

AC line powered chips
Isolated power supplies
Electric automobile books
Transportation alternatives
Better magnetic refrigeration

Some of the statements you'll see on the web sure do amaze me. Stuff such as "flywheel powered cars are 98 percent efficient". Or "the entire world will suddenly run out of oil next Tuesday morning at 4:42 am".

A quick question: Which is more efficient, a heat engine or a fuel cell? Before you answer, do note that the *Power Engineering* magazine folks report the latest of power plants are approaching a stunning 60% thermal efficiency by use of close coupled multi-cycling. While another power utility is extremely proud of their real world 50% electrical efficiency fuel cell installations.

As always, there will be intelligent choices and reasonable tradeoffs. As always, a good starting point should be accurate tech info from unbiased sources. Let's see where this leads us as we seek out some...

Transportation Alternatives

A personal transportation vehicle consists largely of an energy carrier and an energy converter. Three valid measurements of the energy carrier are "How heavy is it?", "How much room does it take up?" and "What is the total cost per mile?". Gasoline is your baseline energy carrier at 9000 watt hours per liter and 13,500 watt hours per kilogram. With a cost of roughly seven cents per mile for the consumables and thirty cents per mile for payments, taxes, and insurance.

These figures define the capability of the carrier itself. Such figures do have to get adjusted downward when you factor in how efficiently your energy can get used and how much structure or containment or whatever is needed to safely hold the carrier.

Naturally, any proposed alternates also must be adjusted downward as well. Figures must also be modified for the distortions caused by taxes or any hidden subsidies.

Because of thermodynamic laws, an ICE internal combustion engine has to throw away a lot of heat in order to produce a little mechanical

power. The best you can even hope to do is called the *Carnot* efficiency limit. Determined solely by the high side and low side temperatures. The typical auto ICE efficiency at your flywheel is around 30 percent.

The claims of "how much better" the alternatives might be are often outrageously overstated. For instance, a typical electric motor of suitable size and price probably provides an efficiency no better than 90 percent. Its controller will be hard pressed to

hit 85, and its wiring will be unable to exceed 98. Combine these for a realistic 75 percent efficiency.

And, no, regenerative braking does not help nearly as much as some of its more vocal proponents claim.

What if you add a fuel cell to the mix? It does turn out that the best of hydrogen electrolysis cells are one sixth endothermic, so you'd pretty much expect the best fuel cell to end up as one sixth exothermic. Meaning that 83 percent is the best you are

HYBRID:

- 1994 Hybrid Electric Vehicle Challenge D. Stephens
- Advanced Components for Electric and Hybrid Vehicles, EVIS
- Advancements in Electric and Hybrid Vehicle Technology, SAE
- Designing a Fuel Cell Hypercar, A. Lovins
- Design Innovations in Electric and Hybrid Vehicles, B. Bates
- Electric & Hybrid Vehicle Design Studies, SAE
- Electric & Hybrid Vehicle Technology, N. Bagot
- Electric & Hybrid Vehicles: Implementation of Technology, SAE
- Hypercar Sampler, A. Lovins
- Strategies in Electric and Hybrid Vehicle Design, B. Greene
- Tools & Strategies for Hybrid Electric Drivesystem Optimization, A. Lovins
- Ultralight Hybrid Vehicles; Principles and Design, A. Lovins

OTHER:

- Batteries and Fuel Cells for Electric Vehicles, Electrochem Society
- Build Your Own Electric Vehicle, B. Brant
- The Car That Could: The Story of GM's Electric Vehicle, M. Shnayerson
- Convert It, M. Brown
- Electric Vehicle Battery Systems, S. Dhameja
- Electric Vehicles: A Decade of Transition, B. Bates
- Electric Vehicles: Driving Towards Commercialization, R. Sims
- Electric Vehicles: Technology, Performance, & Potential, IEA
- The Ev Encyclopedia: A guide to Electric Vehicles, B. Batson
- From Gasoline to Electric Power, G. Powers
- Future Drive: Electric Vehicles & Sustainable Transportation, M. Delucchi
- Green Cars: Earth-Friendly Electric Vehicles, J. Coughlan
- History of the Electric Automobile: Battery-Only Powered Cars, E. Henry
- The Keys to the Car: Electric & Hydrogen Vehicles, J. Mackenzie
- Life With an Electric Car, N. Perrin
- Near Term Electric Vehicle Costs, J. Sawin
- The New Electric Vehicles, M. Hackleman
- Solo: Life With an Electric Car, N. Perrin
- The Lost Chord: The Story Tellers History of the Electric Car, B. Taylor
- Taking Charge - The Electric Automobile in America, B. Schiffer

Fig. 1 – SOME CURRENT BOOKS on hybrid and electric vehicles. More title info can be found at <http://www.tinaja.com/amlink01.html>

likely to do. Combine fuel cells with electric motors and you are down at a 63 percent efficiency limit. Better than gasoline engines, certainly. But not spectacularly so.

Here's how I see some of the key issues that seem to involve personal transportation alternatives...

business as usual– A lot can still be done using conventional IC engines. Such as ceramic cylinders, six cycle operation, ultra lean combustion, a modest hydrogen injection, a valve

timing done on-the-fly, an improved turbocharging, plus an adjustable compression. Possibly even a new bottoming cycle. A company by the name of *Aurora Engineering* has some exceptionally innovative new stuff here. Things like electrically actuated valves and combination starter-alternator-flywheel packages that even can double as ac power generators.

turbines– Turbines do provide high power in a small and a lightweight

package. Superb for airplanes. But these are grossly inefficient at less than full output and usually run only at extreme speeds. I'd expect this one to literally stay off the ground.

liquified natural gas– The energy density here is certainly useful, but still remains significantly less than gasoline. Same goes for propane. The popularity of this method waxes and wanes with the relative economics of oil versus gas. And gets distorted by taxes, subsidies, and hidden agendas. Infrastructure is obviously limited. I don't see this option getting very far unless economics radically change.

grain alcohol– When based upon an American farm corn economy, a lot more energy will go into producing alcohol than you can ever hope to get back. From an energy standpoint, the process could be considered a giant funnel. You pour gasoline in the top and alcohol dribbles out the bottom. Further, alcohol additives appear to be causing far more problems than they solve. Yes, there is definitely a third world subsistence potential by using *bagasse* (sugar cane residue) or similar feedstocks. Otherwise, this scheme makes no engineering sense whatsoever. At least not to me.

steam engines– Believe it or not, the steam powered automobile was done in by hoof and mouth disease. Seems they drained all those public horse troughs just as inferior gas engines were starting to discover production economics. A steam engine is vastly simpler, offers high power on every stroke, and needs neither a clutch nor a transmission.

Key issues remain closed cycle vapor recondensation, corrosion or scaling problems, and any inefficient superheating techniques. This one still has lots of potential, but seems to lack a credible champion.

pure electric– The energy density of batteries seems rather abysmal when compared to gasoline. Only 35 watt hours per kilogram for lead acid and ten times that for lithium. The range, weight, and charging infrastructure remain key problems. It also turns out that most batteries operate by knocking loose *one* single electron in its outer shell. So, the smaller the atom, the better the energy density. I

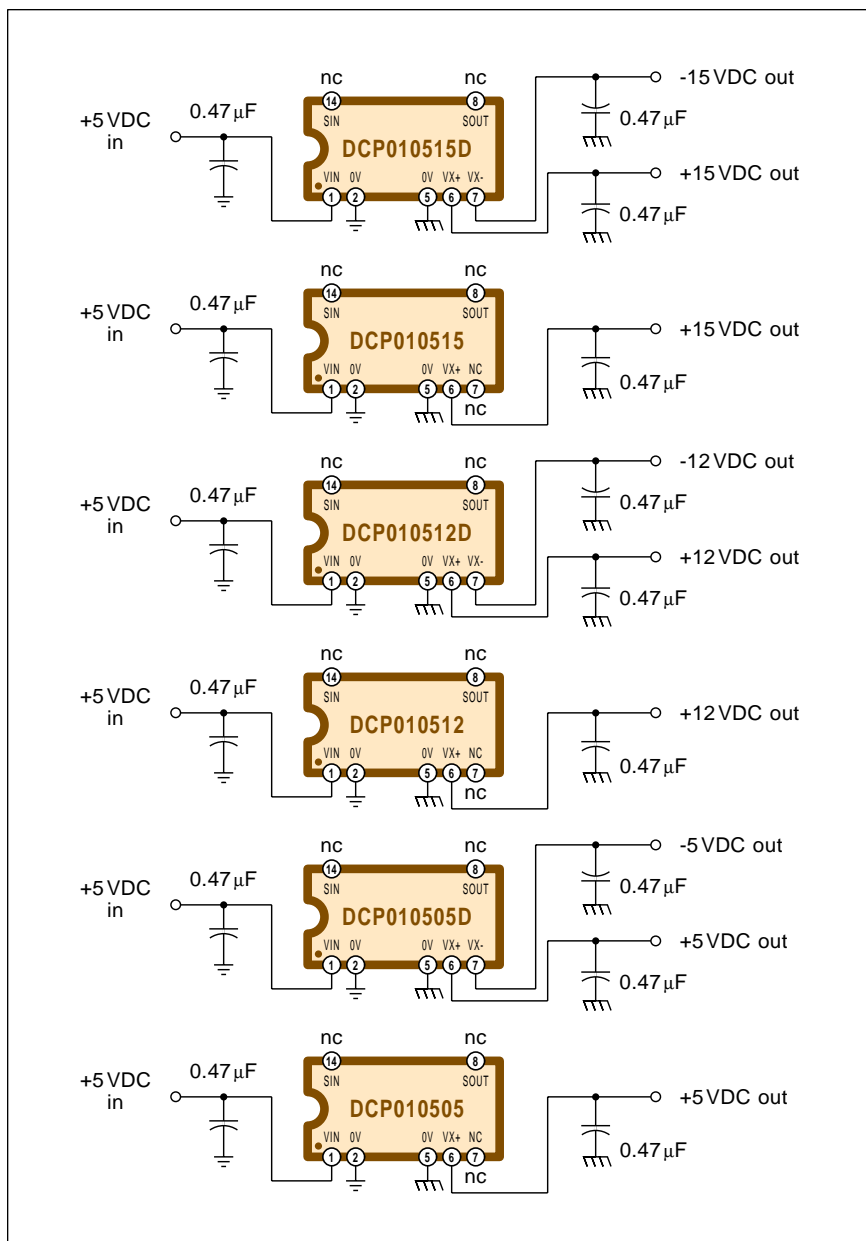


Fig. 2 – NEW ISOLATED POWER SUPPLY hybrid devices from Burr-Brown offer 50 mils output, 1000 volt isolation and a \$6 cost in a 14-pin minidip.

see nothing *ever* beating out lithium (atomic number=3) for the ultimate energy densities.

A useful website here is found at www.evworld.com

Because laptop computers are an instant and a billion dollar market for improved battery technology, I would expect these folks to inadvertently "solve" the electric car problem. In spades. They clearly have the money and the motivation.

fuel cells– Your essential difference between a battery and a fuel cell is that the fuel cell continually receives external chemical energy from one or more product streams. Often by using hydrogen and oxygen. Your crucial advantage of a fuel cell is that it is *not* a heat engine and thus will *not* be Carnot limited at its best efficiency. Another major advantage is that its main waste product is water.

Central issues in fuel cells today involve the reforming of methane or gasoline to make useful feedstocks, and trying to get the efficiency and performance up and the costs down. Fuel cells are still not very efficient, nor all that great at any suddenly changing power levels. *Ballard* is one high profile source. A leading website here is www.fuelcells.org A major technical publication is the *Hydrogen and Fuel Cell Letter*.

hybrids– Any ICE run at a constant speed is easily optimized. Batteries aren't all that heavy if you don't use that many of them. In a *serial hybrid*, the engine drives a generator which powers your motors, eliminating the drive train. In a *parallel hybrid*, both engine and electric motors can drive the wheels, and both can be *one half* of the needed peak power.

I believe this one is by far the best near-term solution. Amory Lovins of the *Rocky Mountain Institute* is one champion of hybrid vehicles. Be sure to visit his site at www.rmi.org

hydrogen– Energy density by weight of hydrogen is outstanding. Giving you three times gasoline at 39,000 watt hours per kilogram. Hydrogen routed to either an ICE or a fuel cell produces primarily water vapor as waste. Sadly, the energy density by volume as a gas is a pitifully absurd 3.5 watt hours per STP liter. Even

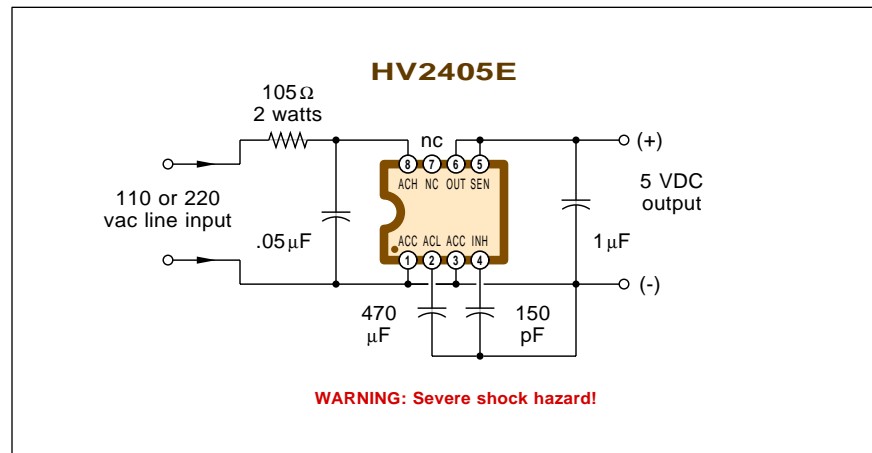


Fig. 3 – AC LINE OPERATED 5 volt power supply uses a new Harris chip. Note that safety isolation is NOT provided.

when liquified, there is around four times less hydrogen in a gallon of liquid hydrogen than there is in a gallon of gasoline.

The "make it or break it" issue of a hydrogen economy involves finding dense ways to safely store hydrogen. A graphite nanotube storage scheme pioneered by Nelly Rodriguez offers eight times the density of gasoline. This one does seem slow coming out of the lab. Mostly because of lifetime and reuse considerations.

More on hydrogen advantages and disadvantages in [MUSE112.PDF](#)

Hydrogen safety is discussed at www-osma.lerc.nasa.gov Don't even think of doing anything involving hydrogen unless you visit this site!

powerballs– These are simply spheres full of sodium. Cracking the sphere underwater generates hydrogen. The

densities involved are about the same as liquid hydrogen. All hydrocarbon pollution is eliminated by not using carbon. But to me, it seems that a lot of safety, hazmat, and the recycling issues have not yet been realistically addressed. So far, this option seems to be a one man show at *Powerball Industries* in Utah.

More powerball details are found at www.powerball.net/index.html

A variation on powerballs sparks aluminum under water to generate hydrogen. Similar to an EDM spark machining. This ploy appears to be mostly urban lore pseudoscience and obviously fails to deliver. If you have your electricity already onboard, you are clearly much better off routing it directly to your wheel motors. The sapphire-hard aluminum oxide waste product is highly abrasive and quite fouling as well.

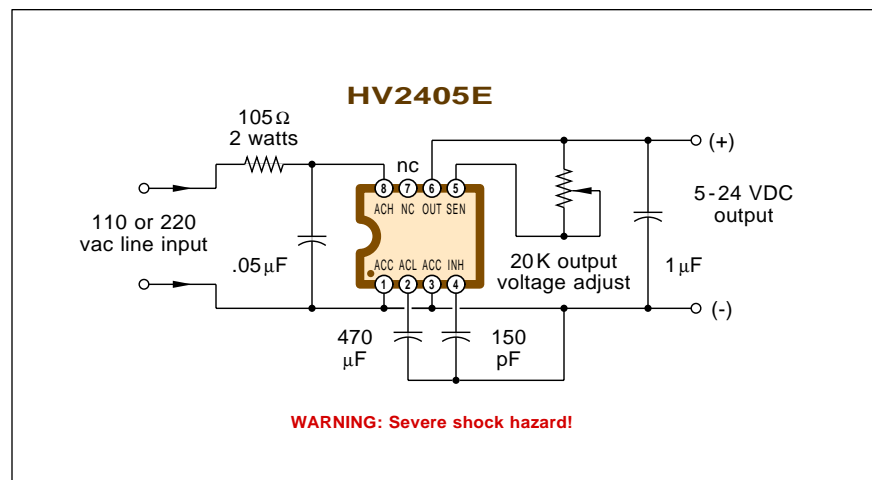


Fig. 4 – ADDING A POT gives a 5 to 24 volt variable output range.

SOME SELECTED ALTERNATE TRANSPORTATION RESOURCES

AEE Energy Books

PO Box 1026
Lilburn GA 30226
(404) 925-9558

Aurora Engineering

4823 S Marine Avenue
Lawndale CA 90260
(310) 675-0804

Automotive Industries

PO Box 2056
Radnor PA 19080
(215) 964-4876

Ballard Power Systems

9000 Glenlyon Pkwy
Burnaby BC V5J 5J9 CANADA
(604) 412-3123

Battery & EV Technology

25 Van Zant St Ste 13
Norwalk CT 06855
(203) 853-4266

Robert Bentley

1033 Massachusetts Ave
Cambridge MA 02138
(617) 547-4170

Chilton Publications

825 7th Ave
New York NY 10019
(212) 887-8400

EPRI Journal

PO Box 10412
Palo Alto CA 94303
(415) 855-2000

EV World

Box 461132
Papillion NE 68046
(402) 339-9877

Home Power

PO Box 520
Ashland OR 97520
(800) 707-6585

Human Power Vehicle Assn

PO Box 51255
Indianapolis IN 46251
(317) 876-9478

Hydrogen & Fuel Cell Ltr

Grinnell St PO Box 14
Rhinecliff NY 12574
(914) 876-5988

ITS World

859 Willamett St
Eugene OR 97401
(541)343-1200

Natl Renewable Energy Lab

1617 Cole Blvd
Golden CO 80401
(303) 231-7681

Power Engineering

1421 S Sheridan Rd
Tusla OK 74112
(918) 835-3161

Powerball Industries

2095 W 2200 S
West Valley City UT 84119
(801) 974-9120

Railbike Newsletter

3502 Buckskin Rd
Coeur d'Alene ID 83814
(208) 765-2831

Rocky Mountain Institute

1739 Snowmass Creek Rd
Snowmass CO 81654
(970) 927-3851

SAE

400 Commonwealth Dr
Warrendale PA 15096
(412) 776-4841

Whole Earth Review

PO Box 38
Sausalito CA 94966
(415) 332-1716

flywheels— Ordinary flywheels offer about the same energy density as lead acid batteries, while premium ones pretty much approach lithium. Safety and gyroscopic problems have been solved. A crucial limitation is windup time. If you are trying to "charge" your flywheel ten times faster than you use it, then you need ten times the drive motor. My feelings on this one are "maybe for buses". But buses are getting replaced by modems.

nitrogen power— This scheme is just plain cute. Take a tank full of liquid nitrogen and expand the gas into an ordinary heat sunk cylinder. Using ambient as the *hot* side of your ultra simple heat engine. As with steam power, there's no need for a clutch or transmission. Stock air motors work just fine. You get decent efficiencies and lead acid performance done at *one twentieth* the cost. Summer air conditioning is also trivial.

Nitrogen power seems a student project favorite. Several nitrogen car links appear on my website.

thermoelectric recovery— Some older Peltier and related thermoelectric devices have been proposed to try and recover energy from exhaust or muffler heat. The devices to date are so ludicrously inefficient that they never can even hope to return their cost, let alone accomplish anything

useful. Usually a minor tire pressure adjustment can deliver more energy savings for you.

A somewhat random assortment of my favorite alternative automotive resources is shown as this month's resource sidebar. Additional info on some of these topics is also found at www.tinaja.com/h2gas01.html

Electric Car Books

I have added access to most of the more accessible books on electric vehicle subjects to my web site at www.tinaja.com/amlink01.html A summary listing appears in figure one. Again, I overwhelmingly feel that hybrids completely blow away electrics on all counts. And should continue to do so until fundamental battery energy density problems are economically resolved.

NEED HELP?

Phone or write all your US Tech Musings questions to:

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

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

Isolated Power Supplies

Those *Burr Brown* folks have just introduced a new series of *isolated* hybrid power supplies. All these \$6 devices are the size and shape of a 14 pin minidip, give you output currents to fifty mils and can provide safety isolation to 1000 volts.

Some more details appear in figure two. Inside the hybrid is a 400 kHz oscillator, a tiny toroidal transformer, and some output diodes. Only two external capacitors are needed to get these to work. Obvious uses include ac line isolation, eliminating hum and ground loops, doing high side current sensing, and comm line isolation.

These also let you do such tricks as a very low frequency on-off data translation or letting both sides of a bridge rectifier tie to ground. These track the input voltage and offer only ten percent regulation, so some low dropout post regulator might also be needed for your app.

As shown, various models do offer single and dual outputs. You can also conjure up your own custom isolated power converters. Through use of the individual bits and pieces separately sold as Burr Brown's PWS745 and PWS750 products.

By the way, one fast way to pick up nearly any data sheet is to use the great service at www.questlink.com

NAMES AND NUMBERS

Alfa Aesar
30 Bond Street
Ward Hill MA 01835
(800) 343-0660

Appliance Manufacturer
29100 Aurora Rd #200
Solon OH 44139
(216) 349-3060

Burr-Brown
6730 S Tucson Blvd
Tucson AZ 85706
(520) 746-1111

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

Harris Semiconductor
2401 Palm Bay Rd NE
Palm Bay FL 32905
(800) 442-7747

Home Power
PO Box 520
Ashland OR 97520
(800) 707-6585

Integrated Design & Mfg
One SME Drive
Dearborn MI 48128
(313) 271-1500

Kentek
19 Depot Street
Pittsfield NH 03263
(800) 432-2323

Math Works/Matlab
24 Prime Park Way
Natick MA 01760
(508) 647-7000

MCP Systems
511 Commerce Drive
Fairfield CT 06432
(800) MCP-0222

Polytek Development
55 Hilton St
Easton PA 18042
(610) 559-8620

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

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

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

THAT Corp
734 Forest St
Marlborough MA 01752
(508) 229-2500

Time Compression Tech
203 N LaSalle #2100
Chicago IL 60601
(312) 558-1548

Another Approach

The obviously needed part, though, seems lacking so far. A 79 cent chip which starts off with a raw 110 volt AC input and then cheaply outputs isolated and hassle free +5 volts at an amp or whatever. There is a *Harris HV2405E* that does accept ac line voltage as its input, but this one does *not* include your essential safety isolation. The high power (2 watts) dissipated in their input resistor also severely limits your efficiency and package size. Very nicely, though, this works equally well at 110 and 220 volts without using any jumpers or switching at all.

A fixed 5 volt circuit is shown in figure three, while an adjustable 5-20 volt version is in figure four.

New Tech Lit

From *Texas Instruments*, a new two volume amplifier chip databook

library. From *Harris*, a nice booklet about *Semiconductor Solutions for Multimedia, Video, and Imaging*.

From *That Corporation*, a new \$3 rms level detector ic giving you wide bandwidth, a log output, and crest factors as high as eight. Intended for electronic music apps. From *NTE*, a fat new semiconductor directory that cross references over 260,000 chips of one sort or another.

From *Aesar*, a free periodic table of the elements wall poster. Certain new low temperature alloys that melt at 158 degrees Fahrenheit are offered by *MCP Systems*. The intended use is for low cost prototyping and mold making intermediates. Useful casting plastics and moldmaking materials are sold by *Polytek*, who have a free *Developments* newsletter. Another source is *CasiCraft*.

A wide variety of educational and other laser products gets stocked by *Kentek*. Ask for catalog #118.

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Micro Cookbook I	\$19.50
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PostScript Show and Tell	\$29.50
PostScript Video & secrets	\$29.50
PostScript Reference II	\$34.50
PostScript Tutorial/Cookbook	\$22.50
PostScript by Example	\$32.50
Understanding PS Programming	\$29.50
PostScript: A Visual Approach	\$22.50
PostScript Program Design	\$24.50
Thinking in PostScript	\$22.50
LaserWriter Reference	\$19.50
Type 1 Font Format	\$16.50
Acrobat Reference	\$24.50
Whole works (all PostScript)	\$380.00
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(520) 428-4073

Tech Musings

A new *magnetocoloric* magnetic refrigeration material is described in *Science* for March 27, 1998 on page 2045. This material is six times more effective than the previous ones and operates at room temperature. Thus, only one sixth of the newer material is needed for a home refrigerator or similar heat transfer system.

Basically, any magnetic material absorbs heat energy whenever it is magnetized and releases heat energy when raised above its *Curie Point*, where it totally loses its magnetic properties. While not quite solid state (your material has to slowly move from source to sink and back again), the mechanics involved are simpler than a compressor. No freon or other fluids are involved. Additional mag refrigeration coverage appears in the March 1998 release of *Appliance Manufacturer* on page 14.

We saw more details on magnetic refrigeration back in [HACK33.PDF](#), in

[RESBN63.PDF](#), and in volume III of my *Hardware Hacker* reprints.

Walt Pyle has released his new *Hydrogen Solar Chronicles* book. A useful hands-on compendium of his collected reprints from *Home Power* magazine. More info on his book is at www.tinaja.com/h2gas01.html

Time Compression Technologies is a new trade journal on Santa Claus machines, rapid prototyping systems, CAD/CAM, and industrial design. A lot more on the Santa Claus machines themselves and lots of links are at www.tinaja.com/santa01.html

Our second trade journal for this month is the new *Integrated Design & Manufacturing*.

Some nice reprints on wavelets are newly offered by those *MatLab* folks. Additional resources and links are at www.tinaja.com/wave01.html

Some great bargains in *Tektronix* 2213 oscilloscopes newly appear at www.tinaja.com/barg01.html

Bunches of freebie tutorials about wireless and communications topics appear at www.iec.org

For all the fundamentals of active filters in an easy to understand and easier to use format, check out my *Active Filter Cookbook*. Details per my nearby *Synergetics* ad. Or pick up your catalog instantly online at my www.tinaja.com/synlib01.html

Magic Sinewaves are a brand new opportunity which lets you generate surprisingly efficient and elegantly simple high power waveforms for use in industrial, automotive, solar, and home energy efficiency areas. I've recently posted a lot of new files to www.tinaja.com/magsn01.html

Our usual reminders that most of the mentioned resources appear in the *Names and Numbers* or *Alternative Automotive Resources* sidebars, that we offer a free US helpline per the nearby box, and that my *Guru's Lair* website is <http://www.tinaja.com>. ♦

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