NASA FACTS

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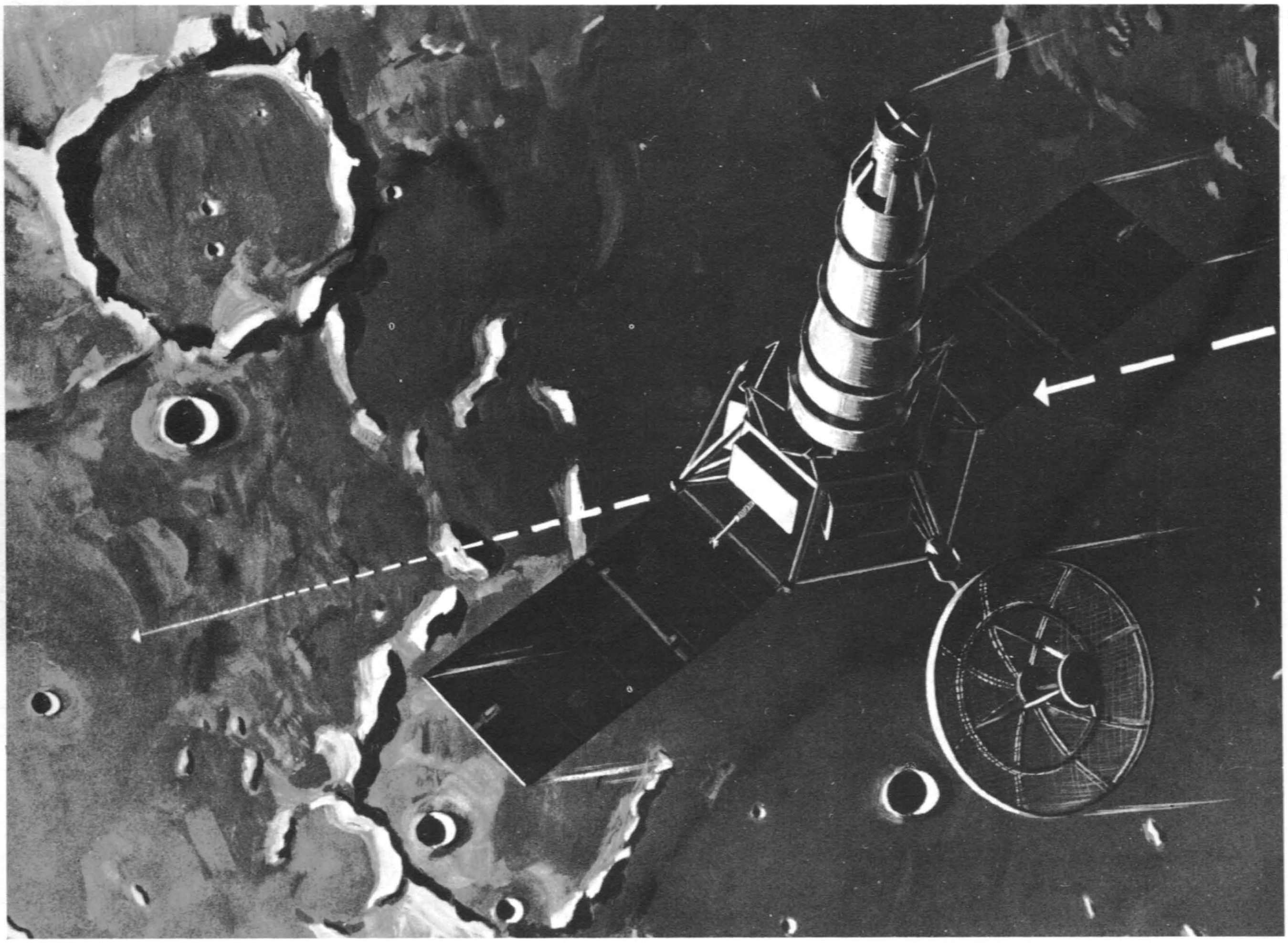
PROJECT RANGER



Ranger plummets towards the moon. Broken arrow indicates flight path (artist's sketch).

Before man can journey safely to the moon, he must acquire information that has defied centuries of observation. An important step toward meeting this requirement is NASA's Project Ranger which, on July 31, 1964, gave man a closer look than ever before at the moon.

Knowledge of the moon has been based largely on observations through telescopes on earth. This knowledge is seriously limited by the moon's great distance from earth and by earth's atmosphere, which veils or distorts lunar images. The resolution, or ability to distinguish objects, of earth's most powerful telescopes permits man to detect lunar objects no smaller than a half mile in size. Ranger VII, launched July 28, 1964, telecast pictures to earth that revealed lunar features as small as 15 inches across. The craft transmitted the photographs on July 31 before it crashed in the northwest corner of Mare Nubium—the Sea of Clouds—about eight miles from its targeted impact area. This area now has been designated the Mare Cognitum by the International Astronomical Union. The term "Mare," which is "sea" in Latin, was given to certain areas of the moon by early astronomers.

OPENS NEW ERA IN LUNAR ASTRONOMY

Although relatively near earth as compared to other celestial bodies, the moon is fundamentally still a scientific mystery. Astronomers have mapped the moon's visible face and have named its perceptible craters, mountains, valleys, and plains. But, unable to discern the fine details of the lunar surface, they debate its structure and strength.

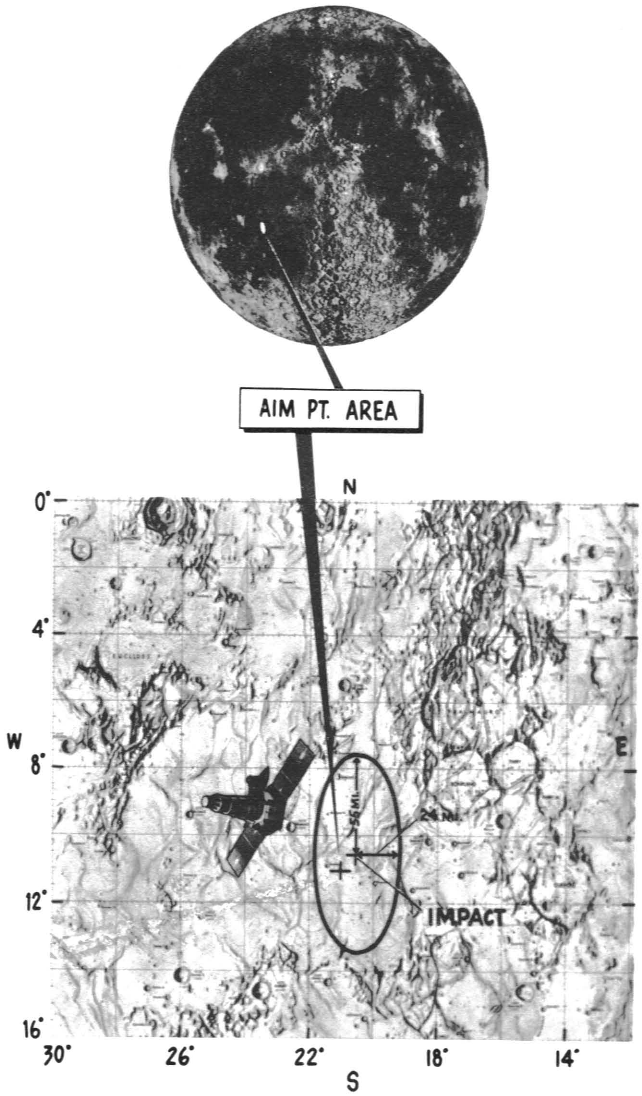
As a result, engineers designing the landing gear for the Surveyor soft-landing spacecraft and the Apollo section that American explorers will land on the moon's surface (the section is called the Lunar Excursion Module, or LEM) are concerned whether a landing site that appears from earth to be smooth and firm is actually so. They ask whether it could be a vast dust bowl capable of engulfing a spacecraft. They wonder whether it is strewn with boulders or pitted with craters too small to be seen from earth.

Ranger VII opened a new era in lunar astronomy by sending pictures of the moon showing features 2000 times smaller than previously detectable through earth based telescopes. Dr. Gerard P. Kuiper, who heads a team of scientific investigators studying the Ranger VII photographs, presented an interim report on August 28, 1964. Highlights of the report included:

. . . The seemingly smooth Sea of Clouds is dotted by thousands of small craters that do not show up on photographs taken through telescopes on earth.

. . . An outlying ray of the Crater Tycho is peppered with craters. Lunar rays appear through earth telescopes as light streaks radiating from some craters.

. . . With the exception of several chunks of matter in one crater, no boulders were visible.



Photograph of moon (above) outlines aiming point area in Sea of Clouds where Ranger VII landed at 6:25:49 a.m. EDT, July 31. Map (below photograph) shows targeted and actual impact points.

Also notable was the absence of fissures in the lunar surface.

. . . Based on a study of pictures taken about 1600 feet above the moon, 90 percent of the slopes of the lunar surface are calculated to be between one and fifteen degrees. This appears to be more level than previously anticipated.

. . . While some areas are clearly unsafe for landing, others are believed to be sufficiently level and smooth for touchdown by the Apollo Lunar Excursion Module as presently designed; however, no knowledge of the surface strength could be obtained from the Ranger photographs.

RANGER VII is the first of the Ranger series of spacecraft to provide close-up photographs of the moon. Plans call for Rangers VIII and IX to augment this information. Of earlier spacecraft in this series, Rangers I and II were test vehicles not intended for lunar picture taking; Rangers III and V missed the moon and soared into orbit around the sun; and Rangers IV and VI struck the moon but failed to send data.

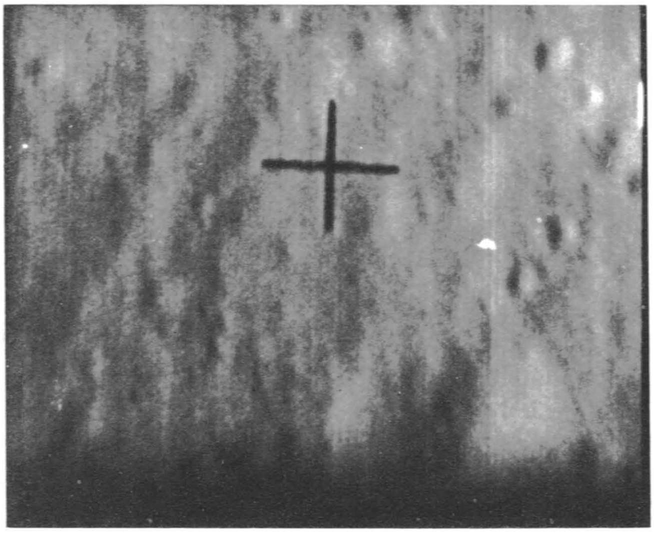


Photo taken by Ranger VII at 3000-foot altitude shows area 100 feet in each side. Note rounded shoulders of secondary craters (see text).

. . . Most of the craters revealed for the first time by Ranger photographs are believed caused by debris that was thrown up by collisions of meteoroids (random chunks of matter speeding through space) with the moon. The main crater created by the meteoroid impact has been termed a primary crater. The debris from these primary craters may fly many miles before falling back to the lunar surface. The craters resulting from matter thrown up by the impact of this debris are called secondary craters. There may also be craters created by matter thrown up from the secondary craters.

. . . Primary craters may be identified by their sharply defined edges as contrasted with the relatively rounded shoulders of the secondary craters. The rounded instead of sharp edges are believed to be partly due to the lower impact velocities of the debris thrown from the larger primary craters.

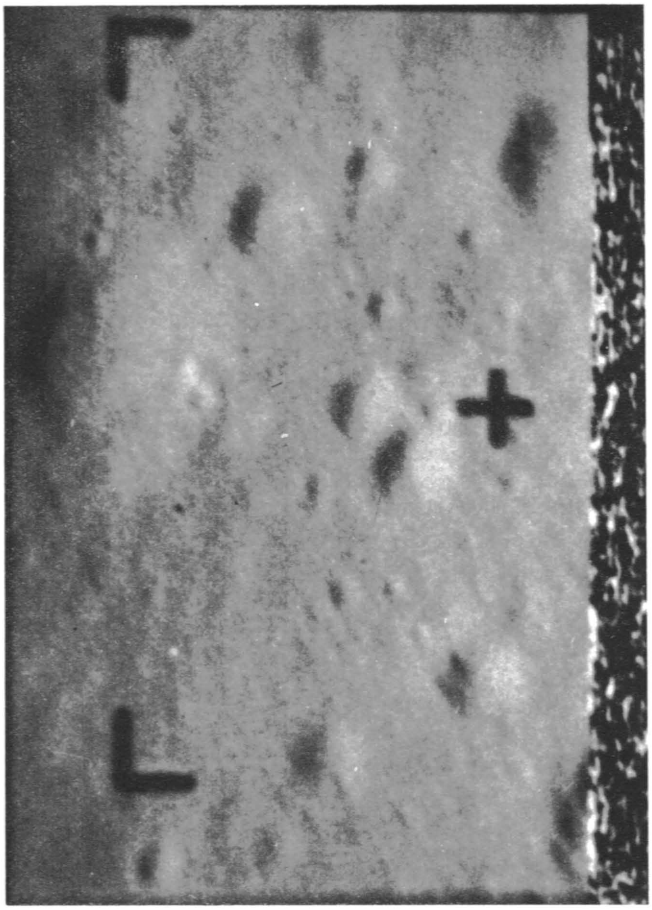
. . . What appear to be lava flow lines are visible. One lunar theory holds that some craters are the remains of extinct volcanoes. For a long time, scientists believed that the moon had no further volcanic activity. In recent years, however, astronomers on earth have observed through their telescopes what appear to be gaseous emissions from the moon's interior.

. . . Erosion seems to be a significant force on the moon despite the absence of wind and water. It is theorized that incessant bombardment by meteoroids and by protons (particles of atoms) emanating from the sun may have pulverized the boulders, filled the fissures, and smoothed the edges of the less sharp secondary craters.

Experimenters cautioned that the Ranger photographs which cover a relatively small area of the moon are not necessarily typical of the moon as a whole and they strongly emphasized that their findings are preliminary. They stressed that the Ranger pictures are designed to advance knowledge about the moon's topography only and that the Surveyor program is intended to provide information about the strength, or hardness, of the moon's surface.

Ranger VII sent an aggregate of 4316 pictures of the moon as it plummeted to the lunar surface. The photographs have been made available to scientists throughout the world. It is anticipated that these photographs will receive close attention and study by lunar scientists for many years to come.

The only other spacecraft to provide man with photographs of the moon is the Soviet Lunik 3. In 1959, Lunik 3 took about 30 pictures of the moon's hidden side (see "The Moon," below) from distances of 4300 to 43,000 miles. The pictures gave no fine detail, but did indicate that possibly the moon's hidden portion may not be as rugged as the area visible from earth.



Last picture by Ranger VII, taken about 1600 feet above the moon, reveals features as small as 15 inches across. Receiver noise pattern at right results from spacecraft crash on the moon while transmitting.

THE MOON

Although many lunar features are beyond the reach of his ground-based instruments, man does have significant facts: The moon's diameter is 2163 miles, about one-fourth that of earth. Its gravity is one-sixth that of earth, meaning that a 156-pound man on earth would weigh only 26 pounds on the moon. The moon's mean altitude in its elliptical orbit around earth is 238,857 miles.

The moon takes about 27⅓ days to revolve around earth and the same time for one complete rotation on its axis. For this reason, the moon always presents the same face to earth.

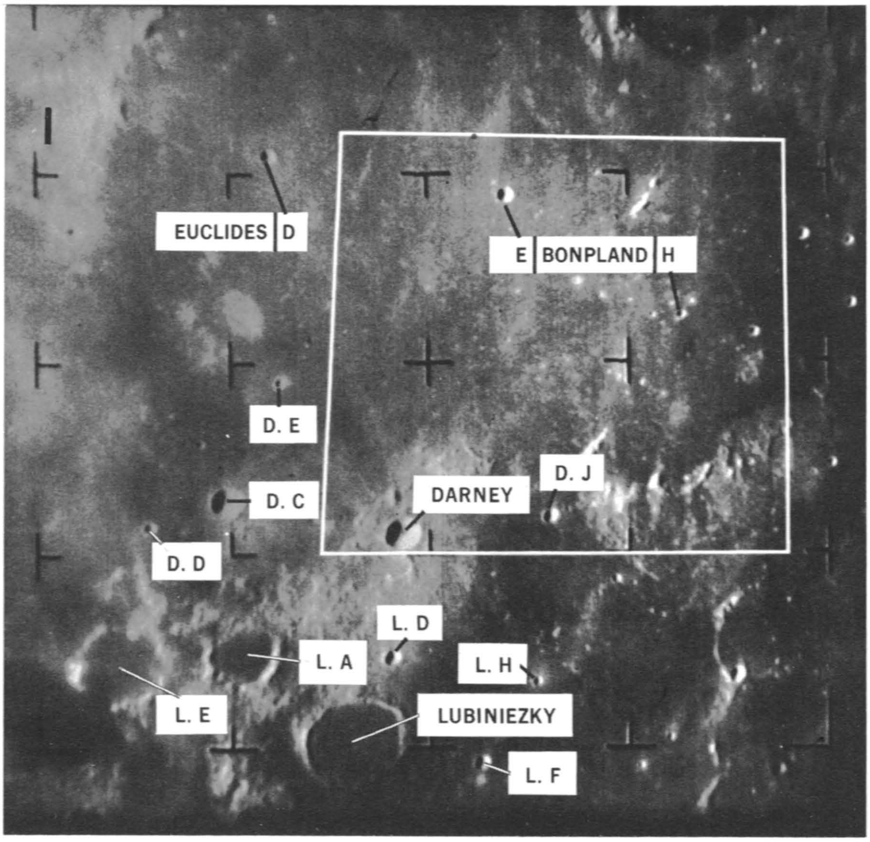
However, about 59 percent rather than the expected 50 percent of the lunar surface is visible from earth. This is due to the moon's librations, which are to and fro, or nodding, motions that result from slight changes in velocity and the gravitational pulls of the sun and planets as the moon circles earth.

The moon is believed to have no appreciable atmosphere to diffuse light and heat nor to shield it from bombardment by meteoroids and radiation. Day and night, the stars, sun, and earth and other planets shine steadily in the moon's jet black sky. During the day (which is about 13⅔ earth days and nights), the moon's surface may be as hot as 260 degrees Fahrenheit while during the equally long night the temperature falls as low as 243 degrees below zero Fahrenheit.

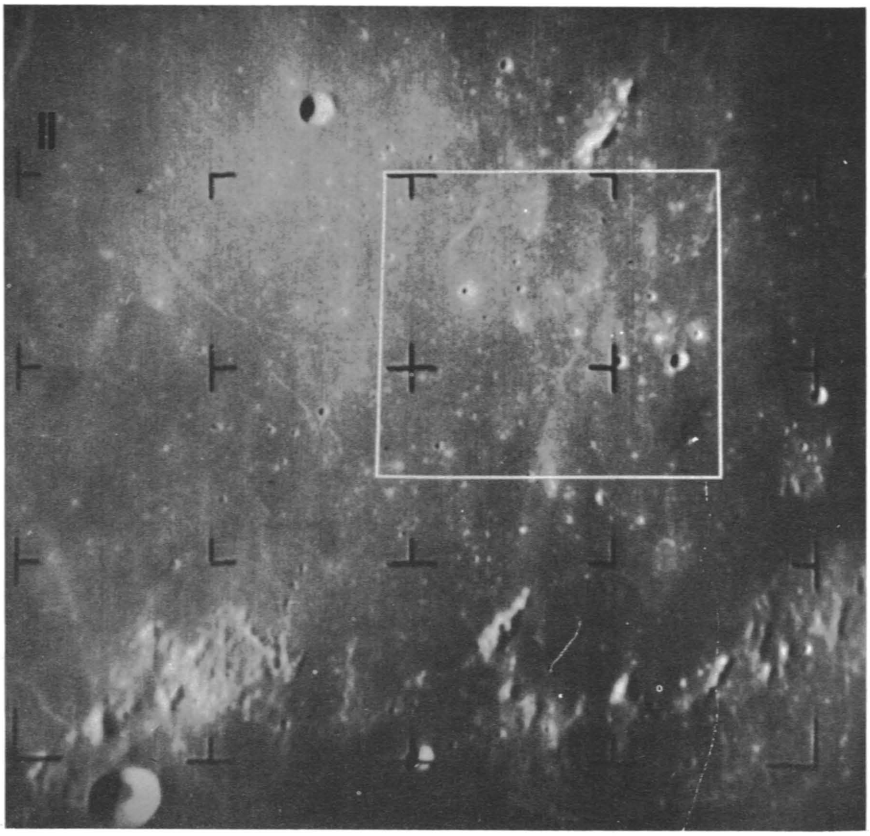
Some scientists believe that the primeval moon was captured by earth's gravity as it flew nearby during an early stage in the solar system's formation. Others theorize that the moon was torn from the primordial earth.

Eroded by neither wind nor rain, the moon's matter immediately below the level affected by meteorites and radiation may have changed little during the satellite's lifetime. As a result, the moon may offer an opportunity to study the matter of the solar system as it was billions of years ago. Just as the Rosetta Stone gave the first clue toward deciphering Egyptian hieroglyphics, study of lunar material may help answer key questions regarding the origin and evolution of the solar system and perhaps how life may have begun.

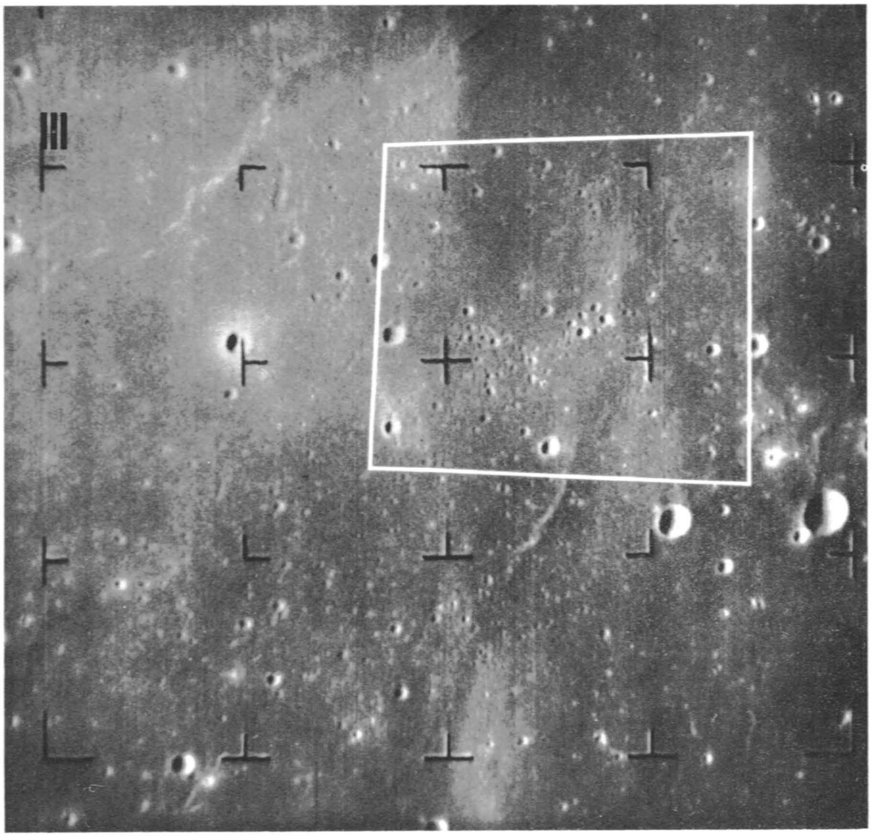
Some telecasts by Ranger VII as it plunged toward moon's surface. In each picture, the area covered by the next photograph is outlined in white. Black lines, drawn on camera lens, are used for scale references and as an indication of whether picture is distorted. North is at top.



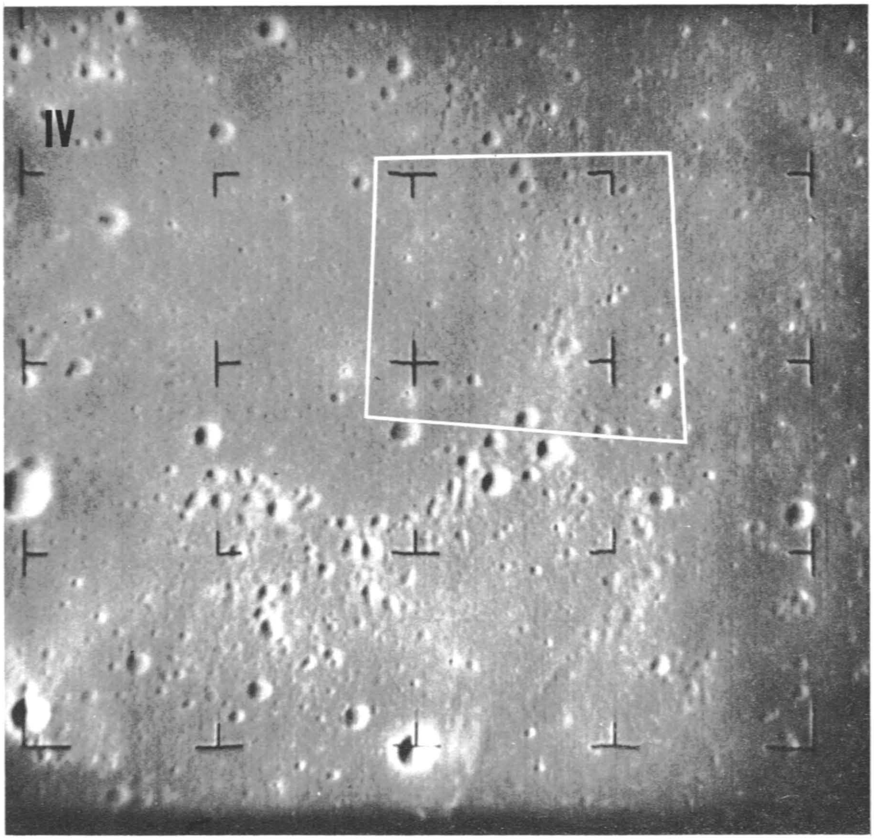
Picture taken at an altitude of 480 miles, has about the same resolution as photographs by earth-based telescopes. A number of physical features visible from earth are identified.



Altitude: 235 miles.
Area: 113 miles on a side.
Smallest Visible Crater: About 1000 feet in diameter.
Feature: Note increase in detail of Bonpland H and its twin crater (to left of Bonpland H).

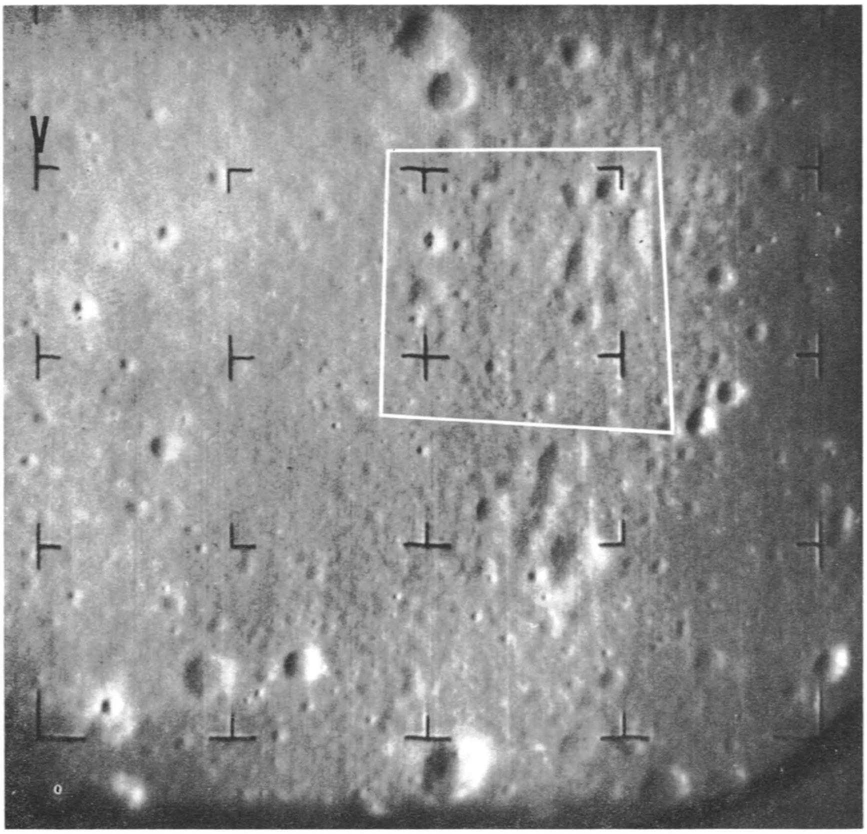


Altitude: 85 miles.
Area: 41 miles on a side.
Smallest Visible Crater: About 500 feet in diameter.
Features: Cluster of secondary craters in part of a ray of the Crater Tycho becomes distinct (center of picture. Lunar rays appear from earth to be light lines radiating from some craters). Detail of Bonpland H and twin crater is increased.

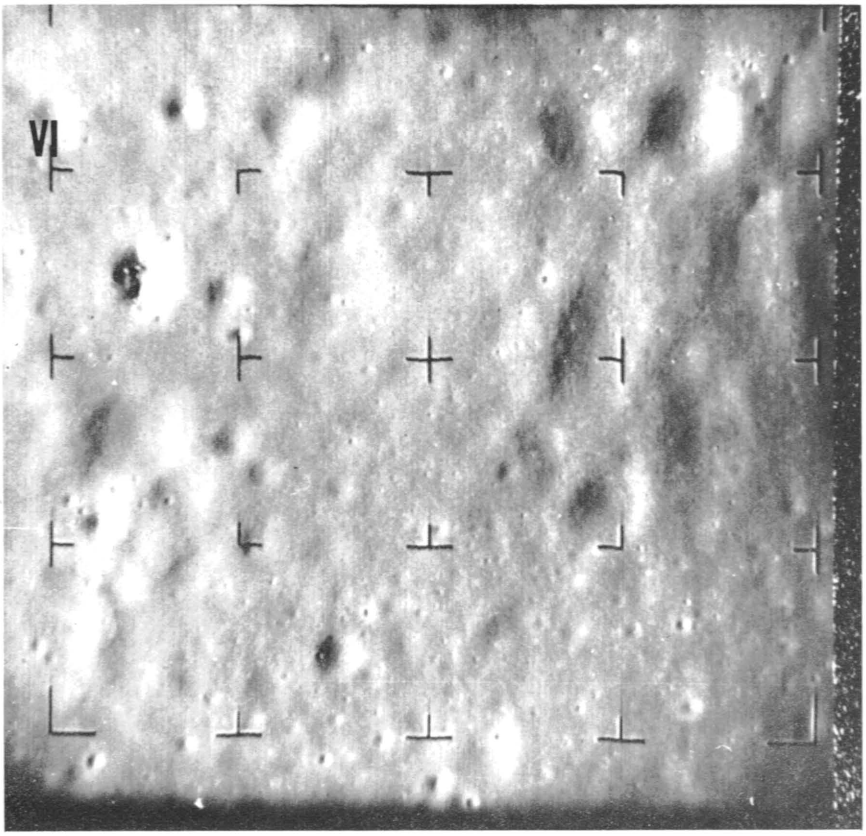


Altitude: 34 miles.
Area: 16 miles on a side.
Smallest Visible Crater: About 150 feet in diameter.
Features: Greater resolution of craters in outlying ray of Tycho.

Picture series continued on page 7.



Altitude: 11 miles.
Area: 5.5 miles on a side.
Smallest Visible Crater: About 45 feet in diameter.
Features: Crater near upper left of area outlined in white.



Altitude: 3.6 miles.
Area: 1.8 miles on a side.
Smallest Visible Crater: 30 feet in diameter; 10 feet deep.
Features: Angular rock mass in crater (noted in picture above) at upper left. Preliminary study indicates the mass to be several separate chunks.

THE RANGER TELEVISION SYSTEM

The remarkably clear pictures of the moon telecast by Ranger VII were accomplished by a complex high quality system of television cameras and transmitters on Ranger and a ground receiving network at the Goldstone, Calif., station of NASA's global Deep Space Network. This network tracks, controls, and gathers information from NASA spacecraft sent to the moon and beyond.

Ranger is equipped with six television cameras and associated transmitters and power supplies. The system is mounted on the spacecraft's hexagonal base within a compartment shaped like a truncated cone.

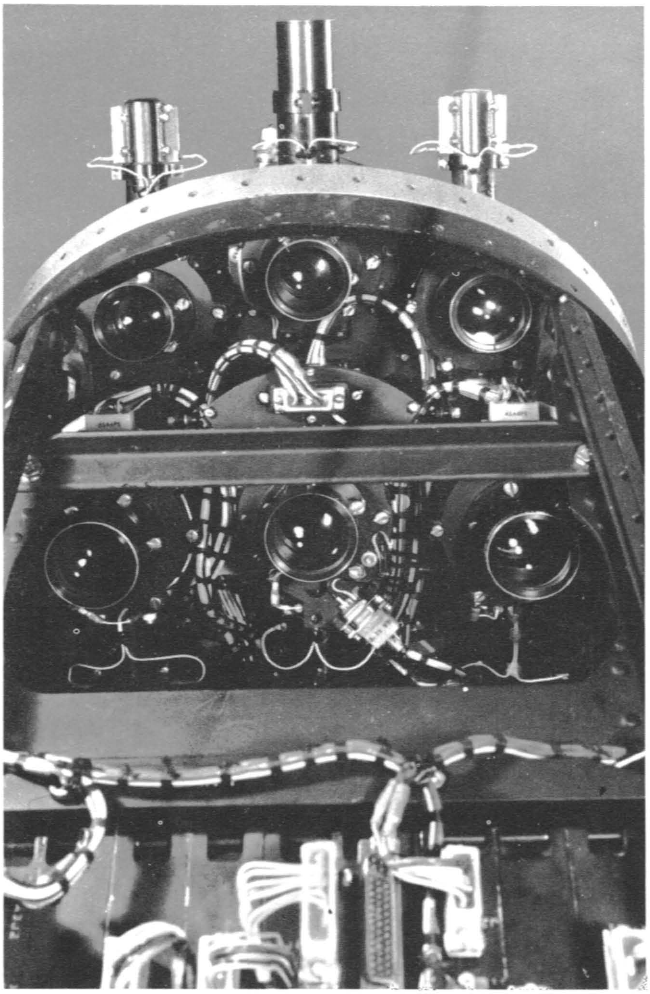
The system includes two full-scan (F) and four partial-scan (P) cameras. Their difference is that the F cameras shoot a larger area than that of the P cameras but the P cameras can pick up more detail.

The television system is designed to telecast about 300 pictures a minute during the 15 to 20 minutes before Ranger crashes on the moon. The first pictures show about as many details as the best telescopes on earth. The last few telecasts reveal lunar features smaller in size than a bushel basket.

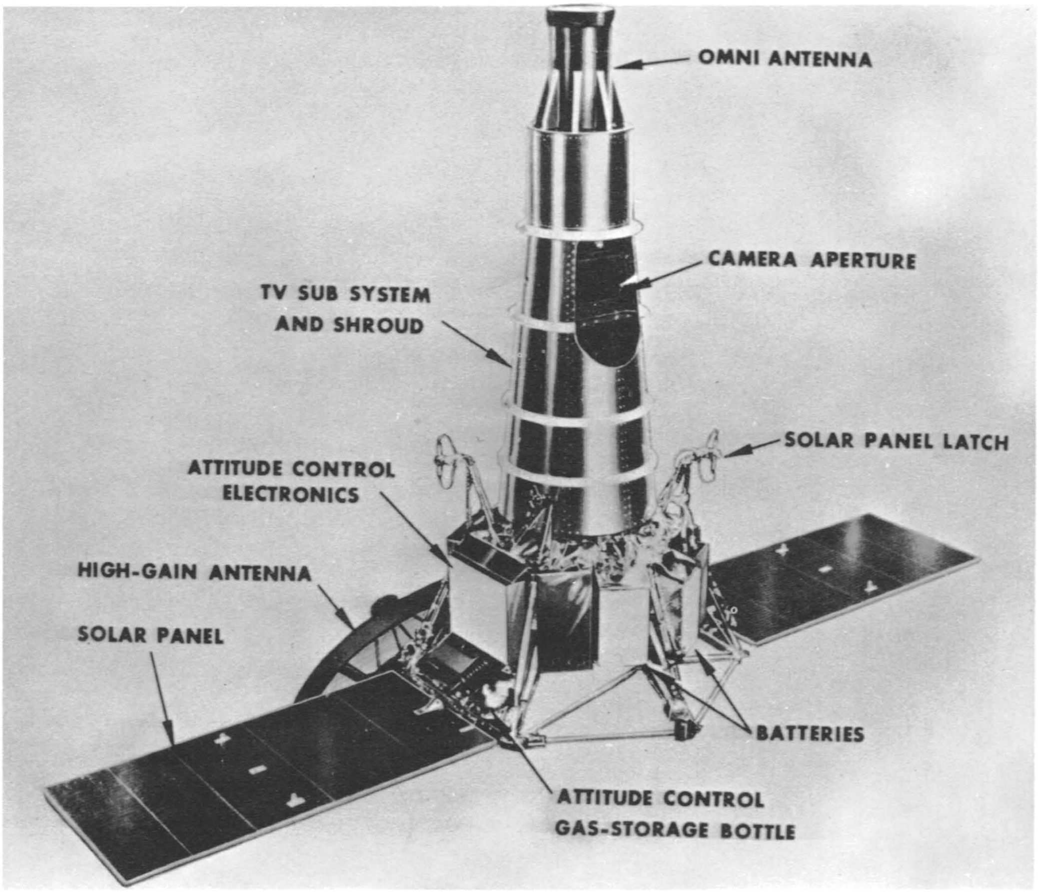
Behind the shutter of each camera is a vidicon tube about the size of a water glass. The tube's faceplate is coated with a photo-conductive material on which light and dark areas seen through the camera shutter form an image. This image is rapidly scanned by a beam of electrons. The beam can differentiate light and dark areas by their comparative resistance (light areas have high resistance; dark areas, low). As the electron beam sweeps across the image, it is converted into an electrical signal that is amplified and radioed to earth. The vidicon faceplate image is erased so that it can take new pictures by saturation with high intensity special lights and high frequency electron beams. The whole process takes a fraction of a second.

The radio signals from Ranger are picked up by the 85-foot diameter antennas at the Goldstone station, amplified, and fed to two kinescopes which are similar to small television sets. Before these sets are 35-mm. cameras. The signals are also recorded on magnetic tape similar to that used by television studios to record live shows for later telecasts.

The radio signals appear on the television sets as a dot of light moving across the screen. The camera lenses are set to stay open long enough to photograph the light through a complete sweep over the screen. By this means, the cameras make meaningful still photographs.



Head-on view of Ranger's six television cameras. The pictures received from Ranger are more than twice as good as those received on ordinary home television sets.



Principal equipment of Ranger. (On-board rocket is not visible in this view.)

THE RANGER "BUS"

The Ranger "bus" is the basic vehicle to which the experiments (in this case, the television system) are attached. It contains Ranger's principal power supply; telemetry instruments to report on the spacecraft's condition and operation; a command system to enable personnel on earth to control the craft; timing, orientation, and temperature control devices; and a small rocket system for in-flight correction, if required, of Ranger's course.

Ranger sends information to earth principally through a dish-shaped, high-gain antenna. This kind of antenna focusses radio signals in a narrow beam, thus sending a signal with maximum strength in a given direction.

Ranger is also equipped with an omni-directional antenna which disseminates radio signals in all directions. Although the signals from the omni-directional are far weaker than those from the high-gain antenna, they serve as a communications link when the high-gain antenna is not pointed to earth (as during launch and mid-course correction. See "From the Earth to the Moon," below.) The omni-directional antenna also functions at all times to receive commands from earth to the spacecraft.

During Ranger's flight, two solar panels extend from it like butterfly wings. The panels hold a total of 9792 solar cells. These photoelectric devices convert sunlight into 200 watts of electricity for powering spacecraft equipment. Auxiliary power is furnished by two silver zinc storage batteries which are used when the solar panels are not functioning, particularly during launch when they are still folded and during mid-course correction.

During its flight, Ranger must be positioned so that its solar panels face the sun for power and its high-gain antenna points to earth. A complex system of sun and earth sensors, gyroscopes, and nitrogen gas jets keep the craft oriented.

Ranger's rocket engine can operate in bursts as short as 50 milliseconds (50/1000ths of a second). It can generate as much as 50 pounds of thrust for 98½ seconds.

Telephone statement by PRESIDENT LYNDON B. JOHNSON to Dr. Homer E. Newell, NASA Associate Administrator for Space Science and Applications, and Dr. William H. Pickering, Director, Jet Propulsion Laboratory, Pasadena, Calif. July 31, 1964 . . .

"On behalf of the whole country, I want to congratulate you and those associated with you in NASA and the Jet Propulsion Laboratory and in the industrial laboratories. All of you have contributed the skills to make this Ranger VII flight the great success that it is. We are proud of the tremendous technical achievement which this successful flight represents.

"This is a basic step forward in our orderly program to assemble the scientific knowledge necessary for man's trip to the moon.

"The pictures obtained of the lunar surface should prove extremely useful. They will be a guide in constructing the lunar excursion module and in planning the trip. We shall now be able to better map out our descent route. We'll be able to build our lunar landing equipment with greater certainty and knowledge of the conditions which our astronauts will encounter on the moon.

"I recognize that this great success has come only after a number of failures and partial failures in our efforts to send probes to the moon. This success should spur us on to added effort in the future.

"The fact that our Soviet competitors have had many unpublicized failures to the moon and the planets also confirms the complexity of today's success.

"On behalf of a grateful nation let me again congratulate you on this magnificent achievement. All of you today have helped further the peaceful exploration of space."

SPACECRAFT DIMENSIONS

At launch, Ranger is 5 feet in diameter at its hexagon-shaped base and 8¼ feet long. When cruising in space with solar panels and high-gain antenna extended, Ranger spans 15 feet across the panels and is 10¼ feet long. Ranger weighs 806½ pounds, of which 381½ pounds is the TV system.

LAUNCH CONSIDERATIONS

Among major considerations governing Ranger launches are the requirements that it must obtain useful photographs of the moon and that the orienation system must be able to do its work.

The launch must be timed so that Ranger reaches the moon's sunlit portion when long shadows will be cast by any but smooth physical features. Caught by the cameras, the shadows indicate how rugged or flat the land is. Such information is important to science and vital for manned landings.

Moreover, attitude control requirements make unacceptable the periods of the new and full moon. The spacecraft must lock upon the earth and sun for orientation, and in these periods, the sun and earth sensors cannot adequately orient Ranger. Technical limitations on target areas and on satisfactory lighting angles preclude launchings during the moon's first quarter.

These two factors limit Ranger's launch to a period during the moon's third quarter (see sketch).

Other constraints are the location of the Cape Kennedy, Fla., launch site and the two thousand mile per hour speed at which the moon circles earth. As a result of these and other considerations, the launch window (time interval) for Ranger's flight to the moon is restricted to periods of from 90 to 150 minutes daily during a 6-day period that occurs about every 28 days.

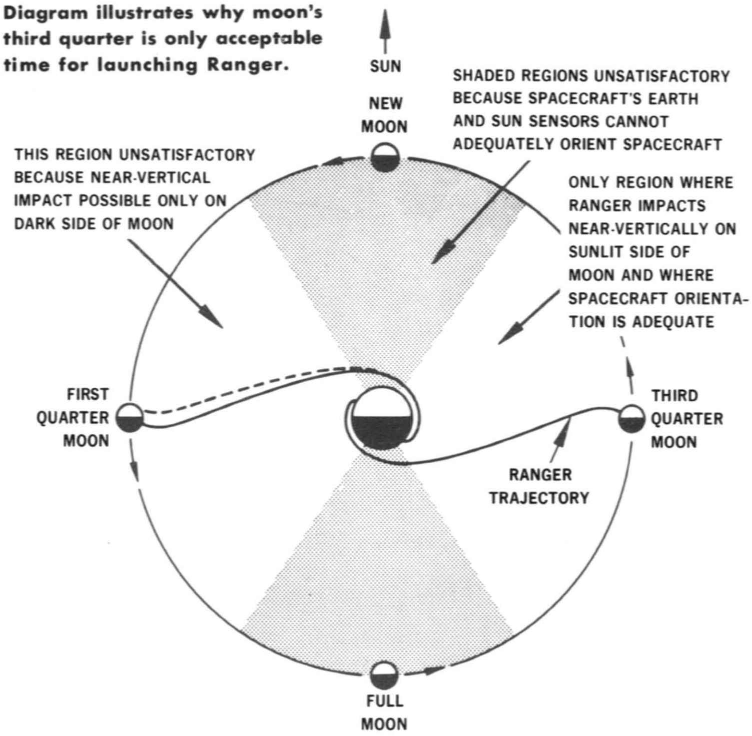
When rocketed to the moon at about 24,500 miles per hour, Ranger must be centered within a ten-mile-wide imaginary corridor leading to where the moon will be when Ranger reaches the altitude of the moon's orbit. In aiming their craft along its narrow curving flight path, launch personnel must consider not only the effects of the gravitational pulls exerted by the earth and moon but also by the sun, Jupiter, Mars, and Venus. All influence the motion of a spacecraft coasting between the earth and moon.

FROM THE EARTH TO THE MOON

In brief, Ranger's flight plan is as follows:

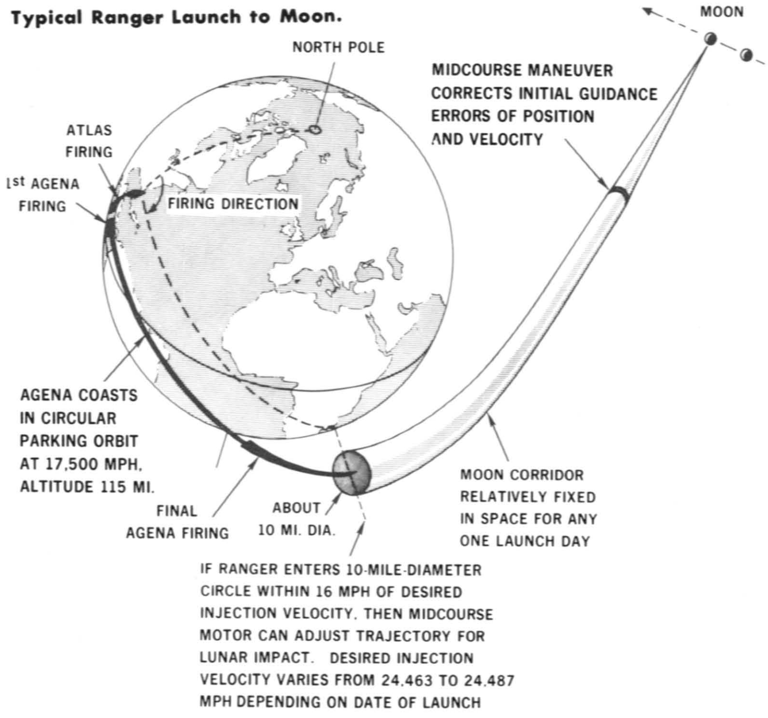
A two-stage Atlas-Agena launch vehicle rockets Ranger from Cape Kennedy. The Atlas exhausts its fuel and falls away. The Agena

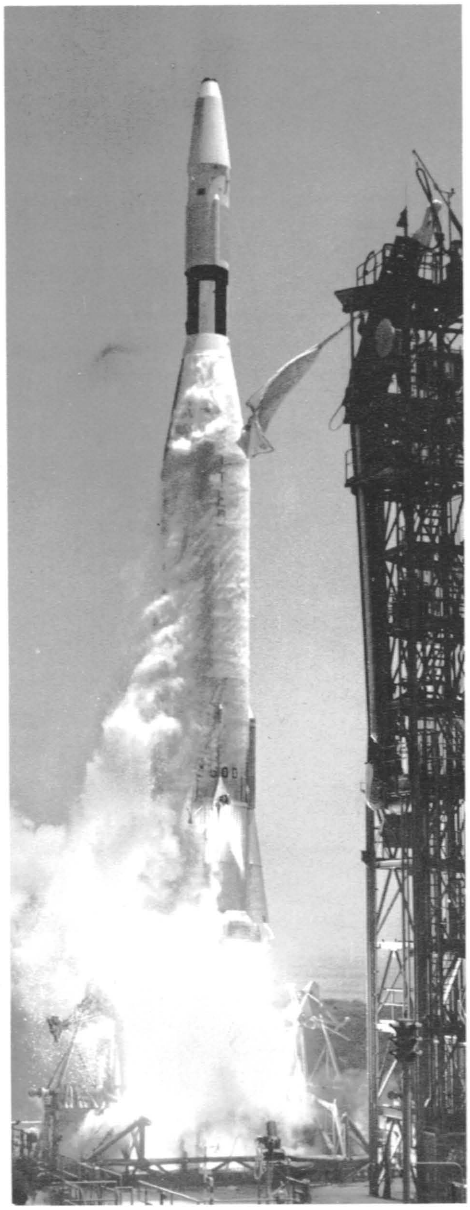
Diagram illustrates why moon's third quarter is only acceptable time for launching Ranger.



MID-COURSE MANEUVER: The mid-course maneuver of Ranger VII was conducted on July 29, 1964, when the spacecraft was about 100,000 miles from earth. The maneuver, initiated at 6 a.m. EDT and completed at 7:25 a.m. EDT, changed Ranger's speed by 67 mph. Even if the maneuver had not been made, Ranger would have struck the moon. However, it would have curved around the moon's leading edge and landed on the moon's hidden side.

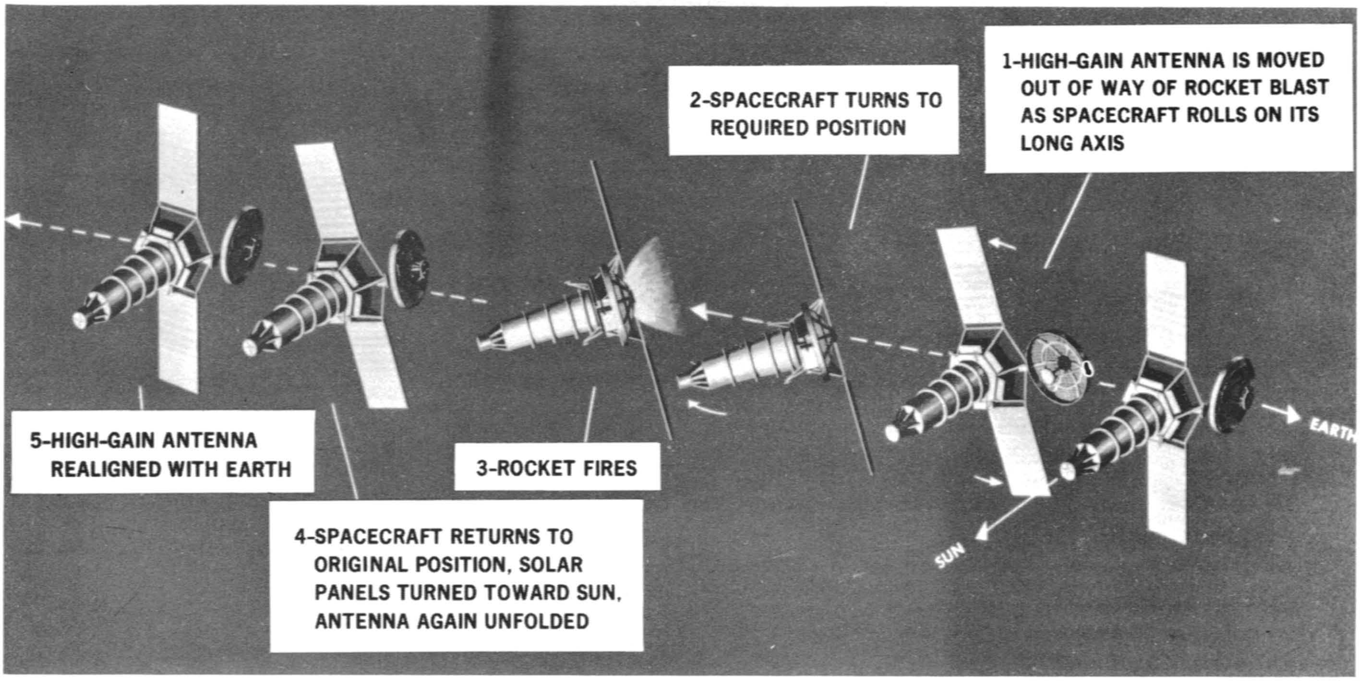
Typical Ranger Launch to Moon.





Atlas-Agena rocket vehicle launches Ranger VII to Moon.

OTHER UNMANNED LUNAR PROGRAMS: Ranger is one of three NASA projects designed to provide information about the moon with unmanned spacecraft. Another, Surveyor, will be equipped with braking rockets to enable it to make a gentle landing on the moon. Surveyor will telecast the moonscape, analyze lunar surface and subsurface material, measure moonquakes and meteorite impacts, and check the moon's surface for strength and stability. A third project, called Lunar Orbiter, is aimed at developing an unmanned spacecraft to be guided into a low-altitude lunar orbit, photograph the moon's surface, and provide more information on the moon's size, shape, and gravity.



Mid-course Maneuver.

ignites, propels itself and the attached Ranger into an orbit a hundred miles above earth, and then turns off its motor.

After coasting to a predetermined location, the Agena engine is restarted to accelerate from 17,500 miles per hour to 24,500 miles per hour. The latter is the initial velocity needed to send a craft to the moon.

Agena's main engine stops. Agena separates from Ranger and fires auxiliary rockets and jets to maneuver out of the Ranger's vicinity. Ranger's attitude control system of sun and earth sensors and gas jets properly orients the craft. The solar panels unfold and face the sun. The high-gain antenna extends and locks on earth.

Ground controllers compare Ranger's programmed trajectory with its actual flight path. If the spacecraft is off course, the controllers determine when, how long, and in what direction Ranger's on-board rocket must fire to put the spacecraft on target.

The mid-course maneuver consists of five principal operations (see illustration), all directed from earth. When performed at the right time, it can shift the location at which Ranger reaches the moon's altitude as much as 7500 miles in any direction.

After the mid-course maneuver, Ranger resumes coasting flight. A final or terminal adjustment of orientation may be made to refine the aim of its cameras.

About 15 minutes before impacting on the moon, it begins telecasting pictures of the lunar surface to earth. Ranger crashes on the moon at about 6000 mph some 66 hours after launch from earth.

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