EP-70

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

MR-4

# mission report

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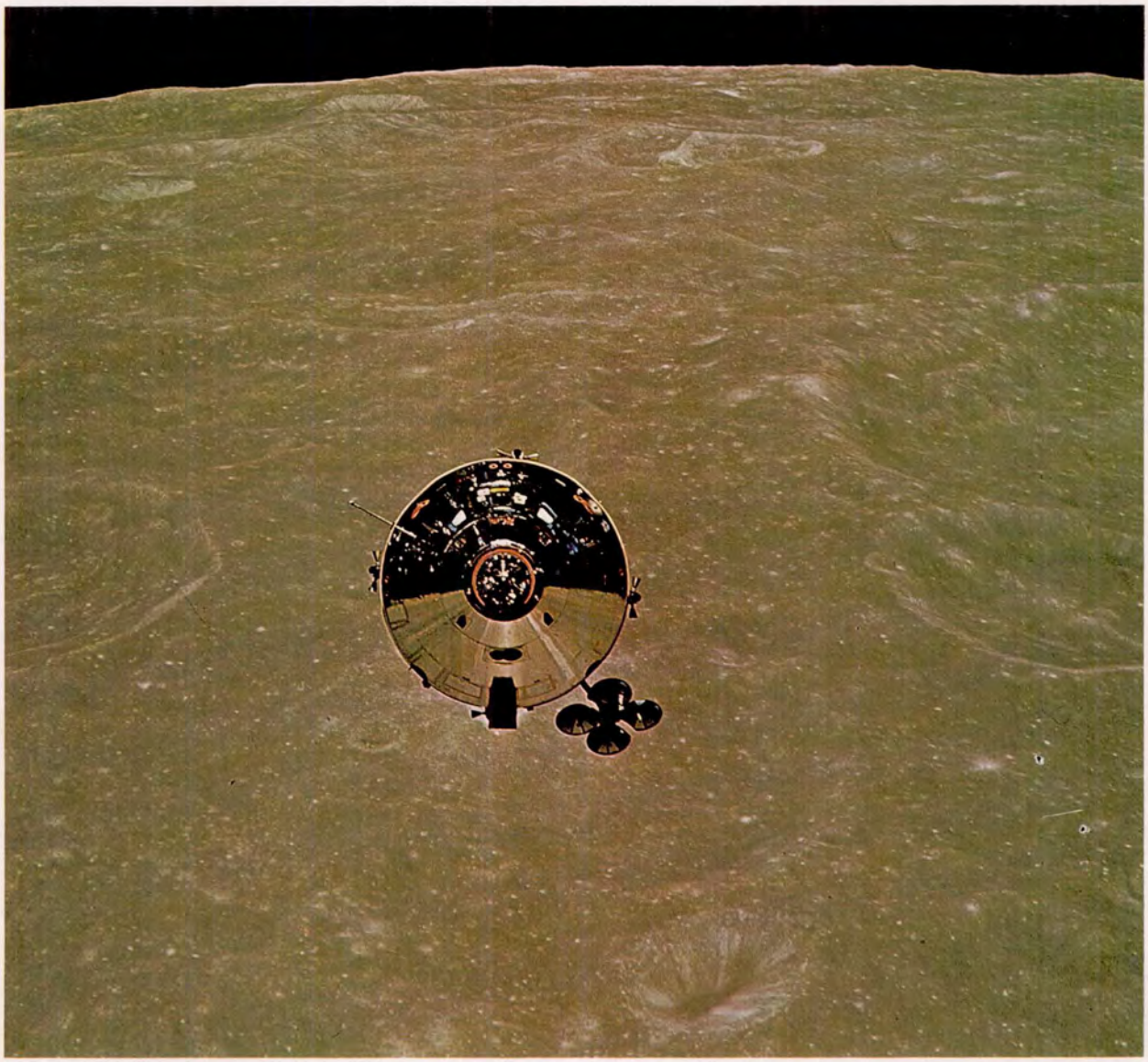
## APOLLO 10



*"Charlie Brown" photographed in lunar orbit by "Snoopy", the Lunar Module.*

JUNE 17, 1969

Eight days and three minutes after leaving launch pad B at Complex 39 at the Kennedy Space Center, Apollo 10 splashed down 3 miles from the Pacific aiming point. Spacecraft Commander Thomas P. Stafford, Lunar Module pilot Eugene Cernan and Command Module Pilot John W. Young —flying the Command Module (CM), code-named Charlie Brown *—thus rang down the curtain on the dress rehearsal mission for the lunar landing which, if all goes well, will be made in July.

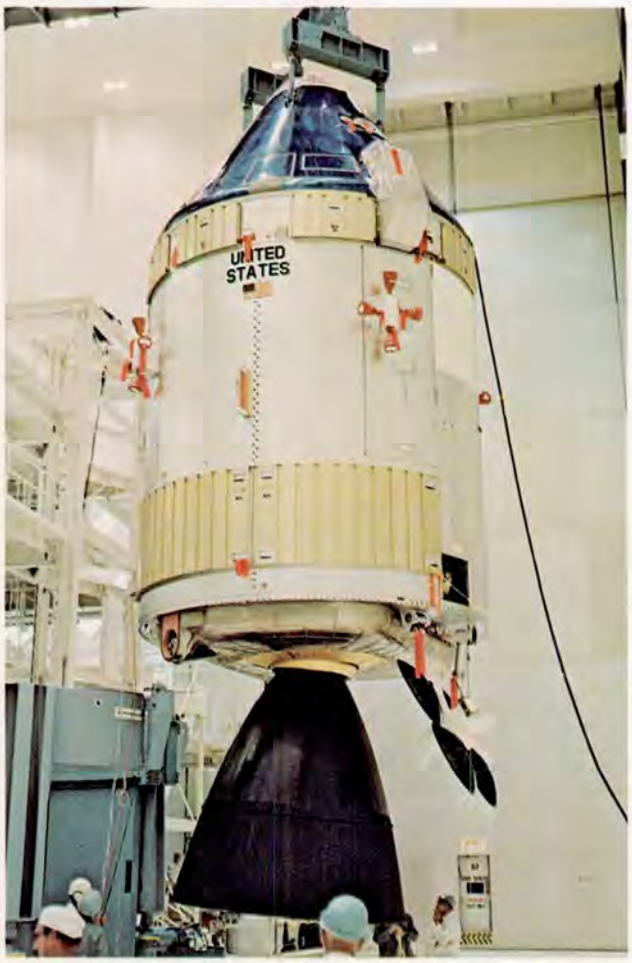
There were a few chilling moments when the Lunar Module (LM), code-named Snoopy, gyrated wildly as the descent stage was cast off about 12 nautical miles above the surface of the moon, but, nevertheless, it was a nearly flawless flight. The LM descended to within 8.4 nautical miles of the moon for a close-up inspection of the preferred landing site for Apollo 11 in the Sea of Tranquility. In two circuits of the moon, the landing radar received a thorough checkout and the crew did extensive surface photography and landmark tracking.

Once their low-altitude tasks were done, Stafford and Cernan jettisoned the descent stage, fired the ascent engine, and flew up to join Young and the Command and Service Module (CSM). The latter had been monitoring the work of the LM from a nearly circular parking orbit of approximately 60 nm up from the moon during the eight hours that the LM had been separated from the mother ship. The vital docking was smoothly executed. Although weary from a work-filled day, the crew did not seem ready for sleep. They were given clearance to sleep late the following day, but perhaps because of excitement or the stimulus of their mission, slept only five hours.

* The code names of Charlie Brown for the CM and Snoopy for the LM are taken from the popular comic strip by Charles L. Schulz. For this mission, Snoopy, the beagle, has exchanged the goggles and scarf of the World War I flying ace for a space helmet. Around the Manned Space Center, Snoopy has become the symbol of quality performance and those who do outstanding work are awarded a silver Snoopy pin.

*MSC—More properly, Manned Spacecraft Center*

*The Command and Service Module being checked by technicians. The cone at bottom is the nozzle of the Service Propulsion System engine.*




## Accomplishments

In swooping low over the moon and then executing a complicated set of orbital maneuvers to rejoin the mother ship, the LM did everything required for a lunar landing except the actual landing itself. The LM demonstrated convincingly its operating capabilities in cislunar space and validated the two propulsion systems in the moon's environment. These are vital to the lunar landing missions.

*The first stage of the giant Saturn rocket. The five engines, red nozzles showing at bottom, produce 1.5 million pounds of thrust each.*

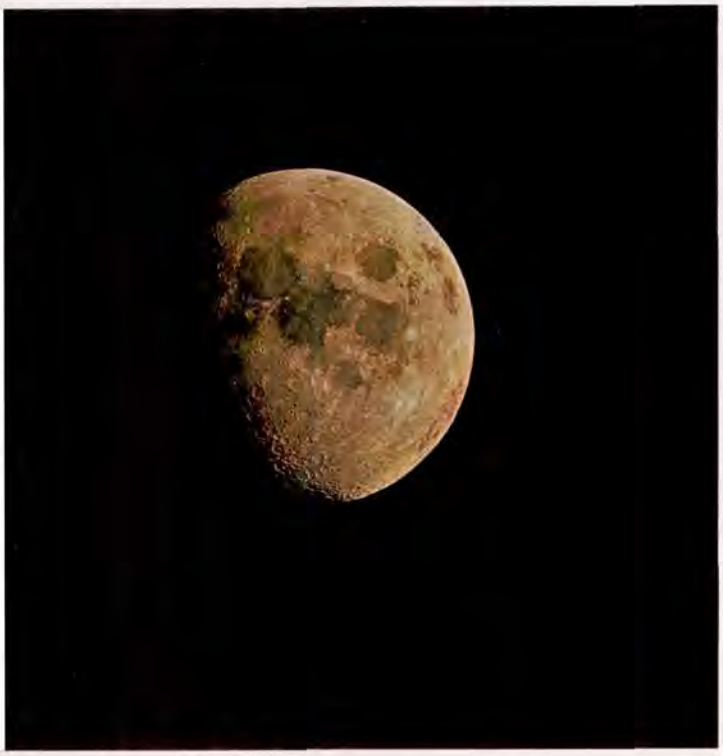
Other major accomplishments included the determination that the preferred landing site is smooth but that the pilots of Apollo 11's LM will have to be accurate in touching down at the right spot. It was also dramatically demonstrated that men can overcome problems in space and save a mission from possible disaster where instruments alone would fail.

**The TV Spectacular**

For the more than a billion viewers all over the world, the high points of an exciting flight were the live colorcasts from space. The 15-pound color TV camera, specially developed for this flight, performed beyond expectations. It recorded the initial docking maneuver after the Apollo and the Saturn third stage had entered the lunar flight path. It photographed earth from various points in space. It relayed some crew activity inside the cabin of the Command Module. It transmitted shots of the lunar surface from various angles and distances. It photographed the LM in lunar orbit and generally made a pictorial documentary of the flight. All things considered, the images that came through on the home receiving sets were remarkable for color fidelity and definition.

Thanks to Apollo 10, the remaining obstacles to achieving the national objective set 8 years ago by the late President John F. Kennedy—a manned lunar landing before the end of the decade—have been cleared away. Some scientists have noted that the epochal moment when an astronaut scoops some moon dirt into the palm of his glove will signal a new era in the history of man.

*On the return course to Earth, the crew photographs the receding Moon.*



## LIFTOFF AND INTO THE LUNAR TRAJECTORY

Saturn-Apollo 10 rose—deliberately, majestically—from its pad on Complex 39B at precisely 12:45.5 p.m. EDT Sunday May 18. It was half a second late according to the pre-launch schedule—a "delay" which occasioned some tongue-in-cheek comment from media observers. The events of the pre-orbit flight—the roll sequence, jettisoning the launch escape tower, first stage cut-off and second stage burn, second stage cut-off and third stage burn—ticked off like clockwork.

As the flight approached 40 nautical miles altitude, Stafford, a seasoned veteran of two Gemini flights, was exclaiming "What a ride!" and his crewmate Cernan, co-pilot of Gemini 9 repeated "Fantastic." Ground controllers concurred.

After 11 minutes 52.8 seconds of flight, the third stage of the Saturn inserted the spacecraft into a nearly circular orbit approximately 103 nm in altitude at its high point and 100 nm at perigee. Its 250,000-pound-thrust engine was then shut down and the astronauts spent two earth orbits conduct-

*Earthrise from lunar orbit. Spacecraft camera photographs planet Earth as it appears above the Moon's horizon.*

ing a thorough checkout of the CSM systems. Save for a few very minor difficulties–a primary evaporator dried out, so backup equipment was switched on to replace it–everything was working well. The ground communications link was remarkably clear.

Over Australia, in the 2nd orbit, the crew was given "Go" for translunar injection (TLI). The third-stage J-2 engine was restarted and fired for 5 minutes 42 seconds to increase the spacecraft's velocity from its earth-orbital speed of roughly 17,400 mph to the 24,250 mph required to put it on a lunar course.

Once in a lunar trajectory, Young changed places with Stafford–who had been in the middle couch for the opening phase of the flight–and began the final preparatory maneuvers for the outward leg.

Young separated the CSM from the adapter which houses the LM in a protective shroud atop the third stage, and flew to a point 50 feet ahead of the still-joined LM and third stage. He then pitched the CSM 180°, in effect a half-somersault, so that the cone end of the CM, with its docking probe, pointed toward the LM. Using the CSM thrusters, Young flew slowly back toward the LM and third stage with a closing rate of three inches a second–about 1.6 mph. Keeping the two craft aligned, Young eased the docking probe into the LM's docking collar and the ten locking latches clicked into place, firmly linking the LM with the CM. A check of the locking latches showed that they were well in place. The umbilical cords that connected the LM systems with the CSM power source were plugged in.

Young maneuvered the linked spacecraft safely clear of the third stage. The latter's residue of fuel was dumped, imparting enough additional velocity to the stage to put it into a different trajectory in which it would loop around the back of the moon and be slung into a solar orbit where it may remain until the end of time.

**The First Color TV**

The docking maneuver was highlighted with the first of a series of colorcasts from space. Cernan photographed the approach to the LM and, two hours later, treated earthlings to a color view of their own planet from thousands of miles in space. Picture resolution was good and the color a technological and an aesthetic triumph. Cernan identified the Rocky Mountains, Baja California, and asserted that he could almost see the Los Angeles freeways. He described Alaska as being "socked in" with cloud cover and pointed out a low-pressure weather system over New England.

**The Lunar Coast**

As Apollo 10 approached the midway point on its long outward coast to the moon, the astronauts took advantage of a regimen confined mostly to routine duties. Refreshed by what Stafford termed "a great night's sleep" and feeling "just tremendous," the spacecraft commander played a tape of Andy Williams singing ". . . In My Beautiful Balloon."

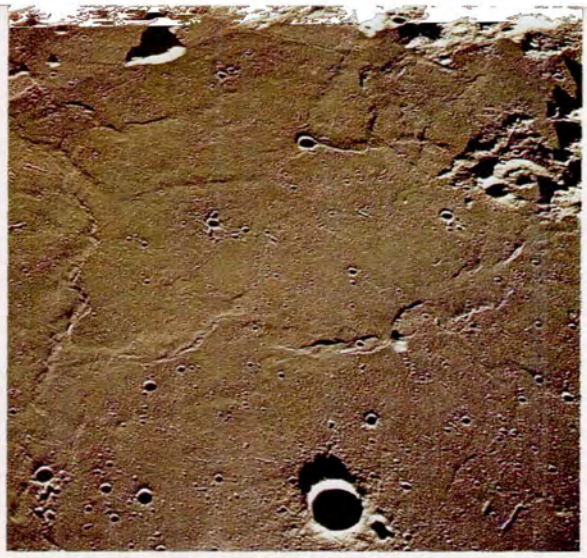
The mid-afternoon TV "spectacular" featured a variety show interspersed with color TV of the receding earth and the astronauts inside the cabin. A Frank Sinatra tape of "Fly Me To The Moon" came over the radio, the rendition evidently suffering from having to span 130,000 miles to reach earth. When the camera was turned on Cernan, he displayed drawings of Charlie Brown in space coveralls, and his beagle Snoopy wearing the scarf of the World War I flying ace. Next camera subject showed Stafford and Young side by side–except that Young was upside down. The latter appeared entirely at ease in his inverted position. Stafford demonstrated the strange effect of weightlessness by moving Young up and down with little more than a touch of the hand. Young quipped, "I do everything he tells me."

Cernan provided another weather report from 100,000 miles in space. He noted that most of Europe was under a cloud cover; Portugal, Italy (south of Rome) and Bulgaria had clear skies as had Arabia, Israel and Jordan. Most of the eastern coast of the United States was cloudy.

More palatable food may have contributed to the crew's high spirits. The freeze-dried diet, now standard for manned flight, was supplemented by individually wrapped commercial bread and the makings for ham, chicken and tuna salad. But the TV performance suggested that all the ham wasn't in the salad makings. The only sour note struck by the astronauts was their distate for the chlorinated drinking water.

**At Variable Speeds**

Apollo 10's outward journey proceeded almost exactly as expected. The 24,250-mile-an-hour velocity at which it entered the lunar corridor was steadily reduced by the gravitational drag of earth

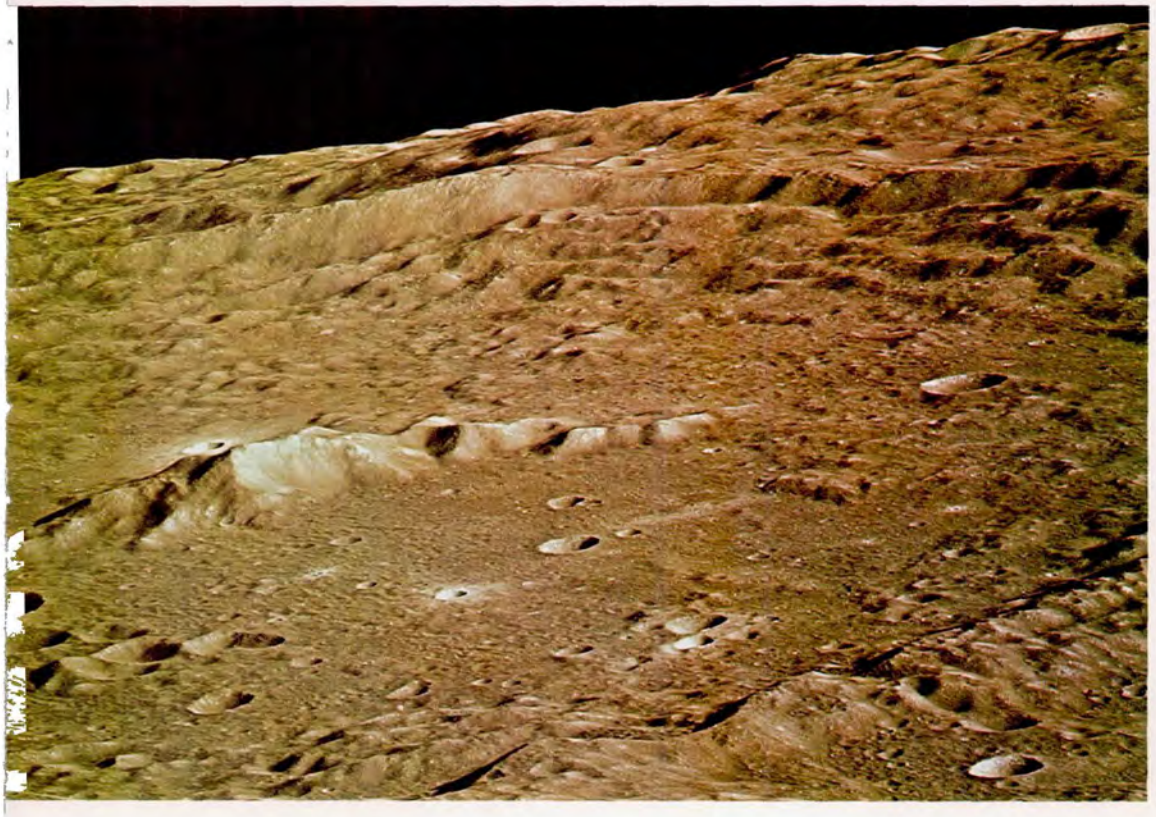


*At left: A westward view across Apollo Landing Site 3.*

*Left below: Mare Crisium in the highlands east of Site 2.*

*Below: A relatively young crater as evidenced by white ejecta.*

*Below: A large unnamed crater on the lunar backside.*



to approximately 2,000 mph. Then, as the spacecraft entered the moon's gravitational field, the pull of the moon overcame the braking effect of the earth and the spacecraft picked up speed to a peak of 5,500 mph (relative to the moon) just before entering lunar orbit. To achieve orbit, it was necessary to use the CSM Service Propulsion System—a 16,000-pound-thrust engine—in a retro-fire mode, to slow the spacecraft's speed to roughly 3,600 mph and permit its capture by the moon's gravitational field. Testament to the precision of the flight out was the need for only one of several planned mid-course corrections.

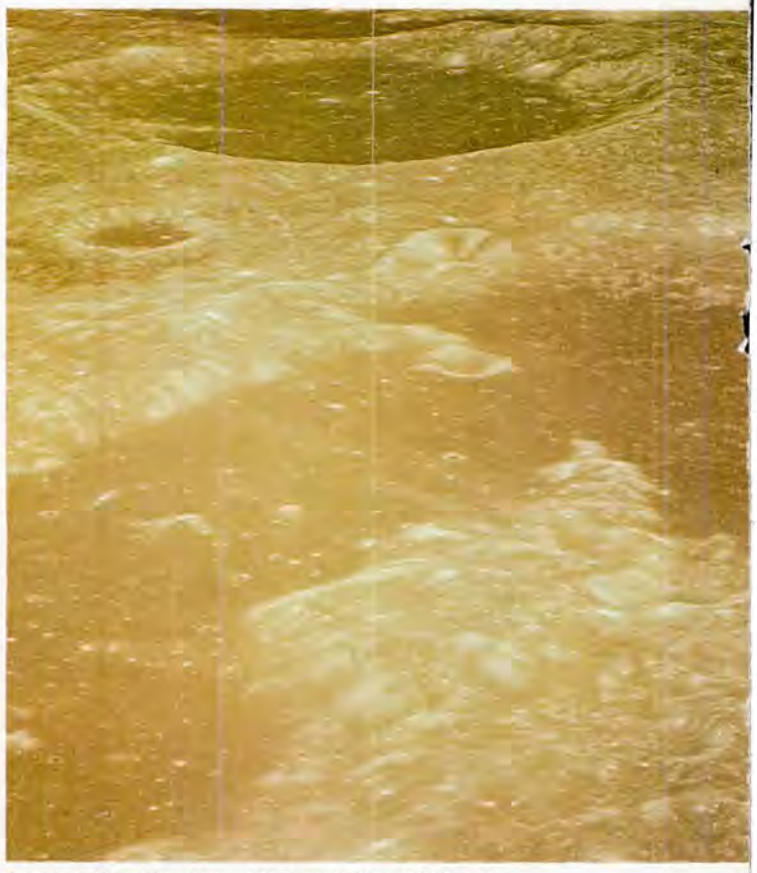
## IN LUNAR ORBIT

On May 21, Apollo 10 swept into an elliptical lunar orbit with a high point of 170 and a low of 60 nm. Subsequently, the orbit was circularized to approximately 60 nm. (Ground control reported its dimensions as 63 by 59 nm.) Not more than 20 minutes into their first orbit, the crew began vivid descriptions of the lunar features over which they were passing. The first comment came from Stafford who noted that they were moving out of the highlands into the mare area—the so-called dry seas. He reported a "couple of real good volcanoes"; an observation of considerable interest to astronomers because of the until-now unresolved controversy as to whether the moon had seen volcanic action at some previous time. Young described the volcanoes as ". . . . all white on the outside but definitely black inside."

The first landmark the crew spotted was the Sea of Crisis, bathed in lunar sunrise. Young observed that it really stood out and that he had no trouble recognizing it. Stafford said the sides of the ridges crossing the mare floor went "straight down just like the Canyon Diablo in New Mexico."

The crew found the "dark" side of the moon surprisingly well lighted by earthshine and had no trouble picking out landmarks. Cernan commented that the side away from the earth was "lit up like a Christmas tree," and Stafford found the details "phenomenal."

As the spacecraft swung out from behind the moon on its third orbit, the crew operated the TV camera for the sixth time and showed earth viewers historic first pictures of the moon in color. The colorcast opened with views of the Sea of Smyth on the dark side of the moon. The initial images on the TV screen were somewhat washed out, a phenomenon previously noted when the sun angle relative to the landmark was vertical. But as the spacecraft moved west toward an area where the sun angle was oblique, surface features were sharply, even starkly, defined. As Stafford turned the camera on the Sea of Fertility and the large crater Langrenus, Astronaut Joe Engel of the support team at the Manned Space Center in Houston called the picture detail "fantastic—absolutely unbelievable." The crater's two-mile-high walls and the 7,000-foot peak in its center stood out in all their ruggedness.



*Large crater Firmicus at top, with Sea of Waves in foreground.*

Much of the moon's surface was shown to be roughly structured, grey-white and, under certain lighting conditions, having a brownish tint. There were areas of huge boulders; some of them black and others black and grey. The preferred landing site was revealed to be free of boulders and pocked with a scattering of small shallow craters, but with enough smooth areas for a landing. Shots of the earth showed its apparent size as somewhere between that of a golf and tennis ball.

**Thursday, The Big Day**

May 22nd was scheduled as a work-filled, action-packed day for the crew. If anything the events of the day went beyond the plan. It began with a problem. Insulation in the docking tunnel had come loose earlier in the flight and clogged a vent; the

incident had let the LM slip about 3.5° out of line with the CSM in its joined position. Ground control advised the crew not to undock if the angle exceeded 7°. Ground control feared that if the angle became too large, the locking latches in the docking collar would be damaged and the LM, on its return from its solo flight, would be unable to make a secure hook-up with the mother ship. This would create difficulties for Stafford and Cernan's return to the CSM—the only component of the Apollo spacecraft able to return to earth and withstand the extreme temperatures of re-entry.

As this instruction was acknowledged, the spacecraft passed behind the moon, which ended all communication with the ground for the period it was on the far side. A tension-filled 36 minutes followed, relieved only when the Apollo and the LM re-estabished radio links with the ground and advised that they had successfully separated and were flying formation—"station keeping"—some fifty feet apart.

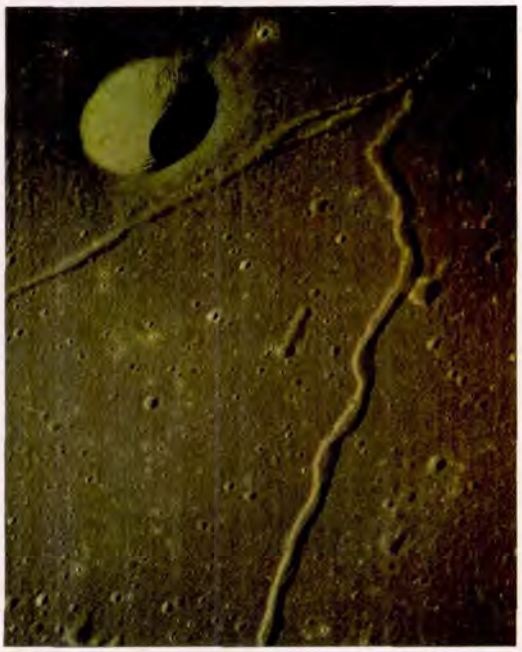
As Stafford and Cernan readied the LM for its descent to a low point only 50,000 feet from the moon's surface, the levity and gaiety that had characterized the outward leg from earth vanished. The exchanges with the ground were brief and workmanlike as the two struggled to complete certain tasks within the time allotted. Cernan summarized in edgy tones, "There are so many things to do in such a short time."

It was mid-afternoon before they were ready for the descent. Young in the CSM experienced momentary difficulty getting current into the homing receiver that was essential to the relay of the LM's rendezvous radar signals. He overcame the problem by recycling a power switch and reported receipt of the signals to the two pleased crewmen in the LM.

At 4:35 p.m., EDT, the LM descent engine was fired in a braking mode and the LM moved toward an orbit the low point of which would take man closer to the moon's surface than ever before. Young kept a lonely vigil in the CSM, ready to undertake the delicate and extremely complex rescue mission if something went wrong with the LM.

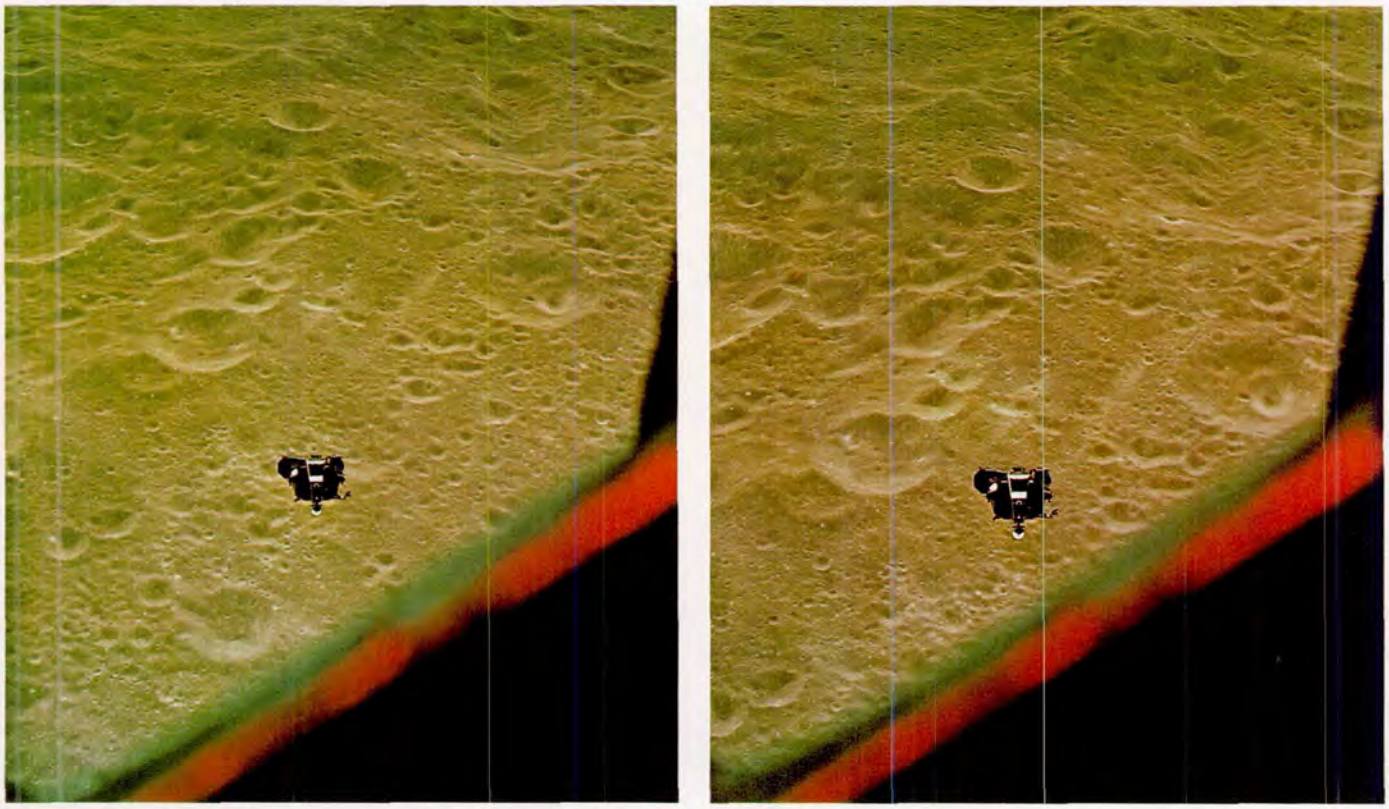
Amost an hour later, Cernan excitedly commented, "Hello Houston, we is down among it!" The LM had reached a point 8.4 nm above the Sea of Tranquility where Apollo 11 is intended to land. The two crewmen alternated with rapid-fire descriptions of the lunar surface that was passing beneath them.

What they saw appeared to stretch their vocabularies. The landing site was "pretty smooth, like wet clay, like a dry river bed in New Mexico or Arizona." "Earthshine—got to be magnificent!"



*Left: Crater Maskelyne and a rill nicknamed "Diamond Back" by the crew.*

*Crater Godin in the highlands east of landing site 3, from the CSM.*



*"Snoopy", the Lunar Module, comes up from 8.4 nautical miles of the Moon's surface to rendezvous and dock with "Charlie Brown", the Command Module.*

The mare's "a beautiful sight!" "Enough big boulders to fill Galveston Bay."

**A Guidance System Problem**

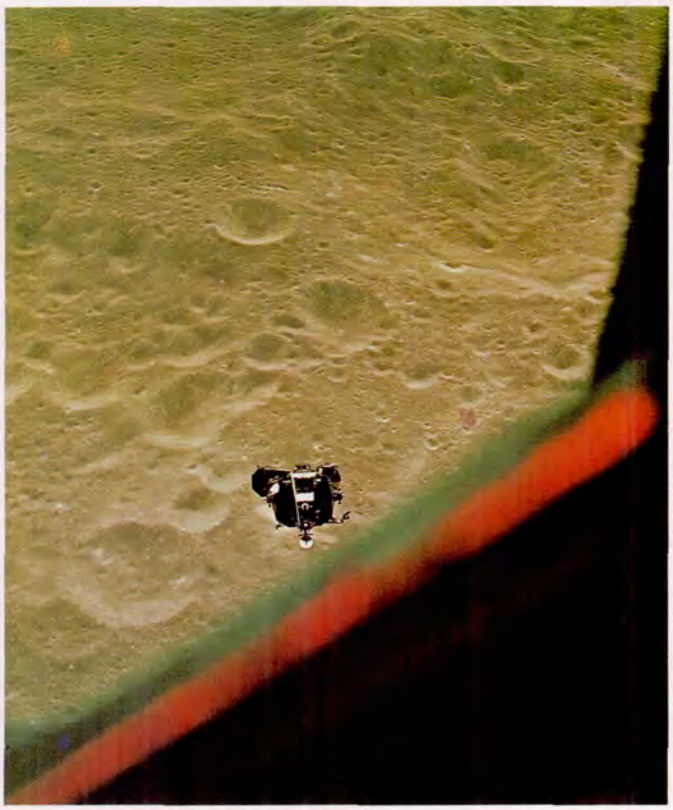
At the low point of the LM's second swing around the moon, Stafford and Cernan prepared for insertion into rendezvous orbit, a delicate maneuver using the LM's ascent engine—to bring them up for a rendezvous and docking with Young in the CSM. Before firing the ascent engine, the descent stage, with its power plant capable of a wide range of power settings controlled by the crew, had to be cast off. Just before the lower segment was cut loose, the LM gyrated. Stafford took manual control of the LM and restored the proper orientation. Then the descent stage was jettisoned, as planned, and the LM stabilized. The episode took some eight seconds.

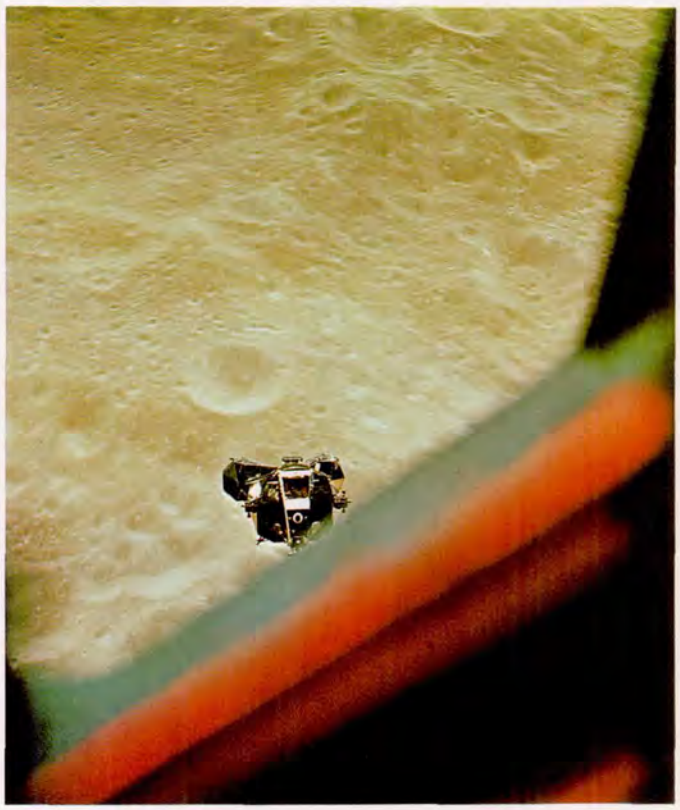
Analysis indicates that the problem was caused by a malfunction in the backup guidance system. When the trouble began, the LM was under the control of this system. The system shifted its control modes which produced the LM's erratic behavior. Once free of the descent stage, the astronauts shifted the ascent stage to the primary guidance system control and there were no further difficulties.

During the period that the CSM and the LM were separated, some communications problems arose. But the astronauts and Ground Control at Houston worked around them and they had no adverse effect on the flight.

**The Final Rendezvous**

With the LM back on its good behavior and the jettisoning of the LM lower stage accomplished, Stafford and Cernan fired the ascent engine at 7:44





p.m., May 22nd. A 15-second-burn sent the LM into a looping orbit above and behind the CSM. From a maximum separation of 320 nm, by 10.07 p.m. they had closed to within 38 nm. A sequence of three burns of the LM's small reaction-control thrusters brought the LM within docking range. During the docking maneuver, the LM played a passive role and Young linked the two spacecraft. The docking was complete at 11:11 p.m. and 14 minutes later Stafford and Cernan came through the tunnel into the CSM. As Cernan emerged, he declared, "Man, I'm glad I'm getting out."

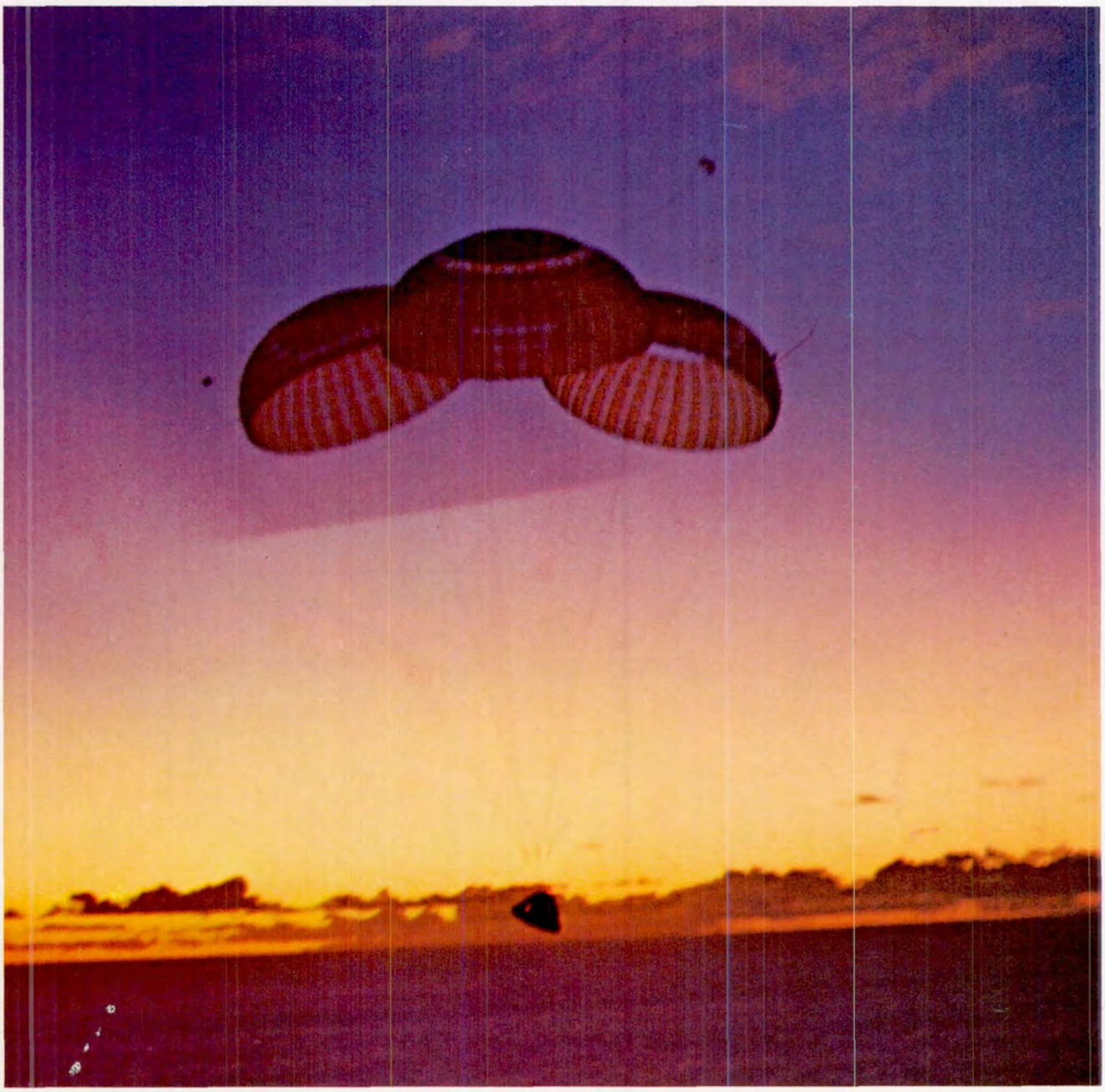
The LM had flown independently eight hours with Stafford and Cernan standing all the while as if they were driving a bread truck. They were maintained in their position by a web of belts and harness.

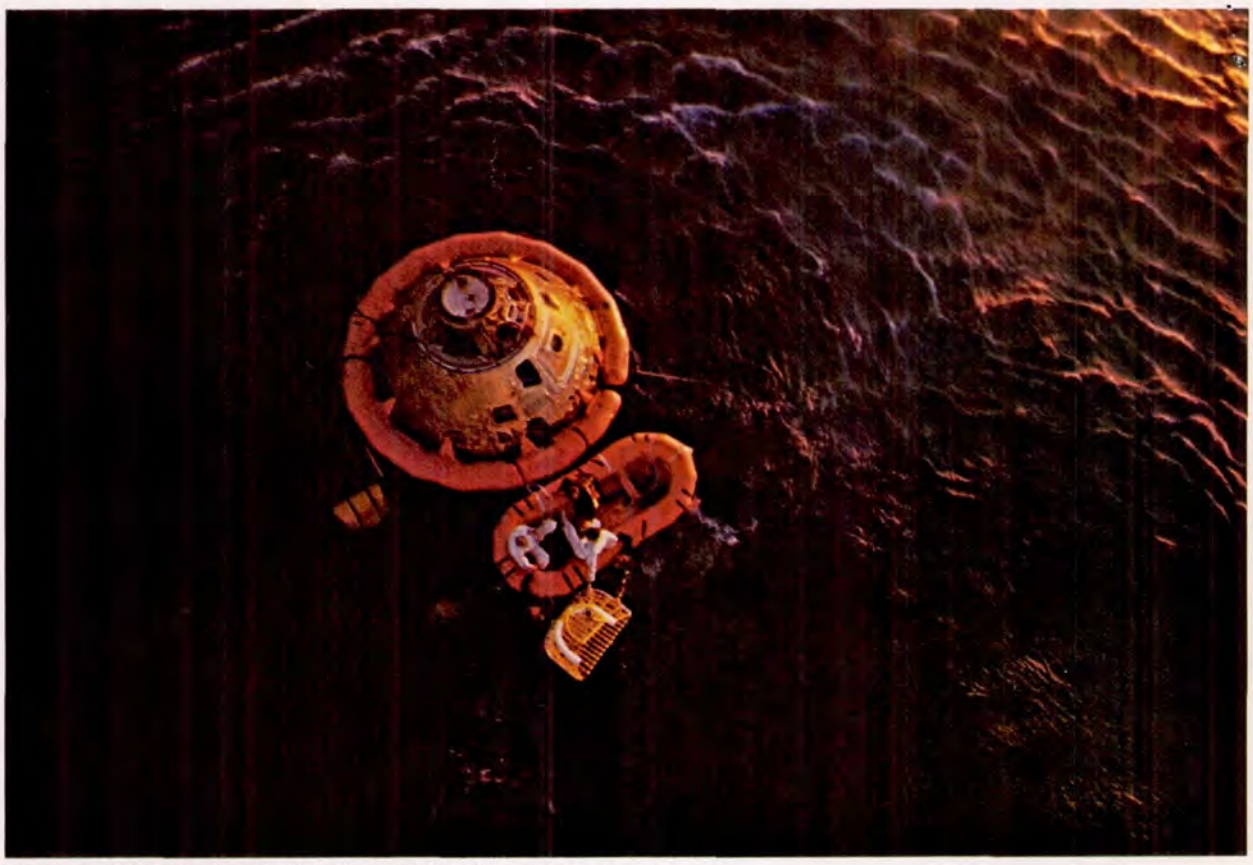
When advised of the docking, Houston control broke out a large cartoon showing Snoopy kissing Charlie Brown. The accompanying balloon read, "Smack. You're right on target, Charlie Brown." With the tunnel locked up, the LM was cast loose and a firing of its engine drove it into an orbit around the sun.

**A Day's Orbit and Return Home**

Friday, May 23, was a day of relaxation in lunar orbit. The crew did some landmark tracking and worked on the lunar photography that had been written into the mission. There were more color-casts; one at 1:00 a.m. Saturday morning was the best up to that point of the flight. The astronaut crew reported some minor discomfort. Fibre particles floating around the cabin got under the space suits and caused the astronauts to itch. It also got into the crew's noses and throats, irritating their respiratory tracts. Stafford was uneasy for a

*Just before splashdown. The Apollo spacecraft drops toward the ocean surface with a Pacific sunrise as a backdrop.*





*The end of the voyage. Apollo 10 in the Pacific awaiting recovery.*

time about the reappearance of the LM descent stage. It appeared above and in front of the CSM —an unwelcome companion in its dead state—then dropped behind.

At 6:25 a.m., while on the far side of the moon, the crew fired the SPS to gain the velocity needed to escape from lunar orbit and enter the narrow corridor that would take them back to the good earth. So exact was the burn that the speed achieved was only .4 mph less than planned. Houston told the crew that they "were coming right down the fairway." The mid-course corrections that had been written into the flight plan were eliminated as unnecessary.

The return leg of the flight featured more colorcasts. A few hundred miles from the moon, the camera zoomed in on the huge crater Tsiolkovsky, named by the Soviets after the Russian theorist on rocketry. The pictures disclosed that the crater is fractured almost symmetrically into a number of pie-shaped pieces. Its outside walls look chalk-white; the inner, tan. The color of the floor is a chocolate brown and a pair of mountain peaks at the center are white.

The final colorcast showed a brilliant half-disc of earth resplendent in blues, greens, and browns, through swirls of white clouds.

When the camera focused on the crew, they had shaved. This had not been done before in space because of concern that shorn hair might escape in the cabin and cause difficulties with the instruments. The crew avoided this by using tube shaving cream and capturing the scrapings in swabs.

**An Applauding Press**

The U. S. press, as well as the press in other nations, was lavish in its flight coverage and lauded the performance of the astronauts. Moscow Radio provided the contrast by qualifying its wishes of success to the crew "whose members were prepared to make up with their courage for any insufficient reliability of their aircraft."

**Recovery**

As the Apollo 10 moved out of lunar orbit, the prime recovery ship, the carrier **Princeton,** took up its station 450 miles east of Samoa. The Governor of Samoa gave the crew a reception.

In the Houston control center, where the astronauts will be flown for de-briefing, a large sign had been put up. It reads "51 days to launch":— a reminder (if one is needed) to all hands that the lunar mission is near.

*Crew (left to right) Cernan, Young, and Stafford*

## THE APOLLO 10 CREW

**Colonel Thomas P. Stafford, USAF** was flying his third mission on Apollo 10. His first mission was the history-making Gemini 6 which accomplished the first successful rendezvous of two manned, maneuverable spacecraft with Gemini 7. In June of 1966, he flew again as command pilot of Gemini 9 and performed three different types of rendezvous with the unmanned Augmented Target Docking Adapter. He had logged 98 hours and 11 minutes in space prior to the Apollo 10 flight.

He holds an honorary Doctorate of Science from Oklahoma City University. He has been awarded two NASA Exceptional Service Medals and the Air Force Command Pilot Astronaut Wings, and was co-recipient of the 1966 Harmon International Aviation Trophy. He was born in 1930 in Weatherford, Oklahoma. A graduate of the U.S. Naval Academy, he is married and has two daughters.

**Commander John W. Young, USN,** was also going into space for the third time. He piloted the first manned Gemini flight, a 3-orbit mission, in March 1965. On this flight, the trajectory was modified for the first time for a manned spacecraft. In July of 1966, Young was the command pilot of Gemini 10 which rendezvoused and docked with an Agena target vehicle. The Agena main engine was fired and the linked spacecraft ascended to what was then a record altitude of approximately 475 miles above the earth.

Young was graduated a Bachelor of Science from Georgia Tech in 1952. He has two NASA Exceptional Service Medals, Navy Astronaut Wings and three Distinguished Flying Crosses. A test pilot, he has 4,500 hours flying time, of which more than 3,900 are in jet aircraft.

Born in San Francisco, California in September 1930, he is married and has two children.

**Commander Eugene A. Cernan, USN,** was making his second trip into space. His first flight was with Colonel Stafford on the Gemini 9 mission. On this mission, he walked in space for 2 hours and 10 minutes. He was backup pilot for Gemini 12 and backup Lunar Module Pilot for Apollo 7.

Cernan received a Bachelor of Science degree in electrical engineering from Purdue University and a Master of Science degree in aeronautical engineering from the U.S. Naval Academy Postgraduate School. His decorations include the NASA Exceptional Service Medal, Navy Astronaut Wings, and the Distinguished Flying Cross.

He was born in Chicago, Illinois in March, 1934. He is married and has a daughter.

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