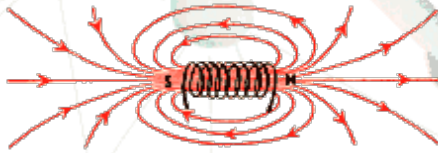


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## Fun with electromagnets

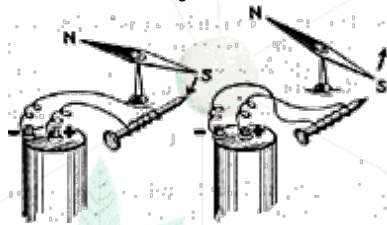
### Part one: the electromagnet



An electric current flowing through a wire produces a magnetic field. Coiling the wire produces a stronger magnetic field. Coiling it around a soft iron core increases the effect; raising the current or the number of

coils increases it further. Electromagnets are based on this simple principle.

A basic electromagnet can be constructed around a long carriage bolt. Almost any iron core will work, but the bolt is simpler to work with. Screw a nut on to the end of the bolt so that there are two stops on either end, the nut and the head of the bolt itself. Wrap a piece of paper around the bolt between the nut and head and tape in place. Leaving a foot or so free, coil an insulated wire around the length of the bolt, between the head and the nut. Once the end is reached, coil the wire back to the other end. Repeat until there are several layers. The free ends of the wire should be at opposite ends of the bolt. Tape the wire so that it stays in place. Leaving a foot or so free, cut the wire off at the end. Strip the insulation off the ends of the wires. When the wires are attached to a battery (dry cell), the electric current around the wire and bolt will form a magnetic field. Don't use it too long, as the battery will drain very quickly.



When constructing an electromagnet,

- o It is best to use magnet wire, as it is thinner, and you can get more turns in a smaller space.
- o The best core to use is soft iron. If cast iron or steel is used, it will be magnetized after the current ceases.
- o The wire of the coil is usually separated from the core by a layer or two of paper, which serves as an insulator.
- o The wire should be wound in smooth even layers.
- o The outside diameter of the electromagnet should not be more than twice the diameter of the core.
- o When winding a large coil, it will speed things along if you mount the core in a hand drill (unpowered).



A bit more elaborate setup is described in *Experimental Electricity for Boys*, by Willard Doan, 1959. This configuration acts more like a horseshoe magnet, giving the lifting strength of both poles at the same end. Keep in mind that this is from an older source, so some materials may need to be substituted.

"We need the following materials:

- two pieces of iron rod, 1 3/4 inches (44.5mm) long by 5/16 inch (8mm) diameter
- one bar of iron 2 3/4 inches (70mm) long, 1/2 inch (12.5mm) wide, 1/8 to 3/16 inch (3mm-4.75mm) thick
- four disks of fiber board or bakelite, 1 inch (25mm) diameter by 1/16 inch (1.5mm) thick
- 100 feet (30m) No. 23 enameled magnet wire

For the magnet cores, take two pieces of iron rod 1 3/4 inches long and 5/16 inch in diameter. They should be the softest iron possible. The unthreaded part of a carriage bolt of the right size will do very nicely. It may be softened further by annealing, that is, heated to a red heat and allowed to cool very slowly. At one end of each piece file a shoulder back 1/4 inch (6mm), reducing the diameter to 3/16 inch (4.75mm). This completes the cores (see Fig. 6-3).

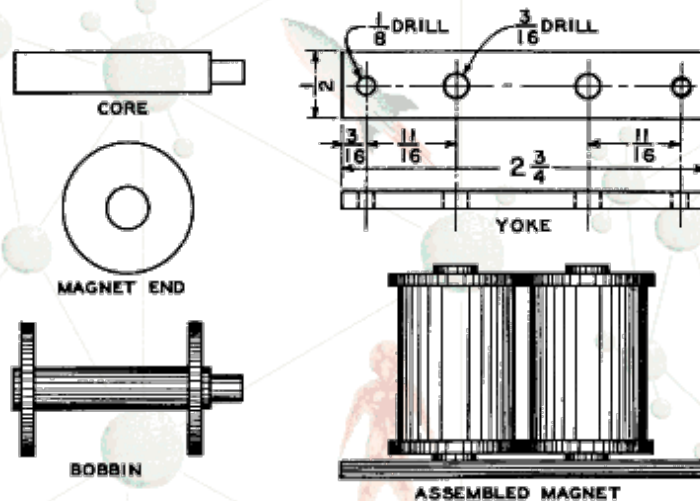


Fig. 6-3. Details of the construction of an experimental electromagnet.

To make the wire bobbins, cut four disks one inch (25mm) in diameter from fiber or other good insulating material about 1/16 inch (1.5mm) thick. Drill a hole in the center of each, slightly under 5/16 inch (8mm) in diameter, so it will make a tight fit when, forced on the core, using a vise. The assembled bobbin should look like Fig. 6-3. Two small holes should be drilled in each bobbin nearest the shouldered end of the core to allow the beginning and end of the wire to come through.

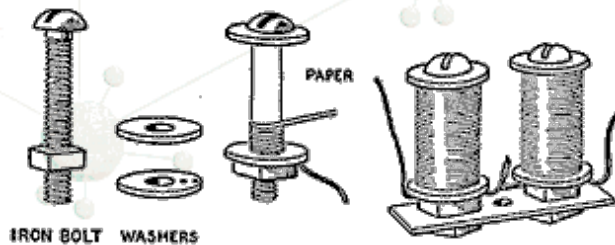
Wrap three or four layers of paper over the core for insulation.

Now we are ready for the winding of the coils. Wind each bobbin almost full of No. 23 or No. 24 insulated (preferably enameled) copper wire. This will require about 100 feet (30m) of No. 23 wire and slightly more if No. 24 is used. Wind each layer smoothly with the turns as close together as possible. Do not allow one turn to cross over another. Put a layer of paper, such as typewriter or thin wrapping paper, between each layer of wire. This makes it much easier to put on the wire and also acts as insulation between the layers. After the winding is completed, cover it with a protective wrapping of friction tape.

A yoke for the magnet coils may be made out of a bar of soft iron 1/8 or 3/16 inch (3mm-4.75mm) thick, 1/2 inch (12.5mm) wide, and about 2 3/4 inches (70mm) long. Drill a hole 3/16 inch (4.75mm) from each end for a mounting screw. Drill holes 1/2 inch (12.5mm) each side of the center in which the filed-down portion of the soft-iron cores will fit tightly. Insert the core ends, being sure the shoulders fit snugly against the yoke, and peen down the projecting ends to fasten the cores solidly to the yoke. Take a flat file and carefully dress down the outer ends of the cores so any flat object placed against the ends will fit perfectly against the surfaces of both cores.

Now with a compass as indicator and a dry cell for power, determine the coil connections. The coils must be connected in series so that one core will be a north pole at the end while the other core presents a south pole. Connecting the two inner ends of the coils together may give the desired effect or it may be necessary to connect an inner end to an outer end. The magnet should be used only intermittently on a single dry cell. Two dry cells may be used for a short period of time. If wound with No. 23 magnet wire and to the given dimensions, the completed magnet will have a resistance of approximately 2 ohms. With one dry cell this would draw a current of 3/4 ampere; with two dry cells, 1 1/2 amperes."

A horseshoe effect can also be accomplished more simply, as in the following diagram.



### Coming soon

More fun with electromagnets, including buzzers, bells, telegraphs and telephones. Check back!



The [electromagnetic horn](#) page.

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Last updated Dec 30, 2008

