INVERTERS

By Phred Tinseth

1. INVERTERS--The Basic Basics:

Converter? Inverter? Confused? A CONverter is standard equipment on most RVs. Connected to commercial power or an auxiliary generator, it changes 120 Volt AC power to 12 Volt DC. Some of this is fed direct to RV circuits and some is fed to the batteries through a battery charger. An INverter does the inverse. It takes 12VDC from the batteries and changes it to 120VAC so standard electric items may be operated without "plugging in" or running a generator.

Once you know what an inverter is and what it does the basic question remains: Do you need an inverter? Or, alternately, Can you make use of an inverter? Enough to justify the cost? More than anything else, the answers are a matter of "lifestyle."

People who use full hook-ups every night might not need an inverter. People who don't mind irritating their neighbors with a roaring generator and its fumes might not. People who have adequate 12VDC equipment (TV, radio, etc.,) and don't feel the need to run micro-wave ovens and similar AC items might not.

But there are many people who need, or can make use of an inverter. Consider the person who must rely on a breathing machine: Their travel is severely limited and they are locked into commercial campgrounds. So much so that they often stop RVing. An inverter can return their freedom. Then there are those with computers--RVs are subject to easy power outages (pulled plugs, unreliable campground hookups, stalling generators) that can wipe out a computer. Some buy back-up power supply systems (for big $) without realizing that all they contain is a small, rechargeable battery and, a miniature inverter. The much larger RV battery system is far superior and only requires adding an inverter. And some people do need/want to use microwaves, large TVs, VCRs, stereos, kitchen appliances and power tools. An inverter can actually pay for itself when used for these purposes.

2. COMPARISON SHOPPING

Gather literature from manufacturers and dealers. Use the 800 numbers in ads (and see later). Check particularly "Trace," "Heart Interface," "PowerStar" and "STATPOWER" brands for RV use. There are other excellent inverters also, but these state-of-the-art inverters are those against which others are measured. Contact RV Solar Electric for copies of technical reports on these inverters by recognized authorities. In any case, COMPARE:

Output Power-- In watts. You'll need to get an inverter capable of more than the max watts you'll use at one time. For how long? This figure may be hard to find. Use the manufacturer's website or 800#. Anyone that can't give an answer should be eliminated. Good companies will show, for example, that their 1,500 Watt inverter might operate at maximum power for 15 minutes and at 1,100 Watts continuously. If their inverter actually does run continuously at its rated power, that should be the only number--but you'd better quiz 'em and make sure.

Surge Power-- Should range from about 2 times output power to 6 times output power. You need this to start heavy loads, capacitor-start motors and the like. For how long? Most manufacturers don't commonly list this figure. It's short, usually 2 minutes or so. Nothing wrong with that because that's all that's needed. If it lasted much longer, it would just get hot and ruin itself

Idle Current or No Load Power Drain-- An important figure if you'll leave it turned on (idling) so that it automatically delivers full power when an appliance is turned on. This can equal nearly 20 watts of 12-volt power in some brands. (20W at 12V = 1.7Amps). You certainly don't want an idling/standby inverter to constantly drain over an amp-and-a half from your battery. Quality inverters draw only a fraction of an amp (as little as a tenth, or much less, of an amp) at idle.

Efficiency-- Is a critical figure. It should exceed 90% overall in [most] inverters. It should not vary much from partial to full loads. Beware of inverters that advertise 90+% overall efficiency but may drop to less than 50% at some load levels.

The above are the key comparison figures. Others, such as output voltage and frequency regulation should also be compared but will be similar in high-quality inverters. Note that top quality inverters will regulate voltage, for example, to within 2% of the rated 120VAC. This is better than your power company, which usually regulates voltage to only ±5%!

Cost-- is the final comparison. As when buying anything else, just make sure you don't mix apples and oranges.

Mixing apples and oranges is common when shopping for inverters. It's complicated because of the brands and models within brands that can vary widely in capacity and quality of components. Even though they look alike, they may not be alike. Many inverter manufacturers make top-of-the-line models for reliability, maximum performance and durability. They'll then make a similar model intended for light or intermittent use (sometimes called a "consumer" version). There's nothing wrong with this. The "lighter" model will work well if used as intended and can often be 50% or so cheaper. What you have to remember is TANSTAAFL (There Ain't No Such Thing As A Free Lunch). If you're a serious RVer, you'll be demanding the maximum from an inverter. Get the top model with the capacity you need. If you're just going to watch a bit of TV or similar, you might be satisfied with the light-duty version. I get lots of mail saying, "I was going to buy an XYZ inverter for $800 but I found the same one in a truck

stop for $300." No they didn't! The look alike and may have had the same or similar brand name, different model name and was rated at lesser watts. BIG difference. (It may also have been a pirated phoney copy from who-knows-where--and probably was in the above example--because of the ridiculous difference in price.)

4. WHAT INVERTER SHOULD I BUY?

It depends on what you're going to use it for. You don't buy a 20-ton truck to pull a 10-foot camper. You don't pull a large trailer with a tiny plastic car. If you only want to operate a computer or similar low-energy user, all you may need is a small (300 watt) inverter. If you're going to run a microwave or power tools, you may need a 1,200 watt or larger inverter. You may actually find it more efficient to have more than one inverter.

5. TYPE of Inverter

Not brand, but type. Just as there are types of engines (gas, diesel, etc.), there are types of inverters (or different technologies). Cost plays a part. You can still find low-tech, square-wave inverters for sale. They're grossly inefficient, using most of the electricity they consume just to run themselves. Their simple electronics lead to other problems also -- such as square TV pictures. But they're CHEAP! If you're just going to run a simple item for a few minutes, you might get by with one of these for $75 (for about 200 watts) and up. A few of the "rotary" inverters are still available (an electric motor turns an alternator). Also very inefficient and noisy, they're also cheap. Except for special cases, like a huge power tool operated for a few minutes, this type can be ignored.

Technological advances have led to very sophisticated, solid-state inverters. From 100 to over 5,000 watts, ultra-efficient, with all sorts of advantages. Some of these use less than 10% of the energy consumed when fully loaded and way less than 1% at lesser inputs to run their own components. Phenomenal! At first glance, these are not cheap. But in terms of efficiency and the $ per watt cost compared to what you get out of them, they're cheaper than the el-cheapos. Some can be held in your palm and simply plugged into a 12VDC receptacle. Other, larger output models, require elaborate installation. Some have features and options well worth an added cost.

6. GENERAL SELECTION AND SIZING--Some guidelines and rules of thumb:

Use: Microwave and more? You'll need over 1,200 watts capacity. You'll also need at least 200AH (Amp Hours) of battery capacity (to run a microwave for brief periods). You'll need more battery reserve for longer periods and heavier loads. If you'll be cooking full dinners for 30 minutes, you'll need a 400AH battery capacity. Just a TV? Usually 200W is enough. A variety of things? There are two ways to go:

One. Get a good, efficient 1,200W or larger inverter and feed the whole place. The best ones are 90+% efficient and no longer need to be matched to the load. They'll do nearly as well running a small load as a big one. Incredible but true.

Two. If you don't need a big inverter, consider a smaller one or maybe more than one inverter. Maybe 800W for about anything less than a microwave. Perhaps a 300W for TVs, VCRs, stereos and satellite systems. A 200W palm-size may operate a TV, small stereo, computer or breathing machine. The breathing machine is a prime inverter use. A palm size can be easily plugged into RV or tow vehicle cigarette lighter receptacle and can bring freedom to the camp-ground bound.

COST: You do the best you can. A 1,200+ watt may cost over $1,000. A "variety pack" may cost about the same or less, possibly more (depending on what you need). A variety, though, offers flexibility--and you don't have to buy it all at the same time.

BATTERIES: Technically, you can run anything you want from an inverter -- if it's big enough and you have enough batteries and if you have a way to keep them charged. But an RV, while it may be a home, is not a homestead. Space and weight are considerations. You can't create a "blivet" (10 lbs of horse poop in a 5-lb bag). Nor can you drag out 200 miles of extension cord as you drive along. Small inverters can be used on a one-battery system with hardly any difference in amp draw. Large inverters will demand two batteries or four (or more) with heavy loads.

7. DETAILED SELECTION AND SIZING--The size and type of inverter depends on:

• Continuous running wattage of all loads to be run at one time.

• Surge power needed to start heavy loads.

• Quality of power needed (wave form and regulation).

• Efficiency needed.

• Options and safety features desired.

• **Continuous running wattage of all loads to be run at one time.** List all items you'll run at one time. Add up Watts. (From labels as W or VA, or as measured with an ammeter, or calculated as Watts = Volts x Amps, so 120VAC x 5A = 600 Watts.) Examples: Computer 160W, Monitor 40W, Printer 110W could operate from a 300W inverter. But, if total is near the max rating of the inverter, look closely at inverter manufacturer's data sheet. Some will state, "200W for 25 minutes, 140W continuous" or similar. (Not bad if drilling a hole. Terrible if running a computer.) With microwaves, don't mistake cooking power for actual running power. Read the label. A 500W cooking-capacity microwave might use over 1,000 watts actual power.

• **Surge power needed to start heavy loads.** Some tools need heavy jolts to get started, then less electricity after they're running. (Pressing a drill hard and then hitting the trigger, for example.) In the computer example above, items can be turned on one at a time. A large TV with built-in VCR can't. Everything comes on at once, but after the

VCR motor settles down and the picture tube warms, all is well. If the inverter is just slightly undersized, often it can be turned on first, without a load. Then the TV/VCR can be turned on. If it goes off after a second, repeated attempts will gradually "warm" it. This is hard on the equipment. Better to buy a larger size inverter. Again, a good inverter's literature will state something like,"200 watts to 140 watts continuous." (Almost no inverters have enough surge power to start a fairly-good sized air compressor or air conditioner.)

• **Quality of power needed.** Most of the new, sophisticated inverters provide a "quasi" sine wave that is remarkably close to perfect and suitable for almost any application except exotics like a laser printer. Cheap, square-wave inverters provide square TV pictures. (There ain't no such thing as a free lunch.) Still, many household appliances (blenders, sewing machines) will run from a square-wave inverter if that's all you need. On the other hand, don't be penny wise and pound foolish. That cheap $75 inverter is electrically inefficient and severely limited. It's going to waste a lot of valuable battery power just running itself. A $130, 200-watt, hi-tech inverter will do much more and do it efficiently.

• **Efficiency.** A measurement of how small an amount of electricity an inverter uses just to run its own "innards." If you're just going to run a drill a few minutes, you don't care. If your TV, VCR, computer is going to run for hours, this is a prime consideration. Some of the quality inverters mentioned idle at less than one-tenth of an amp and are well over 90% efficient. You can leave them running 24 hours a day.

• **Bells and Whistles, Options, Safety Features.** Quality inverters in medium to large sizes will have several features: Remote switching (some with monitors) so you don't have to go outside to turn them on. Low voltage warnings--to alert you it's going to shut itself off pretty soon. Circuit breakers. Monitor lights--so you don't leave it on and run down your battery. These are important. A few inverters have automatic load switch protection that keeps them from being energized if there is already 120VAC in the lines (from commercial power or generator). Plugging an inverter into a "hot" circuit will destroy the inverter in seconds (and they won't honor your warranty in such cases). Battery chargers built into the larger inverters are another worthwhile option. No, they don't use a battery to charge a battery. They simply use some of the existing circuits in the inverter (that are far superior to those in an RV converter) to operate a very sophisticated battery charger (that is also far superior to anything in a standard RV converter).

NOTE: See added page near end for comparison of various popular inverters.

8. DO's AND DONT's

DO--yourself a favor and gather some information. Flea markets are littered with useless, old-fashioned inverters that people thought were bargains. Read surplus catalogs carefully -- bargain inverters from military aircraft are grossly inefficient (because an engine is always running) and many operate at 400Hz, or cycles per second, instead of

the standard 60Hz. Plug into one of these and fry lots of things (clocks are amusing to watch).

DO--read the instructions very carefully, more than once, and hilite the critical steps before attempting to connect an inverter. Some have elaborate instructions (good), but critical safety precautions are buried in the text and easily overlooked.

DO--locate an inverter as close to the batteries as possible, with as heavy a cable as possible (read the instructions). But DON'T put the inverter in the same compartment with the batteries unless you enclose it in its own, vented to the outside, "mini" compartment. Even if you're fortunate enough not to have a spark cause a battery explosion in a poorly located inverter, battery gases in the air will literally "eat" the insides of the inverter.

DO--ventilate an inverter well. They get warm. They need fresh air, just like a stereo or computer. Inverters do well in outside RV compartments as long as they are protected from the elements.

DO--consider small, palm-in-your-hand inverters if that's what you need. Unless your wiring is very skimpy or has puny connections, you can plug these into standard 12VDC receptacles, avoid installation problems and save money. Again, for medical machinery like breathing machines, you can easily move the hand helds from living place to car, etc.

DON'T--ever-attempt to connect the 120VAC output of an inverter to your electrical system with a simple jumper cord using a male connector (plug) at each end. The electrical shock hazard might/might not be a big deal, BUT, you WILL, someday, forget to unplug the inverter before connecting to commercial power or starting a generator. You will then lose an inverter. Guaranteed! (And they won't honor the warranty.)

DO--consider load transfer switches even though they may cost more. (Read the above again and see more details later.)

DO--make sure the transfer switch, if you use one (you might need two in tandem), will handle three sources of power if you also have a generator. (Many remote homeowners, without access to commercial power, can use simple, cheaper switching devices just to go from generator to inverter. RVs might come on commercial power anywhere.)

DO--make sure you know what you're doing when wiring or get help from someone who does. But **DON'T** get help from someone who doesn't know what he's doing. Guaranteed he will short the whole business out. Even if you use a "professional" electrician, DO make sure he understands that neutral and ground wires in an RV are NOT bonded together. (More later and in the "Batteries ...." poopsheet 120 VAC section.)

DO--consider an inverter as a priority item if medical appliances keep you tied to commercial power. (You can even plug the small ones into wheel chair batteries in many cases.)

DO--buy an inverter from someone who will let you return it for full (or nearly full) credit if it's in like new condition, original box, etc. Some inverters will cause radio/TV interference. Some will cause interference only on certain brands or models within brands. Ask first. Good dealers will know most of the static or interference-prone items and can advise you in advance. Good dealers will also allow you to bring your RV to their place of business so inverters can be temporarily connected to test interference.

DO--notice that I haven't mentioned solar panels except casually. An inverter runs from a battery. The battery doesn't know or care where its charge came from. Also note that an adequate solar system can eliminate the need for a generator or commercial power except as a backup.

DON'T--let the above scare you away from inverters. They're perfectly safe if used properly. They're not difficult to install if you follow the instructions. They can just about pay for themselves depending on what you use them for. Some of us used to modify all sorts of things to operate on 12 volts. It can be clumsy, things can get damaged and such modifications void warranties. I encourage people to make a hobby out of electronics so they can do this, but it's really not necessary with the efficiency of today's inverters.

9. "TRUE" SINE WAVE INVERTERS

Do you need one? Generally not. "Quasi" sine-wave inverters provide electricity that so very closely approaches a "true" sine wave (that of commercial power) that, for most applications, nothing more is needed. Some, very few, appliances require a true sine wave. (Most laser computer printers, for example.) Do not confuse "true" or "quasi" sine waves with the crude "square" waves of cheap inverters.

Alternating current varies, above and below, a "base line." It does so in a **smooth** wave that changes position, or polarity, (in the case of standard U.S. power) 60 times per second. This is the 60 cycle (or hertz) power we use as normal AC electricity. This is a "true" sine wave. A "quasi" sine wave is produced by hi-tech inverters. It is created by pulses that create small stair-steps of increments that almost equal the smooth sine wave. Cheap inverters simply change polarity in abrupt "jolts." The abrupt drop and rise of these jolts is alternating current, but the abrupt change results in a "square" wave form. That square wave form causes square TV pictures and will not operate some motors or other electric appliances.

So why not go for the best and use a true sine-wave inverter? Cost is a chief reason: Just as the quasi sine wave is more expensive than the square wave, the true sine wave is more expensive than the quasi. A much more important reason is efficiency: A true sine wave inverter is not as efficient as a quasi (yet, but the newest ones are really close).

10. MULTIPLE INVERTERS CONTINUED...

Ideally, you get a huge inverter with battery charger option and cable it up and that's all there is to it. There are other things to consider though. Suppose the monster poops out

and you have to return it for repair? Then you have nothing. Suppose you have many different AC needs? Suppose, as above, you need true sine wave power for a computer printer? Suppose you need to run a breathing machine in RV and tow vehicle? (And need to move an inverter from one to the other?) Depending on your circumstance, it may be better to use multiple inverters. What I have used as an example:

First, I use two battery banks and two photovoltaic systems. Redundant? Yes, but I've always got a spare and can switch back and forth or connect them together. The main system feeds a large inverter with 4-stage built-in battery charger for running the "house" and all computer equipment.

The second system feeds a mid-size inverter (with battery charger option) and powers my audio/video equipment. Either system can also power the other (within wattage limits) and can be switched over. I use hand-held inverters to power small items independently. All these inverters, together, cost little more than a large house inverter would and provide flexibility. I can change things around when I want. My point here is not to brag about quantity, but to point out that there are many ways to go depending on *your lifestyle, not anyone else's*.

Currently, for example, I've changed my lifestyle and travel in a mere 21' MH. I retained the 2,500 watt, pure sine wave, STATPOWER inverter, but drastically reduced the number of solar modules and batteries.

11. SOME BUYING TIPS

Quality inverters seldom sell at "discount" though there are occasional "sales." Some people think this is price fixing, but it's really not. Respectable dealers have a limited range of prices. Most will operate at the bottom of that range (or near it). This allows them a reasonable profit and you a fair deal. Considering that these things are expensive, that dealers must spend a great deal of time with customers before the sale, and that respectable dealers often will spend even more time after the sale in educating you, it all makes sense. Respectable dealers will often "sweeten" the deal a bit, though, by furnishing extras, such as switches, battery connection cables, free UPS shipping and the like.

I used the word respectable several times in the above. BEWARE the dealer who isn't. Some dealers, in order to avoid price guidelines, will call themselves "distributors" and will sell you an inverter with you being listed as a "dealer." Some people think this is great. They love to get things "wholesale." Well, they're not really getting it wholesale. What they are getting is absolutely no support after the sale. I've seen dealers pull this scam. They'll claim to sell an inverter at "cost." Baloney! If they did that, they couldn't remain in business. Once done though, when you ask for help, they refer you to the manufacturer and may even say something like, "You're a dealer now, you're supposed to know what to do, contact the manufacturer."

An added page at the end lists a few respectable, trustworthy dealers. There are many more. Read the ads in "Home Power" magazine. Use your consumer skills. Since the prices are all about the same, I recommend you choose a dealer who will be there, available to help, when you need help. (Here's the benefit you gain from stable pricing: They have to compete with one another. If they can't do it with $, they can do it by offering service.) You might have to pay for a telephone call. It'll probably be worth it. And you might get referred to the manufacturer if necessary. The manufacturers mentioned (and some others) will help you. They'll talk you through a trouble shoot. If that doesn't work, they'll have you send it back. Failure Rates run less than 1% among major inverter manufacturers. Almost unheard of in any other product.

Buying A Used Inverter can be a very good way to go **IF** you deal with a reputable dealer. The reason for this is that people don't usually trade in an inverter because there's something wrong with it (like they do cars). They trade them in to upgrade to a bigger one or one with different features. Some dealers will work with you, like RV Solar and BackWoods.

12. INSTALLING AN INVERTER

This can't be all inclusive because inverters vary. All quality manufacturers include detailed instructions. Many good dealers add to these with booklets or extra poop sheets of their own. These are based on the questions/problems their customers have come up with and can be most valuable.

Your first step in installing an inverter is to: RTFM (Read The * Manual)!

• Installation is electrically simple IF you follow the instructions! Do not just start screwing things together. Some inverters are indestructible. Others aren't. Some are DC polarity protected. If you hook up the cables backwards, it just won't work. Others aren't. If you hook up the cables backward, you'll fry the thing (and they won't warrant your foolishness).

• Spend some time planning the installation. Some people spend as much time planning as they do in the actual installation. It usually pays off.

• Locate large inverters as close to the batteries as you can, but not in the same compartment (unless you construct a shield or mini-compartment). Battery gas "eats" electrical components (and inverter sparks can ignite battery gas).

• No large inverter should be more than about 10 feet from the battery connection. DC voltage drop from battery to inverter is critical. On the other hand, the AC line from the inverter to appliances can be about as long as you like.

• Follow instructions as to size cable manufacturer recommended for your inverter and its distance from batteries. You can increase the size of the cable, but do not decrease it. (That's size of thickness--not length.) Use the same size cable to connect from battery to

battery as you use from battery to inverter. Using a nice, big #4/0 cable from battery to inverter isn't going to do much good if the batteries are interconnected with the skimpy crap found in most RVs.

• Clean and maintain your batteries and use silicone dielectric "grease" (not caulking) on battery terminals and all electrical connections. Vaseline will work, but not as good. If you're spending several hundred $ or more on an inverter, what's $4 more? Dielectric grease available at about any auto store.

• Cable terminals must be properly attached. Don't economize by getting some cheap, stiff, household-grade cable and just crimping or hammering on cheap copper terminals. Use good welding cable. Measure distances carefully and have a welding supply store or similar attach the terminals if you don't have the proper tools. Best of all, measure carefully and order the best cables anybody can buy (for little more than the cost of auto store junk) from "Wrangler Power Products NW" (SOURCES at last page).

• **RADIO FREQUENCY INTERFERENCE (RFI)**--is produced, to more or less an extent, by all inverters. Some brands have less than others, but all have it because it's the nature of the task they perform. (Almost all fluorescent lights create the same interference. So do some TVs.) You may eliminate all or most of it by:

• Locating inverter away from TV, radio, etc. This is usually all that needs to be done. It works well in most RVs since batteries and inverter are in some underneath compartment. (As an aside, fluorescent lights can often be relocated if they interfere. Sometimes, just a few inches or pointing them at a small angle away from TV is enough.)

• Twisting the big cables from battery to inverter. This is a pain in the ass, and can reduce the 10' distance from inverter to batteries since twisting reduces overall length of cable. What twisting does is allow the radiating field from cables to oppose each other and, at least partly, cancel each other out. You might not have to do this if inverter is properly located. A test is to temporarily hook up inverter with a set of automotive jumper cables. Turn it on. Attach a light to medium load and see what happens. You shouldn't get lines, sparkles or red stuff on TV. You might still get some buzzing on AM radio. If no interference, congratulate yourself and don't bother twisting. (Here's a good example of how you can gain by buying from a good inverter dealer. He'll be able to temporarily cable up an inverter and help you find a suitable location for it. It's a service that the good guys provide)

• Covering the cables with a sheath can help. I use a stainless steel braid (expensive). Some people report good results with copper foil.

• "Boxing" the inverter in with a cage made of copper window screen has also helped some few people.

• Using co-ax shielded cable for all antenna lead-ins (instead of 300 ohm twin lead) helps and is something you ought to do anyhow. Similarly, use high-quality, shielded cables to attach TV, stereo, VCR, etc., to one another (not the cheap junk that came with it).

• Electronics stores ("Radio Shack" and others) carry better-shielded audio/visual cables. They also have a variety of line filters, electronic traps and similar gimmicks for audiophiles. If you can find a knowledgeable Rad Shk guy you might get some good advice. "Home Power" magazine has had several articles on defeating RFI.

TRANSFER SWITCHES AND SIMILAR. Some form of insuring that your inverter cannot be "on line" feeding 120VAC into the system while a generator or commercial power is attempting to do the same is essential. This is true for inverters and for people who don't have an inverter, but only a generator--or who have both.

The simplest (and most reliable) transfer is the style found on older RVs. A receptacle in the RV (usually in the power cord compartment) connects to the generator. The RV main power cord (umbilical cord) can only be plugged into one receptacle at any one time. With this system, you can't connect to one AC source without first disconnecting from another. It's as close to idiot proof as you can get, but can still be defeated by the truly stupid. Earlier, under Do's and Dont's I mentioned never using a simple jumper cable with a male plug on both ends to connect an inverter AC output to a handy wall receptacle in an RV. Some people insist on doing this and eventually will see their inverter fry.

The manual plug-in works, but some people don't want to go outside and change plugs. Manual switches (called disconnects) make it easier. They can be mounted inside, with AC sources wired to them. Moving a lever, that disconnects from one source before connecting the next (electric people call them "make after break" or "break before make"), does the same thing easier. These switches are, of necessity, large and still require that the RVer get up off his butt and do something physical.

Electric transfer switches with relays can do the same thing and can do it automatically. If the inverter, for example, "senses" that there is 120VAC on the line, it won't come on. Sounds perfect? Not so. Electric relays, like anything electric, can fail. I've seen two RVs catch fire when the relay "hung up" and allowed a conflict. In one case, where the transfer switch was mounted on the floor under a cabinet, serious damage resulted. In the other case, the relay was mounted in a converter by the converter manufacturer, easily viewed, and the RVer was able to (panic) and pull the plug in time when smoke was first seen.

Suppose the RVer hadn't been home?

I prefer not use an electronic transfer switch in my own RV. Some of the best inverters have them built in and dealers who I greatly respect use them. This is strictly my own opinion. Quiz your dealer about this and decide for yourself.

FUSING and SWITCHING. (Not transfer switching, but switching the whole system off when something goes kaputt.) This is important and often ignored in RVs. If you attempt to install an inverter in a fixed home, the building inspector will demand fused disconnects. Not using them, in violation of the National Electric Code, will result in your insurance company voiding your claim when your house burns down. RVers seem to think none of this applies to them. They're wrong. The RV insurer can also void your claim if you've done something stupid. ANYTHING connected to a battery must have a fuse in the circuit (the only exception being the "break away" switch on trailers). Fusing inverters used to be a big problem because the line loss when going through available fuses and connectors was so great it interfered with inverter efficiency (and the disconnects could fill a coffin they were so big). No longer. "Ananda Power Technologies" developed a realistic, 400 amp, disconnect. (See "REAL GOODS" and other suppliers in Home Power magazine.) I highly recommend these. They're expensive, but the individual components and others as good are readily available. Someone building a house or starting an RV from scratch should definitely consider the whole "APT" load center. In an existing RV, though, you can buy just the fuse, its terminal blocks and its top-quality switch. This is not an ordinary fuse. It's a Class "T" type fuse. Expensive, reliable, all sorts of good features. (See "Wrangler" for details.)

The Catastrophe fuse--is a good idea and highly recommended. We usually think of fuses as being in the positive (+) line. A catastrophe fuse, though, is mounted in the negative (-) cable that goes from the battery to the RV frame (the RV's common ground). In the case of a catastrophe (or major meltdown) in the electrical system, this fuse will (almost always) blow. When it does, all "hot" lines have no ground, thus no complete circuit, thus the catastrophe stops. (RV Solar Electric has been a key innovator in these and has the best details.) These are large fuses (300 amp and more) mounted in special fuse blocks. I recommend Class "T" fuses for this also.

GROUNDING. This can get confusing because of the varying methods used by inverter manufacturers. Some use a case ground (the case of the inverter is grounded) some don't, but use a separate ground connector. Further, there's a difference between "houses" and RVs in the way the AC systems are grounded. A permanent house has the AC neutral (white) wires connected to a terminal strip in the load center. The bare/green ground wires go to a similar terminal strip. Both strips (in a house) are then bonded together and a heavy ground wire goes to a ground rod or water pipe. Obviously this won't work in a mobile RV. In an RV, the neutral wire's terminal strip remains isolated. Only the bare/green ground wire's strip is wired to the vehicle frame. Wiring an RV the way a house is wired will result in you sometimes becoming the path to ground. Occasional small shocks when standing on the ground and touching the RV metal frame? More severe shocks when standing in a puddle of water and touching RV? Pets chained to an RV flailing around wildly? All indicate this fault. You avoid it by paying attention to what you're doing and by making sure that anyone who helps you install an inverter (or any other electrical equipment) understands this. It's not unusual to find professional electricians, RV technicians and installers of alternative-energy equipment (to say nothing of RV manufacturers) who don't understand this (or forget because they're in the

habit of doing "house" installations). Reading the installation instructions carefully usually solves all this.

It would be nice to come up with a comprehensive guide on the grounding methods used by various inverter manufacturers. Transfer switches also vary, with wiring on some having to be adjusted for RV use. The problem is inverters keep changing. In the meantime, I recommend you buy an inverter from someone who knows exactly what, if any, modifications need to be made. Should you buy from anyone else, quiz them about this. Don't let them sluff you off. The dealer should be able to tell you if the inverter conforms to the National Electric Code (NEC) standard, The Underwriter Lab (UL) standard (used in most RV/Marine units) or some oddball standard the manufacturer dreamed up--as well as tell you how to wire things properly. Major manufacturers should furnish the same information in their installation instructions. Those instructions, in the best units, will include very detailed wiring instructions. Some inverters have the neutral and ground wired together inside the inverter. Do not open the inverter to correct this. You can hurt yourself, the inverter and void the warranty. Instead, make sure that the AC circuit from the inverter, at the first connection point to your RV electric system, separates the neutral and ground. FOLLOW THE INSTRUCTIONS.

PHANTOM LOADS. The big inverters, as mentioned earlier, have an "idle" state--i.e., when turned on, but not operating a load, they revert to a very-low, energy-saving current. As soon as you turn on a load, the inverter immediately comes up to full power. Many appliances, though, are always "on" to some extent, even when turned off: Microwave clock. Instant-on TVs that have remotes that remember channel settings. Many radios and stereos. These always draw a trickle of power. In some cases that draw is enough to make the inverter come fully on and stay there (a phantom load). Some inverters have an idle current that can be adjusted to correct most of this. In other cases, people find it necessary to put an on/off switch at the outlet the appliance plugs into. There are other phantom loads: Nightlights. Clocks. Any rechargeable item that runs from one of those little power-cube transformers you plug in. Electric toothbrushes, shavers, etc., that also run from plug-in power cubes.

Look at it this way though: When on the road, with or without an inverter, your micro wave, AC, TV, etc., are "off" and you usually reprogram when you stop and plug in to commercial power. No real difference with an inverter. Most people find they don't need to reprogram all that automatic stuff anyway. Individual channel numbers can be keyed into a TV remote. Microwave clock isn't really needed, just used as a timer when the thing is on.

Rechargeables can be better recharged with those that plug into the 12VDC, rather than 120VAC, system (Real Goods, Rad Shk, etc., have them). Similarly, power cubes that run off a wall socket (no recharging taking place) also are available in 12VDC versions. The little cubes that run things or recharge them from 120VAC are notoriously inefficient anyway. Any time you change from AC to DC or DC to AC, there's an energy loss (a law of physics). In some cases, it's an acceptable trade-off (as when running a battery charger). Similarly, if when running an inverter, you change DC to AC, that's also an

acceptable trade off. But, to then take the inverter AC and change it back to the DC you started with, is not. It's unnecessary and a waste of power. 12VDC versions are much more efficient. Also, the power-cube device, say a rechargeable shaver, might consume only one-tenth of a watt; however, the inverter is using perhaps 3/4 watt to provide that one tenth. Not too swell. Phantom loads can be a nuisance, but I've found it no more so than the usual plugging and unplugging.

Finding/Fixing Phantoms. With commercial power, generator and inverter off, unplug (don't just turn off) every AC-powered device/appliance in the RV. Don't forget anything. Turn inverter on. It should remain in "idle" state. (If not, you forgot to unplug something.) One at a time, plug an appliance/device in. Does inverter come up to full power? You have a phantom. Attempt to adjust idle current on inverter to avoid this. Unplug the device, make a note of what you did and plug in the next one. Repeat as needed. Once done, if you kept notes, you'll know what the phantoms are. Some phantoms (mainly those little power cubes) can be dealt with by changing them to DC as mentioned earlier. Clocks won't usually start an inverter--but won't run either. Replace them with battery-operated clocks. Night lights are likely culprits, but can be turned off. Consider using DC Light Emitting Diodes (LEDs) as night lights. Wired into the DC system (with a resistor to reduce voltage) the yellow (or newer white) LEDs provide enough light to keep you from falling over your shoes on the way to the john. LEDs use so little DC you can leave them on all the time. Big appliances might need On/Off switches where they plug into a receptacle. You could insert a plug-in switch at receptacle, attach an in-line switch on wire to appliance, or put common items like TV, VCR, etc., on a receptacle strip. These are nice because one switch shuts off everything plugged into the strip and most strips include a circuit breaker.

Once you've gone through this drill, plug everything back the way it's supposed to be. Leave any AC night lights off and turn important things on one at a time. If you're lucky, everything will work. Sometimes, if you have a very low amp draw appliance, it won't come on if you have adjusted the inverter's idle current so that it can't detect the thing. The simplest way to get one of these low-energy users to start up the inverter is to turn on one of those AC nightlights. That will usually "kick" the inverter on. When you're done with whatever task the thing was doing, shut it and nightlight off.

MEASURING AC FROM AN INVERTER. If you measure the AC output from an inverter with a standard volt meter, you'll get a surprise (if you didn't read all the instructions) because you won't read the usual 120VAC. For economy, standard voltmeters are set up to read the "average" of a true sine wave. Meters capable of reading the "true" voltage of any AC wave (like the quasi-sine wave of most inverters) called "Root Means Square or RMS" (which we needn't get into here) cost almost $300 (yikes!). You don't need one. Once your inverter is installed and properly operating, read the AC output with a standard meter and record it. In the future, if you suspect something is amiss, measure it again (under similar load, etc.,). If OK, the readings should be similar. Some inverter instructions list the approximate reading obtained from a standard volt meter. Some don't but your dealer or the manufacturer can tell you. (One of my inverters measures a normal 84VAC, another a normal 104VAC. I know of one model that

measures 145VAC.) Don't panic. Incidentally, commercial power isn't really the "110" or "115" or "120" we refer to anyway. It's (ideally) 117VAC±5%. Further, that's just an average of the voltage. The actual range of volts of a true sine wave of commercial AC is about 175. Interesting, useless information for around the camp fire, but it explains the variations in "normal" voltage readings from an inverter.

SOME PRECAUTIONS WHEN USING COMPUTERS AND OTHER SENSITIVE ELECTRONICS--WITH OR WITHOUT AN INVERTER.

If running a computer from a large inverter that feeds other circuits, do not turn on an additional heavy load while the computer is running. The momentary surges/variations can mislead the computer's sensitive protective circuits and cause a "crash." (This is a good reason for using multiple inverters.) This same thing often happens in a regular house on commercial power, where repeated computer crashes are often found to be caused by a refrigerator, air conditioner or washing machine on the same circuit. (Amazing how long it takes some people to figure this out.)

Most computers work well on the "quasi-sine wave" output of inverters. Some, few, have ultra-sophisticated protective circuits built in (the newest "Macs" for example). These devices "see" the slight irregularities in power as an indication of trouble and may crash or refuse to operate.

As mentioned earlier, many laser printers will only operate on a "true" sine wave. Before you spend big $ on a true sine wave inverter, consider: Do you really need a laser printer? Unless you're doing professional graphics to make a living, you probably don't. Quality ink jet printers easily produce "camera-ready" quality printing. Another reason to consider not using laser printers is that they're enormous energy hogs. The intense heat used to bond the print media/toner to paper uses a LOT of electricity.

Some very-high quality stereos and TVs suffer inverter interference that's hard to defeat. This is really a credit to their manufacturers (some SONY models are an example). They've produced the best in audio/visual quality. That "best quality" though, means they're super-sensitive. They'll pick up the slightest "glitch" and put it on screen as a sparkie. Here's yet another good reason to work with a knowledgeable dealer who can tell you of many appliances that can be interfered with. Actually, there are so many RVers using inverters, that you can usually find neighbors willing to let you run an extension cord over, plug in and try their brand of inverter out on your TV or such.

• A Note on Using Inverters with Medical Equipment. No inverter manufacturer will recommend running "life support" equipment from an inverter. This is the 24hr a day stuff that keeps people alive. It needs lots of hospital equipment with backups. However, as mentioned several times earlier, there's medical augmentation equipment like breathing machines that aren't so critical. Perfect for inverters. Don't get confused.

• A Special Note on Generators--With or Without an Inverter. Many of the problems that can surface with inverters are common to generators. Wiring and grounding, as discussed

above, are typical. All too many RV generators have (inside) the neutral and ground wires bonded together. Why? Beats me. In any case, check this out. I suspect that one of the "transfer switch" hangups I mentioned was due to this. "Onan" is known for this. It's easy to correct. If you don't know how, go to an independent service tech since most RV shop techs won't know what you're talking about.

13. A COMPARISON OF POPULAR INVERTERS

Don't Mix Apples and Oranges! There are similar inverters here, but not identical ones. Use this only as a sampling to compare features important to you. Cost and many other available models aren't listed. Too changeable. I recommend you check with the four major vendors in the Source List (later) before buying. There are occasional sales.

Also, the inverters in the table below are "known, good" performers. As mentioned earlier, inverters are updated frequently. Use the table to compare, then see what's "new and improved."

Note that in the "Source" references in Section 14, Trace, Heart and Statpower inverters are listed separately. All three are now incorporated into the "Xantrex" company (www.xantrex.com). It's still easier to their independent web sites though.

MODEL	Model numbers or names used by each manufacturer.
CONT. W	Continuous watts.
SURGE W	Max surge watts.
IDLE A	12 VDC Amps consumed when in "idle" or "standby" mode.
ADJ?	User Adjustable Idle as Yes or No.
EFF	Peak Efficiency. In some cases a range is shown. In all cases, the dealer or manufacturer will have graphs showing efficiency across the full power range. Demand a copy. You need to know how efficient the thing is at the power range you will usually use.
CHGR	Battery Charger available as--Included (INCL), Optional (OPTL) or NO. I don't list charger features. Most are similar, 3-stage chargers. All are excellent. Dealer/manufacturer sheets will describe features such as adjustable voltage settings.

POWERSTAR--A highly sophisticated inverter with no frills. No adjustments. No battery charger. (Company VP says, "We make Inverters.") And they make a great inverter! Cost is less than the big ones with fancy features. Size is much less and these weigh in at only 5 lbs and are smaller than a shoe box. Free 800# for tech advice. Usually they fix and return. Loaners sent you if you're in a bind. Sometimes they just send new one. Only company I know of with "upgrade" policy. If you buy small (400-700 Watt), you can upgrade later to bigger one for only the difference in price. Hellova good deal. Too much

RFI on these in my opinion.

MODEL	CONT. W	SURGE W	IDLE A--ADJ?	EFF	CHGR
1300	1,300	6,000	0.06 NO	90% at ½	NO

TRACE ENGINEERING--This is the "Maytag" washer commercial (the bored repairman) but Trace can prove it. Almost no returns for repair. No free 800# for troubleshooting, but they accept collect calls. Full range of great inverters. True sine wave available. Too many other optional equipment items to list here (e.g., they make one of the best solar regulators). Noted for very-low RFI on some models. I do like my Trace. No bad comments. Trace took a lot of slams for poor/rude customer service. They've since added more people and trained them properly.

MODEL	CONT. W	SURGE W	IDLE A--ADJ?	EFF	CHGR
DR1512	1,500	3,000	0.045 YES	94% at ½ of full power	INCL
SB2512	2,000	6,000	0.028 YES	96% at "some" levels	INCL
SW2512	2,500	~7,000	0.04-0.08 YES	96% peak. **Pure sine wave.**	INCL

HEART INTERFACE--Yet another success story. It's amusing to watch Trace and Heart compete, the engineers vying to come up with just a tiny bit more performance than the other guy. Heart is popular with boaters because its construction is almost impervious to the elements. Free 800# with techies to assist you. Very low RFI. (My old Heart 300W had none.) Heart is reputed to take a long time to make repairs. I can't say because mine never needed repairs.

MODEL	CONT. W	SURGE W	IDLE A--ADJ?	EFF	CHGR
Freedom Series 10 - 30	1,000 to 2,000	3,000 to 5,500	0.12 YES	92 - 94% peak.	INCL
Freedom 458 Series	2,000	~8,000	0.12 YES	93% peak.	INCL

STATPOWER--Makes the best sine-wave inverter available today. Rated as such by Home Power Magazine, THE authority in the field of alternative energy. Pricey, but will handle an entire RV (less A/C of course). This is my primary inverter. Don't be put off by Idle A and EFF factors below. Remember this is pure sine wave--and the quality of power is better than most power companies can provide.

MODEL	CONT. W	SURGE W	IDLE A--ADJ?	EFF	CHGR
Prosine 2.5	2,500	4,000	0.25 YES	88%	INCL

Notes on Efficiency: Peak efficiency is usually at something less than full power. I suggest you get the graphs from manufacturer or dealers referred to above, then size your inverter needs carefully, then figure what your inverter will usually be doing. E.G., if you'll be doing things most of the time in the half-power range, and that's where peak efficiency is, then that might be what you need. Running at full power, with slightly reduced efficiency, would then be OK if not for long periods.

14. SOURCES

"Home Power Magazine--The Hands-on Journal of Home-Made Power." This magazine is the prime information resource for anyone interested in living or RVing a better way. Old phuds like me (and anyone else who is serious) consider this the prime reference for what's new, what really works, etc., in alternative energy. Now available on many newstands and in some libraries. Far better to subscribe. $22.50/yr (6 issues of well over 100 pages) 2d Class mail.. $36 for 1st Class mail. "Home Power Magazine." Box 520, Ashland, OR 97520. (800) 707-6585. Most back issues available. CDs with issues 1--70+ available. Web site at www.homepower.com puts each current issue online for free reading (PDF format).

INFORMATION FROM MANUFACTURERS. Call for basic literature/brochures/etc. Make sure you get efficiency graph for models you're interested in. Be nice. Don't tell them to send you everything they've got on everything they make.

Heart Interface. (800) 446-6180. In WA (206) 872-7225. www.heartinterface.com If you buy a Heart, use this same number for tech assistance.

Trace Engineering. (360) 435-8826. (www.traceengineering.com) No 800#. That's OK. RV Solar Electric (below) has all their data sheets and has an 800#. Once you buy one, Trace will accept collect calls if you have problems.

STATPOWER. A very nice line of inverters. Make the highest rated true sine wave. (800) 668-0003. (www.statpower.com)

EXELTECH. Very highly rated line of true sine wave inverters. (800) 886-4683. (www.exeltech.com)

PowerStar Products. (800) 645-4004. (408) 973-8502. Use same 800# if have trouble.

INFO FROM VENDORS/DEALERS: Some send free stuff, some charge for catalogs. All are great, Honest, trustworthy.

RV Solar Electric. 14415 No. 73d St., Scottsdale, AZ 85260. (800) 999-8520. (602) 443-8520. (www.rvsolarelectric.com) Nobody knows more about solar systems, inverters, etc., (for RV use) in this country than these people. This is where experienced RVers go. Call for their free informative newsletter/catalog. Get on their mailing list. Buy their book, the "RVer's Guide" (info on solar energy, inverters, much more) for $12.

These people have been listed in no less than "The Whole Earth Catalog" (we're talking a big recommendation here), as having "What you need to know if you're going to live in an RV." Their info a "must have."

Real Goods Trading Corp. 555 Leslie St., Ukiah, CA 95482. (800) 762-7325. (707) 468-9292. (www.realgoods.com) The "Solar Living Source Book" this company uses as a catalog is 690+ pages of valuable info. It's a text book on living a better way. An excellent staff of experts will answer your questions. The book costs $24.95. (But if you're a cheapskate, get your librarian to borrow a copy, if they don't have one, under ISBN 0-930031-82-2-etc.) Real Goods website has most of their info free. Another "must have."

Backwoods Solar Electric Systems. 1395 Rolling Thunder Ridge, Sandpoint, ID 83864. (208) 263-4290. (www.backwoodssolar.com) No 800#, but they do return calls at their expense if you don't take advantage of them. Free Catalog/Planning Guide (is also the best source for generator selection info--they tell it like it really is) . This is another textbook. Good deals on inverter trade ins. Free periodic newsletter has latest tips and is most valuable.

West Marine. Box 50050, Watsonville, CA 95077. (800) 538-0775. (www.westmarine.com) Giant catalog ($5 refundable) with page-after-page of tips, how-to's and product comparisons. You really need this catalog.

Wrangler Power Products NW. We spend big $ on equipment, then buy flimsy junk at RV and discount auto stores to tie it all together. Doesn't make sense. Do yourself a favor and get Wrangler's free catalog. Heavy-duty cables and connectors, fuse holders assembled to your specs, heavy-duty switches, lots more. Top quality. 4444 S.E. 27th Ave., Portland, OR 97202. (800)962-2616. (www.wranglernw.com)