science news
OF THE WEEK

APOLLO 12

More footsteps on the moon

This week's second manned lunar landing underlined Apollo's flawless engineering and left some time for research as well

Wide World Photo

Bean descends Intrepid ladder.

Man's second visit to the moon this week, while perhaps less of a milestone than the first, was certainly at least as fulfilling. Up until the actual landing, even the prospects of again reaching the moon seemed hardly to faze space-seasoned groundlings at the Manned Spacecraft Center in Houston. But the spirit of discovery in ebullient Charles (Pete) Conrad and rookie Astronaut Alan Bean produced enthusiasm often exceeding that surrounding the more historic feat of Apollo 11.

The story of the moonward leg of the flight—indeed of all the manned Apollo flights so far—was one of minor and not-so-minor difficulties overcome to produce success. Before liftoff, a liquid hydrogen tank sprang a leak, an amplifier failed and a liquid oxygen pump broke down; yet typically, the mighty Saturn 5 booster left the pad only two-thirds of a second past the scheduled 11:22 a.m. EST Nov. 14.

Less than a minute after launch, the flight took a hair-raising turn as a brilliant bolt of electricity appeared between the rocket and the ground. With Apollo 12 barely a mile and a half above the earth, virtually all of the electrical equipment in the spacecraft suddenly shut down, leaving row upon row of abruptly opened circuit breakers glowing ominously green.

"I don't know what happened here," said spacecraft Commander Conrad. "We had everything in the world drop out." Even the vital inertial platform, heart of the sensitive guidance system charged with getting Apollo to the moon and home again, was "just drifting all over the place." As in the infamous New York blackout, effects triggered new ones like falling dominoes: Overload detectors automatically disconnected from the spacecraft's power-supplying fuel cells for safety, throwing the entire spacecraft electrical load on the batteries, whose suddenly overburdened output dropped enough to shut down the telemetry system, and so on.

Yet within three minutes, the cool-thinking crew had restored all the circuits to operation, and no sooner had the spacecraft entered the earth's shadow, than command module pilot Richard Gordon used Apollo's computer-aided sextant to take star sightings and reset the critical guidance platform.

Days later, with the astronauts comfortably on the moon, the source of the sudden bolt had still not been agreed upon. Theories ranged from a discharge of static electricity built up in the rocket, to an unusual form of lightning leaping up the booster's ionized exhaust stream from the gound.

In addition, about 30 hours into the flight, Apollo 12 became the first moon mission to abandon the major safety provision used on Apollos 8, 10 and 11. Because of the requirements for getting into a moon orbit of proper altitude, Apollo 12 had to leave the trajectory shared by its predecessors, which would have returned it automatically to earth after a swing around the moon in the event that it had failed to lock into lunar orbit. Although considered a reasonable risk by space agency planners, the non-self-returning trajectory could have sent the astronauts into the sun, had the spacecraft's main engine failed to do its job.

Nevertheless, the landing was a gem, particularly because it represented a triumph for National Aeronautics and Space Administration engineers who had wracked their brains for computer techniques and other ways of improving landing accuracy, after Apollo 11's many-mile miss of its target in July (SN: 7/26, p. 73). At stake in the pinpoint landing question could be more difficult, but scientifically interesting, sites for future Apollo missions (SN: 8/9, p. 112), as well as flight chances for scientist-astronauts.

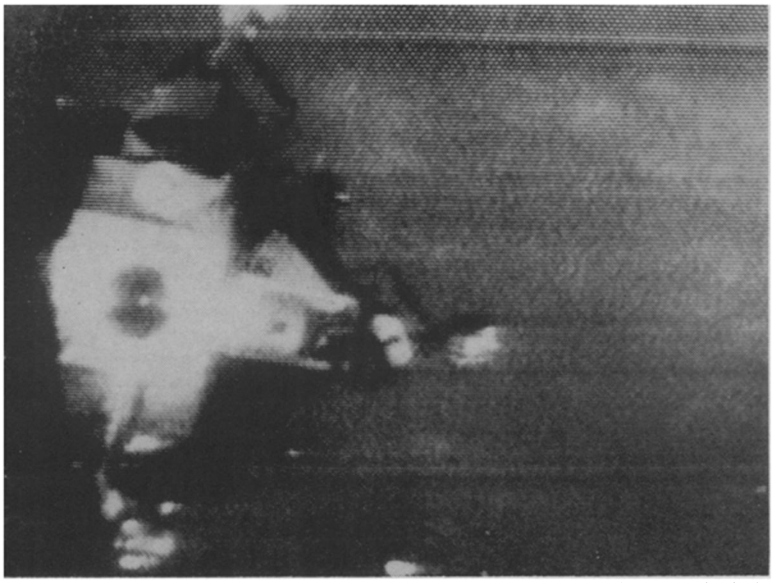
Together, the new techniques added up to a mighty plus. In the final powered descent to the lunar surface—a total time of less than 12 minutes—they canceled out accumulated errors that would have left the lunar module five miles north of its target: the area of Surveyor III robot spacecraft, which landed on the moon on April 19, 1967.

With scant minutes to go, Conrad peered out the triangular LM windows, looking for landmarks learned during months of tedious photo, map and simulator training. "I think I see my crater," he said. "I'm not sure." Then suddenly, "Hey, there it is, there it is. Son of a gun, right down the middle of the road."

And with Bean calling out the rapidly decreasing altitude and speed, Conrad, amazed by his own fortune and prowess, quickly picked an inviting spot and set his space ship Intrepid down, 25 feet northwest of the rim of the crater in which Surveyor III reposed—a mere 600 feet away.

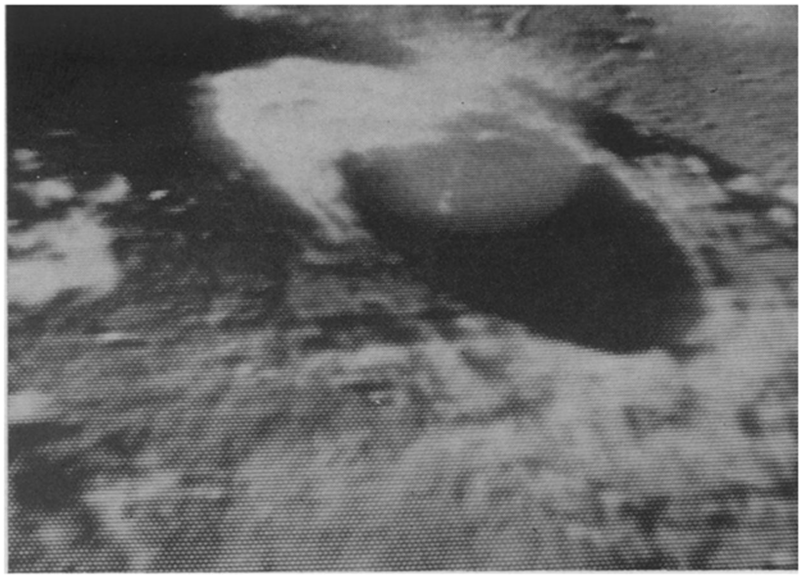
On the surface, Apollo 12 faced twice the workload of its predecessors, with two excursions onto the lunar surface scheduled instead of one. The first was devoted to the mission's prime scientific goals: rock samples and deploying the initial Apollo Lunar Scientific Experiments Package (SN:7/19, p. 58). The second: more rocks and a visit to Surveyor III.

One of the first things noted by Conrad was that lunar dust seemed to build up against one rock facing the Surveyor in which he was interested. This could be an indication of the fineness of moon dust in the landing area—the astronaut at one point observed to Bean that in a compressed clump of the dust, the individual particles were all but indistinguishable—possibly suggesting that the Ocean of Storms site is older than Apollo 11's base in the Sea of Tranquility, giving micrometeorites a longer time in which to pulver-



Wide World Photo

Intrepid breaks away from Yankee Clipper.



Wide World Photo

Moon crater televised from lunar orbit.

ize the surface material.

Dust, which once was thought deep enough to forbid lunar landings, seemed to be everywhere. The final phase of the descent to the surface kicked up so much that Conrad joked about having almost to make an instrument landing—a blind touchdown. Later, both astronauts complained about the omnipresent moon dirt leaving their spacesuits filthy and doing the same thing to the white heat-reflecting coatings on the ALSEP instruments. Dust on the instruments, Conrad worried, might produce dangerous hotspots on the sensitive experiments in the blistering lunar day. "There's just no way they can keep clean."

As they walked about the surface, the astronauts were able to take advantage of one small but insignificant addition made following Apollo 11: a pair of so-called saddlebags designed to pick up interesting rocks at any point in their labors, rather than only when the official rock boxes were open. On the surface they saw again the glass beads that had been discovered in the samples from the first landing mission (SN: 9/6, p. 176); other glassy bits were found in rocks themselves.

Other moon chunks in the area seemed to represent bedrock, making them valuable as indicators of what lies below the dust. By contrast with the less excitable Apollo 11 moon walkers, the astronauts seemed constantly enthralled with the variety of rocks, often exclaimed, "Look at that!" or "I never saw one like that before." They commented especially on some puzzling volcano-shaped mounds, about four feet high and five feet across the top with 15- or 20-foot long sloping shoulders. Neither Neil Armstrong nor Edwin Aldrin, the two moon explorers for Apollo 11, could suggest any idea of what the mounds might be.

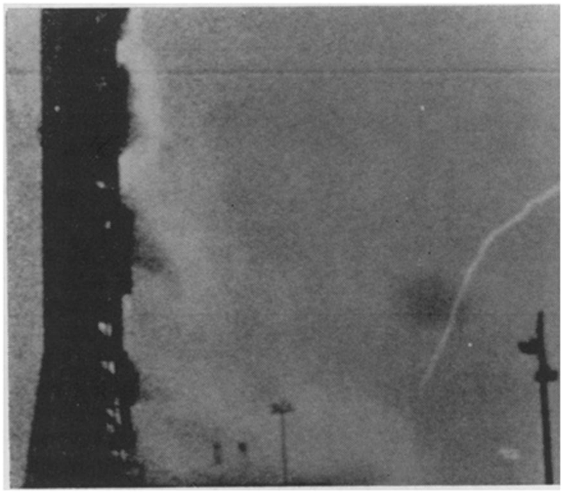
Deploying the ALSEP experiments posed a few problems. But, as with the rest of the mission, none of the difficulties seemed insurmountable. At one point, the plutonium fuel element for ALSEP's radio isotope power supply refused to be dislodged from its storage enclosure for placement in its generator housing. But careful pushing and pulling with the specially provided claw tool freed it undamaged.

Perhaps the most important experiment of the batch, a passive seismometer similar to that left by Apollo 11, gave some pause, first over whether it could be firmly seated on the dust-cloaked ground despite some tamping by the astronauts, and second when its large, metal foil base refused to lie flat after being so long folded within the LM. "Just pile some dirt around the edges," radioed Houston, and it seemed to turn the trick. Later, when the astronauts were walking back to their spacecraft, the device clearly detected their footsteps.

The ALSEP instruments were set up about 600 to 700 feet west of the LM on approximately the opposite side of it from the Surveyor. This offered lunar traverses in directions as different as possible, and kept the instruments comfortably out of range of the blast of the LM when it took off from the moon.

Besides the seismometer (deemed so important that it was the only instrument selected to go on every Apollo from 11 on) the other ALSEP instruments, all of which were deployed, include:

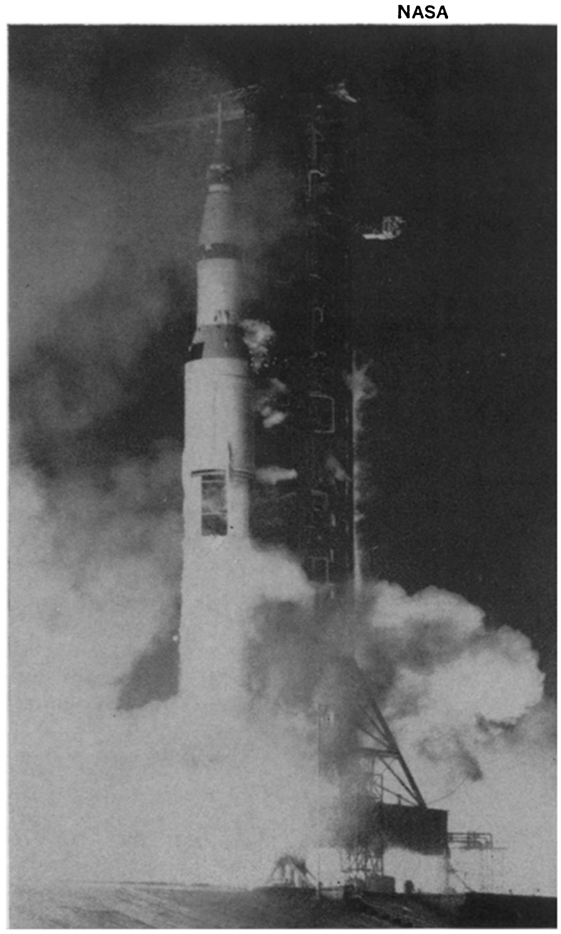
- A magnetometer with three skinny arms aligned to measure the moon's magnetic field in three axes and capable of measuring a field as weak as one percent of earth's.
- A solar wind spectrometer far more elaborate than the simple foil sheet left by Apollo 11 and equipped with seven electronic sensors in a device called a Faraday cup to measure the type, charge and direction of particles from the sun.

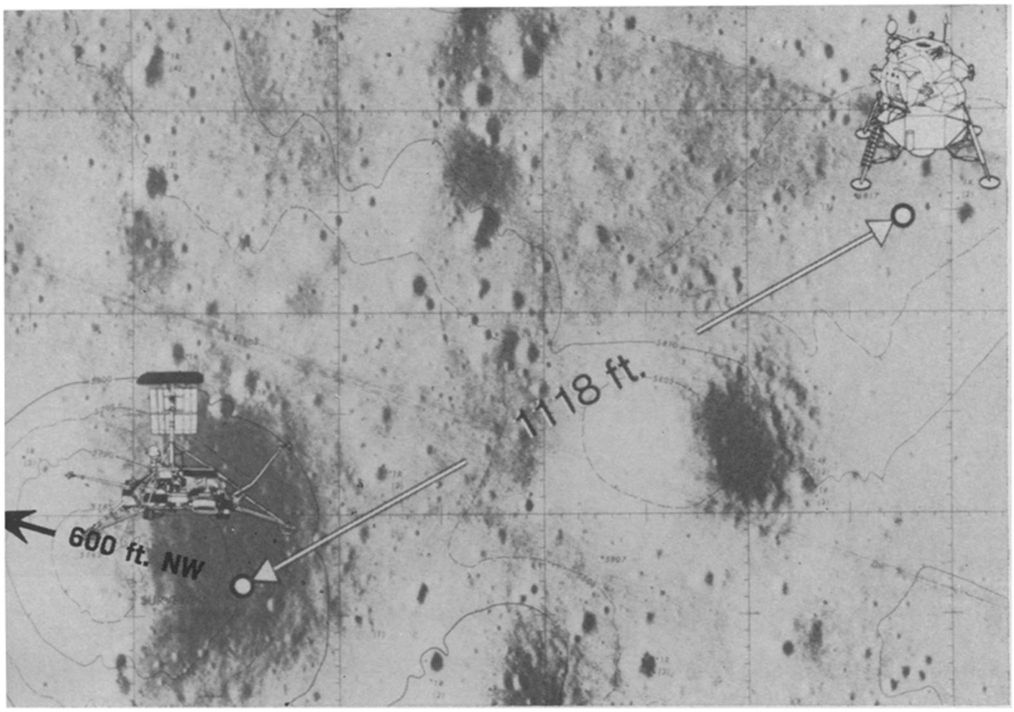


Wide World Photo from NASA

The Bolt down the rocket trail 41 seconds after the on-time blastoff.

NASA





NASA

Intrepid landed 600 feet from Surveyor—virtually a pinpoint landing.

▪ A suprathermal ion detector designed to study the flux, numbers, density, velocity and energy per unit charge of positive ions near the lunar surface.

▪ A cold cathode ion gauge to measure the density of whatever lunar atmosphere may exist.

After setting up the experiments, the astronauts were asked by ground controllers to visit a large crater about a thousand feet away. "Well, we're not getting many rocks by going that far," Conrad said, "but if that's what you want, that's what you want."

Their observations included photos as well as rock sampling, but the majority of the geological data were to be gathered on the second trip outside the lunar module. One casualty of this moonwalk, however, was the LM's color TV camera, which apparently burned out when it was inadvertently aimed into the sun while Bean was carrying it over to be mounted on a tripod.

Slightly more than 12 hours after the LM hatch closed behind the reentering astronauts, it opened again for their second sojourn. Loaded with cameras, tools and bags for rock and dust samples, Conrad and Bean began their trek across the airless surface, with its unearthly dearth of color.

Knowing that study of the eerie lunar surface itself was the main goal of their mission, the astronauts had given particular attention to preparing for this excursion; Conrad alone had devoted more than 250 hours to intense geological training. The extensive cramming more than paid off.

As they traveled, following a predetermined, clover-shaped path that took them in and out among several small craters, at most about a quarter-mile from the LM, the two astronauts became aware that there were differences from Apollo 11's Tranquility Base, more than 1,000 miles to the east. "It's not at all like Neil's rock," observed an intrigued Bean referring to Apollo 11 commander Neil Armstrong's first moonwalk.

They reported, for example, a complete lack of any micro-breccias—combinations of minerals held together in a matrix of some other rock—as well as very few of the glassy-pitted vesicular rocks so common in the Apollo 11 samples, though they did see many of the glass beads noted from the previous flight. They also described a seemingly greater variety of rock types, including coarse-grained granitic formations, "brick-looking" rocks and others so rich in shiny surfaced facets that they were iridescent.

On the way, the moon walkers took hundreds of color, black and white, stereo and polarized-light photographs, as well as taking core-tubed samples from greater depths than were obtained during Apollo 11's trip, one of them perhaps 32 inches long.

The prize gained by Intrepid's precision landing, however, was Surveyor III, which will give space scientists and engineers the first chance they have ever had to examine the effects of long exposure—two and a half years—to space conditions. Unprotected by earth's atmospheric blanket, the automatic spacecraft has been incessantly bombarded with micrometeoroids, cosmic rays, and particles from the solar wind. The design of future space stations and lunar laboratories depends greatly on data about the degradation of metal parts, optical surfaces, electronic components and insulation materials, as well as about the effects of space on earthly microorganisms that may have survived the journey.

Besides using special tools to remove the television camera, camera cable (whose bacteria count was measured on earth before launch, offering a comparison), dirt scoop (with "a free sample" of the original dirt still in it), and some metal support straps, the astronauts noted that mere exposure to the sun seemed to have taken its toll. The white coatings on the spacecraft all appeared to have changed color, ranging from tan to dark brown, its multicolored photographic comparison chart seemed also to have changed and the white solar panels had become black.

Some of the changes may turn out to be dust deposits rather than color alterations, but this still might have a thermal effect on long-life structures. In addition, some glass, while not cracked, was apparently warped by the heat of the lunar day.

They completed the round trip to Intrepid, gathering still more rocks and dust on the way for a total of as much as 90 pounds. On the second trip alone they had covered more than a mile.

Takeoff from the moon came on schedule, after some 32 hours on the surface. After the duo rejoined astronaut Richard Gordon, who had been photographing future Apollo landing sites from orbit aboard the command module, the only experiment remaining in the mission was to send the now-empty Intrepid crashing back into the moon by remote control, in hopes of providing a major tremor for the seismometer. The 5,500-pound spacecraft, hitting the moon at a predicted 5,508 feet per second, was expected to provide a total of more than 30 million-foot pounds of momentum, though the shallow impact angle, probably about four degrees, would determine the amount reaching the instrument.

All of the other ALSEP instruments were believed to be in working order as well, with scientists merely waiting for them to reach thermal equilibrium before beginning to gather data.

The next Apollo mission is now scheduled for launch at 3:10 p.m. on March 12, 1970, aimed for the ancient, mountainous Fra Mauro area, barely 200 miles from the Apollo 12 base, but believed to be composed largely of material violently ejected from a large crater to the south. That crew will be the first in the Apollo program to include two rookies, Ken Mattingly in the command module, and Fred Haise as second man in the LM. Commanding the flight will be James Lovell, who held the command module pilot's job during Apollo 8's flight to orbit the moon. □