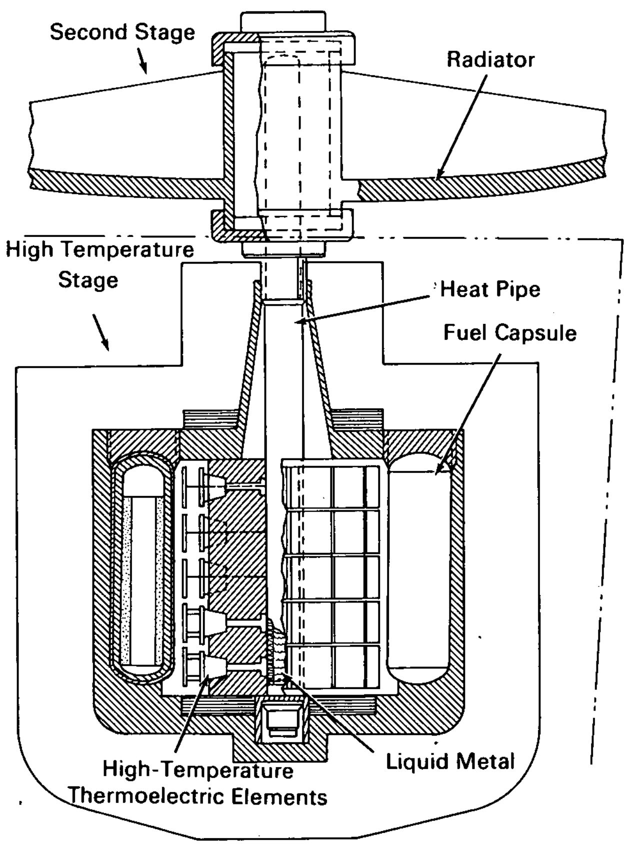
NASA TECH BRIEF

Thermally Cascaded Thermoelectric Generator



Radioisotope-thermoelectric-generators (RTG) use thermoelectric elements which convert thermal energy to electrical power. It is acknowledged that there is no ideal thermoelectric material; rather, the available materials are each efficient in the conversion of heat into electrical power within specific temperature ranges. It is intuitively apparent that a serial combination of a high-temperature thermoelectric material and a low-temperature thermoelectric material would have a higher conversion efficiency than any single material.

A high efficiency thermoelectric generator has been designed and fabricated which utilizes a high-temperature thermoelectric material in thermal series with a low-temperature material. The provision of a thermally cascaded generator, with two stages connected in thermal series by means of an elongated heat pipe containing a liquid metal and a wick, increases the overall efficiency of the RTG system.

The thermally cascaded, thermoelectric generator, shown in the figure, consists of a high-temperature stage coupled to a second low-temperature stage by a heat pipe which contains a wick and liquid metal. Heat generated in the isotopic fuel capsules is radiated to the first high-temperature stage located within the cylindrical array of fuel capsules; an array of silicon-germanium (Si-Ge) thermocouples converts a portion of this heat to electrical power. The heat rejected from the first stage is absorbed by the liquid metal (contained in the heat pipe) as latent heat of vaporization. The vapor produced by this energy transformation process travels within the heat pipe to the second stage, where it condenses and transfers the heat to the lower temperature thermoelectric wafers. Lead-telluride (Pb-Te) material is used in this stage to increase the conversion efficiency. The heat input to the second stage is at a temperature of 850° K to 950° K and is rejected by the radiator fins at about 450° K.

The thermal impedances of all the components of the system are carefully matched so that the operating temperature is optimum for the system and not for the individual stages or components. When properly constructed, the system produces approximately 50%

(continued overleaf)

more power than could be produced by either stage alone.

The arrangement of the two stages, coupled together by the heat pipe, and the placement of the Si-Ge thermocouples, eliminate direct contact between the generators and the thermocouples; this eliminates the mechanical and chemical stability problems inherent in fabricating a thermally cascaded generator. The heat pipe and radiators are selected to insure that each stage operates in a temperature range where it is more thermoelectrically efficient.

Note:

Requests for further information may be directed to:

Technology Utilization Officer
NASA Pasadena Office
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Pasadena, California 91103
Reference: B70-10280

Patent status:

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Source: Robert Flaherty of
Westinghouse Electric Corp.
under contract to
NASA Pasadena Office
(NPO-10753)