Updated: 10/2002

BATTERIES--AND OTHER ELECTRIC STUFF
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12VDC electricity first. 120VAC electricity follows.

This starts with the basics then gradually gets more advanced, with more extensive tests and interpretations. Some topics are mentioned several times, usually with more details and explanation, sometimes for emphasis. Even experienced RVers should start with the basics -- there are a lot of misconceptions when it comes to batteries.

THE BASICS
First things first. A 12-volt battery is not a 12-volt battery. Twelve volts is just a nominal, convenient term used to distinguish one battery from another. A fully-charged 12-volt battery, allowed to "rest" for a few hours (or days) with no load being drawn from it (or charge going to it), will balance out its charge and measure about 12.6 volts between terminals.

When a battery reads only 12 volts under the above conditions, it's almost fully depleted. Actually, if a battery's resting voltage is only 12.0 to 12.1 it means only 20 to 25% of its useful energy remains. It's either a goner or it has been deep cycled, and a battery can only be deep-cycled a limited number of times before it is indeed dead.

12-volt batteries supply useful energy only through a limited range -- from over 14 volts (when fully charged and unrested) down to 10.5 volts in use/under load (when lights dim, pumps groan and TV pictures get small). No 12-volt battery will remain at over 14 volts for more than seconds unless it's being charged. The lowest limit is 10.5 volts (used in testing) and obviously unsatisfactory in practical use. Experienced RVers try to use no more than 20% to 50% of the energy available in a battery before recharging. That means they never let resting voltage get below 12.5. They never use more than 50% before recharging (resting volts of 12.3) except in an emergency. They know that, if resting voltage ever reaches 12.1, they have deep-discharged one cycle and that a battery is good for only so many cycles (from as low as 20 in an automotive battery to 180 in a golf cart battery, with the typical RV/marine battery good for no more than 30).

RESTING VOLTAGE--IMPORTANT TO UNDERSTAND
Resting voltage causes some confusion, although it shouldn't. It means with no charging and nothing drawing electricity. No night lights, clocks (to include microwave), radio or TV memories (some have circuits that remain "on" even with the unit turned "off" to recall preset channels, etc. -- so-called "phantom loads."). And don't forget the LP gas detector/auto shut-off -- a real energy user. No reefer on (the "brain" in a three-way uses 12 volts even when running on AC). Needless to say, testing voltage this way can be a real pain in the ass. You need to do it, though, so you can find the phantom loads and hidden users that will haunt you later. If you're just interested in checking the battery, there is an EZier way to do it: If you have two or more house batteries, disconnect one of them and charge it fully with a reliable manual charger. The other(s) will run your RV while the disconnected one "rests." Overnight is OK. A day or two is better. Then check the resting battery's voltage, reconnect it and repeat the test on another one. You only need to make this test once or twice a year -- it's a good time to clean your batteries and connections as well. (More later on converters, manual chargers, meters and correct voltage.)

MANAGEMENT
You need to know what you can get out of your battery without dropping it below an acceptable voltage, but it's not a daily exercise. Done a time or two (or three) with notes taken, you'll soon know how many hours you can run lights, TV, etc., before recharging is needed. This is how experienced RVers calculate how many days they can rally or park in the boonies before cranking up a smelly generator. It's a mix of conservation, intelligent charging and battery care.

It's best to practice the below test while you're on an electrical hookup so you can recharge faster when finished:

- Switch reefer to LP and turn off unnecessary 12V appliances.
- Fully charge battery(s).
- Record the time.
- Shut off converter or battery charger (or unplug your RV if it's a cheapo with no way to switch it off).

- Run off 12 volts for 24 hours (or some convenient time) using appliances and lights as you would normally.
- Occasionally check a digital volt meter (see later) and record time when meter drops to each % Of Charge setting on chart (later in this poop sheet). Don't, though, go below the 50% level in this test.
- Simultaneously record the appliances you have running and how many minutes they run (that's each appliance, including number and type of lights, if you really want to do this right).
- When you reach the voltage that approximates 50% Of Charge (on chart later in this sheet), turn your battery charger back on. You now know how long you can run the house, in "normal" use, without charging, before chancing a "deep cycle." Do some simple math (below) to refine this and calculate where you can conserve electrical use to extend your time.

NOTE: When measuring above, when the battery is under load, but not being charged, volt meter will read lower than actual battery state. For example: If TV and lights are on, the meter might read 12.4. Don't panic. Turn heavy loads like those off. Watch meter. If batteries aren't substandard, it will increase volt reading then stabilize. That's the point where you take your reading. (An easy, quick way to observe this is to watch the meter while you run enough water to make the pump start. You'll see a drastic drop in voltage. Shut water off. When pump stops you'll see meter reading start to creep back up.)

SOME SIMPLE MATH -- Either before or after the 8-step test above you need to calculate the amp hours you use:

Quick way: After the test above you found you could run (x) hours of lights, (y) hours of TV, (z) hours of etc., before reaching the point where you were about to deep-discharge the battery.

Proper way: Highly recommended that you do this at least once.

1. Record actual minutes any given appliance was running.
2. Convert to Amp Hours as follows: 2a) Read label on appliance for amp draw. Can't find it? Look for Watts or VA (same thing for our purposes). Watts = Volts x Amps, so 60W = 12V x A and 60 ÷ 12 = 5 amps. (If this doesn't make sense you didn't pay attention in school.)

3. Whatever, your appliance draws 5 Amps. If it was running an hour, that's 5 AH (Amp Hours) because AH = Amps x Time (in hours). And if it didn't run an even hour? Then use minutes ÷ by minutes in an hour (e.g., 60 minutes ÷ 60 minutes [the minutes in an hour] =1, so if the appliance was on 12 minutes and it was drawing 5 amps, then AH = 5 x 12/60 or 1AH (or 5 amps for 1 hr 15 min = 5 x 75/60 = 6.25AH).

TIPS: Almost any appliance will have a label or the same info in its booklet. The circuit boards on some reefers, water heaters and furnaces use 12 volts also. It's only a small amount, but should be considered because it's being consumed 24 hours a day and the total can add up. (On the other hand, the 12 volt fan on a furnace uses an enormous amount of electricity -- don't miss that one.) Doing it the proper way allows you to predict in advance how many Amp Hours you'll use. Don't be alarmed if your 105AH battery, when voltage indicates it's at 50% of capacity, has given you a lot less than the 50AH you expect. Most batteries are seriously overrated by the manufacturer, seldom yielding 80% of their stated rating. (See more on battery capacity later.)

CHARGING VOLTAGE

Charging voltage is different. Some more basics: If you read articles on how electricity flows, you see comparisons as to how water flows. This is okay up to a point, but water also flows by gravity. Electricity doesn't, it has to be "pushed" (just as water has to sometimes be pumped).

You have to have more "juice" at one end of a wire than you need at the output or electricity won't flow. The wire you pump electricity through and the connections in the lines resist the flow. You have to overpower it. Similarly, batteries have an inherent resistance to take a charge because of their chemical makeup. It's like "making a blivet" (a blivet is 10 pounds of poop in a 5 pound bag). You have to force more electricity into a battery than it would like to accept or it won't be fully charged. To charge a standard 12-volt battery, you have to bring it up to above 14 volts (amount varies with the type of battery).

The typical wet-cell battery (a tub of lead plates in a mixture of sulfuric acid and water) needs to be charged up to about 14.+ volts in order to adequately distribute those funny little things called electrons through the plates. Once that's done, the battery can rest. As it does, the electrons distribute themselves and eventually balance out at 12.6 volts (more or less, depending on the type battery and its condition). This is your starting point. Doesn't sound like much, does it?

MORE AMPS AND VOLTS
I mentioned earlier that you should only draw a battery down to about 12.3 volts before recharging. Obviously, there's more to it than that. Amperes are the measure of actual power available. They're usually converted to amp(ere) hours (AH). Think of it as the amount of (nominal) 12-volt power you can draw out of a battery for a certain amount of time. It's not just three-tenths of a volt. It's 12 (nominal) volts for a certain amount of time. The three-tenths stuff is nothing more than a difference in measurement -- like the difference between three-fourths of a tank of gas and a half tank.

Look at voltage as two things: First, a force that pushes electrons -- Second, as a handy measurement.

Look at amperes as two things: First, a quantity of energy (like you would a gallon of gas) -- Second, as a handy measurement. From a (nominal again, don't forget) 12-volt tub of energy, you can extract just so many amperes of power.

Keep in mind that the laws of physics prevent you from getting more out of something than you put into it! Keep in mind that waste (those wires, battery contents and such) prevents you from taking out as much as you put in. Keep in mind that you're going to have to put in about 10% more electrical power than you use (high school physics). A battery bank is like a "money" bank or checking account -- if you repeatedly take more out than you put in, you'll eventually be in trouble.

MORE ON CHARGING
Not all batteries are the same. Standard wet-cell batteries can be charged to 14.+ volts (usually 14.3 but depends on the manufacturer). Gel-cell batteries and other sealed batteries should never be charged to more than about 14.1 volts (again, may vary depending on manufacturer). And these figures only pertain when the charger will be disconnected as those levels are reached (as with a generator, solar system, portable charger, or engine alternator). As the volts drop (usually down to about 12.6 to 13.3),

charging begins again, either manually or through an automatic regulator. Note also: The maximum charging voltage quoted for gels by the manufacturer is as a sustained voltage, not an intermittent one. That means brief over-voltages before a regulator shuts off are OK.

Sustained charging, where the batteries are "floated" at a constant charge (as in the RV converter or with an automatic portable charger) should not be done at more than 13.8 volts (and 13.65 makes batteries last longer). It's supposed to keep the batteries "up" to a reasonable level without undercharging or overcharging them (the assumption being you'll "top them off" by driving). Unfortunately, many cheap chargers and RV converters don't regulate very well. Overcharging destroys batteries quickly. Undercharging destroys batteries too, but more subtly as the battery stratifies and will no longer maintain a charge. In effect, the 100 amp/hour RV battery becomes a 10 amp/hour battery after consistent undercharge. It will read full voltage, but as soon as a small load is placed on it, it drops to nothing. RVers who remain plugged into commercial power for long periods often never know this has happened until they unplug, because the converter's transformer also supplies power directly to the RV circuits while it's charging the battery -- or trying to. (More later.)

EQUALIZING

Sometimes an equalizing charge can correct the above situation. **BUT, don't ever try to equalize a really sealed wet battery or gel-celled or AGM battery!** You've got to be really careful when doing this! The battery is going to "gas" (bubbles in the cells, hydrogen gas escaping). It shouldn't be violent, spewing acid an over the place, just gentle to rapid bubbling but it requires caution. It's usually done by hooking up a manual charger, then bringing the voltage up to 14.1 or 14.3 and, instead of stopping as usual, keeping it there, at about a 5-amp charge, for three to six hours (until voltage reaches 14.5 to 15). Do this with the caps off of a standard battery so you can see what's going on. About three hours is usually normal for one of these equalizing charges.

Follow safety precautions, use safety goggles, plenty of ventilation, etc. If it works, you lucked out. If not, buy a new battery (as you should have in the first place).

Some battery people recommend equalizing in this manner every three months (or after 5 deep cycles). I think the wear and tear on a 12V battery from equalizing this often does more damage than it's worth.

Batteries held at 13.8 or so for long periods get lazy and like it there. They need some "equalizing" also. Not as drastic as above, fortunately. If you drive occasionally, your engine alternator should do it (assuming the regulator is set properly). So will a solar electric system or a good, well-regulated independent battery charger. If nothing else, use the manual charger once in a while when parked and plugged in, but just bring volts up to 14.+ (whatever's appropriate) and stop there.

Six volt heavy-duty batteries (like golf carts, etc.) differ. Their heavy plates and other construction features allow periodic equalizing. I recommend the same 5 amp charge rate, for three to six hours (until voltage reaches a maximum of 16.5) every six months or so. It varies, with some people doing it monthly (which might mean another problem).

CHARGE/DISCHARGE RATE

You'll see references in battery books to the proper charge rate. C/10, C/20, etc. Sometimes it can be confusing. What you need to know is that it means the "time" it takes to fully charge a "dead" battery at a certain amp rate. For example: A 105AH battery will fully recharge (from dead) in about 10 hours at about 10 amps of charge (C/10) or about 20 hours at 5 amps of charge (C/20). Faster charge rates, like C/5 or C/8 shouldn't be used with most batteries because the high amperage required for such a fast charge damages the battery. C/5 on a dead 105AH battery requires pounding in over twenty amps. (This is sufficient reason to stay away from fast-chargers in service stations where a gigantic amount of amps are pummeling your battery when they "charge" (destroy) it in 20 minutes. And when you buy a battery off the shelf, don't let the guy "put it on a charger for just a few minutes" or it will be damaged before you ever use it.

Now, for real life: You'll seldom be charging a "dead" battery. The C/20 rate of 5 amps will charge your partially discharged battery just fine in a lot less than 20 hours. And, since your typical RV converter only puts out a low amp charge anyhow (only 3 or 4 or so), you're about at the safe C/20 rate all the time. If you're in a hurry, plug in your manual charger as well and just keep an eye on things.

TROUBLESHOOTING AND TESTING

Don't just replace batteries and keep on trucking! Find out what went wrong first. Is the converter working? Voltage too high? Too low? Is it connected to the battery? Fuse blown? Wire broken? Contacts cruddy? Kill switch on motor home on or off (whichever is appropriate -- and the wrong position a common fault among motor homers)? How many times have you deep-cycled? Short in the system? Been hooked up a long time? Automotive regulator/alternator OK? (More later.)

Measuring, metering, testing and troubleshooting require only a few tools and basic knowledge. Much of it is common sense, requiring no tools. Do not ever depend on the red/yellow/green idiot meter installed in most RV's. Get a digital meter. You need a digital meter to accurately read battery voltage to tenths of a volt. You should have an Analog (needle face) meter also. You can't tell the difference between battery voltages with an analog with great accuracy, but they are better in some ways (because it's easier to see rapid changes) than digital meters for reading fluctuations. (Much more later.)

Get a 12-volt troubleshooting light/test lamp from any auto store cheap or make your own. (Meters will indicate voltage even if there's only one strand left in a wire. Test lamps won't light if there's not enough wire to carry the load.)

Get a decent hydrometer if you have wet-cell batteries and can remove the caps. Don't get a cheapie with colored, floating balls. Learn how to read a hydrometer. (See more later.)

MAINTENANCE

Maintenance is all-important. Crud on top of a battery provides a path between poles. It's a "short." One most people never notice, but it uses energy constantly.You don't need to slop baking soda all over. Often just a spray 'n wipe with household cleaner is all that's needed.

- Corrosion will build up. Some-times you can't even see it. Take contacts apart and clean them. (Now is when you might use baking soda, but don't let it get in the cells.) Done once or twice a year, it's

fast and easy.
- Before putting things back together, coat all surfaces (thinly) with silicone dielectric grease. That's before, not after. You won't accomplish a thing by smearing grease on top of corrosion.
- Never use red battery spray. It just makes things worse. The red/green felt, noncorrosive washers are okay.
- Label or color-code cable and wire ends. Make a diagram. If you don't, you'll just hook things up wrong. (More on maintenance later.)

MORE DETAILS ON BATTERIES (MOSTLY GEL CELLS and AGM)
Much of the same material applies: All batteries need to be maintained. All batteries need to be kept charged -- but not overcharged or undercharged. All need clean connections and good, stout cable and wire of the proper size. No battery should be routinely deep-cycled. Of most importance, charging needs to be well regulated.

And here's where the difference between gels, AGMs and regular, wet-cell batteries starts to show up seriously.

- **Wet cell** (flooded) batteries: Suspended plates, usually with some form of separators (so plates don't touch each other) are immersed in liquid electrolyte. These may be charged, just as a starter battery, which makes things a lot simpler.
- **Gel** batteries: Plates are suspended in a thick gelled electrolyte that insures stability and eliminates voids or "air pockets" at the plates. The best gels are those by "East Penn Mfg." (under "SeaGel," Prevailer" and other labels -- but the East Penn name will appear somewhere). Competitors are lite weights. Gels are seldom charged to more than 14.1 volts initial (bulk) charge and 13.8 (13.65 is better) as a "float" charge (see later).
- **AGM** (Absorbed Glass Mat) batteries: A dense fiber matting between the plates and a liquid electrolyte provide
similar features to gel batteries but are much more rugged since they were designed for use in aircraft and rough terrain vehicles. The best AGMs are those made by "Concorde" (usually under the "Lifeline" label but Concorde will appear somewhere). AGMs (like gels) are very sensitive to overcharge. 14.38 volts is recommended for the initial (bulk) charge and 13.38 as a "float" charge.

Pros and Cons:

Standard, old-timey flooded batteries are cheap (initially). They'll do the job (golf carts or similar better than RV/Marine stuff). See remarks elsewhere. They will vent gas and fluid, but it can be replenished with distilled water. They require a *lot* of care.

Gells and AGMs can do a better job and last longer, BUT also require special care. They're rather expensive initially (but my six gels are in their tenth year, as good as new, and the cost nets out to less than standard batteries). *However*, they are very carefully charged and that requires an expensive charger/regulator. Gels and AGMs don't need a lot of maintenance and cleaning (other than a quick spray and wipe from a household cleaner) UNLESS you do something stupid and overcharge them. They won't spill acid, are very shock resistant, don't pass gas (pun intended) unless seriously overcharged, have a VERY low self-discharge rate (nice when the RV is in storage) and have a very long cycle life.

I've used golf cart batteries, regular batteries and gels. As I'll repeat with more detail elsewhere, golf carts and similar batteries are, all things considered, the best solution. Were I to have to replace my batteries today (they're in the living compartment in a small RV), I'd go with AGM. In a bigger RV, I'd go with golf cart or fork lift batteries.

You should never charge a **gel** battery to more than 14.1 volts (or to more than the voltage specified by the manufacturer) before the regulator shuts off the charger except for very brief periods. Then, as a battery is "floated" (kept on the charger with a charge applied to keep it up to a reasonable level), it should never exceed 13.8 volts (better, for long life is a maximum of 13.65 volts). Again, though, you don't float the battery permanently. You occasionally bring it up to 14.+ (this is EZ with a solar regulator or better quality battery charger that will perform regulating tasks frequently and automatically. (more later.) **AGMs** are charged similarly, just with different voltages.

Actually, you'd be foolish to keep (float) any battery at a sustained charge of over 14 volts. You'd just wear it out prematurely and it would be spewing acid all the time, making a mess. But with a regular, wet-cell battery with removable caps, you can add water and clean up the corrosion. With a gel, or any other (really) sealed battery, you can't add water. All you can do is watch the battery deteriorate.

Gel batteries and AGMs do have caps, but **don't ever try to remove them.** First, you'll violate the warranty. Second, you'll contaminate the inside. When it dies early, the dealer/factory will know you did this and will void the warranty. Also, if you overcharge a gel or AGM battery, the factory can detect that, too. Again, no more warranty. Gel and AGM batteries are expensive. Retailing at about $300 each in the Group 27 size, they are available for less than $175 plus freight from many alternative energy dealers. The best info source is SKP Noel Kirkby at **"RV Solar Electric"**. He can refer you to a good dealer (www.rvsolarelectric.com). Check also with Back Woods Solar (www.backwoodssolar.com) and **West Marine** (www.westmarine.com). No matter what price, these are not $55 pieces of RV junk you get at a discount store and return for almost full credit because you screwed up.

So why bother with them? If they're expensive and so sensitive? Because they do a superior job in some cases. Venting to outside air isn't needed. (They can vent gas and fluid if you seriously overcharge them or do something catastrophically stupid.) Moot point, because you will take pains to never overcharge them anyway (won't you?). You can keep them inside the RV (or in a basement compartment). They stay clean and need very little service (other than a spray'nwipe with household cleaner and an occasional check for tight connections) and, more importantly, will be temperature consistent (more later). Piling a bunch of batteries on the tongue of a trailer or directly behind the grill of a Class "A" motor home is not a good idea. you just overweigh the front of the thing and end up with a wallowing vehicle. The back bumper is also bad for the same reasons, plus more, as you overweigh and flex the frame and create leaks (if you don't break the frame, hitch or the vehicle skin). These battery mounting schemes also lead to ultra-hot and ultra-cold temperatures.

TEMPERATURE

Temperature is important when charging any kind of batteries. A really hot battery (EZ to achieve if they're sitting out in a cheap, plastic box) will overcharge well before the voltages listed earlier. Keeping batteries "indoors" helps keep them at about an ideal temperature (of about 68 to 77ºF). Actually, high temperature only becomes a real problem when the battery is being "floated." A 13.8 volt float can easily become a 14+ a-whole-bunch float at 90º. Temp can also be a winter problem as batteries try to freeze and their amp hour capacity is reduced by over 30%.

MORE ON REGULATING CHARGE
There are only a few RV converter/combination battery chargers that are worth having. Most do an absolutely lousy job and you haven't the faintest idea what wild voltage (or lack of) is going to your batteries. Some converter/chargers do work. Check yours no matter what kind of battery you use. With the thing operating, and the battery reasonably-well charged, and not much more load on the battery than the TV antenna amplifier and reefer brain (RV reefers with a circuit board use 12 volts all the time, just to operate the board), put a digital volt meter across the "house" battery terminals. Leave it there awhile and see if it's holding the batteries to around 13.8 volts. (Or is it charging them up to something ridiculous?) (Or is it charging at all?) Some, even fewer, RVs use a separate battery charger (not as part of a converter). Generally, these are pretty good (and expensive). But check them the same way. It's not at all uncommon to find stock RV battery chargers floating batteries at 14.3 volts or higher. The best chargers regulate in two, three or four stages. First, anytime there's sufficient demand, they full charge to 14.+ volts (adjustable by you). Second, they revert to a "float" charge of about 13.8 (which in good chargers is adjustable again). Some have a third, "equalizing" stage, automatic or manual, that should also be adjustable. (There are some four-stage chargers also.)

If you want to use gel or AGM batteries, you must have a good, reliable, user-adjustable regulator and charger. The best way to charge batteries is with a solar electric system. (Again, check first and last with "RV Solar Electric" above.) A solar system (if it has a user-adjustable regulator) will let you set the charge cut-off at desired volts. Usually, anytime the solar system achieves that, it will cut off and drop to about 13.1 volts before resuming (some solar regs will back off to a float voltage). This gives the batteries a "rest" and keeps them from overcharging. (And, of course, at night, solar systems don't do anything, so there's a good rest, too.) For a backup, you can use a generator or commercial power. Make sure your generator (if it has a direct DC 12 volt charging outlet) is set to regulate at proper volts! If it just charges through your converter, you'll have checked that above, but recheck it with the generator running. Do the same with an independent charger. Many others are available. Check with **"West Marine."** Huge catalog that has page-after-page of comparison info and tips. If you're going to buy a big inverter anyway, consider those with a battery charger option. For $220 additional (or included at no cost), you get a user-adjustable charger that would cost over $400 as a stand-alone. (See my Source List and Inverter poop sheets.)

AUTOMOTIVE CHARGERS
How about the automotive charger when you're driving? Same drill. Most automotive chargers (alternator and voltage regulator) are factory set for cut off at 14.3 to 14.7 volts. There are user-adjustable, automotive regulators. If you can't easily find one, check **"Ample Power," "West Marine"** or, best of all, **"Wrangler Power Products"** (see Sources). Wrangler is especially easy to work with and most knowledgeable. Ford products use external regulators, which makes it easier (and cheaper). Some (like GM) and others use internal regulators (built into the alternator). That's not too swell an idea anyway, they get too hot and wear out. In those cases, you can get a special alternator and external regulator. (Wrangler knows just what will work.) It can get expensive, but most RVs need a better alternator anyway.

CABLES AND CONNECTIONS
Tying the system together is important. No point spending a lot of money on batteries and chargers and wiring it up with skimpy junk. Large battery cables can be found in good auto stores like **Big A** that carry things for trucks and West Marine that carries things for boats. Best is to get cables from **Wrangler** (www.wranglernw.com) custom-made to your lengths with terminals that match your vehicle. Smaller wiring is also important. You can get it locally, but get the right size. Pay attention to terminal ends and splices. Don't use the cheap clamp-on stuff that RV shops use.

DON'T EXPECT MIRACLES FROM GELS or AGMs!
Gels are expensive, require careful charging, monitoring with a digital meter and protection from extreme temperatures. Most of us who use them are pleased and sure the extra care is worth it. Those who are not satisfied usually abused them or assumed they would work miracles. Confusion abounds with these batteries. They are not "regular" batteries. Amp Hour (AH) ratings of these confuse everybody. Group 27 size only 86AH when almost any RV/Marine battery is l05AH? Yes, BUT RV batteries

are usually 25% overrated. There's more to it. There's AH and effective AH. Gels (for example) are fully charged at a resting voltage of 12.9 to 13.1 volts instead of the usual 12.6 volts, thus start to deliver electricity from almost 13 volts, instead of 12.6 and that equals more efficiency. Depending on use, you can get more effective AH from gels than the rating. This does not mean you can draw 250AH from a pair of gels in one day with heavy loads and no recharging. Again, there's no magic or miracles. Also, that difference in voltages means you can't just connect a gel or AGM battery to a regular battery or to sets of golf cart batteries. Nor should you connect regular batteries to golf cart (or similar) battery sets. Mismatch will damage them.

TYPES OF GELS AVAILABLE
Sonnenschein (German) originated the principle and has been selling the battery for many years. East Penn Mfg. bought U. S. rights and is manufacturing and selling them under the **DryFit Prevailer** or **Deka** label. These are the best gel-celled batteries you can buy at this time. Johnson Controls (**Dynasty**) and **Exide** (among others) are trying to compete, but their batteries are lighter and, as of now, just don't measure up as well. No doubt all this will change.

BATTERIES TO IMPROVE?
The government's electric car mandate has already resulted in significant improvements in battery technology. It won't be too long until these improvements are on the market. If the batteries you have now are OK, you might want to baby them along, as long, as you can. That means make sure your battery charger isn't over or under charging, that you don't deep-cycle them and you maintain them. If you need batteries, you should investigate gels (technically, gelled electrolyte) or AGM.

6 VOLT BATTERIES
Check on 6 volt batteries also. The right 6 volt batteries, golf cart or fork lift, connected in series-parallel to furnish 12 volts are, all things considered, the best battery source for RVs. (More later.)

MORE DETAILS ON BATTERIES AND ASSOCIATED ELECTRIC THINGS
Giant, motive power, truly deep-cycle batteries (as used in industry) are ideal for a fixed residence: but, with their enormous size and weight are not practical in an RV. Similarly, a bank of 2-volt telephone-cells

connected in series-parallel (to = 12V) can provide a super, long-life power source. Again, though, there would be a space problem and the weight would be well over 600 pounds.

Eliminating these power sources out of necessity, let's also eliminate another bad choice: The typical RV arrangement of one or two automotive-grade batteries in plastic boxes mounted on the tongue of a trailer. Out of sight and out of mind; never serviced; corroding away in freezing cold and broiling sun; generally two inches deep in water; green, cruddy terminals connected to a bunch of multi-colored, go anywhere, frequently shorted wires. The whole mess tied down with a plastic strap and buckle that nobody can operate (so they never do), which is just as well, maybe, because it will break.

Almost as bad is the huge, homemade plywood box that sits on the rear bumper, has most of the same failures and interferes with weight distribution. It puts undue stress on the frame and creates leaks in the roof. At worst, it bends the frame and it cracks the roof and sides (just like cargo boxes and motorcycles). You can put some weight on a bumper, but not much. How much depends on the RV, its GVWR and its construction. Frequent articles in RV pubs point out the need for strict weight control. The articles do nothing more than point out the rules of basic physics--heed those rules or destroy your RV. Note, for example, that the further the rear end is from the wheels, the less weight you can put on the rear end. Note also that the further the front end is from the wheels, the weight you add to the tongue can drastically increase tongue weight. Too much tongue weight equals a broken hitch.

If possible, RV batteries need to be in an inner compartment. (A battery loses 30% or more of its capacity in cold weather.) Most batteries need to be vented as well. This can cause problems when using the next best thing to the giant batteries mentioned above--pairs, in series parallel, of 6V fork lift or golf cart batteries. These weigh more and are taller than standard batteries. So, when they're crammed into an existing compartment, there's no way to service them. (Most RV battery compartments don't allow for servicing "normal" batteries either.)

If you only need two batteries, it's not too much of a problem. You can build a slide-out tray (that probably won't work well), ignore your batteries (the usual solution) or build a better compartment. You can build an insulated battery box on the tongue or bumper for two (maximum 4), but pay attention to what you're doing--no heavy plywood, certainly no particle board. An aluminum frame, with aluminum flashing can make a water-tight box that weighs little. Lining it with urethane, aluminum-coated foam is effective and also light weight. (You'll need a plywood bottom, covered with aluminum, vinyl or fiberglass since batteries weigh about 60 lbs each.) A spray of vinyl undercoating (fiberglass gel coat if you know what you're doing) will acid proof the interior. Best is to put the batteries inside the coach in a vented (if necessary) compartment.

An example: I use six, true gel-cell batteries. The same size as Group 27 (l05AH) RV batteries but much heavier. Venting isn't necessary (if they ever gas, it means you've got other problems). The batteries are easy to get to, stay clean and are temperature consistent. Wiring is simpler. "Basement" style trailers and motor homes can easily do the same thing, with batteries well protected but outside the living area. A further example: In my travel trailer I had six golf cart batteries under the kitchen sink (in a vented compartment). Easy to get to and maintain and, again, temperature consistent as well as clean and easy to phiddle with. Get creative.

Here are two alternatives when using regular or golf cart batteries in a tight place (neither totally successful): Some people attempt to solve the non-access problem to batteries in a small compartment with the use of "battery bobbers" (clear plastic caps with floats inside) that let you peer inside and estimate water level. A help, but some bobbers stick and some leak and sink (that's the way things work now days). There's still the matter of not being able to use a hydrometer, though one can keep a pretty good eye on battery performance with a digital voltmeter (if you take the time to learn what you're doing). If the compartment is too tight, you can peer in and get an idea of corrosion, but only with great difficulty and with crud being spread around (and with spectacular pyrotechnics when you short your wrist watch or ring to ground). At this point some people buy "Hydrocaps" (not to be confused with bobbers) which cost about $7 each, but really do reconstitute vapor and prevent loss of fluid and gassing. Hydrocaps aren't foolproof. If the battery is seriously overcharged and overheats, the caps can melt down and the battery burst open. Catastrophe time!

Back then to two choices: Put the batteries where they can be serviced or use maintenance-free batteries. You say, "I've heard all about those lousy things that die in 18 months." Fact is, they weren't really lousy, just very shallow cycle batteries. Had the manufacturer told us this (that they shouldn't be deep cycled), that problem wouldn't have resulted. Also, these batteries (sealed wet-cell batteries) shouldn't be overcharged much above 14V because they will gas and fluid can't be added. No real problem there either -- if people know it. These "wet" (fluid filled) sealed batteries have for the most part been written off by serious RVers. Not so much because of the shallow cycle (because in a properly sized system you'll almost never deep-cycle your batteries anyway) and not because of the critical voltage limit (because in a good system you'll have an adjustable regulator that prevents overcharge), but because they aren't really maintenance free, they are maintenance prohibitive. They are vented, they can gas and when they do, there's nothing you can do about it except watch them deteriorate. True gel batteries have this same fault, but perform so well many think they're worth the extra care needed.

There are some so-called maintenance-free batteries that aren't really sealed. You can remove the caps and add fluid. The caps do reconstitute some of the vapors and return fluid to the cells. (Call them maintenance friendly?) On these, the caps can be removed and fluid added and specific gravity checked. In most cases though, the holes through the case (when caps are removed) do not have any ridge around the edge to prevent crud from going into the cells. Cleaning these is difficult as any acid remover (baking soda) that gets into the cell will neutralize it. Most of these batteries are intended as engine starting batteries. They're not generally recommended as "house" batteries unless the RV is driven frequently or on hook ups most of the time because they have a very few deep cycles in them. (I had one, in the small, Group 24 size, bought in 1980 for just a few dollars. In almost constant use as a tool battery and charged with excess energy from the solar system, it remained clean and held a full charge after over 7 years. The secret? Maintenance and careful charging.)

Some of the batteries I've tested: For over a year, I tested three "sets" of batteries at the same time, using each on alternate days. 2 **Sears Die Hards**, 2 **Goulds ActionPac**, 2 **Trojan** T-105 golf carts. I won't go into detail here. Conclusion was that the Golf Carts were superior in every category (including cost). I wouldn't hesitate to use golf carts (or better yet the L-16 Fork Lift batteries) again if I had enough room for the bank of six that I need. For over two years I tested a bank of six **"StowAway/Watchman"** sealed, wet cell batteries. Maintenance prohibitive, but with careful charge regulation there was little or no gassing and when I disposed of them, all were as good as new. I then used a bank of 6 golf cart batteries for over 5 years. They were as good as new when I changed RVs. I then used 2 **"Delco/Voyager"** maintenance-friendly batteries. They worked and didn't cost much. They began to gradually degrade after two years.

I have now used, for over ten years, six **Sonnenschien/DryFit Prevailer/Deka** true gel-cell, sealed batteries (not sealed wet cell batteries). They perform better than any batteries I've used. However, you must never overcharge these batteries. They cost about $175 each at discount and up to $300 retail. They must, therefore, be protected by an excellent regulator and charging system (more cost). I now have another motor home and am installing Concorde AGM batteries in it.

In Summary: If you have a large bus (not just a motor home that looks like a bus), you should investigate the massive, industrial batteries. If you have a reasonably-sized motor home or trailer, consider the fork lift (**Trojan** L-16 or =) or golf cart (**"Trojan"** 105, 125, 145 or =) -- assuming you have a place to put them. **"Exide"** and **"Interstate"** also manufacture good golf cart batteries. If space is minimal, cost is no object and reliability is important, consider the AGM batteries or true gel cell batteries. **"Sonnenschien/DryFit Prevailer/Deka"** are excellent. **Exide, Dynasty** (from Johnson Controls Corp.) and **Interstate** do make true gels at a lesser cost, but they are not as good in my opinion. (They're trying to compete and doing so with lighter -- thus cheaper -- material.) Eventually, they will produce batteries as good as Sonnenschien (Sunshine in German). Finally, there's the **RV/Marine**, so-called, deep cycle battery. They're cheap and should last 3 to 5 years if you take care of them. (Keep in mind that RV/Marine usually means any battery with a rope tied to it.) I do not recommend sealed, wet-cell batteries (the disadvantages of true gels with none of the advantages). I do not recommend automotive batteries -- ever.

CHARGING AND RATINGS

This brings us to the rating of batteries. There is a whole bunch of information that may or may not (and usually does not) appear on a battery label.

CCA (Cold Cranking Amps)
A test conducted at 0°F, it measures the maximum current a battery will produce, for only 30 seconds, down to an end voltage of only 7.2V. (Note that maximum current is never stated.) This test is valid only in selecting the battery to be used in starting your engine. It cannot be converted to a figure useful in determining low amp draw over long periods as in the RV house battery. (It has to do with the extraction of electrons from the chemistry of the battery. You're not interested in all that.) When buying a starting battery, as long as the CCA is equal to, or greater than, the cubic inch size of the engine, it's big enough (except in the case of some diesels that need two starting batteries).

AH (Ampere Hour) Rating
A given number of amps for a given number of hours (amps x hours) down to an end point of l0.5V is used to calculate the frequently seen AH rating. The l0.5V end point is standard, but you seldom see the actual amps and times used to calculate it. Some manufacturers put the AH rating on their batteries; they just don't tell you how they measured it. Usually, though, there's a chart listing capacities in amps and time. Multiplying these will allow comparing one brand against another. (They use a variety of times and amp draws, but some should be the same.)

Reserve Capacity
This is a specific technical term (like CCA), but unlike CCA it can be applied to battery ratings in a way that makes more sense. Reserve capacity, in minutes, is the time it takes a battery to reach the 10.5V end volts, at a 25 amp draw, at 80°F. So, if reserve capacity is (x) amps for (y) minutes, then we can calculate Amp Hours easily. Using a typical RV/Marine battery with a reserve capacity of 154 minutes, at 25 amps, that equals 3,850 amp minutes or 64.2 amp hours. But, the battery is supposed to be about a l05AH battery! And it is. But at a different amp draw. You'll seldom have a constant 25 amp draw in an RV. More likely, you'll have a mixture of high and low draws (microwave on for several minutes at 80+ amps, pump at 7 amps for less than a minute, TV at 5 amps fairly constant, a few lights at 5 amps, etc.). Another major brand of

battery, while it doesn't state "Reserve Capacity," does list on the chart pasted to it: "25 amps/8 hours." That comes to 70AH, not the rated 105AH. Obviously, they used different numbers for their tests. Clearly, the "official" figures quoted by manufacturers and the charts and typical numbers they use are measured according to their own boundaries.

In Summary: No battery is going to give you the stated amp hour capacity. They fudge the figures just as refrigerator manufacturers do. (A reefer's cubic footage is calculated before they include shelves, fins, etc.) It's my experience that batteries are only 75-80% of their rated capacity to start with under real-world conditions). In use, a battery won't even approach that when first installed. After a few days of use/charge/discharge it will build up, but never more than to 80% of stated capacity. Further, AH is a valueless figure unless they tell you how they reached it. Look for it anyway, because at least one manufacturer has "RV/Marine" batteries with more than one AH rating. If you know the "Brand X l05AH" battery usually sells for so many dollars and you see "Brand X RV/Marine" on sale for an unrealistically low price, then they may be peddling the 90 or 84AH version. Reserve Capacity is a good figure if they state it. Amp Hour over time charts are not fool proof, because you don't really know what the boundaries of the test were, but they are a pretty good way to compare one battery against another.

Deep Cycling

Let's consider something here: One does not deep cycle a battery daily as a matter of course. If one did, then the maximum life of any battery would equal the available number of cycles and no battery would last more than 6 to 9 months. Ideally, what you need is a battery (batteries) that will provide the power you require without being cycled (depleted from resting full charge) by more than 20 to 50% before being recharged. (If you have a 100AH battery and take no more than 20AH from it before recharging, it might last longer than you will.) Unfortunately, this isn't realistic, but you can take up to 50% from a battery before recharging and still get long life. Simple arithmetic--how many AH used versus how many AH available will tell you how many batteries are needed. Keep in mind that you shouldn't expect but 80% of the manufacturer's rating. So a 105AH battery is really about 84AH. MAX! No battery will give you its rated output in real life! They're rated down to an end point of 10.5 volts. By then, lights get dim and TV picture small. A Specific Gravity of about 1.200 or a voltage of

12.25 to 12.3 means the battery is about 50% discharged. By the time it's down to 11.8 or 12 volts, it's almost dead.

AMP Hours and Battery Capacity
One amp for 100 hours, or any combination, should allow you to rate batteries, but it doesn't work like that. (It's a logarithmic, not a linear, progression.) Further, capacity, in AH, depends on several things: size, amount/type electrolyte, plate thickness, etc. You don't want to investigate all that crap. Of key interest to us are:

Rate of Discharge: Generally 20 hours for automotive, 6 for golf cart and 8 for RV/Marine. A 180AH golf cart will, technically, give you 30 amps for its rated 6 hours, but it will not give 60 amps for three hours. (Has to do with things like heat at this higher rate due to extreme chemical action demanded--stuff you don't want to fool with.) It will give one amp for about 105 hours, though, which is nice to know. Don't just read AH. Read the charts when comparing batteries.

Specific Gravity: Full charge SG will run from about 1.260 in an auto battery to about 1.275 in a golf cart. High SG (more acid) allows more juice (current) to be drawn--but only up to a point; then the battery deteriorates--fast. Golf cart plates are made to handle this, RV/Marine somewhat, automotive not at all. Don't try to get more AH by adding acid (or vinegar instead of distilled water), the battery will just die sooner.

Temperature: Batteries are made to perform best at 77°F. At higher temps, they put out more, but die sooner. At lower temps, they put out less, but last longer (unless you let them freeze).

DON'T FOOL AROUND WITH BATTERY SAFETY
I know from experience. I shorted out a battery. It blew up. It just takes one little spark. Your face can be horribly disfigured and you might be blind--assuming you're not seriously killed. Removing the ground lead first and replacing it last usually precludes sparks--but not always. Let things air out first and pay attention. Mark cable ends and terminals as prominently as you can. Wear safety goggles.

MORE ON SPECIFIC GRAVITY--and checking resting voltage
If you have standard batteries, get a good hydrometer (not one with colored floating balls in it). It must have a tube inside with SG increments

clearly marked and a built in thermometer with a temperature correction chart. It's unlikely that a new battery, even freshly charged, will give more than 80% of its rated output. You'll get more after it's been used and recharged a few times--unless it's faulty. Check SG anyway to establish a "baseline" reading.

Look especially for differences between cells. A variation of .050 between any means a possible problem. This is after it's charged and bubbled a bit to mix chemicals thoroughly. If it's a new battery and this happens, take it back. If old, plan on replacing it soon. It probably has a stratified/shorted cell. Initially, there's no need in checking SG until a battery reaches about 70% of full charge and is bubbling/gassing slightly (not boiling like a coffee pot). Then, take readings once each hour and write them down. When three successive readings are alike, the battery is as charged as it will get. Record readings for each cell and battery. Disconnect battery from any charge or load and leave it overnight (24 hours is better). Check SG again. Readings may be a bit lower, but should be consistent. Record these as your new baseline: your normal, full charge, resting values.

Do this again after two weeks or a month of use. Readings may be slightly higher, but again, should be consistent. If the batteries have been constantly overcharged or undercharged, it will show up here. You should have checked that your battery charger was set properly before starting all this, but if you get abnormal readings check that your charger is regulating properly (see later). If you have to add water this soon, you are almost definitely overcharging. Once you've done the above tests, you shouldn't have to do it more than twice a year unless you detect a problem. You should check water level about once a month. Ideally, you shouldn't have to add water more than two to four times a year. More than that probably indicates overcharging.

Using a Hydrometer Without Making a Mess
Stick it in a cell until it just rests on top of the plates. Squirt in and out a few times--gently, don't splatter. Then fill until the inner tube floats. Too little and it will rest on bottom of hydrometer. Too much and it will hit the top. In either case, you'll get false readings. Don't remove the thing from the cell to read it, you'll just drip acid all over. Take your reading and write it down. Read at the fluid level, not at the slight curvature where the fluid touches the inner tube. (Before moving to the next cell, don't forget to

squirt the acid back in.) Note temperature on thermometer and correct reading as indicated. Note, again, that all readings for a battery should be within .050 of each other. Keep in mind you might have a cheap or faulty hydrometer. El cheapos have a paper SG scale in the tube that slips up and down.

MORE ON MAINTENANCE

- A properly charged battery should almost never need a baking soda scrub. If you're not overcharging and spewing acid all over and if your terminals and contacts have been properly treated with silicone dielectric, all you should generally need is a spray and wipe with a household cleaner. Many RV converters aren't well regulated and do overcharge or undercharge batteries. If your battery is cruddy, use baking soda and water but don't get the stuff in the cells! You don't need to slop soda all over either. Take all the connections apart and clean them. If you leave corrosion in the end of a wire near the terminal, it'll just come back. Look closely, if there's white and/or green crud in the wire and you can't clean it, either replace the cable or cut off the bad part of a wire and replace the terminal. Use a battery terminal brush (any auto store) to clean terminal and cable end.
- Before putting everything back together (you did label everything didn't you?), coat every single connection with a thin coat of "silicone dielectric" (any auto store). No, not silicone caulk or glue! Dielectric is similar to spark plug boot grease silicone but not as thick and sticky. A four-ounce tube will cost a few dollars but will last for years. Don't skimp on this step and don't skimp on cost by substituting Vaseline. (It's a petroleum product, won't last and makes a mess.) The idea is to put a thin film on all contact surfaces and not just smear it over corrosion. Don't use red battery spray! It just makes a mess. Red/green felt washers are OK. If you do the job right, you won't need them.
- Add distilled water as necessary. Don't use anything else! There is no battery magic that will work. Your money will be better spent on a new battery. Don't underfill; don't overfill. Wipe up spills.
- To prevent corrosion in wires and cables: Use good stuff. Skimpy little #4 battery cables from an el-cheapo auto store won't get it. I have all my main cables made to order by "Wrangler Power Products." All are

#1/0 size (or larger) with sealed ends to prevent corrosion and are red or black as appropriate. Terminals applied by Wrangler are highest quality "mil spec" and match bolts and connectors.

- Smaller wires are done by me. I do not use insulated crimp-on terminals--way too much line loss and chances for falling apart. First, strip the end (with the proper tool). Then apply a thin smear of silicone dielectric and crimp on an uninsulated terminal. Heat the terminal (carefully so you don't melt the wire's insulation) and enough silicone will creep into the strands to prevent corrosion. Continue and apply rosin-core solder. If you practice a little you'll soon see how to apply just enough heat and solder to avoid a mess. Then I apply coded wire markers near the terminal (**Radio Shack** and others sell them in pages that easily peel and stick). Lastly, I use adhesive, clear, heat shrink tubing from Wrangler --not just regular heat shrink tubing -- to seal the connection and cover the wire label.
- Before connecting the terminal to a battery or terminal strip, just a thin film of silicone dielectric is applied to the terminal/lug. It's not as big a deal as it seems and I do not have any corrosion.
- Do not use in-line fuses or plastic crimp-in connectors that simply squeeze a sharp prong through wire insulation (the kind almost every RV shop uses to tap into wiring). All they will do is cause bad connections and corrode. Splice wires in properly or, better, install a terminal strip.

METERING BATTERIES

If you have maintenance free (maintenance prohibitive) batteries, you can't have fun with a hydrometer. Even if you can use a hydrometer, you don't need to (or want to) do it more than a couple of times a year. Use the chart (see later) to keep an accurate check on state of charge. When taking SG readings, measure voltage at the same time. Keep in mind that if a battery is charging, voltage will read about ½ to 1 volt higher than actual. Note that chart voltages (later) are as little as .05 apart. You can't read that accurately on an analog (dial/needle-faced) meter. You need a digital meter. You don't need to spend over $200 for a professional model. See ads in electronics magazines for reasonably priced meters. You need a 3½ digit" meter (reads to two decimal places) and get one with at least a 10 amp current measure (20 is better). At present, the best deal is a Metex brand #M3800 3½ digit at 20 amp capacity for $40 from: JAMECO. (See Sources.) All RVers need one of these anyway.

MORE ON UNDERCHARGE AND OVERCHARGE
"Under" results in stratification. "Over" simply eats the plates. Use a regulator to prevent overcharge. When you think a battery is charged, too high a SG means over. Too low means under. Compare with an accurate voltage check. You should only need to add water a few times a year. More means battery's gassing too much. You can't tell by feeling the heat of the battery case any more (better plastics). You must put about 10% more energy into a battery than you take out (more high school physics-- anytime energy is transformed, there must be some loss). An "old" battery can require more. Compare how much you're putting in versus what you take out and size your system accordingly.

CONNECTING BATTERIES IN PARALLEL, SERIES and SERIES-PARALLEL

This is really simple, but it's amazing how many RVers screw it all up!

In series, volts increase; amps remain the same.
In parallel, amps increase; volts remain the same.

In Parallel: you connect the (+) of one 12vbat to the (+) of the other. Connect (-) of one to the (-) of the other. You will then have still have a 12volt bat, but with greater amp hour capacity. This is now an ordinary 12V bat, except that instead of being in one "box," it is in two boxes.

In Series: If you were to hook two 12 volt batteries in series, you'd have 24 volts. Clearly not the thing to do unless you have a bus conversion or custom rig that uses 24Volts. However, many RVers use 6 volt (usually golf cart) batteries. E.G., Two 105AH 6v in series would still = about 105AH but @ a nominal 12V.

Wiring in Series:
To visualize it easier. Start with a simple block diagram. Two 6V batteries.
On left bat, place (-) at left end, place (+) on right end.
On right bat, place (-) on left end, place (+) on right end.
Draw a line from (+) on left bat to adjacent (-) on right bat.

This is now an ordinary 12V bat, except that instead of being in one "box" with cells all connected in series on the interior, it is in two boxes joined with a cable. It's still a single 12 volt bat, electrically, so START THINKING OF IT THIS WAY and don't confuse yourself by thinking of it as bat 1 and bat 2.

At this point, you've got two unused bat posts -- just like an ordinary 12 volt bat; one neg that goes to chassis ground and one pos that goes to normal 12V isolator/supply/etc.

Series/Parallel:
Just repeat the series step above with two more 6 volt bats and you end up with two 12V bats. Think of it this way instead of as four 6V bats! You now have two (-) unused posts. Connect them together (just as you would when connecting two ordinary 12V bats in parallel). Repeat for the two unused (+) posts.

It's really quite simple. The problem many people have is in thinking that this is very complicated. It's not.

The only time you think of the bats as four 6V bats is when you disconnect them for maintenance and cleaning. And then, only to make absolutely certain that you don't screw up when putting them back together.
Toward this end, it's essential that you clearly label posts and cable ends!

TROUBLESHOOTING

House Battery: The intent here is to determine if the battery itself is good, and, in its role as a "house" battery, how you can test it, the house wiring and charging circuit.

Situation: You're charging the battery from any one of several sources. Everything has been working fine; but for no apparent reason and all of a sudden, there's no electricity. Don't just start taking everything apart! Look around for the obvious. Is the battery still there? Is everything in one piece? (A nearby lightning strike can blow the top off.) Are the cables connected? I once spent an hour roaming around with a volt meter only to find I'd simply left the negative cable off.

Steps:
Connect a volt meter across the battery. It should read some, reasonable voltage even if well discharged (unless it's dead). If voltage is adequate, and assuming things are normal, try moving/twisting the main cable

clamps at the battery. Often, even on a clean-appearing battery, a thin film of corrosion builds up between post and connector (that you can't see). While the corrosion builds up very gradually, its effect can happen suddenly.

- Next, especially if the connections are cruddy, place the tip of an upright, flat-bladed screwdriver on top at the circular junction of post and clamp and give it a good sock with your fist (not a hammer).
- Do the same with the other post. If bad connections are the problem, the above should allow at least some electricity to flow--enough to indicate the problem. If the above helps at all, take things apart and clean them.
- If the above doesn't help, first disconnect the charging source then disconnect the battery (you might as well go ahead and remove it). Before you start phiddling with the battery, attach a pair of jumper cables from a known, good battery to the RV cables.
- Attach the (+) cable first. If you don't let the loose end touch something, there should be no sparks because there's no place for electricity to go (yet).
- Then attach the (-) cable to the "good" battery. (Again, there should be no sparks if you don't screw up.)
- Finally, attach the last (-) end to the RV cable (If the bad battery was removed, sparks at this final connection shouldn't hurt anything. This seems like a roundabout way to do all this but there's a reason for it.
- If there's now electricity in your house, you know you had a discharged battery. Perhaps a bad battery, but not necessarily. Again, before you start phiddling with the "bad" battery, you need to check the charging system. The idea here is find out why the battery discharged.
- Run a load (lamp or whatever) to remove the surface charge from your "good" temporary battery. Depending on what kind of battery charger you have, you may need to run the battery down to about 13V or less to get the regulator to allow charging to resume. Keep measuring voltage. When charging resumes, it will increase.
- If the voltage doesn't increase, it's possible that your charging source (converter, generator, solar system) isn't working or the flow is interrupted.

Make the dumb checks first:

- Is the converter working? Is the "kill" switch on or off on some motor homes? It's unlikely, because then you should have had a gradual loss, not a sudden one. It is possible though.
- And it's possible you have a bad battery AND a bad charging system. RV converters with built-in battery chargers can really confuse you. There are two outputs to these things: One furnishes 12V direct from the transformer to most house circuits. The other goes from battery charger portion to battery. If you've been plugged into commercial power, the main transformer may have been running everything while the battery charger was not working. Also, the "kill" switch may have been off or fuse from charger blown. (Check the dumb things first.)
- Put a volt meter at the battery end while you're doing it. Quite often, a little manipulating will clear things right up. If not, go back to the source of the charging system with your volt meter. Is there power at the charger output? At the output to battery terminal at solar panels or solar regulator?
- Again, check fuses carefully. You can't tell if a fuse is bad by looking at it, you need to measure it with a test lamp. Remember that a meter can indicate "good" if there's only a slight contact but a test lamp won't work if there's not enough to carry the load.
- If this also fails, you may have to check at the charging source with no battery attached. It's easy with an RV converter, but if you use a solar system or wind generator you may not be able to (some can be severely damaged if run without a load). RTFM (Read The F****** Manual)! Our purpose in checking at the source (with or without battery connected) is to see if there's anything there.

If there's still no voltage, now starts the onerous process of checking the whole system.

- Do it logically. Go all the way to the source first. Disconnect generator, solar panels, whatever, from the system. You can now measure them in operation without damaging anything (except some wind chargers). If the charger works, you know that you have two long pieces of wire (+) and (-) with a problem somewhere. Don't ignore the (-) wire. It is every bit as necessary as the (+). Reconnect charger and battery if necessary.
- Go to some logical halfway point with your volt meter. One way or the other, you'll get voltage (unless you missed something at the source).

Continue in this manner, roughly going halfway (each time on the dead side). Unless you screw up, you'll soon isolate the problem to just a few feet of wire. If something hasn't been left unconnected or the wire been cut, you'll usually isolate the problem to a connection or fuse.

- Look at things, pull on wires to make sure they're really attached. This is where bad crimped connections show up. (I spent an hour helping someone track down a solar system this way. Every crimped terminal fell apart in my hands. He'd crimped them with normal pliers.) Look for corrosion at terminals, just as at battery cables. Remember that just because a converter is buzzing, it doesn't mean the battery charger is working. If working with a solar system, never try to put a jumper across the solar (+) and battery (+) to bypass the regulator--you'll fry it. However, if you disconnect those wires from the regulator, then you can put them together.

All the above can be done with a volt meter or test lamp. In fact, a test lamp works better at continuity checks, because a volt meter might indicate power if only one strand of wire is still connected while a test lamp won't light if it doesn't have a circuit heavy enough for the load.

TO CHECK THE BATTERY ITSELF--MORE ON RESTING VOLTAGE

It can be checked with a hydrometer, but a battery can read OK and still be faulty. Here's a good way to check a battery. It takes time, but it's worth it:

- Charge it fully, preferably with a good battery charger or an independent, manual, automotive charger (you need one anyway for emergencies). This can take awhile if it's been deep discharged (dead).
- Measure voltage. It should be quite high--over 13 volts and 14.+ is better. Disconnect the charger. Leave the battery (with nothing connected to it) at least 6 hours. Overnight or 24 hours is better.
- Measure voltage again. It should be 12.6 volts. If not, even if it's 12.5, it's a goner or it's going. If it reads 12.6, it still might be bad.
- A commercial battery shop can check this with a variable load tester. So can you. If the battery is at least a so-called l00AH RV/Marine type, it should start most engines in decent weather. Connect a volt meter

across it. If it doesn't start, jump start it. Run the engine at a nice, fast idle (1,500 to 2,000 rpm).

- If the voltage rises to over 14 volts in only 4 or 5 minutes, you have a bad battery. Due to things we won't dwell on here, the AH capacity has been severely reduced (stratification, deep discharges, etc.). What you have is a battery that has about a l0AH capacity instead of l00AH. It tests OK because it has some capacity (might run a lamp a few hours), but not enough. This common problem often drives people nuts. It tests OK, it just won't last long.
- The same test works on auto batteries. They test OK but won't start an engine.

SHORTS/DRAINS/LEAKS
Actually, they rarely occur. What most people think is a short causing their battery to go down overnight is really the l0AH condition described above, a bad charger (or problems in associated wiring or contacts) or a hidden load. The most common hidden-loads are gas leak detectors with automatic LP shut off, inverters left on and faulty trailer breakaway switches (common). It is possible, though, to have a short. A bad one will usually repeatedly blow fuses (or start a fire--so do not just put in a bigger fuse). The most common, and hardest to find and fix, is having run a screw through the skin where it penetrated wires or connected (+) to skin or frame. The contact can be so slight it leaks to ground without visible results.

Easiest way to check for a short
Disconnect the charging source and disconnect the positive cable from the battery to the RV system. Attach a volt meter positive (+) probe to the battery (+) post. Attach the voltmeter negative probe to the end of the (+) cable that you removed from the battery. Switch off disconnect/unplug everything in the RV that uses 12V electricity. Don't forget clocks, TV amplifiers, refrigerator "brain" (reefers with circuit boards use 12V to run the circuit board even when operating on 120VAC or LP), and such at water heater and furnace also. Also shut off converter (or disconnect from commercial power). If you've really disconnected everything, your volt meter will read zero--unless there's a short or hidden load. With a digital meter, you may read a thousandth of an amp or so--no problem.

To check, turn on one lamp. The volt meter should read battery voltage, but the lamp should not come on. To check further, shut off the lamp and replace volt meter with your 12V test light. If it comes on, you have a short, hidden load or forgot to turn something off. Before you start tracking wires down, go to your fuse panel and remove fuses one at a time until you isolate the circuit or circuits at fault. This can be tricky if your system has been modified. Look for add ons (like two wires connected to one fuse) or isolated fuses tapped into battery charging line and similar.

Once you have the circuit isolated, you can reconnect the (+) cable at the battery and move to the fuse panel. If you haven't a diagram showing what's on that circuit, you can energize all the others and see what doesn't work in the RV. (You should have a diagram of every RV circuit and all wires should be labeled. It's the only way to keep things from getting screwed up.) Leave the fuse out of suspect circuit and, instead of using a volt meter, use an ammeter (of at least 10 amps) connected in the same way. With everything on the circuit off, there should be a zero amp reading. If there is a reading, then you have a short or hidden user. Remember, though, that things like breakaway switches are often unfused and unprotected (because it's so important to be able to stop). When checking these type circuits you may have to disconnect the wire.

TROUBLE SHOOTING ENGINE ELECTRIC and STARTING BATTERY

Starting Battery: Similar to the "house battery" checks. It works well, then all of a sudden, nothing or just a clicking of the starter solenoid. Again, don't just start taking things apart! Do the dumb stuff first: Did you leave the lights on? Is the transmission selector really in park? Twist cable connectors as in house battery. If it even tries to start, you probably just have crummy connections. If you got nothing, not even a clicking solenoid, don't forget to check the "ignition tag" wire. From the coil to the solenoid, there is a small wire that only allows the solenoid to operate when the ignition is turned on. This wire, at the coil end particularly, is often connected with a slip-on connector that is easily dislodged when checking oil and such (and often is so loose it just falls off).

If corroded connections were the cause, and twisting/scraping got the thing going, go home and clean things up. When doing so, closely examine cable ends for crud as with house battery. Hard-start-when-hot is common to many engines. People build metal shields or buy those especially made, wrap starters in asbestos, point fans at them, buy racing car starters and all sorts of things to correct the problem, when in many cases all they needed was heavier cables. All the cable electricity must make a complete path: from battery-to solenoid-to starter and the ground cable must be properly connected also. Most Big A and similar good auto stores carry heavy stuff for trucks. Better, get cables from Wrangler.

Even if corrosion was the problem, if it's been going on for some time, you may have had a continuous undercharge. The battery may just be low, or ruined. You can't test it properly until it's been fully charged, so get the thing started with a jump start if you have to and go home. Clean things up, charge the battery with an independent charger and test as you did the house battery. You can't do it properly in the street. A service station will just sell you a new battery--needed or not.

JUMP STARTING THE SAFE WAY
It may seem like a pain in the ass, but it's better than acid in the eyes--or worse. Remove caps from the "dead" battery if possible. In winter, check for ice in the battery (if you can). Don't ever try to jump a battery with ice in it. It'll blow almost surely. Cover cap holes with a damp cloth (but don't short out the terminals). Connect a jumper cable from the (+) post of one battery to the (+) post of the other. Connect the (-) cable: First to the (-) post of the good battery. Check that all extra accessories are turned off, then start the engine of the "helper" vehicle. Only then should you connect the last (-) to the bad one. Don't connect it to the (-) post, but to an engine bolt at least a foot away (so any sparks will be well away from the battery itself. If the problem was due to your battery, the thing should start. Remove the (-) cable from the engine bolt first, then the rest in reverse order from the way you hooked them up to ensure against sparks.

If it's running, and alternator/regulator are OK, you no longer need a good battery to keep it running unless you let the engine die. Electricity from alternator feeds the whole thing. You do need a battery connected, though, or you'll burn up the alternator. The thing to do is go home, if possible, or to a shop if you're so inclined. In either case, the main thing is to find out why it happened, not just start replacing things.

If the starter wouldn't turn, the problem is probably between the starter and battery, but not necessarily. The ignition tag switch mentioned above is a very good bet. So is the neutral safety switch on most vehicles. Also, some won't start if seat belt interlocks aren't in place, or are disconnected. Look closely at wires to/from the ignition module as well. Some can melt and short if near manifolds. More often, and common with hot RVs, is the wire insulation bakes slowly over time and crumbles off. The bare wires will then short out. It's maddening when they do this intermittently (touch each other only when driving as wind and vibration jostle them). Usually, you'll get a clue that this is happening because it'll only occur, initially, as a slight "miss." Don't ignore clues! If something is acting a bit odd, get it checked out before it quits.

If the thing won't start with a jump, and you're in a bad place (like blocking the pump in a service station), you might be lucky and they'll shove you out of the way so you can try the tests above and expedients below. Often, they'll just call a tow truck and drag you away whether you like it or not. It really is a good idea to subscribe to one of the major road emergency services like those of Good Sam or Escapees. (Not just some free or el cheapo like AAA.) Further, the newer vehicles are so complicated there's very little you can do anyway. And diesels are another animal. Trailer Life or Motor Home had a couple of excellent articles on the limited things owners can do with diesels. You should write them and get reprints (or check any number of web sites) before you need them.

Prevention is most important and most ignored. Be alert for odd noises, "misses" and such. Look under the hood. Check things. Not just oil and water. Probe around wires and check belts and hoses. Replace them every couple of years. (If the old ones are still OK, keep them for spares.) Check tire pressure, don't just kick them. Check brakes and fuel lines. Peer under the rig, with engine running, and look for leaks. Connect a volt meter across your battery, then start the engine and make sure voltage increases. Change oil at a place that will let you go down in the pit and look at all the junk on the underside. Do similar with your "house" equipment. Spending months at a park with a hook up is nice, but once in a while you need to disconnect and run self contained for a day or so.

DOING IT YOURSELF

What follows is for those so inclined or in a desperate situation in the middle of nowhere. Here are some things you might try to get it to start even if it doesn't want to. A lot of this requires two people. Tell each other when you get ready to turn something on and **be careful doing this!**

First things first. It's nice to have a full set of service manuals, but they'll cost over $150 in most cases. They'll also include a lot of tests that can only be made with the specialized equipment at a dealership. In almost every case though, since the 70's, the set includes an electrical and vacuum trouble shooting manual that can be bought separately and includes all sorts of tests and pictures. Call "Helm, Inc." (see sources) and get this one at least. Helm is mostly for "domestic" vehicles. The (800) number for customer service at most importers will eventually get you to someone that handles their manuals. At Toyota, I asked for the owner's manual (no charge), then asked for elect/vacuum/etc., manual ($15 and it's very excellent). If you can use the internet, go to a good search engine (Google the best) and use the "advanced search" option to type in exact phrases. It's amazing how much info is out there!

Starter won't turn. You've made the checks above. Connect a volt meter to the small ignition tag wire at the solenoid. If there are two, one is a ground wire, you might have to try the other. Turn on ignition and you should read volts. Check that solenoid is grounded either through the mounting bolt on a single-tag model or second line on the double-tag model. Recheck ignition tag at coil. Disconnect it and turn ignition on. Measure volts at wire end to see if anything is coming from ignition switch. Also, is it getting to the ignition switch? People who leave a large bunch of keys hanging in a switch can wear out switch contacts. If electricity is getting to the solenoid, either from the above (or from a jumper right from the battery post), and starter won't turn, and there is 12V at the big solenoid post that comes from the battery, connect a jumper cable (not just tiny wire) across the two big lugs at the solenoid. Careful, you're bypassing everything and if starter is good, it should turn.

Some vehicles have two solenoids: One near the battery and another at the starter itself. If you bypass the first, as above, and the starter still doesn't turn (assuming a good battery), then the problem should be in the cable from solenoid to starter, the starter itself, or the solenoid at starter. The fastest way to find out is hook up the jumper cable to the (+) terminal at the starter. Then crawl out from under there and connect the other end to the battery (+) post. Be prepared to immediately disconnect the jumper end at battery (+) during this step. If ignition was turned off, disconnecting will stop everything. If in run, and the engine starts, you'll want to disconnect to keep the starter from turning with engine running (ruin). All the above can be tricky and dangerous so if you don 't fully understand it, have someone show you how to do It before doing it for real.

Once you've done all the above, you should pretty much know what's bad. Unless you overlooked something, about all that's left is a burned out starter or the linkage to the engine's flywheel (in which case you should have been able to smell the trouble). The final way to check the starter is take it off, lay it on the ground (with foot holding it in place) and attach a set of jumper cables from the battery (be careful). All this will allow you to isolate problems. You should have a second battery in your vehicle anyway. Also a spare starter, solenoid, (and voltage regulator, alternator and ignition module too). Fuel/ignition problems wouldn't have kept the starter from eventually turning (even if engine didn't start).

FAST ALTERNATOR/REGULATOR TEST

For vehicles with a separate regulator, like Ford: Measure battery volts with everything off (BASE). Measure volts with engine running at about 2,000rpm and all accessories turned off (NO LOAD). Measure volts at same rpm with headlights and heater blower on high (LOAD). If NO LOAD is 1 to 2 volts higher than BASE, and LOAD is at least 2 volt higher than BASE, both regulator and alternator are OK. If both LOAD and NO LOAD are higher than BASE, alternator must be working. (But may be too skimpy for your RV. Extra running lights, video rear view systems, lights on toad cars, etc., can really load an alternator. So much so that it can't produce enough to keep up. Even factory high-power alternators aren't enough--since they're made as cheap as possible (check with **"Wrangler"** for one that won't poop out). If NO LOAD is much more than 2 volts higher than BASE, check regulator ground (mounting screws) and repeat test. If still over 2 volts, disconnect regulator wiring plug and repeat test. If volts drop to BASE, replace regulator. This is a partial and typical test. A factory trouble shooting manual should include tests for yours.

I hesitated to describe some of these tests because differences in vehicles can screw things up. Get the right book for yours. I've left out the simple stuff on checking for spark and fuel (when starter turns but engine won't start) because all trouble shooting books have that. GM electronics can give you a fit; but, as a wise, old RVer says, "Get a GMC and you get what you deserve." (Nowadays, all electronics can give you a fit.)

DUMB TESTS
From the term Durbert Dumbutt--stereotype of the average RoVer (this is not really a derogatory term):

- When something goes wrong, don't just start taking things apart. Look for the "dumb" stuff first. There's an expression: "Don't just stand there, do something." At times, it's wise to "Don't just do something, but stand there -- and think."
- Check the simple things first. If your car won't start is the battery still there -- or stolen by a druggie?
- Men, listen to your wife. A friend described a bucking, misfiring engine. He pulled off and got tools and meters and started dismantling things and checking them. His wife kept trying to ask a question. He told her to go make coffee. What she was trying to ask was why one of the ignition wires was hanging loose.

Make the Durbert tests first. Performance is sluggish. Tuneup? Why not check for dirty air cleaner first? Bog down on hills? Lots of reasons, but check air cleaner and fuel filter first. Transmission slipping? Might be expensive. But might be as little as ½ quart low on fluid. First add fluid, then find out where it's leaking, then get it fixed. Ammeter not working? Smoke from under hood? Burned alternator? Maybe. But maybe just a loose belt. Standing along the highway creates confusion and stress. Get a simple, trouble-shooting guide and do things logically.

BATTERY ISOLATORS
Almost everybody has one. Most people never pay attention to them. I do. And I've got mine remoted to a switch on the dash to avoid the [many] problems they can cause. Most isolators send a charge to the batteries automatically. I don't want to do that. Normally, my solar system keeps the "house" batteries charged just fine. There are times, in bad weather, when I need to boost the batteries, so when on the road I hit the switch that goes to the charge line to house batteries and the engine alternator charges them in the normal way. A cheap, voltmeter on the dash keeps me informed when to shut charging off.

SOURCES AND REFERENCES
You can get factory manuals from the factory but it's a chore. Call "Helm, Inc." publication div. (800) 782-4356. Get the order sheet for your vehicle. It will list all the pubs available. Don't confuse them with the name of your motor home, but tell them the chassis stuff. ('92, Ford, E-350, etc). Also note other sources for manuals and info above.

Contact **"Technical Service Publications Service Manuals."** 3000 Schaefer Rd., P0 Box 1902 Room 2004, Dearborn, MI 48121-9973. Ask for "Motor Home Service Guide." (Might not be valid.)

For GM try **"Chevrolet Customer Assistance Center."** 5505 Corporate Dr., P0 Box 7047, Troy, MI 48007-7047. (800) 222-1020. Ask for the "Chevrolet Motor Home Service Guide."

Battery chargers: The best you can buy are made by **"Ample Power Co."** 2442 NW Market St., #43, Seattle, WA 98107. (800) 541-7789 (see Sources). They specialize in equipment for ocean-going boats so what they make is ultra-reliable and ultra-expensive. They also publish two books: "Living on 12 Volts with Ample Power" ($25) and "Wiring 12 Volts for Ample Power" ($20). Primarily for boats, but with 12V info not available elsewhere. "Living" has lots of info on refrigeration. "Wiring" has what you need to know. I consider both essential. Read these and find out how cheezy RV converters really are. Also available from Amazon.

Quality battery chargers also available in boating stores (see **West Marine** below), alternative energy stores (see **Backwoods Solar** below) and a very few, good RV stores. Look for user-adjustable voltage settings. Cost minimum $250 and up for good ones. The best stand-alone (independent) battery charger currently available is the "True Charge" model made by "Statpower." If getting a big inverter anyway, consider one with battery charger option -- a top quality charger that would cost much more as a stand alone.

"RV Power Products" 1058 Monterey Vista Way, Encinitas, CA 92024. (800) 493-7877 (www.rvpowerproducts.com). Their "solar" regulator/chargers are the best you can get for an RV.

Tying it all together.
Cable, wire, switches, fuse blocks. High-output, reliable alternators that

won't crap out the first time you use them, adjustable voltage regulators plus much more are available from **"Wrangler N. W. Power Products"** 4444 SE. 27th Ave., Portland OR 97202. (800) 962-2616. (www.wranglernw.com) Free catalog. I use them exclusively. Top quality.

Solar electric stuff + More: If you're interested in solar systems, inverters and other innovative devices, the prime source for RVers is **"RV Solar Electric."** Subscribe to their free newsletter. Buy their "Rver's Guide to Solar Battery Charging." Get their "Installation Guide" ($5 refundable with purchase) even if you buy equipment elsewhere because it has info that no one else provides. 14415 N. 73d St., Scottsdale, AZ 85260. (800) 999-8520. (www.rvsolarelectric.com) This is a great info source. Reliable people who won't mislead you or rip you off. There are a lot of sharks out there selling solar products, inverters, etc., at "dealer cost + a few pennies" and similar nonsense just to try to shaft their competitors. But when you're in trouble, they're no help. RV Solar Electric will help you. Nice people who are interested in the long term, not the short term profit. I use them almost exclusively.

Batteries: RV Solar Electric will be glad to answer questions on gel cells and such and refer you to a reliable dealer. West Marine is very competitive in alternative batteries also. Golf cart and fork lift batteries are better bought (and cheaper) from a "regular" battery store than an RV store. Best source for AGM batteries is "Backwoods Solar."

Boating Stores: Many, like RV stores, sell crap at inflated prices. Good, big ones carry alternators, regulators, isolators, etc., of far better quality than RV stores. The best is **"West Marine"** P0 Box 50050, Watsonville, CA 95077-5050. (800) 538-0775. (www.westmarine.com) Huge catalog (5$ refundable -- but they'll send one free if you whine a little) has page after page of buying advice, product comparisons and tips. Most highly recommended.

Meters: "JAMECO," mentioned in this poop sheet, is my preferred source for meters that will do what RVers need at a reasonable price. 1355 Shoreway Rd. Belmont, CA 94002. (800) 831-4242. (www.jameco.com) Their Metex Brand #M3800 $40 Jameco part # 27115, digital meter, with volts to two decimal places and current measure to 20 amps is perfect for RVs.

For the latest info on alternative energy: "Home Power--The Hands-on Journal of Home-Made Power" $22.50 per year (for 6 issues of well over 100 pages to US. Zip codes 2d Class) or $36 for 1st Class. P0 Box 520, Ashland, OR 97520. (800) 707-6585. (www.homepower.com) has current issue free. Also on news stands. A must have for people interested in alternative energy. What's new, what really works, hi-tech and low yet they never "talk down" to you.

This is an absolute MUST-HAVE reference for RVers. **"Managing 12 Volts: How to Upgrade, Operate and Troubleshoot 12 Volt Electrical Systems,"** by Harold Barre. Some book and RV stores ($13.97 from Amazon) 219 pages. The best book ever published on this subject.

"RV Electrical Systems" covers both DC and AC systems and is another MUST HAVE. Extraordinary detail without getting into engineering. Covers things nobody else does. By Bill and Jan Moeller, Some book and RV stores ($15.37 from Amazon) 265 pages.

BATTERY CHART

What percent of charge is equivalent to what specific gravity and how gel batteries state of charge relate is debatable. Everybody has their own opinion and many of the experts disagree. The chart below is only my opinion, based on many such charts, some very sophisticated tests involving elaborate equipment by others and my own "real RV world" tests using a variety of meters available to any RVer as well as an extraordinarily-accurate monitor/controller from Ample Power tied to a computer. Laboratory tests use electrical loads that simulate the real equipment. My tests used real-world RV equipment under normal living conditions. Differences in my tests and yours might involve: The fact that my meters were all calibrated to an accurate master reading. The amp draw of my loads being measured rather than extracted from a label, etc. Regardless, your readings will be accurate for your system (though you might come up with slightly different numbers). I encourage you to make your own measurements and write in your own numbers.

% Of Charge	**Standard Battery Typical Specific Gravity (After Temperature Correction)**	**Standard Battery Equivalent Resting Volts**	**Gel-Cell Battery Equivalent Resting Volts**

100%	1.260 (auto) to 1.280 (industrial)	12.60-12.75	12.90-13.00
95%	1.255	12.60-12.70	12.80
90%	1.250 (Resting S.G. for standard RV battery.)	12.60-12.65	12.70
85%	1.245 (Same as above. No point being too picky.)	12.60	
80%	1.235-1.240 (We try not to discharge below this point.)	12.50-12.55	12.60
75%	1.225-1.230 (1.230=minimum SG for a charged battery.)	12.50	
70%	1.220 (Anything below 1.220 is "poorly" charged.)	12.45	12.50
65%	1.215	12.40	
60%	1.205	12.35	12.40
55%	1.200	12.30	
50%	1.190-1.195 (Try to never discharge below this point.)	12.25	12.35
45%	1.185	12.20	
40%	1.180	12.15-12.20	12.25
25%	1.160-1.170 (Dangerously low; battery being damaged.)	12.10-12.15	
20%	1.150 (Cells die soon at this point. Bye-bye battery.)	11.80-12.00	12.15

NOTES:

1. Keep in mind that listed voltages are "Resting" Volts.
2. Maintaining an 80% State Of Charge, when the battery is in use (under load), is a goal. It can't be maintained for long without some form of charging taking place. A converter or independent battery charger (assuming they're working properly) will do this. So will an adequate Solar Electric System. A generator won't do this well at all--it would need to run constantly or be repeatedly started and stopped -- not too practical.
3. However, maintaining a 50% State Of Charge should be no problem and battery will not be damaged at all. (See Management) In this case though, a generator could do the job.

4. The cautions in the Specific Gravity column pertain to batteries that are left at this level (or that continue to be used) without charging. It is not uncommon, under a heavy load, for batteries to drop to this level temporarily. It's only when your battery is not being charged and under load that the 25% and 20% State Of Charge cautions indicate a damaging deep cycle.

NOTES BASED ON RVer's QUESTIONS AND COMMENTS
No, this is not a book. It's not intended to be. (Any book is outdated months before it's ever published. It's stuff everybody assumes you know, so they never bother to tell you about it. The Ample Power books are excellent. Some of the installation guides that come with purchases include a wealth of info. RV Solar Electric, Trace, Heart Interface and Statpower inverters are examples.

"HYPE" is more prevalent in battery manufacturers statements than in any other area of RVs (a field that's renowned for excess hype). Distributors and dealers add their own baldly exaggerated statements and just make things worse. You have to use your consumer skills and weed out the BS. My description of battery types in this poop sheet should help you avoid all that nonsense.

The "big" names in batteries are all about equal. Moreover, they have their batteries in stores literally everywhere which makes for EZ returns when you're on the road. Trojan, Exide, Interstate are the most common. Keep in mind there are only about six major manufacturers of batteries in the U. S. (at this time). Many of the batteries you see in stores are made by these and have "house" labels. Nothing wrong with that if you know how to evaluate what you're getting. (You can put your label on batteries too, if you buy enough of them.) Why, then, don't I recommend Delco (made by GM)? Because many of their innovations are not well thought out in my opinion.

Gel cell and AGM batteries are another exception. As mentioned earlier, some manufacturers are trying so hard to compete price-wise that their batteries are "light weights" (literally and figuratively).

There will be great advances in batteries pretty soon. Along with that will come a lot of really nutty stuff. Be careful.

If you can't find "uninsulated" wire terminals in the proper size, get insulated ones and cut the insulator off. It's EZ. A few scores from front to back with a sharp knife, then twist it off with a pair of pliers. If you don't want to bother with all that solder stuff, at least get a pair of professional electricians crimping pliers (the best make a double crimp, won't release until the crimp is sound, use a ratcheting mechanism, etc., Cost about $50). You'll be better off crimping and soldering.

Don't economize with solid-copper household (Romex or UF) wire in an RV. It doesn't make full contact at terminals (resulting in heavy voltage drop) and will bend and flex so much that it will break or come loose. Use stranded copper wire. Protect all wire where it comes in contact with sharp edges. DO use appropriately hefty wire and cable and DON'T use skimpy stuff.

What do I use in my RV?
Former motor home had solar array of 13 panels. Divided into two systems. One, with 4 PV modules, feeds 2 gel cells and inverter with battery charger for audio/visual stuff and uses RV Solar's "Solar Guard" regulator. The other, with 9 PV modules feeds 4 gel cells and large true-sine-wave inverter with battery charger, for computer and house RV stuff like microwave, heavy tools, etc., and uses a "Solar Boost 50" from "RV Power Products" regulator (the best you can get). The systems can be tied together with switches or charging can be switched from one to the other. Inverters are manually switched or plugged in. I don't rely on automatic transfer (relay) switches that can hang up. I keep a standard automotive battery charger in case of emergency. I do not use standard RV appliances (reefer, freezer, furnace or water heater). See Sources and Resources. Current, smaller mini-motor home is similar to above but with smaller solar system and battery bank.

120 VOLT AC ELECTRICITY

It's not my intention here to write a book on AC electricity, but to cover those aspects that are peculiar to RV use. **"RV Electrical Systems"** (mentioned above under Sources and References) is your must-have reference for all things AC. It goes into much greater (and well illustrated) detail. (I'm interested in covering those things that can drive U Nutz.)

First thing first: The neutral and ground in an RV electrical loadcenter are NOT to be bonded together.

The RV chassis is isolated from ground by definition. Metal leveling jacks and such, mounted on the vehicle frame do not make an adequate ground contact. Therefore, in an RV, you always want to have a "floating" neutral, where the neutral and vehicle ground never come together. When you bond the neutral and ground together in an RV, you have a "floating" ground (rather than neutral) and this will result in nutty things happening.

Combined with ANY receptacle (at campground post or in RV) having reversed polarity, it may result in YOU becoming the path to ground in certain conditions (like standing on wet ground and touching metal vehicle parts). Usually you just feel a slight "tingle," but it can get serious. One result often seen is a dog, chained to a metal bumper, bouncing up and down.

The above electrical faults result in breakers breaking and Ground Fault Interrupters (GFI's) that don't GFI (and pity the poor drunk who stands alongside the RV, with his hand leaning on the metal frame, and takes aleak).

This shouldn't happen if there's no reverse polarity at ANY receptacle, because the ground wire is still grounded and does not become a hot wire by the fact that current of near-zero voltage is flowing in it. So, then, everything should still work OK and normal. The dog would still be happy right up to the time you drive off down the highway -- dragging the whole affair -- dog and all. (I've seen this happen.)

However, the whole purpose of the third ground is to be a fail safe, so current is not allowed to (normally) flow in this wire. Having more than one grounding point CAN make this possible. (See later.)

RoVers can come on a bad electrical receptacle almost anywhere. Frequently in a camp ground, where the "electrician" is the guy who mows the grass and does other "high-tech" chores. They can also have one or more reverse-wired receptacles in their RV. (Factory RV wiring is not usually done by mental giants.)

One inverter manufacturer's manual has a note about disconnecting a certain "pin" so this "double ground" won't happen. One inverter manufacturer now makes a "Marine" (same as RV) Model to preclude this (and it's not supposed to be sold for use in a fixed residence).

50 Amp and 30 Amp Electricity to the RV

When the four wires from a 50 amp cable enter the RV, you have two "hots," a neutral and a ground. The wires then usually enter a dual "load center" (or two individual load centers). It's set up just like in a "house," EXCEPT the neutrals go to an insulated neutral bar. The ground wire goes to a separate "ground" bar.
While the neutrals are bonded together and common, the neutrals and ground wire are NOT bonded to the metal load center as a "common" (as is done in a house where there's an independent ground).

The neutral and ground are common only at one place -- the meter and load center bars on a "house" or the power receptacles in the "box" you plug into at a camp ground.

It's essential that the "neutrals" be floating (not connected to ground) throughout an RV.

CHECKING POLARITY -- and seeing if there's any electricity at the receptacles

So far, there doesn't appear to be a simple, automated, LED-readout polarity checker available for 50 amp receptacles. It's no big deal though. You can do it with a simple multimeter. You're going to be checking the 50 amp receptacle at the CG power post or similar. These things are nothing more than standard mobile home connectors and quite simple.

Here's a simple description as any electrician and every electrical book has it. If it's unclear, use the book mentioned above for more details and illustrations. As you face the [50 amp] receptacle at the camp ground hookup, you'll
see three vertical, flat slots. The outer (left and right vertical slots) are 120VAC "hot" outlets. The inner (center/lower) flat, vertical slot is the neutral. The round hole is the ground.

Set multimeter for AC volts and go to the higher range (usually 750). Put one probe in left hot slot and one probe in extreme right hot slot.You should read about 240VAC.

Next, move one "hot" probe to neutral (center) slot. You should read about 120VAC. Move hot probe to other hot slot. You should again read about 120.

Next, move probe from neutral slot to round ground hole. You should again read about 120 VAC. Move probe from first hot slot to other hot slot and again should read about 120VAC.

Above readings indicate receptacle and polarity are OK.

NOTE!

IF, however, you did not read 120VAC from either hot slot to the round ground. Leave one probe in ground and move the probe from the hot slot to neutral. If you now read volts, you have reversed polarity. Not safe.

If there is a big difference in voltage readings from hot slots to neutral and hot slots to ground, there's a short to ground
somewhere and the receptacle is not safe to use.

Here's a (usually good) quickie option:
You should, if a real RoVer, have a 50 amp to 30 amp adapter. You should also have a 30 amp to 15/20 amp adapter and it goes without saying that any experienced RoVer will have also have a standard 15/20 amp polarity checker. Plug the string together and you will be able to check polarity of one of the 50-amp hot legs. While you're there, disconnect the 30A adapter and polarity checker from the 50A. Plug the 30A and polarity checker into the 30A receptacle and again check polarity. Do it again at the 15/20 receptacle.

Here's something a lot easier: You can buy, make or have made a 50A adapter that has two adapters on short cables coming out of it. A 30A is attached to one of the 50A hot connectors (inside the plug) and a 15/20A to the other 50A hot. Makes for easier checking of polarity and is also very handy for hooking other things to without cluttering up the whole box.

If you have a 30Amp RV, it's simpler. You'll just be dealing with one hot, one neutral and one ground. Just stick a 30A by 15/20A adapter in the 30A receptacle and plug the polarity checker into it.

If all the above checks out OK, plug RV cable into receptacle. Go into RV. Once there, with circuit breakers on, simply plug standard polarity checker into any AC receptacle. Reading on the polarity checker will tell you if it's OK.

I have no idea how your RV is actually wired. It might have been miswired at the factory (often happens because somebody doesn't know what they're doing). Some previous user might have tinkered with the system as well.

In essence, when you plug in an RV, you are really just plugging in an extension cord and the things in the RV (at the end of that cord) are the equivalent of plugging an appliance into an extension cord in a house (electrically, no more than plugging a microwave in a wall socket).

As above then, there should be only ONE connection where neutral and ground are bonded. And that is at the house or RV park hook-up, and BEFORE it ever gets to the RV (unless you want to pound in an eight foot ground rod every time you park).

The simple hardware store polarity checker referred to will do what you need, but others will do far more. See the book above "RV Electrical...." for a range of more sophisticated checkers and how to use them. The book also includes details on what to do if you find a fault.

GENERATOR AC

Less than full output. Most of the less expensive generators as used by RVers and for emergency use by homeowners do not actually put out "peak" voltage. Some only provide enough power to run a battery charger at about 50% of efficiency. Increasing the speed of the generator just a bit can sometimes overcome this. If not, there are voltage boost transformers that can restore full charging amps. Check with "Backwoods Solar" for expert info on these.

Here's one that screws a lot of people up:

If you have a permanent on board generator, many have the neutral and ground at the generator bonded together. That's a no-no. Some generators can cause problems -- depending on how they're wired tothe RV. Onan is especially sticky. In my case, I wired the gen only to a receptacle in the RV umbilical cord compartment just like the one on the commercial 120VAC campground power source. In order to use the gen, I had to disconnect from commercial power first. A bit clumsy, but idiot proof and safe. I did this with a PowerStar inverter (with no bat charger) also. Since then, I've used Heart, Trace and Statpower inverters with battery chargers. I've not disconnected (or otherwisetrifled with) anything. I've had no problems.

If using an inverter, for example (you don't want to invade the interior parts of and "screw around with them"), and it has a neutral/ground bond, then that item (inverter) should be the single "bond to ground" for the RV. This is the answer from the "experts." Duh...?

CONTINUITY CHECKS

Checking ohms (resistance) to track your AC problems isn't really going to do you a lot of good unless you disconnect EVERYTHING from thespecific item you're checking. This can be one hellova job (if you do it right) and often won't accomplish much anyhow because of the "hidden" things it will never occur to you to check (or disconnect).

Examples:

You turn off power and start checking resistance. However, one of your lights was turned "on" when you turned off power. The resistant element in that light is still there, power or none. So, when you do your ohm-meter number, you'll get a reading.

Any of a number of appliances, plugged into the AC line, be they turned on or off, will give the same erroneous resistance readings because:

They might have (like a microwave) a clock that runs whether on or off, or a phantom load (as from an instant-on TV, stereo, radio, clocks and similar).

ANY line that has ANY kind of transformer in it, be it on or off, such as one of those plug-in thingies used to recharge shavers (or anything else).

ANYthing that has a transformer or "inductor" such as a "filter" or "coil" in the line as in a line filter for stereo, CB, etc. These can behard to find if you don't know what you're doing, because a radio filter, for example, can be buried in the innards of your converter --and if you aren't very expert, you'll not know what it is, let alone how to find it.

The key component of a GFI or GFCI (Ground Fault [Circuit] Interrupter--same thing), be it in a receptacle or circuit breaker, is a very small transformer. This will confuse you when measuring ohms also.

If you had a line with a break in it and bypassed it with another, are you sure there are no "taps" to anything else still on the old line?

You MUST have good ground connections all the way through all the circuits, or you won't get dependable readings.

MORE ON GFI

Keep in mind, the slightest amount of moisture (or bug poop, etc.) can set off a GFI. Not only if in the GFI, but if in any receptacle "downline" from the GFI (if so wired).

There are two ways to wire GFI's:
In one, common in RVs, the GFI is the FIRST receptacle in a circuit from the breaker at the distribution panel. Subsequent receptacles are then also protected. This is usually done so that an outside receptacle will be protected. There's nothing wrong with this if everything is done properly.
A better way (I think) is to use individual GFI receptacles where needed (bath, kitchen, outside). Each is installed as a normal receptacle, but the "load" wires from GFI are capped. The GFI then protects only its own two outlets. This isn't overly expensive and makes trouble shooting a lot easier.

I've seen many GFI outlets wired up backwards, where input goes into "load" and output is wired to "line" (or line in).

Pushing the "test" button on a GFI momentarily shorts "hot" to "ground."

This is the way it's supposed to work.

The best way to check a GFI is with power on. If it doesn't workproperly after all the above possible faults have been corrected, start physically disconnecting things one-at-a-time. Eventually, you should solve the problem (find the culprit).

An experiment:
Hook up a GFI temporarily (with "load" wires capped) to an extension cord. Plug it into a non-protected receptacle in the RV. Measure volts from plus to neutral, neutral to ground, plus to ground. Record them. Plug the thing into a (correctly wired) receptacle at your hookup.
Repeat.
What are the differences?

Push the test button. Try it again.

If you're interested, this will entertain you for a day or two.
The above checks are something you really ought to do with a new RV.
Once is enough if you write it all down (make a chart).

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