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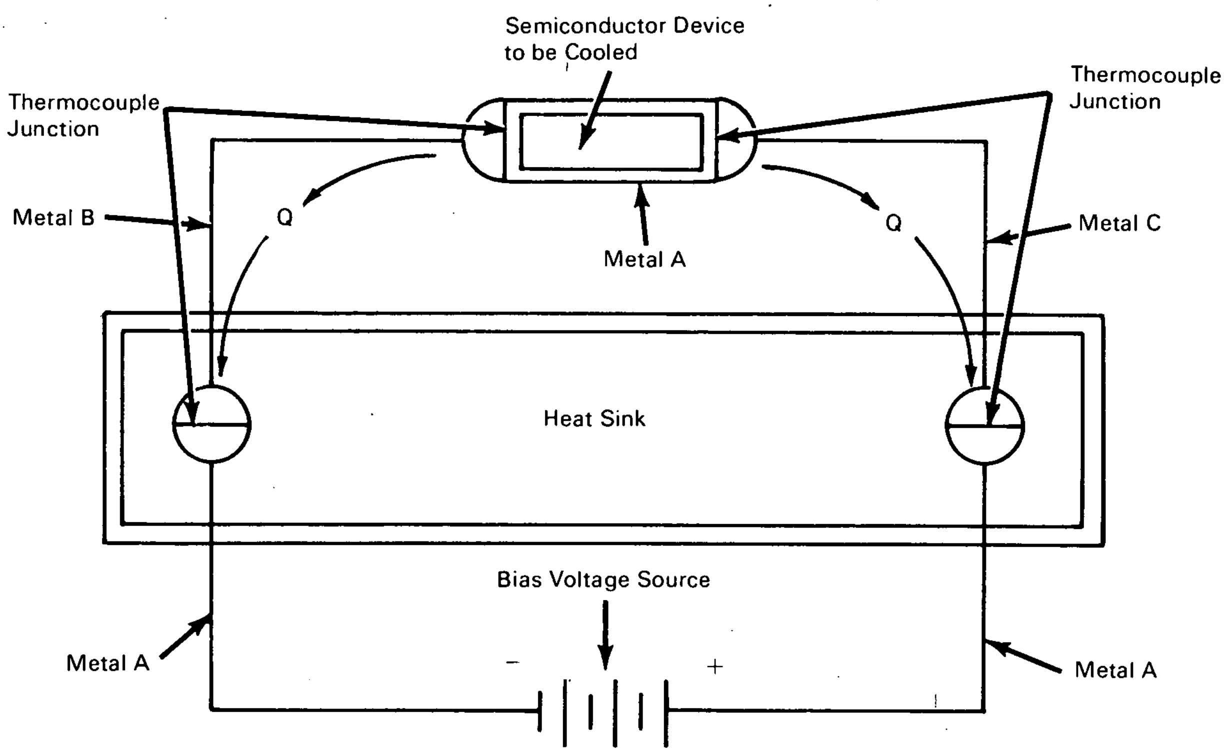
NASA TECH BRIEF

Semiconductor Cooling by Thin-Film Thermocouples



Thermocouple junctions made of bimetallic thin films have been incorporated into the active region of certain solid-state circuit components to improve their heat dissipation characteristics. These junctions use the Piltier effect to remove heat, with the electric current itself providing the heat transfer medium.

Thermocouple-type cooling devices have previously been used as an integral part of a circuit only in the case of a semiconductor junction in contact with an electroluminescent diode. However, the advantage of the efficient cooling produced by such junctions is negated by other problems: semiconductor junctions form rectifiers, they produce a large change in circuit impedance, and have relatively large space requirements. These problems limit the usefulness of semiconductor thermocouples in circuit design.

Metal alloy junctions, although less efficient cooling devices than semiconductor junctions, have the definite advantages that they do not rectify, they change the impedance of the circuit only slightly, and require very little increase in space.

Consider the thin-film, metal-alloy thermocouple cooling circuit shown in the figure. Given a dc bias, the four alloy junctions will exhibit the Peltier effect.

(continued overleaf)

The amount of heat transferred at a junction is given by the equation: $Q = (k_2 - k_1)\,JT$ where

- Q is the heat flux in watts per cm^2 (positive Q implies heat absorption)
- k_1 is the absolute Seebeck coefficient of the alloy on the current input side of the junction
- k_2 is the absolute Seebeck coefficient of the output side alloy
- J is the current density in amp per cm^2, and
- T is the junction temperature in °K.

If the three metal alloys A, B, and C are chosen so that $k_B > k_A > k_C$, heat will be absorbed by both of the junctions which surround the device, and rejected by both junctions at the heat sink.

Notes:

1. This innovation may be applied to assist conventional cooling techniques for many electronic devices, such as Impatt, LSA, and Gunn devices, detector diodes, and power transistors. It should interest engineers and circuit designers who use these or other temperature-sensitive devices.
2. No further documentation is available. Specific questions, however, may be directed to:

   Technology Utilization Officer
   Headquarters
   National Aeronautics
   and Space Administration
   Washington, D.C. 20546
   Reference: B70-10495

Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA Code GP, Washington, D.C. 20546.

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