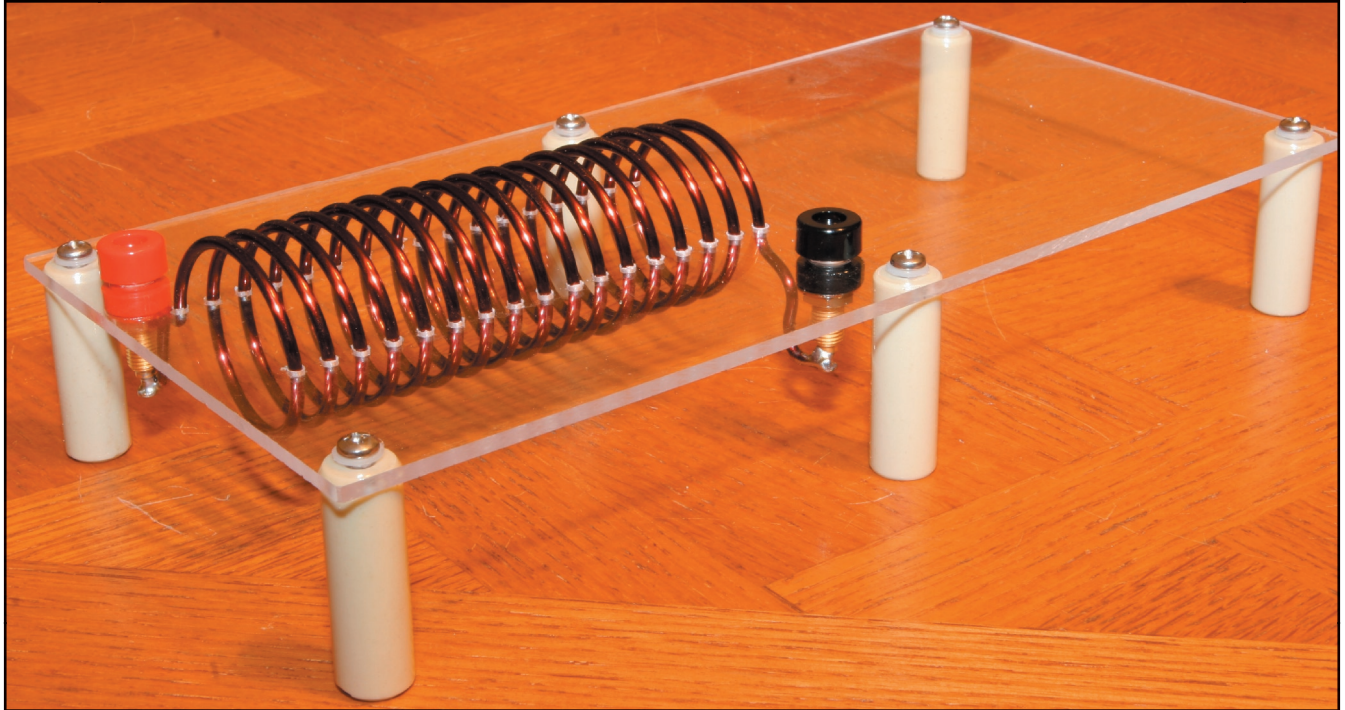


The Invisible Electromagnet

A Transparent Magnetic Field Viewer



A Transparent Magnetic Field Viewer

Background

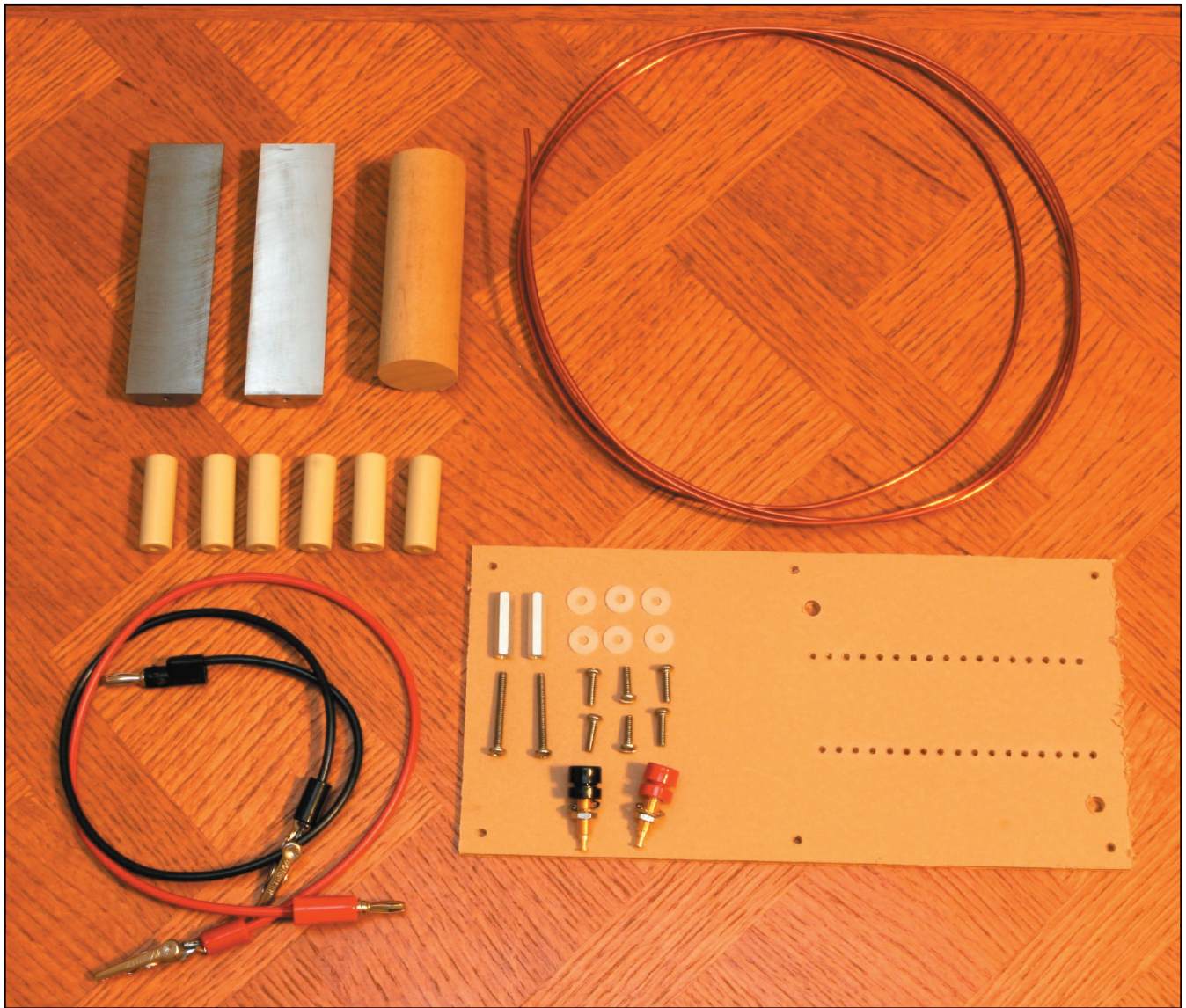
A magnetic field is generated whenever an electric current flows. While invisible to the naked eye, an object's magnetic field can be traced with a magnetic compass or iron filings. The Transparent Magnetic Field Viewer allows for the exploration of the magnetic field that is produced by a coil of wire.

Overview

The body of the magnetic field viewer is constructed from a $\frac{1}{8}$ " thick sheet of clear acrylic. 11 gauge wire is wrapped around a wooden core and then fed through holes drilled within the acrylic sheet. When an electric current is passed through the coil, a magnetic field is created that can be viewed by sprinkling iron filings on the acrylic sheet. Cores of differing materials can be inserted within the coil to see how the magnetic field is altered.

Component List

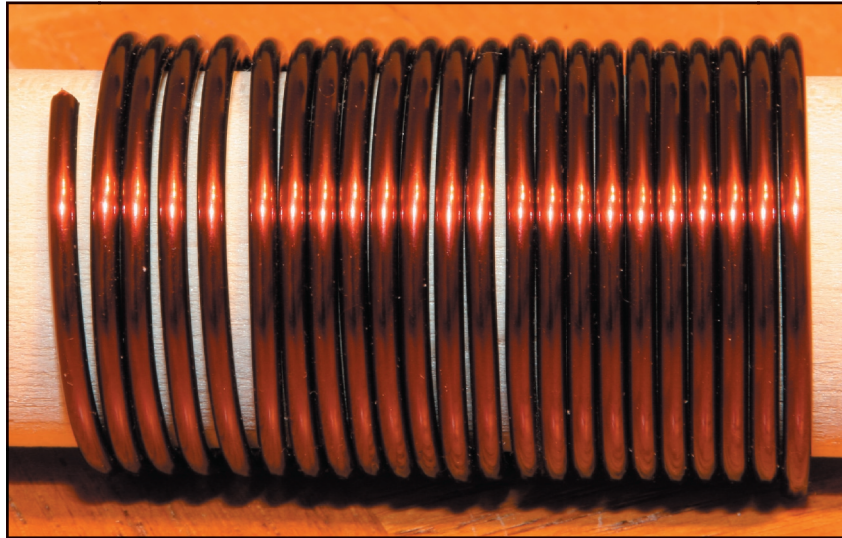
- 11 gauge solid core, enameled magnet wire (2.1 meters needed)
- 1 $\frac{1}{4}$ " diameter wood dowel (4 inches needed)
- $\frac{1}{8}$ " thick acrylic sheet ($9\frac{3}{4}$ " \times $4\frac{3}{4}$ ")
- ceramic spacer, 1 $\frac{1}{2}$ " long, threaded for #6-32 (6 needed)
- #6-32 \times $\frac{1}{2}$ " machine screw (6 needed)
- #6 nylon washer (6 needed)
- aluminum hex spacer, 1" long, threaded for #6-32 (2 needed)
- #6-32 \times 1 $\frac{1}{4}$ " machine screw (2 needed)
- banana plug panel mount (2 needed)
- banana plug patch cord (2 needed)
- aluminum core (1 needed)
- steel core (1 needed)



All of the components have been gathered. All of the holes have been drilled in the acrylic sheet but its protective paper has not yet been removed.

Coil Preparation

1. Cut a 2.1 meter length of 11 gauge, solid core magnet wire.
2. Wrap all of the 11 gauge wire around a 4 inch length of 1 1/4 inch diameter dowel rod. The coils should be packed as closely together as possible and wound as tightly around the dowel as possible.
3. Once all of the wire has been wrapped around the dowel, it is helpful to tap the ends of the wire with a rubber mallet so that they follow the curve of the dowel.

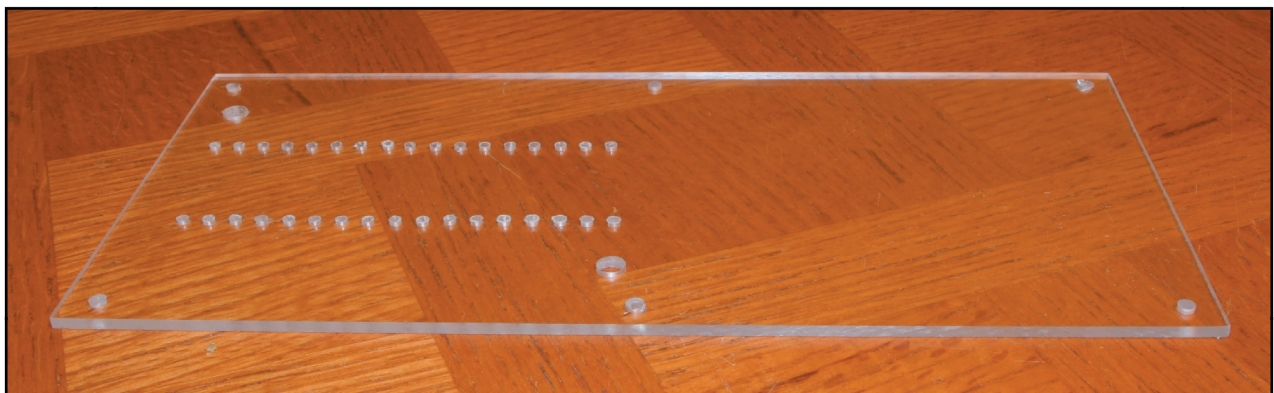


The 11 gauge magnet wire has been wrapped around a wooden dowel.

4. The coil is now complete. Remove it from the dowel and set the coil aside for now.

Base Preparation

1. Obtain a clear, transparent acrylic sheet from your local plastics dealer. The sheet should be 1/8 inch thick, 9 3/4 inches long and 7 5/8 inches wide.
2. Use the drill pattern found in **Appendix A** to drill the appropriate holes in the acrylic sheet. Care should be taken while drilling as acrylic is a relatively brittle material and is easily cracked.



Holes for the coil, legs and banana plug panel mounts have been drilled in the acrylic sheet.

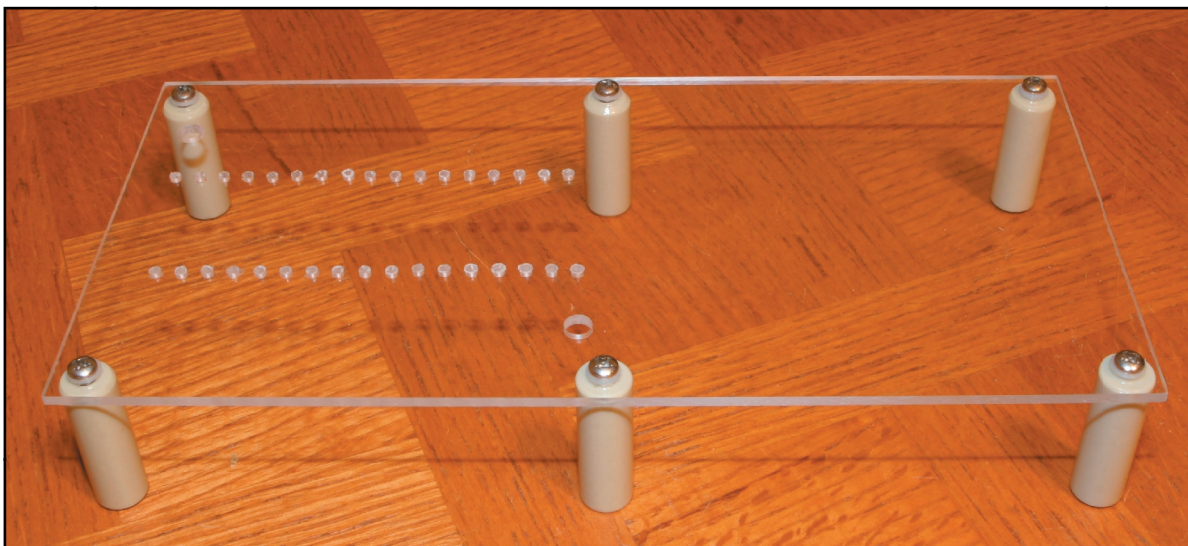
3. The base is now ready. Remove any protective paper covering the acrylic sheet prior to final assembly.

Core Assembly

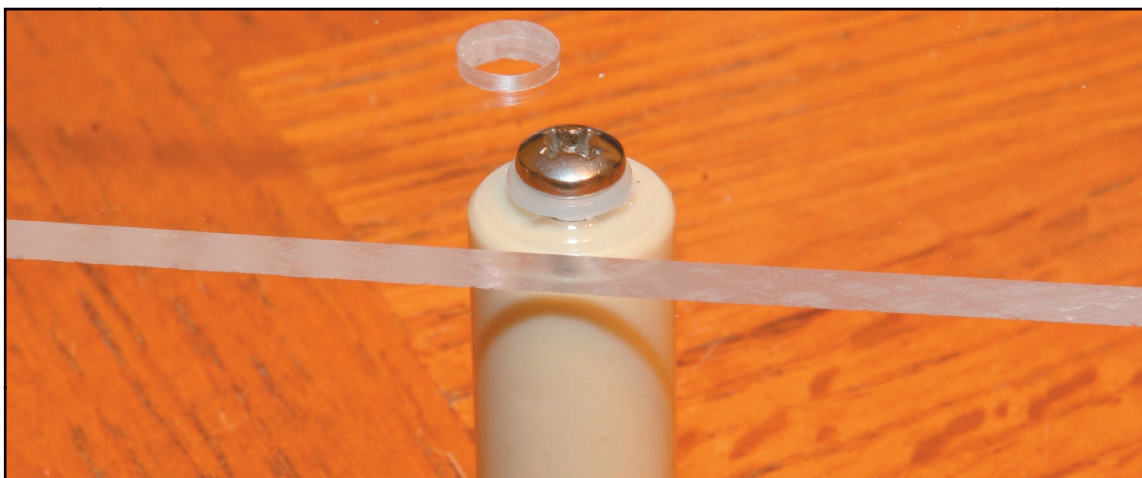
1. Have a local machine shop construct two metal cores based on the drawings found in **Appendix B**. One core should be made from aluminum and the other should be made from 1018 steel or similar material.
2. Construct a handle for each core using one #6-32 \times 1 1/2" machine screw and one #6-32 \times 1" aluminum hex spacer. Thread the hex spacer onto the machine screw and then thread the screw into the core's threaded hole.
3. The cores are now complete.

Final Assembly

1. Attach the 6 ceramic spacers to the acrylic sheet. Use a #6-32 \times 1/2" machine screw and a #6 nylon washer to attach each ceramic spacer to the acrylic base. Do not over tighten the screws as the acrylic could crack.

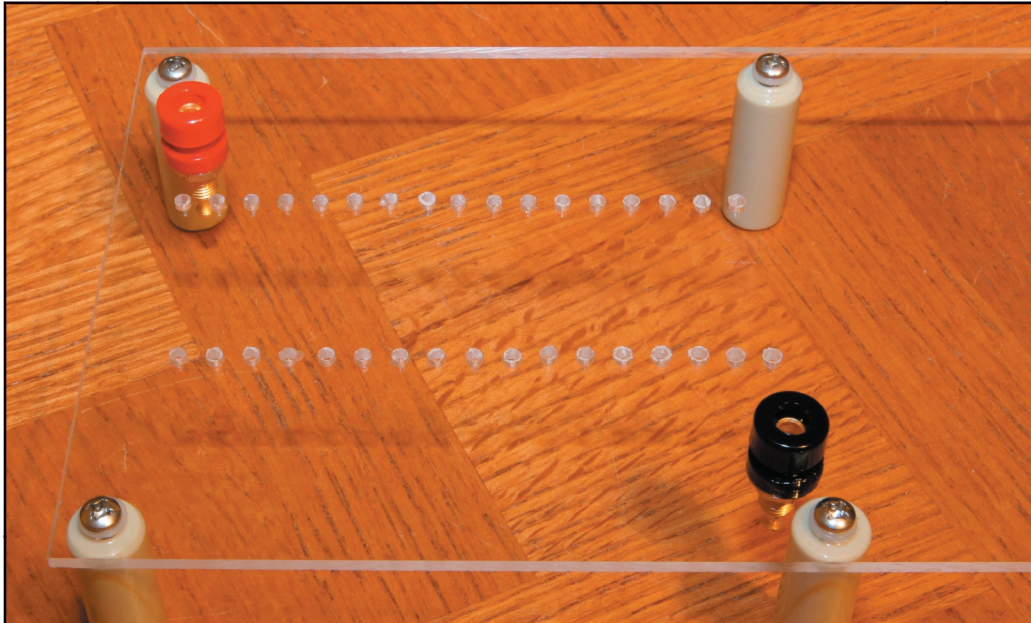


Six ceramic spacers have been attached to the acrylic base.



Close-up detail of one of the attached acrylic spacers.

2. Attach the two banana plug panel mounts to the acrylic base. Again, be careful not to over tighten these items.



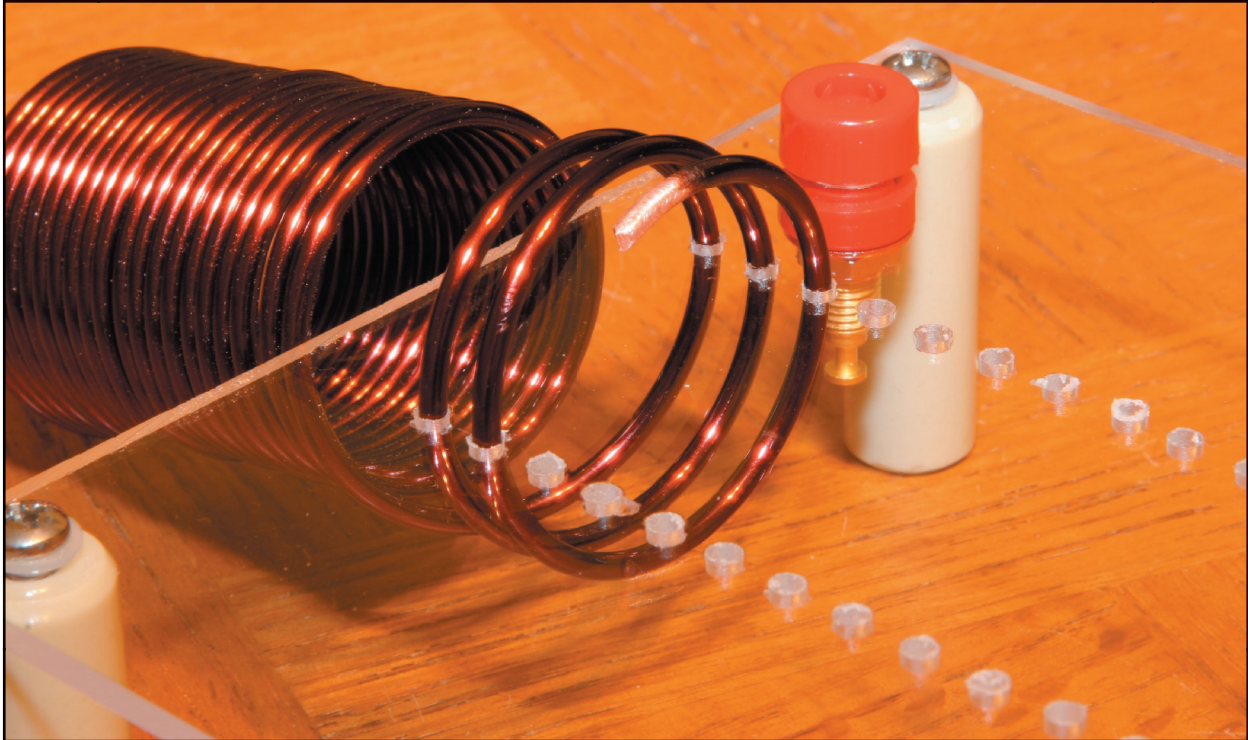
Two banana plug panel mounts have been attached to the acrylic base.

3. Pull one end of the wire coil apart slightly. Use sand paper to remove about half an inch of the wire's insulating coating.



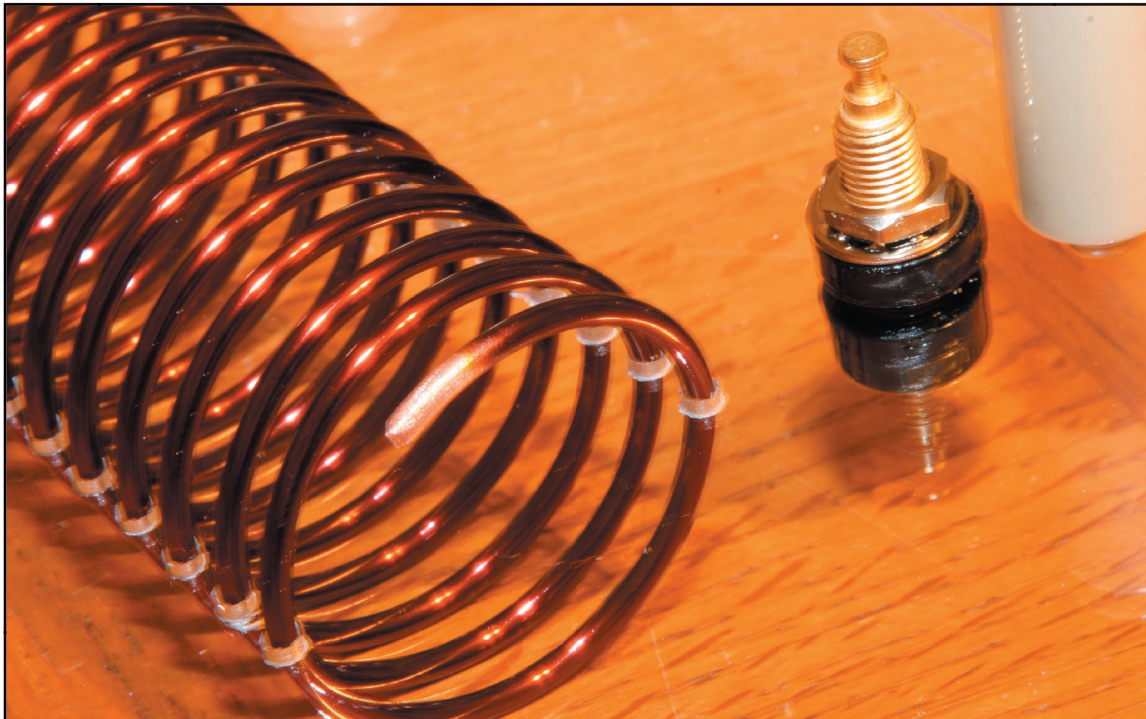
The insulation has been removed from a section of the coil.

4. Feed the wire coil through the holes in the acrylic base. If the base is orientated as it is in the photographs above, the coil will pass upwards through the upper row of holes in the acrylic base and downwards through the lower row of holes.



The coil is fed through the acrylic base.

5. Keep feeding the coil through the acrylic base until it reaches the far banana plug panel mount.



Enough of the coil has been fed through the acrylic base so that it can be bent to reach the banana plug panel mount's solder post.

- Bend the leading end of the coil's wire so that it reaches the soldering post of the nearest banana plug panel mount. Solder the wire to the soldering post.



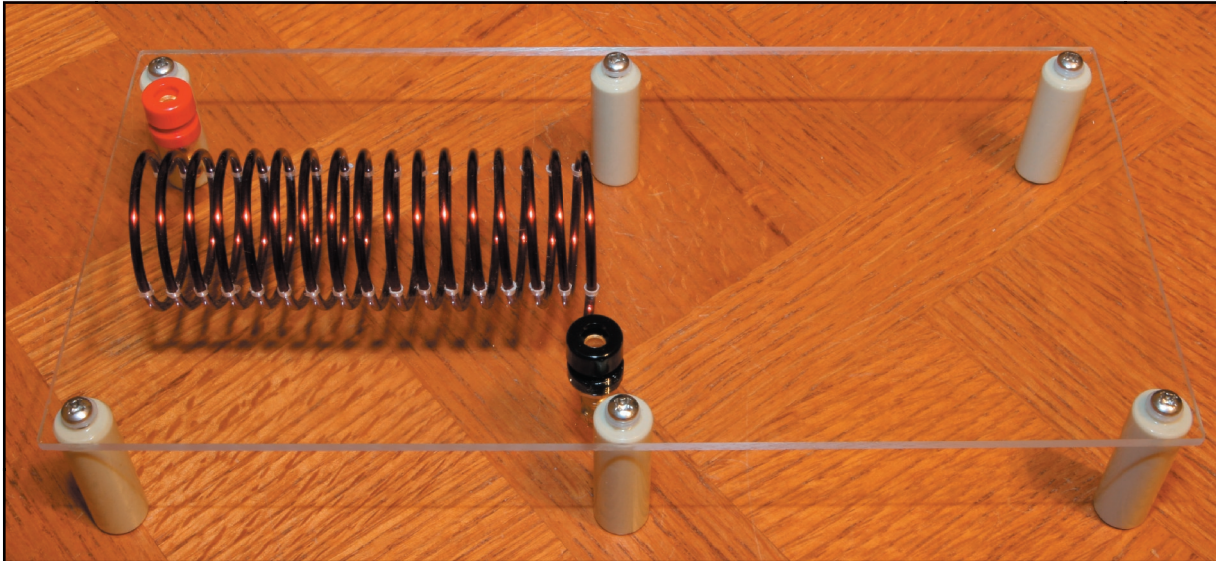
The coil's leading end has been soldered to the banana plug panel mount's soldering post.

- Bend the trailing end of the coil's wire so that it reaches the soldering post of the nearest banana plug panel mount. Trim the wire as necessary and remove about half an inch of the wire's insulating coating. Solder the wire to the soldering post.



The coil's trailing end has been soldered to the banana plug panel mount's soldering post.

8. That's it! Your magnetic field viewer is now ready for operation!

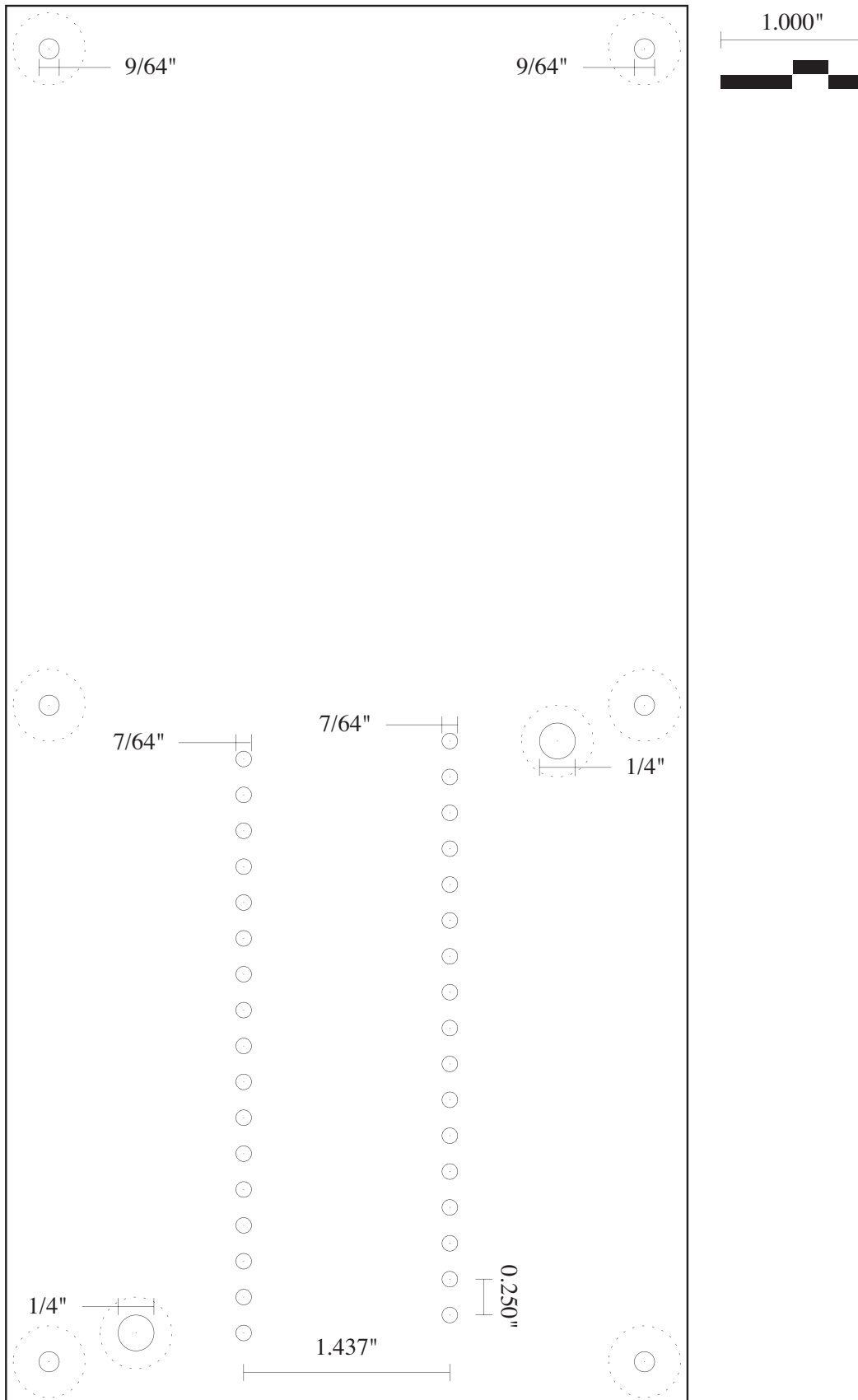


A completed magnetic field viewer.

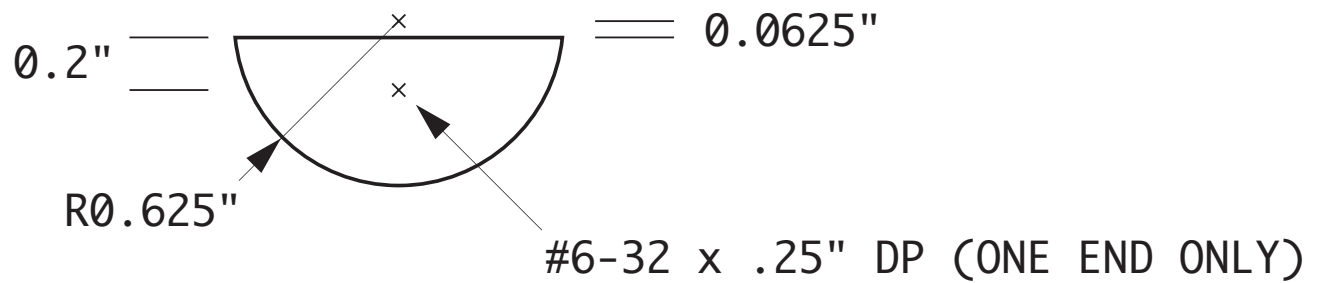
Operation

1. Attach an appropriate current source to the magnetic field viewer with patch cords. **MAKE CERTAIN THAT YOUR CURRENT SOURCE IS INTERNALLY LIMITED!!** Since the wire coil has a very low resistance, it will appear as a short circuit to an external power supply. An external ballast resistor may be necessary, depending on the power supply you use.
2. Allow current to flow through the wire coil. Sprinkle iron filings onto the acrylic base. Gently tapping the acrylic base will help the iron filings align themselves with the magnetic produced by the coil. Placing the device on an overhead projector will allow the pattern produced by the iron filings to be seen by a large group.
3. Slide the aluminum core into the bottom half of the coil. How does this affect the strength of the magnetic field? Why?
4. Slide the steel core into the bottom half of the coil. How does this affect the strength of the magnetic field? Why?
5. Where is the magnetic field the strongest? Where is it the weakest?
6. Take care when removing the iron filings from the magnetic field viewer as they can scratch the acrylic.

Appendix A - Acrylic Base Drill Pattern (reduced to fit to page)



Appendix B - Core Drawings



MATERIAL: 1 ALUMINUM (4.5" in length)
1 1018 STEEL (4.5" in length)