Don Lancaster's

RESOURCE BIN

number fifty eight

Getting a charge out of batteries.

Our usual reminder here that the *Resource Bin* is now a two-way column. You can get tech help, consultant referrals and off-the-wall networking on nearly any electronic, *tinaja questing*, personal publishing, money machine, or computer topic by calling me at (520) 428-4073 weekdays 8-5 Mountain Standard Time.

US callers only, please.

I'm now in the process of setting up my new *Guru's Lair* web site you will find at (where else?) *www.tinaja.com* This is the place you go for instant tech answers. Among the many files in our library, you will find complete reprint sets for all of the *Resource Bin* and other columns. Plus a brand new Synergetics Consultant's Newtwork & lots of links to unique web sites.

You will get the best results if you have both *Netscape Gold* and *Acrobat Reader 3.0* installed. This new reader does utterly amazing things online.

A Look at Batteries

Take a fresh lemon and stick a bare copper wire and an iron nail into it. Now connect a voltmeter between the wire and nail and you should observe a voltage. Switch to an ammeter, and watch for a few mils of current.

This is one simple example of an *electrochemical cell*. Which is often and wrongly called a *battery*.

Just as that original battery was a grouping of cannon, your electrical battery is supposed to be a *group* of cells. A normal flashlight is supposed to have *one* battery of *two* cells. But nearly everybody says "battery" when they mean "cell".

An electrochemical cell consists of an *electrolyte* through which electrons freely find their way between any two dissimilar conductors. An *anode* at the negative terminal and a *cathode* at the positive terminal. At one time, these electrolytes had to be liquid. But these days, you will find gels, pastes, and even a few solid electrolytes.

When an external circuit is closed, a current results. Caused by a chemical reaction that forces electrons from the (+) *cathode* on over to the (-) *anode*. As that electrical energy in your current gets "used" externally, the amount of chemical energy remaining in the cell decreases. Thus *discharging* the cell.

A *primary* battery is normally a one way sort of thing. It starts with a high chemical energy and usually is able to discharge only once.

Some examples of primary batteries are carbon zinc flashlight cells, higher current *alkaline* cells, small *mercury* or *silver oxide* cells for long life at rather low currents, and brand new long life, high current *lithium* cells.

Any *secondary* battery is reversable. You can initially *charge* it by "filling" it with electrical energy. Energy that is converted into higher levels of stored chemical energy. You then *discharge* it into a load as needed.

One common secondary battery is the *lead acid* battery you'll find in any automobile. Other secondary batteries include *nickel cadmium* and *nickel metal hydride* cells used for everything from cordless phones to toothbrushes. And *lithium polymer* variants.

NEXT MONTH: Don reveals insider secrets for starting up your own tech venture.

You may find quite a bit of overlap between primary and secondary cells. Some flashlight cells can be recharged a few times. With less bang for your buck each time. Those secondary cells cannot get recharged forever. They'll typically have a *useful lifetime* of a few hundred to several thousand charge and discharge cycles.

Every battery technology trades off energy density, lifetime, cost, current levels, temperature, terminal voltage, discharge properties, rechargability, convenience, and safety.

A Closer Look

A lead acid battery is made from a sulphuric acid electrolyte solution, a lead cathode, and a lead oxide anode. To discharge your battery, an external current is drawn. Reversibly forcing lead, lead oxide, and sulphuric acid into lead sulphate and water. Thus reducing the stored chemical energy.

To charge your battery, an external current is applied. Reversibly forcing the combination of lead sulphate and water back into lead, lead oxide, and sulphuric acid.

Thus raising the available chemical energy to higher levels.

Somewhat similar reactions do exist for all popular battery chemistries. No one battery is "best" for all uses. So a dozen or more choices of chemistry are popular today.

There's several important measures of how "good" a battery is. These are collectively called the *energy density*.

This energy density sometimes gets expressed *by weight*. Telling you *how heavy* your battery has to be.

While *Watt hours per kilogram* is the norm, *Watt hours per pound* will often get used instead. Note that there are 2.2 pounds in a kilogram.

If your energy density is expressed *by volume*, it tells you *how big* or *how bulky* the battery has to be. While *Watt hours per liter* is the norm, *Watt hours per cubic inch* or a *Watt hours per cubic centimeter* might sometimes get used. There are 61 cubic inches or 1000 cubic centimeters in one liter. A liter is also called a *cubic decimeter*.

As a rule of thumb, the Watt hours per liter will be *two or three times* the Watt hours per kilogram. For typical chemistries most of the time.

Ferinstance, some alkaline primary cell may offer you an energy density of 140 Watt hours per kilogram or 400 Watt hours per liter. A nickel metal hydride cell might provide an energy density of 65 Watt hours per kilogram or 170 Watt hours per liter.

In general, a primary battery can deliver longer life for a given weight and volume. But at less convenience and higher operating costs.

My fire pager can barely make it overnight without having to recharge its older NiCads. But it easily goes for several days on alkalines. And more than two weeks on lithium.

Here are some battery resources…

Duracell

The *Duracell* folks have lots of free battery brochures. These can get you educated in a big hurry. Included are lifetime discharge curves and full tech specifications.

Let's review what you'll find in a few of these brochures…

Carbon Zinc cells are in those plain old primary flashlight batteries. While the cheapest of the lot, they are not really as cost effective as the newer choices. Typical energy densities are 50 Watt hours per kilogram or 150 Watt hours per liter.

By the way, an old caver's trick on flashlight cells: Always *reverse* to top cell in your backup light source. That way nothing awful happens when it inevitably turns on in your pack.

Alkaline Manganese Dioxide cells are a newer and a better substitute for carbon zinc. The high costs are more than offset by longer life and fewer surprises. These are really great for flashlights, toys, and intermittent high current loads. Energy densities are as high as 140 Watt hours per kilogram or 400 Watt hours per liter.

The **Mercuric Oxide** or **Silver Oxide** battery systems are typically offered as tiny coin cells. They are usable for computer real time clocks, watches or calculators. The output voltage is very stable and flat. Energy density is 110 Watt hours per kilogram or 450 Watt hours per liter.

Mercury cells are being phased out because of safety and toxicity.

Zinc Air cells are a safer and newer primary replacement for the mercury cells. These unusual cells have an *air access hole* in them. They are best used for continuous but low currents. They also do not self discharge until the air seal is removed.

Since one of the products "used up" in a zinc air cell is external, they have a big time energy density advantage. Namely 350 Watt hours per kilogram and a stunning 1200 Watt hours per liter. But note that these are suitable for small and light loads only. They are unlikely to end up very useful for electric vehicles.

Nickel Cadmium secondary cells are one of the earliest of rechargables. These still remain popular today for test equipment, toothbrushes, and in some cordless appliances. At 40 Watt hours per kilogram or 120 Watt hours per liter. But with some bad habits.

Cadmium is a deadly heavy metal and is tricky to properly dispose of. Certain NiCads have a *memory effect* where if you lightly discharge them all the time, they will forget entirely what a deep discharge is.

Note that typical NiCads have an extremely low internal impedance. If you short circuit one, an exceptionally high current is quite likely. Possibly exploding the cell. And welding both shortee and shorter.

Nickel Metal Hydride secondary batteries are a big improvement over NiCads. With higher energy densities and safer chemistry. They largely lack NiCad's undesirable memory effects. Important uses include laptops, video cameras, and cellular phones.

The new primary **Lithium** cells are often the "best". Outstanding life gets combined with superb energy density and higher per cell voltages.

But prices are still way high.

Lithium is by far the lightest metal and is plentiful in sea water. Sadly, lithium is extremely reactive and has been a bear to tame for battery use.

Some lithium technologies are now reaching 400 Watt hours per kilogram and 1000 Watt hours per liter.

Watch out for new rechargable and extremely lightweight *lithium polymer* cells from *Argonne* and others.

Interestingly, these apply a "warm" technology that has to hold the cells at 60 degrees C or so. A good review of lithium polymer possibilities appear in the Sept. 1996 *Automotive Industries* on pages *75-77*.

One source for specialized custom high efficiency lithium cave lighting devices is *HDS Systems*.

Yuasa-Exide and Panasonic

Ordinary **lead acid** batteries use a wet chemistry. One which has to get

SOME BATTERY TECHNOLOGY RESOURCES

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

Argonne Natl Laboratory
9700 S Cass Avenue
Argonne IL 60439
(630) 252-2000

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

B&H Photo-Video
119 West 17th St
New York NY 10011
(800) 947-9901

Battery Council Int'l
111 E Wacker Drive
Chicago IL 60601
(312) 644-6610

Battery Technology
5700 Bandini Blvd
Commerce CA 90040
(800) 982-8284

Benchmarq
2611 Westgrove Dr #101
Carrollton TX 75006
(214) 407-0011

Burgess
1335 Barclay Blvd
Buffalo Grove IL 60089
(708) 215-9600

Butterworth-Heinemann
313 Washington St
Newton MA 02158
(617) 928-2500

Dallas Semiconductor
4401 Beltwood Pkwy S
Dallas TX 75244
(214) 450-0400

Duracell
Berkshire Industrial Pk
Bethel CT 06801
(800) 431-2656

Eagle Picher
PO Box 47
Joplin MO 64801
(417) 623-8000

EEM
645 Stewart Ave
Garden City NY 11530
(516) 227-1300

Electrochemical Society
10 S Main St
Pennington NJ 08534
(609) 737-1902

Electronic Comp News
1 Chilton Way
Radnor PA 19089
(215) 964-4345

Electric Pwr Res Ins
PO Box 10412
Palo Alto CA 94303
(415) 855-2000

Eveready
Hwy 441 North 147114
Alachua FL 32615
(904) 462-3911

Gould
35129 Curtis Blvd
Eastlake OH 44095
(800) 722-7890

HDS Systems
Box 42767
Tucson, AZ 85733
(520) 881-2632

Home Power
PO Box 520
Ashland OR 97520
(916) 475-3179

Ind Battery Mfg Assn
100 Larchwood Drive
Largo FL 33540
(813) 586-1408

Johnson Controls
900 E Keefe Avenue
Milwaukee WI 53212
(414) 961-6500

McGraw Edison
PO Box 28
Bloomfield NJ 07003
(201) 484-3500

Panasonic Batteries
PO Box 1511
Secaucus NJ 07096
(201) 348-5266

Power Express
14388 Wnion Avenue
San Jose CA 95124
(800) 228-8374

Rayovac
601 Rayovac Drive
Madison WI 53711
(608) 275-4692

Real Goods
966 Mazzoni St
Ukiah CA 95482
(800) 762-7325

Rocky Mountain Inst
1739 Snowmass Creek
Snowmass CO 81654
(970) 927-3851

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

SAFT
2155 Paseo Americas #31
San Diego CA 92173
(800) 328-9146

Tadiran
2 Seaview Blvd Ste 102
Port Wash NY 11050
(516) 621-4980

Union Carbide
PO Box 1467
Ramona CA 92065
(619) 279-4500

Unitrode
7 Continental Blvd
Merrimack NH 03054
(603) 424-2410

Varta Batteries
300 Executive Blvd
Elmsford NY 10523
(914) 592-2500

Yuasa-Exide
645 Penn Street
Reading PA 19601
(215) 378-0333

maintained, ventillated, and remain right side up. A *gel cell* instead uses a gelled electrolyte. These normally are usable in any position and are sealed from the environment.

Gel cells are often used for alarm systems, for emergency lighting, and for uninterruptable power supplies. Their typical energy densities are 25 Watt hours per kilogram and 60 Watt hours per liter. Cheap, but not so great compared to newer cells.

Uh, *Duracell* is not in the lead acid business. Instead you'll have to go to *Yuasa-Exide*, to *Johnson Controls*, or to *Panasonic* for the gel cells. These are usually stocked by *Mouser*, *Digi-Key*, and all of the usual suspects

Additional ads for battery suppliers are found in the *EEM Master*. And in *E.E. Times*, *Electronic Component News*, and similar trade journals.

Get a Charge Out Of This

Newer rechargable cells are quite fussy over how you charge them. You can't simply shove a bunch of current into them and blithely walk away.

The latest of charger circuits will use pulse techniques. Which carefully measure cell voltage and temperature. Important suppliers for the intelligent charger chips now include *Benchmarq*, *Unitrode*, and *Dallas*.

A review of charger resources can be found as my file HACK80.PDF on *www.tinaja.com*

You can expect the next generation of batteries to have some degree of built in intelligence. A thermistor at the least. Maybe even a full micro to provide both safety and "gas gauge" functions. *Amp* is a leading proponent of new multi-pin battery connectors that ease adding smarts to these next generation power sources.

The Battery Reference Book

This fat textbook by T. R. Crompton is sold by *Butterworth Heinemann*. All of the major battery technologies are exhaustively covered in depth.

Lead acid, nickel, silver, alkaline, carbon zinc, zinc chloride, mercury, lithium, manganese dioxide, sodium sulphur, metal air, zinc halogen, and scads of others.

The second edition was revised in 1995. The text is British, so you'll see some European emphasis. Plus a few rough spots in the translation. As an example, they'll use cubic decimeters instead of liters in their notation.

One electrochemistry publication is *Interface*. Edited by the *Electrochemical Society*. In the area of trade groups, you should find an *Independent Battery Manufacturers Association* and a *Battery Council International*.

And, of course, the web is crammed to the gills with online battery info.

1-800-BATTERIES

There are several newer outfits that now specialize in one stop shopping for all replacement battery packs. For video cameras, cellular phones, and laptop computers. You should find ads for many of these in *Nuts & Volts*.

One high profile supplier is *Power Express*, who have a 1-800-BATTERIES catalog. Two competitors are *Battery Technology* and *B&H Photo Video*.

Home Power

As we've seen a time or two before, *Home Power* magazine is *the* source for most alternate energy topics.

Including, of course, the batteries used for most solar and wind energy storage. You'll find lots of advertisers, tech info, and detailed reviews.

I've provided a hot link to the Home Power site on *www.tinaja.com*

Yet another source for home energy battery storage products is *Real Goods*.

Electric Car Batteries

Most of the heaviest trucks and the most powerful locomotives found in the world today *are* electric. And have been so for decades. Thus, your key problem is making electric cars *more* wimpy, not less.

There's been great heaping bunches of hidden secret agendas, regulatory hassles, market uncertainties, lack of infrastructure, and the misdirection in most auto battery research.

Do note that the energy density of gasoline is ridiculously higher than any known battery technology. When all is said and done, gasoline today is a "better" choice by a factor of nearly *one hundred*. This is your main reason electric cars have yet to make it very far out of the driveway.

Until batteries *dramatically* improve, a hybrid car having a small constant speed diesel engine, a limited battery set, and not less than four in-wheel motors makes the most sense to me.

But today's laptops, cellulars, and video cameras form an instant and a baggage free new multi-billion dollar market for new battery technology.

A fresh market that *demands* energy densities far in excess of that needed for an automobile. Thus, your laptop computer aftermarket industry will shortly and certainly "solve" the key electric car problem.

Your leading resources on electric car batteries include *SAE*, *EPRI*, and *Automotive Industries*. The best take on alternate hybrid vehicles is available from the *Rocky Mountain Institute*.

Many homebrew electric car topics also appear in *Home Power*. Also in RESBN51.PDF on *www.tinaja.com*

A Challenge

Is there any battery research you can do on your own?

For decades now, there has been a perpetual motion scam eeking out a meager existence on late night talk shows. In several cases, exceptional battery life extensions are claimed. In a system that involves high voltages, sudden inductive switching, and "lots of sparks".

Life extensions which occasionally disappear when you place a diode in series with the cells. Could there be a real effect hidden in the hype?

While, of course, remaining within the bounds of physical and chemical reality. And the real world.

Theoretically, if so much as a scrap of the zinc case still remains on an ordinary flashlight cell, recoverable energy remains. Such a cell does not "run down" by fully depleting all its chemical energy. Instead, processes involving *polarization* will gradually increase the cell's internal resistance to the point where useful energy can no longer be drawn.

Life curves tell us that discharging such a cell only a few hours per day gives much longer life than running it continuously. Those electochemical "cells" used by the electroplating folks often are *reversed* every now and then. Purposely *unplating* a tad. For cleaner and smoother results.

What happens if you *recycle* some part of the drawn energy as narrow and high current spikes? Say a *reverse* ten amps for a twentieth of a second every five seconds. Against a normal half amp draw.

One amp second back for five out.

Because of inherent nonlinearities, this pulsed return current just *might* depolarize better than a continuous draw can polarize. *Possibly*, a longer battery net life could result.

Conceivably, you could have this electronic disk that snaps on top of the top cell of your flashlight. A disk that magically extends battery life by discouraging polarization.

The big bucks question that you can personally explore today is whether such a *recycle effect* exists at all. Casual observation says it should. And if this effect exists, is it cost effective enough and dramatic enough to bother with?

A *Basic Stamp* project, obviously. Switching with a power Mosfet. And some PC data acquistion. And always fresh cells from identical lots inside the same package.

Limit your experiments to carbon zinc or alkaline cells *only*. Don't even *think* of trying this with NiCads! Just to stay on the safe side, use a "bomb shelter" consisting of a paint can full of sand. And some fuses.

Fixed resistor heating loads are a much more controllable choice than a nonlinear light bulb filament. A good digital voltmeter is a must.

This Month's Contests

Let's have two contests this month. Tell me about a battery resource I am not familiar with. Or run that pulse recycling experiment to see if you can come up with a useful result.

There will be a largish pile of my new *Incredible Secret Money Machine II* books going to the dozen or so better entries, plus an all-expense-paid (FOB Thatcher, AZ) *tinaja quest* for two that will go to the very best of all.

Send all your *written* entries to me here at *Synergetics*, rather than to *Nuts & Volts* editorial. ✦

Microcomputer pioneer and guru Don Lancaster is the author of 33 books and countless tech articles. Don maintains his no-charge US tech helpline found at (520) 428-4073, besides offering all of his own books, reprints, and consulting services. Don also has two free catalogs full of his resource secrets waiting for you. Your best calling times are 8-5 on weekdays, Mountain Standard Time.

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Full reprints and preprints of all Don's columns and ongoing tech support appear here. You can reach Don at Synergetics, Box 809, Thatcher, AZ 85552. Or send any messages to his US Internet address of don@tinaja.com

