BASIC ELECTRICITY: Part 1 Electricity

I am going to try to keep this a simple as possible, not because I think you can't understand it. I assume that to master the art of boat building you have to be smart. Mainly, I don't want to end up writing a book on electricity. I want to this to be simple, but complete enough to give you a basic understanding of how this electrical stuff works. When I was much younger I worked on radars and computers on Coast Guard ships and when people asked us "how does it work?" we would say magically, mystically, wonderfully, electronically. But it's actually a lot simpler than that. However, to some it still seems like magic.

So what is electricity? As we all learned in grade school the world is made up of atoms. Atoms are made up of electrons, protons and neutrons. What we are interested in are the electrons, surrounding the nucleus of the atom. Electrons can be dislodged from their atom and attached to another one giving it an excess of electrons. Excess electrons give an atom a negative charge. Atoms with not enough electrons have a positive charge. Through a chemical reaction or other force, electrons can be made to flow though a conductor from the negative to the positive and used as electricity. So electricity is really just a stream of electrons flowing through a conductor from point A to point B and back to where they came from (a complete circuit). This flow is called current.

All of us have experienced this either by getting a static discharge off of a door knob or other metal object, or by seeing nature's ultimate display of electricity, lightning. This is simple exchange of electrons from one point to another. We use this every day in our homes, our cars, our cell phones and every other electric or electronic device we use, but we give little thought to what is actually happening.

In grade school most of us had a science teacher show us an experiment where a strip of lead with a wire attached and a strip of zinc with a wire attached, were put into a glass jar filled with acid. This is what is called a voltaic cell, or battery. The other ends of the wire were connected to a light and lo and behold it lit up!

Battery History http://www.extremetech.com/article2/0,1697,1155265,00.asp

That is about as basic a battery as there is. What is happening here is not magic, just simple chemistry. The acid is an electrolyte. An electrolyte is a fluid that allows electrons to flow through it from one pole to another. Salt water is a pretty good electrolyte. Fresh water is not but will still conduct current and is more dangerous if current gets into the water.

When you put two dissimilar metals near each other in an electrolyte, one of the metals gives up electrons to the other metal. But this only happens if there is a complete circuit, which is the wire and the light. So the electrons flow from one plate to the other through the wire and the light and back to the plates. This doesn't go on forever though. One plate will gradually disappear and soon there will be no more electron flow. Then the light goes out. Where does it go? It gets plated onto the other plate. Remember this, because this is crucial to how batteries work, and how galvanic corrosion works. In fact this is called the Galvanic Process.

If we didn’t have a light in the circuit, just a wire, electrons would still flow, but it would happen so fast that our primitive battery would be dead in no time at all, or the wire would get too hot and melt. This is called a short circuit. The positive side is connected directly to the negative side. The light we put in is called a load. It provides some resistance to the flow of electrons and slows down the process. Also the filament in the light gives off some of the energy of the electrons in the form of light and heat. Otherwise no work would get done by the electrons. So for electricity to do work there needs to be a load in the circuit. This can be lights, appliances, electronic equipment, or motors, all of which put the electrons to work. The wire getting hot and melting is the basic principle behind a fuse. If too many electrons are flowing through the wire, the fuse is designed to get hot and melt at a predetermined amount of current flow. This breaks the circuit, or what is called an open circuit, and stops the current flow, the same way throwing a switch does.

So now we know what current is. It is electron flow. The amount of current is measured in Amperes, or milliamperes. The symbol for Amperes is A, or milliamperes mA.

What drives this current is called voltage. Voltage is a measure of potential energy contained in the battery and is measured in volts. The symbol for volts is V.

The load is resistance to current flow and is measured in something called ohms, named after the guy who discovered it. The symbol for this is either R or the Greek letter Omega. I will just use R.

Types of Electricity

Yes, electricity comes in different flavors, AC and DC. No, that is not a rock group. AC stands for alternating current, which is what we all have in our houses, and most appliances run on AC, and is usually 110 volts (nominally 120 volts but usually referred to as 110), or 220 volts for some large appliances such as clothes dryers. DC stands for Direct Current and is usually low voltage such as six (6) volts or twelve (12) volts. Many of the small electronic devices we commonly use, such as cell phones, calculators, and iPods all run on DC. Your car also uses DC and most small boats use only DC. However, as the boats get bigger they use both AC and DC, until you get into the ship sized yachts that use only AC. First though, I will deal with DC because it is simpler to explain and what most small boats use.

Direct current comes primarily from batteries. You can get it by converting AC to DC but for now I will stick with batteries. The simplest batteries are single cells such as the D cells used in flashlights, or AA and AAA cells used in most small electronic devices. A long time ago, someone discovered that any single cell battery, no matter how big, puts out about 1.2 volts. Over the centuries that has been upped to about 1.5 volts. The larger you make this cell, the longer it will last, and the more current you will get out of it (amperes) but you still won’t get any more than 1.5 volts.

So how do we get typical twelve volt and six volt batteries? These are lead-acid type batteries and have about 2.0 volts per cell, compared to the 1.5 volts of most flashlight-type cells. If you tie a lot of these cells together in series (I’ll explain series in a minute) they add up. So three cells is six volts, and six cells is twelve volts. So actually that twelve volt battery in your car or boat is really six cells (count the vent caps) wired together to make twelve volts.

Series means battery cells that are connected together thus; the positive pole on the first cell is wired to the negative on the second, and the negative on the first is wired to the positive on the second, and so on until you have the voltage you need.

Parallel means just the opposite. All the positive poles are connected to each other and all the negative poles are connected to each other. This still only gives you twelvw volts but it increases the amount of current. This is commonly done in boats and recreational vehicles to make a large battery bank to power all the DC equipment on board. Two or more twelve volt batteries will be connected in parallel to increase the current, to run more equipment, or to run your equipment for a longer time. However, if you have something that runs on 24 volts or 48 volts, you can connect twelve volt batteries in series to get the desired volts. In series you add the voltages. In parallel you add up the amperages.

See the Figure below, and the photo of two deep cycle batteries in parallel. The battery on the right is the starting battery and not connected to the two deep cycle house batteries. However, in this instance there is a switch which allows the house batteries to be used to start the engine.

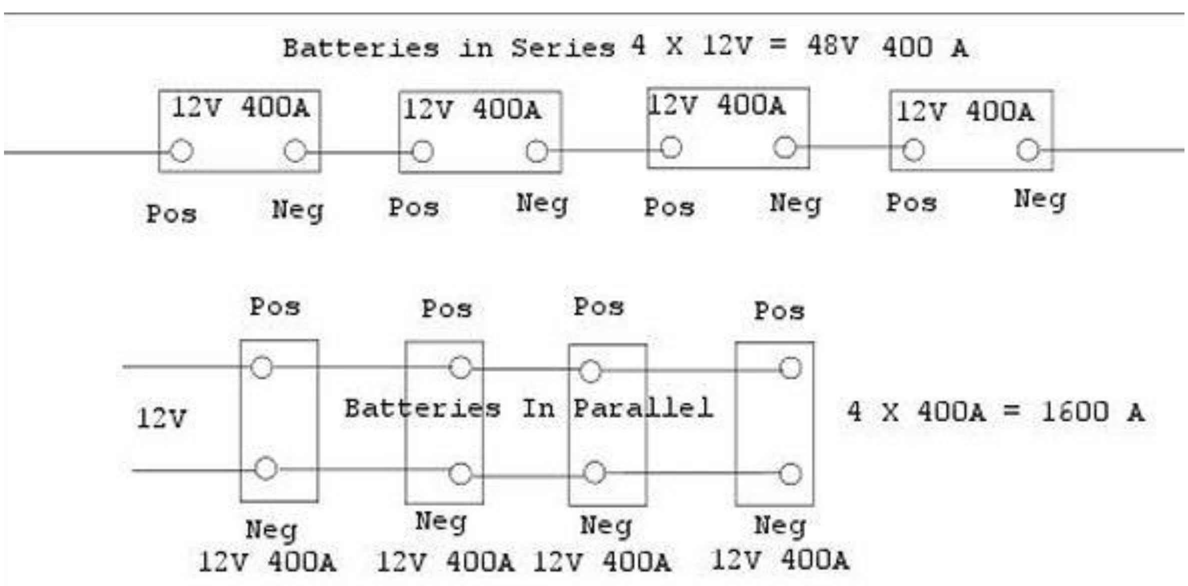

Fig. 1 Batteries in Series and Parallel

Fig. 2 Deep Cycle Batteries on the left, starting battery on the right.

Why DC? DC has certain advantages. It comes in convenient sized packages; for example, your typical automotive batteries. Also, low voltage DC does not present the big shock hazard that AC does. Plus that, most equipment used on small boats is designed specifically to run on DC. You don't need a large generator to produce DC, and you can easily recharge the batteries from an alternator on your engine, or with a charger on shore power.

Why is it called direct current? Because the current flows in only one direction, as opposed to AC which flows both directions. For low power devices, DC is more than adequate to supply your power needs.

See Wikipedia on Direct Current http://en.wikipedia.org/wiki/Direct_current

So what about AC? It's called Alternating Current because the current flow switches direction every $1/120^{th}$ second, meaning it takes 1/60 of a second to go through a complete cycle, or 60 cycles per second, now called Hertz after the inventor, and shown as Hz.

See Wikipedia on Alternating current
http://en.wikipedia.org/wiki/Alternating_current

Alternating current's biggest advantage is that it can be easily transformed to higher or lower voltages with a transformer. To send lots of power a long distance, a high voltage up to hundreds of thousands of volts is used ("High Tension" lines). The current is much less, so the voltage drop is much less. Some of the newest long-distance lines now use DC, as new methods of converting DC up and down in voltage have been developed.