ALL ABOUT

Thermoelectric Coolers

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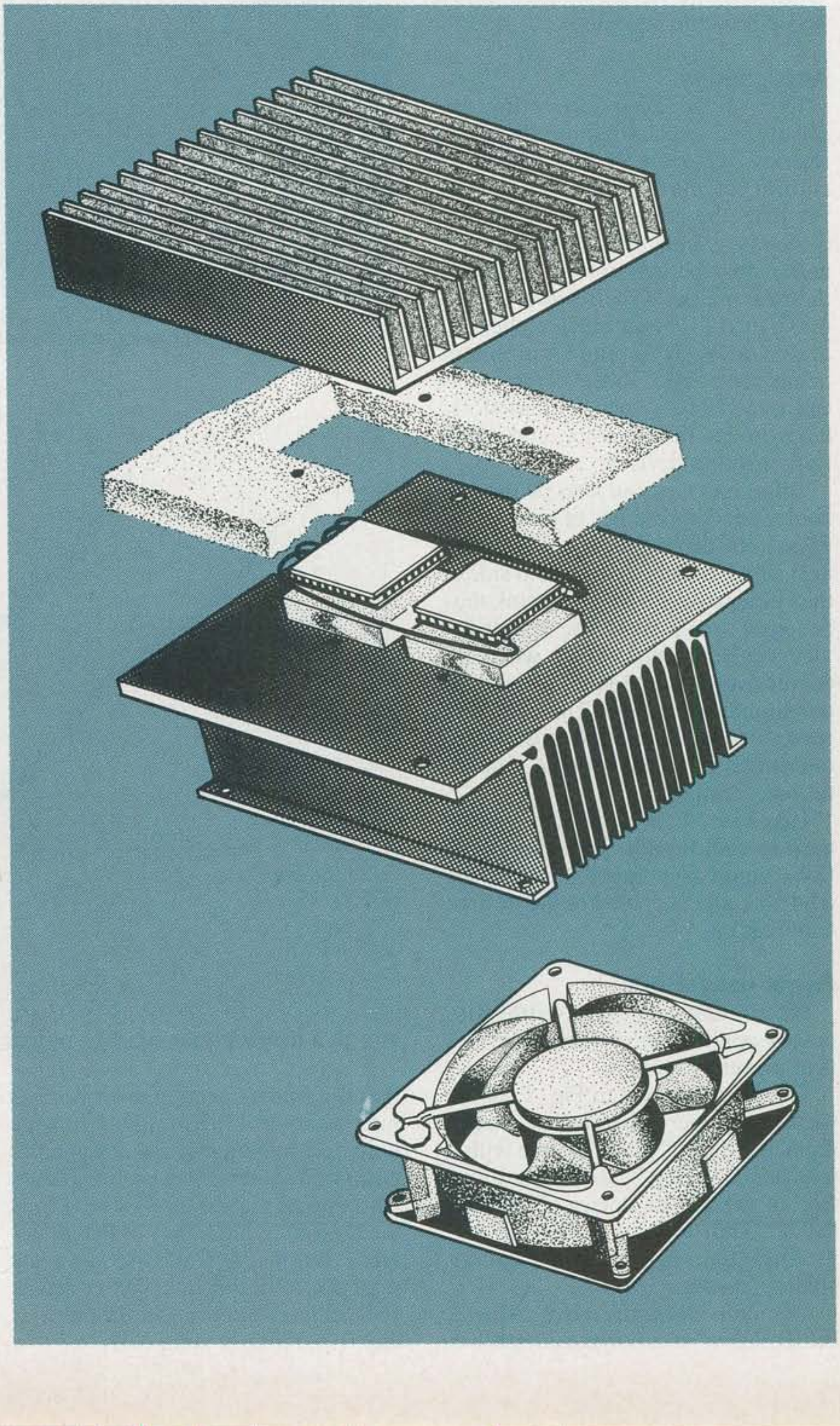
Here's a look at Peltier devices—tiny solid-state heat pumps that can be used in a wide variety of cooling or heating applications.



SINCE THE LAST CENTURY WE'VE KNOWN that when you form a closed circuit of two dissimilar metals and two junctions, a current may flow between the junctions. That happens when there is a temperature difference between the junctions, or when the metals have different temperatures.

The phenomenon is known as the *Seebeck effect*, and is the fundamental principal behind the thermocouple. Generally speaking, the greater the temperature differences, the higher the current. Also, the combination of metals that are used will affect the current flow.

The reverse of the Seebeck effect was discovered in 1834 by James C. Peltier. He found that passing an electric current through a junction formed by certain types of dissimilar materials could cause an increase or decrease in temperature. Peltier also found that the direction of current flow dictated whether heating or cooling occurred, and that the amount of temperature change was determined by the type of material and the size of the junction. In his honor, that effect is called the *Peltier effect*, and it is the fundamental principal behind Peltier devices. In this article, we'll examine Peltier devices, and how they are used, in more detail.

Semiconductor thermoelectric devices

Since the discovery of the Seebeck and Peltier effects, we've discovered that they are not necessarily limited to metals. In fact, they are seen strongly in semiconductors. Figure 1 shows the arrangement of a simple semiconductor Peltier device. It consists of two pieces of semiconductor material; one is p-type, and the other is n-type.

When current is applied, charge carriers move through the two materials; causing cooling of the top surface and heating of the bottom surface. That action is basically that of a heat pump—heat is pumped from the top to the bottom of the device. If the applied current is reversed, then the top surface will be heated, and the bottom surface cooled. The device is then a heater. Most practical thermoelectric devices, like the Marlow (10351 Vista Park Road, Dallas, TX 75238) MI 1069 shown in Fig. 2, consist of many such elements. In those, the elements are connected in series electrically, and in parallel thermally.

The tiny devices are capable of putting out great quantities of cold and heat, regardless of whether they are used as a cooler or heater. Therefore, a practical semiconductor cooler or heater absolutely requires a heat sink. Otherwise, the device would overheat and fail within seconds.

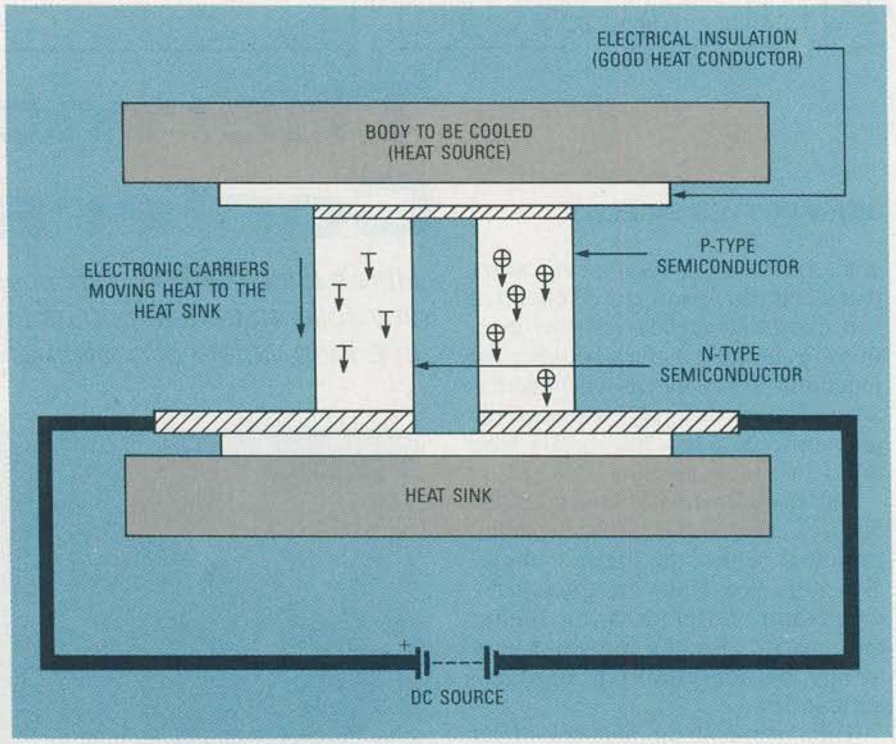


FIG. 1—A BASIC THERMOELECTRIC COOLER. The action is similar to that of a heat pump, conducting heat away from the cold side to the hot side.

Applications

One of the most interesting applications, especially for the electronics experimenter, is localized cooling of electronic components. For that, the cold side of the Peltier device is mounted directly to component using thermal epoxy, solder, or thermal grease. When power is applied to the Peltier device, heat is drawn away from the component being protected. Those components can include IC's, power transistors, laser diodes IR detectors, and solid-state imaging devices.

Peltier devices can also be used to cool moderate volumes of air or other gasses. In that application, a finned heat sink is attached to the cold side of the Peltier device. That heat sink thus becomes a *cold sink*. The Peltier device cools the cold sink; when air passes over the cold sink, a small air conditioner is created. The cold sink serves the same function as the evaporator coil in a conventional air-conditioner design.

Likewise, Peltier devices can be used to cool liquids. In that application, liquid is pumped through the cold sink and is cooled to the desired temperature.

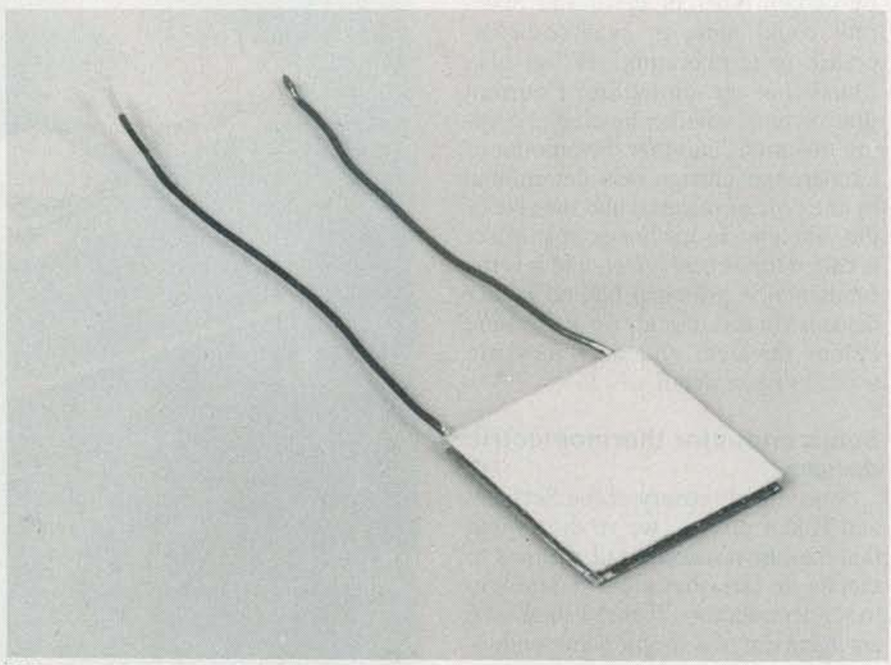


FIG. 2—A COMMERCIAL PELTIER DEVICE. This single-stage unit is the Marlow MI 1069.

Power generators

One interesting, and little-discussed application of Peltier devices is as power generators.

The circuit shown in Fig. 1 can be used as a power generator by simply replacing the DC power source with a load and applying heat to the top surface of the Peltier device. Note that the delivered power will have a polarity that's the opposite of the battery polarity shown.

One consideration when using a Peltier device as a power generator is that the solders used in most devices melt at about 138°C (although some units use solders that are designed to withstand short term exposure to temperatures as high as 200°). That limits the maximum efficiency of Peltier devices, but it is still possible to use a solar collector to heat a Peltier device and achieve outputs and efficiencies that rival those of solar cells.

Thermoelectric coolers are available in single-stage configurations at prices that range from about $15 to $50. For applications where a high degree of cooling is required, single-stage units can be ganged; that is the hot side of one unit is attached to the cold side of the other. Commercial units with up to six stages are available. **R-E**