Don Lancaster's

Tech Musings

November, 1998

A look at rail guns
DNA error correction
Pitfalls of Windows 98
An air conditioning servo
Faraday motion experiments

This month I thought we just might take a look into two wildly different topics. Each with its own set of problems and unique opportunities…

Rail Guns

Michael Faraday once ran a rather profound experiment. One that went something like figure one. He took a block of wood and milled two long parallel slots in it. These slots were then filled with mercury. Mercury is one of those very rare liquids which conduct electricity fairly well. It is also dense enough to let you *float* most metals. Mercury is also a deadly cumulative poision, so do *not* try this experiment on your own.

He then took a "U" shaped wire and bent it so it would float in the mercury pools as shown. When a dc current was applied, the wire quickly *moved away* from the terminals. Thus proving one of the fundamental two "motor laws" that…

$$f = Bli$$

…or that the force acting on any conductor will be proportional to the magnetic field strength multiplied by the length of the conductor at right angles to it times the current through the wire. We saw a lot of details on this back in MUSE117.PDF

When your circuit gets closed, a current loop is formed by the battery, those mercury channels, and the wire float. That single turn current loop sets up a magnetic field. Thus, the interaction from the above equation creates a force on the loop.

A *rail gun* is simply any modern rerun of this experiment. Figure two shows us several possibilities. The conductive carrier or projectile in a *sabot* gets sent down the rails when a high current gets discharged into the rails from a bank of capacitors. The usual object of the game is to get the carrier to quickly leave the rails.

The term *sabot* literally means a "shoe". Especially a wooden Dutch one. And *sabotage* might come about whenever you throw the shoes into machinery. In military parlance, a sabot is any expendible carrier for a projectile. In the case of a rail gun, the sabot should end up both highly conductive and a good lubricant.

In nuclear fusion lab experiments, a rail gun can cleanly and directly shove a solid hydrogen pellet exactly where it is required. As a terrestal weapon, a rail gun would have no theoretical limit on muzzle velocity. There would often be no observable muzzle flash as well.

As a launch vehicle, the rail gun spreads the acelleration out over much longer periods of time. Thus being much more gentle on human riders and cargo. And giving a way to launch to orbit without fuel. Out in space, a rail gun gives us a fuel-free means of acellerating a second stage or a smaller vehicle.

Lots of benefits here.

And, of course, as a science fair project, a rail gun can be a sure fire winner since it could literally blast away all of your competition. Along with any uncooperative judges.

Limitations

The only tiny little problem is that nobody has figured out how to build a really good rail gun. The currents involved are extreme, and approach tens to hundreds of millions of amps. There is often a fundamental conflict between electrical and mechanical friction. You want to minimize both. While graphite is an obvious choice, its conductivity is only moderate at best. Rail-to-projectile welding can be a serious problem. If the projectile leaves your rails for even an instant, extreme voltages result.

Which causes arcs and welding.

Longer rail guns work best under vacuum to minimize frictional air losses. A major but subtle problem is what takes place when the projectile leaves the rail ends. If there is still current, you get a destructive arc. If you shut the current off too soon, you end up with a dynamic brake.

Usually, multiple hits from many capacitor banks are needed. Properly profiling and switching the currents

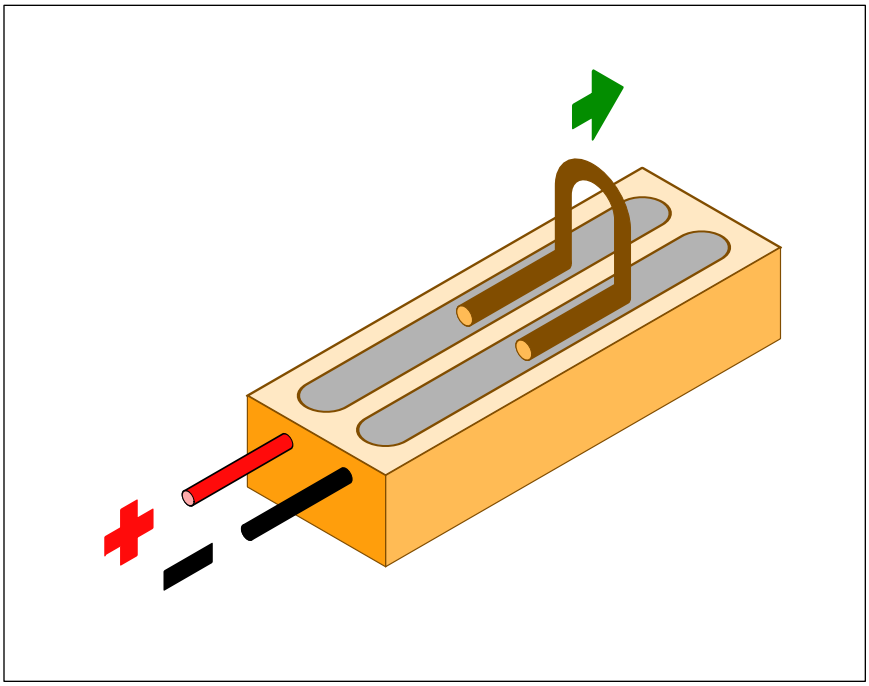

Fig. 1 – IN THIS FARADAY EXPERIMENT, the wire floats away as current is applied. Thus proving the fundamental f = Bli motor rule.

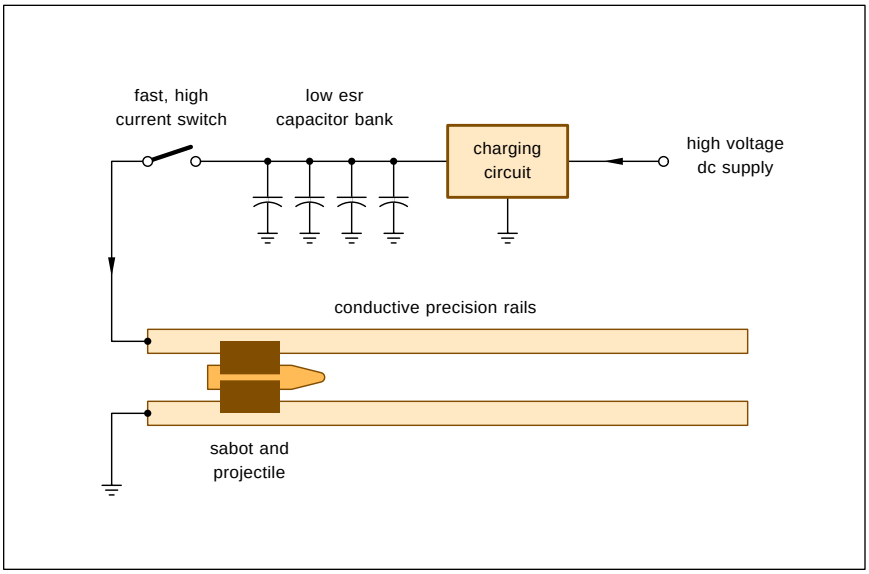

Fig. 2 – A RAILGUN is simply the Faraday f=Bli experiment in disguise. Discharging the capacitors acellerates the carrier.

is not trivial. Speed sensing feedback is a must. Finally, railgun efficiency is ridiculously low. Which gets made even worse by those extremely high energy levels involved.

Special capacitors are required. They must have an ultra low ESR or *effective series resistance*. They also do have to provide extreme levels of energy storage as well as capable of being rapidly discharged. Note that most conventional capacitors will violently explode when subjected to railgun conditions.

As far as I know, all railguns to date are still in the lab. Any practical applications remain elusive. And are likely to stay that way.

The best starting point on railguns is found in the *IEEE Transactions on Magnetics* issue for January of 1995. A good, but difficult, book on the fundamental physics is *Newtonian Electrodynamics* by Peter Graneau. More details on this title appears at *www.tinaja.com/amlink01.html*

Yes, you can build your home rail gun. But most efforts so far barely manage to get the projectile to leave the rail ends. This is not a technology that scales down well, because of the extreme currents involved. And some serious electrical safety issues might keep you from making a science fair project out of this.

Two fine websites to get you going here do include Bill Beatty's *Science Hobbiest* at *www.eskimo.com/~billb* Plus *The Rail Gun Page* you will find at *ww3.hmc.edu/~jengel/rail.html*

I've gathered together a few other rail gun web site resources for you as this month's resource sidebar.

But do watch out for false hits on railguns when you surf out on your own. There's a lot of sci-fi dreck and pseudoscience garbage here. I sure got sucked in on the "weapons list" showing barely believable railguns as installed on a recently deployed U.N. tactical aircraft. Only to find out later that it was really just an RPG role playing game.

Not to mention that Railgun's last album is one of their best.

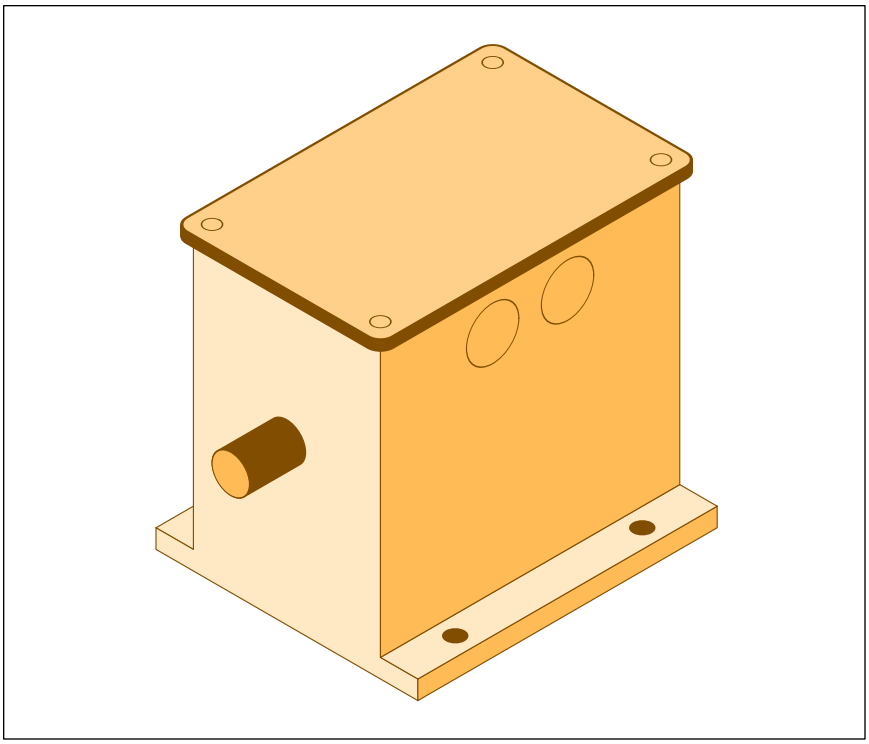

Fig. 3 – THE MODUTROL IV is a servo normally used in air conditioning. On a control voltage input, the shaft goes to selected position at high torque. The 90 degree peg to peg time is thirty seconds.

Industrial Strength Servos

The air conditioning people have been keeping a big bunch of "secret" rotary actuators all to themselves. Uh, one in particular seems to have some heavy tail-twisting capabilities that can be applied anywhere.

But first, let's review…

Say you want to precisely control the position or speed of a shaft. You have choices of *open loop* using a *stepper*, or *closed loop*, with a *servo*. And short for *servomechanism*. In a servo, position is continually sensed and used as correctional *feedback*. Servos are usually more complex but more accurate. Generally, it is easier to accurately measure something than it is to precisely position somewhere under variable load.

You might be familiar with those

small servos used in model airplanes. These accept a *duty cycle modulated* rectangular wave and should output a mechanical position. Low duty cycle twists left. A mid duty cycle of 50% centers. High duty cycle twists right.

Combining these servos with PIC's and the *Basic Stamp* or other micros leads to all sorts of interesting new options. Go to *www.parallaxinc.com*, *www.micromint.com* and to *www.see.com* for lots of applications info.

But what if you need some serious tail-twisting? *Honeywell* has their *Modutrol IV* air conditioning servo that just might work well for you.

Some details on this beast appear in figures three and four.

A typical Modutrol sits in a zinc die cast box about 4 x 6 x 7 inches. There is a half inch shaft coming out both ends of the box.

Most Modutrol's accept the usual "furnace control" 24 volt ac as the line power input. Some include an internal transformer for a direct 110 volt operation.

There are three input contol lines that you can connect to a 1K volume control or some *ratiometric* voltage source. When you adjust the volume control, the shaft position precisely follows. Typical Modutrols offer 35 inch pounds of torque, and twist 90 degrees in thirty seconds. A pair of programmable limit switches may be optionally provided.

The usual app is to open or close a damper in an A/C duct. Providing just enough cooling to meet the room's needs. But the torque is more than enough to open or close nearly any reasonable sized valve. And there should be all sorts of new mid-sized robotics uses for these.

The Modutrol IV has its internal potentiometer that senses the current shaft position. Which gets compared against the input control voltage with a comparator. If low, an ac backgear motor gets powered in the clockwise direction. If high, the same motor is powered counterclockwise. A modest amount of *hysteresis* is added to the comparator. This prevents continuous "hunting" for small input changes. The hysteresis will also dramatically reduce power consumption. Because your motor starts and then stops only on significant input changes.

The entire motor and gear train is apparently sealed in oil for long life and maintenance free operation. The power when actually operting is 27 watts or so. Standby power is quite low. A humongous gear ratio lets a small high speed motor generate a lot of low speed torque. The other end of the shaft does come out of the case. But Honeywell recommends using this end only for an indicator or a pointer or or some other light load. The shafts both have two flats and a grooved ring on them.

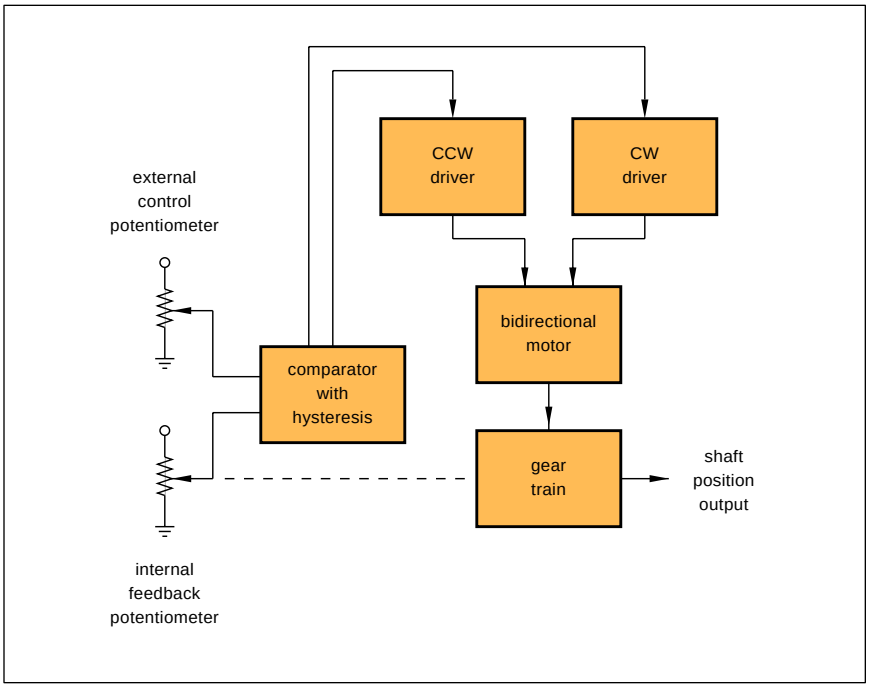

Fig. 4 – INSIDE THE MODUTROL is a classic servo that has dead-band hyteresis. High torque results from a small motor and a vrey large gear reduction train. The mechanism is sealed in oil.

Yeah, the thirty seconds pin to pin is kinda slow. And they prefer a 25 percent duty cycle under heavy load. But my, oh my, the tail twisting here. You should be able to come up with all sorts of new shop or farm remote control uses for one or more of these.

Plus heavy duty robotics.

No, these Modutrols are not cheap. Their *Grainger* wholesale pricing is several hundred dollars. Some lower cost competitors surely must exist. As must a used and auction market. And these sure are a superb starting point for serious robotics.

I do have a few surplus Modutrols at *www.tinaja.com/bargte01.html* if you want to play with them. Let me have your thoughts on what you can do with a powerful and convenient rotary actuator. Or tell me about any other higher power actuators that you may have run across.

Whither Windows 98?

I just lost several days and some monumental frustration in trying to upgrade and older cheap computer to Windows 98. This finally worked, but not without some rather rude suprises along the way.

First, note that Windows 98 is an evolutionary improvement. For most people, there's no urgent need to do an immediate upgrade. Win 98 is somewhat faster and somewhat more stable. It *eventually* will let you use multiple monitors and far better USB *Universal Serial Bus* printers and such. Second, make *absolutely* sure you have got everything *currently* and *freshly* backed up.

My klutzy old *Packard Bell* was picking up a few bad habits (such as a memory leak, difficult restarts, and excessive clacking), so I thought an upgrade would miraculously repair things. The Win 98 upgrade promptly caused a fatal exception blowup and trashed all my IDE drivers. This left me without a CD ROM drive, a 120 meg floppy, and even the A: drive. The latter of which was removed

when the big floppy was installed.

A call to *Packard Bell* (Their 900 line support has worked well for me) suggested a new BIOS patch upgrade. *Agoura* 1.20 in this case. I got their patch using another computer and then reinstalled the original A: drive.

This cured the fatal execption, but not the trashed IDE drivers. It used to be you could reset blown drivers by changing a NoIDE flag with *Resedit*, but this flag is apparently gone or obscurely renamed.

After this, I tried reinstalling Win 95. This was a big time mistake that *really* caused problems. I then used 125 floppy disks to back up every file I could. Besides my work files, this included fonts, Netscape Mail, the internal tax files, sig files, other apps, and bunches of other stuff.

Next, I tried completely clearing the *Windows* folder and did a W95 reinstall. This did not work because the registry was apparently blown at this point. So (gulp) I re-inited the C: hard drive and reinstalled Win 95. I then reinstalled Win 98. Everything worked just fine.

Well, sort of. I still can not get Netscape's "You Have Mail" flag to work. And *Wordpad* is ridiculously slower than it used to be. A hint or two would certainly be welcome.

The bottom line: Your best way to upgrade to Windows 98 is to avoid doing it at all on an older or flakey computer. If you must, the route of a full save, an online compatibility check, a hard disk re-init, and full reinstallation is probably the fastest, safest, and cheapest way to go.

Besides, your system was probably long past due for a cleanup anyway.

New Tech Lit

The July 17, 1998 issue of *Science* magazine on page 329 asks us "How good is the error correction on the DNA code?" Incredibly so, it seems. For DNA cleanly beat out *millions* of other trial codes. It was not even close. Very intriguing research here. There is still a buck to be made by publishing a complete DNA pocket card. Might as well show the access points to the key subroutines and the diagnostics while you are at it.

From *Microchip Technology* their latest *Technical Library* CD ROM on PIC Microcontrollers. Alternates to the PIC appear in a similar CD ROM from *Atmel*. A third CD ROM from *TelCom Semiconductor* covers charge pumps, fan controllers, temperature sensors, and MOSFET drivers.

Lots more PIC support is found at *www.tinaja.com/pic01.html*

From *Unitrode* a new UCC3926 integrated curent sensor. This has a 20 amp rating and does include an internal shunt resistor.

New *VersaPad* combination touch pads and signature grabbers are now offered by the *Interlink Electronics* folks. Several development kits are also newly available.

Details on micromachined spray techniques are in a new ap note from *Spray Chip Systems*. And *FlexiForce* now offers a new system of ultra-thin force sensing transducers.

Several different epoxy samples are available from *Tra-Con*. *Reid Tool Supply* has their interesting catalog full of all sorts of tools and mechanical items. There are lots of interesting possibilities here.

Three trade journals for this month include *Forming & Fabricating* and *Stamping Journal* on lots of sheet metal work. Plus *BookTech* for book publishing insiders. This latter title is adding *Book-on-demand* publishing info in it. More on BOD is found at *www.tinaja.com/bod01.html*

FactsFinder is that free GPS nav house organ from *Trimble*.

Parallel Port Complete seems to be your definitive book on dealing with PC parallel printer ports. More details on Jan Axelson's book is at *www.tinaja.com/amlink01.html*

A new extended tutorial on buying mil surplus electronics can be found at *www.tinaja.com/glib/resbn81.pdf* Examples of the kinds of goodies you can get from Uncle can be found at *www.tinaja.com/barg01.html* Secret

SOME RAILGUN WEB SITES

http://129.7.21.70/enl/annrep94-95/rail.html
http://es.epa.gov/techinfo/facts/railgun.html
http://fpl.firemoth.com/
http://http.bsd.uchicago.edu/~c-henkle/btech2/0966.html
http://iml.umkc.edu/physics/sps/railgun/railgun.html
http://madsci.wustl.edu/posts/archives/dec96/851510255.Eg.r.html
http://me.udel.edu/~morrison/rail.html

http://sunflower.singnet.com.sg/~wspclip/Books/physics/2770.html
http://web.nps.navy.mil/~pao/railgun.html
http://weber.u.washington.edu/~buckwadl/RAM/ram.html
http://www.access1.net/ninteach/research.html
http://www.eecs.kumamoto-u.ac.jp/.eecs/labs/akiyama-lab/subjects/railgun
http://www.engr.uiuc.edu/Publications/summary97/ece/FUSION.html
http://www.eskimo.com/~billb/amateur/capexpt.html

http://www.iap.com/jbarber.html
http://www.io.com/~bolie/Tech/railguns.html
http://www.isd.net/anowicki/SPBI1112.htm
http://www.mhi.co.jp/tech/htm/e633213a.htm
http://www.millennial.org/~jwills/orbit/SPBI113.htm
http://www.nrl.navy.mil/nrl/heritage/review8.html
http://www.onr.com/user/shadow/RiftsFolder/Railgun.html

http://www.sandia.gov/pulspowr/peng/seraphim.html
http://www.sover.net/~geoffk/coilgun.html
http://www.sti.nasa.gov/thesaurus/R/word12648.html
http://www.uiuc.edu/colleges/eng/summary/ece/FUSION.html
http://www.utexas.edu/research/cen/rd/rd02/02.html
http://www.west.net/~steamer/massdriv.htm
http://www3.hmc.edu/~jengel/rail.html

NEED HELP?

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Web page: *www.tinaja.com*

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Atmel
2325 Orchard Pkwy
San Jose CA 95131
(408) 441-0311

BookTech
401 N Broad St 5th Fl
Philadelphia PA 19108
(215) 238-5300

FlexiForce
307 W 1st St
Boston MA 02127
(617) 269-8373

Forming & Fabricating
One SME Drive
Dearborn MI 48128
(313) 271-1500

Grainger
2738 Fulton St
Chicago IL 60612
(312) 638-0536

Honeywell
1985 N Douglas Dr
Golden Valley MN 55422
(800) 328-5111

IEEE Trans Magnetics
445 Hoes Ln
Piscataway NJ 08855
(800) 678-IEEE

Interlink Electronics
546 Flynn Rd
Camarillo CA 93012
(805) 484-8989

Kepro Circuit Systems
640 Scarlet Oak Blvd
St Louis MO 63122
(800) 325-3878

Lakeview Research
2209 Winnegabo St
Madison WI 53704
(608) 241-5824

Microchip Technology
2355 W Chandler Blvd
Chandler AZ 85224
(602) 786-7200

Reid Tool
2265 Black Creek Rd
Muskegon MI 49444
(800) 253-0421

Science/AAAS
1333 H St NW
Washington DC 20005
(202) 326-6400

SprayChip Systems
9841 Greenbelt Rd #101
Seabrook MD 20706
(301) 552-5570

Stamping Journal
833 Featherstone Rd
Rockford IL 61107
(815) 399-8700

Synergetics
Box 809
Thatcher AZ 85552
(520) 428-4073

TelCom Semiconductor
1300 Terra Bella Avenue
Mountain View CA 94043
(800) 888-9966

Tra-Con
45 Wiggins Ave
Bedford MA 01730
(800)-TRA-CON1

Trimble Navigation
585 N Mary Ave
Sunnyvale CA 94086
(800) 545-7762

Unitrode
7 Continental Blvd
Merrimack NH 03054
(603) 424-8610

test equipment manual sources at *www.tinaja.com/glib/resbn80.pdf*.

Mil surplus can now be bought direct over the web. Often for less than a penny on the dollar. You can now pay by VISA, and sometimes the feds will even deliver. You can also find out who paid how much for what. Again done online.

But you do have to know what you are getting and definitely must have a plan for pkup, use, and storage. With a little care, though, astounding bargains abound.

I also have got a nearly new and complete printed circuit plate-thru lab by *Kepro* available at one quarter the new cost. Email *don@tinaja.com* or see *www.tinaja.com/bargte01.html* for full details.

For all the fundamentals of digital integrated circuits, check out my *CMOS* and *TTL* cookbooks. Either by themselves or as part of my bargain priced *Lancaster Classics Library*. Details per my nearby *Synergetics* ad. Instant book access is available at *www.tinaja.com/amlink01.html*

As usual, most of those mentioned items are in our *Names & Numbers* or *Railgun Websites* sidebars. Always look here first before calling our free US technical helpline.

Let's hear from you. ✦