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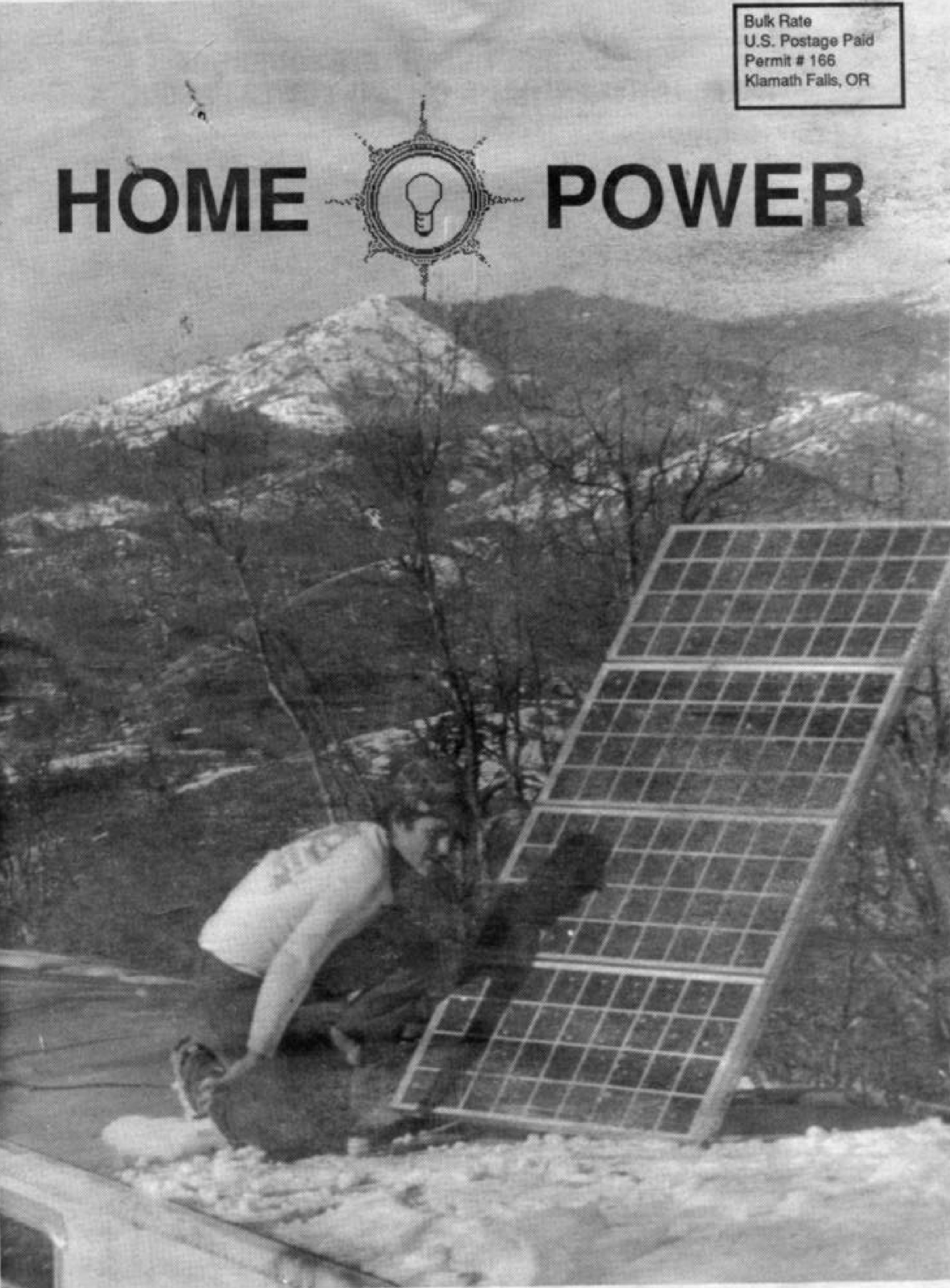

Home Power

Home Power People for Issue 2

Paul Cunningham
Windy Dankoff
Brian Green
Don Hargrove
Glenda Hargrove
Stan Krute
Alex Mason
Karen Perez
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& Laser Work by
IMPAC Publications
Ashland, OR

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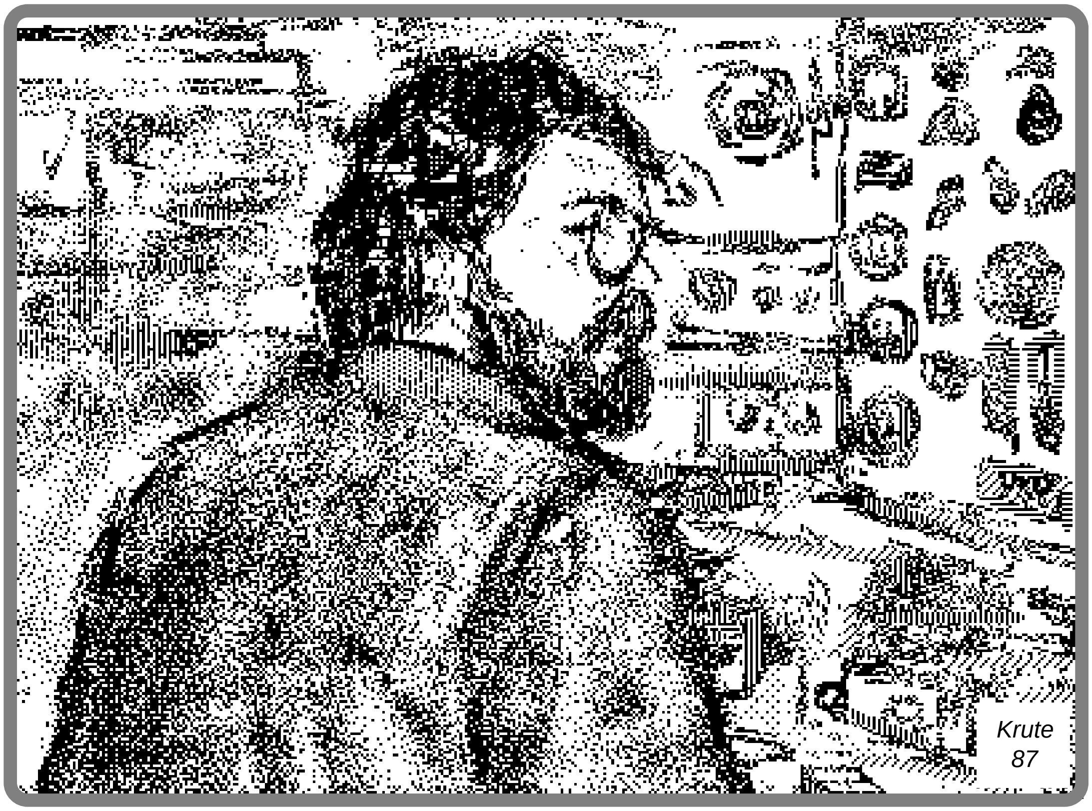


Thanks to all of you who responded to the first issue of Home Power. The support, praise, and information has been overwhelming. At times, working on the first issue, we wondered if anyone really cared about home style AE. We no longer doubt. Your response has replaced doubt with certainty. We are everywhere, and we care about energy and the environment.

Everytime another batch of subscription returns comes in (about 100 per day), all other work stops. Everyone opens and reads your comments. Your interest and support has warmed our hearts and given us the energy to carry on. It's like re-meeting old friends.

Many of you have asked who and what is Home Power Magazine. Well here are the facts of the matter. Home Power is basically 3 of us (Glenda, Karen & I) working full time, 3 others part-time and many folks contributing information and articles. We are not financially supported by anything or anyone other than the ad space we sell. We started Home Power about a year ago with less money than it takes to buy a used car. It took us 8 months to sell enough ads to put the first issue in your hands. It has taken us 2 months to sell enough ads to produce this issue. To date, all revenue has been spent on printing and mailing; no one has received any salary. We've been doing it for free because we have faith in this project and AE. We have high hopes. The challenge for us is to deliver Home Power to you free and make enough out of it to eat regularly. Time will tell.

Some of you have been sending money to help out. We thank you for this, it has certainly helped. We are not going to charge a subscription fee, even though many of you have written you would cheerfully pay for this info. However, if you can afford it, and wish to send us whatever you think Home Power is worth to you, then thanks. It'll help out.

For those who haven't yet responded to Home Power, please fill out the Subscription Form. Some of the forms have arrived damaged in the mails. If you are not getting your copy of Home Power, please let us know. We are listening to your ideas & comments. This issue has information you have requested. Keep telling us what you want to know and we'll do our best to get it into Home Power.

This month begins our THINGS THAT WORK articles. Many of you have asked for specific equipment tests and recommendations. Well, Home Power is supported entirely by advertising, so this puts us in a delicate position. Here is our idea concerning specific equipment testing and recommendations. Actually, its not really our idea, we borrowed it from Thumper Rabbit: "If you can't say something nice about something, then don't say anything at all."

We will test and recommend specific types and brands of equipment in the THINGS THAT WORK columns. In order for a piece of equipment to be featured in this column it must meet three criteria:

1) It must do its job as specified by its manufacturer. This is determined by actual objective testing in running AE systems.
2) The equipment must survive. Once again this is determined by real life testing in actual AE systems.
3) The equipment must represent good value for the money spent on it.

If you see equipment in the THINGS THAT WORK (TTW) columns, then you can purchase it and know that it met the three criteria above. Equipment not meeting these criteria will not be in the TTW column. This gives manufacturers that don't meet these criteria a chance to try again. We are a fledgling industry. A bad review can kill a small company. We are interested in fostering the growth of AE. And as such we are going to follow Thumper Rabbit's advice. Any comments on this?

Our Thoughts on Alternative Energy People

Consider AE people as pioneers. When we move beyond commercial power we have, by definition, moved to the edges of society. Power lines, like crime, disease and pollution, follow the spread of mass culture. AE people are truly pioneers. Not only in an electrical sense, but also on the frontiers of attitude and perspective.

What we are doing now is novel-- we make our own power instead of relying on someone else. We have chosen this for many reasons-- the best deals in property are beyond the power lines, the desire to do for ourselves, our concern for our environment, and many other reasons. Whatever the reason, we are all charting new routes to self-sufficiency and happiness. What we are doing now may be unusual, but our efforts point the way to a livable future we can all share.

Resources now used commercially to produce electricity are finite. We are using them up at an alarming rate. The consequences of unrestricted combustion, tinkering with the atom's interior, and damming our rivers are now apparent. "Only a stupid bird fouls its own nest." The world's peoples are looking for something better, something that can provide our power without polluting and bankrupting future generations.

Alternative energy users light the way to a better future. So, stand up, give yourself a pat on the back. You deserve it. Thanks for having the courage to look the future (not to mention the power company) in the face and not flinch.

We cannot personally answer your letters and comments, the volume is simply too great. We are starting a letters column in this issue. We encourage you to send your AE experiences to Home Power. We will print articles, comments and letters written by readers. The only requirement is the communication of information and experience. Home Power is a forum for this exchange. Information stands on its own merits, and any having merit will be communicated within these pages. So let other Home Power readers learn from your experiences. In the words of Bob Dylan, "You can be in my dream if I can be in yours." Let's dream together...

Rich, Karen, Glenda & the Whole Crew

Photovoltaics and Our Future-- an Editoral

by
Windy Dankoff

Our concept is site produced and consumed energy. ***Home Power.*** *Perhaps no source better fits our future energy demands than the photovoltaic (PV) cell. This editorial presents some thoughts on one of our possible energy futures, this one using the PV- RP.*

Solar cells are made of inert mineral materials, similar to ordinary sand. These cells convert light directly into electricity without moving or wearing parts. Silicon crystal cells have been in use since 1955 and their life expectancy appears to be limited by the materials sealing them from the elements. Today's high quality PV modules are a permanent investment-future improvements will NOT render them obsolete.

PV technology has significant advantages to the small-scale user:
1) PVs are **BENIGN**. In use, it consumes only sunlight and presents no significant hazards or environmental alterations. There is almost no way to abuse PV energy. Even short-circuiting the modules will not harm them.
2) PVs are **UNIVERSAL**. The world's largest megaWatt arrays are made up of small modules, similar to those used in remote homes. PVs are an energy technology where progress in utility/industrial scale systems trickles down to the small, independent user. PV modules produce energy from light, not from heat. In fact, they're most efficient when they are cold! We have sent PV systems as far north as the Arctic Circle. People simply don't live where the sun never shines. Everyone has PV potential!
3) PVs are **MODULAR**. You can start with a small array and expand as you wish.
4) PVs are virtually **MAINTENANCE-FREE**. You need not be technically talented to clean off leaves, snow or bird droppings.

As PVs Get Less Expensive...
Retail prices of PV modules have been dropping by ≈15% per year since the last big price breakthrough in 1979, when prices dropped 300%. Many people continue to wait for another big break to happen, and are quite unaware of the gradually decreasing cost of PVs. Technical innovations, reported as potential breakthroughs over the past ten years, are available NOW. The prices just never dropped suddenly enough to make front page news.

While we all anticipate continuing price drops, please keep in mind that the costs of the PVs themselves is only 20% to 40% of an installed cost of a typical PV home system. The general public continues to buy and use appliances and lighting that are so inefficient that even if PVs were free, few people could afford the huge battery bank, inverter, etc. required to power their homes. To continue present trends in energy abuse and waste, while waiting for price breakthroughs in PVs, is to completely miss the point of energy independence. The point is to pay attention to the design of an entire system, not just the price of the PVs.

As PV prices continue to drop, we foresee the use of more powerful solar arrays as a more significant trend than reduced system costs. Oversized PV arrays on homes will allow them to perform like the popular solar calculators, reliable even in dim light and affordable in cloudy climates.

What you see in this magazine-- efficient and reliable batteries, inverters, controls, appliances, and the techniques of energy management-- are the result of over 20 years of quiet revolution in energy technology. Right NOW, an estimated 30,00 American homes are powered primarily by PVs. In fact, you are already a PV user. Many of the radio/TV broadcasts you receive and the phone calls you make are relayed by PV powered satellites. The Home Power Magazine you are now reading is composed and illustrated using PV powered computers. An increasing number of appliances, from watches to yard lights, are PV powered. PVs have found many commercial uses-- radio repeaters, livestock watering, electric fencing, ocean navigation buoys, billboard & sign lighting, and the monitoring of remote pumps, pipelines, and the weather. The uses of PVs are only limited by our audacity and imagination.

PV technology stands ready to economically and reliably serve the greater public. All that stands between us and a healthier, solar powered society is OUR understanding, acceptance and support. PVs are ready for us. One purpose of this magazine is to get US ready for PVs.

Windy Dankoff is the Owner and Operator of the Windlight Workshop. He's been doing it right since 1977. You can write him via POB 548, Santa Cruz, NM 87567. Check out his ad on page 40.

A Working PV/Engine AE System

by
Richard Perez

Many readers of Home Power are asking for real examples of working AE systems, complete with specific equipment lists, performance data, and cost analysis. Well, we hear you and here is the first of our system reports. Please remember that this and all working systems represent a compromise between many factors. Location, electrical power needs, finances, and hardware availability all make their impressions on the working system. Alternative energy systems are a process: we enter and leave this process in the middle. Nothing here ever really has a start or a finish. Changing needs and emerging technologies make it best to plan for change. So read ahead and see how this family rolls their own power.

Location & Site:

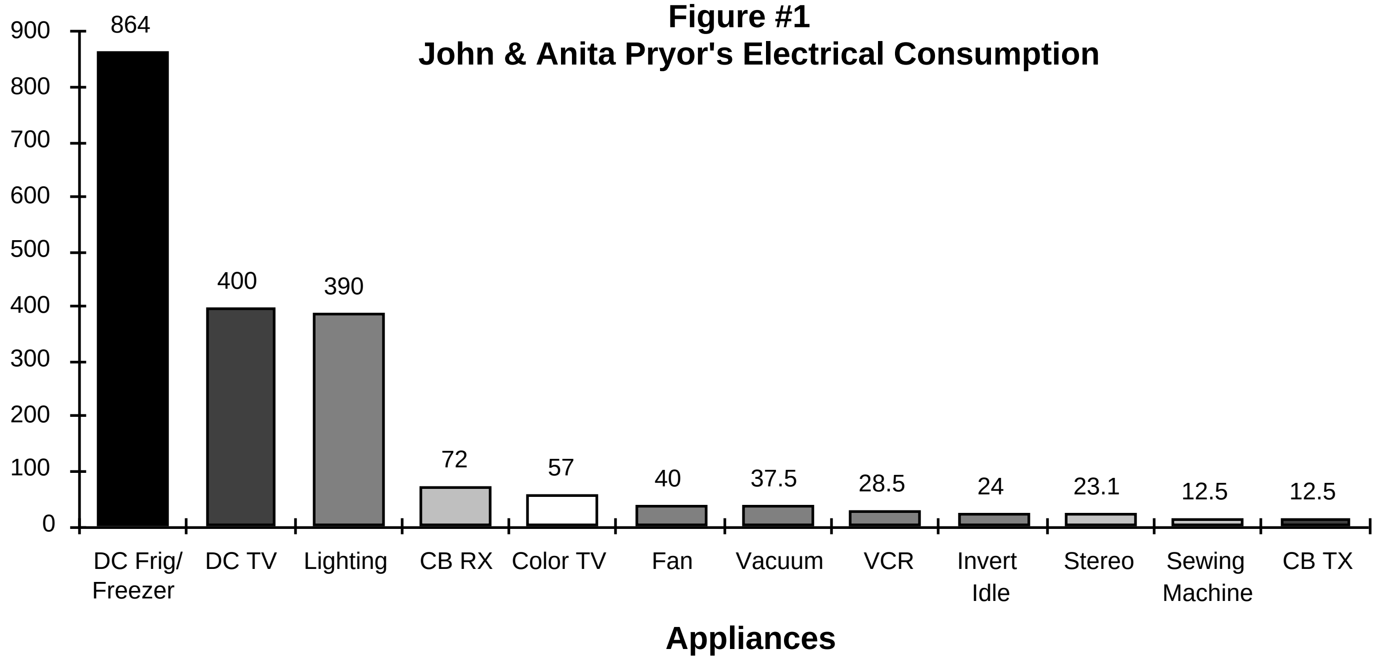
John and Anita Pryor live high in the Siskiyou Mountains of Northern California. Their homestead is about 3 miles from the nearest commercial utility. Altitude is about 3,200 feet with a panoramic view of Mt. Shasta some 50 miles to the South. Solar insolation is about 240 full sun days yearly. While the location appears to have wind potential (at least in the Summer), no real survey of wind conditions has been made at the Pryor's location. Water sources at this site, while more than enough for domestic use, lack the fall or flow for hydro power potential. The commercial electrical utility wants just under $100,000. to run the power lines to John & Anita's homestead.

Electrical Power Usage

The Pryor's household represents a fairly standard consumption profile for two people living on alternative energy. Their appliances include a 12 VDC electric refrigerator/freezer, a 12 VDC B/W TV set, 120 VAC lighting, 22" color 120 VAC TV, 120 VAC Video Cassette Recorder, 120 VAC Sewing Machine, various 120 VAC kitchen and household appliances. A detailed profile of how John & Anita use their homemade electricity is in the column graph shown in Figure 1.

The vertical axis of the graph is calibrated in Watt-hours per day, while the horizontal axis details the various appliances. The Pryor's total electrical power consumption is about 2,030 W-hrs. per day. Their consumption is both 12 VDC from the batteries, and 120 VAC from the inverter. DC portion of the consumption is about 1,372 W.-hrs./day, while the remaining

Figure #1
John & Anita Pryor's Electrical Consumption



656 W.-hrs./day are AC via the inverter. John and Anita are into energy conservation, their daily electrical consumption is less than 20% of the average American household.

DC Appliances

From the graph it is very apparent that the largest single user of electricity in John & Anita's system is the 12 VDC refrigerator/freezer. This 12 cubic foot refrigerator/freezer consumes about 860 Watt-hours per day on the yearly average. While this amounts to 48% of the energy the Pryors produce and use, it is very low in comparison with conventional refrigeration. Specialized AE refrigerator/freezers are initially more expensive than their standard household counterparts, but they quickly pay for themselves by saving energy.

Two other DC appliances are worthy of note. The 12 VDC B/W TV allows low powered viewing and doesn't require the use of the inverter. The CB radio is the homestead's only communication and is also 12 VDC powered. Note that the receive and transmit states of the CB are detailed separately in the consumption profile. This technique works for other appliances that consume energy at differing rates as they perform their functions.

AC Appliances

The Pryor's use about 390 W.-hrs. per day in lighting. They are currently using 120 VAC fluorescent types for about half their lighting, with incandescent 120 VAC lightbulbs picking up the remainder. All lighting is powered via the inverter. John is going to installing 12 VDC fluorescent lighting in the future.

All other usage of 120 VAC really doesn't amount to much in terms of energy consumption. This is one nice feature of inverter type systems. Standard household appliances such as color TVs, stereos, vacuum cleaners, and sewing machines can be used with the inverter. Even though some of these appliances consume substantial amounts of energy while running, they are only running occasionally for short periods of time. Consider the case of a vacuum cleaner. A vacuum may consume some 400 Watts of power, but if it is only used about 5 minutes daily, then its total energy consumption is about 33 Watt-hours per day. Not a very substantial amount of power when compared with the cleaning wonders accomplished by the vacuum. The situation is much the same for many AC appliances.

SYSTEM HARDWARE

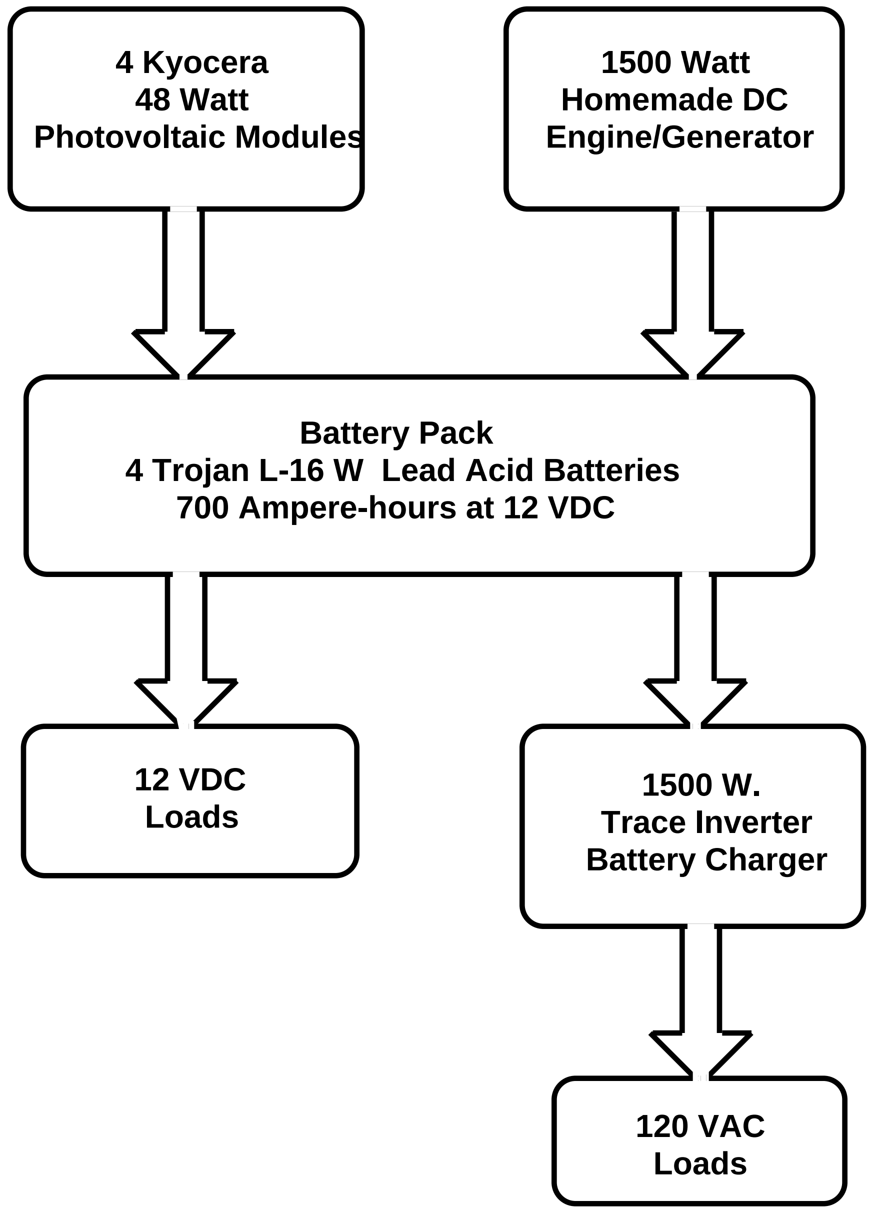
The AE system the Pryors are now using was first specified and modeled by the EnergyMaster computer program. This program, written by the Electron Connection Ltd., simulates the operation and costs of solar/engine systems. Its use allowed the Pryors to properly size their system to meet their specific needs at the lowest possible cost. A diagram on this system is contained in Figure 2.

Power Sources

The Pryors use two energy sources- photovoltaics and a homemade 12 VDC gasoline engine/generator. The computer specified eight PV panels, each 48 Watts, for this system. However, finances forced John and Anita to make do with only four 48 Watt Kyocera photovoltaic modules. These 4 modules produce about 950 Watt-hours of energy on an average sunny day at John & Anita's location. This makes their system about 47% solar powered. One of the nice things about PVs is their expandability. John and Anita can add more panels to their system whenever they wish. The cost of the four Kyocera PV modules was $1,400.

The mounting rack made by John and Anita is simple to build, very strong and inexpensive. This rack uses standard

Fig. #2- Pryor's AE System Diagram



hardware store materials and adapts easily to wall, roof, or ground mounting. The rack also allows seasonal elevation adjustment of the 4 panels it holds. Construction of this rack is covered in this month's Solar article. The cost of the mounting rack was $75.

The remainder on the power is produced by a homemade engine/generator set. This unit uses a single cylinder, horizontal shaft, gas engine to drive an automotive alternator. This engine/generator set is capable of delivering 40 amperes of 12 to 16 VDC directly to the batteries. A field controller, made by Electron Connection, regulates both the alternator's output current and voltage. Details for the construction of this engine/generator and its control system are featured in this month's Engine section.

While this generator does consume gas and is noisy, it allows the Pryor's to get by until they have more PVs. When they do add more PVs to their system, then the generator quietly recedes into the background, only to be run during extended cloudy periods. Such an engine/generator costs about $750. to construct. This represents a first class job- Honda OHV motor, high Amp. alternator (we like the 100 Amp. Chrysler models), welded steel base, control system and heavy cast pulleys.

Power Storage

John and Anita use four Trojan L-16W batteries to store their electricity. This series/parallel battery pack stores 700 Ampere-hours of 12 VDC energy. This amounts to about 8,600 Watt-hours of storage. Once the batteries have been derated by 20% (if you don't know why, then see Home Power #1- Battery article), there is 6,900 Watt-hours of usable energy stored in the battery. At the rate that John and Anita consume power, this battery pack stores about 3.3 days worth of energy for them. The cost of their batteries was $880. With proper care we expect these batteries to last about 10 years. Details on proper battery cycling and care are in Home Power #1.

John & Anita located the batteries in their kitchen directly opposite their woodstove. While Anita is not happy about having them inside, she realizes the importance of keeping her batteries warm in the Winter. The preceding year, the Pryor's kept their batteries outside in the cold. They noticed the substantial decrease in the batteries capacity due to cold temperatures.

Power Conversion

The Pryor's are using a Trace 1512 inverter with built-in battery charger. This inverter converts the DC energy produced by the PVs and stored in the batteries into conventional 120 VAC, 60 cycle house power. It has a rating of 1,500 Watts output. John purchased the built-in battery charger even though he now lacks the 120 VAC powerplant necessary to drive it. John is looking forward to the day when he will have a large AC generator to handle periods unusual power consumption.

The Trace contains a metering package that is very useful. John and Anita rely on this package for most of their system metering. This LED digital meter reads battery voltage, charge current from the built-in charger, and peak voltage plus frequency of any 120 VAC power source feeding the charger. This metering package is just the ticket for generator users. They can adjust the frequency of their powerplants using this meter's information. The Trace's battery charger accepts 120 VAC from a powerplant and recharges the batteries. John now has a small 650 Watt, 120 VAC Honda generator, but it lacks the power to effectively run the 80 ampere charger in the Trace inverter. The best it can manage is about 27 Amps into the batteries. This inverter cost John and Anita $1,458. with the optional charger and metering package.

John and Anita have nothing but praise for their Trace inverter. It powers all the AC appliances they brought with them to their mountain home. John likes the way he can use his wall full of stereo and video equipment. Anita spends many hours working with her sewing machine. All these appliances are standard 120 VAC household models. The Trace inverter makes their operation possible and efficient on PV produced, battery stored, DC energy.

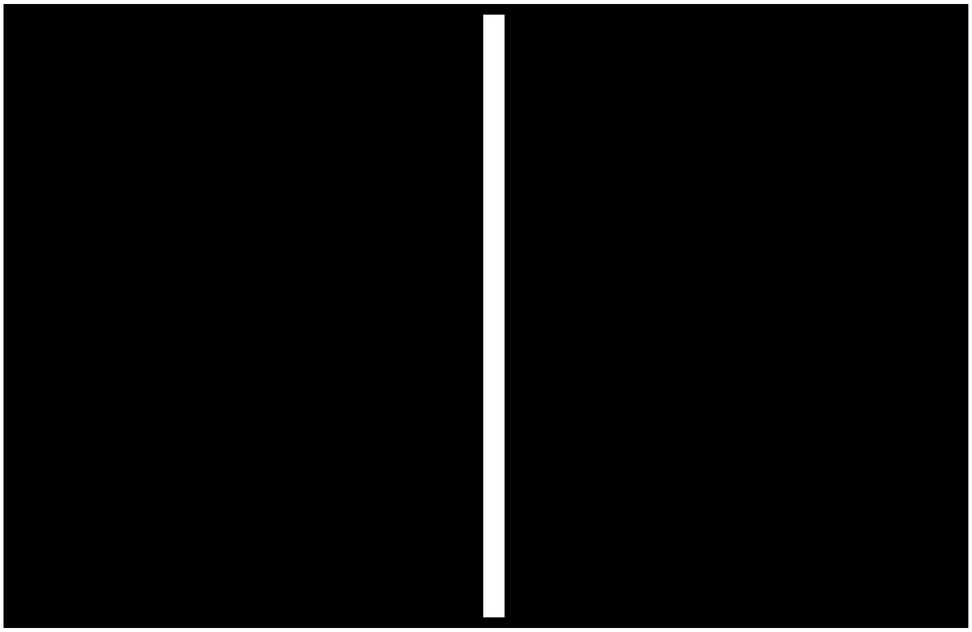
SYSTEM OPERATION

The batteries will store enough energy for 3.3 days of operation. On an average basis, the four PV panels extend this storage period to about 5 days between generator rechargings. This amounts to generator operation about every 4 days during the Winter months and about once a week during the Summer. John and Anita are putting some 1,100 hours yearly on their mechanical generator. This costs them about $30. per month in fuel and maintenance.

John and Anita are their own power company. They both watch their battery voltage and electrical consumption like hawks! Generating their own electricity has taught them the lessons of conservation and energy management. They are looking forward to completing their system by adding more PVs and more batteries. Four more PV modules will make them almost totally solar powered. This will reduce their operating expenses and allow them to use more energy. Anita has a washing machine on the back porch that she's giving the eye.
Since the data was collected for this report, John has moved his refrigerator/freezer. This move from the warm kitchen to the much colder back bedroom has cut John's wintertime power consumption by about 40%. One such details the success or failure of AE systems rest.
John reports that no matter the season, he can leave his system unattended and be sure of ice cubes in the freezer & full batteries when he returns. Thanks to the four PV modules on the roof. Since the four modules only produce 12 Amps or so in full sun, there is no need for regulation. The full current output of the modules is about a C/50 rate, far too slow overcharge the hefty L-16 battery pack of 700 A-H.

System Cost Data

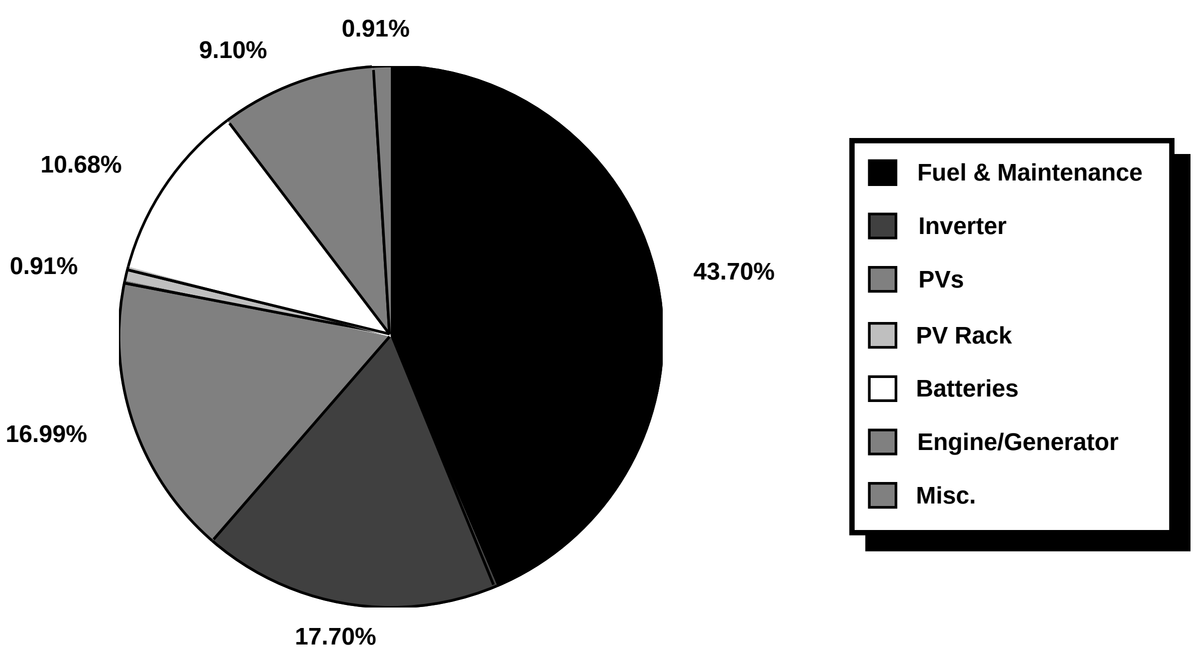
The Pryors have spent about $4,700. on hardware to this point. This is substanially less than the $100,000. or so the power company wanted just to run in the lines (never mind the monthly bill). With a current operating cost of $30. per month, this system supplies their electricity at about $1.10 per kiloWatt-hour. This figure includes all hardware and fuel amortized over a ten year period. Fig. 3 shows how the money is spent in this system. Note that their expenditure for fuel is still substantial. If you add it all together, it costs John and Anita about $8,000. to buy and operate the system they now have for a ten year period. Not a bad solution to back country electrical needs. And at 8% of the power line cost! With the addition of 4 more PV modules, the system will become more efficient and produce its power for about $1.00 per kiloWatt-hour. These additional panels will reduce the generator operating time to 450 hours yearly and the operating



cost to about $10. per month. It will also extend the average storage in the 4 batteries from 5 days to over 11 days.

That's it for our first system review. Please write us and let us know if this is what you had in mind. Once again, this is a real, operating system; not a computer simulation. While it may not be texbook ideal, it does show what can be done with initiative, perserverance, and a limited budget. If you want to correspond directly with John and Anita Pryor, drop them a line at POB 115, Hornbrook, CA 96044.

Fig. #3- The Bottom Line-- Where John & Anita's AE Bucks Go



How to Mount and Wire PV Modules

by
Richard Perez

This article explains how to make your own PV mounting rack, how to install it, and how to wire up the whole works. This is in response to many reader requests for this info. So, all you PV panels languishing under beds, relaxing in closets, and vacationing in garages: Listen Up, here's your chance to get your people to put you in the Sunshine to do your thing.

Face It SOUTH

The critical consideration in mounting PV modules is the yearly path of the Sun. The PV modules must receive maximum sunlight. Consider shading from trees and buildings. The decision of where to mount should be made only after careful consideration of all your options.

The PV modules, in most nontracking situations, should face South. The closer the plane of the rack is to facing true South, the better overall performance the PVs will deliver. Only consider mounting surfaces that are within 15° of facing true South (within 10° is much better). Any surface further off will require more complex, asymmetrical mounting racks. If you don't have a roof or wall that is suitable consider ground mounting. Since PVs produce low voltage DC current, keep the wire lengths to the battery as short as practical. See the Basic Electricity article in this issue dealing with wire sizing in low voltage DC systems for specifics.

Where you are going to put your PVs determines the type of rack you need. Roof mounting (on either pitched or flat roofs), wall mounting, and ground mounting are all possibilities. So consider the variables and pick the best for your situation. These racks can be used in all three types of mountings.

So Which Way is South?

Determine South with a good compass and someone who knows how to use it. Be sure to allow for the difference between magnetic North and true North. This difference is called magnetic declination. In California for example magnetic North is some 19° East of true North. If you don't know your magnetic declination, then go to the library and look it up.

Mounting Racks-- your PVs hold on the World

The obvious purpose of the rack is to attach the panels to a fixed surface. At first glance this seems simple enough, but consider wind, snow, falling ice and temperature variations, not to mention possible leaks in the roof!

We are going to talk about a simple to build rack that can hold up to four panels. This rack uses inexpensive hardware store parts. It mounts on roofs, walls, or on the ground with the appropriate foundation. In all mounts, the rack is adjustable for panel elevation, and allows seasonal optimization of the racks tilt. This rack approach was developed by Electron Connection Ltd. for its customers. Its design and application are so simple that I'm sure many others are using just about the same technique.

The Rack Materials

The rack is constructed out of slotted, galvanized, steel angle stock. This stock is available at most hardware stores. Our local store sells National Slotted Steel Angle (stock #180-109) for about $7.00 each retail. This stuff is 6 feet long, with two perpendicular sides each 1.5 inches wide. The stock is about 1/8 inch thick, with a heavy galvanized coating. Its entire length is covered with holes and slots that will accept 5/16 inch bolts. We have had no problems with corrosion or electrolysis with this galvanized stock after three years in the weather. We haven't yet tried this material on a seacoast, and would welcome feedback from anyone who has. To the left is a drawing of a typical length of this steel angle.

You can shop around locally, and may encounter different sizes and lengths. Six foot lengths are long enough to mount 4 of just about any type of module. We use this angle on Kyocera, Arco and Solec panels without having to drill any holes in either the angle or the PV modules. Working with this stock is like playing with a giant erector set. The only tools you really need are wrenches, a hacksaw (to cut the angle), and a drill for making holes in the surface holding the rack.

The amount of steel angle stock you need depends on the size & number of panels you wish to mount, the mounting location, and your particular environment. Let's consider the rack shown in the photoon the next page as an example. This rack holds four 48 Watt Kyocera PV modules and is bolted to the almost horizontal metal roof of a mobile home. Each PV module is 17.4 inches wide and 38.6 inches long. The mounting holes on the bottoms of the PV modules match the hole cadence in the slotted angle. This particular rack used 9 of the 6 foot lengths of the steel angle. Four lengths comprise the framework for the modules. Three lengths make up the legs and bracing, while two more lengths are used as skids on the roof. Strictly speaking, the skids are not essential, but do add rigidity and relieve stress on the mounting points on the sheet metal roof. We don't want any leaks.
A rack could be built with the about half the materials. The top and bottom pieces of the rack holding the panels, the brace on the legs, and the skids could all be deleted. If this were done then the rack would be roughly equivalent to most commercial models. In our opinion, PV modules should be mounted as securely as possible. Many commercial racks use the PV modules' frames as a structural members in the whole module/rack assembly. This rack does not do this. Many

commercial racks use 1/8 inch aluminum angle. This rack uses steel of the same thickness; it is much stronger.

This rack lives in snow country, with lots of high winds. Consider that the rack holds some $1,400. worth of PV modules. We figured that the additional $35. the extra bracing costs to be worth it in terms of security. It's comforting to be inside during a howling snow storm and know that when its all over the PVs will still be there. Don't skimp on materials for your rack. Use extra bracing to make it as strong as possible. Remember that it holds over a thousand dollars worth of PV modules. The 9 pieces of slotted angle cost us about $65., and are well worth it.

Laying Out the Rack

You could design the entire rack on paper after first making all measurements of the critical dimensions on the modules. This takes time, and is subject to measurement inaccuracies. We have a simpler idea, with no measuring required. Let's treat the entire project like an erector set. We assemble the entire rack on the ground first, even if it must be disassembled to be finally installed. This assures no surprises upon final installation.

Lay a thick blanket or sleeping bag on a flat, smooth surface. Place all the modules, face down on the blanket and lay on the side angle pieces that connect the panels. See the diagram.

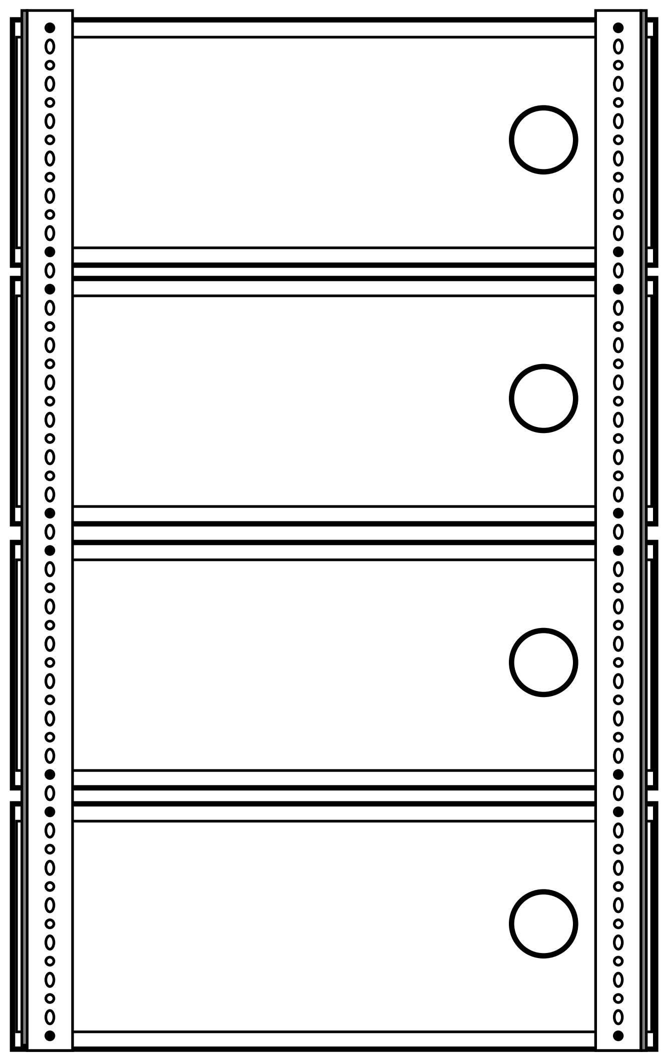
Note that no measurement is required. Simply align the mounting holes in the module frames with the holes on the angle. We usually leave any extra angle on these pieces, rather than trimming it off. It comes in handy. On this particular rack the 4 Kyocera modules mounted perfectly, with no trimming of the 6 foot side rails necessary. The distance between the mounting holes on the modules determines the width of the rack.

Cut two pieces of angle to form the top and bottom rack rails. These should be trimmed exactly to fit inside the framework created by the side rails. The net result is all four panels are encased by a perimeter of steel angle. Use 1/4 inch bolts about 1 inch long, washers, lockwashers, and nuts to secure the modules to the framework. The bolts on the corners of the framework go through the module, the side rail, and the top (or bottom) rail. The result is very strong.

If you don't have four panels to put on the rack right now, you can use several pieces of angle stock in place of the missing panels. We strongly recommend building the four panel version. If you don't, then system expansion is going to be harder. Also building a smaller rack costs about as much when the waste on the 6 foot lengths of angle is considered. So build for the future, and see how easy it is to add a panel or two once their rack is already in place.

The Skids

We usually leave the skids uncut six foot lengths. The skids form the base for roof, wall or ground mounting. If the rack is to be wall mounted the situation is much the same except the skids are vertical instead of horizontal. In all cases, one end of the skid is connected directly to the module frame rails by bolts. This forms a rotating hinged point for rack elevation adjustment. This hinge line points East and West (so the rack faces South) in horizontal applications, and up in vertical



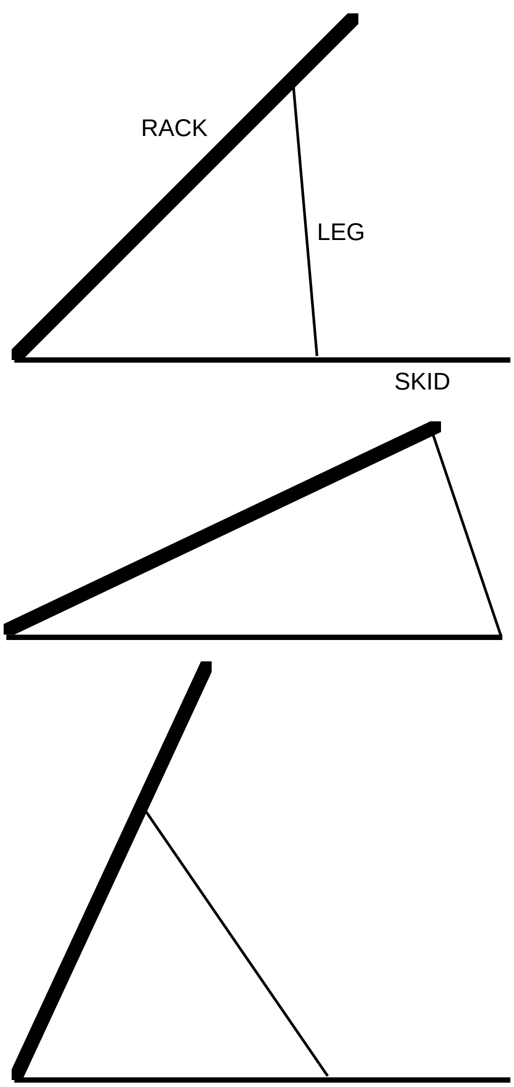
applications.

The Legs

The actual length of the legs varies depending on where the rack is mounted, your latitude, and whether or not you want adjustability. The slant or pitch of a roof is another factor that determines the length of the legs. Let's consider the simplest case, that of mounting on a flat roof or on the ground. In this case the skids are horizontal and level with the ground. Figure 4 illustrates the geometry of this situation for adjustable racks for latitudes around 40°.

In the adjustable rack at 42° latitude, the legs are 3 feet, 4.25 inches long. Altitude adjustment is accomplished by unbolting the legs and repositioning them along the rack rails and mounting skids as shown in Figure 4. On a horizontal surface these 3+ foot legs allow adjustment of the angle between the rack and horizontal from 32° for Summer use, to 57° for Winter use. Twice yearly adjustments during the Spring and again in the Fall increase the PV output by about 5 to 8%. This is really not a very great increase in performance, but the success or failure of an AE system depends on attention to detail. We personally consider that a 5% increase in our PVs performance is well worth the twice yearly expenditure of 15 minutes of our time to adjust the rack.

Fig. 4- Rack Geometry



On roofs that are not horizontal (and most aren't), the legs get shorter as the roof gets steeper. A good overall, nonadjustable, mounting angle is your latitude. If you live at 40° latitude, then mount the rack so that the angle between the rack's face and horizontal is 40°. The table shows the proper leg lengths for South facing roofs and a variety of latitudes. This table assumes the use of 6 foot rack rails and skids. The top of the table contains roof angles from 0 degrees (flat) to 60 degrees from the horizontal. The left side to the table shows latitude in 5 degree increments. The actual leg lengths in feet are in the body of the table.

Consider someone living at 38° latitude with a 25° slant on his roof. The table shows a leg length of 1.36 feet. Note that this table shows leg length decreasing as the roof's angle approaches the latitude. Once the roof's angle becomes greater than the latitude, the legs are attached to the bottom of the rack rather than the top. Instead of raising the top of the rack to face the Sun, we raise it's bottom.

If you're into math, the formula used to generate this table is based on the Cosine Law. Here is a solved and generalized equation that will give leg lengths for all situations regardless of rack or skid dimensions, latitude or roof angle.

L= length of the Leg in feet
R= length of the Rack in feet
S= length of the Skid in feet
P= the angle of the roof's plane to the horizontal in degrees
A= your latitude in degrees

The geometry is much the same for wall mounting, but the skids are vertical. In any case, don't be afraid to mount the skids however you must, adjust the rack's elevation, and cut the legs to fit. This approach while, low tech, gets the job done

MOUNTING SURFACE ANGLE

LATITUDE	0.00	5.00	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	50.0	55.0	60
60	6.00	5.54	5.07	4.59	4.10	3.61	3.11	2.60	2.08	1.57	1.05	0.52	0.0
55	5.54	5.07	4.59	4.10	3.61	3.11	2.60	2.08	1.57	1.05	0.52	0.00	0.5
50	5.07	4.59	4.10	3.61	3.11	2.60	2.08	1.57	1.05	0.52	0.00	0.52	1.0
45	4.59	4.10	3.61	3.11	2.60	2.08	1.57	1.05	0.52	0.00	0.52	1.05	1.5
40	4.10	3.61	3.11	2.60	2.08	1.57	1.05	0.52	0.00	0.52	1.05	1.57	2.0
35	3.61	3.11	2.60	2.08	1.57	1.05	0.52	0.00	0.52	1.05	1.57	2.08	2.6
30	3.11	2.60	2.08	1.57	1.05	0.52	0.00	0.52	1.05	1.57	2.08	2.60	3.1
25	2.60	2.08	1.57	1.05	0.52	0.00	0.52	1.05	1.57	2.08	2.60	3.11	3.6
20	2.08	1.57	1.05	0.52	0.00	0.52	1.05	1.57	2.08	2.60	3.11	3.61	4.1
15	1.57	1.05	0.52	0.00	0.52	1.05	1.57	2.08	2.60	3.11	3.61	4.10	4.5
10	1.05	0.52	0.00	0.52	1.05	1.57	2.08	2.60	3.11	3.61	4.10	4.59	5.0
05	0.52	0.00	0.52	1.05	1.57	2.08	2.60	3.11	3.61	4.10	4.59	5.07	5.5
00	0.00	0.52	1.05	1.57	2.08	2.60	3.11	3.61	4.10	4.59	5.07	5.54	6.0

every time.

Mounting the Rack on a Roof

A roof is a difficult place to do a good job. The steeper the roof, the more difficult the installation. On steep roofs we prefer to assemble the whole rack, complete with PV modules (already wired together), legs and skids on the ground. Then transfer the whole assembly (about 50 pounds) to the roof for final mounting. We have successfully used the skid mounting technique on metal, composition shingle, composition roll, and shake roofs from 15° to 45° of pitch.

Don't mount the PV modules themselves directly on the roof's surface. PV modules require air circulation behind them to keep them cool. If you are blessed with a pitch that equals your latitude and a South facing roof, please resist the temptation to mount the modules directly on the roof. The high Summer temperatures underneath the modules will greatly reduce their performance and can cause the actual PV cells to fail. So leave at least 2 to 3 inches behind the modules for air circulation .

$$L = \sqrt{R^2 + S^2 - 2RS \cos(A-P)}$$

Use at least 4 bolts (5/16 inch diameter) to secure the skids to the roof. Use large fender washers inside the roof, and lockwashers on the outside. Liberally butter the entire bolt, washer and hole in the roof with copious quantities of clear silicone sealer. When everything is tightened down and the silicone sealer has set, we have yet to have any problems with leakage.

Ground Mounting

If you are ground mounting, take care to pour or bury a massive cement foundation for securing the skids. Ground mounting exposes the PV modules to all sorts abuse. They may be hit by everything from baseballs to motor vehicles. So pick your spot wisely, and provide lots of mass to hold the rack to the ground. Cement blocks, or poured cement strips are best.

Wiring the PV Modules Together

PV modules are usually set up for 12 volt operation. The module contains between 32 to 44 PV cells; each cell is wired to the next in series. Thus the voltage of all the cells is added to produce a nominal 14 to 20 volt output for recharging batteries in 12 VDC systems. Each PV module is a selfcontained polarized power source. Each module has a Positive terminal and a Negative terminal, just like a battery.

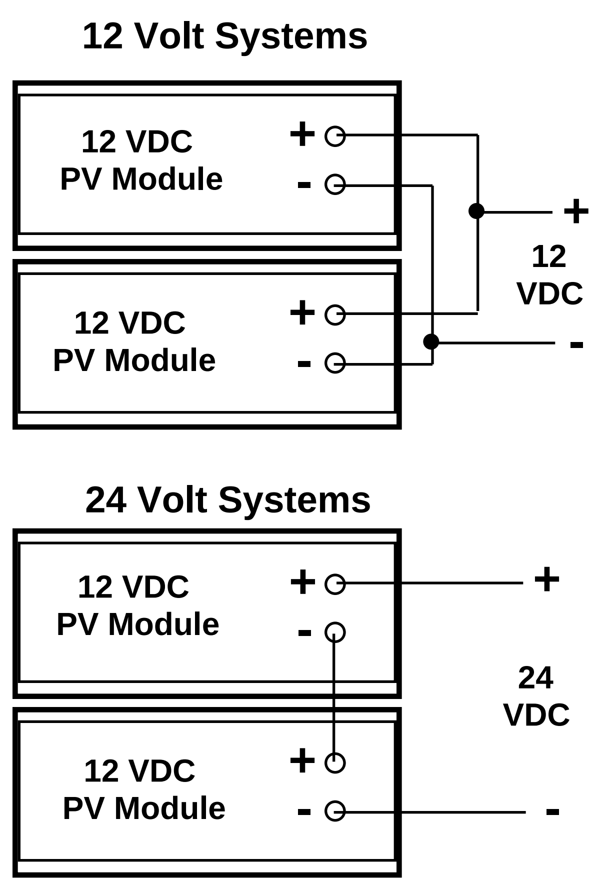
The PV modules can be wired in parallel which adds their current, or in series which adds their voltage. Systems using 12 VDC will wire the modules in parallel, which systems using 24 VDC or higher will wire the modules in series. Figure 5 illustrates the basic idea of either series or parallel wiring of PV panels.
Use good quality heavy gauge copper wire (THHW or THHN insulation) to make series or parallel connections between the individual PV modules. Solder all possible connections. Most modules use mechanical ring type connectors to connect the wiring to the actual panel. If you use these connectors, solder the wire to them, don't just crimp the wires into the connector. Use shrink tubing instead of tape on all wire to wire connections. Be sure to use polarization indicators on all wires. We use red tape at the ends of all positive wiring.

Wiring the PV arrays to the battery is straight forward, using only two lines. These two wires carry the entire current of the array. Total wire length (consider both wires) and array current determine the wire gauge size necessary. See the Basic Electricity article on low voltage wiring in this issue for specific info on determining the wire gauge necessary for your PV array.

It is a very good idea to electrically ground the framework of your panels and rack. Make a good solid electrical connection with the rack with a bolt assembly through one of the rack's slots. Use at least 8 gauge wire connected to an 8 foot long, copper flashed, ground rod. Drive the ground rod at least six feet into the ground. Adequate grounding eliminates static build up on the panels during thunder storms and may reduce the possibility of actual lightening strikes on the panels.

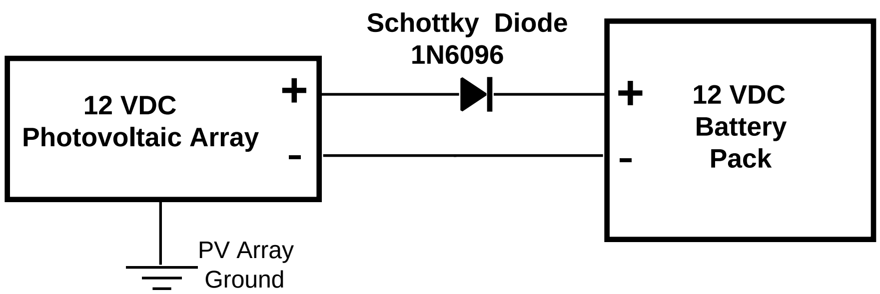
The only remaining electrical element in the system is the addition of a diode to keep the array form discharging the battery overnight. Our testing indicates that SOME panels don't really leak too badly at night. For example, without a blocking diode we measured a 44 cell in series Kyocera

Fig. 5- Wiring the PV Modules



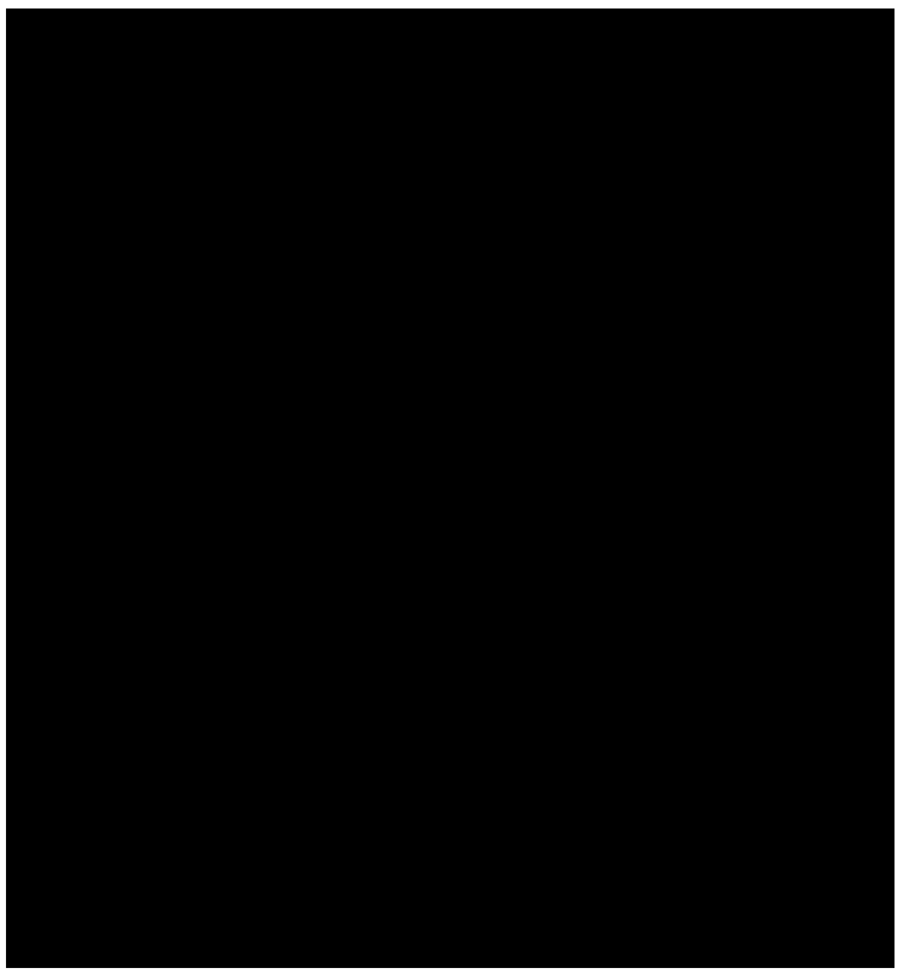
module as leaking only .002 amperes at night. We, however, still use a low loss diode inserted forward bias in the positive line between the PV array and the battery. Use a Schottky (hot carrier) power rectifier with a current rating at least double the current output of the PV array. Use the appropriate voltage rating for your system. The hot carrier type diodes have about one third the voltage loss of regular silicon diodes. Figure 6 is a wiring schematic of the 12 VDC sample PV system shown in the photograph in Figure 2.

Fig. 6- PV System Schematic



This wiring diagram does not contain any regulator for the PV system. Many systems do not require a regulator for the PVs. A good rule of thumb is: IF your PVs don't charge the batteries at more than a C/20 rate, AND if the system is ALWAYS being used, then you do not need regulation. In other cases, wire the regulator into the system following the manufacturer's instructions.

This article gives you the basic information so you can figure out what to do for your own particular system. If after reading this, you don't feel comfortable the concepts involved, please seek the aid of someone to help. Proper positioning, mounting and wiring of your PVs is essential if they are deliver their maximum power.



Back Country Communications

by

Brian Green- N6HWY

Now that you are settled down on your AE homestead, what do you miss most about city life? Ma Bell? The ability to communicate with the outside world? I hope to pass on some alternatives for those living beyond the telephone lines.

When I made the big move from the San Francisco Bay area in the Fall of '74, AE was an extension cord from my "62 Chevy to an old car radio in my travel trailer. Pacific Power and Light poles were a mile from my place. That spring there was enough cash to buy a CB radio, but not much else, so I built an antenna. No biggie, in '65 I had an amateur license, novice class. Using 17 feet of wire, 30 feet of coax feed line and a mast made of 2 x 2's, I put together an antenna and could talk to folks! That's how I met Richard Perez, N7BCR and his lovely wife Karen, KA7ETV.Of course, our Ham tickets didn't happen right away but the sharing of information did. Over the years, lots of AE ideas and information have been chewed on over the air while drinking our morning coffee.

Fun and games aside, the ability to contact the outside world has saved life and limb on more than one occasion. Case in point: when my friend's wife was injured while cutting firewood, (a branch flew up and shattered her sunglasses, lodging a piece of glass in her eye). He was able to use the radio in their truck to call someone in town, who in turn phoned the hospital. An Opthomologist was waiting for them when they arrived in the emergency room and the eye was saved. Thanks for being there, Dave Winslett KF6HG.

I know there are some Hams out there among our readers, I just don't know how many. There are also many who would like to get their tickets. It is a bit of work to get the code and theory down; however, it's worth it since it opens up a whole new world.

If Ham radio isn't your thing, CB can provide local communication with like-minded people. It also gives you access to that emergency phone call and is inexpensive.

Another alternative is the mobile telephone. These phones range from simplex through a local switchboard to full duplex, just like the telephones downtown.

In future issues, I'm going to go into detail on each of these forms of communication. I'll cover costs, availability, limitations and accessing information.

This writing business is pretty new to me. I'm a forklift operator by trade, so how about some feedback for this column? Information sharing is what this whole thing is about.
73 (Best Wishes),
Brian Green
13190 Norman Drive
Montague, CA 96064

Hams mobile on Interstate 5 between Weed, CA & the Oregon border can give us a call on 146.400 simplex. Somebody is usually around from 0800 to 2400, PST.

Seeking Our Own Level

by
Paul Cunningham

This second issue of Home Power Magazine gives me the opportunity as Hydro Power editor to wax philosophical. A chance to put aside thinking about the "hows" of generating electrical power from water and to reflect on the whys, by still waters, of course.

Around a decade or more ago a certain realization was taking hold. Yes, we could escape the prescribed route of greater specialization, consumerism and urbanization that North American culture had mapped for us. The ultimate metaphor for carving out our new lifestyle from the social and spiritual wilderness was to generate our own electricity from wind, sun, and water. Home Power. We were and are literally putting the power back into our own hands. It was a matter of the amperage and the ecstasy. Becoming more conscious of our energy generation and consumption also brought the realization that we really needed very little electricity to be comfortable.

So where are we now?

This is difficult to assess since the people involved are by their situation a very decentralized group. Yet, I receive letters from all over the world from people who know something about head and flow, nuts and volts, and also from those who don't, but believe in the magic of turning water into electricity. The truth is, we are everywhere. We are part of an unnoticed, but vital and growing, network of people who are interested in generating their own power. And now this spectrum has broadened to a great degree.

Reasons for small-scale power generation range from the practical (beyond the commercial power lines) to the environmental (small scale generation is less harmful than megaprojects or nukes). The original trickle of backwater hydro power enthusiasts has swelled. Water, of course, is not deterred by obstacles-- it flows over them, wears them down through time and seeks its own level. Something like this is happening with the alternative energy movement in general. The part that is successful has persevered and attracted a following on its own terms.

A very interesting aspect of this movement is what can be offered to the developing countries. Progress does not have to mean expensive large projects and centralization of power generation. Individual people can master this simple, small scale technology. This mastery will dramatically change their lives. Just a little energy production can produce vast improvements in the quality of life. Alternative energy can provide lights for a village to work or read by, or power pumps to move water for drinking or irrigation, or power tools for cottage industries. The possibilities of alternative energy are endless and revolutionary. The surface has barely been scratched.

So Let's Change...

Clearly the world needs a new blueprint for development and change. Alternative energy is definitely part of this new blueprint. At least, there is now some groundwork in this field that proves its viability . This, alone, is an accomplishment. This magazine will help in a technological and philosophical exchange of ideas. Home Power is a forum for small scale alternative energy. Right now there is no other publication that seriously addresses the requirements and interests of people involved in personal power production. We need a higher profile if we hope to be one of the keepers of the light.

It is unclear why home-sized water power, in particular, is so little known. It is true that other forms of comparable energy sources receive far more attention. The supreme reliability of photovoltaics and the romance of wind power are well established. Somehow the use of residential sized hydro-power has been largely overlooked. Part of this is likely due to the sound of the output figures. Although a water power system may produce 100 watts of power 24 hour per day, it sounds like so much less than a PV (or wind) system that has a peak output of 1,000 or 2,000 watts. Yet the water system could easily produce more total power output over a given time span. And be much cheaper.

I read recently in a magazine (New Shelter) a comparison of three types of alternative energy systems. It was stated that "experts agree" that a hydro site capable of less than 500 watts continuous output is simply not worth bothering with. It is safe to say that a wind or PV system with this level of output would be at least a five figure investment. My own household operates on a maximum of 100 watts of continuous power input and runs quite successfully on less when water flow drops. Please understand that all forms of alternative energy technology are site specific. At any given location there may be compelling factors that favor one form. This site specific nature still doesn't explain the low proliferation of water power.

This discussion does not imply competition between the various forms of alternative energy. The situation is one of cooperation rather than competition. Many times more than one type of power generation can be used to produce a hybrid system that is both more reliable in output and more cost effective than a single source. The point being made is simply that the very useful source of water power should not be overlooked.

So far no large business has attempted to develop the personal sized hydro market. The advantage to the small manufacturer like myself, of course, is that we can still remain in business. The small hydro market has such a low profile that raising it by any means would probably be helpful to all involved. At present, none of the few small manufacturers has the business machinery to aggressively promote their product or to greatly increase production if it was required. The industry is in its infancy.

A Look Forward

Improvements in magnetics and electronics make possible devices that would be a quantum leap ahead of the present day offerings. Higher-frequency generation using the new super magnets, coupled with solid state switching, could create cheaper and more efficient machines. Although more advanced machines are not strictly needed, a certain amount of R&D is necessary to produce any product. This will continue and is healthy for both the industry and the consumer.

But thus far the machinery itself is not the limitation on its use. The consciousness of the market is controlling the growth of alternative energy at this time. This became very clear to me when I first started my business. Most of my sales went to the U.S. West Coast even though my location is in Atlantic Canada.

The main work needing to be done is increasing the awareness of potential alternative energy users. So you corner the market. What if there is no market? I believe the market is unlimited but no one has noticed. This is certainly the case in developing countries. Most areas have little or no power. And these people are not likely to be reading our English language publication.

So This Is The Challenge!

To spread the word any and every possible way. This is why we are here with Home Power. Hopefully this will set in motion the realization that we (and our planet) will benefit more from small local power systems than the centralized capital-intensive types.

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I NOW use alternative energy (check one that best applies to your situation).

- ☐ **As my only power source**
- ☐ **As my primary power source**
- ☐ **As my backup power source**
- ☐ **As a recreational power source (RVs etc.)**

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- ☐ **As my backup power source**
- ☐ **As a recreational power source (RVs etc.)**

My site has the following alternative energy potentials (check all that apply).

- ☐ **Photovoltaic power**
- ☐ **Water power**
- ☐ **Wind Power**
- ☐ **Other**______________________

I now use OR plan to use the following alternative energy equipment (check all that apply).

NOW	FUTURE		NOW	FUTURE	
☐	☐	**Photovoltaic cells**	☐	☐	**Gas or diesel generator**
☐	☐	**Wind generator**	☐	☐	**Batteries**
☐	☐	**Water power generator**	☐	☐	**Inverter**
☐	☐	**Battery Charger**	☐	☐	**Control systems**
☐	☐	**Instrumentation**	☐	☐	**PV Tracker**

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- ☐ **Wind Power**
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Build Your Own 12 VDC Engine/Generator

by
Richard Perez

This small, easy to build, generator is the answer to a burning AE question. What do we do when the sun doesn't shine, the wind doesn't blow, and the creek dries up. This generator is a back up power source for times when our AE sources don't meet our demands. It is optimized to do only one thing-- properly recharge batteries.

Engine/Generator Overview

Before we actually discuss the construction of this engine/generator, let's examine the job it is designed to do. It is the nature of this task that determines the various design decisions we need to make when constructing this back up generator and its control system.

Source Capacity

Every AE system should have at least one power source capable of recharging the batteries at between C/10 to C/20 rates of charge. For example, a battery pack of 700 ampere-hours periodically needs to be recharged at a minimum of 35 amperes (its C/20 rate). To figure the C/20 rate for your pack simply divide its capacity in Ampere-hours by 20. The resulting number is the C/20 rate in Amperes. The C/20 rate is the minimum necessary for equalizing charges. If the batteries cannot be equalized they will fail more rapidly.

Power Source Control

Most energy sources that charge batteries need to be controlled. If the charging source is not controlled, then the batteries may be overcharged or charged too rapidly. They can be ruined. The most common method of control is voltage regulation. This works fine in cars and in batteries with shallow cycle, float service. Voltage regulation alone is not enough for deeply cycled batteries. They must also be current regulated to prevent too rapid recharging.

Voltage Regulation

Voltage regulation only is OK for batteries that are very shallowly cycled. In shallow cycle service the battery refills almost immediately since it has only had a small amount of its energy removed. In deep cycle service the batteries have had about 80% of their energy removed before recharging. If deep cycle batteries are recharged from a source that is voltage regulated, they will be charged at the total output current of the source as it struggles to bring the batteries immediately to the set voltage limit. If the charging source has say 55 amperes available, then it will charge the batteries at this 55 amp. rate. If the battery is a 100 ampere-hour battery, then the C/10 rate for this battery is 10 amperes. The 55 amperes from the source would recharge the 100 ampere-hour battery at a rate over five times faster than it should be charged. This will result in premature battery failure, higher operating costs, and much lower system efficiency.

Constant Current

Constant current charging means that the batteries are recharged at a fixed amperage rate until they are full. The voltage of the batteries is left unregulated until the batteries are full. The rate of charge is usually between C/10 and C/20. Constant current charging assures that the batteries are not charged too rapidly. Rates of charge greater than C/10 produce heat which can warp the heavier plates of the deep cycle batteries. Too rapid recharging wastes energy in heat, and gradually ruins the batteries.

Solar Cells and Wind Machines

It is easy not to put up enough wind or solar to do the job. Wind and solar sources are currently expensive enough that the tendency is not to buy enough power to adequately run the system and recharge the batteries. If you are running stand alone wind or solar sources be sure that they can deliver at least a C/20 rate to your batteries. Wind and solar systems also need a motorized backup to provide constant, on demand, power for equalizing charges.

Motorized Powerplants

The motorized plant is reliable, high in power, and relatively cheap to purchase. The motorized source has the distinct advantages of delivering large amounts of power when you need it. This is very different from wind and solar systems, where you have to take it when you can get it. Its major disadvantage is that it requires fuel. Motorized sources do not usually suffer from being undersized. If the power source is capable of delivering between C/20 and C/10 rates of charge to the batteries, then the system is happy.

Lawnmower Engines and Car Alternators

The idea here is to use a lawnmower engine (or other small horizontal shaft motor) to drive an automotive alternator. The alternator puts out between 35 and 200 amperes (depending on its size) of 12 to 18 volt DC energy to charge the batteries. The first engine we used actually came from an old lawnmower we bought for $35. We got a 35 ampere Delco alternator from a dead Chevy in the junkyard for $15. We bolted the entire works to a thick wood slab, and used an old oven heating element as a crude resistive field controller. The unit ran and charged our 350 ampere-hour battery for 2 years before the motor died.

Type and Size of Motor

We've since tried many different combinations of motors and alternators. Small gas motors between 3 and 8 horsepower are ideal for this job. We found that the Honda small engines will run about 5,000 hours without major work, Tecumseh engines about 800 hours, and Briggs & Stratton engines about 600 hours. The Honda also has the advantage of a 100 hour oil change interval, compared with 25 hours for both the Tecumseh and the Briggs & Stratton. If you consider the operating life and operating cost of small engines, then the higher quality units are much less expensive in spite of their higher initial cost. The engine's size is determined by the size of the alternator. This assures a balance between system efficiency and cost. A 35 ampere alternator can be driven by a 3 hp. motor. A 100 ampere alternator needs at least a 5 hp. motor. For alternators between 100 and 200 amperes use the 8 hp. motor.

Type and Size of Alternator

Just about any automotive alternator will work in these systems. What really counts is the size of the alternator. Its current output (amperage rating) should be sized to match the capacity of the battery pack. The more capacity the battery pack has the bigger the alternator which charges it must be. The alternator must be able to deliver at least a C/20 rate of charge to the batteries. We have had good results with 35 ampere Delco alternators for battery packs under 700 ampere-hours. Batteries up to 1,400 ampere-hours are fed with the 100 ampere Chrysler alternators. Packs larger than 1,400 ampere-hours should have a 200 ampere rated alternator. The higher amperage alternators are measurably more efficient than the smaller ones.

The higher amperage alternators are more difficult to find. Try your local auto electric shops, they may have a source for these high amp jewels. Regular alternators up to 70 amperes are usually available from junkyards at less than $20. Alternator rebuilders can provide rebuilt units from $40. to $150. These alternators are a good investment. They are designed to run under the hood of a hot car on a Summer's day. In the type of service we give them they run cool and last a very long time. I've seen these alternators last over 10 years with just the replacement of bearings and brushes.

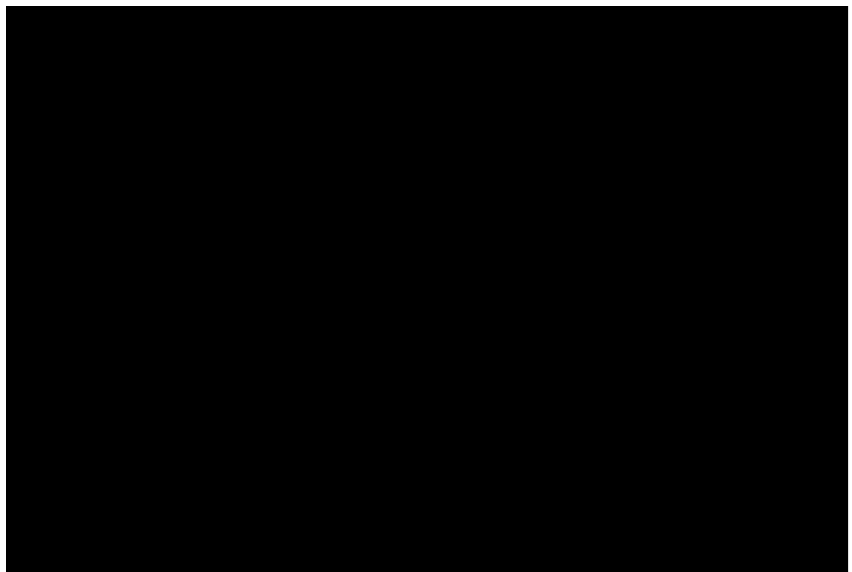
The more modern alternators contain their voltage regulators within the alternator's case. These internal regulators need to be disabled before these alternators are useful in this system. If you can't do this yourself, then take the alternator to an alternator shop for help. Some alternators have what is known as an "isolated field", these need to have one field lead grounded and simply feed positive energy to the other field lead. The older Delco types are very simple and straight forward to use, they require no modification.

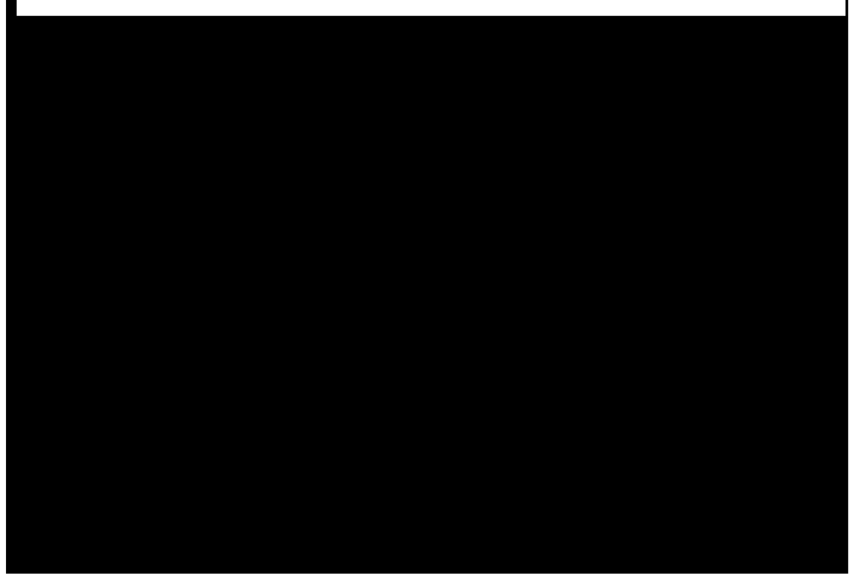
Getting it all together- Assembly

We originally bolted both the alternator and the motor to a wooden slab about 16" by 24" and 4 inches thick. Be very careful on this step. If the motor pulley and the alternator pulley are not properly aligned, then the unit will wear belts out very rapidly. These units work best on heavy metal bases. There is a lot of vibration and the wooden slabs give up after a few years. Either add a sheet of 1/4" to 3/8" steel between the wood and the motor/alternator, or make the base completely out of metal. A local welding shop made us a base out of 3/8" steel plate with a welded 1" by 2" steel square tubing perimeter for $50. You can see it in the photograph. If you can weld the materials cost about $18.

We coupled the alternator to the motor with an "A" sized Vee belt. Keep the belt length to a minimum by mounting the motor and alternator close together. We use belts between 28 and 33 inches in total length. The stock pulley on the alternator works well. The best sized motor pulley is between 5 and 6 inches in diameter. This pulley ratio gears up the alternator for better efficiency while allowing the motor to run about 2,200 rpm. We have had very poor results with the lightweight cast aluminum pulleys. These light pulleys were not up to the job and broke frequently. We're now using cast and machined iron pulleys (such as the Woods SDS pulleys) that work very well and are extremely rugged.

Use heavy bolts with lock washers to secure everything to the base. Be sure to get the alternator turning in the right direction. Electrically it makes no difference, but the alternator's fan is designed to suck air from the back of the alternator and to exhaust this air in front around the pulley. If the alternator's fan is running backwards then the alternator will





overheat when heavily loaded.

Use large wire to hook up the output of the alternator. Something between 6 gauge and 2 gauge is fine, depending on the length of the runs. Locate the motor/alternator as close as possible the batteries. This keeps power loss in the wiring to a minimum. Consult the Basic Electricity article in this issue for details.

Control Systems

The first motorized charger we built worked fine, but we had problems controlling it. We were using a stock car voltage regulator. It wanted to charge the batteries far too quickly; in many attempts the large load stalled the motor. We have experimented with many forms of control for the alternator and have finally arrived at several which work well.

All alternator controls work by limiting the amount of power supplied to the alternator's rotating magnetic field. All alternator control starts with controlling the field's energy.

Car Voltage Regulators

Car voltage regulators will not work well in deep cycle applications. The regulator makes its decisions based only on the system's voltage. This is fine with the average car battery which is cycled to less than 1% of its capacity before being refilled. The deep cycle battery, however, is almost empty when it is recharged. The car voltage regulator attempts to instantly bring the system's voltage to about 14 volts. A 12 volt deep cycle lead-acid battery will not reach a voltage of 14 volts until it is almost filled. The net result is that the car regulator dumps the entire output of the alternator into the batteries until they are full. This is most always too much energy too fast for a fully discharged battery.

To compound the problem, the car regulator's voltage limit is set too low for deep cycle service. This low voltage limit means that the batteries are charged too slowly when they are almost full, resulting in many extra hours of generator operation to totally fill the battery pack. Since the car regulator is set at about 14 volts, we are unable to raise the system voltage up to over 16 volts for the essential equalizing charges.

Resistive Field Controller

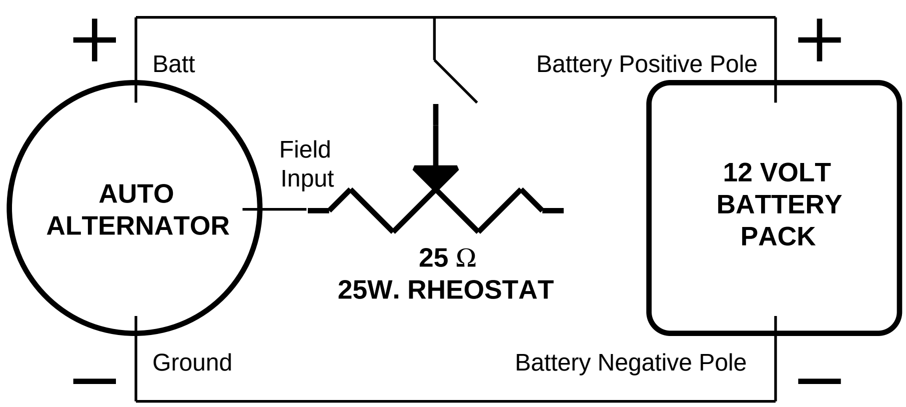
The simplest and cheapest form of alternator control is to use resistance to limit the amount of energy that is fed to the alternator's field. The idea is very simple, insert resistance between the battery's positive pole and the wire feeding the alternator's field. Resistance in the neighborhood of 2 to 25 ohms works well. Adjust the resistance until the charge rate into the battery is between C/20 and C/10. The less the resistance in the field line, the higher the amperage output of the alternator. Originally we used a nichrome wire heating element from an old electric stove as a resistor. We used more or less wire (hence more or less resistance) with a wire clip lead. It worked fine. A better resistor to use is a 0 to 25 ohm rheostat (an adjustable power resistor) rated at least 25 watts. This allows smooth adjustment of the alternators output. Figure 2 shows the wiring hookup for a resistive field controller.

Using resistive field control produces a system which is current regulated only. The resistive circuit does not provide any form of voltage regulation. When the batteries are full the system voltage can get very high, over 16 volts. Voltage this high can damage 12 VDC appliances that are on line at the time. The highest voltage for most 12 volt equipment is 15 volts. If you are using resistive field control, be sure to monitor the system's voltage and reduce the current output of the alternator to keep the system voltage under 15 volts when appliances are being used.

Mk. VI Electronic Field Controller

We eventually solved the problem of control by designing a series of electronic field controllers that regulate both the amperage and the voltage of the alternator. With this electronic field control, we simply set the desired charge rate, and set the system's voltage ceiling. The battery is recharged at a constant rate until it is full. When the batteries are full, the voltage limit predominates and the system is voltage regulated, thereby protecting the batteries from overcharging. And also protecting all electrical equipment on line. The amperage output is adjustable from 0 to the full rated output of the alternator. The voltage limit is adjustable from 13.5 volts to 16.5 volts.

Fig. 2- Resistive Field Controller



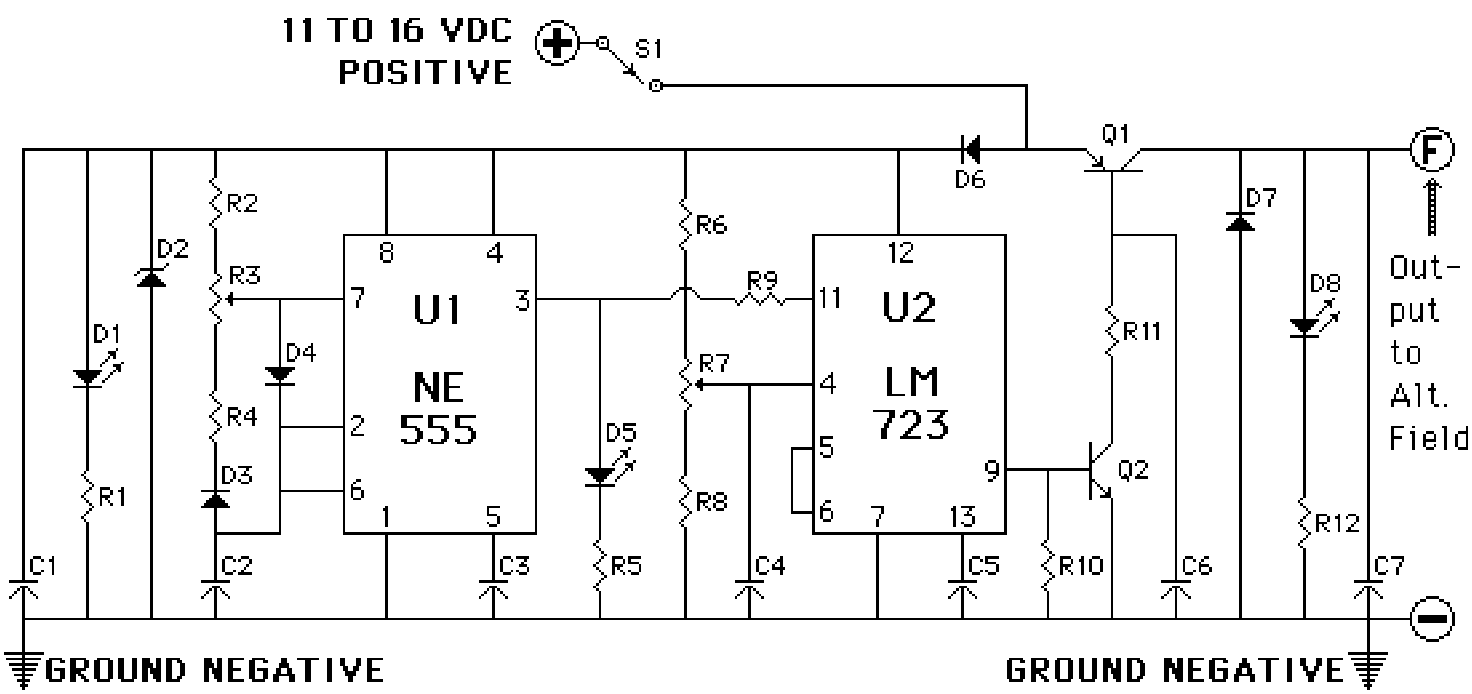
For the intrepid electronic builder, this electronic field controller's schematic is included. This field controller uses off the shelf parts available at Radio Shack. Printed circuit boards, kits, and completed field controllers are available from the Electron Connection Ltd., P.O. Box 442, Medford, Oregon 97501. Complete installation and operating instructions are included. Write for more info.

Motorized Sources for Equalizing Charges

The motorized source is the best type to use for the equalizing charges. Its voltage output is capable of being adjusted to over 16 volts in order to accomplish the equalizing charge. The motorized source is capable of delivering a C/20 rate of charge for the least 7 continuous hours necessary for battery equalization. Remember the batteries must already be full before the equalizing charge is started.

Users of solar and wind systems should consider constructing a lawnmower powerplant just to equalize their batteries. The very nature of wind and solar energy makes it very difficult to equalize the batteries without such a motorized power source. This generator makes excellent backup power for times when Mother Nature isn't cooperating with our energy demands.

MARK VI FIELD CONTROLLER



Integrated Circuits
U1- NE555 Timer, in 8 pin DIP
U2- LM723 Voltage Regulator, in 14 pin DIP
Transistors
Q1- MJE 2955, or any PNP with Ic>5 Amps.
Q2- 2N2222A
Diodes
D1- Red LED
D2- 18 Volt Zener
D3 & D4- 1N914
D5- Yellow LED
D6- 1N4004
D7- 1N1202A, or any 3+ Amp. diode

Resistors
R1, R5, R9, & R12- 1 KΩ
R2- 4.7 KΩ
R3- 100 KΩ Potentiometer
R4- 4.7 KΩ
R6- 3 KΩ
R7- 1 KΩ Potentiometer
R8- 3.3 KΩ
R10- 4.7 KΩ
R11- 100 Ω, 10 Watts
All resistors 1/4 Watt & 5% unless otherwise noted.

Capacitors
C1 & C7- 0.1µf
C2- 0.047 µf
C3, C4, & C6- 0.01 µf
C5- 0.0001 µf
All capacitors are 25 Volt rated

The Fireside

by

Don Hargrove

To understand our increasing need for renewable energy, we must know that our future lies not in the hands of those who abuse, but in the hands of those who efficiently use our valuable resources.

In this and future articles I will discuss heat: its definition and its use. By being aware of this basic technology, we can gain a working knowledge of heat's daily application in various systems.

WHAT IS HEAT?

Heat is a form of invisible energy. Only the work that heat does can be seen. For instance: when the gas in your automobile engine is ignited, the burning gases expand. This expansion causes a release of heat (energy), which in turn causes work to be done. This work then becomes mechanical energy.

TEMPERATURE AND HEAT

All matter consist of molecules in motion. This motion is defined as internal energy or heat. The amount of this internal energy depends upon how rapidly the atoms or molecules are moving. The faster these particles are moving, the hotter the object is and the higher amount of internal energy it contains.

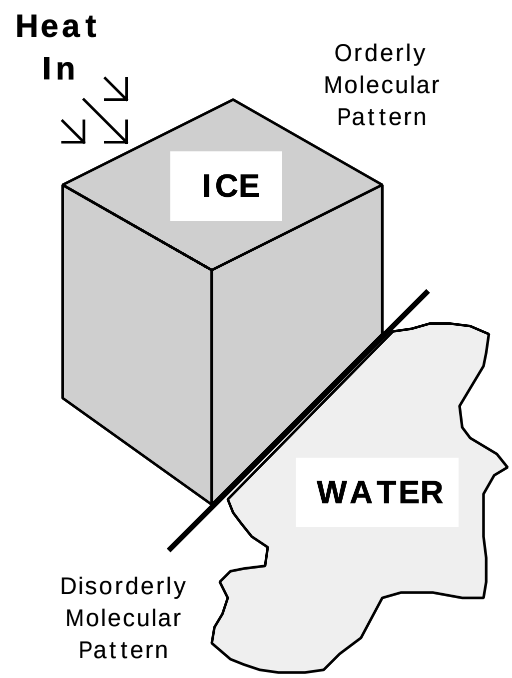
TEMPERATURE is an indication of an object's internal energy. A thermometer measures this in degrees; Fahrenheit and Centigrade (Celsius) being the two most common scales. The temperature of an object determines if that object will gain or lose internal energy. Heat always flows from a hotter object to a colder one. This is a temperature "hill". Like water, heat flows downhill. The greater the difference in temperature between two objects, the steeper the hill, and the faster the heat will flow between the two objects. The hotter object is giving up some of its internal energy to the colder one. Given enough time, these two objects will equalize their temperature.

It is important to remember that heat and temperature are not the same thing. Temperature is an indication of the amount of internal energy and heat is the transfer of this internal energy between two objects. Heat is measured in two basic units: BTUs (British Thermal Units) and calories. One BTU is the amount of heat needed to raise one pound (approximately one pint) of water one degree Fahrenheit. One calorie will raise one gram (0.035 ounce) of water one degree Centigrade. These units are calculated at sea level atmospheric pressure (one atmosphere).

Heat and temperature tell only part of what is happening. Let's look at what happens to an object when heat flows into it. As the heat raises the internal energy of the object, its molecules start moving more rapidly. The more heat an object has, the more disorderly its molecular pattern becomes. Science defines the amount of disorder in a system as entropy.

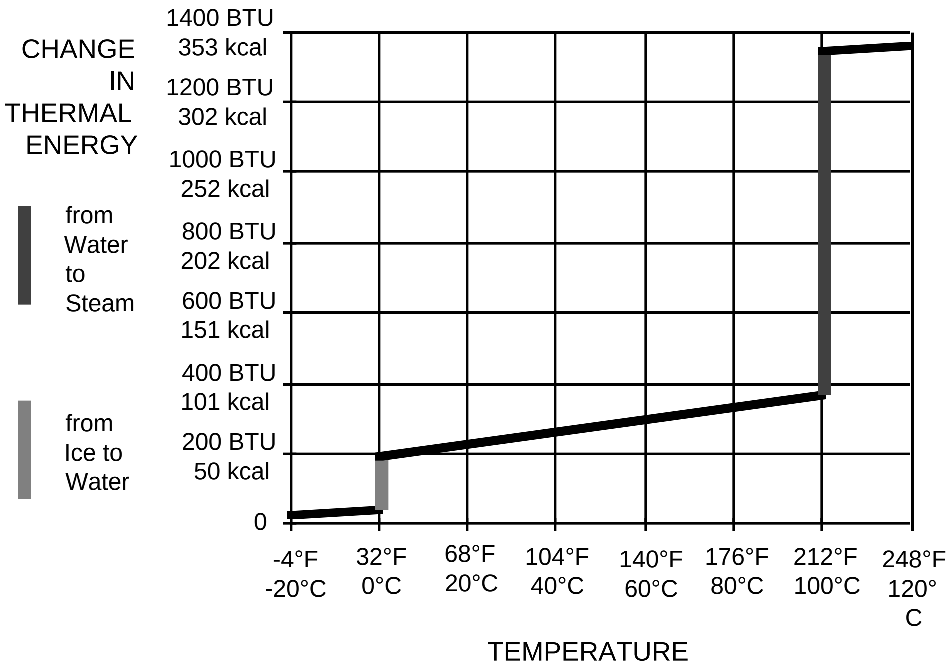
Heat flowing from an object will decrease its internal energy, its amount of molecular disorder, and thus its entropy. The temperature of the object will usually change, according to the direction of heat flow, but not always. When an object changes its physical state (from solid to liquid to gas), energy, disorder, and entropy change, but the temperature will remain the same until the particular change of state is completed.

As an example of heat content versus temperature see the following graph. It shows how many BTUs are required to raise one pound of water from -4°F to 212°F at sea level (1 atmosphere). For comparison, kilocalories (1000 calories=1 kilocalorie) are also given. It takes 1 calorie to raise the



temperature of 1 gram of water 1 degree Centigrade.
454 grams = 1 pound
454 calories = 1.8 BTUs
1.8/454 = 0.00397 BTUs in 1 calorie
454/1.8 = 252 calories in 1 BTU
252/1000 = 0.252 kilocalories in 1 BTU
Note that there is no change in temperature until there is a change of state. Ice stays at 32°F until it is completely melted. To accomplish a complete change of state from ice to water requires 144 BTUs of latent heat. Now that the ice has completed its change to water, each added BTU will cause a rise in temperature of 1°F, until the water reaches its boiling

Energy, Temperature & Changes of State for One Pound of Water



point of 212°F. At this point, 972 BTUs are required to complete another change of state from water to steam. The temperature, however, remains at 212°F until all the water has become steam. Once again, the temperature will start rising 1°F for each BTU added. There is one added requirement for the temperature of the steam to continue rising. Steam is water in its gaseous state. Were it not contained, this "water vapor" would simply expand and eventually recondense elsewhere. Therefore a high pressure vessel is needed to contain this expansion. Now, any addition of BTUs to the vessel containing the steam will cause a corresponding rise in temperature. The water molecules within this steam now have a very high internal energy and they are moving at an extremely high rate of speed.

HOW HEAT TRAVELS

Heat passes from one place or object to another by three methods.

CONDUCTION is the movement of heat through a material without carrying that material along with the heat (that is, without changing the conducting materials physical structure). Example: Heat a copper rod on one end only. The copper molecules in the heated end will start vibrating due to the increased internal energy. These vibrating molecules will strike unheated copper molecules next to them, transferring heat. This chain reaction will continue until the entire rod is heated. Note that the copper molecules themselves have not moved. It is only their internal energy bumping against each other causing the heat transfer.

CONVECTION is the transfer of heat by movement of heated material. Example: the suns rays hit the earth and heat it. The air next to the ground is heated by conduction. This heated air expands, becomes lighter, and rises. Cooler air, being denser and therefore heavier, will flow downwards to replace the lighter air. This process is called convection and the flow of heated air upwards is known as a convection current. Convection occurs in liquids as well: the bottoms of oceans, lakes, and rivers are the coldest.

RADIATION

Conduction and convection transmit heat by particle vibration. Heat can also move through a vacuum which contains no matter. Heat can move as radiant energy. When this radiant energy strikes an object, the particles in that object speed up. An example of radiant heat, or infrared as scientists call it, is the heat striking the earth from the sun.

Understanding basic heat definitions and the different ways heat moves will help us to better and more efficiently use it. In following issues, I will show you practical applications of the rules of heat. I will compare methods of using and saving BTUs. Look forward to reading about solar heating, thermostats, stack robbers, methods of heating living space and water, BTU content comparisons of differing materials and lots more. Until then--stay warm, hopefully as efficiently as possible.

Things that Work

Home Power tests the Trace Model 1512, 1.5kW. Power Inverter

Test Environment--
We tested the 1512 at our site located about 12 miles from any commercial utilities. This place has been totally powered by alternative energy since 1976. Photovoltaics and motorized generators (both 12 VDC and 120 VAC) are the power sources. We hooked the 1512 inverter to 2 Trojan L-16W batteries (350 ampere-hours at 12 volts) for the test period. The 1512 was wired to the batteries with 0 gauge copper cables with a combined length of less than 6 feet. The inverter is used to power a variety of test equipment, computers, printers, power tools, kitchen appliances, and some lighting. The 1512 was constantly monitored by a DC powered oscilloscope (fully isolated from the 1512's output by its own internal battery power supply), a DVM, and an analog expanded scale AC voltmeter during the entire testing period of three weeks. Testing was conducted by Richard Perez.

Packing, Installation Instructions, and Owner's Manual
The unit was packed very well and survived UPS shipping. The shipping container is first class. We first turned our attention to the installation instructions, and operator's manual. It is well written, very thorough, and has a folksy flavor that is refreshing. The short form for immediate hookup is a very good idea for impatient customers. All the instructions are clear and concise. No one should have any trouble installing or operating the model 1512. All that is necessary is to read the manual.

The manual is very detailed in comparison with those of other inverter manufacturers. It may be a little too technical for some, but it is good to see this information available to the users. The discussion of the various types of loads and how they function on this inverter is very good, and will help non-technical users understand such things.

Inverter Operation
The 1512 powers inductive loads better than any inverter we have ever used. Regardless of size or type of load (we tried all kinds), the inverter was very consistent in its output waveform. We saw on the oscilloscope that we could not get the inverter's waveform to go out of the modified sine wave mode. This is amazing and almost unique. The Trace is very different from some inverters, which put out a wide variety of glitchy waveforms on inductive loads (especially small ones). The Trace 1512 inverter powered inductive loads such as fluorescent lights, stereos, TVs, satellite TV systems, sewing machines, computers, and motors better and quieter than many other modified sine wave inverters.

Our inductive AC equipment happily consumed the power made by the 1512. One very dramatic case was our computer equipment. This computer equipment has had problems with overheating when powered by other inverters. It ran much cooler on the 1512.

The Trace inverter is among the most efficient types we have tested. The 1512 met Trace's specs for efficiency. The 1512 inverter produced noticeably less heat when powering large inductive loads. For example, we used a large 720 watt vacuum on the inverter. When powered by another inverter this vacuum began serious overheating after only 20 minutes of continuous usage. The inverter itself was also very warm. When the vacuum was run on the Trace 1512, neither it or the 1512 showed any appreciable heating after over 2 hours of continuous operation.

The 1512 has excellent voltage regulation and is within Trace's specs. Regardless of load size, load type, temperature, and battery voltage, the 1512 did not vary over 2 volts (measured by us) in its AC output voltage. We tested the inverter on input voltages from 11 to 15.3 VDC. Temperature ranged from 10° C. to 40° C. Loads ranged from 25 watts resistive to 1.2 kW. inductive. Trace has really accomplished a great deal in the area of voltage regulation. Trace's digital approach to inverter design has produced an incredibly stable inverter. We were not able to measure any deviation from 60 cycles in all our testing. This is a big plus for anyone powering TV, video equipment, or audio equipment from an inverter.

The 1512 met Trace's specs. for power output. We repeatedly tried to overload the Trace inverter, but we couldn't kill it. The 1512 protected itself from any damage due to overloading. We tried resistive and inductive loads up to 3kW, with starting surges over 10kW. In the past, inverters would not survive being so grossly overloaded.

Battery Charger Operation
The battery charger was a very pleasant surprise. Not only is it easily user programmable, but its range of operation is much greater than anything else available. The 70+ Ampere current output of the 1512's charger is nearly twice as powerful as any comparable unit. The battery charger's voltage output can be set high enough to fully recharge deep cycle batteries. The Trace 1512 is the only inverter/charger we've seen that can effectively cycle the batteries; it is unique.

The Trace is the best for operation with a motorized generator. The 1512 will recharge the batteries faster than any other type of inverter/charger we've ever seen. This results in less generator operating time, and greater fuel economy. The programmable nature of the charger makes overcharging or too rapid charging of the batteries impossible. The 1512's current output was very constant over the entire recharging voltage range of our test batteries. Inverter to generator automatic changeover is smooth and positive. The Trace 1512 has the best built-in battery charger in the industry.

On the down side...
It was very difficult to find anything to complain about with the Trace 1512. The only feature we didn't like was the inverter's audio buzz. This audio noise is loud enough that the inverter should be located where no one will have to listen to it. A little noise is a very small matter in comparison with the inverter's many fine points.

Conclusion

Things that Work

The Trace 1512 is one of the finest modified sine wave inverter available. We found that it meets all of Trace's specifications. It is as far ahead of most other inverters as a Corvette is from a Model T. The 1512 is the first inverter to combine digital technology with ease of use, efficiency, and sheer toughness. The list price of $1,310. (with optional charger) is in line with the 1512's superb performance. We are recommending the Trace 1512 as an excellent buy. You can get more info on the 1512 from Trace Engineering Inc., 5917 195th NE, Arlington, WA 98223, or phone 206-435-8826.

Build an Accurate Battery Voltmeter

by
Alex Mason

The battery article in last month's Home Power gave information and graphs that determine a battery's state of charge using voltage measurement. Many readers wrote in and asked for details about accurate voltage measurement for their systems. So here is a homebrew project-- a simple to make, accurate voltmeter that can be left on line all the time.

Voltage vs. State of Charge

The state of charge (SOC) of a lead acid battery can be determined by measuring its voltage. Details and graphs about the relationship between SOC and voltage are in Home Power #1. If you don't have a copy of HP#1 to refer to, then please write Home Power (POB 130, Hornbrook, CA 96044) and we'll send you a copy of Home Power #1, postpaid, for $2.

Analog vs. Digital Metering

Without any doubt digital metering is more accurate and easier to read than analog metering. Digital metering reads out in numbers (either LCD or LED like your digital watch), while analog meters use the old standard electromechanical meter movement (like the fuel gauge in your car).

If you wish to go to the expense of a digital multimeter (DMM), then I recommend the Fluke Model 77 which costs about $145. It is very accurate (0.3%) and well worth the money because it is so versatile. We use one for all sorts of metering jobs. The problem with using DMMs for battery measurement is that they use small internal batteries to power the meter. This is OK for most uses, but in an AE system we need to have a readout on our battery's voltage ALL the time, 24 hours a day. This means that the expensive DMM is tied to a single purpose, and constant operation wears out the DMM's internal, expensive, batteries very quickly. What is necessary is an accurate battery voltmeter that can be left on line all the time, and is powered by the large batteries in the AE system, not by small internal batteries.

Expanded Scale Analog Battery Voltmeter

This metering circuit was developed by Electron Connection Limited for its customers. While Electron Connection encourages you to build this circuit for your own use, we do reserve all commercial rights to this design. The idea is to use an analog dc ammeter in a circuit that will accurately measure the batteries voltage. This circuit produces an expanded scale voltmeter. Most analog voltmeters start reading a 0 volts. This is really a waste for battery systems as a lead acid battery will have about 10 to 11 volts even when just about empty. So the portion of the meter's scale between 0 and 10 volts is not used. Wasting this portion of the meter's scale decreases the resolution and thereby the accuracy of the meter. This circuit allows the meter to start reading at 11 volts and to display full scale at 16 volts (a very fully charged battery while still under charge). This is called an expanded scale, and makes the meter much more accurate to use.

All the components for this metering project are available at most Radio Shack stores, or from just about any electronics supply house. Cost of the parts should be between $20. and $40., depending on your hardware sources. Construction time is about 1 hour for an experienced assembler. This circuit is powered by the battery under measurement, and never requires the use of small batteries to power the meter.

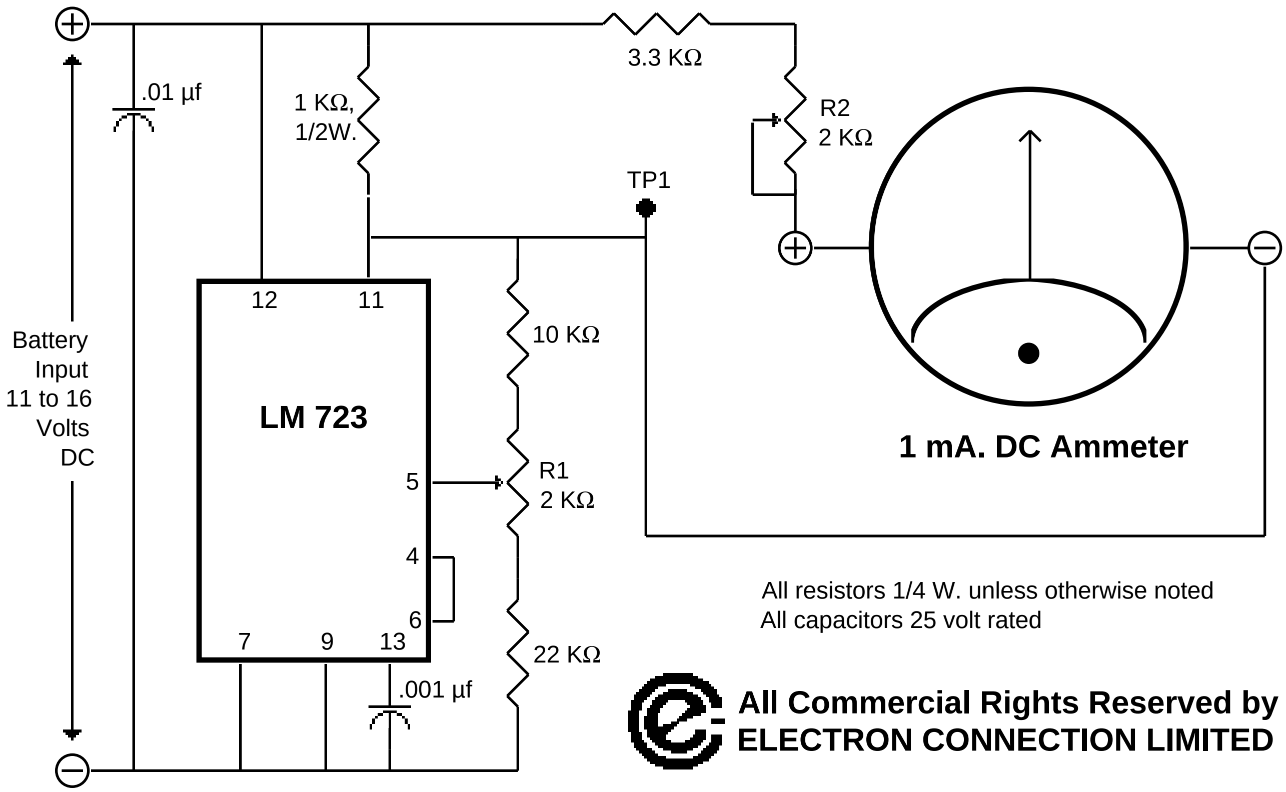
We don't have space here to give an electronics primer for those not familiar with electronic construction. What we do offer is the schematic for the circuit on the next page. If you can't figure out how to build this meter from the schematic, then please seek out an electronics person who can aid you. For those wishing the meter already constructed and calibrated, please send $75. to Electron Connection Ltd., POB 442, Medford, OR 97501, and allow six weeks for delivery because we hand build each and every one to order.

Electronic Nitty-Gritty

This circuit uses a 1 mA. DC Ammeter as an expanded scale voltmeter. The meter has its ground elevated to 11 volts by the use of an LM 723 voltage regulator in shunt mode. This makes the meter very accurate as there are no series semiconductors in the measurement circuit. Full scale reading and the 11 volt ground level are both adjustable by using the potentiometers in the circuit. R1 is the adjustment for the shunt regulator. Adjust R1 until Test Point 1 (TP1) is at 11 Volts. Then adjust R2 until the meter reads the battery's voltage at the time. Use an accurate DMM to calibrate this circuit.

Average power consumption of this meter is about 5 milliWatts. When on line 24 hours a day, power consumption is less than 0.1 Watt-hours per day. This meter is super-efficient and can be left on line all the time with a minimum of power consumption.

11 to 16 VDC Expanded Scale Battery Voltmeter



All resistors 1/4 W. unless otherwise noted
All capacitors 25 volt rated

Low Voltage Wiring Techniques

by
Alex Mason

In many AE systems it is efficient and inexpensive to use the low voltage DC electricity directly from the batteries. Here is all the info you need to get this energy down the line, to the job, with a minimum of loss.

Resistance- The BIG Problem

Resistance is the impedance to electron flow within any material. All electrical wiring, connections, plugs, and switches have some electrical resistance. This resistance causes losses within the entire low voltage circuit. The idea with low voltage wiring is to minimize this resistance, and thereby the associated losses. The reasons for this are: 1) we don't want to waste power, and 2) 12 VDC from the batteries is already low enough in voltage, we can't afford to lose any more than necessary transferring this energy from the batteries to the load. Low voltage at a load causes substandard performance. It means slow motors, dim lights, and generally poor appliance operation.

The Entire Circuit

Every electrical appliance in a system must have a complete circuit to the batteries. Consider the lightbulb on the ceiling. The electrons that power this lightbulb follow a very specific path to accomplish their purpose. Every electron originates at the battery's negative pole. From this pole it makes a journey through the wiring, connections, and switch(es) to the lightbulb. After any given electron passes through the lightbulb it makes its way through the wiring, connections, and switch(es) back to the positive pole of the battery. This path is set. Every electron must make this entire journey in order to do work. Every electron must pass through each circuit element (piece of wire, connection, plug and/or switch) in order to complete the circuit. In technical terms, what we have here is a series circuit. A series circuit means that there is only one path available to the electrons.

A series circuit is like a chain: it is limited by its weakest element. The total resistance of a series circuit is the sum of all the resistances within that circuit. Each individual element within the circuit introduces losses based on its resistance. The primary lesson to be learned here is that ANY (and it only takes one) high resistance element within the circuit will make the ENTIRE circuit's resistance high enough to be unacceptable. Every element within the circuit must have low resistance for the entire circuit to have low resistance. It only takes one piece of undersized wire, one funky connection, or one wornout switch to make the loss of the entire circuit unacceptable. So, in low voltage circuits we must consider every element in the circuit. It is not good enough to use properly sized wire if it is connected improperly, or if the wire is connected to a switch (or any other single circuit element) with high resistance. Attention to the details of the circuit is essential. Let's look at the individual elements that make up the circuit.

Wiring

The size of the wire (or gauge) feeding the load is critical. Wire size is specified in any application by considering two factors: 1) the amount of current that the wire transmits, and 2) the total wire length (both conductors) from the battery to the load. Ohm's Law (see Home Power #1 if this is a new idea for you) gives us the relationship between voltage, current, and resistance in an electrical circuit.

$$E = IR$$

Wiring makes up many of the elements in a circuit. Larger sizes of wire have more copper in them, and hence lower resistance. Wire size is specified by a gauge number. The lower the gauge number, the larger the diameter of the copper wire, and thereby the lower its resistance. The actual resistance per 1,000 feet of various copper wire gauges is detailed in Table 1, the Copper Wire Table. We encourage you to use only copper wire in your AE system. Aluminum wire has greater resistance (about twice for the same cross sectional area) and is virtually impossible to interconnect without higher resistance connections. If you don't think so, then try soldering an aluminum wire sometime.

From the Copper Wire Table, we can calculate the resistance of any particular piece of wire. The resistance per foot times the number of feet gives us the total resistance of a length of wire. When estimating the resistance of wiring be sure to include BOTH conductors, i.e. if an appliance is 100 feet from the battery, then the total wiring length is 200 feet (there are two wires actually, each one 100 feet long).

If we know the amount of current being consumed, the resistance per foot of any given wire gauge, and the length of the total wire in the circuit, then how do we determine the actual gauge of wire we should use? The answer is determined by exactly how much loss we find acceptable. In general, consider a 5% loss to be the maximum acceptable (2.5% is better). If we are using 12 VDC, then 5% voltage loss is 0.6 volts (2.5% is 0.3 volts). Consider the following equation to specify exactly which wire gauge to use for any given application.

R = Resistance expressed in Ohms (Ω) per 1000 feet.
E = Maximum allowable voltage loss in the wiring, in Volts.
I = Amount of current flowing through the circuit, in Amperes.
L = The length of wire in the complete circuit, in feet.

This equation gives us a value in Ohms per 1,000 feet. Simply find the copper wire gauge size that has LESS than this amount of resistance per 1,000 feet, and you've found your wire gauge size.

$$R = \frac{E}{I\,L}\ (1000)$$

Consider a PV array that produces 12 amperes. This array is located 100 feet from the batteries. What gauge size of wire should be used to keep the voltage loss in the wiring to less than 0.6 volts? Well, there is 200 feet (two conductors, remember) of wire in the circuit, and a current of 12 amperes flowing. The equation above gives us a maximum resistance of the wire as 0.25Ω per 1,000 feet. By consulting the Copper Wire Table, we find that 4 gauge wire has a resistance of 0.2485Ω per 1,000 feet. Since this is less than the 0.25Ω/1,000 ft. the equation generated, 4 gauge wire is the size to use.

TABLE 1- THE COPPER WIRE TABLE

	RESISTANCE				DIAMETER	
WIRE GAUGE	OHMS PER 1000 FEET	FEET/ OHM	OHMS/ KM.	METERS PER Ω	MILS	MM.
0000	0.04091	20400	0.1608	6219	460.0	11.68
000	0.06180	16180	0.2028	4932	409.6	10.40
00	0.07793	12830	0.2557	3911	364.8	9.266
0	0.09827	10180	0.3224	3102	324.9	8.252
2	0.1563	6400	0.5127	1951	257.6	6.544
4	0.2485	4025	0.8152	1227	204.3	5.189
6	0.3951	2531	1.296	771.5	163.0	4.115
8	0.6282	1592	2.061	485.2	128.5	3.264
10	0.9989	1001	3.277	305.1	101.9	2.588
12	1.588	629.6	5.211	191.9	80.81	2.053
14	2.525	396.0	8.285	120.7	64.08	1.628
16	4.016	249.0	13.17	75.90	50.82	1.291
18	6.385	156.6	20.95	47.74	40.30	1.024
20	10.15	98.50	33.31	30.02	31.96	0.8118
22	16.14	61.95	52.96	18.88	25.35	0.6438
24	25.67	38.96	84.21	11.87	20.10	0.5106

Get on the Bus

In reality houses and systems contain many circuits. Some of these circuits are straight series types as mentioned above. Others are parallel circuits, where two or more loads are supplied electricity by the same piece of wire. The mathematical analysis of all these circuits can become very complex. A way around this complexity is to use a standard wiring technique that is very effective in low voltage systems--The Bus.

A bus is a heavy set of wires used to carry current to other smaller wires which eventually feed the loads. The battery's energy can be distributed by two heavy wires (usually 2 or 4 gauge) that run the entire length of a building. Smaller 8 or 12 gauge wires are soldered to this bus to supply the individual loads. This structure is similar to the skeleton of a fish, a heavy spine with smaller bones attached to it. This technique allows low voltage energy to be distributed with a minimum loss. Ideally, each load should have its own individual feeder wires soldered to the bus. All feeder wiring lengths should be as short as possible. This technique also allows the use of standard wiring components like switches, plugs and sockets, which will not accept the huge diameter of 2 or 4 gauge wire.

Solder Connections When Possible

In standard 120 VAC house wiring, it is very unusual to solder connections. In low voltage systems, soldered connections should be made wherever possible. All wire to wire connections should definitely be soldered. Mechanical connections using wire nuts are OK for higher voltage systems, but these connections have too much loss for low voltage systems. Soldering assures a permanent, low resistance connection. Mechanical connections gradually oxidize over a period of time. While copper is a very good conductor of electricity, copper oxide is not. Gradual oxidation in mechanical connections increases their resistance. Remember, a single high resistance connection within the circuit will make the resistance of the entire circuit high. So get into solder. Once you've made a good solder joint, it's good forever.

Switches, Sockets & Plugs

The switches, sockets and plugs in a low voltage systems must have low loss (i.e. low resistance) just like every other component in the system. We can assure low loss in these components by two techniques. The first is to purchase specialized low voltage switches, sockets and plugs. These components have more massive contacts, with higher contact pressures, to deliver low resistance. These components are expensive and hard to find.

Another technique is to use standard 120 VAC components and to derate them. Derating means that we run only a portion of the rated current through the component. Derate 120 VAC switches, sockets and plugs by at least a factor of three. Consider a plug or a switch that is rated to handle 15 amperes of current at 120 VAC. If we run 5 amperes or less (15/3) through the component, then its losses will be acceptable. Derating allows use of the more commonly available, higher resistance, components by reducing the current we run through them.

In any case, keep the use of switches, sockets, and plugs to a minimum in a low voltage system. If an appliance can be soldered to its power wiring, then this should be done. If you are using standard 120 VAC sockets and plugs in low voltage systems, be sure to use the 3 conductor types. The three-prong type of sockets and plugs are polarized. They will only connect in one fashion. If they are wired with proper polarity to start with, it is impossible to plug in a polarized low voltage appliance backwards. This can save electronics, fluorescent lights and other DC appliances from being connected backwards and destroyed. The third conductor on these plugs and sockets can also be used to carry current.

Simply wire this third connector (normally used for the ground in AC systems) in parallel with either of the power wires. This even further reduces the overall resistance of the plug and socket combination.

Low voltage wiring is not difficult. It only requires that you cozy up to Ohm's Law. If you can work with the concepts of resistance, voltage and current, then you can apply these concepts in your system. Low voltage wiring requires attention to detail. Consider every element in the circuit. If you keep the individual losses within components to a minimum, then the overall system will take care of itself.

the Wizard

So, are you interested in a FREE LUNCH? Will you go for it?

"What is anti-entropic?", you ask. Well, here's one definition: An anti-entropic process is one which creates more energy than it consumes. There are three basic strategies which may provide a path to the free lunch.

1) Create a feedback process to continually regenerate the source, using only a portion of the output. This is a source multiplier.
2) Create a process that is more than 100% efficient. This is a direct energy multiplier.
3) Find an infinite and undiminishable power source. This is equivalent to finding God in the physical universe.

These paths are possible and can be implemented through the proper understanding and use of leading edge physical theories in the following areas:

1) The basic structure of matter & energy.
2) The nature of gravity & magnetism: how they interrelate.
3) Space & time.

Even today the first short-term approaches to the free lunch are being taken. This will hopefully lead to an era of unparalleled abundance.

Go with the Wizard. Onward into the Future!

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We are desktop published (via Macintosh computers) and can setup and layout your advertisement if you so desire. Camera ready display advertising is also accepted.

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Surface shipping may take up to 2 months to get to you. All issues shipping in mailing envelopes to withstand the rigors of international mailing.

It's Happening!

SunAmp Seminars

SunAmp Power Company will be holding PV seminars Feb. 19-20, Mar. 20-21, at the SunAmp offices in Scottsdale, Arizona, USA. Cost of the seminar is $145. For Additional info contact: SunAmp, POB 6346, Scottsdale, AZ 85261, or call 602-951-0699.

Letters to Home Power

Edited by
Glenda Hargrove

We encourage you to write your questions and remarks to Home Power Magazine. We will do our best to see that they are answered and published. So go ahead air your views on AE. We're all listening.

Thanks for sending me the first issue of Home Power... I would be interested in information on Eastern companies who are into AE. Any info on these? Good work!-- Mason NH
Editors: We are in the process of finding these companies. Readers can help by keeping their eyes open to prospects, and spreading the good word.

I hope you will do product evaluations so readers can be steered away for the junk and turned toward the truly useful and well made AE products.-- Burketville ME
Editors: Check out the Things that Work column. This column will be featured in every issue of Home Power.

I would like a buy, sell & trade column by and for the readers.-- Bulls Gap TN
Editors: This is what we have in mind for the MicroAds section on page 38 of this issue. We encourage our readers to use this service (the rates are dirt cheap!) to exchange info and equipment.

Good Luck on your endeavor! What are the chances of getting back the AE tax credits when Reagan leaves?-- Boney Fingers Homestead, Harford NY
Editors: We have no idea, but we can all hope. We suggest writing your congresspersons and senators and let them know how you feel.

Very informative. I'm new to this AE power thinking and need all the information I can get for future investments, Thanks.-- L. Bacon, Oroville CA

I'm delighted you found me- sign me up for lots more!... I have been using PV since '83 and have set up 7 houses- and still keep learning. It's really far out for people to share their energy and knowledge the way you are. Please keep doing this mag. I am sending a small check to help with postage, and if you need to charge a subscription I'd pay for more with this kind of writing.-- Honolulu HI
Editors: Thanks for helping out. We are adamant about keeping Home Power free to the readers.

QUESTIONS & ANSWERS

1. Does anyone make a 24VDC/120VAC modified sine wave inverter? *Yes, both Trace Engineering and Heliotrope General make excellent inverters. Their ads are in this issue.*

2. What is the efficiency of used batteries (car, phone co., etc.)? *The efficiency picture is pretty grim for used batteries. A new lead acid battery is around 70% to 80% efficient, and the used types vary widely depending on their condition. Since it is very difficult to tell the condition of a used battery without cycling it, don't to rely on used batteries unless you can check out the particular battery. See if it delivers its rated Amp-hr. capacity in actual service.*

3. What is the shelf life of a dry charged battery? *Dry charged lead acid batteries have been fully charged and then had their electrolyte removed. They can be stored for many years if they are kept dry and at room temperatures.*

4. How much can you boost the performance of PV panels by using reflectors, without compromising the life expectancy of the panel? Is temperature a significant factor? *Yes, a PV module can have it performance increased by applying more than light to it. This can be done with reflectors or lenses. Two suns on the panel will give twice the current output at the same voltage, and so on. Temperature can be a problem. In general, PVs perform better when they are cooler. In extreme cases, over temperature can cause premature cell failure. So if you are going to put more than one sun on the panels, you must keep them cool somehow. This is a good subject for a future article.*

5. Why are 12 Volt appliances, lights, etc. so much more expensive than 120 VAC equipment? *The reason is mass production and distribution. For every low voltage appliance made, there are probably over ten thousand 120 VAC types made.*

6. What sort of things can damage PV panels? Will partial shading of a panel damage it? *No, shading a PV panel will do it no harm. The sort of things that destroy PVs are very high (over 250°F.) temperatures, baseballs, dropped tools, etc. PVs are virtually indestructible unless you go at them with a sledge hammer!*

7. Is there a computer/printer available that will run on 12 VDC system rather than an inverter? *Yes, several companies have computer equipment that will run on low voltage DC (Radio Shack & Compac). These computers usually have limited display capabilities to accommodate battery power. Many other types of 120 VAC computers can be easily modified for low voltage operation. In general, it is more cost effective to use 120 VAC computer equipment with an inverter than to pay extra for the more limited 12 VDC gear.*

8. How do you go about selecting a battery charger to go best with your system? *See this month's engines article for a discussion of battery recharging. The charger should be able to deliver at least a C/20 rate to the batteries. C/20 means the capacity of your battery pack in Ampere-hours divided by 20. This gives the lowest amperage charger that will be effective. Also consider chargers with adjustable voltage limits, these will*

be able to perform the essential equalizing charge on the batteries.

9. How do you size 12 Volt wiring for both main and secondary circuits? *See this month's basic electricity column, it's got all the info you need.*

10. How do you ground a PV system for lightning protection? *Attach a heavy (8 gauge) wire to the framework of the panels, or to their rack. Connect this wire to an 8 foot long copper grounding rod. Drive this rod 6 feet into the ground and pray you don't take a direct hit. Grounding reduces static buildup on the panels and according to experts reduces the chances of being hit by lightning. Lightning protection is mostly a matter of faith. I personally have worked at a mountain top (7,500 ft.) commercial TV transmitter and have taken many lightning strikes. Sometimes the lightning will ignore all grounding and fry everything anyway. Maybe the best lightning protection is a pure and fearless heart... Rich.*

11. Where can I buy Windmachine propeller blades? *Try Santa Rosa Machined Props, POB 214235, Sacramento, CA 95821, tele: 916-972-9525.*

Home Power MicroAds

Rates: 5¢ per character, include spaces. $10 minimum
Deadline: 10th for that month's issue.
Send check with Ad.

Refrigeration- Energy efficient DC and AC refrigeration for domestic use and vaccine storage. Available in sizes ranging from1 to 19 cu. ft. Most models can powered by less than 3 PV modules. **SunFrost, PO Box 1101, Dept. PH, Arcata, CA 95521. Call 707-822-9095**

For Sale- **JACOBS** twin motor electric w/Contro Panel, stub tower, $685. John Beck, 701-663-7399.

For Sale- 32 V, 1800 W., **JACOBS** with flyball gov.- $1800. ROHN SSV-80 ft. tower, never used- $3500. 32 VDC appliances; ARCTIC KOLD 8 cu. ft. refrigerator- $450., 500 Watt ROTARY INVERTER- $375. 200 Amp. ARC WELDER- $150, 5 gal. Vacuum- $75. FRED RASSMAN, RD#1, BELMONT, NY 14813, tele: 716-268-5112

For Sale- Motorola IMTS Radiotelephone, full duplex & 12 VDC. In perfect working order. Range over 40 miles on base station antenna. Has it's own individual telephone number, NOT a RCC system. No operators, pick it up and dial, just like downtown, except no telephone lines. Cost new $1,700., will sell for $850 firm. 916-475-3179 or write POB 371, Hornbrook CA 96044

For Sale- Heart Inverter. Model # H12-1000. 1,000 Watts, in good working condition, 12 VDC input. Sell for $500.
916-475-3179 or write POB 371, Hornbrook CA 96044

For Sale- Large Hydro Turbine, Pelton type, in excellent condition. 16 inch intake, 29 inch turbine diameter. Also 32 VDC generator for turbine. $600. each or best offer. Ward, 8000 Copco Rd., Ashland, OR 97520
or 503-482-0074

GB's Herb Basket. Herbs for your Bath, Herbs for your Kitchen. Herbal Gift Baskets. Send SASE for listings. GB's Herb Basket, 19101 Copco Rd., Hornbrook, CA 96044 or 916-475-3179.

Home Power People

Rich

Karen

Glenda

For all you Techno freaks out there, the digitalized images of the Home Power crew on this page were produced using a Macintosh computer, a CBC video camera, and the wonderful MacMagic imaging software. The whole mess was powered using Kyocera PVs, Trojan batteries, and a Heliotrope inverter.