INTERAVIA

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Space News in Brief

• **The UNITED STATES** • Following the successful launches of Intelsat 4 and Apollo 14 and of the NATO B communications satellite (see below), these are the NASA launchings scheduled for the rest of 1971:

February • 25. **Interplanetary Monitoring Platform. (IMP-I).** A small geophysical research satellite.
• **Solrad 10.** A US Navy solar radiation detection satellite.

March • **ISIS-B.** A NASA/Canadian ionospheric study satellite.
• **Planetary Atmosphere Experiments Test (PAET).** A sub-orbital launch to investigate techniques of entry into planetary atmospheres.

April • **Barium ion cloud.** A NASA/W. German atmospheric study experiment.
• **Orbiting solar Observatory (OSO-H).** A large Observatory-class satellite for sun studies.

May • **Two Mariner craft** will be launched within a week of each other and will attempt to orbit Mars at about 1,600 km (1,000 miles) height in November. This will be the first attempt to orbit a planet.
• **Small Scientific Satellite (SSS-A).** This will mainly investigate magnetic phenomena.

June • **UK4.** A NASA/UK satellite for ionospheric studies.

July • 25. **Apollo 15,** with David R. Scott, Alfred M. Worden and James B. Irwin as crew will land in the Hadley Rill area, in the S.E. mountain wall of Mare Imbrium.

July–September. • **Intelsat 4** no. 2.

September • **AFCRL-A.** A satellite to investigate magnetic storms.

October–December • **Intelsat 4** no. 3.

Late 1971 • **Orbiting Astronomical Observatory (OAO-C).** The fourth launch in the OAO programme. OAO-B failed to orbit after launch on November 30, 1970 (see S.N.I.B. for 1/1971).
• **Co-operative Applications Satellite (CAS-A).** A NASA/French meteorological satellite.
• **Highly Eccentric Orbiting Spacecraft (HEOS-B).** An ESRO scientific satellite, to be launched by NASA.

• **A second NATO Communications satellite** was successfully launched from Cape Kennedy on February 3 and placed in a geostationary orbit over the equator at approximately 26° West longitude. It will provide emergency back-up for the 1st NATO satellite, orbited in March 1970, and will supplement its services during peak periods. The first satellite is some 6,000 km (3,700 miles) distant, at 18° West longitude. The 130 kg (285 lb), 160 cm (63 in.) high satellite will beam coverage only to the northern hemisphere, from the state of Virginia, USA, to Ankara, Turkey,

• **A new NASA Chief Administrator** was appointed by President Nixon on February 27. He is James C. Fletcher, who has been associated with many aerospace projects and government space committees. He leaves a post as President of Utah University. George M. Low, acting administrator since Dr Paine's resignation in late 1970, will remain with NASA.

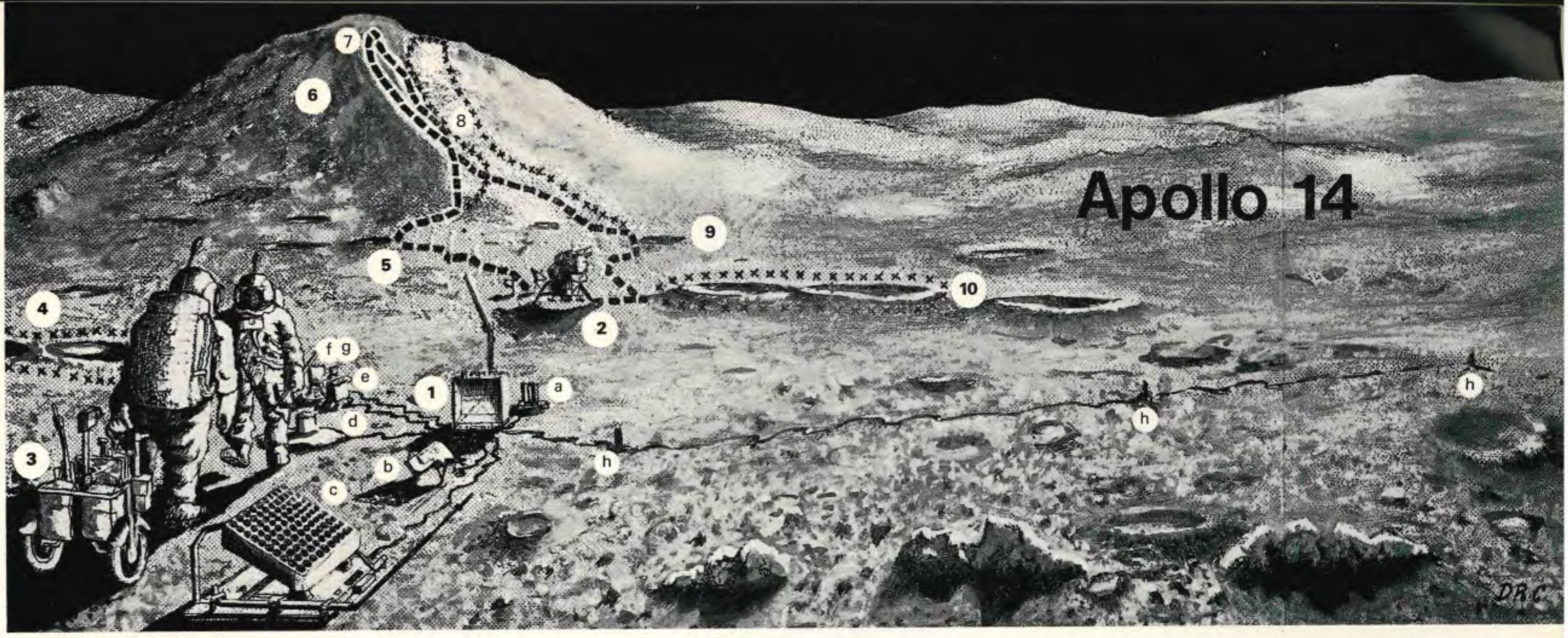
• **EUROPE** • **US/European co-operation.** Theo Lefèvre, Belgian Minister of Science and Chairman of the 13-nation European Space Conference returned in early February from discussions with US Government space officials on possible US/Europe co-operation in space research. He stated that the US will welcome European co-operation in the Post-Apollo programme, on condition Europe contributes some $1,000 million (about 10% of the programme costs) spread over ten years. But he was disappointed that the US still seemed reluctant to supply carrier rockets in aid of many European projects. In Lefèvre's view, the only alternative to such an uneconomical partnership is continuation of the ELDO carrier vehicle programme (see next item). • **Europa 3.** On January 27, ELDO announced the award of a DM 18 million ($5 million) contract to the Cryorocket consortium for studies and development work on a new high energy rocket engine. This will be an oxygen/hydrogen liquid fuel engine and will be for the upper stage of the planned 2-stage Europa III rocket, scheduled for launch in the late '70s. Cryorocket is a consortium set up

This picture shows one of the first launches of a *Skylark* upper atmosphere sounding rocket from a new, rail-transportable launcher (at the UK test range near Aberporth, Wales). The launcher was developed by MAN (Maschinenfabrik Augsburg-Nürnberg) on behalf of W. Germany's aerospace research institute (DFVLR), and is being marketed by the British Aircraft Corporation, the prime contractor for the rocket. *Skylark*—one of the most successful European sounding rockets—can carry a 100 kg payload to a height of 200 miles (320 km), and over 260 *Skylark* launches have been carried out within the ESRO and British space programmes.

by MBB (Messerschmitt-Bölkow-Blohm) and SEP (Société Européenne de Propulsion), with headquarters in Paris. The ELDO Council had previously approved financing of the preliminary development phase of Europa 3, to the tune of $35 million up to mid-1972. Financing Europa 3 are W. Germany, Belgium, France and the Netherlands. • **The ESRO council** elected Dr. Hocker of W. Germany as Director General of ESRO as from April 15. Hocker succeeds Professor H. Bondi. • **France's PÉOLE satellite** (see S.N.I.B. for 2/1971) was stated in mid-February to be in a 514×749 km (319×465 mile) orbit. This is slightly lower than anticipated, but systems are stated to be performing satisfactorily. • **ERNO Raumfahrttechnik** is working on a 100 kg (220 lb) weather satellite concept, which could be orbited by a Black Arrow rocket. It would appear daily over the same spot at some 500 km (310 miles) altitude. ERNO is also currently testing the L21 *Bumerang*, an aircraft-launched test vehicle designed to investigate re-entry problems (see S.N.I.B. for 1/1971).

• The **SOVIET UNION** • **Lunokhod 1** continues to astonish the sceptics. From January 21 to February 6 it had spent its 3rd lunar night in the crater close to the Luna 17 lander stage. On February 7, a radio session lasting some 5 hours was held with the vehicle and it was moved 323 m (1,060 ft) due North, crossing several craters of 30–40 m (100–130 ft) diameter, including the negotiation of slopes of up to 15°. It then entered a larger crater, emerged, and ended with a "photographic" session which included five pictures comprising a panoramic view of surrounding terrain. Even when reproduced on newspaper, this picture showed surprising detail, and again testifies to the very high quality of the Soviet equipment and TV link. During the lunar mid-day, from 12–15 February, the vehicle was left stationary, for the low contrast reasons given in last month's S.N.I.B. Later, Lunokhod was moved, and stopped on the crest of a ridge. Here, it dug a small trench, some 10 cm (4 in.) deep and analysed the soil sample. During another 6-hour session, it explored a crater of 500 metres (1,640 ft) diameter and some 6 m (19.7 ft) depth. When parked, on February 19, against the onset of the lunar night, Lunokhod had traversed some 5.23 km (3¼ miles) since its start, had negotiated some 80 craters, analysed over 200 soil samples and obeyed over 3,000 radio commands from Earth. The vehicle's next and 5th period of activity was due to start on March 6. • **A further Meteor weather satellite** was launched on January 20 into a 630/679 km (391/421 mile) orbit, with inclination of 81.2° and orbital period of 97.6 minutes.

• **Japan's second satellite,** named *Tansei* (light blue) after the school colours of Tokyo University, where it was developed, was launched at 0400 hrs GMT on February 16, by a four-stage MU-4S booster. Officially entitled MR-T1, the 63 kg (139 lb) vehicle was placed in a 998/1,275 km (620/792 mile) orbit—instead of the 622/3,830 km (387/2,380 miles orbit planned: technicians said the error was due to a fault in the control system. However, the satellite contains a purely test payload—i.e. telemetry equipment to convey data on its position and performance to Earth—as a rehearsal for the scientific satellite Japan hopes to launch later in 1971. *Tansei* is an all-Japanese vehicle developed by the Tokyo University Aeronautics and Space Institute, in co-operation with the Nissan Motor Co, makers of Datsun cars. The launch was from Japan's Uchinoura base. ✦✦



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Apollo 14

Last month's Interavia gave a brief factual account of the Apollo 14 mission, and its many difficulties. The following article deals generally with the scientific aspects of the mission.

Like the subsequently abortive Apollo 13, Apollo 14 had been welcomed as the most science-orientated Moon expedition so far. Although NASA has still not reached the stage where it is using the scientist-astronauts invited into training in 1967, yet this mission had a more concentrated programme of experiments than any previous one. Despite the Apollo 13 setback, NASA is evidently now confident that the basic soundness of the Saturn/Apollo flight and landing system have been sufficiently proved and that no fundamental changes are necessary here. Consequently, the Administration can afford to concentrate more on the scientific aspects of the programme—even though it continues to use only former pilots and test-pilots as astronauts.

Glossary of Acronymes

ALSEP	Apollo Lunar Surface Experiments Package
ASE	Active Seismic Experiment
CCIG	Cold Cathode Ion Gauge
CPLEE	Charged Particle Lunar Environment Experiment
CM	Command Module
CS	Central Station (of ALSEP)
EVA	Extra-Vehicular Activity
LM	Lunar Module
LPM	Lunar Portable Magnetometer
LRRR	Laser Ranging Retro-Reflector
MET	Modularised (or Mobile) Equipment Transporter
PSE	Passive Seismic Experiment
RTG	Radio-isotope Thermo-electric Generator
SIDE	Supra-thermal Ion Detector Experiment
SWCD	Solar Wind Composition Detector

Importance of Fra Mauro site

From a selenological viewpoint, the importance of the Fra Mauro landing site is high. The Fra Mauro formation is a highland area measuring some 150 miles from North to South by some 200 miles wide, the centre lying about 900 miles almost due south of the centre of Mare Imbrium. Now Mare Imbrium is the largest recognisable impact structure on the Moon: it is believed it resulted from a giant mass striking the lunar surface during the early formative period of the Earth and planets, and that the Fra Mauro highlands comprise an ejecta blanket produced by that impact. If this theory is true, then the Fra Mauro area must contain ejected material dating from the pre-impact body of the Moon—some of it possibly from as deep as 160 km (100 miles) below the original lunar crust.

This original material, however, will be buried deep beneath the lunar regolith—the layer of rubble and lunar soil churned up by later meteorite impacts and, possibly, moonquakes—which is believed to cover most of the Moon's surface to a depth of 3-6 metres (10-12 ft). But Cone Crater, the rim of which was so nearly reached by the astronauts, is thought to be a depression caused by a relatively recent meteor impact, piercing the lunar crust to a depth of some 76 metres (250 ft). It was to be hoped, therefore, that around this crater, and especially round its rim, would be some thrown-up pre-Imbrium material which had not yet been covered by regolith. Analysis of this would help to establish—or to refute—the theory (based on lunar material analysis) that the Moon is about 4,600 million years old, even though none of the rocks brought back by Apollo 11 and 12 were as old as that.

The exact landing spot chosen by NASA was a point 3° 40′ 19″ south latitude by 17° 27′ 46″ west longitude (see fig. 3). Pre-mission pictures had indicated the presence of the large boulders which Shepard and Mitchell were able to photograph in close-up

Above. Panoramic view of Apollo 14 landing site. - - - - denotes actual traverse of 2nd EVA: x x x x denotes traverses proposed, but not achieved. *Key:* 1—ALSEP Central Station: a-h—ALSEP equipment: see Glossary and text for explanation of terms: a—Plutonium Generator (RTG); b—Grenade Launcher; c—Laser Reflector (LRRR); d—PSE; e—CPLEE; f—SIDE; g—CCIG; h—(3) geometers. 2—Lunar Module. 3—Mobile Equipment Transporter (MET). 4—*Doublet* craters. 5—*Valley* crater. 6—*Cone* crater. 7—Highest point reached by astronauts and white rock area (see text). 8—*Flank* crater. 9—*Weird* crater: soil mechanics experiment and core samples taken. 10—*Triplet* craters.

Below. Diagram showing ideal lay-out of ALSEP equipment. *Key:* 1, 2, and a-h as fig. 1; j—marker flags; k—flight path of grenades, with distances from launcher.

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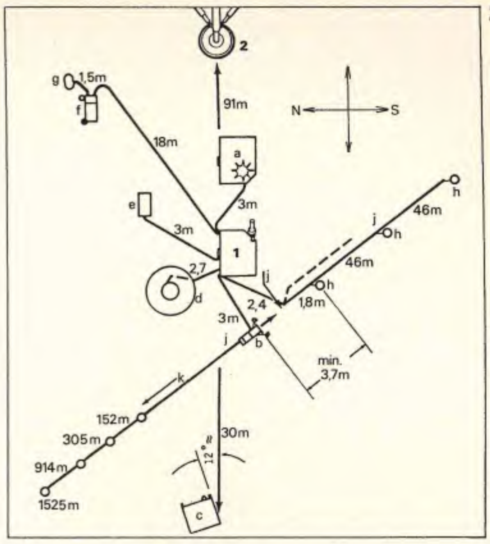

This photo shows the positions of seismic experiments in Apollos 12, 13 and 14. *Key:* A—Apollo 14 events: 1—LM landing site; 2—planned LM ascent stage impact; 3—actual ascent stage impact; 4—planned SIVB stage impact; 5—actual SIVB stage impact. B—Apollo 12 events: 1—ALSEP position; 2—LM ascent stage impact. C—Apollo 13 SIVB stage impact. *Inset of Moon:* I = Mare Imbrium; M = Fra Mauro area. Rectangle shows approximate area of larger map.

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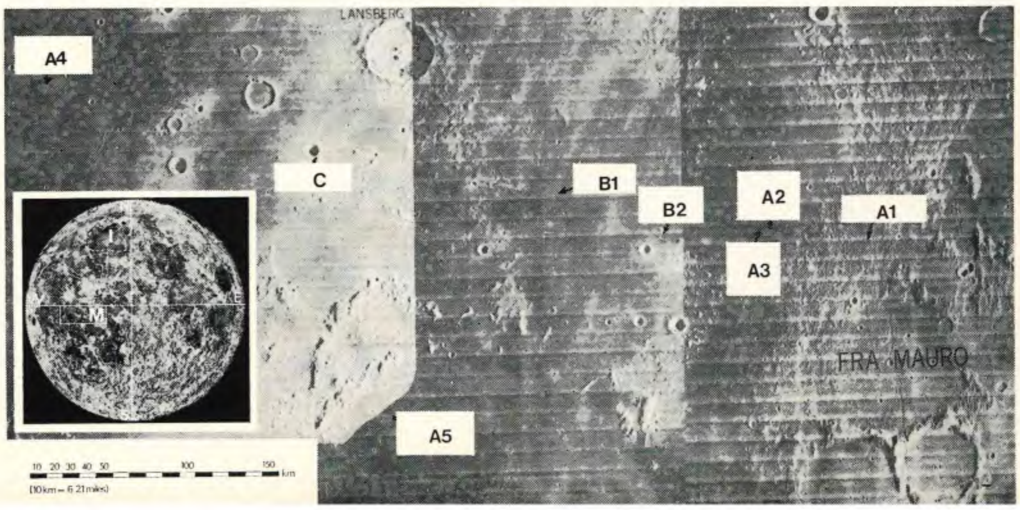

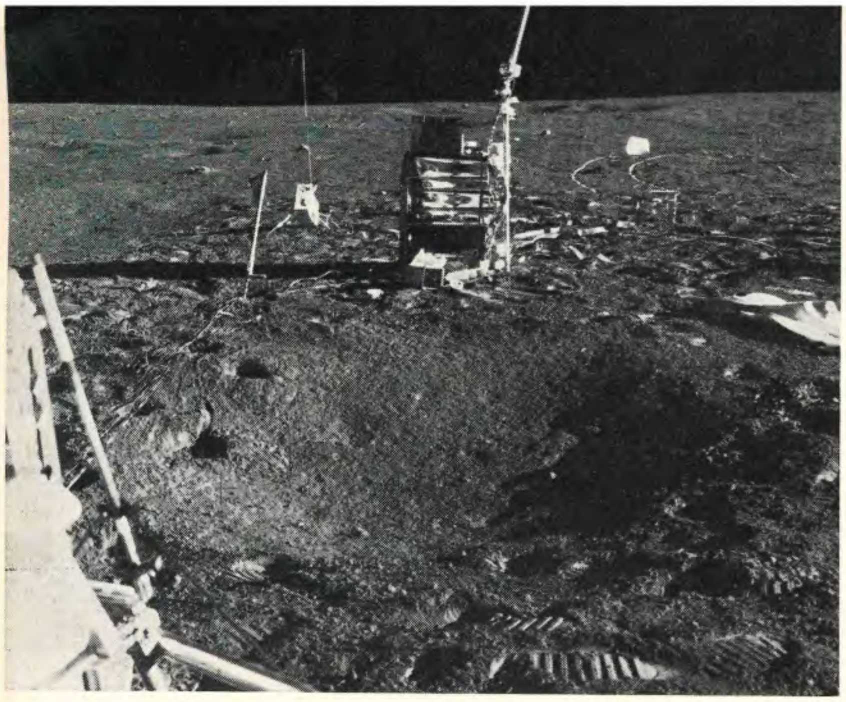

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The ALSEP Central Station and some of the ALSEP experiments of Apollo 14. To left of the CS is the Grenade Launcher with marker flag. The CPLEE is faintly visible to the right of the CS. A portion of the MET shows in the lower left hand corner.

the station could not be registered as deep beneath the surface as hoped. Apollo 12 readings had suggested the Moon has an outer crust consisting of boulders piled on top of one another like rubble, and this might go as deep as 16-32 km (10-20 miles), and it had been hoped Apollo 14 readings would probe deep enough to find the base to this layer. Vibrations were, in fact, recorded to a depth of more than 20 miles; the bottom was *not* reached—but this fact alone is interesting.

The LM impact, after the two moonwalkers had transferred to the CM, went off as planned. The LM struck the Moon some 66.0 km (41 miles) from the Apollo 14 site and about twice that distance from the Apollo 12 station. This impact of an object of known mass and velocity helped Ground Control to calibrate the PSE's at the two Apollo sites. All impact positions are shown in fig. 3.

during EVA 2, when scientists were particuarly intrigued by one described by the astronauts as almost pure white, with small black specks. Shepard was able to chip off a lemon-sized lump and there are high hopes this may prove to date from very early in the Moon's history.

A further interest was added to the Fra Mauro site by the fact that the seismotor left by the Apollo 12 astronauts about 177 km (110 miles) to the west had relayed to Earth signals of an intriguing nature. They seemed to indicate monthly moonquakes occurring regularly in the Fra Mauro region as the Moon passed through its perigee.

Seismographic experiments

Now this fact was of great interest to seismologists, who—along with the selenologists—had a field-day with Apollo 14. No less than five seismological experiments were planned and carried out in further efforts to investigate the composition of the Moon. Viz.: (1) a Passive Seismic Experiment (PSE); (2, 3) two Active Seismic Experiments (ASE); (4) impact of the S IV B stage on the Moon; (5) similar impact of the Lunar Module (LM). Experiments 1, 2 and 3 were part of the Apollo Lunar Scientific Experiment Package (ALSEP).

The PSE, consisting of a round-topped cylindrical instrument covered by a 5 ft diameter insulating shroud, was placed close to the ALSEP Central Station (CS). Its functions are to determine the frequency of moonquakes, to measure the approximate azimuth and distance to lunar epicentres, and to record the frequency and location of meteorites striking the Moon. It is similar to the PSE deployed during Apollo 12, and, like its predecessor, is also powered by a SNAP-27 RTG (see below) via the CS. The ALSEP layout is shown in figs 1 and 2.

The ASE consisted of two separate experiments, the " Thumper " and the Grenade Launcher. First, the astronauts deployed three geophones, the first about 3 m (10 ft) from the CS, then two more placed 46 m (150 ft) apart in a straight line. Also close to the CS was placed the fibreglass and magnesium grenade launcher, designed to fire four projectiles to land and explode at the distances shown in the diagram. Firings were to be conducted from Earth, by remote control, some time after the end of the mission. After laying out the geophones, the astronauts returned to the CS, using the " Thumper "—a 113 cm (44.5 in) long rod-like instrument, designed to fire 21 small explosive charges, approximately one every 6 m (15 ft). This was operated by Mitchell, as shown in fig. 5 below. At first, the astronaut found the trigger somewhat difficult to pull and only 14 of the charges "thumped" the lunar soil: each had about the force of a .22 calibre rifle bullet, and was picked up by the geophones, permitting measurement of the elastic properties of the Moon's subsurface to a depth of some 23 m (75.5 ft). Of the four grenades to be launched, each contains a radio transmitter which will enable start-and-stop times to be telemetered back to Earth vie the CS. Consequently, as the launch angle is pre-set, precise range can be calculated. The geophones will provide data on the seismic wave travel time, and correlation of this with range will establish wave velocity through the lunar crust—giving information on its nature to a depth of up to 457 m (1,500 ft).

Due to the difficulties in " transposition " docking (see last month's issue), the S IV B (third) stage was placed in its lunar impact trajectory later than intended and struck the Moon somewhat wide of the scheduled spot (see fig. 3). Weighing almost 14 metric tons (30,836 lb), it hit the Moon at over 4,000 nmph. Vibrations, picked up by the Apollo 12 PSE, 166 km (103 miles) away, lasted three hours and reached some 32 km (20 miles) below the lunar surface. The impact was, unfortunately, about 140 km (90 miles) closer to the Apollo 12 PSE than intended, consequently vibrations reaching

LM pilot Ed Mitchell operating the " Thumper " as part of the Apollo 14 Active Seismic Experiment (see text). In the background is Mission Commander Alan B. Shepard Jr.

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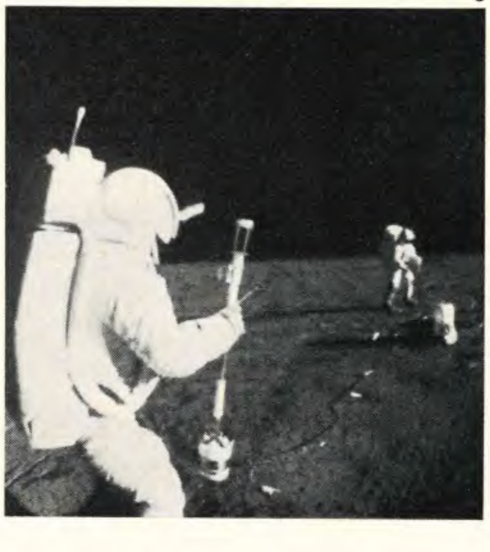

Other instrumented experiments

The remaining instruments laid out by the astronauts in the ALSEP were the SIDE, the CCIG and the CPLEE (see Glossary). SIDE is designed to measure the energy, velocity, flux and mass of positive ions at the lunar surface. It is connected by a short cable to the CCIG, which measures the pressure of neutral particles to indicate the lunar atmosphere pressure. The two instruments will also help to detect any volcanic processes existing in the Moon. The CPLEE measures the energy of solar protons and electrons reaching the lunar surface, and, among other functions, will help in the understanding of solar flares, and their relationship to Earth phenomena: it will also study characteristics of the Earth's magnetic tail.

The CS serves as a power-distribution and data-handling point for the ALSEP experiments. Its power source is a SNAP-27 radioisotope thermo-electric generator (RTG), as first used on Apollo 12. The fuel for this consists of about 3.8 kg (8.36 lb) of plutonium-238, which generates heat as a result of spontaneous radio-active decay. An assembly of lead telluride thermo-electric elements converts this heat into at least 63.5 watts of electrical power: there are no moving parts.

Two further experiments—which did not form part of the ALSEP—were the Laser Ranging Retro-Reflector (LRRR) and the Lunar Portable Magnetometer (LPM). The LRRR consists of 100 fused silica reflector cubes (see title picture) which permit long-term measurements of Earth—Moon distance by acting as a passive target for laser beams directed from Earth observatories. Data gathered will help understanding of the Earth's rotation rate fluctuations and axis " wobble " and of the Moon's size and orbit. Similar stations were set up by Apollos 11 and 12, and the combination of the three should permit precise control in the study of lunar motion. The LPM was a package which, in Apollos 11 and 12 was set up on the lunar surface, but, on this occasion, was carried in the MET on the second EVA. The astronauts used it to measure variations in the lunar magnetic field at different points in their geology traverse. Data gathered will help determine the location and strength of lunar magnetic sources, and will aid in understanding of the lunar structure.

A final experiment laid out by the astronauts was the Solar Wind Composition Detector (SWCD). As used in Apollos 11 and 12, this consists of a sheet of thin aluminium foil supported on a staff. Solar wind particles embed themselves in the foil to a depth of several hundred atomic layers, whilst cosmic rays pass through. At the end of the astronaut's stay on the Moon, the foil was rolled up and brought back to Earth for analysis. This time the SWCD had an exposure of 25 hours, compared with 17 on Apollo 12 and only two on Apollo 11.

Soil and rock investigation

Apart from the experiments enumerated, most of which depended on complex instruments to be left behind on the Moon, the astronauts had numerous other tasks connected with geology (or, more accurately, the new science of selenology), orbital photography (conducted by Roosa in the Command Module), and other evaluations of hardware and lunar working techniques.

As far as soil samples were concerned, the astronauts gathered and photographed more than any previous mission: in all, some 43.5 kg (96 lb). The surface immediately round the landing site proved to be of a very fine adhesive dust and it was not till the 2nd EVA (February 6) that Shepard and Mitchell met extensive fields of larger rocks and boulders—en route for and on the flanks of Cone Crater. On their return, Shepard attempted part of the Apollo 14 " Soil Mechanics Experiment ". His intention was to dig a straight-walled trench of some depth so that he could examine the strata but, although he found it easy to dig down some 46 cm (18 in.), loose soil continuously falling from the walls prevented much worthwhile observation. This experiment also had relevance to the design of future lunar shelters and vehicles. As per instructions, the astronauts also picked up a football-sized rock, weighing about 11.3 kg (25 lb) and Mitchell sank tubes to take four core samples.

Although analysis of the 20% of Apollo 14 samples reserved for immediate investigation will take several years, some results of preliminary inspection may be given. At first sight, geologists remarked, the rocks appeared quite different from the basalts found by Apollos 11 and 12. This was confirmed by one preliminary analysis in mid-February. The sample was found to be ten times richer in radioactive thorium, uranium and potassium than the Apollo 11 and 12 samples, suggesting a much greater age—though final age-dating will not be complete until the middle of this month. The lemon-sized white rock chip mentioned above was found to have less radio-activity than expected. One mystifying feature noticed by scientists was that some rocks had sharp facets or " fracture faces ", as though they had relatively recently (in geological terms) been chipped off a larger rock. There is, at present, no explanation for this.

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Above left. Captain Shepard beside a medium-sized boulder. *Above right.* The size of these boulders is shown by the 14 inch (35 cm) hammer and small sample bag lying on one of them. This is one of the white rocks found near the summit of Cone crater (see text).

The in-flight experiments

No space is available to describe in detail the photographic and communications experiments carried out by CM pilot Roosa in lone lunar orbit. These included photography of candidate landing sites—especially of the Descartes crater area (approx. 8-13°S × 16°E), currently scheduled for the Apollo 16 landing; investigation of visibility at high sun angles, to determine whether landings could safely be made with angles greater than 14°, as they would normally be if a launch was postponed for over 24 hours (the sun angle was 10° for Apollo 14); a lunar landmark identification experiment, and numerous others connected with space navigation and communications.

During the return flight from the Moon the astronauts in the CM carried out four experiments with a bearing on industrial processes which could one day be carried out in the zero gravity of space. These were all " prepacked " experiments—i.e. the apparatus had been set up prior to the flight and only required activation by one of the astronauts: the amount of electric current required was very small.

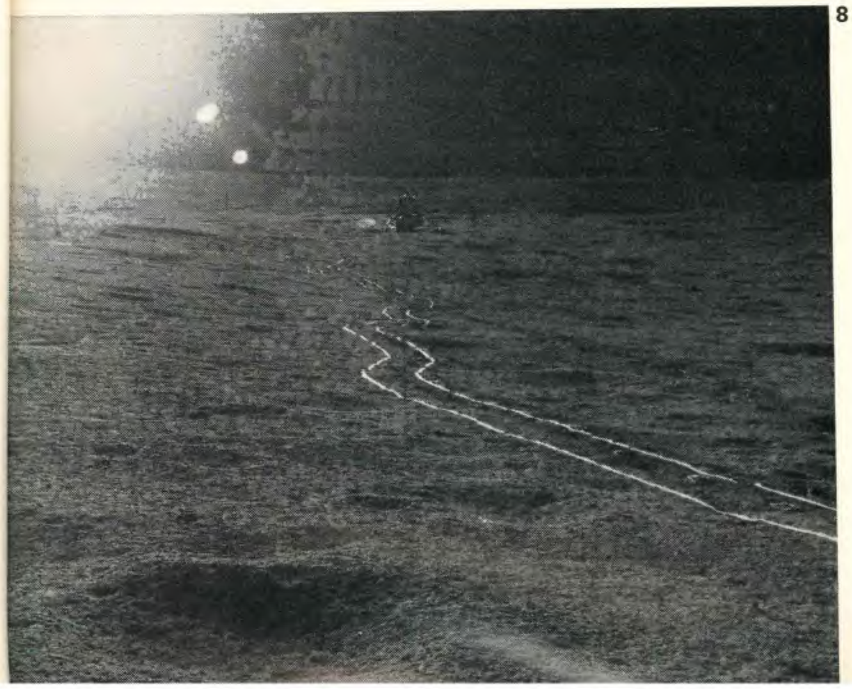
Experiment No. 1 was concerned with electrophoretic separation, and took place in a small box container with an observation port. Electrophoresis occurs when an electric current is applied to a slightly acid or alkaline solution containing organic molecules: the molecules will begin to move through the liquid—and the speed at which different molecules in a mixture move is conditioned by the nature of the molecule. This process is used, on Earth, in the preparation of pure vaccines and biological samples—but is complicated by problems of sedimentation of the materials and convection flow. The Apollo 14 experiment was designed to see if these problems would be surmounted in a weightless environment. In the experiment box were three tubes • one containing a mixture of blue and red organic dyes • one containing human haemoglobin • one containing DNA (the molecule which stores the genetic code) from salmon sperm. The manner of separation of each material was filmed in colour through the viewing window.

Experiment No. 2 was designed to test heat and convection flow in liquids and gases under weightless conditions, and involved heating samples of pure water, a sugar solution and carbon dioxide. Temperature alterations were indicated visually by colour changes in " liquid crystal " thermometers, and were, again, filmed.

Experiment No. 3 studied the behaviour of two sets of liquids when transferred from one container to another under zero gravity conditions. One set of the coloured fluids was passed directly from one tank to another, the other set was passed to a second tank through baffle plates of two different types. The action was filmed. Results of this experiment will have a bearing on refuelling operations and fuel storage in space (e.g. with the Space Shuttle, Space Tug etc.).

Experiment No. 4 did not require to be filmed. Named the " Composite Casting Experiment ", it involved the preparation of castings of various materials in a zero-g environment. Samples of metals, fibre-reinforced materials and single crystals were processed in a small heat chamber, for examination on return to Houston. On Earth, preparation of a homogenous cast of different materials is difficult because gravity tends to cause sedimentation.

These experiments mark a further stage in the investigation of how space may be used to solve terrestrial technical problems. But if the results of all the Apollo 14 experiments resemble those of the previous Moon landings, they will no doubt pose at least as many new problems as they solve!



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This picture shows clearly the fine, minutely-pitted nature of the surface in the Apollo 14 landing area. The white parallel lines are tracks left by the MET.