BUILD AN OCEAN-SPANNING CRYSTAL RECEIVER

DX reception with a totally passive circuit

BY HOWARD D. LASH

ALTHOUGH most people think of the crystal set as a simple radio suitable only for short-range reception, a properly designed crystal set can receive signals from thousands of miles away. The Ocean-Spanning Crystal Receiver covers the 49-, 41-, and 31-meter international broadcast bands and can be modified for other frequencies. It employs no means of signal amplification. The author's prototype, in use near Chicago with a 150-foot longwire antenna and an earth ground, regularly provides good reception of Radio South Africa, the BBC, Deutsche Welle, and other shortwave broadcasters. Although the project doesn't generate an ear-splitting audio output and lacks the microvolt-level sensitivity and sharp selectivity of today's communications receivers, it will perform well with a good antenna and earphones.

About the Circuit. The Ocean-Spanning Crystal Receiver is shown schematically in Fig. 1. Signals picked up by the external antenna are applied to binding post *BP1* and coupled to the receiver's tuned circuit, air-core inductor *L1* and the *A* portion of dual-section variable capacitor *C2*, by dual-section variable capacitor *C1*. Section *B* of this capacitor couples the bottom of the tuned circuit to binding post *BP2*, which is connected to a solid earth ground.

Tuned circuit *L1C2A*, which is adjusted for resonance at the frequency of interest, is inductively coupled to air-core inductor *L2*, forming an r-f transformer that has a tuned primary and variable coupling between its windings. Signals appearing across the secondary are demodulated by germanium detector *D1*, a 1N34A diode connected across binding posts *BP3* and *BP4*. Earphones *TR1*, connected across binding posts *BP5* and *BP6*, have high-impedance elements that transduce the demodulated waveform into an audio output.

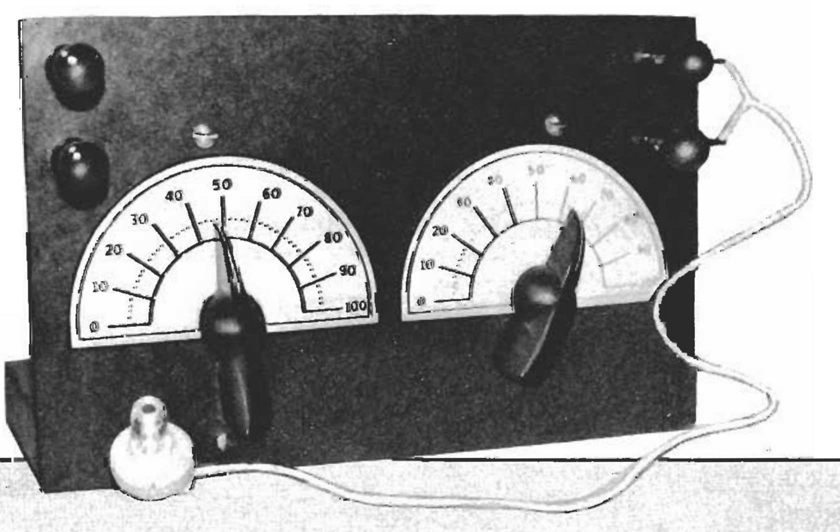
Capacitor *C2B* isolates the tuned circuit somewhat from ground to make it more selective. Additionally, because the capacitive reactances of *C1A*, *C1B* and *C2B* are smaller at high frequencies, there is less likelihood of signals from medium-wave broadcasters reaching the detector. Variable capacitor *C1* and the variable coupling between *L1* and *L2* allow adjustment of selectivity. The main function of r-f transformer *L1L2*, however, is to minimize shunting of the tuned circuit by the detector circuit. Connecting the network *D1TR1* directly across *L1* would result in considerably lower volume of received signals.

Construction. The r-f transformer should be assembled first. Inductor *L1* should be wound on an electrically inert, thin-walled cylindrical form (preferably a celluloid or plastic tube) measuring 5 inches long and 2 inches O.D. An acceptable substitute form can be made as follows: Cut a sheet of thin poster board 5′ by 6¾″. Gently curl up the sheet into a cylinder 5 inches long with an outer diameter of 2 inches, allowing ½ inch for overlap. With the glossy edge facing the outside, apply thin coats of rubber cement on the two edges that will touch. When the cement has dried, press the edges together, being careful not to crush the cylinder. Now squeeze the cylinder gently until it is completely round.

In constructing *L1*, refer to the photos, where *L1* is the coil wound using light-colored wire. Drill two ⅛-inch mounting holes in the coil form ⅜″ in from each edge. Make a tiny pinhole 1″ in from one edge of the form, noting its correct position in relation to the mounting holes. Push one end of a 83-inch length of coil wire through the hole from the outside of the form, and pull it out through the near end of the form. Number 22, double-cotton-covered (d.c.c.) wire is the best to use for *L1* and *L2*, but it might be difficult to obtain. Enameled wire of the same gauge can be used instead.

Allow at least 8″ of wire to extend out through the end of the coil form. Wind 10½ turns of No. 22 d.c.c. wire or 9½ turns of No. 22 enameled wire onto the form. Now cut the wire 8 inches beyond the end of the winding. Make another pinhole in the form at the end of the winding, insert the wire, and pull it out through the same end as before. Temporarily hold the winding in place with a few strips of celluloid tape, then apply a little household cement to the edges of the winding to secure it in place. When the cement has dried, remove the tape and set the completed *L1* aside.

The coil form for *L2* is similar to that for *L1*, but is 1½″ long and has an *inside* diameter of 2⅛″. A substitute coil form can be made in the



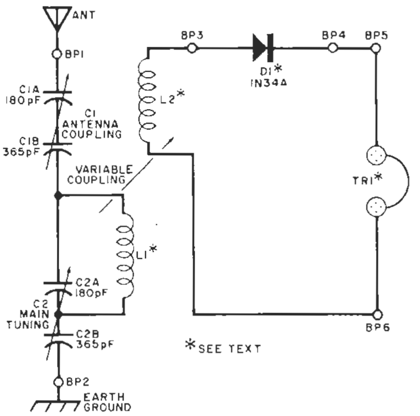


Fig. 1. Schematic diagram of the circuit for the Crystal Receiver.

same manner as for *L1*. Cut the poster board into a strip 7¼" by 1¼".

The relative sizes of the coil forms permit *L2* to slide freely on the form of *L1* and over its windings, thus providing variable coupling. If *L2* is a little large, tape can be applied to opposite sides of the form of *L1* to build it up until there is just a slight amount of friction between the two forms.

When the desired sliding action has been obtained, remove the form of *L2* from *L1*. Measuring ¼" back from one edge of the form, wind 30 turns of No. 22 d.c.c. or enameled wire. Make sure that the coil is wound in the same direction as *L1*. Having allowed 6" of loose wire on each end of the coil for connections, secure the coil with tape and cement the edges as was done for *L1*. When the cement has dried, slide the form of *L2* onto that of *L1*.

All receiver components mount on a 5" x 8" panel ⅛" or ¼" thick. Acceptable materials to use for the panel are fiberboard, plastic or bakelite. Do not use a metal panel, and do not enclose the receiver in a metal cabinet. It can be mounted in a wooden or plastic cabinet if desired, but easy access must be maintained so that the coupling between the windings of the r-f transformer can be adjusted. Perhaps the easiest method of construction is simply to fasten the panel to a 4-inch x 8-inch x ¾-inch wooden base to hold it upright. The wooden base can be finished according to your preference, but a fiberboard panel should not be painted because the proximity of carbon pigments can degrade the performance of the Crystal Receiver.

When drilling the front panel, follow the guide shown in Fig. 2 exactly. The exact positions of your variable capacitors' mounting holes may differ from those of the capacitors used by the author, so drill the holes to suit the capacitors you have. The holes for the shafts will be correct in any case.

Now mount all the parts except for the r-f transformer and detector diodes, using the photos of the prototype as guides. Note particularly how the binding posts and circuit tie-points are positioned. The prototype employs Fahnestock clips in place of binding posts *BP3* and *BP4* to secure diode *D1*. Part of the Fahnestock clips had to be filed away for adequate clearance of the mounting bolts. Fahnestock clips can also be used in place of *BP1*, *BP2*, *BP5* and *BP6*.

The use of Fahnestock clips to secure *D1* is to facilitate substitution of one diode for another. Not all diodes perform equally well, especially at high frequencies, even ones having the same part number. The capacitor tuning knobs can either be vernier types or pointer types, the latter requiring separate dial scales.

When all parts have been mounted, interconnect them with No. 14 copper wire, according to the schematic diagram. Keep each wire as far away from other wires and receiver components as possible.

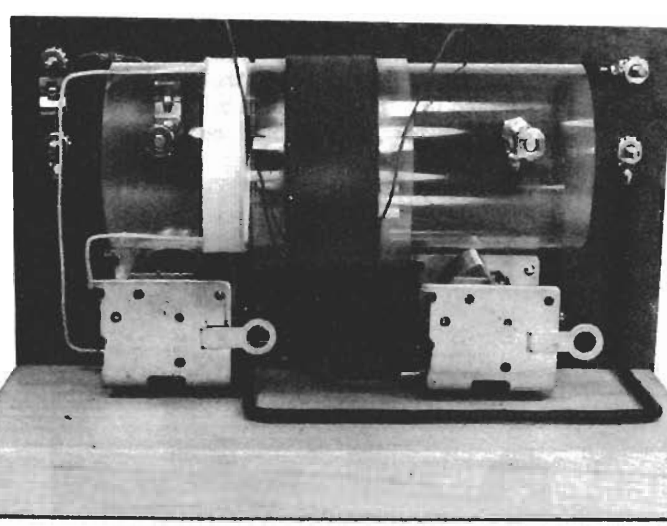
Now mount the spacing nuts and the r-f transformer onto the bolts so that *L1* is close to the detector diode. Then put one more nut on each of the transformer's mounting bolts to hold it in place. Finally, solder the coil wires to the appropriate places, cutting off all excess wire. Don't cut the leads of *L2* too short or it won't be able to slide completely across the form of *L1*. Recheck all connections against the schematic diagram.

PARTS LIST

BP1 through BP6—Binding posts
C1,C2—Dual-section (365-pF and 180-pF), air-dielectric variable capacitor
D1—1N34A germanium diode (see text for selection procedure)
L1—10½ turns of No. 22 d.c.c. wire or 9½ turns of No. 22 enameled wire wound on a 5-inch long, 2-inch O.D., air-core cylindrical form.
L2—30 turns of No. 22 d.c.c. or enameled wire wound on a 1½-inch, 2⅛-inch I.D., air-core cylindrical form.
TR1—High-impedance crystal earphone or magnetic headphones (see text)
Misc.—Antenna, earth ground, No. 14 solid copper wire, two vernier control knobs or pointer-type knobs and dial scales, solder lugs, suitable front panel and base or nonmetallic enclosure, suitable hardware, solder, cement, etc.
Note—Calibrated (0 to 100) tuning-capacitor dial scales for use with 1¼-inch pointer-type knobs are available for $1.00 for three dial scales from Howard D. Lash, 19 East 157th Street, South Holland, IL 60473.

Set-Up and Use. For best reception, an antenna mounted outdoors, in the clear, and as high as possible should be used. Good results have been obtained with a longwire antenna. Dimensions of the longwire are not critical; the longer the better, with integral multiples of a half-wavelength at the frequency of interest being the best. The usual precautions against lightning strikes and against contact with high-tension wires should be observed.

Except where shortwave reception is extremely poor, you should be able



Rear view of author's prototype shows construction of r-f transformer. L1 is light wire, L2 is dark.

to receive some shortwave stations with this radio. An indoor antenna should be as high and shielded by as little structural metal as possible. Connect the free end of the antenna lead-in wire to *BP1* and another wire from *BP2* to a good earth ground.

Garden-variety magnetic headphones are unsuitable for this receiver. The only magnetic headphones that work well with this circuit have extremely high input impedances, as, for instance, Trimm "Featherweights," whose impedance is rated at 24 megohms.

For several reasons, however, crystal earphones are the transducers of choice. They are cheaper, more readily available, and, above all, much more sensitive than magnetic headphones. Magnetic headphones, however, do attenuate background room noise—which can enhance the intelligibility of received signals.

If the crystal earphone or pair of magnetic headphones you obtain has a cable terminated with a two-conductor phone plug, cut off the plug and solder pin plugs to the conductors instead. Then attach the pin plugs to *BP5* and *BP6*.

Gather a number of germanium diodes and select one, connecting it between *BP3* and *BP4*. Use this as a detector in your first listening session, while experimenting with control settings to familiarize yourself with receiver operation. Shortwave reception in the 49-, 41- and 31-meter bands is generally best at night.

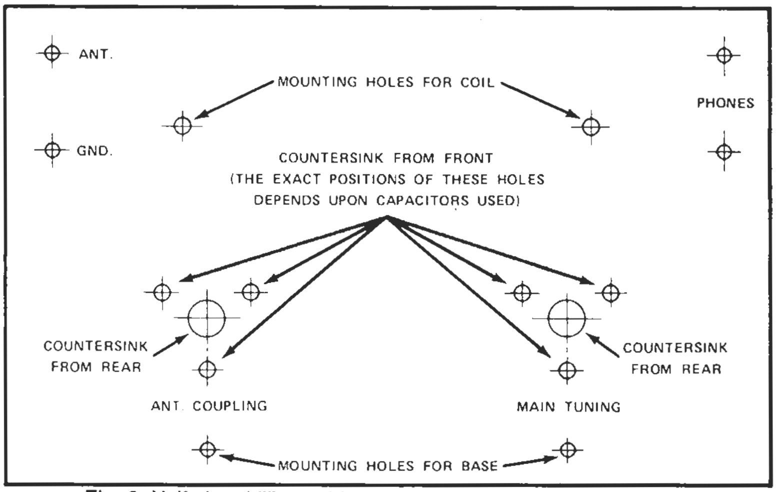
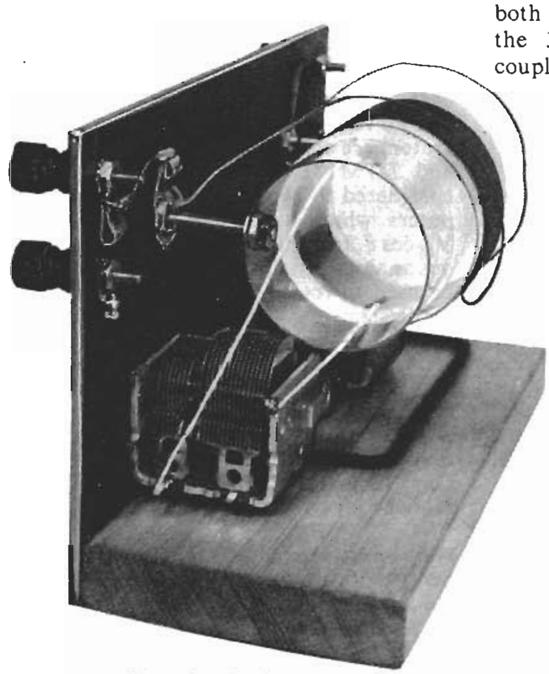


Fig. 2. Half-size drilling guide for front panel. All holes are 9/64 inch except two for capacitor shafts. These are 3/8 inch.

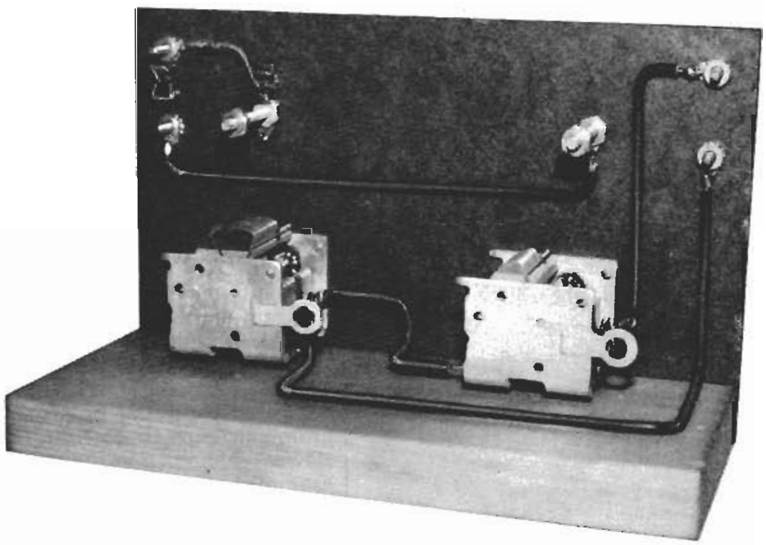
There is a certain amount of interaction between adjustments of the tuning capacitors and of the coupling between the windings of the r-f transformer. (The main tuning knob is the one that controls *C2*.) Decreasing the coupling between *L1* and *L2* (by moving *L2* away from *L1*) shifts the control range of *C2* upward in frequency. It also decreases signal volume and increases receiver selectivity. Reducing the effective capacitance of antenna coupling capacitor *C1* has similar effects. Appropriate adjustments of *C1* and the coupling between *L1* and *L2* will, thus, optimize tuning range, signal volume, and selectivity.

As a guide, employ minimum interwinding coupling and capacitance (of both *C1* and *C2*) for initial tuning of the 31-meter band and maximum coupling and capacitance for initial tuning of 49 meters. The settings for 41 meters will be between these extremes. The antenna employed, the effectiveness of the earth ground, and the wire used in winding the coils all affect these adjustments. Often, a number of different combinations will tune the same station; choose (and log) the combination that yields the best results. When you have developed a feel for tuning the receiver, try a number of germanium diodes and select the one that performs best. A station on the 31-meter band is best for this test, with one on the 41-meter band as second choice.

The Ocean-Spanning Crystal Receiver is now optimized for shortwave reception. Although it can't compete with a triple-conversion superhet, it can, in light of its simplicity, deliver amazing results. ◇



View showing how transformer and variable capacitors are mounted.



Back of receiver with r-f transformer removed. Connections between components are with No. 14 solid copper wire.