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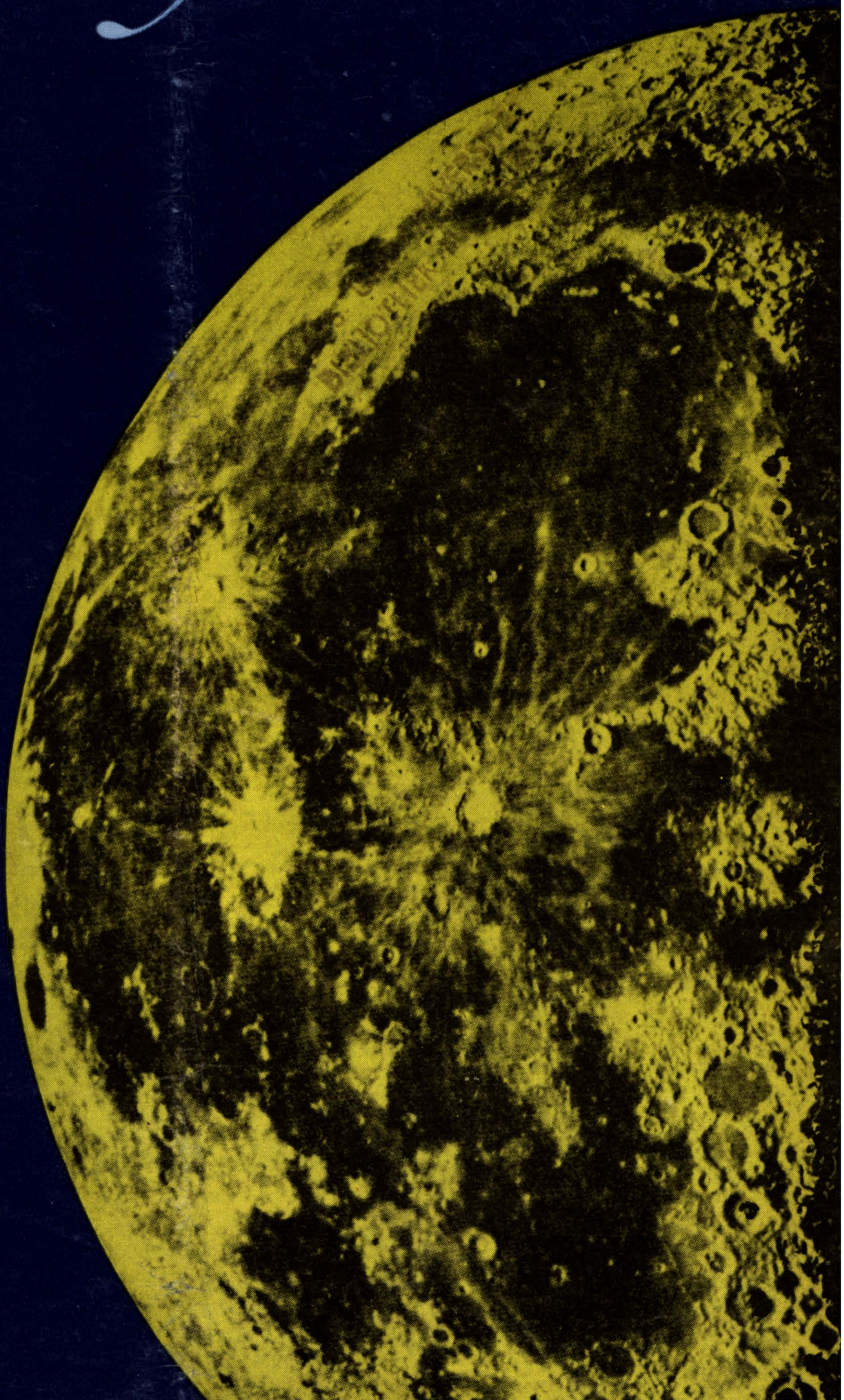
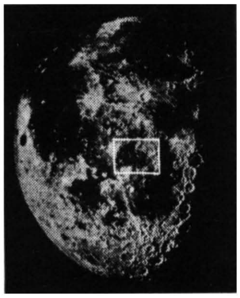
SR / RESEARCH
SCIENCE & HUMANITY

WHAT THE MOON RANGER COULDN'T SEE

By John Lear





—Courtesy LPL.

SR / Research

SCIENCE & HUMANITY

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RESEARCH IN AMERICA

WHAT THE MOON RANGER COULDN'T SEE

TUCSON, ARIZONA.

THEY made a robot in the shape of a dragonfly and named it Ranger VII, thereby expressing their hope that it would range the face of the moon. For eyes, they gave it camera lenses, and taught it how to photograph by blinking the shutters. Near the place where its nose should have been, they put a radio antenna like a saucer, and taught the robot how to send pictures back through the saucer to the earth. When all this was done, they folded the dragonfly's wings, set the mechanical insect on top of a rocket, and fired the rocket into orbit around the earth. Finally they shot the robot out of the orbit, told it to unfold its wings, and pointed it onto a curving path across 243,665 miles of sky. The path ended in a dry lunar lakebed that hadn't been thought important enough to be named.

Within a few miles this way or that, Ranger VII reached the moon at just the point where its orders said it should. It crashed at a speed of a mile and a half per second, destroying itself in fulfilling its mission. But during the last 1,000 seconds of its flight it returned to earth 4,316 pictures of the moon, so incredibly clear that in them it is possible to mark the robot's landing spot.

The latitude was 10.7 degrees south. The longitude was 20.7 degrees west. The local altitude was roughly fifty feet.

To put these geographical coordinates in everyman's language: Ranger VII crashed into the top of a lunar hill.

The angle of the slope remains to be determined, but the close-up photographs plainly show a terrace on the hillside, and some distance below the terrace an appreciable valley.

The hill is elongated rather than circular; its surface looks as smoothly rounded as a sand dune or a snow bank; it cannot be seen at all through even the strongest earthly telescopes, though a mountain to the north of it and a ladle-shaped cluster of craters to the south appear in many photographs taken by earthbound astronomers long before Ranger VII was thought of.

When the geographical position of this hillock is noted on telescopic photographs of the moon's full and third quarter phases (see pages 36 and 41, respectively) Ranger VII's landing place is seen to lie directly in the path of bright great circle arcs that have mystified astronomers for hundreds of years. No other features of the moon's face have provoked such wildly divergent speculations as these curving lines of light. Whether enormous lowland craters like Mare Imbrium were formed by volcanic action or falling meteorites had been a subject of long and acrid debate, but the question about the lunar rays did not stop with the *how* of their forming; it went all the way down to the fundamental *what were they?*

Rays. That's what they were. Everyone agreed on that. And there the agreement stopped.

The rays sprang out from lunar craters in all directions, like the spokes of a wheel. Not, however, from all craters. Only from certain sharply delineated ones, some not otherwise conspicuous.

The rays would emerge faintly about twelve hours after the sun rose over the lunar horizon. They would brighten gradually for one or two days. While the sun rode high in the lunar sky, they would shine with spectacular brilliance. As the sun went down from the zenith, they would fade. Twelve hours after lunar sunset, they would disappear.

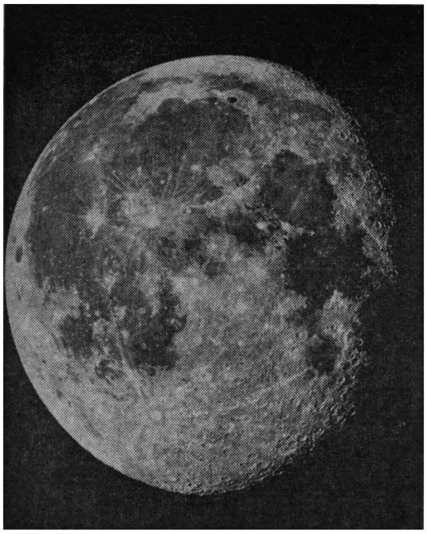
At first their brightness seemed to depend on the angle at which they were illuminated by the sun. But in time astronomers saw that this was not so. The reflective power of the rays actually changed with the angle between the line along which the sunlight struck the moon and the line along which the reflection was seen from the earth.

WHAT could the rays be? They never varied in width. Nothing seemed to stop them in their coursing across the moon's face. They went up mountains and down valleys, over crater walls and across the crater bottoms and on out over the opposite walls; they plunged down cliffs; they went in and out of pits. Yet they never cast shadows. Their tracks sometimes did seem to be more prominent on the side of obstacles facing the craters where the rays originated, but ghost tracks could always be found on the far sides of every thing the rays encountered. What could possibly explain such apparent indestructibility?

Some astronomers said the rays must be cracks in the moon's crust. Others said the rays were streaks of dried salt. Still others suggested the presence of strings of transparent glass beads. And others thought the rays must be the splashings of falling meteorites.

One point seemed undisputable. The craters from which the rays emanated must be younger than many other of the moon's geographical features. Otherwise, the rays would be blotted out by succeeding events instead of crossing over practically everything in sight.

The most spectacular set of rays converge on the crater Tycho, named for the famous sixteenth century Danish astronomer, Tycho Brahe. Tycho lies in a huge nest of craters near the moon's south pole. Its own crater is fifty-six miles wide. The mountains surrounding it reach 12,000 feet above the crater's floor. A central peak rises from the floor. The peak would be the only sign to distinguish Tycho from its host of neighbors were it not for Tycho's rays. De-



—From "The Measure of the Moon" (Baldwin).

Tycho's rays cradle The Moon.

pending on the astronomer making the estimate, Tycho's rays go out as far as 1140 or 1254 or 1440 miles from the crater rim. Nobelist Harold Urey has suggested that one of the rays, which crosses Mare Serenitatis, goes entirely around the moon. Because of its scintillating emanations, Tycho dominates the lunar landscape when the moon is full. At that time the disc takes on the appearance of a peeled orange, with Tycho at the navel.

The ray that stretches from Tycho to the lakebed where Ranger VII landed is approximately 625 miles long. Successive photographs snapped by the robot before it crashed explained the nature of the rays for the first time. They are chains of secondary and tertiary craters formed by ejection of debris during the formation of a primary crater. The fifty-foot-high hill on which Ranger VII crashed is a relic typical of the elongated dribbling that would have been expected from the fall of a curtain of rock. What probably happened can be compared to the shoveling of snow. When a shovelful is thrown onto snow accumulated roundabout, some of the shovel's burden will scoot onward from the point at which the shovel load strikes.

OF course I do not report the foregoing information on my own authority. It is derived from a daylong talk here in Tucson with Professor Gerard P. Kuiper, creator and moving force of the Lunar and Planetary Laboratory of the University of Arizona. Professor Kuiper is the chief scientific investigator of Ranger VII's findings on the moon. We sat down together at his desk on a Saturday morning, just after breakfast. We parted well after sundown. In the ten and a half intervening hours he allowed me to peer through his scientifically sophisticated eyes onto a new frontier of astronomy, the like of which has not opened up for four and a half centuries.

For a long while after the Italian Galileo in 1609 borrowed the Dutch idea (which some historians credit to Hans

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PERSONALITY PORTRAIT—XCVIII

THE PORTABLE ASTRONOMER

Prof. Gerard P. Kuiper

"SUPPOSE there were people on planet Mars, and you were one of them. Suppose you had been watching planet earth for most of your life and thought of visiting the place. You would want to learn as much as you could about the safety of such a trip. You would study the earth through various instruments which you would invent for the purpose. You would confirm that planet earth had an atmosphere swimming around it. You would find signs of water vapor in the atmosphere. You would also discover that temperatures on the earth often fell low enough to cause the water vapor to freeze. Knowing that water was liquid, you would think of raindrops. Thinking of frozen drops, you might visualize hailstones. But would you predict a snowflake?"

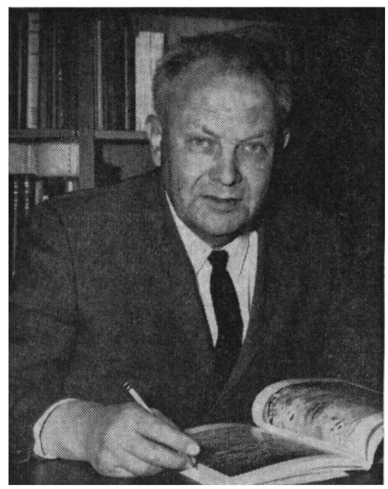
After Professor Gerard P. Kuiper asks this question, he doesn't just sit and watch you looking goggle-eyed. He starts to answer the question.

"You probably would know about crystals, and you would suspect some interesting patterns in water crystals because of the offbeat way the two hydrogens and the one oxygen hook together. But would you predict a snowflake? If you had never seen a snowflake, would you dare to imagine such exquisite mathematical symmetries as snowflakes?"

The Professor doesn't offer to finish the answer, and in the unfinished nature of it lies his point. Science must always expect the unexpected. At the same time, it must try to reduce the unexpected to manageable proportions.

The Lunar and Planetary Laboratory which Professor Kuiper runs in a red brick building on the campus of the University of Arizona in Tucson is an effective example of this type of management. Into it he has gathered astronomers, physicists, chemists, geologists, communication engineers, and map-makers. Among the apparatus is a fat tube half as long as the building. In it gases are mixed in various proportions to simulate atmospheres. The mixtures are analyzed spectroscopically, and the resulting light patterns are matched against the patterns displayed by the atmospheres of the planets of the sun. Atmospheric pressures can be deduced by this process, and Professor Kuiper's lab team has in fact deduced the pressure of the atmosphere of Mars.

When the laboratory first announced this Martian finding, the pressure reported was so low that the National Aeronautics and Space Administration refused to accept it as an influence in planning exploration of Mars. However, the Kuiper reputation (he had served with distinction at Harvard and Yerkes



—Denis Milon, LPL.

for many years before coming to Arizona) encouraged other astronomers to zero in on Mars to check his observations. One by one they announced concurrence with his radically new appraisal. NASA could no longer afford to ignore the evidence, for the first NASA probes to Mars were supposed to drop instruments by parachute, and an atmosphere as flimsy as the one Professor Kuiper predicted would not hold a parachute open. The Mars probe being worked on now is of a different, hardier design.

Perhaps his birth in Holland, a country that has struggled for centuries to hold back the sea, has something to do with Professor Kuiper's ease in contemplating the grand environment of the universe. A strong genetic dose of farsightedness must be built into him. Pure luck seldom accounts for sweeping changes in direction such as the one he undertook with the opening of the 1960 decade. Generally, successful practition-

Lippershey and others to Zacharias Janssen) of magnifying lenses to see across great distances, astronomers could make no more revealing searches through the telescope than could be accomplished with the unaided eye. As time passed, telescopes grew steadily bigger, and cameras were attached to their eyepieces for keener seeing. Yet men still could not penetrate the ultimate mystery of the lights and shadows on the moon's face. Now Ranger VII has proved that it is possible for robots to carry cameras directly to the lunar surface and there to discover thousands of geographical details in regions which look absolutely flat and bare in pictures taken through telescope lenses up to 200 inches across.

THE availability of such details is not, in and of itself, advantageous to scientific understanding. Details can confuse as well as clarify. The first task of science, therefore, is to determine criteria capable of establishing order in the midst of complexity. And Professor Kuiper has admirably performed this function in his analysis of the flood of data returned to earthly TV screens by Ranger VII. Tentatively, subject to the usual revision or contradiction by critical colleagues, he has found what appears to be a governing pattern in Ranger VII's close-up pictures of the moon. To his exquisitely trained eye there seems to be a direct proportion (at one point in our conversation he went so far as to call it a one-to-one correlation) between the degree of brightness of the lighted portions of lunar images in earthbound telescopes and the number of secondary craters like those forming the moon-circling ray which Ranger VII landed at the end of.

Saturday Review readers can check Professor Kuiper's principle of proportionality for themselves by examining the series of pictures reproduced on pages 41 to 43 of this issue of the magazine. They should not, however, jump to the conclusion that this discovery removes the long train of problems that lie between the crash-landing of a robot on the moon and the landing alive on the lunar surface of a man who is thereafter able to return alive to earth.

Ranger VII has placed an unexpected tool in the hands of astronomers. The tool seems applicable to the lunar garden plot that Ranger VII caught sight of at close range (for comparative dimensions, see photos on pages 35 and 41). But even in that small arena the real utility of the tool must be tested. There are, for example, extremely dark spots in the two overlapping lakebeds surrounding Ranger VII's landing site. Are these spots composed of lava, as many astronomers—Professor Kuiper included—suppose? Another Ranger could answer the question. Suppose the answer were positive; could we be certain that the correlation is not merely some trick of sunlight? Can the details in the Ranger VII photographs be extrapolated accurately across the entire face of the moon? Again the answer can be given by other Rangers. So much more information needs to be gathered that it seems reasonable to suggest dispatch of at least half a dozen more Rangers to the moon rather than depending on the necessarily localized findings of the two more now scheduled by the National Aeronautics and Space Administration.

Before the Ranger VII flight, the dangers of landing a man on the moon were purely speculative. Ranger VII proved that at least one danger is real. That danger is the risk of toppling the landing craft in a string of small and irregularly spaced craters. How many other equally unsuspected dangers may lurk in the countless unknowns of the lunar surface? Is it comforting to learn that Ranger VII crashed on a hill invisible

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ers of modern astronomy worked with telescope lenses 100 or 200 inches across. They hunted the farthest stars. Professor Kuiper turned his attention close to home, concentrating on the solar system.

The course he has followed may fairly be described as portable or bargain basement astronomy. The moon Rangers have revolutionized observation of the heavens; telescopes orbiting above earth's atmosphere will extend the revolution indefinitely, for they will operate around the clock instead of merely at night. If earth-based astronomy is to have a role in this mobile context, telescopes will have to be smaller and must be assigned more specialized objectives in order to cut costs. Professor Kuiper already is testing his belief that the volcano cones of the Hawaiian archipelago afford the clearest seeing on earth. And an electronic genius in his laboratory—Harold Johnson—has built one telescope on a peak in the Catalina mountains for little more than half a million dollars, and automated another to the point where high school students can drive it like a truck.

For the moment, at least, Professor Kuiper is quite content to let the Rangers explore the moon. He has no ambition to make the trip himself. His candidate for that job is one of his colleagues on the Ranger science advisory team, geologist Eugene Shoemaker (the other team members are Nobelist Harold Urey, Ewen Whitaker of the Kuiper lab, and Raymond L. Heacock of JPL). The Professor is much too happy growing evergreens around the patio behind the house he and his handsome wife, Sarah, their son Paul and daughter Lucy fill with banter, love, and laughter.

—WILL JONATHAN.

from earth? Is it reasonable to consider sending out a second generation of lunar exploring robots—the Surveyors, designed to descend slowly to the moon and there to sample the rocks of the countryside— when superficial scanning of the Surveyor blueprints reveals fuel tanks so placed as to explode on impact with uneven ground like the ground one often finds on hilltops? Would it not be saner to postpone Surveyor expeditions until the Rangers have made a thorough reconnaissance of all the contrasting major features of lunar terrain: the great, apparently flat lowland basins that occupy two-fifths of the moon's visible hemisphere (it is always the same hemisphere); the chains of circular mountains; the craters of all sizes, those with rays and those without?

THERE has been too much instant science in the American program for exploring the moon. To those unfamiliar with this new phenomenon, it can be explained that instant science is an intoxicating brew that drives respectable researchers to a fate worse than death. Instant science is concocted in the following manner. A competent and if possible eminent scientist is captured by granting him tax moneys to finance his favorite type of experiments. The scientist is then squeezed of his life juices periodically. He is called upon to report findings he is not yet certain of. Where necessary, hired writers state the uncertainties for him in such terms as to persuade unwitting Congressmen that the uncertainties are certain. If the captive scientist resists the squeezing, he is reminded sharply of his obligation to his country and to the well-being of his fellow scientists. If, on the other hand, he helps to stir the instant science, his reports become the basis for more generous appropriations by the Congress, the research he loves is supported more richly than ever, and he may even be invited to the White House to shake the hand of the President and answer politically loaded questions on which the future of the entire planet is professed to hang.

No amount of instant science could extinguish the genuinely brilliant achievement of Ranger VII. But enough of the heady stuff was brewed at strategic moments to pressure Congress into approving another extravagant budget for putting a man on the moon by 1970. Though Professor Kuiper won't discuss it, it is a matter of record that the Jet Propulsion Laboratory of California Institute of Technology, holder of the primary NASA contract for the nine scheduled Ranger missions, propelled the Professor onto a national TV network by inviting him to California for a press conference. The press was in the audience alright; so were millions of lay taxpayers; and when the Professor said he couldn't interpret Ranger VII's pictures to mean a deep layer of dust on the moon's surface, spokesmen for JPL and NASA turned this negative statement into a positive declaration that man could safely go to the moon as soon as a suitable vehicle was ready to carry him. When the Science and Astronautics Committee of the U.S. House of Representatives asked him to explain his observations under quieter circumstances in Washington later, the Professor scrupulously qualified his tentative interpretations to emphasize the doubts.

Professor Kuiper's remark about the dust did in one sense cheer moon travel enthusiasts. For lunar observations of various sorts—optical, radio, radar, thermal, photometric, spectrographic—had been widely read to signify the presence of a dust layer at least a few inches and perhaps a few miles deep. The last of Ranger VII's photos was taken only 1,000 feet off the moon; it showed primary craters as little as three feet in diameter and one foot deep. The outlines of those tiny craterlets registered as sharply as did the walls of the biggest craters. Such a correlation was not theoretically compatible with a deep dust layer, which presumably would swallow small crater-forming projectiles with little or no trace.

Now the supposed origin of the supposedly deep dust was the constant hail of meteorites to which the moon is almost certainly subject. The earth is pelted with a comparable showering, but these sometimes sizeable objects are reduced to powder by the friction of their passage through earth's atmosphere. The moon, being one quarter the size of the earth, is too small to possess sufficient gravitational attraction to hold any mass of gas around itself. Hence meteorites striking the moon would tend to strike as discrete objects and simultaneously pulverize the lunar surface and themselves.

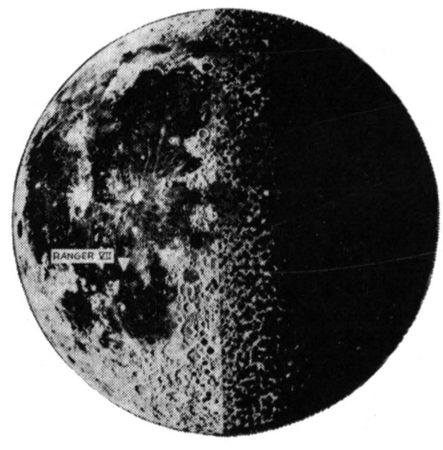
SINCE the Ranger VII pictures appeared to deny the presence of a deep lunar dust layer, Professor Kuiper had to postulate an alternate fate for meteorites hitting the moon. What he came up with was a model of a sand-blasting operation. He now supposes that the meteorites, instead of shattering themselves and piling up dust on the moon's surface, must strike with such force in the lunar vacuum that either one of two events occurs:

FIRST, the particles glance back into space, chipping off bits of the moon and driving those ahead, or

SECOND, the particles pierce the lunar surface and convert it into a kind of rocky sponge to uncertain depth.

Professor Kuiper did not arrive at the sand-blasting model through study of the Ranger VII photos alone. He matched the Ranger close-ups with telescopic pic-

THE RUSSIAN LUNIK II was first to reach the moon. It made a direct flight in thirty-seven hours, landing on September 14, 1959. Its impact point is marked on the globe above. In the next month, Lunik III performed a spectacular maneuver that has not been duplicated since. Lunik III approached the moon while the earth-facing hemisphere was dark, and photographed the sunlit hemisphere on October 7, 1959, at a distance of 40,000 miles beyond the moon. Storing the pictures automatically, Lunik III then orbited out to an apogee 292,000 miles from earth, swung back to perigee at 29,000 miles and there transmitted its pictures to earth on October 18, 1959. Crash points of Ranger VI and VII are shown below.



The Log of Ranger VII

THE assignment was to photograph the earth-facing hemisphere of the moon close up and send the pictures back to earth on a TV screen. Since the pictures were to be gathered out of the sky by a big dish in the desert at Goldstone, California, and since TV signals can travel only over direct lines of sight, the mission required the moon to be somewhere above the Goldstone horizon at the time the pictures were snapped. The higher above the horizon the moon was, the less risk there would be of pictures blurred by electromagnetic noises originating on earth. When the moon was directly overhead, the risk would be lowest of all. It could not be a new moon, or a first quarter moon, or a full moon(see top sketch, this page); only a third quarter moon would do. Only then would the sun throw shadows at angles conducive to revealing photography while the moon was moving into Ranger VII's line of flight. All these conditions would be met at approximately half past five, Pacific Standard Time, on any morning of the week beginning with July 30, 1964.

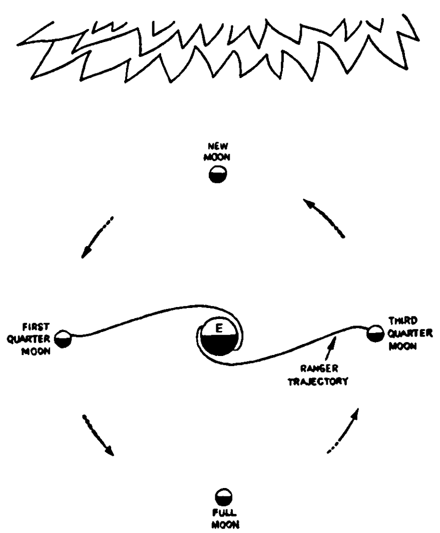
At that time, the moon would be 238,000 miles over the Goldstone dish. But straight-line travel would tax available fuel capacity. A more economical scheme (see middle sketch, this page) would be to go into orbit 115 miles out from earth and then use the orbit as a rare-air springboard (magnifying the reaction to any given thrust) for the big jump onward. The elapsed time on such a trajectory would be sixty-eight and a half hours, allowing an hour for asking directions on the way. By counting backwards from the approximate Goldstone deadline of 5:30 A.M., the rocketeers computed the earliest launch from Cape Kennedy (nee Canaveral) in Florida for about noon, Eastern Standard Time, July 27.

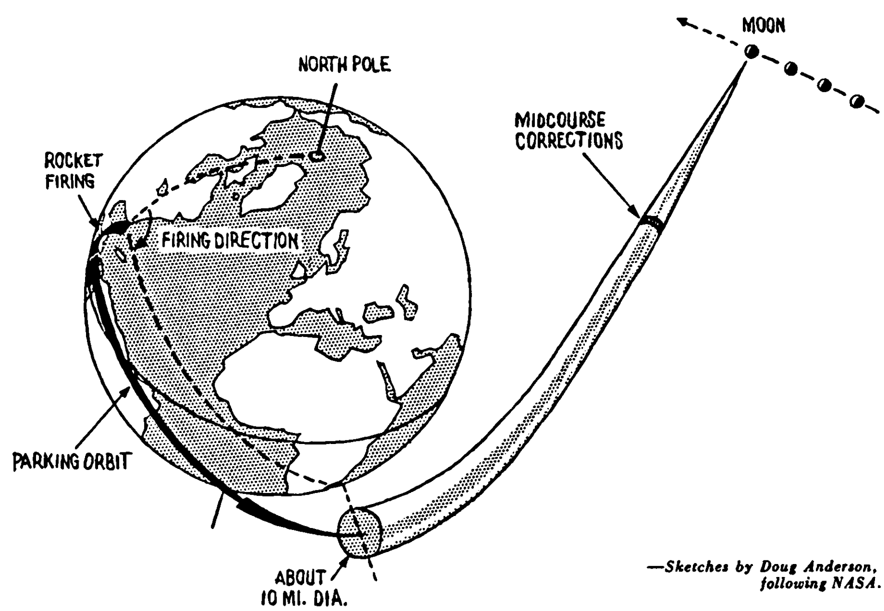
Technicalities interfered on July 27. But on July 28, nine minutes and fifty-two seconds before noon, EST, Ranger VII took off.

The Atlas carrier rocket lifted the Agena B rocket on its nose over the West Indies. As the Atlas dropped behind, the Agena B fired and coasted over the Atlantic. Off Africa's western coast, the Agena B fired again and fell away after driving Ranger VII into a ten-mile-wide tunnel of sky which should pass through the space the moon would enter in the early hours of July 31 when the Goldstone dish was directly below.

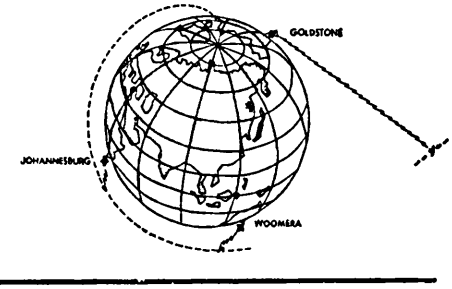
The guidance motors aboard Ranger VII carried only a small amount of fuel to correct any skewing that might occur in the tunnel entry. If a large correction had to be made, it should be soon. While the remaining pathway was still several hundreds of thousands of miles long, any given change in the angle of direction would have a proportionally greater leverage. The first good chance for correction came five hours after launch, when enough readings of Ranger VII's position were in hand to give a sure result. Ranger VII's trajectory then was so close to the ideal that the correction was delayed for eleven more hours. Then a relatively small landing place could be chosen. The choice fell at 11 degrees south latitude, 21 degrees west longitude. Ranger VII landed at 10.7 degrees south, 20.7 degrees west. At Goldstone the time was 5:25:49 A.M., PST, July 31.

This stunning achievement should not be mistaken for a purely American exploit. There must be a great triangle of earthly observation points for any continuous watch on interplanetary space (see bottom sketch, this page). Ranger VII's triumph belongs to Africa and Australia as well as to the United States.





—Sketches by Doug Anderson, following NASA.



tures taken in infrared and ultraviolet light. If the color of the moon were uniform, the red and blue images would cancel out into a neutral grey. However, the cancellation did not occur. Instead, the rocks of the moon displayed different colorations. The differences clearly lined up with structural formations normal to crater walls. These differences would not be observed if the rocks were coated thickly with dust.

The sand-blasting concept is not entirely new. It had been suggested earlier by Soviet scientists (who also had proposed chains of craterlets to explain the lunar rays). The blasting model furthermore fits observations reported sometime ago by Professor Thomas Gold of Cornell University. In telescopic pictures of the moon, Dr. Gold had read evidence of considerable erosion. As much as two and a half miles had been worn off the tops of mountains, he estimated. Accepting a common belief among astronomers that the oldest features of the moon were formed between 4,000,000,000 and 5,000,000,000 years ago, the British-born cosmologist had guessed that the erosion process proceeded exceedingly slowly.

The net sum of the evidence here recited is that the Congress and the people have been misled about the true significance of the Ranger VII mission. The pictures sent back home by the ingeniously constructed robot dragonfly contain no more assurance of the safety of a manned landing on the moon than existed before Ranger VII took off. On the contrary, one sure danger has been discovered that had not been suspected before. The apparent disappearance of the supposed danger of impenetrable dust is accompanied by the equal danger of a landing surface that may be as fragile as a tea biscuit. Ranger VII couldn't possibly have seen what matters most of all when human expeditions to the moon are being weighed: the bearing strength of the lunar face. Given man's present limited knowledge of soil physics, no photograph could tell whether the moon's surface will hold a spaceboat or even a lone man.

PERHAPS we should stop acting as though it were a foregone conclusion that a man could land on the moon. Perhaps we should stop pretending that we know how to keep him alive there if he could land. Perhaps a sense of humility in the face of frightening natural grandeur would not only fit the real circumstances but would actually add a dimension to our capability in dealing with forces immeasurably more powerful than ourselves. If NASA and JPL had been less arrogant in the past, they might not have suffered the indignity of public censure for carelessness in the Ranger program from the House Committee on Science and Astronautics. If, instead of taking the posture that "we have acted and we cannot be wrong," they had heard out friendly criticism and offered reasonable reply to questioners, it would by now be commonly understood that many of the misfortunes encountered by Ranger VII's predecessors were inevitable attributes of calculated risks.

Although Rangers I, II, and III all failed to achieve their advertised objectives, they did the pioneering essential to confirm the workability of the parking orbit concept. They proved that a rocket engine could be turned off to enter orbit at a set point and turned on again to leave orbit at another set point. Rangers IV and V also failed to perform as advertised. Yet they proved that the moon could be reached conveniently from a parking orbit by vehicles presently available with presently available chemical fuels. Ranger VI burned out its TV broadcasting apparatus before it got to the moon; nevertheless, it got there; furthermore, it came within a few miles of the spot at which it had been pointed, 238,000 miles distant from the pointers. Ranger VII, profiting from all the errors that had gone before, snapped photographs which Professor Kuiper has described as 2,000 times sharper than the best pictures ever taken through a telescope on earth.

Even in the incandescent glow of the triumph of Ranger VII, however, JPL was still unable to overcome its weakness for Olympian claims. The moon map it displayed before a nationwide TV audience (see page 42, bottom, left) made it appear that Ranger VII's picture-taking range encompassed about a third of the sunlit moon visible to earth. The camera eyes did sweep out that area, true. But the first two-thirds of the pictures taken were not as informative as ground-based telescope photos. By the time Ranger VII's cameras were close enough to the moon to bring out detail comparable to the detail visible through telescope lenses, the area covered by the pictures was only a fraction as big as JPL's boasts (see page 41). And the "2,000 times better" photos referred to by Professor Kuiper showed much smaller patches of the moon.

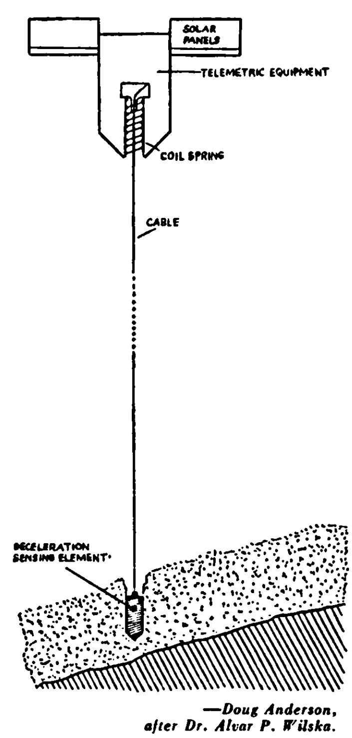
When a magnificent tool is at hand, intelligence commands its productive use. The Ranger vehicle now ranks in that category. Professor Kuiper's responsibility as chief scientific investigator for NASA extends only through Rangers VIII and IX. But during our long conversation here he repeatedly expressed the opinion that the hundreds of men who contributed to JPL's ultimate success in the Ranger project had built up a combination of skills too valuable to be dismantled. "The JPL team must be held together," he said. "Its disintegration would be a calamity."

If international prestige can help hold the team together, Professor Kuiper is functioning as an effective adhesive. He made up an album of the 200 pictures snapped by Ranger VII's "A" camera (the one with the largest field) and entered it in the scientific literature at the regular meeting of the International Astronautical Union in Hamburg, Germany, on August 31. In this manner the pictures were opened to analysis and interpretation by astronomers, cosmologists, and geophysicists everywhere. The authenticity of the document can be attested by any layman familiar with television broadcasts. In the first two of Ranger VII's picture frames, stutter lines appear just as they do when the TV set at home is warming up.

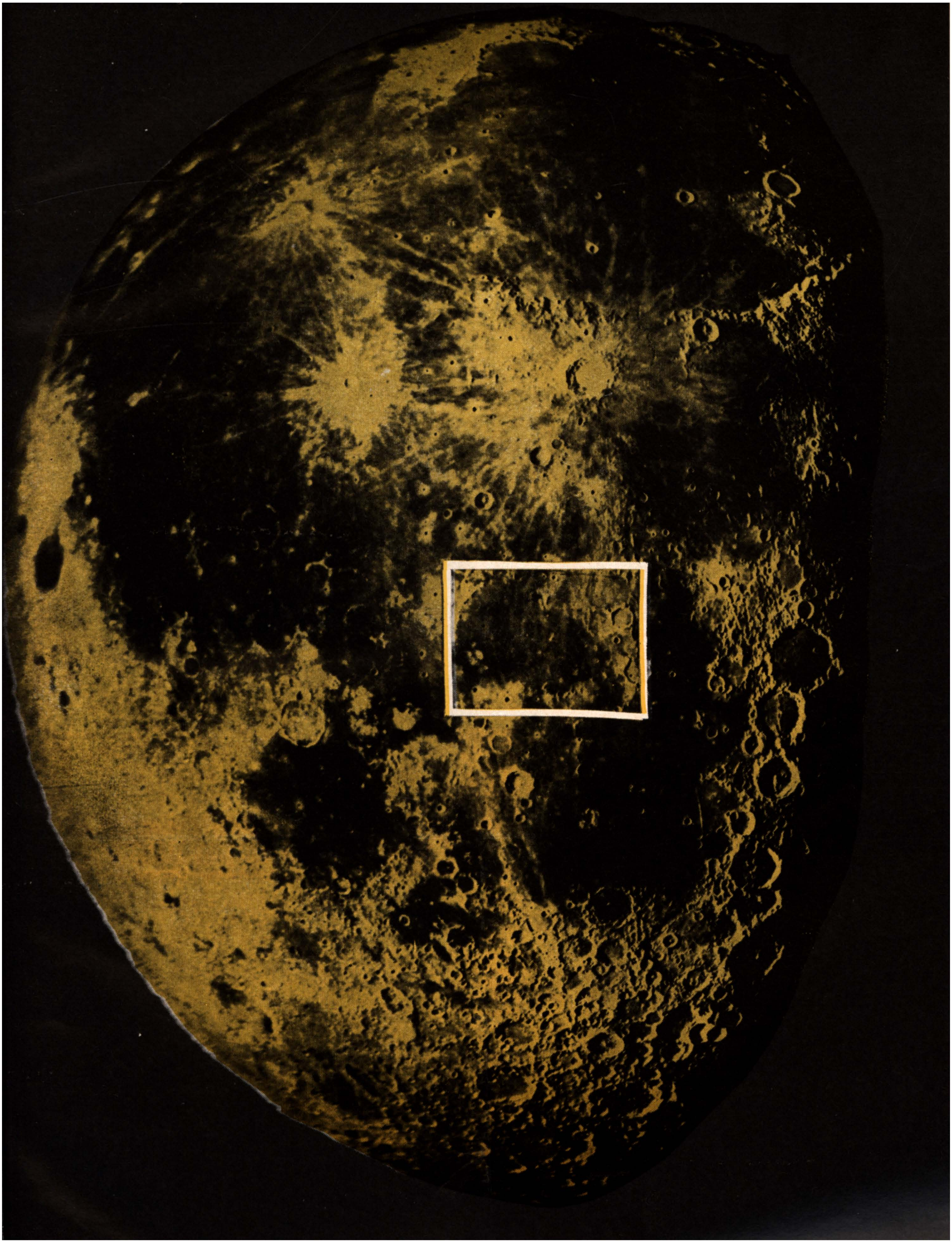
—JOHN LEAR,
Science Editor.

Gunning the Moon

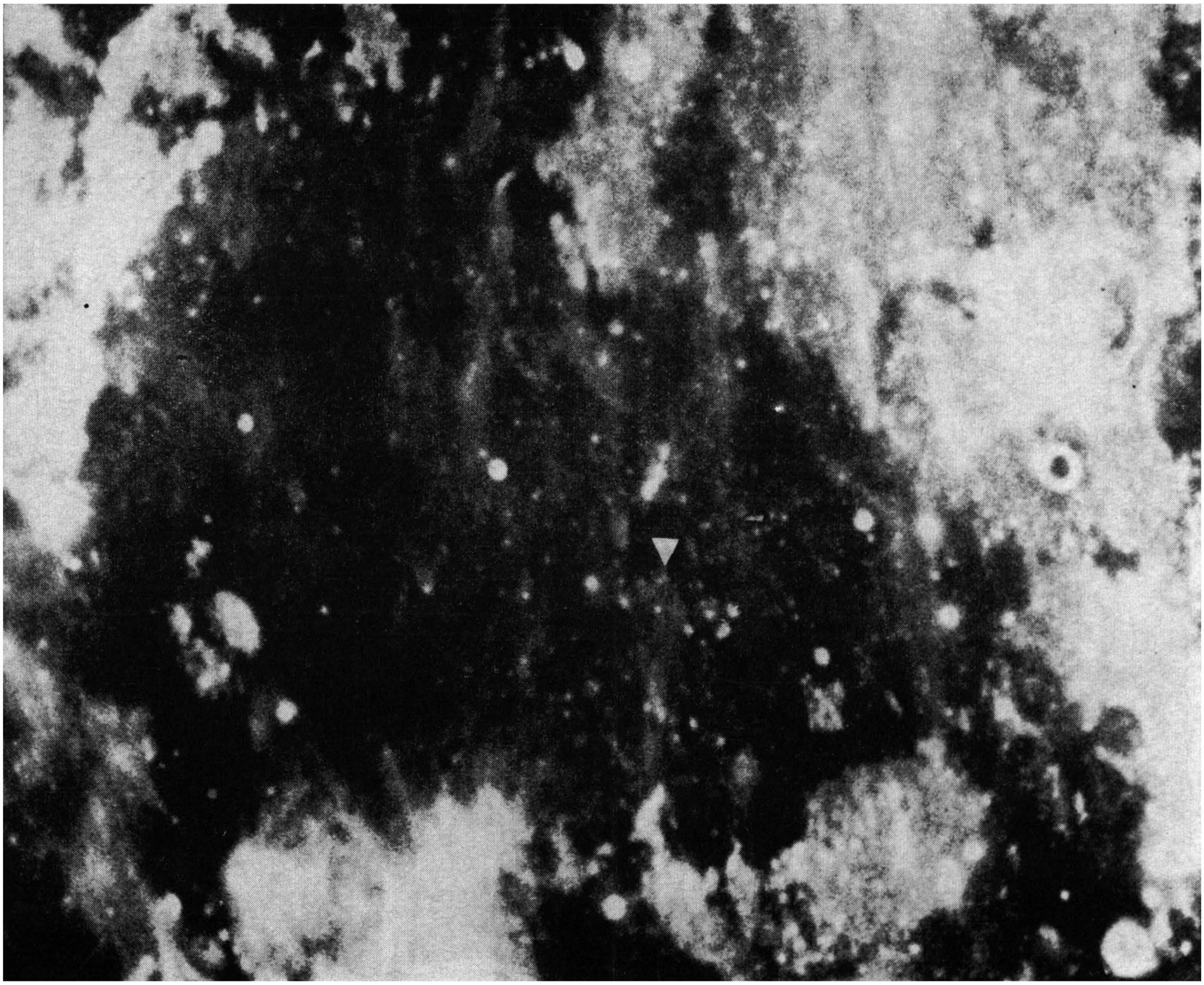
DR. ALVAR P. WILSKA, Finnish-born physician-physicist in the Lunar and Planetary Laboratory of the University of Arizona, offers the following proposal for determining the bearing strength of the moon's surface. A Ranger vehicle would carry within it a hollow cylinder like a gun barrel. Inside the barrel a spring would be coiled behind a steel plummet. Within the plummet would be a rugged accelerometer calibrated to register changes in speed. Seconds before the Ranger was due to crash on the moon, the spring would be released, firing the plummet with a trailing umbilical cable through which the accelerometer readings would be flashed in simple dot-dash code to a radio transmitter in the Ranger.



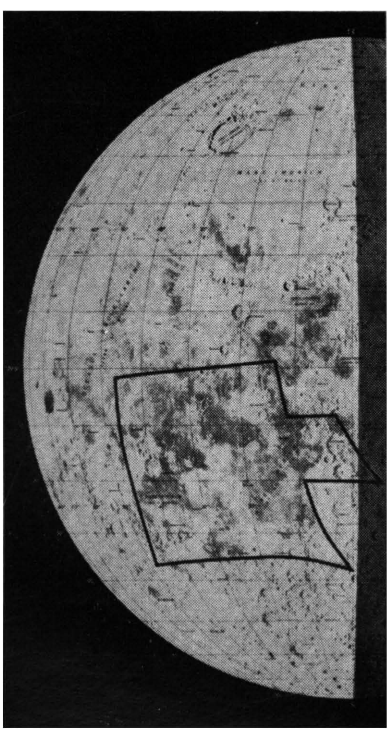
—Doug Anderson, after Dr. Alvar P. Wilska.



Moon at third quarter. Photo courtesy Lunar and Planetary Laboratory, University of Arizona.



—Courtesy Lunar and Planetary Laboratory, University of Arizona.

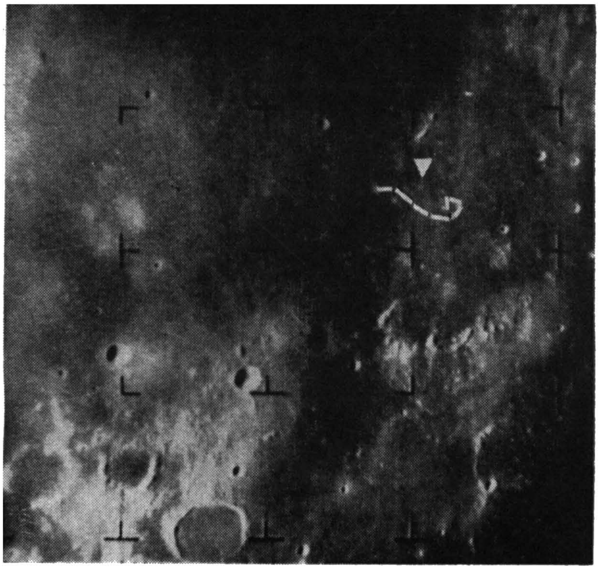


—JPL—NASA.

THE ASSIGNMENT WAS TO PHOTOGRAPH THE MOON SO CLOSE UP that if a dwarf should be lying there sunning himself his presence would be clearly outlined. To obtain such clarity, the picture scanning frame was filled with 800 resolution lines, half again as many as are on a standard TV screen. Two independently powered batteries of cameras were used: one with two lenses, the other with four. The two-camera battery took big pictures; the four-camera battery took only the central 200 of the 800 lines. Since the smaller pictures could be snapped faster, the cameras taking them could continue snapping up to 1,000 feet off the moon.

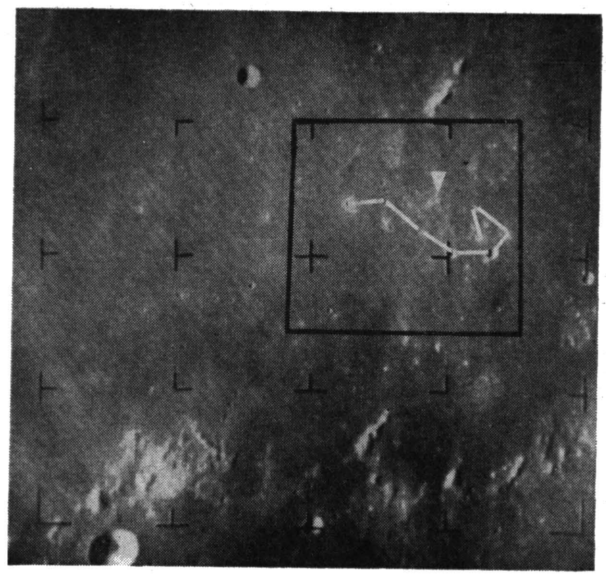
The first big pictures covered the area marked on the moon map at the left. These were less clear than pictures taken through telescopes on earth, and Ranger VII's snapshots did not equal telescopic clarity until the area covered shrank to the size of the white-bordered rectangle on page 41. The telescopic photo immediately above these words corresponds to that white-bordered rectangle and to the Ranger VII picture at top left on page 43. Captions on page 43 log Ranger VII's plummeting. The crash landing site is marked by the point of a small solid white triangle in each photo.

Watch the fuzzy white spotted ladle under the white triangle in the picture on this page sharpen and grow in the page 43 photos until it is too large to be seen. After the last vestige of the ladle disappears, all details in subsequent photos are invisible to earth.



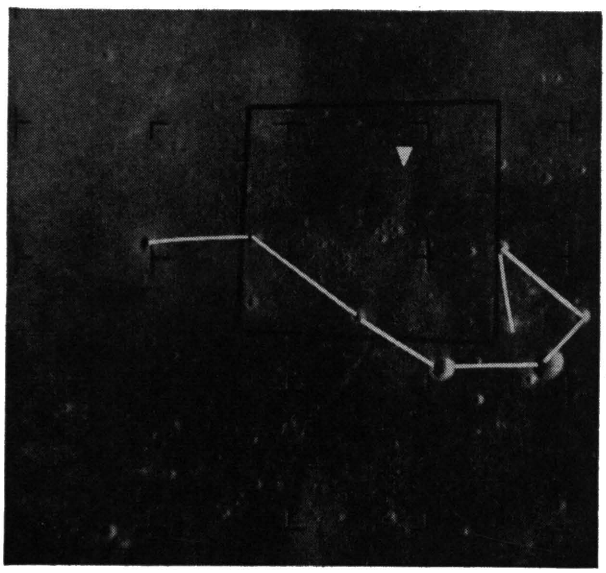
—JPL—NASA.

Snapshot 480 miles above the moon.



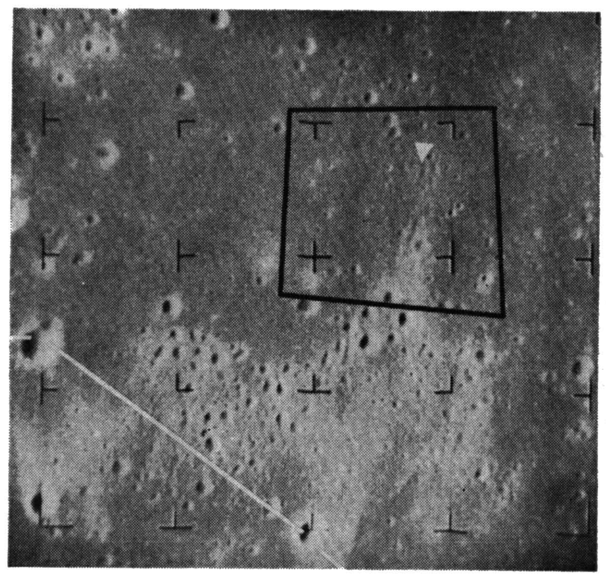
—JPL—NASA.

235 miles up; 113 miles wide.



—JPL—NASA.

85 miles up; 41 miles wide.

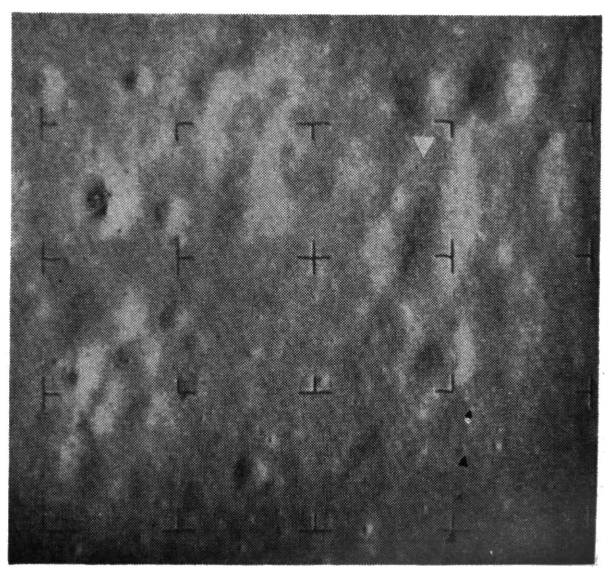


—JPL—NASA.

34 miles up; 16 miles wide.

—JPL—NASA.

12 miles up; 4 miles wide.



—JPL—NASA.

3 miles up; 1⅓ miles wide.