



# Heartland Science

Ohio's Legacy of Discovery & Innovation



## Aviation & Aerospace

From the Wright Brothers to the Moon

### Electricity for Deep Space Missions

John H. Birden and Kenneth C. Jordan in 1955 developed the electric power generator used on most United States deep-space missions. At the time, they worked at the Monsanto Research Laboratory in Miamisburg, Ohio. They called their invention the "Thermo-Electric Generator." Since that time, Radio isotope thermoelectric generators have gone through many design changes, but they have been incorporated in most U.S. planetary probes. In fact, in the past three decades, the U.S. has launched 25 missions involving 44 RTGs (Radioisotope Thermoelectric Generators).



As seen on the photo to the right of Saturn (Voyager 2 photo), the invention was critical to our ability to explore space, especially areas beyond Mars. Once a spacecraft reaches Mars, the sun's light is not strong enough to allow solar panels too convert the light into electricity. Without power, space exploration is not possible. The RTG generates electrical power by converting heat to power using thermoelectric couples.



Radioisotope Thermoelectric Generators can provide continuous power for over twenty years -- very important for long term space missions. The Apollo missions to the moon; the Viking missions to Mars; and the Pioneer, Voyager, Ulysses, Galileo, and Cassini missions to the outer Solar System have all incorporated RTGs. At the moment, NASA and the U.S. Department of Energy are working on a new RTG that will operate on planetary bodies as well as in the vacuum of space.

### How Radioisotope Thermoelectric Generators Work

Radioisotope thermoelectric generators (RTGs), are used when spacecraft must operate at significant distances from the sun (usually beyond the orbit of Mars), or where the availability of sunlight and therefore the use of solar arrays is otherwise infeasible.

RTGs, as currently designed for space missions, contain several kilograms of an isotopic mixture of the radioactive element Plutonium (Pu) in the form of an oxide, pressed into a ceramic pellet. The pellets are arranged in a converter housing and function as a heat source to generate the electricity provided by the RTG.



Jim Irwin (Apollo 15).  
The large black object at the bottom  
is the Radioisotope Thermoelectric  
Generator (RTG).

The radioactive decay of the plutonium produces heat, some of which is converted into electricity by an array of thermocouples made of silicon germanium junctions. Waste heat is radiated into space from an array of metal fins. Plutonium -- like all radioactive materials and many non-radioactive materials -- can be a health hazard under certain circumstances and in sufficient quantity. RTGs are therefore designed with the goal of surviving a crash without releasing any plutonium.