HARDWARE HACKER

Thoughts on the Newman motor; continuous battery rejuvenation; linear stepper motors and drivers; robotic bearings; new literature

By Don Lancaster

Several readers have asked me where to go to obtain good prices for larger-than-hacker quantities of electronic parts. Say you need a few thousand light-emitting diodes right now and at the lowest cost. Where do you go? One quantity parts source that shouldn't be ignored is the classified section of *Electronic News*, a trade weekly. Here you will find all sorts of surplus, distress and odd-lot quantities of mainstream components at literally unbeatable prices. There are only two minor catches: there's usually a $50 line minimum or $100 order minimum, so these great sources are not for onesie-twosie users; and stock exists only on a "here today, gone tomorrow" basis.

Turning to some other news, the Postscript page-description language has now in fact become an industry standard, as the last and most obvious holdout—Hewlett-Packard—finally caved in to user demands. H-P now joins Adobe, Allied-Linotron, Apple, IBM, QMS, Qume and hundreds more already in the club.

Note that the Postscript language is in the public domain and anyone can use it for any purpose. There are all sorts of hacker opportunities here. Of all the computer languages I have ever seen anywhere, Postscript is far and away the most fun and most addictive, both physiologically and psychologically.

Write or call per the "Need Help?" box if you need any more information on getting started with Postscript.

What are your views on the Newman motor?

The story so far goes something like this: A few years ago, a backwoods Mississippi inventor by the name of Joseph Newman created a new motor which, under some circumstances, appeared to create more energy than it consumed. Some other supposedly competent engineers looked at the motor and, surprisingly, agreed. A major battery company even offered some development funding.

Newman attempted to patent his invention and was treated extremely shabbily by the patent office bureaucrats. The device was tested by the National Bureau of Standards, and the results ended up at best controversial. Newman went to the media and became first a media event and then a part of a media circus.

For three wildly different backgrounds on all this, check out the more or less middle-of-the-road story in the May 1987 issue of *Discovery* magazine (page 48), the NBS report on the motor's testing, and Newman's own book on the subject.

The motor itself is relatively conventional. It does have an unusually high amount of winding inductance and is also an unusually high voltage device.

Under the most credible circumstances, the usual demo of the motor goes something like this: Ordinary dry batteries are connected to a load and completely flattened. The motor is run, apparently increasing speed and performance as it goes along.

The batteries are then reconnected to the original load and are then used to drive the original load for a much longer time than they did when fresh.

As a microcomputer pioneer, I have had more than my fair share of arrows in

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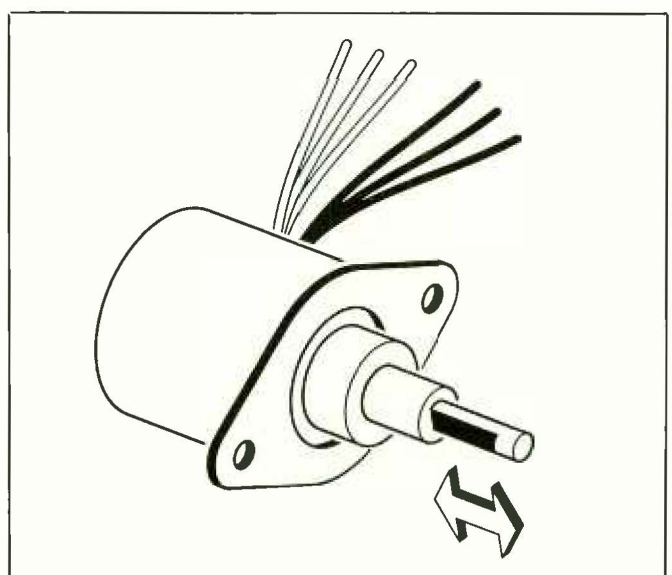

Fig. 2. The Airpax 92100 is a smaller linear stepper than the Hurst SLS.

my back, and I will always champion the maverick individual who is doing things on his own. I even wrote a classic book on this matter titled *The Incredible Secret Money Machine.* On the other hand, I do have a traditional engineering education and industry background and am pretty much a fan of the second law of thermodynamics.

My personal views on perpetual motion, UFOs, psychic phenomena, *et al* is simply this: Give me a simple, duplicable and verifiable way of showing the effect and I will believe. Until then, I will remain a skeptic, albeit one who seeks out any controversy and loves to rattle any establishment cages—or at the very least, run a stick over the bars.

What I cannot fathom is why *any* inventor or hacker would ever attempt to patent *anything.* If a Las Vegas casino owner had the gross effrontery to offer the same odds as the patent office does, he would be tarred and feathered and run out of town on a rail.

Not one patent in 300 will ever generate any positive cash flow. Not one patent in 3,000 exists that can't be thrown out or severely minimized through a diligent enough search for prior art in obscure places. For most individual hackers and inventors most of the time, attempting to patent something results only in outright theft of their precious time, money and sanity. [*There are enough success stories emanating from patents to continue to encourage inventors to go this route. Odds don't seem worse than those offered by lotteries. Nevertheless, there's a lot of wisdom in what is said if the inventor doesn't have the money (personal or corporate) to challenge a patent violator—Editor.*]

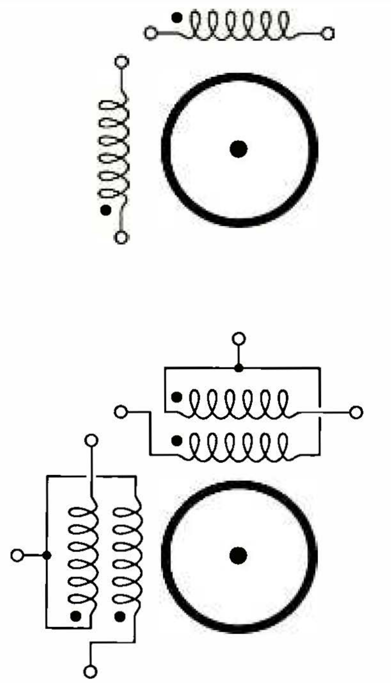

Fig. 3. The two main types of stepper-motor windings.

So what is really going on?

Okay, here's my theory on what's happening here. It may be all wet, but it does fit the facts more closely than anything else I have seen. It leaves the inventor and laws of thermodynamics more or less intact. It also gives hardware hackers an opportunity to experiment with something that just may turn out to be worthwhile, and in a research area that has not been thoroughly plowed over.

The motors tested always seem to involve lots of high voltage, r-f energy, transients and pulses, and lots of sparking. As we've seen, batteries are normally involved in the excess-energy demonstrations. What we really have here is a simple battery rejuvenator.

Total energy in a carbon-zinc flashlight cell is vastly in excess of the amount of light you can get running a flashlight. As long as even a tiny scrap of the zinc case remains, there is still energy to be gotten. People have known for quite a while that you can "recharge" flashlight cells a number of times. But note that this is not really a true recharging. Rather than increasing the chemical potential energy as is done with a lead-acid battery, you are really removing or minimizing processes (particularly polarization) that interfere with getting the already-there chemical energy out. So any recharging is really "rejuvenation."

An example: Say you fish out the old chemistry book and build yourself a wet cell by placing two dissimilar metal electrodes in an electrolyte. Sure enough, you get an output current and may even light a lamp with it. But after a while, the lamp gets dim.

You look closely at your cell and find that there are all sorts of bubbles on one electrode. These bubbles act as an insulator that reduces the cell's current density. So you whap the beaker a good one, all the bubbles float upward, and the current goes back up near its original value. Being a Rube Goldberg type, you build a solenoid "whapper" that clunks the beaker every now and then. By "feeding back" some of the cell's energy in a rejuvenation process, the total useful energy you get out is much higher.

Question: Might there be some continuous rejuvenation process that can be

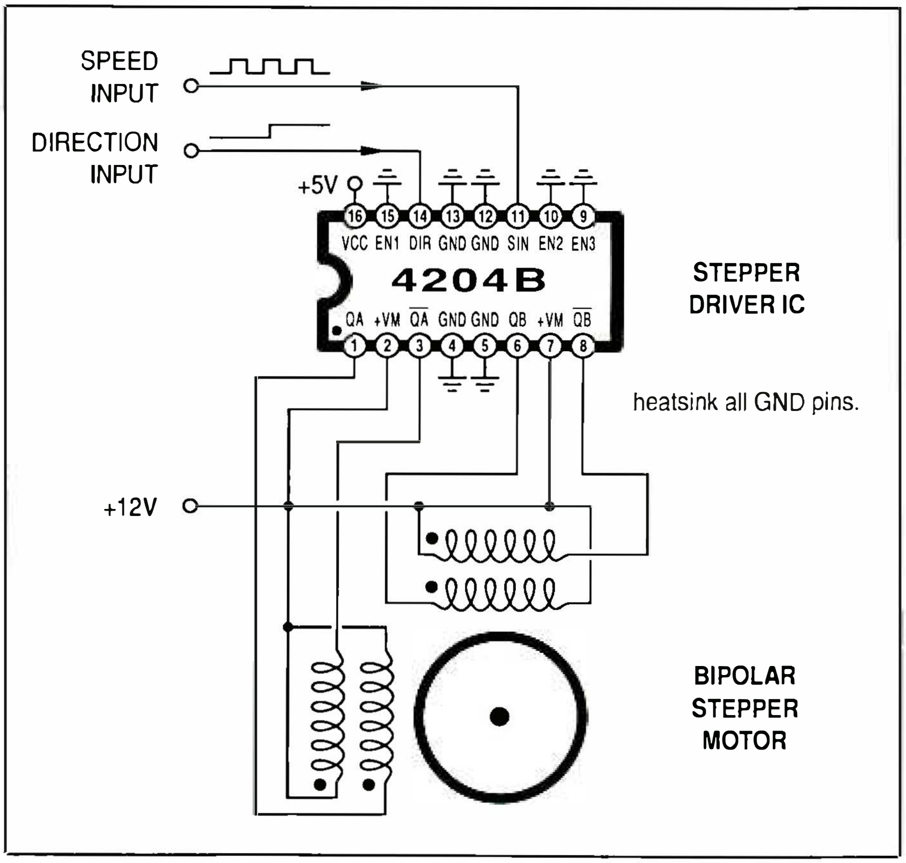

Fig. 4. A typical small stepper-motor driver circuit.

done by feeding back pulses, ac or r-f energy into a dry battery? The answer to this is almost certainly yes. Can the process be made very efficient, worthwhile and workable with many popular types of cells? That remains to be seen.

Note that the electroplating people do this sort of thing all the time. They first plate for a fairly long time and then purposely reverse the current to unplate for a short time. The reversals end up giving a far smoother finish with fewer sharp edges or imperfections.

Ferinstance, what if you did discharge a battery for 5 seconds into a 100-milliampere load and then sent a 10-ampere pulse back into it for 5 milliseconds? You would then be returning one-tenth the energy to the battery, but it might very dramatically lengthen overall battery life.

While you are experimenting on this, there's a related project that could easily become commercially successful. What if you had an efficient inverter that worked down to, say, 0.5 volt? You could now really flatten a flashlight battery while at the same time maintaining a constant bulb brightness. Similarly, portable radios and cassette players could be run much longer on "dead" batteries without distortion.

For maximum efficiency, you could even run the inverter on a pulse basis that always tries to match the load impedance to the cell's present source resistance. In theory, this can increase the life of the cell by an additional 30 to 50 percent.

A law called the "maximum power transfer theorem" explains why a car battery's impedance is carefully matched to the impedance of the starter. This is the only way maximum possible power can be delivered during cranking. The same idea could substantially increase flashlight cell life.

A safety tip: Do not try to feed back excess pulse, ac or r-f energy into a lithium or nickel-cadmium cell! Even with plain old flashlight cells, you might consider using a "bomb shelter" consisting of a paint bucket filled with sand and having a plastic cup inside.

Let me know what you come up with on this. It seems there are plenty of possibilities here.

What is a linear stepper?

Take an ordinary stepper motor, but make it hollow at its center. Then feed a threaded shaft through the center and drive it with a nutplate on the stepper's armature. As the stepper is stepped, the nutplate turns, which, in turn, advances or retards the threaded shaft. This would give you a way to push or pull things in tiny and accurate increments under computer control with lots of force over fairly long strokes.

Uses? They're multitudinous, including: animation tables; printed-circuit drills; numeric controlled milling machines; plotters; robotics; valve actuators; electronic engine controls; production equipment; research projects; point-of-purchase displays; and dozens of applications that haven't been mentioned or possibly even imagined.

Figure 1 shows the Hurst model SLS linear actuator. It is a 12-watt unit that delivers 25 pounds of force in 2-mil (0.002-inch) increments over an 8-inch length. Single evaluation units cost just under $50, though the price drops to less than $20 when these are purchased in quantity. The onesie price seems rather steep, until you take into account the "compared to what?" factor.

We are using this dude locally to model a new type of solar pump that is simpler

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Cheshire Industrial Park
Cheshire, CT 06410
(203) 272-0301

Eastern Air Devices
1 Progress Dr.
Dover, NH 03820
(603) 742-3330

Electronic News
7 East 12 St.
New York, NY 10003
(212) 630-0951

Hurst Mfg.
Box 326
Princeton, IN 47670
(812) 385-2564

Motion Magazine
2030 Hillman Circle
Orange, CA 92667
(714) 974-0200

Motorola
P.O. Box 20912
Phoenix, AZ 85036
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Powerconversion
2472 Eastman Ave.
Bldg. 34
Ventura, CA 93003
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Reticon
245 Potrero Ave.
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SGS-Ates
1000 E. Bell Rd.
Phoenix, AZ 85022
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Sprague
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and far more versatile than traditional pumping methods. Using computerized stepping, the stroke and speed can be independently adjusted. This can eliminate any need for inverters or storage batteries, while at the same time simplify the pump mechanism to a single moving part.

On custom order, lead screws up to several feet long can be obtained. Note that there is no theoretical limit to the stroke you could get out of one of these, so long as a lead screw of the required length is available. Maintaining precision and avoiding any binding would, of course, get worse with increasing length.

You would have to keep the lead screw itself from rotating any on its own, usually with an external restraint. Details on this depend on your intended use.

Figure 2 shows a smaller *Airpax* Series 92100 unit. This is much smaller than the SLS linear actuator and gives only a 0.5-inch maximum stroke in 2- or 4-mil steps and with a force slightly greater than 1 pound. Price is around $20 each, but you might be able to find an Airpax Series 92100 unit for free (or nearly so) at your local junkyard, as some automobiles use these devices for their computerized carburetor idle adjustments. Unfortunately, I don't know which specific models to send you after. Be advised, though, that there are also some plain old throttle solenoids that look about the same as these; so make sure you are getting a "real" stepper when you make your visit to the junkyard.

You can step these up to 400 steps per second, which means they can travel the 0.5-inch stop-to-stop distance in something like 0.6 second. But you lose force at higher stepping rates.

On other models, you can get other pitches on the lead screws, which lets you trade off resolution per step against speed of travel.

We are using this one locally to adjust the teeth on a cotton picking machine. The stepper acts as a sort of micrometer, advancing until it touches each tooth. The number of steps needed then tells the mechanic how much shim to add.

Whether or not you care about cotton picking, what we have here is an easy and precise way to eliminate a tedious and time-consuming job. If the teeth are too close, you destroy the machine; if they're too far away, your yield and grade go down.

Another source of linear actuators is *Eastern Air Devices*, but their military look and their refusal to include pricing in their mailings doesn't bode well for hackers.

Tell ya what. Let's have us another contest. A free book to the best ten entries and a free tinaja quest for two (FOB Thatcher, AZ) for the best overall entry. Just dream up a new or interesting use for one or two linear steppers, or tell me a specific automobile make or model that uses a linear stepper.

Fair enough?

How does a stepper motor work?

A stepper motor consists of a toothed magnetic rotor and a toothed iron stator. The number of teeth sets the step angle and number of steps per revolution. In the absence of any electrical input, the rotor will "lock" to the stator by seeking out paths of minimum magnetic reluctance.

Two sets of windings are provided. The "A" winding is active one-third the distance between teeth, while the "B" winding is active two-thirds the distance between teeth.

A four-step process is used to advance to the next tooth position. The A winding is first activated, attracting the toothed rotor one-third of the distance to the next tooth. Then the B winding is activated, attracting to the two-thirds point. Next, the A winding has its current reversed to repel toward the two-thirds point. In the final step, the current in the B winding is reversed, repelling the rotor to its new and final position.

Speed is determined by the number of steps applied per second. Direction is determined by the roles of the A and B windings.

As Fig. 3 shows, there are two different ways that stepper motors can be wound. In a "unipolar" stepper, there is only a single A winding and only a single B winding. This is cheaper and has more power, but it requires you to electronically reverse the high-current feed through each winding. Thus, what you gain is stepper economy, you lose in driver cost and complexity.

In a "bipolar" or "bifilar" stepper, there are two separate A windings and two separate B windings. Each winding is in the opposite sense of the other; so a current in one winding will attract the rotor, while the same current in the other winding will repel the rotor. These bipolar windings are much easier to drive, but they cost more and offer less power than the unipolar stepper's winding scheme.

You can usually tell which type of stepper you have by counting the number of leads that are on it. Assuming that all leads are brought out separately, a unipolar stepper will have four wires, while a bipolar stepper will have six. For most hacker uses, bipolar windings are the overwhelmingly favorite choice.

How do I drive a stepper motor?

Most stepper manufacturers have available driver circuits for their devices, though they tend to be older hybrid designs that are overpriced. Instead, there are several suppliers of single- and double-chip stepper-motor drivers. These include *Sprague, SGS-Ates* and *Motorola.*

Figure 4 shows a circuit for the Sprague UCN-42-4B single-chip stepper driver. While I haven't yet been able to check out this chip (stay tuned), it looks like a typical modern circuit with 1.5 amperes of drive capability and internal thermal and overload protection.

To use the Fig. 4 circuit, you provide two inputs. The first is the direction input that decides whether the stepper will go forward or backward. The second is a train of square-wave pulses that set the speed to be traveled in the chosen direction.

By the way, the best two places to find out all about steppers and stepper motors are *Motion* and *Powerconversion* industry magazines.

What's in the goodies barrel this month?

There sure has been a lot of interest in the CCD and photodiode imaging products we looked at two months back. In fact, it is the number-one Helpline topic. Just in the nick of time, Reticon has come up with a brand new and free "Image Sensing Products" handbook, while Texas Instruments has a new literature package and applications note titled "CCD Output Signal Processing."

Xilinx has a "Programmable Gate Array Design Handbook" out on the next step beyond EPROMs and EPALs—entire gate arrays that you can electrically program yourself. Prices are still quite high, but these arrays are bound to become great future hacker components.

Any of you hackers who are into robotics will be interested in the $9.95 Nyliner bearing evaluation kits from the Thomson Industries folks.

I've got my usual goodies in stock, including the classic *TTL Cookbook, CMOS Cookbook* and *The Incredible Secret Money Machine.* Write or call for a complete list that includes some neat stuff. Let's hear from you. **ME**

NEED HELP?

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

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