The Motors that Make Our Boats Go
By Allan Wing

In the past few years many of us have been looking for motors to make our Polo Springers run faster and longer on a single battery charge. As a result, we have looked at many motors. Along with this I have received many questions about motors. So I figured that a look inside a basic motor and an explanation of how it works would be helpful.
To do this I took apart a basic 540 can motor. It is called a can motor because the motor case is a pressed can. Examples of this motor are a Johnson 540 or the popular Graupner Speed 600 that powers most of our Springers.

Figure 1 is a picture of the motor after it is taken apart. The motor consists of 3 basic parts, the armature, the end plate and the can. The armature is the round piece that turns inside the motor. In these can motors the armature has 3 poles, each wound with a coil of wire and a commutator (figure 2 shows a close up of the commutator on the end of the armature) that provides connection to the brushes. The end plate holds the bearing for one end of the armature and the brushes that contact the commutator. The final piece is the can which has the bearing for the other end of the armature and the magnets.

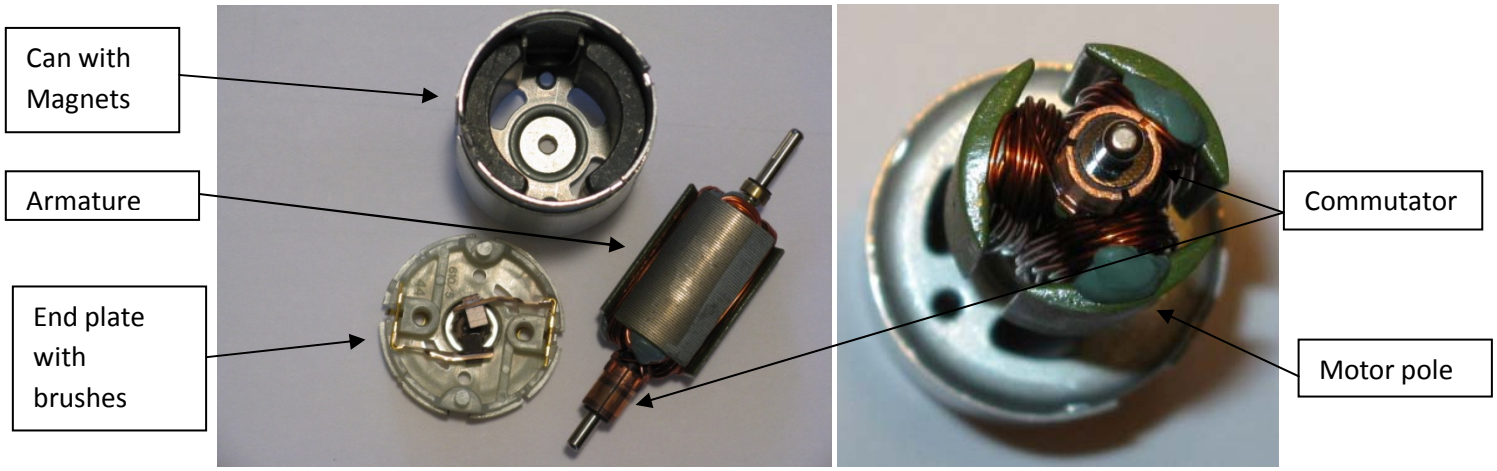

Figure 1 Motor Parts

Figure 2 Commutator

The motor operates by sending electric current through the windings and creating an electromagnet of one of the 3 poles. This causes the pole to be either attracted to or repelled from the magnets in the can. A magnet has two ends; they are labeled either North or South. This comes from the fact that if you take a bar magnet and suspend it from a string one end will point north and the other south. So the convention is that one end is north seeking and the other is south seeking. When two magnets come next to each other two north or two south ends will repel and a north and south end will attract. The magnets in the can motor are constructed that the inside of the magnet is one end and the outside is the other end. (See figure 3). The ability to make magnets with this shape greatly improved permanent magnet DC motors. The magnets are positioned inside the can such that one magnet has a north side of the magnet facing inward and the other has the south side of the magnet facing inward.

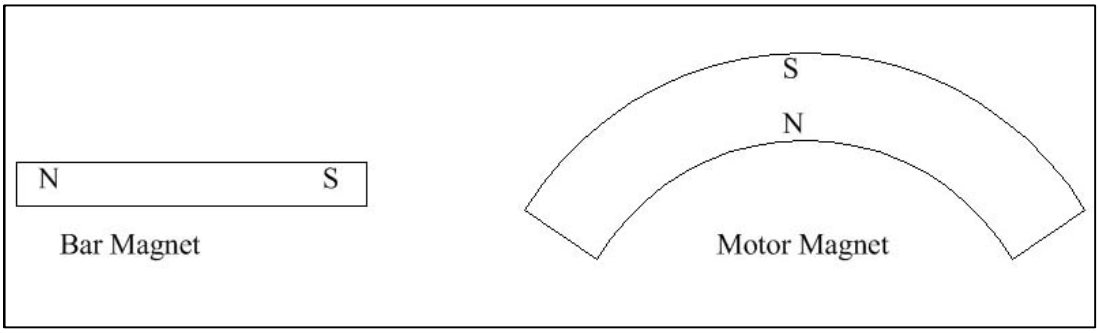

Figure 3 Magnets

The operation of the motor is shown in figure 4. The brushes carry current to the commutator. The result is for the poles of the motor with the north/south ends as shown. The pole marked S is pulled up toward the top magnet that has the north side facing inward. The other motor poles receive current that make them North. The upper pose is repelled from the top magnet and the lower pose is attracted to the bottom magnet. As the armature turns the brushes contact other areas of the commutator and the current in the poles of the armature are changed to keep the attraction and repulsion forces going. This results in the armature rotating.

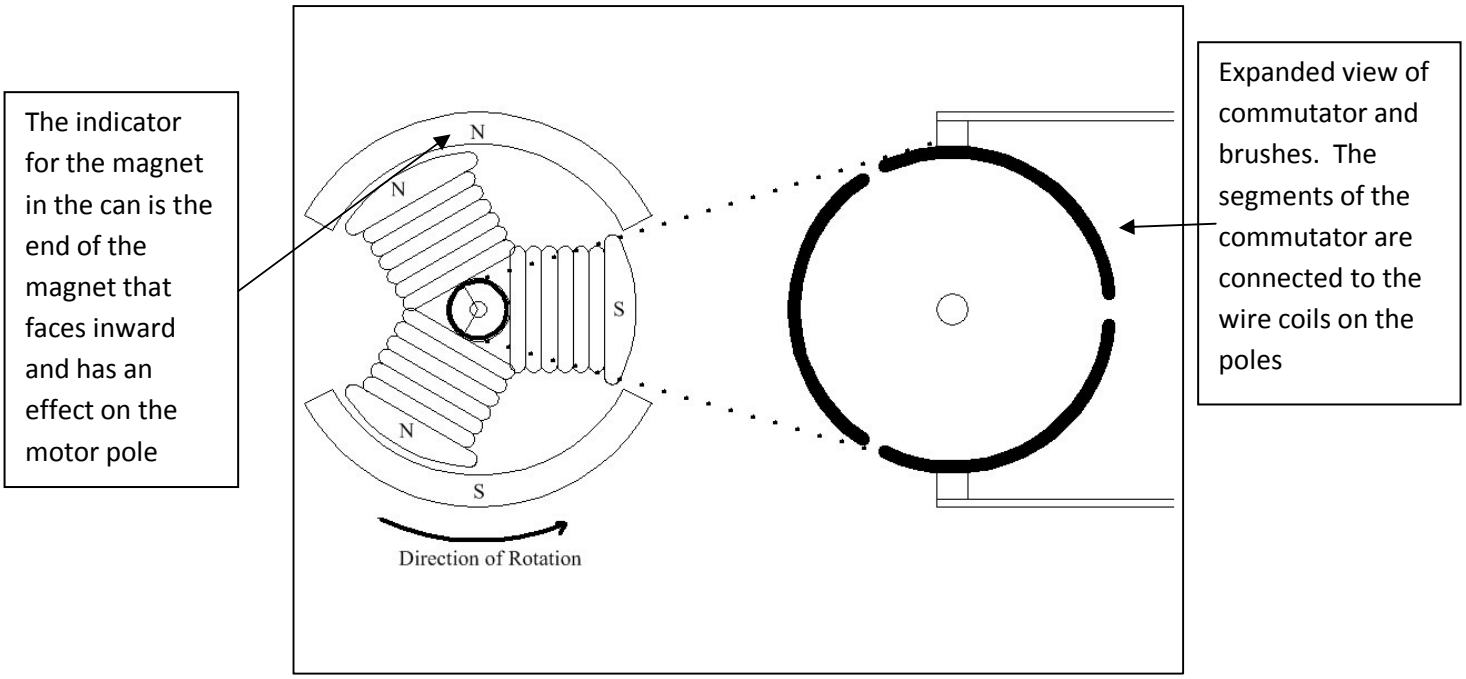

Figure 4 Motor detail

The direction of rotation is determined by the polarity of the voltage applied, reversing the voltage will reverse the direction of rotation. The speed of rotation is determined by the voltage applied.

The speed of the motor is determined primarily by two things, the applied voltage and the number of wire turns on the armature. Motor speed is proportional to the applied voltage. That means that a motor will turn twice as fast with 6 volts applied as it turns with 3 volts applied. The second is the number of turns of wire on the armature. As the armature turns in the magnetic field created by the fixed magnets it creates an internal voltage much like a generator. As the armature spins faster the voltage rises until it approaches the applied battery voltage. The more turns on the armature the faster that voltage rises hence the sooner the internal voltage approaches the battery voltage. This results in a motor with a slower top speed. With more turns the motor draws less current and creates more torque. With less turns the motor will turn faster but it will have less torque and draw more current under load.