JSC-23454
LESC-26676

CATALOG OF APOLLO LUNAR SURFACE GEOLOGICAL SAMPLING TOOLS AND CONTAINERS

Judith Haley Allton
Lockheed Engineering and Sciences Company
Houston, Texas

March 1989

Prepared for NASA/JSC Solar System Exploration Division
Contract NAS 9-17900, Job Order J2-J60

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Table of Contents

Among their other monumental milestones, the *Apollo* missions to the Moon achieved the first collection of extraterrestrial materials for return to Earth. Two generations of scientists around the world have dedicated major portions of their lives to study of the 382 kg of rocks and soils that were collected, in total, by the six manned expeditions (*Apollo* 11, 12, 14, 15, 16, and 17) during 1969-72. Indeed, availability of lunar samples for laboratory analysis revolutionized planetary science by driving sophistication of both the necessary analytical technology and the interpretive models for origin and evolution of the solar system.

An essential ingredient in the scientific success of *Apollo* was design, fabrication, and operation of tools and containers for collecting and preserving the lunar samples. Major effort was invested in building hardware to meet stringent scientific requirements for non-contamination of samples while remaining within constraints of size, weight, power, and operability by pressure-suited astronauts. Some tools and containers worked very well as originally designed whereas others required revisions, based on experience gained during early missions. In all cases, the devices were operated with the greatest possible skill and resourcefulness by the astronauts on the lunar surface -- a factor that is difficult to translate into systems designed for robotic operation.

As NASA embarks on its next initiative for exploration of the solar system, geologic sampling missions remain key features in all scenarios. Accordingly, it is essential that the *Apollo* sampling experience be used to full advantage in planning future sampling activities, whether they be robotic missions or missions piloted by human crews. Regardless of whether the missions aim at the Moon, Mars and its moons (Phobos and Deimos), or more distant targets such as asteroids and comets, all sampling activities will share a certain minimum set of common goals and problems. *Apollo* represented the first implementation of those goals and the first confrontation with the attendant problems. Although many volumes have been written about scientific results of lunar-sample studies, descriptions of sample tools and containers used on the lunar surface have remained scattered among internal reports that have become more inaccessible with time.

This report summarizes the hardware that was used to collect and preserve lunar samples until the time that they were delivered to the receiving laboratory and curatorial facility at the Johnson Space Center. The catalog format was chosen to individually feature tools and containers for engineering purposes, with a minimum amount of ancillary descriptions. Emphasis was placed on summarizing important physical characteristics (dimensions, weight, power, materials of construction); where known, references to original technical documents are cited. No attempt has been made to chronicle development or testing of the hardware although, when known, experiences that exerted major influence on design or modifications are mentioned. In some cases, the passage of time has been too great and the recoverable information is unavoidably incomplete. Finally, an appendix showing various inventories of flight-spare or prototype devices is included to assist future tool and container designers who might find it important to directly inspect hardware.

Although this catalog was conceived and developed at my initiative and direction, full credit for its successful completion must go to Judy Allton who painstakingly researched, compiled, and remeasured every item to the fullest possible extent.

James L. Gooding
Solar System Exploration Division
NASA/Lyndon B. Johnson Space Center

February 27, 1989

History of tool and container development

OPERATIONAL REQUIREMENTS

Since the tools and containers used on the moon were handled by astronauts in space suits, tools had special operational requirements. Space suit gloves were bulky, stiff and fatiguing to operate. The sense of touch was greatly diminished. Therefore, large gripping surfaces were needed. Weight and volume were carefully rationed, so the tools and containers were made as light-weight as possible. Mechanisms were designed to accomodate the abrasive, fine lunar dust. Materials had to withstand the lunar thermal range of 100 to 380°K.

In addition, for crew and spacecraft safety NASA had restrictions on flammability and outgassing characteristics of materials carried aboard the Apollo vehicles.

SCIENTIFIC REQUIREMENTS

To insure that important scientific analyses were not compromised by contamination from the tools or containers, the scientific community proposed use of certain materials. They recommended that materials for tools and containers be selected to minimize contamination from Pb, U, Th, Li, Be, B, K, Rb, Sr, noble gases, rare earths, micro-organisms and organic compounds. Acceptable materials included aluminum alloy 6061 and 300 series stainless steel, which were the main structural components of tools. Teflon was the only acceptable plastic, although Viton was acceptable for backup, exterior seals. MoS_2 was agreed upon for a lubricant, as was use of soft indium metal for sealing surfaces. In practice fluorosilicone was used instead of Viton on the rock box seals. Post-mission sample analyses showed that indium interfered with detection of siderophile elements.

Catalog format

NOMENCLATURE

The information in this catalog was obtained for each tool or container by part name or part number that was assigned by its manufacturer or by the Apollo project. Neither part names nor part numbers were consistent across all data sets. Where practical, tools and containers are grouped by simple names used in earlier literature. Significant variations in configuration are described separately, within the groups, and the names of these configurations were modified by the author to distinguish the physical differences in the objects (lighter weight, shorter, etc.)

SOURCES OF INFORMATION

Missions: Three basic types of records were used for documenting the flight histories of the tools in this catalog: 1) the Flight Stowage Lists for each mission (except for the Apollo 11 list which could not be located for this study; *Sample Information Catalog, Apollo 11* was used instead), 2) the packing list for each of the Apollo Lunar Sample Return Containers (ALSRC, the rock boxes) and 3) photographs taken on the lunar surface. The Flight Stowage List details each observable piece of equipment packed into the Lunar Module; tools and containers relating to lunar sampling were identified from the list. Gaps in the data arose because some items were packed inside of others. Since tools and containers packed inside of the ALSRC were not itemized on the stowage list, the packing list for the ALSRC was used to verify these flight objects. Due to imprecise nomenclature in a few cases, configuration of the object was deduced from weight compared to a known configuration. Conclusions based on data other than those given here are explained in footnotes.

Weights: Most hardware weights cited in this catalog were taken from the Flight Stowage Lists (weights given to the nearest 0.1 lb) or the ALSRC packing lists (weights given to the nearest gram). Averages of similar objects were used. Exceptions were made if the weight systematically changed by mission, indicating modification of the object. In this circumstance, the weight from the latest mission was used, since, presumably, the object was improved in later versions. Weights taken from other sources are footnoted.

Dimensions: Engineering drawings provided the dimensions for all of the equipment fabricated by NASA and for some of the contractor-made hardware. Footnotes indicate if dimensions were derived by direct measurement of a typical or a similar object or if the dimensions are estimated.

Materials: When specific compounds or alloys are specified, the data were taken from engineering drawings. General descriptive terms like "aluminum" or "teflon" were deduced from the appearance of the object or indirectly from engineering drawing references to parts being anodized. Exceptions to these data sources are footnoted.

A. TOOLS AND CONTAINERS USED TO COLLECT LUNAR ROCKS AND SOILS

Contact Soil Sampling Device
Contingency soil sampler
Core tube
Drill
Extension Handle
Hammer
Lunar rover soil sampler
Rake
Scoop
Tongs
Trenching tool

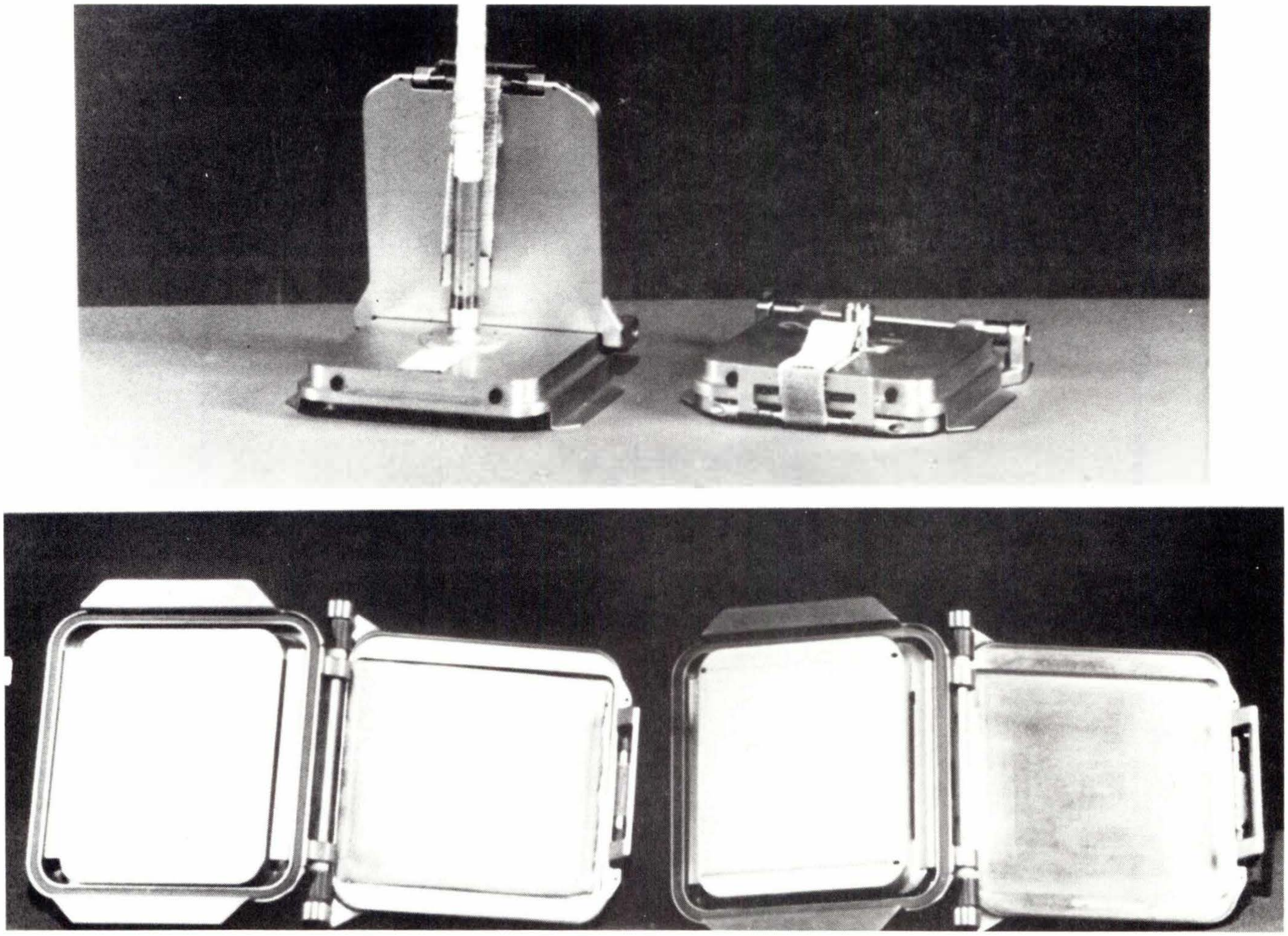

Fig. 1 (A ,left) Contact Soil Sampling Device open in the sampling position. (A,right) Device closed for stowage after sampling. (B, left) Device open showing beta cloth sampler. (B, right) Device open showing velvet cloth sampler (NASA photo S72-43792).

WEIGHT:	**500 g**
DIMENSIONS:	**17.0 cm box width**
	15.9 cm box length
	4.2 cm box thickness

DIMENSIONS OF SAMPLE PAD: 9.5 X 10.6 cm

MANUFACTURER: NASA, Johnson Space Center

APOLLO MISSIONS: Two Contact Soil Sampling Devices (Fig. 1) were flown only on Apollo 16 to collect special samples of the uppermost layers of lunar regolith. One device had a sampling pad covered with **beta cloth**, and the other had a pad covered with **velvet**.

OPERATION: To sample regolith undisturbed by the descent engine on the lunar lander or dirt scattered by human activities, the astronauts cautiously approached a large boulder far away from the lander. They carefully extended the sampler down to the protected surface on the farside of the boulder using a long handle for that purpose [18,26].

MATERIALS: The devices were identical except for the material comprising the sampling pad. The boxes and the sampling pad supports were aluminum alloy 6061-T6. These devices contained more organics and other materials that were typically avoided in lunar sampling tools and containers. Inside the box in the immediate sample environment were:

Seal	silicone rubber tubing
Adhesive	primer SS-4120 (General Electric Silicone Products)
	RTV-102 (General Electric Silicone Products)
Adhesive	primer X R5001 (3 M Co.)
	EA 954 (Hysol Div., Dexter Corp.)

BETA CLOTH SAMPLER

USE: The beta cloth sampler (Fig. 2) was designed to sample the uppermost 100 μm of the lunar regolith.

MATERIALS: The sampling pad was covered with beta cloth, teflon-coated beta yarn type X4484 (Owens Corning Fiberglas Corp.) (Fig. 3.)

VELVET CLOTH SAMPLER

USE: The velvet cloth sampler was designed to sample the uppermost 1 mm of lunar regolith.

MATERIALS: The sampling pad was covered with white nylon velvet, TL-390 (Martin Fabrics, J.B. Martin Co.) (Fig. 4).

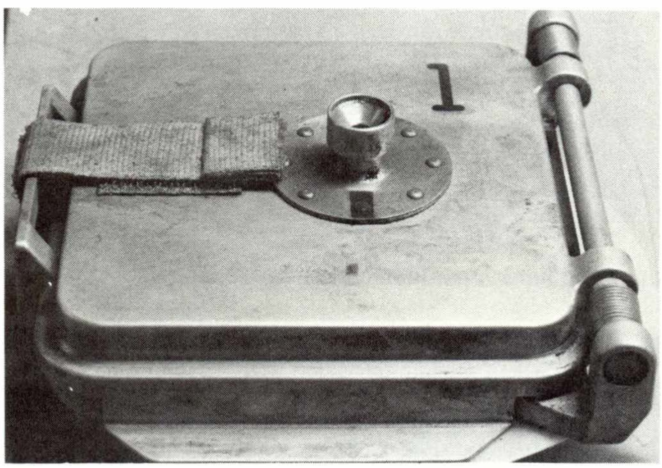

Fig. 2. Beta cloth Contact Soil Sampling Device as received in the laboratory, with lunar dust adhering (NASA photo S72-39186).

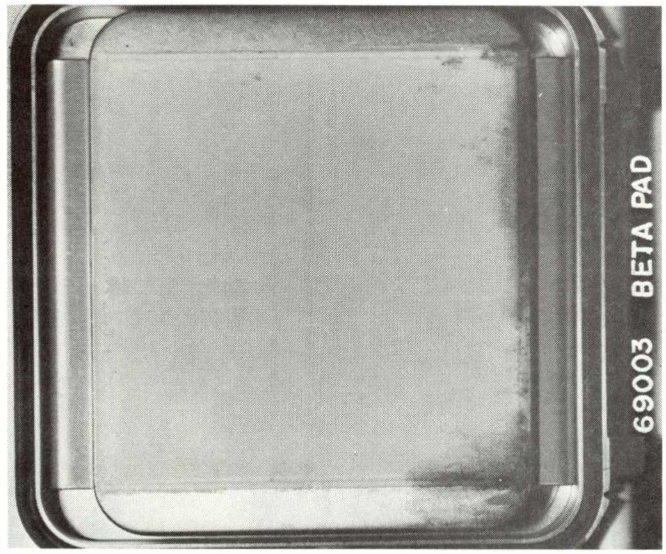

Fig. 3. Close-up of Beta cloth sample pad containing lunar sample 69003 along right-hand side of pad. The small weight of soil recovered on this device has not been removed from the pad for analysis (NASA photo S75-20313).

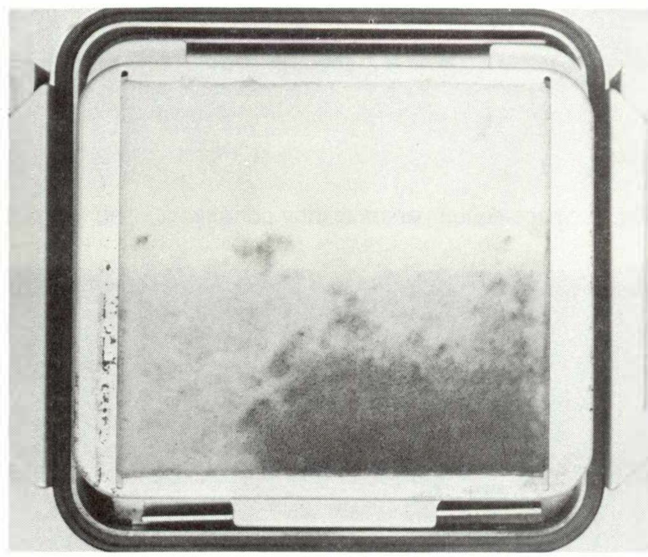

Fig. 4. Close-up of velvet cloth sample pad containing lunar sample 69004. The small amount of sample recovered on this pad has not been removed for analysis (NASA photo S75-20266).

Fig. 5. Space-suited person testing contingency soil sampler in simulated lunar regolith (NASA photo S69-31048).

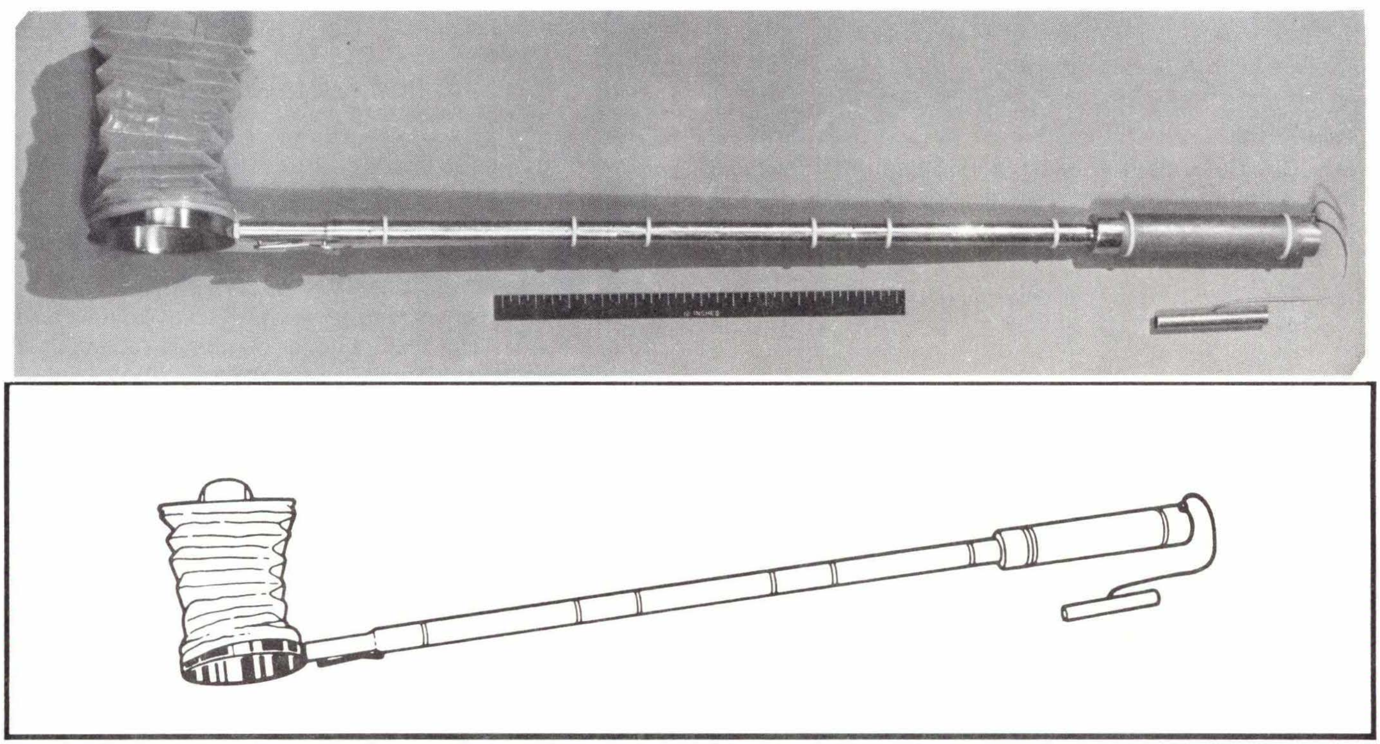

Fig 6. Contingency soil sampler in extended configuration (NASA photo S68-54937, drawing from [35]).

The contingency soil sampler (Figs. 5-7) was a device which allowed the astronauts to quickly take a soil sample very soon after they stepped out on the lunar surface. The sample was taken near the Lunar Module and stored for ascent (take-off), to insure that some lunar soil would be returned to Earth in the event of an emergency.

WEIGHT:	**1200 g**
DIMENSIONS:	**95 cm overall length**
	10 cm bag diameter

WEIGHT: 1200 g was an average weight for "Container, contingency sample, soft" for missions 12, 14 and 15 as given in the flight stowage lists. Author has assumed that this was the contingency sampler, although the weight appears to be greater than tools of comparable size (see LRV Soil Sampler).

DIMENSIONS: The dimensions were estimated from photos.

MANUFACTURER: The contingency sampler was not made by NASA. It may have been Union Carbide, Nuclear Division, Oak Ridge, TN

APOLLO MISSIONS: The contingency sampler was taken on missions 11, 12, 14 and 15.

MATERIALS: The bag was made of teflon [35].

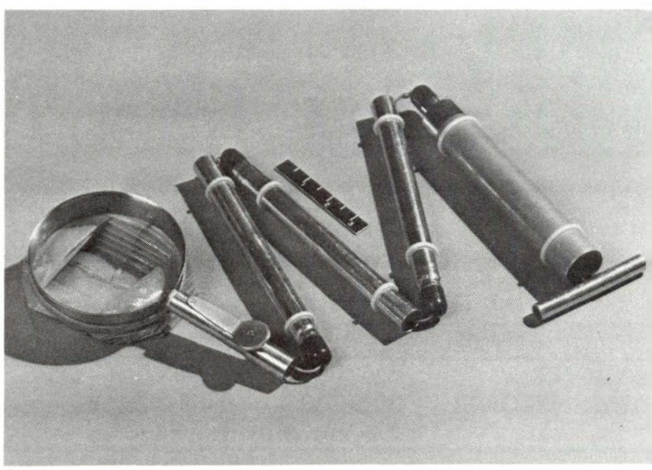

Fig. 7. Contingency soil sampler in folded configuration (NASA photo S68-54939).

Fig. 8. A 2-cm diameter core tube, attached to a shorter style extension handle, is being driven into the regolith at the Apollo 12 site (NASA photo AS12-49-7243).

Two styles of core tubes were used on the moon to obtain continuous soil columns down to 70 cm in depth (Figs. 8-18). The initial style, used on the early missions, was a thick-walled, small diameter tube called a **core tube**. This tube was designed to be easily opened in the laboratory; however, the soil column obtained in this type tube was disturbed by the collection process. Therefore, a wider diameter tube with thinner walls was designed and fabricated for the last three missions. This tube was called a **drive tube** to distinguish it from the earlier core tube (both tubes took cores and both tubes were driven into the regolith). A soil column collected in a drive tube was not significantly distorted by the coring process [28].

MANUFACTURER: NASA, Johnson Space Center

2-CM DIAMETER CORE TUBE

WEIGHT:	**327 g, assembled core tube**
DIMENSIONS:	**39.9 cm, overall length**
	2.8 cm outside diameter

WEIGHTS:

Core tube	94 g
Inner sleeve (split liner)	46 g
Follower	5.5g
Adapter (plug)	63 g
Pin	20 g
Bit	70 g
Cap	28 g
Cap dispenser with 4 caps	168 g
Cap dispenser with 3 caps & chisel bit	311 g

DIMENSIONS: 31.8 cm inside length containing soil
2.0 cm inside diameter

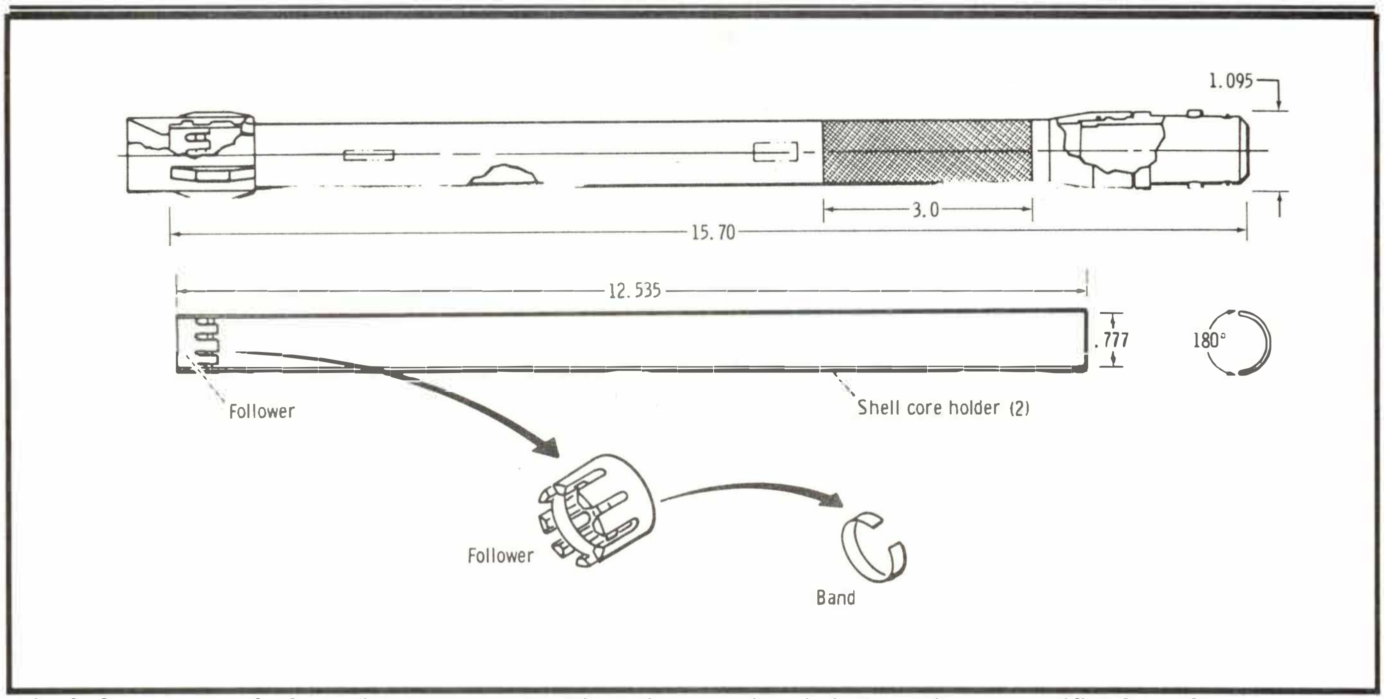

Fig. 9 Components of a 2-cm diameter core tube. Dimensions are given in inches. Diagram modified from [2].

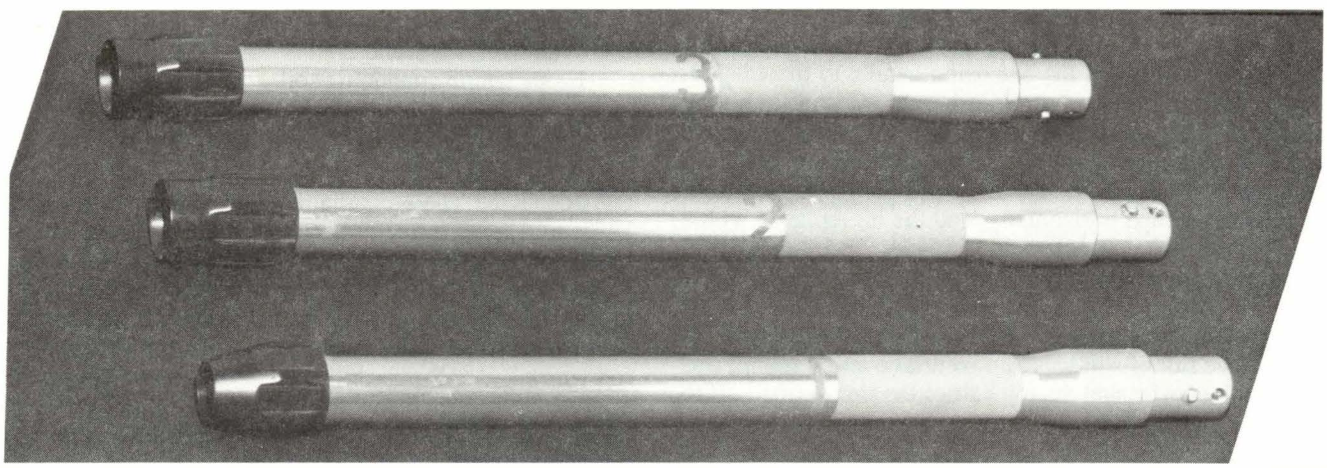

Fig. 10. Apollo 2-cm diameter core tubes showing two styles of bit. The upper two tubes have inverted funnel-shaped bits typical of Apollo 11. These bits, designed for use in fluffy soil, did not work well in the relatively dense lunar soil. The tapered bit on the bottom core tube was used on Apollo 12 and 14 (NASA photo S69-31856).

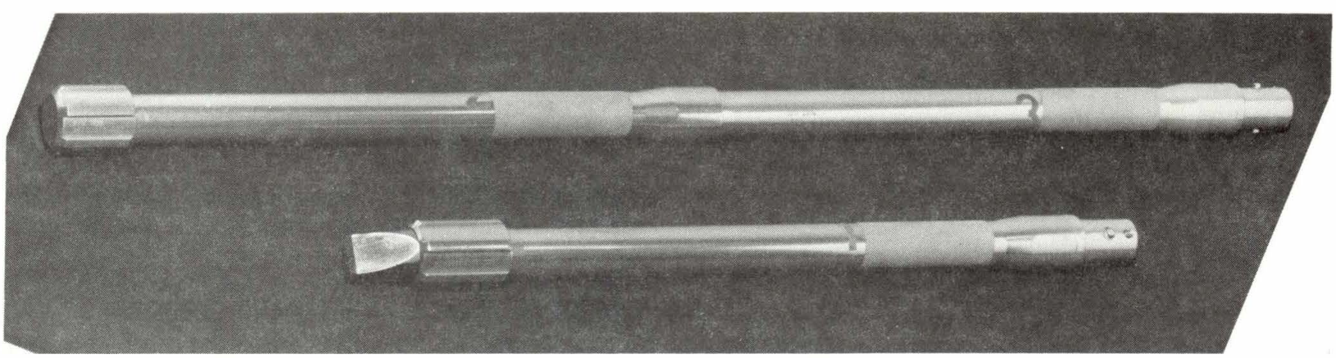

Fig. 11. Two 2-cm diameter core tubes screwed together with cap on end. The bottom tube has chisel bit attached; however, the core tube was never used as a chisel (NASA photo S69-31858).

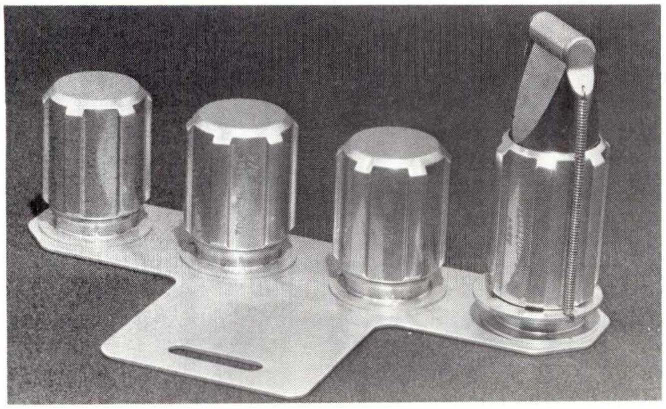

Fig. 12. Dispenser with caps and chisel bit for 2-cm diameter core tubes (NASA photo S69-31845).

CAPACITY: 100 cm^3

OPERATION: The core tube contained a thin inner sleeve which was cut in half and held together by heat-shrinkable teflon tubing. In the sleeve a follower was placed at the bottom end. A bit was screwed on the bottom and an adapter screwed into the top of the tube. Tubes were presented to the astronauts in this configuration.

The astronaut attached the extension handle to the adapter, placed the core tube and drove it in into the soil by hitting the top of the handle with a hammer. The follower rode atop the soil as it entered the tube, forming a restraint for the upper soil boundary. The core was then extracted from the regolith, turned horizontally, and the bit replaced with a cap. The extension handle was removed. Two tubes could be screwed together to take a longer core.

Once back at the laboratory, the cap was unscrewed, and the inner sleeve full of soil was removed. The teflon tubing was sliced with a razor, and the top half of the sleeve lifted off to reveal the soil column.

APOLLO MISSIONS: The 2-cm diameter core tubes were used on missions 11, 12 and 14; however, the shape of the bit changed after Apollo 11.

MATERIALS:

Core tube	Aluminum alloy 6061-T6
Inner sleeve	Aluminum alloy 6061-T6 with PTFE shrinkable tube
Follower	PTFE teflon with metal spring
Bit	17-4 stainless steel (early bits were made of aluminum alloy 6061-T651)
Adapter	Aluminum
Cap	aluminum alloy 6061-T651

4-CM DIAMETER DRIVE TUBE

WEIGHT: 300 g, one tube without cap
110 g, caps & dispenser
90 g, ram tool
DIMENSIONS: 42.0 cm overall length, tube
4.4 cm outside diameter, tube

WEIGHTS:

Upper tube	184 g
Lower tube	196 g
Plug	73 g
Keeper	37 g
Cap	13 g
Cap dispenser with 3 caps	112 g
Ram	90 g

The weights given are from Apollo 16 and 17. Apollo 15 core tube weights were different which suggests that minor modifications were made after that mission: upper tube 176 g, lower tube 191 g, keeper 22 g, caps 15 g.

DIMENSIONS:

Inside diameter, tube	4.13 cm
Wall thickness, tube	.13 cm
Inside length containing soil	34.9 cm

CAPACITY: 470 cm^3

OPERATION: The 4-cm diameter drive tube consisted of a lower tube, plug (top closure for the tube and adapter to the extension handle) and keeper (inserted into the tube to restrain soil). Unlike a follower, the keeper was placed in the top of the tube and only after soil filled the tube, was the keeper emplaced using a ram tool. This ram was a slender rod which was inserted through a small hole in the top plug to push the keeper firmly against the soil. Use of a keeper, instead of a follower, reduced the resistance of the soil entering the tube.

The lower tube contained a steel bit and was used for a single section core. The upper tube was threaded at the bottom and was screwed into a lower tube to make a double-length corer. A cap was snapped onto the bottom end of the tube after it was extracted from the regolith.

APOLLO MISSIONS: The 4-cm diameter drive tubes were used on missions 15, 16 and 17.

MATERIALS: The thin-walled core tubes were milled from 6061-T6 aluminum alloy tube of 2 in. O.D. and 1.5 in I.D. The bit in the lower tube, made from 17-4 PH stainless steel, was attached to the tube by magnetic forming. The plug and the ram were mainly 6061-T6 aluminum.

Fig. 13. A double length drive tube attached to an extension handle is being driven by an Apollo 15 astronaut. The top one-third of a lower tube, an entire upper tube, and the bottom portion of an extension handle are visible (NASA photo AS15-82-11161).

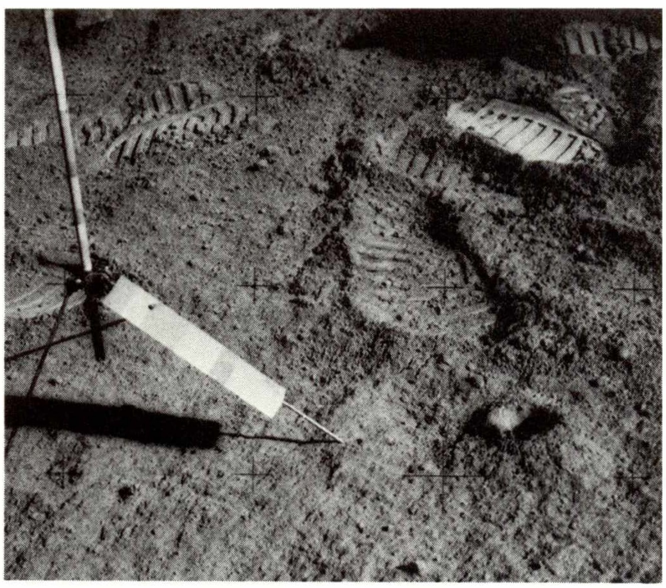

Fig. 14. Hole remaining in lunar regolith after drive tube in previous photo was removed (NASA photo AS15-82-11163).

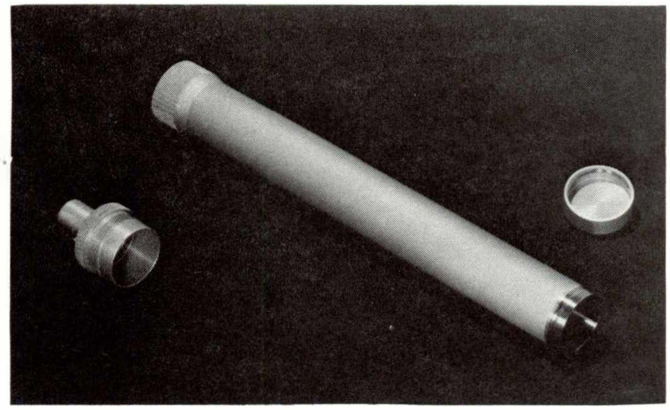

Fig. 15. Lower tube configuration of 4-cm diameter drive tube with plug (top end closure and adapter to extension handle) and cap (bottom end closure) removed. The shiny bit is stainless steel and is permanently attached to the aluminum tube (NASA photo S71-16527).

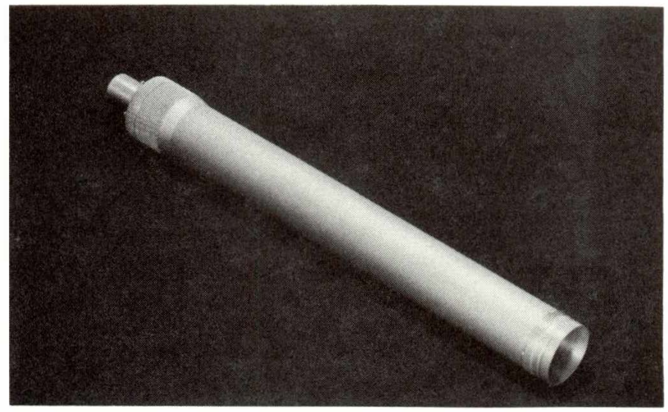

Fig. 16. Upper tube configuration of 4-cm diameter drive tube with plug in place. The external threads on the bottom allow this type tube to be screwed into a lower configuration tube to lengthen the core barrel (NASA photo S71-16256).

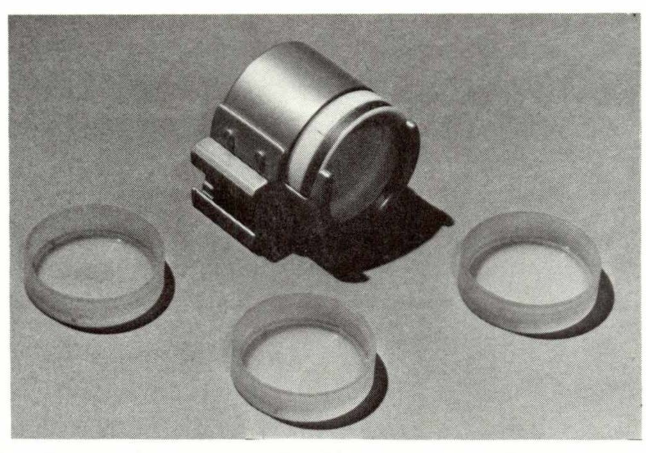

Fig. 17. Cap dispenser with teflon caps. Translucent caps, of the type shown beside the dispenser, were used on Apollo 16 and 17. (NASA photo S71-45845).

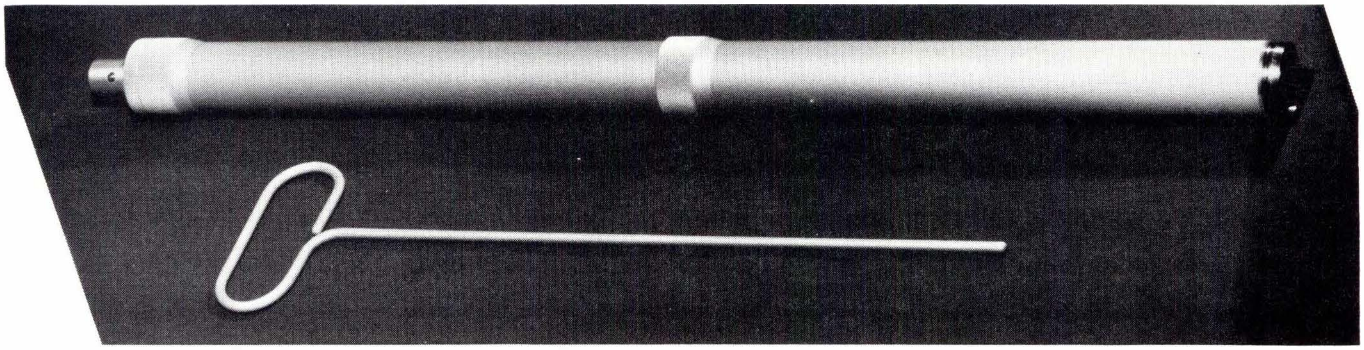

Fig. 18. A double length corer made by attaching an upper drive tube to a lower drive tube. The slender rod is a ram device which allows the keeper to be pushed down to the surface of the soil to confine it inside the tube. The ram was inserted through a small hole in the plug. (NASA photo S71-16525).

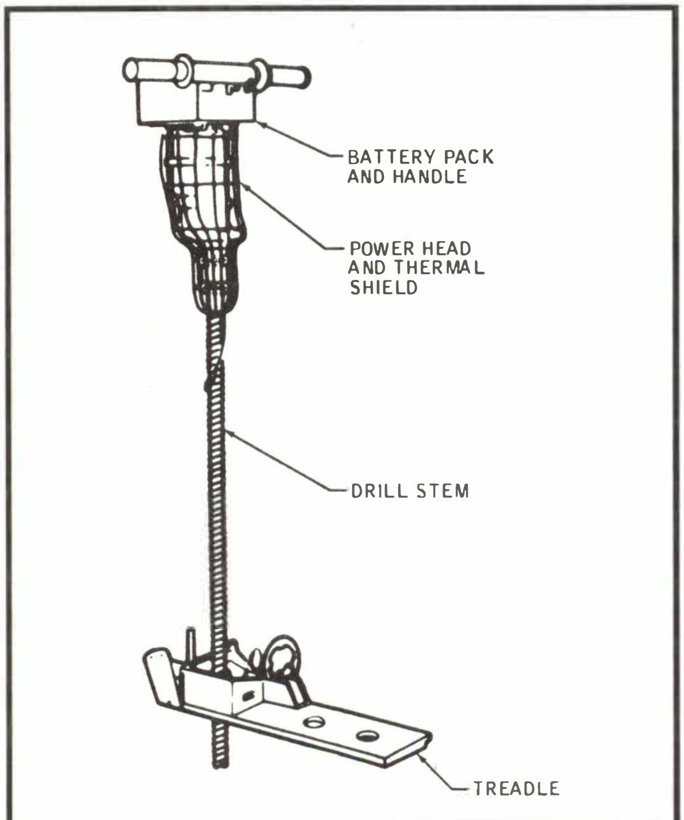

Fig. 19. Components of drill corer. Drawing from [37].

WEIGHT:	**13400 g**
DIMENSIONS:	**58 x 24 x 12 cm (packed configuration)**
POWER:	**430 watts**

SYNONYMS: Apollo Lunar Surface Drill (ALSD)* (Figs. 19-20)

WEIGHT: The total weight of the drill, the sum of the 4 components described in this section, was 13400 g.

DIMENSIONS : When packed as shown in Fig. 21, the dimensions were 58 x 24 x 12 cm.

POWER: The power head normally operated at 430 watts.

USE: This rotary-percussive drill was used to obtain a continuous soil column up to 3 m in length and to provide holes for emplacement of 2 heat flow probes.

OPERATION: The astronaut first attached the handle (which also served as an "on/off" switch) to the power head with battery. Then he set this aside while he assembled the bit, lower core stem and one or two upper core stems. These were attached to the power head and drilled into the regolith. The power head was detached and one or two more upper core stems were added. The power head was re-attached and drilling continued. When the desired depth was achieved, the drill was briefly powered at that depth to clear the flutes of "cuttings". The power head was removed, the treadle was installed over the protruding stems, and the drill string was jacked out of the soil. The string was placed horizontally in a fixture on the rear of the rover. Exposed ends were capped as the string was broken into 2 or 3 sections for packing.

MANUFACTURER: Martin Marietta, Denver, Colorado

APOLLO MISSIONS: The surface drill was used on Apollo missions 15 through 17. To obtain a soil column on missions 15 and 16, six core stem tubes were used, and on Apollo 17 eight core stem tubes were used.

COMPONENTS: Parts of the drill are described here as 4 components.

- Drill Stem
- Power Head
- Battery
- Accessories

DRILL STEMS

WEIGHT: A weight of 1200 g , the amount attributed to the drill stem component in the total drill weight, represents the weight of 5 upper stem tubes, one lower stem tube and the bit. Each upper stem tube weighed 198 g, while the lower stem tube weighed 176 g. and the bit weighed 48 g (Figs. 22,23).

DIMENSIONS: The exterior diameter of the drill stems was 2.5 cm, while the interior diameter was 2.0 cm. The length of an upper stem tube was 42.5 cm, which included 2.5 cm of overlap where the tubes screwed together. Thus each tube was capable of holding a column of soil 40 cm long. The lower stem tube was shorter because the bit was attached to it. The lower stem tube was 39.0 cm long, and the bit was 6.0 cm long. When the bit was attached to the lower stem tube the length was 42.5 cm, like an upper stem tube.

CAPACITY: A 3-m length drill string (which required 8 core stem tubes, as was done on Apollo 17) had a capacity of 940 cm^3 of soil.

MANUFACTURERS: Chicago Latrobe, cutting tips; Martin Marietta drill stems

MATERIALS: The structural metal of the tubes was titanium alloy Al-4V. The threaded joints were lubricated via an electrochemical process, similar to anodizing, called canadizing. This process produced a hardened surface impregnated with a fluorocarbon with controlled porosity into which TFE was deposited. The bit was made of Hy-tuf steel into which 5 tungsten carbide cutting tips were brazed. Caps for the tubes were teflon.

*All technical characteristics of the drill were obtained from [13,25], except for individual drill stem weights and dimensions. These were taken from ALSRC packing lists or measured by the author.

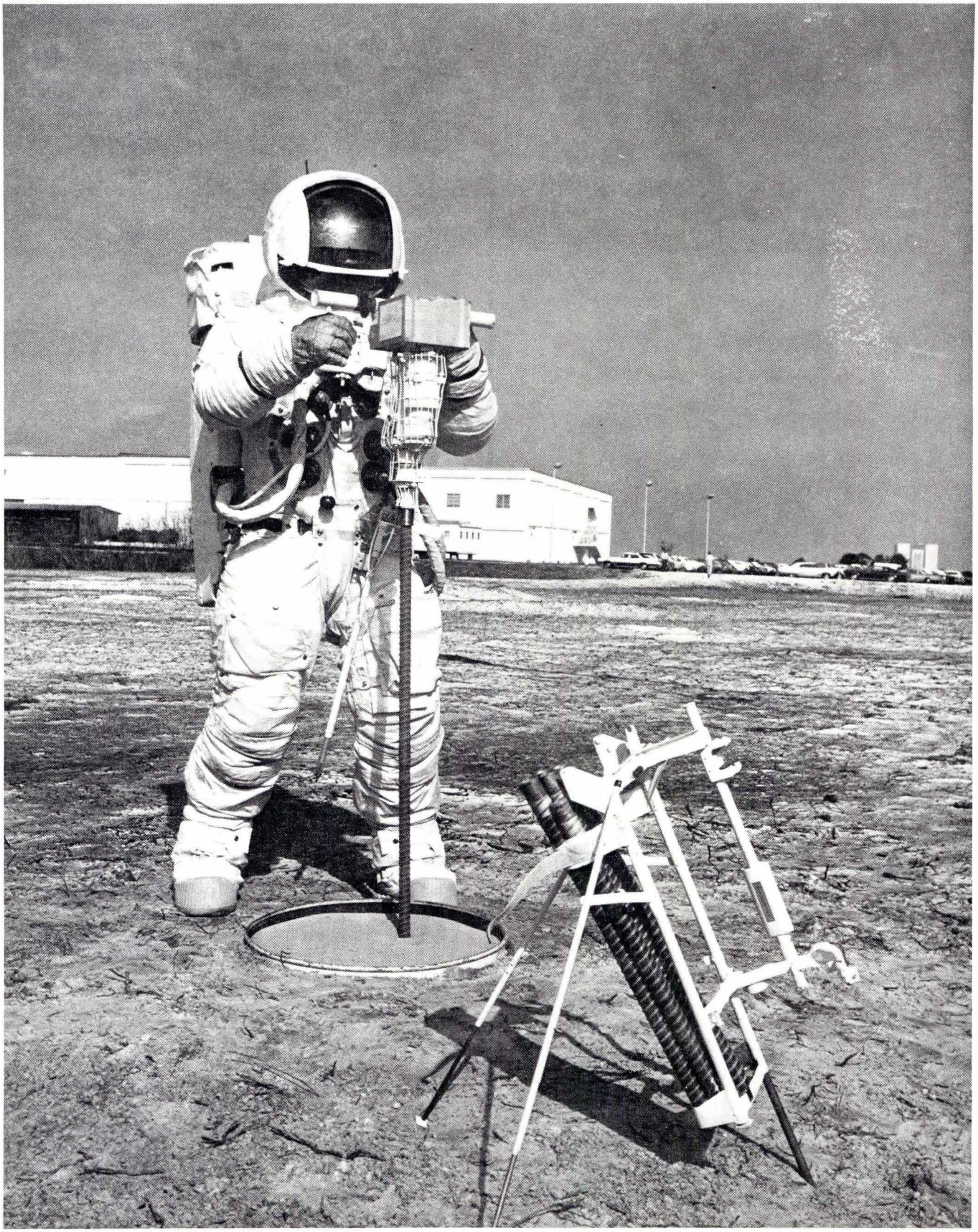

Fig. 20. Apollo Lunar Surface Drill being tested by subject in space suit. The handle, battery, power head and drill stems are visible. A stand containing bore stems is in the foreground (NASA photo S70-29673).

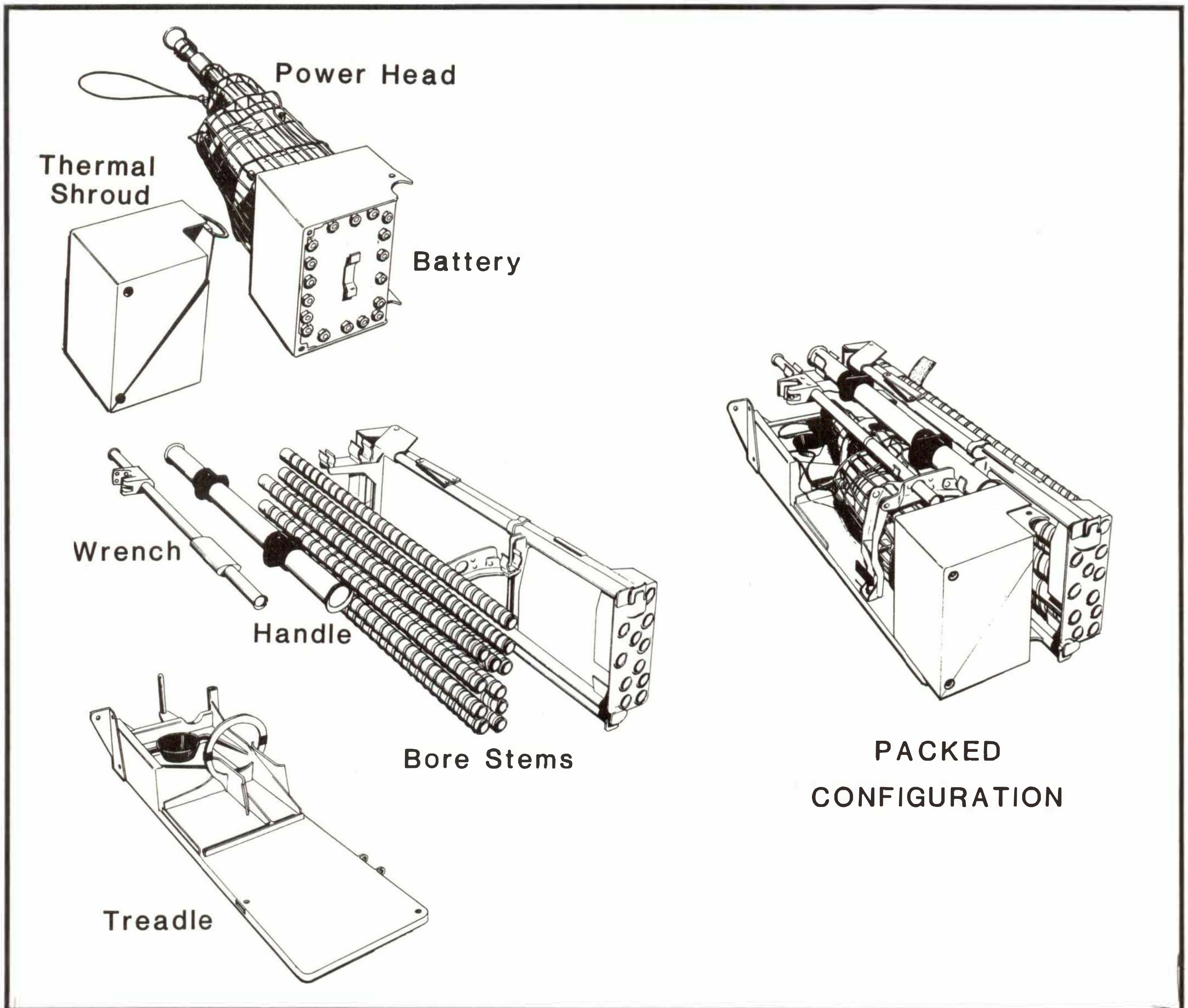

Fig. 21. Packing configuration of Apollo Lunar Surface Drill. Core stems were packed separately by the Lunar Receiving Laboratory. Drawing modified from [13].

SPECIAL MATERIAL PROCESSING: On Apollo 17, to reduce lead contamination of the cored soil from the drill stems and bit, the core stems were treated with nitric acid and special processes were employed in the application of lubricant and color-codes. Excess brazing compound was removed from the core bit to reduce silver and copper contamination.

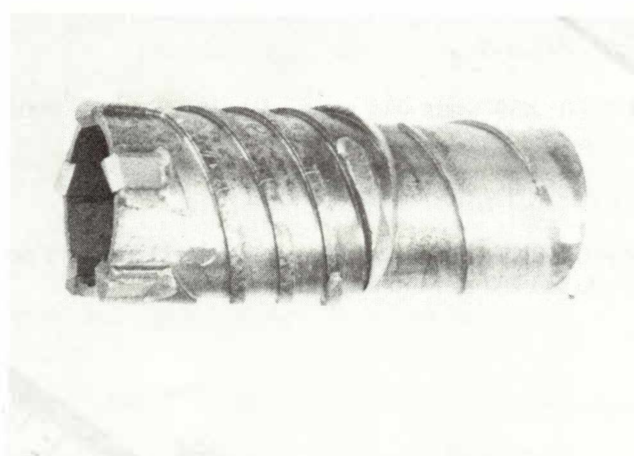

Fig. 22. Drill bit with 5 tungsten carbide cutting tips. The bit is 6.0 cm long, and the narrow end is typical of threaded joints between the stem tubes.

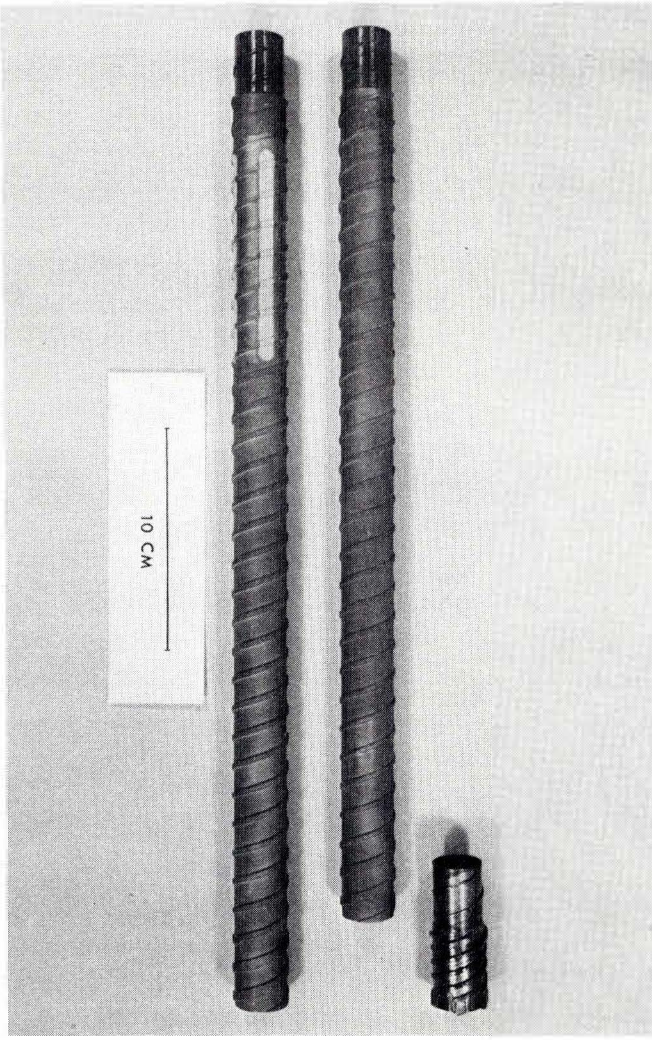

Fig. 23. Standard length tube (upper stem section), bit-holding core tube (lower stem section) and drill bit (NASA photo S89-25295).

DRILL POWER HEAD

WEIGHT : 4000 g

POWER: 430 watts was required by the 0.4 h.p. brush commutated, direct current motor.

MANUFACTURER: Black & Decker

OPERATION: The power head delivered 2270 blows per minute and 280 RPM to the drill stem.

MATERIALS: The power head housing was magnesium alloy QE-22A-T6 coated with a white thermal paint. The teflon-based fluorinated lubricants were DuPont Krytox 143-AC oil and 240-AC grease.

DRILL BATTERY

WEIGHT: 3500 g.

DESCRIPTION: 16 silver oxide-zinc cells

MANUFACTURER: Yardney Electric Corp.

DRILL ACCESSORIES

WEIGHT: 4700 g

DESCRIPTION: Included treadle, 12 bore stems, bore stem adapter, thermal shroud, thermal guard, handle and actuator assembly, wrench, 2 core stem caps and retainer. The treadle included a jacking mechanism to aid in extracting the drill string from the soil (Fig. 24). When drilling holes for heat flow probe emplacement, bore stems were used. These resembled drill stems, but were made of epoxy fiberglass containing glass and boron filaments. The bore stem bit had a solid face.

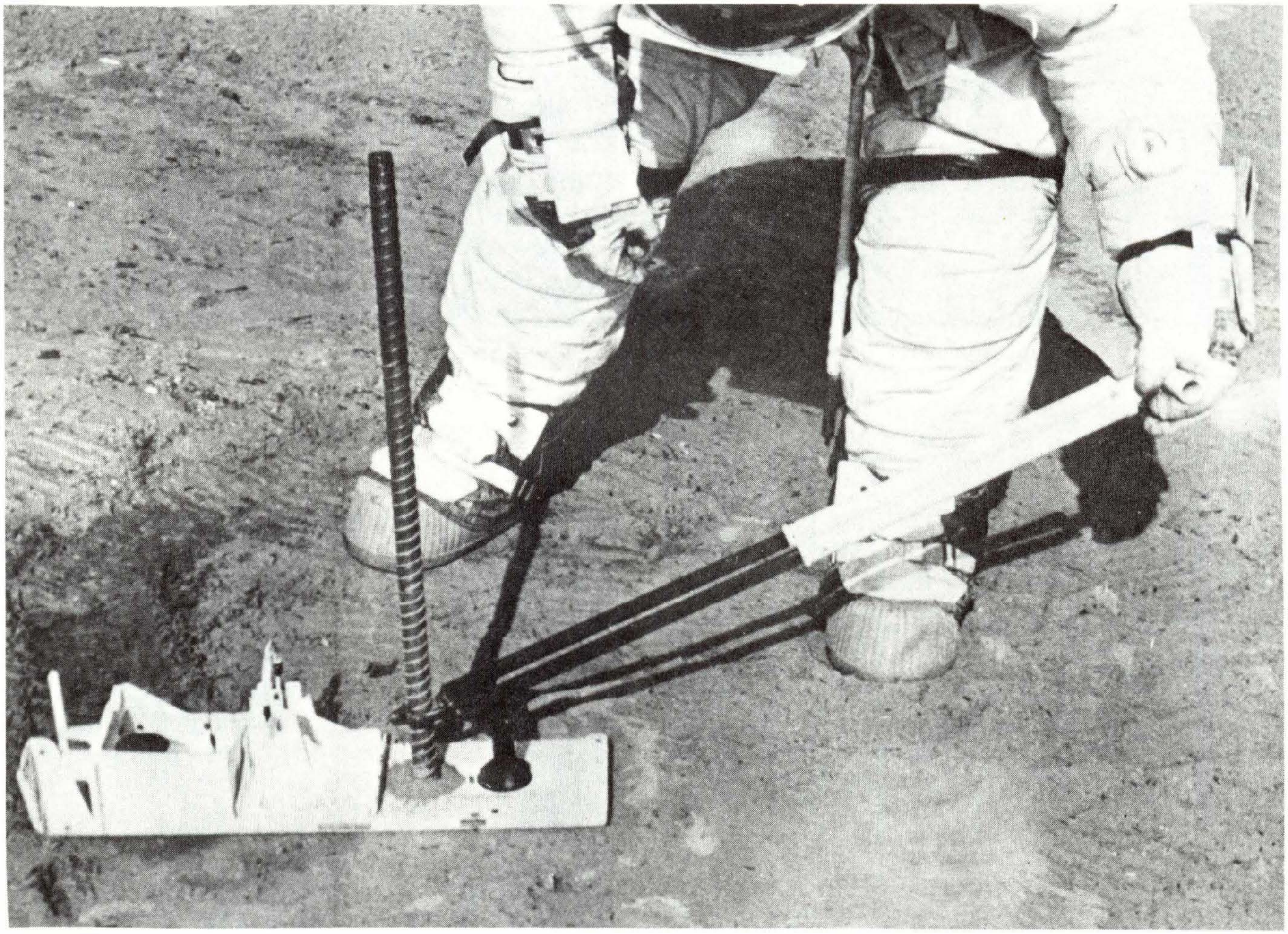

Fig. 24. Treadle with a device to aid in extracting the drill string from the soil. (The treadle is so named because its original purpose was to hold the drill down by foot when drilling into rock. In fact, the drill was screwed into the soil by the external flutes, and consequently, was difficult to remove unless the flutes were completely cleared of "cuttings" by powered action at constant depth.) Photo from [13].

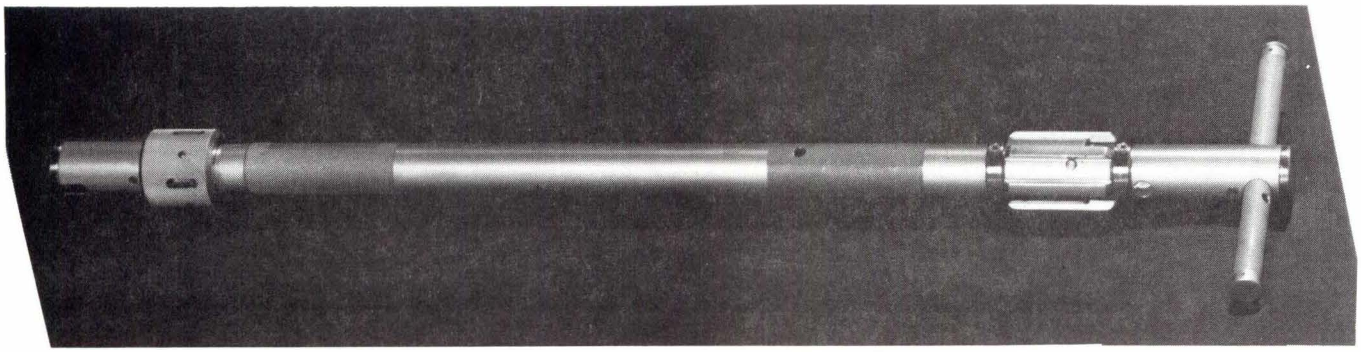

Fig. 25. Shorter style extension handle used on early Apollo missions (NASA photo S69-31844).

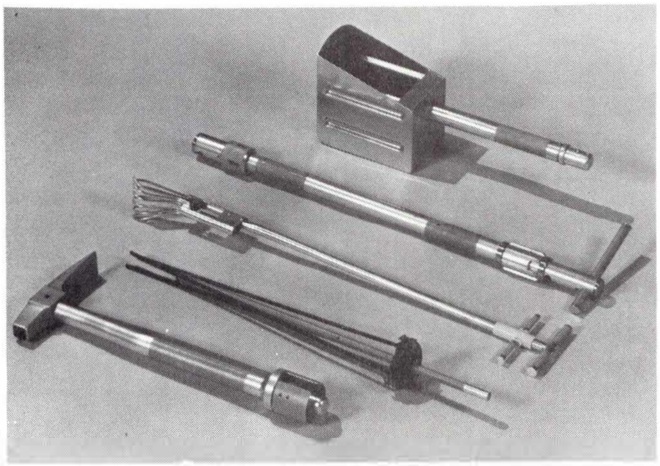

Fig. 26. Tools of the type used on Apollo 11 (L to R): lighter weight hammer, gnomon, shorter tongs, shorter extension handle, box-shaped scoop. The extension handle was used with the hammer and the scoop (NASA photo S69-31860).

Two styles of extension handles (Figs. 25-30) were used on the moon. The model used on the later missions was slightly longer, heavier and more streamlined in appearance.

USE: A single extension handle could be used with a scoop, hammer, rake, core tube or drive tube, thus, saving the added weight of each tool having a long handle (Fig. 26). When attached to a core tube or a drive tube, the extension handle was pounded with the hammer to drive the tubes into the soil (Fig. 27).

MANUFACTURER: NASA, Johnson Space Center

SHORTER EXTENSION HANDLE

WEIGHT:	590 g
DIMENSIONS:	61 cm overall length
	15.5 cm width of 'T' handle

MATERIALS: The 'T' handle and the main shaft of the extension handle were made from aluminum alloy 6061/62-T6. The end pounded by the hammer was reinforced with 303 stainless steel.

APOLLO MISSIONS: This shorter extension handle was used on Apollo 11 and 12.

Fig. 27. Shorter style extension handle attached to core tube and being driven with a hammer by astronaut Buzz Aldrin on Apollo 11 (NASA photo AS11-40-5964).

LONGER EXTENSION HANDLE

WEIGHT:	770 g Apollo 14
	820 g Apollo 15, 16, 17
DIMENSIONS:	76 cm overall length
	15.5 cm width of 'T' handle

MATERIALS: The long shaft was aluminum alloy 2024-T3, and the end pounded by the hammer and holding the 'T' handle was 303/316 stainless steel (Fig. 28).

APOLLO MISSIONS: This longer extension handle was used on Apollo 14, 15, 16, and 17 (Figs. 29 and 30).

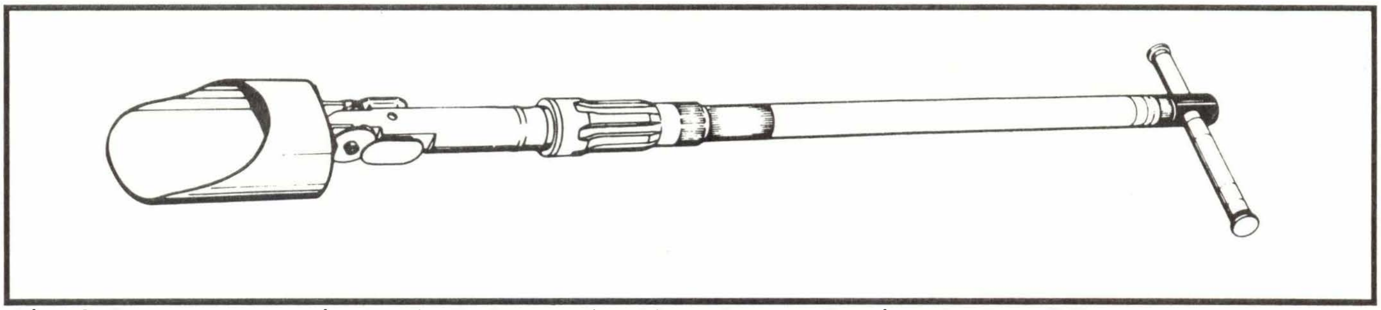

Fig. 28. Longer style extension handle attached to adjustable-angle scoop. Drawing taken from [37].

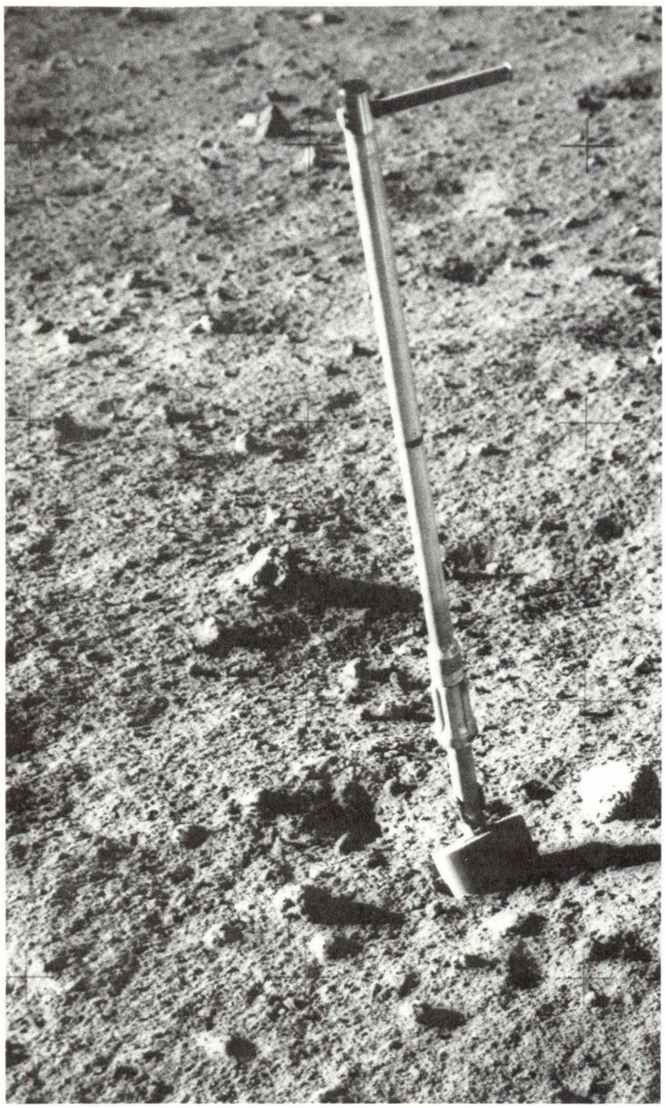

Fig. 29. Longer style extension handle attached to scoop at Apollo 16 site (NASA photo AS16-109-17846).

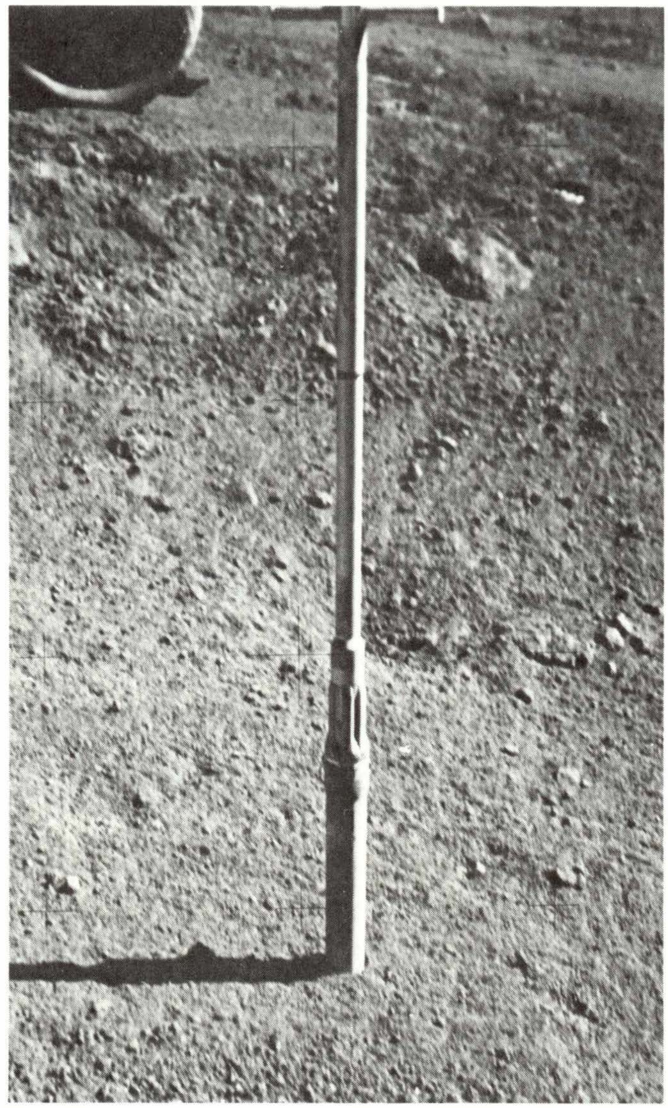

Fig. 30. Longer style extension handle attached to drive tube at Apollo 17 site (NASA photo AS17-146-22291).

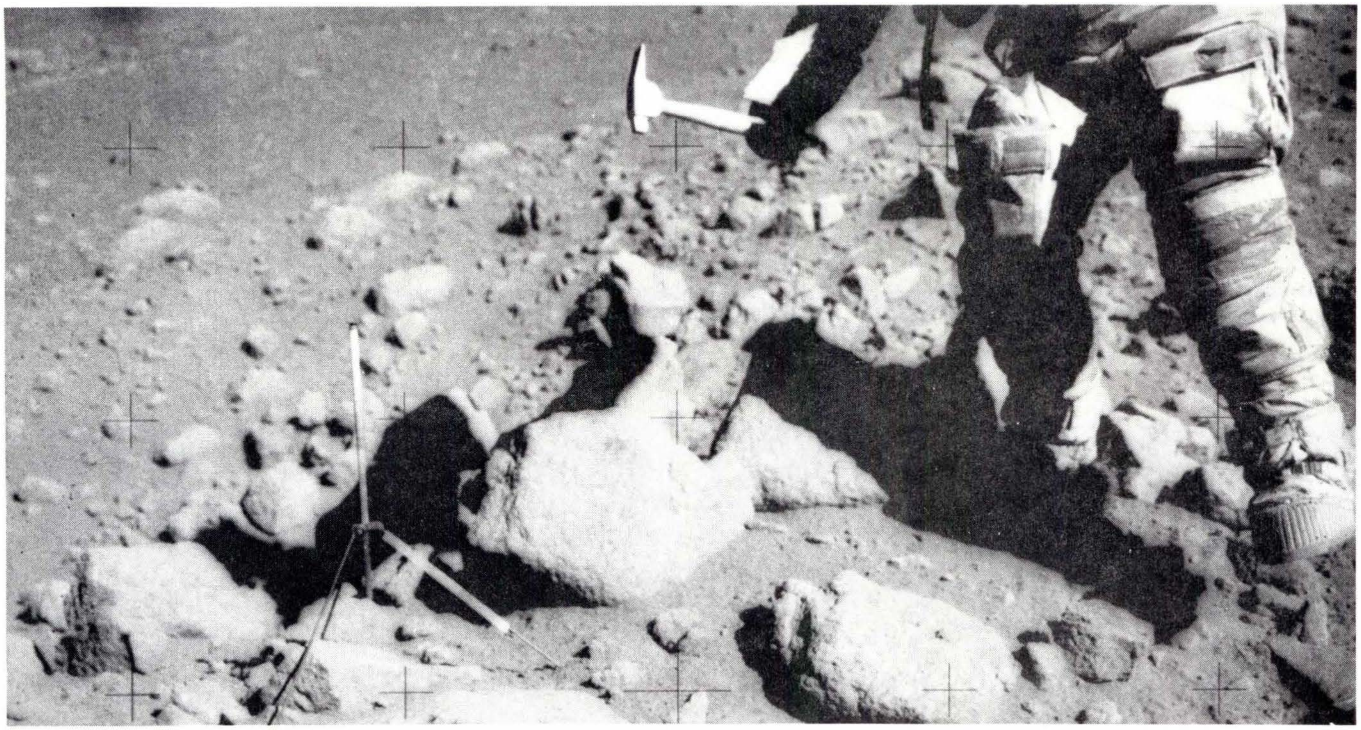

Fig. 31. Heavier weight hammer in use on Apollo 15 (NASA photo AS15-82-11140).

Two basic styles of hammers (Figs. 31-34) were used on the moon. The model used on later missions was heavier with more surface area on the side of the hammer head.

USE: This tool was used to break chips from rocks or to drive core tubes into the soil (Figs. 31 and 27) It was designed to be used as a hoe for digging furrows when attached to an extension handle (Fig. 32).

MANUFACTURER: NASA, Johnson Spacecraft Center

MATERIALS: The hammer head on both styles of hammers was made of tool steel [AISI S5] which was coated with vacuum deposited aluminum. The handles on both styles were made of aluminum alloy 6061-T6.

LIGHTER WEIGHT HAMMER

WEIGHT:	860 g
DIMENSIONS:	41 cm overall length
	16 cm hammer head length
	3.8 cm hammer head thickness

APOLLO MISSIONS: Hammers of this style were used on Apollo 11 and 12 (Fig. 33)

HEAVIER WEIGHT HAMMER

WEIGHT:	1300 g
DIMENSIONS:	39 cm overall length
	16 cm hammer head length
	3.8 cm hammer head thickness

APOLLO MISSIONS: Hammers of this style were used on Apollo 14, 15, 16 and 17. However, there were minor changes in configuration of the handle and adapter through out these missions.

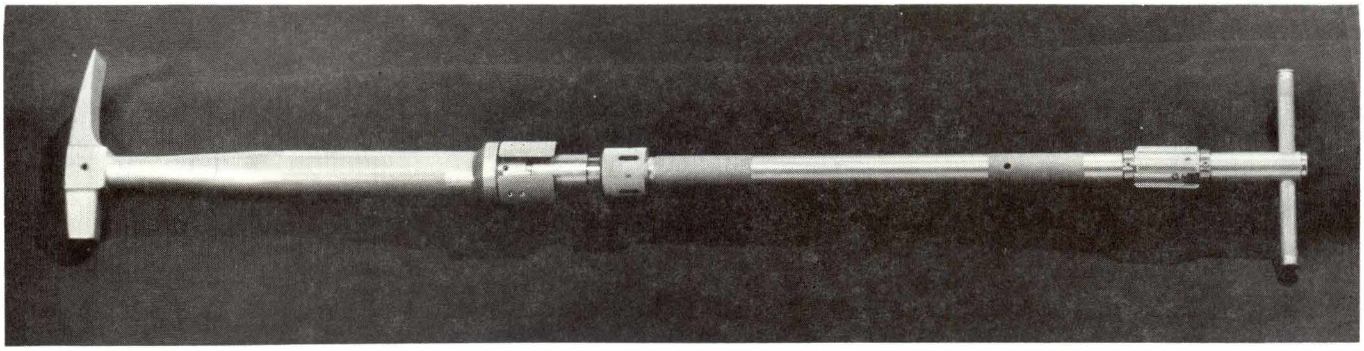

Fig. 32. Lighter weight hammer attached to extension handle for use as a hoe (NASA photo S60-31849).

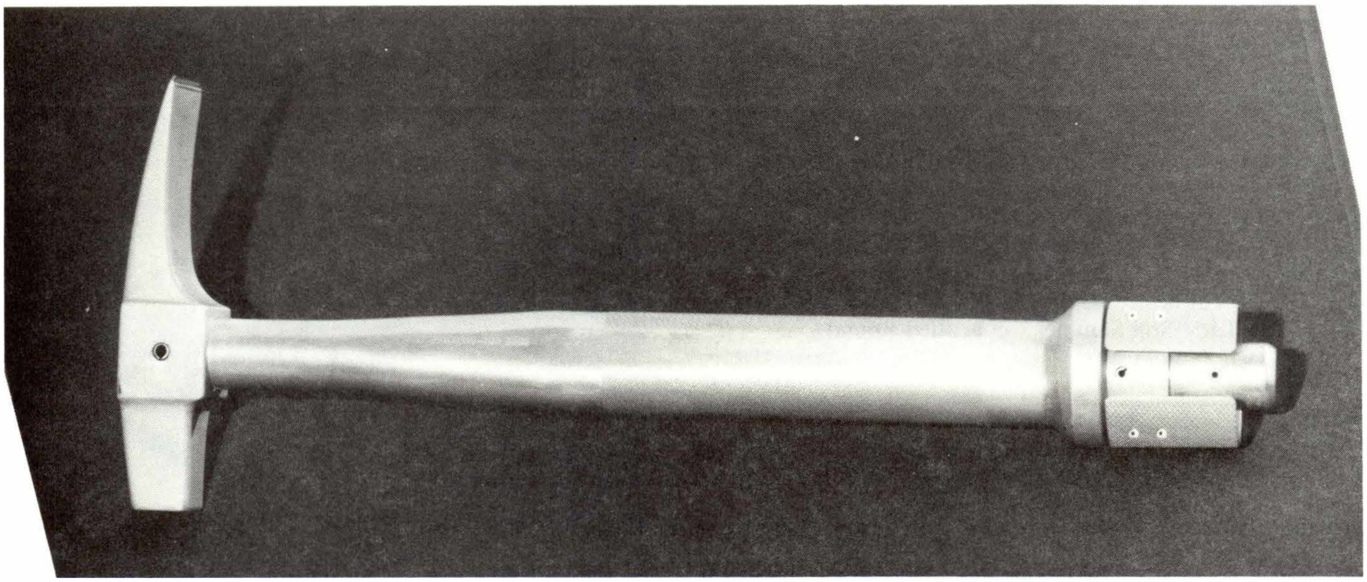

Fig. 33. Lighter weight hammer of the type used on Apollo 11 and 12 (NASA photo S69-31847).

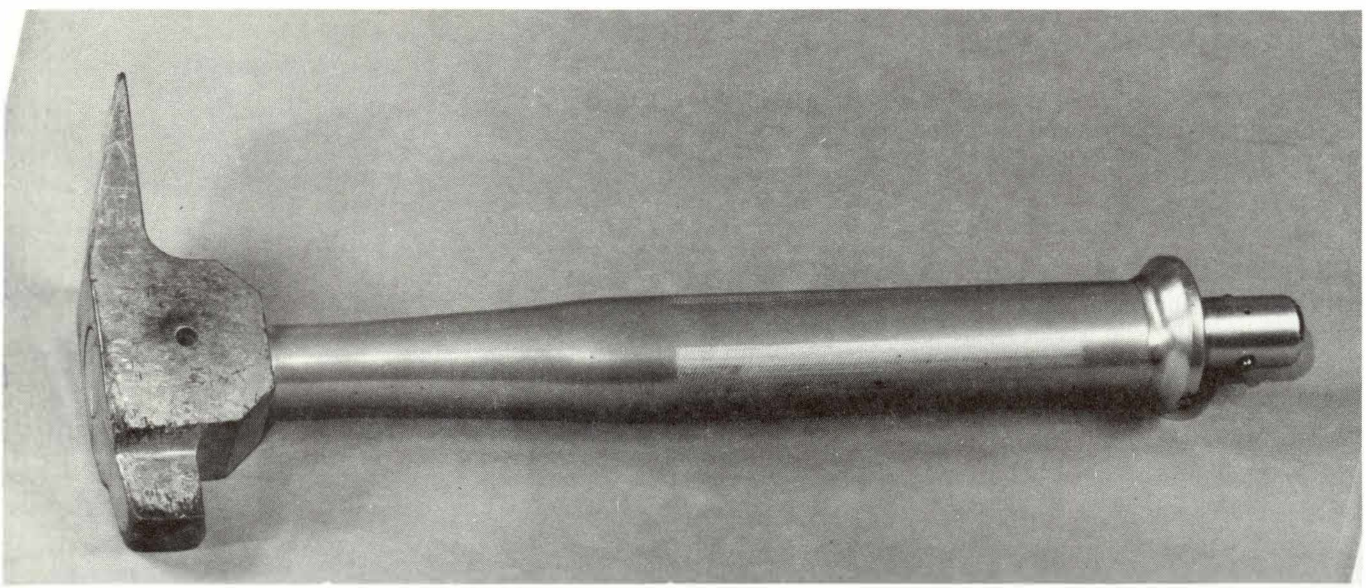

Fig. 34. Heavier weight hammer of the type used on Apollo 14, 15, 16, and 17 (NASA photo S71-22471).

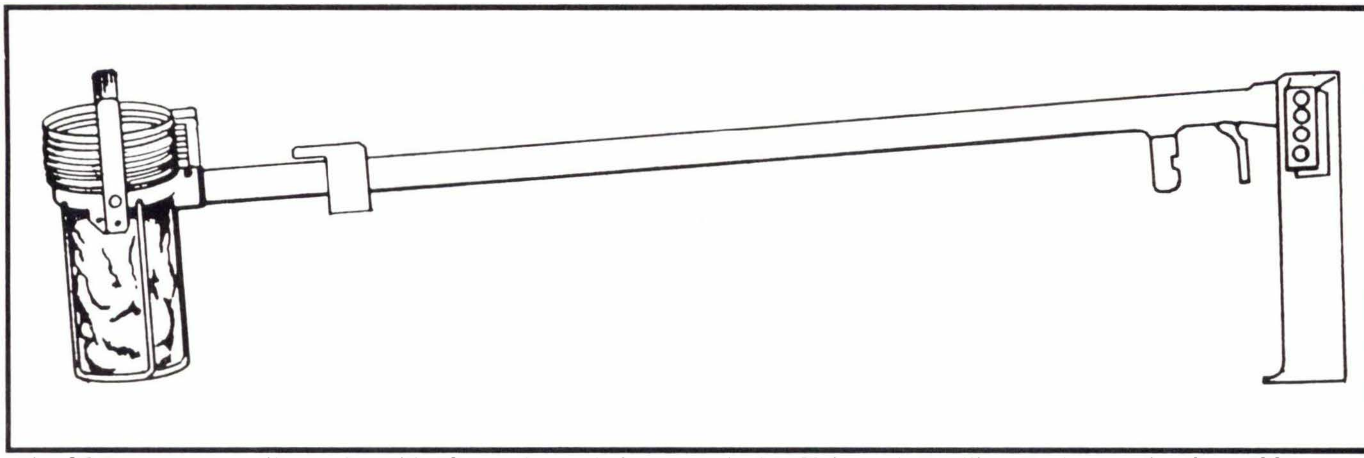

Fig. 35. Lunar rover soil sampler with 12 round sample bags attached to Universal Handling Tool. Drawing from [22].

The LRV (lunar roving vehicle) soil sampler (Figs. 35,36) consisted of a ring which held 12 nested cups for collecting soil. This device was attached to a long handle called the Universal Handling Tool which enabled the astronauts to obtain lunar soil samples without getting off the rover. As each sample was taken, the cup full of soil was removed, sealed and put away. Thus, 12 soil samples were taken before the set of nested cups needed to be replaced. The cups used in the LRV Soil Sampler were called Round Documented Sample Bags.

WEIGHT:	**140 g**
DIMENSIONS:	**25 cm approximate length**
	8 cm cup diameter
	13 cm cup depth

WEIGHT: It was not clear whether the 140 g weight, taken from the Apollo 17 Flight Stowage List, excluded the the 12 sample cups or Univeral Handling Tool. Based on weight comparisons with other tools, it was unlikely that the UHT was included in the 140 g.

DIMENSIONS: The 25 cm length cited was estimated from a photograph and included only the sampler, not the Univeral Handling Tool shown in Fig. 35.

APOLLO MISSIONS: Apollo 17.

MATERIALS: The plastic bags, which were probably teflon, had an aluminum supported rim to facilitate sealing the sample [22]. The basket frame and rim appear to be stainless steel, and the handle appears to be anodized aluminum.*

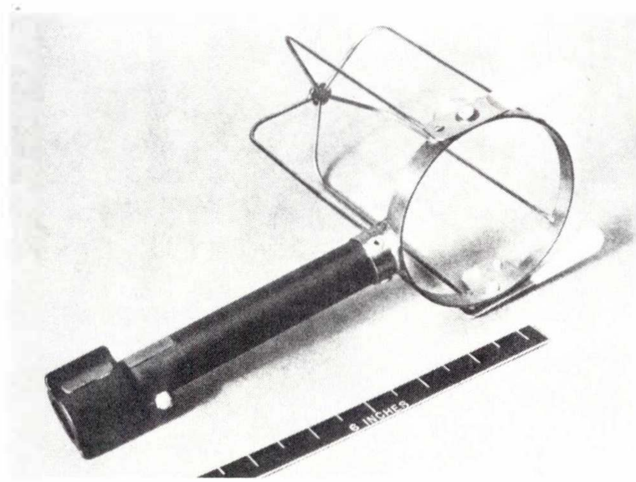

Fig. 36. LRV soil sampler. Photo from [22].

* Observation of typical LRV soil sampler basket by author.

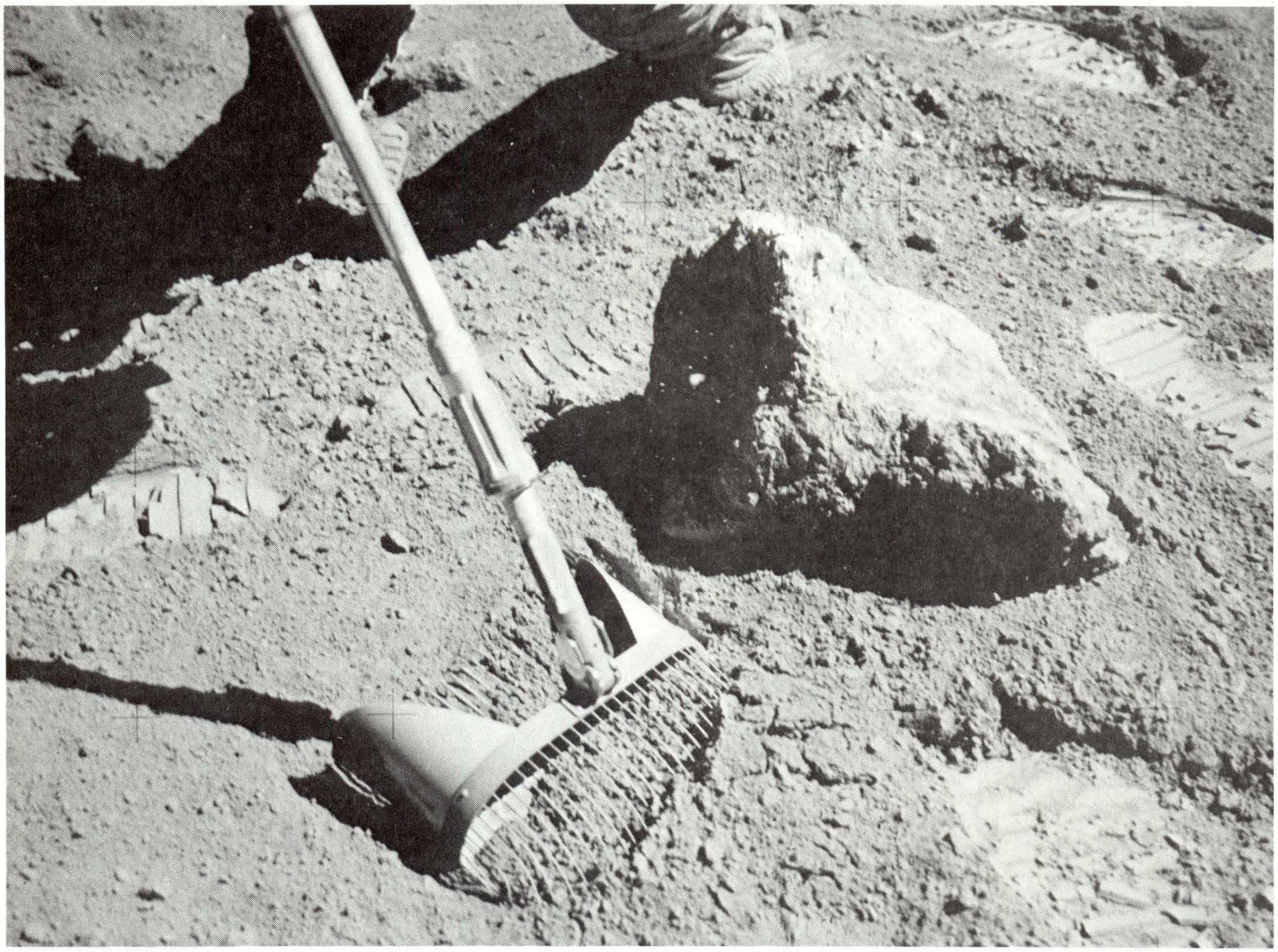

Fig. 37. Rake being used in soil on Apollo 16 mission (NASA photo AS16-116-18690).

WEIGHT:	**1500 G**	
DIMENSIONS:	**29.4 cm**	**basket length**
	29.4 cm	**basket width**
	10.4 cm	**basket thickness**
	22.3 cm	**handle length**
	1 cm	**tine separation**

USE: The rake was used to gather a representative collection of pebbles > 1 cm from the regolith. It was used with an extension handle, and the angle of the basket was adjustable. First, an undisturbed bulk sample of regolith was taken. Then approximately 1 m^2 of surface was raked to collect all pebbles greater than 1 cm.

APOLLO MISSIONS: The rake was used on missions 15, 16 and 17 (Figs. 37 & 39).

MANUFACTURER: NASA, Johnson Space Center

MATERIALS: The tines on the rake basket were made from 17-7 PH stainless steel wire 1/16 in. in diameter. The spout-like sidewalls on the basket were made from aluminum alloy 6061-T6 (Fig. 38)

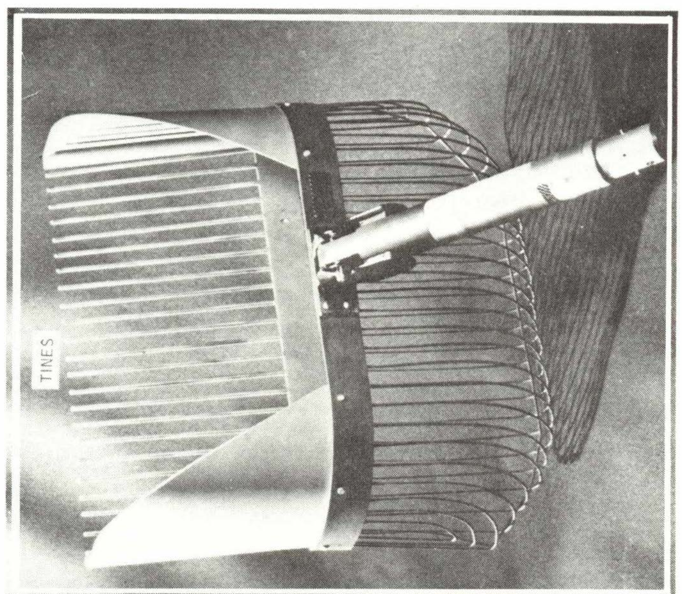

Fig. 38. Lunar soil rake showing stainless steel tines, aluminum sidewalls on basket and adjustable angle handle. Photo from [22].

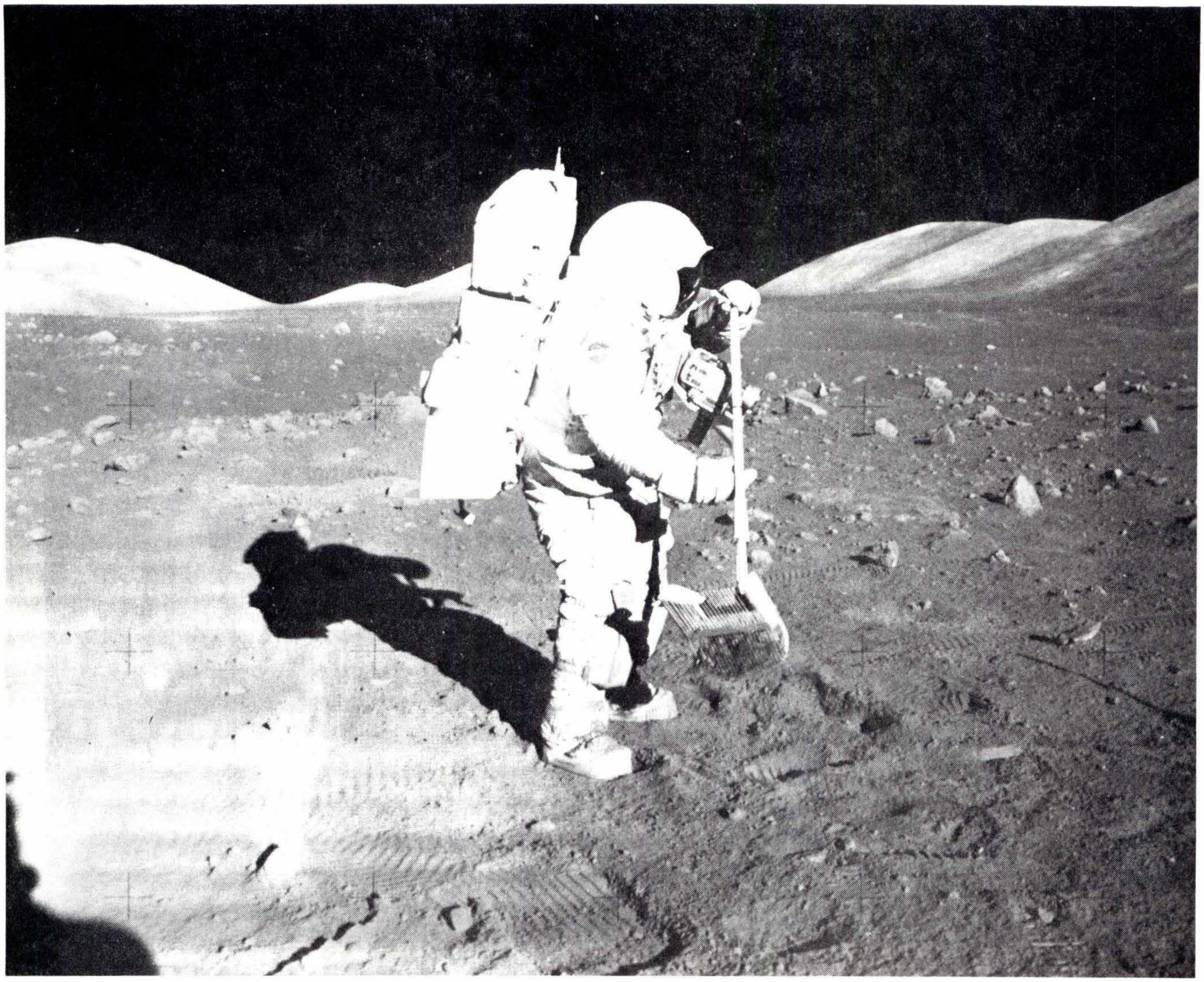

Fig. 39. Apollo 17 astronaut has collected tens of rocks > 1 cm in diameter by raking the soil. Rake marks are visible in soil (NASA photo AS17-134-20425).

Four styles of scoops were used on the moon to collect soil samples (Figs. 40-47). Two styles, a box-shaped scoop and a small scoop, maintained a fixed angle between the handle and the scoop mouth. These were used on early missions (11,12 and 14). Later, on Apollo 15, 16 and 17, scoops with an an adjustable angle between the handle and the scoop mouth were used in place of the rigid scoops. All four scoops were made to be used with an extension handle. Due to reduced gravity and the cohesiveness of lunar soil, scoops required a cover and a rotating scooping technique to control the soil (otherwise, the soil was propelled in an arc, often covering astronauts or equipment with dirt).

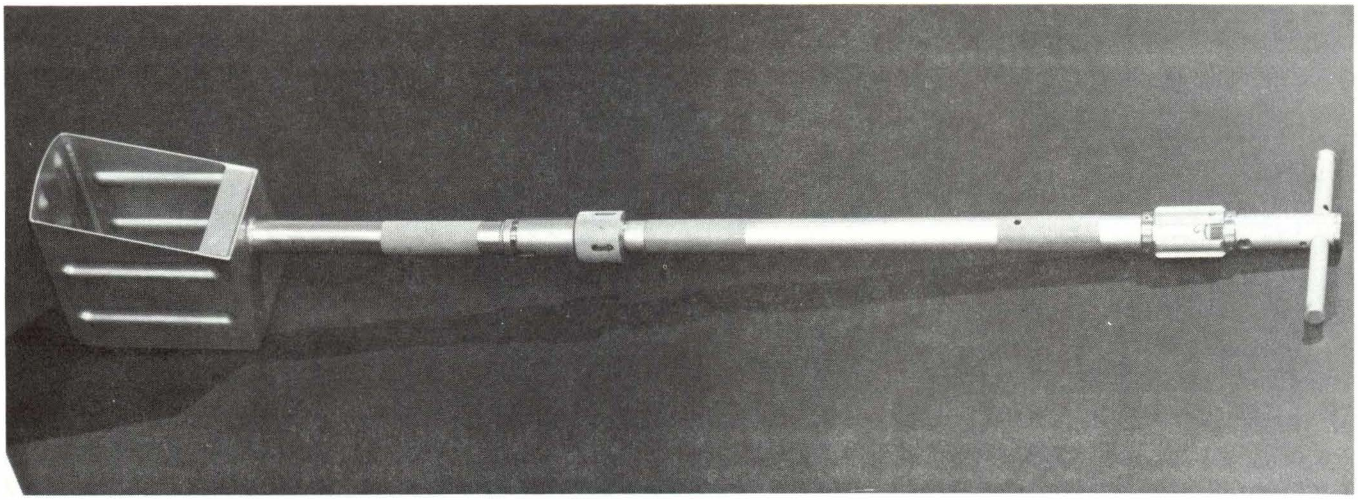

Fig. 40. Large, box-shaped scoop attached to shorter model extension handle (NASA photo S69-31583).

LARGE, BOX-SHAPED SCOOP

WEIGHT:	**400 g**
DIMENSIONS:	**39 cm overall length**
	15.2 cm box height
	9.3 cm box width
	15.2 cm box depth

MANUFACTURER: NASA Johnson Space Center

MATERIALS: The pan structure (box-shaped portion) was made of aluminum alloy 6061. A stainless steel wire mesh sieve was designed to cover the pan opening, but no evidence was found of fabrication or use of the mesh.

APOLLO MISSIONS: The box-shaped scoop was flown on Apollo 11, 12 and 14 [1,2,11]. Techniques for using this scoop are shown in Fig. 42.

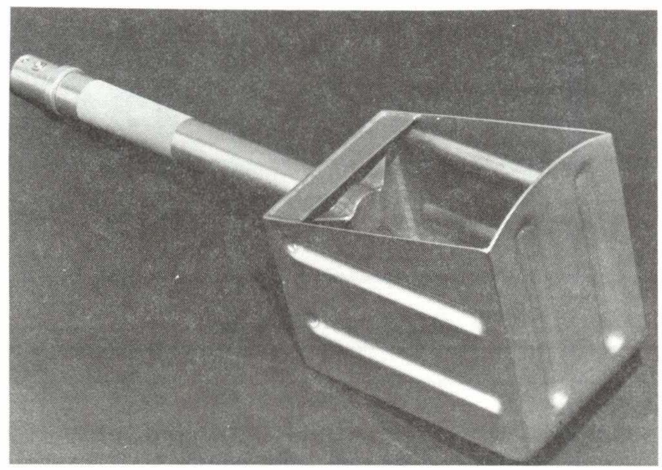

Fig. 41. Box-shaped scoop (NASA photo S69-31846).

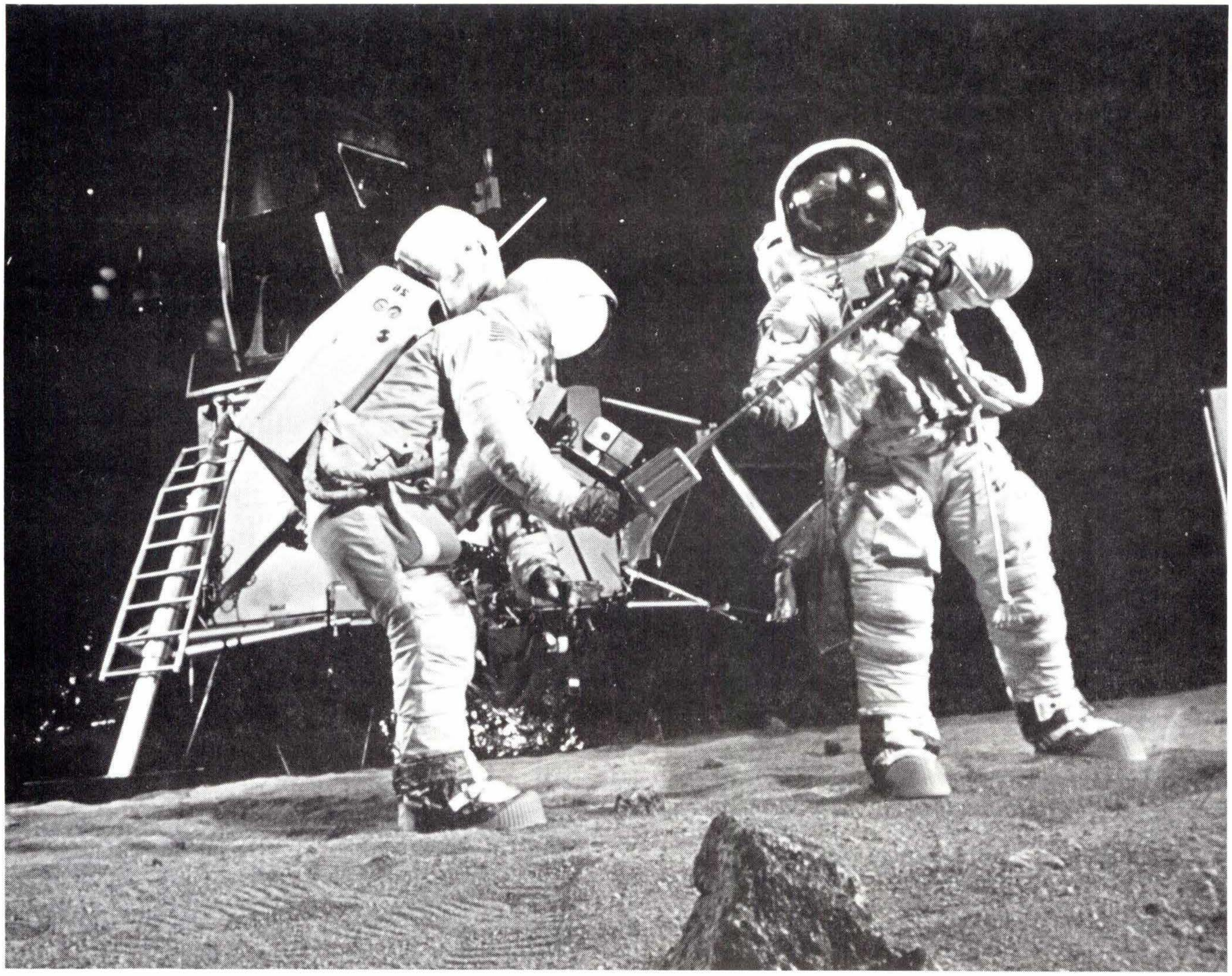

Fig. 42. Astronauts practice using large, box-shaped scoop to fill sample bag with soil in simulated lunar setting (NASA photo S69-32243).

SMALL SCOOP

WEIGHT:	**163 g***
DIMENSIONS:	**34 cm overall length**
	6.6 cm pan width
	3 cm pan height

MANUFACTURER: NASA Johnson Space Center

MATERIALS: The scoop pan was made from aluminum. The edge of the pan was reinforced with a steel blade, for use as a chisel.+ The top of the scoop, where the extension handle could be attached, was reinforced with steel# for absorbing blows during use as a chisel; however, the scoop was not used as a chisel on the moon.

APOLLO MISSIONS: This scoop was used on Apollo 12 and 14. It was part of the tool set for the small tool carrier.

* Typical scoop weighed and measured for this catalog.

+ Uel Clanton, personal communication (1989)

Based on appearance of typical scoop examined for this catalog

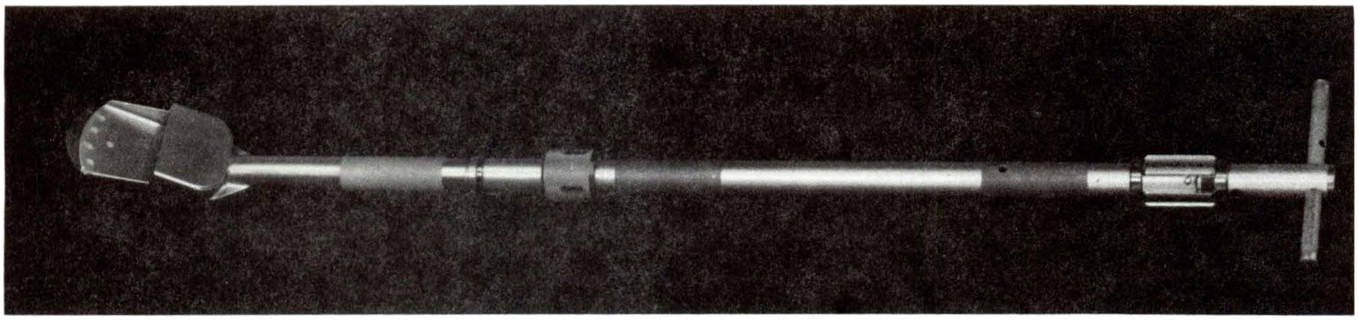

Fig. 43. Small, non-adjustable scoop attached to shorter model of extension handle (NASA photo S69-31850).

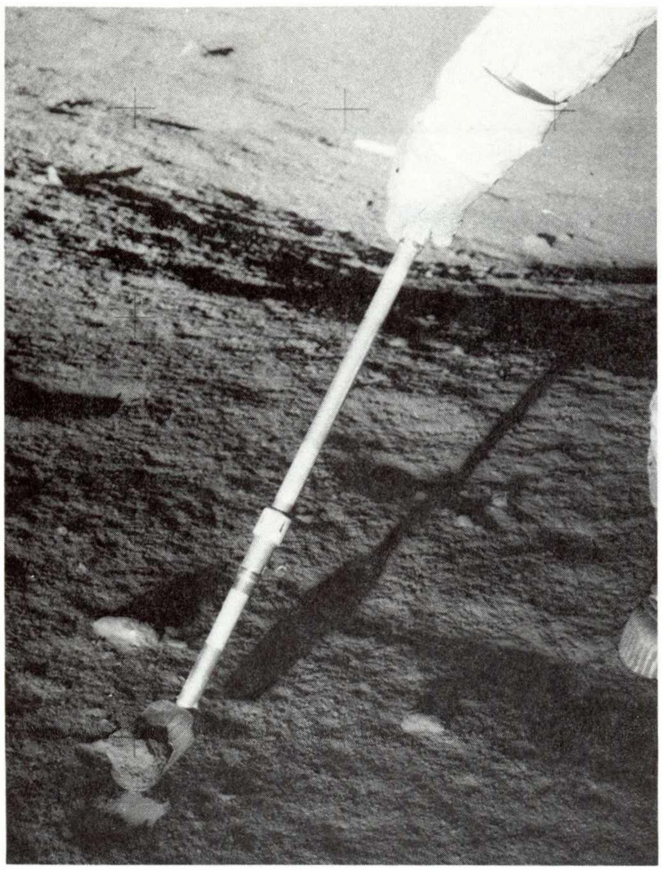

Fig. 44. Use of small, non-adjustable scoop on moon during Apollo 12 mission (NASA photo AS12-49-7312).

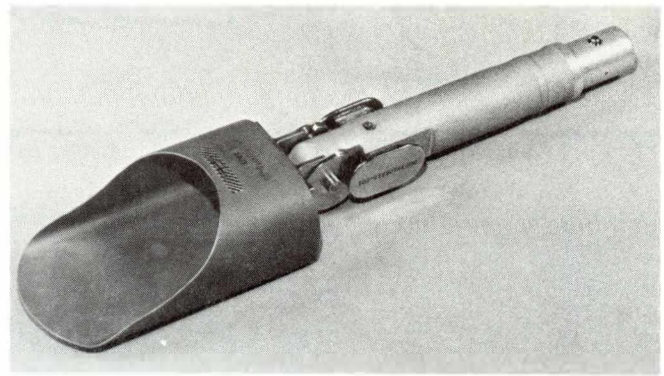

Fig. 45. Small, adjustable-angle scoop (NASA photo S71-22472).

SMALL, ADJUSTABLE-ANGLE SCOOP

WEIGHT:	**516 g**
DIMENSIONS:	**32.8 cm overall length**
	7.3 cm pan width
	4.6 cm pan height
	12.7 cm pan length

MANUFACTURER: NASA, Johnson Space Center

MATERIALS: The pan was made from 17-7 PH stainless steel.

APOLLO MISSIONS: This scoop was used only on Apollo 15, the first mission to employ the large tool carrier mounted on the Lunar Roving Vehicle. The scoop was stowed for use on this tool carrier. Later missions employed a larger version of the adjustable-angle scoop. All adjustable-angle scoops were designed to be pushed or pulled.

LARGE, ADJUSTABLE-ANGLE SCOOP

WEIGHT:	590 g
DIMENSIONS:	35.4 cm overall length
	11.4 cm pan width
	5.1 cm pan height
	15.2 cm pan length

MANUFACTURER: NASA, Johnson Space Center

MATERIALS: The pan was made from 17-7 PH stainless steel.

APOLLO MISSIONS: The large, adjustable-angle scoop was flown on Apollo 16 and 17 and was stowed in the lunar rover tool carrier.

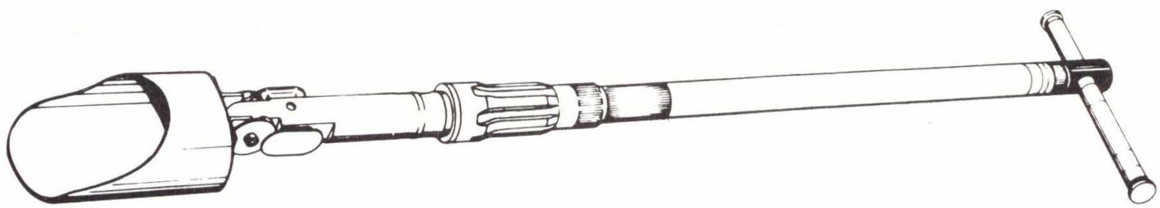

Fig. 46. Small, adjustable-angle scoop attached to longer model extension handle.

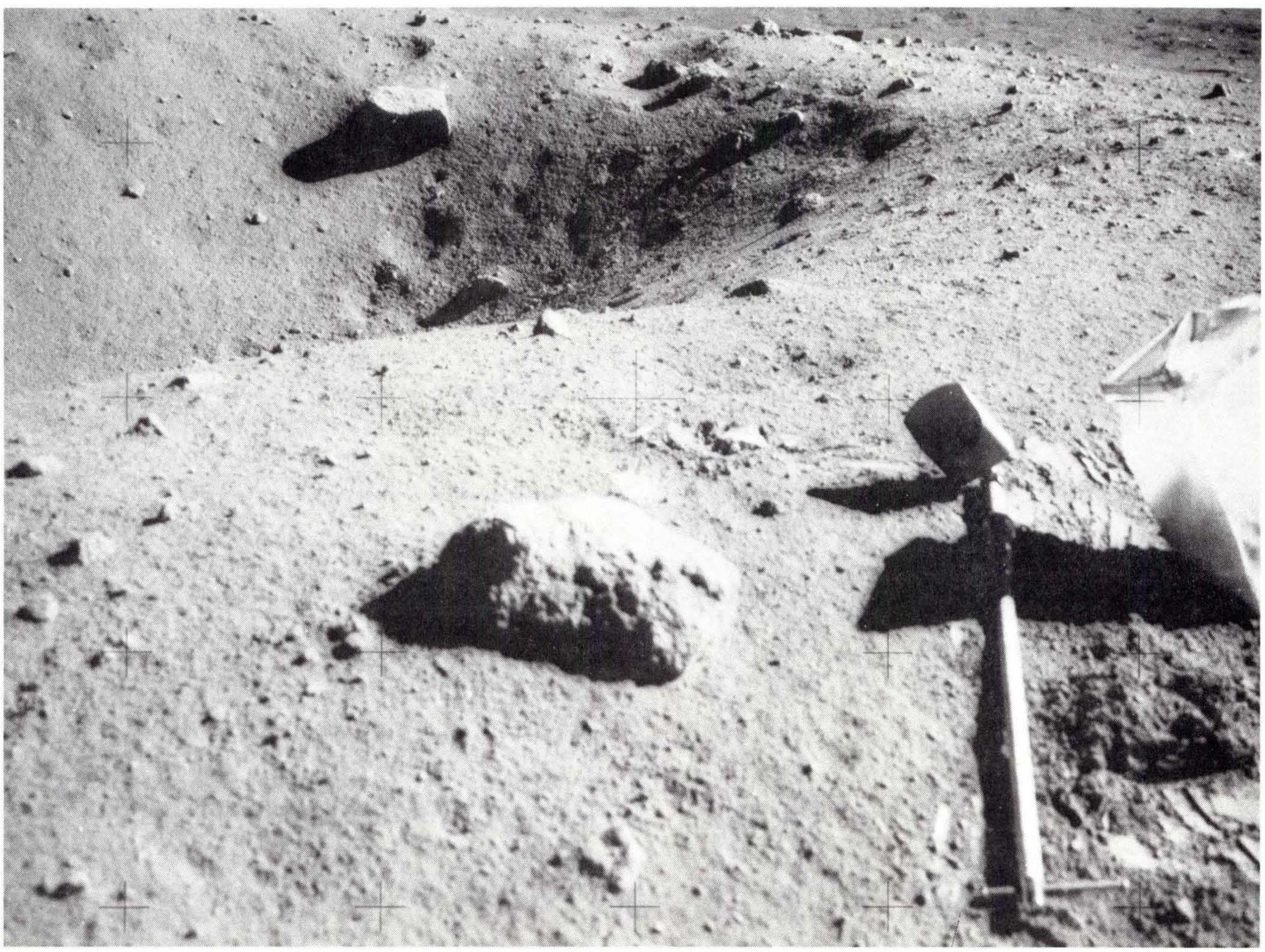

Fig. 47. Large, adjustable-angle scoop with pan adjusted for maximum tilt on lunar surface during Apollo 17 mission (NASA photo AS17-138-21160).

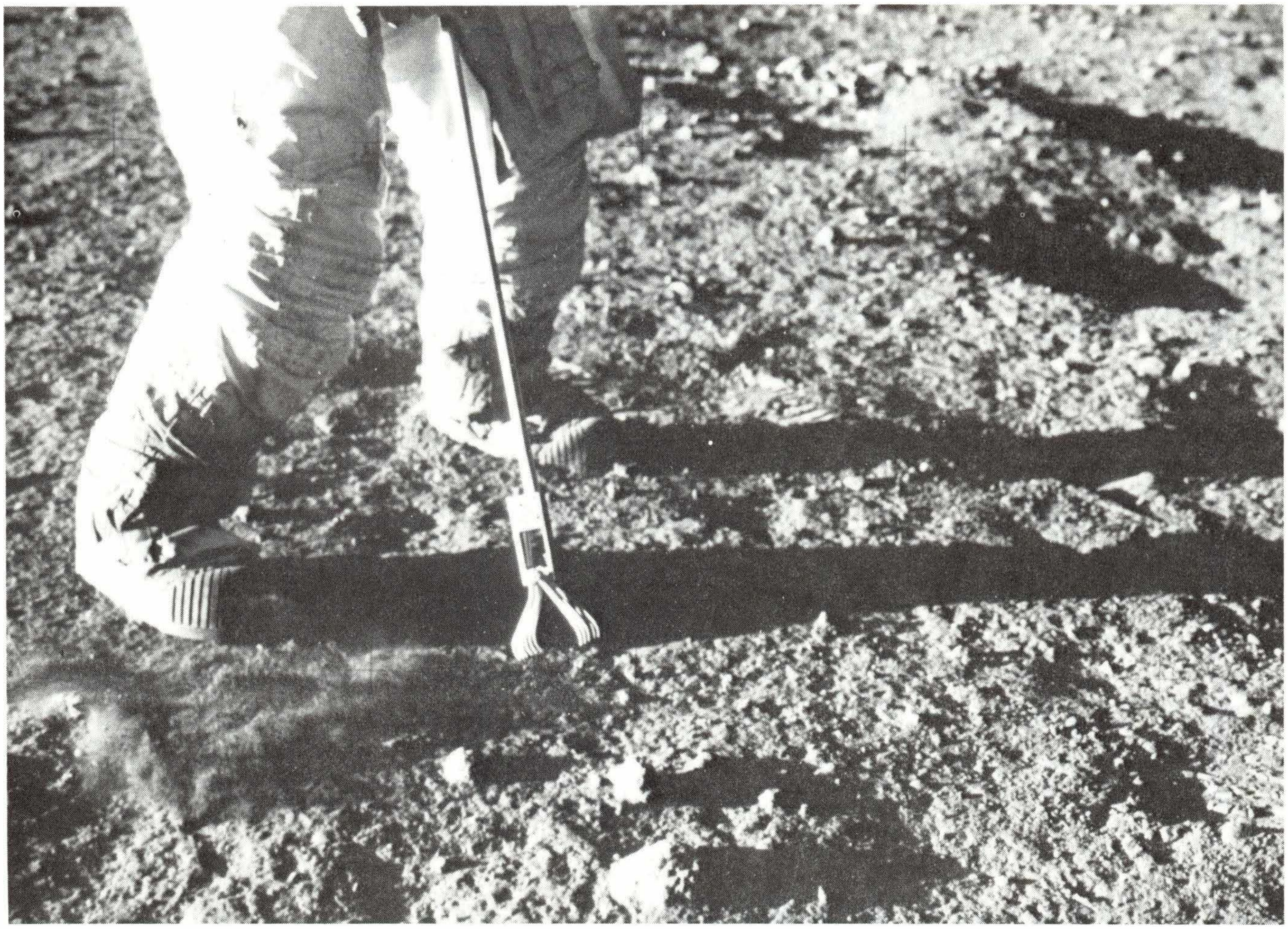

Fig. 48. Shorter model tongs in use during Apollo 12 mission (NASA photo AS12-47-6932).

Two styles of tongs were used on the moon (Figs. 48-51). On the early missions the tongs were slightly shorter and had tines made from aluminum. The 32-inch tongs used on later missions had tines made of stainless steel.

USE: Tongs were used for picking up individual rocks with dimensions less than 6-10 cm (Fig. 48). The shorter tongs were carried fastened to the astronaut's waist. The 32-inch tongs were carried in the large tool carrier aboard the rover.

MANUFACTURER: NASA, Johnson Space Center

SHORTER TONGS

WEIGHT:	140 g
DIMENSIONS:	67 cm overall length
	10 cm width of T-handle

MATERIALS: The tines were made from aluminum alloy 6061-T6 round stock 1/8 in. in diameter. The handle was made from aluminum (Fig. 49).

32-INCH TONGS

WEIGHT:	230 g
DIMENSIONS:	80 cm overall length
	12 cm width of T-handle

MATERIALS: The tines were made from 17-4 PH stainless steel 1/8 inch in diameter. The handle was aluminum (Figs. 50 and 51).

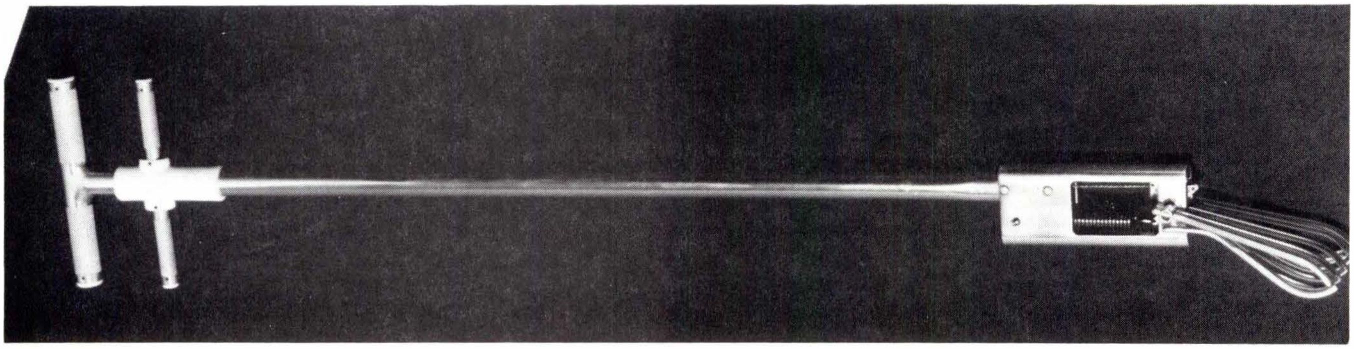

Fig. 49. Shorter style tongs (NASA photo S69-31855).

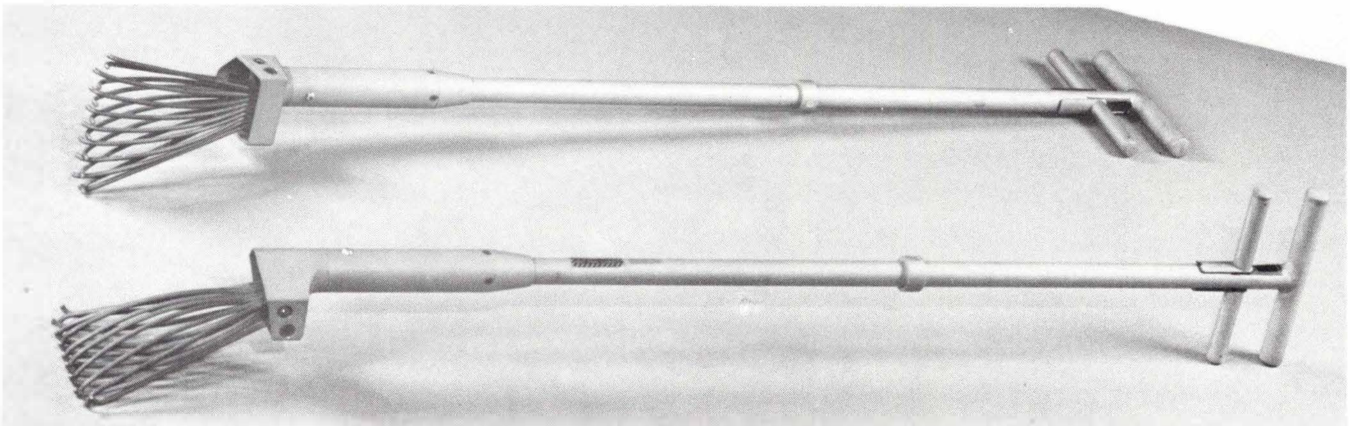

Fig. 50. 32-inch tongs (NASA photo S71-22469).

Fig. 51. 32-inch tongs on lunar surface in Decartes region, Apollo 16 (NASA photo AS16-116-18712).

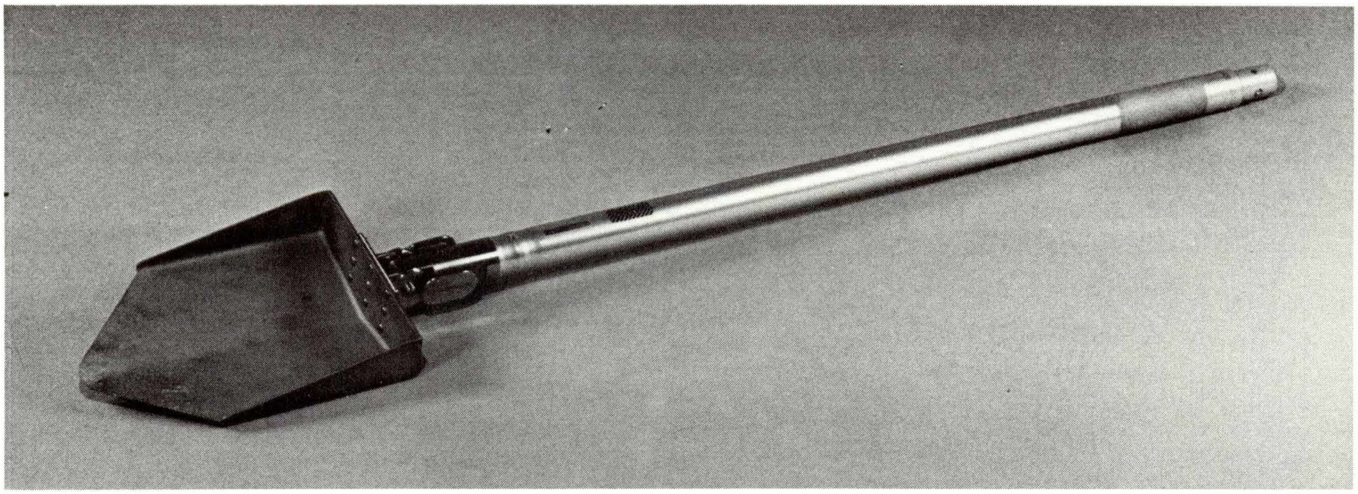

Fig. 52. Trenching tool with adjustable angle blade (NASA photo S71-22470).

WEIGHT:	**1315 g**
DIMENSIONS:	**93 cm overall length**
	15.0 cm blade width
	5 cm blade thickness

SYNONYMS: shovel

USE: The adjustable-angle trenching tools was used to dig trenches in the lunar regolith.

MANUFACTURER: NASA, Johnson Space Center

APOLLO MISSIONS: The trenching tool (Fig. 52) was used on Apollo 14. The larger, adjustable-angle scoops were developed and flown on later missions, and they were used for trenching.

MATERIALS: The shovel blade was made from 310 stainless steel.

B. TOOLS USED TO SUPPORT SAMPLE SELECTION AND DOCUMENTATION

Brush-scriber-lens
Gnomon
Weight scale

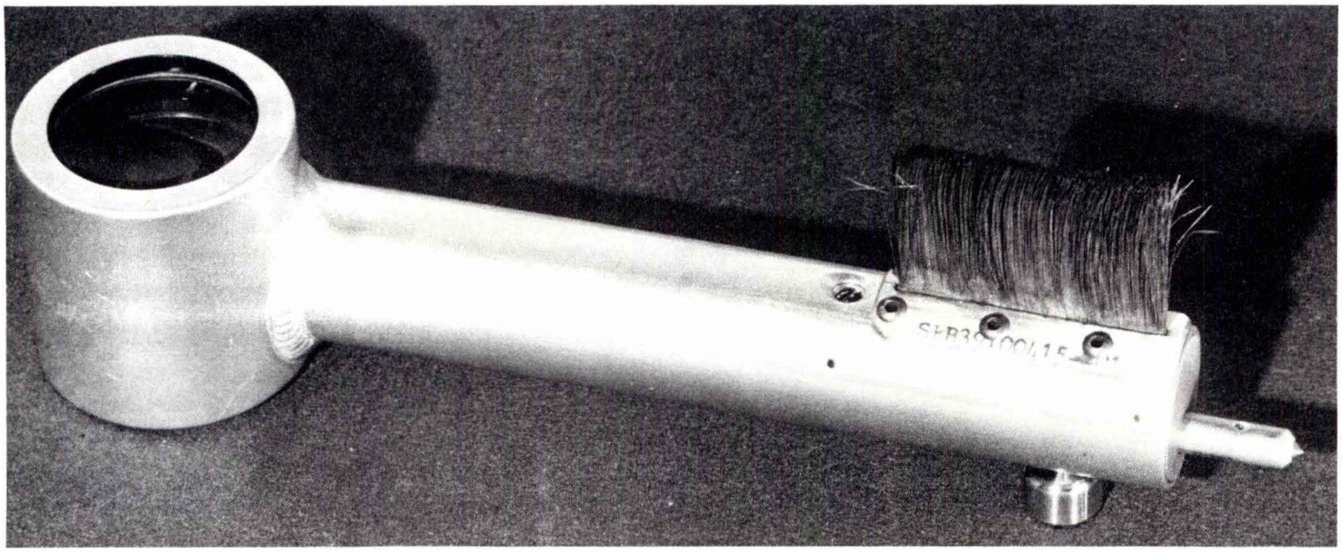

Fig. 53. Brush-scriber-lens (NASA photo S69-31852).

WEIGHT:	**208 g**
DIMENSIONS:	**20.2 cm overall length**

The brush-scriber-lens (Fig. 53) was intended to aid the astronaut in observing and marking hand-sized specimens of rocks. References about the use of this tool on the moon were scarce; it is likely that this tool was not used on any mission. The brush-scriber-lens was carried on Apollo 12 and 14 as part of the tool complement for the small tool carrier (Fig. 63). The author did not determine if the brush-scriber-lens was taken on the Apollo 11 flight. The brush-scriber-lens housing appears to be aluminum, and the brush bristles appear to be steel.* The scriber tip was carbide.+

* Observation of typical tool by author.

+ Uel Clanton, personal communication (1989), Clanton also notes some difficulty in using a hand lens through a helmet visor.

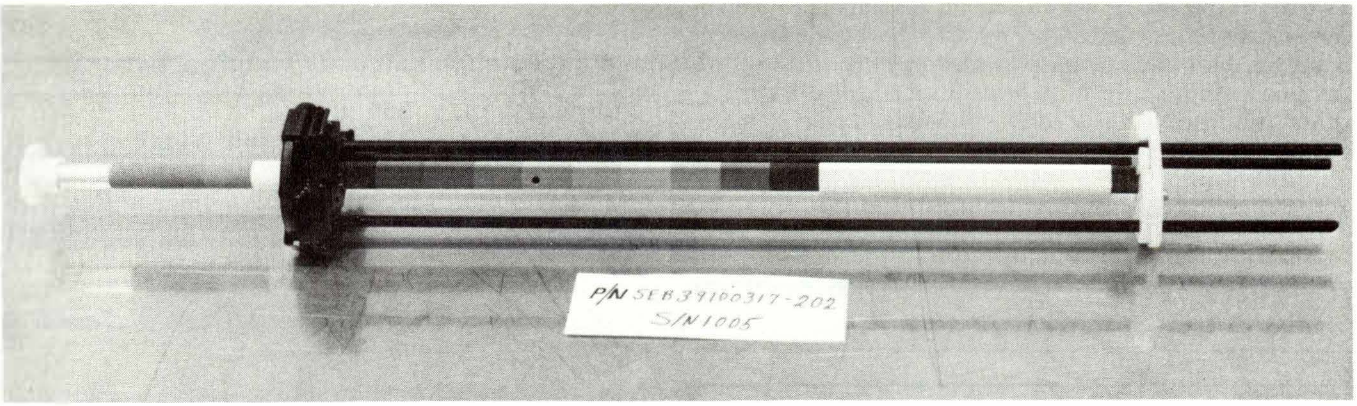

Fig. 54. Gnomon of the configuration used on Apollo 12 and 14, folded for stowage (NASA photo S69-53044).

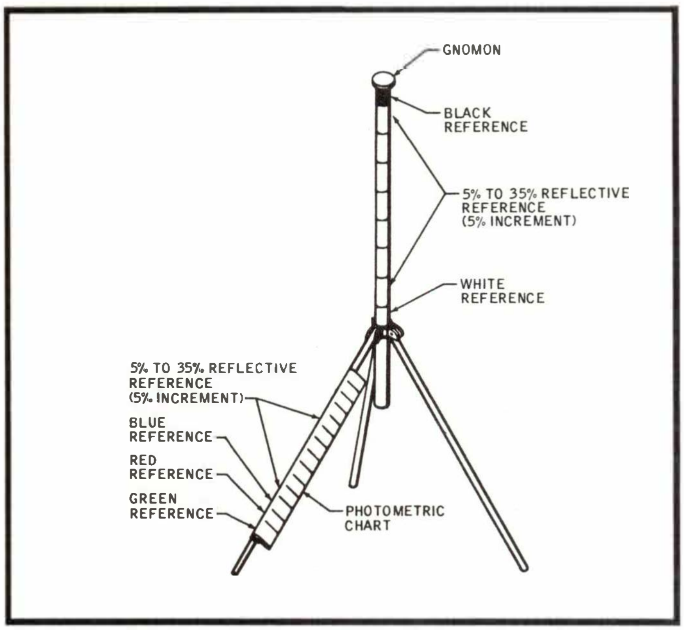

Fig. 55. Gnomon of the configuration used on Apollo 15, 16 and 17. Drawing from [37].

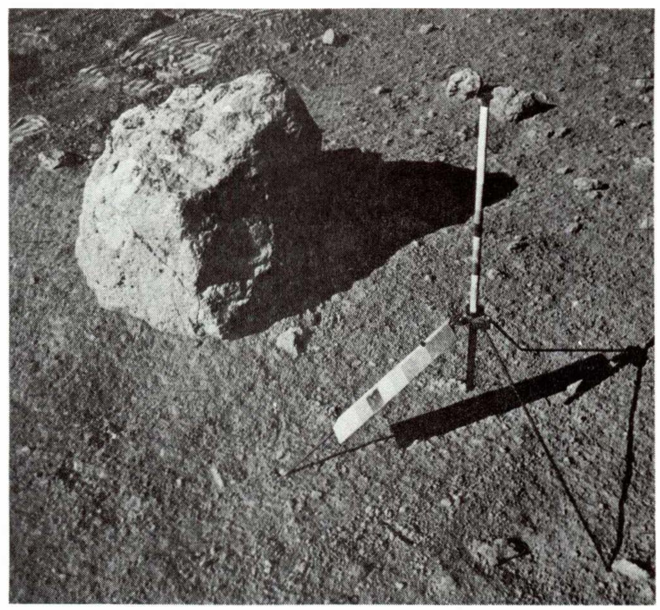

Fig. 56. Gnomon at Apollo 17 site (NASA photo AS17-137-20963).

WEIGHT:	**270 g**
DIMENSIONS:	**53 cm overall length, stowed**
	62 cm height, deployed

MANUFACTURER: NASA, Johnson Space Center

USE: The gnomon was a gimbaled stadia rod mounted on a tripod, such that the rod was free to point vertically (Figs. 54-56). The shadow cast by the staff indicated sun angle and, hence, direction. The rod length and the painted scale provided a reference for estimating the sizes of nearby objects. Shades of gray ranging in reflectivity from 5 to 35% and a color scale enabled more accurate determination of rock and soil colors by comparison.

APOLLO MISSIONS: The gnomon configuration used on Apollo 12 and 14 is shown in Fig. 54. The gnomon evolved a little on each of the later missions, Apollo 15, 16, and 17 (Figs. 55 and 56). The principal addition was a gray and color scale to one of the tripod legs.

Two types of scales were used on the moon to weigh containers of rocks and soil (Figs. 57, 58). Pre-determined limits for the weight of samples that could be lifted off of the moon were in effect. A heavier scale called a **spring scale** was used on the early missions. Later, a more compact **sample scale** was carried.

MANUFACTURER: NASA, Johnson Space Center

SPRING SCALE

WEIGHT:	**500 g**
DIMENSIONS:	**38 cm overall length**

APOLLO MISSIONS: This scale was carried on Apollo 11 and 12.

MATERIALS: The structure of the scale body was aluminum alloy 6061-T6.

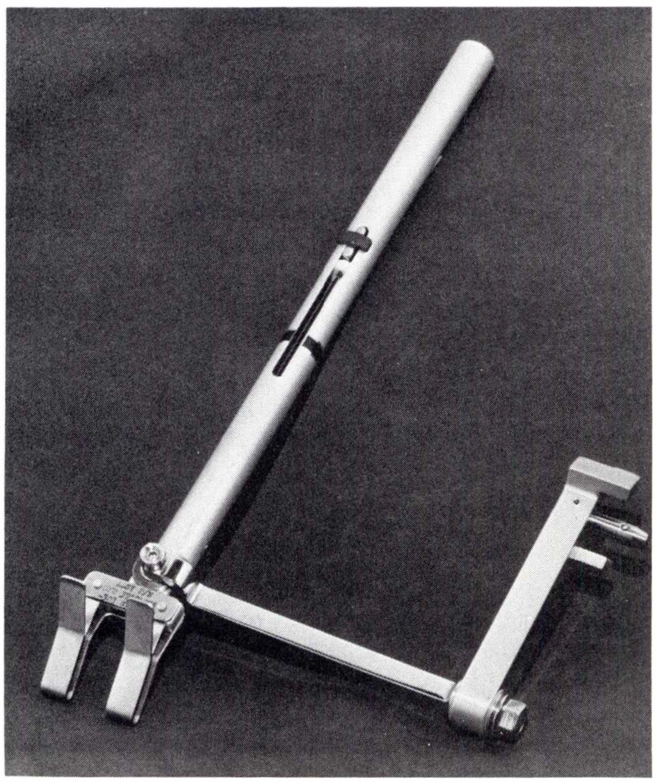

Fig. 57. Configuration and dimensions of spring scale.

SAMPLE SCALE

WEIGHT:	**230 g**
DIMENSIONS:	**35 cm overall length**

CAPACITY: The sample scale was graduated in 5 lb. increments to a maximum capacity of 80 lbs (lunar weight) [22].

APOLLO MISSIONS: The sample scale was used on missions.14, 15, 16 and 17.

MATERIALS: The scale housing was made from aluminum.

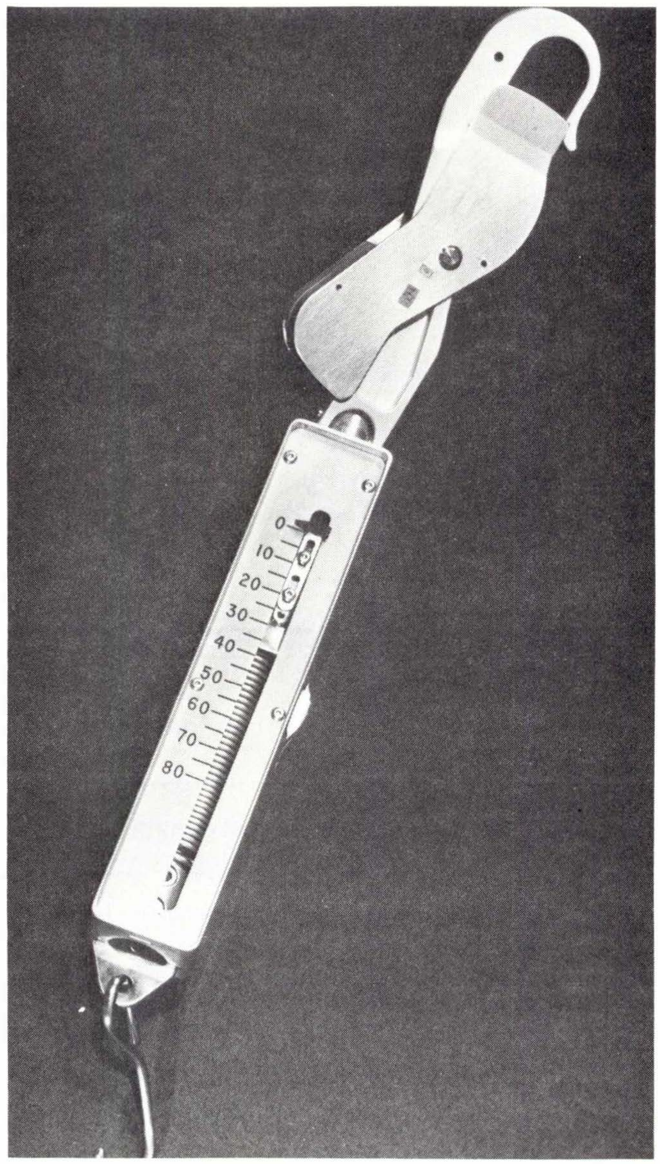

Fig. 58. Sample scale (NASA photo S70-36083).

C. TOOL CARRIERS

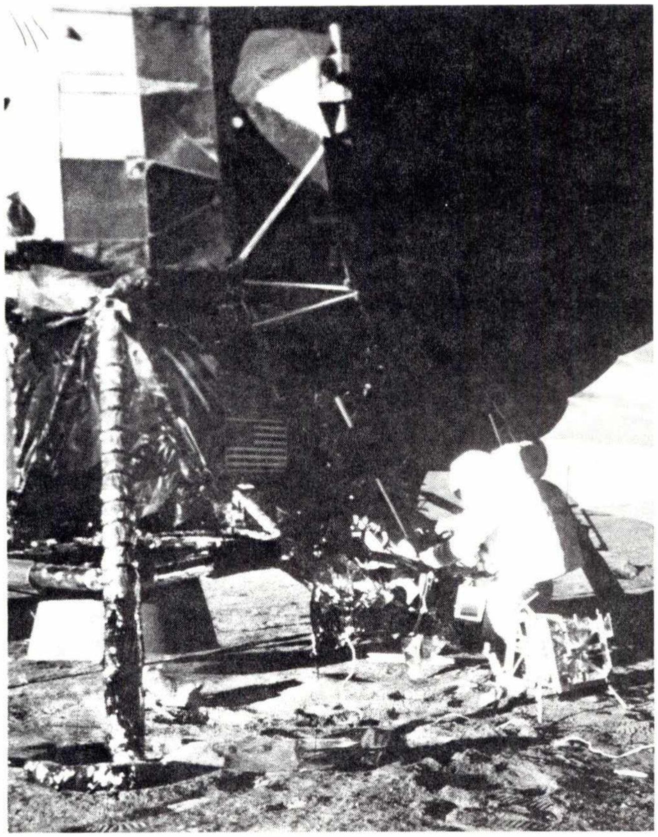

Fig. 59. Astronaut and small tool carrier at base of Apollo 12 Lunar Module (NASA photo AS12-47-6988).

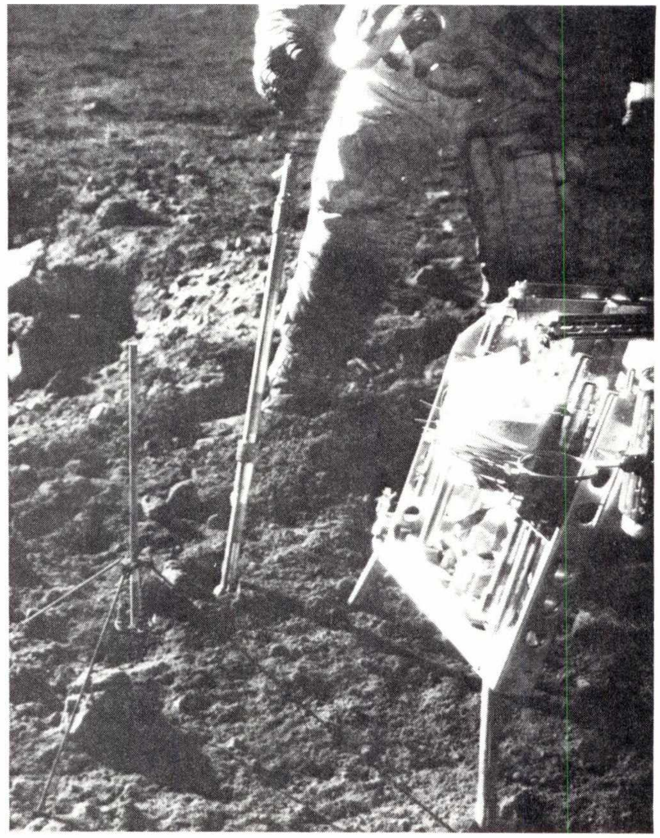

Fig. 60. Apollo 12 astronaut using tools on small carrier (NASA photo AS12-49-7320).

SMALL TOOL CARRIER

WEIGHT:	**4200 g (without tools)***
DIMENSIONS:	**67 cm overall height**
	70 cm length of side at feet
	41 cm width of tool rack
	47 cm height of tool rack

USE: The small tool carrier made the geologic hand tools convenient and accessible for the astronauts (Figs. 59-63). Smaller tongs, shorter extension handle, 2-cm diameter core tubes and caps, round and flat rectangular documented sample bags and dispensers, small non-adjustable scoop, lighter weight hammer, brush-scriber-lens and gnomon were among the tools on the carrier (Figs. 61 and 62).

MANUFACTURER: NASA, Johnson Space Center

MATERIALS: Observation of a typical small tool carrier indicated that most of the structure was sheet aluminum. The tote bag was made of a white woven cloth with a slick finish (laminated teflon over woven teflon?).

APOLLO MISSIONS: The small tool carrier was transported by hand on Apollo 12 and on board the 2-wheeled cart, called the modularized equipment transporter, on Apollo 14. The author did not verify that no tool carrier was used on Apollo 11; however, most tools on Apollo 11 were stored on a work station on the Lunar Module.

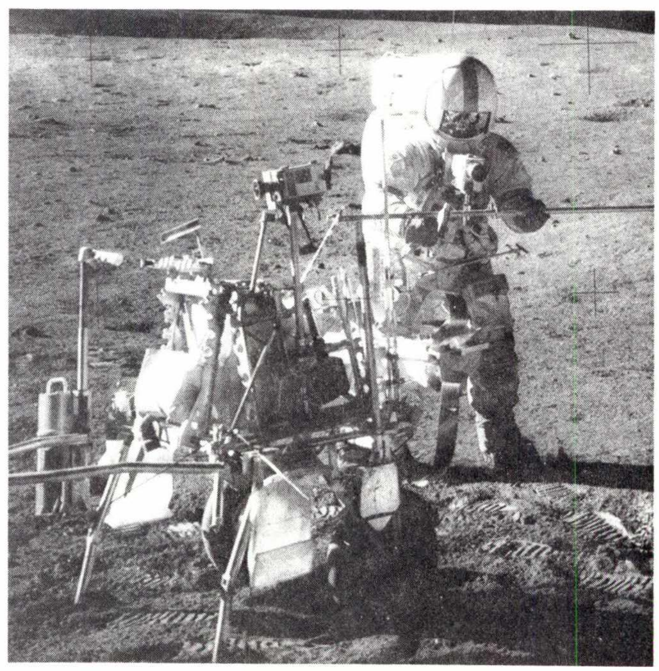

Fig. 61. Small tool carrier mounted on the modularized equipment transporter (MET), a two-wheeled cart (NASA photo AS14-68-9405).

* Typical carrier weighed on 250-lb. capcity Detecto scale

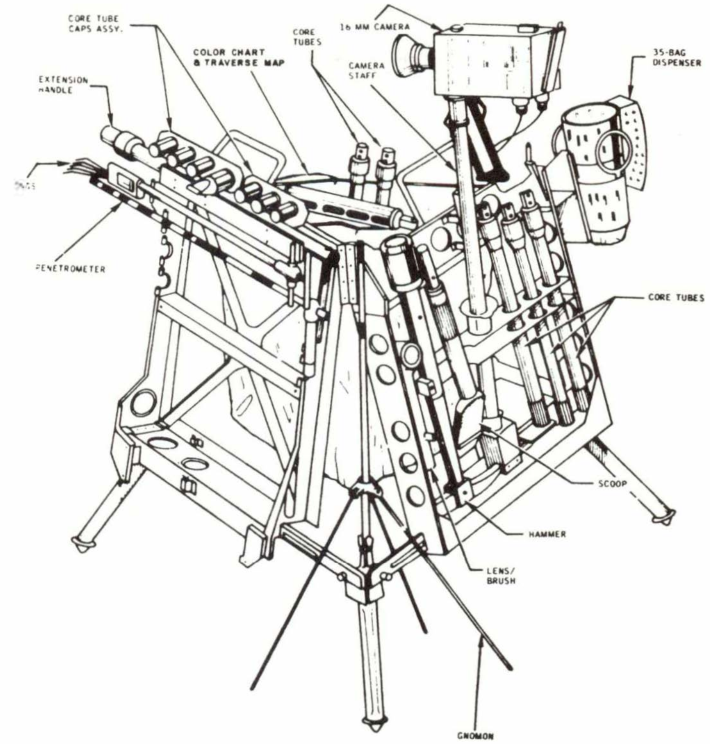

Fig. 62. Small tool carrier with tools labeled. Drawing from Apollo 14 Lunar Surface Procedures ((1970).

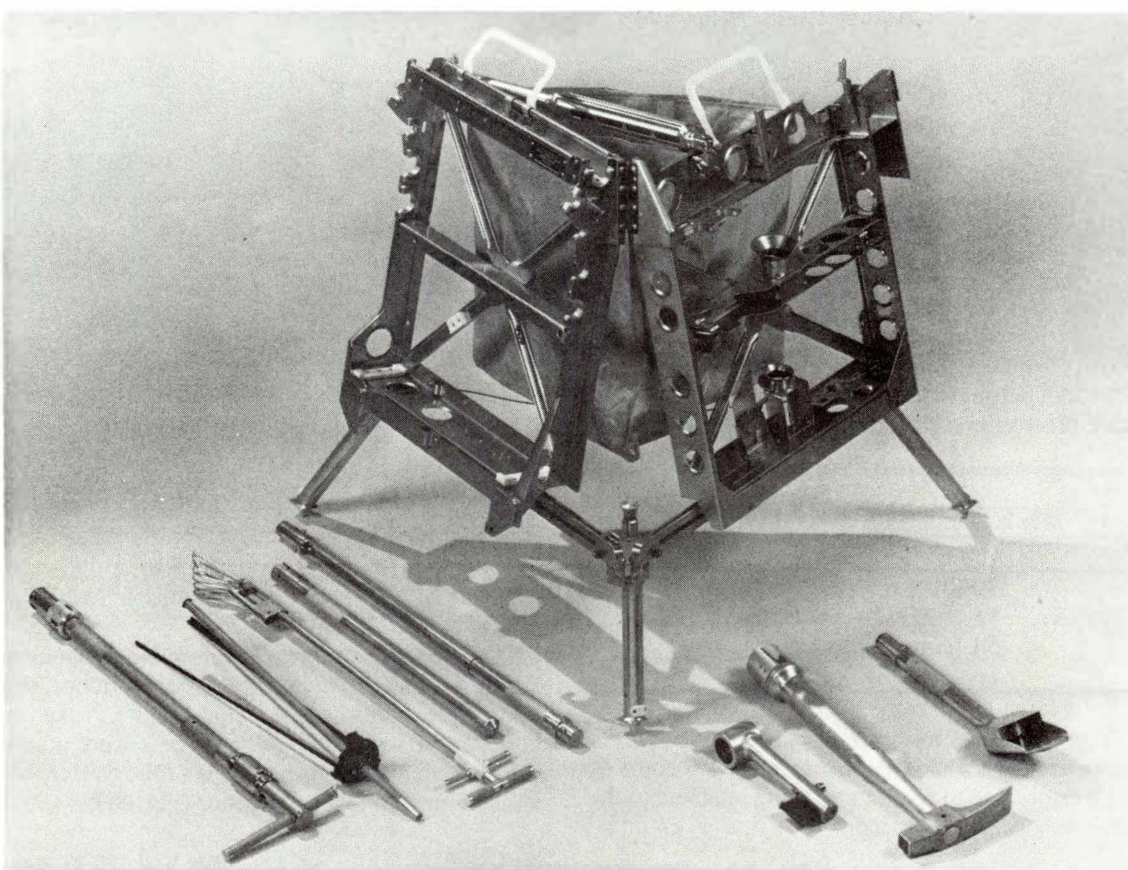

Fig. 63. Small tool carrier with tools displayed alongside (NASA photo S69-31867).

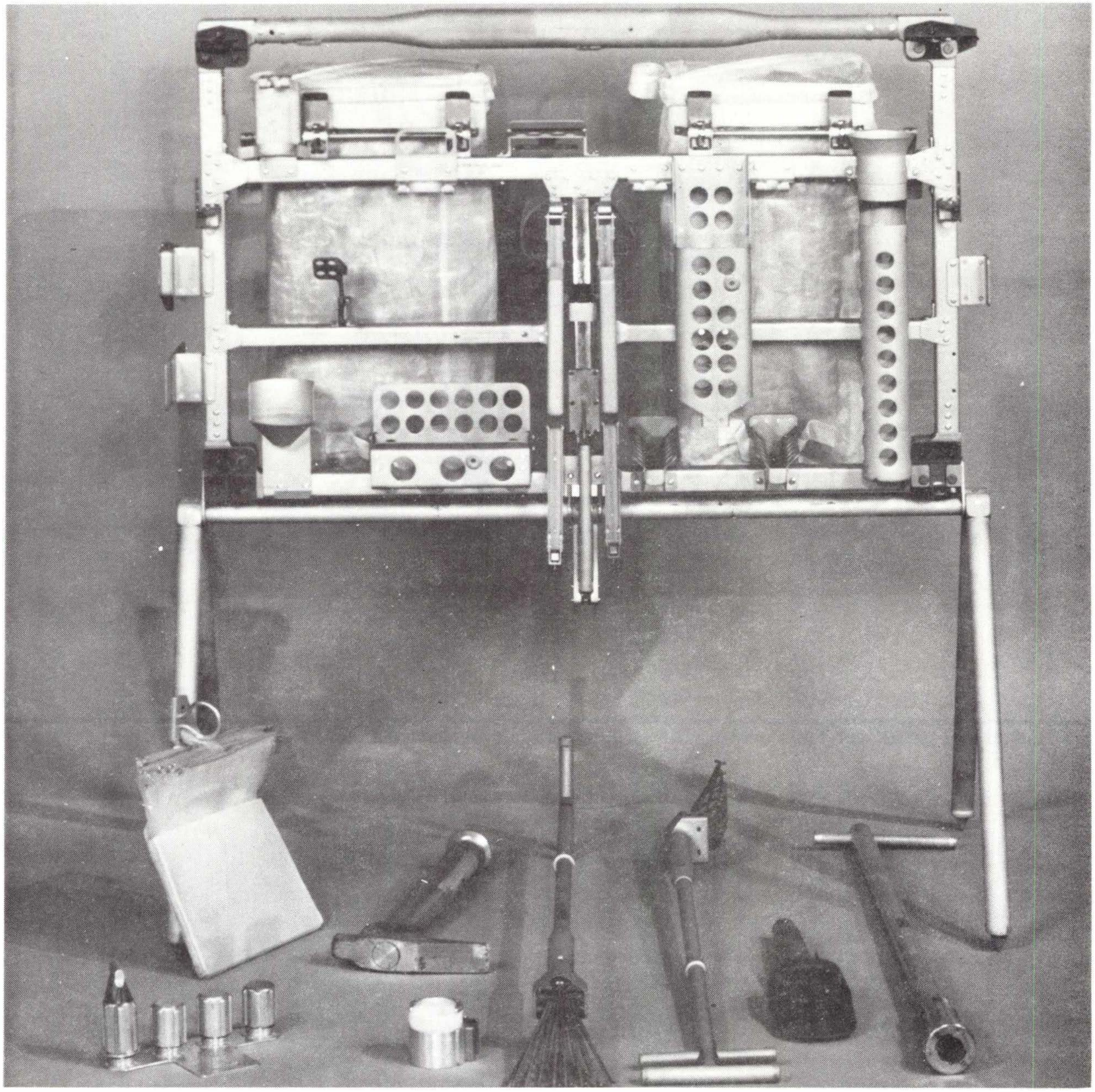

Fig. 64. Large tool carrier with tools displayed left to right: core tube caps (not used on last 3 missions), documented sample bags, hammer, drive tube caps, 2 pair of tongs, adjustable-angle scoop and extension handle (NASA photo S71-22476).

LARGE TOOL CARRIER

WEIGHT:	**5900 g**
DIMENSIONS:	**86 cm side to side**
	54 cm height
	16 cm thickness

WEIGHT: A typical empty tool carrier weighed 5900 g on a 250-lb capcity Detecto scale. The stowage list weight of 8000 g was probably due to some tools being attached to the carrier when it was weighed for flight.

DIMENSIONS: The dimensions were for the configuration with the legs folded, as in the lunar surface photographs (Figs. 67-69).

MANUFACTURER: NASA, Johnson Space Center

USE: The large tool carrier provided convenient access to flat documented sample bags, hammer, tongs, small or large adjustable scoop, extension handle, rake and sample collection bags (Figs. 64-66). Tools were attached to both the forward and backward sides of the carrier, which rotated about a hinge like an open door (Fig. 68).

APOLLO MISSIONS: The large tool carrier was attached to the lunar rover on Apollo 15 and 16.

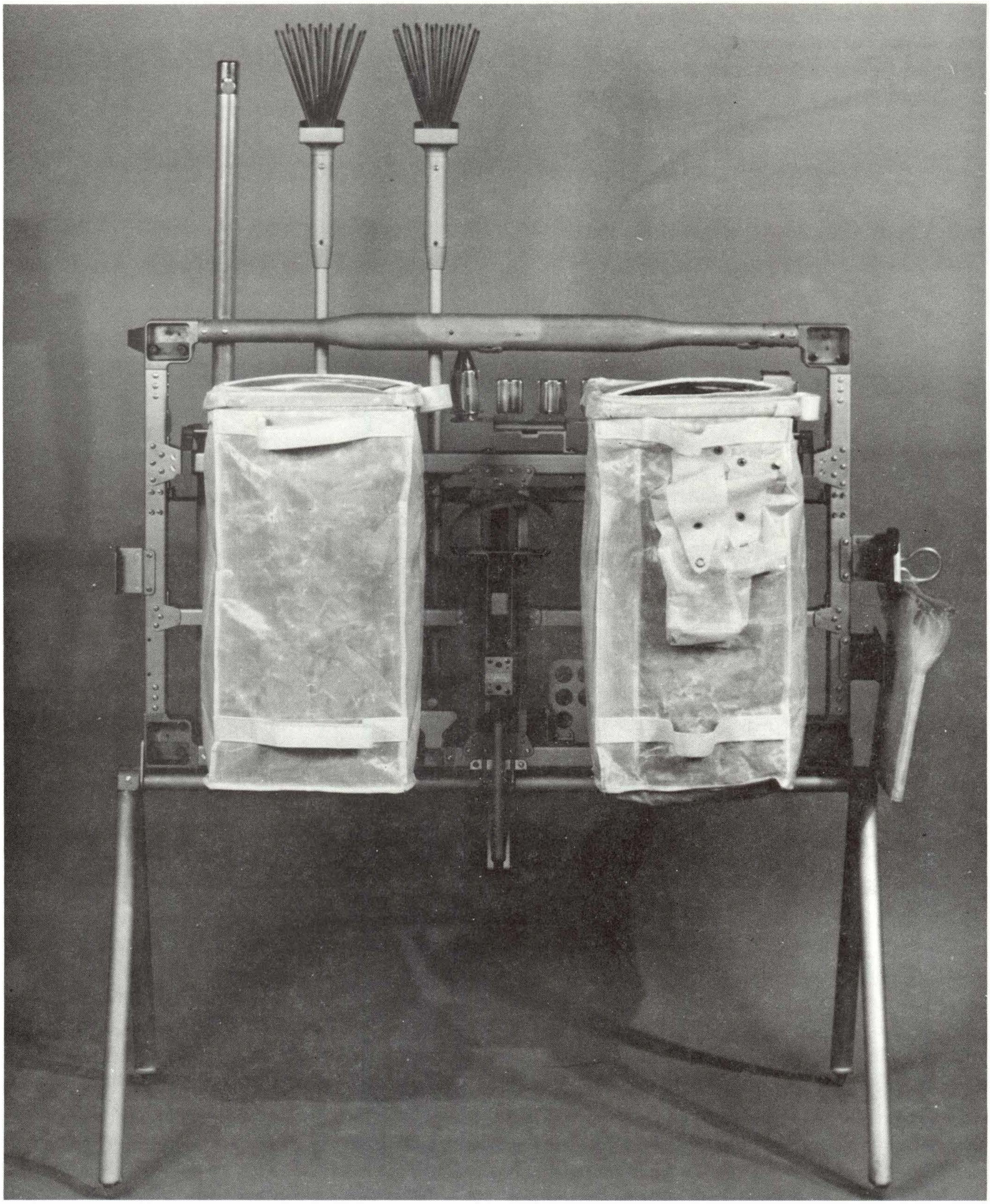

Fig. 65. Large tool carrier as viewed from behind the rover looking forward. The white bag on the left is Extra Sample Collection Bag (without pockets); the right-hand bag is a Sample Collection Bag (NASA photo S71-22475).

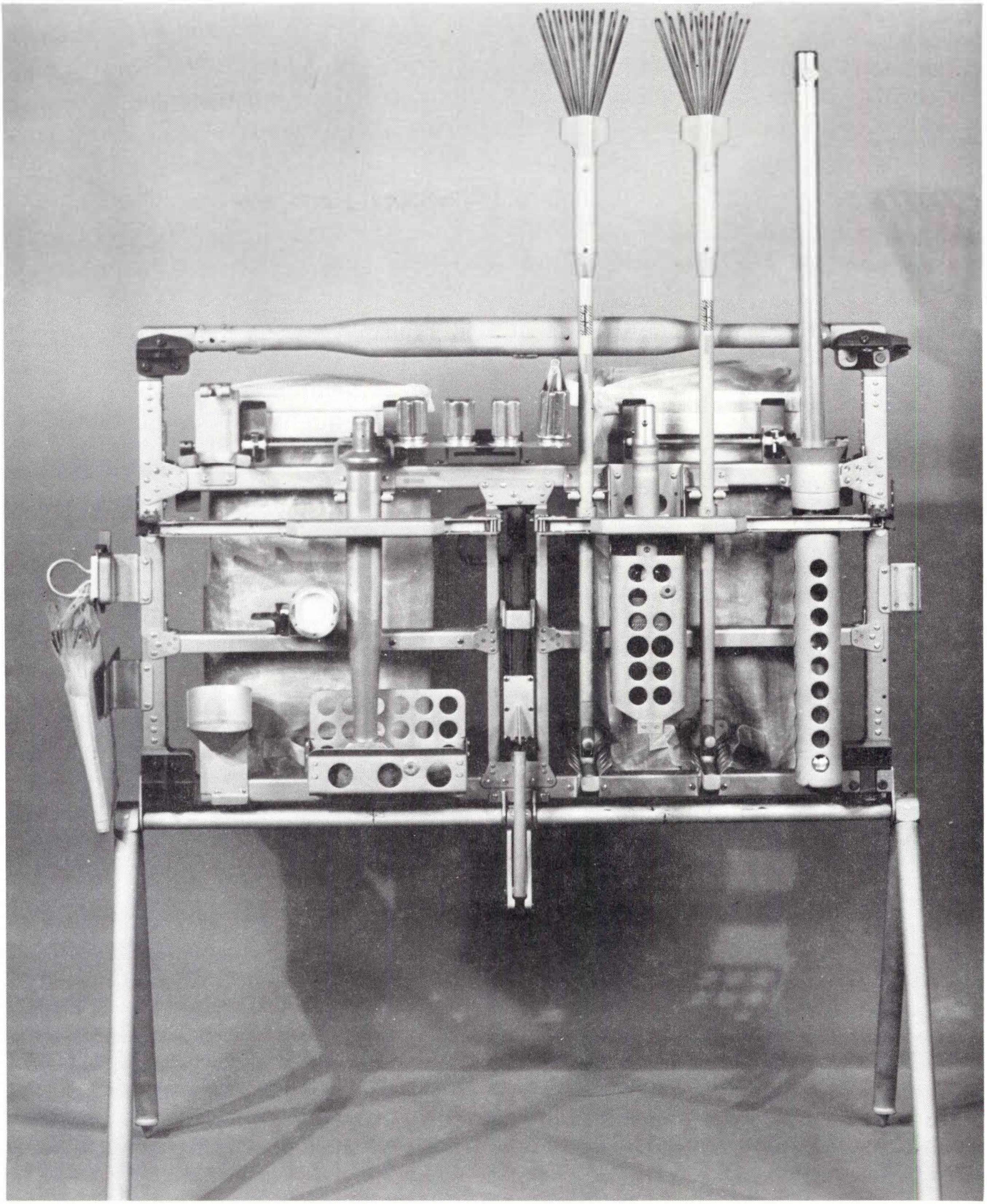

Fig. 66. Large tool carrier, the side facing forward on the rover, the side opposite that viewed in Fig 65 (NASA photo S71-22477).

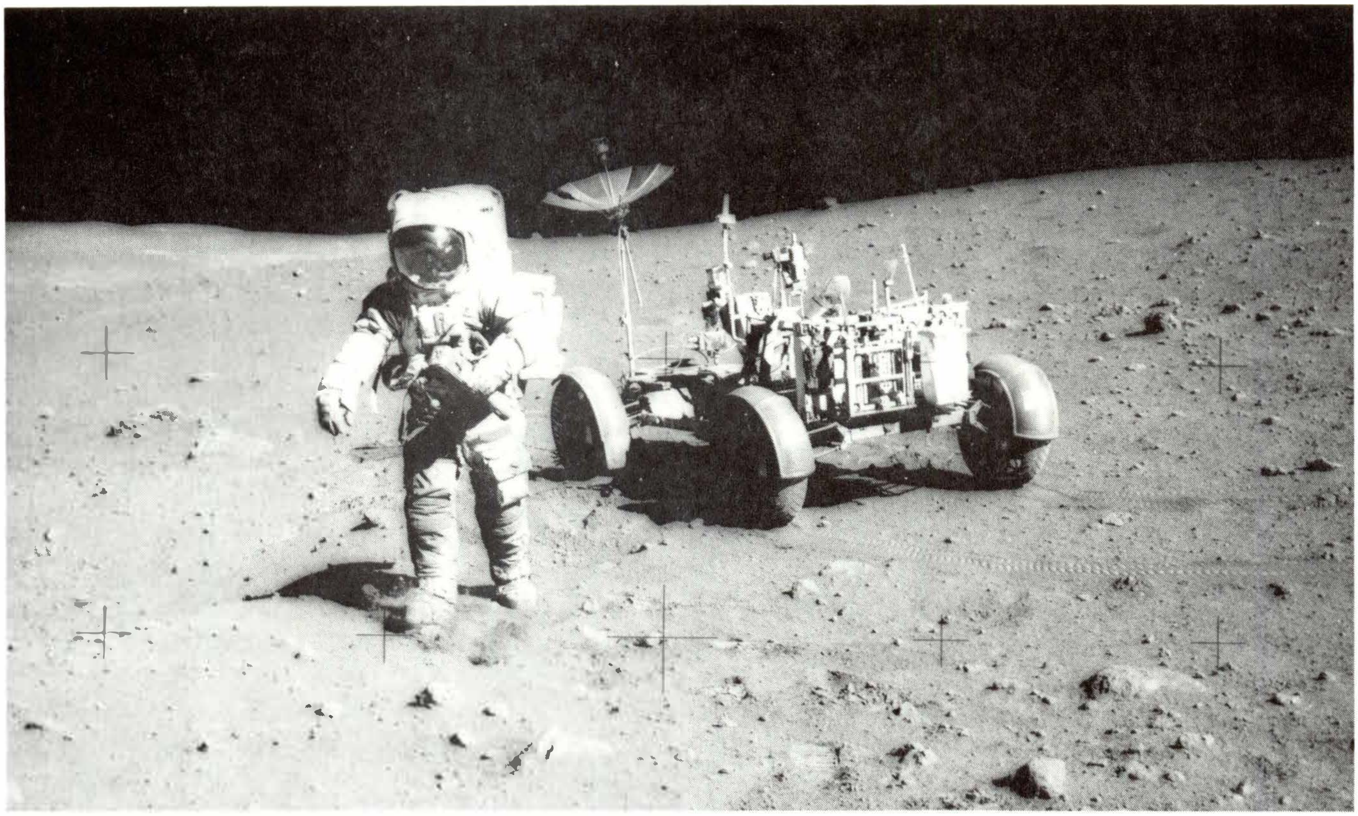

Fig. 67. Large tool carrier on Apollo 15 rover. A Sample Collection Bag hangs on carrier (NASA photo AS15-82-11168).

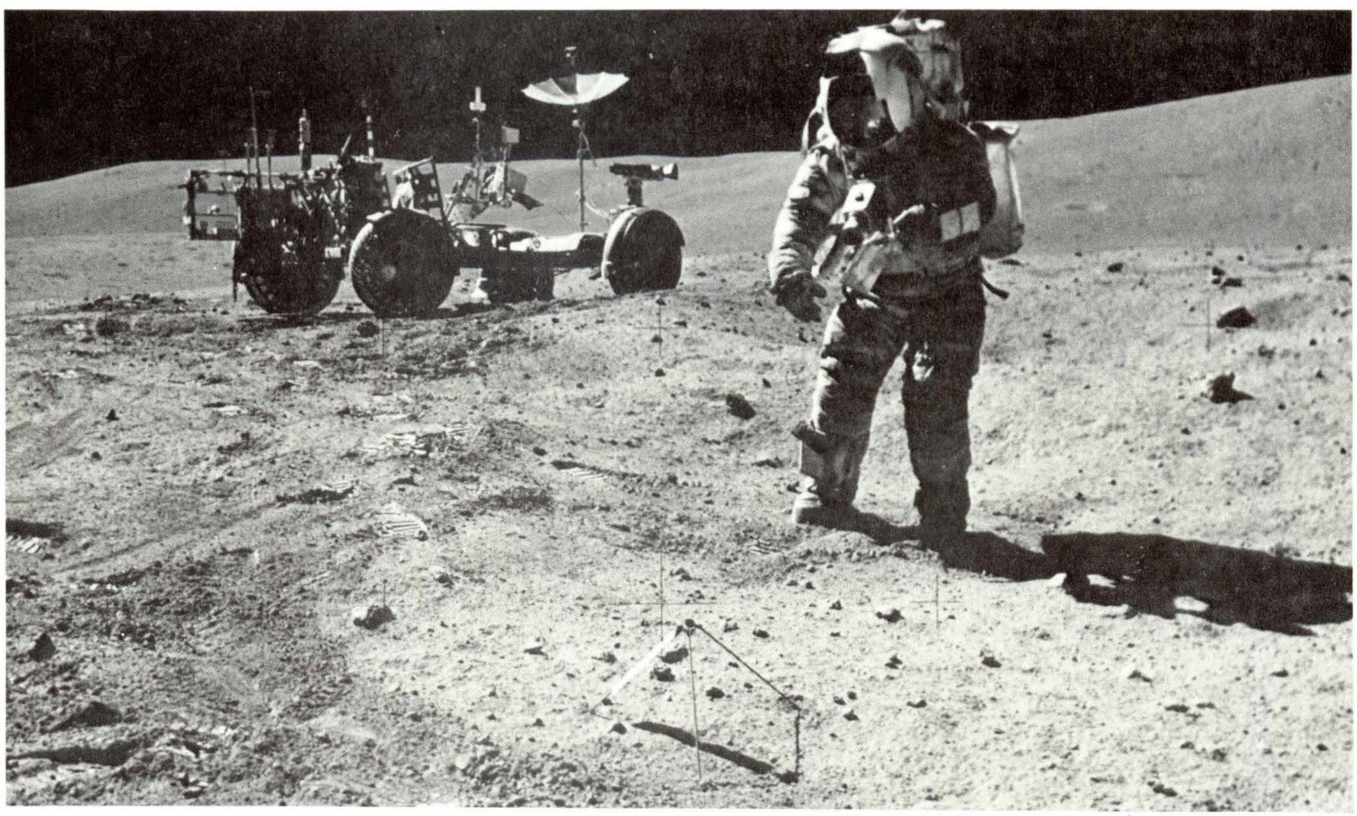

Fig 68. Apollo 16 lunar rover with large tool carrier opened outward to allow access to tools on both sides of the carrier (NASA photo AS16-117-18825).

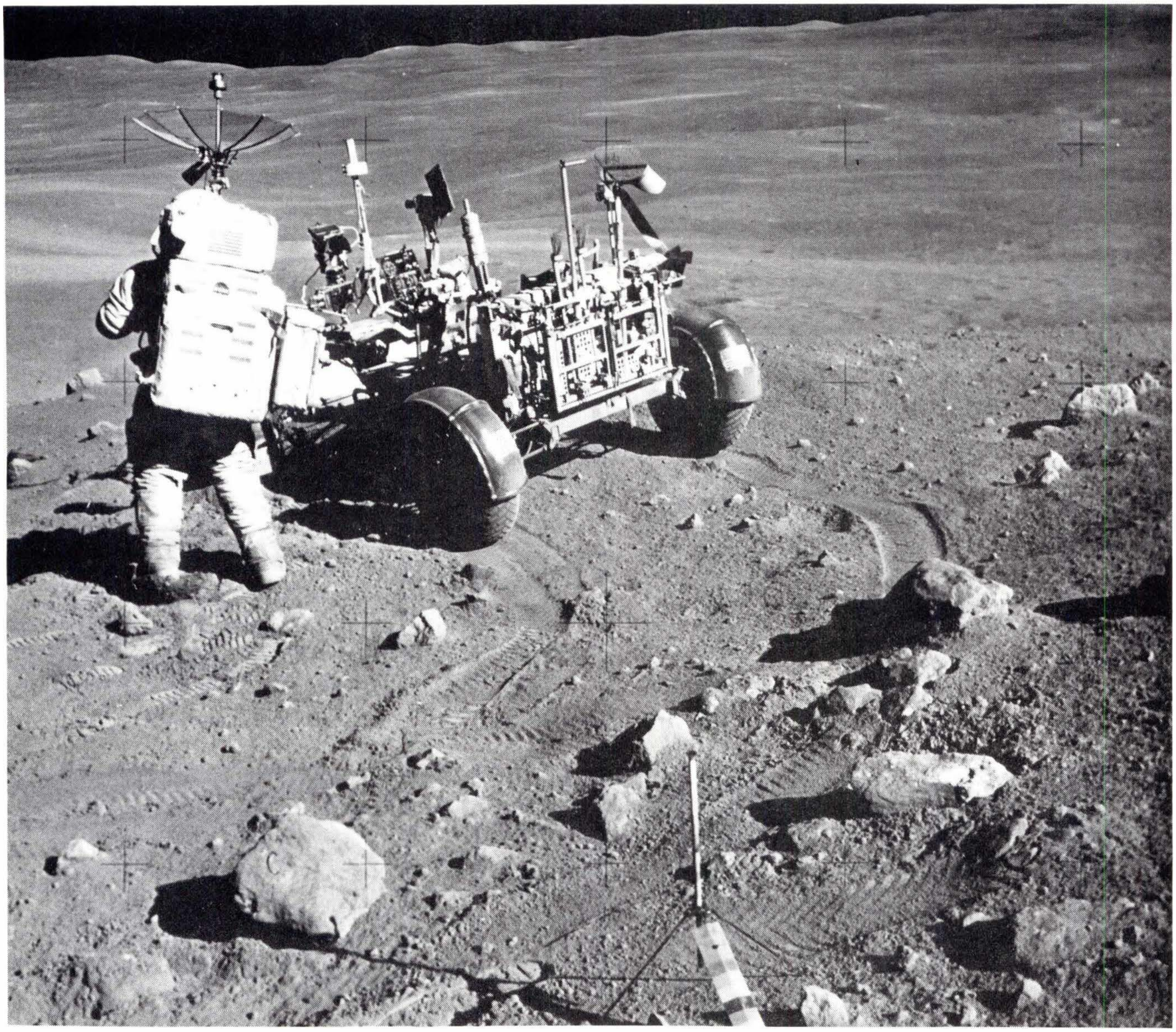

Fig. 69. Large tool carrier, with rake visible, on rear of Apollo 16 rover (NASA photo AS16-107-17446).

D. CONTAINERS USED TO PACKAGE ROCKS, SOILS AND OTHER SAMPLES ON THE MOON

Apollo Lunar Sample Return container (ALSRC)
Core Sample Vacuum Container(CSVC)
Documented sample bag
Gas Analysis Sample Container (GASC)
Lunar Environment Sample Container (LESC)
Magnetic Shield Sample Container (MSSC)
Organic sample monitor
Protective padded sample bag
Special Environment Sample Container (SESC)

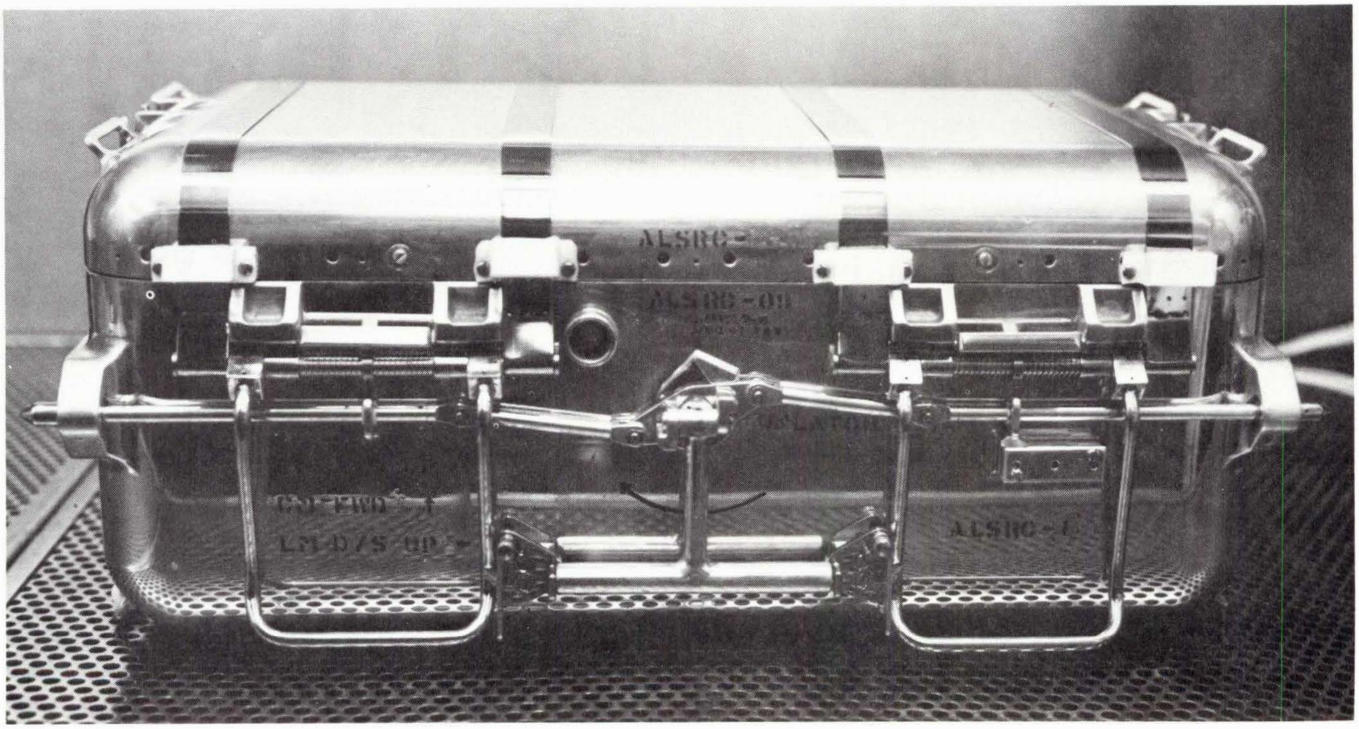

Fig. 70. Apollo Lunar Sample Return Container, serial number "09". This "rock box" served on both the Apollo 12 and 16 missions (NASA photo S72-37196).

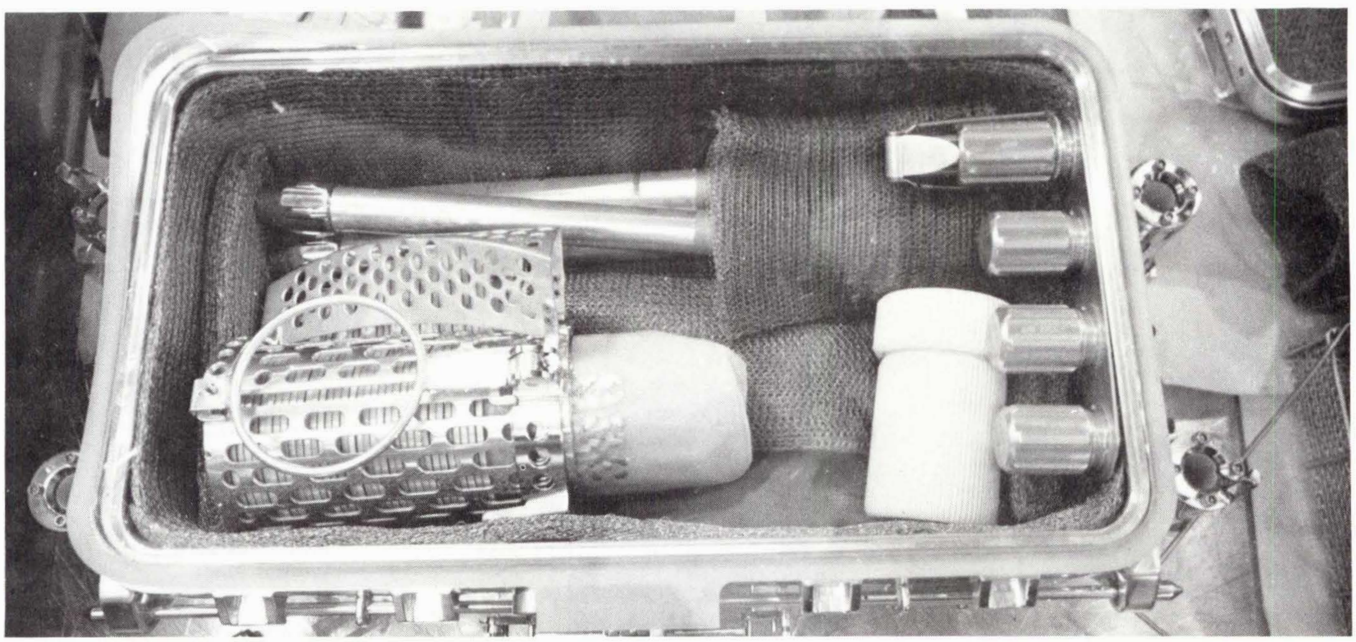

Fig. 71. Apollo 14 Lunar Sample Return Container prior to flight packed with round documented sample bags, 2-cm diameter core tubes, core tube caps, and Magnetic Shield Sample Container (believed to be the white cylinder) (NASA photo S70-29818).

WEIGHT: 6700 g
DIMENSIONS: 48x30x20 cm, outer envelope

SYNONYMS: ALSRC, rock box

WEIGHT: 6700 g was the average of all 12 rock box weights, as given on the packing lists for each ALSRC. The "bare box" weights ranged from 5900 - 7700 g, and the boxes plus packing material (York mesh) ranged from 6800 - 8900 g. Although there may have been minor changes in configuration from mission to mission, the main differences in weight appear to be due to the weight of packing mesh, either lining the "bare box" or added as padding. For example, ALSRC "09" had a weight of 7200 g for Apollo 12 and 6400 g for Apollo 16. The earlier missions tended to use more mesh as padding.

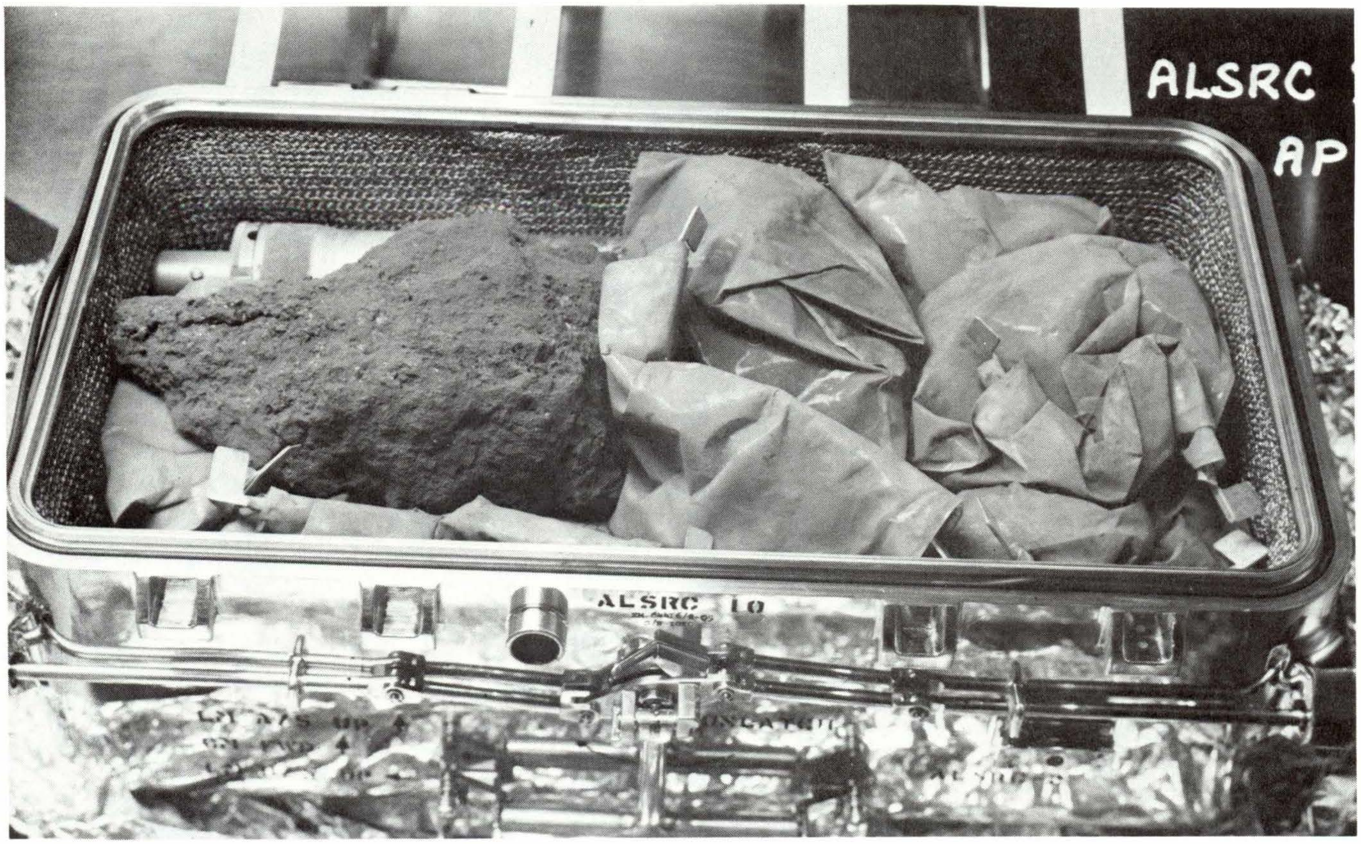

Fig. 72. Apollo 16 Lunar Sample Return Container upon opening in the Lunar Receiving Laboratory. The box contains a large rock, several documented sample bags with the fold-over aluminum tabs, and a 4-cm diameter drive tube (NASA photo S72-36984).

DIMENSIONS: The outer envelope for an ALSRC was 48 x 30 x 20 cm. This included the hinges and latches. The exterior box dimensions were 48 x 27 x 20 cm. The box wall thickness was about 2 mm; however, the box had numerous ribs for strength.

CAPACITY: With liner in place, the ALSRC interior volume was about 16,000 cm^3 [22].

MANUFACTURER: Union Carbide, Nuclear Division, Oak Ridge, TN

APOLLO MISSIONS: Two ALSRC's were used on each Apollo mission.

USE: The Apollo Lunar Sample Return Container (Figs. 70-75) preserved a lunar-like vacuum around the samples and protected them from shock during the return flight and until they were opened in the Lunar Receiving Laboratory. In practice, substantial leakage was detected in 4 of the 12 ALSRC's returned from the moon. This was attributable, in most cases, to pieces of equipment or dust interfering with the seals, in spite of the precautions taken to protect the sealing surfaces.

OPERATION: The ALSRC was an aluminum box with a triple seal (one knife edge in soft indium metal and two fluorosilicone o-rings). Prior to flight, the box was closed under vacuum so that it would not contain pressure greater than lunar ambient. On the moon, while samples were being loaded, the seals were protected by a teflon film and a cloth cover, which were removed just prior to closing the box. The ALSRC was held in a fixture at waist level to aid the astronauts in closing the cam latches (Fig. 73). Four straps attached to the two cam latches transferred even pressure for the knife-edge seal., and two latch pins secured the closure. York mesh, lining the box and as packing pads, dampened the vibration and shock to samples during the return flight.

MATERIALS: The ALSRC box and lid were each made from a single block of 7075 AA aluminum alloy. The lining and padding used was York mesh, a knitted 0.011 inch diameter wire, 2024 aluminum alloy. The soft metal sealing surface was an alloy of 90% indium and 10% silver. The two sealing o-rings were compound L608-6 fluorosilicone (much of the previous literature reports the o-rings to have been Viton A). The indium seal protector and lid spacer, used prior to final sealing on the moon, were teflon.

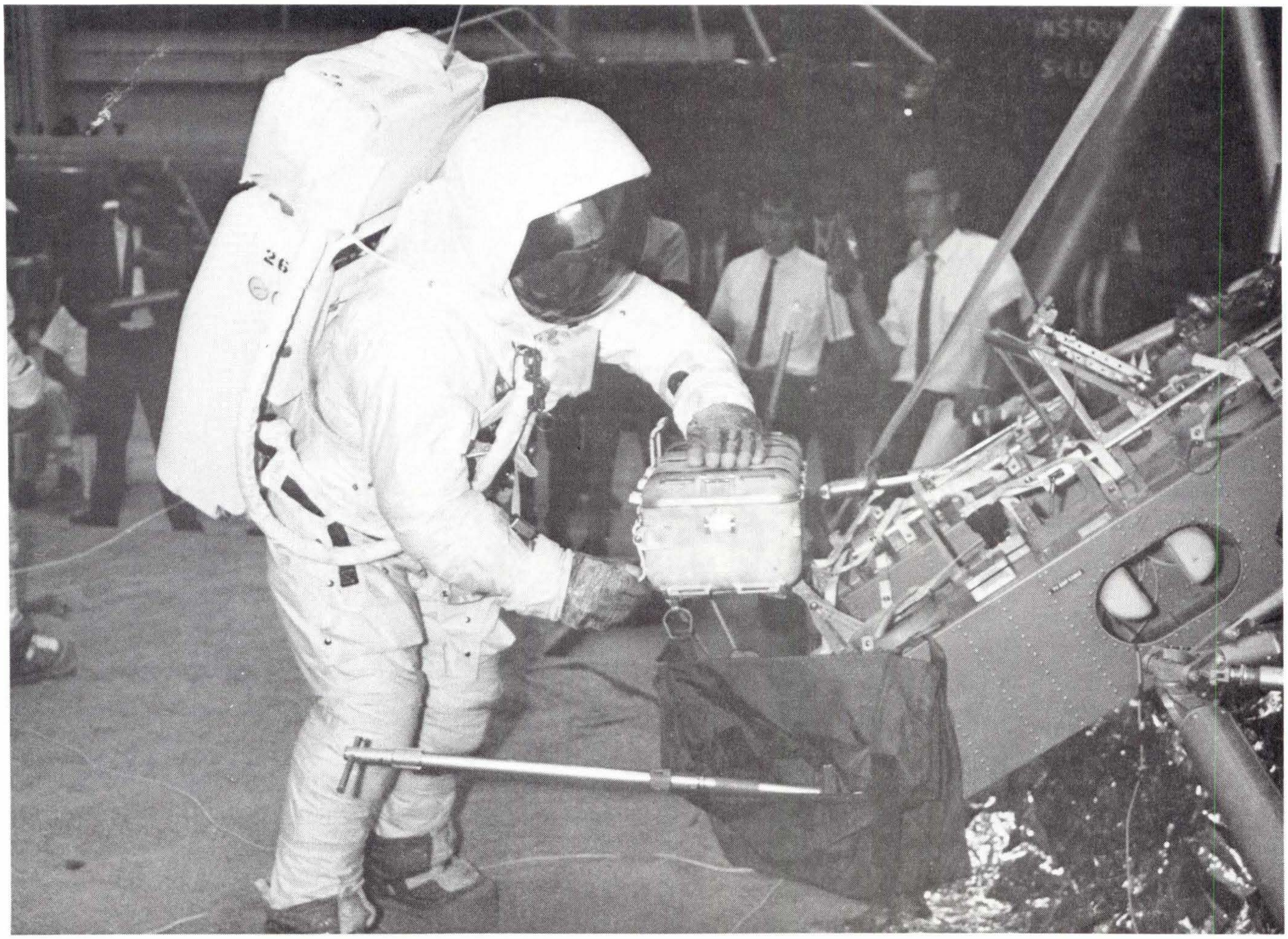

Fig. 73. Astronaut practices closing an Apollo Lunar Sample Return Container at waist-level work station on a lunar module during a simulation of lunar extra-vehicular activity (EVA) (NASA photo S69-31080).

Fig. 74. Teflon cloth seal protector, deployed as if on lunar surface, during packing of ALSRC prior to flight. The box lining is York mesh (NASA photo S88-52674).

Fig. 75. Close-up view of indium seal in rock box full of lunar samples in documented sample bags. The aluminum tab on one of the bags was entrapped in the knife-edge and indium seal; thus, the seal was not good. One of the fluorosilicone o-rings, dark in color, is visible just outward of the indium seal (NASA photo S72-37750).

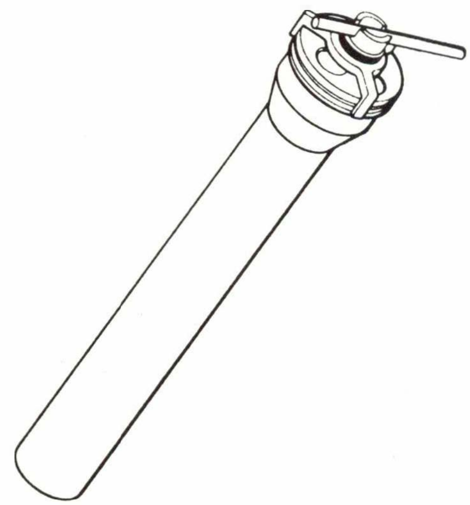

Fig. 76. Core Sample Vacuum container (CSVC) Drawing from [37].

WEIGHT:	**493 g**
DIMENSIONS:	**41 cm overall length**
	6.1 cm outer diameter

SYNONYMS: CSVC

MANUFACTURER: Uncertain; Union Carbide, Nuclear Division, Oak Ridge, TN, was likely the manufacturer since the CSVC was a derivative of the Special Environmental Sample Container.

USE: The Core Sample Vacuum Container, because of its vacuum sealing capability, provided a receptacle for a 4-cm diameter drive tube so that a subsurface sample of lunar regolith could be returned without exposure to terrestrial atmosphere or spacecraft cabin gases.

OPERATION: The CSVC was a derivative of the Special Environmental Sample Container, elongated to accomodate a 4-cm diameter drive tube. See the SESC for operational description of sealing surfaces. The section just below the knife-edge contained an insert with fingers that gripped the knurled part of the drive tube and provided lateral and longitudinal restraint [22].

APOLLO MISSIONS: One 4-cm drive tube core sample was sealed in a CSVC on Apollo 16 and one on 17. Neither core sample has been opened to date.

MATERIALS: See SESC for material description.

Fig. 77. Cup-shaped documented sample bags in 35-bag dispenser hanging on small tool carrier at Apollo 12 site (NASA photo AS12-49-7243).

Documented sample bags (Figs. 77-85) were numbered bags with closures that allowed samples to be identified and kept separate from one another. These bags were grouped into dispensers which provided easy access for the astronauts. Although documented sample bags of several different configurations were used on the Apollo missions, two basic shapes described most bags, cup-shaped and flat rectangular. This study did not determine the configuration of the bags used on Apollo 11. Those bags weighed 9 grams each.*

CUP-SHAPED DOCUMENTED SAMPLE BAGS

35-BAG DISPENSER:

WEIGHT:	**710 g,**
DIMENSIONS:	**26 cm overall length estimate**
	13 cm overall width estimate

DIMENSIONS: Dimensions were estimated from Fig. 78.

MANUFACTURER: The cup-shaped bags in Figs. 77 and 78 were made by contractors to NASA. Union Carbide, Nuclear Division was the probable manufacturer.

APOLLO MISSIONS: Cup-shaped bags in 35-bag dispensers were used on Apollo 12 and 14.

MATERIALS: The bags were made of teflon film reinforced by an aluminum band around the rim. This band

* Uel Clanton (personal communication, 1989) noted that the astronauts had difficulty opening Apollo 11 bags

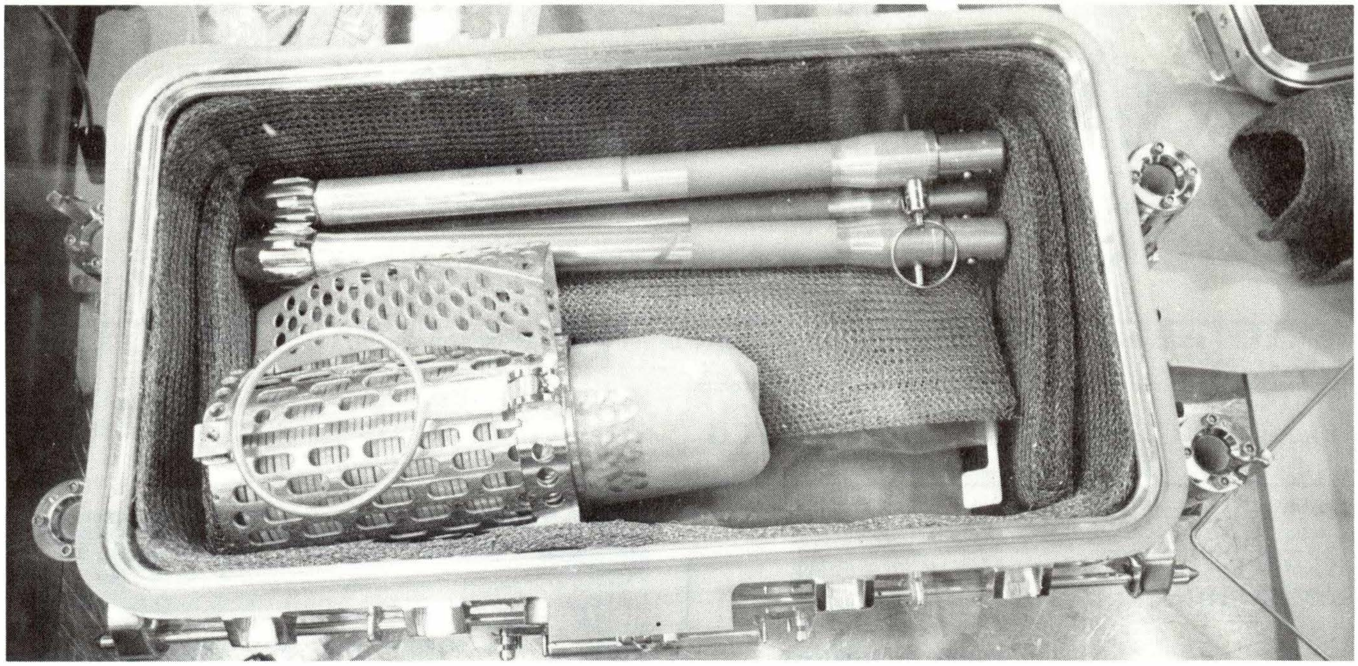

Fig. 78. Cup-shaped documented sample bags, of the type used on Apollo 12 and 14, in a 35-bag dispenser packed for Apollo 14 flight (NASA photo S70-29816).

gave the cup shape, held it open so a sample could be inserted and provided the closure for the bags after the sample was placed inside. The tab on the band was a handle for the astronauts to grasp.* The proto-type bags in Fig. 79 show the aluminum bands. Unlike this proto-type, the 35-bag dispenser bags were numbered on the plastic part of the bag. The 35-bag dispenser was metal, probably aluminum or stainless steel.

48 BAG SET FOR LRV SOIL SAMPLER:

WEIGHT:	**358 g**
DIMENSIONS:	**8 cm cup diameter**
	13 cm cup depth

The 48-bag set of sample bags for the LRV soil sampler were grouped into four batches of 12 each. The sampler accomodated 12 bags at one time.

APOLLO MISSIONS: These bags were used on Apollo 17.

MANUFACTURER: The cup-shaped bags used in the LRV soil sampler (Fig. 80) were manufactured by NASA at Johnson Space Center.

MATERIALS: The cups were made of plastic [teflon?] with aluminum rims [22].

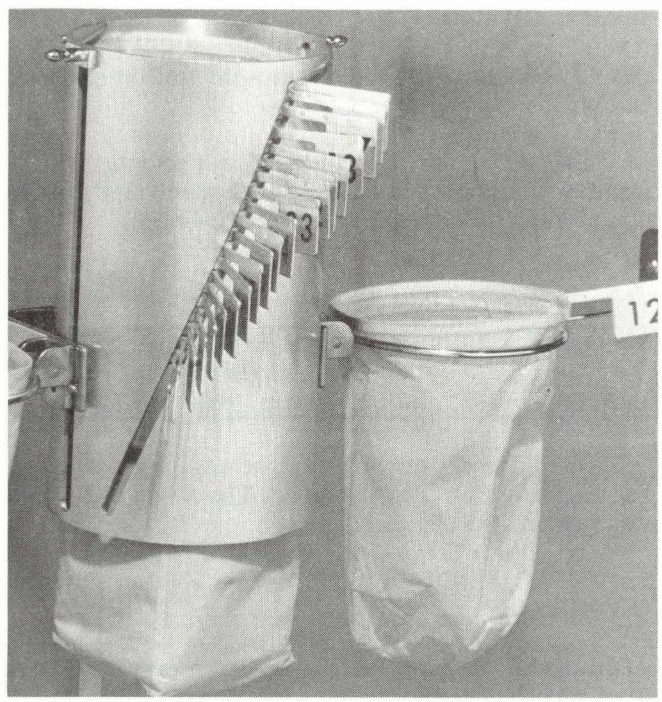

Fig. 79. A proto-type of the 35-bag dispenser for the cup-shaped documented sample bags showing the aluminum band re-inforcing for the top of the bag (NASA photo S68-54935).

* Uel Clanton, personal communication (1989)

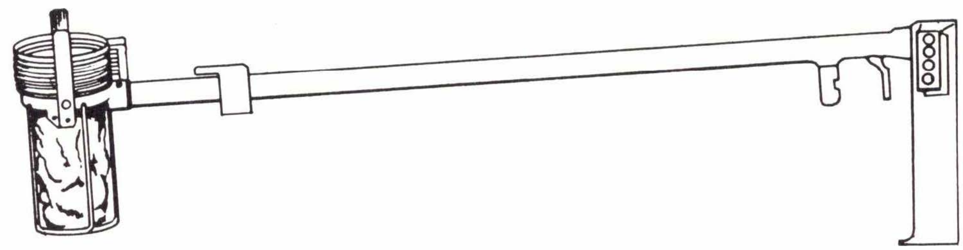

Fig. 80. Cup-shaped documented sample bags were also used in LRV soil sampler on Apollo 17. Drawing from [22].

FLAT, RECTANGULAR DOCUMENTED SAMPLE BAGS

EARLY MISSIONS BAGS:

WEIGHT:	**170 g, 15-bag dispenser**
DIMENSIONS:	**15 x 15 cm, bag size**
	23 cm, length dispenser
	6 cm, diameter dispenser

DIMENSIONS: Dimensions were estimated from Fig. 81.

MANUFACTURER: Probably Union Carbide, Nuclear Division, Oak Ridge, TN

APOLLO MISSIONS: These bags were used on Apollo 12 and 14.

MATERIALS: The bags appeared in photographs to be made of transparent teflon film with aluminum rims for closure tabs. The dispenser was a metal cylinder.

LATER MISSIONS BAGS:

WEIGHT:	**441 g, 20-bag dispenser**
	10.2 g, single bag
DIMENSIONS:	**20 x 19 cm, bag size [22]**

WEIGHT: The bag dispenser weight was the average of 19 bag dispensers used on the moon. The single bag weight was measured for this study.

MANUFACTURER: Union Carbide, Nuclear Division, Oak Ridge, TN

APOLLO MISSIONS: The 20-bag dispensers were used on Apollo 15, 16 and 17.

OPERATION: These documented sample bags were designed to hold an 11-cm diameter rock. Each of the flat bags had a unique number by which to identify the samples placed inside. Two tabs were attached to the top center of each bag. One tab attached the bag to the dispenser and tore away when the astronaut pulled the other tab. This process also caused the bag to be opened. After the sample was placed inside the top was rolled down and the aluminum tabs folded over to secure the rolled configuration.

MATERIALS: The teflon bags had an aluminum rim for a closure tab. The dispenser was made of teflon with aluminum mounting bracket.

Fig. 81. The flat, rectangular documented sample bags used on the early missions are visible protruding from their cylindrical dispenser in the left side of the rock box (NASA photo S70-52550).

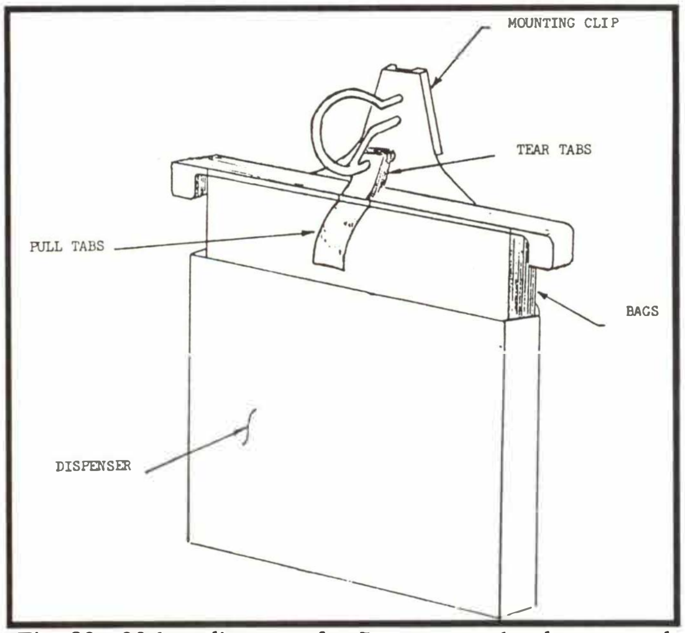

Fig. 82. 20-bag dispenser for flat, rectangular documented sample bags used on Apollo 15, 16 and 17. Diagram was taken from [15].

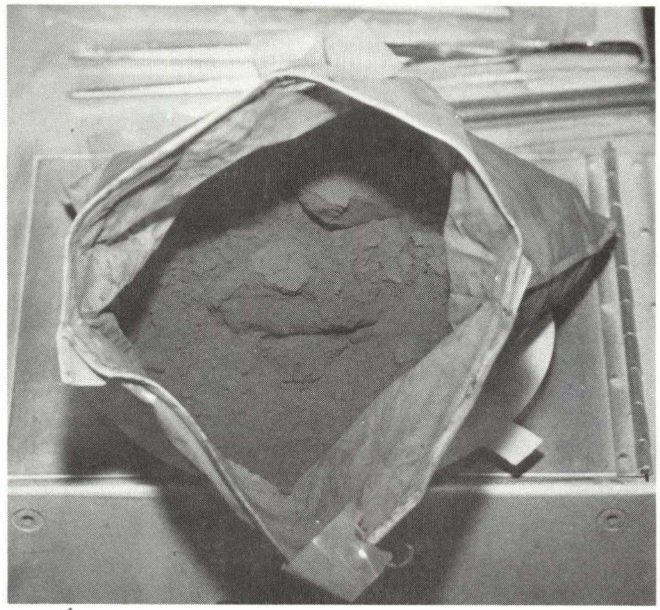

Fig. 83. Flat, rectangular documented sample bag opened in laboratory to show Apollo 17 soil 74220, weighing 1180 g. The aluminum rim holds the bag open (NASA photo S73-15561). S73-15061

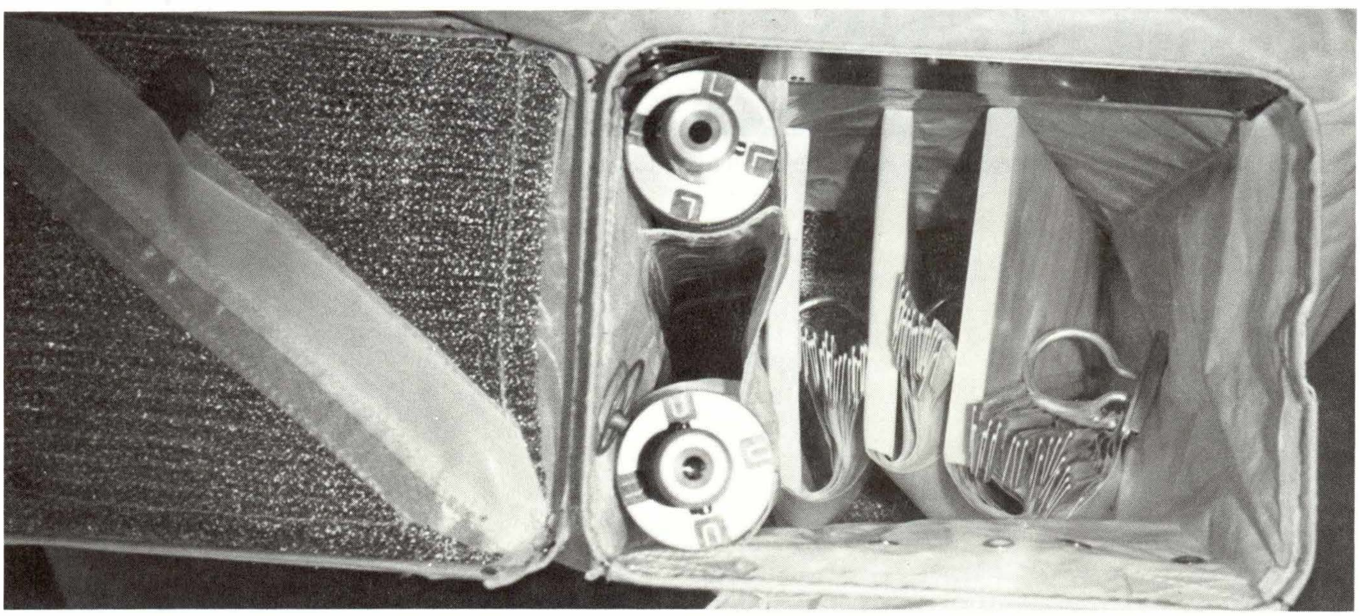

Fig. 84. Three 20-bag dispensers packed inside of a Sample Collection Bag prior to a flight (NASA photo S88-52669 taken from Union Carbide photo no. 143401).

Fig. 85. Apollo 16 astronaut examines large boulder with a 20-bag dispenser attached to his right wrist (NASA photo AS16-116-18649).

Fig. 86. Gas Analysis Sample Container (GASC). The knife-edge on the can and indium alloy sealing surface on the lid are visible (NASA photo S88-52660 taken from Union Carbide photo no. 121372).

WEIGHT:	**160 - 250 g**
DIMENSIONS:	**9.5 cm overall length**
	3.8 cm outside diameter

SYNONYMS: GASC

WEIGHT: Weight of 3 GASC's: 159, 173, 247 g. Reason for differences is not known.

DIMENSIONS: Overall length of 9.5 cm was measured for this study. The height of the can was 6.4 cm, the inside diameter was 3.7 cm, and the wall-thickness was 0.3 mm.

CAPACITY: 69 cm^3

MANUFACTURER: Union Carbide, Nuclear Division, Oak Ridge, TN

USE: The GASC (Fig. 86) was a reliable vacuum sealed container used for holding a small amount of lunar soil within a larger volume. Upon return to Earth the thin-walled bottom of the container was punctured to analyze the lunar atmosphere.*

OPERATION: The Gas Analysis Sample Container was a smaller version of the Special Environmental Sample Container and was operated in a similar manner (see section on SESC).

APOLLO MISSIONS: GASC's were used only on Apollo 11 and 12.

MATERIALS: The can and the lid were made from 304L stainless steel. The metal sealing surface was an alloy of 90% indium and 10% silver. The seal protectors were teflon.

* D. D. Bogard, personal communication (1989)

WEIGHT:	**467 g**
DIMENSIONS:	**?**

Little documentation about the Lunar Environment Sample Container was discovered in this study. One LESC was packed into Apollo Lunar Sample Return Container # 1008 for Apollo 12. The 467 g weight given above was from the packing list for that ALSRC. One 269 g sample was returned from the moon in the LESC [41].

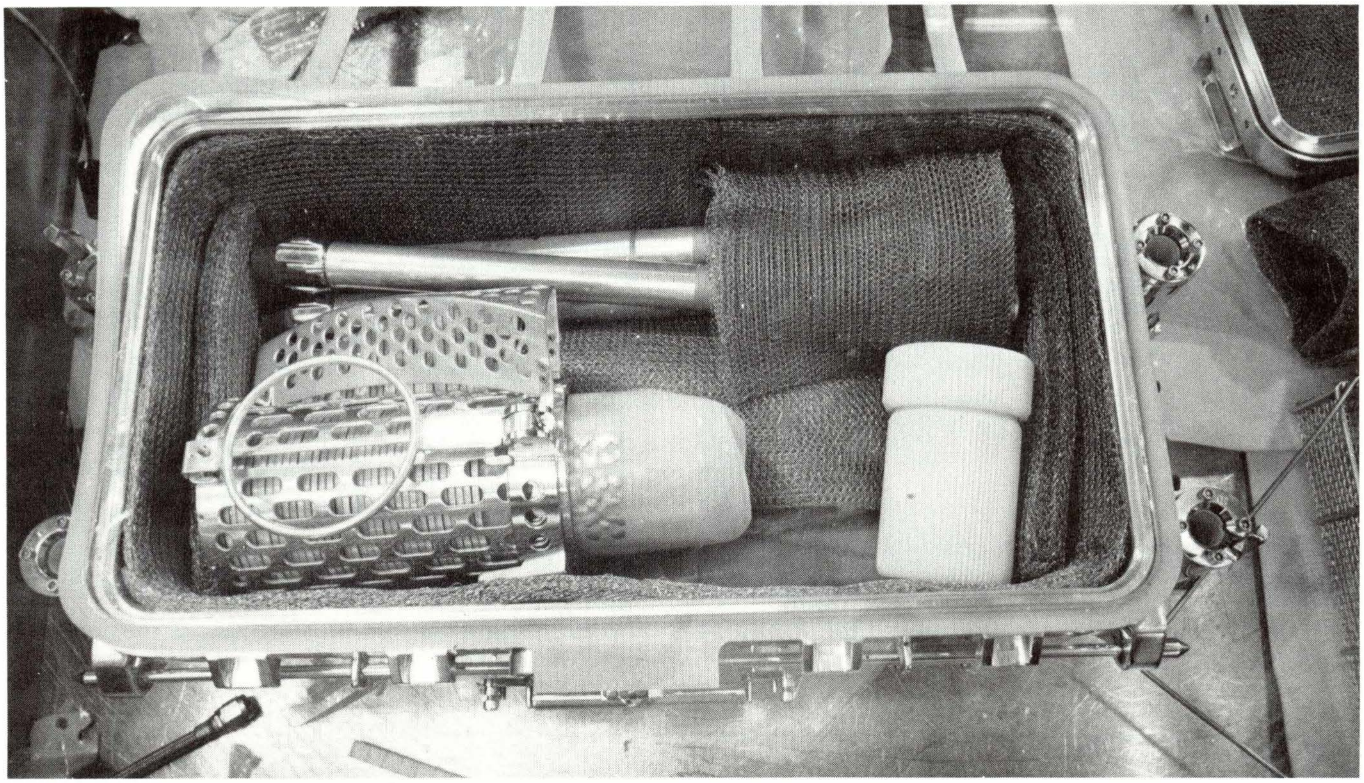

Fig. 87. Apollo 14 ALSRC packed for flight with round documented sample bags, 2-cm diameter core tubes and Magnetic Shield Sample Container (MSSC). The white cylinder is believed to be the MSSC because it is approximately the correct size and all of the other objects have been identified (NASA photo S70-29817).

WEIGHT:	**440 g**
DIMENSIONS:	**5 cm internal diameter**
	10 cm internal depth

SYNONYMS: MSSC

DIMENSIONS: Outer dimensions were not determined in this study.

USE: The magnetic shielding experiment resulted from concern that magnetic fields in the space and spaceraft environment were influencing magnetic characteristics of lunar rocks. Two residual magnetic rock samples, both a microbreccia and a crystalline rock, were to be collected near the end of the Apollo 14 mission and placed in the Magnetic Shield Sample Container. The shielding characteristics of the container and the radiation environment of the stowage location in the spacecraft were to be documented [42].

APOLLO MISSIONS: The MSSC (Fig. 87) was flown on Apollo 14, but the voice transcript and the catalog of returned samples do not record that the sample was ever taken.

MANUFACTURER: Union Carbide, Nuclear Division (?)

MATERIALS: LSAPT* minutes (1970) indicate a concern that iron, nickel and molybdenum in the inner container might contaminate other lunar samples. The outer container, in Fig. 87, appears to be teflon (the identity of the MSSC in that picture was by approximate size and elimination of other objects in photo).

* Lunar Sample Analysis and Planning Team (LSAPT) was the standing committee that reviewed and recommended policy on curation and analysis of lunar samples.

Fig. 88. Organic Sample Monitor packed for Apollo 14 flight (NASA photo S70-18751).

Fig. 89. Organic Sample Monitor packed for Apollo 15 flight (NASA photo S71-36040).

WEIGHT:	**78 g**
DIMENSIONS:	**42 cm bag length**
	12 cm bag width

WEIGHT: The weight included the teflon bag with the metal mesh inside.

MANUFACTURER: Union Carbide, Nuclear Division, Oak Ridge, TN

USE: An organic sample monitor (Figs. 88-89) consisted of a teflon bag with rolls of very clean aluminum metal mesh inside. These bags were packed inside of the Apollo Lunar Sample Return Containers. Upon return to Earth, the mesh samples were distributed to investigators for use as a "blank" or background measurement for organic compounds. While these organic monitors served to evaluate contamination of the samples from the spacecraft and the astronauts, they were not useful for evaluating contamination from the descent engine exhaust because they were enclosed in the ALSRCs during the lunar landing procedure.*

APOLLO MISSIONS: Organic sample monitor were used on missions 12, 14, 15, 16 and 17.

MATERIALS: The bags were made of teflon film and had aluminum tabs end closures. The rolls of metal mesh were aluminum.*

* M. A. Reynolds, personal communication (1988)

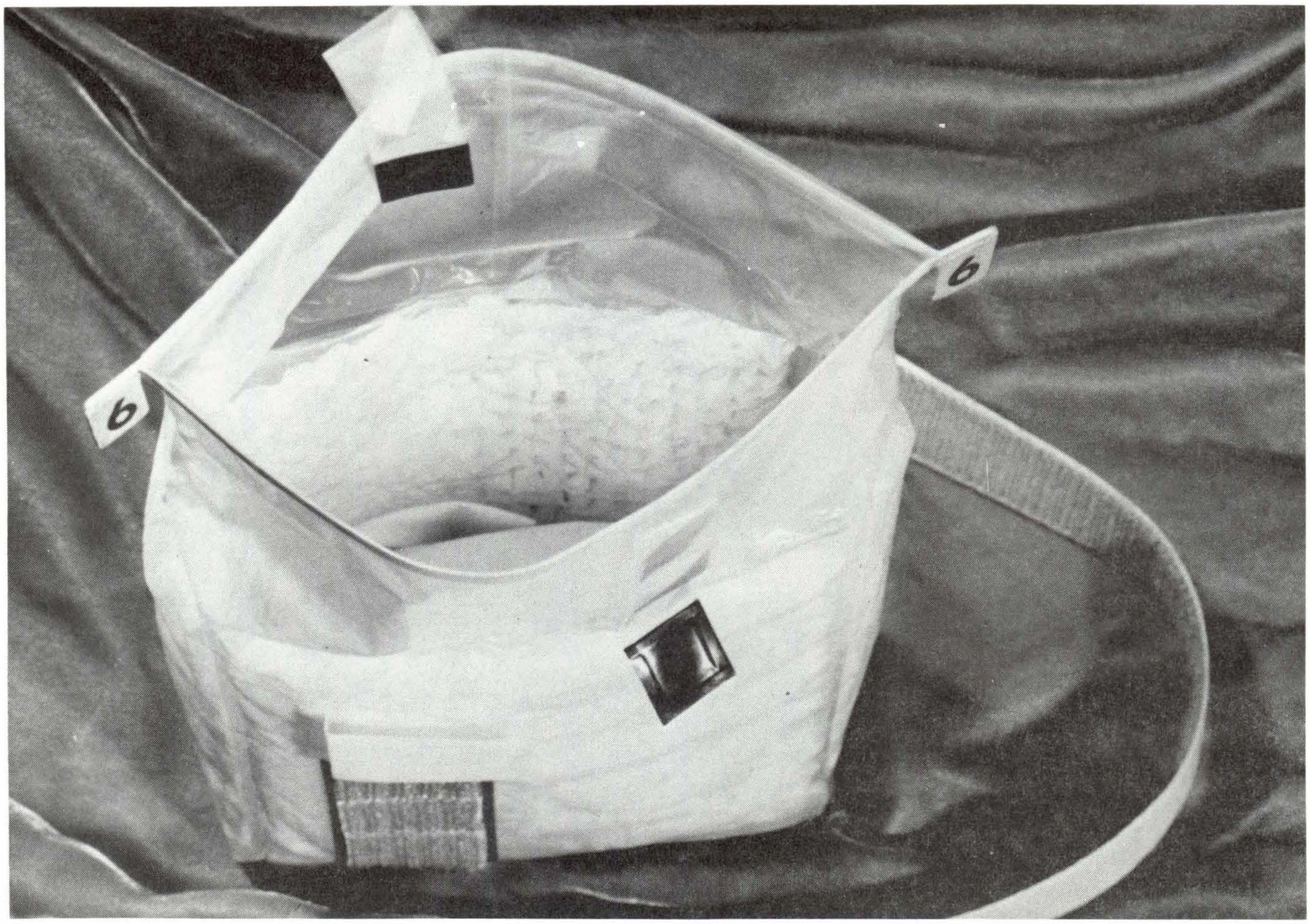

Fig. 90. Protective Padded Sample Bag (NASA photo S72-43790).

WEIGHT:	**220 g**
DIMENSIONS:	**21 cm overall length**
	15 x 14 x 5 cm, padded volume

WEIGHT: A typical Protective Padded Sample Bag was weighed for this study.

DIMENSIONS: The padded volume formed a box of 15 x 14 x 5 cm (Fig. 90). A flap with an aluminum closure tab extended an additional 6 cm from the 15 cm dimension.

MANUFACTURER: Union Carbide, Nuclear Division, Oak Ridge, TN

USE: The padded bags were used to cushion fragile rocks and prevent rock surfaces from being abraded.

APOLLO MISSIONS: Two Protective Padded Sample Bags were used on Apollo 16.

MATERIALS: The typical PPSB examined for this study appeared to be made of teflon film with an aluminum tab closure. The padded portion was knitted from flat, white teflon (?) ribbon 3mm wide. The pads were completely enclosed by film teflon. After the aluminum tab was rolled down and secured the bag, a velcro strap further insured that the bag would not come open.

Fig. 91. Apollo 12 astronaut holds Special Environmental Sample Container (SESC) full of soil. The seal protectors have been removed and the container is ready to be closed (NASA photo AS12-49-7278).

WEIGHT:	**360 g**
DIMENSIONS:	**21 cm overall height**
	6.1 cm outer diameter

SYNONYMNS: SESC

DIMENSIONS: The overall height, from top of the handle to the bottom of the grip was 21 cm, and the outer diameter of the can was 6.1 cm. The can, without the lid, was 12.7 cm tall with an inside diameter of 6 cm and a wall thickness of 0.5 mm.

CAPACITY: 360 cm^3

MANUFACTURER: Union Carbide, Nuclear Division, Oak Ridge, TN

USE: The SESC (Figs. 91-94) provided a knife-edge seal into metal to insure that the sample inside was not exposed to terrestrial atmosphere or spacecraft cabin gases.

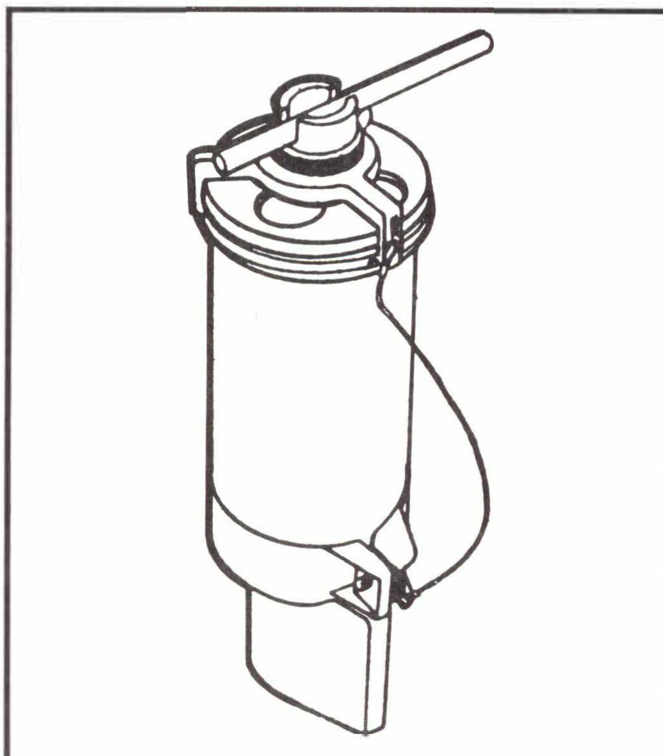

Fig. 92. Special Environmental Sample Container (drawing from [35]).

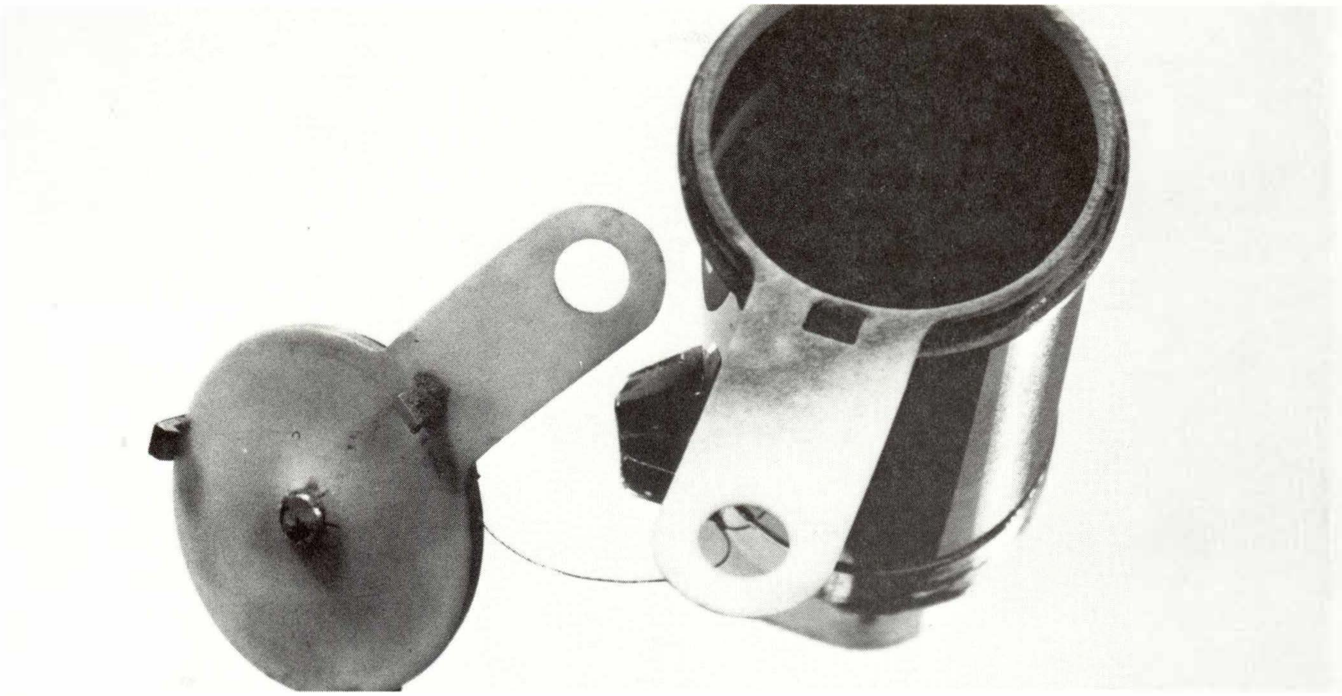

Fig. 93. SESC, with seal protectors in place, after being filled with simulated lunar dust in an experiment to test the ability of the seal protectors to keep the sealing surfaces clean (NASA photo S88-52667, taken from Union Carbide photo no. 137775).

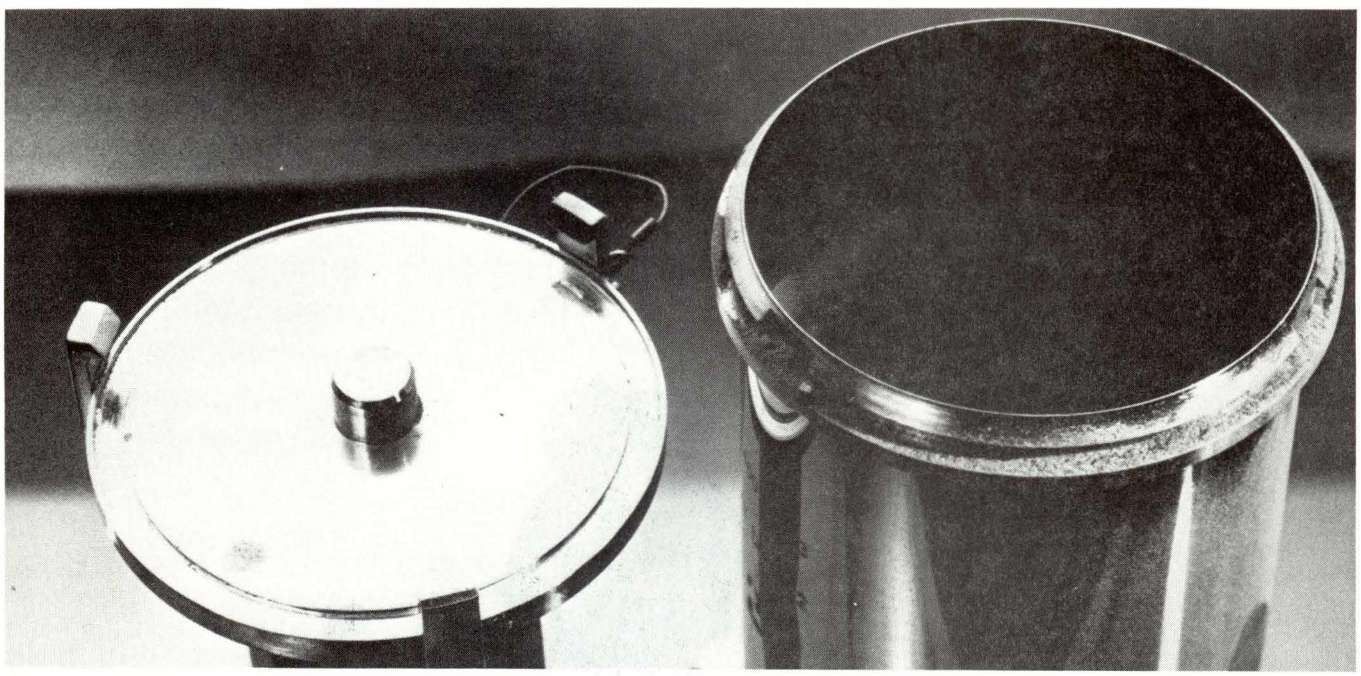

Fig. 94. SESC with seal protectors removed after test (see Fig. 92). Simulated lunar dirt got onto the sealing surfaces in this test (NASA photo S88-52666 taken from Union Carbide photo no. 137774).

OPERATION: Both the knife-edge on the can and the indium alloy on the lid were packed for flight with teflon sheets covering the sealing surfaces to prevent dust from interfering with the seal. After the astronaut filled the container with soil or rocks, he removed these seal protectors and closed the can. A torque handle allowed the lid to be pressed onto the knife-edge of the can lip.

APOLLO MISSIONS: Special Environmental Sample Containers were used on all Apollo missions.

MATERIALS: The SESC can and lid were made from 304L stainless steel. The indium alloy seal in the lid was indium with 10% silver, and the seal protectors were sheet teflon.

E. CONTAINERS USED TO CARRY ROCKS AND SOILS ON THE MOON

Sample Collection Bag (SCB)
Weigh bag

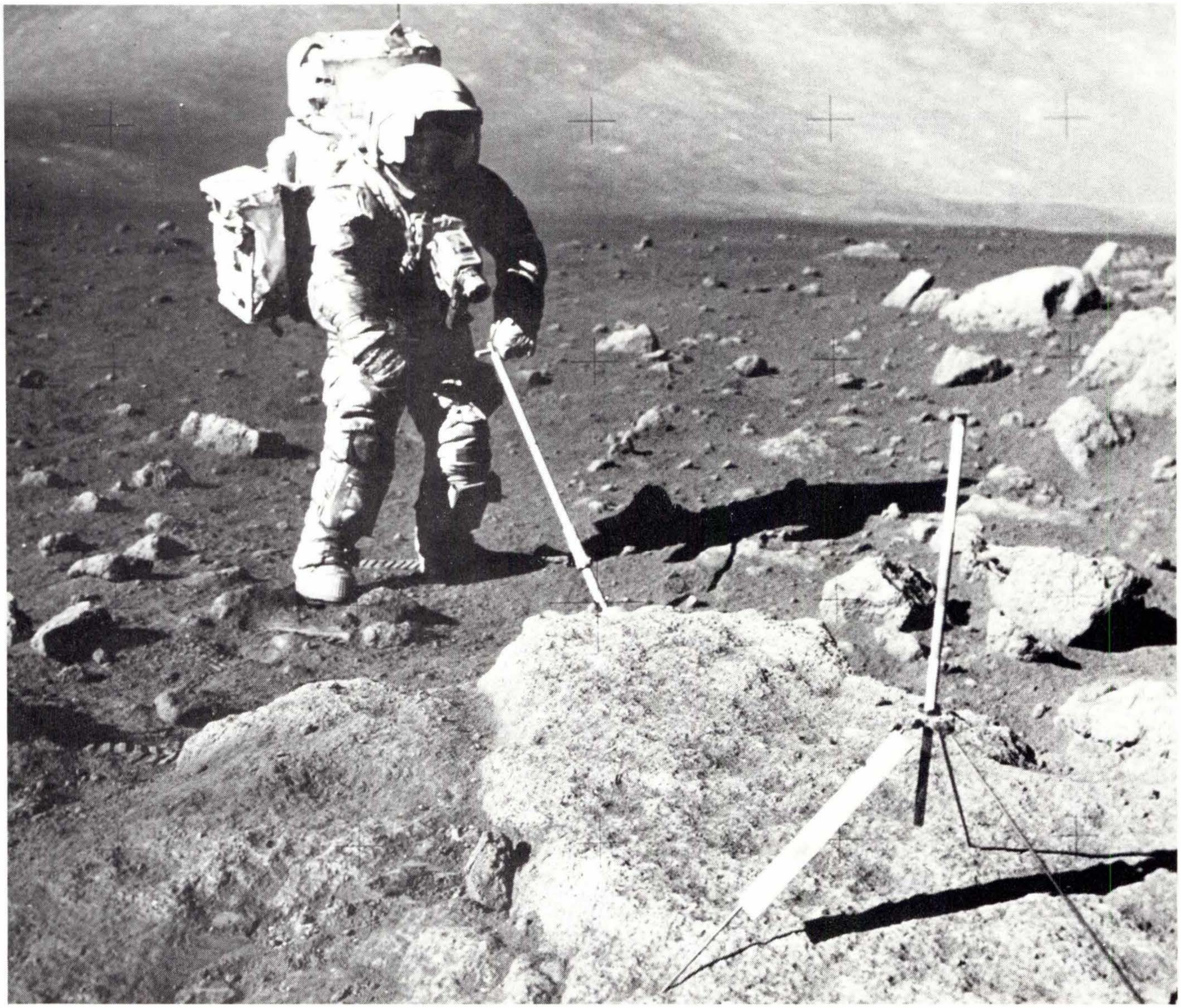

Fig. 95. Apollo 17 astronaut carrying a Sample Collection Bag (NASA photo AS17-145-22157).

Two styles of Sample Collection Bags (SCB) were used on the moon. Both styles of bags were made of the same materials and of the same dimensions; however, the **Sample Collection Bag** (Figs. 95-100) had interior pockets for holding drive tubes, exterior pockets for holding the Special Environmental Sample container and the drive tube cap dispenser and straps to facilitate removal from the Apollo Lunar Sample Return container. The **Extra Sample Collection Bag** (ESCB; Fig. 97) had none of these pockets and, consequently, it weighed less than the Sample Collection Bag.

USE: The Sample Collection Bags replaced the weigh bags from earlier missions. The SCBs were carried by the astronauts on their backpacks or on the rover tool carrier and were used to carry the samples as they were collected. Both loose rocks and samples in Documented Sample Bags as well as drive tube core samples were placed into a Sample Collection Bag or an Extra Sample Collection Bag. The lid on the bag flipped fully open for large samples and drive tubes, but smaller samples were dropped directly into the closed bag through a diagonal slit in the lid. The SCBs and ESCBs exactly filled an Apollo Lunar Sample Return Container; thus, two SCBs containing samples on each mission were sealed inside the ALSRC's for return to Earth. The contents of the remaining SCB/ESCBs were exposed to spacecraft cabin atmosphere and Earth's atmosphere during the return trip.

MANUFACTURER: Union Carbide, Nuclear Division, Oak Ridge, TN (?)

APOLLO MISSIONS: SCB/ESCBs were used on Apollo 15, 16 and 17.

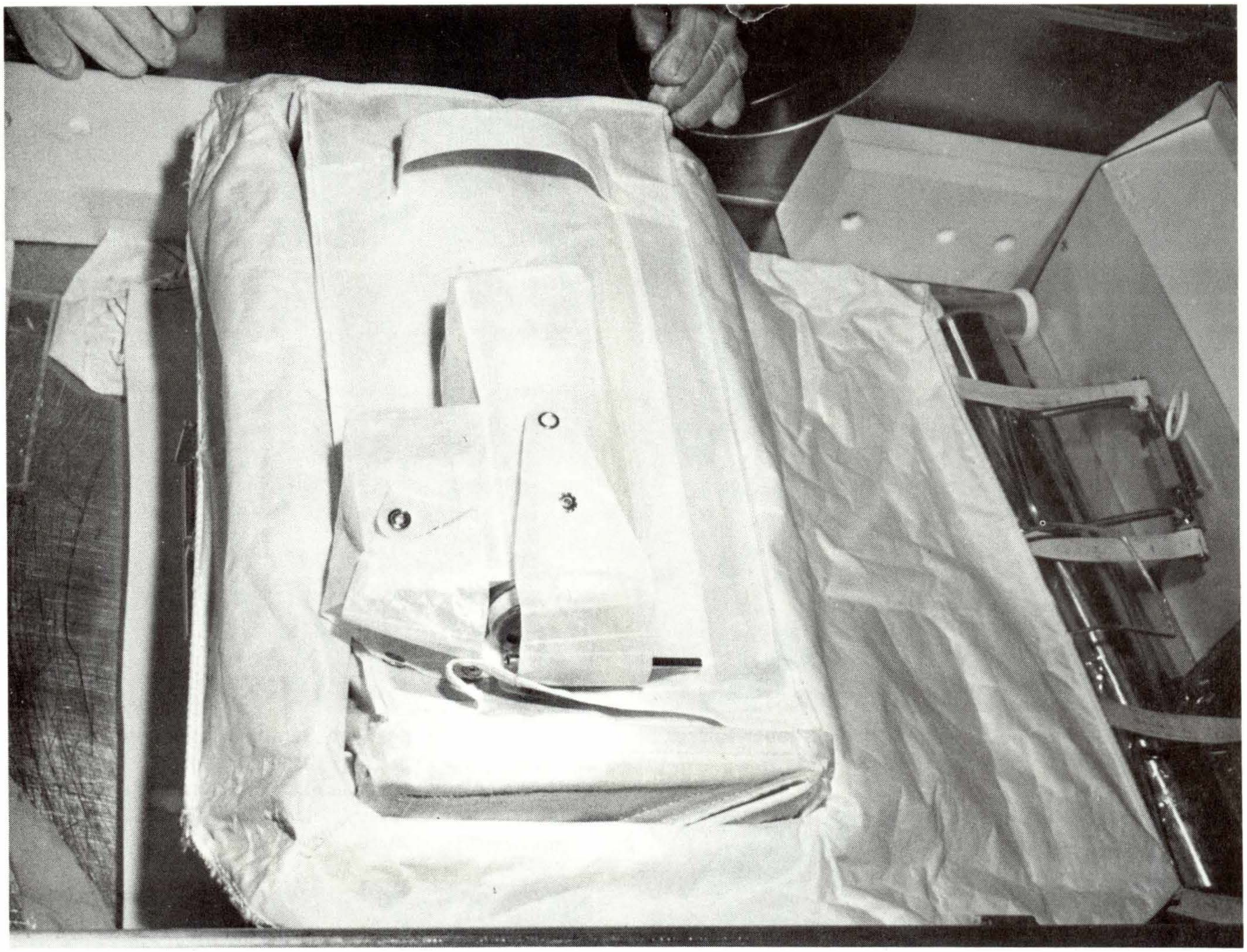

Fig. 96. Sample Collection Bag packed into Apollo Lunar Sample Return Container before the Apollo 15 flight. The edges of the ALSRC are draped with white material similar to that of the SCB. The SCB is lying on its side with the lid toward the viewer. The exterior pockets containing a Special Environmental Sample Container and a drive tube cap dispenser are visible (NASA photo S71-36042).

MATERIALS: A light-weight metal frame gave the bag shape, and metal mesh was used to stiffen the bottom and top of the bag.* The fabric of the bag was a laminate of TFE teflon cloth vulcanized between two sheets of FEP teflon film [22].

SAMPLE COLLECTION BAG

WEIGHT:	762 g
DIMENSIONS:	42 cm high
	22 cm wide
	15 cm deep
CAPACITY:	13869 cm^3

EXTRA SAMPLE COLLECTION BAG

WEIGHT:	557 g
DIMENSIONS:	42 cm high
	22 cm wide
	15 cm deep
CAPACITY:	13869 cm^3

* Observation of typical bag and photographs

Fig. 97. Extra Sample Collection Bag on lunar surface at Apollo 16 site (NASA photo AS16-107-17473).

Fig. 98. Top of closed Sample Collection Bag The fabric texture and the diagonal slit through which samples could be dropped is visible. The white fabric in the background is part of the seal protector for the ALSRC (NASA photo S88-52673).

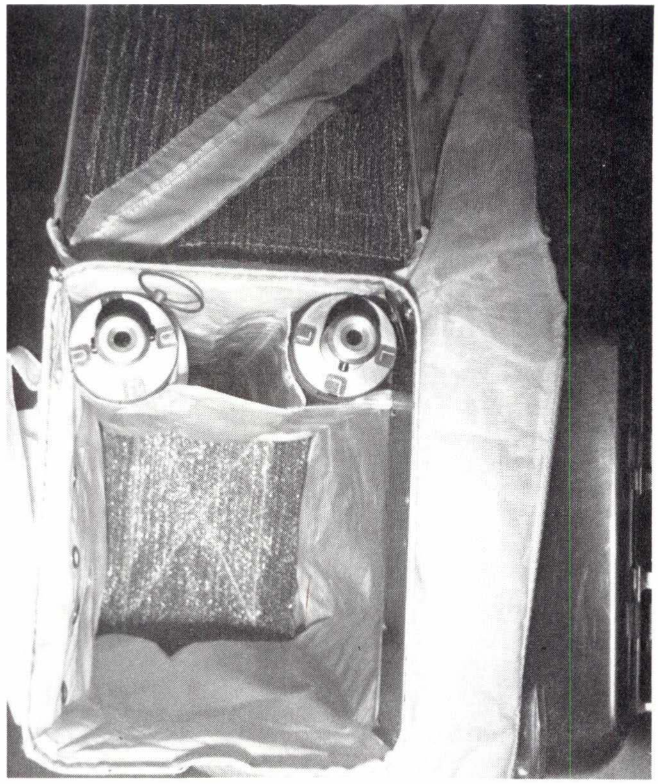

Fig. 99. View into open Sample Collection Bag . Two drive tubes are placed in the interior pockets. The metal mesh stiffener in the lid and in the bottom and the underside of the diagonal slit are visible in the lid (NASA photo S88-52671).

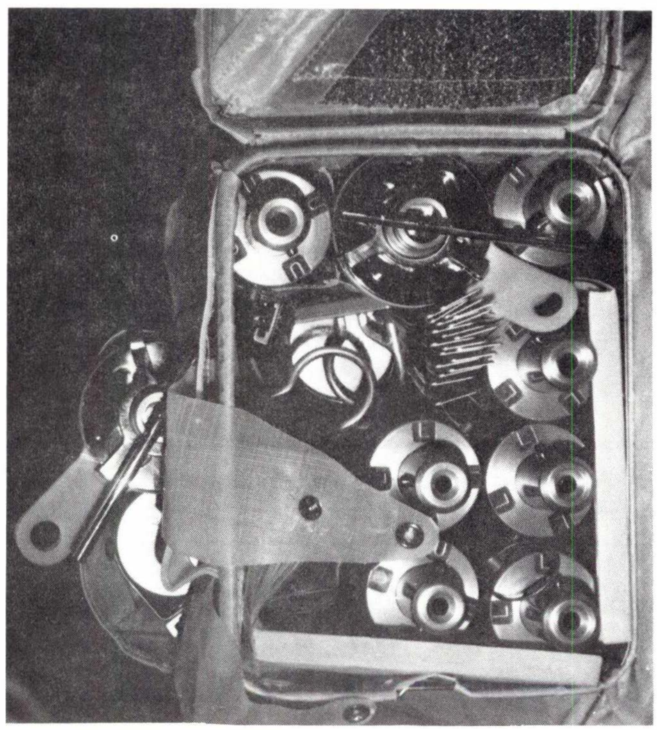

Fig. 100. View into SCB loaded for flight. Seven drive tubes, 2 cap drive tube dispensers, 2 SESCs, and 2 Documented Sample Bag dispensers are visible (NASA photo S88-52662).

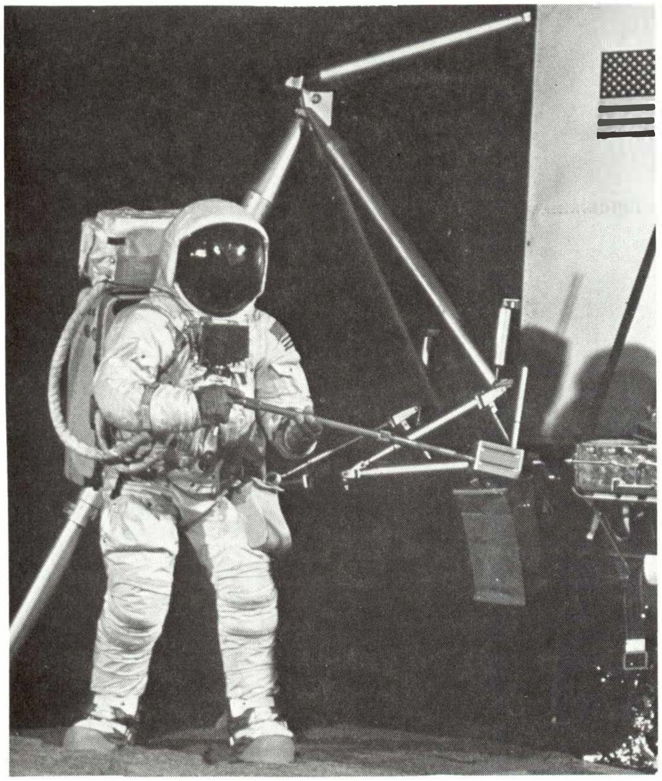

Fig. 101. Space-suited person practices filling a weigh bag with soil using a box-shaped scoop during a simulation of lunar sample collecting activities (NASA photo S69-32248).

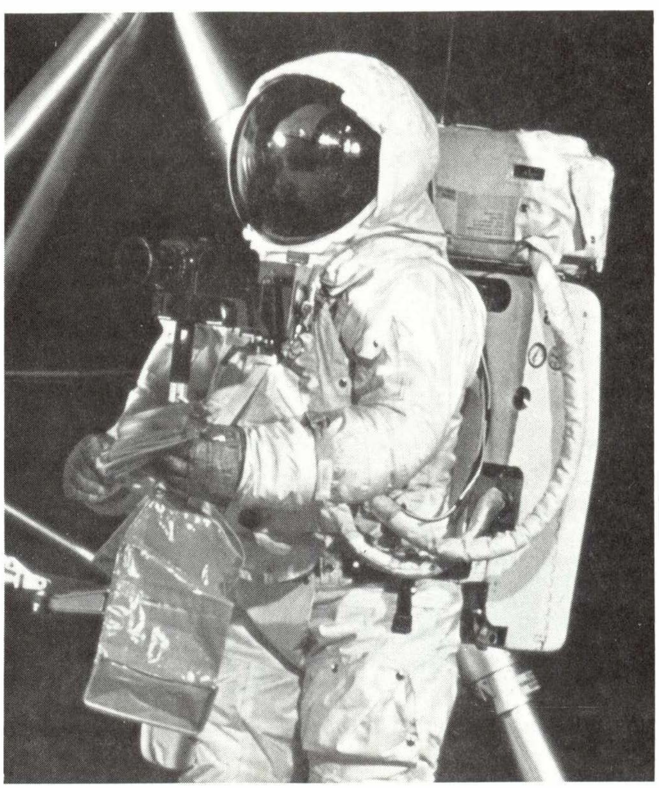

Fig. 102. Empty teflon Weigh Bag is attached to another "astronaut" during the simulated lunar surface activities shown in Fig. 100 (NASA photo S69-32242).

DIMENSIONS:	**42 cm approximate height**
	22 cm approximate width
	15 cm approximate depth

DIMENSIONS: The dimensions given were those of the Sample Collection Bag. The two styles of bags appeared to be of similar dimensions in photographs.

CAPACITY: 14000 cm^3. The estimate of capacity was based on the dimensions taken from Sample Collection Bags.

USE: The weigh bags (Figs. 101-104) were used on the early Apollo missions to hold the rock and soil samples as they were collected. The bags were attached to waist of the space suit or to the lunar module with a tether hook. On Apollo 14 the bags were hooked to the Modularized Equipment Transporter, the two-wheeled cart. Rectangular metal frames shaped the bottom of the bag and formed the opening at the top. Weigh bags full of samples were placed inside of Apollo Lunar Sample Return containers for return to Earth.

MANUFACTURER: Uncertain; may have been Union Carbide, Nuclear Division, Oak Ridge, TN

APOLLO MISSIONS: Weigh bags made from a plastic film were used on Apollo 11 and 12. Apollo 14 weigh bags appeared in photographs to be made from a woven cloth. Sample Collection Bags replaced the weigh bags on later missions.

PLASTIC FILM WEIGH BAGS

WEIGHT:	**136 g, bag**
	70 g, tether hook

MATERIALS: The Apollo 11 and 12 weigh bags were made from teflon film.* Rectangular metal frames gave shape to the top and bottom.

CLOTH WEIGH BAG

WEIGHT:	**276 g, bag**
	77 g, tether hook

MATERIALS: The Apollo 14 weigh bags appear in photographs to be made of a woven cloth, white in color. Rectangular metal frames gave shape to the bags.

* Uel Clanton, personal communication (1989)

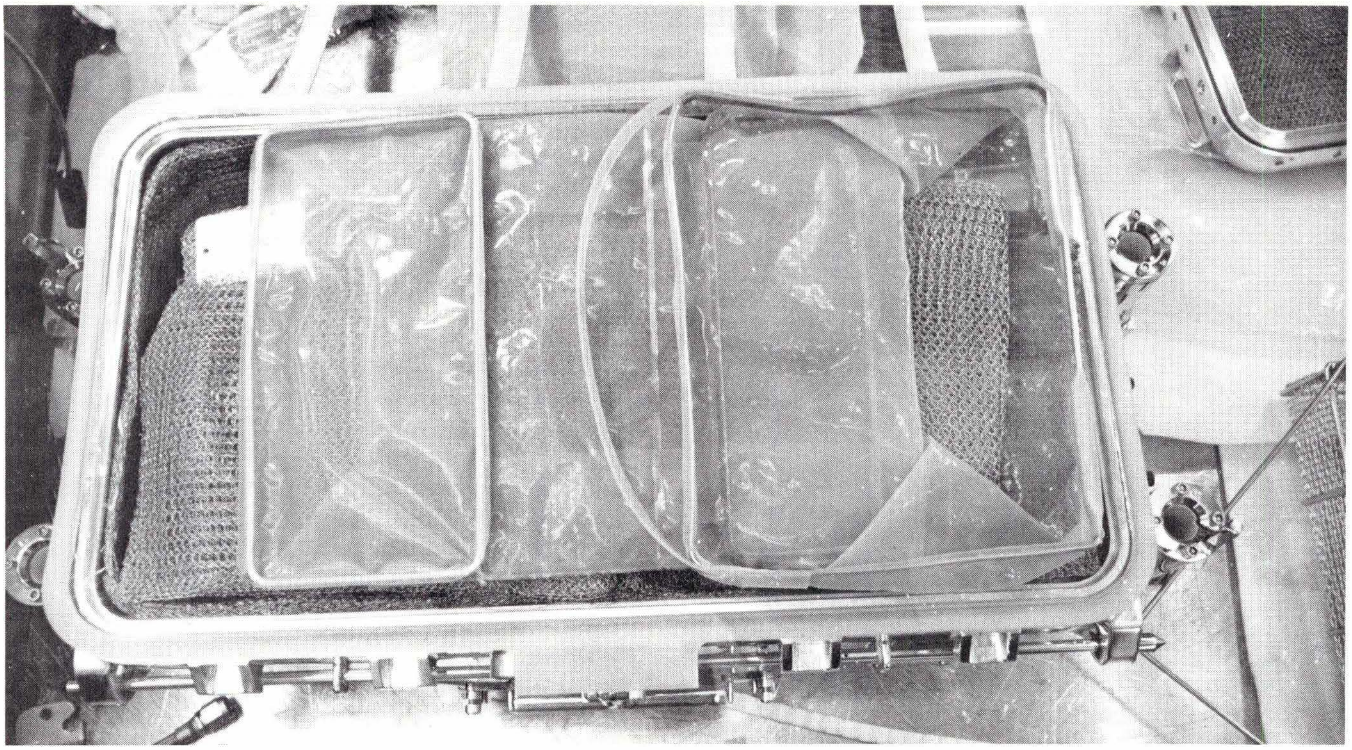

Fig. 103. Weigh bag of the style used on Apollo 11 and 12 packed inside of an Apollo Lunar Sample Return Container. The rectangular metal frames are visible through the plastic film (NASA photo S70-29821).

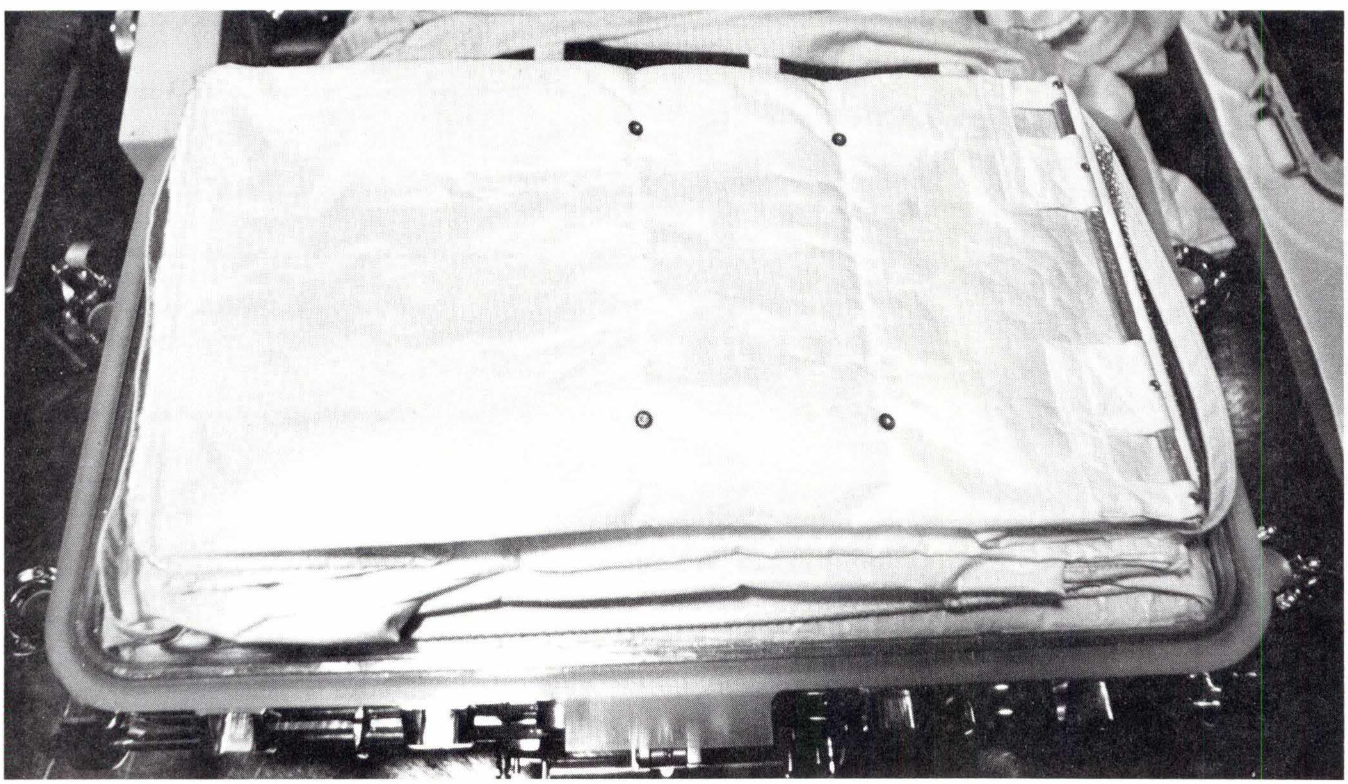

Fig. 104. Weigh bag packed inside of an Apollo 14 Lunar Sample Return Container prior to flight (NASA photo S70-18760).

Weigh Summary for all missions

Apollo 11
Apollo 12
Apollo 14
Apollo 15
Apollo 16
Apollo 17

SUMMARY OF TOOL & CONTAINER WEIGHTS

The six Apollo missions collected 2196 individual samples weighing a total of 381.7 kg. Fifty-eight samples weighing 21.5 kg on Apollo 11 expanded to 741 samples weighing 110.5 kg by the time of Apollo 17. Table 1 shows numbers of samples, weights of samples, average sample weight, and weights of the collection tools and containers for each mission. Since we had no prior experience collecting samples on the moon, the main goal on Apollo 11 was to obtain some lunar material and return it safely to the Earth. As we gained experience, the sampling tools and a more specific sampling strategy evolved. On the later missions, with increased mobility, greater numbers of samples, with smaller average weights, representing more varied locales or conditions were collected. For example, one of the major soil samples from Apollo 11 resulted from placing several scoops full of soil, from a broad area around the lunar module, directly into the rock box. In contrast on Apollo 16, a special device designed to sample the upper mm of soil was used on the shielded side of a boulder to obtain an undisturbed sample weighing less than 2 grams. These trends are illustrated in Figs. 105 and 106. Figure 106 also shows that the collecting tools and containers became more efficient with each mission, since the sample weight increased much faster than the the weight of tools required to collect the samples. The tool and container weight actually decreased on the last mission.

Table 1
Numbers of Lunar Samples, Weights of Lunar Samples and Sampling Tools

MISSION	NUMBER OF SAMPLES	WT. OF SAMPLES, Kg	AVE. WT. OF SAMPLES, Kg	WT. OF TOOLS & CONTAINERS, Kg
11	58	21.555	0.372	22.856
12	69	34.352	0.498	29.172
14	227	42.285	0.186	34.065
15	370	77.311	0.209	50.288
16	731	95.714	0.131	53.029
17	741	110.518	0.149	45.688

Tables 2-7 are lists of tools and containers flown on each mission as verified by the flight stowage lists, the rock box packing lists, the *Sample Information Catalog, Apollo 11*, the *Apollo 14 Voice Transcript* or observed in photographs taken on the lunar surface.

Hammers increased in weight when the head was broadened to facilitate the driving of core tubes. Aluminum box-shaped scoops, steel-bladed small scoops and a trenching tool (shovel with adjustable angle) converged into a single scoop which was capable of all the functions actually needed. This resulting scoop had a steel, covered pan, and the angle of the pan was adjustable. Tongs were lengthened and the tines were strengthened. The rake, added to the later missions, turned out to be very useful. The first large tote bags for carrying samples, called Weigh Bags, were made of teflon film. These evolved into Sample Collection Bags made from teflon cloth laminate and having pockets for special samples. Several styles of small bags for holding individual samples were used on the missions. The most sucessful small bags had aluminum rims with tabs. The rim held the bag open and the tab served as a handle that a space-suited astronaut could grip. The rim and tabs also served as the closure mechanism for the bag.

The greatest need for modification occurred with the core tubes. The initial core tubes were small diameter, thick-walled tubes with a funnel shaped bit for use in fluffy soil. The dense lunar soil did not easily flow into these tubes. The bits were modified for Apollo 12 and 14, and on Apollo 15 completely new core tubes with larger diameter and thinner walls were introduced. These tubes performed well and were used on the remaining missions.

The lens-scriber-brush was apparently never used. In addition, the small scoop and the core tubes were never used as chisels as their designs had permitted.

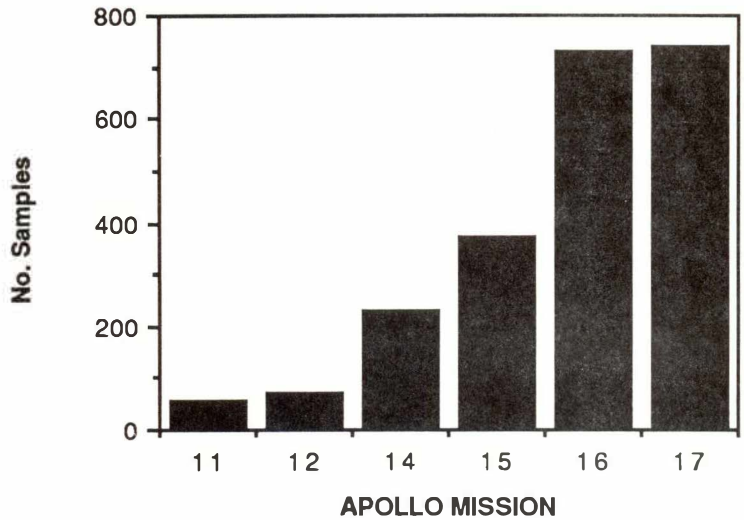

Fig. 105. The number of samples collected on each Apollo mission.

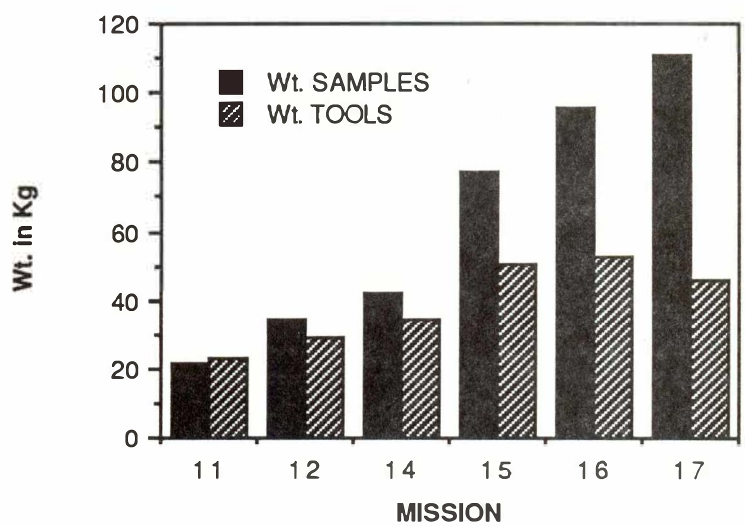

Fig. 106. The weight of samples collected and the weight of the sample collecting tools and containers for each Apollo mission

Table 2.

APOLLO 11

TOOL OR CONTAINER	PART NUMBER	SERIAL NO.	WEIGHT (g)	
Bag, Documented Sample, Flat, Rectangular-shape		16	9.0	
Bag, Documented Sample, Flat, Rectangular-shape		18	9.0	
Bag, Documented Sample, Flat, Rectangular-shape		19	9.0	
Bag, Documented Sample, Flat, Rectangular-shape		20	9.0	
Bag, Documented Sample, Flat, Rectangular-shape	M-11306-EM-020-E	1005	117.0	
Bag, Documented Sample, Flat, Rectangular-shape		17	9.0	
Bag, Weigh	M-10543-EM-001-E	1003	125.0	
Bag, Weigh	M-10543-RM-001-E	1003	141.0	
Bag, Weigh, tether hook	SEB33100200-307	1107	91.0	
Container, Apollo Lunar Sample Return (ALSRC) aluminum mesh packing material			2930.0	
Container, Apollo Lunar Sample Return (ALSRC)	EM-64416/2	1003	5897.0	
Container, Apollo Lunar Sample Return (ALSRC)	EM-64416/2	1004	5897.0	
Container, Apollo Lunar Sample Return (ALSRC) aluminum mesh packing material			2926.0	
Container, Contingency Sample, Soft	M11329-EK-004-D-04*		1180.0	*
Container, Gas Analysis Sample (GASC)	DM-40020-L	1002	159.0	
Container, Special Environment Sample (SESC)	DM-40021-K	1004	376.0	
Drive Tube, 2-cm Diameter	SEB39100375-204	2007	236.5	
Drive Tube, 2-cm Diameter	SEB39100375-206	2008	236.5	
Extension Handle, Short	SEB39100314*		590.0	*
Hammer, Light-weight	SEB39100319*		860.0	*
Scale, Sample	SEB39104275-303	1002	499.0	
Scoop, Box-shape	SEB39103122*		410.0	*
Tongs, Small	SEB39100340*		140.0	*
TOTAL WEIGHT for APOLLO 11			22856.0	grams

* Part weight and/or part number was taken from a typical tool or container. The information is not specific to flight hardware for this mission.

Table 3.

APOLLO 12

TOOL OR CONTAINER	PART NUMBER	SERIAL NO.	WEIGHT (g)	
Bag, Documented Sample		1004	713.4	
Bag, Documented Sample, Flat, Rectangular-shape		1008	170.8	
Bag, Documented Sample, Flat, Rectangular-shape	11306-EM-020-00		170.8	
Bag, Documented Sample, Flat, Rectangular-shape		1003	170.8	
Bag, Organic Sample Monitor	10543-RM-015-00		90.2	
Bag, Organic Sample Monitor			101.9	
Bag, Weigh, tether hook		2067	69.0	*
Bag, Weigh	M-10543-RM-001-02	1002	135.9	
Bag,Weigh		1003	132.9	
Bag, Weigh	M-10543-RM-001-02	1001	136.8	
Bag, Weigh		1004	132.9	
Bag, Weigh	M10543RM001-02		140.0	
Bag, Weigh	M10543RM001-02		140.0	
Container, Apollo Lunar Sample Return (ALSRC)	EM-64416/2-02	1009	7200.0	
Container, Apollo Lunar Sample Return (ALSRC)	EM-64416/2-01	1008	7756.0	
Container, Apollo Lunar Sample Return (ALSRC), aluminum mesh packing material			199.0	
Container, Apollo Lunar Sample Return (ALSRC), aluminum mesh packing material			930.9	
Container, Contingency Sample, Soft	M11329-EK-004-D-04		1180.0	
Container, Gas Analysis Sample (GASC)	DM-40020	1005	246.7	
Container, Lunar Environment Sample (LESC)		1011	468.8	
Container, Special Environment Sample (SESC)	D-M-40021-01		360.0	
Drive Tube, 2-cm Diameter, cap	SDB39100378-002		33.8	
Drive Tube, 2-cm Diameter	SEB39100375	2010	272.2	
Drive Tube, 2-cm Diameter	SEB39100375-210	2011	272.3	
Drive Tube, 2-cm Diameter	SEB39100375	2012	271.2	
Drive Tube, 2-cm Diameter, cap & bracket assembly		2004	315.2	
Drive Tube, 2-cm Diameter	SEB39100375-209	2031	272.8	
Extension Handle, Short	SEB39100314-206		590.0	
Gnomon	SEB39100317-202		227.0	
Hammer, Light-weight	SEB39100319-203		860.0	
Scale, Sample	SEB39104275-303		498.0	
Scoop, Box-shape	SEB39103122-301		410.0	
Scoop, small	SEB39100310*		163.0	*
Tongs, Small	SEB39100340-203		140.0	
Tool Carrier, Small	SGB39101165*		4200.0	*
TOTAL WEIGHT for APOLLO 12			29172.3	grams

* Part weight and/or part number was taken from a typical tool or container. The information is not specific to flight hardware for this mission.

Table 4.

APOLLO 14

TOOL OR CONTAINER	PART NUMBER	SERIAL NO.	WEIGHT (g)
Bag, Documented Sample, Cup-shape		1006	713.4
Bag, Documented Sample, Cup-shape, 35 bag dispenser		1005	710.8
Bag, Documented Sample, Flat, Rectangular-shape 15 bag dispenser		1006	162.3
Bag, Organic Sample Monitor		1007	89.0
Bag, Organic Sample Monitor		1005	89.0
Bag, Weigh, aluminum mesh		1032	37.6
Bag, Weigh		1029	274.6
Bag, Weigh, aluminum mesh		1028	37.7
Bag, Weigh	M10543RM001-04		272.0
Bag, Weigh + tether hook		1032	354.1
Bag, Weigh		1028	281.1
Bag, Weigh, aluminum mesh		1031	36.6
Bag, Weigh		1031	276.4
Bag, Weigh, aluminum mesh		1029	37.4
Bag, Weigh		1027	271.9
Bag, Weigh, tether hook		2064	75.2
Bag, Weigh, tether hook		2066	69.0
Bag, Weigh		1032	280.2
Bag, Weigh + tether hook			350.7
Bag, Weigh, aluminum mesh		1027	37.6
Container, Apollo Lunar Sample Return (ALSRC), aluminum mesh packing material		55.6	
Container, Apollo Lunar Sample Return (ALSRC)	EM64416/2-03	1007	7337.2
Container, Apollo Lunar Sample Return (ALSRC), accessories		1006	410.5
Container, Apollo Lunar Sample Return (ALSRC)	EM64416/2-03	1006	7285.0
Container, Apollo Lunar Sample Return (ALSRC), aluminum mesh packing material			55.8
Container, Apollo Lunar Sample Return (ALSRC), accessories			357.4
Container, Contingency Sample, Soft	M11329-EK-004-D-05		1180.0
Container, Magnetic Shield Sample (MSSC)	10550-RM-001-01	1003	441.5
Container, Special Environment Sample (SESC)		1016	349.4
Container, Special Environment Sample (SESC), shroud			65.7
Container, Special Environment Sample (SESC) shroud			79.1
Container, Special Environment Sample (SESC), shroud			67.3
Container, Special Environment Sample (SESC)		1017	349.8
Container, Special Environment Sample (SESC)		1013	355.6
Drive Tube, 2-cm Diameter		2022	277.3
Drive Tube, 2-cm Diameter		2043	294.1
Drive Tube, 2-cm Diameter, cap & bracket assembly		2007	168.8
Drive Tube, 2-cm Diameter cap & bracket assembly		2009	311.0
Drive Tube, 2-cm Diameter		2023	275.5
Drive Tube, 2-cm Diameter		2024	276.2
Drive Tube, 2-cm Diameter		2044	297.0
Drive Tube, 2-cm Diameter		2045	295.6
Extension Handle, Long	SEB39105248-302		770.0

continued next page

Apollo 14 continued

TOOL OR CONTAINER	PART NUMBER	SERIAL NO.	WEIGHT (g)	
Gnomon	SEB39100317-202		227.0	
Hammer, Heavy-weight	SEB39100319-206		1225.0	
Lens-scriber-brush	SEB39100406*		208.0	*
Scale, Sample	SEB39105200-301		227.0	
Scoop, Box-shape	SEB39103122-301		408.0	
Scoop, Small	SEB39100310*		163.0	*
Tongs, Small	SEB39100340-203		140.0	
Tongs, Small	SEB39100340-203		140.0	
Tool Carrier, Small	SGB39101165*		4200.0	*
Trenching Tool	SEB39106130-302		1315.0	
TOTAL WEIGHT for APOLLO 14			34065.0	grams

* Part weight and/or part number was taken from a typical tool or container. The information is not specific to flight hardware from this mission.

Table 4.

APOLLO 15

TOOL OR CONTAINER	PART NUMBER	SERIAL NO.	WEIGHT (g)
Bag, Documented Sample, Flat, Rectangular-shape 20 bag dispenser		1003	439.4
Bag, Documented Sample, Flat, Rectangular-shape 20 bag dispenser		1002	436.4
Bag, Documented Sample, Flat, Rectangular-shape 20 bag dispenser		1005	443.0
Bag, Documented Sample, Flat, Rectangular-shape 20 bag dispenser		1004	443.0
Bag, Documented Sample, Flat, Rectangular-shape 20 bag dispenser		1001	447.1
Bag, Documented Sample, Flat, Rectangular-shape 20 bag dispenser		1006	435.0
Bag, Extra Sample Collection	M10543RM004-03		544.3
Bag, Extra Sample Collection	M10543RM004-03		544.3
Bag, Extra Sample Collection	M10543RM004-03		544.3
Bag, Extra Sample Collection	M10543RM004-03		544.3
Bag, Organic Sample Monitor		1017	67.1
Bag, Organic Sample Monitor		1018	66.3
Bag, Sample Collection	M10543RM004-04	SCB 1	763.8
Bag, Sample Collection	M10543RM004-04	SCB 5	760.1
Container, Apollo Lunar Sample Return (ALSRC)	EM64416/2-05	1012	6438.7
Container, Apollo Lunar Sample Return (ALSRC), cloth teflon wrap			55.0
Container, Apollo Lunar Sample Return (ALSRC), accessories			478.3
Container, Apollo Lunar Sample Return (ALSRC)	EM64416/2-05	1011	6490.0
Container, Apollo Lunar Sample Return (ALSRC), accessories			404.7
Container, Contingency Sample, Soft	M11329-EK-004-D-06		1224.7
Container, Special Environment Sample (SESC)		1018	356.0
Container, Special Environment Sample (SESC)		1012	355.0
Container, Special Environment Sample (SESC), teflon shroud			37.2
Container, Special Environment Sample (SESC)		1015	349.6
Drill System (ALSD)	467A8060000-099		11703.0
Drill, Stem, cap rack assembly		003	60.8
Drill, Stem + Bit		027	228.3
Drill, Stem		020	198.9
Drill, Stem		010	195.5
Drill, Stem, cap rack assembly		003	57.7
Drill, Stem		022	199.8
Drill, Stem		023	199.4
Drill, Stem		011	196.4
Drive Tube, 4-cm Diameter		2012	292.2
Drive Tube, 4-cm Diameter		2007	280.3
Drive Tube, 4-cm Diameter, teflon shroud			37.0
Drive Tube, 4-cm Diameter		2005	277.0
Drive Tube, 4-cm Diameter		2009	277.6
Drive Tube, 4-cm Diameter		2014	296.2
Drive Tube, 4-cm Diameter		2003	278.3
Drive Tube, 4-cm Diameter		2008	293.1
Drive Tube, 4-cm Diameter, cap & bracket assembly		2009	116.5
Drive Tube, 4-cm Diameter		2004	292.5
Drive Tube, 4-cm Diameter, cap & bracket assembly		2010	116.3

continued next page

Apollo 15 continued

TOOL OR CONTAINER	PART NUMBER	SERIAL NO.	WEIGHT (g)
Drive Tube, 4-cm Diameter		2010	295.0
Drive Tube, 4-cm Diameter, cap & bracket assembly		2011	116.5
Extension Handle, Long	SEB39105248-306		816.0
Gnomon	SEB39100317-302		272.0
Hammer, Heavy-weight	SEB39100319-301		0.0
Rake	SEB39106380-303		1497.0
Scale, Sample	SEB39105200-302		227.0
Scoop, Small Adjustable	SEB39105725-301		0.0
Tongs, 32-inch	SEB39106245-301		454.0
Tongs, 32-inch	SEB39106245-301		454.0
Tool Carrier, Large	SGB39105801-402		7893.0 #
TOTAL WEIGHT for APOLLO 15			50288.9

The weight of the tool carrier, from the Flight Stowage List, probably included the weight of the scoop and hammer, each of which was listed as 0.0 gram weight.

Table 6.

APOLLO 16

TOOL OR CONTAINER	PART NUMBER	SERIAL NO.	WEIGHT (g)
Bag, Documented Sample, Flat, Rectangular-shape, 20 bag dispenser	11306-EM-030-00	1015	440.4
Bag, Documented Sample, Flat,Rectangular-shape, 20 bag dispenser	11306-EM-030-00	1016	434.9
Bag, Documented Sample, Flat, Rectangular-shape, 20 bag dispenser	11306-EM-030-00	1013	438.6
Bag, Documented Sample, Flat, Rectangular-shape, 20 bag dispenser	11306-EM-030-00	1007	444.1
Bag, Documented Sample, Flat, Rectangular-shape, 20 bag dispenser	11306-EM-030-00	1018	436.7
Bag, Documented Sample, Flat, Rectangular-shape, 20 bag dispenser	11306-EM-030-00	1014	441.0
Bag, Documented Sample, Flat, Rectangular-shape, 20 bag dispenser	11306-EM-030-00	1017	439.1
Bag, Extra Sample Collection	M10543RM004-03	SCB8	563.5
Bag, Extra Sample Collection	M10543RM004-03	SCB7	569.1
Bag, Extra Sample Collection	M10543RM004-03	SCB6	562.1
Bag, Extra Sample Collection	M10543RM004-03	SCB5	565.0
Bag, Organic Sample Monitor	10543-RM-015-01	1023	71.0
Bag, Organic Sample Monitor	10543-RM-015-01	1019	68.7
Bag, Protective Padded Sample (PPSB)	11306-EM-600-00		227.0
Bag, Protective Padded Sample (PPSB)	11306-EM-600-00		227.0
Bag, Sample Collection		SCB1	742.7
Bag, Sample Collection		SCB2	764.1
Bag, Sample Collection		SCB3	779.3
Bag, Sample Collection		SCB4	763.8
Container, Apollo Lunar Sample Return (ALSRC), accessories			313.7
Container, Apollo Lunar Sample Return (ALSRC), packing frame			73.1
Container, Apollo Lunar Sample Return (ALSRC)	EM64416/2-05	1009	6593.0
Container, Apollo Lunar Sample Return (ALSRC), accessories			317.8
Container, Apollo Lunar Sample Return (ALSRC)	EM64416/2-05	1010	6596.1
Container, Core Sample Vacuum (CSVC)	11306-EM-500-00	1001	493.8
Container, Special Environment Sample (SESC)	DM-40021-05A	1020	355.6
Device, Contact Soil Sampling, Beta Cloth (CSSD)	SEB39107672-303		540.0
Device, Contact Soil Sampling, Velvet Cloth (CSSD)	SEB39107672-304		500.0
Drill System (ALSD)	467A8060000-129		11113.0
Drill, Stem		018	177.6
Drill, Stem		012	195.2
Drill, Stem Caps		A-H	44.8
Drill, Stem		024	200.1
Drill, Stem		015	193.3
Drill, Stem		014	198.1
Drill, Stem		019	201.0
Drill, Stem Bit		180	48.7
Drive Tube, 4-cm Diameter	SEB39106393-304	2043	301.9
Drive Tube, 4-cm Diameter	SEB39106392-304	2054	311.4
Drive Tube, 4-cm Diameter	SEB39106392-304	2032	315.9
Drive Tube, 4-cm Diameter	SEB39107125-303	2021	109.5
Drive Tube, 4-cm Diameter	SEB39106393-304	2027	303.0
Drive Tube, 4-cm Diameter	SEB39106392-304	2034	315.5
Drive Tube, 4-cm Diameter	SEB39106392-304	2036	313.4

continued next page

Apollo 16 continued

TOOL OR CONTAINER	PART NUMBER	SERIAL NO.	WEIGHT (g)	
Drive Tube, 4-cm Diameter	SEB39106392-304	2038	314.7	
Drive Tube, 4-cm Diameter, cap & bracket assembly	SEB39107125-303	2019	111.5	
Drive Tube, 4-cm Diameter	SEB39106393-304	2029	302.3	
Drive Tube, 4-cm Diameter	SEB39106393-304	2045	301.2	
Drive Tube, 4-cm Diameter, cap & bracket assembly	SEB39107125-303	2013	109.7	
Drive Tube, 4-cm Diameter, cap & bracket assembly	SEB39107125-303	2020	110.4	
Drive Tube, 4-cm Diameter	SEB39107125-303	2017	110.5	
Extension Handle, Long	SEB39105248-308		816.0	
Extension Handle, Long	SEB39105248-308		816.0	
Gnomon	SEB39100317-303		272.0	
Hammer, Heavy-weight			0.0	
Rake	SEB39106380		1497.0	
Scale, Sample	SEB39105200-302		227.0	
Scoop, Large Adjustable			0.0	
Tongs, 32-inch	SEB39106245-301		454.0	
Tongs, 32-inch	SEB39106245-301		454.0	
Tool Carrier, Large	SGB39105801-404		8029.0	#
TOTAL WEIGHT for APOLLO 16			53028.9	grams

The weight of the tool carrier, from the Flight Stowage List, probably included the weight of the scoop and hammer, each of was listed 0.0 gram weight.

Table 7.

APOLLO 17

TOOL OR CONTAINER	PART NUMBER	SERIAL NO.	WEIGHT (g)
Bag, Documented Sample, Cup-shape			358.1
Bag, Documented Sample, Flat,Rectangular-shape 20 bag dispenser		1022	447.3
Bag, Documented Sample, Flat, Rectangular-shape, 20 bag dispenser	11306-EM-030-00	1019	441.0
Bag, Documented Sample, Flat,Rectangular-shape 20 bag dispenser		1021	446.3
Bag, Documented Sample, Flat,Rectangular-shape, 20 bag dispenser		1023	444.6
Bag, Documented Sample, Flat, Rectangular-shape, 20 bag dispenser	11306-EM-030-00	1020	445.9
Bag, Documented Sample, Flat, Rectangular-shape, 20 bag dispenser		1024	444.3
Bag, Extra Sample Collection	M10543RM004-03	SCB6	561.3
Bag, Extra Sample Collection	M10543RM004-03	SCB2	564.3
Bag, Extra Sample Collection	M10543RM004-03	SCB3	557.3
Bag, Extra Sample Collection	M10543RM004-03	SCB8	565.9
Bag, Organic Sample Monitor		1027	69.9
Bag, Organic Sample Monitor	10543-RM-015-01	1025	70.9
Bag, Sample Collection	10543-RM-004-04A	SCB1	760.5
Bag, Sample Collection		SCB7	762.5
Bag, Sample Collection		SCB5	756.9
Bag, Sample Collection		SCB4	765.9
Container, Apollo Lunar Sample Return (ALSRC), accessories			316.8
Container, Apollo Lunar Sample Return (ALSRC)	EM64416/2-05	1007	6551.1
Container, Apollo Lunar Sampl Return (ALSRC)	EM64416/2-05	1006	6539.0
Container, Apollo Lunar Sample Return (ALSRC), accessories			306.7
Container, Core Sample Vacuum (CSVC)	11306-EM-500-00	1000	492.3
Container, Special Environment Sample (SESC)		1023	349.6
Drill System (ALSD)	467A8060000-139		11068.0
Drill, Stem, upper		062	196.4
Drill, Stem, upper		069	197.1
Drill, Stem, upper		065	199.1
Drill, Stem, upper		063	196.1
Drill, Stem, lower		070	173.5
Drill, Stem, upper		066	195.4
Drill, Bit		179	48.0
Drill, Stem, upper		067	196.9
Drill, Stem, upper		061	192.9
Drive Tube, 4-cm Diameter, cap & bracket assembly		2027	111.9
Drive Tube, 4-cm Diameter	SEB39106392-304	2044	314.8
Drive Tube, 4-cm Diameter, cap & bracket assembly		2024	111.1
Drive Tube, 4-cm Diameter, lower		2048	314.0
Drive Tube, 4-cm Diameter, Ram tool	SDB39106391-302		91.0
Drive Tube, 4-cm Diameter, cap & bracket assembly	SEB39107125-303	2023	112.5
Drive Tube, 4-cm Diameter, upper		2037	302.4
Drive Tube, 4-cm Diameter, cap & bracket assembly	SEB39107125-303	2022	110.4
Drive Tube, 4-cm Diameter, lower		2052	311.2
Drive Tube, 4-cm Diameter, cap & bracket assembly		2026	110.7
Drive Tube, 4-cm Diameter, upper		2035	303.5
Drive Tube, 4-cm Diameter, lower		2050	315.8
Drive Tube, 4-cm Diameter, upper	SEB39106393-304	2031	303.8

continued next page

Apollo 17 continued

TOOL OR CONTAINER	PART NUMBER	SERIAL NO.	WEIGHT (g)
Drive Tube, 4-cm Diameter, lower	SEB39106392-304	2046	316.6
Drive Tube, 4-cm Diameter, upper		2033	299.1
Extension Handle, Long	SEB39105248-308		816.0
Extension Handle, Long	SEB39105248-308		816.0
Gnomon	SEB39100317-304		272.0
Hammer, Heavy-weight	SEB39100319-301		1315.0
Rake	SEB39106380-303		1497.0
Sampler, Lunar Rover Soil	SEB39108280-301		136.0
Scale, Sample	SEB39105200-302		227.0
Scoop, Large Adjustable	SEB39107047-301		590.0
Tongs, 32-inch	SEB39106245-301		454.0
Tongs, 32-inch	SEB39106245-301		454.0
TOTAL WEIGHT for APOLLO 17			45687.6 grams

TOTAL WEIGHT for ALL MISSIONS 235098.7 grams

ACKNOWLEDGMENTS

Information presented in this catalog was generated 20 years ago. Finding these old records -- engineering drawings, flight lists, photographs, logs, memoranda and notes -- was a major effort and could not have been done without the help of many people.

Darcella Watkins and Norma Conklin, Martin Marietta Energy Systems, Inc., enlisted the aid of "old timers" in their organization to identify the current drawing numbers for the rock boxes and other containers built by their predecessor contractor, Union Carbide, Nuclear Division. Ms. Watkins cheerfully sent all drawings requested.

At Johnson Space Center (JSC) many NASA employees and contractors helped search records. Joey Pellarin, Omniplan Corp. in the JSC History Office, enthusiastically and competently located the flight stowage lists (a principal source of information for this catalog) and some obscure, but very helpful memos. Kathryn Starr, Omniplan Corp., and her co-workers in JSC's Engineering Drawing Control Center furnished copies of the many JSC engineering drawings used to verify materials and dimensions. Marie Pierce, Omniplan Corp. in JSC's Programmatic and Engineering Data Services, and Sue Malof, JSC Mangement Services Division, located drawings for outer containers for the lunar tools and verified that some some contractor-furnished drawings are no longer available through Johnson Space Center. Rosemary Hudson, Boeing Company, and her fellow QC record mangers searched files and verified destruction of some documents. Carolyn Fisher, Omniplan Corp., assisted in the search of the JSC Public Affairs Office artifact and exhibit registers. Thomas Winston, Technicolor Government Service in the JSC photo archives, patiently assisted the author in locating and reviewing negatives of tool photography. Margo Albores and Jenny Seltzer, Lockheed Engineering and Sciences Company in the JSC Planetary Science Data Center, processed many requests for photographs and assisted in locating documents. Anita Dodson, of the Lockheed graphics department, added her own imaginative touches to give the document a professional appearance.

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The expertise, efforts and patience of all of these people enabled this catalog to be compiled, and their help was very much appreciated.

REFERENCES

1._____(1969) *Apollo Stowage List, Mission AS-507 CM 108/LM-6, Apollo 12.* Nov. 18, 1969. Manned Spacecraft Center, Houston,TX.

2._____(1969) *Apollo 11 Preliminary Science Report.* NASA SP-214, National Aeronautics and Space Administration, Washington, D.C.

3._____(1969) *Lunar Sample Information Catalog, Apollo 11.* Lunar Receiving Laboratory, Science and Applications Directorate, Aug. 31, 1969, Manned Spacecraft Center, Houston, TX.

4._____(1969) Union Carbide Shipping Order No. Y-95353, Sept. 23, 1969 (contents of Apollo 12 ALSRC).

5._____(1970) *Apollo 12 Preliminary Science Report.* NASA SP-235, National Aeronautics and Space Administration, Washington, D. C.

6._____(1970) *Apollo 14 Preliminary Lunar Surface Procedures.* Lunar Surface Operations Office, Mission Operations Branch, Flight Crew Support Division, Sept. 1970, Manned Spacecraft Center, Houston,TX.

7._____(1970) Lunar Sample Analysis Planning Team minutes, Dec. 1970.

8._____(1971) *Apollo 14 Preliminary Science Report.* NASA SP-272, National Aeronautics and Space Administration, Washington, D. C.

9._____(1971) *Apollo 15 Final Lunar Surface Procedures.* Jul. 9, 1971, Lunar Surface Procedures Section, EVA/IVA Precedures Branch, Crew Procedures Division, Manned Spacecraft Center, Houston, TX.

10.____(1971) *Apollo 15 Mission Report.* Dec. 1971, MSC-05161, NASA, Manned Spacecraft Center, Houston, TX.

11.____(1971) *Apollo Stowage List, Mission H-3, CM110/LM-8, Apollo 14.*.Feb. 9, 1971, Manned Spacecraft Center, Houston, TX.

12.____(1971) *Apollo Stowage List, Mission J-1, CM-112/LM-10, Apollo 15.* Aug. 10, 1971, Manned Spacecraft Center, Houston, TX.

13.____(1971) *Familiarization and Support Manual for Apollo Lunar Surface Drill.* MCR-71-35, Aug. 30, 1971, Martin Marietta Corp., Denver, CO.

14.____(1971) *Lunar Sample Information Catalog, Apollo 15.* MSC-03209,Manned Spacecraft Center, Houston, TX.

15.____(1971) *Lunar Surface Scientific Equipment for Apollo Mission 15 Furnished by Lunar Surface Project Office.* Mar. 5, 1971, NASA, Manned Spacecraft Center, Houston, TX.

16.____(1971) NASA-MSC Packing Procedure for LM-11 (Apollo Lunar Sample Return Containers #1 and #2). Nov. 30, 1971, Union Carbide Nuclear Division, Y-12 Plant, Oak Ridge, TN.

17.____(1972) *Apollo 15 Preliminary Science Report.* NASA SP-289, National Aeronautics and Space Administration, Washington, D. C.

18.____(1972) *Apollo 16 Preliminary Science Report.* NASA SP-315, National Aeronautics and Space Administration, Washington, D. C.

19.____(1972) *Apollo Stowage List, Mission J-2, CM-113/LM-11, Apollo 16.* Apr. 18, 1972, Manned Spacecraft Center, Houston, TX.

20.____(1972) *Apollo Stowage List, Mission J-3, CM-114/LM-12, Apollo 17.* Dec. 12, 1972, Manned Spacecraft Center, Houston, TX.

21.____(1972) *Lunar Surface Scientific Equipment for Apollo Mission 16 Furnished by Lunar Surface Project Office.* NASA, Manned Spacecraft Center, Houston, TX.

22.____(1972) *Lunar Surface Scientific Equipment for Apollo 17.* Lunar Experiments Project Office, Nov. 1972, NASA, Manned Spacecraft Center, Houston, TX.

23.____ (1972) NASA-MSC Packing Procedure for LM-12, Apollo Lunar Sample Return Container # 1 and Container #2. Jan. 5, 1972, Union Carbide Corp., Nuclear Division, Oak Ridge, TN.

24.____ (1973) *Apollo 17 Preliminary Science Report.* NASA SP-330, National Aeronautics and Space Administration, Washington, D. C.

25.____ (1973) *Final Report of Apollo 17 Lunar Surface Drill Mission Performance.* Feb. 28, 1973, MCR-73-18, Martin Marietta Aerospace, Denver, CO.

26. Bailey N.G. and Ulrich G. E. (1975) *Apollo 14 Voice Transcript Pertaining to the Geology of the Landing Site.* U.S. Geological Survey, Branch of Astrogeology, Flagstaff, AZ.

27. Calio A. J. (1970) Revised Lunar Field Geology write-up for Apollo 14 Mission Requirements Document (MRD). Memorandum to Manager, Apollo Spacecraft Program Office, Oct. 7, 1970, NASA, Johnson Space Center, Houston, TX.

28. Carrier W. D. III, Johnson S. W., Carrasco L. H. and Schmidt R. (1972) Core sample depth relationships: Apollo 14 and 15. *Proceedings Lunar Science Conference, 3rd,* pp. 3213-3221.

29. Kramer F. E., Twedell D. B. and Walton W. J. A. Jr. (1977) *Apollo 11 Lunar Sample Information Catalog (Revised).* JSC-12522, NASA, Johnson Space Center, Houston, TX.

30. Parkan W. A. (undated) Packing Procedure for LM-6, Sample Return Container #1, ALSRC 1602. From Parkan's collection of packing procedures housed in Planetary Science Branch Library, NASA, Johnson Space Center, Houston, TX.

31. Parkan W. A. (undated) Test Preparation Sheet No. 678, p. 9. From Parkan's collection of packing procedures housed in Planetary Science Branch Library, NASA, Johnson Space Center, Houston, TX.

32. Parkan W. A. (1969) ALSRC-3606, ALSRC packing procedure and itemized weights for ALSRC 1003 and 1004. Annotated by Parkan Jun. 3, 1969, housed in Planetary Science Branch Library, NASA, Johnson Space Center, Houston, TX.

33. Parkan W. A. (1969) Packing weights for ALSRC 1008 and 1009. Annotated by Parkan Oct. 23, 1969, housed in Planetary Science Branch Library, NASA, Johnson Space Center, Houston, TX.

34. Parkan W. A. (1972) Apollo 17 ALSRC and Flight Hardware Weight Breakdown. Memorandum to Manager, Lunar Receiving Laboratory, Dec. 7, 1972, NASA, Manned Spacecraft Center, Houston, TX.

35. Simmons G. (1971) *On the Moon with Apollo 15, A Guidebook to Hadley Rille and the Apennine Mountains.* June 1971, NASA, Manned Spacecraft Center, Houston, TX.

36. Simmons G. (1972) *On the Moon with Apollo 16, A Guidebook to the Decartes Region.* April 1971, NASA EP-95, Manned Spacecraft Center, Houston, TX.

37. Simmons G. (1972) *On the Moon with Apollo 17, A Guidebook to Taurus-Littrow.* Dec. 1972, NASA EP-101, Manned Spacecraft Center, Houston, TX.

38. Suit K. L. (1970) Apollo Lunar Sample Return Container Premission Processing. Memorandum to Manager, Lunar Receiving Laboratory, Dec. 8, 1970 (Apollo 14), NASA, Manned Spacecraft Center, Houston, TX..

39 Suit K. L. (1971) Apollo Lunar Sample Return Container Premission Processing. Memorandum to Manager, Lunar Receiving Laboratory, Jun. 29, 1971, NASA, Manned Spacecraft Center, Houston, TX.

40. Suit K. L. (1972) Apollo 16 ALSRC and Flight Hardware Breakdown. Memorandum to Manager, Lunar Receiving Laboratory, Jan. 31, 1972, NASA, Manned Spacecraft Center, Houston, TX.

41. Warner J. F. (1970) *Apollo 12 Lunar-sample Information.* NASA TR-R-353, National Aeronautics and Space Administration, Washington, D. C.

42. Zarcaro J. G. (1970) Collection documentation and stowage of magnetic sample to be obtained as part of Experiment S-059 Lunar Field Geology. Memorandum to Manager, Lunar Receiving Laboratory, Apr. 1, 1970 (Apollo 14), NASA, Manned Spacecraft Center, Houston, TX.

TOOL & CONTAINER INVENTORIES

Sampling tools and containers, made for the Apollo program for flight or as training units, spares or prototypes, are curated at several locations. All space hardware which has no further use is curated by the Smithsonian Institution. Some pieces are used for educational purposes in exhibits, and others are still used for reference by those concerned with lunar sample history and fabrication of space tools. Since experience gained in the design of the Apollo hardware may benefit future space missions, the following inventories of lunar sampling tools and containers held by the Smithsonian Institution and Johnson Space Center are provided. These inventories are not a comprehensive listing of existing Apollo sampling hardware, but show only major pieces at two locations.

Table A-1 is a list of lunar sampling tools and containers in the National Air and Space Museum collection. Inquiries about this collection should be addressed to: Derek W. Elliott, Assistant Curator, Space Science and Exploration Dept., National Air and Space Museum, Smithsonian Institution, Washington, D.C. 20560. Items should be identified by the NASM and Catalog numbers. This list was provided by Mr. Elliot in December 7, 1988.

Table A-2 is a list of tools and containers in custody of the Public Affairs Office at Johnson Space Center. Mr. Louis A. Parker, Mail Code AP411, Johnson Space Center, Houston TX 77058, is knowledgeable about this collection. The author compiled this list November 4, 1988 from the Artifact Register and the Exhibit Register in the Public Affairs Office.

Table A-3 is a list of lunar sample containers and core tubes controlled by the Lunar Sample Curator at Johnson Space Center. Dr. John W. Dietrich, Lunar Sample Curator, Mail Code SN2, Johnson Space Center, Houston, TX 77058, is knowlegeable about this collection. The containers were inventoried May 21, 1987, and the core tubes were inventoried February 7, 1989.

Table A-4 is a list of tools controlled by Technical Services Division, Johnson Space Center. Mr. Charles J. Gardner, Mail Code JH42, Johnson Space Center, Houston, TX 77058, is knowledgeable about this group of tools. This list was compiled November 4, 1988 by observing tools through a glass case.

Table A-1. National Air & Space Museum

NASM	Cat. No.	Nomenclature	Part #	Ser.#
5016	1975-0129	Bore Stem	467A8060016-069	N/A
6770	1981-0893	Bore Stem	467A8060016-099	T-38
6770	1981-0894	Bore Stem	467A8060016-099	T-65
6770	1981-0895	Bore Stem	467A8060019-109	T-49
6770	1981-0896	Bore Stem	467A8060019-109	T-64
6770	1981-0897	Bore Stem	467A8060019-109	T-71
5016	1975-0130	Bore Stem	467A8060016-109	N/A
5004	1975-0041	Bore Stem		48
5004	1975-0064	Brush	558-15-10	1001
6364	1979-1046	Brush	SEB39105185-301	2002
6364	1979-1043	Brush	SEB39105185-301	2004
5129	1975-0754	Brush	SEB39105185-301	2007
6364	1979-1044	Brush	SEB39105185-301	2011
6364	1979-1045	Brush	SEB39105185-301	2008
5004	1975-0063	Brush	SEB39105185-301	2013
5004	1975-0030	Brush		2014
5004	1975-0062	Brush-Scribe-Lens	SEB39100406-102	105
7351	1985-0614	Brush-Scribe-Lens	SEB39100406-202	1002
5004	1975-0020	Brush-Scribe-Lens	SEB39100406-202	1003
6786	1982-0077	Brush-Scribe-Lens	SEB39100406-203	2004
5013	1975-0109	Brush-Scribe-Lens	SEB39100406-203	2009
6752	1981-0697	Brush-Scribe-Lens	SEB39100406-203	2010
6752	1981-0698	Brush-Scribe-Lens	SEB39100406-203	2011
5004	1975-0049	Color Chart	SEB39107195-301	2010
4083	1974-0860	Contingency Sampler	M-11329-EK-004-D-02	TR-3
5665	1977-0253	Contingency Sampler	M-11329-EK-004-D-05	1008
5106	1975-0595	Contingency Sampler	M-11329-EK-004-D-05	1009
5016	1975-0139	Contingency Sampler	M-11329-EK-004-D-06	3007
5665	1977-0245	Core Sample Vac. Cont.	M-11306-EM-500-E	1002
6770	1981-0898	Core Stem	PS600100022-005	039
6770	1981-0899	Core Stem	PS600100022-005	043
6770	1981-0890	Core Stem	PS600100022-005	046
6770	1981-0901	Core Stem	PS600100022-005	047
6770	1981-0902	Core Stem	PS600100022-005	054
6770	1981-0903	Core Stem	PS600100022-005	057
6770	1981-0904	Core Stem	PS600100022-005	058
6770	1981-0906	Core Stem	PS600100022-005	none
6770	1981-0907	Core Stem	PS600100022-005	none
6770	1981-0905	Core Stem	PS600100022-007	071
5004	1975-0043	Core Stem	none	none
6770	1981-0908	Core Stem	none	none

Table A-1 continued

6770	1981-0911	Core Stem Bit	467A8050000-011	137
6770	1981-0912	Core Stem Bit	467A8050000-011	139
6770	1981-0913	Core Stem Bit	467A8050000-011	147
6770	1981-0914	Core Stem Bit	467A8050000-011	149
6770	1981-0915	Core Stem Bit	467A8050000-011	165
6770	1981-0916	Core Stem Bit	467A8050000-011	167
6770	1981-0917	Core Stem Bit	none	177
5004	1975-0044	Core Stem Bit	none	none
6770	1981-0918	Core Stem Bit	none	none
6770	1981-0891	Core Stem Cap Set	467A8060003-039	none
6770	1981-0892	Core Stem Cap Set	467A8060003-039	none
5004	1975-0045	Core Stem Cap Set	none	none
6770	1981-0877	Core Tube	SDB39100377-001T	102
6770	1981-0881	Core Tube	SEB39100375-112	2031
6770	1981-0884	Core Tube	SEB39100375-112	2034
6770	1981-0882	Core Tube	SEB39100375-113	2032
6770	1981-0885	Core Tube	SEB39100375-113	2035
6770	1981-0883	Core Tube	SEB39100375-114	2033
6770	1981-0886	Core Tube	SEB39100375-114	2036
5013	1975-0301	Core Tube	SEB3910375-203	2004
6770	1981-0880	Core Tube	SEB39100375-208	2027
2546	1972-0827	Core Tube	SEB39100375-210	2014
2546	1972-0826	Core Tube	SEB39100375-211	2015
6770	1981-0887	Core Tube	SEB39100375-212	2046
6770	1981-0878	Core Tube	SEB39100375-213	2001
6770	1981-0888	Core Tube	SEB39100375-213	2047
6770	1981-0879	Core Tube	SEB39100375-214	2003
4064	1974-0761	Core Tube	SEB39100375-301	1040
6715	1981-0589	Core Tube	SEB39100375-301	2028
6752	1981-0711	Core Tube	SEB39100375-301	2030
5013	1975-0118	Core Tube	SEB39100375-301	2039
5013	1975-0123	Core Tube Shells	SEB39103155-201	2020
6752	1981-0716	Core Tube Shells	SEB39103155-201	2021
6752	1981-0717	Core Tube Shells	SEB39103155-201	2025
6770	1981-0909	Core Tube Cap & Bracket Assy.,	SEB39103185-101	2011
6770	1981-0910	Core Tube Cap & Bracket Assy.,	SEB39103185-101	2011
2546	1972-0837	Core Tube Cap & Bracket Assy.,	SEB39103185-201	2002
6752	1981-0713	Core Tube Cap & Bracket Assy.,	SEB39103185-302	2010
6752	1981-0714	Core Tube Cap & Bracket Assy.,	SEB39103185-302	2013
5013	1975-0120	Core Tube Cap & Bracket Assy.,	SEB39103185-302	2014
5004	1975-0042	Core Tube Cap & Bracket Assy.		2003

Table A-1 continued

4083	1974-0867	Doc. Sample Bag Cups		
6314	1979-0805	Doc. Sample Bag Cups		TR8/TR15/TR16
6314	1979-0806	Doc. Sample Bag Cup	10543-RM-011-00	TR8
6314	1979-0807	Doc. Sample Bag Cups	10543-RM-015-00	1004/TR1/TR7
6314	1979-0813	Doc. Sample Bag Cups		
6314	1979-0814	Doc. Sample Bag Cups		
6314	1979-0815	Doc. Sample Bag Cups		
6314	1979-0816	Doc. Sample Bag Cups		
6314	1979-0817	Doc. Sample Bag Cups		
6314	1979-0818	Doc. Sample Bag Cups		
6314	1979-0819	Doc. Sample Bag Cups		
6314	1979-0820	Doc. Sample Bag Cups		
6314	1979-0821	Doc. Sample Bag Cups		
6314	1979-0822	Doc. Sample Bag Cups		
6314	1979-0823	Doc. Sample Bag Cups		
6314	1979-0824	Doc. Sample Bag Cups		
6314	1979-0825	Doc. Sample Bag Cups		
6314	1979-0826	Doc. Sample Bag Cups		
6314	1979-0827	Doc. Sample Bag Cups		
6314	1979-0828	Doc. Sample Bag Cups		
4083	1974-0865	850 5x5 Flat Doc. Sample Bags		
4083	1974-0866	259 7.5 x 8 Flat Doc. Sample Bags		
6314	1979-0808	Flat Doc. Sample Bags		
6314	1979-0809	Flat Doc. Sample Bags		
6314	1979-0810	Flat Doc. Sample Bags		
6314	1979-0811	Flat Doc. Sample Bags		
6314	1979-0812	Flat Doc. Sample Bags		
5016	1975-0138	Doc. Sample Bags	11306-EM-030-00	1012
5106	1975-0596	Doc. Sample Bags & Disp.		
5665	1977-0286	Doc. Sample Bags & Disp.	M-11306-EM-020-E-2	1011
5665	1977-0287	Doc. Sample Bags & Disp.	M-11306-EM-020-E-2	1010
Unaccessioned		Doc. Sample Bags & Disp.	06-EM-030-00	1008
5004	1975-0038	Lunar Surface Drill Set	MSC78285	
5004	1975-0039	Lunar Surface Drill Set	MSC78643	
5004	1975-0048	Spare Drill Chuck		
5013	1975-0110	Drill Wrench	467A8060010-009	5-6
5016	1975-0131	Drill Wrench	467A8060020-009	3
6752	1981-0699	Drill Wrench	467A8060010-009	2-2
6752	1981-0700	Drill Wrench	467A8060010-009	5-5
6770	1981-0876	Drive Tube (01)	SEB39106393-304	2001
6770	1981-0875	Drive Tube (06)	SEB39106392-304	2006
6770	1981-0874	Drive Tube (17)	SEB39106393-304	2017
6770	1981-0873	Drive Tube (31)	SEB39106393-304	2041
5004	1975-0051	Drive Tube (44)		
6770	1981-0872	Drive Tube (46)	SEB39106392-304	2016

Table A-1 continued

Deaccessioned		Drive Tube Cap	SDB39106489-001	3010
Deaccessioned		Drive Tube Cap	SDB39106489-001	3012
6770	1981-0919	Drive Tube Caps & Disp.	SEB39107125-302	2013
5016	1975-0136	Drive Tube Caps & Disp.	SEB39107125-303	2025
5004	1975-0050	Drive Tube Cap & Disp.		2015
5013	1975-0121	Drive Tube Rammer	SDB39106391-301	2001
6752	1981-0715	Drive Tube Rammer	SDB39106391-301	2002
4083	1974-0860	Extension Handle		TR-4
5004	1975-0031	Extension Handle	SEB39100314-101T	103
5013	1975-0111	Extension Handle	2338102B	21
5013	1975-0115	Extension Handle	SEB39105248-308	2011
6104	1978-1498	Extension Handle	SEB39105248-301	N/A
6104	1978-1500	Extension Handle	SEB39107085-001	2004
7351	1985-0609	Extension Handle	SEB39100314-206	2001
4083	1974-0862	Gas Analysis Sample Cont.		
4083	1974-0862	Gas Analysis Sample Cont.	DM-40020-00	1001
4083	1974-0862	Gas Analysis Sample Cont.		
5665	1977-0254	Gas Analysis Sample Cont.	DM-40020-01	Dev.2
6314	1979-0773	Gas Analysis Sample Cont.	ALSRC-GASC	2006
5004	1975-0046	Gnomon	SEB39100317-302	2011
5016	1975-0133	Gnomon	SEB39100317-302	1004
6770	1981-0889	Gnomon	SEB39107191-001	
6770	1981-0890	Gnomon	SEB39107191-001	
5016	1975-0134	Hammer	SEB39100319-301	2014
6786	1982-0078	Hammer	SEB39100319-206	1007
7351	1985-0612	Hammer	SEB39100319	1004
7351	1985-0610	Instrument Staff	SEB39100370-207	2002
5004	1975-0047	LRV Soil Sampler		
5016	1975-0153	LRV Soil Sampler	SEB3910____-301	1004
2354	1971-0813	LSRC	EM-64416/2-01	1004
2354	1971-0814	LSRC	EE64416/3-01	1003
4079	1974-0799	LSRC	EE64416/2	QU-2
4083	1974-0858	LSRC		TR-2
4083	1974-0858	LSRC		
4083	1974-0858	LSRC		
5016	1975-0142	LSRC	EM64416/2-05	1011
5016	1975-0143	LSRC	EM64416/2-05	1012
5106	1975-0590	LSRC	EM64416/2-02	1008
5810	1977-2505	LSRC	EM64416/2-05	1006
5810	1977-2506	LSRC	EM64416/2-05	1007HRE
5810	1977-2507	LSRC	EM64416/2-05	1008HRE
5810	1977-2508	LSRC	EM64416/2-05	1009HRE
5810	1977-2509	LSRC	EM64416/2-05	1013
5004	1975-0056	Penetrometer	SEB30916050	1001
5004	1975-0057	Penetrometer	SEB39105115-302	1001
6770	1981-0870	Penetrometer	SEB39105115-302	1004

Table A-1 continued

ASRC	Protective Sample Bags	11306-EM-600-00	Dev-1
ASRC	Protective Sample Bags	11306-EM-600-00	Dev-2
5665 1977-0250	Protective Sample Cont.	M-11306-EM-600-E-0	1003
Deaccessioned	Pull Pin	467A8060012-089	N/A
6104 1978-1497	Rake	SEB39106374-001	N/A
6797 1982-0095	Rakehead	SDB39106376-302	
Deaccessioned	Reducer Tool	467A8060014-017	4
Deaccessioned	2 Roller Plungers	SEB39106964-301	N/A
2546 1972-0836	Sample Collection Bag		1035
4083 1974-0863	Sample Collection Bag	M-10543-RM-004-04	TR209
6314 1979-0774	Sample Collection Bag	M-10543-RM-004-02	
6314 1979-0775	Sample Collection Bag	M-10543-RM-004-02	
6314 1979-0776	Sample Collection Bag	M-10543-RM-004-02	1
6314 1979-0777	Sample Collection Bag	M-10543-RM-004-02	9
6314 1979-0778	Sample Collection Bag	M-10543-RM-004-02	12
6314 1979-0779	Sample Collection Bag	M-10543-RM-004-02	13
6314 1979-0780	Sample Collection Bag	M-10543-RM-004-02	16
6314 1979-0781	Sample Collection Bag	M-10543-RM-004-02	17
6314 1979-0782	Sample Collection Bag	M-10543-RM-004-02	21
6314 1979-0783	Sample Collection Bag	M-10543-RM-004-02	22
6314 1979-0784	Sample Collection Bag	M-10543-RM-004-02	24
6314 1979-0785	Sample Collection Bag	M-10543-RM-004-02	29
6314 1979-0786	Sample Collection Bag	M-10543-RM-004-04	TR34
6314 1979-0787	Sample Collection Bag	M-10543-RM-004-04	TR36
6314 1979-0788	Sample Collection Bag	M-10543-RM-004-04	TR39
6314 1979-0789	Sample Collection Bag	M-10543-RM-004-04	TR42
6314 1979-0790	Sample Collection Bag	M-10543-RM-004-04	TR43
6314 1979-0791	Sample Collection Bag	M-10543-RM-004-02	TR203
6314 1979-0792	Sample Collection Bag	M-10543-RM-004-02	TR208
Deaccessioned	SCB Ident. Insertion Tool	M-10543-RM-005	
2546 1972-0829	Sample Scale	SEB39104275-303	1006
4083 1974-0859	Sample Scale	SEB39100518-101T	101
4083 1974-0868	Sample Scale	SDB39204252-002	N/A
4083 1974-0869	Sample Scale	SDB39104253	
5013 1975-0119	Sample Scale	SEB39105200-302	2009
5016 1975-0135	Sample Scale	SEB39105200-302	1004
6752 1981-0712	Sample Scale	SEB39105200-302	1006
5004 1975-0028	Scongs	SEB39105667-___	2001
6715 1981-0588	Scoop	SEB39107533-301	101
6797 1982-0096	Scoop Head	SEB39105725	2005
2546 1972-0825	Large Scoop	SEB39103122-301	2001
5004 1975-0032	Large Scoop		
5004 1975-0065	Large Scoop	SEB39103122-301	103
5004 1975-0066	Large Scoop	SEB39103122-301	102
5004 1975-0034	Small Scoop	SEB39100310-101T	102
6786 1982-0079	Small Scoop	SEB39100310-202	2003
7351 1985-0613	Small Scoop	SEB39100310-202	1001

Table A-1 continued

4083	1974-0861	Special Env. Sample Cont.		
4083	1974-0861	Special Env. Sample Cont.		
5106	1975-0593	Special Env. Sample Cont.	DM40021-3	Dev.2
5004	1975-0040	Surface Sampler	SEB39107672-301	
5004	1975-0068	Surface Sampler	SEB39107672-302	1007
5004	1975-0029	Tongs	SEB39100344-101T	
7351	1985-0611	Tongs	SEB39100340-203	2002
6786	1982-0076	Tongs	SEB39100340-203	2007
6104	1978-1499	Tongs	SEB39106245-301	1001
6752	1981-0701	Tongs	SEB39106245-301	2001
6752	1981-0702	Tongs	SEB39106245-301	2002
6752	1981-0703	Tongs	SEB39106245-301	2007
6752	1981-0704	Tongs	SEB39106245-301	2008
5013	1975-0112	Tongs	SEB39106245-301	2015
5713	1977-0755	Tongs		2004
5004	1975-0033	Trenching Tool	SDB39106126-001	N/A
5013	1975-0113	Trenching Tool	SEB39105211-302	2012
5013	1975-0114	Large Adjustable Scoop	SEB39107047-301	1004
6715	1981-0587	Trenching Tool	SEB36107530-301	101
6752	1981-0705	Trenching Tool	SEB39106130-302	2009
6752	1981-0706	Trenching Tool	SEB39106130-302	2010
6752	1981-0707	Trenching Tool	SEB39106130-302	2007
6752	1981-0708	Trenching Tool	SEB39106130-302	2006
6752	1981-0709	Trenching Tool	SEB39106130-302	1003
Deaccessioned		4 Tubes	467A809001-014	N/A
5665	1977-0284	Weigh Bag	M-10543-RM-001-01	1005
5665	1977-0282	Weigh Bag	M-10543-RM-001-01	1006
5665	1977-0283	Weigh Bag	M-10543-RM-001-01	1007
5665	1977-0275	Weigh Bag	M-10543-RM-001-02	1005
5665	1977-0276	Weigh Bag	M-10543-RM-001-02	1006
ASRC		Weigh Bag	M-10543-RM-001-02	1011
ASRC		Weigh Bag	M-10543-RM-001-02	1012
5665	1977-0277	Weigh Bag	M-10543-RM-001-02	1019
5665	1977-0281	Weigh Bag	M-10543-RM-001-02	1021
5665	1977-0279	Weigh Bag	M-10543-RM-001-02	1022
5665	1977-0278	Weigh Bag	M-10543-RM-001-02	1023
5665	1977-0280	Weigh Bag	M-10543-RM-001-02	1024
5665	1977-0272	Weigh Bag	M-10543-RM-001-04	1037
5665	1977-0273	Weigh Bag	M-10543-RM-001-04	1040
5013	1975-0117	Weigh Bag	M-10543-RM-001-04	1041
5665	1977-0274	Weigh Bag	M-10543-RM-001-04	Dev.
6372	1979-1292	Weigh Bag	M-10543-RM-001-04	Dev.
6372	1979-1293	Weigh Bag	M-10543-RM-001-04	Dev.
6372	1979-1294	Weigh Bag	M-10543-RM-001-04	Dev.
6752	1981-0710	Weigh Bag	M-10543-RM-001-04	TR-35

Table A-2. Johnson Space Center Public Affairs Office

PART NAME	ARTIFACT REGISTER NO.	SERIAL NO.	PART NUMBER, DESCRIPTION
Scoop	312	1003	Apollo 17
Hammer	314	104	Apollo 17 training
Tongs	317	2013	
Lunar sample bag	340		B-11
Rake	341		
Gnomon	342	2003	SEB39107195-301
Tool rack	345	2008	
Hammer	346	1006	SEB39100319-207
Core tube assembly carrier	347	2021	SDB39106387-002
Storage compartment bag	349		M-10543-RM-004-04
Lunar dust container	350	TR-11	DM-40020-01
ALSRC structural simulator	384	3	class 3
ALSRC structural simulator	385	4	class 3
Lunar sample return container	394	LRL-3	EM64416
Lunar sample bag dispenser with bag	406	TR-1	11306-EM-010-00
Lunar sample bag dispenser with bag	407	TR-2	11306-EM-010-00
T-35 tube	411	T#19	467A806006-109
T-35 tube	412	T#69	467A806006-109
Bag, lunar sample, small	2645		10543-RM
Scoop	2720	20	2363742
Sample bag container	2873	1008	11306-EM-010-00
Lunar sample scale	2937	2082	SEB39105200-302
Sample collection bag	4225	1007	M-10543-RM-004-03; "5" Apollo 16
Sample collection bag	4226	1209	M10543-RM-004-03; "3" Apollo 16
Sample collection bag	4227	1210	M10543-RM-004-03; "4" Apollo 16

PART NAME	EXHIBIT REGISTER NO.	SERIAL NO.	PART NUMBER, DESCRIPTION
Core tube	7021		CT/1
Lunar drill stem	7428		467A80600007-009

Table A-3. Johnson Space Center Lunar Sample Curator

PART NAME	SERIAL NO.	PART NUMBER, DESCRIPTION	MISSION
		CONTAINERS	
Apollo Lunar Sample Return Container Container	1010	EM-64416/205	
Apollo Lunar Sample Return Container Container	QU-1	EM-64416/205	
Apollo Lunar Sample Return Container Container	LRL-2	EM-64416/205	
Apollo Lunar Sample Return Container Container, o-ring, 5 ea.		EM-64416-02	
Apollo Lunar Sample Return Container Container, retainer strap, 3 ea.		EM-595461N	
Apollo Lunar Sample Return Container Container, temperature indicators		EM-64416/2	
Organic monitor	1022	10543-RM-015-01	
Organic monitor	1028	10543-RM-015-01	
Organic monitor	1026	10543-RM-015-01	
Organic monitor	1018	10543-RM-015-01	
Organic monitor	1024	10543-RM-015-01	
Organic monitor	1001	10543-RM-015-00	
Organic monitor	1008	10543-RM-015-00	
Organic monitor	TR-18	10543-RM-015-00	
Organic monitor	1003	10543-RM-015-00	
Protective padded sample bag	1006	11306-EM-600-00	
Gas Analysis Sample Container	1007	DM-40020-01	
Gas Analysis Sample Container	2000	LSRC	
Special Environment Sample Container	1011	DM-40021-01	
Special Environment Sample Container	1012	DM-40021-01	
Special Environment Sample Container	1015	DM-40021-02	
Special Environment Sample Container	1016	DM-40021-02	
Special Environment Sample Container	1019	DM-40021-04A	
Special Environment Sample Container	1008	DM-40021-05A	
Special Environment Sample Container	1022	DM-40021-05A	
Special Environment Sample Container	1023	DM-40021-06A	
Special Environment Sample Container			
Core sample vacuum container	TR-2	11306-EM-500-00	
Documented sample bags, flat, rectangular	TR-4	11306-EM-0530-00	
Documented sample bags, flat, rectangular	TR-6	11306-EM-0530-00	
Documented sample bags, flat, rectangular	TR-8	11306-EM-0530-00	
Documented sample bags, flat, rectangular	TR-11	11306-EM-0530-00	
		CORE TUBES	
2-cm diameter core split liner	2007	SEB39103155-201	11
2-cm diameter core, split liner	2019	SEB39103155-201	12
2-cm diameter core	2011	SEB39100375-210	12
2-cm diameter core bit	2013	SDB39100403-003	12
2-cm diameter core bit	2015	SDB39100403-003	12
2-cm diameter core split liner with follower	2017	SEB39103155-201	12
2-cm diameter core split liner	2016	SEB39103155-201	12
2-cm diameter core split liner	2024	SEB39103155-201	12
2-cm diameter core split liner	2018	SEB39103155-201	12
2-cm diameter core bit	2028	SDB39100403-003	14
2-cm diameter core bit	2057	SDB39100403-003	14
2-cm diameter core bit	2058	SDB39100403-003	14
2-cm diameter core	2043	SEB39100375-212	14
2-cm diameter core	2045	SEB39100375-214	14
2-cm diameter core	2044	SEB39100375-213	14
2-cm diameter core	2022	SEB39100375-212	14
2-cm diameter core split liner with follower	2049	SEB39103155-202	14

Table A-3. Johnson Space Center Lunar Sample Curator (continued)

PART NAME	SERIAL NO.	PART NUMBER, DESCRIPTION	MISSION
2-cm diameter core split liner	2069	SEB39103155-202	14
2-cm diameter core split liner	2058	SEB39103155-202	14
2-cm diameter core split liner	2046	SEB39103155-202	
2-cm diameter core split liner	2047	SEB39103155-202	
2-cm diameter core split liner	2048	SEB39103155-202	
2-cm diameter core teflon sleeve, 6 ea			
2-cm diameter core cap & bracket assembly, includes 3 caps & chisel bit	2005	SEB39106185-201	
2-cm diameter core bit	2053	SDB39100403-003	?
4-cm diameter core pull ring	2043	SDB39106488-303	16
4-cm diameter core pull ring	2044	SDB39106488-303	16
4-cm diameter core pull ring	2045	SDB39106488-303	16
4-cm diameter core	2044	SEB39106392-304	17
4-cm diameter core	2048	SEB39106392-304	17
4-cm diameter core	2009	SEB39106393-302	15
4-cm diameter core	2038	SEB39106392-304	16
4-cm diameter core	2035	SEB39106393-304	17
4-cm diameter core	2010	SEB39106392-302	15
4-cm diameter core	2003	SEB39106393-302	15
4-cm diameter core	2045	SEB39106393-304	16
4-cm diameter core	2054	SEB39106392-304	16
4-cm diameter core	2007	SEB39106393-302	15
4-cm diameter core	2050	SEB39106392-304	17
4-cm diameter core	2020	SEB39106392-302	
4-cm diameter core	2037	SEB39106393-304	17
4-cm diameter core	2043	SEB39106393-304	16
4-cm diameter core caps, 9 ea.		SDB39106489-001	
Core tube cap assembly	2016	SEB39107125-302	
4-cm diameter core pull pins, 3 ea.		SDB39106488-301	15
Drill bit	152	467?8050000-011	
Drill bit	179	467A?050000-011	17
Drill stem caps, 5 ea.			17
Drill stem	065	Yellow markings	17
Drill stem	062	Yellow markings	17
Drill stem	069	Yellow markings	17
Drill stem	070	Yellow markings	17
Drill stem	066	Yellow markings	17
Dril stem	061	Yellow markings	17
Drill stem	063	Yellow markings	17
Drill stem	067	Yellow markings	
Drill stem caps, 7 ea.			15
Drill bit	?	??7A8050000-011	15
Drill stem	012	467A8060009-005	16
Drill stem	015	467A8060009-005	16
Drill stem	014	467A8060009-005	16
Drill stem	024	467A8060009-005	16
Drill stem	019	467A8060009-005	16
Drill stem	018	467A8060009-007	16
Drill stem caps, 2 ea.			16
Drill stem caps, 2 ea.			
Drill bit	180	467A8050000-001	
Drill stem	011	PS600-1-00022-005	15
Drill stem	027	PS600-1-00022-005	15
Drill stem	010	PS600-1-00022-005	15
Drill stem	020	PS600-1-00022-005	15
Drill stem	027(?)	PS600-1-00022-005	15
Drill stem	023	PS600-1-00022-005	15

Table A-4 Johnson Space Center Technical Services Division

PART NAME	SERIAL NO.	PART NUMBER, DESCRIPTION
Extension handle, long		
Extension handle, short		
Gnomon		
Lens-scriber-brush	2008	SEB39100406-203
LRV soil sampler cup holder		
Rake		
Sample scale		
Spring scale		
Scoop, box-shape		SEB39103122-301
Scoop, small	2004	SEB39100310-202
Scoop, small adjustable	2009	SEB39105725-301
Tongs, shorter	2015	SEB39100344-202
32-inch tongs	2016	
Tool carrier, large	2003	SEB39106150-301
Tool carrier, small		
Trenching tool	2011	SEB39106130-302

*U.S.GOVERNMENT PRINTING OFFICE:1989-661-008/00008

GLOSSARY OF ACRONYMS

ALSRC	Apollo Lunar Sample Return Container
CSSD	Contact Soil Sampling Device
CSVC	Core Sample Vacuum Container
ESCB	Extra Sample Collection Bag
GASC	Gas Analysis Sample Container
LSAPT	Lunar Sample Analysis Planning Team
LESC	Lunar Environment Sample Container
LRV	Lunar Roving Vehicle
MET	Modularized Equipment Transporter
MSSC	Magnetic Shield Sample Container
NASM	National Air and Space Museum
SCB	Sample Collection Bag