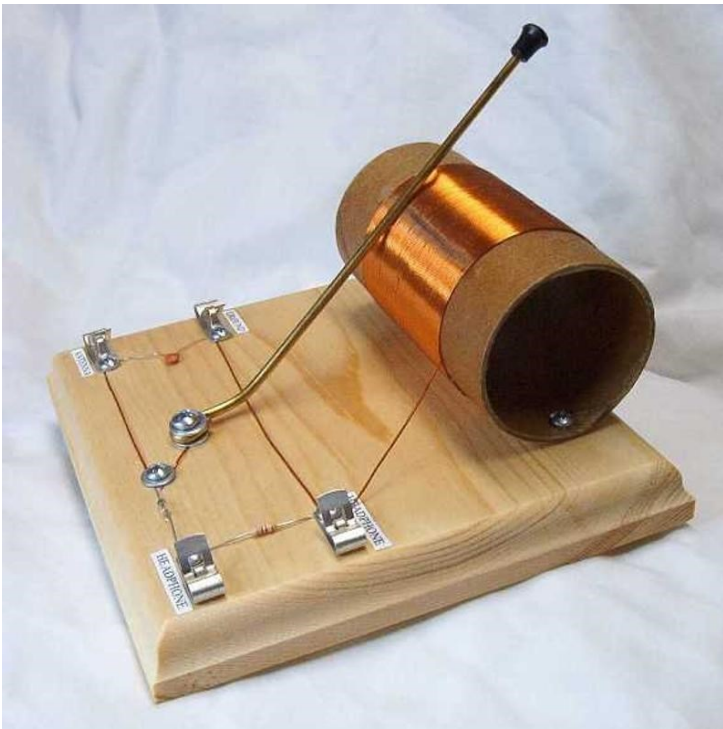


Tech corner – AM crystal radio



While not exactly amateur radio-related, an AM crystal radio is one of those projects that you might have done as a kid or wish you had done. Well, this DIY project will give you the opportunity to re-live a once-forgotten time or to build a crystal radio for the first time, from scratch.

The magic of a crystal radio is the fact that you can create a real radio receiver that works without any

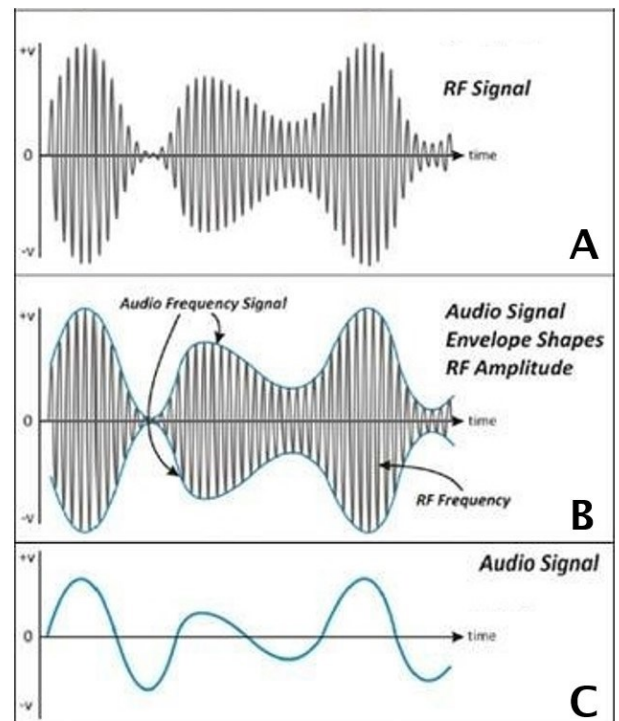
visible power source such as a battery, wall power, or solar panel. Drawing solely from the energy of the existing AM broadcast radio waves, you can tap into that power to bring your creation to life. But to make use of that mysterious power source, you'll need a good antenna and a good ground.

How it works

Without going into too much technical detail, let's examine how this is done. AM radio waves appear as a sine wave that oscillates at what we call the carrier frequency. For example, the radio station KSL AM transmits a carrier wave of 1160 kHz (or 1.160 MHz). But the amplitude (strength) of the carrier signal changes (is "modulated") according to the presence of a sound wave such as music or a broadcaster's voice. When the signal arrives at the antenna (Figure A), it's a constant-frequency carrier wave whose amplitude has been modified by a sound wave.

However, many AM signals are present in the air at any given time, so we need to have a tuned circuit to filter out all but the frequency of interest (bandpass filter). Next, to extract the sound from that wave, we recognize that the waveform envelope (shape) is symmetric about the time axis (Figure B). So, we need to remove either the signal half above the axis or below it, which can be done with a diode rectifier, in this case called a detector, so that only, say, the positive part of the signal proceeds through the circuit.

Finally, we need to recover the shape of the positive waveform, and that's accomplished by a capacitor, which performs two tasks. The capacitor will act like a low-pass filter in that the higher (carrier) frequencies are shunted to ground. At the same time, the capacitor removes the DC bias of the signal, centering it about the time axis (Figure C).



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All that remains is for the earpiece to transform that electrical audio-frequency (AF) envelope into actual sound. We'll be using a ceramic (sometimes called "crystal") earpiece, because the signal is too weak to be heard through a conventional earphone or head set. Also, because modern high-impedance, weak-signal ceramic earpieces are piezoelectric, the capacitor is built into them, so we might not even need a discrete component capacitor.

The heart of this radio is the crystal, so-called because a thin wire called a cat's whisker once attached to galena crystal formed a crude semiconducting junction that was originally used as a rectifier. Later, it was discovered that the same rectifying effect could be achieved by attaching the cat's whisker to any dissimilar crystal-line material such as a *blued* razor blade. In our case, we'll use a modern Germanium diode for the rectifier, and the fact that it's encased in glass seems to promote the visual reminder of it being a crystal.

Let's see what it's going to take to build an AM crystal radio set. The object is to build the circuit from this schematic diagram. The keys to a well-functioning crystal radio are the antenna and the ground, which I'll address at the end. I used old-fashioned **Fahnestock clips** because they're easy to install and are a quick disconnect for electronic parts, especially for the antenna, the ground, and the earpiece, all of which should be easily and quickly removable. The most visible component is the tuning coil, which is an air-core inductor, using a bicycle spoke as the variable tuning sliding rod.

Parts list

One **3/4" project board**, about 7"x 9"

4 oz **20 AWG enameled magnet wire**

One **crystal earpiece**

One **82 k-ohm ¼-watt resistor**

Eight **½" #8 pan-head wood screws**

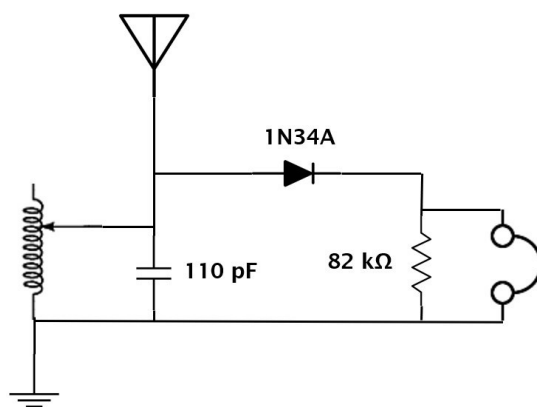
Three **#8 stainless washers**

Construction

Drill two 1/16" holes in the cardboard tube 5 inches apart. Insert about eight inches of the magnet wire into one of the holes, and begin winding the wire tightly around the tube, as evenly and as closely together as possible. To prevent kinking the wire, it might be easiest to place the spool of wire on some stable horizontal bar, then pull the wire straight off the spool onto the tube by rotating the tube with one hand while keeping the wire tight with the other.

When your windings reach the other hole, thread about eight inches of the wire through the hole and secure the wire. Re-inspect the coil, to make sure the windings are still tight and have no gaps between them. Lay a strip of glue across the windings on one side, and another on the opposite side. Drill two #8 holes six inches apart, next to one of the glue stripes.

Using two 3/4" wood screws, mount the coil to the board near the edge on one side, on **small standoffs**,



One **7" long 2" ID cardboard tube**

One **1N34A germanium diode**

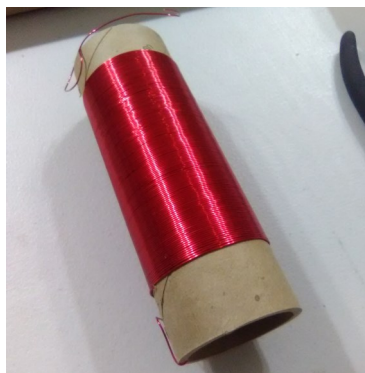
Six **Fahnestock clips**

Two **220 pF ceramic capacitors**

One **24" stainless steel bicycle spoke**

Sandpaper, tape, glue, **spaghetti bead**

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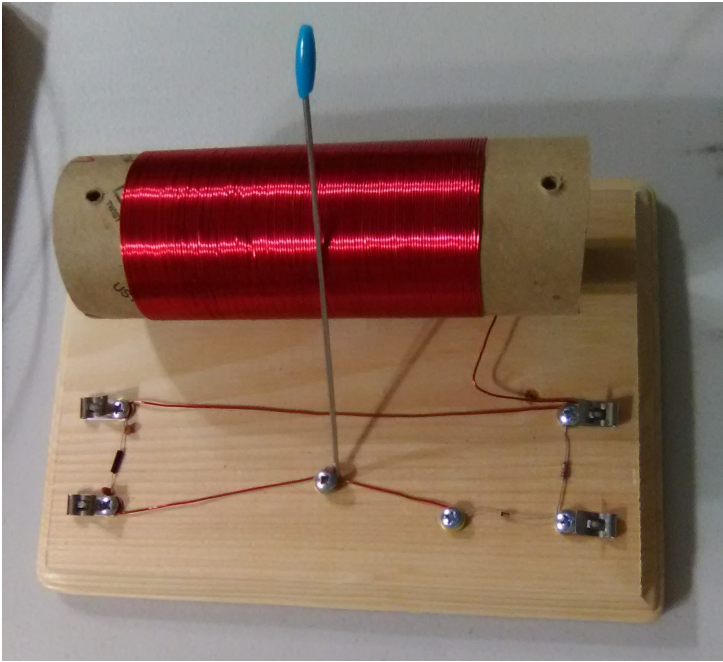
making sure no part of the coil sticks out over the edge of the board. Facing the board with the coil on the back (opposite from you) end, mount four Fahnestock clips, two near the left end of the board, and two near the right end. Install the 82 k-ohm resistor between the screws of the two right clips, then install the 110 pF capacitor between the screws of the two left clips. If you're using 220 pF capacitors, you'll need to connect a couple of them in series, as shown at the right, to make 110 pF.

Cut three pieces of the unused magnet wire, one 7", one 4", and one 2" long. Strip the ends of all three wires by scraping or sanding the enamel off, exposing the shiny copper surfaces. Cut the left coil wire to about three inches, and place it inside the tube, near the edge of the tube. Estimate the length of the right end of the coil wire, then cut and strip that as well. Attach the right coil wire to the back right clip screw. Attach the 7" wire to the two back clip screws. Attach the 4" wire to the front left clip screw and a 3/4" screw at the front center of the board. Attach the diode between the right front clip screw and another 1/2" screw about 1 1/2" to the left of that clip, with the cathode (black stripe) on the left end. It really doesn't matter which way the diode faces, but we'll follow the schematic.

Make sure the bicycle spoke is unpainted, clean, and shiny, then cut off any portion of both ends that aren't perfectly straight. Twist about 1/2" of one end into a hook shape, to wrap around a wood screw. Attach one bared end of the 2" wire to the front-center wood screw and the 1/2" diode screw, then momentarily remove the 3/4" wood screw. Slip the 3/4" wood screw through a washer, then through the bicycle spoke hook, then a second washer, then through the loop of the 2" wire. Drill out the spaghetti bead with a 2-mm bit, or 5/64" bit, since that's close to 2 mm, the size of a typical bike spoke. Attach the spaghetti bead to the exposed end of the bicycle spoke, which is now the tuning rod.

Make sure the rod can move freely across the coil, but with some resistance to ensure a good contact. On the coil, mark the path where the rod contacts the coil. Use sandpaper to scrape off the enamel insulation of the coil wire, exposing the shiny copper surface of the coil track. Clean all dust and enamel residue from the wiper and the coil. Your crystal radio is now ready for operation. For a finishing touch, I added some LRFs (little rubber feet) to the underside of the board.

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Almost there

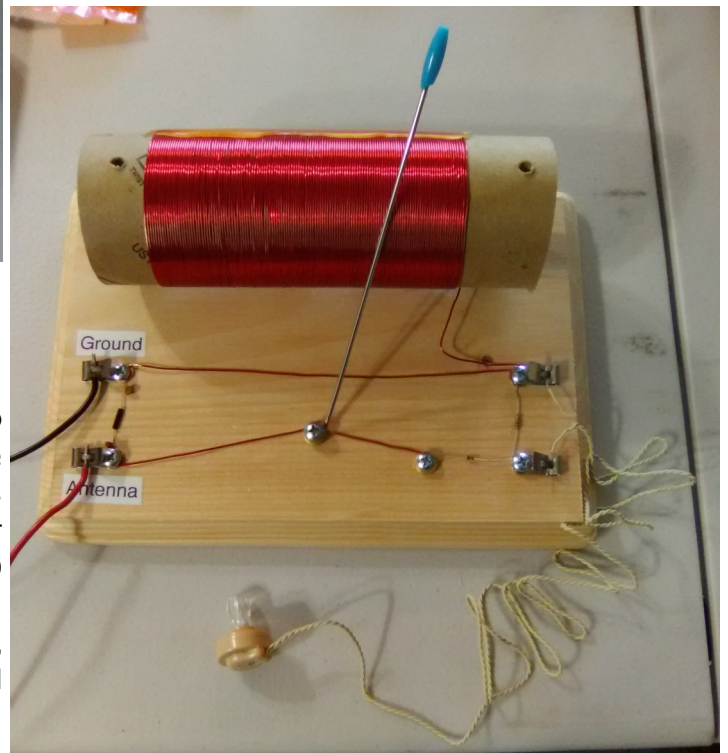
Let the magic begin

For your antenna, simply use a long wire (insulated, to prevent accidental contact with other metal) and drape it over your bushes, trees, vinyl fences, etc., as high as you can get it. I recommend 18 gauge stranded. Your antenna wire should be as long as you can make it (30 feet to 120 feet is good), but keep it away from metal objects such as chain-link fences, aluminum siding, and gutters. Bare one end, and bring it to your crystal set.

For the ground, again simply use an insulated 18-gauge stranded wire, and connect it to an outside ground rod, grounding system, or other reliable ground. Your house (third prong on the outlet) ground might be bonded to your electric service; I tend not to count on it, but it's better than nothing.

For a crystal radio, don't underestimate the power of a good ground. If you want the ideal ground, you should have multiple ground rods outside, bonded together and to your electric service by a buried 4-gauge bare copper wire. Your ground wire should then be attached to the nearest ground rod, which should be located right outside the room where your crystal radio sits.

Attach the bared ends of the earpiece to the two right clips. Attach your ground wire to the upper left clip and your antenna wire to the lower left clip. Slip the earpiece into your ear, tune into a nearby station with the tuning rod, and enjoy!



The finished product

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