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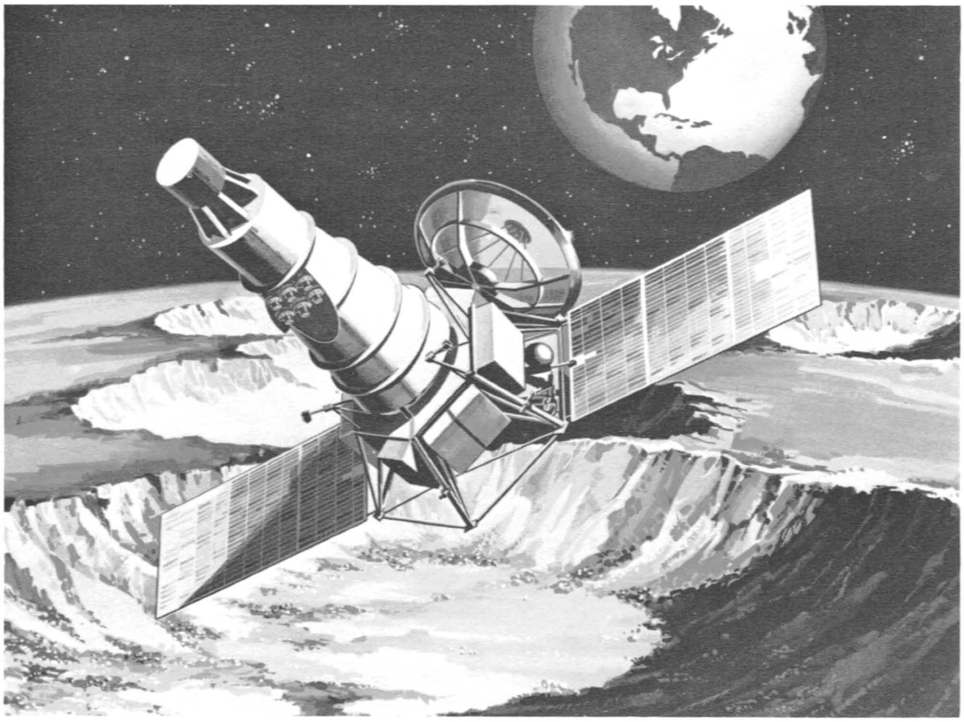
NASA FACTS

An Educational Services Publication of the National Aeronautics and Space Administration

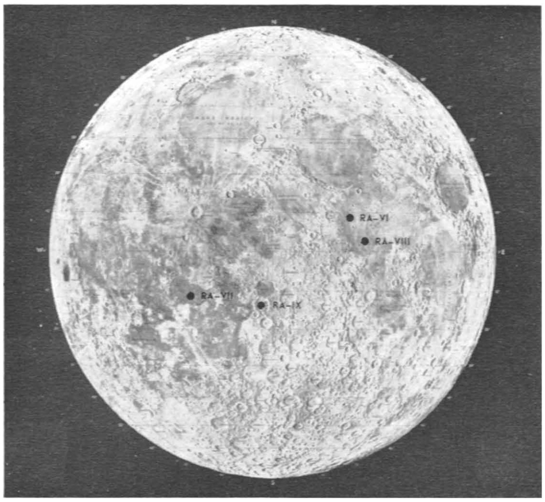
PROJECT RANGER



Artist's conception of Ranger as it telecasts photographs to earth and hurtles toward moon.

NASA Project Ranger has made possible the greatest single advance in lunar knowledge since Galileo first studied the moon through a telescope more than three centuries ago. Ranger telecasts to earth revealed lunar surface features as little as 10 inches across. In contrast, even the most powerful telescopes on earth enable man to discern lunar features no smaller in size than a half mile.

In all, Rangers VII, VIII, and IX provided 17,255 close-ups of the moon before crashing on the lunar surface. (Ranger IX was the last of the series. Rangers I through VI furnished no lunar information.) It is anticipated that the Ranger photographs will be studied by lunar



Landing points calculated for Rangers VI, VII, VIII, and IX. Ranger VI sent no pictures.

scientists throughout the world for many years. Moreover, information derived from the pictures has contributed to the design of the Apollo Lunar Excursion Module. This is the section of the Apollo spacecraft in which American astronauts will land on and take off from the moon.

PRELIMINARY OBSERVATIONS

The aiming and landing areas of the three successful Ranger spacecraft were: the northwest corner of Mare Nubium (Sea of Clouds) for Ranger VII; the western part of Mare Tranquillitatis (Sea of Tranquillity) for Ranger VIII; and the Crater Alphonsus for Ranger IX. (The seas were so named by early astronomers who thought the moon had water. They are actually lunar plains.)

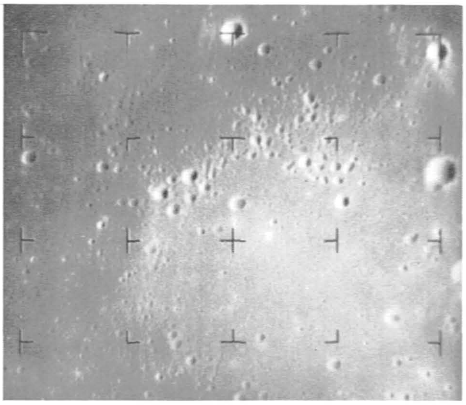
The lines on the photographs sent by Ranger were drawn on the camera lenses. The lines provide frames of reference for measuring distances and determining whether the pictures are free of distortion.

Ranger VIII swept over the mountainous area near the center of the moon's visible face before closing in on Mare Tranquillitatis. Rangers VII and IX made more vertical descents.

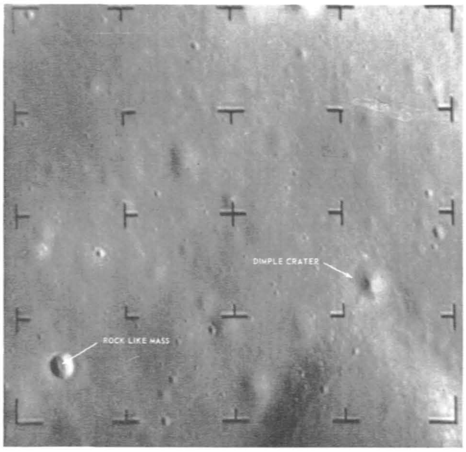
Results of preliminary investigations by a team of scientists studying the Ranger photographs are being disseminated throughout the world. The team is headed by Dr. Gerald P. Kuiper, Director of the Lunar and Planetary Laboratory, University of Arizona, Tucson, Arizona.

Through large telescopes on earth, Mare Nubium has a yellowish tinge while Tranquillitatis has a bluish tone. The colors are attributed by some scientists to bombardment by protons emanating from the sun; by others, to different types of materials on the lunar surface. Scientists wanted to compare the two plains in more detail. A study of Ranger close-ups of Mare

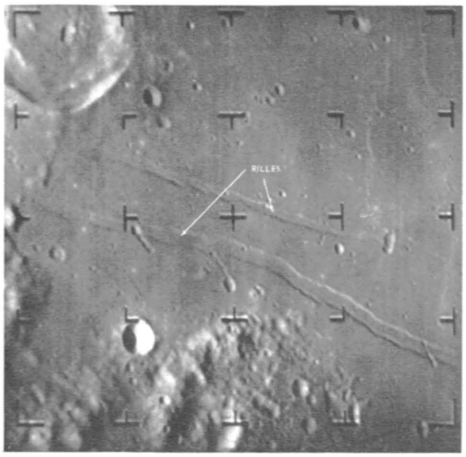
Rilles, long deep depressions on the moon's surface, were believed due to settling between faults, or cracks, in the moon's crust. Rangers VIII and IX revealed many more rilles than can be seen in earth's telescopes. They also showed that some rilles are apparently chains of craters. Still others appear to be a combination of crater chains and settling.



Ranger VII close-up of part of ray from large crater reveals cluster of secondary craters. Ranger VII was 34 miles above the moon when it took this picture. Lunar rays appear from earth as light, whitish lines radiating from some craters.



Ranger VIII picture taken five miles above the moon shows dimple crater at right and crater containing a rock-like mass in lower left.



Ranger VIII photograph snapped at 270-mile altitude shows two separate rilles. With dividing topography, the lunar surface in this area resembles somewhat a divided superhighway on earth.

Nubium and Mare Tranquillitatis revealed no major differences in the topography of the two areas.

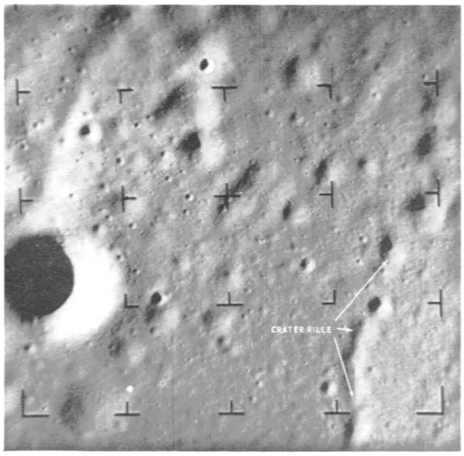
Both Mare Nubium and Mare Tranquillitatis are dotted by thousands of craters that do not show up through telescopes on earth. Their slopes, however, are calculated to range from one to 15 degrees, an inclination more level than previously anticipated. The seas are believed to be sufficiently level for landing by the Lunar Excursion Module as presently designed. While parts of the seas are so badly pitted by craters that they are clearly unsafe for landing, others are sufficiently smooth to permit a safe touchdown. Still to be determined, however, is the bearing strength, or firmness, of the surface.

Despite the absence of wind and water, erosion appears to be significant on the moon. Such erosion is indicated by the gentle rounded slopes of the mountains and crater rims and the apparent filling in of fissures, or cracks, in the moon's surface. Scientists are uncertain as to why erosion occurs. One theory is that it results from incessant bombardment by meteoroids (pieces of matter larger than atoms speeding at random through space).

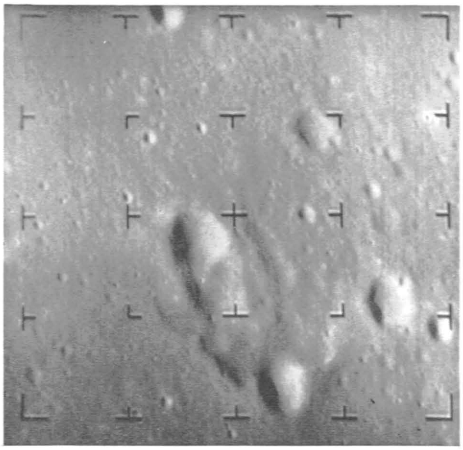
Boulders, rocks, or boulder- or rock-like masses are apparently scarce on the moon's surface. The very few photographed by the Ranger cameras were at the bottoms of craters. Among attempted explanations of this phenomenon are that meteoroid bombardment pulverized isolated boulder-like masses or that the rocks gradually sank into a soft lunar surface.

Most of the craters revealed for the first time by Ranger are believed caused by the debris thrown up when large meteoroids hurtled into the moon. The crater resulting from this impact has been termed a primary crater. The craters that were created by debris which was thrown up by the impact and subsequently fell back to the moon are called secondary. There are also tertiary craters dug by matter thrown up during the creation of secondary craters.

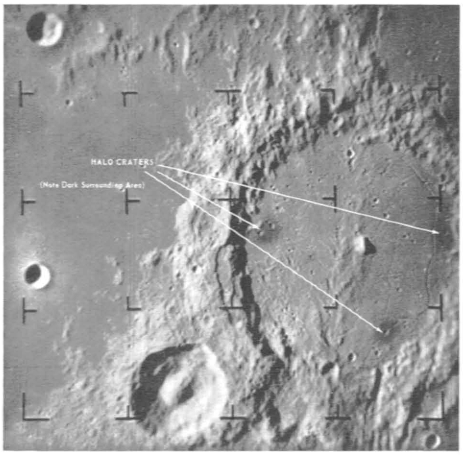
Scientists identify the primary craters by their more sharply defined rims as contrasted with the relatively rounded shoulders of the secondary



Ranger IX photograph at 12.2 mile altitude resolves a rille (near right margin) as actually a chain of craters.



Ranger VIII picture from 27½ miles up shows mysterious surface depressions, including one that appears to be square shaped (upper right).

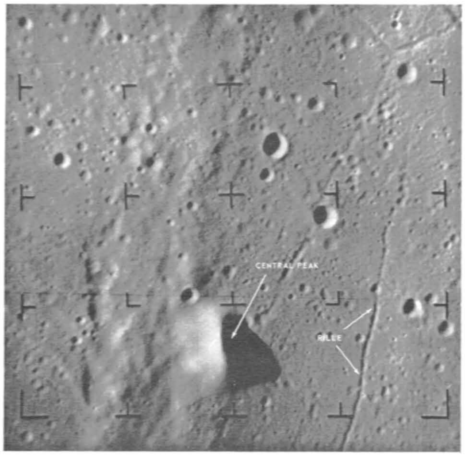


Ranger IX snaps the 70-mile diameter Crater Alphonsus from an altitude of 258 miles. Note "halo" craters (surrounded by dark material) and mountain peak (at approximate center).

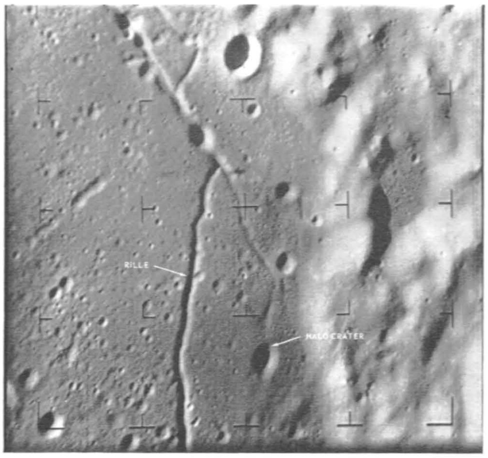
and tertiary craters. The sharper rims of the primary craters are believed to be partly due to the higher energy involved in collision of meteoroids with the moon.

Ranger's scientific investigators believe that photographs of the Crater Alphonsus provide strong evidence of volcanic activity on the moon, which was long believed to be a cold, dead body. At approximately the center of Alphonsus is a mountain peak around which astronomers in recent years have observed through telescopes what appeared to be gaseous emissions.

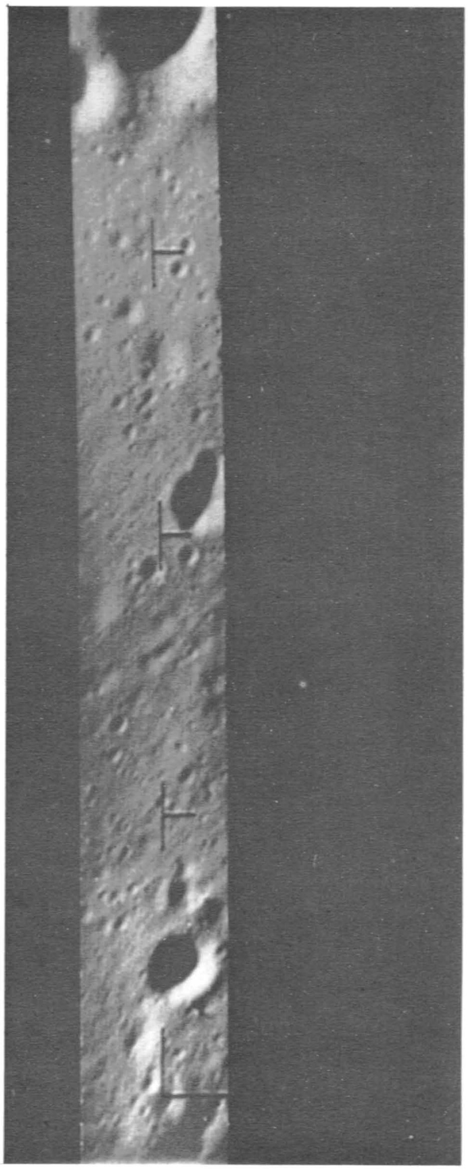
Scientists wanted a closer look at Alphonsus to gain clues to the nature of the suspected eruptions. Among the features within the crater are certain smaller craters surrounded by dark "halos." A few such "halo" craters are visible from earth. Ranger revealed other "halo" craters, also evidence that the "halo" was apparently due to a deposit of dark material on the lunar surface. Scientists of the Ranger investigating team believe that the black material erupted from the moon's interior through the "halo" craters. The escape of such material indicates that the moon may not be dead.



View of Crater Alphonsus from 58-mile altitude. The 3300-foot central peak is prominent. Rilles include combinations of depressions and crater chains.



Ranger IX picture of the Crater Alphonsus taken from a 115-mile altitude shows the crater floor marred by rilles and small craters and part of the surrounding wall which, surprisingly, shows soft contours and appears relatively smooth.



Last picture from Ranger IX, taken four-tenths of a second prior to impact, shows craters as small as 10 inches across. Transmission of the complete photograph was interrupted when Ranger crashed.

Ranger close-ups revealed that the floor of the Crater Alphonsus, like the floors of Mare Tranquillitatis and Mare Nubium, are pitted by hundreds of craters not visible from earth. Long, deep rilles (depressions or crevasses) were revealed in Mare Tranquillitatis and the Alphonsus crater. (The crater floor and lunar seas look relatively smooth from earth.) Some of the rilles in the Crater Alphonsus, on closer inspection, proved to be chains of craters.

An interesting feature revealed by the Ranger cameras is the aptly named "dimple" crater. A close look at this kind of crater suggests that soft material from the moon's surface is draining to caverns below. Sometimes, lines of dimple craters are seen, suggesting that deep long subsurface canyons may be hidden below a thin surface layer.

Ranger pictures indicate that the mountains and crater rims are less scarred by craters than the seas and crater floors. Moreover, the crater rims and mountains were shown to be gently rounded instead of rough and jagged as previously believed. In addition, while pictures alone provide no indication of surface strength, comparisons by the scientific investigating team of photographs of the seas, Crater Alphonsus, and mountains suggest that the mountain tops and crater rims afford more solid surfaces. As a result of these considerations, mountain peaks and crater rims may be more suitable than the plains, or seas, for landing a spacecraft.

The area within Mare Nubium—the Sea of Clouds—photographed by the first successful Ranger spacecraft, Ranger VII, was designated Mare Cognitum—the Known Sea—by the International Astronomical Union.

RANGER MARKSMANSHIP

The launch of Ranger IX was so accurate that the spacecraft would have struck less than 400 miles from its target even without a mid-course maneuver. With the maneuver, Ranger IX landed less than 3 miles from its target. Ranger VII impacted within 8 miles of its target. Ranger VIII hit the moon only 15 miles from its target.

PRIOR SCIENTIFIC INFORMATION

Lunik 3, the only other spacecraft to provide close-range photographs of the moon took about 30 pictures of the moon's hidden side (see below) in 1959. The pictures, snapped from distances of 4300 to 43,000 miles from the moon, provide no fine detail but indicate that the hidden side may not be as rugged as the area visible from earth.

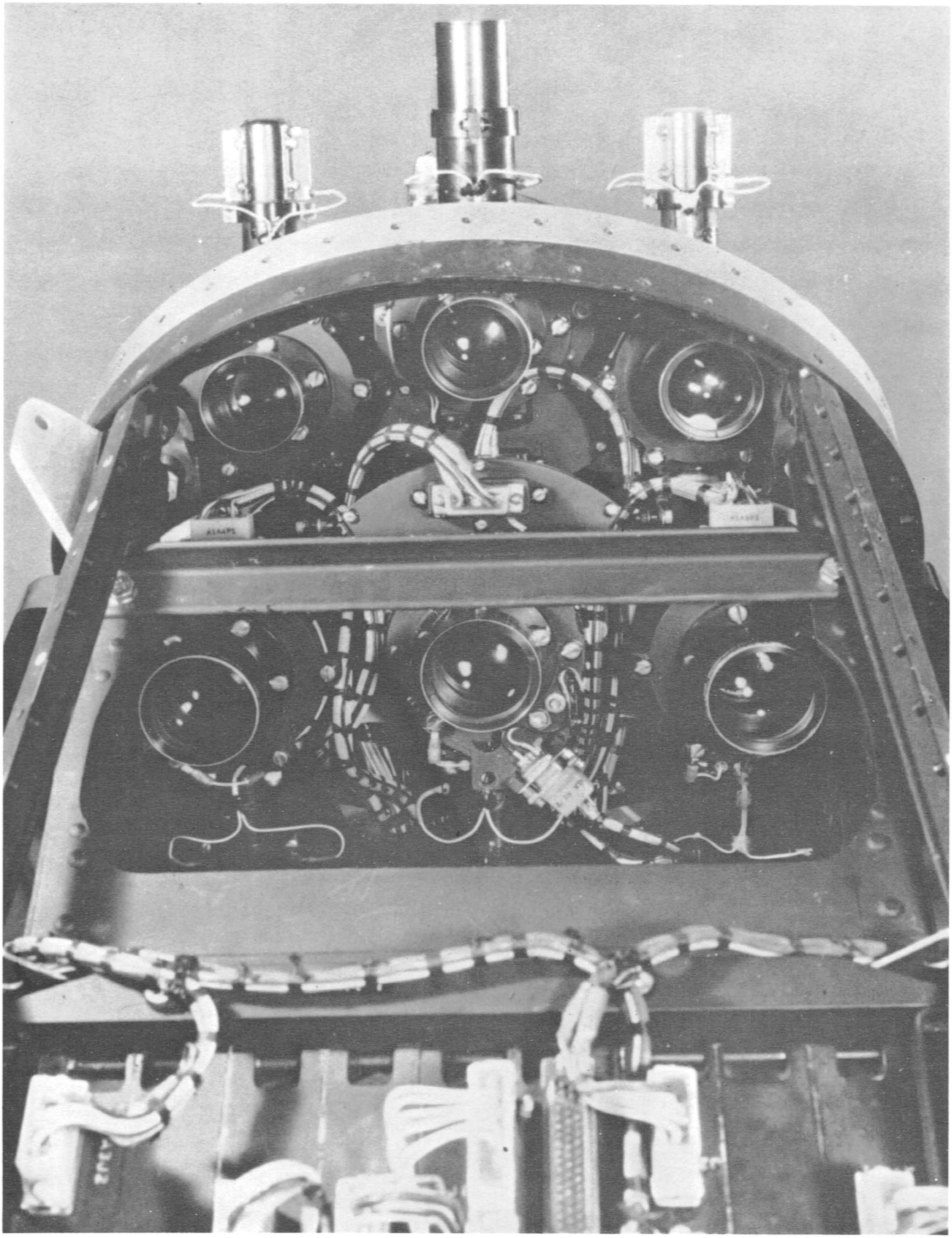
With ground-based optical and radio telescopes, man can see the great lunar plains and the larger mountains and craters. He has calculated the moon's diameter at 2163 miles, about one-fourth that of earth. He figures the moon's gravity as one-sixth that of earth, meaning that a 156-pound man would weigh only 26 pounds on the moon. He has computed the moon's mean distance from earth at 238,857 miles.

He has found that the moon takes about 27 1/3 days to revolve around the earth and to make one complete rotation on its axis. For this reason, the moon always presents the same face toward earth.

However, for a number of reasons including the moon's librations and the way the moon rotates, 59 percent rather than the expected 50 percent of the moon's surface is visible from earth. The librations, which are nodding motions, result from slight variations in the moon's velocity and the gravitational attractions of the sun and planets as the moon revolves around the earth.

The moon is believed to have no appreciable atmosphere to diffuse light and heat nor to shield it from meteoroids and radiation. As a result, the stars and planets shine steadily day and night in the moon's jet black sky. Its surface is bombarded by radiation and meteoroids. Surface temperatures are extreme and vary from 260 degrees Fahrenheit in the sunlight to as low as 243 degrees below zero Fahrenheit in the shade or on the night side.

Some scientists theorize that the primeval moon was captured by earth's gravity as it swept nearby during an early stage in the solar system's formation. Others hypothesize that the moon was torn from the great cloud of dust and gas that was the primordial earth.



Head-on view of Ranger's six television cameras. These constituted the payloads for Rangers VI through IX.

Eroded by neither wind nor rain, the matter of the moon below the surface layer, which has been greatly affected by meteoroids and radiation, may have changed little during the satellites lifetime. As a result, a lunar landing by man may offer an opportunity to study the matter of the solar system as it appeared billions of years ago. Just as the Rosetta Stone gave mankind the first clue toward deciphering Egyptian hieroglyphics, study of ancient moon matter may help answer key questions regarding the origin and evolution of the solar system and perhaps even how life began.

RANGER TELEVISION SYSTEM

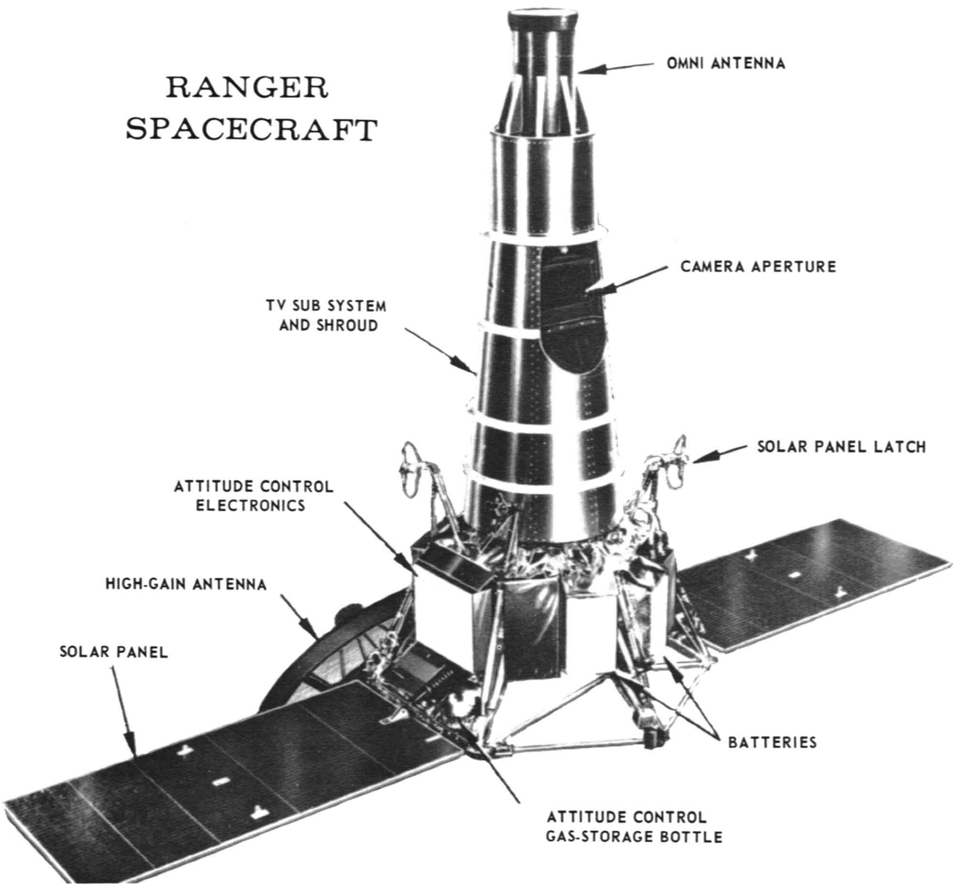
A complex high quality system of television cameras and transmitters on Ranger spacecraft and a ground receiving station at Goldstone, California, made possible the remarkably clear Ranger close-ups of the moon. The Goldstone facility is part of NASA's global Deep Space Network that tracks, controls, and gathers information from NASA spacecraft sent to the moon and beyond.

Six television cameras with associated transmitters and power supplies were mounted on Ranger within a compartment shaped like a truncated cone. Two of the cameras were full-scan (F), and four were partial-scan (P). Their difference is that the F cameras shoot a greater area than the P cameras. However, the P cameras make sharper and more detailed pictures than the F cameras.

The camera system was turned on at an altitude which would provide pictures equivalent in detail to those taken by the best telescopes on earth. The system continued to operate until Ranger's crash on the moon. On the average, about 300 pictures per minute were taken during approximately 20 minutes as Ranger headed for the lunar surface.

Briefly, the Ranger camera system operated as follows:

Behind the shutter of each camera was a vidi-



Principal equipment of Ranger. Its rocket is not visible in this view.

con (television) tube about the size of a water glass. This tube's faceplate was coated with a photo-conductive material on which light and dark areas seen through the shutter formed an image. A beam of electrons scanned the image, differentiating between light and dark areas by their differences in resistance (light areas have high resistance; dark areas, low). As the electron beam swept across the image, it was converted into an electrical signal that was amplified and radioed to earth. Then, high-intensity light and high-frequency electron beams erased the image on the faceplate. The whole process of image acquisition, conversion, transmission, and erasure took a fraction of a second.

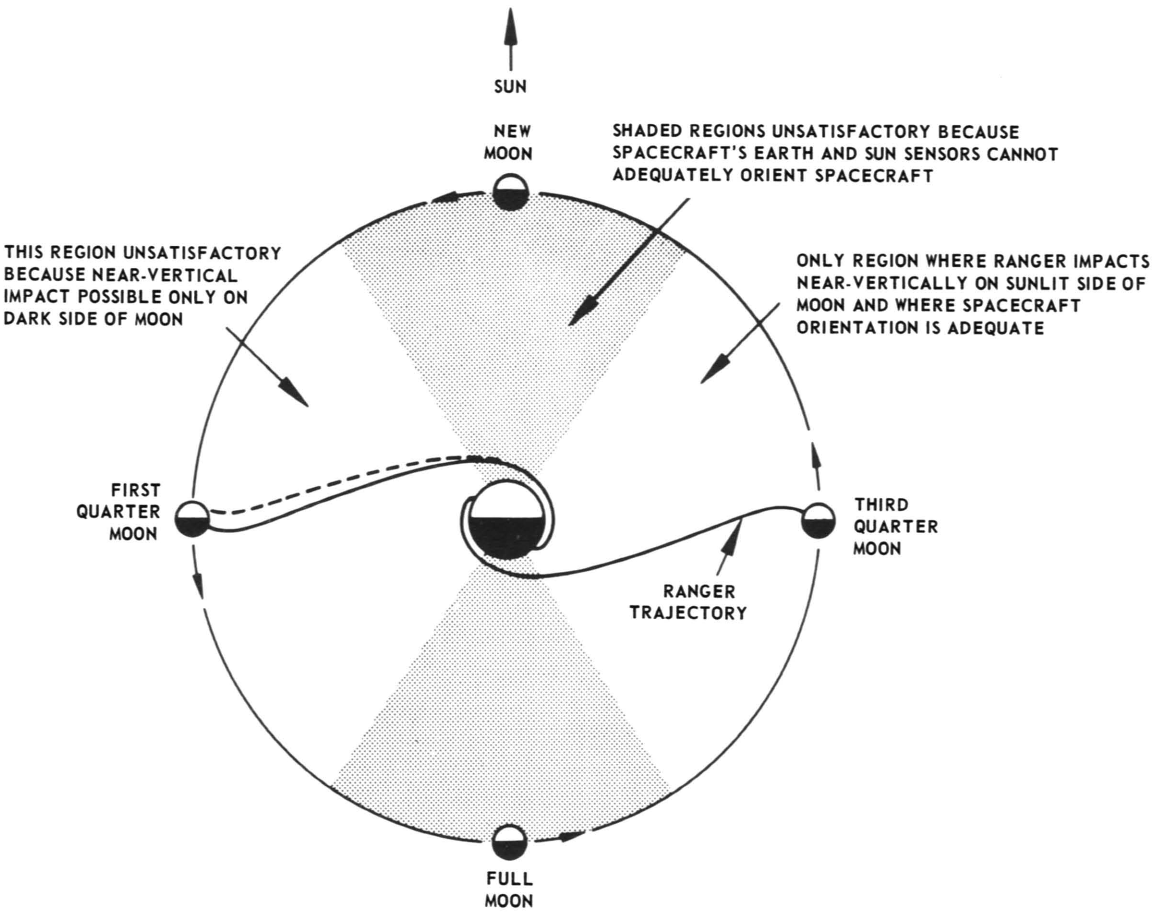
Huge 85-foot diameter antennas at the Goldstone station picked up and amplified the Ranger video (picture) signals. The signals were fed to two kinescopes, which are similar to small television sets, and recorded on film by 35-mm. cameras. The signals were also channeled to magnetic tape recorders like those used by television studios to record shows for later telecasts.

Another historical first was achieved on March 24, 1965, when the Nation's television networks presented "live" pictures that Ranger IX was sending as it hurtled into the Crater Alphonsus. Special apparatus electronically converted for use by American television equipment, and fed directly to the major American television networks, 100 of the more than 5000 pictures transmitted by Ranger IX.

RANGER "BUS"

The basic vehicle on which the Ranger experiments such as the television system were mounted is called the "bus." It held Ranger's principal power supply; telemetry instruments that reported on the spacecraft's condition and operation; a command system that enabled ground personnel to control the craft; timing, orientation, and temperature control devices; and a small rocket system for in-flight correction of Ranger's course.

The "bus" was equipped with two kinds of



Artist's sketch depicts why moon's third quarter was only acceptable time for Ranger launch.

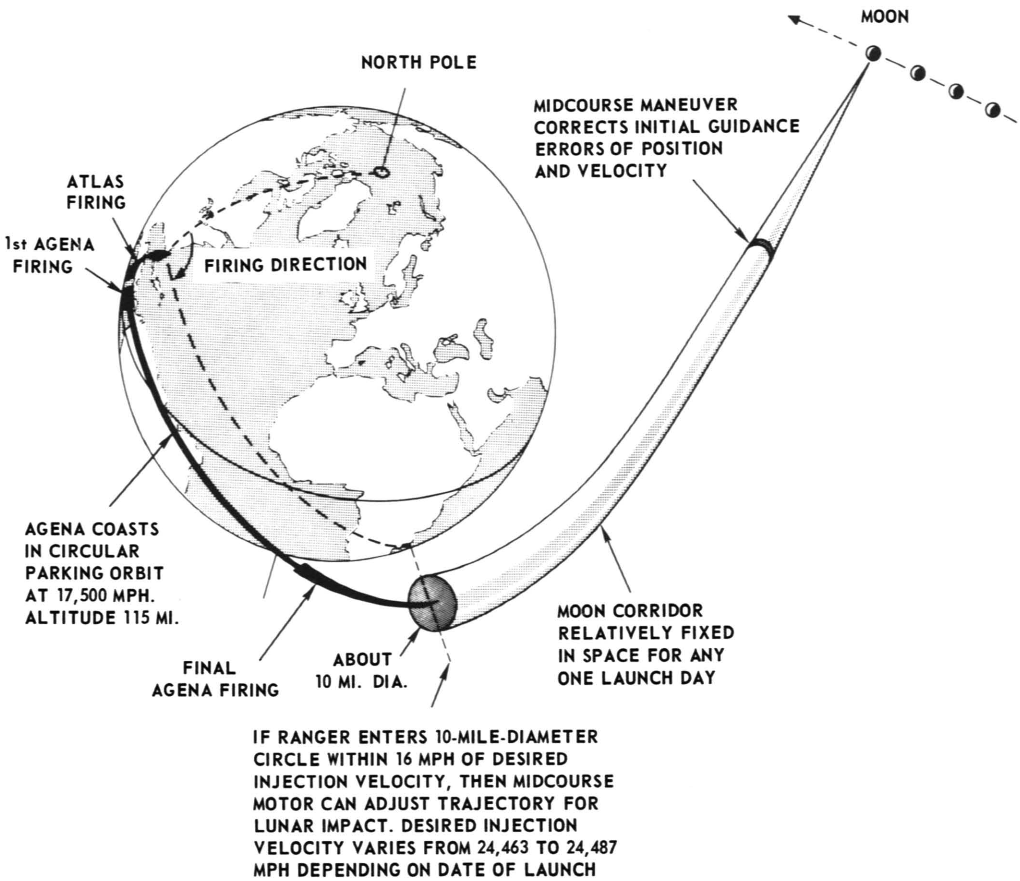
antennas. Information was sent principally through a dish-shaped high-gain antenna. This antenna focussed radio signals in a narrow beam of maximum strength.

The second antenna was called omni-directional because it radiated radio signals in all directions. Its signals were far weaker than those from the high-gain antenna. However, they were useful in maintaining contact with Ranger when the high-gain antenna was not pointed at earth, as during launch and course correction (see "From the Earth to the Moon," below). The omni-antenna also functioned to receive commands sent to Ranger from earth.

Two panels, extended from Ranger like butterfly wings, provided electricity for running the spacecraft. The panels held a total of 9792 solar cells which converted sunlight into 200 watts of electricity. Two silver zinc rechargeable batteries provided power when the solar cells could not function, as during launch. The batteries were recharged by the solar cells.

A system of sun and earth sensors, gyroscopes, and nitrogen gas jets kept Ranger oriented in space, locking its solar panels on the sun for power and its high-gain antenna on earth for communication. Ranger was also equipped with a rocket engine for changing its course while in flight. The engine, controlled from earth, was capable of generating 50 pounds of thrust for 98½ seconds. It could be operated in short bursts lasting as little as 50 milliseconds

Ranger IX is the last spacecraft in the Ranger series. Following up Ranger's initial surveys, NASA plans a series of Lunar Orbiter spacecraft to map the moon from both high and low altitudes with high resolution cameras, and to provide more information about radiation, magnetic and gravity fields, and meteoroids in the moon's vicinity. Finally, as a prelude to manned exploration, NASA intends to land a series of Surveyors to check the moon's surface for strength and stability, analyze surface and subsurface matter, telecast the moonscape, and report on radiation and meteoroids at the moon's surface. Surveyor will also demonstrate the technology of a soft landing by means of braking rockets on the airless moon.



Typical Ranger launch.

(50/1000th of a second). The motor weighed 46 pounds.

DIMENSIONS

The Ranger "bus" and television package were 5 feet in diameter at the hexagon-shaped base and 8¼ feet long from the base to the peak of the television assembly. With the solar panels extended and the high-gain antenna deployed, Ranger was 15 feet across the panels and 10¼ feet high. Ranger weighed about 807 pounds.

LAUNCH CONSTRAINTS

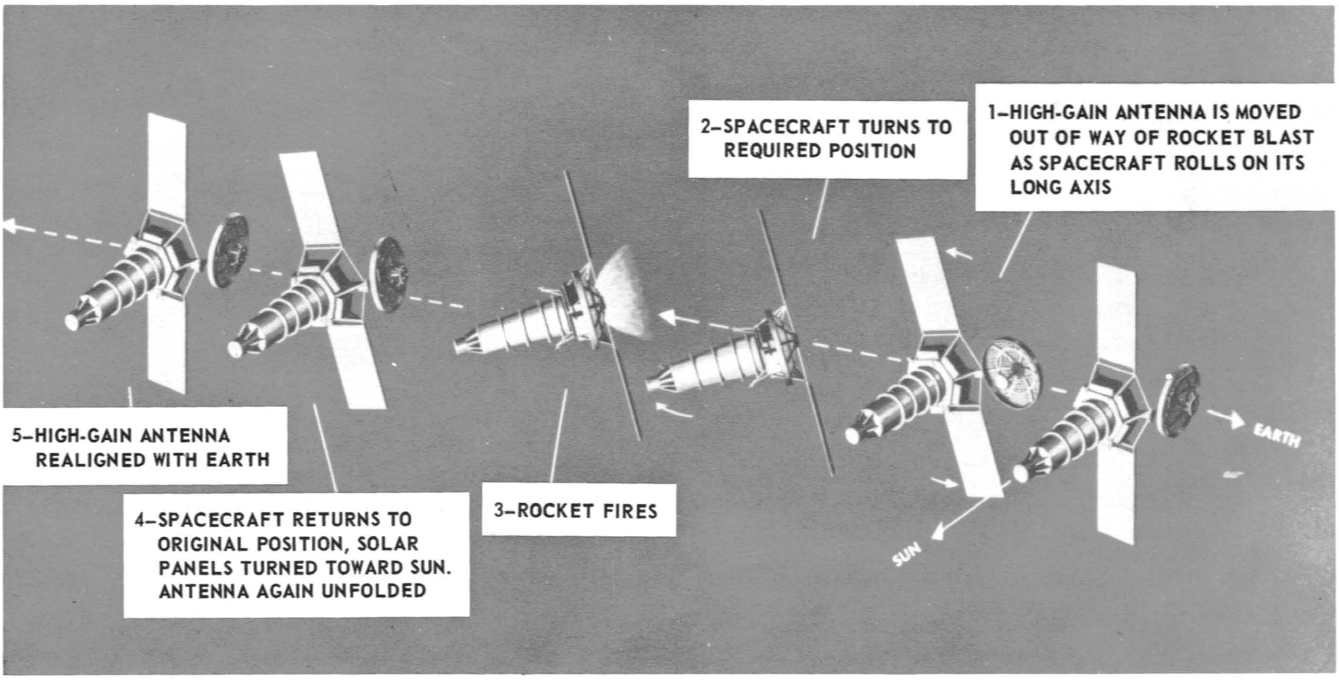
Timing was one of the important considerations in launching Ranger. Among the limitations in timing was that Ranger had to reach the sunlit section of the moon when long shadows were being cast by protruding surface features. The shadows indicated the ruggedness or flatness of the landscape.

The fact that the spacecraft had to lock on the earth and sun for orientation made the periods of the new and the full moon unacceptable. Technical limitations on target areas and the requirement for satisfactory lighting angles precluded launchings during the moon's first quarter. As a result, Ranger could be launched only during the moon's third quarter (see sketch).

Other considerations were the location of the Cape Kennedy, Florida, launch site and the approximately 2000-mile-per-hour velocity at which the moon circles the earth. Because of these and other constraints, the launch window (time interval) for sending Ranger to the moon was limited to periods varying from 90 to 150 minutes daily during six successive days occurring every 28 days.

In aiming their craft, Ranger launch personnel had to take into account the gravitational pulls not only of the earth and moon but also of the sun, Jupiter, Mars, and Venus. All influenced the flight of Ranger in space.

The Ranger launch team had to aim Ranger at the center of an imaginary ten-mile-wide



Midcourse maneuver, which normally occurred about 16 hours after launch of Ranger.

corridor leading to the point in space where the moon would be about 66 hours later. Ranger would hurtle through this tunnel initially at approximately 24,500 miles per hour.

FROM THE EARTH TO THE MOON

The typical Ranger flight was, in brief, as follows:

A two-stage Atlas-Agena rocket vehicle launched Ranger from Cape Kennedy. The shroud which protected Ranger during ascent through the dense part of the atmosphere was ejected about 5 minutes after launch. Less than a minute later, the Atlas first stage separated and fell away, and the Agena second stage ignited, propelling itself and Ranger into a 115-mile-altitude earth orbit. The Agena then automatically turned off its motor.

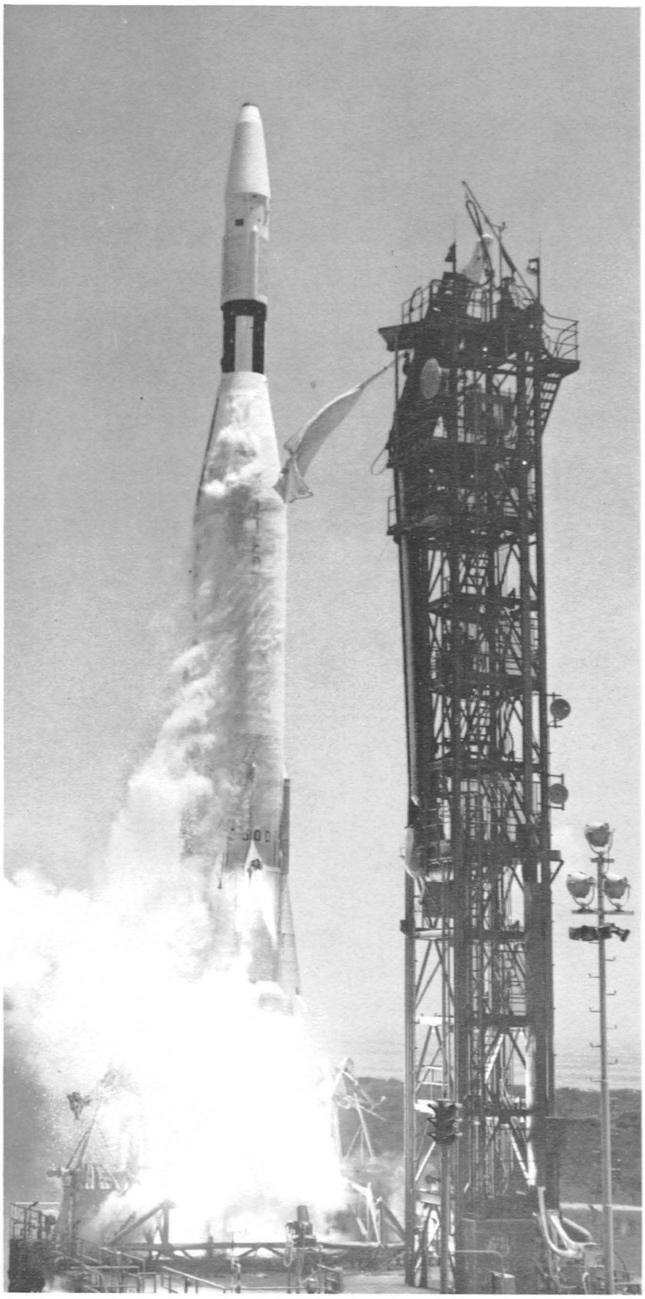
After Agena and its attached Ranger had coasted to a selected point in orbit, the Agena engine was restarted by an electronic timer. The combined vehicles accelerated from orbital velocity of about 17,500 miles per hour to about 24,500 miles per hour, the initial speed needed to launch a spacecraft to the moon.

Agena's engine stopped as it and Ranger were injected into a lunar trajectory. Typically, this occurred about 12 minutes after launch. Two minutes and 40 seconds later, Agena separated from Ranger, firing auxiliary rockets and gas jets to slow slightly and move back from Ranger's vicinity. Ranger's attitude control system of sun and earth sensors and gas jets oriented the spacecraft. Ranger's solar panels unfolded and faced the sun. The spacecraft's high-gain antenna extended and locked on earth. The time: approximately 63 minutes after launch.

Ground controllers compared Ranger's intended trajectory with its actual flight path. They calculated when, how long, and in what direction Ranger's rocket must be fired for Ranger to strike its targeted location on the moon.

The mid-course maneuver consisted of five principal steps (see illustration). Conducted properly, the point at which Ranger reached the moon's altitude could be adjusted as much as 7500 miles in any direction.

After the mid-course maneuver, Ranger resumed coasting flight. It began taking pictures and telecasting them to earth about 20 minutes before impact. About 66 hours after launch from earth, Ranger crashed into the moon at approximately 6000 miles per hour.



Atlas-Agena launch vehicle starts Ranger on its flight to the moon.

SOME FACTS ON RANGER LAUNCHES

CRAFT	LAUNCH DATE	GOAL(S)	RESULT
Ranger I	August 23, 1961	Looping orbit stretching 500,000 miles from earth; equipment test; acquisition of space environmental data.	Low-altitude (approximately 100-mile) orbit.
Ranger II	November 18, 1961	Same as Ranger I.	Same as Ranger I.
Ranger III	January 26, 1962	Send pictures of the moon and other scientific information.	Missed moon and soared into solar orbit.
Ranger IV	April 23, 1962	Same as Ranger III.	Curved around moon and struck side away from earth. Sent no information.
Ranger V	October 18, 1962	Same as Ranger III.	Missed moon and soared into solar orbit.
Ranger VI	January 30, 1964	Send close-up pictures of the moon.	Crashed precisely into the lunar Sea of Tranquillity without sending pictures.
Ranger VII	July 28, 1964	Send close-ups of lunar Sea of Clouds.	Objective achieved; 4304 pictures transmitted and received on earth.
Ranger VIII	February 17, 1965	Send close-ups of lunar Sea of Tranquillity and highland area west of the sea.	Objective achieved; 7137 pictures returned.
Ranger IX	March 21, 1965	Send close-ups of Crater Alphonsus and vicinity.	Objective achieved; 5814 pictures returned.

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