Electrical and Instruments

(Ed: The following is a series of articles which appeared in the Leisure Owners' magazine 'Saltings', and is reproduced, with only minor adjustments, with the kind permission of the Editor and the author, John Smith)

1. The Basics

1 -- From Little Acorns

"Let's start from the very beginning, a very good place to start".

That piece of plagiarism probably won't be my last, but at least it is good advice. When considering the process of installing an electrical system into a small boat, then it is helpful to think things through from the beginning, even for a relatively simple system. In the first instance, my guess is that we, (as yotties), probably concentrate on what we want to fit on board in the way of electrical gadgets; VHF radio, GPS, depth sounder, a few cabin lights etc. Then we think about where to put all the gadgets, and what is needed for wiring them to an electric supply.

This is not an unreasonable approach, and not to be poo-poo'd. However, it is very easy to concentrate on the undoubted advantages offered by an onboard electrical system, and just as easy to ignore the monster that we propose to invite aboard.

HUH? What do you mean? MONSTER! I can be cagey about the 240-volt mains supply at home, but a 12 volt "monster"?

See what I mean? We are taught that the domestic 240-volt mains supply is a hazard, and not to be treated lightly because it can deliver a fatal electric shock, so we take reasonable precautions. The 12-volt supply as used on most boats, and most road vehicles, does not offer a shock hazard, but what it does do is to

INCREASE THE RISK OF STARTING A FIRE.

Oh that! Aren't you being a bit of a scaremonger?

Yes, I am, because it can so easily happen, especially on a boat with its potentially wet environment, and a fire on a boat is one of the worst things that you can experience.

Come off it! How often do you hear about a boat fire? They must be as rare as ice cubes in hell.

Thankfully they are rare because most installations comply with the suggested guidelines, and are built into the boat during manufacture. However, the Department of Transport is worried enough to issue a Merchant Shipping Notice about it, and as you may know, small pleasure craft come into the category of Merchant shipping. If you have access to the Internet, go to www.mcga.gov.uk/msn/msn1557.pdf (if you don't have Internet access, get in touch with me and I'll send you a copy). So, before launching into a DIY project, your FIRST thought should be:

"How can you arrange your installation so as to reduce the risk of fire to a minimum".

2 -- Cause and Effect

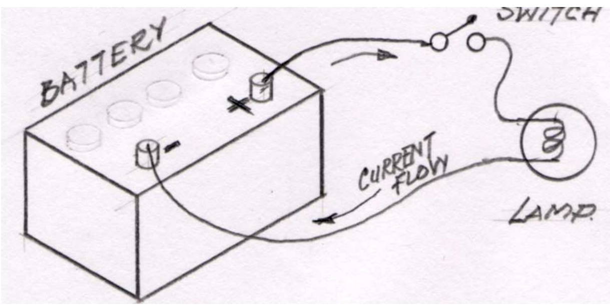
OK then. What does cause an electrical fire?

The simple answer to this is that one of the effects of an electric current is to produce heat. Whenever an electric current flows through an electrical resistance then its energy will be converted (transformed) into heat. The higher the current, and the higher the electrical resistance, then the greater the amount of

heat produced.
Under the “wrong” conditions, an electric wire can glow red-hot, then it becomes a hazard. Under the “right” conditions, the effect becomes useful, as in a light bulb, or a heater.
I suppose I knew that already. So, what can we do about it?
Well, we can’t stop the heat from being produced; after all, it is a natural effect. What we can do is to design the installation so that: -
1. The resistance of all circuits is as low as practical.
2. We guard against excessive current.
3. Any part of an installation is not against, or close to, anything that could easily catch fire.
4. All parts of the installation are protected from physical damage.
That all sounds rather vague and technical. What exactly does it mean?
It’s not as bad as it sounds, and there’s lots of help and advice available. In fact, some very clever folks (they call themselves the Institute of Electrical Engineers) have sorted most of the problems, all that is except for the hard bit, which is actually putting the kit into the boat. Anyway, there’s another advantage to all of this, you will finish up with an efficient system, so your battery will last longer and your gadgets will perform properly.
Tell you what, we’ll take a closer look at that list, and sort out exactly what each item means in practice. Is that OK for you? Good.

3 -- Go with the Flow

Remind me why they are called “Circuits” when it’s clear to me that the cable goes from one place to another, and not round in a circle?
Well, there are usually two wires in a cable. One wire is for carrying the current from the supply to the appliance, (e.g., from a battery to a lamp), while the other wire is for taking the current back to the supply. We name the two terminals of the supply the Positive (+), and the Negative (--). Positive is the “go”, Negative is the “return”.
Ah! I remember now. That’s why the wires are usually coloured! Red is for the Positive, and Black is for the Negative.
You’ve got it! However, what most folks forget is that the current not only flows through the wires and the lamp, but it also flows through the supply to complete the “circuit”, otherwise the flow won’t be continuous.
Let me make a sketch a showing a battery, switch, and a lamp. When the switch is closed it will complete the circuit so that the lamp lights I’ve drawn in some arrows to show the path of the current.



Yes, we did that sort of thing when I was at school. The positive volts flow through to the negative volts.
Ah! That’s another misconception. Volts don’t flow; they simply push. It’s the current that flows, and we measure current in Amperes or Amps for short.

But what puzzles me is why doesn't a current flow inside the battery from its Positive to its Negative?
Yes, it does seem odd, but the battery does what it does by "forcing" its (**+**) terminal go to a higher Electric Potential than its (**-**) terminal. When current flows in the external part of the circuit, the (**+**) side loses energy to the lamp, so the battery has to keep "pumping up" the (**+**) side in order to maintain the Potential Difference (Voltage) between the (**+**) and the (**-**) sides. The current carries the energy away from the battery to the rest of the circuit. This process carries on until the battery runs out of energy, and that's why the battery discharges while it's in use.
OK. I'll believe you.

4 -- Powerful Stuff

So then, if the wire filament inside a lamp gets hot enough to glow, why doesn't the circuit wire do the same?
Good point. The simple answer is that the lamp is designed to have a higher electrical resistance, whereas the circuit wire is designed to have a lower resistance. Then there's the matter of Power.
Ah! I've heard of that, it's in Watts isn't it?
That's right, or another way of looking at it is: Watts = Volts x Amps.
I thought there'd be some maths in here somewhere!
'Fraid so. Let's take an example. Suppose that we want to fit a simple 12-volt battery, and a cabin lamp. The lamp will probably be rated at something like 12 Volts, 20 Watts.

So, the lamp needs: $\frac{\text{Watts}}{\text{Volts}} = \frac{20}{12} =$ **1.67** Amps.

From Ohms Law, the lamp's resistance will be: $\frac{\text{Volts}}{\text{Amps}} = \frac{12}{1.67} =$ **7.19** Ohms.

Now, let's suppose that the two feeder wires have a resistance of 1 Ohm each, and the battery has a resistance of 1/100 (0.01) Ohm.
For a series circuit, as in the example, we find the total circuit resistance by adding all of the individual resistances together, which gives us 9.2 Ohms.

To find the actual current flow, we use $\frac{\text{Volts}}{\text{Ohms}} = \frac{12}{9.2} =$ **1.3** Amps.

Notice that the circuit current is now 0.37A less than the current needed for the lamp. The lamp won't be as bright as you'd hoped for.
So where's the missing current gone?
Actually, there isn't any missing current, but there is some missing voltage! The resistance of the wires is limiting the current, and at the same time causing a Volts Drop along their length. It's this voltage that's missing from the lamp.
The voltage across the lamp becomes

Volts = Amps x Ohms = 1.3 x 7.19 = **9.35**V, instead of 12V.

The actual power of the lamp is now 9.35 x 1.3 = **12.2**W instead of the expected 20W.
The power lost in the wires due to the volts drop will be:

$\text{Amps}^2 \times \text{Ohms} = 1.3^2 \times 2 =$ **3.38**W.

So the wires are warming up a bit.

5 -- Irresistible Force, Immovable Object

It seems to me that this "electrical resistance" in the wires is a bit of a nuisance.
Can't we get rid of it?

‘Fraid not old chum. From a practical point of view every wire, termination, switch, contact, connection point, fuse, and gadget will have some resistance. Why, even so-called insulation is really a very high resistance material, and when we open a switch contact, all that we are doing is inserting a high resistance air gap. So you see, resistance has its uses as well.

Its name seems to be self-explanatory, but what exactly is it?

The property that we call Electrical Resistance was first “discovered” by a Mr Ohm, hence the name of the unit. He gave us the much quoted “Ohms Law”, which basically says that when an electric current flows round a given circuit, the higher the applied voltage is, then the higher the current will be. The ratio of Volts to Amps is the resistance of the circuit.

Ohms Law is often shown as an equation:

$$\frac{\text{Ohms}}{\text{Amps}} = \text{Volts}$$ which we can re-arrange to give:

$$\text{Volts} = \text{Amps} \times \text{Ohms}$$

I see! So, if I remember my maths, if we decrease the Volts, or increase the Amps, then we can make the Ohms smaller. Problem solved!

Ah, no. This is a non-commutative equation; it works one way but not the other. Years of research have shown that Resistance is not dependent on voltage or current, but upon the circuit’s material, length, and cross-section area. So, you see, all that we can do is to arrange so that the wires are made of very good conductive material, are kept short, and have a large cross-section. The best conductive wires that we could use are Gold, Silver, or Platinum, need I say more? So, as a reasonable affordable alternative we use Copper. Wires are made of other materials, (e.g. Aluminum), but although they are a tad cheaper, they’re not as good as copper. Similarly, we could use an enormously thick wire, but could we handle it? (Or afford it?). So, we use the thickest wire that does the job. As for the length involved, we only have a limited choice here, but careful consideration can make the run as short as possible.

6 -- The Thick And The Thin Of It

So why do they make cables that have two, or more, wires inside a common covering, when separate wires will do the trick just as well?

Of course, you can use separate wires, and they are available in a variety of colours, as well as red and black. Having two, or more, wires enclosed in a common cable sheath simply makes installation less work.

The cable sheath does three jobs. It is made of a fire-resistant material, protects the wires and insulation against physical damage, and keeps the wires of a circuit together. However, the manufacturer has no control over the environment in which the cable is installed, that’s why they often put a sheath over the insulation of single wires, as well as over multi-wires.

That makes sense.

Now, I know that wires are made in different thicknesses, and that some are solid cored, some are stranded, and some are tinned. Some are even made out of metal other than copper. How is a chap supposed to make a simple choice from what’s available?

Horses for courses, old chum. All those different wire types are made available by the manufacturers to cater for a wide variety of applications, that’s why electrical engineers are paid. For our purposes though, we can considerably narrow the choice down. On most boats, you won’t be installing any long lengths of wire, and by long, I mean several hundred yards. You probably won’t require specially armoured cable, neither will you be using a high voltage supply. All that we need to concern ourselves with is finding wires that have a fire resistant covering, a fairly low electrical resistance, and are not too

difficult to install.
The first point is already catered for, just about every wire made for carrying a fairly high current will have a fire resistant sheath.
The second point means that you should choose copper wire that is as thick as you can handle in order to keep its electrical resistance low, which brings us to the third point.
Ease of installation. That includes things like pulling it through narrow spaces, getting it to bend around corners, and will it be relatively easy to terminate. Don't forget that the equipment terminations will have to be able to accept the wire's thickness. In most cases, you'll find that a multi-stranded wire will be better than a solid core wire, with the added advantage that it will "give" as the boat flexes, whilst sailing, or withstand vibration when motoring. Mind you, multi-strand wire will be somewhat thicker than an equivalent solid wire, but that shouldn't be too much of a problem.
A chap I know used ordinary house cable on his boat. Is that acceptable?
Yes, provided that the cable used is at least 1.5mm^{2}per wire, and preferably 2.5mm^2 His is probably a solid core cable, twin and earth, so it may give some problems by breaking off as it flexes, especially where it is terminated. I bet it was a pig to install as well.
Much better to go to a car spares shop, and buy the sort of wire used in car wiring harnesses. It's available in a variety of thicknesses, is usually marked with its practical current-carrying capacity, and has the recommended fire resistant insulation.

(Ed: The table below might be helpful in making your selection of cable size. As John says, a car parts place is the best bet – but you really need to go to a supplier to the trade e.g. Partco. A 50m reel of 17amp cable cost me about £11, locally, in 2004.)

Sample data re current carrying capacity etc

Dia of each strand (mm)	No of strands	Approx area mm^2	Approx max capacity Amps
0.2	24	0.75	4.5
0.3	14	1	9
0.3	21	1.5	13
0.3	28	2	17
0.3	44	3	27

7 -- Hot Diggardy

It's late afternoon, you're sailing along on a comfortable broad reach with a mile or so to go, then the breeze dies. A bit anxious to get to your mooring before sunset, you start the motor. Now there's lots of vibration causing things below decks to rattle and shake. One of your cabin lamp connections falls off and comes to rest against the other. You now have what is known as a Short-Circuit. Nothing happens 'till you try to turn on the lamp.
Soon after the switch contacts close you notice two things:

1. There is no light.
2. There is a smell of hot plastic filling the cabin.
Oh dear! You haven't fitted a high current protector into your lighting installation. You try to switch the current off, but the switch contacts are now hot enough to be welded together. Undaunted, you think of disconnecting the battery terminals, but by the time that you've found the clamp spanner and opened the battery box you realise that you may have a fire on board.

Looking back to our example circuit, this is what happens from the electrical point of view. The only resistance offered to the current consists of 2.0 Ohms in the wiring plus a niggardly 0.01 Ohm in the battery, giving a total circuit resistance of 2.01 Ohms.

The circuit current is $\frac{\text{Volts}}{\text{Ohms}} = \frac{12}{2.01} = 6$ Amps.

The heat power in the wires is $\text{Amps}^2 \times \text{Ohms} = 36 \times 2.01 =$ **72** Watts.

There is also just over one third of a watt causing the battery to fizz, so with hydrogen gas, oxygen, and hot wires you now have a potentially explosive situation.
So what you're saying is that if a fuse had been fitted, then the fuse would have blown, so breaking the circuit?
Obvious, isn't it. But I'll tell you this, there are a few folks who do have fuse holders fitted, but because they don't have any spare fuse cartridges, they put a piece of silver paper into the fuse holder and hope that everything will be alright. Then they forget about it.
Now, is that asking for trouble, or is that asking for trouble?

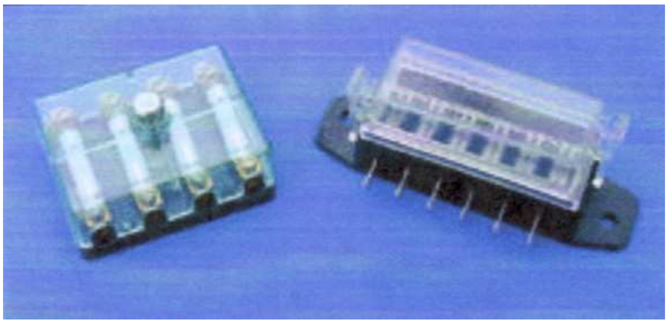
8 --Give Me a Break

OK smarty-pants! So you've convinced me that a fuse is a good thing to have, but what sort of fuse, and where should it go in the circuit?
It depends on what you mean by "what sort of fuse?"
All fuses work in the same way. The essential part is a small length of thin, soft metal, wire in series with the circuit. Being thin, the fuse will have a slightly higher resistance so that when a current flows the fuse will get hot. Should the current rise sufficiently, the fuse wire will melt, and as it's made from a soft metal, the melting temperature will be reasonably low. The circuit gets broken before any really serious damage is done elsewhere.
Sounds like a good idea. But wait a minute. Didn't you say that a hot wire is a bad thing to have around?
You're right, it is, and that's why a fuse wire is always enclosed in a protective tube. The tube is to protect other things from the hot fuse wire, but it also protects the fuse.
But you've still not answered my question! What sort of fuse, and where?
Point taken.
First, let's have a look at fuse "ratings". As you probably know, fuses are "rated" in Amps, and are typically marked 2A, 5A, 13A, etc. But the Amp is the unit of current, so the idea gets around that the rating marked on the fuse is the value of current at which the fuse blows.
Well, it is, isn't it?
That seems to be a reasonable assumption, but the fact is that the marked rating is the **maximum** amount of current the fuse will carry **without** blowing. So, if a fuse is marked "10A" then it will easily pass up to 10 Amps without blowing.

Presumably then, a 10A fuse will blow at anything over 10 Amps?
Yes, but the big unknown is by how much, and when. 11 Amps may blow the fuse, but it could take as long as 60 minutes to get the fuse hot enough, if it ever gets hot enough. Higher values of current simply shorten the time taken to blow the fuse. To get a 10A fuse to blow within 2 seconds will probably need something in the order of 50 Amps, or more.
I see. So, if I have a 12 Volt, 20-Watt lamp, that passes 1.67 Amps, then a 1A fuse will always blow, and a 2A fuse could be too big. What then?
It does seem that way, but you don't need to be picky. Don't forget, a fuse is a last ditch safety device, not a precise current-measuring instrument. Its main purpose is to blow in the event of a **severe** over-current situation, such as a short-circuit.
As a general rule of thumb, you can fit a fuse that is rated at about 1to 2 times the expected maximum normal current, so for your example a fuse rated at 3A, or 5A, will be fine as it's the closest one that's available. Don't be tempted to put in a 10A fuse instead "just in case it blows too often".
Of course, you cannot expect a standard fuse to protect gadgets that may become faulty. Some faults allow a higher current than normal to flow, and so cause a gradual build-up of heat, but this may not be sufficient to blow the fuse. For that sort of situation you can install either a special type of fuse, or a sensitive circuit breaker.
Now, let's have a look at some types of fuses: (Courtesy of the Index Marine catalogue).

The picture shows the commonest cartridge types, glass tubed, ceramic tubed, and plastic coated blade-type. The ceramic type actually has the fuse wire mounted on the outside, and is often called "continental type". Each works in the same way, but each has a different fuse holder for it to fit into.

And here are the fuse holders.



These are fuse boxes, with holders for several fuses in each. The one on the left is for the "continental" cartridge type. The one on the right is for the bladed type.

Ah! But how can we tell which is the better type?

There isn't a "better type". You have to decide which type is the most easily replaced, its cost, and its availability. For example, you may live close to a car spares shop, in which case you'd be better off using the bladed type, or the ceramic type, as these are mostly found in road vehicles. Alternatively, a yacht chandler could stock all types.

You may decide to use "in-line" fuses, where each fuse is contained inside its own individual holder, like these. These in-line fuse holders usually take the glass type of fuses, but the one at the top of the picture takes the bladed type (the funny looking bit on the arm is a cap that goes over the top of the fuse).

Right then. That deals with "what". Now how about "where"?
The general rule is to include a fuse at a point in the circuit where it gives the maximum amount of protection.
Supposing that you had installed your simple battery/switch/lamp arrangement, then you need to put the fuse in the (+) wire so that it protects as much of the installation as possible, and that means as close to the battery (+) terminal as you can get it. In this position, the fuse protects most of the wiring, the switch, the lamp, and any intermediate connecting joints.
By the way, in case you're tempted to, there's no need to put a second fuse in the (-)wire, in fact it's a distinct disadvantage to do so.
Once the fuse is in place the only unprotected part of the circuit will be the very short piece of (+) wire between the battery and the fuse, and the battery itself.
To protect the battery, make sure that the battery terminals are clean, and clamped tight, lightly greased, and covered so that you can't accidentally drop a spanner across them. Better still, box in the battery completely, but fix the whole thing down firmly so that it can't move about, and include a small air hole in the box so that the battery fumes can get out. If you do box the battery in, you could mount the fuse holder onto the outside of the box, and so keep the unprotected length of Positive wire as short as possible.

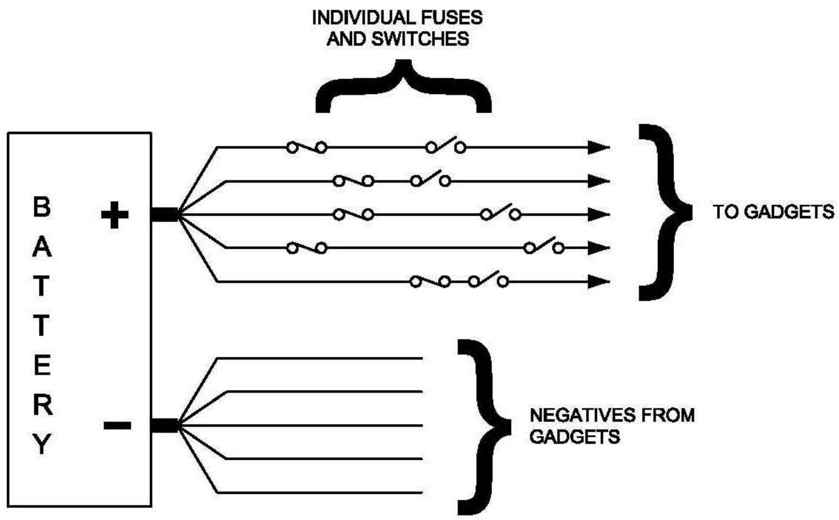
9 -- Branches in All Areas

Look here, it's all very well talking about a battery/fuse/switch/lamp installation, but later on, I'll probably want a bit more than that. What I have in mind is eventually to put in another lamp (or two), a depth sounder, a speed/distance log, some navigation lights, an auto helm, and so forth. These will all involve some cost, and a fair amount of work, so I'll probably do the jobs as, and when, I can. Now, in the light of what you've been saying, each time I put in a new gadget, all I have to do is to construct a simple circuit consisting of a length of cable, a fuse, a switch, and the gadget, then connect it to my battery, right?
That's the general idea. But now that you're getting down to something meatier you really ought to take into consideration five further points, and these concern the more practical aspects of your

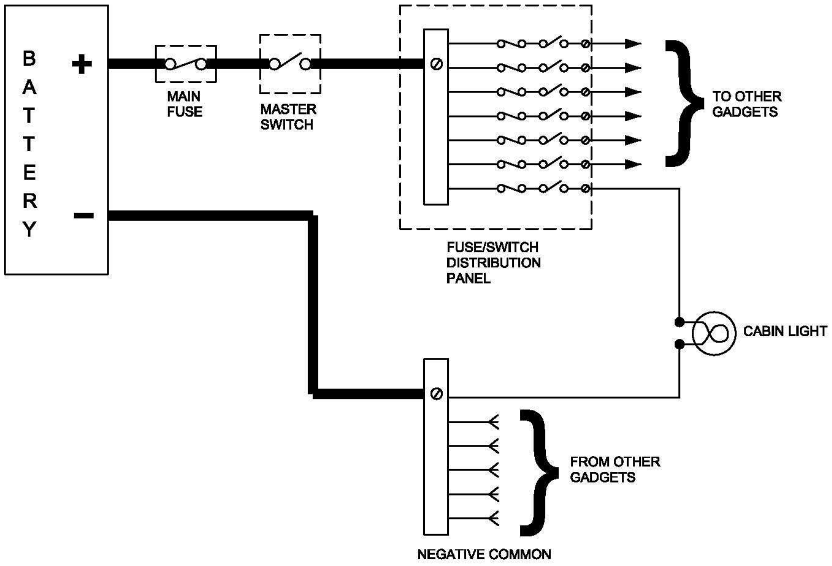
proposed installation: -
1. Just how many wires do you think that you can physically connect onto the battery terminals?
2. How will you be able to tell one circuit from another when you need to trace any faults, and all wires look the same?
3. Similarly, if you have decided to use individual in-line fuses, how will you be able to tell one fuse from another?
4. Where will you mount all the switches?
5. Will your battery cope when everything is switched on?
Damn. I had a feeling it wouldn't be that simple.
Yes, I'm afraid that you need to do a little bit of forward planning, but not to worry, there is a way of giving you a degree of flexibility. The usual method used is called "**Distribution**".

The idea behind the method is that you use reasonably thick wires to extend the battery terminals to a more convenient place, terminate these wires onto strips of multi-terminals, then connect to your gadgets from these distribution points with thinner wire.

So, instead of your installation looking like this:



It will look more like this:



The first drawing shows you the sort of cat's cradle of wires that could result at the battery terminals if you just keep on adding extra circuits willy-nilly. Plus, you'd have to find somewhere to put the individual fuses and switches.

The second drawing shows how you can keep things a bit tidier. In fact, the assumption is made that every installation will be done using the distributive principle, so equipment is manufactured for the purpose.

The drawing does look a little bit daunting, at first, but you can break it into simpler chunks.

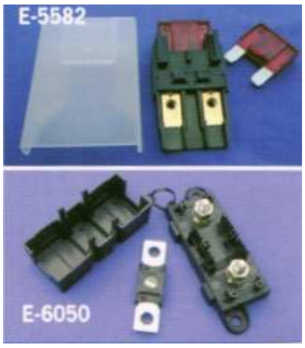
First, starting from the battery (+) terminal, you can see how a single wire leads first to a separate main fuse, then on to a master switch, and on to a fuse/switch distribution panel. The battery (–) terminal has a single wire leading to a negative common. This negative common can be a solid brass bar, drilled and tapped to take several screw-type terminals. Alternatively it can be a strip of "chocolate block" type connectors, or similar. Either way, it serves to gather all the negative wires in a common place.

Together, the battery, the main fuse, the master switch, and the (+) and (-) wires up to the distribution points is called the "Primary Circuit". Once again, by courtesy of the Index Marine catalogue, here are

some pictures of fuse/switch panels. The above show ready-made panels for 3, 6, and 12 fuse/switch combinations. The fuses shown are the bladed type, and the switches are rocker type.

(*Ed: there is a photo of a home made switch panel at p91)*

Below are some negative commons .and some main fuses .and a Master switch



If you now look back at the distribution drawing, notice how the fuse/switch panel is in the (+) side of the wiring. The panel comes ready-made with the positive common (or positive bus bar, bus for short), the fuse holders, and the switches (one for each of your gadgets). Of course, you need to have already determined how many fuse/switch combinations that the panel must hold. There are also places provided on the panel for labelling each circuit.
Each and every circuit from the fuse/switch panel to a gadget, and back to the negative common (or negative bus) is called a "Secondary Circuit". The wire gauge for each secondary circuit need only to be thick enough to serve that particular gadget, so this will make the effort of installing the wire much easier.
On a final note: the Primary Circuit **should** have a double pole master switch (according to the DoT MSN No M.1557), but DPST switches are not easy to find.

10 -- Is Yours Big Enough?

Huh? Oh! You're referring to my battery, of course.
What else, pray?
Well? How do I find out whether mine's big enough, or not?
You'll soon know if yours isn't big enough, it runs out of electricity very quickly. What you really need to know is how long will your gadgets run before your battery needs recharging. Of course, I am assuming that you will be using a rechargeable battery.
Yes, I suppose so. They seem to be the done thing.
All rechargeable batteries (they're called "Secondary Batteries") work by using the same principle. By passing an electric current through the battery from the (+) side to the (--) side, the electric charge gets absorbed inside the battery. When we switch a gadget on, the resulting circuit current passes through the battery from the (--) side to the (+) side, so some of the stored electric charge is given up. When all of the stored charge is gone, the battery is said to be Flat, so needs to be recharged. This charging and discharging is not 100% efficient, you never get out as much electric charge as you put in, but a battery in reasonable condition could be as much as 80% efficient.
Also, the battery will respond to being over-charged, or over-discharged, or old age, in a

disadvantageous way. Oh, and they don’t like being very cold, or very hot. In other words, if you don’t look after it, it will die on you. Generally speaking, Lead/Acid batteries hate being in the discharged state, even partial discharge, if left, shortens their useful life. The strange thing is that if you charge a battery, then leave it unused for a while, it will discharge inside itself, and lose about 7%-8% in a week, that’s why it’s a good idea to give it a frequent “Trickle Charge”.

Yeh, this is all very well for you eggheads, but how big should it be?

Sorry about that, I got carried away a bit. When we speak of how big a battery is, we really mean its “Capacity”, how much electric charge it will deliver, rather than it’s physical dimensions, although the higher the Capacity then the larger the battery will be.

Battery capacity is quoted by the manufacturer in Ampere-Hours (AH), which is the discharge current (Amps) flowing for a time (Hours). However, there is a reservation (isn’t there always?). The AH figure for a given battery is usually based on the 20 Hour rate. In other words, if you have an 80AH battery, and your gadgets need 4A, then the fully charged battery should last for a discharge time of 20 Hours.

However, if your gadgets need a higher current, then the battery will last for a disproportionately shorter time, it may very well deliver 80A, but not for a full hour. There again, you could draw one Amp for a lot longer than 80 Hours.

Also, during the battery's discharge, the liquid inside it will fizz, and this fizzing will increase the battery's internal resistance. The increase in the internal resistance shows as a drop in the on-load terminal Volts, so the current also drops. All this makes choosing a size of battery a bit difficult.

A good point to start is to assume that you have switched on **all** your gadgets at the same time. Because all the secondary circuits are connected in parallel, you simply add all the current flows together, multiply this Amperage by the amount of time that you switch them on for, and you will get the minimum useful AH size for your battery. Add a bit on for inefficiencies etc (say 20%), then go out and buy the next nearest size up from that.

Alternatively, you can write a list of all your gadgets, then alongside each gadget write in the current that it draws, and how long you expect it to be used for each day. From this list you can now calculate the required daily AH requirement to estimate the battery capacity that you will need.

I have a better idea. I’ll ask around, and find out what other folks use. They’ve probably sorted out most of the problems already.

You do that. (I wish I’d thought of that).

11 -- Further Developments

Oh! There you are. I’ve been hoping to bump into you for some time.

Hi there. Nice to see you again. How are you getting on with your wiring project? Any progress to date?

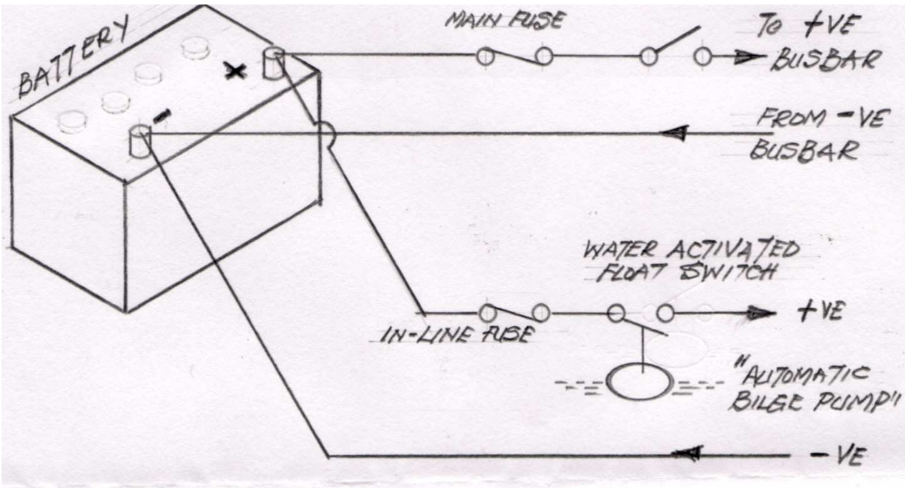
Yup. It’s all going very well, thanks muchly.

In return for some trips out on the wate, I persuaded a couple of friends to help with the awkward wiring runs, but finding a suitable place for the new switch panel was a bit tricky. The problem was to find a spot that had a big enough surface for the panel, and at the same time had enough space at the back for the wiring. Now, I must admit that I have a small problem.

Well, that’s what friends are for, what’s up? Nothing too serious I hope.

It’s just that I want to put in an automatic electric bilge pump, but the trouble is that the switch panel I bought didn’t come with enough switches and fuses on it. So what I need to know now is, how do I

connect the pump circuit into the existing system? And another thing, even if I could connect the pump to the existing switch panel, with the master switch off when I leave the boat unattended the pump wouldn't work.
No problem. Just build an auxiliary circuit separate from the other ones. You should follow the general rule of fuse/switch/gadget, but instead of connecting the new circuit to the existing switch panel, you connect it directly to the battery terminals. Most, if not all, battery connection clamps have auxiliary terminal screws mounted on them for just this purpose, or you can use a suitable diameter crimped wire "eye" terminal under the clamping nut. As for a fuse, you will probably have to use an in-line type in the (+) wire. Now, I know that the automatic bilge pump will have a water activated switch, but you should include a separate switch to act as the pump's master switch as well.
The connections will be like this:



Now that looks easy enough, I didn't realise that I could connect something else directly to the battery. Are you sure that it's OK to do that?
Why not? As long as a fuse protects the circuit, and you take a bit of care with the wiring run.
If you look under the bonnet of most cars you will see similar auxiliary wires connected to the battery, and the same principles apply to road vehicles as to boats. Just make sure that you protect the pump wiring from water corrosion.
You can connect almost any low current auxiliary circuit in the same way, the limitations being that:

- It should be a low current circuit, (e.g. not for starting an engine).
- Don't put a lot of extra wires on the battery terminals, set up a second set of (+) and (-) bus connections in parallel with the original Primary Circuit.

John Smith, LOA, (2004)

2.Fitting Instruments

It is useful to have a depth sounder and log on the boat, or a combined instrument, and fitting these is relatively straightforward. The three main steps are:

- Deciding the position of, and fitting the display heads
- Similarly for the echo sounder transducer and log impeller
- Connecting them

Display Unit.
Many of the older depth sounders were fitted below decks, presumably because the traditional rotating LED was not easily seen in bright sunlight. 'Ditch crawling' in the shallow waters of the East Coast, I needed always to know how much water I had, so I moved mine into the cockpit.
Most modern units are about 125mm square, and a pair – or a single, combined unit - will fit readily on the cockpit bulkhead; I put mine on the port side (*Ed: there is a photo at p92).* The manufacturer's instructions for the installation are usually very clear and simple.

Transducer & Impeller
Siting of these is trickier. The manufacturers' instructions usually give illustrations of where and where not to fit them, and can be summarised as avoiding turbulent water caused by the keels, skeg etc. Because of the fixed cabin sole and the twin keels, there is not a lot of choice on the Wych.
I mounted both mine under the sink on the grounds, that this was the nearest I could get to the centre line of the boat. The log proved to be a pain. Inevitably the paddle wheel weeds up and has to be removed for cleaning. The makers supply a cap or blanking plug, which has to be applied as soon as the impeller is withdrawn. Varying quantities of water will find their way into the boat, depending how dexterous you are; one more expensive type has an in-built flap-valve, which lets in very little water. Lying on my stomach on the cabin sole, with my arms stretched above my head trying to withdraw the log and cap off the skin fitting was not the easiest of tasks. Removing the water from a relatively flat area was also a pain.

Most (sensible) people seem to have fitted their logs in the loo compartment. Here, the log is forward of the keels, and if by some mischance, the compartment begins to fill with water, the boat will not sink, because the top of the compartment is higher than the water level outside the hull. When selecting the precise site, ensure that there is enough room to withdraw the impeller. Use a hole saw to cut the hole for the skin fitting, but stop cutting as soon as the centre drill has penetrated the hull. Finish off the hole from the outside, thus ensuring clean edges to the hole.

I always use a ply backing plate between the skin fitting nut and the inside of the hull. Use the hole saw to cut a hole in a piece of 6mm marine ply, cut this into a square of about 60mm, chamfer off the top edges, and you have a 'washer'. Clean the peripheries of the hole inside and out, apply a generous coating of sealant, and fit the skin fitting – do not over tighten, otherwise you will squeeze out all the sealant.

On the basis of the fewer holes through the hull the better, I used an in-hull mounting for the transducer; this can also be fitted whilst afloat. Most, if not all, manufacturers offer this as an optional kit, and the method is straightforward. The transducer sits in an oil-filled tube, which is 'stuck' to the inside of the hull. Take particular care when cleaning and roughing the hull and tube to ensure that the epoxy mix or glass fibre seals the tube properly to the hull, otherwise the oil will slowly leak away. It is worth carrying a small bottle of castor oil to top up the tube –usually the problem if the echo sounder starts playing up.

Connections

Power has to be supplied only to the display heads, to which also run the co-axial cables from the transducer and impeller. One of the fiddliest jobs is threading the cable to the display heads, so that the cables are out of sight and secure from damage by loose items in lockers etc. Quite large hole are need through bulkheads etc because of the moulded plugs on the cables. Make sure that the cables are clipped, epoxied, ‘sealanted’ or whatever, to keep them secure.

The power wiring need only be very thin flexible wire – 14/03 is more than adequate - and should be fitted in accordance with the guidance given in the article on ‘Electrics’. Strictly, one should have a switch and fuse for each of these ‘gadgets’; I grouped all my low current-instrument wires (log, echo sounder, wind instrument and GPS) onto one switch/fuse to save space on the switch panel. The downside of this arrangement is that, if one instrument develops some form of fault, which blows the fuse, I lose all my instruments.

To mask the back of the instruments and cables, visible from inside the cabin, I fitted a dummy bulkhead. This was made from faced 6mm ply, cut snugly to fit – no screw holes were drilled at this stage. A small block of wood, with sufficient depth to clear the cables etc, was temporarily taped with masking tape in each corner of the bulkhead to check that the dummy panel would lie flat. After adjusting the thickness of one or more blocks, these were epoxied to the well-roughened face of the bulkhead. After careful measurement, the panel was drilled to accept four c/s brass screws and was fixed to the mounting blocks. This, apart from hiding the cable, gave a useful surface on which to mount other things. (*Ed: just visible in the photo at p92)*

Barri Hopkins (2005)