nuclear power on the moon

Atomic energy has been operating on the moon since the flight in November of Apollo 12. Astronauts Charles Conrad and Allan Bean, the second pair of men to walk on the surface of the moon, took with them a nuclear generator and set it in position to provide the electricity to operate scientific instruments and subsystems which are providing continuing information. In his report at the end of 1969 Dr. Glenn T. Seaborg, Chairman of the US Atomic Energy Commission, was able to report that the generator was successfully withstanding immense temperature variations. Some details are given in this article.

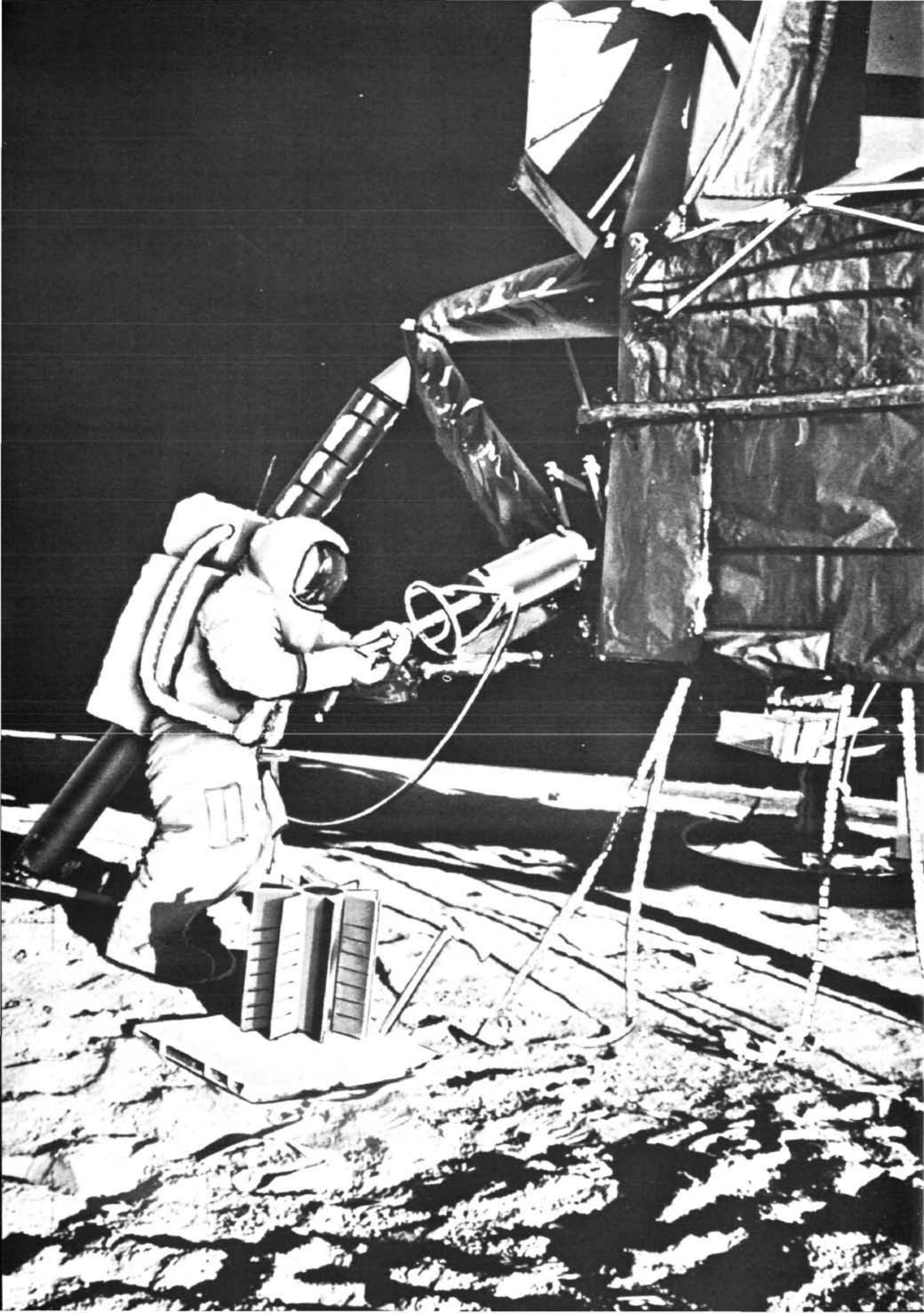
The nuclear assembly was carried on the outside of the lunar module on its journey to the moon. This allowed the heat generated by the fuel capsule to be dispersed in space and for adequate shielding to protect the astronauts.

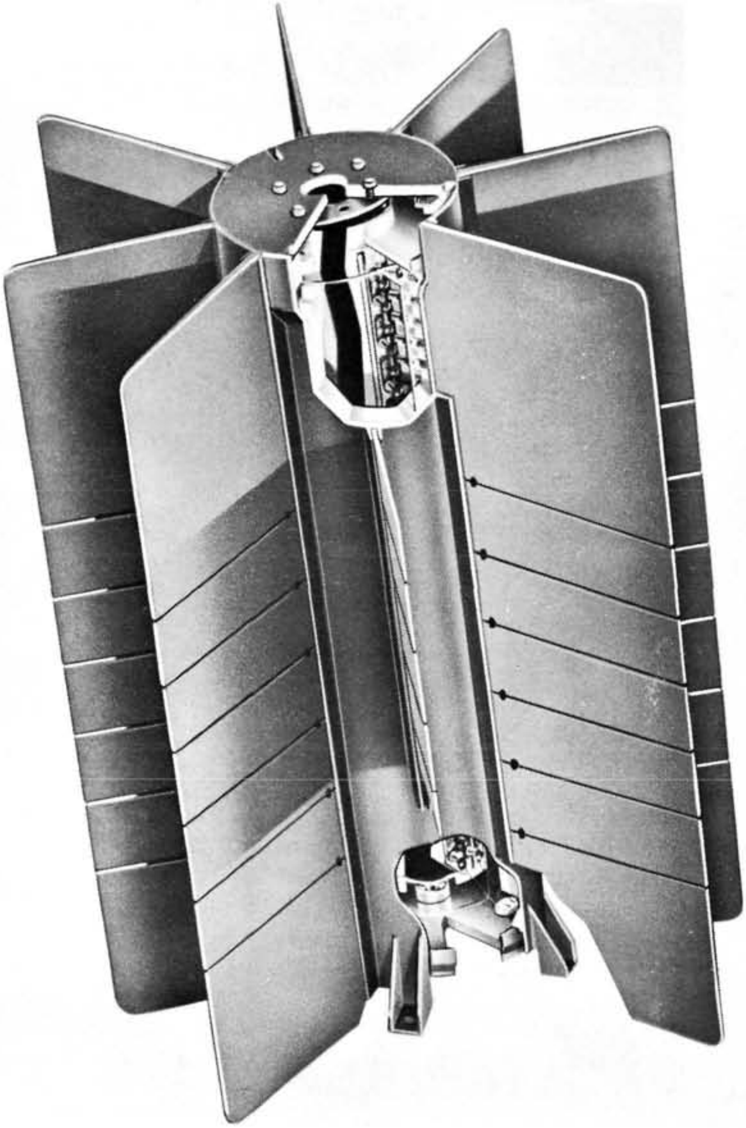
The power is provided by SNAP-27, one of a series of radioisotope thermoelectric generators, or atomic batteries, developed by the Atomic Energy Commission. The SNAP (Systems for Nuclear Auxiliary Power) programme is directed at development of generators and reactors for use in space, on land and in the sea.

While nuclear *heaters* were used in the seismometer package on Apollo 11, SNAP-27 on Apollo 12 marked the first use of a nuclear *electrical* power system on the moon. It was designed to provide all the electricity for continuous one-year operation of the National Aeronautics and Space Administration (NASA) scientific instruments and supporting subsystems deployed by the astronauts on the lunar surface.

With the moon in darkness for 14 days out of each 28-day period, solar panels as a source of power for lunar experiments would be operative only 50 per cent of the time because of their dependence on the rays of the sun. Nuclear generators operate independently of light from the sun. Therefore, experiments powered by a nuclear generator can provide data continuously rather than on a less than full-time basis as would be the case with solar cells.

A nuclear power generator of different design is providing part of the power, along with solar cells, for the Nimbus III satellite which was launched in April 1969 — the first use of a nuclear power system on a NASA spacecraft. Other systems of this type have also been used on navigational satellites. Altogether, eight nuclear power systems, before SNAP-27, have been launched in the United States space programme.





A cutaway view of the radioisotope thermoelectric generator
now operating on the moon. It converts heat directly into electric energy to operate special instruments. Photo: General Electric, USA

Description

The basic SNAP-27 unit was designed to produce at least 63 electrical watts of power for the Apollo 12 experiments. It is a cylindrical generator, fueled with the radioisotope plutonium-238, about 18 inches high and 16 inches in diameter, including the heat radiating fins. The generator, making maximum use of the lightweight material beryllium, weighs about 28 pounds unfueled.

Photo taken on the moon of the plutonium fuel
being removed from its cask for insertion in the power generator SNAP-27. Photo: supplied by USAEC

The fuel capsule, made of a superalloy material, is 16.5 inches long and 2.5 inches in diameter. It weighs about 15.5 pounds, of which 8.36 pounds is fuel.

The plutonium-238 fuel is fully oxidized and is chemically and biologically inert.

The fuel capsule was contained within a graphite fuel cask during the operational mission. The cask was designed to provide re-entry heating protection and added containment for the fuel capsule in the unlikely event of an aborted mission.

Once on the moon, the fuel capsule was removed from the cask and inserted into the generator, which was placed on the lunar surface near the module.

Operation

In the generator the spontaneous radioactive decay of the plutonium-238 within the fuel capsule generates heat. A thermopile assembly of 442 lead telluride thermoelectric elements converts this heat — 1480 thermal watts — directly into electrical energy — at least 63 watts. There are no moving parts.

Advantages and Applications

Nuclear power is considered essential to the development of a long-lived, reliable, strong, relatively small and lightweight electrical system for a variety of space applications including earth orbital satellites, lunar missions and probes to distant planets. Many present spacecraft power systems depend on the use of solar cells for generating electrical power for direct use and for recharging chemical batteries. Ever-increasing power requirements, however, are creating difficult problems in the design of increasingly larger solar cell panels and associated battery storage systems. Additionally, nuclear power sources would be required for any exploration missions travelling great distances from the sun. The size of the solar cell array required for such missions would be too large to be practical.

The unique properties of plutonium-238 make it an excellent isotope for use in space nuclear generators. At the end of almost 90 years, plutonium-238 is still supplying half of its original heat. It emits mainly the nuclei of helium (alpha radiation), a very mild type of radiation which requires very little shielding. The generator which houses the isotopic fuel essentially shields this radiation and thus avoids a weight penalty for radiation protection of the spacecraft hardware. A thorough review was conducted to assure the health and safety of personnel involved in the launch and of the general public. Extensive safety analyses and tests demonstrated that the fuel would be safely contained under almost all credible accident conditions.