

WAS FRANKENSTEIN A GOOD FISHERMAN?

ELECTRICITY IN BOATS

by: Russ Roy

When Mary Shelly wrote Frankenstein, she got it basically right. She had heard of Italian scientist Galvani's work where he applied electrical voltage to a muscle in a dissected frog's leg and got it to contract. Electricity was quickly assumed to be a "vis viva" or life force, so Frankenstein got an electrical jump start in the original movie and proceeded to star in more than 200 more of them.

Today we know that electricity plays a very important role in nature: nerve impulses are electrical in nature and muscle contractions (and relaxations) are also dependant on electricity. Too much of anything can be bad, however, and electricity is no exception. During our last GOFC club meeting, Dave Abril and Wiley Horton discussed electrical wiring in boats with some practical do's and don'ts. There just isn't enough time to cover a complicated subject like electricity in 30 minutes however, so here is the first of a series of articles on electricity with this one focused on electrical safety.

There are three quantities we need to consider: voltage, electrical current, and resistance. Voltage is the common name for potential difference. A device like a car or boat battery can maintain a potential difference of about 12 volts by using the energy released by chemical reactions going on inside it. Once the chemical energy is exhausted, the battery will no longer be able to maintain a potential difference. It is the potential **difference** that is important. A battery whose terminals were at 1,000,012 volts and 1,000,000 volts would be exactly the same as a battery whose terminals were at 12 volts and 0 volts. Potential difference can be thought of as a "cause." What does it cause? Electrical current!

Electrical current refers to the motion of electrical charge. Charges can move in wires, in water and other solutions, and in empty space. The unit of current is the ampere or amp. As current flows it can carry energy and this energy can do work, running our electrical appliances, including VHF radios, GPS units, and so on. As far as electrical danger is concerned, I was often asked by my physics students which is more dangerous, current or voltage. Actually both are necessary; there will be no current without a potential difference. In practice what actually matters the most is the third quantity: resistance.

When a potential difference is maintained in a circuit (any closed path that the current can flow in), the amount of current that flows is determined by the size of the potential difference and the amount of resistance present in the circuit. If V is the potential difference, I is the current and R is the resistance present, then the three quantities are related by the simple equation:

$$V = I R$$

This is often called Ohm's Law, but, in fact, it isn't, and since this isn't a physics class we don't have to worry about it! What we do have to worry about is when a human body becomes part of a circuit and current flows through it.

A current of 0.001 amp (1 milliamp) is enough for most people to get a "tingle." Currents of about 0.01 amp (10 milliamp) can cause severe muscle contraction. This contraction is enough so that a person would not be able to release a wire if his hand had grabbed it. Ten milliamps flowing through the muscles in the chest that

we use to breathe would cause the muscles to be unable to function with death soon to follow. If a current of about 70 milliamps goes through the torso so some of it goes through the heart, the heart muscles will begin to contract irregularly (ventricular fibrillation). If the regular beating of the heart is not quickly restored, brain damage and even death will soon take place.

Any time a potential difference occurs across a human body, current will flow through it. So if, for example, you were to grab the two terminals of your boat battery with your two hands, current would flow through your chest and through your heart. Would this be enough to electrocute you? That depends on the resistance of the body. Electrically, a human body is mostly a big bag of salty water. This has very little resistance and a lot of current would flow. The only resistance in a body is in the skin. Clean, dry skin can have a resistance of 10,000 ohms or more. Using our equation above, we get

$$V = I R$$

$$12 \text{ volts} = I (10,000 \text{ ohms})$$

$$I = 0.012 \text{ amps}$$

or just enough current for a tingle. On the other hand, if the skin is wet and/or dirty, the resistance might be only a few hundred ohms,

$$V = I R$$

$$12 \text{ volts} = I (300 \text{ ohms})$$

$$I = 0.04 \text{ amps.}$$

This is enough to shut down respiration and might even cause fibrillation. People electrocuted by car batteries are not unusual. And people doing electrical work in a boat with their hands covered by salt water (a good conductor which breaks down the resistance of the skin) are at high risk.

You don't have to touch the battery terminals directly, of course, you can touch the wires or any parts of the circuit. If you have one hand on the battery and you are standing in Gulf water, electrical current can flow from the battery, through you, and into the Gulf and finally, into the Earth. You have, as electricians say, become "grounded."

If you are having electrical problems on your boat, you don't want to add electrocution to those. Be careful what you touch, and think carefully about what you are doing. The more you know about electricity and electrical circuits, the safer you will be.

Our next article will look at two handy devices to use in analyzing the electricity on our boats.