Thermoelectric modules, multiple video monitor setups, $5 toner cartridge refills for laser printers, unique hacker sources

By Don Lancaster

There have been a lot of help-line calls lately, with a lot of you working on some really exotic things, like home recorded CD disks using photo techniques, neon sign sequencers, cattle weighing stations, vehicle position sensing, gas-leak alarms, laser-printed sheet music, voice synthesizers, perspective drawing software, capacitance meters and bunches more.

I guess it was Pogo that first introduced the concept of the *insurmountable opportunity*. We seem to be buried in them today. One thing fer sure, there never was a time like the present to be into hardware hacking. There's so much out there that can be done in so many newer, better, cheaper, and more powerfully different ways.

But, my oh my, where do we even start? Maybe by asking . . . .

How do thermoelectric modules work?

They don't! At least not well.

Since there has been mucho interest on this, let's have at it anyway. A thermoelectric module is a solid-state cooling device. All you do is input a current, and heat moves through the device, cooling one side and heating the other.

Figure 1 shows a typical package. This one is the *Cambion* No. 801-2007. Similar units are also available from *Melcor*. This dude measures some two inches square and can move up to 22 watts of heat when powered by a 12-volt car battery at 7 amps. Cost is in the $20 to $30 range.

Solid-state cooling modules use the Peltier effect. Figure 2 shows details. You start with bismuth telluride or some other semiconductor. Then cut it into blocks while heavily p-doping some of them and n-doping others.

When a current is applied in the proper direction, the electron carriers in the n material and the hole carriers in the p material "tow" thermal energy along with their motion. In both cases, the heat gets moved downward, creating a hot side and a cold side.

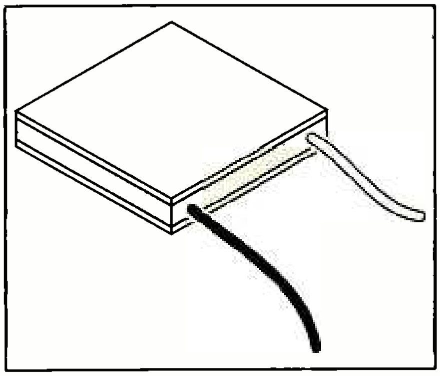

Fig. 1. Typical thermoelectric module.

The amount of heat you move depends highly upon the temperature differential you have to maintain. As Fig. 3 shows, this particular device can hold a 60-degree C difference between the hot and cold side *provided you pump no heat through it*. On the other hand, if you maintain both sides at the same temperature, you can pump up to 22 watts of heat through the device.

In most uses, of course, you will both want to cool something and move heat, so you must use the middle of the curve. For instance, you can pump 8 watts of heat at a 40-degree centigrade drop. To put this into perspective, this module can, under ideal conditions, make a small ice cube in around one hour.

The trouble is that conditions are never ideal for TE modules. There are a number of nasty gotchas that will gang up on you when you try to use them.

Thermoelectric modules are rather expensive, mostly because they have not been improved one iota in the last two decades. Worse yet, these modules are horribly inefficient. In a typical use, you have to input 5 watts of power to provide just 1 watt of cooling. Mechanical air conditioners are almost 50 times more efficient than this!

The heat sink you connect the hot side of the module to must be absolutely flat, machined to within 0.001 inch over its entire area and carefully covered with a thin layer of thermal grease. Obviously, those portions of a module not thoroughly contacting the heat sink cannot deliver any useful cooling.

The real killer to most TM module applications lies in the thermal drop between the heat sink and the ambient temperature. For higher-power uses, a fan or water cooling is almost essential.

For instance, a large plain old heat sink will have at best a 1-degree C-per-watt temperature rise above ambient. Say you want to pump the 8 watts at a 40-degree drop. The heat sink will have to sink these 8 watts, plus an additional 32 watts or so of input power for a total of 40 watts. At 1 degree C per watt heat sink

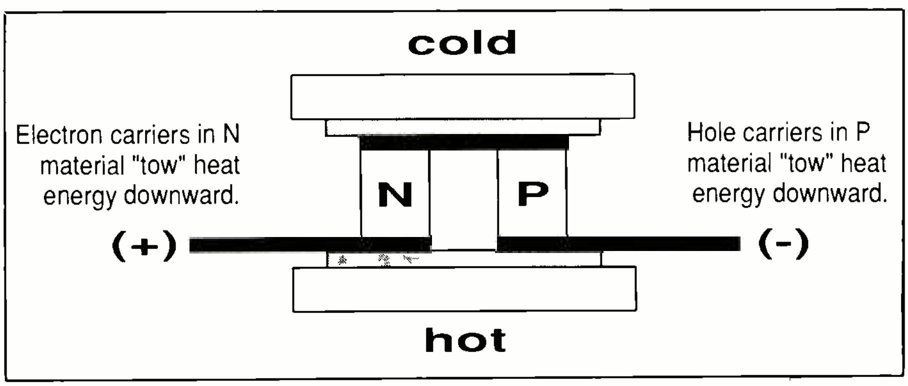

Fig. 2. How a thermoelectric module works.

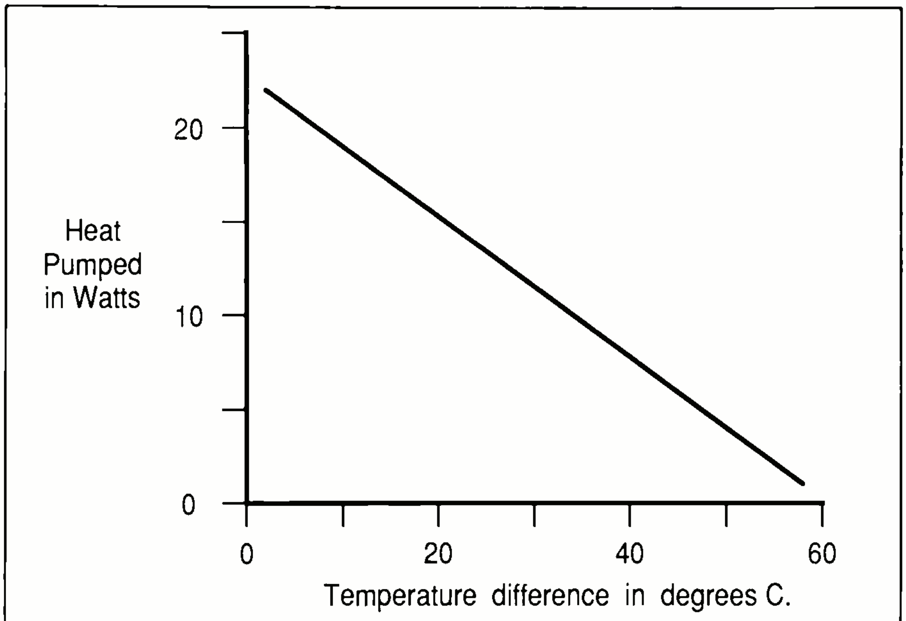

Fig.3. In thermoelectric modules, heat pumped depends on temperature difference as shown here.

rise, the heat sink will warm to 40 degrees C *above* ambient temperature.

So, a low thermal drop from heat sink to ambient is absolutely essential. Also essential is an incredible amount of insulation around whatever you are cooling, for any net heat into the area being cooled will only make matters much worse than they already are.

The modules are reversible by reversing the current. Because of the inefficiency, the heating mode is five times more effective than the cooling mode.

One side effect of this inefficiency is that you must run the modules off nearly pure direct current. The least bit of power supply ripple will dramatically cut the cooling ability, since the ripple troughs will heat five times better than the ripple peaks will cool.

A car battery is often the best choice to drive a TE module. You can temporarily demonstrate a module by holding it between your thumb and finger and then connecting the module to a single alkaline D cell. Do not use the D cell for more than a few seconds at a time.

What good are TE modules? You definitely can't buy a 4 × 8 foot panel of these and use them to air-condition your house. But they are lots of fun to play with. These are a sure-fire topic for a winning science fair project or student paper. Besides that, though, thermoelectrics are limited to specialized and low-load uses where nothing else can do the job, such as coolers for infrared detectors, dew-point humidity sensors, chillers for microscope stages, and for thermal management in satellites.

Both Cambion and Melcor have lots of interesting tech literature on thermoelectrics, so you may want to contact them both for more info.

Can more than one monitor be used with a personal computer?

Yes, if you are careful enough about it. If you are lucky, you might even be able to put some of the monitors as much as several hundred feet away from the computer with which it is used.

There are some gotchas involved, though. First, it is far and away best to run one continuous cable from monitor to monitor, rather than using a bunch of separate cables from computer to each monitor.

Secondly, just about all monitors have provisions to terminate or not terminate their inputs. Termination is done by putting a 75-ohm resistor directly across the video input. Sometimes this is done with a switch at the back of the monitor. Other times, you have to use a solder jumper or a custom plug of some sort.

Regardless of the method used, *only the final monitor in the daisy chain should be terminated!* All of the intermediate monitors should be switched to their unterminated, or high-input-impedance, mode.

Naturally, you should keep cables as short as possible, and never use a long cable without terminating its far end. For longer runs, you will get the best results with "real" coaxial cable and BNC connectors, instead of plain old audio cable and the usual phono plugs.

For extremely long lengths of cable, you might need a video buffer of some sort. *RCA* has a 3450 video op amp that could be useful here. There's also a new product called the Rabbit, that's in the *Heath* catalog, among many other places. This device gives you a way to extend VCR signals all over your house by cable. I'm not sure if this product also handles baseband video.

Tell me about toner cartridge reloading

Toner cartridges used in both the Laserwriter and the Laserjet laser printers cost nearly $100 each and are only good for 2,500 copies, giving you an operating toner cost of around 4¢ per page. Yet, you can easily reload these cartridges up to six or more times, using a 3-minute process that costs $5 and needs no special tools.

If you are an owner of a laser printer,

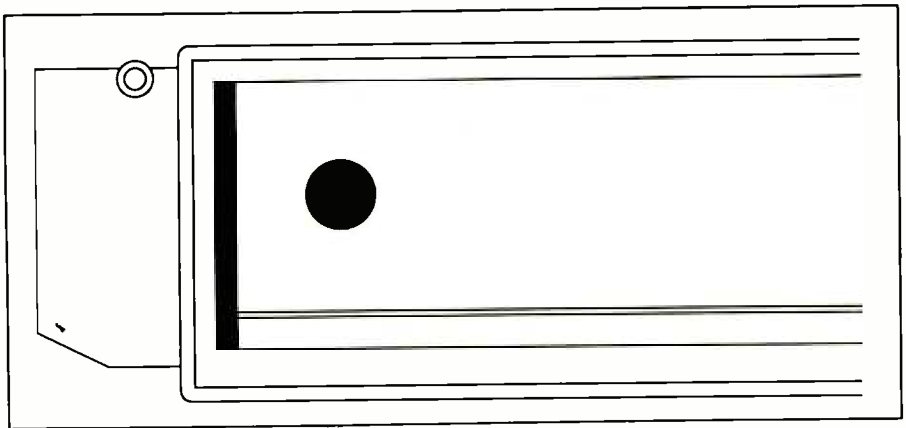

Fig. 4. Large black dot indicates where to add filling hole to top of fresh toner tank.

you'll get dramatically lower toner costs while at the same time producing much blacker images. The blacker images result because the cartridge itself does not get up to full blackness until *after* the second or third reload, and because the refill toner is usually blacker than the original. If you do not own a laser printer, this could be an interesting and profitable sideline business for you, since toner cartridge refills can easily be resold for as much as $19.

First, you will need a reliable source of refill toner. Three sources that I have found useful are EP-350 refills from any *Minolta* copier dealer, kits and pads from *Laser Printer Products*, and wholesale CX toner from *Repeat-O-Type*. Their CX toner sells in bulk for as little as $5 per refill. Around 170 to 225 grams of toner (0.4 pound) is needed per refill.

One gotcha here. It is extremely important to use monocomponent *negative-acting* toner intended specifically for organic drum laser printers. Ordinary copier toner refills definitely will *not* work.

Two simple modifications must be made to the cartridge for refilling. Note that you do *not* have to disassemble the cartridge. What you have to do is add a filling hole to the toner tank and an emptying hole to the spent toner holding tank.

First, pop off the large cardboard label by lifting an end with a pocket knife. The toner tank will be under this label. As Fig. 4 shows, you melt a ½-inch diameter C-shaped hole in the end of the tank with a soldering iron. Then, while the plastic is still hot, snap this hole off and trim the bead with a pocket knife.

Be very careful to get no plastic chips into the hole and do not under any circumstances sand the hole or use steel wool on it. Acutal refilling is done with a plastic funnel and dumping one bottle of toner into this hole, while tilting and shaking slightly.

After refilling, tape the hole shut and replace the label. Put a new label on top of the existing one and write the cartridge history on it. Include the date, brand of refill, number of the refill, and any drum defects noted.

To provide an emptying hole in the holding tank, turn the cartridge upside down and find the area shown in Fig. 5. Then melt a ¼-inch hole in the area shown. This hole can be sanded smooth without major problems. Go outside and shake the used toner out of this hole. Since there are some baffles in the holding tank, you will have to rock the cartridge back and forth a few times to get rid of all the spent toner. When finished, tape the hole shut.

For successive refills, just untape the holding tank, empty and retape. Then untape the toner tank, fill and retape. You should also use the special tool to clean the corona wire at this time.

Instead of replacing the fusion wiper pad, just remove the wiper portion of it and lay a new wiper in place. I've found that you can use both the top and bottom surfaces of the new wiper this way. Wipers cost around 50¢ each.

Keep the toner cartridge right-side up as much as possible while you do your refilling. It is definitely *not* feasible to ship cartridges refilled this way except by hand carrying.

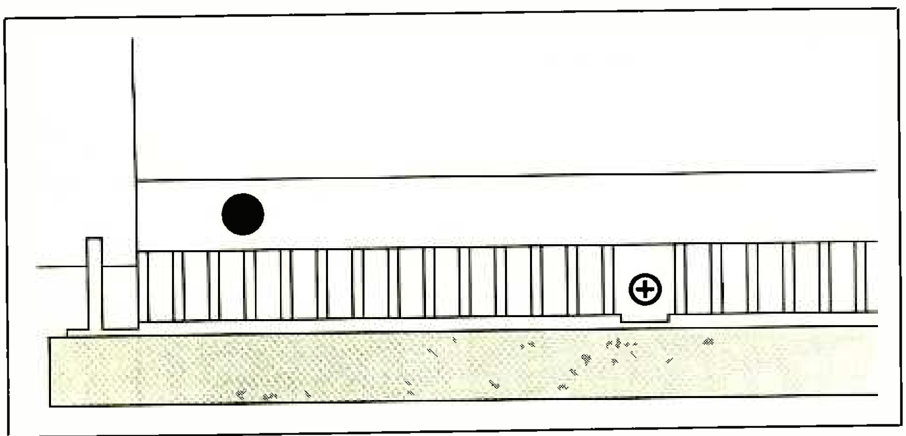

Fig. 5. Large black dot indicates where to add emptying hole to bottom of spent toner tank.

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There is absolutely no need to take the cartridge apart. But if you really want to open one, the special screwdriver needed is a #10 tamper-proof torx insert bit from *EVCO*'s No. 945B700 set, that is also available from *Jensen Tools*.

How about a grab bag?

Sure thing. Here we go . . . .

Meredith Instruments has a $75 special on helium-neon lasers that include power supplies. Low-cost ceramic resonators that are useful as filters and crystal replacements are available from *Radio Materials*. An RS-232C adaptor kit for null modems and custom interfaces is bargain priced at $10 from *L-COM Inc.* Shape memory (nitional) and super-elastic alloys are newly available through *Beta Phase Inc.*

A new catalog from *Circuit Specialists* lists all sorts of unique hacker integrated circuits available in small quantities. *Signcraft* is a neat magazine on sign painting. For the location of your nearest *Apple Computer* club, call (800) 538-9696, extension 500. One low-cost source of clock parts, electronic and otherwise, is *Precision Movements*.

A new component from *Adistor Technology* can be used for low-cost fuel-vapor detection and other "sniffer" applications. *Motorola*'s new MC14534 LCD driver should very much simplify low-power microprocessor display interfaces. For "old-line," high-quality tools that are hard to get elsewhere, check into the catalog from *C.S. Osborne*.

For some new products of my own, check into my *Postscript Show & Tell* that shows off laser printers on the Apple, Mac, or PC (plus others), or the newly bound reprint volumes from my *Ask the Guru* column.

As our usual reminder, this is your column and you can get technical help per the box below. If you haven't done so already, be sure to write or call for your copy of the brand new free stuff list. **ME**

NEED HELP?

Phone or write your **Hardware Hacker** questions directly to:

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