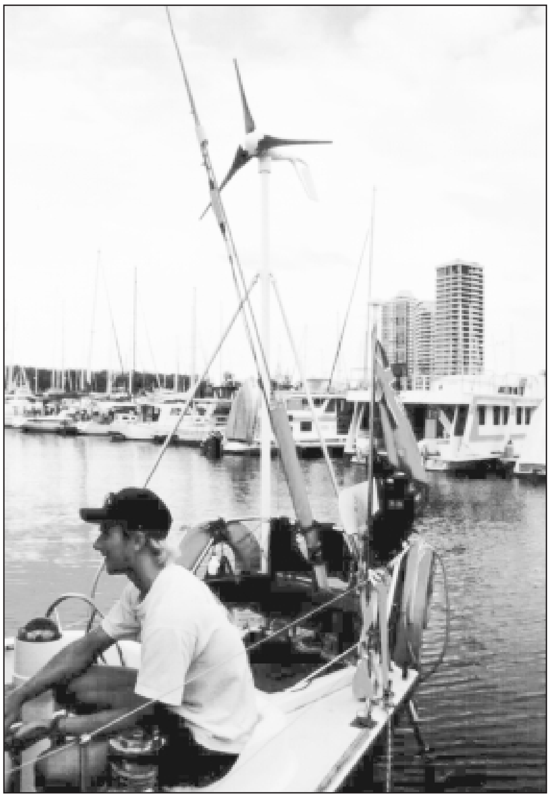
not another article *on* boat electrics

by MARTY STILL

YES, another one, b-o-r-i-n-g! Actually it's not really about boat electrics, more about electrics in general but is certainly relevant to boats.

First thing I would like to make very clear is that I am not an electrician, not household, auto or marine. However, I have been mucking around with boat electrics for years and have lived on alternate energy, one way or the other, for the past 12 years, seven years on my last boat, *Shanty*, and the past five years in a solar powered house in the Gold Coast hinterland. I have attended a couple of alternate energy courses but most of my very limited knowledge comes from hard won experience, therefore I leave it up to you to be my judge.

Since I ceased cruising six years ago I have been involved in the alternate energy business and as the Australian distributor for Air Marine wind turbines, (about 2000 of which I have sold around the countryside), plus solar panels and accessories, refrigeration and all other forms of boat equipment, most of which has been sold by mail order destined for owner installation. In this capacity I have had to trouble shoot a lot of systems, *over the phone,* for a great variety of people. To say the least, this has been an interesting and educational exercise and has given me a huge insight to exactly how much people *don't* know about their electrical systems. I have read numerous articles on boat electrics, every one of them says that you should hook your solar panels up this way, batteries in series that way, in parallel that way, come on, this is information you get from the equipment supplier. What I want to do here is to give you some very basic and very essential knowledge to ensure that your **basic** electrical system can operate to its full potential. Some may feel that I am being patronising but each of the instances mentioned here are actual cases that have repeated themselves over and over again.



Okay, where shall we start? How about wiring, let's face it, we'd be nowhere without it? Read, *voltage drop,* very important, especially on a 12 volt system because you don't have a whole lot of volts to play with in the first place. The amount of times I have quizzed people about their wiring size and they say to me; "Well, it's pretty big, I've had it in the garage for years, it's house stuff, you know". This tells me precisely *nothing*, I don't know what some sparkie left in your garage.

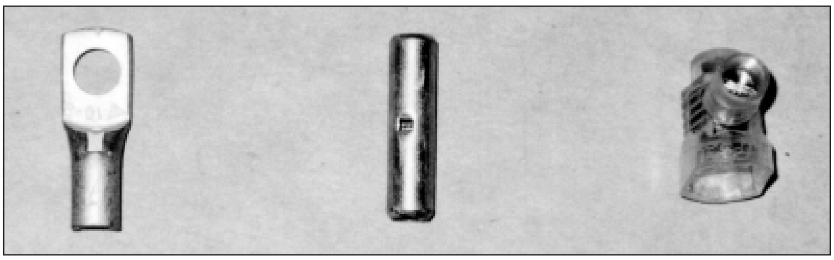
Now, when I first started waltzing in Haymans Electrical, wonderful and very helpful people they are, the guys would duck for cover, I could imagine them muttering from behind the counter, "*look out, here comes that mad 12 volt bloke again*". Why? Because 240 volt AC and 12/24 volt DC are very, very different from each other, so different that many a household electrician will shy away from a DC job. The trouble I had getting a sparkie to hook up our new household inverter to the house system was just incredible. Just because it was an inverter and the power did not come from the grid, scary stuff.

The basic difference is that if you have 10 amps AC running through your wire it will produce less heat than 10 amps DC, this is because AC is exactly that, alternating current, it is not continuous but travels in pulses, giving it a chance to cool. If you've ever been stupid enough to stick your finger into a live light socket, as I did when I was a kid, you'll know exactly what I'm talking about. Man, you can feel them pulses. Anyway, the hotter the wiring gets the more resistance it has to power transmission, therefore, 12 volt wiring needs to be heavier than 240 volt AC wiring for a given amperage. As a rule of thumb, if a switch is rated 10 amps AC I will $^1/_3$ that for DC.

We have technology so there's no voodoo involved to discover voltage

LEFT: Air wind turbine on a cruising boat, a good charging source especially in open waters

BELOW: From left to right. Good crimp type connector for 8mm² cable. In line crimp type connector. Screw connector. These do a pretty good job but are harder to seal from the environment and tend to snag on things if running inside a tube or pipe



drop. So here is a very useful fact for you. *For each one amp of power you have running through a one metre length of wire you will lose .0183 of a DC volt.* Don't blame me, blame whichever smartarse it was who figured it out. Whoever it was, this single fact gives you great knowledge. Here's how it goes.

Remember first that a wind turbine, solar panel, engine alternator or generator, is just another charging source. So, let's say you have a distance of 10 metres from your charging source to your batteries, not switchboard, batteries. Your actual length of wire run is twice that, that is, to your batteries *and back*. The equation is simple from here, 2 x 10 metres = 20 metres, geez I'm good. Now, if you have a charging source capable of giving you, let's say 30 amps at 18volts, we know that for each amp of current we will lose .0183 volt per metre of cable, so 20 metres x 30 amps = 600, wow, I am good, times that by our known voltage drop, .0183, that gives us a number, a factor if you like —— 10.98. Let's now say that you have found some old wire in the bilge that you know is $3mm^2$ because its label is still vaguely legible through the rust on the reel, divide your 10.98 by the wire size and this will give you the voltage drop you will experience at the assumed 30 amps output if you use that wire. That's 3.66 volts, sheesh that only leaves 14.34 volts! (Now you know why solar panels have an open circuit voltage of around 18). Reject! Easy isn't it? Now let's say you are happy to accept 1 volt drop. Divide your 10.98 x 1 and that will give you the wire size you need to achieve your acceptable drop at 30 amps. I told you that 10.98 was an important number, didn't I? So if you can only accept .7 volt drop in your line, then 10.98 -:- .7 = $15.68mm^2$ cable, .5 volt drop, then 10.98 -:- .5 = $21.96mm^2$ cable you will need, and so on.

Let's reinforce this with a real and common scenario.

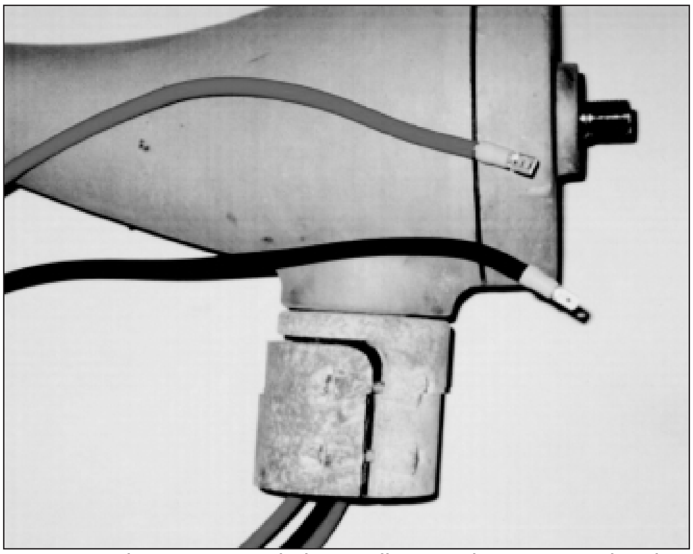
You have 2 x 80 watt solar panels on your boat that will give a maximum amperage of around 12. Distance to your batteries is seven metres.

Length of run (7 X 2 x 12 amps x .0183) = a factor of 3. Divide that factor by your allowable voltage drop, say 1 volt. Bonus! Now you can use that $3mm^2$ cable you found in the bilge to achieve that result. Too easy! This simple formula takes all the guesswork out of voltage drop and will ensure that your system is able to work up to expectations, if you get everything else right. Remember that if you use wiring that is too small it is just the same as having a water tap that is half closed, it will block the flow, then it gets hot, smokes out, and burns your boat to the water line. Great fun.

While on the subject of burning to the water line; I am amazed at how many people have solar panels, wind turbines etc, with no fuse or circuit breaker in the circuit. UNDERSTAND THIS, **every** electrical circuit needs to be **protected** by a fuse or a circuit breaker, if it isn't and something shorts out, your wiring or electronics may well burn out with possible disastrous consequences, especially disastrous if you happen to be out in the middle of the ocean at the time. One theory in that that seems to hold true is that everything, (especially electrical things), in this world run on smoke, if the smoke gets out it's a pretty good indication that it's stuffed because with current technology you cannot get the smoke back in. So the best thing is to keep the smoke captive right where it belongs. Fuse it!

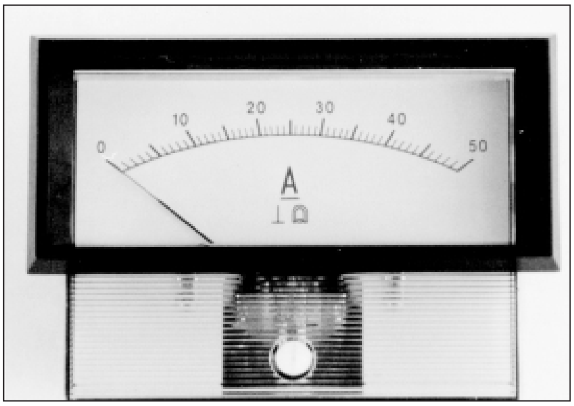
Okay, connections, next to wire size, this would have to be the single most common problem I come across.

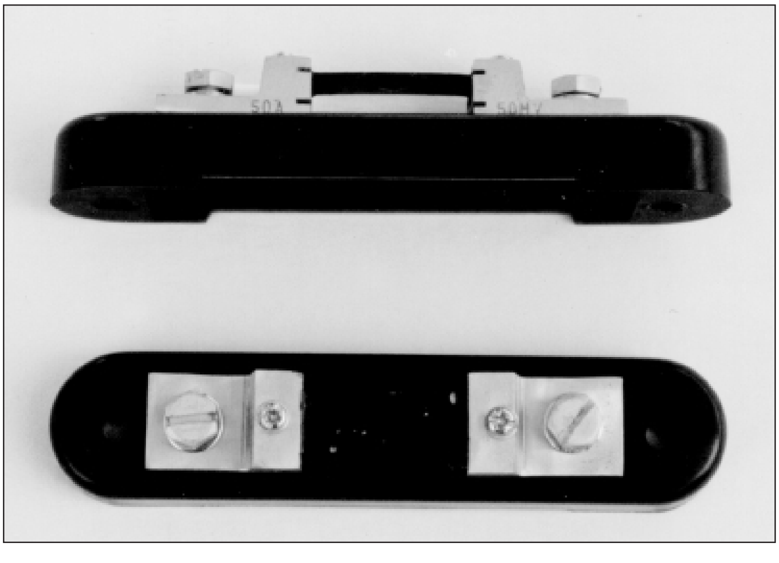
Clean and adequate sized connections are of prime importance in your electrical system. Electricity needs a clean path to follow. The amount of times I have had a wind turbine returned to me because 'it's not producing power' or is 'cycling', (cutting in and out). I have tried to trouble shoot the problem over the phone. "Yes, the wiring in the boat is of the correct size".



THERE'S nothing wrong with these yellow spade connectors but they are just not up to the task being asked here, on a high output wind turbine. If you wouldn't use a bed sheet for a spinnaker, don't use these connectors on high amperage devices

"Yes, the connections are all good". When all avenues of inquiry have been exhausted I request the unit be returned to me for testing. The moment I take the unit out of the box I can see the problem. Good terminals? Yeah right! What I see is a couple of these little yellow blade connectors hanging off the end of the turbine's wires. So what's the problem with that? Okay, first, these blade connectors are good for about six amps in my book and the turbine is capable of producing more than 50 amps. This may be okay in light conditions when the turbine is not producing much power but when the wind gets up the power finds a partially closed 'tap' due to the undersize connections and the power cannot get through. Also, especially in a marine environment, terminals tend to oxidise quickly, this fine coating over the surface of the metal further closes the electrical 'tap'. My first job is to cut off the terminals, test the unit and it usually works just fine. We all know this, haven't we been putting Vaseline on our car and boat battery terminals to stop this happening for ever? We have, haven't we? This oxidisation can happen between your battery terminal and battery lug and completely close down your system. Alright, clean, correctly sized terminals are an absolute must.





So what is a good connection?

If you solder all connections you have done the very best thing you can for your system. What I do for connections that may be exposed to damp or salt invasion is to solder the connection, making sure to have some heat shrink tube over the wire before hand. Then place the heat shrink over the soldered connection and run a small amount of electrical silicone inside the ends of the heat shrink tube. Allow the silicone a little time to 'firm up' before shrinking. This is a little time consuming but will give you as good a seal as you can reasonably expect to get in a marine environment and will pay dividends in the long run. If the wire may be subject to a bit of chafe, possibly inside a vertical tube, (like a mast), a wrap of amalgamating rubber tape around the connection for good measure wouldn't hurt any and will allow you to sleep at night. If you must use connectors, use good quality crimp type heavy duty connectors then treat with heat shrink the same as a soldered connection. These terminals are not removable once fitted and will need to be cut to uninstall so you may as well solder the connection in the first place. Never, under any circumstances use bullet or spade type connectors for any high amperage functions. If you use them on low power appliances then coat with a little lanolin or Vaseline just as you would your battery terminals.

What next? How about this I've come across this one heaps of times. What is a shunt?

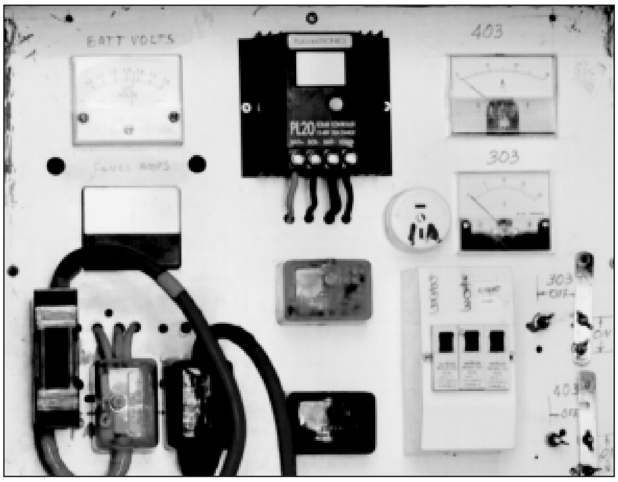
The amp meters I handle are good quality and use a separate shunt when the amperage exceeds 30. The meter itself needs very little power to run it and all amp meters have some sort of shunt mechanism. An external shunt is something that looks like a fuse but what it is in reality is a metal bar power conductor that has a very small and known resistance to electrical current, this jigger shunts a little power off to one side to run your meter, hence the name. Your main cables should be connected to the big terminals on your shunt and two very small wires should be led off the smaller terminals to run your meter. I have had many people think the shunt is a fuse, connect the meter direct to the power supply and blow it up **instantly.** "The meter went right up to 50 amps and then stuck there", the plaintiff cried. It is not a fuse! You can go to your local car parts place and buy a 70 amp meter for about $8 but the old saying of 'buyer beware' comes home to roost here. Why? Because for one it is hard to read low current on a meter such as this and if you run sustained high current through such a meter you will let out the smoke, and we all know what happens when the smoke gets out. Plus they usually rust in a salt environment. Do yourself a favour, pay the extra money and fit a good ammeter, it will last for years.

Why do we have amp meters?

I digress a little here with good reason. The year is 1985 and I'd just launched my new boat. I went to start the motor to get off the mooring and found my batteries were flat. After hand cranking the diesel, and, being a flat calm day, motored five hours to my destination. I thought that would fix the batteries, even though the fridge was running to chill some coldies. The alternator light had gone out so I assumed all was fine but at the end of the five hours, instead of having fully charged batteries they were still not in good shape. Why is it so? After checking the system I found the main output wire on the back of the alternator had a little

TOP LEFT: A good ammeter with clear increments

LEFT: And this little baby is a shunt. You can clearly see the large and small terminals



LEFT: This home brewed set up has two wind turbines and a solar array. While there is a PL regulator monitoring volts, input and output through the shunt, (black thing, far left) each turbine and the solar array has its own ammeter. Also a volt meter for the whole system, (top left). Naturally, the system is fully fused

BELOW: The Plasmatronics PL40 regulator on our home system

rust on the terminal, this was enough to block almost all of the charge from the alternator, rust, obviously, is not a good conductor. A quick hit with a file, a little Vaseline, another hand crank of the diesel and all was well. What does that have to do with amp meters? Okay, in that particular case I had no other indication of charge apart from the alternator light. Had I had an ammeter I would have known instantly that there was a problem, sure the light had gone out but that's all. The engine is running but no power is getting through, the wind is blowing and the turbine isn't charging, the sun is shining and the solar panels aren't putting in power. **Why?** This is a whole lot better than, "Oh shit, my batteries are flat and we're being blown on to a lee shore and I can't start the engine". "Jeez, those rocks look awful close all of a sudden, beam me up Scottie"! Some folk fit one of these whiz bang meters that measures all power into and out of the battery, these are fine but you need to be able to isolate your separate charging circuits in order to check if a specific function is operating as it should, for convenience I prefer an instantaneous analogue type meter for each function.

Volts, amps and specific gravity

Many people have asked me this question.

What is the difference between volts and amps? The best way I know to describe volts and amps is to come back to the water tap. Volts are always there, volts are the water pressure always sitting behind your tap, the higher the water in the tank, (or charge in the battery), the more the pressure but it doesn't flow until you turn on the tap, (or light), that's your amps. As you use amps your volts pressure drops and when your tank is empty, that's that, no power. It's as easy as that. Now, a 12 volt system isn't really 12 volt and it's not really a fully charged system unless the batteries are brought up to at least 14 volts, depending on battery type. If your voltmeter is showing 12 volts with no systems turned on then your batteries are flat. On a boat, checking the specific gravity is about the best way to determine battery charge status and battery condition. You can buy a hydrometer from K-Mart for about $5, bargain. Different batteries have different specifications. Following, is some of the spec's for Apex deep cycle batteries, your battery supplier should be able to give you spec's on the battery you choose for your application.

Battery must stand idle for at least five minutes. If the battery has been on charge it should be used for two to three minutes and then allowed to stand for at least three minutes.

Specific gravity	Open circuit volts	Charge state
1.277	2.12 per cell	100%
1.227	2.07 per cell	75%
1.127	2.02 per cell	50%
1.111	1.96 per cell	25%

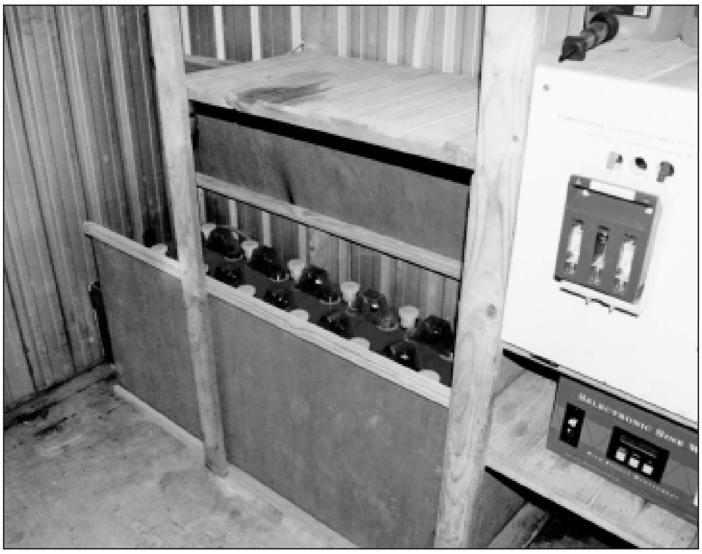
This shows us that a battery showing a specific gravity of 1.227 with open circuit volts of 2.07 per cell, (12.42 volts total), the battery is actually only charged to 75%.

Another test is to put a 200 amperes resistance load on the battery for 30 seconds, after this each cell should have the same open circuit voltage, a difference of just .15 volts indicates that the battery is no longer fit for service. This shows that consistency of readings is more important than the actual specific gravity or open circuit voltage. If you have six cells with an SG reading of 1.111, that battery is quite possibly only flat, but if you have a battery showing five cells at 1.227 and one cell at 1.111, that battery is in trouble.

The specifications vary with temperature and go into far greater detail than that described here and I will be happy to email them in full to anyone on request.

Solar regulators

A quick word on solar regulators. There are dozens on the market, some better than others. Personally, I reckon that one of the best for your dollar these days is the Plasmatronics PL. Not the cheapest regulator around but if you are installing a new system in your boat the PL can be your solar regulator for any battery type, amp meter, voltmeter and, with the addition of a shunt and interface, data log for all charging sources all rolled into



LEFT: 6 x 2 volt x 1100 Amp hour batteries make up our home power storage. A 1200 watt Selectronics Inverter supplies our 240 volt needs including running tools for building my new boat

one. In addition to that the PL can be used as an automatic anchor light. One of the Pl functions when programmed for a wet vented cell battery system is that it will allow your batteries to come up to 15 volts, (12 volt system) each day before going into a two hour absorption mode at 14 volts before going into float mode, 13.8 volts. Then, every 40 days or so it will attempt to drag your batteries up to 16 volts to equalise the cells. And, they are made in Australia. This regulator really looks after your battery system.

Let's finish up here with voltmeters

I would always have a voltmeter on my boat. It is not the be all and end all of system monitors but it gives you a quick indicator as to your battery condition. If your batteries are in good shape and charged, you can put them under load and they will still be showing 12.2 or 12.3 volts. If you are only reading 12 volts or less either your battery is flat or it is in trouble. A multimeter is such an inexpensive but valuable piece of equipment on a boat I am surprised there are still people floating around without one in the kit. You can get a simple analogue meter at Dick Smiths for about $40, a great investment. Make sure you get one that has an amps function. With even the simplest of multimeters you will be able to check volts, amps, resistance, diodes, all that fun stuff. It can save you pulling down your entire solar or wind system just to find the trouble was in the battery box. Even more, if you have bought a secondhand boat, before installing anything electrical, you can test polarity of the wires. Just because it is red doesn't necessarily mean it is the positive wire. It depends who installed it. If you don't have a multimeter, get one and learn how to use it, once you have mastered the dark art you will wonder how you ever got along without one, they're great.

Okay, I've rambled on long enough.

I hope this small section may be of some help to you to help yourself. Basic electrics is not a dark art, more like common sense and keep all connections clean. If you are installing complex and expensive electronics that you don't understand, get a professional in to help. Apart from that, the *12 Volt Doctors Practical Handbook* is not a bad place to start and the *12 Volt Doctors Alternator Book* for the more adventurous among you. A note here, when your alternator karks it, it is often only the brushes that have gone, not the regulator or the field winding. If you pull the thing down yourself, replace the brushes, about $6 (and the bearings if necessary) and you'll be back in business for a fraction of the cost of a changeover alternator, probably less than $20. Have fun! ❖

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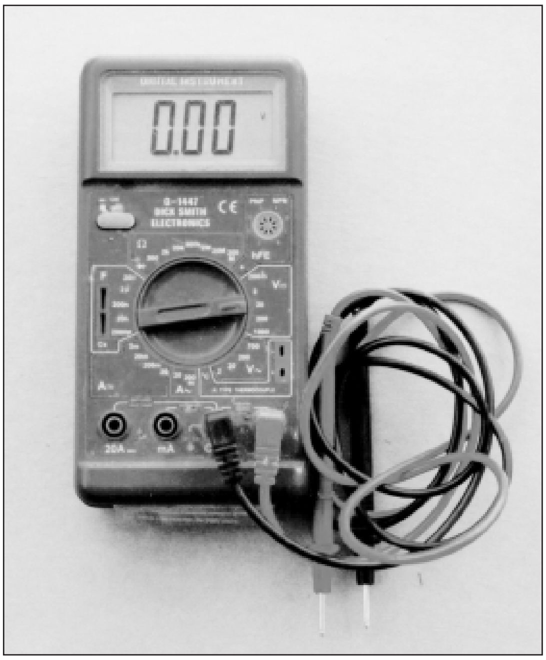

LEFT: A Dick Smith special, $75. It might not be as accurate as a U Beaut $300 touch but it is plenty good enough for your average yachtie, me included.

BELOW: Our home power supply five x 80 watt solar panels. On a house you have the advantage of being able to set the panels up at the correct angle to the sun for maximum output. Made all the better with no mast or rigging to shade them