The Ultimate Green Radio

. . . great "Beginners' Night" project!

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What do you get when you mix two empty aluminum cans, a couple of empty toilet paper tubes, and a germanium diode? The Ultimate Green Radio!

Although the accompanying photo may raise a few eyebrows, this is no joke. The unique crystal radio described in this article really works! It's a little tricky to tune, but it is super selective and loud. And it has, of course, all the attributes of a crystal radio: It receives standard AM broadcasts, has no active components, and requires no power whatsoever! All it requires is a good antenna and a pair of high impedance headphones (2000 Ω or better). You'll be hard pressed to find any other electronic device as environmentally friendly, so I've named it The Ultimate Green Radio.

Another appealing attribute of this unique crystal radio is that virtually all the parts can be salvaged from waste artifacts found in the average home. The crystal radio described in this article was built completely from salvaged parts and common household items except for the germanium diode (12¢) and two Fahnestock clips (11¢ each).

The unique aspect of the UGR is its homemade aluminum can variable capacitors. Normally, air dielectric variable capacitors, with their elaborate meshing plates and ball bearing shafts, are used. Such variable capacitors are both expensive and difficult to find. I developed the aluminum can variable capacitors to solve the availability and cost problems. They replace $30 worth of the traditional air variable capacitors, at the cost of the deposit value of two empty aluminum cans—and provide a great example of recycling ancient

Photo A. *Finished—and ready to start listening to the radio!*

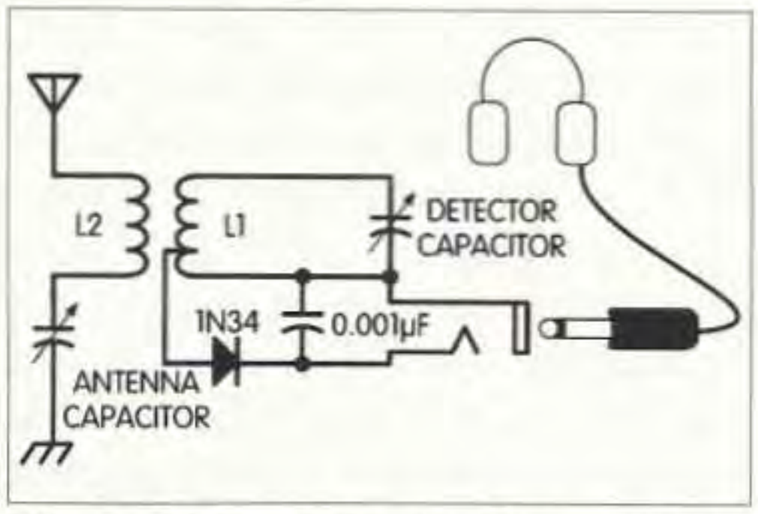

Fig. 1. Schematic for the Ultimate Green Radio.

technology: They're really a variable capacity version of the granddaddy of all capacitors, the Leyden jar (circa 1745).

The crystal radio is almost as old as radio itself. Although it may be basic ancient technology, the crystal radio has launched more engineering careers than any other single electronic project. I built my first crystal radio in 1942. It was my Aladdin's lamp—my first solo experience with science—and it launched my engineering career that spans over 40 years. Therefore, the UGR is an ideal project to share with a youngster—it's inexpensive, it involves no hazardous voltages, and it demonstrates many electronic principles (inductance, capacitance, resonance, detection, etc.). It also illustrates something very important to young minds: Complex modern technology is just the resourceful integration of basic concepts and components, incorporated into the simple crystal radio. And, of course, the UGR also demonstrates a direct approach to recycling.

About the circuit

The basic circuit (**Fig. 1**) used for the UGR was developed in the 1930s by Elmer G. Osterhoudt 6NW, a well-known ham operator and prolific inventor. The circuit incorporates an antenna tuner, inductive coupling between the antenna tuner and the detector tuned circuit, and a germanium diode tapped into the low (or cold) end of the detector coil to keep the headphones from swamping the tuned circuit. This design ensures optimum transfer of energy from the antenna system and produces very sharp selectivity.

Gathering materials

Bathroom wastebaskets generally contain one or more empty toilet paper tubes. The family recycling bin will likely produce a couple of empty aluminum beverage cans. A small piece of pine board can be salvaged from an old packing crate or from the trimmings pile at a local lumberyard. A couple of discarded overhead projector transparencies (view foils) can be plucked from your office wastebasket. Items such as magnet wire, germanium diode, 2000 Ω headphones, Fahnestock clips, solder lugs, etc., are probably lurking in your junk box (we hams are pioneers in recycling!). Whatever you're unable to scrounge, you can purchase at a local ham swap meet, Radio Shack™ or Antique Electronics™.

Winding the coils

Coil winding is a unique experience and can be quite frustrating if you do not have good vision and a steady hand. Allow yourself about 20 minutes to wind each coil. Once you begin winding, consider yourself committed to finishing the task. Find a time when you will not be interrupted. Begin by marking the toilet paper tubes (a/k/a coil forms) as depicted in **Fig. 2**. Make the mounting holes first, then make the small holes at either end to secure the wire by threading it through the holes at the beginning and end of the coil. When winding the wire around the tube, try not to overlap previous windings; keep them side by side and close together. Since the cardboard tubes are quite thin, be careful not to squash them while handling (however, keep the windings tight on the tube). Once wound, cellophane tape can be wound around the ends of the windings for a little extra security.

Dealing with the tap on the detector coil: The tap is formed by making a hairpin loop (about three-quarters of an inch tall), then twisting it together a couple of times. After the tap is formed, continue winding the rest of the coil. After the coil is completed, carefully scrape the enamel coating off the twisted tap, using a pocket knife or fine grit sandpaper. It is necessary to remove the enamel from the tap to expose the bare copper. This will allow you to solder a wire to the tap. Go easy with the scraping so that you do not cut through the wire—just remove the enamel coating. The enamel must also be removed from the ends of the coils so they can be soldered during assembly.

Producing the aluminum can variable capacitors

Select two undented, non-sticky aluminum cans. Inspect the transparencies: They must not be wrinkled or punctured. Cut the transparencies exactly five inches by 11 inches, and the aluminum foil tape exactly two inches by nine inches (use a paper cutter if you have access to one).

Carefully wrap the transparency tightly around the can, and be sure that any printing on the transparency faces

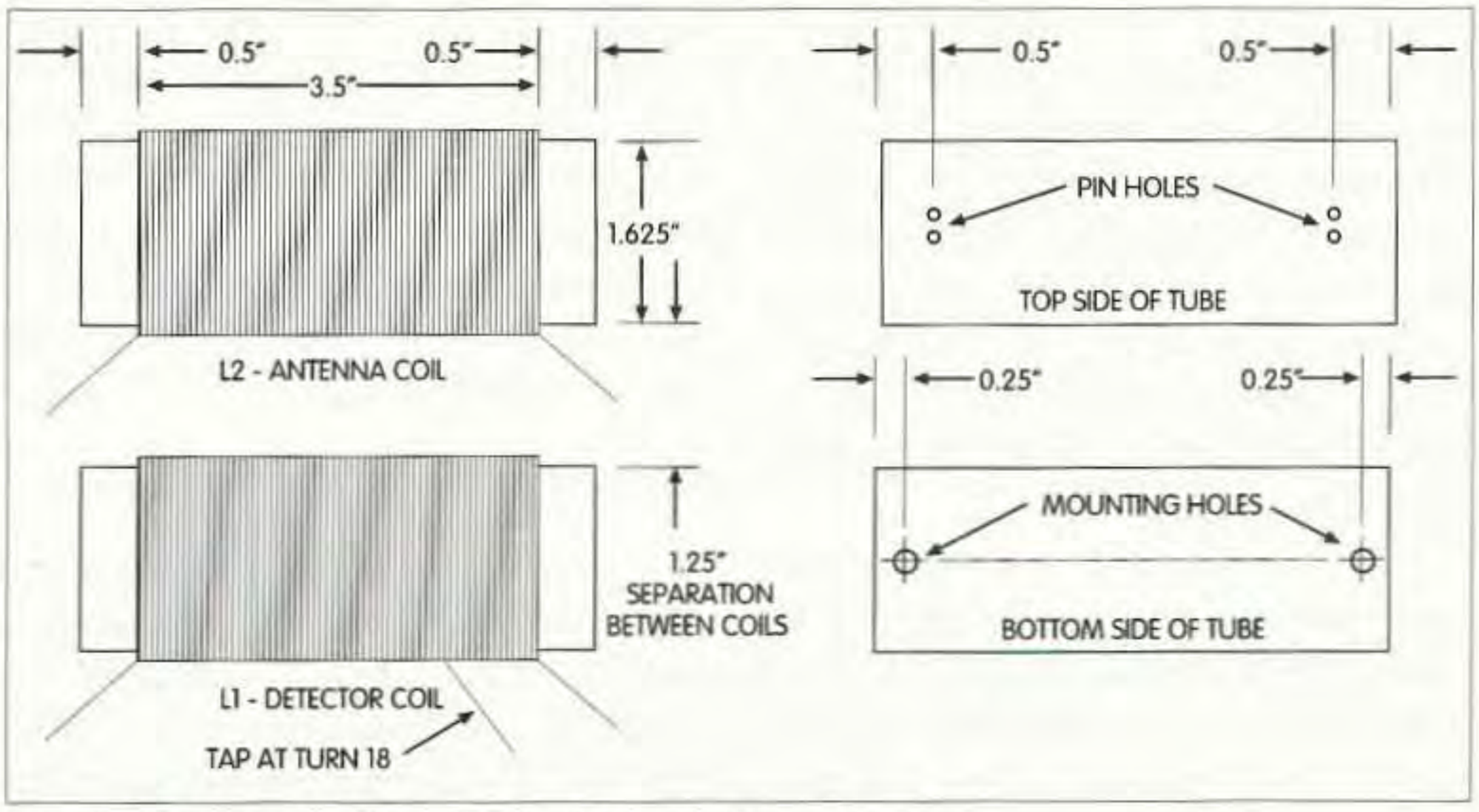

Fig. 2. Coil specifications for the Ultimate Green Radio.

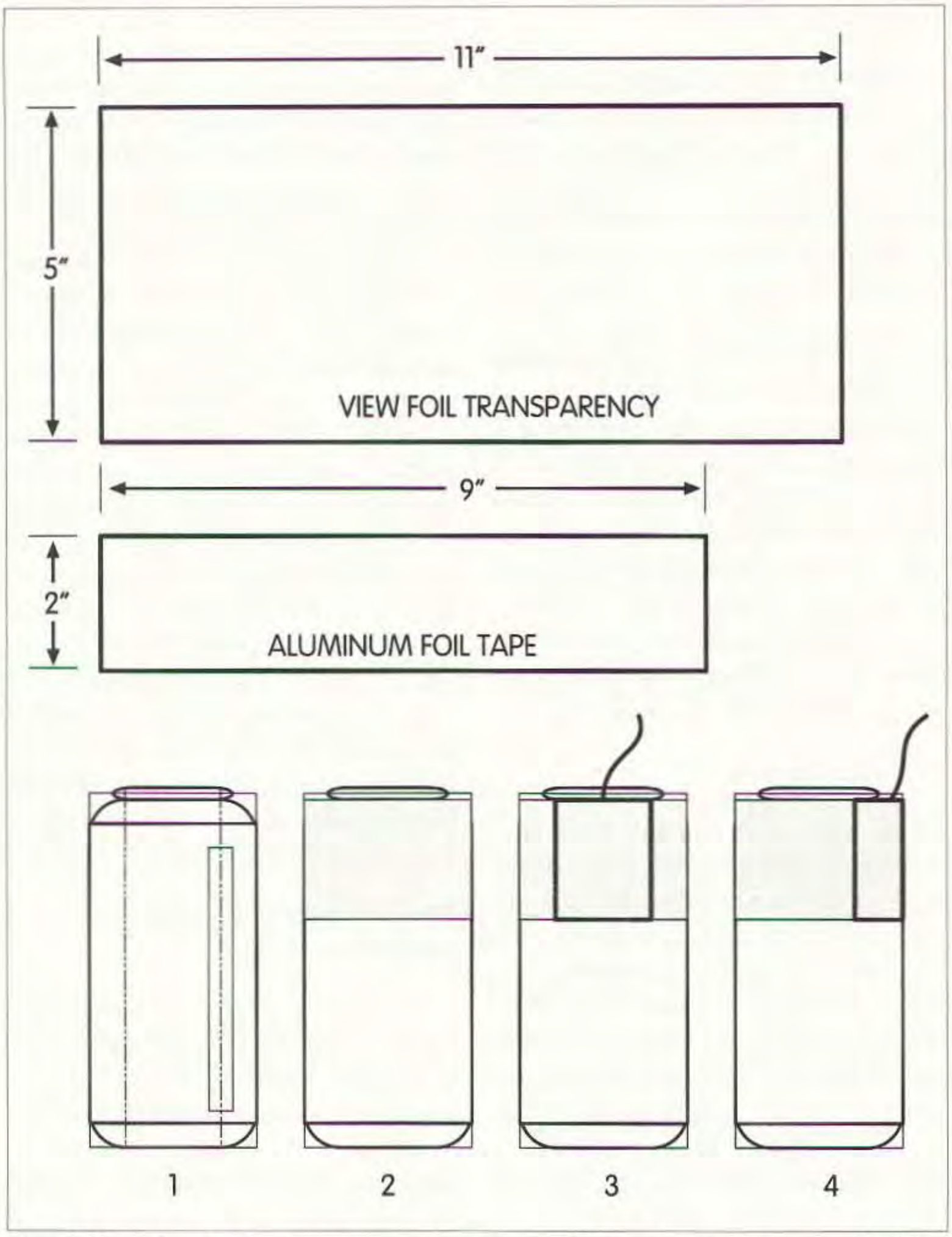

Fig. 3. *Wrapping the transparency, making the desoldering-braid contact, and holding everything down with the aluminum tape.*

outward. The transparency will overlap itself a couple of inches. Set the can upright on a flat surface, and while holding the transparency onto the can to keep it from unwinding, slide the wrapped transparency down until it touches the flat surface. Make sure that the bottom of the transparency is square and flush with the flat surface. Now, tape the wrapped transparency where it overlaps, using cellophane tape (**Fig. 3-1**).

I found it useful to apply the aluminum tape by temporarily placing the transparency sleeve onto a full unopened can (and you can return the unopened can to the refrigerator when you have finished). Before applying the aluminum tape, turn the can sideways, then slip the transparency sleeve down the can so the top three inches of the sleeve are below the shoulder of the can. Wrap the tape around the transparency sleeve so that the top of the aluminum tape is about one-quarter inch from the top of the transparency sleeve (**Fig. 3-2**). You are now ready to install the electrode for the aluminum tape.

Connecting to the aluminum foil

A piece of desoldering braid is used to make electrical contact with the aluminum foil. This contact will be completely frictional, so make sure that it is a good, tight physical contact. Prepare 12 inches of braid and attach it to the aluminum foil tape using another piece of aluminum tape (approximately three inches long) to hold it in place (**Figs. 3-3** and **3-4**). Now check to be sure that the completed transparency sleeve slides freely up and down on the can, but that it is tight enough so it will remain in position once it is set. Repeat the process for the second aluminum can variable capacitor.

Mounting the parts

The original UGR was built on a piece of lumber salvaged from an old packing case. It is nine inches wide, eight inches deep, and three-quarters of an inch thick. Any size board will work as long as it provides enough space for the aluminum can caps and two coils. The coils are mounted using 1-1/2 inch #6 x 32 bolts and nuts. All other parts are fastened using small screws, as shown in **Fig. 4**.

Parts List

Qty.	Description
L1, L2	115 turns each of #22 gauge enamel-covered magnet wire (RS# 278-1345)
2	empty aluminum beverage cans
2	overhead projector view foils (new or used)
22"	2"-wide aluminum foil tape
10"	3/4"-wide transparent cellophane tape
38"	desoldering braid (RS# 64-2090)
1	.001 µF fixed capacitor (RS# 272-126)
1	1/4" phone jack (RS# 274-252)
1	1N34 germanium diode (RS# 276-1123)
Pine board, 9" x 8" x 3/4" (approximately)	
Miscellaneous hardware; nuts, bolts, screws & solder lugs	

Table 1. *Parts list. For L1, a tap is placed at turn 18 of 115 turns of wire. The windings occupy 3-1/2 inches. For L2, 115 turns of wire are closely spaced and occupy 3-1/2 inches. A total of approximately 105 feet of wire is needed for the coils.*

Attaching the aluminum can variable capacitors to the board requires a little ingenuity. The aluminum cans are mounted by carefully punching a hole in the bottom of the can, then feeding a screw through the opening in the top of the can and into the hole. Before tightening the screw completely, place a seven-inch piece of desoldering braid beneath the can to make electrical contact with the bottom of the can (the braid should extend beyond both edges). The screw is then tightened into the wood to mount the can and to make good electrical connection between the bottom of the can and the desoldering braid (see **Fig. 4**).

Soldering

Solder lugs are cheap and readily available, and I recommend that you use them. When soldering the germanium diode (1N34), be careful not to get the diode any hotter than necessary. If possible, have someone grasp the lead of the diode (between the solder joint and the diode body) with a pair of long-nose pliers while the part is being soldered. This will draw the heat away from the diode and into the pliers. If you don't have anyone to assist you, wrap a rubber band around the handles of a pair of long-nose pliers (to keep the jaws closed), and then connect the pliers between the solder joint and the body of the diode. When soldering, be very careful that the soldering iron does not touch the transparency sleeves. It doesn't take very much heat to ruin them.

About headphones

There is really no substitute for a good pair of high impedance headphones (2000 Ω or greater). A good pair of headphones will last a lifetime. Ham flea markets are a good place to buy used headphones (but be sure they are at least 2000 Ω). New phones are available at Antique Electronics; call (800)-706-6789.

About antennas

The better the antenna, the better the crystal radio will work. This crystal radio functions entirely upon the very small voltages induced into the antenna by the signals transmitted by the radio stations. Make the antenna as high and long as you can. An antenna 100 or more feet long is recommended. You can hang the wire from trees, between houses, or from almost any available support. If you intend to use an amateur dipole with the UGR, keep in mind the following: If the antenna contains a balun, it will have to be bypassed. If it is fed directly with coax, tie the braid and center conductor together. For good reception, at least a 40-meter dipole fed with open line will be required. Remember, a half-wave antenna for the BC band is about 500 feet long!

For best performance a crystal radio should have a good earth ground. This can be accomplished by connecting the ground connection of the UGR to a pipe driven three or more feet into the ground, or to a nearby cold water pipe (assuming you have metal plumbing!).

Operating the Ultimate Green Radio

The UGR is a little tricky to tune. This is because:

- Both the antenna and detector tuned circuits must be tuned to the same frequency;
- The tuning process itself is skill-intensive (not unlike playing the trombone);
- Both the antenna and detector circuits tune very sharply. It just takes a little practice. Keep in mind that the aluminum can variable capacitors track very closely. For example, if a station is located near the high-frequency end of the band, both of the transparency sleeves will extend well above the top of the cans, and about the same amount. As stations lower in frequency are tuned, the sleeves will be proportionally lowered onto the can. The aluminum can variable capacitors are adjusted by grasping the transparency sleeves below the aluminum foil, and carefully and slowly moving them up or down.
- To help manage the friction between the can and the sleeve (thereby enhancing fine adjustment) slowly rotate the sleeves back and forth about an inch while moving them up and down.

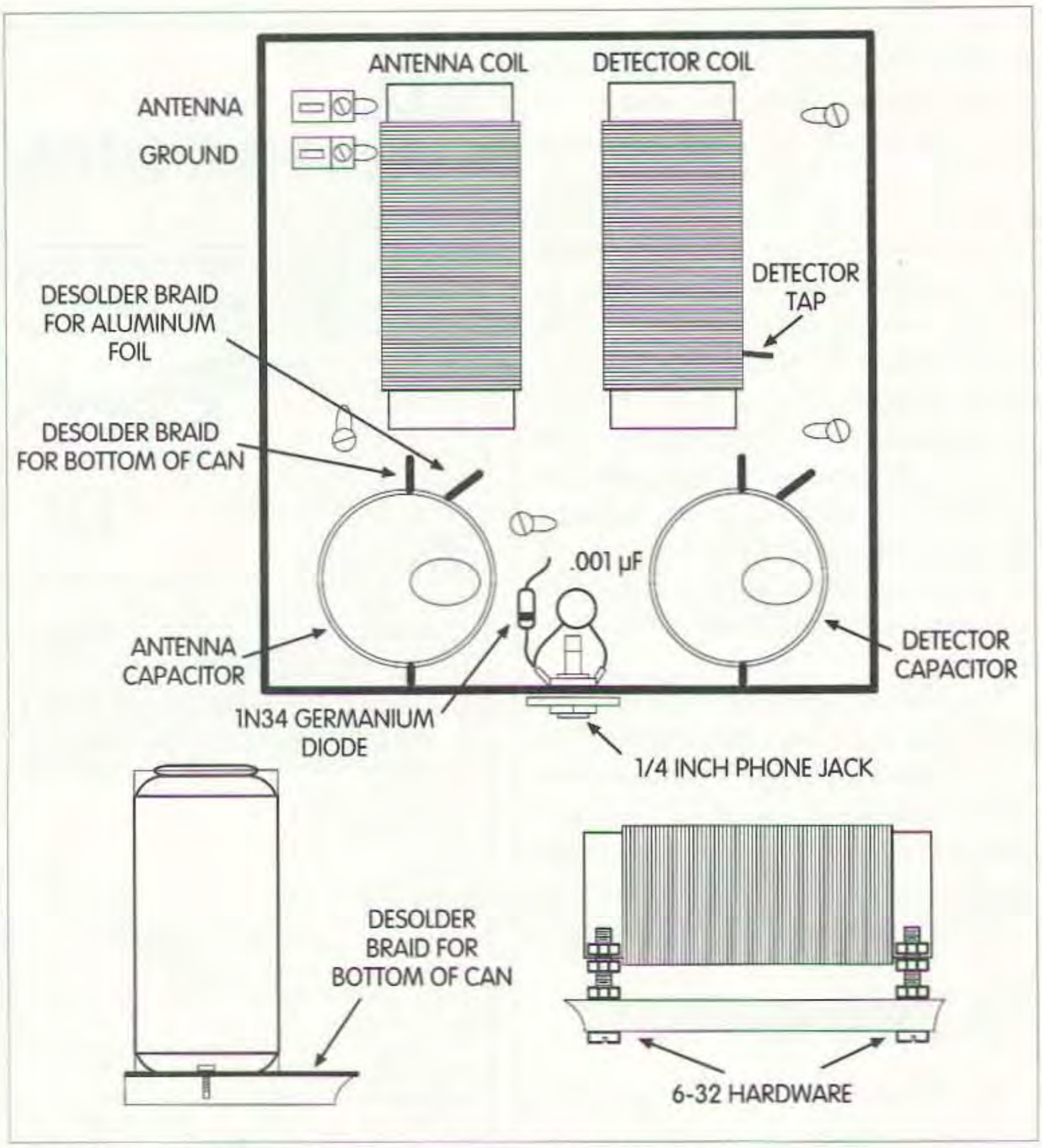

Fig. 4. *Parts identification, mounting, and wiring information.*

Unlike most radios, the UGR does not have dials for logging stations. However, you will be able to produce a log by using the printing on the can to index the position of the bottom of the foil. The Nutritional Facts label on the side of the can works well for this purpose.

Okay, let's try it. Attach the antenna and ground to the UGR. Connect the headphones and put them on. Place both transparency sleeves so that the bottoms of the aluminum tape are even with the shoulders of the cans. Now, carefully—and very slowly—move both of the transparency sleeves downward at the same time and at the same rate. In this way they will be roughly tuning to the same frequency as they move down the can. Once you hear a station, leave the antenna capacitor sleeve where it is and carefully tune the detector sleeve for the maximum volume. Once you have done this, carefully tune the antenna sleeve for maximum volume. You may have to jockey back and forth between the two capacitors until you get it just right. After you get a station tuned in, check the position of the bottom of the aluminum tape on the detector capacitor and log its position relative to the printing on Nutritional Facts label. Continue this process as you move the sleeves down the can. Once you have gained the tuning skills, it's a lot of fun to tune.

The Ultimate Green Radio, although a low-tech, low-budget project, illustrates a number of important concepts—especially from an environmental perspective. With our landfills overflowing, the ozone layer perforated, and our air and water polluted, the message is clear: We must learn to be less wasteful and careless, and try to find innovative ways to clean up our planet and keep it that way. The Ultimate Green Radio, with its straightforward display and utilization of waste artifacts, is an ideal instructional aid to stimulate creative recycling solutions—and might cause us to take another look at items we classify as "trash."

Another important message is that older technology is, in many cases, superior to modern technology in terms of simplicity, efficiency, and environmental impact. The simple crystal radio described in this article is constructed almost entirely of household waste, yet it is a fully functioning radio with wonderful fidelity and selectivity, and it operates at an efficiency unmatched by modern technology. And best of all, anyone can build one—even an eight-year-old (with a little loving guidance from grandpa). 73

Typical Antenna Installation

Try to get your antenna as high and long as possible, but keep it away from power lines. Nylon ties make excellent insulators; they are strong, light and inexpensive. You can use a the bungee cord to keep the antenna taut and prevent it from breaking during windy periods. While most wire sold as antenna wire is bare copper, #18 gauge stranded copper insulated wire is easier to work with and will last for years. The color of the insulation can be selected to make the wire nearly invisible.

An earth ground can be made by driving a metal rod or pipe at least three to four feet into the ground. The best way to accomplish this is to purchase a ground rod of the type used by electricians for grounding the electrical service, which are available at most well-stocked hardware stores. If your home is plumbed with metal pipe, a cold water pipe also can be used. The best way to make connection to the ground rod or cold water pipe is to use a ground clamp. They are readily available at hardware stores, too.