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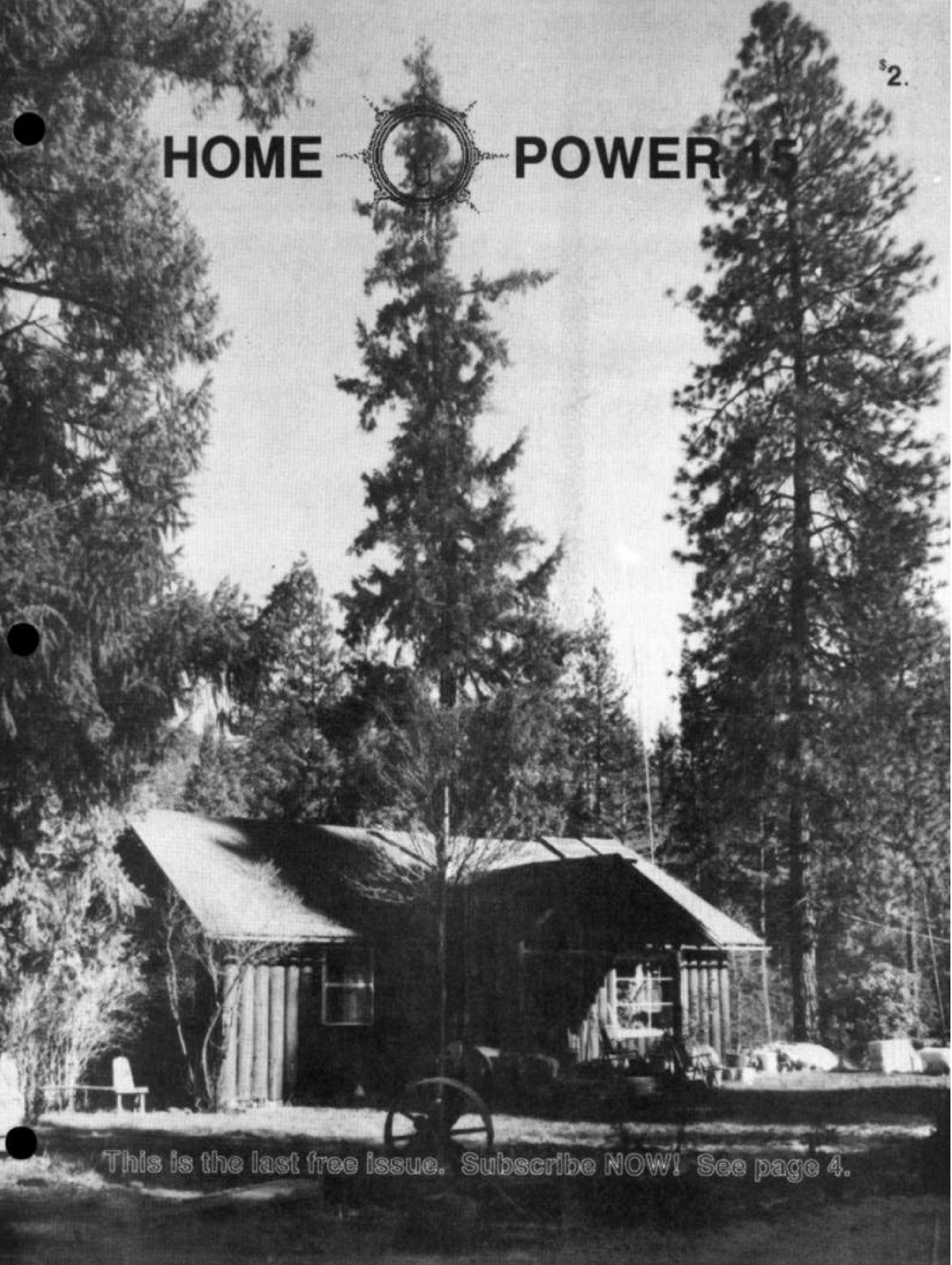
# HOME POWER 15



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# Home Power

THE HANDS-ON JOURNAL OF HOME-MADE POWER

## People


B. Bonipulli
Twyla Browning
Sam Coleman
Donald Fallick
Jerry Fetterman
Brian Green
George Hagerman
Scott Hening
Phil Jergenson
Stan Krute
Alex Mason
Lynne Mowry-Patterson
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## Think About It

"You can't hold a man down without staying down with him."

Booker T. Washington 1856-1915.

## Cover

Joyce Eichenhofer's home, along the Salmon River in California, is powered by phoovoltaics and hydro power.

Photo by Brian Green

# From Us To YOU

This Is The Last Free Issue
Of Home Power, So Please:

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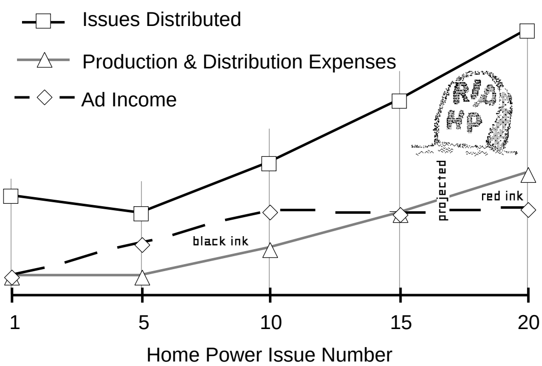
As mentioned last time, this fifteenth issue is the last free Home Power. Economic realities have forced us to start charging subscriptions. Here's a picture:




Though ad revenues have grown, the number of issues we send out, and thus our costs, have been growing even faster. Over 90% of our costs come from printing, distribution, and equipment. Only three of us get any kind of salary, and that's below minimum wage. Everything else is lovingly donated: articles, photographs, illustrations, and miscellaneous good works. As you can tell by examining the graph, if Home Power doesn't tie its income to its circulation, we'll die. We can't let that happen.

That's why we have to start charging. We think $6 a year is a reasonable price. That's just $1 per issue. Many of you seem to agree. We've already received a pile of paid subscriptions. Some are for more than one year. Thank you all.

And a special thanks, as always, to our advertisers. They've paid the freight this far. (And you readers have helped them do it, by buying their goods and services.) Many advertisers have shown their faith in the Home Power future by buying new multiple-insertion contracts. Thank you, business friends.

So: if you don't want to miss a single issue, send in that $6 for each year of a paid subscription to Home Power. You'll find the form on page 27.

We hope to see **all** you peaceful, planet-loving co-conspirators next time out. The best is clearly yet to come.

*SK for the Home Power Crew*

# Runaway Washing Machine

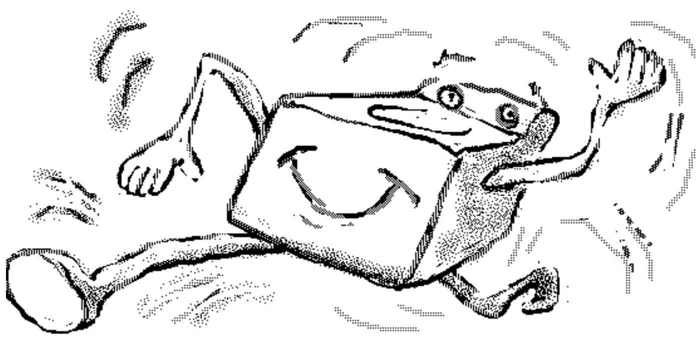
Daniel K. Statnekov

A terrible racket and clatter I heard
A moment or two ago
Got up from my desk to find the cause
See for myself and so

I walked from my study to the laundry room
To search for the source of the noise
And found that the washer had run away
From a dryer that sat with great poise

It was during the cycle that spins the clothes
When out of kilter it went
Hopping along on its one cubed foot
Its hoses were stretched and bent

Some imbalance, I gathered, had caused it to leave
Its appointed place in the room
Now it shimmied and shook, a machine run amuck
It wobble forcasting some doom



Stan Krute

I started to reach for its switch, then I paused
To enable the drama full play
The washer continued its haphazard march
Passed me by as it went on its way

But before it could crash it got to the end
Of its thick electric chord
Unplugged itself from the power supply
And didn't shake any more.

# Teaching Kids about Batteries & Photovoltaics

George Hagerman



Hiding in photo1 is the reflection of high-voltage transmission lines that carry nearly 1400 megawatts to heavily populated northern Virginia. This image captures the energy choices facing today's youngsters in an increasingly populous and resource-scarce world. Disposable or renewable fuels? Centralized or distributed generation? Next century's energy picture will be shaped by this decade's school children. Not all will be utility or government planners, but all will be energy consumers and voters. Will they have the knowledge to make wise choices, or even to ask the right questions?

**Some are asking questions now!**

An unexpected result of my free, one-line listing in the Yellow Pages has been a small but steady stream of requests for help on school projects. Last year, after getting three calls in one week, I invited parents and their kids to my office to show them some solar basics and discuss their ideas. One young lady proposed to compare the cost of producing hydrogen from electrolysis of water by solar energy and by batteries. She borrowed a 2-watt panel and did a fine job on her project. A sixth-grader decided to build a miniature home power system - a small cardboard house, a penlight bulb, two rechargeable AA cells (in series), and two 6V/50mA mini-panels (in parallel) on the roof. Well all this inspired me greatly, and I began to realize that if we're going to stop the destruction of this planet, education is where it's at. Then I received a call from Lucy Negron-Evelyn.

**The El Ingeniero Program**

Lucy is Executive Director of Non-Profit Initiatives, Inc., in Silver Spring, Maryland. Each year she conducts a summer program called "El Ingeniero". This is a six-week course for gifted Hispanic-American junior high school students, funded by NASA as part of an effort that encourages minorities to pursue careers in engineering.

The main focus of El Ingeniero '89 was hydraulics, but Lucy asked if I could spend a few days teaching the kids about solar energy. Jumping at the chance, it was soon apparent that I had much to learn. This article attempts to pass on some of the lessons.

**Photo 1**. Student-built battery chargers reinforce the principles learned in this course. Photo by George Hagerman.

**Overall Approach**

The course consists of two main activities. Through lectures and experiments, the students learn the relationship between solar cells, batteries, and electrical loads. They learn about the design process that determines the proper size, number, and arrangement of these components. This process is the same,whether you are powering a portable tape player, a remote weather station, an orbiting satellite, a house, a village medical clinic, or even a whole community of homes and businesses.

As a second activity, each student designs and builds a battery charger for their favorite battery-powered gadget. This is something that they can use the rest of their lives, daily reinforcing the principles learned from lectures and experiments. It is also a solar energy application that will save most students the cost of 50-100 disposable batteries each year! Although the environmental advantages of this are significant and important, it really hits home when you can reach these kids in terms of their weekly allowance.

This article focuses on the lectures and experiments. The design, construction and performance of the battery chargers built by El Ingeniero '89 will be detailed in the next issue of Home Power. Building the charger can be a course all by itself, as can the series of lectures and experiments. The course is more effective if both activities are combined, but lack of equipment or budget may make this impossible. The lectures and experiments are presented here in six sessions, but this may be modified to fit a particular teaching schedule (e.g. regular school session vs. summer workshop).

This article describes the course not as I taught it, but as I would teach it again. It was my first teaching experience, and there are many things I'd do differently. Several new experiments have been added, and although not yet used in a classroom, all have been thoroughly tested to be sure they work.

**Session 1 - Lecture on Batteries and Loads**

The sun's rays are not always available when you need the power. A reading lamp connected directly to a PV panel is a useless item. The concept of battery storage is fundamental to the application of solar energy (or any other intermittent resource).

Given the hydraulic focus of El Ingeniero '89, electrochemical storage cells were introduced to the class as little tanks of water. Voltage is analogous to the water's height (pressure), and capacity is analogous to the tank's volume. Electric current is analogous to the flow of water out of the tank, through a valve which represents the load. As the cell discharges, the tank drains, and the water level (cell voltage) drops - slowly for a small load (nearly closed valve), quickly for a large load (nearly open valve).

The size of a cell (AA, C, D, etc.) is related to its capacity, not its voltage. This fits the water tank analogy, since a AA cell and a C cell are about the same height, but the C cell is significantly fatter. Cell voltage is related to the nature of the electrochemical reaction - 1.5 volts for zinc-carbon, and 1.25 volts for nickel-cadmium.

This is an opportunity to take some of the mystery out of what goes on inside a battery. Soak a piece of paper towel in lemon juice and sandwich it between a nickel and a piece of aluminum foil. This nickel-aluminum (Ni-Al) cell will develop an open-circuit potential of about half a volt.

What's happening? When dissimilar metals are "bridged" by an acid or alkaline solution, chemical reactions cause one metal to develop a positive charge, the other a negative charge. The negative charge is a build-up of free electrons, and depends on the metals involved. For example, a nickel-iron (Ni-Fe) cell has twice the voltage of a Ni-Al cell, which can be shown by replacing the aluminum foil with a steel washer.

The nickel-cadmium (Ni-Cad) reaction is reversible, and Ni-Cad cells are rechargeable. The discharge curves (voltage vs. capacity) for zinc-carbon, alkaline, & Ni-Cad cells are compared. Zinc-carbon and alkaline cells do behave like little cylindrical tanks of water - as the cell drains, voltage drops almost linearly. Ni-Cad cells behave more like hollow-stemmed wine glasses - very little change in voltage until the cell is almost empty, and then voltage plummets as the last bit of water drains from the glass stem. The electrical consequences are explained for something like a flashlight. Zinc-carbon & alkaline cells give early warning of their demise as the light gets gradually dimmer. With Ni-Cads, you get a nice bright light throughout most of the cells' life, and then, poof ... sudden death.

The mathematical relationship between battery capacity, current drain, and discharge time is explained, as is the meaning of a "C" or "C/5" rate. A chart is drawn on the board showing the capacity of different Ni-Cad cells. Simple questions are offered - "If two D cells are used in a flashlight that draws 800 mA, how long will they last?".

**Photo 2.** A four-cell Ni-Fe battery made from nickels, steel washers, and a weak acid electrolyte (vinegar also works). When the bent wire of the LED shown is touched to the face of the terminal nickel, it lights, and the voltage drops to about 1.8 volts. Stacked next to the Ni-Fe battery are eight Ni-Al cells in series, fashioned from nickels and cut square pieces of aluminum pie plate. Photo by George Hagerman.

Finally, the class is shown how individual cells can be connected in series (add voltages, same capacity) or parallel (same voltage, add capacities).

It is explained how a certain threshold voltage is required to operate any given load. Returning to our simple Ni-Fe cell, switch off the classroom lights and show how four in series (Photo 2) have enough voltage to power a light-emitting diode (LED). The class should be able to guess how many Ni-Al cells are required to produce the same LED brightness.

It should be emphasized that the ability to develop adequate voltage depends only on the number of cells in series, and not their size. For example, a tape recorder takes four fat C cells - will it run off four tiny AAA cells?

The kids may be skeptical, so set it up in front of the class. Sure enough, tunes start to emanate from the machine. The digital multi-meter used earlier can now be used to show a current drain of about 140 mA. Judging from the chart on the board, how long are those AAA's going to last? Should the kids use a "C" or "C/5" rate to calculate the answer? If Session 1 is in the morning and Session 2 is in the afternoon, have the students listen to the tape recorder during lunch and see if it stops when they predicted it would.

**Session 2 - Experiments With Batteries and Loads**

Six experiments are set up at different locations in the room. The students should work in groups of two or three. This way they can help each other and talk about what they are doing. If the groups are too large, then the quickest kids will do all of the "hands-on" work, while those that are slower, or more shy, hold back.

Another way to ensure active participation is to give each student a work sheet. This has specific questions for each experiment, which can be answered only if the student DOES something, like changing a wiring connection and reading a meter.

With only six experiments and 25 kids working in pairs, they can't all be occupied at once. One solution is to divide the class in half, with one group working on experiments, and the other on building their battery chargers. Then half-way through the session, the two groups switch.

The six experiments and the principles they demonstrate are described below. Component wiring connections are illustrated in Figure 1. Parts access is given at the end of this article. Many of these components are reused in the photovoltaic experiments shown latter photos.

**Experiment BL1** demonstrates the different discharge characteristics of Ni-Cad and zinc-carbon batteries, and the difference between open-circuit and loaded voltage. It requires six AA Ni-Cads, two of which are fresh, two of which are half-discharged, and two that are dead. Six zinc-carbon cells, at comparable states of charge, are also required. Mark the cells with letters or numbers ahead of time, but don't tell the kids which marks go with which states of charge - they should determine that from voltage and/or load behavior. A low-drain load, like an AM radio, can be used for comparison with the high-drain lamp.

**Experiment BL2** demonstrates the importance of connecting loads in parallel rather than in series. The current drains of submerged and dry pumps should be measured when they are individually in circuit, then together in series, and finally together in parallel. When in series, the dry pump acts like a bottleneck, limiting the amount of current flowing through the circuit, thus reducing the output of the submerged pump. This also shows that a loaded motor draws more current than a free-spinning one.

**Experiment BL3** demonstrates the difference in current drain between a motor starting from rest and one already running. Starting current will always be more than running current, and depends on where the motor comes to rest (relative position of magnets, windings, and such). This is of considerable importance for motors that may be powered directly off photovoltaic panels, which are current limited. Examples include fans for venting cars or attics, and pumps for delivering water to irrigation systems.

**Experiment BL4** demonstrates the effect of voltage on motor speed. As a load, the motor may be considered a valve for electrons. When the voltage (or electron pressure) is increased, more electrons flow through the valve per unit time. As long as the mechanical load on the motor doesn't change, this greater flow of electrons results in more speed. Stall the motor, and the valve opens wide, draining the battery.

**Experiment BL5** demonstrates the effect of wire resistance on voltage drop. Again, the flow of electrons in a wire may be likened to that of water in a pipe. Electrons start their trip at a cell's negative terminal with a certain amount of potential energy (voltage), which is converted to other forms (heat, light, sound, shaft horsepower) as they travel through the circuit. This potential energy is completely lost by the time they reach the cell's positive terminal. Ideally, very little energy should be lost as they flow to and from the load. If the pipe (or wire) is too small, significant amounts will be lost to friction (heat), and not as much will be available to operate the load. When all four spools of wire are in circuit, two additional Ni-Cad cells are required to properly operate the load. Replace any one of these six good cells with a dead Ni-Cad. This shows how a "dead battery" may result from only one bad cell.

**Experiment BL6** demonstrates the effect of mechanical loading on the current drain of a motor. Most motors don't spin freely, but do work like lifting weights, pushing vehicles, and moving air or water. This experiment uses a commercially available motorized game that lifts little plastic dolphins to the top of a spiral track. They roll down to the bottom, where they are picked up by a slowly spinning wheel and carried to the top again. The wheel spins behind a cardboard sheet. Magnets on the wheel rim pick up the dolphins, which have small magnets on their sides. As the dolphins slide along the cardboard on their way to the top of the track, friction loads the motor, causing an 80 mA. jump per dolphin. These "leaping" dolphins are fun to watch and teach an important principle that applies to many practical situations: an electric winch lifting a heavier weight, a solar car driving up an increasingly steep hill, or a pump filling a higher reservoir. In all cases the current drain will increase. If the voltage source can't deliver any more current, then the rate of lifting will slow, the car's speed will drop, and a sea-level gusher will turn into a mountain-top trickle.

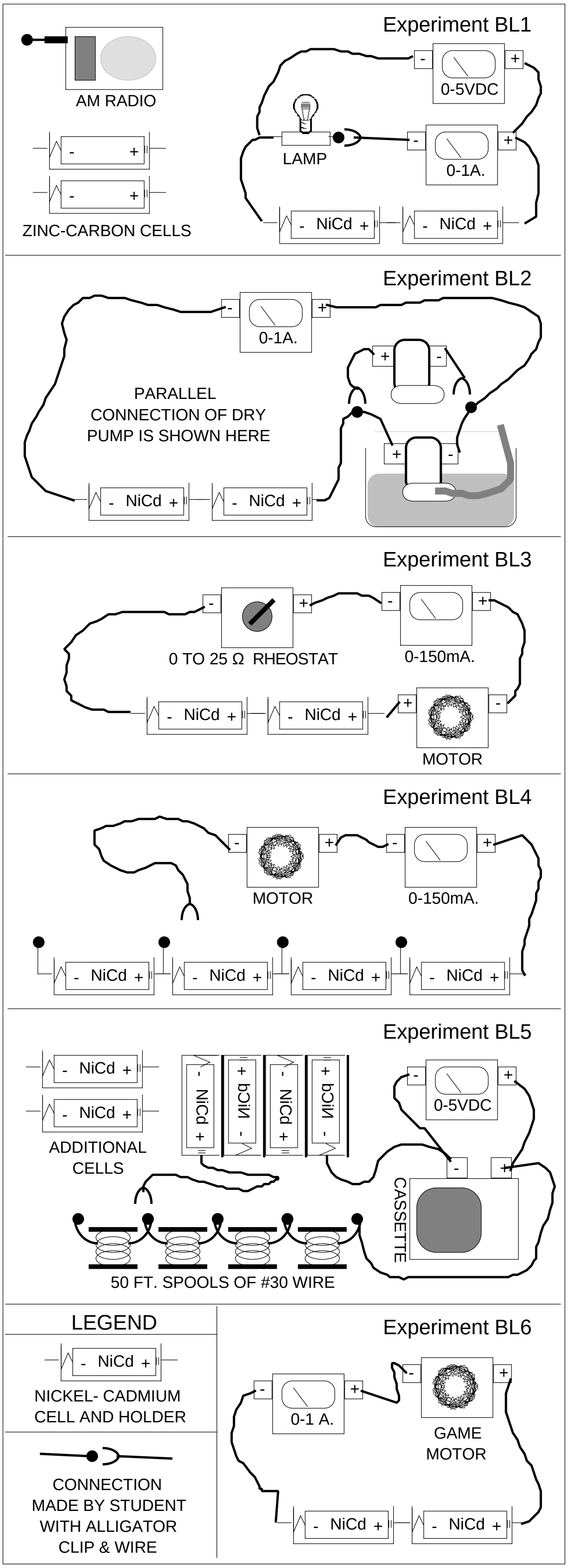



Figure 1. Six Battery and Load experiments.

**Session 3 - Lecture on Photovoltaics**

Placing photovoltaics into context with other renewable energy technologies requires a brief overview of the four main methods for directly harnessing the sun's rays. These are passive solar heating (via solar building design), active solar heating (via special collectors for air or water), solar thermal electric (parabolic reflectors producing high-temperature steam running turbine/generators), and photovoltaics (direct conversion of photon energy into electron potential). Because wind is a result of unequal heating of the earth's surface by the sun, and waves are generated by wind blowing over water, these are also forms of solar energy.

The photovoltaic (PV) effect is explained very simply: when light strikes a PV cell, it "kicks" electrons up to the surface layer from a deeper layer. Just as the voltage of an electrochemical cell depends on the two metals involved, the potential energy developed by a PV cell depends on the material composition of its upper and lower layers. The characteristic potential of silicon-based PV cells is about half a volt. At low levels of illumination (say on an overcast day), the voltage of a PV cell depends on the intensity of light striking its surface, but over most of its useful operating range, voltage varies only slightly with light intensity. On the other hand, the amount of current delivered by the cell depends strongly (and linearly) on light intensity. (the number of photons arriving per unit area per unit time). No matter how much potential energy it has, an electron cannot leave the cell's surface until a photon arrives to "kick" another one up from the lower layer to take its place.

An electron also can't leave if it doesn't have anywhere to go, so in an open circuit, electrons "kicked" up by newly arriving photons fall back into the lower layer, until a circuit is completed. Open circuit PV cells behave much like electrochemical cells. Connected to a load their behavior is markedly different. For the power drains used here, a Ni-Cad cell's ability to deliver current is unlimited. A tiny AAA cell can deliver as much current as a big bad D cell; not for nearly as long, but it can still deliver. The current delivered by a PV cell is limited by the rate of photon arrival.

Therefore, except when very lightly loaded (almost closed electron valve), the PV cell is a constant-current source. The current flowing through a medium load (half-open electron valve) is almost the same as that flowing through a short circuit (wide open electron valve). No matter how open the valve is, the rate of electron flow (current) is governed by the rate of photon arrival, which is the product of cell area and light intensity.

Light intensity is affected by shading and angle of incidence. If photons are absorbed or reflected by the atmosphere, clouds, tree branches, or glass, then their rate of arrival at a PV cell is reduced. Even if there is nothing between the cell and its light source, the light intensity is affected by the angle at which light strikes the cell's surface. This can be illustrated on a chalkboard by drawing a beam of parallel rays striking a plane at various angles of incidence.

Thus, less solar energy reaches the earth's surface during the winter; not only because the days are shorter, but also because the sun is at a lower angle in the sky. This reduces the angle of incidence and also means that the sun's rays have to pass through more of the atmosphere.

Just as a battery is a series/parallel combination of electrochemical cells, a solar panel is a series/parallel combination of PV cells. Panel voltage, like battery voltage, can be increased by wiring cells in series. Wiring PV cells in parallel increases the amount of current that the panel can deliver under a given light intensity, having exactly the same effect as increasing the cell's area.

At this point, break out a bunch of different PV cells and panels. The cells (protected in clear plastic boxes) can be handed around the class. Note the grid of fine wires on the cell's surface, which collects electrons "kicked" up by the light. This is the negative terminal. The metal surface on the back side of a cell is it's positive terminal. Briefly describe the different silicon cell types: single crystal, polycrystalline, and thin-film. Have the kids look at the panels. Can they distinguish series and parallel cell connections? If it happens to be sunny outside, show that panels of the same size may be high-voltage/low-current or low-voltage/high-current. What does this imply about series vs. parallel cell wiring?

Also if you can get outside, demonstrate the constant-current feature of PV panels. Using the same tape recorder that drew about 140 mA from the Ni-Cad cells, connect a PV panel to its battery compartment terminals. Show the effect of tilt angle. Hold the panel at an angle just above the threshold at which the tape slows noticeably. Have one of the kids move the jumper cables from the tape recorder to a current meter, and note the short-circuit current. Can they guess beforehand what it will be? At lesser angles of incidence, the rate of photon arrival doesn't send enough electrons around the circuit to operate the load, eventhough its electron valve is open enough to accommodate them.

Tape recorders are great for showing all sorts of things. More importantly, if you put on a tape with tunes that the kids know, you'll grab their attention immediately. There's nothing like a little "Straight Up" by Paula Abdul (from Forever Your Girl, copyright 1988 by Virgin Records America, Inc.) to get feet tapping. PVs should make you feel like dancin'!

**Session 4 - Experiments With Photovoltaics**

This is the one session that must be held outside on a bright day. What is bright"? If you can see sharp edged shadows on the ground for at least five out of every ten minutes, then all of the PV experiments will work.

**Experiment PV1** demonstrates that decreasing light intensity strongly affects current output, but it has little effect on voltage except at the lowest illumination levels. First, the panel is tilted at various angles, such that the students can collect enough data points to plot open-circuit voltage vs. short-circuit current. The panel is then returned to a position that is perpendicular to the sun's rays, and the effects of increasing cloud thickness are simulated by placing one, two, or three layers of translucent white foam over the panel. Are transmission efficiencies of multiple layers additive or multiplicative? Finally, a piece of opaque cardboard is used to completely shadow a portion of the panel. It has different effects, depending on whether it is oriented vertically or horizontally.

**Experiment PV2** demonstrates that if just one cell in a string of series cells is completely shadowed, then it develops a high resistance, causing a large voltage drop when the panel is under load. In this way, it has the same effect as a dead electrochemical cell in an otherwise good battery. The panel shown I used evidently has a few cells that are not of such high quality, since Paula still played up to tempo when one of these lesser-quality cells was shaded. Partially shading many cells in the panel has much less effect than completely shading just one good cell. Since even a single bare branch can cast a shadow large enough to cover an entire cell, the moral of the story is: avoid trees, and be particularly sure that they won't shade the panel in winter, when shadows are longest.

**Experiment PV3** simulates a solar powered irrigation system and the effect of starting vs. running current on system operation. Orient the panel so it is perpendicular to the sun's rays. Tilt the panel back until output from the pump stops just shy of the tip of the clear plastic tubing that comes with the pump. Note the angle, and tilt the panel back even farther, so that the sun "sets" completely, and the pump motor stops. Now slowly raise the panel to the angle noted earlier. Depending on what position the pump motor came to rest, it may be that there is not enough PV current to start the pump motor. The angle of incidence may have to be much higher, and it will be much closer to "solar noon" before the system starts to operate. If you want to keep the experimental set-up dry, it is better to use something deep like a cottage cheese container, rather than the shallow bowl shown in the photo. The clear plastic tubing should be duct-taped to the inside wall of the container, so that the pump is held level.

**Experiment PV4** demonstrates the effects of parallel and series connection of individual PV cells. First, short-circuit current and open-circuit voltage are measured. Then a submerged pump is connected, and it will be seen that wiring the PV cells in parallel has no effect on pump output, but wiring them in series does. This reinforces the principle already shown with batteries, that increasing voltage increases motor speed for a given mechanical load. Now connect a dry pump in parallel. Do the students recall why not in series? If the light intensity is high enough, it can be seen that the second pump will have no effect on the first one's performance as long as both are running smoothly. If the dry one is stalled by stopping its impeller with a toothpick, the output of the other pump drops dramatically. If current delivery is limited (as it is with PVs), and one valve opens wide (stalled motor), most of the electrons will take the path of least resistance, leaving the other load without adequate current.

**Experiment PV5** demonstrates that PVs can recharge Ni-Cads, and that current into the Ni-Cad equals current out (or very nearly so). The procedure is as follows. First, a dead Ni-Cad is connected to a motor, which has a 4.4-ohm resistor across its terminals so that it will only run for a few seconds on the "rebound" voltage of the dead Ni-Cad. The motor I used draws 10 to 15 mA at 1.2 volts without the shunt resistor, 100 mA with it. The Ni-Cad is then charged for two to four minutes, depending on sky conditions. The trick here is to continuously adjust the tilt of the panel, so that the charging current remains at exactly 50 or 100 mA. By casting a "weather eye" to the sky during this period, the student can anticipate upcoming tilt adjustments and will start to gain a feel for the effects of clouds and angle of incidence on PV output. The newly charged battery is then connected to the motor, again monitoring the current flow. A watch with a second hand (or digital second counter) is used to measure the time it takes the current to drop from 100 mA to 95 mA (it will plummet very quickly after that, and the motor will stop; the student should then switch the rotary dial on the current meter to "OFF" in order to avoid excessive discharge of the Ni-Cad).

**Experiment PV6** demonstrates the effect of PV voltage on how much charging current flows through a battery. It also demonstrates the need for (and the energy cost of) a blocking diode. First, the battery open-circuit voltage is measured, as well as the open-circuit voltage and short-circuit current of six, five, four, three, and two PV cells in series. This should be done with and without the diode. The diode can be taken out of circuit simply by clipping the jumper cable below, rather than above, the barrel of the diode, as shown in the photo. Then, battery charging current is measured for each of the different numbers of PV cells. This should be done without the diode first, so that the negative current flow (battery discharging into PV cells) can be seen for the two-cell configuration. Then the diode is placed in circuit, and it can be seen that this acts like a one-way valve to electron flow. As the student works back up to six PV cells, it will be seen that there is a price to be paid for this protection.

**Session 5 - Quiz & Session 6 - Wrap-Up**

Painful as it may seem, this is the best way for you to learn what you taught, rather than what you think you taught. Try to set up test problems that force the students to apply the principles that they

**Experiment PV1** - Effects of tilting and shading on open circuit voltage and short circuit current.

**Experiment PV2** - Effects of shading on PV cell resistance and panel's ability to operate a load.

**Experiment PV3 -** Effect of tilting on the ability of the PV to start a pump (sunrise) and keep it running (sunset).

ALL PHOTOS BY GEORGE HAGERMAN.

**Experiment PV4** - PV cells in series and parallel.

**Experiment PV5** - The mA.-minutes delivered to a battery under PV charge will almost equal the mA.-minutes discharged through the motor.

**Experiment PV6** - Battery charging current as a function of number of PV cells in series. Also, the need for(and energy cost of) a blocking diode.

ALL PHOTOS BY GEORGE HAGERMAN.

have learned. You may even want to base these on some additional experiments. Should the students be told ahead of time, so they can study for it? Although surprise quizzes are not popular, they probably are a better measure of the actual working knowledge of a student. On the other hand, reviewing for a test is a valuable learning exercise in itself. What to do? Toss a coin.

Return the quiz during session 6 and review any class-wide weak points. Open the floor for discussion. You may also want to hand out materials for further reading. These can include ideas for science fair projects.

**Access - Experimental Equipment**

The components needed to setup the experiments described in this article are specified in Table 1. It should be noted that some components (500mA. PV cells, 0-5 VDC meter, 0-1 Amp. meter, and motor with color wheel, all shown in the photos) came from a "Photovoltaic Demonstration Kit" made by Solarex Corporation (# ES 602073005), which is no longer available. Therefore, other sources have been located for these components.

The 500 mA. solar cells are really too large, but I used them because they came with the Solarex kit. A better choice for experiment PV4 would be a 300 mA. cell. Bare cells require soldering, whereas the encased cells have wire leads already installed. The best choice for experiment PV6 are encased 100mA. cells. One advantage of these cells is that the Radio Shack meter can be used instead of the higher priced 0-1 Amp. meters.

Meters should have a large enough range to measure the maximum expected voltage or current, yet not so large that only tiny needle movements result from experimental manipulations. The 15mA. DC motor specified in Table 1 is a close duplicate of the Solarex kit motor, but it is not well matched to the 0-150 mA. meter. A better choice may be the 80 mA. motor, but this has not been tested. Regardless of motor, be sure to buy either color wheels or propellers, so students can plainly see changes in motor speed. For one dollar, Solar World sells a package of three color wheels with shaft adaptors or two friction-fit propellers. The Edmund DC pump at 2.5 Volts (experiment BL2) draws 120 mA. dry , 360 mA. submerged, and >800 mA. stalled. At 1.0 Volts (experiment PV4), it draws 90 mA. dry, 180 mA. submerged, and >300 mA. stalled.

If you would like to design other experiments using different sizes of PV cells, try Solar World (10 to 650 mA. output) or Astropower (2.0 A. output). A good paperback text for high school or college students is The Solarex Guide to Solar Electricity. Although out-of-print, Solar George has a large stock of these for sale five dollars each (less in volume). Even more intriguing to the educator, Solar George has developed a 36-cell, 5-watt, "build-your-own" panel kit, which retails for about $35.00.

**Access - Other Ideas for Energy Education**

Here is a short, but by no means exhaustive, selection of materials that I've come across.

Solar Energy Experiments for High School and College Students, by Thomas W. Norton, copyright 1977, Rodale Press, Emmaus, PA. Most of the experiments are concerned with solar heating, although some interesting exercises in solar astronomy and measurements are also included.

Energy Education Guidebook, prepared by Design Alternatives, Inc. of Washington, DC, under contract to the Community Services Administration. It is available from the National Appropriate Technology Assistance Service (NATAS), P.O. Box 2525, Butte, MT 59702, tel. (800) 428-2525 (in Montana, dial 800-428-1718). This book describes a variety of projects, including some other renewable technologies, like a small wind generator and a simple bio-gas digester. NATAS can also provide an extensive bibliography of other energy education materials and resources.

| PV Cells & Panels | Volts | Amps | Supplier | Part # | Cost | Experiment # |
|---|---|---|---|---|---|---|
| Thin-film Panel | 12.00 | 0.110 | Solarex | SA-0680 | $16.70 | PV1 |
| Solarex Panel | 11.00 | 0.350 | AEE | SX-2 | $26.00 | PV2 |
| Solar Energizer | 3.00 | 0.300 | Solar George | NA | $15.00 | PV3 |
| Bare Cell | 0.50 | 0.275 | Solar World | SC-6 | 2/$5.00 | PV4 |
| Encased Cell | 0.50 | 0.300 | Solar World | 3-300 | $4.50 | PV4 |
| Bare Cell | 0.55 | 0.300 | Radio Shack | 276-124 | $3.95 | PV4 |
| Thin-film Panel | 10.50 | 0.170 | Chronar | CP06-0606A | $7.90 | PV5 |
| Encased Cell | 0.50 | 0.100 | Solar World | 1-100 | 6/$9.00 | PV6 |

| Other Components | Supplier | Part # | Cost | Experiment # |
|---|---|---|---|---|
| AA NiCad Cell (New) | Radio Shack | 23-125 | 2/$4.69 | BL1-6 &PV6 |
| AA NiCad Cell (New) | All Electronics | NCB-AA | $2.00 | BL1-6 &PV6 |
| AA NiCad Cell (Used) | All Electronics | NCB-AAU | $1.00 | BL1-6 &PV6 |
| Alligator Clip Jumpers | All Electronics | MTL-10 | 10/$2.50 | ALL |
| Alligator Clip Jumpers | Radio Shack | 278-1156 | 10/$3.99 | ALL |
| Battery Holder 1-AA cell | Radio Shack | 270-401 | $0.59 | BL1-6 &PV5-6 |
| Battery Holder 4-AA cell | Radio Shack | 270-391 | $1.19 | BL5 |
| DC Motor (15mA. idle at 0.5VDC) | Solar World | MC 05/07 | $4.50 | BL3-4 & PV5 |
| DC Motor (80mA. at 0.5 VDC) | Solar World | MRE-260 | $2.10 | BL3-4 & PV5 |
| DC Pump (120MA. dry idle at 2.5VDC) | Edmund Scientific | J50,345 | $6.95 | BL2 & PV1&3 |
| Dolphin Game ("Jumping Flipper™") | Spencer Gifts | 702886 | $16.99 | BL6 |
| Lamp (#243- 270mA. at 2.3VDC) | Radio Shack | 272-1124 | 2/$0.99 | BL1 |
| Lamp Base (E-10 with terminals) | Radio Shack | 272-357 | $0.79 | BL1 |
| Multi-Meter (Digital with large display) | Radio Shack | 22-193 | $69.95 | Calibration |
| Multi- Meter (0-150mA., analog) | Radio Shack | 22-212 | $12.95 | BL3-4 & PV1,5 |
| Multi- Meter (0-150mA., analog) | Radio Shack | 28-4012 | $7.95 | BL3-4 & PV1,5 |
| Panel Meter (0-1Amp, analog) | Frey Scientific Co. | 16224 | $17.25 | BL1,2,6 & PV4 |
| Panel Meter (0-5VDC, analog) | Frey Scientific Co. | 16213 | $17.25 | BL1,5 & PV4,6 |
| Radio AM (40mA. at 4.5VDC) | Randix | PWR-7 | $1.60 | BL1 |
| Rheostat (0-25 Ω at 2 Watts) | Radio Shack | 271-265 | $2.99 | BL3 |
| Wire (insulated #30, 50 FT spool) | Radio Shack | 278-501 | $2.39 | BL5 |

**Table 1.** Equipment for battery, load and PV experiments

The Florida Solar Energy Center, in cooperation with the Governor's Energy Office, has prepared the Florida Middle School Education Project, which describes a variety of classroom, homework, and experimental activities dealing with energy production, consumption, and conservation. It is available from the Public Information Office, Florida Solar Energy Center, 300 State Road 401, Cape Canaveral, FL 32920, tel. (407) 783-0300.

Finally, Jim Masker, who teaches at a private school in California, has developed his own short course in photovoltaics, including among other things, a solar-powered boat race across a swimming pool, and the design of a "home power" system for a dormitory room. He has also put together a self-contained kit (including an intense light source) for PV experiments. Descriptions of both are available from Jim Masker, Cate School, P.O. Box 5005, Carpinteria, CA 93013, tel. (805) 684-4127.

Jim and I have been discussing the possibility of convening a short workshop at the Willits Energy Fair, where energy educators could get together, share ideas from their "bag of tricks", and brainstorm some new ones. If you've had experience teaching kids (or adults) about energy, and would be interested in attending such a workshop, then please contact either one of us. George Hagerman, SEASUN Power Systems, 124 East Rosemont Ave., Alexandria, VA 22301,telephone 703-549-8067.

**Acknowledgements**
First, I'd like to thank Richard and Karen Perez for their encouragement, patience, creative layout, and meticulous editing. Their input was invaluable. Many thanks also to Michael Meredith, a neighbor here in northern Virginia (see his Micro Ad), who definitely has the talent to put together a short course in solar thermal electricity. He loaned me a 12-inch multi-faceted parabolic mirror that fascinated the kids. A coil of copper tubing is located at the mirror's focus, such that when water is slowly fed through the coil, a puff of steam comes out the other side. Truly ingenious! I'd also like to thank Dr. John

## Supplier Access

**AEE**
Alternative Energy Engineering
POB 339
Redway, CA 95560
707-923-2277 • 800-777-6609

**All Electronics Corp.**
POB 567
Van Nuys, CA 91408
818-904-0524 • 800-826-5432

**Astro Power**
30 Lovett Avenue
Newark, DE 19711
302-366-0400

**Chronar**
POB 177
Princeton, NJ 08542
609-799-8800

**Edmund Scientific**
101 E. Glouchester Pike
Barrington, NJ 08007
609-573-6250

**Frey Scientific Co.**
905 Hickory Lane
Mansfield, OH 44905
419-589-9905

**Radio Shack**
500 One Tandy Center
Fort Worth, TX 76102
817-390-3011

**Randix Industries Ltd.**
Granite Park, Fortune Blvd.
Milford, MA 01257
508-478-8989

**Solar George**
George Newberry
POB 417
Big Pine Key, FL 33043
305-872-3976

**Solar World**
2807 North Prospect
Colorado Springs, CO 80907
719-635-5125

**Solarex Corporation**
1335 Piccard Drive
Rockville, MD 20850
301-948-0202

**Spencer Gifts**
1050 Black Horse Pike
Pleasantville, NJ 08232
609-645-3300

Wohlgemuth, who arranged a special tour of the Solarex Technical Center in Frederick, Maryland, where students could see how silicon is turned into solar cells and panels. The tour was well-organized and quite impressive.

Last, but certainly not least, I'd like to thank Lucy Negron-Evelyn for giving me the opportunity to teach the students of El Ingeniero '89. These kids were wonderful, and their attentiveness and eagerness to learn convinced me that batteries and photovoltaics were not "too technical" to teach at the junior high school level. Their positive response and hard work inspired me to really polish the course, as it is presented here. I'm only sorry that I can't teach them again. Assistant Instructor, Edgar Hurtado, helped in a variety of ways, as did Lucy's teaching assistants: Alan, Rosa, and Janet. Thanks guys!!



***This is the last FREE issue of Home Power. If you want to keep getting HP and think it's worth six bucks a year, then SUBSCRIBE NOW!***

# PV/Hydro Systems and a visit to the Lil Otto Hydroworks!

Richard Perez

I was delighted when Bob-O Schultze and Otto Eichenhofer invited us to visit some PV/Hydro systems along the Salmon River. The Salmon River runs madly through northern California, and if you want power along the River, then you make your own. The independent folks living along the Salmon have been doing just that. Brian Green, our HP photographer, and I saddled up and drove up and down the icy mountain roads to the little town of Cecilville, CA. Everyone in Cecilville makes their own power. The nearest utility is over thirty miles away- through some of the most rugged mountains in the USA.

**The Cecilville Scene**

We met Bob-O and Kathleen at the General Store in Cecilville (pop. 20). Kathleen, Bob-O's wife, was doing the driving since Bob-O was recovering from an argument with a large tree that nearly cost him his leg. The Cecilville Store, hub of all neighborhood activity, is powered by a 15kW. diesel engine generator. While few folks live inside the micro village of Cecilville itself, many live up and down the serpentine one-lane road that follows the Salmon River's course. Almost all the folks along "the River" have engine/generators. Many are using micro or nano hydro systems and photovoltaics.

**Joyce Eichenhofer's Home**

Our first stop was the home of Joyce Eichenhofer, which is pictured on the cover of this issue. Joyce lives right next to the Salmon. Her beautiful house is powered by home-made electricity.

Joyce uses a combination of three power sources. Visible on her roof are four photovoltaic panels (2 @ Kyocera 48 Watt panels and 2 @ Solavolt 36 Watt panels). This PV array produces about 168 Watts, or about 12 Amperes at 13.5 VDC, when under full sun. Bob-O mentioned that at Joyce's location the Winter sun only shines on the panels for about 2 hours daily (Summer performance is much better). During the Winter, Joyce falls back on her Lil Otto Hydroelectric system for power. Lil Otto turbines are made by her son, Otto, so she gets factory service and no doubt a right price. Her Lil Otto turbine runs on a working pressure of 18 PSI generated by about 40 feet of head. She uses a 9/32" nozzle, consuming about 9.7 gallons per minute, to produce an output of 1.35 Amperes. Joyce's turbine is producing about 18 Watts, with a daily output of 430 Watt-hours. During the Winter, Joyce's PV panels produce a daily average of about 336 Watt-hours because the mountains shade them most of the time. So during the Winter, Joyce's nanohydro turbine produces more electricity than the PV array (even though the PV array has a peak output almost ten times greater). The third power source is an aged 2 cylinder diesel engine/generator. When all else fails, Joyce can fall back on the generator to source her system. This 6 kW. generator also sources the machine tools in the Lil Otto Hydroworks! building nearby (more on this later).

Joyce uses lead-acid batteries, housed in her basement, to store the power her PVs and nanohydro produce. She uses two Trojan L-16s, a 200 Ampere-hour, 12 Volt Interstate diesel starting battery, and an assortment of other 12 Volt batteries. Total capacity of her battery pack is about 500 Ampere-hours at 12 VDC. Joyce's system also uses a brand spanking new Trace 2012 inverter to convert the DC stored power in the batteries into 120 vac for her appliances. Also located in the basement is a Heliotrope CC60 PV charge controller that rides herd on the array's output. I asked Otto why he had such a large (60 Ampere) control on the 12 Amp array. He replied he's looking forward to expanding his mom's array soon.

Electrically speaking, Joyce has all the conveniences. For example, her refrigerator/freezer is a super-efficient, 12 VDC operated, SunFrost RF-12. This refrigerator/freezer consumes about 290 Watt-hours daily in Joyce's kitchen. Otto is busy taking data on the SunFrost's performance with a motor run-time meter. Joyce's home is primarily wired for 120 vac, but there are a few special 12 VDC circuits directly supplied by the battery. Joyce uses 12 VDC for a fluorescent light on the ceiling of the kitchen, for her CB radio and for the SunFrost. Entertainment electronics are powered by 120 vac from the Trace inverter. Joyce runs her washing machine when Otto's out in the shop and the large generator is operating.

**The Lil Otto Hydroworks**

We also visited the shop that Bob-O and Otto use to make their nanohydro turbines. Against a background of machine tools, ranks of Lil Otto turbines march down their assembly line, jump into boxes, and travel to streams & springs round the world. It was inspiring to see the obvious care and thought that goes into their manufacture. Bob-O and Otto start out with a permanent magnet

Bob-O Schultze and Otto Eichenhofer sit under Joyce's back porch. Located between them, a Lil Otto turbine produces 18 Watts of power while consuming only 9.7 gallons of water per minute (40 feet head). Photo by Brian Green.

An exploded view of a Lil Otto turbine showing the various sub-assemblies inside. Photo by Brian Green.

Fly cutting the water intake hole in the side of a Lil Otto case. This is a delicate operation that must be done precisely because it determines the position where the water jet hits the turbine wheel.
Photo by Brian Green.

Bosch generator. This generator is coupled to a molded turbine wheel made by Powerhouse Paul Cunningham at Energy Systems and Design in Canada (see ad this issue). The generator is housed in a sealed PVC pipe case. Bob-O and Otto are now installing a new "gravity tube" along the shaft of the unit to eliminate water infiltration to the generator's inards. The unit is supplied with a blocking diode (to keep the generator from becoming a motor) and filtration to keep electrical noise from interfering with radios and TVs. There is a 0-8 Ampere output meter on Lil Otto's top so operation can be checked at a glance.

The Lil Otto units will produce up to five amperes, with enough head and flow. Where this turbine really shines is in the gallons per minute required for operation. This turbine consumes very little water. For performance data on these turbines, see HP#13 "Things that Work!" article about Lil Otto. Bob-O and Otto deserve credit for intelligent and efficient use of off-the-shelf components in manufacturing Lil Otto turbines. For example, the housings are sections of stock PVC pipe. The various sized nozzles used (and there is one to fit every site) are stock Rainbird™ sprinkler nozzles.

Well, we were ready for more. Obviously Otto's mom, Joyce, was satisfied with her PV/Hydro system and was justly proud of her inventive son. But she's Otto's mom and could be biased. We asked to talk to some paying customers. Bob-O smiled and invited us on a trip down River.

**Getting down River**

This turned out to be an adventure in itself. The road that winds along the Salmon from Cecilville to Forks of Salmon is mostly one lane with sharp 100+ foot drops into the surging river. Kathleen drove first because she had a CB radio in her car. The CB radio is essential because you have to know when a log truck is coming so that you can pull out in a place that is wide enough for the log truck to pass. Kathleen (also a ham radio op) kept us advised of traffic on our 2 meter ham radios. As I drove along I had trouble keeping my eyes on the road, the scenery was too distracting. Rock cliffs plunged down into the foaming river. From bends in the road, large mountain meadows filled with trees soothed my senses. I like mountains and the peace they give. The Salmon Mountains are very beautiful. It is easy to understand why these folks live in such a remote place.

**Terry & Betty Ann Hanauer's Home**

After about 30 minutes of driving we arrived at another PV/Hydro system at the home of Terry and Betty Ann. Betty Ann, a school teacher, took time off to show us her well built and immaculate home. This large, owner built home, houses their family of six people. Their home has been powered by site-generated electricity since 1987.

Power sources at the Hanauer home are much the same as at Joyce Eichenhofer's home. The Hanauers use a PV array composed of three 36 Watt Solavolt panels. On an average day this array makes about 600 Watt-hours of electricity. These panels are fortunately located on one of the sunnier locations along the river. Terry & Betty Ann also use a Lil Otto turbine. This Lil Otto, however, is located at a much better site than Joyce's. At Terry & Betty Ann's site the turbine has 72 feet of head to work with (32 PSI dynamic pressure). Here the turbine produces 2.5 Amperes with a 1/4 inch diameter nozzle consuming 10 gallons per minute. Terry & Betty Ann's turbine produces 33 Watts and makes 810 Watt-hours of electricity per day. Combined production of both the PV array and the nanohydro turbine is about 1,400 Watt-hours daily, and that's enough to run a household with four kids! Terry & Betty Ann also use an engine/generator (Onan two cylinder 6kW. powered by propane) for extended cloudy periods and times of intense power consumption.

Terry & Betty Ann use a battery pack of four Trojan L-16 batteries to store the power produced by Lil Otto and the PV array. This battery pack is housed in an insulated blister on the outside of the house. Bob-O Schultze fabricated a custom regulator for the PV array. A Trace 2012 inverter with 110 Ampere battery charger is used to power the house and recharge the batteries when the generator is running. Betty Ann says that with four kids, the washing machine gets alot of action. She starts the generator, does the washing and refills her batteries all at the same time.

The Hanauer's home is wired for 12 VDC lighting, which spends lotsa time operating. The Sabir refrigerator/freezer is powered by propane. Betty Ann is a gourmet cook and her kitchen is filled with good things. Among these things are many kitchen appliances (food processors, grinder, mixers, blenders and such) that all run from the inverter. Betty Ann said that cooking was more enjoyable because she didn't have to start the generator just for a few minutes of kitchen appliance use. Everyone likes not having the generator

Lil Otto on the rocks. Since the entire turbine weighs less than 20 pounds, it's easy to mount. Here Lil Otto sits on a pile of rocks. Photo by Brian Green.

Betty Ann Hanauer in her kitchen. Photo by Brian Green.

yammering while reading or listen to the stereo.

Hot water is produced by a large solar collector located next to the PV array. Betty Ann told us that in the Summer, even with wash and four kids to bathe, there is more than enough hot water being produced by their solar collector to meet their needs.

**Lessons Learned**

From experience, the folks along the river have learned a great deal about making their own power. They've learned that even a trickle can be turned into a watt. They learned to use a variety of natural power sources without damaging their environment. And certainly, they've learned contentment and happiness.

**Last free issue of HP. Either subscribe or miss out!**

# Siting for Nano-Hydro- A primer

Bob-O Schultze KG6MM

Nano-Hydro is the ability to generate 3 Amps *or less* of hydropower at least some of the year. An amazing number of rural, and especially mountainous, homesites have this capability. Most anyone who has a couple of acres in the mountains somewhere has seen the phenomenon of little springs popping up everywhere after a couple of good rains or during snowmelt. True, most of them seem to pop up in the driveway somewhere or worse, in the cellar, but since most folks tend to build toward the base of the hill rather than the top, a lot of those seasonal creeks or springs can be harnessed to provide power during a time of year when the PV's aren't exactly boiling the batteries! The really fun thing is that as long as the water flows, you're producing power-24 hours a day and the sun doesn't have to shine at the time.

**Why Nano-Hydro?**

There are some nice advantages to a nano-hydro system. In most micro and larger hydro installations half of the cost of the system is the pipe. Usually, somewhere between 2" - 6" PVC is used in order to get enough water to the wheel without incurring horrendous pressure losses. Priced any 6"PVC pipe lately? Whew! With a nano system, 2" pipe would be the high side with most systems running 1-11/2" pipe. I've seen a fair number of set-ups get away with 3/4" and even one which used 1/2" poly but that guy was really into low-ball!

Another factor is the lack of a need for any kind of regulation in most systems. At ±3 Amps/hr, that's only a C/33 charge rate for a 100 A-hr battery and less than C/100 for a set of Trojan L-16's. Not much chance of warping the plates there!

**Have you Hydro?**

As with any hydro situation, what you get depends mostly on the pressure and volume of water you can deliver to the generator. Of the two, pressure-whether you call it Head, Fall, or PSI-is the bigger factor. Up to 100 PSI (225'Head) or so, the more you have the better you'll like it.

Exact measurements are not important unless you have very little or very much Head. As a rule, anything between 25' and 250' will work to some degree or another. Below 25' gets dicey unless you have a lot of water-say...20GPM or better, and even then the output may not be worth the investment. At 250' of head or better, you'll have hydro up the wazoo, but you may have to invest in heavier duty pipe to handle the pressure and unless you have lots of water, (in which case you should be thinking about a larger, possibly automotive alternator-based system) you'll need a very small nozzle to restrict the flow enough to keep your pipe full. A very small nozzle, in turn, means very good filtration at the intake to keep clogging down to a minimum. None of these things are insurmountable, just factors to consider before you buy your components.

**Figuring Head**

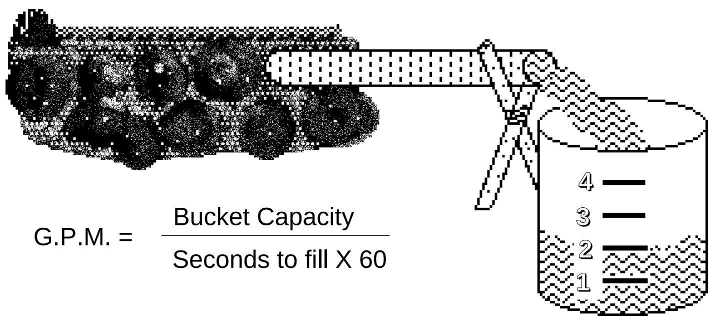
Figure if you've got a drop that's clearly twice the height of your house or better, you're in the ballpark. If you need or want to know a more exact figure, I like the garden-hose method. You'll need two people (it's possible to do this with one, but frustrating and not nearly as much fun), a 25' length of hose, a tape measure, something to write with and on, and unless it's summertime, raingear and gumboots-kinky!

One person starts at the water source with one end of the hose and the other person goes down the hill with the other end and the tape measure. Fill the hose (getting the air out) and have the downhill person elevate the hose just until the water stops flowing. Measure from the hose end straight down to the ground and record your finding. Make a mark on the ground so the uphill person can find it, both put their thumbs over the hose ends, walk down and measure another station. **Note**: you'll have to top off the hose a little each time to be accurate, so if you're not following a live streamcourse, the uphill party should have a jug of water along for this purpose. Continue down until you reach your proposed generator site, add 'em up, and there you are. Keeping track of the # of stations will also tell you how much pipe to buy.

**Measuring G.P.M.** (Gallons Per Minute)

Since we're not dealing with massive amounts of water here, the bucket method works as well as any with a lot less hassle. You'll need- a 4 or 5 gallon plastic bucket, materials to make a temporary dam at the source (plastic sheeting, a tarp, rocks, maybe a shovel), a piece of pipe large enough to handle all the flow of your spring or creek & long enough to get the bucket under, a couple of sticks and string to support the pipe, and a watch capable of measuring seconds. (If you've wondered when you'll ever get a chance to use the stopwatch feature on your digital, Eureka!)

Before you head up the hill, dump exactly 1 gallon of water into the bucket and mark the level. Dump another gallon in and mark the 2 gallon level, etc,etc, until the whole bucket is marked. Set your test up something like this:




$$\text{G.P.M.} = \frac{\text{Bucket Capacity}}{\text{Seconds to fill X 60}}$$

**So, now what?**

OK, at this point you should have a handle on three things: Head , GPM , and length of pipe needed. Now, measure the distance from your hydrogenerator site to your batteries. Given these four factors, any reputable hydroplant dealer should be able to advise you on: 1) the kind of systems he has available suited to your site 2) the right diameter of pipe to buy, and 3) a close estimate of the amount of power you can generate.

**Equipment**
What sets nanohydro systems apart from other hydrogenerators is the use of permanent magnet generators for the power source. The advantage to this is that no power is fed back into the machine to electrically generate a magnetic field, as is the case with most alternators, so all of what you produce you get to stuff into the batteries. The disadvantage of a PM set-up is that the maximum output is limited by the inherent strength of the magnets. Normally that's not a problem in a nanohydro situation because your GPM and/or Head are too marginal for a larger, more powerful system anyway. Depending on which system you buy or build, that might limit the amount of power you can generate at maximum run-off periods.

**Access**
As of now, there are only three manufacturers of permanent magnet nano-hydro generators that I know of.

**Lil Otto Hydroworks!**
POB 8
Forks of Salmon,CA 96031
916-462-4740

**Energy Systems & Design**
POB 1557
Sussex, N.B. Canada E0E 1PO
506-433-3151

**Photocomm Inc.**
POB 649
North San Juan, CA 95960
916-292-3754

Shop around. There are Nanohydro systems available that produce meaningful power down to 1.2 GPM @ 50' Head, while others work as low as 3' Head but need lots of water. Once you know the capabilities of your site and what's available and suitable, you're armed with the right ammo to make intelligent decisions and choices. Good Luck and ***Happy hydro!***

# Pocket-plate Nicads in Home Power Service

Richard Perez

I have just recovered from a pain in the neck that lasted twenty years. It started with our first lead-acid battery's arrival in 1970. I've had this pain for so long it became normal and I hardly noticed it anymore. The energy portion of my life revolved around these lead-acid batteries. All the decisions and compromises in our system were to accommodate the cranky lead-acid cells. The list of Dos and Don'ts was seemingly endless. "Thou shalt not discharge more than 80% of the energy in the lead-acid cells." "Thou shalt perform regular equalizing charges." "Thou shalt recharge the cells as soon as possible." "Thou shalt keep all connections clean and bright." A never ending litany of limitations and chores all related to the lead-acid cell's delicate and cranky nature-- a real prima donna… Well, things have changed. Nicad cells offer vastly better power storage for home power systems. We like these nicads so well that we are replacing all our lead-acid systems with nicads as quickly as we can afford it. What better compliment can we at Home Power pay?

**The NiCad Saga**

During the last nine months we've been experimenting with over 100 wet, pocket plate, nickel-cadmium cells. These cells are made by a variety of manufacturers. None of them are new and all were supplied by Pacific West Supply in Oregon. Some were reconditioned, others were not. Some cells are high rate cells and others are medium rate cells. These experiments have been carried out in four different test systems. Two of the systems are PV/generator sourced, one is stand-alone PV with no generator at all, and one is grid connected.

This article is not a primer on NiCads (already done in HP#12, pg. 16), or a test report on a particular cell type (HP#13, pg. 17). This article discusses the different types of nicads now available to home power users and how to effectively apply these cells in our systems. The info here was learned by actual hands-on testing and experience. These tests were conducted on cells between 57 and 2 years old. All had been retired from service by their original purchasers. What we have here is a wide cross section of used nicad cells. As such, any deficiency due to aging should be apparent. We are very pleased with the life potential of these cells. For example, we tested a Gould XWR7 nicad cell that is over 57 years old and still delivering its rated capacity!

**Different Brands of Nicads**

The different brands we have tested are -- SAB NIFE, Edison, Alcad, and Americad. SAB NIFE is a Swedish company and the oldest maker of nicads. Edison Battery Co. made all types of cells for years starting around 1900 and is now owned by SAB NIFE. Americad is a company also now owned by SAB NIFE. Alcad is a British company that has also been around for years. The point here is that pocket plate nicads are made by a variety of companies. And to confuse matters further, each company makes several types and many sizes of cells. The happy news for us home power types is that all pocket plate nicads are light-years ahead of even the finest lead-acid cells.

**Different Types of Nicads**

Regardless of manufacturer, pocket plate nicads come in three basic types-- low rate cells, medium rate cells, and high rate cells. All the different types share the same pocket plate construction described and illustrated in HP#12. The major difference between the types is the number and thickness of the plates that make up the cell.

**Low Rate Cells**

The low rate cells use a fewer number of thicker plates. They are designed for very slow discharge rates (<C/10) and are the least common type to find used or reconditioned. The reason for this is that fewer are initially made and sold by the various manufacturers. They are so rare that we've not yet found ten cells for a working 12 VDC pack, and so we have no direct data.

**Medium Rate Cells**

Most (≈65%) of the cells we tested (like the ED-160 in HP#13) are medium rate cells. They have a greater number of thinner plates than do the low rate cells. They are designed with average discharge rates of C/10 to C/5 in mind. These cells are very plentiful since railroads, hospitals and airports use them for uninterruptible power. The medium rate cells are the easiest type to find reconditioned and/or used.

**High Rate Cells**

The high rate cells have the largest number of plates and the thinnest plates of all the types. The are designed for rapid discharge at rates around C/1 to C/0.1. They are mainly used to start large engines like diesel locomotives and jet aircraft. For example, a 120 Ampere-hour cell will be asked to deliver thousands of Amperes for several seconds to a minute. They are plentiful reconditioned and/or used. Please note: if we were discussing lead-acid cells, then thin plate construction results in reduced cell longevity. In a pocket plate nicad cell, with its supporting steel electrode framework, this it not true. High rate cells have the same high longevity potential as other nicad cell types.

**Applying Nicads in Home Power Systems**

So what manufacturer, type, and size of cells are best for me? Well, as to manufacturer, all the brands we tested met their specified Ampere-hour capacities and voltage/current curves. Regardless of brand, they all performed as their makers said they would-- and these are used (and sometimes not even reconditioned) cells. As to type, both the medium rate and high rate cells are designed for far more demanding current drains than they will ever see in a home power system.

**Sizing the Capacity of a Nicad Pack**

Sizing nicads is not very different from sizing lead-acid storage. Watt-hours stored is Watt-hours stored. The battery should still be sized with at least four days of storage capacity. However, the nicads allow total cycling. This means that we can totally empty the cells, something we should never do to a lead-acid system if we want it to last. Since lead-acid systems require that 20% of their capacity never be used, we pick up a 20% reduction in the Ampere-hour capacity of the nicad pack. Since the nicads keep their voltage higher in relation to discharge rate, a smaller capacity pack will supply the high surge requirements of an inverter. In general, we've been sizing the nicad pack with about 30% less capacity than the lead-acid pack it replaces with no noticeable loss in system performance. With nicads, if there is not enough capacity then more can be added anytime.

In terms of charge efficiency and charge retention, the nicads offer about the same performance as brand-new lead-acid systems. The major difference here is that the lead-acid's efficiency drops radically as it ages (due mostly to increased self-discharge). The nicad's efficiency and low rate of self-discharge remain constant over its long lifetime.

**Mix and/or Match?**

We've been experimenting with mixing different sizes and brands of nicad cells within the same battery pack. Here's what has been working and what hasn't.

- All nicad cells that make up a battery should be of the same cell type, either all high rate cells or all medium rate cells. Don't mix different rate nicad cells in the same pack, either as series or parallel elements.

- A series string of nicad cells (ten cells in series for a 12 volt system and twenty cells in series in a 24 volt system) must all be of the same size, type and brand.

- Parallel packs within the main pack may be of different brands and sizes. For example, a series string of ten ED-160s (160 A-h) may be placed in parallel with a series string of ten ED-80s (80 A-h). The resulting pack would contain 240 Ampere-hours at 12 VDC (note: all these cells are medium rate cells). The system we are now using at the Home Power office contains: a ten cell series string of Alcad 120 A-h cells in parallel with a ten cell series string of SAB NIFE 120 A-h cells. These are all high rate cells.

These configurations are experimental and they are working. Ideally, a nicad pack should be totally composed of identical cells. But considering that we are talking about reconditioned and recycled cells here, this isn't always possible, but always desirable.

**Charging**

We have been amazed at how well these nicads have functioned with power sources like PV modules designed with lead-acid charging characteristics in mind. The nicad cells are designed to be recharged rapidly, within a four to seven hour period. They are capable of accepting charge rates and voltages far beyond those usually found in our systems. A good analogy here is that a nicad battery in a home power system is like an NFL quarterback in a high school football game.

**Voltage under Charge**

If a nicad cell is fully charged and being recharged at rates as low as C/40, then the cell's voltage can rise as high as 1.65 VDC. This means that a single PV panel can push a nicad pack of ten ED-160 as high as 16.5 VDC. While this is not harmful to either the nicad cells or the PV panels, it can cause some 12 VDC appliances to overheat (the old fry&die syndrome). See charge curves printed in HP#13.

The nicads have an overall higher charge voltage profile than lead-acid systems. When any battery is under charge its voltage is elevated. The degree of elevation depends on several factors: cell electrochemistry, cell state of charge, recharging current, and cell temperature.

**Charge Regulation**

I recommend that regulation be used in nicad systems even though the battery doesn't need it. Regulation is used to protect the many low voltage appliances on line. Number One appliance is the inverter. Most quality inverters will operate at ≈15.5 VDC (12 Volt models) and ≈31.0 VDC (24 Volt models). Thus, 15 to 15.5 VDC makes a good voltage regulation point in 12 Volt systems. And 30 to 31 VDC in 24 Volt systems.

Now, these voltage limits mean that the recharging current is reduced to the nicad pack before it is actually full. This makes the total refilling of the pack slower, but it still happens. And all the appliances on line are protected. What we really need is for inverter manufacturers, and all other low voltage DC appliance manufacturers, to widen the operating voltage range of their products. Consider that 12 VDC appliances should operate between 11 VDC and 18 VDC, and 24 Volt appliances should operate between 22 VDC and 36 VDC. If this were the case, then no charge voltage regulation would be required by nicad based systems. Let me be clear on this, the problem here is in the appliances, not the nicads or their power sources.

We have been using the Heliotrope CC20 and CC60 PWM regulators on the PV arrays feeding the nicad cells. These regulators provide an adjustable voltage limit that is very effective. Heliotrope has also just introduced the CC60B, a 60 Ampere (either 12 or 24 VDC system) PV charge controller specifically configured for nicad storage systems.

**Current**

In terms of recharging current, home power systems are lightweights. These nicad cells are designed to be rapidly recharged at very high rates (≈C/4 to C/7). The current input from our PV arrays, microHydros and wind machines is easily handled by the nicad. In fact, by recharging the cells at lower than design rates, we realize increases in cell operating efficiency. It is nice to know, however, that if we have to fire the engine/generator to recharge the nicad cells, then we can do the job quickly.

**Equalizing Charges**

The nice thing about nicads and equalizing charges is that they aren't necessary. No cell equalization is required in nicad packs, while it is mandatory in lead-acid systems. Equalization is the controlled overcharge of a battery that is already full. Equalization is required by lead-acid batteries to keep all the individual cells at the same state of charge. Equalizing charges, by definition, represent energy produced and NOT stored. A basic waste. And in most of our systems, we use an engine/generator for equalization because it provides the constant current necessary for the seven hour controlled overcharge. None of this wasted energy is required by nicads.

In nicad cells wired into batteries, the individual cell voltages tend to converge as the cells function as battery. In lead-acid batteries, the individual cell voltages tend to grow apart, while in nicad cells they tend to come together. That's what I call a happy chemical reaction! Here is a sample of the data. We installed ten Americad HED-120 cells in a stand alone PV system (see Wizard's system this issue). The cells differed in individual voltages by 0.15 VDC, and that's alot! After six weeks of stand-alone PV service, the difference in voltage between the highest and lowest cell was 0.005 VDC. Bottom line is that the wasted energy and expense of equalizing charges is history in nicad systems.

**Discharge**

Discharging the nicads is much the same as lead-acid types, except that the voltage of the battery stays higher. This results in better appliance and inverter performance. All medium or high rate nicad cells we tested are capable of handling the surge currents demanded by large inverters. For example, our microwave consumes, via the inverter, over 500 Amperes for about 0.1 seconds as it starts. Even a small nicad pack of 120 Ampere-hours is capable of delivering stored power rapidly enough to satisfy the inverter's surge requirements. A well designed home power system uses at least four days of battery storage. This means that average discharge rates are low (≈C/100). These cells will deliver at rates around C/7. They have no problem delivering the current.

Nicad cells will take total discharge. This is to say that if the cells are occasionally fully discharged they will not lose any capacity. With lead-acid systems, any total discharge results in permanent loss of capacity and premature failure. As yet we haven't enough data to accurately discuss the relationship of depth of discharge to cell life. However, there is evidence that, while the nicads survive total discharge, it certainly doesn't do them any good. Early indications are that constant and regular deep cycling may reduce cell life. More on this as the data becomes hard.

**Temperature**

You can put your nicads outside. No longer do you have to shelter battery electrochemical reactions under your roof. Lead-acid batteries had to be kept warm in the Winter. Not only could they freeze (which ruins them forever), but they lost capacity and efficiency whenever they got below 50°F. Nicads will operate at -13°F (-25°C.) with only minimal loss in capacity. With special low temperature electrolytes (KOH up to 1.30 gr./ml.), nicads will operate at -58°F. (-50°C.). Eventhough nicads will not operate when frozen, they will not be damaged and will work as soon as they thaw out. At the average discharge rates encountered in home power systems (>C/10), nicads will deliver greater than 90% of their rated capacity at cell temperatures greater than -13°F.

**Routine Maintenance**

Nicads require only simple maintenance. They do, however, demand that the user perform this maintenance. How well the user performs this maintenance primarily determines the nicads lifetime. If the capacity of the pack is sized properly, then the quality of user maintenance is the most important factor affecting how long the cells will last.

**Cell Water Level**

Electrolyte level should be checked at least monthly and DISTILLED WATER added if necessary. Use only distilled water. Do not use tap water, rain water, well water, spring water, or soda water. Electrolyte water loss is directly related to overcharging the cells. Moderate overcharging doesn't damage the nicad cells, but it does run up the distilled water bill. In no case should a nicad cell be operated with the electrolyte level below the tops of the plates. This can result in arcing within the cell and possibly explosion. In the cells we tested, the minimum and maximum levels for the electrolyte are marked on the transparent cell cases. It's easy to see at a glance where the level of the electrolyte is, and thus we have no excuse for letting the cells get low on water.

**Cell Oil Layer**

Check the thickness of the mineral oil layer floating on top of the electrolyte. This oil layer is there to prevent carbon dioxide in the air from reacting with the potassium hydroxide electrolyte. For technical data about this phenomena, see George Patterson's article in this issue. From a user's maintenance standpoint, there should be a layer of mineral oil between 1/8 and 3/16 of an inch thick floating on the surface of the electrolyte. If you need to add more oil then use Chevron "Utility Oil 22". Don't use motor oil, mineral oil from the drugstore, cooking oil, or anything else. If you fail to maintain the oil layer, then the cell's electrolyte will gradually become polluted with carbonates and will require replacement. If the oil layer foams when a fully charged cell is under charge, then this is a good indicator that the oil layer is too thin. So add more oil to foaming cells.

**Physical Maintenance**

This is simple. Keep the cell tops free of moisture, oil, dust and sundry funk. The cells we've been using seal much tighter than lead acid types. This means that what is inside the cell stays inside the cell. Apart form dusting the cell tops with a damp paper towel occasionally, we've done no physical maintenance. Compared to a lead-acid system, corrosion of battery cables is nonexistent in nicads. Don't let this lull you into thinking that the chemical contents of the nicad are benign. Nicads contain a powerful base (caustic) electrolyte (like a solution of lye). The electrolyte will burn the skin, particularly eyes. Flush electrolyte from the body with copious quantities of fresh water. And be careful!

**Electrolyte Replacement**

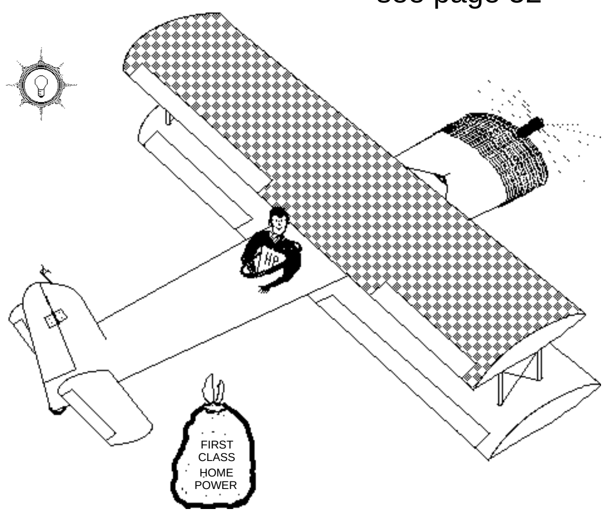
After a period of years (about 5 to 20) all nicad cells require that their electrolyte be replaced due to atmospheric carbonate contamination. How long depends how well the user maintains the oil level of the cells. See George Patterson's article in this issue for the technical details of electrolyte replacement. The procedure can be accomplished by a careful and responsible user.

**Access**

From the number of calls and letters we've been getting recently at HP, the interest about nicads is very high. Home Power is read by many folks who have had the lead-acid experience and are looking for something better. We urge you to communicate your nicad data and experiences to the common fund. Do this so we may all share what works. I will chew the rag about nicads via phone: 916-475-3179 or write me C/O Home Power Magazine.



see page 52

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# Experiences with NICAD Cells from Pacific West Supply

George Patterson

NICAD cells were picked up from Pacific West Supply in Amity, OR on Saturday, Dec. 8, 1989. They consisted of twenty-three ED-80's, nine ED-160's, four HIP-8's and one XWR7 dating back to 1933. The XWR7 is a pocket plate NICAD cell with a rated capacity of 35 amp-hour at the 8 hour rate. The Jungner Nickel-Cadmium Pocket-Type (NIFE) HIP-8's are high rate cells with a capacity of 80 amp-hr. and a cell weight of 6.4 kg. The Edison ED-160 cells are rated at 160 amp-hr. for the 5 hr. rate. The ED-80's at 80 amp-hour for the 5 hr. rate. Edison ED series cells are medium rate cells. The design of the ED-80 and ED-160 cells are the same except that the ED-80s are 12 1/4" tall while the ED-160s are 18 1/4" high. Two ED-80's are otherwise equivalent to one ED-160 cell electrically.

**Testing**

Testing this myriad of cells started with adjusting the electrolyte of each cell to a specific gravity of 1.190 gr./ml.. This was accomplished using a high quality hydrometer. Use only a brand new hydrometer that has NEVER been used to test lead-acid cells. All cells that were not yet reconditioned were filled with distilled water to the maximum level mark on the cell's case. The specific gravity was then adjusted either by adding distilled water or more highly concentrated electrolyte. The concentrated electrolyte is a solution of KOH in water with a specific gravity of between 1.19 and 1.22 gr./ml.. The cell was then charged and gassed for about 15 minutes in order to completely mix the solution. After another 10 minutes of charge, the specific gravity was measured with a hydrometer. It took several such episodes to achieve the desired value of 1.190 gr./ml., approximately 40 minutes per cell on average. Excess electrolyte was then removed from each cell to bring the level to the maximum mark.

**Titration for Potassium Carbonate**

Potassium carbonate concentrations in the cells' electrolyte were measured by titration and recorded. All cells were then charged prior to testing their ampere-hour capacity using a computer controlled system that produced the discharge curve of each cell with capacities to 1.1, 1.0, and 0.9 volts. Most of the Edison cells obtained were of the "Low Temperature" variety. They all had specific gravities for the electrolyte of approximately 1.220 gr./ml. after being filled with distilled water to the maximum level. Although the higher specific gravity has a low freezing point, <-36 degrees Centigrade, the higher density has a somewhat detrimental influence on the cycle life of the cells. The positive electrodes tend to lose capacity on cycling more rapidly than when the usual electrolyte concentration is employed. As cycle life is my most important consideration, the value of 1.190 gr./ml. was chosen.

**Foaming & Battery Oil**

During charging, three of the ED-160 cells foamed up and out of the vent caps. Upon inspection of all of the ED-160 cells, battery oil Chevron "Utility Oil 22" was added to bring the oil level on top of the electrolyte to 1/8"-3/16". This immediately reduced the foaming and the charging proceeded at the C/10 rate until >140% of rated capacity was reached. The cells were then allowed to rest for at least 24 hours, then discharged during the capacity test.

**Battery Cell Testing System**

The cell testing system consists of a computer with printer and digital voltmeter controlled over a IEEE-488 instrument control bus. The computer is a standard IBM-PC (IBM and PC AT are registered trademarks and PC XT is a trademark of IBM corp.) clone with software written in the Turbo Pascal (Turbo Pascal is a trademark of Borland International, Inc.) language. The software controlling the digital voltmeter functions over the IEEE-488 bus. All data is repeated every 30 seconds with the computer performing the necessary calculations and data storage. After all of the data is collected, a graph of the discharge curve is plotted on the color display and the printer provides a hardcopy of the discharge curve. Figure 1 shows a schematic of this computerized cell testing system.

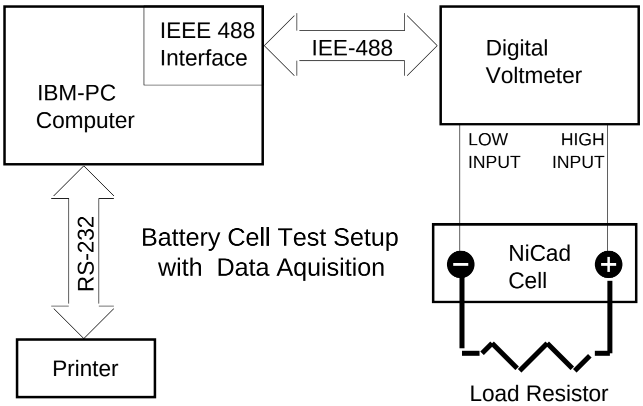


Figure 1. Setup for measuring the ampere-hour capacity of an electrochemical storage cell.

**Discharging**

Each cell under test is discharged through a resistor. This provides a constant current drain for the cell under test. Resistors and several feet of #14 copper wire were used since they were easy to fabricate. Almost any desired value can be made without special tools. To load the Edison cells at a C/5 discharge rate, reference the cell product literature. It was determined that for the ED-160 cells a current of 32 amps was desired and for the ED-80 cells a discharge current of 16 amps is correct. Copper wire has a temperature coefficient of +3900 ppm. For this reason we characterized the resistance of the wire over the range of cell voltages from 1.5v. to 0.8v. and programmed the computer with the resistor's characteristics. This allowed for reasonable measurement accuracy to be maintained. We characterized the local resistance while in use by measuring the voltage across the cell under test and the current through the load resistor with a DC clamp-on current meter. From ohms law E=IR, we calculated the resistance of the load while in use. Power dissipated in the resistor is proportional to the temperature ($T^{1.5}$) of wire. On initially connecting the resistor, it heats up within a few minutes to its maximum value and then slowly cools until the end of the test at 0.9v. In practice the resistor value changes only by 1.7% during the test. The resistor for measurement of the ED-80 cells has a nominal value of 0.080Ω initially with a final resistance of 0.0789Ω. The initial current was 15.6 amps and the end of the test current 12.7 amps.

**Monitoring**

Since the current was not constant during the test we needed to monitor it every 30 seconds. By integration the total amp-hour capacity of the cell was determined. The program, written in Turbo Pascal, requires the operator name, cell type and load resistance for input. The computer provides the time and date. After everything is under way, the computer commands the digital voltmeter to take a voltage reading every 30 seconds, 120 readings per hour. The voltage reading is divided by load resistance to calculate current. The current divided by 120 is used to convert it to amp-hours (coulombs). During the test the computer adds all of the amp-hour values until three voltages are found. The voltages are 1.1v., 1.0v., and 0.9v. The total amp-hour capacity is specified to a discharge of 1.0v. at the 5 hour rate. We are most interested in this value. The output from the computer produces a graph of voltage versus time (discharge characteristic) and a table of amp-hour capacities to the above three voltages. The test is terminated at 0.9v. Figure 2 shows shows a typical discharge curve obtained from testing an ED-80 cell, serial #088569192. This4 year old cell's tested capacity is 99 A-h, while its rated capacity is 80 A-h.

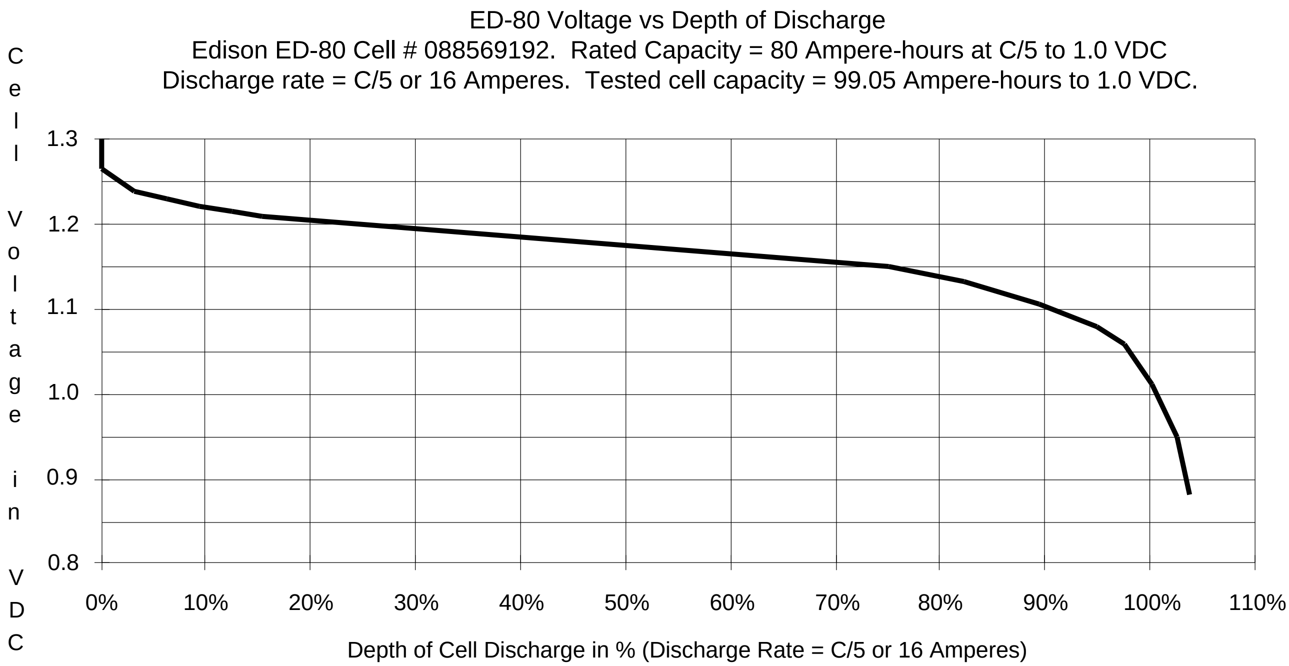


Figure 2. Cell Voltage vs. State of Charge Curve for an ED-80 cell.

**Date Codes**

The Edison ED series batteries manufactured by SAB NIFE, Greenville, NC have date codes stamped into the top of the cells. Each cell has an individual date code/serial number consisting of nine numerals. If the cell has been reconditioned by Pacific West Supply, two additional characters follow the nine numerals. In the nine digit serial number date code, such as 088569159, the first two numerals represent the month and the next two numerals represent the year of manufacture. In this example, we see that the first two digits are 08, representing the month of August. The second two digits of this example date code are 85, representing the year 1985. The remainder of the date code is the cell serial number for the date of manufacture. If the two characters "RC" follow the nine digits, the cell has been reconditioned by Pacific West Supply.

**Capacity Test Results for ED-80 Cells**

Thirteen ED-80 cells were charged and then discharged through the capacity test system. The results of this test are shown in Figure 3. Average capacity of the cells (in use since 1985) was 98 amp-hrs. at a C/5 (16 ampere) discharge rate to a cell voltage of 1.0v.

**Testing a 57 Year Old Nicad Cell**

A Gould XWR7 nicad cell was tested. This cell was made in 1933 and selected at random from a pile at Pacific West Supply. Its rated capacity is 35 A-h. The cell's exterior was cleaned and the cell's electrolyte replaced. The cell was then charged and discharge tested for six complete cycles. The results of the testing are shown in Figure 4. Note the increase in capacity as the cell was cycled. This increase in capacity after a few cycles was demonstrated by many of the cells tested. By the third cycle, this 57 year old cell was testing at greater than its original rated capacity.

**Nickel Cadmium Cell Reconditioning**

The process for understanding the reconditioning of NICAD cells involves knowledge about the condition of the cell. Measure the $K_2CO_3$ (potassium carbonate) concentration by titration. If the potassium carbonate concentration is greater than 15%, it is time to recondition the cell. If impossible to determine concentration, assume a five year reconditioning period for aggressive use of NICAD cells. For service where the NICAD cells are not overcharged repeatedly and the oil levels are maintained properly consider ten years as the approximate renewal period for electrolyte. Reconditioning is defined as replacement of the electrolyte and oil followed by a complete charge/discharge cycle where the capacity is confirmed.

**Reconditioning Process**

The first step in cell reconditioning is to physically inspect the cell for damage. The case should be tight and without cracks. Clean the exterior of the cell with disposable towels.

Cell Capacity Tests
Edison ED-80 NiCad Cells
Rated capacity 80 Ampere-hours
at C/5 discharge rate to 1.0 VDC
Discharge rate= C/5 or 16 Amperes

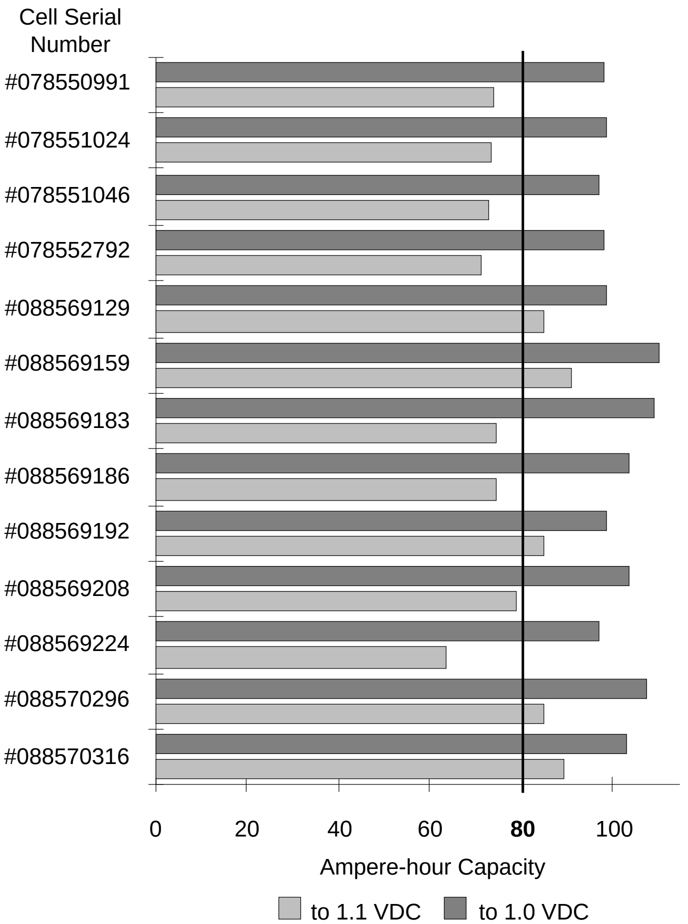


Figure 3. Capacity test results for 13 ED-80 cells.

**Titrate the electrolyte** (see instructions below) to determine the degree of carbonate contamination of the electrolyte. If the$K_2CO_3$ concentration is less than 15%, then there is no advantage to electrolyte replacement. If the $K_2CO_3$ concentration is greater than 15%, then electrolyte replacement is required.

**Charge cell at C/10 rate for 16 hours.**

**Remove electrolyte** from cell by turning the cell upside down and pouring the electrolyte into a plastic bucket. Dispose of this caustic electrolyte in a responsible manner!

**Replace electrolyte** with "NEW" electrolyte within five minutes. Damage will occur to the cell if it is dry for greater than five minutes. Use KOH electrolyte with a specific gravity of 1.190 gr./ml., consisting of KOH dissolved in water, and LiOH. The lithium hydroxide should be approximately 12 gr./liter of electrolyte. If you are mixing your own electrolyte using dry KOH & LiOH flakes,let the exothermic reaction cool before testing specific gravity.

**Add mineral oil** to provide approximately 1/8" oil float on the surface of the electrolyte. Use Chevron 22 Utility Oil only.

**Clean cell case** and terminals of any dirt or electrolyte spillage.

**Test cell capacity.** If the equipment is available certify the cell's capacity by cycle testing as described in this article.

**Place cell in use.**

**Cell Electrolyte Levels**

Several episodes of electrolyte and oil foaming out of the cell caps were experienced. This was due to overfilling the cells with electrolyte and oil. Electrolyte levels were observed to change with the state of charge. If cells are filled when discharged and subsequently charged, they will be over full by as much as 3/8". Maintain the cell oil and electrolyte levels in the charged state to prevent this occurrence. If some oil foams out of the cell during charge, replace it as necessary with Chevron Utility Oil 22 (Product of Chevron USA). The proper amount of oil on top of the electrolyte will reduce foaming. If oil enters the plates due to a very low electrolyte levels excessive foaming can be the result. To prevent this, check electrolyte levels often to determine the rate of water usage for each cell. Replenish only with distilled water.

**Titration for $K_2CO_3$ in Alkaline Electrolyte**

This titration process was obtained via personal communications with David Dwyer at SAB NIFE. With this process I have measured carbonate concentrations between 0.74% and 19.27% accurately.

**Materials required**

Hydrochloric Acid, 1 N
Buret, 25 ml.
Buret stand, white porcelain base
Pipette, 5 ml.
Phenolphthalein pH indicator, 1%
Methyl orange, 0.1% (w/v) Aqueous
Erlenmeyer flask, 250 ml.

Cell Capacity Test
Gould XWR7 Nicad cell (made in 1933)
Rated capacity 35 Ampere-hours at C/8 rate to 1.0 VDC
Discharge rate = C/8 or 4 Amperes

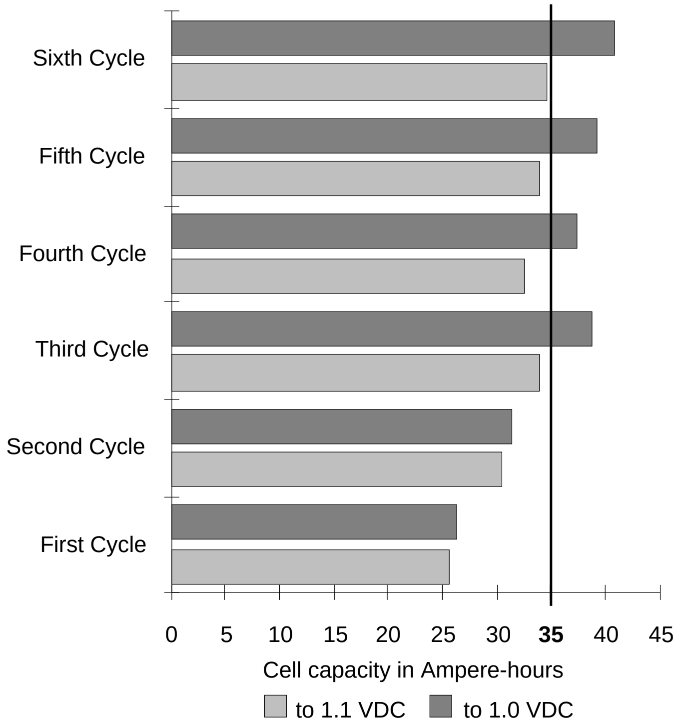


Figure 4. The 57 year old Nicad still lives!

Graduated cylinder, 100 ml.
Distilled water

**Procedure**

1. Using pipette remove 5 ml. electrolyte from cell and transfer to the 250 ml. Erlenmeyer flask.
2. Add 50 ml. distilled water to the Erlenmeyer flask.
3. Add 2 drops phenolphthalein pH indicator to the Erlenmeyer flask. Note the pink color to the liquid.
4. Using the buret, titrate with 1N HCL to clear. Record the number of milliliters 1N HCL to clear as A= ml.
5. Add 4 drops methyl orange to Erlenmeyer flask. Note the yellow-orange color.

$$\frac{2\,(B-A)}{B} \times 100 = \text{\% Potassium carbonate in electrolyte}$$

6. Continue the titration until the yellow-orange color changes to pink-orange. Record this final value of the titration as B= ml.

For NICAD cells up to 15% is considered all right. If the $K_2CO_3$ exceeds 15%, renew the electrolyte.

**Access**

George Patterson, 3674 Greenhill Rd., Santa Rosa, CA 95404

*Many thanks to George Patterson for all the time and work he's into testing nicads. The material we had space for here was a tiny fraction of the data he buried us with. Good Work!* RP



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| ☐ | ☐ | **Wind generator** | ☐ | ☐ | **Batteries** |
| ☐ | ☐ | **Water power generator** | ☐ | ☐ | **Inverter** |
| ☐ | ☐ | **Battery Charger** | ☐ | ☐ | **Control systems** |
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HP#15

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**SEE SUB FORM ON PAGE 27.**

## *Shopping for a better World?*

Karen Perez

Sometimes I feel like this tiny little drop in a very large bucket. How can such a tiny drop help this enormous planet with such enormous problems? Here's a way to make your drop count!

Have you ever wondered how the products you buy impact the planet and all the lifeforms on it? Here's a nifty pocket guide to help you do just that. "Shopping for a Better World" is a quick and easy guide to socially responsible supermarket shopping. This handy 289 page pocket reference tells you how companies rate on giving to charities, women's advancement, minority advancement, military contracts, animal testing, disclosure of information, community outreach, nuclear power, South Africa, environment, and family benefits.

We sure shop differently since Michael Welsh from the Redwood Alliance sent us a copy - Thanks Michael!

One copy of this little gem can be had for $4.95 plus $1 postage or 5 copies for $15 plus $3 postage by sending a check to Shopping for a Better World, POB 656, Big Bear Lake, CA 92315. Or call 714-584-1080, outside CA 1-800-848-8876.

**OOPS!**
We made a mistake in Bobier Electronics ad in Home Power #14. The "New Lifetime Warranty" (12 & 24 volt models) is for Bobier Electronics NDR 30 Charge Control System. We mistakenly placed the "New Lifetime Warranty" text in the Linear Current Booster ad. We apologize for this mistake and wish to set the record straight.

# The Wizard's MicroPV System

Richard Perez

High in the snowy mountains of Oregon, the Wizard lives in a mushroom shaped dome. His small round home is about eight miles from the commercial electricity. He makes all the power he needs with a single photovoltaic panel. This system is a prime example of what can be accomplished at low power levels, and at very low cost.

**Micro Consumption = Micro System**

The Wizard's needs are small. He lives alone in his small cabin. The appliances in his system reflect his choices for electrical power. The main appliance is a single incandescent car tail light. This light consumes about 26 Watts (≈2.2 Amps. at 12 VDC) and is operating about four hours per day (the Wiz reads alot). The second appliance is a Shortwave/FM/AM radio receiver. This Sony radio works on 9 VDC and the Wiz uses a DC/DC converter to lower his system voltage for this radio. The radio only consumes 1.8 Watts (0.15 Amps at 12 VDC into the converter) and is operated for about eight hours per day. The third and last appliance is a coffee grinder that the Wiz powers via his small inverter. Total average power consumption for this system is about 120 Watt-hours daily.

**Power Source- PV**

This system uses a single ground mounted Kyocera J48 PV panel as its ONLY power input. There are no generators in this system. The PV panel produces about 3 Amperes of current under full sun. At the Wiz's location it makes about 200 Watt-hours daily on average. The single PV panel actually produces about 80 more Watt-hours daily than the Wizard uses. This overproduction helps refill his battery quickly after several cloudy days in a row.

The panel is mounted on an EchoLite™ adjustable PV rack. The mount is fastened to a heavy wooden base which merely sits on the ground. Since the Wiz's dome is not in a good location for PVs (big shade trees all around), the panel had to be located about 75 feet from the dome. The heavy mounting base is movable and the Wiz can position his panel in different places for different seasons. This way he can work his way around the shade trees. The panel is wired to the battery directly with 10 gauge copper wire with UF insulation. There is a 20 foot loop of wire next to the panel so that it can be repositioned in a wide area.

**Power Storage - Nicads**

The Wizard uses nickel-cadmium cells for power storage. This battery is composed of ten Americad HED-120 (high rate) cells wired in series. These are reconditioned nicads from Pacific West Supply in Oregon. The resulting nicad battery has a capacity of 120 Ampere-hours at 12 VDC. This battery stores enough power to last the Wizard for 12 sunless days in a row. While cloudy periods of four or five days are common here, cloudy periods longer than a week are very rare.

The battery and PV system has no regulator. The only appliance in use during the day is the radio whose DC/DC converter will run at up to 32 VDC input. Hence no regulation is required because the charge rate of the PV panel (3 Amperes or a C/40 rate for the 120 Ampere-hour battery) is too low to damage the nicads. Voltage in this system gets up to 16.5 VDC on a sunny day when the nicads are full. This is fine with the nicads which bubble merrily along. The only problem encountered by the Wiz was slightly increased distilled water consumption by the cells.

The Wizard's mountain dome. This dome is a twelve sided stressed plywood building with a floor area of 180 square feet. The only wood above the floor is 3/8" plywood. This dome has been withstanding the rugged Oregon weather since 1972. Also shown in this photo are the PV panel, and Buckwheat, a renewable energy powered security system.

Photo by Richard Perez.

In the days before nicads were affordable, the Wizard used a motley assortment of lead-acid batteries. The Wizard says the nicads provide brighter incandescent light at night, less voltage depression under load, and vastly reduced "mopping up" of the cells' tops. He is very pleased with the nicads performance in his system.

The ten Americad HED-120 nickel-cadmium cells powering the Wizard's system. These reconditioned, high rate cells probably saw original service starting a diesel locomotive.
Photo by Brian Green.

**Power Processing - Inverter**

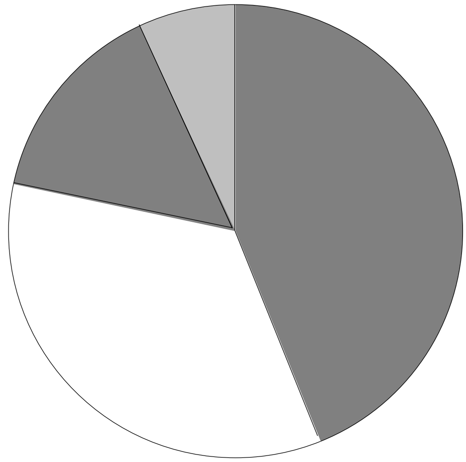
This system uses one of the new Powerstar 200 Watt inverters. Since there is a review of this inverter in this issue, I'll be brief here. This inverter converts the 12 VDC stored in the nicads into 120 vac for use in conventional appliances. The 200 watt size is ideal for the Wizard as he only uses the inverter to power a coffee grinder. Actually, the inverter is large enough (as is the rest of the system) to power larger appliances, but the Wiz ain't interested.

**What did it all cost?**

The table and chart below detail the costs of this microPV system. At around a thousand dollars, small PV systems can effectively power lights and communication in a mountain cabin.

**Stand-alone PV lessons learned**

The Wizard has learned several lessons about using PVs as the only power source for a system. While the Wizard's system is very small, the concepts and proportions involved here apply to all systems regardless of size. The PVs should produce at least 50% more power than is consumed daily. The battery should store at least ten days of power. Keep the system simple. Parts left out cost nothing & cause no service problems.



| System Components | Cost | % |
|---|---|---|
| Americad Nicad Battery | $450.00 | 44% |
| Kyocera PV Module | $350.00 | 34% |
| Powerstar Inverter | $150.00 | 15% |
| EchoLite PV Bracket | $70.00 | 7% |
| | | |
| Total System Cost | $1,020.00 | |

**Access**

For more info on this microPV system, please write: The Wizard, C/O Home Power, POB 130, Hornbrook, CA 96044.

CARLSON

# Things that Work!

## A Sovonics PV panel & the Ovonics Battery

### tests conducted by Sam Coleman and Richard Perez

Since the mention of the Emergency MicroPower Systems (EMPS) in HP#13, we have been buried with requests for more information about a portable, solar powered system for emergency use- primarily communications with a side order of small time lighting. Well, we've come up with a working system that features three new components. One is a fold-up thin-film PV made by Sovonics. Another is a brand new Ovonics nickel-hydride battery that offers high density storage, without toxic cadmium! The third is the Powerstar inverter ("Things that Work!" this issue).

**The EMPS**

This Emergency MicroPower System consists of three basic components: the PV panel, the battery, and the inverter. Also used in the EMPS are a collection of power supplies, cords and adaptors to increase flexibility and utility in portable and emergency situations. This EMPS is a MICRO system. It can power communications devices like radios, and small efficient TVs. It can also power efficient lighting, like the new PL-5 fluorescents (5 Watts input) whose light equals a 25 watt incandescent. The EMPS can also intermittently power high-tech electronics- 120 vac VCRs, video cameras and computer equipment. The EMPS is not designed to power large loads like refrigerators or washing machines. The whole EMPS package weighs less than six pounds and fits easily into a backpack or briefcase.

**The Sovonics PV Panel**

The tiny fold-up PV is 19.4" wide, 13.5" tall and 1/4" thick when extended to catch the sun. Folded the PV measures 9.75" wide, 13.5" tall, and about 1/2 " thick (the size of a medium notebook). The panel weighs 2 pounds. The photovoltaic surface is thin-film amorphous silicon , deposited on stainless steel by the revolutionary Sovonics process. The thin-film PV is in a vinyl case with large grommets at the corners, very handy for securing the panel. Electrical access is via a polarized SAE connector, cord and male cigar lighter plug, all supplied with the panel. We inadvertently left the panel outside during bad weather, the rain and freezing did it no damage. We just hung it up inside to dry out.
The cost of this panel is $143.

Electrically speaking this panel produces 6 Watts (0.430 Amps at 14.5 VDC actually measured) under full sun. In a reasonable solar location, this micro PV panel will produce about 35 Watt-hours daily.

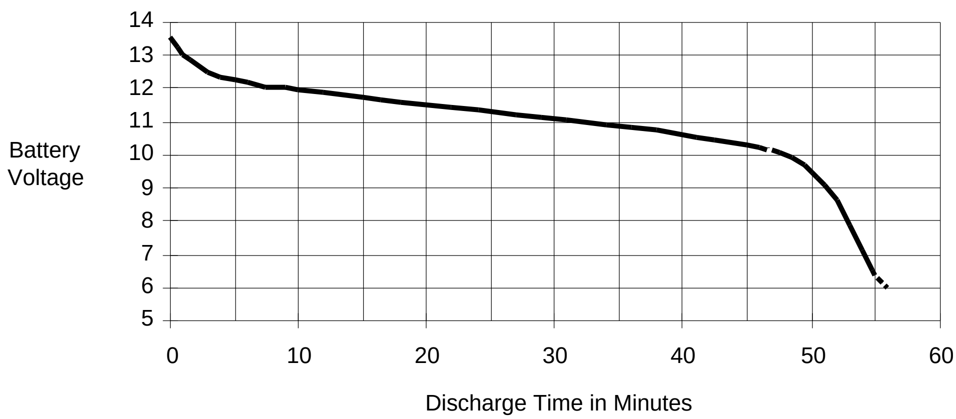
**The Ovonics Nickel-Hydride (NiH) Battery**

Nickel-hydride batteries are revolutionary variations of nicads. Instead of using toxic cadmium for the cell's cathode, Sovonics uses non-toxic metal hydrides. The resulting cells have about 75% more electrical capacity than a nicad of the same size and weight. The nickel-hydride cells have no memory effect. Small nicad batteries made by the "sintered plate" process display a memory effect. This means that if you don't regularly use all the power from the nicad cells they will lose capacity. This memory effect is not found in pocket-plate nicads, only the smaller sintered plate cells. Nickel-hydride batteries do **not** display memory effect and retain their capacity regardless of cycle regime.

The pack we tested was composed of ten NiH cells in a series string, encapsulated in a plastic box. The resulting battery is a nominal 12 VDC pack with a rated capacity of 3.4 Ampere-hours (≈44 Watt-hours of power storage). The cells are in a standard "C" sized flashlight cell format. Electrical access is via a female cigar lighter plug on a short wire pigtail. The Ovonics battery pack is 6.5" long, by 3.25" wide, and 1.5" tall. It weighs 2.5 pounds, complete with case, cord and connector. Cost for this high-tech storage system is $186.27, about 40% more expensive than using sintered plate nicads of the same Ampere-hour capacity. We think that the additional cost of this battery is justified by its high capacity and low weight- just what is required by an EMPS.

We immediately went to work charging and discharging the Ovonics NiH cells. We first selected a brutal discharge rate of about C/1. This means that we emptied the entire pack in less than an hour. As a test setup we used a 40 Watt, 120 vac, lightbulb plugged into the Powerstar inverter fed by the Ovonics NiH battery. All measurements were made by a Fluke 87 recording digital multimeter. The actual average discharge current for this test was

Discharge Curve for Ovonics Nickel-Hydride Battery
Average Discharge Rate = 3.87 Amperes or C/0.93
Rated Capacity = 3.4 A-h. Tested Capacity = 3.6 A-h.



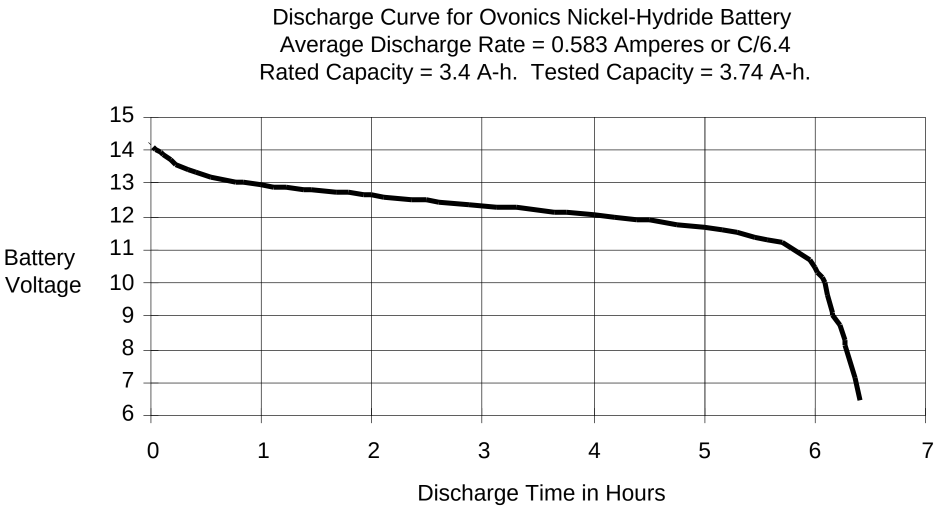
3.87 Amperes or a C/0.93 rate. The actual capacity we obtained was 3.6 Ampere-hours, more than Sovonics rates the pack! The voltage vs. time curve for this ≈C/1 rate appears on page 33.

We then tried a more civilized discharge rate of 0.58 Amperes or C/6.4. Actual tested capacity was 3.74 Ampere-hours. This is 0.34 Ampere-hours more than rated and about 87% more capacity than a sintered plate nicad pack of the same size. The voltage vs. time curve for the C/6.4 discharge rate is shown below. These new Ovonics NiH cells are hot stuff! In its charge and discharge cycles, the Ovonics NiH cells behave much like the sintered plate nicads. Voltage and current curves are much the same and the NiH cells can be used interchangeably with nicads, the only difference is vastly greater capacity.

**System Performance**

The EMPS is a totally solar powered system cycles ≈ 27 Watt-hours daily. It interfaces directly with automotive systems. For example, the PV panel can recharge a car battery & the car battery can power an inverter or recharge the portable Ovonics pack. And the system is still capable of total stand-alone solar operation!

The performance of this collection of EMPS hardware is entirely dependent on the user. The user selects the appliances (loads) that will be run from the system. If you select an efficient radio and light, then the system works well. For example the EMPS will supply enough power for continuous operation of a radio receiver (0.6 Watts) and about three hours of lighting daily with a PL-5 fluorescent.




The EMPS can be stored in a small box until needed. When the grid fails, it is ready to go, providing essential communication and lighting. The EMPS also makes an excellent, lightweight, portable micropower system for backpackers, aviators, and boaters. The EMPS contains all the same components found in larger home power systems- the only difference is proportion. This makes the EMPS an ultrafine educational tool.

**Access- Complete EMPS**

We have a problem here. This EMPS and several of its components are so new that few companies offer a complete working EMPS package. None offer this particular EMPS for sale. Electron Connection Ltd. has decided to offer a complete EMPS for sale via mail. This EMPS consists of a 6 Watt Sovonics PV micropanel, Powerstar inverter, Ovonics NiH battery pack,an ac charger for the battery, a DC/DC converter, a "Cigar Y", and all the plugs, cables and connectors detailed in this article. Electron Connection will ship this entire EMPS package, postpaid, anywhere in the USA for $465., add $25. for shipping outside USA. Contact: **Electron Connection Ltd.**, POB 442, Medford, OR 97501 or call 916-475-3179.

Not only does the NiH battery offer better performance than sintered plate nicads, but it's environmentally safer because it doesn't use cadmium. Many states and the federal government are considering a deposit on toxic batteries (up to $1 per cell). NiH batteries offer increased performance and savings, not only for our pocketbook, but for the planet. Sovonics is now working on cell prototypes with increased capacity. In the future, the NiH cell technology may be developed to the state that we'll be using them in home systems and electric vehicles. The smaller sizes are available now. The Ovonics NiH cell is a working reality.

**Other EMPS Components**

In order to make an EMPS flexible and useful, a variety of other components should be included. The first is a power supply that will recharge the Ovonics battery from a 120 vac source. We used a small wall cube that produced a solid 0.5 Amperes at 14.5 VDC into the Ovonics pack. This supply functions well on either grid or inverter. The second power supply we included is a DC/DC converter/regulator that allows the PV panel to directly power radios, tape recorders, etc. without any battery in the system. This is handy if you want to run something and the battery is discharged. The DC/DC converter comes with an assortment of DC power plugs that will fit just about any device. The last EMPS accessory is a set of two female cigar lighter plugs wired in parallel with a single male cigar lighter plug. The "Cigar Y" allows the system to be simultaneously charged and discharged.

**Access- EMPS Components**

**Sovonics**
1100 West Maple Road
Troy, MI 48084
313-362-3120

**Harding Think Tank**
633 Washington
Grand Haven, MI 49417
616-847-1966

**Alternative Power & Light**
Rt3, POB 128
Cashton, WI 54619
608-625-4123

**Backwards to the Future**
Rt1, POB 225
Pullman, MI 49450
616-236-6179

**Lake Michigan Wind & Sun**
E3971 Bluebird Rd.
Forestville, WI 54213
414-837-2267

**Sunlight Energy**
2225 Mayflower, N.W.
Dayton, OH 45420
513-832-3114

**Solar Technologies**
1725 Sugar Creek Trail
Greenfield, IN 46410
317-326-2440

# Things that Work!
# Home Power tests the Powerstar Inverter

tests conducted by Sam Coleman and Richard Perez

When we unpacked the Powerstar inverter we were surprised. Could an inverter this tiny really put out 200 watts? Don't let the small size fool you, it's a midget powerhouse wherever you need 120 vac from a 12 volt battery.

The Powerstar inverter is at home in the woods, in vehicles, or in your backpack. Photo by Brian Green.

**The Powerstar**

The inverter was heavily packaged and arrived in good shape via UPS. The only documentation was a specification sheet. The Powerstar is so simple to use we didn't need instructions. Only two connections are needed, both plug-ins. One is the inverter's DC input via a male cigar lighter plug. The other is the inverter's 120 vac output, via a single standard ac female socket.

The Powerstar is 5" long, 2.6" and 1.7" tall. It weighs 15 ounces. Its case is a beautiful piece of extruded, anodized aluminum and is the inverter's heatsink. The supplied DC cord is 18" long and made from 16 gauge wire. There is a small neon indicator that shows when the unit is making 120 vac.

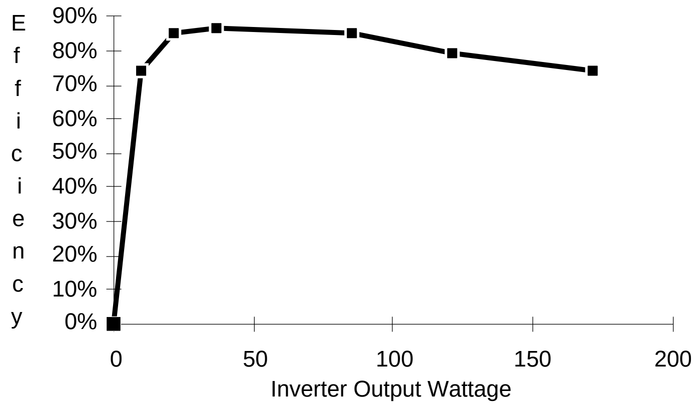
**Test Situations**

We tested the Powerstar on a variety of batteries in two systems and the Ovonics battery as a portable test. The inverter was powered by both lead-acid and large nicad batteries. We used a variety of loads, from incandescent lightbulbs to coffee grinders and computers. Electrical data was taken with a Fluke 87 recording digital multimeter. This meter allowed us to detect the true RMS voltage of the inverter, its positive & negative peak voltages and frequency.

**Test Results**

We ran a variety of loads and took data on the inverter's performance. No load power consumption was measured at 0.24 Amperes at 12.60 VDC, about 3 Watts. The various load tests and a graph of the inverter's efficiency appear below.

IIt's apparent from the table that the inverter is capable of producing its rated 200 watts. We were able to sustain this 200 watt level for more than 5 minutes without the inverter shutting down. We then added an additional 40 watts bringing the total output up to 240 watts. After about 5 seconds the inverter shutdown (as it should) and protected itself from overload damage. We were able to




| Load Type | Inverter Volts rms | Inverter Amps ac | Inverter Watts ac | Inverter Vpeak+ | Inverter Vpeak- | Inverter Hz. | DC Volts In | DC Amps In | DC Watts In | Inverter Efficiency |
|---|---|---|---|---|---|---|---|---|---|---|
| No Load | 114.7 | 0.000 | 0 | 170.4 | 170.8 | 59.28 | 12.60 | 0.24 | 3 | 0% |
| 10 Watt | 113.4 | 0.090 | 10 | 164.4 | 165.2 | 59.15 | 12.80 | 1.07 | 14 | 74% |
| 25W. Lightbulb | 112.9 | 0.194 | 22 | 163.2 | 164.4 | 59.38 | 12.50 | 2.05 | 26 | 85% |
| 40 W. Lightbulb | 112.2 | 0.327 | 37 | 161.6 | 161.6 | 59.35 | 12.60 | 3.35 | 42 | 87% |
| 100 W. Lightbulb | 111.4 | 0.766 | 85 | 155.2 | 156.8 | 59.48 | 12.50 | 7.98 | 100 | 86% |
| 140W. Lightbulbs | 110.9 | 1.094 | 121 | 151.6 | 153.2 | 59.44 | 12.53 | 12.20 | 153 | 79% |
| 200W. Lightbulbs | 111.4 | 1.540 | 172 | 126.0 | 127.6 | 59.78 | 11.14 | 20.70 | 231 | 74% |

sustain the manufacturer's rated continuous wattage of 140 watts indefinitely. We would rate this inverter at a solid 140 watt output. The peak voltages were very stable until the inverter was overloaded, then they dropped off. The RMS (Root Mean Square or average ac) voltage remained constant throughout the test. The inverter's frequency stayed around 59.5 cycles per second (Hz.), within specs. Efficiency is slightly less than the 90% claimed by the manufacturer. Our efficiency figures show the inverter ranging from 74% efficient at 10 watts output to 79% at 140 watts output. Peak efficiency was reached at between 25 and 100 watts output where the inverter is about 86% efficient. The inverter refused to die from repeated overloading. In our test the Powerstar functioned properly (rms voltage, peak ac voltage and frequency all within spec) with a battery voltage as low as 9.6 VDC.

The Powerstar ran all the test loads without problem. This included a variety of inductive loads using motors and power supplies. We had enough faith in the Powerstar to plug in over $4,000 worth of Macintosh computer equipment and rock-n-roll! The Powerstar ran a Mac SE with a hard drive and the Hewlett-Packard DeskWriter (300 dpi) jet printer with no problems.

**Conclusions**

With a price tag of $149.95, the Powerstar offers incredible value in a midget portable inverter. We see many applications where folks want to run a 120 vac appliance from a vehicle or portable battery. The list of appliances that the Powerstar will run is endless- just about anything under 150 watts, indefinitely. The Powerstar opens new vistas of instrument, video and computer use from either portable or vehicular systems.

**Access**

Powerstar Inverter Manufacturer
**Powerstar Products Incorporated**
10011 North Foothill Blvd.
Cupertino, CA 95014
408-973-8502
Dealers interested in stocking the Powerstar please contact:
**SunAmp Power Company**
8502 East Cactus Wren Rd.
Scottsdale, AZ 85253
602-951-0699

Single Powerstar inverters available from ($150 shipped postpaid):
**Electron Connection Ltd.**
POB 442
Medford, OR 97501
916-475-3179

and from other Home Power advertisers.

**IF YOU DON'T WANT TO MISS AN ISSUE OF HOME POWER, THEN BE SURE TO SUBSCRIBE NOW!**

# ENERGY FAIR UPDATES

The Energy Fairs are going high amperage nationwide! The voltage has always been here, and now the current is freely flowing! The Fairs in Willits, CA and Summertown, TN are off and flying. Instead of writing about them, we are running full page layouts that they have produced by themselves. The ATA PV workshop at Willits will begin on July 30, 1990. If you are interested in attending this two week ATA PV course preceding the Willits Fair, then contact Johnny Weiss at 303-963-2682. Part of the ATA course at Willits will be helping the Home Power Crew set up our PV system for production of an issue of Home Power while at the Willits Fair. ATA will also be conducting a PV course on Cape Cod on July 9, 1990.

**Energy Fair Update From the Midwest**

The first "Midwest Renewable Energy Fair" organizational meeting was held January 6, 1990 and was attended by a very energetic group of 15 organizers. The following is the product of our first meeting.

The Fair will be held at the Portage County Fair Grounds, in Amherst, Wisconsin, on August 17, 18 and 19, 1990. Our objective is to educate, demonstrate and promote the benefits of the efficient use of renewable energy. Our target and scope will primarily be the general population of the upper midwest states, though we are also planning for a large number of current renewable energy users. Expected turnout has not been estimated as of this writing.

To reach the objectives, the Fair will include:
• Booths for manufacturers, dealers, cottage industries and educational displays. All are to relate to renewable energy and energy conservation products and practices. Selling of merchandise will be allowed at the Fair.
• Demonstrations of different types of energy systems.
• Workshops for novices as well as current users seeking further information. Some of the proposed workshops include: How Systems Work, System Designing and Sizing, High Efficiency Appliances, Energy Efficient Construction, Transportation, and Patterns of Energy Use and Their Environmental Impact.
• The FIRST Midwest Solar Car Rally.
• Entertainment and Food.
• A notable keynote speaker.

T-shirts and bumper stickers will soon be available. Price has not yet been determined. We urge all potential exhibitors, participants, volunteers and sponsors to contact us at:
Midwest Renewable Energy Fair
286 Wilson Street, Amherst, WI 54406 • 715-592-4047

**Solar Festival in Vermont**

The ATA Workshop at Independent Power & Light Co. will be held June18 to 29, 1990. David Palumbo is planning a Solar Festival on July 28-29, 1990. This is not a Fair but a get together at his home/business. Davis is planning on workshops, demonstrations, folks sharing ideas and generally having a good time.

If you are interested in the ATA Workshop or attending David's Solar Festival please contact: David Palumbo, Independent Power & Light, RR#1 Box 3054, Hyde Park, VT 05655, 802-888-7194.

**The Truxton, New York Energy Fair!!**

There will be an Energy Fair held on July 21 & 22, 1990, hosted by the Common Place Cooperative in Truxton, NY. Common Place is a 437 acre land trust located in the rolling hills of Central New York State, 35 miles south of Syracuse, NY. Our land trust is a cooperative neighborhood of six passively heated solar homes, half of which also utilize solar and/or wind power for home electric use.

The local community of Cortland County has mobilized together to oppose the proposed New York State radioactive waste dump in the tiny community of Truxton, NY. This Energy Fair will provide an opportunity for us all to demonstrate that viable alternatives to nuclear power exist RIGHT NOW. The closing of nuclear power plants will eliminate the need for new radioactive waste dumps. Toward this goal, our Fair will stress energy efficient technologies, conservation techniques and renewable power generation.

The following is a tentative agenda for this exciting 2 day event:
• Alternative energy hardware and service
• Solar home tours • Solar electric workshops
• Solar/wood water heating workshops
• Super insulating techniques
• Energy conservation through new technology
• What is a land trust? • Anti-nuclear dump rally
• Swimming • Camping • Hiking • Music • Organic garden tours
• Raffle, to win AE products

We are still planning, so we encourage all of you to share your ideas for the Fair. We welcome all alternative energy and conservation equipment dealers and installers out there to come and show off your goods and services. We also welcome home owners and concerned citizens to participate by giving workshops, playing music, or volunteering to help set up and run the Fair.

We welcome everyone to come and have a great time collecting information, talking, meeting people, playing and making it an event worth remembering. Best of all, it will be FREE, FREE, FREE! Free admission and no charge for displays. For more information contact Hank Collette at 607-842-6849.

**Planet-Fest "90**

On July 12-15th, 1990, at the LOTH-LORIEN Nature Sanctuary near Bloomington, IN, there will be a special gathering called Planet-Fest '90. Sponsored by EARTH-BASE PROJEX, Inc., a unique organization engaged in environmental research and the development of alternative technologies. Planet-Fest '90 will bring together a wide variety of ecological groups, alternative energy specialists, Earth spirituality organizations and concerned conservationists for a 4 day "energy fair". PLANET-FEST '90 will focus on practical solutions to environmental problems, both personal and planetary. There will be a host of workshops, product demonstrations and discussion circles with emphasis on non-polluting lifestyles, advancements in alternative energy and the means to bring about planetary transformation.

More information can be obtained by sending a legal size self-addressed and stamped envelope to PLANET-FEST '90, c/o PO Box 1328, Bloomington, IN 47402-1328.

# The Farm's Full Page

WILLITS
Full
Page

# the Wizard Speaks…
## The ELFS-Land Manifesto

The following relational matrix of freedom shall be implemented EVERYWHERE on Planet Earth. This matrix shall apply to all life-forms in at least a species manner and to conscious, self-aware, intelligent entities in an individual manner.

1. Freedom from non-consensual activities, interactions, experiences, etc.
2. Freedom of consensual activities, interactions, experiences, etc.
3. Freedom of adequate resources and habitats
4. Freedom of positive progress

**The Lords of ELFS-Land**
Sealed and delivered by The Wizard

# Nerd's Corner

We try hard to keep the info in Home Power accessible to anyone who managed to stay awake during high school science. And all of you techies cuss us out for not getting down with some heavy nerding on high tech stuff. Well, here it is: a column that assumes that you are experienced. This column is for electronic and computer techies to get as complicated as necessary without providing basic access for non-electronic types. Damn the transistors, full speed ahead!

### LASER PRINTERS & INVERTERS

We also use Macintosh™ computers to create our catalog, correspondance, flyers, reports, etc. When we purchased our Mac, we bought an Imagewriter II printer to produce our output. Unlike the Imagewriter I which operated fine from inverter power the Imagewriter II preformed horribly under inverter power. Something to do with the controls on the head impact mechanisms under inverter power caused output to be of varying darkness, with many lines coming out with little or no ink. So we were left with an amazing computer, whose output required a trip of 140 miles for laser quality printing or the running of our generator for moderate quality. We next tried using our ancient but semi-trustworthy daisy-wheel printer with a software and hardware interface, but had extremely bad luck with the software.

After almost one year of having little luck getting satisfactory output from the Mac we decided to look into buying a laserwriter (Hewlett Packard DeskWriter was not on the market then). We called Heart Interface (we run our house from a Heart HF24-2500SX) to see if they had any experience with laser printers running off their inverters. They had reports of a laserprinter running from a 1200 watt inverter in Hawaii that eventually had a meltdown, but attributed that to the size of inverter rather than the inverter power. Heart Interface however just received a Ricoh laser printer and after my request tested it on their inverter and said there was no problems. So there we were, with information on one meltdown and one positive experience. Being partially masocistic we decided to bite the bullet and order a Apple Laserwriter IINT. Well, it has worked like a charm for over 1 year and I suspect it will give us years of support.

Jerry Fetterman, Yellow Jacket Solar, Box 253, Yellow Jacket, CO 81335, (303) - 562-4884

### Instrumentation Notes

We have just been trying the new Fluke 87 digital multimeter. We recommend it highly to get down and measure it nerds. It will record data and figure average measurements for up to a 35 hour period. This means it will function as a highly accurate ampere-hour meter. It will measure true RMS voltage (even on inverters!). It will measure peak ac voltages with an access time of 1 millisecond. It will measure frequency, duty cycle, and capacitance. It also does regular DMM jobs like resistance, transistor testing, ac and DC volts. It will also make current measurements up to 10 amps DC. The Fluke 87 will also function as a 4 1/2 digit meter at slower rates. Basic aquisition time is 100 ms., peak readings are taken at 1 ms., and 4 1/2 digit readings take 1 second. Basic DC accuracy of the 87 is 0.1%, and that's good enough for what home power types are doing. We like the electroluminescent back lighting panel that allows reading the large LCD display in the dark. The meter beeps when it acesses either new minima or maxima (record mode). We found it very useful for detecting peaks and lows in system performance. The 87 DMM contains a host of other features that we've yet to even try (the manual is over 42 pages long). It does swell high-tech stuff like transfering data to computers via a "no wires" audio path. The 87 sends data out as sound! At three hundred bucks, it ain't cheap, but then it does so much that anyone needing accurate or esoteric measurement will find it cheap. I took considerable flak from the HP crew for spending $300 of out collective resources on a meter. After everyone saw all the amazing and accurate information it provided, then the frowns turned to smiles. Much of the accurate data on batteries and inverters in this issue was taken with the Fluke 87. Contact: Fluke Instrument Corp.at 800-443-5853 for access to a local or mail order Fluke dealer.

Richard Perez, C/O Home Power, POB 130, Hornbrook, CA 96044 916-475-3179

# Electric Vehicle Frames

Phil Jergenson

Busy times here in Willits. Between building EVs & helping with SEER'90. This Solar Expo & Rally concept has been gaining momentum since 1984. Called Tour De Sol, it has been becoming a national event. According to our European contacts, there are some 36 such shows scheduled in Europe this year. Many of these teams are anxious to come to our SEER Rally. This will be a good chance for everybody to check out each others technology. Our Mendocino County event SEER & others like it are what this country needs to help move us more quickly into the solar age.

**Ten Years of EVs**

In the last ten years, I've built from scratch around ten electric transporters. Those experiences have helped me realized the user friendly results of box beam construction. In comparison, my welded framed vehicles seem like dinosaurs.

In keeping with HP's hands on approach, I'm showing you how to drill your own box beam for frame construction. With this approach it's easy to be accurate.

**Photo 1.** Carefully line up the ends of 3 or 4 pieces, which have their ends cut off at a 90° angle.

**Photo 2.** Mark your first hole 3/4" in from the end. For crisp lines, I use a .5mm, soft lead H-B drafting pencil.

**Photo 3.** Use masking tape to hold the measure in place. Notice that I've moved the measure to 1 1/2" mark to the first hole. This makes counting your spacing easier.

**Photo 4.** Carefully place your marks every 1 1/2" down the length of one of the pieces. Notice how the numbers must be multiples of 3", every other hole. This will tell you whether your counting and marking are accurate.

**Photo 7 .** Starting at one end, drill the holes through both sides. Continue down the tubing's length. Don't let chips build up against the table or back stop pieces. This can cause the holes to be off center. Flip part on its side and drill the other half. Don't let your drill clog.

**Photo 5.** Next, using a square, mark all your pieces with one clear line. Be exact! There's no room for sloppiness. Box beam tubing is expensive.

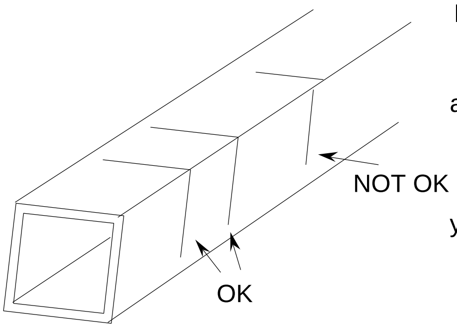



**Illustration 6.** Now, flip all the pieces on their sides. Pay attention!. Make sure that both of your marks line up on ALL the pieces or your holes will be off. Wipe off any inaccurate lines and try again.

**Photo 8.** Notice the nifty way I built the back stop. This may be any square material, as long as it's straight. Also notice the chip clearance area under the back stop. An occasional shot of WD40 on the drill tip keeps it cutting smoothly. Replace or sharpen the bit after drilling about 100 feet of tubing, dull aluminum melts to the cutting edge. I use a 13/32 " drill bit to cut box beam.

# Muddy Roads

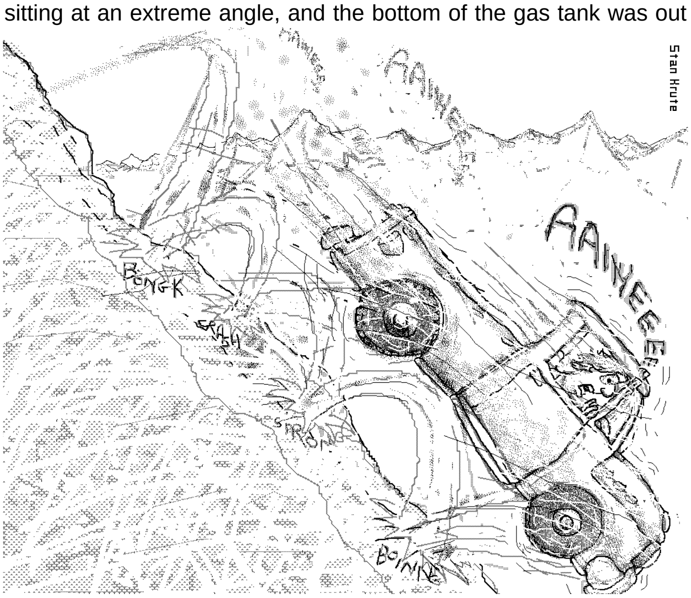
Donald Fallick

## The Day After Christmas

It was the day after Christmas, so I decided to take the non-recyclable trash to our private landfill, halfway up the side of the canyon. To reach it, you turn off the county road, up a very steep track, past my neighbor's house, then make a sharp left and go like crazy, 'cause the road is falling off the mountain, steep as inflation, and slippery with dust, mud, snow, or ice, depending on the season. I had my mind all fixed for ice, so I wasn't ready when I hit a muddy spot. The rear end slid majestically off the road, and I came to rest broadside, with the rear wheels two feet lower than the front ones. Took me a day to locate come-alongs, chains, ropes, and to work up the courage to ask my friend Tim for help. "Don't you have enough sense to stay away from that road this time of year?" he wanted to know. Told him I allowed myself one real damfool stunt a year, and time was running out.

## Interesting Events Tend To Clump

By jacking up one end of the truck and pulling it off the jack with the come-along, we got the truck back on the road, heading downhill, in only four hours. Not until then did I discover that I'd left the ignition on overnight, and the battery was dead. I just happened to have my spare deep-cycle battery in the back of the truck, so we swapped batteries and tried again. While we were warming up the motor, it ran out of gas! No, I'm not quite that dumb. The truck was sitting at an extreme angle, and the bottom of the gas tank was out




of reach of the fuel intake. Now, the old truck's brakes are real bad. In fact, only the left front brake works at all, so we chocked the front wheels and left to get gas. I only had about a gallon in the gas can at home, but thought it might be enough, so we walked the mile home and back with the gas can. It wasn't enough. Walked home again and took the car into town for gas. When I got back, Tim had gone home. My teenage daughter was the only one I could convice to come help.

## A Smart Daughter

We got to the truck, gassed it up, and tried to start it. Now the deep-cycle battery was dead. No, I hadn't left the ignition on again. I just ran down the battery trying to start the motor without enough gas. Figured I'd have to roll-start it. Unfortunately, my daughter wasn't strong enough to pull the chocks. Seems the truck had crept forward until all its weight was on one chock. So we swapped places. She stood on the brakes and I dug out the chock. Finally got it out and quickly got into the truck, before daughter's leg got tired. Then she refused to ride down with me. Smart kid! She had to climb out the passenger window, 'cause the door doesn't open from the inside, and I sure wasn't about to go around and open it for her. Sprained her ankle on the mirror.

## Lay Back And Get Down

I started out in granny gear, but the motor wouldn't start. Popped the clutch several times without success, while the truck accelerated down the hill. When I thought the 22-year-old synchros were about to fly apart, I tried for second gear, missed and got neutral, then couldn't get back to either first or second!

My run-away rig was rapidly gathering speed, and the right-angle turn was coming up fast. In desperation, I crashed the transmission into third gear, popped the clutch … and the motor caught! Double-clutching into second, I rounded the turn on two wheels, pumped the brake for all I was worth, and finally got it into first gear as I passed my neighbor's house. Made the county road with no problem, except that my heart will never be the same. "Oh, life on the farm is kinda laid-back!" (from "Thank God I'm A Country Boy"). Yeah.

# CQ HOME POWER HAMS

KE5HV • KG6MM • N6HWY • KB6HLR

**Regional Home Power Nets**
**(local times indicate local nets)**

7.230 MHz on Sundays at 1330 Pacific, Central & Eastern.
3.900 MHz on Wednesday at 2000 Pacific & Eastern time.
14.290 MHz Sunday at 1900 UTC.

**Novices**

Wednesdays at 0300 UTC-
7.107 to 7.110 MHz. Listen for Dave KB6HLR
7.110 MHz on Wednesdays and Saturdays at 0500 UTC.

Here's a postcard HP received asking for help in setting up a net. Sounds like interesting fun for communication nerds that could help our oceans. Anyone interested?

**Windsurfing from LA to Maui for the environment**

Aloha, I saw your article in Home Power and was impressed. I am extremely concerned with our environment and play an active role to preserve it. In June of this year, I will attempt to sail a modified windsurfer from Los Angeles, CA to Maui, HI. I have sponsors lined up and ESPN has agreed to do some shots. Earthtrust will benefit and help me document ocean pollution along the way. Would you be interested in setting up a communication system - Ham, SSB, marine net, or airline net. Power would have to be solar with weight being a major factor. Please Respond. Mahalo.
Steve Fisher, POB 12506, Lahaina Maui, HI 96761

# H A P P E N I N G

## Light Wheels Set to Go

Steve Stollman

Some think of New York City and Washington DC in terms of gangs, where those in grey flannel can make the ones in black leather look like the good guys. Yet, the decisions made (or more often put off) in those cold citadels reach everywhere, and these must grow elements in both the private and public sectors fear one idea above all others, "Less is More".

**The Simple Truth**

No where is the simple truth of this idea more evident than in transportation. The common bicycle, for instance, has been shaved down so skillfully that frisky tenement dwellers bound up four flights with it, yet they can still offer a friend a ride across town. Now ingenious electrical engineers and backyard tinkerers are applying the same components to the building of solar cars. Especially here in European-style cities of the north east, more people equals less distance between points, less room equals more need of space-saving, clean energy alternatives.

**Dirty Water**

Does this mean we're coming to take away your pickup? Well, as my mother used to say, "You don't throw away the dirty water until you have the clean", but for God's sake we've got to stop drinking whatever the hell that funky stuff is in the bottom of the bucket. It's bound to be a two step process. First, we must expose , as widely as possible, the best existing examples of human, solar and electric vehicles. Second, we need to encourage an ambitious program, especially in schools, to design and construct the human/solar/electric transportation system of the future and do it now.

**Join Us**

So, join us in moving together, from NYC to DC, about 300 miles, in late July 1990. For six days, by pedal and electron power we will push through some of the most densely populated regions of the world outside the Indian sub-continent. We'll stop off at least twice each day to set up our exhibits and show off our fleet. Local bicycle clubs are being invited to organize rides around us to increase participation. Heavy media attention is anticipated. Major exhibits, trade shows, and conferences in NYC and DC (and a preview during Earth Day) will bracket the event.

**Not just another contest**

A nationwide contest is being organized and educational materials are being assembled. Top prizes will be awarded for those making the most ingenious use of recycled materials instead of another two-dimensional speed race. Awards for aesthetics, utility, ease of construction and other factors will also be issued and individuals, as well as schools, will be eligible. State fairs will be invited to provide a venue and exhibition space for entrants. Suggestions are welcome for creating proper categories or any other elements.

**Getting in touch**

For more information about Light Wheels and the other events listed below, contact Steve Stollman, International Conference on Appropriate Transportation, 49 E. Houston St., New York City, NY 10012 or call (212) 431-0600.

**In the same vein**

Here's a list of some of the events planned for the summer of 1990.
Earth Day - April 22
New England Solar Race - May 23-27
Tour de Sol - June 29-July 3
GM Event - July 9-19
Northern California Solar Race - August 11-12

## Enersol Helping the Third World

Enersol Assoc., Inc., has begun a new program, Energy Enterprises Development. This program helps the serious unemployment and environmentally destructive energy use in the Dominican Republic. Enersol and local partner organizations are working together to make the PV trade grow in the Dominican Republic. This grass roots approach has resulted in over 500 installations in the Dominican Republic, helping under employed rural Dominicans.

The program is helping the Dominicans organize PV businesses, offering help with training, business loans and marketing support. The first phase began last summer with a seminar sponsored by the U.S. Peace Corp. This project will provide permanent jobs for 30 rural Dominicans, installing 1000-2000 PV systems in the first two years.

Religious and service organizations in the U.S. have already backed the program, but Enersol is still raising the $138,000 needed to run it. Enersol director, Richard Hansen, points out that financing Energy Enterprise Development would favorably affect the country's long-term energy consumption and national balance-of-trade. Very small PV systems can replace large quantities of kerosene and drycell batteries. The net benefit would be between $175,000 and $750,000 in foreign exchange needed for energy imports over the life of the systems. The most obvious benefit is at the community level. The countryside would be brightened and more people could earn a decent living because of PV's and Energy Enterprise Development. Contributions are gratefully accepted. A $25.00 contribution to Enersol, for its work in the Dominican Republic, gets you a subscription to Enersol's newsletter Interchange. For more info contact:

Philip Covell, Enersol Assoc., Inc., 1 Summer St., Somerville, MA 02143, 617-628-3550

## Macrocosm USA

Macrocosm USA - Environmental, Political and Social Transformation for the 90's is now collecting the most powerful articles, essays, news clippings, position papers, excerpts, stories, artwork, photographs, brochures, handouts, quotes, poetry and resources concerning ALL progressive movements in order to publish this inspirational educational primer, empowerment and resource guide for the 90's. The challenges and changes; people, communities, churches and organizations making a difference. No topic too small, if vital. Revisions will be accepted until the Green Conference, September 1990, but submit now! Send material queries or inquiries for synopsis, outline, etc., to: S.L. Brockway, POB 969, Cambria, CA 93428.

## PV Training in New Mexico

Western New Mexico University is offering a two week intensive photovoltaic training course beginning May 29, 1990. The program will include complete design and product specification for PV systems, successful working system characteristics, as well as a hands-on installation done to electric code standards. The course includes a handbook for designing PV systems in any location or for any use. College credit is available. Western New Mexico University is located in SW New Mexico next to the Gila Wilderness. Spanish language translation is available. For more information, contact Tom Enos at 505-535-2400 or 505-535-4298.

**SunAmp Seminar**

SunAmp Power Company will hold a two day PV seminar on March 9th and 10th and May 11th and 12th, 1990. This seminar is designed for everyone from professionals to do-it-yourselfers. Some of the topics will be: Introduction to PV hardware, demonstrations of systems, instrumentation, information access, system design and marketing. Cost of the seminar is $145.00 ($100.00 for each additional person in the same party) which includes two lunches, refreshments, syllabus & classroom materials. For more info., contact Steve at SunAmp Power Company, POB 6346, Scottsdale, AZ 85261, 602-951-0699 or Toll Free 1-800-677-6527.

**Earth-Base Projex**

Earth-Base Projex, a space age research corporation engaged in the development of stand-alone closed loop ecosystems, is searching for volunteers interested in contributing their expertise towards the design and construction of EARTH-BASE 1. EB-1 will demonstrate the viability of self-powered self-sustaining closed circuit home-based ecosystems. If you are adept at organic greenhouse gardening, solar technologies, environmental science, computer programing, DC electronics, waste composting, or other talent or skill which may be valuable to EARTH-BASE 1, please send $3 for a complete information packet to EARTH-BASE PROJEX, PO Box 1328, Bloomington, Indiana 47402. EB-1 will be a quantum leap into a non-polluting future.

# Letters to Home Power

We Print 'em Unedited

Selected, Entered, & Illustrated by Stan Krute

## Wind Power Reading Lists

Dear Karen,

Thank you for the nice letter and information regarding the availability of wind machines.

Yes, I would like to correspond with other wind enthusiasts, so please print my address in your column. The phone number I supplied (800-523-2929) is for the U.S. Conservation and Renewable Energy Inquiry and Referral Service. They will send out a "Wind Energy Reading List" and a "Wind Energy Technical Reading List" upon request, as well as information on solar power (I haven't tapped any of that material yet; one renewable source at a time!)

From poring over the Reader's Guide at the library I've culled a list of reports published in Popular Science, Mechanix Illustrated, and Mother Earth News during the early 70's thru the 80's regarding home-brewed wind turbines, developments, etc. Since researching is such a pain, I'd be happy to send my reading list to any interested reader upon receipt of a self-addressed stamped envelope.

Also: If anyone has any knowledge or experience with the use of induction generators in a wind-powered utility tie-in, I'll send you a self-addressed stamped envelope.

Again, thanks for your help and for Home Power.

Sincerely, Bob Coletta, 43 Barstow Road, Warwick, Rhode Island 02888

*Thanks, Bob. Seems to us that it's time for some wind energy advances. Your research and networking should help catalyze events. Readers, this one's in your hands now. SK*

## DC Motors From Old Generators

Thanks for all the information in your Home Power magazine. I read each issue thoroughly and always learn something new each issue.

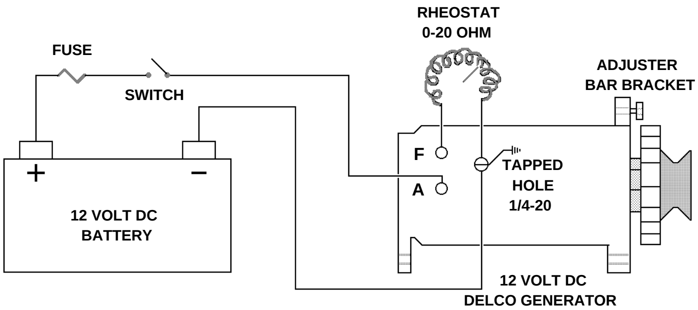
If you have use for an economical direct current motor that develops about 0.25 to 0.5 horsepower, and will run on 12 volts, let me tell you how I made one to run a small air compressor.

Look around in junkyards or generator repair shops and obtain a generator from a large General Motors car made in the late fifties or early sixties. They produced 40 to 45 amperes at 14 volts DC. The price should be less than $10 for a good used one to about $45 for a remanufactured unit.

Hooking one up is very easy and does not require any disassembly of the generator. All you need is a DC rated switch of 50 amperes or more, an inline fuse of about 40 amperes, some 8-gauge wire, and a variable resistor rated at about 100 watts and 15 or 20 ohms.

To connect it together run a piece of wire from the battery negative to the main frame of the generator. There is a drilled and tapped 1/4-20 hole *(that means it's 0.25 inches in diameter and tapped 20 threads to the inch. SK)* near the terminal studs that will work fine.

Next, connect the switch and fuse in series to the terminal stud stamped "A". Lastly, connect the variable resistor between the "F" terminal and the tapped hole where the negative wire is hooked.




If everything is connected correctly, clamp the generator down, clear your work area, and close the switch. The generator should now run as a direct current shunt motor. Adjusting the resistor will control the speed of the motor. Be sure to turn the motor fast enough to allow the cooling fan to maintain airflow through the motor, and do not disconnect the field lead while current is flowing in the motor. If everything is tuned up right, the motor speed will be about 3600 revolutions per minute, the field current will be about 0.5 to 1.5 amperes, and the total line current will be a little under 40 amperes.

If you need more power, obtain a heavy truck generator. The hookup is the same except you must increase your wire gauge, fuse, and switch accordingly. These generators produced about 80 amperes, and will require about 60 amperes to run as a motor. You may need to experiment a little; these are approximate values.

Lon Beville, Rt. 2 Box 1170, Starke, Florida 32091

*I love to see old machinery reincarnate. Thanks a bunch, Lon. Sounds like this technique'll make some fine strong motors. SK*

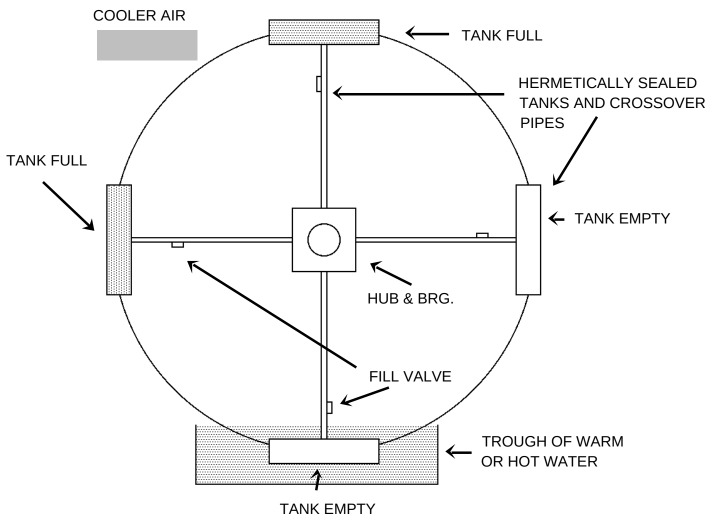
## Minto Wheels, Anyone ???

Dear Home Power

Have been enjoying your publication since the first issue thanks to Windy Dankoff placing my name on your list.

Enclosed is a check for $6.00 for my next year's subscription.

Here is an idea for an energy source that a friend told me about. It is called the Minto Wheel and is a heat engine powered by temperature differentials.



The liquid in the tanks is one of the refrigerants, or butane or propane. Air is evacuated from a pair of tanks and the pair's crossover pipe, and enough liquid added to fill one tank plus supply vapor for the opposite tank.

The wheel produces torque when a part of the liquid is vaporized by the warm-hot water and forces the rest of the liquid to the upper tank. There must be a temperature differential between top and bottom tanks. Since the top tank is full, and thus heavy, and the bottom tank empty, and light, gravity turns the wheel. The cycle is continuously repeated as long as the temperature differential is maintained. Do not choose a liquid that will produce too high a pressure for your tank walls. At least 8 tanks should be used; 12 would be better.

In an example, a wheel 20 feet in diameter was used. 12 tanks (6 pairs) were mounted on the wheel. Each tank was 4 inches in diameter and 60 inches long. Using the refrigerant R-11, with a water temperature of 100° Farenheit in the trough and an air temperature of 60° Farenheit at the upper tank, the wheel will produce 9380 foot pounds of torque per revolution and turn at about 4.5 revolutions per minute.

The wheel, or two of them for more power, could be attached to an automobile differential to transfer power. That would also increase the output revolutions per minute.

Butane and propane will work at lower temperatures, and with as little as 5 to 10 degrees Farenheit of temperature differential, but do not put out as much work as the refrigerants. That's due to differences in liquid densities, heat of vaporization, etcetera.

**Any welding of tanks and handling of working liquids should only be done by qualified persons.**

The author suggested using 4 inch diameter aluminum irrigation pipe for tanks as the aluminum transfers heat fast. If steel tubing is used, 0.5 inch diameter copper pipe mounted on each side of each tank, with elbows brazed into tank walls, speeds up heat transfer.

If a person has a source of warm or hot water, this wheel would produce a lot of work.

The author of this paper is Wallace Minto, and I believe it was written 8 to 10 years ago.

Best Regards, Don Jung, P.O. Box 69, Austin, New York, 89310

*Don! You've got our attention. Thanks. You or anyone have more real-world data/experience with these wheels? How do we access the Minto paper? What's the least ecologically-harmful liquid that works in the tanks? What about using the sun to heat the bottom trough ? What does Brg. in the illustration stand for? Hmmm .... if it scales up cleanly we could have a new theme park ride: 300 foot high ThrillAMintos, with output driving park waste water through purification membranes, then pumping the cleaned product to depleted wetlands. SK*

### Reflectors, Ni-Cad Charging, and Power Supply Tweaks

Dear Folks,

I just finally finished reading the last issue of Home Power. As usual I loved it. I always find myself going back and rereading them two or three times. There is so much info in them that I never retain it all the first time through. I have a couple of things I would like to say, and one question.

First, the question. Has anyone done any experimenting with reflecting surfaces and solar panels? It seems to me that there would be, or should be, an economic advantage in using reflections of the sun to produce more power, but I am not that technically informed on the workings of solar panels.

Second, after purchasing myself one of those nifty little portable 2 inch diagonal screen color TV sets from Radio Shack, I started having a problem with my rechargeable batteries. I remembered reading something about them in a back issue of Home Power, but couldn't remember which one. I got lucky and only had to go back to issue #11. You guys have almost as much info in the Letters and Q&A sections as in some of the articles. You should consider an index by subject and issue of the Q&A stuff. (Like you don't have enough to do already!) Really though it would be a big time-saver for people with short memories.

The problem I was having is that, up until I got the TV, I used my AA nicads in my Walkman, and they lasted about a week. I charged them in pairs in a standard GE-type charger, but used them in the Walkman three at a time, which meant that one of the batteries usually sat in the charger for two weeks between use. (My short memory again.) When I got the TV I started using the nicads four at a time. Regular AA cells lasted 4 to 6.5 hours in the TV, but my nicads only lasted 1.5 to 2.5 hours. I remembered reading the Q&A article and looked it up. I have two 9-volt battery spots on my recharger. I hooked up alligator clip leads to the positive and negative connections on one side. Then, holding the negative lead to the case, I just tapped the positive lead to the top of each cell three or four times quickly. I did this to cells that were already recharged, then put them into the TV. I got 3.5 hours usage from them and they were still going. I normally switch the cells each evening after 2.5 to 4 hours use, because even though they may not be fully discharged, they do not hold enough charge for the next day's use. I haven't had any problems with them since doing this. By the way, I commute to and from work on public transportation. I don't watch TV that much on my days off.

Lastly, I would like to share some information I found in an unusual source. As you know, many electronic devices, like clock radios and other things which plug into 110 volt AC sources, use a transformer, and actually run on 3, 6, 9, or 12 volts DC. If you open up these devices, the power supply is easy to spot.

***(It's also easy to hurt yourself. If you're not qualified to deal with electrical devices and high AC voltages, DO NOT DO THE FOLLOWING PROCEDURE. Find someone who IS qualified. A body is a terrible thing to fry. SK)***

After unplugging the appliance, open it, and follow the power cord to the transformer. Plug the unit back in. Measure the voltage coming out of the other end of the transformer from the power cord input with a voltage meter. This should read between 3 and 12 volts DC. Unplug the unit again. Follow the transformer output circuitry to the bridge rectifier circuit, or a similar group of diodes. On the other side of the diodes there is usually a large or medium-size cylinder. This is an electronic capacitor. Plug the device back in, and again, using the voltage meter, measure the voltage to the capacitor leads. This should be between 3 and 12 volts DC.

Unplug the device again. Using a soldering iron, gently heat and remove the capacitor leads from the printed circuit board. In their place, solder two long hook-up leads, making sure to use different colors of wire, and paying attention to which side is positive and which side is negative. Now, whatever voltage you found on the capacitor leads is the key to how many batteries you need to use to power the device. How long you want to run it and its current drain will determine what size batteries you will want to use. You could even use a voltage reduction circuit or device to run the device off of a standard 12 volts DC house set-up.

This information is courtesy of Uncle Sam, sort of. It's from a military manual on improvised field radio detonation techniques. Like they say, "Any port in a storm." I hope your readers get some peaceful use from this information.

Keep up the good work.

Sincerely, Rev. Joseph Christie, P.O. Box 20233, New York, New York 10009

### The People Behind The Technology

I enjoyed reading your recent evaluation of the Windseeker wind generator and thought you might be interested in a couple of background details. of the Windseeker operation.

1. David Calley, the wizard that designed the Windseeker, is the son of Doug Calley, an ex- physics/math teacher at Verde Valley School where I was headmaster before I was appointed Arizona's Director of Energy for a short time. I remember arriving at Verde Valley School 20 years ago and seeing some kind of home-built wind machine on top of a telephone pole. "Oh, that's Doug Calley's latest project," I was told. Doug and his wife Louise live in the first entirely energy independent home I was ever exposed to. They have all the electrical amenities and they became a reinforcing inspiration for our own past 11 years of no utility bills, and no fossil fuel back-up.

2. The entire Windseeker machine shop and production line is powered by Windseeker energy, backed up, if you can call it that, by a PV array.

Way to go Calleys. Keep it up.

Sincerely, Gerry Cunningham, Box 976, Patagonia, Arizona 85624

*Thanks for the good people story, Gerry. We're sure they and you will (keep it up, that is). SK*

### Thirty One Years Of Home Hydro On The Ranch

Gentlepersons:

It has been to our edification and delight that your alternative energy publication exists.

We began producing hydroelectric power here at this ranch in 1959 with a monstrouly-inefficient DC generator and 18-inch Pelton wheel running off of 65 feet of head.

About 1960, I talked my folks into purchasing a Winco AC generator. By the way, AC works as well as DC, with beter efficiency and application.

In 1980 we changed the hydro site to accomplish a 96-foot drop via a four inch diameter water line, and installed a Risdon twelve inch diameter Pelton-type wheel. By going to a smaller diameter impeller, we were able to use a more reasonable pulley configuration to the generator, which being two-pole, has to run at 3600 revolutions per minute to achieve 60 cycles AC. The actual power produced with one nozzle is about 600 watts. In the winter months, with extra water available, we turn on a second nozzle, which then produces about 900 watts. Since the distance from the generator to the house is about 340 feet, and the power line is number 6 copper wire, our line losses have been an empirical two to three percent, which for us is tolerable.

In typical operation we regulate our system manually at the house by loading. Energizing a 60-watt light bulb will usually drop the house voltage by three volts. Our house rule is to operate between 100 and 120 volts. This policy has been most successful in that none of our transformers in the solid state equipment have never failed.

A more common operational problem is brush failure, which allows spiking of the AC power that has, on occasion, blown the primary fuses in our VCRs.

A typical day starts with turning off the hot water heating elements and starting the refrigerator freezer unit. It is set to run full duty cycle for four to eight hours, depending on the season and climate. Daytime use of a computer and printer, as well as modest lighting, are in harmony with the system once the refrigerator has started. Evenings typically witness more significant lighting, plus the use of the satellite system, VCR, or hi-fi until bedtime. In winter months, a forced-air fan motor is a constant component of the load. At bedtime the hot water heaters are activated, and most lights turned off until the 100 volt criterion is met. With the use of a simple aC relay, the bathroom heater switches off and the kitchen heater goes on sometim in the middle of the night. In the morning, we have twenty gallons of hot water free of charge.

Incidentally, a 500,000 volt power transmission line looms over our generator shed. It is a pleasure, both for self-sufficiency and economy, to be free from public power.

Yours truly, Edwin Dyer, P.O. Box 23, Big Bend, California 96011

*Our hats are off to you and your family, Edwin. This is great stuff you're doing. Thanks for the detailed report. SK*

### More Fine Philosophy And Practice

Dear Home Power People -

We want to thank you for putting out such an informative and thought-promoting magazine. Fortunately, we have been on your mailing list from issue #1. Our hope is that you'll stay as down to earth as you have been.

We have been in our self-built and self-financed home now for almost 3 years. The public utility department power is about 2000 feet away. We have gone back and forth over what to do -- home power ? or line power? Thanks to you guys we have gotten enough information **and** support to be independent.

There are so many folks out there that think you're half-cocked for not being conventional. Gradually, we are getting our independence together, as money allows. Even if we are just a drop in the bucket for alternatives to a consumer existence.

We can pass these ideas on to our children, that there are many things we can do without, and hope that eventually the world will join us in using clean and energy -conserving sources.

Anyway, I have meant to send you money in the past, so here is some for our subscription, and some extra for the other 14 issues.

Merry Christmas and thank you.

Jim, Janet, Jesse, and Kylan Hulsiga

P.S. -- We also support your advertisers.

*We salute you, Hulsigas. So does the planet. SK*

### Fluorescent Fun And C-64's Freed From AC

Hi Folks,

Thought I'd drop you a note concerning the use of Philips PL bulbs with ballasts from various types of fixtures.

Most 12 volt fixtures that use two 15 watt tubes utilize all four pins on each tube. If you try to use that ballast to power two PL-13 bulbs, you will find it is impossible to make it work by hooking it up to the two pins on the PL bulbs. I have found a simple way to make two pin PL bulbs work with almost any ballast. The trick is to make the two pin PL bulb into a four pin bulb, and then wire it the same way as the four pin standard tube.

To convert the PL bulb from two pin to four pin, you cut the bottom of the base off, as you would do to cut the wire off the capacitor inside the plastic base. Instead of just cutting one of the wires to the blue capacitor, cut both wires near where the two sets of wires are soldered together. Pull out the capacitor and the small glass bulb, and discard them. You will be left with two bare wires leading into the glass tubes. These are the other two pins. Solder an insulated wire to each of these and note which one goes to which tube. I use a glob of silicon (not GE) to keep the bare wires apart and add strength.

Now you can wire the bulb as if it is a four pin standard tube. A standard 30 watt fixture will light two PL-13 bulbs very brightly.

Incidentally, Hosfelt Electronics, 2700 Sunset Boulevard, Steubenville, Ohio 43952, has a 12 volt fluorescent light available for $12.95. This unit uses a single 15 watt tube (included) and is a bit on the ugly side, but it has some interesting features. It has a switch that can make it flash on and off every three seconds. The brightness can be adjusted by turning a small printed circuit mounted potentiometer on the circuit board. It also turns itself off after 12 hours of continuous use. The ballast can be used to power a PL-13 bulb. A good deal for $12.95.

A note on converting Commodore-64 computers to low voltage. The C-64 works on 12 volt DC, 5 volt DC, and 9 volt AC. Just use a voltage regulator 7805 device for 5 volt DC, and forget the 9 volt AC altogether. The 9 volt AC is only used to keep the time of day clock chips perfectly accurate. Everything, including the clock chips, works fine without the 9 volt AC. The 1541 disk drive also uses 5 volt DC and 12 volt DC.

If you or any of the readers have any questions about this, feel free to call me.

Sincerely, Quintin Myers, 19344 Kiowa Road, Bend, Oregon 97702, 503-382-4633

*Thanks, Quintin. The C-64 computer has always had a warm spot in my heart: great sound, graphics, and learning opportunities for pretty low prices. SK*

### More on ElectroMagnetic Radiation

Dear Karen,

Regarding "The Wizard Speaks" on page 38 of Home Power #13 -- Those wishing a more detailed introduction to the possible health consequences of extremely low frequencey (ELF) electric and magnetic fields should read "Annals of Radiation" by Paul Brodeur, in the New Yorker magazine -- a three-part series that began in the June 12, 1989 issue. Good journalism on an important and largely neglected topic.

Sincerely, Michael Mideke, P.O. Box 123, San Simeon, California 93452

*Thanks, Michael, for bringing this to our readers' attention. SK*

### Of Phantom Loads And Satellite Equipment

Dear Editor;

Concerning the Phantom Loads article in the 14th issue of Home Power, I would like to pass along to the readers the very large example of this problem that I experienced.

With a Weston Wattmeter, I determined that the Chaparral Sierra III Integrated Satellite Receiver/Descrambler uses 85 true watts when ON and 80^^ watts when OFF. The descrambler and r-f/i-f *(Whazzatt ??? SK)* stay ON when TURNED OFF in order to receive updates to descrambler codes.

I have taken trips lasting several days with the whole thing un-plugged with no ill effects. Should the codes be changed while one is away, in just a short time the updated codes will be received.

73's and Best wishes.

Robert G. Hester, 12510 Nearwood Road, P.O. Box 226, Perblossom, California 93553-0226, Amateur Radio W6LYA

*Yep, the Phantoms be a pesky crew. I check my own Home Power system nightly before going to bed, and try to track any culprits down. My biggy is a computer modem with its power transformer on the wrong side of the switch. SK*

### A Note Of Caution Regarding Tankless Water Heaters

Dear HP Folks:

I told you back around issue #2 that you should charge me for your great little mag. Here's my six bills with no complaints.

I'd like to raise an issue about tankless water heaters. The January 1988 issue of Consumer Reports contains test results on four brands. Their conclusions fall rather short of substantiating the claims made by the manufacturers, especially on the issue of energy savings. While I do not consider Consumer Reports infallible, I do suggest that anyone contemplating purchase of such a unit read and consider this article first.

Sincerely, Lee W. Harwell, 1377 Genesee Street, Rochester, New York 14611-4201

*Thanks for your sub and the water heater pointer, Lee. SK*

### Fear Of The Unknown ?!?!

We have just started reading your magazine a few months ago and we are completely thrilled! We will be building our house out in the boonies this spring and your magazine is answering so many questions that we have. The stories are understandable and relevant. The advertisements are helpful too. Simply put -- your magazine has changed our thinking that alternative energy was a very strange, abstract, complex idea into one that is not only **exciting**, but logical and practical. We no longer fear the unknown. Thanks.

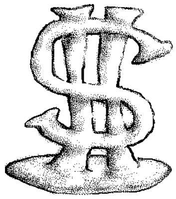
Larry and Renee Thompson, P.O. Box 79, Boonville, California 94515

*The Home Power crew blushes and thanks you back. SK*

**Letters To Home Power**

**Departmental Policies And Practices**

1. We print 'em unedited.
2. For publication, we like 'em short, sweet, practical, and positive.
3. We DO fix any extremely obfusucatory/painful errors of grammar, spelling, and/or usage.
4. We print full addresses, so folks can get in touch with you, unless otherwise specifically requested not to.
5. We get lots of great stuff, and everyone reads it all, but can neither print nor respond to each piece due to space/time crunches.
6. Thank you thank you thank you for the wondrous letters you all send. You are us.



# Home Power's Business

"The man who on his trade relies
Must either bust or advertise."
Thomas Lipton - 1870.

## Display Advertising

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| Full Page | $1,200 | 67.5 sq. in. |
| Half Page | $672 | 33.8 sq. in. |
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| Quarter Page | $377 | 16.9 sq. in. |
| Sixth Page | $267 | 11.3 sq. in. |
| Eighth Page | $214 | 8.5 sq. in. |

Maximimum Vertical Ad size is 9 inches
Maximum Horizontal Ad size is 7.5 inches

We can set up and lay out your display ad. Camera ready advertising is also accepted. For current, detailed reader demographics, call us.

Long term display advertising is discounted, so buy ahead and save.

Home Power is published bi-monthly. Ad Deadline for the April/May 90 issue (HP#16) is 15 March 1990.

Call **916-475-3179** for further details.

## International Subscriptions

Due to the high cost of international mailing & packaging, we must charge for copies of Home Power that are mailed anywhere that doesn't have a US ZIP CODE.

**2 YEAR- 12 ISSUES**
**INTERNATIONAL RATES:**

Canada: $16. Can. Contact Northern Alternative Power Systems, POB 14, Pink Mountain, BC V0C 2B0
Mexico: Air- $24. Surface: $21.
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South America ( except Columbia and Venezuela), Europe, North Africa: Air- $40. Surface- $23.
Asia, Australia, New Zealand,Pacific Ocean Islands, Africa (other than North Africa), Indian Ocean Islands, & the Middle East- Air $49. Surface $23.

**All payments in US currency ONLY!**

Surface shipping may take up to 2 months to get to you. All issues shipped in mailing envelopes to withstand the rigors of international mailing. If you have friends with a US Zip code who regularly send you packages, then we can ship them an extra copy for forwarding to you for $6 yearly.

## Home Power Mercantile

One insertion per customer per issue.
We typeset all ads. We do the best we can to make your ad look good. If you send too much copy, then you're bound to be disappointed. Flat Rate $80.
Advance payment only, we don't bill Mercantile Ads.
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Issues 2, 3, 4, 5, 6, 7, 8, 9,10,11,12,13, 14 & 15 are now available. Sorry no more Issue #1s are available.

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## Micro Ads

These ads are designed for individuals rather than companies. So use your discretion. The rates are 10¢ per character, including spaces & punctuation.
$15. minimum per insertion. Send check with your ad.

## Printing & Distribution Info for HP#15

# Copies Printed = 21,000
# Copies mailed under 3rd Class labels = 17,213
# Copies shipped in bulk = 2,117
Call or write for bulk shipment info.

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Home Power Magazine (6 issues) via FIRST CLASS US DOMESTIC MAIL for $20. Many of you have asked for faster and more reliable delivery of your issues. So here it is: FIRST CLASS HOME POWER.

## Third Class Home Power

Home Power Magazine (6 issues) viaTHIRD CLASS US DOMESTIC MAIL for $6. NOTE: Third Class mail is not forwardable. If you move, you must let us know.

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HOME POWER CLUB forming in ITHACA, NY. Exchange ideas, experiences, product info, frustrations, etc. Call or write for date and location of first meeting. Chris & Pam, RD1 Box 136A, Berkshire, NY 13736. 607-692-7103 (keep trying)!

FOR SALE TRACE 2012 INVERTER. 12VDC to 120vac, 2kW inverter. Contains the following factory installed options,110 amp battery charger and digital metering package. Cost $1440 new, sell for $1100. Excellent condition. Phone: 916-475-3428

JACOBS WIND ELECTRIC replacement parts, new blades, and blade-actuated governors. We make replacement parts and have new blades for most all wind generators, pre-REA to present models. Many used parts, too. Lots of used equipment available: wind generators, towers, both synchronous and stand alone inverters, and Aeromotor waterpumpers. Best prices on TRACE inverters and SOVONICS PV's. Information: $1; specify interests. Lake MIchigan Wind & Sun, 3971 E Bluebird RD., Forestville, WI 54213 Phone 414-837-2267.

ALTERNATIVE ENERGY EQUIPMENT CATALOG. Everything for stand alone power generation, PV's, Hydro-Electric, Wind Generators, Inverters, Water Pumps, Regulators, Refrigeration, Tools, Books, and much more. 92 pages with design guides. $3. US, $6. foreign: WESCO, Box 936-HP, REDWAY, CA 95560

FOR SALE HEART H12-1200X, 1200 watt ultra high efficiency inverter. 12VDC input, 120vac output, regulated RNS voltage. Reactive load compatible. Has 50 amp battery charger, standby mode for use as an emergency system. Excellent condition. $700. 916-475-3428

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LEARN TO TRAP, FARM, DREAM. Five Issues $9. Living Among Nature Daringly Magazine, 4466 Ike Mooney Rd., Silverton, OR 97381 Samples: $2.50.

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PURE CASTILE & VEGETARIAN SOAPS. Handmade in an AE environment of the finest ingredients, we have soaps, cremes, bath salts and more. Send for our FREE brochure: SIMMONS HANDCRAFTS 42295AE, Hwy 36, Bridgeville, CA 95526

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HEART INVERTER H12-1200SX, + Sears 100 amp 6/12 volt batt. charger. Both 4 yrs. old, ex. cond., inverter $800., charger $150. Both $900. For more info. write 2173 Rocky Creek Rd., Colville, WA 99114.

FOR SALE: Heart model HF24-2500SX, 2500 watt inverter, 24 volt input and SCI Charger Model 1. Both in excellent condition. Both for $900. Tom Casteel, POB 911, Fort Jones, CA 96032

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SOUND CHOICE magazine is a publication of the Audio Evolution Network, an open-minded organization dedicated to the positive evolution of independent music, audio art and related subjects. Send an SASE for more information, or $3 for 96 page sample to SOUND CHOICE, POB 1251, Ojai, CA 93023, USA

NEW BEST INVERTER M 24-2500. 24 DC to 120 AC/240 AC, 10,000 surge, modified sine wave, remote control terminal. $2000. 1/4 amp no load demand option available. FVZ Assoc. Box 61, Wardsboro, VT 05355

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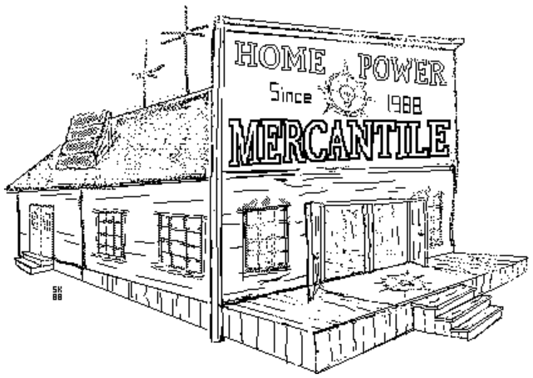


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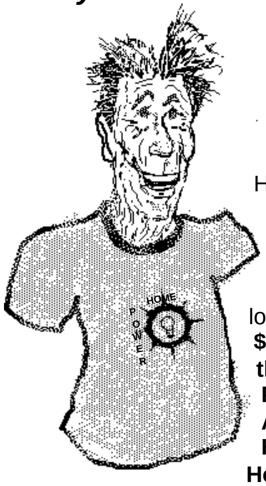


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