Physical Sciences

Miniature Radioisotope Thermoelectric Power Cubes

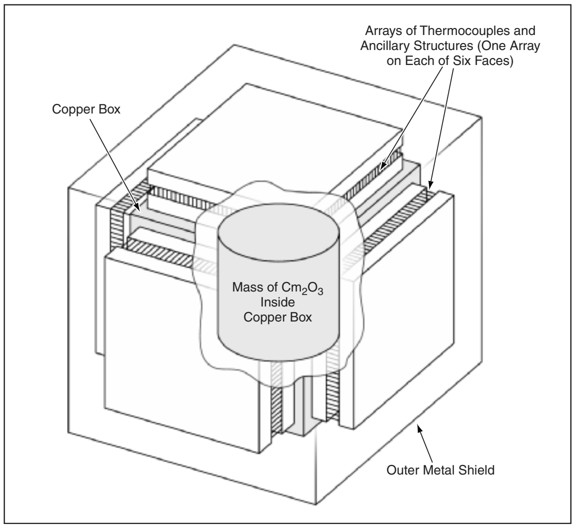
These devices could supply power at extremely low temperatures for years.

NASA's Jet Propulsion Laboratory, Pasadena, California

Cube-shaped thermoelectric devices energized by a particles from radioactive decay of ^{244}Cm have been proposed as long-lived sources of power. These power cubes are intended especially for incorporation into electronic circuits that must operate in dark, extremely cold locations (e.g., polar locations or deep underwater on Earth, or in deep interplanetary space). Unlike conventional radioisotope thermoelectric generators used heretofore as central power sources in some spacecraft, the proposed power cubes would be small enough (volumes would range between 0.1 and 0.2 cm^3) to play the roles of batteries that are parts of, and dedicated to, individual electronic-circuit packages. Unlike electrochemical batteries, these power cubes would perform well at low temperatures. They would also last much longer: given that the half-life of ^{244}Cm is 18 years, a power cube could remain adequate as a power source for years, depending on the power demand in its particular application.

The cubical configuration of a proposed device of this type (see figure) would contribute to thermal efficiency by providing a relatively large area for rejection of heat at low temperature. It would also contribute to thermal-to-electrical energy-conversion efficiency by providing a relatively large heat-transfer area that could be covered with arrays of thermocouples and maximizing the temperature drop across the thermoelectric elements.

The geometric and thermal heart of a proposed thermoelectric power cube would be a cubic box, made of porous copper, that would enclose a mass of about 0.5 g of ^{244}Cm in oxide form. The wall thickness of the box [≈20 mils (≈0.5 mm)] would be sufficient to stop the α particles and contain any ancillary radioactivity. The deposition of radioactive-decay energy in the walls of the box would generate heat at the rate of 4.2 W initially, falling to 2.1 W in 18 years. At the initial rate and under typical anticipated operating conditions, this heating would maintain the temperature of the box at about 200 °C.



A **Power Cube** according to the proposal would be designed to exploit synergies among small size, the cubical configuration, and low ambient temperature to obtain relatively high energy-conversion efficiency.

Thin-film arrays of thermocouples would be mounted on all six faces of the box for efficient conversion of heat into electricity. The portion of the power cube described thus far would be enclosed in a layer of metal that would serve as both a shield and a heat-sinking interface with the environment. The metal shield would also help to contain small amounts of soft γ radiation and neutrons that are emitted from the ^{244}Cm along with the α particles.

According to first estimates, each face would be covered with about 50 thermocouples that would generate 40 mW of power (a potential of 2 V at a current of 20 mA). Hence, the total electric power produced would be 240 mW, corresponding to an overall thermal-to-electrical energy-conversion efficiency of between 5 and 6 percent.

This work was done by Jagdish U. Patel, Jean-Pierre Fleurial, G. Jeffrey Snyder, and Thierry Caillat of Caltech for **NASA's Jet Propulsion Laboratory**. *Further information is contained in a TSP (see page 1).*
NPO-30328

Permanent Sequestration of Emitted Gases in the Form of Clathrate Hydrates

Hydrates would be formed under natural conditions.

NASA's Jet Propulsion Laboratory, Pasadena, California

Underground sequestration has been proposed as a novel method of permanent disposal of harmful gases emitted into the atmosphere as a result of human activity. The method was conceived primarily for disposal of carbon dioxide (CO_2, greenhouse gas causing global warming), but could also be applied to CO, H_2S, NO_x, and chorofluorocarbons (CFCs, which are super greenhouse gases). The method is based on the fact that clathrate hydrates (e.g., $CO_2{\cdot}6H_2O$) form naturally from the substances in question (e.g., CO_2) and liquid water in the pores of sub-permafrost rocks at stabilizing pressures and temperatures. The proposed method would be volumetrically efficient: In the case of CO_2, each