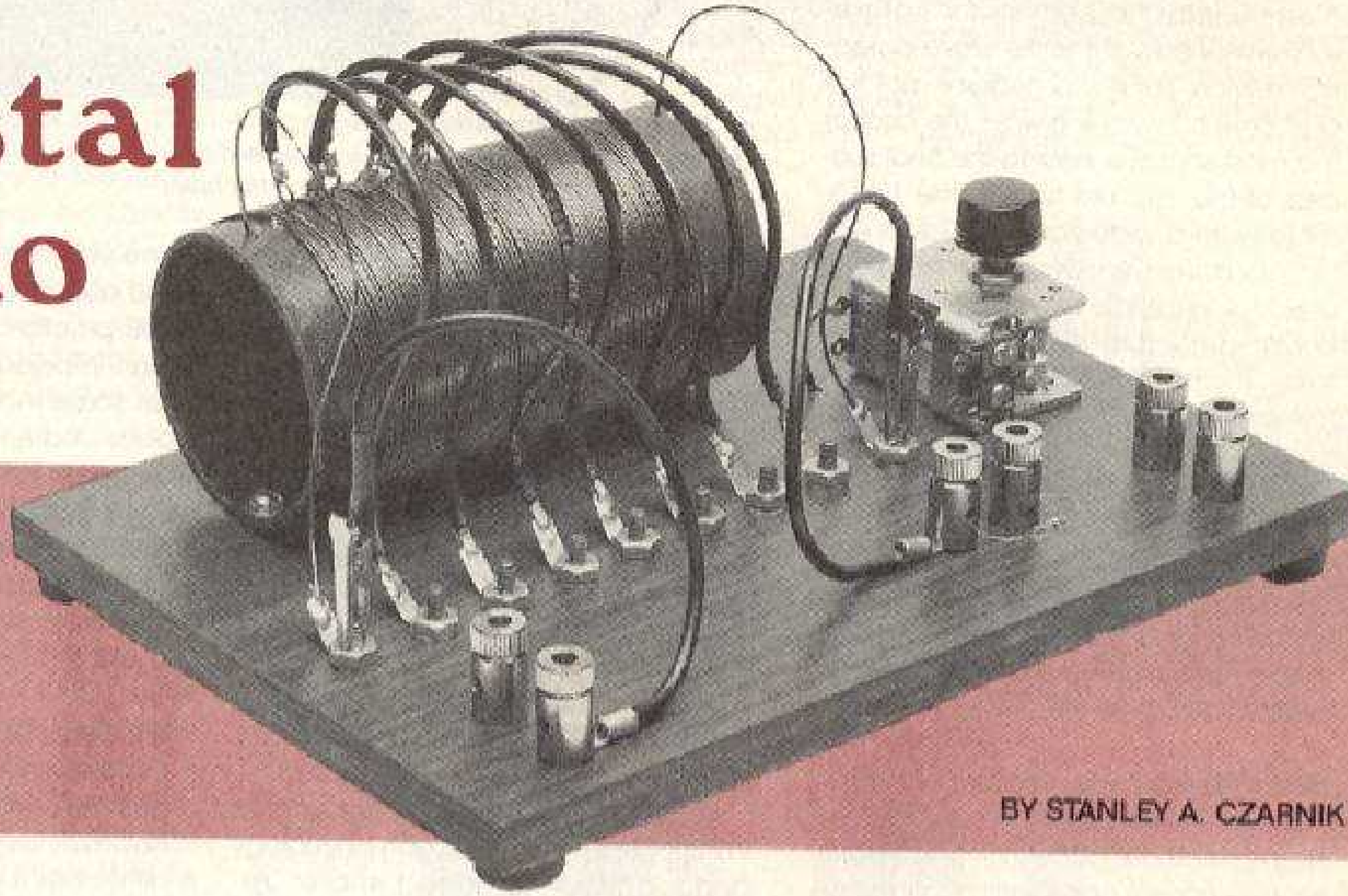
Tapped Coil Crystal Radio



BY STANLEY A. CZARNIK

There's many a way to tune a crystal receiver. This golden oldie does it with a tapped coil and variable capacitor.

Tracing the origin of crystal radio-wave detectors (that's what they called 'em in Grandpa's day) can be a little tricky. One reason is that it took some time for experimenters to appreciate the nature of crystal detection and crystal rectification.

The first relevant discovery was made in 1874 by the German physicist, Karl Ferdinand Braun. Braun noticed that certain metal sulfides conducted electricity in an unsymmetric fashion. The current, in other words, would pass very easily in one direction, but with great difficulty, or resistance, in the other direction. The effect, of course, is rectification, but Braun did not realize that until 1883. Finally, in 1901, Braun harnessed his crystal rectifier to the purpose of radio-wave detection.

Crystal Detectors. In the United States, it was H. H. Dunwoody who discovered the crystal radio-wave detector in the year 1906. The crystal was a piece of carborundum, otherwise known as silicon carbide. Silicon carbide is also the first solid substance known to be electroluminescent. Just imagine: strange illuminations from a crystal set! The phenomenon came to be called *Detektorleuchten*, literally, *detector lights*.

Crystal detection and rectification got a lot of attention. It was very quickly noticed that several natural substances could detect radio waves when in contact with a tiny metal point or small piece of fine wire. Among the substances tried were: galena (lead sulfide), iron pyrites (iron sulfide), molybdenite (molybdenum sulfide), zincite (zinc oxide), cerusite (lead carbonate), and silicon. The wire contact was most often made of gold, silver, copper, or bronze. There were many types of crystal-detectors, but each of them provided a means of holding the mineral specimen and a way of controlling the position and pressure of the wire contact, often called the *cat's whisker*.

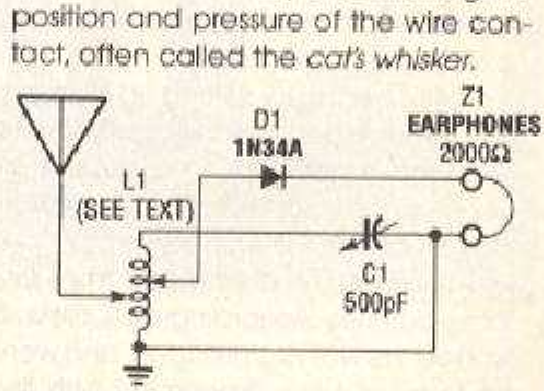


Fig. 1. What makes this crystal radio special is the tapped RF coil. Apart from that, the circuit is similar to many other simple crystal receivers. Exactly where and how the various parts and components are mounted is up to you, but follow the layout shown in the photos if this is your first radio project.

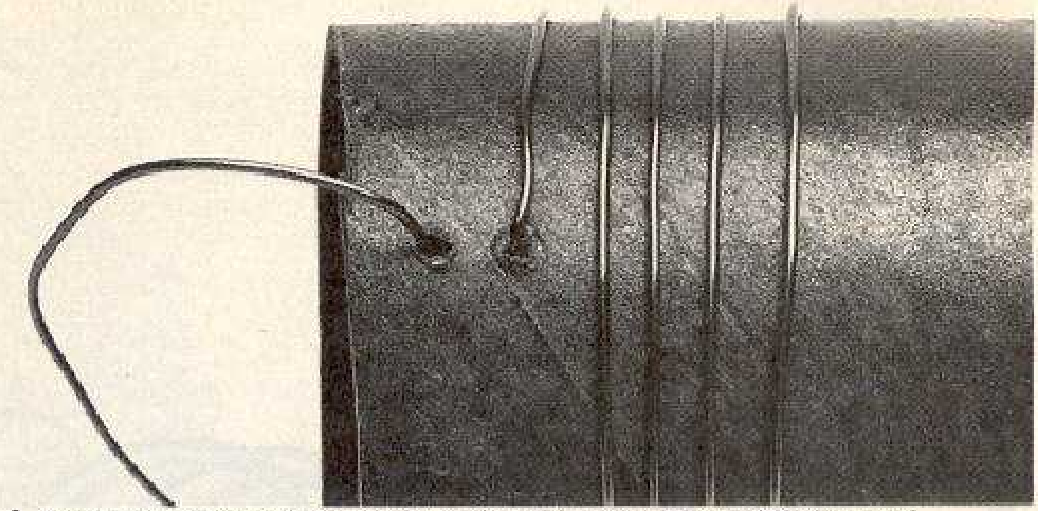
In some detectors, the cat's whisker was replaced with a second mineral different from the first. The two-crystal system was marketed under trade names like Periken Detector, the Pyron, and the Bronc Cell. The two-crystal detector, never very common, was actually more reliable than the conventional single crystal and cat's whisker arrangement.

Alternatives. The crystal detector was a very simple and, perhaps for that reason, a very popular radio-wave detection device. But it was certainly not the only one, nor was it always the best or the most sensitive. Prior to the final success of the vacuum tube in the 1920's, there were a wide variety of other detectors based on every conceivable physical principle. There were electrolytic detectors, electrostatic detectors, magnetic detectors, thermal detectors, primitive spark-gap detectors, and of course the famous *coherer*, which was often little more than a glass tube supplied with two electrodes and some iron filings.

There is also at least one recorded instance of a radio-wave detector made from, believe it or not, a disembodied human brain.

Brain Waves. In September of 1901, A. Fredrick Collins performed a series of experiments designed to "verify, if possible, the casual observation long since made that approaching electrical storms manifested their presence in persons afflicted with certain forms of nervousness and other pathological conditions, though the storm influencing them might be many miles beyond." Collins reasoned that, somehow, the brain picks up the electrical disturbances in the air just as a radio-wave detector reveals the presence of sparks from a spark coil.

Collins began by setting up a simple spark transmitter and an equally simple receiver connected to a couple of needles for insertion into his experimental brains. He started with an unidentified mammalian brain from the local butcher. According to Collins, it worked. He was encouraged, and went on to repeat the experiment with the living brain of an anesthetized cat. According to Collins, that worked too.



1 *Begin coil L1 by pushing a length of 20- or 22-gauge magnet wire down and then up through two small holes punched near the end of the cardboard coil form. Follow that with 4 turns of wire around the tube.*

Finally, and inevitably, Collins decided to try a human brain. "It is a most difficult object to obtain," he says. But he did find one, nice and fresh, a "magnificent specimen." He placed the brain on a slab of glass, inserted the needles, and completed the wiring using his battery-operated telephone receiver. Collins claims that the brain radio enabled him to listen to a bolt of lightening striking a house a quarter mile away.

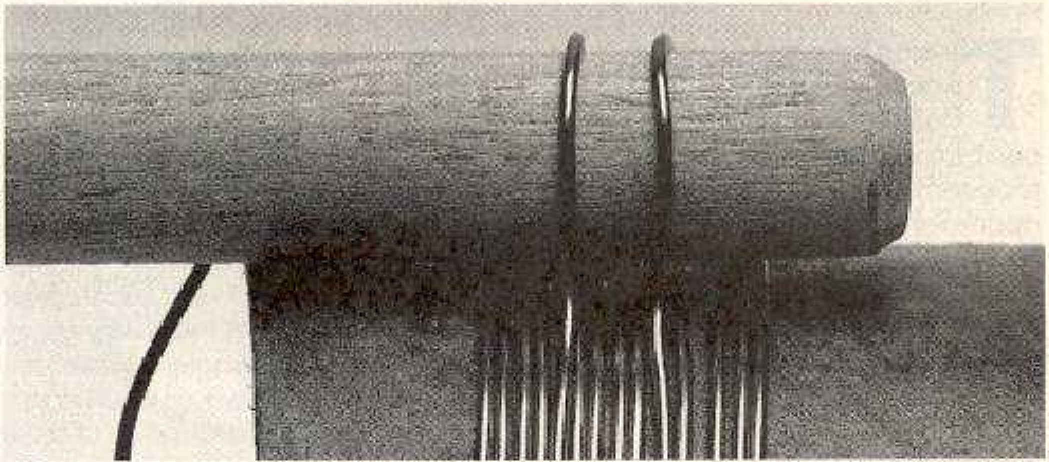
Without a doubt, Collins' circuit ranks as one of the most ghastly and bizarre electrical devices ever constructed.*

(Incidentally, Collins was not unique in his interest in both human physiology and electronics. Indeed, many "researchers" of his day explored the ways that electricity could be used to ease human suffering. Many were well meaning and sincere; others had less altruistic motives. For more on that topic, see the article entitled "Electronic Quackery" elsewhere in this issue.)

The Project. You do, in fact, require a human brain to build a radio, but the one you already have will do just fine! You also need a germanium diode, a 500-picofarad variable capacitor, a high-impedance earphone or headset, some magnet wire, and a few other odds and ends. The *Tapped-Coil Crystal Radio* described in this article features a tapped, radio-frequency coil and a fairly sensitive tuning system. Your radio will certainly operate without an internal power supply of any kind (see Photo 1).

Winding the Coil. What makes this radio special is the tapped coil (L1). It is also the most difficult part to make. However, building one is not nearly as difficult as it looks. There is an easy way to wind the coil. What's necessary is a medium-size nail, some adhesive tape, and a wooden dowel rod between ½ and ⅝ inch in diameter, six or more inches long.

Step 1. Obtain a spool of 20- or 22-gauge, copper magnet wire and a cardboard or thin plastic tube about 2 inches in diameter and about 6-inches long. Punch or drill a small hole about ¾



2 *Wind every 5th turn of wire around a wooden dowel rod about ½ or ⅝ of an inch in diameter. Do that for the first 35 turns of wire. Pinch the wire in towards the bottom of the dowel rod with your fingers as you go along.*

*If anybody knows or is able to discover more about A. F. Collins and his brain radio, I would very much like to hear from you. You can write to me in care of **Popular Electronics**—*Stanley A. Czarnik* inch from one end of the tube. Punch another small hole right next to the first one and about ¼-inch closer to the middle of the tube. Make the holes just large enough to accommodate the magnet wire.

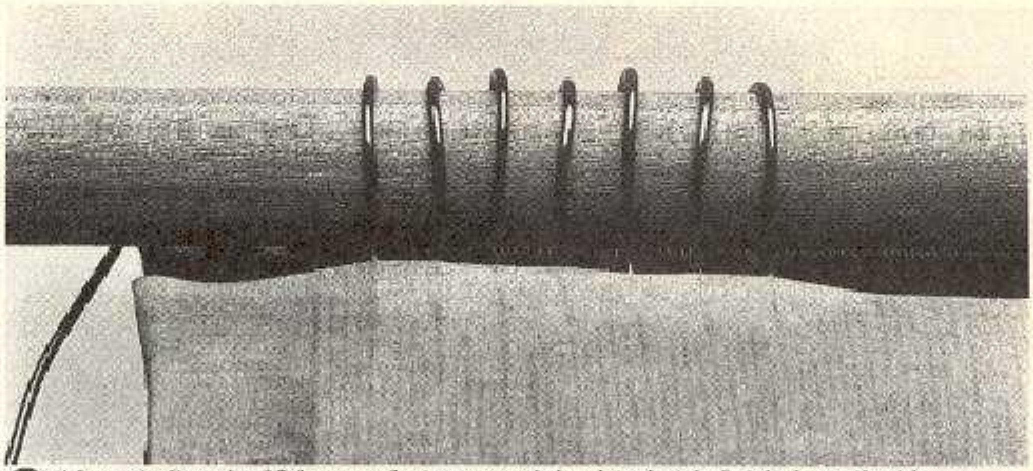
Unroll 8 or 10 inches of magnet wire and push the entire length down through the second hole towards the inside of the tube. Now, push the wire up through the first hole towards the outside of the tube. Pull the wire gently until only a ¼-inch length of wire lies between the two holes on the inside of the tube. The purpose here is to secure the wire at the end of the tube. That prevents the coil from unraveling. Wind exactly 4 turns of wire around the tube.

Step 2. Place the dowel rod directly over the holes and the 4 turns of wire (see Photo 2). Loop the wire around the dowel as shown in Photo 2. Gently pinch the loop in toward the bottom of the rod with your fingers. That loop of wire is destined to become a coil tap. Repeat the operation 6 more times, concentrating the windings together and counting the turns as you go.

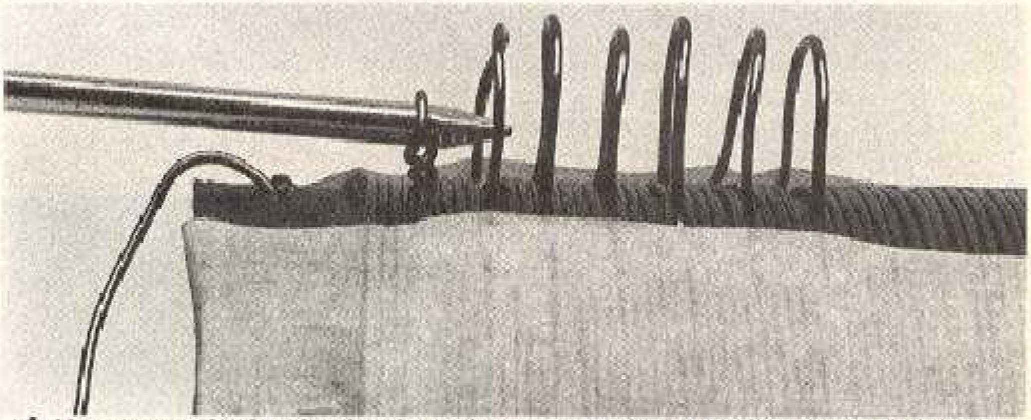
Step 3. When you're finished you should have a total of 7 loops of wire over the dowel rod. Every loop over the rod will be separated by 4 turns of wire under the rod. In other words, every 5th turn for the first 35 turns will have a coil tap (see Photo 3). After placing the 7th and final loop over the rod, complete the RF coil by winding another 45 turns of wire around the tube. That makes a grand total of 80 turns of wire.

Now, before doing anything else, secure the wire next to both sides of the dowel rod with 2 long strips of adhesive tape. You will want to have the tape handy before you finish winding the coil. Taping the wire down is very important.

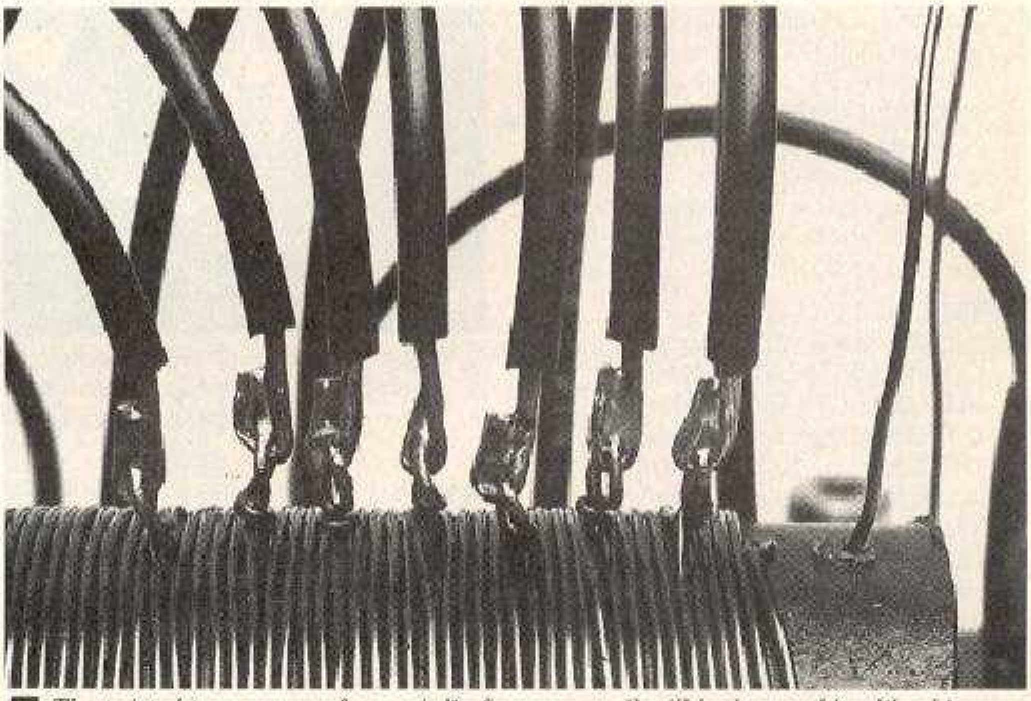
Complete *Step 3* exactly like you began *Step 1*, but at the opposite end of the tube. That means making 2 more holes, the first ¼-inch away from the end of the tube, the second ¼-inch away from the first. Run the wire down through the second hole and up through the first. Measure off an 8- or 10-inch lead and cut the wire at that point. There, you are now a true master coil winder!



3 *After winding the 35th turn of wire around the dowel rod, finish the coil with another 45 turns of wire. That makes a grand total of 80 turns. Tape the wire in place with two long pieces of adhesive tape. Each of the 7 loops of wire around the dowel rod is destined to become a twisted coil tap.*



4 *Now remove the dowel rod and, one by one, twist the loops of wire around once or twice with a nail about ⅛ of an inch in diameter. Do not put too much strain on the magnet wire. A little manual dexterity at this point really helps.*

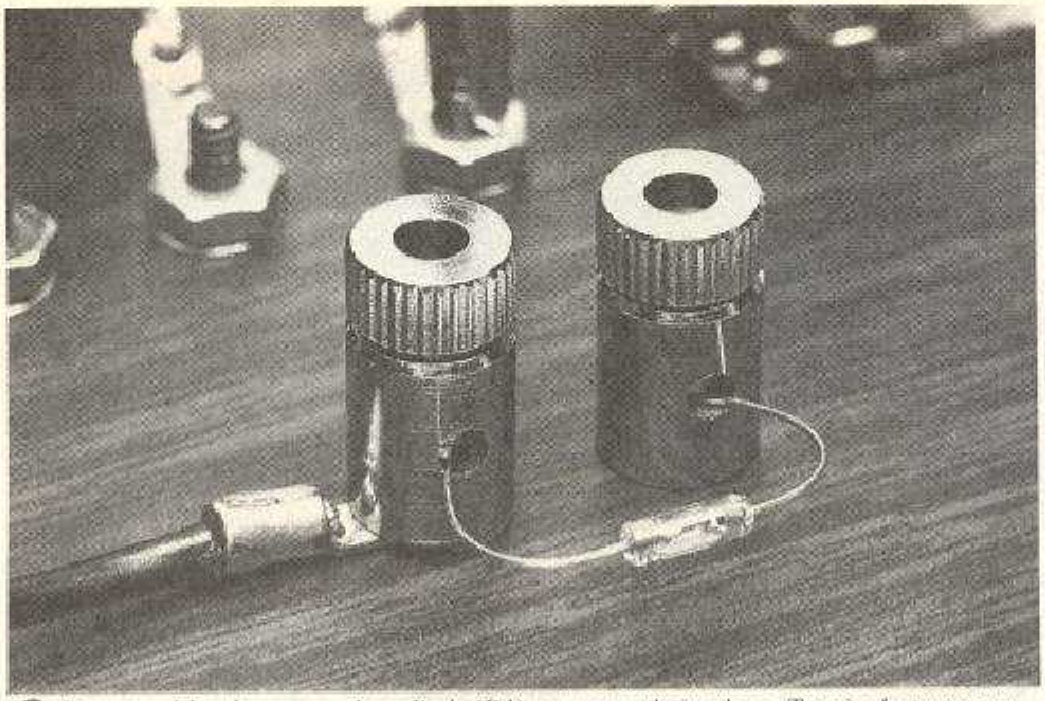


5 *The twisted taps on top of your radio-frequency coil will look something like this when you're all done assembling your coil.*

Step 4. You're ready to twist your taps. Gently remove the dowel rod from under the wire loops. The loops should remain in their place; that is the purpose of the tape. Obtain a nail 2 or 3 inches long and about ⅛ inch in diameter. Place the nail in the first loop and twist the wire around once or twice, or just enough to hold it (see Photo 4). Do not put too much strain on the magnet wire. Remove the nail and repeat the procedure with the other 6 loops.

When you're done, remove the adhesive tape. If you have twisted the taps properly, the magnet wire will not move and the coil will not unravel.

Step 5. Your RF coil is complete, but you still need to wire it up. First get rid of the insulation on each of the twisted taps. One way of doing that is with the sharp edge of an X-acto blade.



6 *Do not solder the germanium diode (D1) permanently in place. Terminal connectors make it possible to experiment with various other diodes and even other detection devices should you ever wish to do so.*

PARTS LIST FOR THE TAPPED COIL CRYSTAL RADIO

C1—500-pF, variable-tuning capacitor
D1—1N34A germanium diode, or equivalent
L1—Hand-wound coil (see text)
Z1—High-impedance headphones, 2000 ohms or more
20 or 22 gauge magnet wire, cardboard or thin plastic tube (about six inches long and two inches in diameter), alligator clips (2), binding posts or Fahnestock clips (6), wooden baseboard (about 6" wide × 8" long × ⅜" thick), wire for antenna and ground connections (about 50 feet), soldering lugs, rubber feet, assorted hardware screws and washers, hook-up wire, solder, etc.

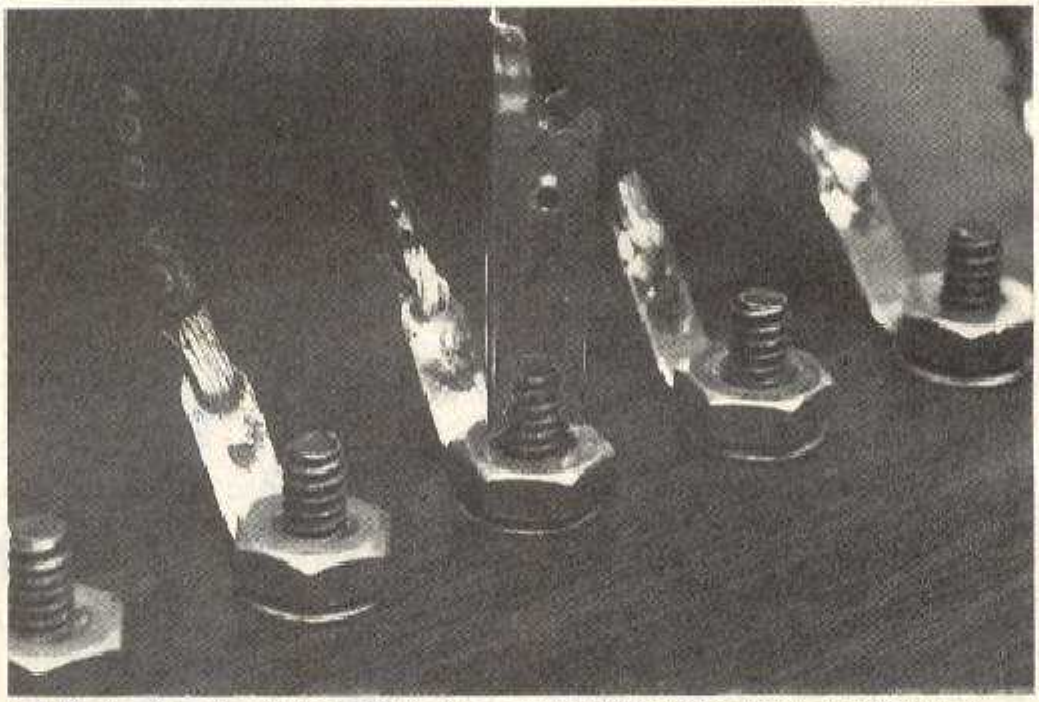
The Tapped Coil Crystal Radio is available as a kit from Yeary Communications, 12922 Harbor Boulevard, Suite 800, Garden Grove, CA 92640. The catalog number is DCTR-1-K and the price is $10.00. Add 12% for shipping (minimum $2.00) and $1.75 for insurance. California residents add 6% sales tax. Also available from Yeary are *All About Crystal Sets* by Charles Green ($7.95) and *Radios That Work For Free* by K. E. Edwards ($7.95).

Finally, cut 7 lengths of hook-up wire each about 7- or 8-inches long. Strip ¼ or ⅜ inch of insulation off one end of each piece of wire, and then, one by one, solder the wires to the coil taps (see Photo 5). You now have finished preparing the most difficult part of the Tapped Coil Crystal-Diode Radio.

lugs and 9 machine screws, one for each coil wire, inserted from the bottom of the baseboard.

You also need a spot for the variable capacitor and places to attach the antenna, the ground, the earphone, and the germanium diode. It is a good idea not to solder the diode permanently to the rest of the circuit (see Photo 6). That makes it possible to experiment with various other diodes and even other detection devices should you ever wish to do so. I chose to use temporary connectors for the antenna, ground, and earphone as well.

Wiring. The radio circuit is not complicated and is similar to other simple crystal receivers (see Fig. 1). I recommend putting as many of the connections as possible on the underside of the baseboard. That contributes much to the finished appearance of the project.



7 *Each coil-tap lead wire is attached to a small soldering lug and a screw inserted from the bottom of the baseboard. Alligator clips provide a means of connection to the coil-tap terminals, and the screws provide a convenient, gripable surface.*

Layout. The rest of the construction is actually very easy, but it does call for some attention to functional design. You need to think about how the radio will look when you're done with it. Exactly where and how the various parts and components are to be mounted is up to you.

The purpose of the taps on the radio-frequency coil is to provide access to a number of different inductor values. That means each tap lead, as well as the beginning and end of the coil itself, must terminate in some sort of connector. You can use Fahnestock clips or a terminal strip. I used some soldering

Drill all holes first, and that includes 4 holes for the rubber feet necessary to prevent the hardware at the bottom of the board from scratching up the furniture. Now mount the variable capacitor, coil-tap terminals, and binding posts. The radio-frequency coil, which is fairly delicate, should be mounted and wired last after all other connections on the bottom of the baseboard have been completed.

Attach two wires to the rotor (moving plates) of the variable capacitor, C1. Connect one of those wires to one of the earphone terminals and the other

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TAPPED COIL RADIO

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to the first coil-tap terminal. If you have designed a radio similar to the one in the photograph, that will be the terminal on the far left. Attach another wire to the stator (stationary plates) of C1 and connect it to the last (the ninth) coil-tap terminal; that should be the terminal on the far right.

Now run a wire from the other earphone terminal to the cathode of the germanium diode, D1. Run another short piece of wire from the first coil-tap terminal to the ground terminal.

Locate your RF coil and attach it to the baseboard with 2 screws pushed through 2 small holes made on the underside of the cardboard tube. Be very careful not to damage the windings on the coil when you make those holes. The twisted taps should be situated on the top side of the tube.

Now, one by one, solder each coil-tap lead wire to the appropriate coil-tap terminal on the baseboard. Make certain that the sequence of coil-tap terminal connections corresponds to the sequence of twisted taps on top of the coil. The length of the lead wires should be trimmed as you go along.

Complete the radio by attaching one end of a 6-inch piece of hook-up wire to the antenna terminal and the other end to a small alligator clip. Now attach one end of another 6-inch piece of hook-up wire to the anode of D1 and another small alligator clip to the other end. The clips provide a secure means of connection to the coil-tap terminals, and the screws provide a nice place to put the clips (see Photo 7).

Operation. There is no space left here for a detailed discussion of antenna systems and ground sources. And anyway, you're probably anxious to try out your new crystal radio. So, go to it!

Attach a wire to the ground terminal of the radio and connect it to a water pipe or a metal water faucet—the one over the kitchen sink, for example. Obtain a long piece of wire and attach it to the antenna terminal. Hang the antenna wire over a nearby door. If you live in or near a big city, such an indoor antenna will work quite well, although a simple outdoor antenna will work even better.

Now, hook up the earphone, and place the alligator clip connected to D1 on coil-tap terminal number 9. Place the other clip (the one connected to the antenna wire) on coil-tap terminal number 1 or 2. Adjust C1 a bit and you should hear a good, clear signal. Move the antenna clip over to the other coil-tap terminals. Then try moving the other clip. Every time you move the alligator clips, you are changing the inductance of the coil. Now go back and adjust C1. The number of inductor-capacitor combinations is very large, and the clarity and variety of the signals you receive may surprise you.

Discovering More. For more information on projects and experiments with crystal radios, see *All About Crystal Sets*, by Charles Green (Allabout Books, Fremont, CA) and *Radios That Work For Free*, by K. E. Edwards (Hope and Allen, Grants Pass, OR), both available from Yeary Communications (see Parts List). For more on the history of crystal sets and other early radio receivers, see *The Cat's Whisker*, by Jonathan Hill (Oresko Books, London) and *Early Radio Wave Detectors*, by V. J. Phillips (Peter Peregrinus, London). For more on the Collins experiment, see "The Effect Of Electric Waves On The Human Brain," by A. F. Collins, published in *Electrical World And Engineer*, Volume 39, Number 8, February 22, 1902, pp. 335-338. ■