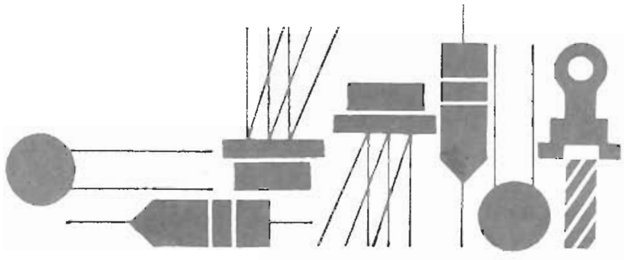


Solid State

By Lou Garner

USING THERMOELECTRIC DEVICES

MOST electronics buffs find great delight in demonstrating their latest hobby project to friends and neighbors, be it a newly constructed audio amplifier, a special-purpose receiver, or whatever. Now you can flabbergast your friends and astonish your acquaintances just by demonstrating the operation of a single, relatively simple solid-state device. And you won't need a bench full of extra equipment to accomplish this marvelous feat. All you'll need is a standard *thermoelectric* (TE) module and a suitable dc power source.

Call in the friend you wish to impress. Place an aluminum cookie sheet on the kitchen table to "protect the surface" (you don't have to mention that its real purpose is to serve as a heat sink). Produce the TE module with a suitable flourish and a few well-chosen comments. Place the module on the cookie sheet and ask your friend to hold it flat in place while you connect the power leads to a dc power supply (in some cases, an ordinary lantern battery). Then ask your friend to continue to hold the module down until it starts to "warm up."

Within seconds, the module's top surface will start to get cold (unless you goofed and placed it on the cookie sheet upside down). Chances are your friend will move his (her?) hand away from the device with some degree of astonishment. Continue watching and, within minutes, a thin film of frost will start to form on the module's top surface. At this point, you can: (a) tell your friend about the device; (b) tell him it's a subminiature air conditioner for pygmy space capsules; or (c) tell him it's a defective heater that gets cold instead of hot.

After you've had your fun demonstrating the device to all your friends, you can use it in a variety of practical applications, from cooling the output devices in a power amplifier to keeping potables at a reasonable drinking temperature. If you're a high school student, you can incorporate the TE device in any of a number of exciting Science Fair projects or, if in college, use it in scientific research work.

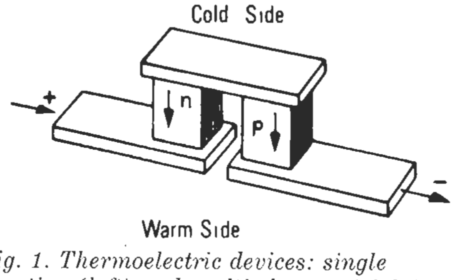
Interestingly, TE devices, in themselves, are not new. Scientists have been working with these units in one form or another for over a century and a half, dating back to 1821, when a German, Thomas Seebeck, discovered that an electric current will flow in a closed circuit made up of two dissimilar metals as long as the junction between the two is maintained at different temperature levels. Named, appropriately, the *Seebeck effect,* this discovery has been utilized for decades in the manufacture of meter and temperature sensing *thermocouples.*

The next major breakthrough was made in 1834, when a French scientist, Jean Peltier, observed that heat energy could be transferred across a junction of dissimilar metals when an electric current was passed through the junction. The junction became, in effect, an electrical "heat pump." This is known as the *Peltier effect.*

Today, TE modules are manufactured using semiconductors and are classified as solid-state devices. The modern Peltier TE cell (Fig. 1A) consists of short sections of p-type and n-type semiconductor materials bonded together with a heavy metallic strap on one side, with electrical connections made to the free ends of the semiconductor elements. Most commercial units are multi-element modules made up by connecting a number of individual cells in series electrically, but in parallel as far as heat transfer characteristics are concerned, as shown in Fig. 1B.

In operation, a dc voltage is applied to the module (or cell), with the positive supply terminal connected to the n-type element, the negative to the p-type. Heat transfer from one side of the module to the other occurs as a result of the continuous formation of new current carriers and their migration through the semiconductor elements to the power terminals. Within limits, the greater the current flow, the greater the heat transfer, provided the transferred heat is dissipated by a suitable heat sink. Unfortunately, internal heating occurs as a result of the current flow, just as in a resistor.

At some point, therefore, the heat generated internally



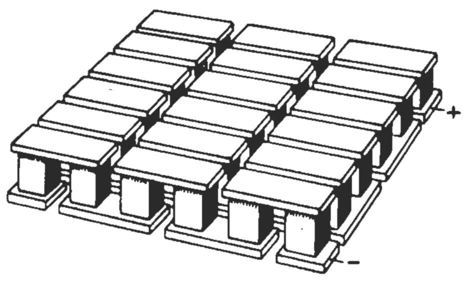


Fig. 1. Thermoelectric devices: single junction (left) and multi-element (right).

offsets the heat transfer and the unit will no longer operate efficiently as a heat pump. In practice, then, each module, depending on its size and construction, has an optimum current rating and maximum heat transfer capability. The direction of heat transfer can be reversed simply by reversing the applied voltage polarity. Thus, a single device can serve *either* as a cooling or a heating element.

As the legendary two-faced god, Janus, a TE device has two facets to its operation. It can "pump" heat *or* it can serve as a low-power electrical generator when heat is "pumped" through it. This can be accomplished by heating one side of the module while cooling the other. This technique has been used in commercial and military applications to generate electrical power in remoter areas.

Peltier-type TE modules are available from a number of major manufacturers, with some models carried as stock items by industrial electronics distributors and the larger mail-order supply houses. Prices vary, of course, depending on type and capacity; but in general they are comparable to the prices of medium-power uhf transistors. In addition to the modules themselves, several manufacturers also offer detailed application notes and handbooks.

The Jermyn type A1357 is typical of the medium-power units. It has a maximum cooling capacity of 20 watts and a maximum current rating of 9 A at 2 V dc. It can be powered by line-operated dc supplies provided the ac ripple does not exceed 15% and can develop a maximum temperature gradient of 60° C when the warm face is no hotter than +45° C. The A1357 sells for $40 each in quantities of up to four units.

Space limitations prohibit our listing all of the firms now manufacturing thermo-electric devices, but the following offer a number of types which should be of particular interest to experimenters and hobbyists:

Borg-Warner Thermoelectrics
Wolf & Algonquin Roads
Des Plaines, IL 60018

Cambridge Thermionic Corporation
445 Concord Avenue
Cambridge, MA 02138

Jermyn
712 Montgomery Street
San Francisco, CA 94111.

Reader's Circuits. Apparently, my discussion of LED's and their applications in last October's column struck a responsive chord among our readers. A number have suggested modifications of the basic circuits I discussed, several have written of their own experiences with these intriguing devices, and others have submitted original designs for new applications. The LED flasher circuit given in Fig. 2, for example, was submitted by Michael E. Lindsey (2625 Fairgreen Drive, Pittsburgh, PA 15241).

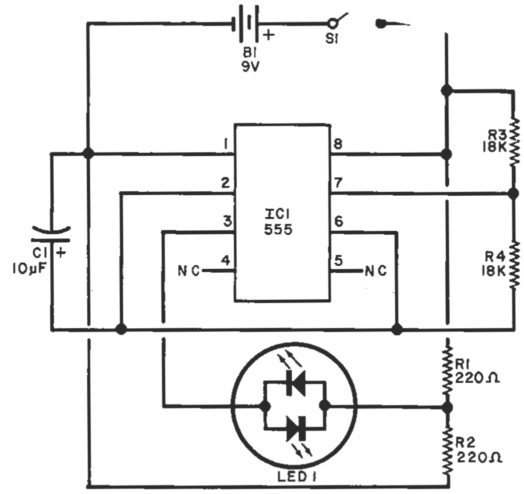


Fig. 2. Reader's flasher circuit uses a 555 tuner and a dual-element LED.

Featuring a single IC timer, a minimum of additional components, and a dual (red/green) LED, Lindsey's design alternately flashes red and green at a rate determined by the timing capacitor's (*C1*) value. The circuit can be used in toys, displays, and models or, if preferred, as a unique type of visual alarm for a control system or intrusion detector.

With neither layout nor lead dress critical and readily available components specified, Lindsey's design can be duplicated quite easily in the home workshop. A standard 555 is used for *IC1*; the resistors are ¼ or ½-watt types, *C1* is a 10 µF, 10-to-15-volt electrolytic capacitor, and *LED1* is a MV5491 red/green dual LED. Operating power is supplied by a 9-volt transistor battery, controlled by a spst toggle, slide or rotary switch, *S1*. A pair of individual LED's may be substituted for the MV5491, if preferred, provided they are connected with reverse polarity, as shown, while the circuit's flashing rate can be changed by using different values for *C1*.

"How simple can you get?" was my initial reaction to the circuit illustrated in Fig. 3. Submitted by reader James C. Graves, Jr. (11A Lin Drive, Eglin AFB, Valparaiso, FL 32542), this square-wave oscillator requires a hex inverter IC, a feedback capacitor, a dc power source, and . . . that's all!!! The basic design may be used as part of a function generator, in a test square-wave generator, as a tone source for electronic musical instruments, in a signal injector for radio-TV servicing, as a simple clock source for digital applications, or even as a code-practice oscillator if a hand key is used in series with the power supply.

James suggests a 7404 for *IC1* and a 30-µF, 6-to-12-volt electrolytic capacitor for *C1*, with the power supply furnishing 4.5 to 5.5 V dc. However, I suspect that other

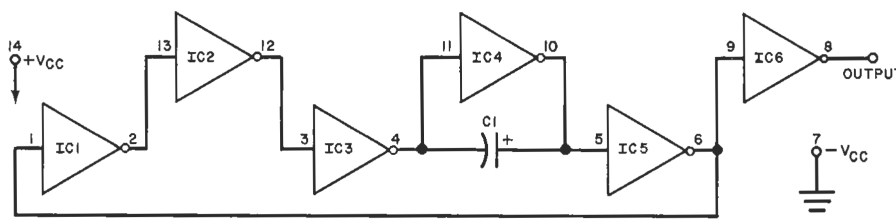


Fig. 3. Square-wave generator uses only a hex inverter IC, a feedback capacitor and a dc power source.