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Special Report:

First Manned Rover on Moon

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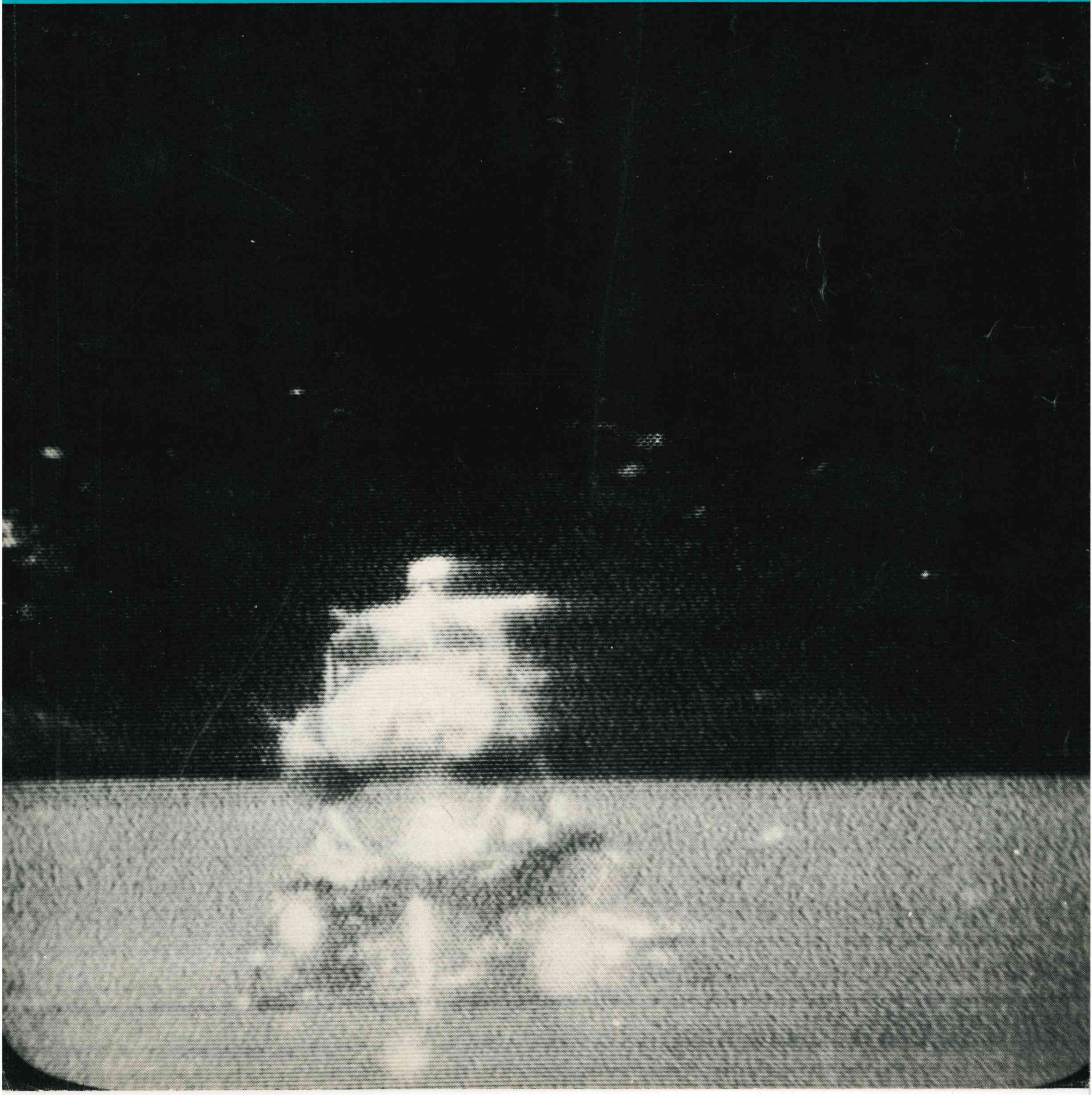


Falcon ascent stage lifts off from moon

Man Must Explore

The full impact of how man can and should explore the moon was demonstrated to every television viewer on this third planet of the solar system by the Apollo 15 mission of Astronauts Dave Scott, Jim Irwin and Al Worden. Looking back, it was incredible how the critics of the Apollo program—laymen, pressmen, politicians and scientists—all refused to believe that it was not just a technical tour de force. They remained completely blind to the possibilities of lunar exploration outlined so vividly from the very inception of the program.

Now even The New York Times, long a waspish critic of manned space flight, hailed the Apollo 15 mission as a great scientific expedition that has proved the moon can be made habitable. It may be just coincidence that the Times acquired serial rights to the Apollo 15 astronauts' personal stories shortly before this mission.

The ethical standards of these commercially peddled serial rights have been questionable ever since they began with the original Mercury Seven, but, in retrospect, they may be a small price to pay for diverting the mindless hysteria of The New York Times editorial page on manned space flight to more perceptive channels.

Keynote Sounded

Dave Scott sounded the keynote of Apollo 15 and, indeed, of the whole Apollo program during his initial moments on the breath-taking moonscape after he first stepped from the Falcon lunar module when he exclaimed:

". . . There is a fundamental truth to our nature: Man must explore."

Apollo 15 was a triumph of the human spirit as well as a clear demonstration of the human body and intellect as a superb space research tool in comparison to remotely controlled automatons from Ranger to Lunokhod. It was also another engineering triumph that has matured from its experimental flight test status of Apollo 7-11 to a reliable lunar transportation system that can put the required men and equipment precisely in place on the lunar surface some quarter-million miles from launch and return the astronauts and their data safely with equal precision.

Apollo 15 represented the full blossoming of this equipment as a transportation system that can now be further developed to put larger and more useful payloads on the lunar surface. Its capabilities, demonstrated so dramatically during Apollo 15, will insure that man's exploration of the moon will never be abandoned.

The old reliables of the Apollo system—the Rocketdyne engines, the Boeing and McDonnell Douglas booster stages, the Grumman lunar module, the IBM computers and instrumentation, the North American Rockwell command and service modules—all performed flawlessly.

But there were some new items of equipment on Apollo 15 that added new dimensions to lunar exploration. They included:

- **The lunar rover,** built by Boeing and Delco Electronics Div. of General Motors, that gave the astronauts the scope and mobility to do more scientific exploration than all previous Apollo missions combined.
- **The RCA color television** that brought the awesome sweep of this dramatic area of the moon into the homes of this country in real time and around the world by satellite communications.
- **The increased mobility space suits** built by ILC Industries that gave the Falcon duo the ability to work harder and perform a larger variety of tasks.
- **The improved PLSS backpacks,** built by Hamilton Standard Div. of United Aircraft, that gave the astronauts longer duration on the lunar surface for their exploration.

But it was the astronauts themselves who where the most effective tool for this lunar exploration. A dozen times, minor glitches that would have aborted an unmanned expedition were corrected by simple human fixes with tape, hammer and new procedures. But beyond that, the ability of the two highly trained intellects being able to transmit a running flow of precise geologic data to earthbound scientists in Houston and to gather the precisely documented samples required for further probing into the mysteries of the moon is unmatched by any machine.

Scientific Feast

Now that mission emphasis can be shifted from flight testing of spacecraft and their subsystems, a maximum of scientific activity was crammed into the lunar time available for both the lunar module Falcon on the surface and for the command module Endeavour in lunar orbit.

It will take intensive study and analysis of the film, rock samples and telemetered data to determine the full value of the scientific treasure garnered by Apollo 15. But already, there are indications that it will surpass anything in the long history of exploration. It will yield even larger scientific dividends than Apollo enthusiasts imagined.

The confirmation of layering in Hadley Rille and the Apennine peaks, the potentially oldest rock yet found, a variety of new geological discoveries, the precise mapping from the command module, the spotting of volcanic ash craters and other features hitherto masked from the most powerful earthbound telescopes and cameras are just a few of the canapes in what must eventually be one of the richest scientific banquets ever served by man. It took a long time for many people to realize that Apollo was truly a program for scientific exploration and not just a stunt flight.

We think Apollo 15 finally carried the message to everybody.

—Robert Hotz

Washington Roundup

Strife Threat

Chaos in airline industry labor relations would result from adoption of proposed Nixon Administration changes in the Railway Labor Act, Stuart G. Tipton, president of the Air Transport Assn., warned the House Commerce transportation and aeronautics subcommittee last week. The panel is considering proposed changes in the law to eliminate congressional involvement in disputes. The Administration bill would amount to repeal of the law, which governs airline labor relations as well as those of railroads, by eliminating the compulsory mediation feature and placing them under the general Labor-Management Relations Act principles.

Tipton expressed fear that **absence of compulsory mediation would put airlines under much greater pressure of a succession of strike threats,** because of the multiplicity of craft-type airline unions developed under the Railway Labor Act. As an alternative, airlines and railroads are jointly sponsoring legislation that would add steps after present mediation procedures run out.

They would have a panel appointed by the Labor, Commerce and Transportation secretaries study the dispute and recommend to the secretaries one of four courses of action: **allow a strike; name a fact-finding board; submit the dispute to binding arbitration or create a special board to make a binding determination** that one of the last offers of either party constitutes the contract.

Labor vigorously opposes the airline proposal. A possible compromise approach suggested by Rep. James Harvey (R.-Mich.) would offer **selective strike authority but give a presidential panel power to make a final offer the binding contract.**

STOL Steals Ahead

Research program designed to **develop a commercially viable short-takeoff and landing (STOL) transport aircraft moved ahead last week, although future funding remains indefinite.** National Aeronautics and Space Administration issued a request for proposals for two experimental STOL aircraft incorporating propulsive lift. Two or more design phase contracts, valued at approximately $1.5 million each, will be issued by NASA with Fiscal 1972 money.

However, NASA remains open to suggestions of cost-sharing by industry for the fabrication phase of the program. The agency originally suggested that industry pool its resources and enter into a joint venture program with the government. This received a **flat industry rejection, with manufacturers indicating they did not wish to be forced to share their data and findings with potential competitors.**

TRANSPO Change-O

TRANSPO-72 is the new official name for next year's transportation exhibition at Dulles International Airport, and **transformation of the show from the concept of its originator, the late Rep. L. Mendel Rivers (D.-S.C.), is almost complete.** Rep. Rivers envisioned the event as a U.S. version of the Paris air show but with heavy emphasis on military aviation. As chairman of the House Armed Services Committee, he cajoled and bargained authorization for the show through a reluctant Congress, with final funding approval coming only after his death.

Under current planning aerospace firms will occupy only one-forth to one-third of TRANSPO-72 exhibition space, and the military will be represented largely to supply flavor and entertainment. Main business of the hopefully-international show will be to bring together manufacturers and designers of all modes of transportation, with stress on intermodal aspects of moving people and freight.

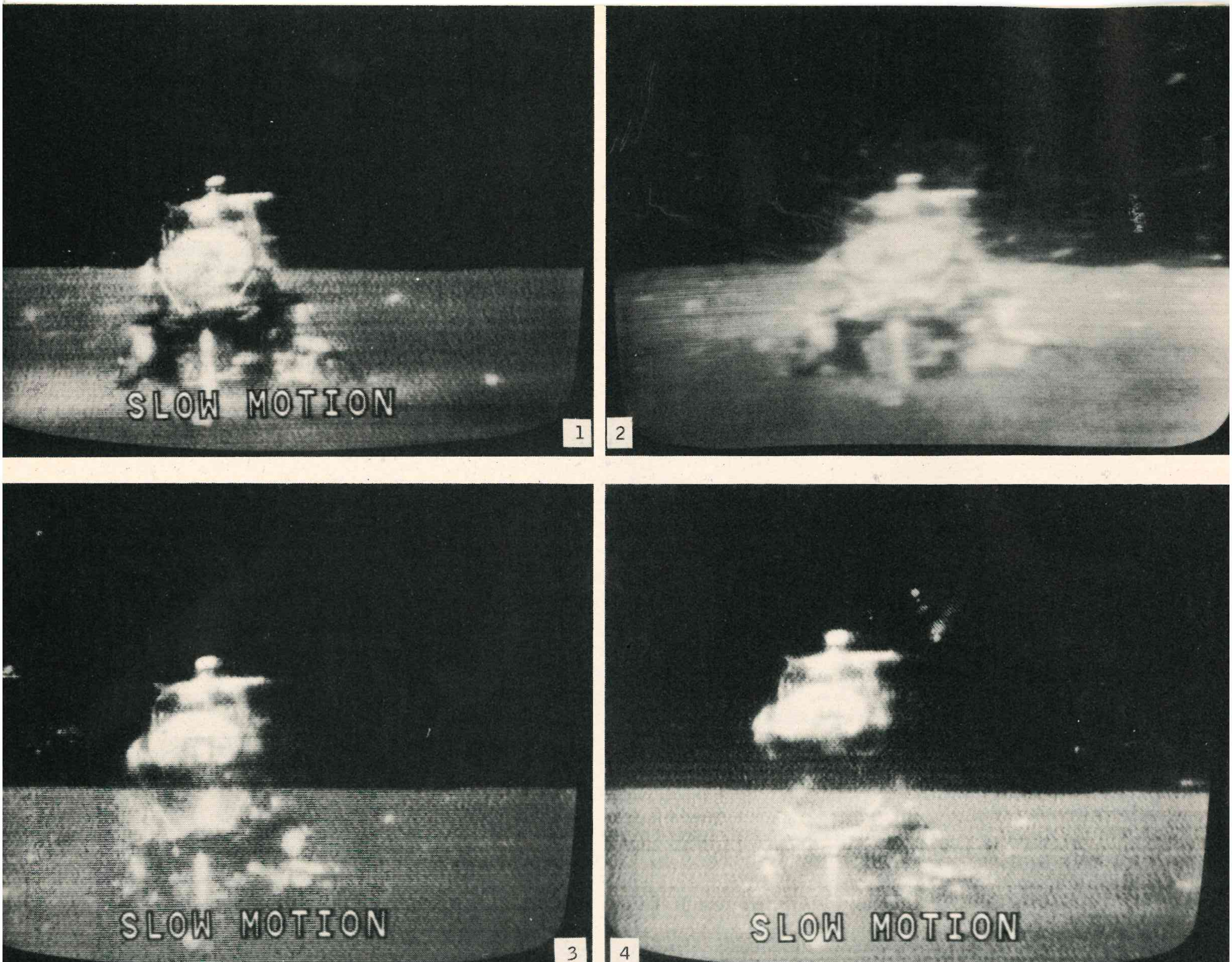
Paternity Suit

Space news made the front page of most Soviet newspapers after Apollo 15 was launched—**but the news was about progress of Russia's unmanned Mars 2 and Mars 3 spacecraft, launched last spring** (AW&ST May 24, p. 22). Coverage of the historic U. S. mission was brief, generally factual, and buried as deeply as is possible within the standard Soviet four- or six-page newspaper.

As usual, reportage **emphasized the dangers and difficulties of the flight, such as the water leak, the core sampler stuck in the lunar surface and the inoperable front-wheel steering of the lunar rover** during the first surface EVA. Occasionally the solution of these difficulties was reported, but not in every case.

The only commentary to appear during the mission was from Pravda's New York correspondent, who brought to the readers' attention the fact that the **two-man lunar rover should be considered a direct descendent of the Soviet Lunokhod-1,** the unmanned vehicle landed at the Sea of Rains last year.

—Washington Staff



Television camera on lunar rover shows lunar module in final seconds of countdown (1) before ignition of ascent stage engine. Engine ignites (2), the blast carrying away bits of insulation. Ascent stage lifts off (3) and begins rapid climbout (4, 5), but with no exhaust plume visible. Dust clouded descent stage (6) but cleared in a few seconds. (Photos off CBS News TV monitor.)

Added Mobility Spurs Geologic Harvest

Lunar rover enables astronauts to explore Hadley-Apennine area for more than 18 hr. in three extravehicular sorties

By Zack Strickland

Houston–Astronauts David Scott and James Irwin roamed the rolling Hadley-Apennine area of the moon for more than 18 hr. during Apollo 15, mining a bonanza of geologic treasures.

It was all made possible through a sturdy little electric runabout, the lunar rover, which emerged from the Apollo 15 mission as a kind of mechanical "fourth astronaut."

Its capability on the lunar surface was called "fantastic" by Flight Director Gerald Griffin at Mission Control Center in Houston. "A great little machine," he said as the last of three lunar surface sorties ended. "I hate to leave it up there."

Even as the astronauts left the moon, the Boeing-built rover was continuing to perform, providing battery power for man's first view of a lunar liftoff through an RCA color camera mounted on the vehicle chassis. As the ascent stage of the Grumman lunar module Falcon separated from the descent stage en route to a rendezvous with the orbiting Endeavour command module, the rover camera sent a clear signal back to earth of the fireworks-like scattering of debris at ignition and the 2 sec. climb off the TV screen.

The rover—officially called the lunar roving vehicle (LRV) by the National Aeronautics and Space Administration—gave Irwin and Scott the tool to range over more than 28 mi. of moon, from the edge of the deep gorge called Hadley Rille to the slopes of the Apennine Mountains. In tandem with an improved extravehicular mobility unit (EMU) made by Hamilton Standard and a new, more comfortable space suit made by ILC Industries, the rover allowed Scott and Irwin to concentrate on the scientific aspects of the fourth successful expedition to the moon.

And this they could do with a minimum expenditure of energy which in previous missions was an overriding constraint to the amount of useful work astronauts could accomplish on the lunar surface. Consequently, Scott and Irwin could collect almost 170 lb. of geologic samples, set up an Apollo Lunar Surface Experiments Package (Alsep), drill holes into the lunar surface to take the moon's temperature, retrieve lunar material from 10 ft. beneath the surface and make the most cogent visual observations of the moonscape yet, all without worrying unduly about how to get from point to point.

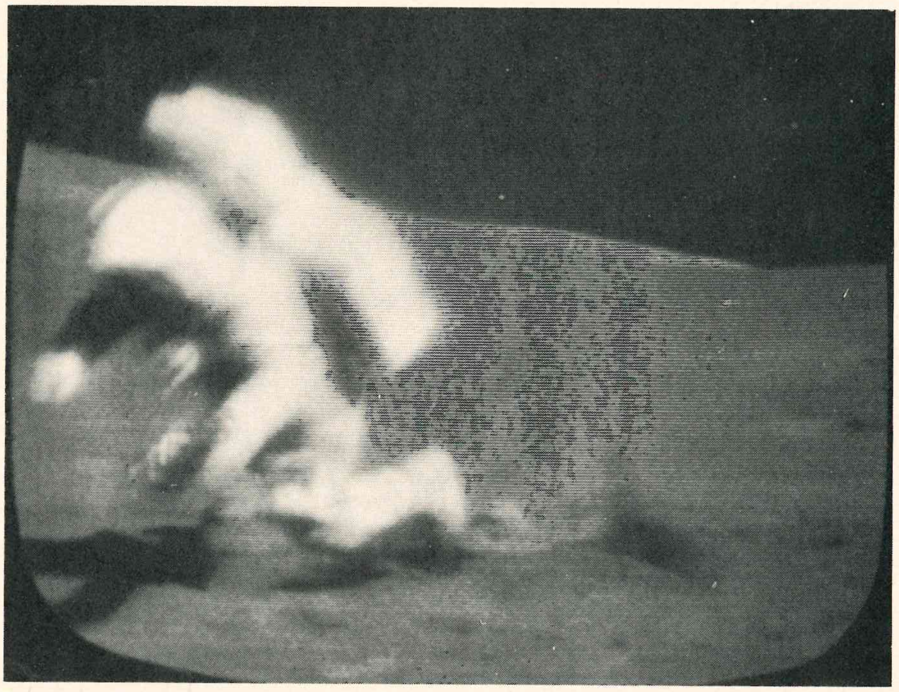
The small, wire-tired vehicle provided not only the principal means of transportation for the lunar surface crew but also served as a mobile television station through which most of their activities were observed on earth. The television camera, its antenna and its lunar communications relay unit (LCRU)—all made by RCA—allowed flight controllers in Houston for the first time to see clearly how lunar exploration chores are carried out. As the astronauts went about their activities, the cameras, remotely controlled from earth, followed them about the lunar surface. Only when the rover was moving from one site to another was the television camera stilled.

The television pictures from the moon were acclaimed by flight controllers and scientists on earth as "superb." Astronaut James Lovell, now deputy director of the science and applications division of NASA's Manned Spacecraft Center, said, ". . . The television camera, as a scientific tool—as well as showing exactly what is going on for the public—is perhaps one of our best facilities . . . on this mission."

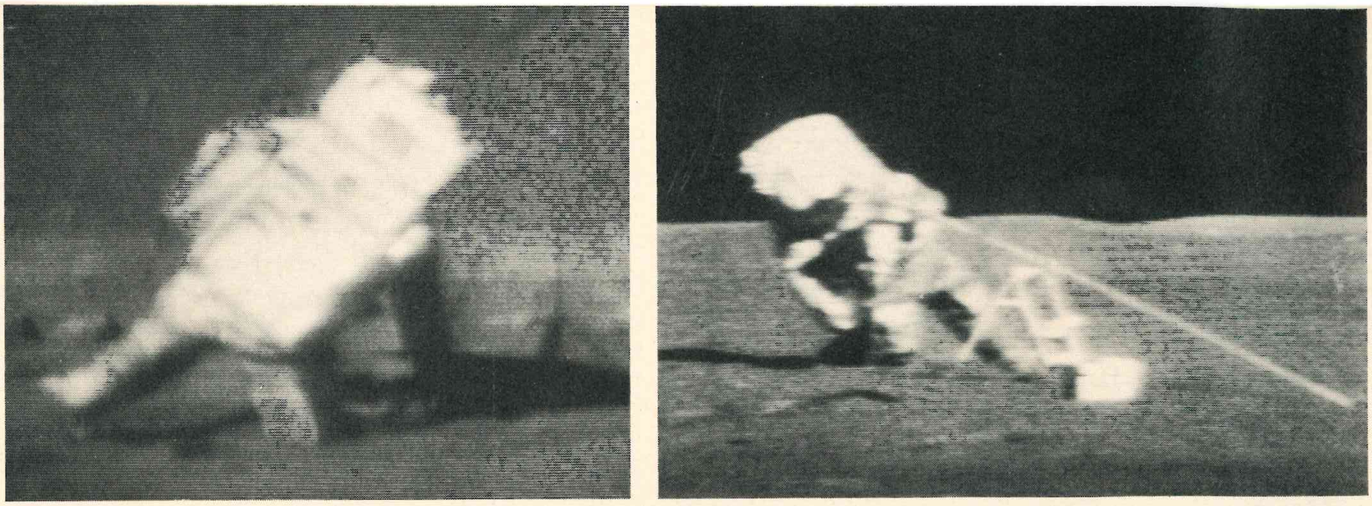
Much of the credit for the television coverage on the lunar surface went to the two men who operated the camera remotely from Mission Control, Edward I. Fendell and G. A. Pennington. Fendell directed the camera during the first and third extravehicular activity periods, Pennington during the second.

The television system turned out to be almost as sturdy as the rover itself, although it was showing symptoms of mechanical problems as the lunar surface activities ended. The gears which allowed the camera to sweep, and tilt up and down apparently became contaminated with lunar dust after the second extravehicular activity period, requiring assistance from the astronauts in correcting the tilt position. This apparent failure caused flight controllers in Houston to make the decision to leave the camera in a fixed position to record the liftoff of the ascent stage from the moon.

Earlier, the flight of the stage was to have been tracked upward by the camera through the remote control unit on earth. However, it was feared the camera might not tilt properly and this would jeopardize the chances of getting any liftoff picture at all. Secondarily,



Astronaut David Scott stumbles on a partly buried lunar rock and pitches forward, his arm and legs working as much as possible in his space suit to prevent a complete sprawl onto the surface. His camera dropped in the process, but he was able to bend over enough to retrieve it, with some help from Astronaut James Irwin.



Kneeling was possible in the modified space suit worn by Apollo 15 astronauts. Scott does so to pick up a large rock during the final traverse near Hadley Rille (left). During the second extravehicular excursion, Scott also knelt in the laborious process of drilling the second heat flow experiment hole (right).

scientists hoped to view an earth/sun eclipse through the lunar camera Aug. 6, and the same caution regarding camera movement prevailed.

But during the early morning hours of Aug. 4, almost two days after Irwin and Scott flew off the moon in the ascent stage of Falcon, the television camera failed after about 10 min. of operation. Any hope of picturing the eclipse for earth viewers died with the camera. Likeliest cause of the failure was a circuit breaker on the rover which tripped when the television system overheated.

Another minor problem with the television system appeared during the first extravehicular activity period, and it gave Scott another chance to prove that man is perhaps the ultimate tool in space. The problem was with a cable leading to the LCRU on the rover. The cable kept interfering with remote operation of the camera. Scott neatly solved the problem by taping the cable to the rover chassis. It caused no more difficulty.

But, by and large, the television system operated on the surface of the moon with minimal assistance from Irwin and Scott. With the exception of correcting the camera when it flopped both forward and backward, the astronauts' major chore was aligning the high-gain television antenna on the rover to provide the best down-link signal to the earth. On occasion, this turned out to be surprisingly difficult because earthshine could be seen only dimly from the moon through the antenna's telescopic sight.

The astronauts utilized a signal strength meter on the LCRU console as an alignment device although it was not designed for that purpose. The meter—called AGC, for automatic gain control—when it peaked told the astronauts they had an optimum signal, in effect fine tuning their optical antenna alignment.

Scott's use of tape as a fix-it implement emerged again as he and Irwin left the lunar module for their second explorative sortie. The metal antenna for voice communication on Irwin's portable life support system (PLSS) somehow snapped off. Scott taped it across the back pack horizontally and it worked flawlessly throughout the grueling mission. When the antenna snapped, this exchange occurred between the Falcon on the lunar surface—called Hadley Base—and Capsule Communicator Joseph P. Allen in Mission Control at Houston:

Scott: "I'm afraid to tell you, but Jim's antenna is broken. And it was broken yesterday when we got in. When we first started out on the operation, there was a big nick out of the antenna which we subsequently taped. And, now, just below the nick, it has broken off . . . I don't know how it got there, but when we first looked at the OPS [oxygen purge system, a part of the back pack], the antenna had about half of it nicked out. We did tape that."

Irwin: "Okay. There we go."

Allen: Roger, Dave. We copied that.

Irwin: I'm reading you loud and clear. Okay?"

Allen: "Okay, Jim. We got your call then."

Scott: "Joe, what I'm doing now is holding Jim's antenna together."

Allen: ". . . And when you hold it together we can read you loud and clear. So that's the problem. I guess we need a tape job on that antenna."

Scott: "Yeah . . . I hope I can get it taped for you."

Then, a few seconds later:

Scott: "Okay, Joe, I think I'm going to take the top nick off the antenna and use it as a splice.

Allen: "That's the old splint trick, you mean."

Scott: "Yeah. We'll give it that try, because, unfortunately, the antenna is broken right off at the root."

Allen suggested that Scott tape the antenna horizontally and Scott agreed.

Said Allen, during the exchange, "And, Dave, while you have the tape up there, from the sound of things maybe you'd better put some up in your pocket for later."

Use of the tape to mend a broken antenna was a minor chore compared with the situation which earlier confronted Irwin and Scott when they began to deploy the lunar rover from the lunar module bay in which it had ridden to the moon. Sturdy and reliable though it later proved to be, at the onset, the lunar roving vehicle was a stubborn piece of equipment.

For more than a half hour the astronauts struggled to free the rover. Scott told Houston he had pulled two pins holding the rover in its saddle inside the bay, but still the vehicle refused to come free.

Scott said to Allen: "Okay, Joe. The situation is that both pins are out of the saddle and it still seems to be connected to the frame of the LRV."

Finally, Scott said to Irwin: "Okay. Let's finish picking up the rover."

Irwin: "Yeah." And this comment: "I remember a guy who once said, 'Dirty dirt!' and is it ever."

Finally, the rover came loose and the two astronauts positioned it for its first run on the moon.

During the struggle to deploy the rover, much of which was seen from earth by the color television camera which had been deployed on a tripod some distance from the lunar module, Irwin lost his balance and fell. It was the first of several falls for both astronauts during the extravehicular activities, one a real header by Scott when he tripped over a rock.

Once, when Scott was about to make a precarious step, his companion warned him: "Careful there. Don't do an Irwin."

Later, in Houston, Dr. Charles Berry, the astronauts' physician, was asked if he were concerned.

"There were a couple of falls, as a

matter of fact," he said, "and we don't like to see anybody fall. But I thought it was reassuring too, the way he [Scott] behaved and didn't fall down. As a matter of fact, he actually kept from falling down, but it was quite a dance in the process. No, I don't think we want them to fall down any more than the crew wants to fall down. But I think he handled that extremely well."

Capsule Communicator Allen, also present at the briefing, added: ". . . If you had to choose between falling on the earth or on the moon, I think Dave made the right choice."

And Lovell, another member of the briefing group, said: "I agree. I think actually that the one-sixth-g makes the fall look more spectacular. But the recovery is better because the [fall] motion is slower perhaps.

At a later briefing, Dr. Berry was asked to comment on the crew's agility on the lunar surface. ". . . They are adapting very well to motion in that one-sixth-g environment," he said. "I think that it is interesting, too, that there is some difference in the way that people move. . . . They haven't really moved in exactly the way that other crews have moved in one-sixth-g. There has been a lot of kangaroo-type hopping with these fellows compared to what some of the other crews have done.

"But we've had a good opportunity to watch them . . . I think that TV on this flight has been an absolutely fantastic tool for everyone to use from the scientists to the flight control people as far as really knowing what is occurring at any given time."

Irwin, unshaken in that first tumble, continued to assist Scott in getting the rover ready for operation. On earth, as the chore was concluded, it was evident that the rover may have been designed to be deployed by one astronaut, but in actuality it had turned out to be an extremely difficult task with two men working at it. Even such relatively minor activities as popping the fenders into place and snapping the two seats upright were not accomplished without some difficulty in the lunar environment.

But finally Scott mounted the 460-earth-lb. runabout and began to tick off his check list for operating the Delco Electronics power train to move the rover across the lunar terrain. This consisted of checking the amp./hr. on the two 33-41 v. dc. silver zinc batteries which provided the energy to each electric motor in the four wheels, the navigational system by which the astronauts were to find their way back to the lunar module and the mechanism for both front and rear steering.

Then, at 120 hr. 29 min. after the Apollo 15 mission began, Scott said, "I don't have any front steering, Joe."

Immediately, Mission Control instructed Scott to run through the switch sequence to activate the front steering. He did so, going through several electrical buss combinations and throwing different circuit breakers. "Still no forward steering, Joe."

Mission Control issued instructions to continue with other operations while engineers in Houston pondered the rover's steering problem. Irwin and Scott began to load the rover with a geological pallet and erect the two antennas which would provide voice and television communications from the rover to earth.

About 40 min. after Scott reported the steering malfunction, Allen said from Mission Control: ". . . Just thinking ahead, we've got a couple of checks to carry out on the rover before you drive off from the site." Scott agreed and Allen suggested: "We'll want you to look at the front wheel steering decoupling lanyard for us and, then after that, physically try to turn the front wheel for us."

Scott: "Gee, watch me flounder around out here. Okay, the decoupling lanyard is taped down, Joe."

Allen: "Roger, that's good, Dave. You might physically try to turn the front wheel, if you think now is a good time."

Scott grasped the wheel and pushed, but it remained in a fixed position. "I don't get much out of turning the front wheels."

Allen: "Okay, I think we're in business. We'll want 15 v. to primary and forward steering to Buss A when you start off."

Scott, puzzled: "What makes you think we're in business. What did I do?"

Ten minutes later, it developed that nobody was in business; the front steering simply would not work and Scott was instructed to deactivate the system, to rely on rear steering only.

Scott gave a final reading, this of the navigational system, which if it worked properly, would guide the astronauts back to the lunar module when they were long out of view of their Hadley Base. "Roll was one left. Pitch is zero. Heading is 240. I'm in system reset and we're driving down to zero and the shadow device is at zero." Irwin and Scott were now 1 hr. 53 min. into the first of three planned extravehicular activity periods. If all went well, the first period could last as long as 7 hr.

Irwin climbed aboard the rover as Allen said from Mission Control: "As a reminder . . . you may want to go to min cooling. It may get chilly while you're riding." The reference was to the cooling system in their space suits, that it be reduced to the minimum.

Climbing into the rover, Irwin said: ". . . This is really bouncy when you get on."

Scott: "Easy, easy, Jim. Easy."

Irwin: "Okay. My foot is hooked on the tool there. Thata boy. You really sit high."

Scott: "Yes, you do."

Irwin: "It's almost like standing up."

Both astronauts discovered they had not properly fastened the belts which would hold them safely in their seats as they bounced over the rolling lunar terrain.

Irwin: "There's something wrong with my safety belt. I'll have to fix it."

Scott: "As long as you're getting off, will you adjust mine?"

Irwin complied with, "I think it's too

Angular rocky surface near Hadley Rille was successfully negotiated by astronauts.

'. . . Exploration at Its Greatest'

Houston—Apollo 15's commander, Astronaut David R. Scott, apparently was aware of his role as both explorer and engineer as he became the seventh man in history to step onto the surface of the moon. His first words were:

"Okay. Okay, Houston. As I stand out here in the wonders of the unknown at Hadley, I sort of realize there is a fundamental truth to our nature: man must explore. And this is exploration at its greatest."

Scarcely pausing for breath, he then launched into a description of how the Grumman lunar module, Falcon, was resting on the moon:

'Well, I see why we are in a tilt. . . . There's so much hummocky ground around here, we're on a slope of probably about 10 deg., and the left rear foot pad is probably 2 ft. lower than the right rear foot pad. And the left front is a little low, too. But the LM looks like it's in good shape. The rover's in good shape.

"Tell the program manager [Apollo program manager, former Astronaut James McDivitt] that I guess I've got his engine bell. It's a little rise right under the center of the LM. The rear leg's in a crater and the rim of the crater is right under the engine bell."

Then he apologized to McDivitt: ". . . Sorry about that, Jim, but IFR landing, you know."

short, Dave."

Scott: "Yep. It sure is. Don't waste time on it, I'll just hang on."

Irwin: "No, let's start out right."

The seat belts were to be a source of annoyance throughout the mission. Both Irwin and Scott agreed that their space suits did not deflate enough for an easy fit of the seat belts in the lunar environment although they had not experienced any difficulty during training on earth.

Seat belts adjusted, Scott said: "Okay, Jim. Here we go." Apollo 15 had been under way for 121 hr. 34 min.

Irwin, to Mission Control: "Okay, we're moving forward, Joe."

Allen: "Roger."

Irwin: "Whew! Hang on. And we're coming around left, heading directly right . . . to miss some craters off to our right. Very subdued craters."

Scott: "Okay, I'm going to take a little zig-zag here . . . hang on, [I've got to] get a feel for this thing.

Irwin: "Nine kilometers an hour, Joe."

Scott: "Hold the geology; let's get the rover squared away first."

A few seconds later, Scott made this observation: "We're doing 10 km. now. We're heading uphill and when we head uphill, it drops down to about 8. No dust, Joe. No dust at all." Then another observation: "The rover handles quite well. We're moving at, I guess, an average of about 8 km. an hour. It's got very low damping compared to the 1g rover [used for training at Cape Kennedy], but the stability is about the same. It negotiates small craters quite well although there is a lot of roll. It feels like we need the seat belts, doesn't it, Jim?"

Scott continued: "The steering is quite responsive even with only the rear steering. It does quite well. There doesn't seem to be much slip. I can maneuver pretty well with the thing. If I need to make a turn sharply, it responds quite well. There is no accumulation of dirt in the wire wheels." The lunar rover wheels were made of piano wire mesh with a titanium overlay in a chevron pattern.

"Just like in the owner's manual," Allen said from Mission Control as he listened to Scott's observations.

At one point, Scott pushed the T-shaped control handle full forward to maximum throttle. "I've got it on the wall here for a minute and we're up to 12 [km./hr.]." Later, Irwin said part of the ride was like a "bucking bronco." Replied Scott: "Yes, man! You back off on the power and it keeps right on going."

Scott reported he was having difficulty seeing craters as he drove into the sun—"zero phase lighting." He said, "The zero phase lighting is pretty tough, Joe. We're going to have to make sure we keep at an angle. Once I look in zero phase, it all looks flat . . ."

Later, as the sun climbed higher overhead during the third traverse, Scott overcame the problem by flipping up the sun visor halfway on his space helmet. This shielded his eyes and he could drive the rover in a more direct line.

The next day, Aug. 1, as Scott and Irwin descended from the lunar lander at Hadley Base to start their second traverse aboard the rover, almost mysteriously, the front steering worked. Allen instructed Scott to cycle the circuit breakers and switches controlling the front steering, and the mechanism appeared to be in perfect working order.

Scott: "You know what I bet you did last night, Joe? You let some of those Marshall Space Flight Center, [which had project responsibility for the rover] guys come up here and fix it, didn't you?"

Allen: "They've been working, that's for sure."

Irwin: "It works, Dave?"

Scott: "Yessir!"

Irwin: "Beautiful!"

Scott began the traverse with rover steering both front and back but turned off the rear steering early in the sortie. He reported the rover worked well with front steering only. But 10 min. later he reported to Mission Control: "It feels like the rear steering, when I turn it off, doesn't center; feels like my rear wheels are drifting. So, I guess I better turn it back on." This he did and drove the rover throughout the remainder of the mission with both front and rear steering engaged.

At Houston, engineers who had studied the problem were still puzzled as to why the front steering failed on the first traverse but worked perfectly on the second and third. Likeliest cause of the earlier difficulty was failure by Scott to fully activate the switches or reset the circuit breakers, although there was the possibility of corroded contacts which were cleaned as Scott repeatedly flipped various switch and circuit breaker combinations.

While the rover doubtless was the star of Apollo 15 with the remotely-controlled camera playing a strong supporting role, the extended portable life support system and the improved space suit also played prominent parts. Without the PLSS and its "buddy system" feature, long sorties away from Hadley Base would not have been attempted. And the space suit allowed the astronauts to carry out the complexities of the mission with a minimum of physical effort.

The life support system allowed the astronauts to travel as far as 5 mi. from the lunar module (a distance they never actually achieved) and still have sufficient supplies of oxygen and water to walk back if the rover failed. The buddy system feature provided a redundancy by which one astronaut could tap his companion's water and oxygen, should his supply of consumables run low. Further, the extravehicular mobility units, for the first time, were equipped with greater quantities of both water and oxygen.

The portable life support systems, however, were never taxed during any of the traverses. Throughout most of the lunar surface mission, when both astronauts were on the portable life support systems, their metabolic rates were well within limits predicted during mission planning. Only during the first EVA were their rates higher than predicted, and consideration was given at one point to cutting short the second EVA because of this. The second traverse, however, turned out to be the longest of the mission, lasting almost 7.5 hr. By then, both Irwin and Scott had adapted to the lunar environment and were using less energy than they had for comparable chores on the first EVA.

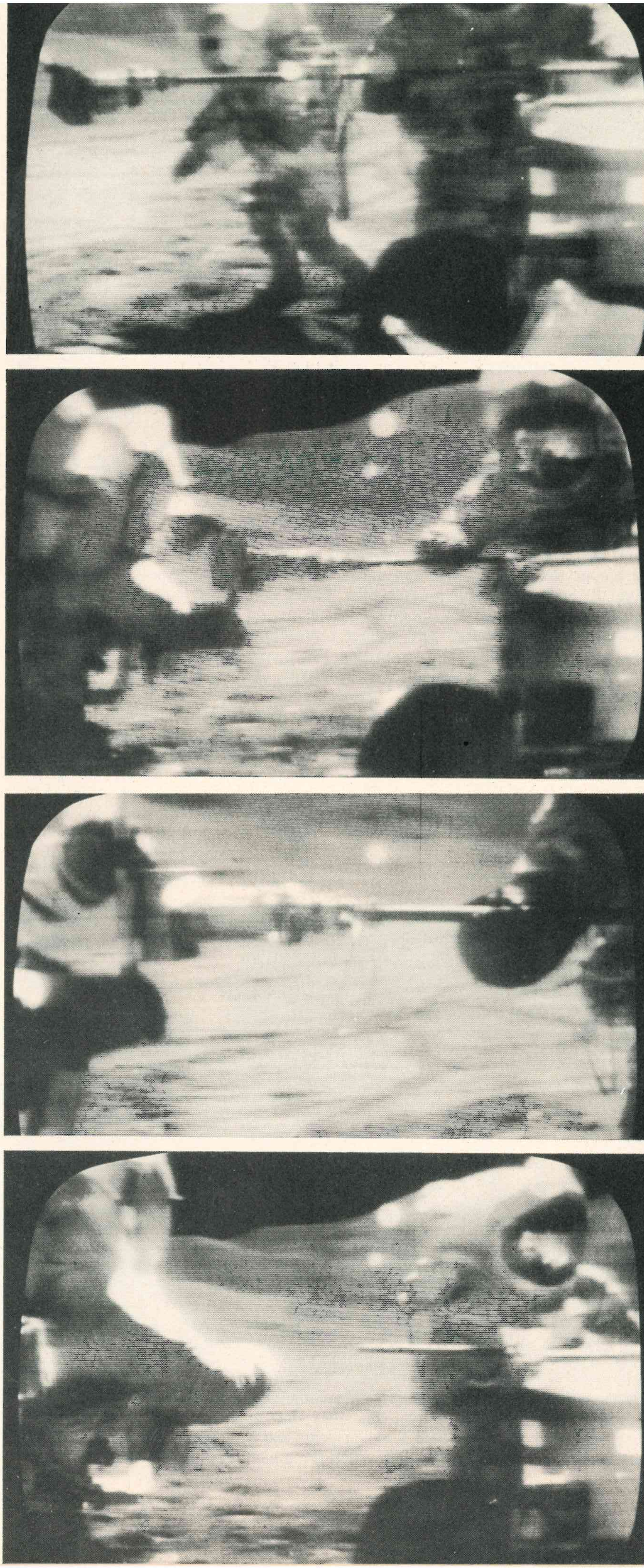
The only problems that occurred with the PLSS were procedural. For the first time, the units were not charged with water before liftoff of the Saturn 5 rocket from Cape Kennedy. Instead, they were charged after the lunar module had touched down on the moon's surface. Probably because the LM landed at an angle, the life support systems were not fully filled with water. The resultant bubble of air in the units caused minor difficulty during the first traverse, particularly for Irwin who got a series of warning "flags" calling attention to the bubble in his back pack.

Bubble Problem

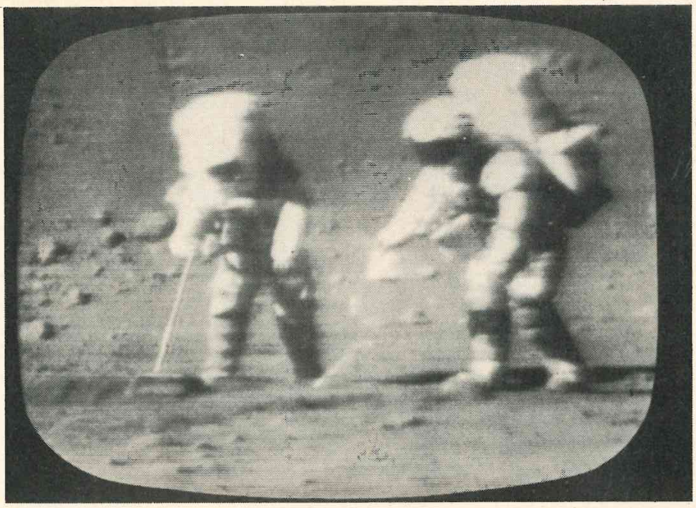
But it was during the astronauts' rest period after the first traverse that the bubble problem really surfaced, when the PLSS were charged for the second time. During the recharging process, to shorten the length of time, the units were tilted so they could be connected to both oxygen and water supply hoses in the LM at the same time. The next morning, as the second EVA period was about to begin, both systems registered large air bubbles. Exit from the lunar module was delayed for almost 30 min. while the units were topped off with water to remove the bubble.

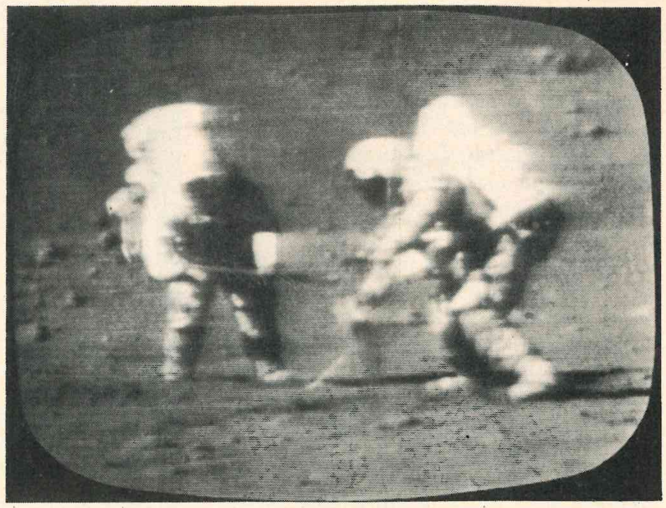
Later, Scott estimated the units were tipped about 30 deg. during the recharge period. Mission Control suggested the units be charged while they were upright before the third traverse. Irwin and Scott complied and there was no more difficulty with air bubbles.

The space suits, while providing far greater mobility for the astronauts, were a paradox. Without the new suits, the lunar surface activities on the scale performed would have been extremely difficult, if not impossible. Yet, donning and doffing the suits at the beginning and end of each EVA consumed hours of the total lunar stay time. Despite the difficulty, however, Scott observed that had he and Irwin not been able to rest in the lunar module with the suits off, the 67 hr. they stayed on the moon would have been intolerable, and the first truly scientific mission of the Apollo program might not have been the success it was.



Astronaut crew works with stubborn core tube (right) to remove drill head. One turns drill while core is held in treadle, which was used as a vise, resting on the rover. After removing drill, Irwin worked core through treadle while Scott used wrench to separate sections.





Rake was used by Astronaut James Irwin to collect samples of lunar surface fines and small rocks mixed in (left). He pours contents into bag held by Scott, with dust spilling back to the surface in process.

Samples Hold Vital Clues to Lunar Origin

By Erwin J. Bulban

Houston–Largest number and probably most significant clues to the origin of the moon, the solar system and earth were collected by Apollo 15 commander David R. Scott and lunar module pilot James B. Irwin during their record 18-hr. 13-min. exploration of the moon's surface.

Geologists, geochemists and others representing the numerous disciplines of the geosciences involved in supporting the mission here directly, said that any one of several accomplishments by the astronauts could be considered as worth the entire mission.

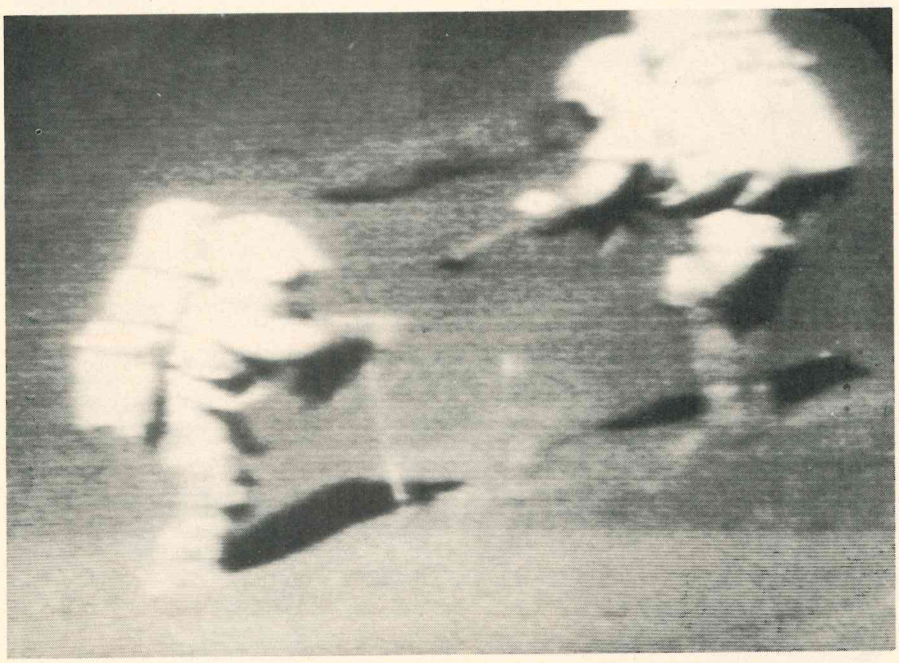
Most frequently mentioned were:

■ **Collection of a rock sample** that, on the basis of description by Scott and Irwin, could be a fragment of the primeval moon.

■ **Obtaining a core sample,** representing an approximately 10-ft. depth of the lunar surface.

■ **Photographic documentation** of unusual phenomena noted in Hadley Rille.

These, plus what appeared to be the greatest variety of soil and rock samples yet gathered in the Apollo program, will, in the opinion of scientists, turn back the pages of lunar history to its earliest days and also provide significant clues not only to the history of earth but perhaps even to its future. Total weight of the samples is approximately 170 lb.



Sample found at Spur Crater during the second traverse elated astronauts, who described it as anorthosite, a crystalline rock that might be part of primordial lunar crust estimated to be about 4.6 billion years old. Erosion has blanked out similar geological evidence on earth, a gap which the lunar sample might fill.

Geoscientists here, who had worked on planning the lunar explorations, were delighted that generally the pre-mission hypotheses concerning what the astronauts would be likely to find at particular areas of their traverses turned out to be accurate.

Geoscientists working at the National Aeronautics and Space Administration's Manned Spacecraft Center in support of the lunar exploration portion of the mission also were impressed by Scott's and Irwin's ability to describe their surroundings and the material they saw and sampled in adequately detailed technical language. This provided science support room personnel with data that were invaluable for effective traverse planning, sample gathering and documentation.

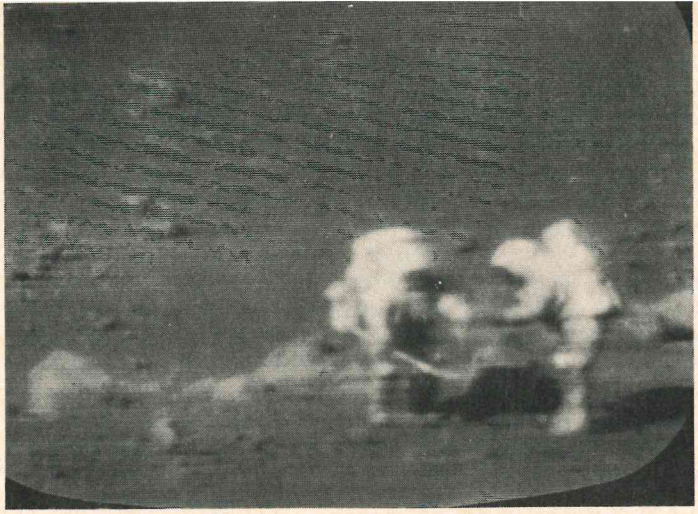
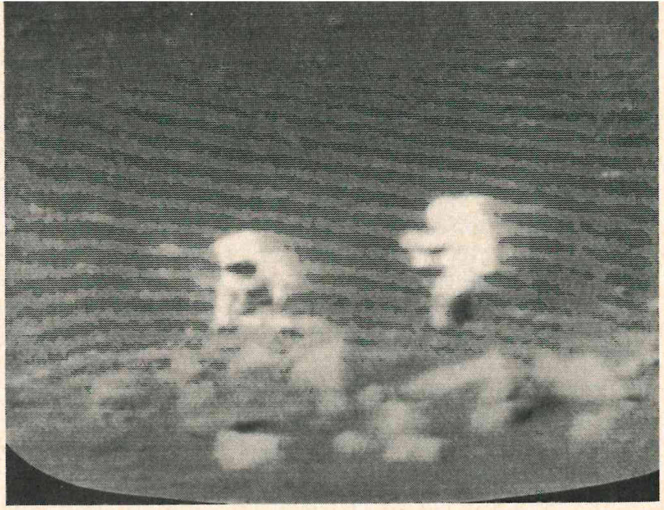
The descriptions by the crew were considered outstanding to the point that, according to one scientist, "we almost literally became extensions of Scott and Irwin's feet."

The scientists' enthusiasm, as they listened to the crew, was aptly transmitted through the capsule communicator and scientist-astronaut, Joseph P. Allen, who during one such episode told Scott and Irwin:

"Keep talking, keep talking. Beautiful description."

Typical of the detailed transmissions received here was this description of a boulder approximately 3 ft. in diameter.

Scott: "Very angular, very rough surface texture; looks like it's partially—well, it's got glass on one side of it with lots of bubbles and they're . . . 1 cm. across and one quarter of it has got all this glass covering on it; seems like there's a linear fracture through one side; it almost looks like that might

Far wall of Hadley Rille is behind astronauts seeking samples on the eastern slope. They moved down the slope to show that, while the grade was steep, it was not a vertical drop-off (right).

be a contact [point where two different materials come together]; it is within the rock. It looks like we have—maybe a breccia [a rock made up of highly angular coarse fragments, which may be sedimentary or formed by crushing or grinding along faults or fractures] on top of a crystalline rock. . . . A definite linear feature through one side . . . about a fifth, and the glass covers both sides. . . . It's got fillet up one side and the other side is in a shadow . . . it's got a fillet on the down-slope side and the up-slope is open and free, in fact, it looks like it's almost excavated beneath it."

Scott and Irwin gathered both samples of the soil fillet and, on direction from the science room, chipped samples from the top and underside of the boulder.

Their descriptions of various materials from time to time brought recommendations from the science support room, through Allen, to either get samples, do documentary photography or move on.

It was in the second traverse, while Scott and Irwin were exploring the vicinity of Spur Crater on a slope of the Apennine Front, that Scott electrified ground personnel listening with:

"Guess what we just found. I think we found what we came for."

Irwin followed with: "crystal rock," and Scott said: "Yes, sir. You better believe it."

And, passing along the science support room's feelings, Allen told the crew: "Yes, sir."

The crew's description of the material and its location, according to the geoscientists, were strong evidence that this fragment was the geological treasure that had been sought since Apollo 11.

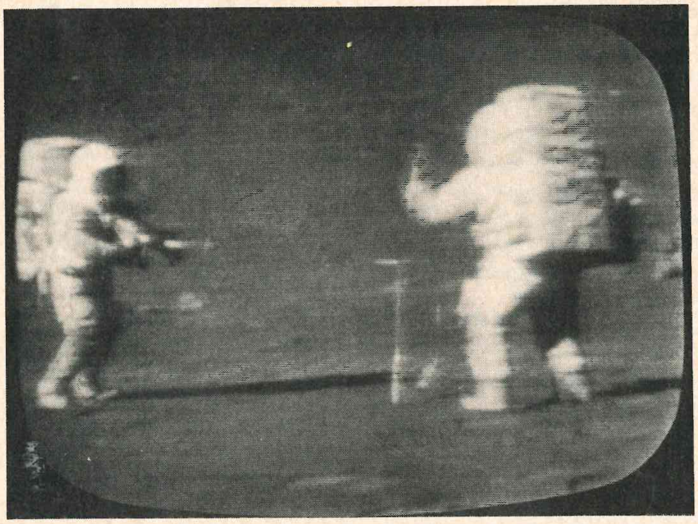
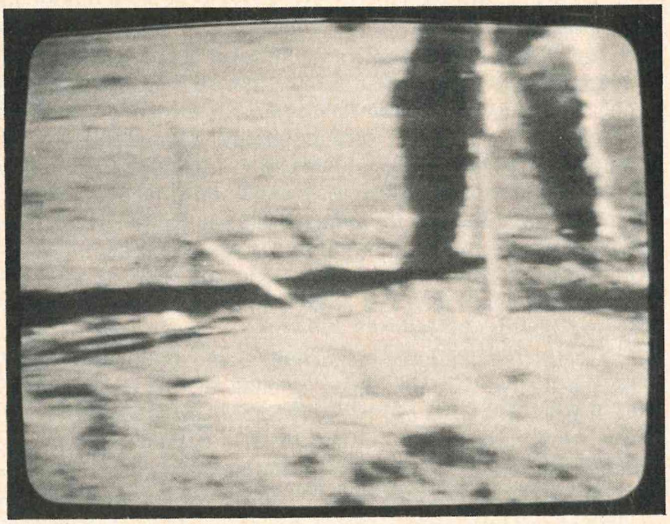
The large crystalline structure described fitted the theoretical parameters of primeval lunar material. Primeval material is not likely to be found in areas of lower elevation because it has been covered by rock flows of later origin.

Scott and Irwin continued to survey the crater area and take samples of a variety of specimens, leading the mission commander to comment to Allen: "Joe, this crater [Spur] is a gold mine."

These reports were welcome news to scientists monitoring the traverse. There was some disappointment during the crew's first lunar traverse the day before, which covered basically a considerable area of dusty, bleak terrain that yielded fewer than anticipated worthwhile rock samples.

The first day's exploration ended in a further disappointment when Scott had difficulty drilling into the soil in the vicinity of the Apollo Lunar Surface Experiments Package [Alsep] attempting to emplace a heat flow experiment.

Scott managed to drill the first hole sufficiently deep to emplace a set of two heat probes, but at the adjacent point, he was unable to penetrate further than 4-5 ft., about half the depth required for proper installation of the probes. The television camera mounted on the Boeing lunar rover graphically revealed his fruitless efforts to drill to the desired

Core sample tubes are hammered into surface during the third traverse (left). Penetrometer was placed by Irwin in the bottom of 12-14 in. trench dug in surface near lunar module to test subsurface bearing strength (right). Irwin said material at this depth, which he described as blackish pebbles, became hard to dig.

depth for the second set of heat flow probes, despite leaning on the drill to accomplish the task.

Scott finally stopped when ground support personnel decided to postpone the attempt until the next day while they did some trouble-shooting on the problem, assisted by the equipment supplier, Martin Marietta.

A prevalent theory was that the lunar soil continued to compact ahead of the drill stem faster than the tool could effectively cut through it. Allen recalled that during a test at Cape Kennedy, ordinary sand that the drill traveled through easily stopped the tool after being compacted with a jack hammer.

Several NASA technicians believed there would be some modifications in procedures developed prior to the drill's next mission, if the equipment continued to be scheduled aboard Apollo 16. One likely area for modification appears to be improved tools to provide better leverage for removing core tubes.

Following the second day's activities, the crew returned to the Alsep site, and Scott resumed his task of drilling the second heat probe emplacement hole, using a stop and go technique. He finally managed to extend the stems, within which the heat probes would be encased to a sufficient depth and then had some difficulty inserting the pair of probes.

When the probes were activated, experimenters said the equipment appeared to be operational, although they expect that about six months will be required for the soil to become stabilized before accurate data concerning subsurface lunar temperatures can be obtained.

Scott later managed successfully to emplace a soil core sample tube near the sight of the heat flow experiment. But then he was unable to withdraw the tube. Irwin came over to assist him and the two astronauts struggled unsuccessfully at the task until Mission Control instructed them to give up and leave the tube in place.

There was considerable concern among geoscience personnel about the crew's inability to withdraw the tube. One of them described the deep core experiment as having importance only second to returning significant rock samples in determining lunar and solar system history.

Not only would the soil strata reveal significant historical layering data, but they would also contain the history of solar radiation bombardment over a period of millions, perhaps billions of years. These traces could be related to primeval lunar, solar and terrestrial histories. Further, such evidence could be extrapolated to show possible, or even probable, solar system and terrestrial life trends. The latter would be of inestimable value in predicting the future earth environment, including decay of its resources.

On the third day, during the last traverse, the crew managed to withdraw the valuable deep core tube and then encountered difficulty in separating the six 16.7-in.-long sections for capping and stowage in convenient lengths. Utilizing a vise-like wrench, they managed to separate them into one three-section segment and three one-section units.

Considered another major lunar scientific triumph was Scott's and Irwin's observations and photographic documentation of what appeared to be layering of the Hadley Rille, a prime exploration site.

Geoscientists considered Scott's detailed description of the rille layering phenomena of great importance and indicated a desire for detailed photo documentation.

Scott: "From the top of the rille down, there's debris all the way and it looks like some outcrops [exposed bedrock or strata] . . . it looks like a layer about 5% of the rille wall with a vertical face [perpendicular plane] and within the vertical face, I can see other small lineations. . . . I can see another one [vertical face], which is somewhat thinner, maybe 5% of the total depth of the rille, however, it has a more well-defined interior—internal layering of about 10% of its thickness. I can see maybe 10 very well defined layers in that unit.

Allen responded: "Beautiful, Dave, beautiful."

Allen later stated that importance of the layering phenomenon ". . . really boggles the mind at the moment."

A scientist explained that such a phenomenon would make it even more difficult to explain the origin of the rille because it had been believed that this type of rille would not have shown the evidence that Scott reported. This will mean that new thinking will have to be factored into theories of these rilles.

The exposed layers normally would indicate considerable erosion as a result of fine dust moving downward, which would have exposed the blocks visible at Hadley Rille, yet the rille did not seem to have been degraded sufficiently as the result of dust erosion.

Irwin hammered a double core tube into the terrain near Hadley Rille to obtain a soil sample, encountering brief resistance shortly after surface penetration. On withdrawing the core, he and Scott noted a rock fragment lodged in the bottom of the core, indicating that perhaps the crew had obtained a sample of lunar bedrock.

An unexpected phenomenon described by the crew was the apparent

Liftoff from the Moon Televised

Houston—For the first time in history, man saw a spacecraft blast off from the moon. No one, not even the eight astronauts who have experienced it, had ever seen such a sight.

The liftoff of the ascent stage of the Apollo 15 lunar module Falcon was seen for about 2 sec. through an RCA color television camera left on the moon by Astronauts David R. Scott and James B. Irwin. Two days later the camera, mounted on the lunar roving vehicle 300 ft. from the Grumman lunar module, quit operating. Earlier, it transmitted the historic picture of a spacecraft launched from the face of the moon in what appeared on earth to be a shower of golden sparks and accompanied by a tape recording on board of the Air Force Song.

The ascent stage rose into the lunar sky 171 hr. 32 min. after Apollo 15 mission began. Nine minutes later, the spacecraft reported its primary navigation and guidance system showed an expected orbit of 40.6 x 8.9 naut. mi. At 171 hr. 53 min. GET (ground elapsed time), Falcon reported it was 94 mi. from the North American Rockwell command/service module Endeavour piloted by Astronaut Alfred M. Worden, third member of the all Air Force crew.

Final maneuvering for rendezvous and docking with Endeavour took place as both spacecraft sped around the back of the moon. At 173 hr. GET, Mission Control reported the spacecraft were only 2.5 mi. apart. About 36 min. later came the report that the Falcon and the Endeavour were once again linked together.

Ascent, rendezvous and docking were uneventful as had been the landing of the Falcon on the lunar surface almost three days earlier. Earlier at 6:16 p.m. EDT July 30, Scott and Irwin had flown their spacecraft to a perfect landing amid the hummocks of the Hadley-Apennine area of the moon despite an approach of 26 deg., the steepest of any lunar landing.

The spacecraft came down near a crater named Salyut, well within the planned landing area and about 1,500 ft. north and east of the targeted landing point. It came to rest at an angle of about 9 deg.

layering they saw in Hadley Mountain, which in the opinion of Allen, was something he doubted any of the personnel in the science support room had expected.

". . . That really boggles the mind at the moment," Allen said, adding that another surprise was a description about "high water" marks on the mountain, which actually referred to markings indicating evidence of receding terrain.

The variety of soil and rock samples obtained by the crew is expected to provide material, that when correlated and evaluated with sample material returned from earlier Apollo missions, will provide a considerable broadening of knowledge of the various processes that modified the early lunar surface to its present configuration.

Subsatellite Placed in Lunar Orbit

Houston—TRW Systems 78.5-lb. subsatellite was spring-ejected into lunar orbit out-of-plane from that of the Apollo 15 scientific instrument module bay at 222 hr. 39 min. ground elapsed time (GET). Shortly before, the North American Rockwell command module accomplished a shaping burn that moved it from a 66.3 by 55.4-naut. mi. orbit to 76 by 54 naut. mi.

Apollo 15 Commander David R. Scott told Manned Spacecraft Center here that he saw ". . . a very beautiful satellite out there . . . looks like it's oscillating about 10 deg." The Center later reported that good data were being received from the subsatellite. Its inclination is 47.6 deg. and useful life 240 days.

The 31-in.-long subsatellite is boom-stabilized to approximately 12 rpm. It is designed to remain in lunar orbit carrying three experiments: an S-band transponder to collect data on the lunar gravitational field; a particle shadows/boundary layer experiment to get data on the formation and dynamics of the earth's magnetosphere, interaction of plasmas with the moon and the physics of solar flares; and a magnetometer to gather physical and electrical property data on the moon and of plasma interaction with the moon.

The command ship Endeavour left its tiny orbiting partner behind to head for home with a transearth injection engine burn at 224 hr. 3 min. GET giving a velocity of 7,500 fps.

Ascent Stage Impact Aids Seismic Tests

Houston—Crash of the Grumman lunar module ascent stage on the moon's surface Aug. 2 has given scientists an important benchmark in evaluating future lunar natural events with their network of seismometers now in three locations.

The module was deliberately impacted on the surface after the Apollo 15 astronauts had completed their stay on the surface and returned to the North American Rockwell command module.

Jettison of the module from the command spacecraft came at 179 hr. 30 min. ground elapsed time (GET) into the mission. This was about 2 hr. and one lunar revolution later than planned because a question arose as to the seal of the command module hatch. The crew reopened both the command and lunar module hatches and cleaned the seals before they were satisfied with the pressurization of the craft.

At 181 hr. 4 min. GET the ascent stage was commanded to make a retrograde burn with its reaction control thrusters, which reduced its velocity by 201 fps. After the burn, the craft weighed 5,315 lb., and it crashed 25 min. later at a 3.2-deg. angle to the surface with a speed of 5,550 fps. Position of the crash was 26.4 N. Lat. by 0.3 E. Long.

Seismic impulses from the crash took 28 sec. to reach the Apollo 15 seismometer about 95 km. to the east and 7 min. to reach the instruments of Apollos 12 and 14, about 1,100 km. to the south.

Because of the known position of the module crash and the energy involved, as well as the travel time of signals to the three seismometers, experimenters now have a valuable calibration technique in determining the position and energy involved in future natural seismic events on the moon—both moonquakes and those caused by impacts of meteoroids.

Dr. Gary Latham of Lamont-Doherty Geological Observatory of Columbia University, principal investigator on the Apollo passive seismic experiment, said the first use of this capability was to be on Aug. 6-7. At that time it will locate more precisely the source of 80% of the moonquake energy that characteristically precedes by two or three days the lunar perigee, which next occurs Aug. 9.

With the two seismometers of Apollos 12 and 14, investigators have only been able to establish this position within a broad region.

Earlier, the McDonnell Douglas S-4B stage of the Saturn launch vehicle had crashed into the moon on July 29 at 79 hr. 24 min. into the mission. Its impact point was 1.0 deg. S. Lat. by 11.87 deg. W. Long., about 188 km. east of Apollo 14's seismometer and about 355 km. east of Apollo 12's.

Signals from the crash took 37 sec. to reach the Apollo 14 site and 55 sec. to reach Apollo 12's. In both cases, this was within 1 sec. of the times predicted by investigators, and Latham said this tends to support the current model of the moon as a heterogeneous structure—a jumble of blocks—without significant layering as a valid one, at least to a certain depth.

He said this depth had been estimated up to 30 km. with previous S-4B crashes, but that the location of the latest S-4B crash enabled him to extend this figure to 50-100 km.

However, he cautioned that the latest data also suggest that there may have been sudden increases in the velocity of seismic impulses at a depth of about 25 km., which is the first indication that the theory of no significant layering to a depth of 50-100 km. may have to be modified.

Apollo 15 lunar surface experiments package (Alsep) and its central station are functioning normally and returning data. Alsep's central power station radioisotope source is delivering a constant 74.1 w.

Passive seismic experiment recorded a signal Aug. 2, probably a meteorite impact. Long period component signal duration was 20 min. The short period signal was 10 min.

The new heat flow experiment temperature thermocouples are indicating a temperature of 192.2F during the present lunar day, equal to 14 earth days. The site will go into the lunar night cycle Aug. 13.

Space Mail

Astronaut David R. Scott made the first cancellation of a new stamp commemorating U.S. achievements in space during a ceremony that came about 1 hr. before the conclusion of the third extravehicular activity of the Apollo 15 mission to the Hadley Apennine region of the moon.

The new stamp actually is two eight-cent stamps printed in horizontal pairs. The left hand stamp depicts the Grumman lunar module on the moon's surface with the earth and the sun in the background. The right hand stamp pictures the astronauts sitting in the Boeing lunar rover vehicle on an adjacent area of the moon. Both stamps have printed at the bottom "United States in space."

Senate Committee Restores F-14 Funding

Washington—Senate Armed Services Committee has approved a $21-billion Fiscal 1972 Defense Dept. procurement authorization bill which restored $801.6 million cut by the House for procurement of the Navy/Grumman F-14 fighter and made deep cuts in the Army Safeguard antiballistic missile system and the Air Force/Lockheed C-5A transport.

Full report on the action will be filed during the congressional recess, which began last week and ends after Labor Day. Floor action is expected in September.

In restoring the bulk of F-14 funding deleted earlier by the House (AW&ST July 12, p. 13), the Senate committee inserted language in its bill to "insure that the $801 million must be sufficient for not less than 48 aircraft." The Navy intends to exercise its Oct. 1 option to order the minimum 48 F-14 fighters under its 1969 contract with Grumman.

All F-14s to be procured under present planning by the Defense Dept. will be the A version, using the Pratt & Whitney TF30-P-412 engine. Navy share of development effort involving the Pratt & Whitney F100-PW-100 advanced engine, to be used in the F-14B and the Air Force/McDonnell Douglas F-15 fighter, will be $100 million for Fiscal 1972. Air Force is sharing program development costs with the Navy on a dollar-for-dollar basis.

Understanding between the Defense Dept. and congressional leaders is that the F-14B will definitely be procured when the advanced engine is ready. Although development of the F100-PW-100 is late in terms of the F-14B, it is on time for the F-15, which is not due to fly operationally until 1975.

In other authorization moves, the Senate committee:

■ Chopped $161.4 million from the Army's planned $1.3-billion Safeguard anti-ballistic missile program for Fiscal 1972, adding language which again restricted deployment to four previously-authorized sites and eliminated anti-missile protection of Washington, D.C. and other populated areas. The Senate bill would limit deployment activities to Grand Forks AFB, N.D. and Malmstrom AFB, Mont. Advance preparation only would be permitted at Warren AFB, Wyo. and Whiteman AFB, Mo.

Aim of the action is to limit Safeguard's operation to the protection of U.S. deterrent forces, primarily the Boeing Minuteman intercontinental ballistic missile sites. Slippage in the system was given as the prime reason for the cut, although increasing costs may have also been a factor (AW&ST Apr. 26, p. 18).

■ Reduced the C-5A procurement by $72.2 million for production and $3.6 million in research and development, leaving a total of $396.4 million in the program for Fiscal 1972. The committee declared that the higher figure requested by the Air Force was greater than necessary to maintain planned delivery schedules.

■ Added $23.7 million for Fiscal 1972 procurement of the Hawker Siddeley AV-8A Harrier vertical takeoff and landing (VTOL) fighter. The funds were added "to provide the additional expenses necessary for a phased program which will lead to the domestic production of this aircraft," according to the committee. McDonnell Douglas holds the U.S. production rights to the aircraft.

■ Reprogramed $44 million from Fiscal 1971 unobligated production authorization for the Army/Lockheed AH-56A Cheyenne armed helicopter into research and development for Fiscal 1972. Of the sum, approximately $36 million would be aimed at settlements between Lockheed and subcontractors and suppliers in the wake of termination of the production program.

Army's proposed restructured development program for Cheyenne envisions a $103-million requirement, of which $61.3 million was requested in the reprograming action (AW&ST July 12, p. 13) and $13.2 million in fresh Fiscal 1972 funds. House and Senate both deleted the $13.2-million request.

Under original Army plans, another $48 million would be paid to Lockheed to complete the program, beyond the Fiscal 1972 funds and reprograming formally requested, and another $20 million would be spent in-house.

Worden Takes First Deep Space Walks

Houston—Apollo 15 Astronaut Alfred M. Worden made a swift and sure 16-min. space walk 171,000 mi. from earth to retrieve film cassettes and inspect the scientific instruments nestled in a bay of the spacecraft service module.

Using hand rails and foot restraints to reach the scientific instrument module (SIM) bay aft of the North American Rockwell command module, Worden experienced no difficulty during the three roundtrips he completed. With fellow crewmember James B. Irwin holding the 25-ft. tether line from the open spacecraft hatch, Worden first exited to retrieve an 85-earth-lb. film cassette from an Itek panoramic camera which he had operated in orbit about the moon.

At 242 hr. 10 min. into the mission, he reported to Mission Control in Houston: "I'm in the foot restraints." Then he freed the cassette from the panoramic camera, tethered it to his arm and made his way quickly back up to the open spacecraft hatch.

"Good work up there, Al," said Capsule Communicator Karl Henize in Mission Control.

Two minutes after he reported he was in the foot restraints at the open SIM bay, Worden told Mission Control: "Okay. Pan camera [cassette] is safely inside."

From Mission Control came a report on the three astronauts' heart rates during the activity—the first space walk ever attempted in deep space. Worden, who was working hardest, had a heart rate of 130 beats/min.; Irwin's heart rate was 116 beats/min., and the rate of the third crewmember, David R. Scott who was piloting the spacecraft, was 71 beats/min. Later, Worden's heart rate dropped to 97 beats, as he became accustomed to the extravehicular activity.

As Worden hovered in the spacecraft door waiting for the panoramic camera cassette to be safely stowed in the command module, Mission Control assured him: "Remember, there is no hurry up there at all." A full hour had been set aside in the flight plan for the spacewalk, but Worden used less than one third of the time. He accomplished the retrieval of the two cassettes and made an unexpected third trip to inspect the SIM bay in less time than he ever took in simulating the chore on earth. Before the mission, he estimated the cassette retrieval would require about 20 min.

Worden's response to the Mission Control caution was: "I'm enjoying it." After he moved down the hand rails for the second trip to the SIM bay, he reported: "Okay, Houston . . . I'll take a look at the V over H." The reference was to a sensor on the panoramic camera that was not operating properly, causing a loss of about one-fifth of the film frames exposed.

Worden said he saw nothing obscuring the field of view of the sensor, and the sensor's glass face was still intact.

But inspecting the mass spectrometer, which also had malfunctioned, Worden said: "It looks like the cover . . . that's jammed." He looked more closely and said, "I thought it was the cover, but I can't tell, Karl . . ."

Then a few seconds later: ". . . Any difficulty with talk back should be because of that cover; it's not fully closed."

The brief inspection over, Worden moved to retrieve the other film cassette, a 23-earth-lb. canister from the Fairchild mapping camera. That camera, too, had operated intermittently during its use in lunar orbit, but Worden said he could detect nothing wrong with it. "Everything looks in order," he said.

At 242 hr. 21 min. GET (ground elapsed time) the second cassette was handed to Irwin in the spacecraft cabin.

Worden asked Houston if there was anything else he should check, and Houston asked for his general observations on the SIM bay. "Maybe I'll just take another look," Worden said, and he went back down the hand rails. He made a quick inspection and returned to the spacecraft cabin.

Worden's activity outside the spacecraft had been monitored on earth by flight controllers through a Westinghouse color television camera mounted on a boom attached to the open spacecraft hatch. Now, at 242 hr. 25 min. GET, the camera was pulled back into the command module, and preparations began for cabin repressurization.

Plan for repressurizing the cabin, so the three astronauts could get out of their pressurized space suits, called for the command module system to bring the pressure up to 3 psi. Then, an emergency oxygen supply in a small chest pack which had been worn by Worden outside the spacecraft was to be "dumped" to bring the cabin pressure up to 5 psi.

At 242 hr. 39 min. GET, shortly after noon EDT Aug. 5, cabin pressure was reported at 5 psi. The extravehicular activity period—measured from about half-way into the depressurization procedure to half-way into repressurization—lasted 39 min. 56 sec.

Pratt & Whitney Protests Shuttle Engine Award

Washington—Pratt & Whitney Aircraft Div. of United Aircraft Corp. last week filed a five-point protest with the General Accounting Office, asking that the National Aeronautics and Space Administration's award of a contract for the space shuttle's main propulsion engine be set aside.

NASA chose Rocketdyne Div. of North American Rockwell as the prime contractor for the engines last month (AW&ST July 19, p. 12). The contract is valued at an estimated $500 million for the first 35 engines. An additional 64 engines are anticipated at a later date.

Pratt & Whitney president Bruce N. Torell, in a telegram to Elmer B. Staats, U.S. comptroller general, listed these points as the bases for the protest.

- The award to Rocketdyne disregarded the objective stated in NASA's request for proposals, which said "The objective of the space shuttle engine program is to provide a high-performance, safe, reliable, cost-effective main engine for the reusable space shuttle vehicle."
- NASA failed to conduct "proper" written or oral discussions, as required by law, with the two contenders.
- Pratt & Whitney believes its proposal was "clearly entitled" to a superior technical evaluation.
- The source evaluation board, according to Pratt & Whitney, found the P&W proposal to be the lowest in cost.
- NASA failed to "give proper consideration to Pratt & Whitney's test-proven flight weight design and greater experience . . ." thus increasing both technical and cost risks.

First DC-10 Service

Los Angeles—American Airlines upstaged United Air Lines by putting the McDonnell Douglas DC-10 trijet into service from here to Chicago at 9:45 a.m. PDT Aug. 5, moving up its Aug. 17 inaugural date.

The surprise service introduction came exactly one week after American and United accepted delivery on the jets (AW&ST Aug. 2, p. 26). The American version was configured for 206 passengers, with lounges in both the first-class and coach sections. The DC-10 will remain in daily service on the run. United is scheduled to begin service Aug. 16.

News Digest

Boeing is negotiating the sale of as many as 29 727 transports to Iberia, the Spanish airline. Iberia also is studying the purchase of additional McDonnell Douglas DC-9 aircraft, as well as some Airbus Industrie A-300B aircraft.

House has approved conference version of the Fiscal 1972 Transportation Dept. appropriation bill (AW&ST Aug. 2, p. 16), ensuring availability of $58.5 million to repay eight U.S. and one foreign airline for risk money advanced for the now-defunct Boeing supersonic transport. House refused to approve the money in its original version of the bill.

USAF pilot serving with the British Royal Air Force Hawker Siddeley Harrier VTOL squadron at Wittering Airbase in England was killed last week in a low level ejection. Capt. Louis V. Distelzweig, Jr., 29, hit the ground before his parachute could open. The airplane was destroyed on impact. Distelzweig took part in a Paris air show demonstration by the squadron (AW&ST July 5, p. 52).

Israel Aircraft Industries has purchased 13 Boeing 707-131 airliners which had been retired from service by Trans World Airlines. Last of the 13 was withdrawn from service in June. The aircraft will be overhauled and modernized at IAI's facility near Tel Aviv and offered for sale.

Army has issued requests for quotations to nine engine manufacturers for a 1,500-shp. gas turbine to power a new helicopter designated Utility Tactical Transport Aircraft System.

McDonnell Douglas Corp. has withdrawn its proposed public offering of $50 million in six-year notes (AW&ST May 3, p. 16) to await more favorable market conditions.

BEA Studies Airbus

London—Aerospace Minister Frederick Corfield last week insisted that British Government will not put political pressure on British European Airways to buy the Lockheed L-1011, but he indicated that the odds of a 17-aircraft order from BEA are slightly in favor of the TriStar against the European A-300B.

It is doubtful that BEA will place an order for any wide-body jet transports until next year, in view of management actions taken recently to cut capital spending.