Physical Sciences

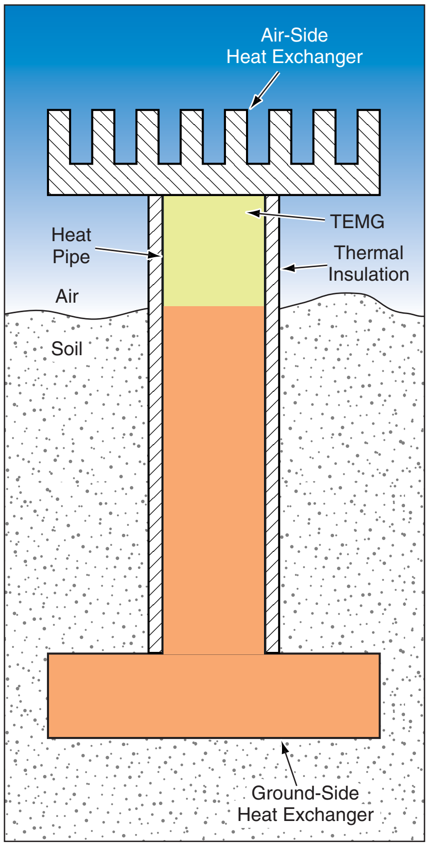
Thermoelectric Air/Soil Energy-Harvesting Device

Small amounts of power would be extracted from natural temperature differences.

NASA's Jet Propulsion Laboratory, Pasadena, California

A proposed thermoelectric device would exploit natural temperature differences between air and soil to harvest small amounts of electric energy. Because the air/soil temperature difference fluctuates between nighttime and daytime, it is almost never zero, and so there is almost always some energy available for harvesting. Unlike photovoltaic cells, the proposed device could operate in the absence of sunlight. Unlike a Stirling engine, which could be designed to extract energy from the air/soil temperature difference, the proposed device would contain no moving parts. The main attractive feature of the proposed device would be high reliability. In a typical application, this device would be used for low-power charging of a battery that would, in turn, supply high power at brief, infrequent intervals for operating an instrumentation package containing sensors and communication circuits.

The device (see figure) would include a heat exchanger buried in soil and connected to a heat pipe extending up to a short distance above the ground surface. A thermoelectric microgenerator (TEMG) would be mounted on top of the heat pipe. The TEMG could be of an advanced type, now under development, that could maintain high (relative to prior thermoelectric generators) power densities at small temperature differentials. A heat exchanger exposed to the air would be mounted on top of the TEMG. It would not matter whether the air was warmer than the soil or the soil warmer than the air: as long as there was a nonzero temperature difference, heat would flow through the device and electricity would be generated.



This **Simple, Reliable Thermoelectric Device** would harvest electric energy from the difference in temperature between air and soil.

A study of factors that could affect the design and operation of the device has been performed. These factors include the thermal conductances of the soil, the components of the device, the contacts between the components of the device, and the interfaces between the heat exchangers and their environments. The study included experiments that were performed on a model of the device to demonstrate feasibility. Because a TEMG suitable for this device was not available, a brass dummy component having a known thermal conductance of 1.68 W/K was substituted for the TEMG in the models to enable measurement of heat flows. The model included a water-based heat pipe 30 in. (76.2 cm) long and 1 in. (2.54 cm) in diameter, wrapped with polyethylene insulation to reduce radial heat flow. Several different side heat exchangers were tested. On the basis of the measurements, it was predicted that if a prototype of the device were equipped with a TEMG, daily temperature fluctuations would cause its output power to fluctuate between 0 and about 0.1 mW, peaking to 0.35 mW during early afternoon.

This work was done by Jeffrey Snyder, Jean-Pierre Fleurial, and Eric Lawrence of Caltech for **NASA's Jet Propulsion Laboratory**. *Further information is contained in a TSP (see page 1).*
NPO-30831

Flexible Metal-Fabric Radiators

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Flexible metal-fabric radiators have been considered as alternative means of dissipating excess heat from spacecraft and space suits. The radiators also may be useful in such special terrestrial applications as rejecting heat from space-suit-like protective suits worn in hot work environments. In addition to flexibility and consequent ease of deployment and installation on objects of varying sizes and shapes, the main advantages of these radiators over conventional rigid radiators are that they weigh less and occupy less volume for a given amount of cooling capacity. A radiator of this type includes conventional stainless-steel tubes carrying a coolant fluid. The main radiating component consists of a fabric of interwoven aluminum-foil strips bonded to the tubes by use of a proprietary process. The strip/tube bonds are strong and highly thermally conductive. Coolant is fed to and from the tubes via flexible stainless-steel manifolds designed to accommodate flexing of, and minimize bending forces on, the fabric. The manifolds are sized to minimize pressure drops and distribute the flow of coolant evenly to all the