, and about 50 in Japan.

Roorkee — a strategic location

The University of Roorkee is located in a strategic position for studying earthquakes. Several other factors make Roorkee a logical choice as headquarters for a graduate research school in earthquake engineering. This school, started 110 years ago, is the oldest technical school in the Orient, and has a well-established civil engineering department with a strong group in structural engineering. A good-sized group of competent graduate students who are interested in problems of structural dynamics is also available. The nearness of the school to Delhi, the capital of the country, is also important, as it is necessary to work closely with various government agencies in order to embody the results of the studies in official building codes.

The Roorkee area is an interesting part of India, the campus being just 20 miles from the point at which the Ganges River emerges from the mountains onto the plains. At this point is located the town of Hardwar, one of the most revered of the Hindu Holy cities. The area is a headquarters for pilgrims who throng to hermitages along the river.

The campus affords a magnificent view of the whole chain of the high Himalayas, and a series of 25,000-foot peaks on the Tibetan border are visible, extending over a vast arc of hundreds of miles.

Roorkee is a starting point for hunting parties. Typical Northern India jungle country starts about 15 miles from the campus, and tigers, leopards and elephants are still to be found in the region.

The University of Roorkee has grown out of a technical school which was developed to train surveyors and technical workers for the irrigation canal systems. The British built up a most remarkable system of canals in Northern India, and Roorkee was the headquarters for the design and construction of the main canal outlet of the Ganges River. This Northern Indian irrigation system is still in some respects the most extensive anywhere in the world, and students now come to Roorkee from all over Asia for special studies in water resources development.

Since becoming the first technical university in India in 1949, the school has been engaged in an extensive expansion program, and many new buildings

continued on page 20

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Consider, for example, the new RCA Mesa Transistor in the picture below. As a lightning-fast electronic switch in a high-speed computer, *it can make 20,000,000 "yes-or-no" decisions a second.* Such speed enables one computer to handle paperwork details for a thousand businesses.

Discovered a little over ten years ago, transistors led to totally new concepts in the *science of electronics*. It was found that transistors could amplify weak radio signals, measure light and heat, switch equipment on and off, convert alternating current to direct current and vice versa to perform a myriad of electronic functions in industry and the home.

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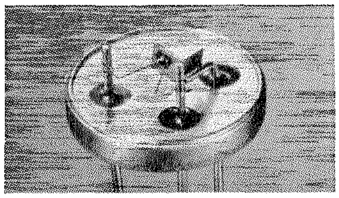
This same leadership in electronics assures the high quality and dependable performance of RCA Victor black & white and color television sets, radios, and high-fidelity systems enjoyed in millions of American homes.



Under the RCA Mesa Transistor's "hat" is its "brain"—a tiny wafer of germanium only a few thousandths of an inch thick. The three attached wires are thinner than a human hair.

The most trusted name in Electronics

RADIO CORPORATION OF AMERICA

Although smaller than a penny the RCA Mesa Transistor does a giant's job in modern computers.

have been completed or are in the course of construction. This development has received the personal attention of Prime Minister Nehru, who has been the moving spirit behind many of the scientific and technical developments in India. The Prime Minister visited the new Earthquake Engineering Laboratory at the school and expressed the opinion that such studies would be of great importance to many of the new construction projects now being planned.

A network of earthquake recorders

Our work in helping with the establishment of the Earthquake Engineering School at Roorkee involved a number of different activities. For instance, an important part of the program is to install a network of strong-motion recording instruments in the Himalayan regions. India is very short of foreign exchange dollars and cannot afford to import such instruments, so it was necessary to set up shop facilities and to train personnel in the design and production of suitable devices. To begin this program, a recording instrument of a simplified type, which had been designed at Caltech, was taken to Roorkee, where it was redesigned in such a way that local materials and processes could be used.

We were fortunate in having in Roorkee the services of a skilled machinist, who was able to understand just what was needed. Everything had to be built quite differently than in Pasadena. For example, no stock sizes of materials were available, so all parts had to be machined from castings. No standard nuts and bolts of any kind could be had, and everything of this sort had to be individually made to order. One interesting problem which arose was the procurement of the small permanent magnets which were used to damp the pendulum in the instrument. Such magnets were not made in India, nor could they be imported under the foreign exchange rules. It developed, however, that small radio loudspeakers were available, and one type was found which had just the right-sized magnets in it.

The instrument manufactured in Roorkee turned out to be entirely satisfactory, and at present a number of them are being built. Although labor in India seems inexpensive, a great deal of it is required; this, plus the high materials cost, makes such instruments relatively much more expensive in India than in the United States. Soon it may be possible to develop and build a more complicated type of time-recording strong-motion accelerometer in Roorkee.

A second type of activity involved the establishment of graduate courses in structural dynamics and in earthquake engineering, to provide the trained men necessary to carry the work forward. Here we were fortunate in having both a fine group of competent and interested postgraduate students, and also several very capable young staff members who could carry on the courses once they were organized. A regular postgraduate course in structural dynamics was worked out and special mimeographed material was prepared.

All lectures in the school are given in English, although it is expected that a gradual changeover to Hindi will take place over the next 10 years or so. The older professors, who have practically all studied in England or in the United States, are of course completely at home in English. The younger staff, the graduate students, and then the undergraduates all show a progressive decrease in proficiency in the language. The Hindi language has not yet developed a suitable technical vocabulary in many fields and there is likely to be a period of some confusion before the complete changeover can be made. The number of people in the country who speak English is so small, however, that the development of the Indian languages seems inevitable.

Setting up laboratory facilities

A second type of teaching activity involved the setting up of laboratory facilities for teaching and research work in dynamic measurements and engineering seismology. Funds of about $5000 were obtained from the Technical Cooperation Mission of the International Cooperation Administration, and about $40,000 were obtained through the United States Wheat Loan arrangement administered by the Government of India University Grants Commission. With this money a good start was made in supplying the basic instrumentation and laboratory equipment needed, and the laboratories are now well equipped. The Indian students seemed to be very interested in laboratory work because it is relatively new in their experience.

Another important part of our research activities was to organize for field inspection of earthquake structural damage. Upon our arrival at Roorkee, we were told by everyone that, although there were earthquakes elsewhere in India, they never had them in Roorkee. Within a month or so, the ground started shaking, and everyone was very frightened. Ever after this, our Earthquake Engineering School was regarded with a certain amount of suspicion. Roorkee is located in the midst of innumerable small villages, in which the construction of the mud houses is of the most elementary type. The usual construction does not even employ sun-dried bricks, but consists simply of heaping up mud to form a thick wall. Even without earthquakes, such construction can hardly hold up.

Earthquake damage studies are often troublesome

continued on page 22

to make in India because of the difficulties of travel in the Himalayan areas. This particular earthquake turned out to have an epicenter right in the region which is being argued over by the Indians and the Chinese, which introduced some additional uncertainties into a proposed field trip to the region.

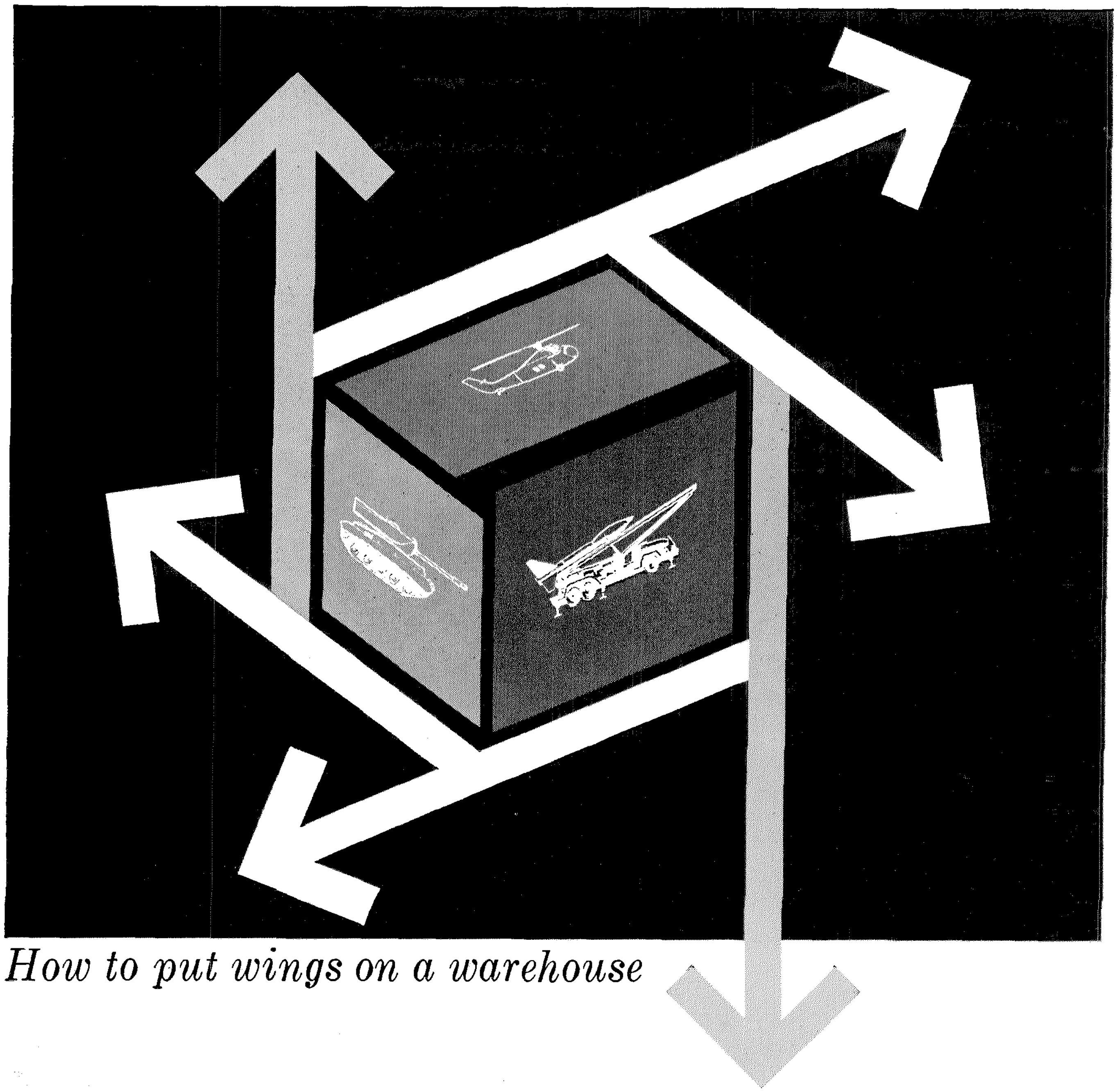
The members of the geology department of the University of Roorkee were very interested in our studies, and were most cooperative in arranging field trips in the Himalayas to investigate earthquake phenomena. One portion of the main boundary fault area of the Himalayas was easily accessible from Roorkee, and a number of interesting trips were made to that region.

Another phase of the work at Roorkee involved the communication of information on earthquake engineering to the practicing engineers in the country. To this end, a symposium on earthquake engineering was organized, and an interesting three-day program was held at Roorkee. About 50 engineers from all over India attended, and many of them contributed technical papers. The proceedings of the symposium have since been published by the University. Professor George W. Housner, on his way from Caltech to the symposium, arranged for the director of the Japanese Earthquake Research Institute to attend the meeting, so that the symposium had quite an international flavor.

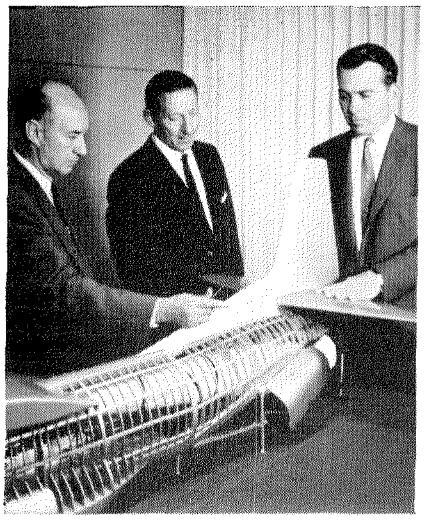
A useful result of the symposium was the appointment by the Government of India of a special committee to formulate an official building code to provide earthquake-resistant design regulations. The chairman of this committee is Dr. Jai Krishna, head of the Structural Engineering Division at Roorkee, who spent some time at Caltech in 1957 and 1959 on earthquake engineering studies.

Since our return from India we have had good news concerning the further development of the program. The Government of India, through the Council of Scientific and Industrial Research, has provided financial support, and the foundations have been laid for a new Earthquake Engineering Laboratory building. We have just heard that one of the young staff members from the structural engineering group will come to Caltech next year for special studies in this field.

As a result of this cooperative research program, there is every reason to hope that Indian engineers will soon be making studies of future Himalayan earthquakes which will be of interest to structural engineers all over the world.



How to put wings on a warehouse



Giving overseas air bases what amounts to local warehouse service on important parts is an Air Force objective. Its present system has slashed delivery schedules up to *20 times*...saved taxpayers several *billion* dollars over the past decade. To improve it further, Douglas has been selected to develop specifications for a comprehensive Material Handling Support System involving better communications, control, cargo handling and loading, packaging and air terminal design. Douglas is well qualified for this program by its more than 20 years in all phases of cargo transport. Air logistics is only one area of extensive Douglas operations in aircraft, missile and space fields in which outstanding openings exist for qualified scientists and engineers. Write to C. C. LaVene, Box 600E, Douglas Aircraft Company, Santa Monica, California.

Schuyler Kleinhans and Charles Glasgow, Chief Engineer and Deputy Chief Engineer of the Santa Monica Division, go over air transport needs relating to advanced cargo loading techniques with Donald W. Douglas, Jr., President of

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Personals

1918

James P. Steele, president and general manager of the J. P. Steele Construction Company on the University of Wyoming campus in Laramie, passed away on October 27, 1959.

1926

Theodore C. Coleman, president of the Coleman Engineering Company, Inc., in Torrance, and his wife left on May 3 for a business trip to Australia, Singapore, Bangkok and Tokyo. The Colemans have a son, Sam, who is attending Colorado College and a daughter, Judy Ann, a graduate of Stephens College, who was married recently.

1930

John W. Towler, director of manufacturing at the Union Oil Company in Los Angeles, has been elected a vice president of the company.

1932

Franklin J. Cline, Jr. opened an office in Fullerton in February as a certified public accountant. He is also secretary of a newly-organized Exchange Club there. The Clines have two children; Tom, 16, and Susan, 8.

William M. Bleakney, PhD, is now senior scientist in the advanced projects laboratories at the Hughes Aircraft Company in Culver City. He designs new systems for military and space projects.

James R. Bradburn is now vice president of manufacturing and engineering for Electro-Data and the Burroughs Corporation in Detroit. He was president of the ElectroData Corporation when it merged with Burroughs in 1956, and has been vice president and general manager of the company's ElectroData division in Pasadena since then.

1934

Nick T. Ugrin, director of industrial relations at the Union Oil Company in Los Angeles, was recently elected a vice president of the company.

1936

Frank W. Davis, vice president of the Convair Division of the General Dynamics Corporation and manager of the Fort Worth plant, received an honorary PhD from West Virginia University on May 30. The Davises have three children; Caroline, 18, Frank, Jr., 15, and William, 9.

1937

Edward J. Horkey, MS '38, is now vice president of engineering at Houston Fearless. He will continue as head of the Horkey-Moore Associates unit.

1938

Charles F. Robinson, MS, PhD '49, has been appointed director of a new research division in Pasadena which has resulted from the consolidation of Bell & Howell Company in Chicago and its subsidiary, the Consolidated Electrodynamics Corporation. He was formerly associate director of research at CEC and has been with the company since 1947.

Howard S. Seifert, PhD, is now on the technical staff of the United Technology Corporation in Sunnyvale, California. He is also professor of aeronautical engineering at Stanford University and is serving as 1960 president of the American Rocket Society. Howard was formerly a lecturer in rocket design at Caltech and most recently was a visiting professor at the University of California, and special assistant for professional development at the Space Technology Laboratories, Inc. in Los Angeles. The Seiferts and their three children are now living in Palo Alto.

Donald D. Davidson has been elected vice president of the Golden Bear Oil Company in Los Angeles. He will be responsible for all manufacturing operations of the company. He has been with Golden Bear since 1952.

1940

Don L. Walter, MS '41, is now vice president of the Marquardt Corporation in charge of the Power Systems Group. Don has four daughters; Terri, Susan, Lisa, and Tina.

John C. Carey, engineering manager of Microdot, Inc., in South Pasadena, fell from the second floor of a building under construction on May 3, while inspecting the work. He died a week later of a skull fracture. He leaves his wife and three adopted children; Deena, 11, John, 11, and Muriel, 7.

1946

Comdr. A. Dave Pollock, MS, was killed in a Navy plane crash on November 1, 1952. After leaving Caltech in 1947 he worked toward the placing of jet aircraft aboard carriers. He not only had one of the first jet carrier-based squadrons but also did the early experimental flying qualities tests for catapulting and arresting jets. This information about Dave, who has been listed as one of Caltech's "lost alumni," came from *Comdr. W. C. Wilburn,* MS, AE '47.

Jose D. Cortes-Guzman, MS, writes from Mexico City that "I have been doing Federal work as a contractor since 1951 in different Mexican states. I own

continued on page 26

all my equipment such as draglines, tractors, scrapers and smaller machines and have my main office in Mexico City. Even though the competition is hard and there aren't many opportunities for work because of the many industrial, social, and political problems of our government, I'm still working for myself and my wife and four children—one girl and three boys, 7, 8, 9 and 10."

1947

David L. Douglas, PhD '51, is now manager of fuel cell engineering at General Electric's aircraft accessory turbine department in Lynn, Mass. He was formerly a physical chemist at GE's Schenectady plant. The Douglases live in Marblehead with their two children.

Joseph Rosener, Jr. is now president of the Plasmadyne Corporation in Santa Ana, a subsidiary of the Giannini Scientific Corporation. He was formerly vice president and general manager of the company.

L. Edward Klein, MS, is now director of development at Monsant Chemical Company's organic chemicals division in St. Louis. He was formerly assistant director of development.

1950

Robert Duff Clark, MS, has been appointed director of research and development at the Axelson Manufacturing Company, a division of U.S. Industries, Inc. Axelson is a 65-year old firm which manufactures pumping equipment for the petroleum industry in Los Angeles. Bob was previously chief engineer at Clary Dynamics in San Gabriel. The Clarks and their two sons live in Fullerton.

Wilbur A. Wikholm writes that "at present I am working for RCA in Van Nuys. I received my MS in engineering from UCLA in 1959. My wife and I now have three daughters – Gretchen, 9, Janine, 7, and Annette, 9 months."

Jerome K. Delson, MS, PhD '53, writes that "after leaving Caltech in 1953 I joined the General Electric Company where I worked with power transformers in Pittsfield, Mass. Then I went to Schenectady, N.Y., and worked in GE's analytical engineering section and in their general engineering laboratory.

"In 1958 I received a Fulbright grant and went to the Weizmann Institute of Science in Israel where I programmed their digital computer, the WEIZAC, for load-flow studies of electrical power systems. After that, I accepted a one-year position with the Palestine Electric Corporation as a consultant to their newly-formed technical development group.

"My wife, the former Esther Harrison of Chicago, and I have enjoyed living in Rehovot at the Institute, and now in Haifa. In our travels throughout Israel, we feel that we have an intimate contact with its ancient history. In September we start our return to America, possibly visiting India and Japan on the way."

1951

Clarence Allen, MS, PhD '54, associate professor of geology at Caltech, recently returned from a three-month trip to Chile, where he studied earthquake faults (and, incidentally, came down with hepatitis – from which he has now recovered). On his travels around Chile, Clarence met a number of Caltech alumni. In Santiago, *Pierre St. Amand,* MS, PhD '53, who is visiting professor of geology at the University of Chile and *Cinna Lomnitz,* PhD '55, director of the University's Institute of Geophysics; in Maria Elena, *Henry B. Suhr,* '33, director of research for the Anglo-Lautaro Nitrate Corporation.

1953

Lawrence Starr writes that he is doing development and sales work in food processing equipment at the Koch Equipment Company in Kansas City, Mo. The Starrs now have two children; Laura, 2½, and John, born on May 2.

Bruce Holloway, PhD, senior lecturer at the University of Melbourne in Victoria, Australia, writes that he recently had a visit from *Sherman Ripley,* PhD '53. "Sherman is a South African," writes Bruce, "and was an official delegate to Sydney in March, 1960. After attending the conference, Sherman came down to Melbourne and stayed with me for a week. He is senior lecturer in physiology in the Medical School of the University of Natal in Durban."

1957

Jacob Lubliner has received his PhD in engineering mechanics from Columbia University and is now working at the Bell Telephone Laboratories. He writes that this is only a temporary job, however, since he will be going to Paris in the fall on a National Science Foundation postdoctoral fellowship. He will be doing research in mechanics at the Polytechnic School. Jacob also writes that *Serge Lang,* '46, (listed as a "missing alumnus" in the Alumni Directory) is associate professor of mathematics at Columbia University.

Rube Moulton, Jr. writes that he has just a little over one year left in the Army. He hopes to take some leave, and travel in Europe this summer.

1958

Richard K. Nelson, ME, is now applied science representative at IBM in New Mexico. Dick was married last summer.

CALTECH ALUMNI ANNUAL PICNIC

Saturday, June 25, 1960

Tournament Park

This year the alumni picnic will be held in centrally located Tournament Park between 9 a.m. and 6 p.m. Price of admission will be $2.00 for adults, $1.00 for children 5-12 years inclusive, no charge for children under 5.

Price of admission includes:

1. Kiddyland rides—safe, sane, entertaining – the kids can ride all day.
2. Carnival booths – for young and old. Prizes for everyone.
3. Exclusive use of swimming pool. (Small additional charge for towels.)

Also available:

1. Catered hot lunch. (Reservations must be made in advance.)
   Lunch: Over 5 years old $1.25 – Under 5 years old free.
2. Sno cones, popcorn, cotton candy and soft drinks on sale.

REMEMBER, that's June 25

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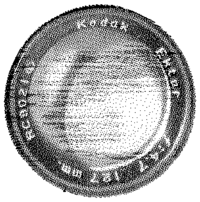
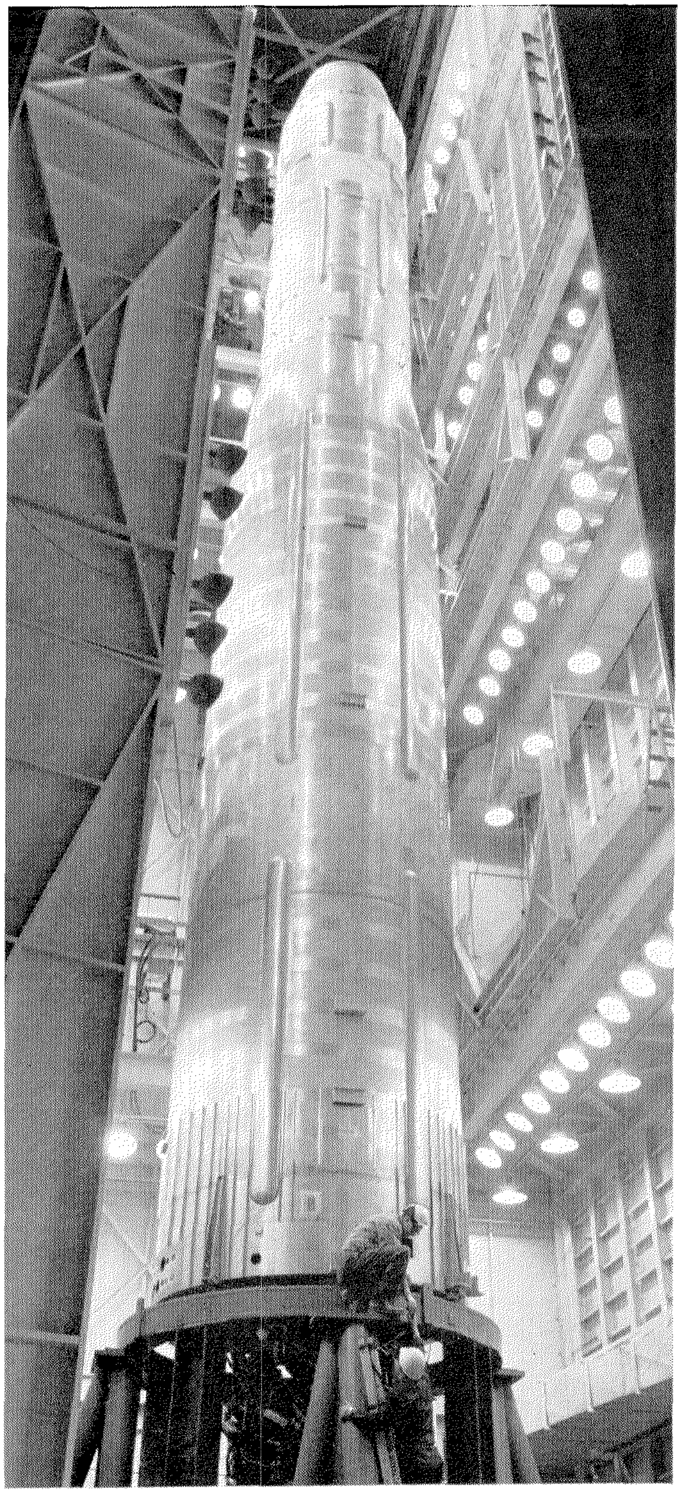
If your sights are set  on outer space–



U.S. Air Force I.C.B.M. "Titan" shown in the vertical test laboratory at the Martin Company, Denver, Colorado.

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TRADE MARK

One of a series

Interview with
General Electric's Byron A. Case
Manager—Employee Compensation Service

Your Salary at General Electric

Several surveys indicate that salary is not the primary contributor to job satisfaction. Nevertheless, salary considerations will certainly play a big part in your evaluation of career opportunities. Perhaps an insight into the salary policies of a large employer of engineers like General Electric will help you focus your personal salary objectives.

Salary—a most individual and personal aspect of your job—is difficult to discuss in general terms. While recognizing this, Mr. Case has tried answering as directly as possible some of your questions concerning salary:

Q Mr. Case, what starting salary does your company pay graduate engineers?

A Well, you know as well as I that graduates' starting salaries are greatly influenced by the current demand for engineering talent. This demand establishes a range of "going rates" for engineering graduates which is no doubt widely known on your campus. Because General Electric seeks outstanding men, G-E starting salaries for these candidates lie in the upper part of the range of "going rates." And within General Electric's range of starting salaries, each candidate's ability and potential are carefully evaluated to determine his individual starting salary.

Q How do you go about evaluating my ability and potential value to your company?

A We evaluate each individual in the light of information available to us: type of degree; demonstrated scholarship; extra-curricular contributions; work experience; and personal qualities as appraised by interviewers and faculty members. These considerations determine where within G.E.'s current salary range the engineer's starting salary will be established.

Q When could I expect my first salary increase from General Electric and how much would it be?

A Whether a man is recruited for a specific job or for one of the principal training programs for engineers—the Engineering and Science Program, the Manufacturing Training Program, or the Technical Marketing Program—his individual performance and salary are reviewed at least once a year.

For engineers one year out of college, our recent experience indicates a first-year salary increase between 6 and 15 percent. This percentage spread reflects the individual's job performance and his demonstrated capacity to do more difficult work. So you see, salary adjustments reflect individual performance even at the earliest stages of professional development. And this emphasis on performance increases as experience and general competence increase.

Q How much can I expect to be making after five years with General Electric?

A As I just mentioned, ability has a sharply increasing influence on your salary, so you have a great deal of personal control over the answer to your question.

It may be helpful to look at the current salaries of all General Electric technical-college graduates who received their bachelor's degrees in 1954 (and now have five years' experience). Their current median salary, reflecting both merit and economic changes, is about 70 percent above the 1954 median starting rate. Current salaries for outstanding engineers from this class are more than double the 1954 median starting rates and, in some cases, are three or four times as great.

Q What kinds of benefit programs does your company offer, Mr. Case?

A Since I must be brief, I shall merely outline the many General Electric employee benefit programs. These include a liberal pension plan, insurance plans, an emergency aid plan, employee discounts, and educational assistance programs.

The General Electric Insurance Plan has been widely hailed as a "pace setter" in American industry. In addition to helping employees and their families meet ordinary medical expenses, the Plan also affords protection against the expenses of "catastrophic" accidents and illnesses which can wipe out personal savings and put a family deeply in debt. Additional coverages include life insurance, accidental death insurance, and maternity benefits.

Our newest plan is the Savings and Security Program which permits employees to invest up to six percent of their earnings in U.S. Savings Bonds or in combinations of Bonds and General Electric stock. These savings are supplemented by a Company Proportionate Payment equal to 50 percent of the employee's investment, subject to a prescribed holding period.

If you would like a reprint of an informative article entitled, "How to Evaluate Job Offers" by Dr. L. E. Saline, write to Section 959-14, General Electric Co., Schenectady 5, New York.

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