

A look at used test equipment
 Some Tesla turbine resources
 Buying mil surplus electronics
 Impulse radio communications
 New "Class D" audio amplifiers

There is an absolute glut of used test equipment around these days. Brought about on the "supply side" by the aerospace cutbacks, through military reductions, industry downsizing, and from community colleges dropping their electronics programs. And, on the "demand side", by more and more use of simulation/emulation and by PC based testing.

You can now pick up first rate lab equipment for a song.

Then again, most of the old stuff is heavy, bulky, and possibly obsolete. Manuals may be missing or may cost more than the instrument. One or two key parts may be unobtainable at any price. Routine upgrades can make, say, a Tek 1240 logic analyzer worth a lot more than a 1230. Or an HP 4955 worth bunched more than a 4953. And getting a fair price when and if you sell is extremely tricky.

I've got a tutorial on surplus and auction sources for test equipment up on my *Guru's Lair* as [RESBN73.PDF](#) What I thought I'd do here is briefly run over the basics, and then take a more detailed look into how military surplus electronic auctions have now gotten far easier to deal with.

Your simplest source with the best prices is right where it always was—at a nearby hamfest. There's extensive listings on the web. Most parts of the country should average four local and two regional hamfests per year. The best bargains happen before sunup or immediately before closing.

Yes, non-hams are welcome.

Naturally, you will find lots of ads for used test gear here in *Electronics Now*, in *Popular Electronics*, and in similar technical magazines.

My favorite sources are the college auctions. Incredible buys are found, especially if you are willing to deal in unsorted ten skid lots and higher. And do happen to catch them during their one-time departmental closeout. And know how to separate the junk from the gems.

An oversimplification: You throw away gear that does not say *Hewlett*

Packard or *Tektronix* on it. As well as everything that's pre solid state. And anything you can't easily lift.

I've found university auctions to not be nearly as good. First, because of higrading from all the competing departments on tight or recently-cut budgets. Second, because your best stuff often gets set aside in a retail storefront, and third because there's a lot more folks who *have* the foggiest

clue what they are bidding on.

One good regional source for info about all types of auctions is the fine *Southwest Auction Weekly*.

Apparently *the* place to go for all electronic test goodies is *Bentley's Auctioneers* in Albuquerque. Their shows tend to be held every second Friday and usually resell Sandia Labs stuff. An example of what I mean by "glut": That last Bentley auction had

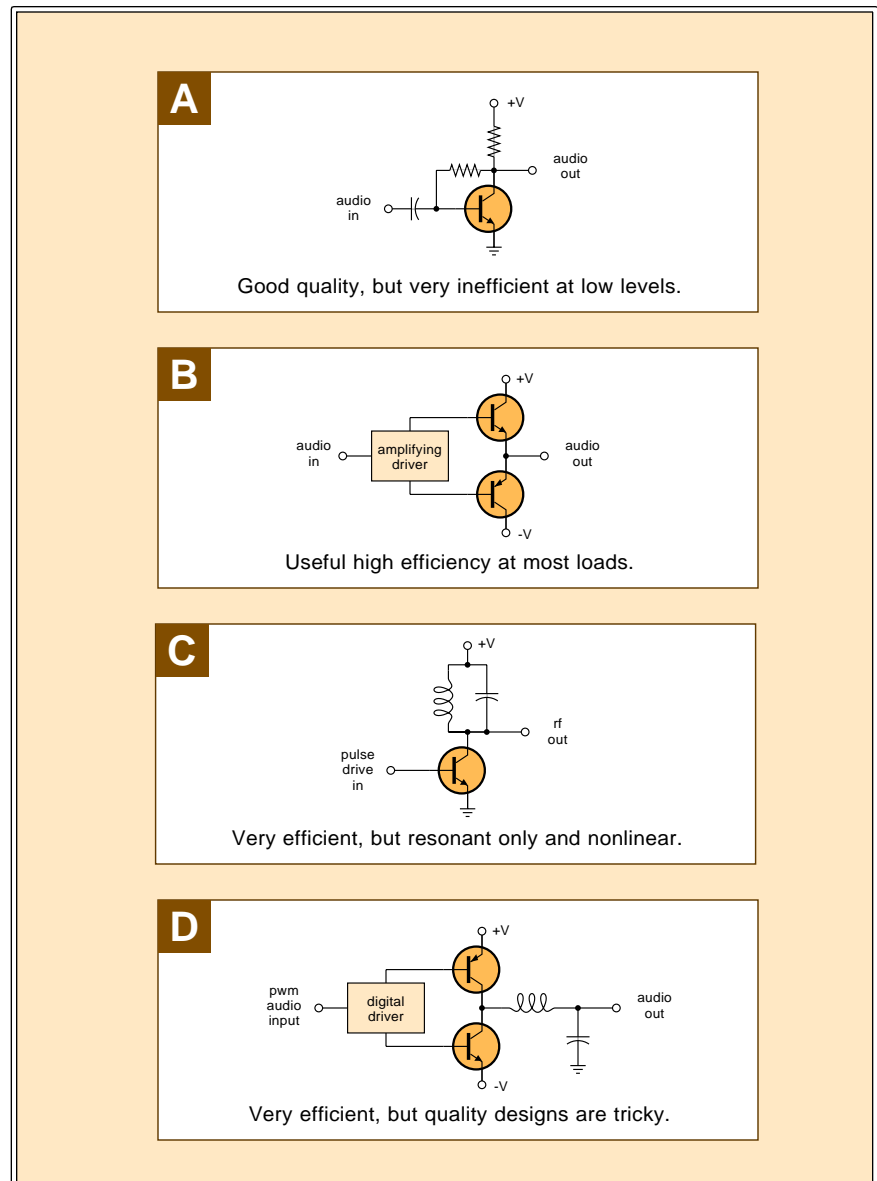


Fig. 1 – CLASSES OF AUDIO AMPLIFIERS.

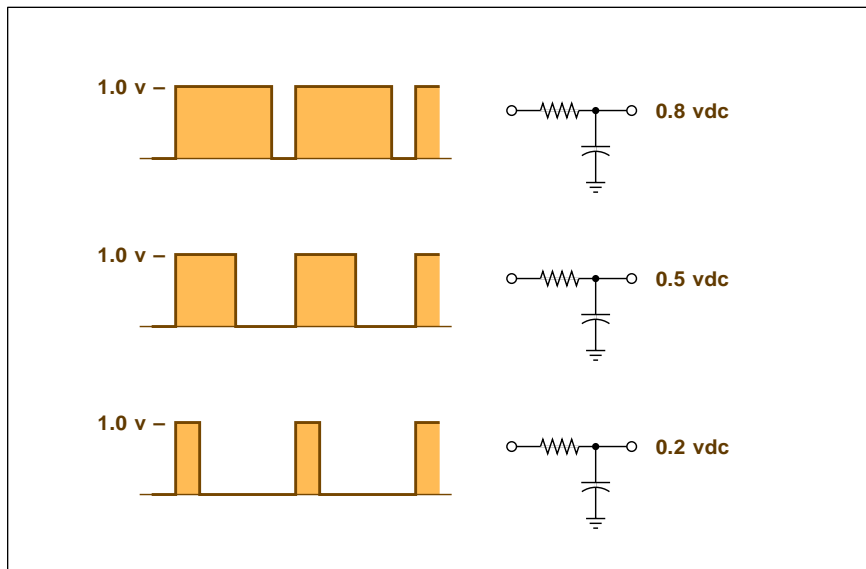


Fig. 2 – THE DUTY CYCLE of "class D" pulse width modulation (PWM) will determine the output amplitude you get after integration or low pass filtering.

fifty semi-loads of electronic gear for sale. All moved on out in a few hours for very low prices.

There are a bunch of direct mail test equipment outfits like *Danbar*, *Tucker*, *Test Equipment Connection*, *Test Equity*, *Metric*, and *Naptech*. All have useful catalogs. Although the asking prices are often outrageously higher than street, these "wish books" do clearly show you what is popular and what is not. For all their higher prices, you usually get such things as full manuals, "like new" cleanliness, warranties, and expertise.

Hint: Take a pile of these catalogs with you to each auction you attend. But be *very* subtle in their use.

These days though, there is no point whatsoever in messing around with those old Tektronix "doghouse" scopes, such as a 545. Go for a 2213 or a 2215 instead. The latter are ideal home lab or student scopes. But if you are a collector or have racked up a lot of nostalgic time on one or more of the doghouses, then Stan Griffith's *Oscilloscopes: Restoring a Classic* is a must. More book details are found at www.tinaja.com/amlink01.html His

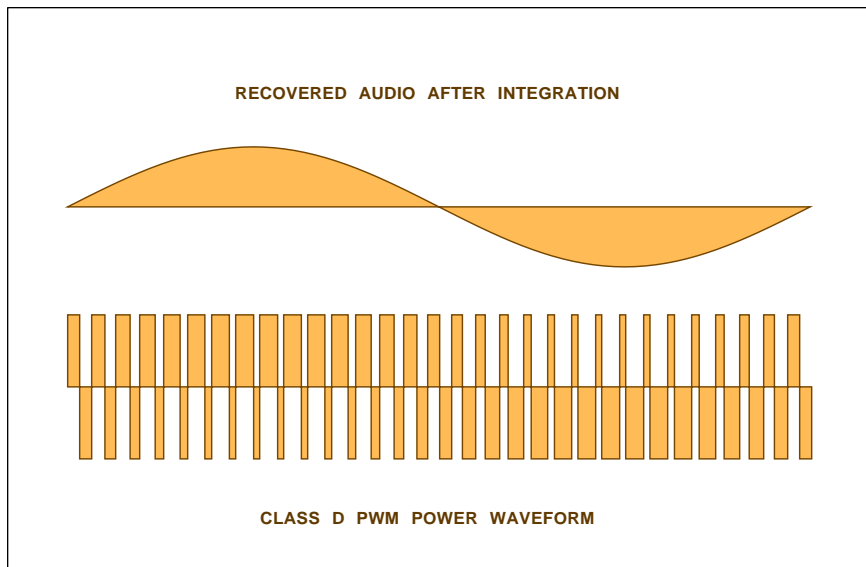


Fig. 3 – HOW LOW PASS FILTERING recovers an audio sinewave from its PPM waveform. The process is basically an integration.

volume on newer scopes is supposed to be in the works. Stan also knows of obscure parts sources.

I've tried to gather together a few used test equipment resources for you in the sidebar. Lots of links to these and related sites can be found at my www.tinaja.com/beewb01.html and www.tinaja.com/dntkwb01.html

By one of those utterly astounding coincidences that mysteriously seem to infest this column, I just happen to have some outstanding buys on Tek 2213 scopes and related goodies up at www.tinaja.com/barg01.html

Buying Military Surplus Electronics

Quite a bit is coming down here of late, so it's time for a review. On one hand, the fed's fresh www.drms.com web site lets you conveniently submit bids online and later pay by VISA. The web makes it ridiculously easier to search for items, to pick up bidder catalogs, and to find out who bid how much for what. Even the losers. On the other, around half of the 140 or so DRMO (*Defense Reutilization and Marketing Office*) locations are going to shut down in the next few months.

Downsizing and all.

There's several acronyms involved here. The website and the service is called DRMS, while the local office and the base signs are DRMO. Some sites also include a RCP, short for *Recycling Control Point*. Who may specialize in bulk thousand-item LDV "low dollar value" sales of "winner takes all" assorted mechanical and electronics parts.

Let us review the bidding process you'd go through step by step. First and foremost, *never bid on anything that you do not personally inspect!* Second, be certain to have a definite plan as to how you are going to pick up and move the items, where you are going to store them, and exactly what you are going to do with them. Finally, never bid more than six cents on the dollar. Unless you just gotta have some item really bad.

Do be sure to factor in your travel costs and time on any buy.

Go to www.drms.com and click on *Public Sales*, then on *Catalogs*, then on *Store Location*. Scan all of the site locations to find out which bases you can reasonably access. Check the list

every week or so, since not every site will get continuously listed.

There's several types of sales. The most common are your *local sealed bid* sale and the *national sealed bid* sale. In the latter, the offerings from widely separated sites are *virtually* collected together. The net has now dimmed the distinction between the two. Local sales tend to have lower valued listings in smaller quantities. Their catalogs are vastly easier to read. And an occasional gem is way more likely to be overlooked.

A DRMO may also operate a real store with fixed prices, stage a local auction, or provide other options.

The *Dynamic Catalog* for any site is a brief inventory listing. Near the sale deadline this gets expanded into their *Official Catalog* that has more details. Sadly, their official catalog may not always appear online. When it does not, you'll have to request a FAX copy instead.

At any rate, you usually scan the dynamic catalogs for nearby bases to see what crops up that you might find of interest. Then verify the additional details in their official catalog. The online bidding process is quite easy. Just fill in the blanks.

Use their powerful national search service to pin down the items being offered. Start with Category 6625 for most electronic test equipment. But watch out for Category 4510, because they are likely to throw in the SINK, KITCHEN. Also use caution with any APPROXIMATE QUANTITY: ONE. Or if the word RESIDUE appears.

Getting onto the base to view the goodies or to pick up your successful bid items can be somewhat of a pain. Details vary with the site, but they go something like this: Near their main gate should be a visitor contact area. Your goal here is a *day pass* for you and your vehicle. They'll *demand* to see your driver's license, the vehicle registration, rental contract (if any), and proof of insurance. This should give you a magic piece of paper to gain base access.

Your key rules here are patience and politeness, combined with an acceptable appearance and demeanor. Also paying *extreme* attention to all details. A wrong turn can literally put you on a gunnery range or a bomber runway. The DRMO is often a fenced

Analytical and Experimental Investigation of Multiple Disk Pumps & Turbines,
W. Rice, *Jnl of Eng Pwr*, July 63.

Analytical and Experimental investigation of Multiple Disk Turbines, W. Rice,
Jnl of Eng Pwr, Jan 65.

Bulk Parameter Analysis for Two Phase Through Flow Between Parallel Rotating Disks, D. Jankowski, *UC Davis Heat Transfer Procs*, June 1976.

Calculated Design Data for the Multiple Disk Turbine Using Incompressible Fluids, Laws & Rice, *Jnl of Fluids Engineering*, September 1974.

Design, Construction, and Investigation of a Tesla Turbine, A. Leaman,
University of Maryland thesis, 1950.

Experimental Investigation of the Flow Between Co-Rotating Disks, Adams & Rice, *Jnl Applied Mech*, September 1970.

Flow Regime Definition for Flow Between Corotating Disks, Crowther & Pater,
Jnl of Fluids Engineering, March 1974.

Investigation and Analysis of the Tesla Turbine, S. Young, *University of Illinois thesis*, June 1957.

Investigations of the Performance of a Modified Tesla Turbine, J. Armstrong,
Georgia Institute of Technology thesis, June 1952.

Potential Flow Between two Parallel Circular Disks with Partial Transmission,
Matsch & Rice, *Jnl Applied Mech*, Mar 67.

Fig. 4 – SOME "REAL SCIENCE" Tesla turbine resources.

area in an obscure corner of the base. You'll usually park outside until you are specifically invited to move your vehicle to their exact pickup point. There'll be an office type of payment area and a separate pickup area. Visa, Mastercard, and certified checks are preferred. Cash seems to be accepted, but most personal checks over \$25 are a no-no. Delivery is normally by way of a fork lift. Additional packing and loading help is *not* provided. Exception: LDV bulk sales will be shipped to you by truck.

Surprisingly, nothing special is needed to get your stuff off the base. Unless clearly told otherwise, you simply drive on out. Just in case, though, be sure to keep all of your paperwork, yourself, and your load together at all times. Especially if you happen to be towing an A-10 Warthog behind you.

Oh yeah. Those WWII jeeps. Uh, military surplus jeeps *always* get cut in half before they are sold. These might make good bookends if you have a *very* large library.

Class "D" Audio Amplifiers

I just realized that it was over three decades since we last looked at this. Way on back in *Electronics World*

for February of 1966. I don't want to impetuously rush into an update, but after more than a few false starts, it finally seems like Class D audio just may be about to hit the big time.

The latest of laptops, wireless, and other new portable electronics all demand high quality audio efficiently delivered from low supply voltages. The object of the game is to use the battery or supply energy *only* when and as it is needed to produce your desired sonic output. The holy grail is an audio amplifier that approaches one hundred percent efficiency at all useful output levels. Combined with speakers or other transducers that are as effective as possible.

Figure one shows the traditional audio amplifier classes. The class A amplifier usually gets biased to half of the supply voltage. The continuous current is high, doubling on audio valleys and going to zeros on peaks. The best efficiency you can hope to have approaches fifty percent. But this can happen *only* at full output. Thus, you will continuously draw power whether you need it or not. But class A audio quality typically has been the best you can get.

One older class B version is shown in 1-B. That NPN power transistor

SOME USED TEST EQUIPMENT REFERENCES

Bentley Auctioneers
3801 Academy Pkwy N NE
Albuquerque NM 87109
(505) 344-1812

Circuit Cellar
4 Park Street #20
Vernon CT 06066
(203) 875-2751

Danbar
14455-C N 79th St
Scottsdale AZ 85260
(602) 483-6202

Electronics Now
500-B Bi-County Blvd
Farmingdale NY 11735
(516) 293-3000

Electronic Servicing
PO Box 12487
Overland Park KS 66282
(913) 492-4857

Metric Equipment
3486 Investment Blvd
Hayward CA 94545
(800) 432-3424

Naptech
11270 Clayton Creek Rd
Lower Lake CA 95457
(800) 336-7723

Nuts & Volts
430 Princeland Ct
Corona CA 91719
(909) 371-8497

Phelps Instruments
2631 Hillside Ave
Norco CA 91760
(909) 279-7347

Probe Master
215 Denny Way
El Cajon CA 92020
(800) 772-1519

R&S Surplus
1050 E Cypress St
Covina CA 91724
(626) 967-0846

Southwest Auction Weekly
Box 61104
Phoenix 85082
(602) 994-4512

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

Test & Meas World
275 Washington St
Newton MA 02158
(617) 558-4671

Test Equipment Conn
525 Technology Park
Lake Mary FL 32746
(800) 615-8378

Test Equipment Plus
3331 W Bright Terrace
Tucson AZ 85741
(520) 575-6967

TestEquity
2450 Turquoise Circle
Thousand Oaks CA 91320
(800) 228-3457

Tucker
1717 Reserve St
Garland TX 75042
(800) 527-4642

ValueTronics
1925 S Wright Blvd
Schaumburg IL 60193
(800) 552-8258

Western Test Systems
530-C Compton St
Broomfield CO 80020
(303) 438-9662

emitter follower provides positive load currents, while the PNP emitter follower takes care of the negative ones. Best efficiency can approach 76% and very little current is drawn at low signal levels. Typical Class B amplifiers introduce bad *crossover distortion* especially on the low level signals. This can be gotten around by keeping both the transistors at least slightly conducting at all times, and is sometimes called Class AB.

The Class C amplifiers of 1-C are largely restricted to very narrow band resonant uses. But these easily can approach 100 percent efficiency. Narrow on-off impulses continuously "ring" a tank circuit which converts the impulses into a continuous output. The transistor or whatever acts as a switch which is either on or off. The output level gets set by your supply voltage, so such an amplifier is much easier to frequency modulate than to change its output amplitude.

The class D amplifier of figure 1-D is almost entirely digital. A pair of switches (often enhancement mode power FET's) generates a very high frequency, high power pulse width modulated squarewave by connecting a filter's input either to the positive or negative supply rail. Your usual switching frequencies are in the 100 kHz region. That low pass filter averages out or *integrates* the *duty cycle* (or on-off time ratio) to create

the audio output. Which, in theory, gives you high efficiency, good audio quality, and no crossover distortion.

To use any class D amplifier, your input audio first has to get converted into some ultrasonic pulse position modulated waveform. This is easily and cheaply done using hardware or software. The deviation from a 50-50 duty cycle sets your instantaneous audio amplitude.

Figure two shows us how the low pass filtered, or *integrated* value of a pulse changes with duty cycle. While figure three shows us how the pulse width variations behave over the full audio sinewave cycle.

One fun older example of class D operation happened on the Apple IIe. Where software let you get more or less useful polyphonic audio from a speaker that was on-off driven.

Traditional problems with earlier

class D amplifiers involved buzzing, distortion, switching losses, rather expensive magnetics, load matching, and power supply sensitivity.

Some Examples

You should shortly be seeing great heaping bunches more on Class D amplifiers, possibly with exotic new names. For now, though, let's look at several of the main players...

Apex Technology— Among the other products, their SA02 runs at 250 kHz and delivers up to 800 watts of output power. Their \$295 unit is intended mostly for motor driving, magnetic bearings, and shaker table use. Their web site is www.teamapex.com

Linfinity Microelectronics— Have the LX1720 controller/driver capable of delivering 35 watts of stereo audio. External power FET's are used to get 93 percent efficiency. Distortion is 0.08%. See www.linfinity.com

Harris— Now offer a new Class D Audio Amplifier Evaluation Board as their HIP4080AEVAL2, giving up to 200 watts of audio output at 94% efficiency. Everything is on the card, the PWM converter, drivers, power FET's, plus a four pole Butterworth output filter. Mono only. The web link is www.semi.harris.com

Tripath Technology— These people

NEED HELP?

Phone or write all your US Tech Musings questions to:

Don Lancaster
Synergetics
Box 809-EN
Thatcher, AZ, 85552
(520) 428-4073

US email: don@tinaja.com
Web page: www.tinaja.com

NAMES AND NUMBERS

AMP

PO Box 3608
Harrisburg PA 17105
(800) 522-6752

Analog Devices

PO Box 9106
Norwood MA 02062
(781) 329-4700

Apex Microtechnology

5980 N Shannon Rd
Tucson AZ 85741
(520) 690-8600

Carousel News & Trader

87 Park Ave W Ste 206
Mansfield OH 44902
(419) 529-4999

Contract Professional

125 Walnut St
Watertown MA 02172
(617) 926-5818

Dallas Semiconductor

4401 Beltwood Pkwy S
Dallas TX 75244
(972) 371-4000

Stan Griffiths

18955 SW Blanton
Aloha OR 97007
(503) 649-0837

Harris Semiconductor

PO Box 17000
Memphis TN 38187
(901) 682-0961

Hewlett-Packard

PO Box 10301
Palo Alto CA 94303
(415) 857-1501

High Density Interconnect

525 Market St Ste 500
San Francisco CA 94105
(415) 278-5242

Lindsay Publications

PO Box 538
Bradley IL 60915
(815) 935-5353

Linfinity Microelectronics

11861 Western Ave
Garden Grove CA 92841
(800) LMI-7011

Micro Linear

2092 Concourse Dr
San Jose CA 95131
(408) 433-5200

Synergetics

Box 809
Thatcher AZ 85552
(520) 428-4073

Tektronix

PO Box 500
Beaverton OR 97077
(800) 835-9433

Texas Instruments

PO Box 809066
Dallas TX 75380
(800) 336-5236

Time Compression Tech

203 N LaSalle St Ste 2100
Chicago IL 60601
(312) 558-1548

Time Domain

6700 Odyssey Dr
Huntsville AL 35806
(256) 922-9229

Tra-Con

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

Tripath Technology

3900 Freedom Circle Ste 200
Santa Clara CA 95054
(408) 567-3000

claim "digital audio amplifiers which really sound great". A full product line ranges from their TAA1102 two watt unit for multimedia computers up through the TA0104, a thousand watt 2-channel device for theater use. Use www.tripath.com

There's newly lots of others, but this sampling should give you a good starting point.

More on Tesla Turbines

Several readers asked for some "real science" references to the Tesla turbines that we looked at back in [MUSE124.PDF](#). So, I've gathered a

few of these together for your use in figure four.

A Tesla turbine usually consists of bladeless disks, and operates through the shear forces of viscous liquids. Because these forces are inherently *irreversible* (or non-adiabatic) in a thermodynamic sense, *Tesla turbines must be inefficient to work at all*. So, this means that unavoidable waste heat *must* get kicked off. Regardless of whether you are in "pump" or "turbine" operating mode.

To me, the three things that seem to restrict Tesla pumps to extremely arcane and specialized apps (such as pumping frozen chickens or moving

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PostScript Program Design	\$24.50
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Acrobat Reference	\$24.50
Whole works (all PostScript)	\$380.00
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Tech Musings

live fish), and to *zero* serious turbine and engine uses are: (A) The inherent inefficiency that is demanded by the *required* thermodynamic reversibility violations; (B) The turbulent flow or otherwise lousy fluid dynamics at the inputs and outputs; and (C) All those experimenters who deify Tesla while not knowing enough math or having the faintest clue how to properly do decent research.

More on thermodynamic basics and on reversibility appeared back in [HACK64.PDF](#) The apparent best use to date for the Tesla turbine seems to be for snowing thesis advisors.

New Tech Lit

Galileo's original lab notes have been posted to [www.mpiwg-berlin.mpg.de/Galileo_Prototype](#) Two other rather interesting web resources are [www.scienceposters.org/sposter-bin](#) and [www.uq.oz.au/nanoworld/gallery.html](#) Think small on this one.

Evaluation software for modeling signal integrity and communications lines is now provided on a freebie CD-ROM from *Amp*.

From *Analog Devices*, details on a brand new AD7730 bridge transducer

integrated circuit. This one uses a single chip to get you directly from a strain gauge or a pressure transducer to a useful digital output.

Details on a totally new *Impulse Radio* communications scheme are described in literature from *Time Domain*. A ten mile range with 0.25 of a milliwatt is claimed. More info at [www.time~domain.com](#)

Buys on classic ethernet cards are at [www.tinaja.com/barg01.html](#)

The latest of "new/old" titles from *Lindsay Publications* now includes *Elementary Wrought Iron* and the 1906, two-volume reprint of *Hopkin's Experimental Science*. More details at [www.tinaja.com/amlink01.html](#)

If you feel like you are stuck on a Merry-go-round, do check into the support group at *Carousel News and Trader*. They've got some great buys on wooden horses. The pony on a recent cover is a mere \$82,000.00.

New trade journals for this month include *HDI*, short for *High Density Interconnect*; *Time-Compression* on rapid prototyping and on Santa Claus machines; and *Contract Professional* on independent consulting.

Free epoxy samples are offered by

Tra-Con. Other free samples include the DS1620 digital thermometer from *Dallas Semiconductor*, and advanced high speed CMOS chips offered by the *Texas Instruments* folks.

For those fundamentals of digital integrated circuits, check into my classic *TTL Cookbook* and my *CMOS Cookbook*. Either by themselves or as part of my bargain priced *Lancaster Library* collection. See my nearby *Synergetics* ad for details. Or you can download the full online catalog at [www.tinaja.com/synlib01.html](#)

Latest of [www.tinaja.com](#) website additions include a lot of early Blat classics, including columns on patent avoidance and direct toner printed circuits. Also a cubic spline length calculation and a sampler of magic sinewave sequences. Along with new links to all of those *Book-on-demand* service bureaus, and the great new *InfoPack* research service found at [www.tinaja.com/info01.html](#)

A reminder that most of the text mentioned items appear in our *Names & Numbers* and *Used Test Equipment* sidebars. Always do look here before calling our free US technical helpline shown in the nearby box. ♦

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