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SNAP - 27

ADVANCED NUCLEAR SYSTEMS

GENERAL
ELECTRIC
MISSILE AND SPACE DIVISION
Valley Forge Space Technology Center

SNAP - 27

NUCLEAR POWER SYSTEM

FOR

THE APOLLO LUNAR SURFACE EXPERIMENT PACKAGE

JULY 1966

MISSILE AND SPACE DIVISION
GENERAL ELECTRIC

The SNAP-27 radioisotope fueled thermoelectric power system is described in this document. Its application as the power supply of the Apollo Lunar Surface Experiment Package (ALSEP) is depicted in Part I by a series of artists renderings which trace the deployment sequence following SNAP-27's arrival on the lunar surface. Part II is a more detailed description of the power supply pointing out the major features of design and performance.

SNAP-27 is being developed by the General Electric Company under the direction of the U.S. Atomic Energy Commission. Major subcontractors are the 3M Company and the Solar Division of International Harvester Corporation.

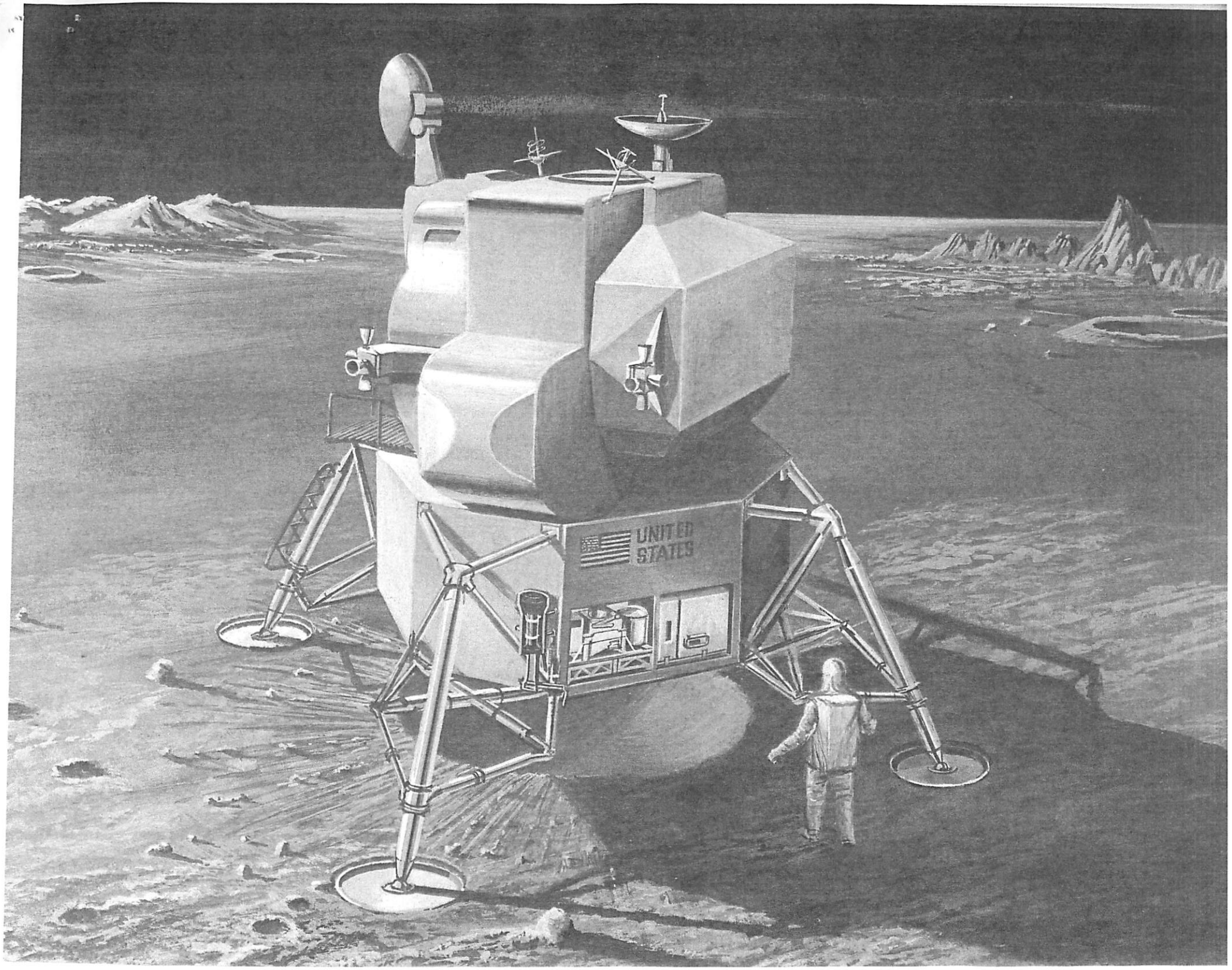
Flight qualified power supplies for incorporation into the Apollo mission will be delivered to the National Aeronautics and Space Administration beginning in July 1967.

Thomas F. Widmer
SNAP-27 Program Manager,
General Electric Missile and Space Division

PART I

APPLICATION OF SNAP-27

TO THE APOLLO MISSION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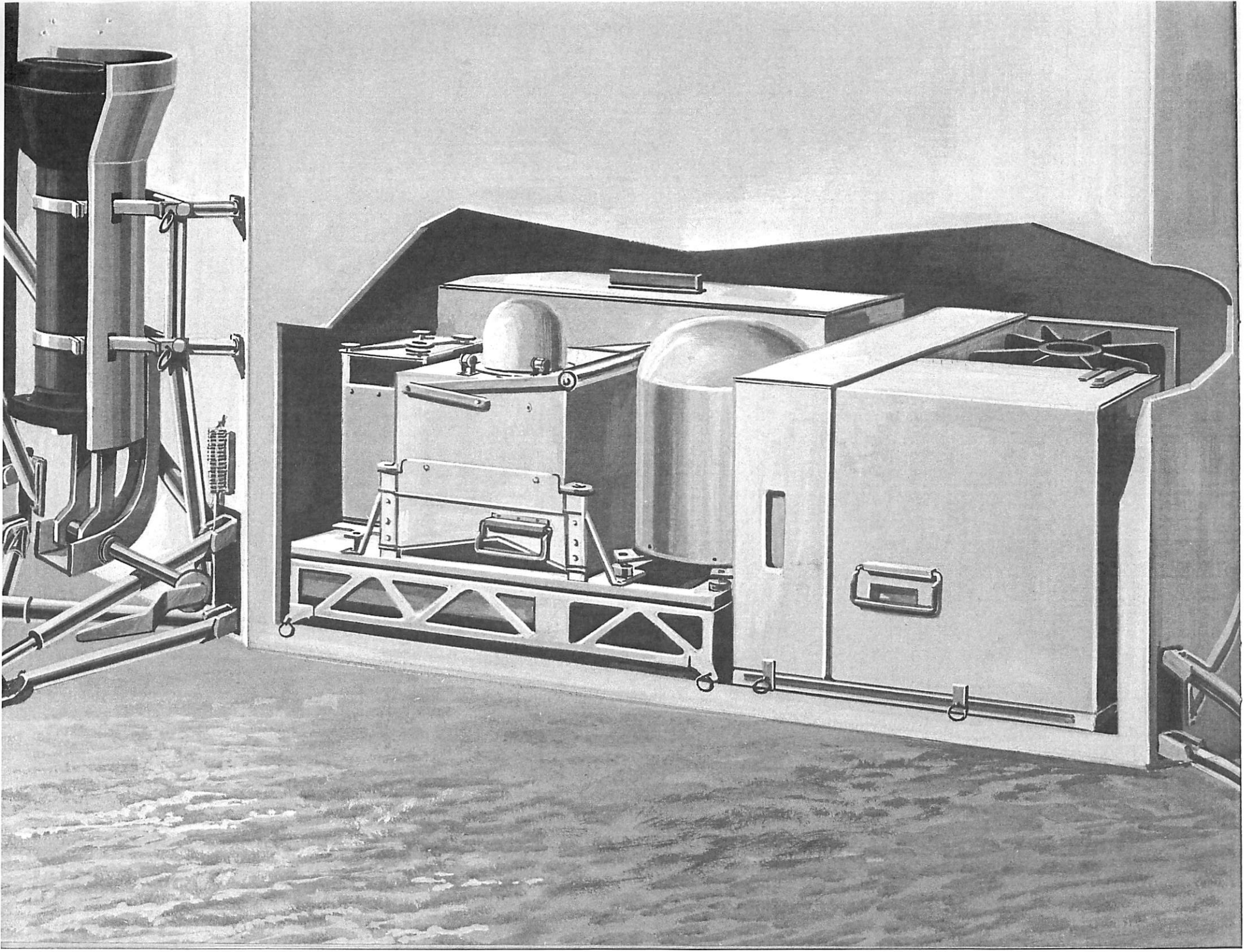
SNAP-27 Subsystems Include:

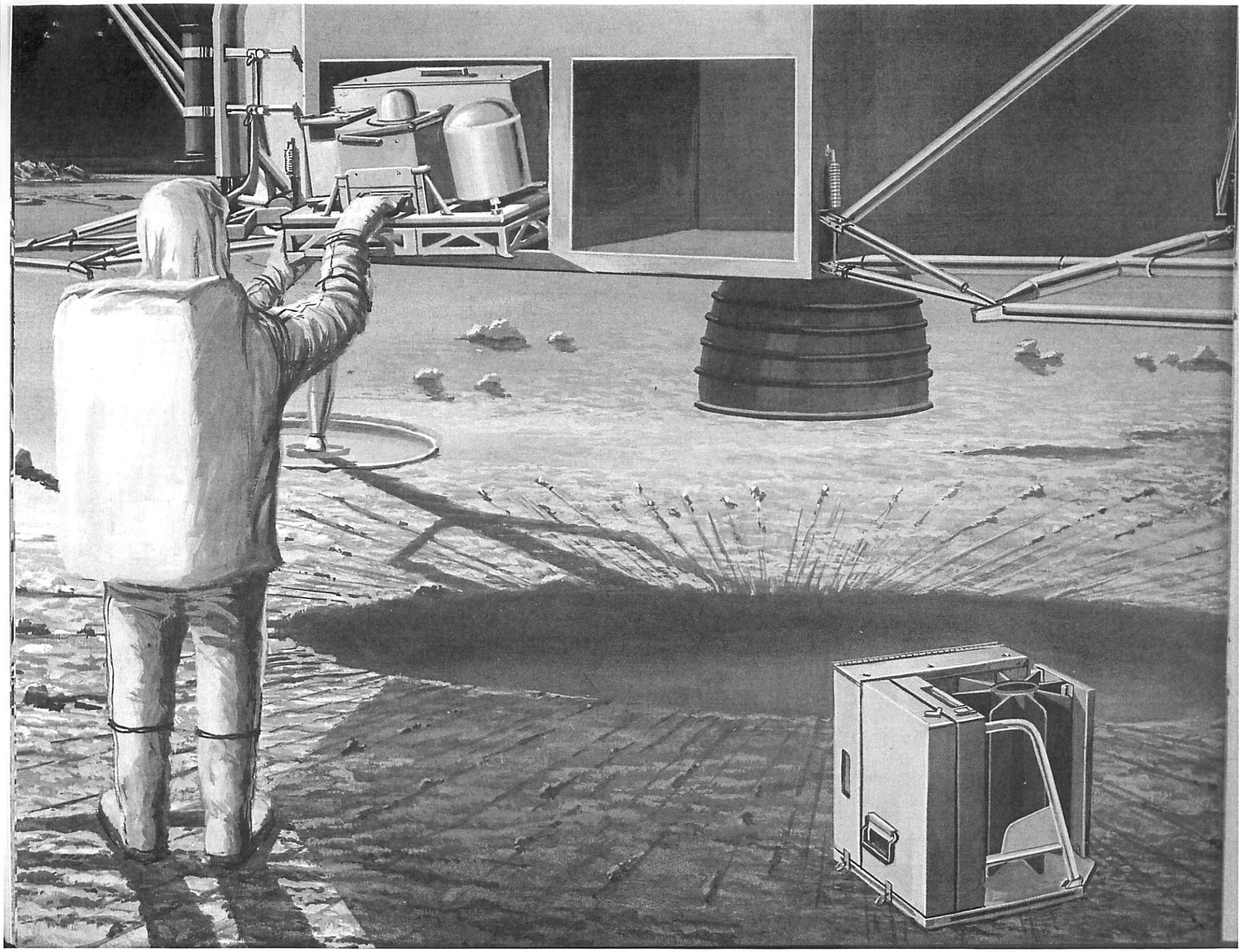
- *A radioisotope thermoelectric generator with a Pu 238 fuel capsule heat source.*
- *A storage cask, attached to the exterior of the Lunar Module (LEM), used to transport the fuel capsule during translunar flight.*
- *A fuel capsule handling tool affording the astronaut a means of removing the fuel capsule from the storage cask and fueling the generator on the lunar surface.*

With the LEM resting on the lunar surface, the astronaut approaches the scientific equipment bay in the descent stage. The ALSEP compartment has been exposed by opening the thermal shield covering the scientific equipment bay. To the left of the ALSEP compartment, near the landing gear struts, is the SNAP-27 fuel storage cask. The generator is out of sight behind equipment in the extreme right hand portion of the ALSEP compartment.

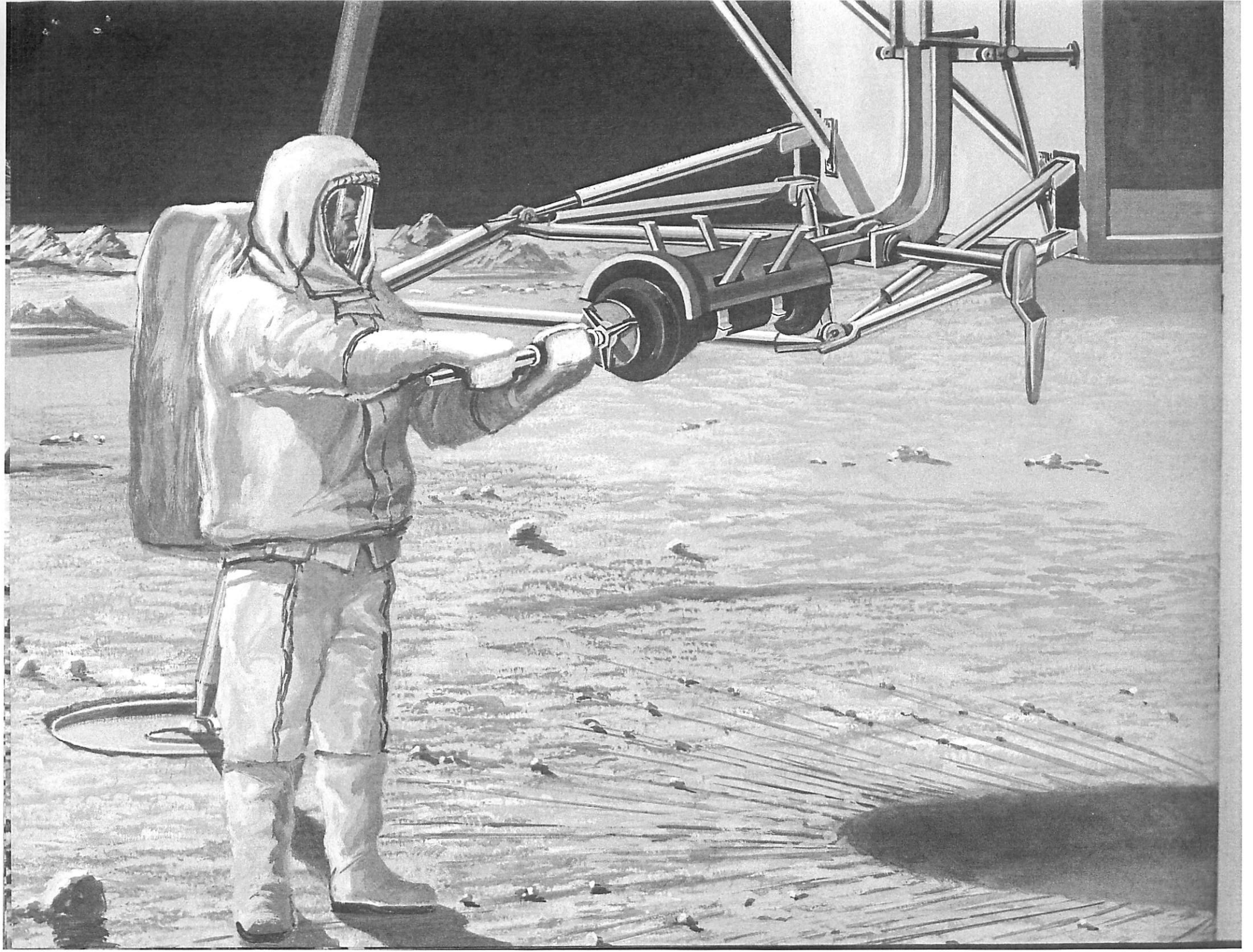


A cutaway view of the ALSEP compartment shows the top of the SNAP-27 generator (finned cylindrical body) in the right rear area of the equipment bay. The fuel storage cask and its mounting structure can be seen at the left. The cask is a small self contained atmospheric re-entry vehicle designed to return the fuel capsule intact to the earth in the event of a mission abort. In the case of this unlikely occurrence, the heat of re-entry melts the small bands which secure the cask to the LEM. The cask is freed from the LEM and allowed to re-enter as a stable aerodynamic vehicle. The heat shield on the cask insures against burnup of the fuel capsule and subsequent dispersion of the radioisotope fuel onto the earth. The fuel cask constitutes an important safety feature in the SNAP-27 system.

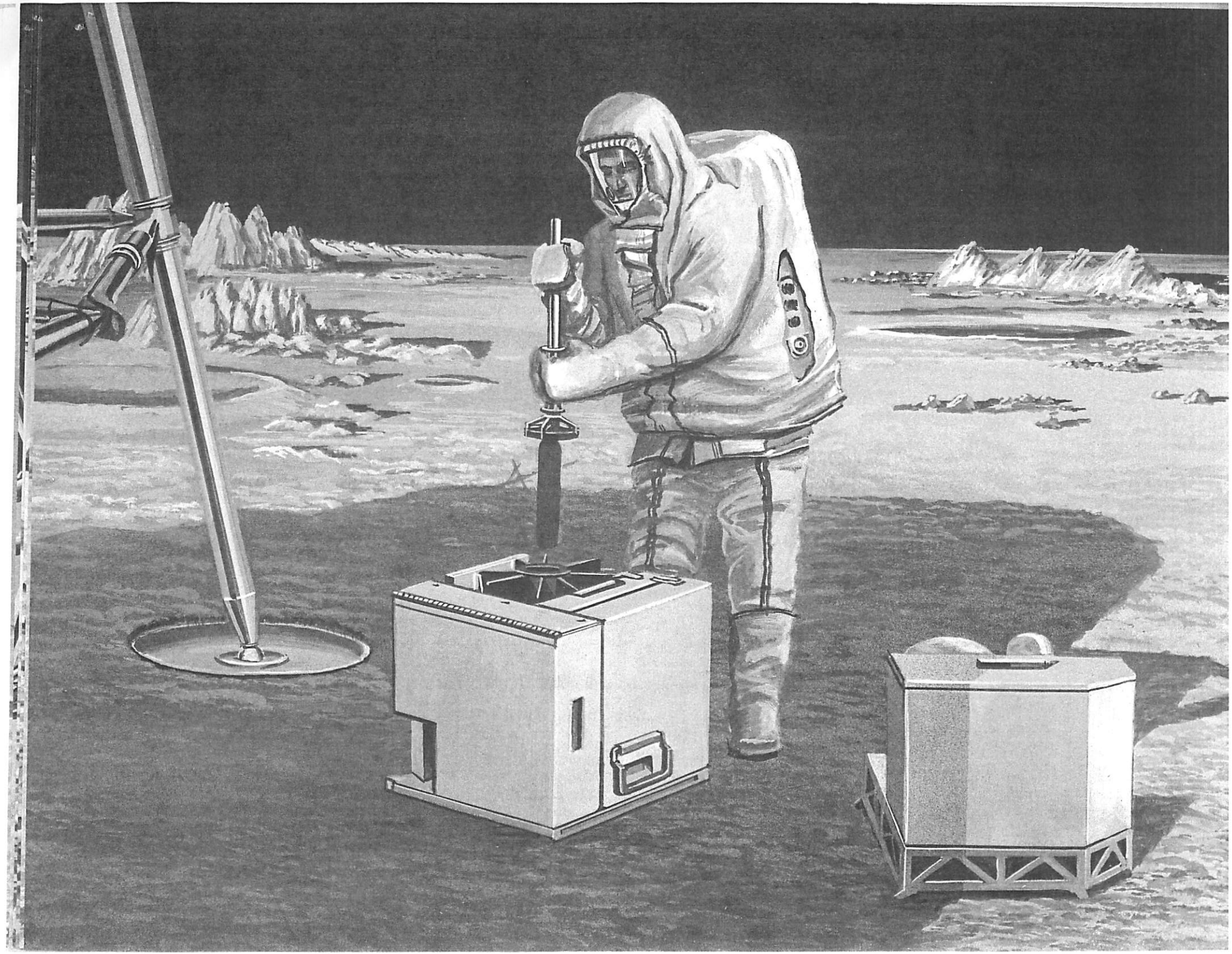
The astronaut removes one of the two ALSEP packages from the storage compartment. Included in the package are the unfueled generator and the Lunar Geological Equipment (LGE) which includes geologist tools and other aids.



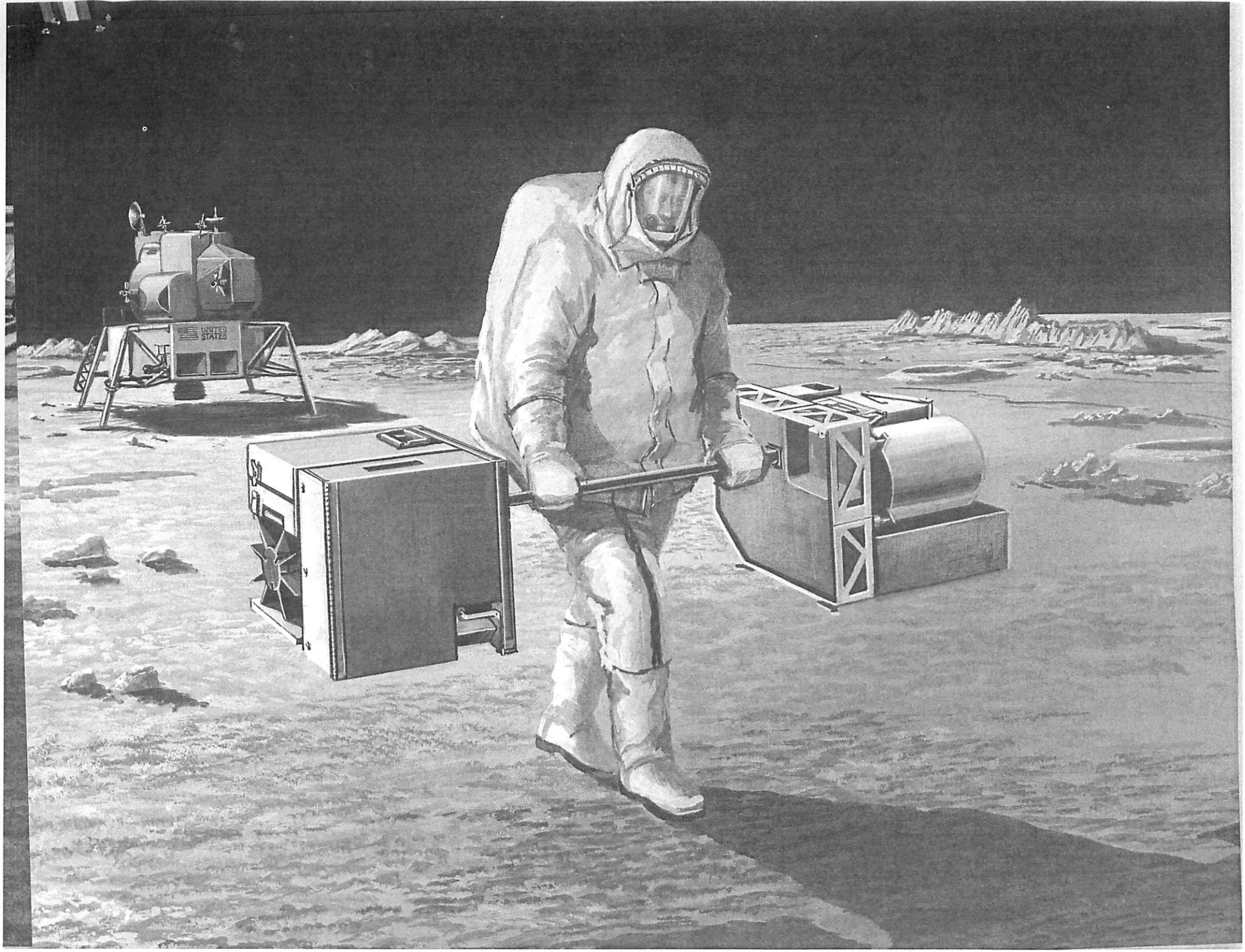
The packaged, unfueled SNAP-27 generator rests on the lunar surface as the astronaut removes the remaining ALSEP unit from the LEM compartment. The unit includes telemetry and data management subsystems, experiment instruments, and thermal control equipment.



After the equipment packages have been removed from the ALSEP compartment, the astronaut prepares for the fueling activity. The fuel capsule is removed from the fuel storage cask by rotating the cask into a horizontal position and engaging the handling tool with the fuel capsule. Attaching the handling tool to the fuel capsule automatically delatches the capsule mounting plate from the cask and the fuel capsule can be removed.



The astronaut inserts the hot fuel capsule into the SNAP-27 generator. The same design feature in the handling tool which frees the fuel capsule from the cask, locks the capsule securely to the generator once it has been properly inserted. Full power operation of the SNAP-27 generator occurs approximately ninety minutes after introduction of the fuel capsule into the generator.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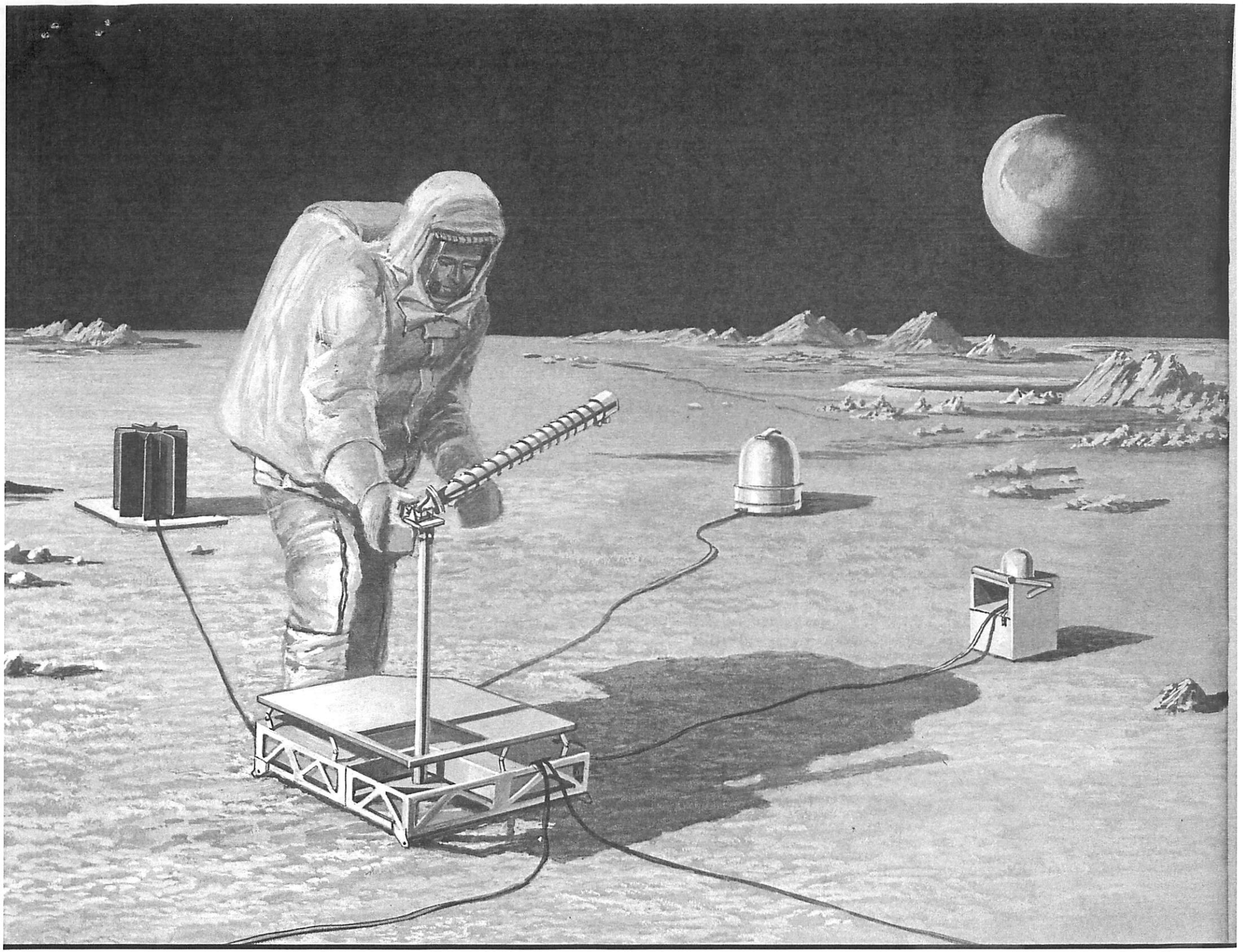
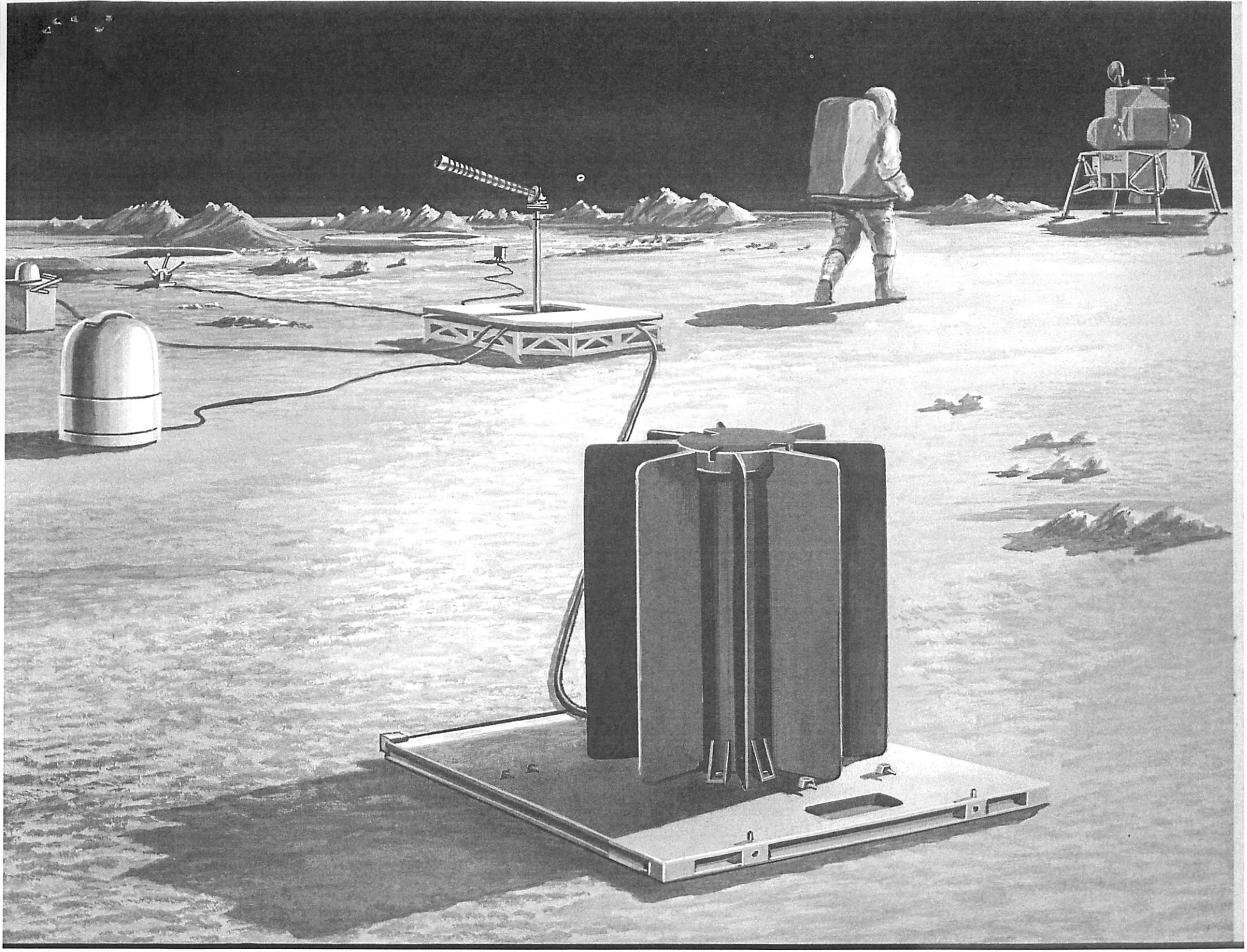
Upon completion of generator fueling activities, the astronaut latches the two ALSEP packages together into a barbell shaped assembly. The ALSEP system weighs approximately 180 pounds on earth, but the effective weight under lunar gravity conditions is only 30 pounds. In this configuration, one astronaut can easily carry the ALSEP package to its operating site several hundred feet from the LEM. Separation distance is required to avoid possible damage to the instruments from debris scattered during the LEM ascent stage take-off.



The SNAP-27 generator is connected to a central station containing the data management and power distribution equipment. The astronaut carefully aims the telemetry antenna toward the earth. He then deploys the various instruments with due regard for their scientific objectives.

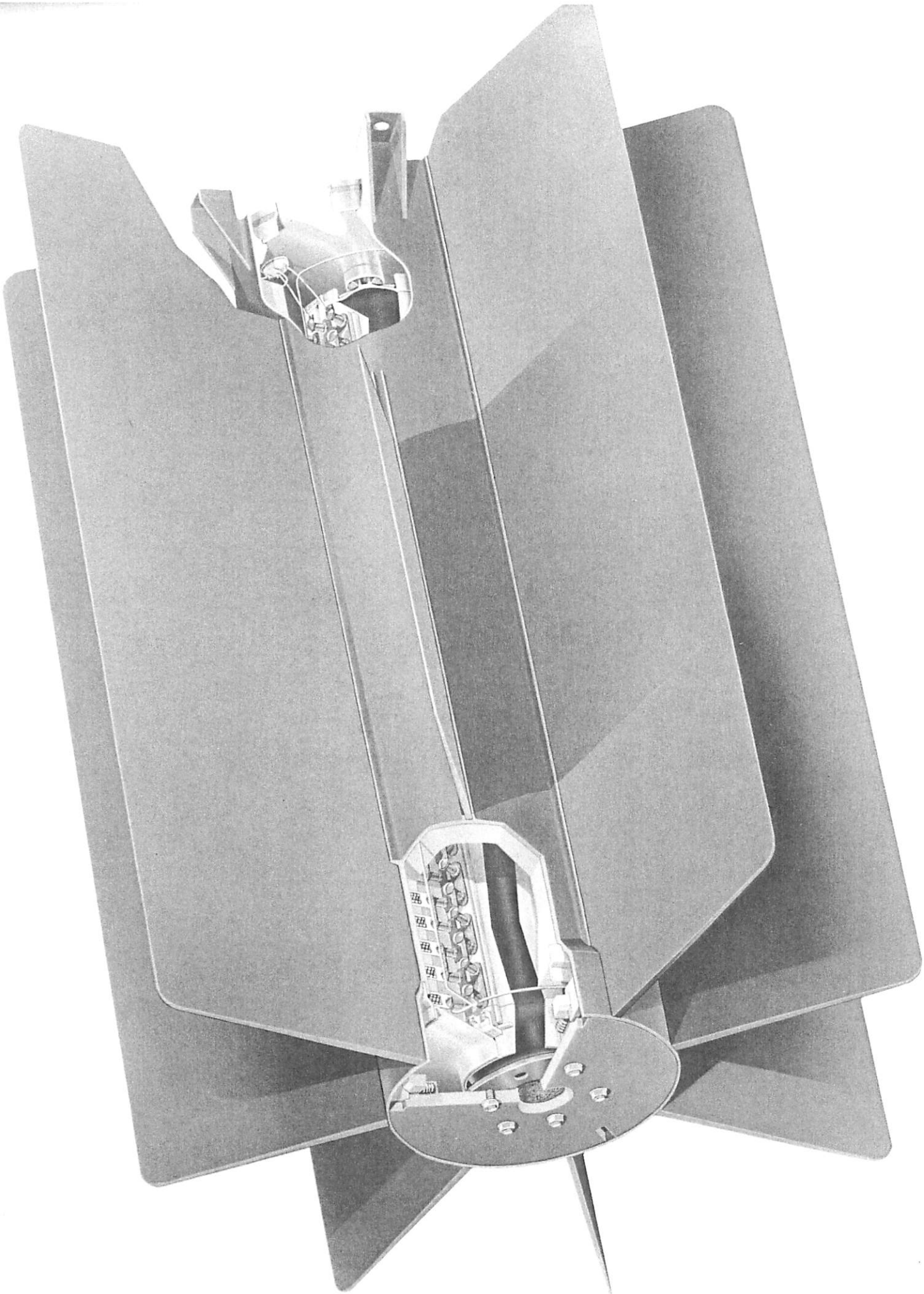


The fully deployed SNAP-27, attached to its mounting pallet, connected by cables to ALSEP's central station, stands ready to provide 56 watts to the ALSEP central station for at least one year. SNAP-27 will operate continuously at this level throughout the lunar day and night.

PART II

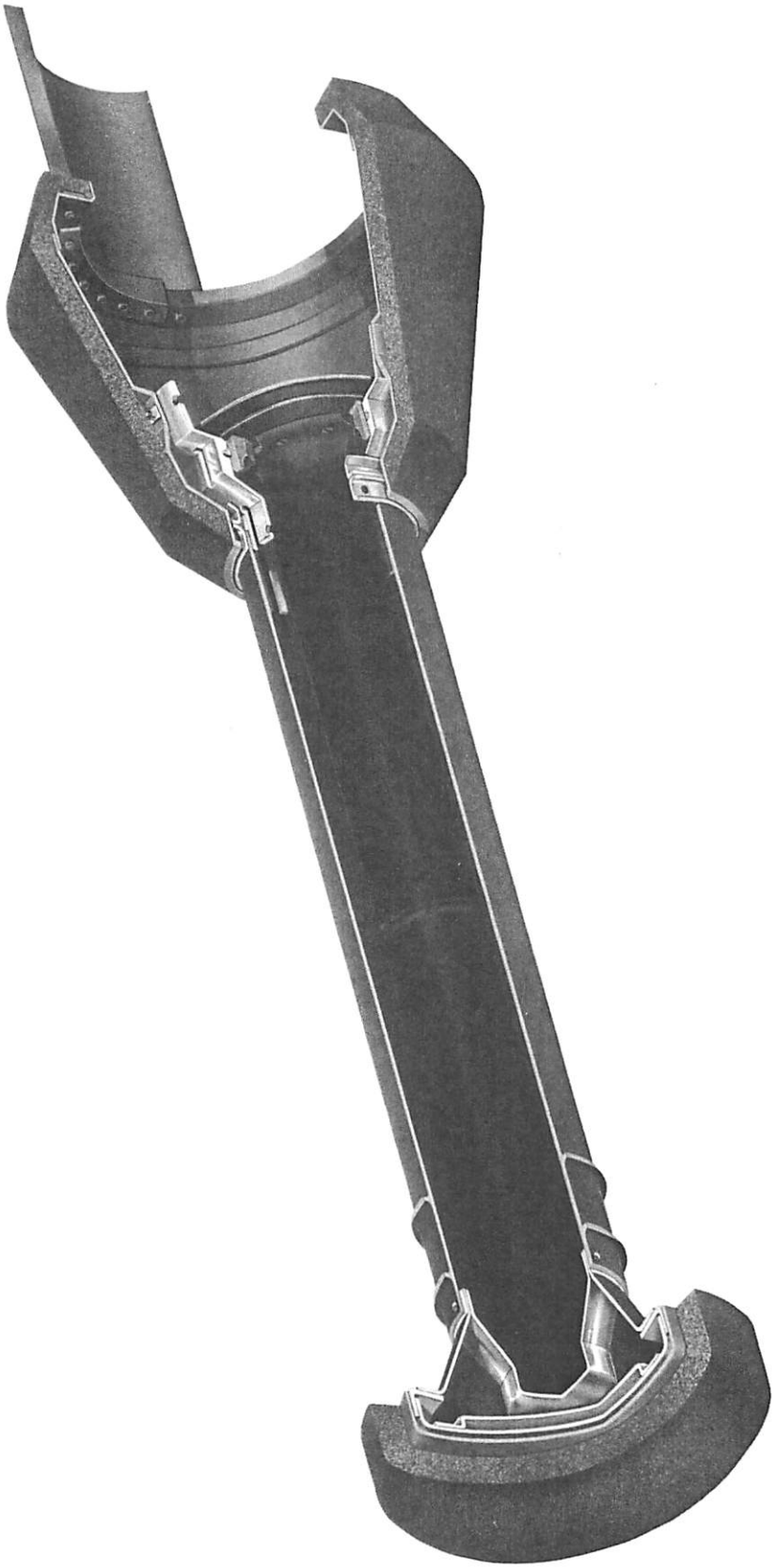
SNAP-27 POWER SUPPLY

DESIGN FEATURES



The SNAP-27 generator assembly, with fuel capsule in place, is shown in cutaway. This complete unit weighs approximately 38 pounds, and produces a minimum of 56 watts (DC) at a nominal 14 volts. Heat generated by decay of the plutonium radioisotope fuel is transferred by radiation to a cylindrical hot frame in the generator. Spring loaded lead-telluride thermoelectric elements, mounted radially around the hot frame, convert heat directly to electrical power. These thermoelements are sealed in an inert atmosphere, and reject waste heat to a set of radiating fins.

Wherever possible, beryllium is used as the main structural material to minimize system weight. Other materials include Inconel and Haynes superalloys for strength at high temperature. Thermoelements are connected in a series-parallel ladder arrangement to maximize reliability. Problems of misalignment under thermal cycling (lunar day - night variation) are reduced by incorporation of a spherical seat at the outer end of each element.



The LEM fuel cask, shown in cutaway, consists of beryllium and titanium structure fitted with ablative heat shield material on the forward and aft ends. Total weight of the cask, without fuel capsule in place, is 7.5 pounds. Shape of the cask is determined by the requirement that it function as a stable aerodynamic re-entry vehicle in the event of mission abort. The central cylinder of the cask provides a free radiation surface for rejection of fuel capsule heat during all operating phases. Elastomeric heat shields on the nose and tail cone are isolated from the fuel capsule by thermal radiation barriers coated with low emissivity gold plating.