my 1st medal detector & it worked

By DANIEL MEYER

THE ALTER EGO OF OUR DEEP SEARCH "IC-67" LOCATOR WILL FIND THOSE SMALL METALLIC OBJECTS AND COINS

PROBABLY EVERY one of us has at one time or another had the urge to go searching for buried treasure. The "treasure" could be really valuable—a pot of gold coins buried during the Civil War, or a platinum locket lost on the beach—or it could be just a few cents dropped in some weeds or an old coffee can lid. A "treasure finder" or metal locator tells you where to dig.

Metal detectors come in two basic types. The one best suited to your needs will depend on just what you are searching for. The bulkier and more expensive transmit-receive detectors can find large objects at greater depths, but do not detect small objects easily. A simple single-loop beat-frequency locator, like the "Beachcomber," will detect objects at a depth of only about 2 feet maximum (depending on size) but can readily find small objects only 1 or 2 inches in diameter.

The Beachcomber can be a lot of fun to have along on a trip to the coast, or to an old battlefield to search for relics. It is lightweight, and operates 6 to 8 hours on an ordinary transistor radio battery. Its speaker is built in, so there are no headsets or wires to get in the way or get lost. And it only costs about $15 to build.

How It Works. The simple circuit (Fig. 1) consists of two r.f. oscillators—operating around 400 to 500 kHz, a detector, and an audio amplifier. The oscillators are identical, except for the coils used to tune them. One coil, *L1*, is tuned to make this oscillator's frequency slightly

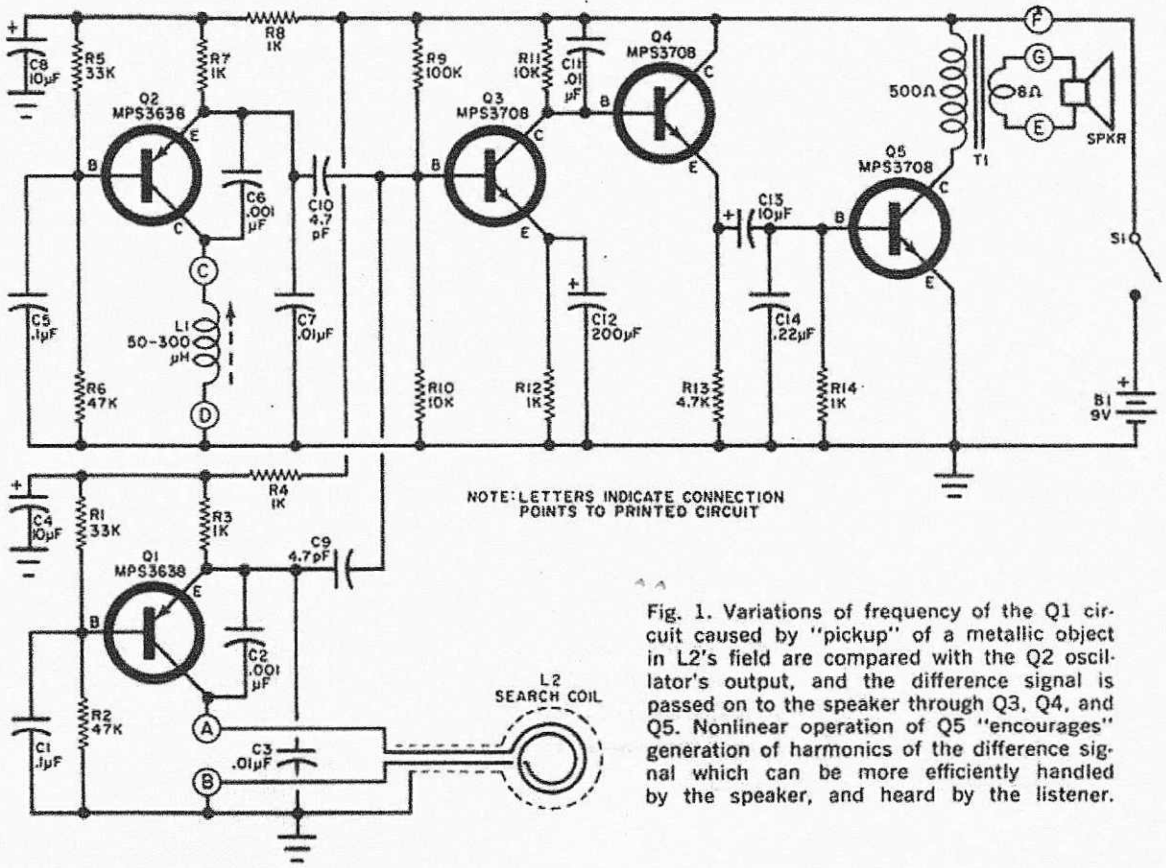


Fig. 1. Variations of frequency of the Q1 circuit caused by "pickup" of a metallic object in L2's field are compared with the Q2 oscillator's output, and the difference signal is passed on to the speaker through Q3, Q4, and Q5. Nonlinear operation of Q5 "encourages" generation of harmonics of the difference signal which can be more efficiently handled by the speaker, and heard by the listener.

higher or lower than that of the search coil oscillator. The two signals are combined in detector stage *Q3*, whose output is the audible difference between the two frequencies. This signal is fed to emitter follower *Q4* and output stage *Q5*, and finally to the speaker.

The search coil oscillator frequency changes slightly whenever the conductance of the material in the field of the loop changes. This means that if the coil passes over a metal object, the oscillator frequency will change slightly, and the pitch of the audio beat note you hear from your speaker will also change. It is easier to hear a small frequency change in a low-pitched sound than an equal change in a higher frequency tone.

To get the best results from the Beachcomber, set the oscillators as near the same frequency as possible. *Both oscillators must be very stable.* Good sturdy construction with no loose parts is a must. The circuit must also be so laid out as to reduce coupling between the two oscillators to the minimum. Other-

PARTS LIST

B1—9-volt battery
C1, C5—0.1-μF, low-voltage disc ceramic capacitor
C2, C6—0.001-μF polystyrene capacitor
C3, C7—0.01-μF polystyrene capacitor
C4, C8, C13—10-μF, 15-volt electrolytic capacitor
C9, C10—4.7-pF ceramic disc capacitor
C11—0.01-μF, low-voltage disc ceramic capacitor
C12—200-μF, 6-volt electrolytic capacitor
C14—0.22-μF low-voltage disc ceramic capacitor
L1—50-300-μH variable inductor (Thordarson WC-11, J. W. Miller #6196, or similar)
L2—Search coil—see text
Q1, Q2—MPS3638 transistor (Motorola)
Q3, Q4, Q5—MPS3708 transistor (Motorola)
R1, R5—33,000 ohms
R2, R6—47,000 ohms
R3, R4, R7, R8, R12, R14—1000 ohms
R9—100,000 ohms
R10, R11—10,000 ohms
R13—4700 ohms
(All resistors ½ watt)
S1—S.p.s.t. slide switch
T1—Transistor output transformer: primary, 500 ohms CT (do not use CT); secondary, 8 ohms, 150 mW.
Misc.—Miniature speaker, chassis box, battery clip, enameled wire, spacers, solder, etc.

NOTE: Printed circuit board for this project is available for $2.50 from DEMCO, 219 West Rhapsody, San Antonio, Texas 78216. A complete kit (excluding the coil form, chassis and rod) is also available for $15 postpaid.

wise, the oscillators will "pull"—suddenly lock together every time the beat frequency is brought down to a low pitch. That is why both oscillators are decoupled from the battery supply and from each other (through *R4-C4* and *R8-C8*) and why such small value capacitors are used for *C9* and *C10*.

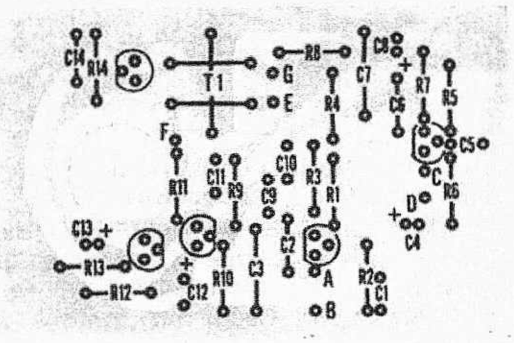
The output stage is purposely designed to produce "distortion," so that the low-frequency beat notes can be heard from the small speaker. If the audio circuit were designed for linear operation and little distortion, the speaker would produce little or no output below 150 to 200 hertz. In this circuit the audio output stage is not biased "on" at all. When it is driven with an audio signal from emitter follower *Q4*, transistor *Q5* conducts and produces an output on each positive half cycle. The signal to the speaker is therefore a series of pulses at the frequency of the beat signal. Since the pulses contain many harmonics, they can be heard down to a few hertz.

Construction. The electronic portion of the metal detector is easy to assemble, and there is no chance of coupling problems or shifting parts if the printed circuit board construction shown is used. The board (Fig. 2) serves as a template to locate the holes for *L1*, the mounting spacers, and the speaker.

Cut a 7/16"-diameter hole for *L1* and another of the correct diameter for your speaker. Then mount the small parts by simply inserting them in the positions indicated by the parts numbers on the top side of the board, turning the board over, and soldering them in place.

File the switch hole in the cabinet to fit the type of switch used. Mount the switch, speaker, battery clip, and *L1* as shown in the photograph (Fig. 3). Wire the switch and battery clip as shown. The lead from the positive terminal of the battery goes to one switch contact, and a short lead should be soldered to the other contact—to go to point *F* on the board. A doughnut cut from plastic foam is placed around the rear of the speaker; the board compresses the foam when it is mounted, and thus holds the speaker snugly.

Now connect the battery and speaker wires to the underside of the board at the points indicated on the schematic diagram. Mount the completed circuit



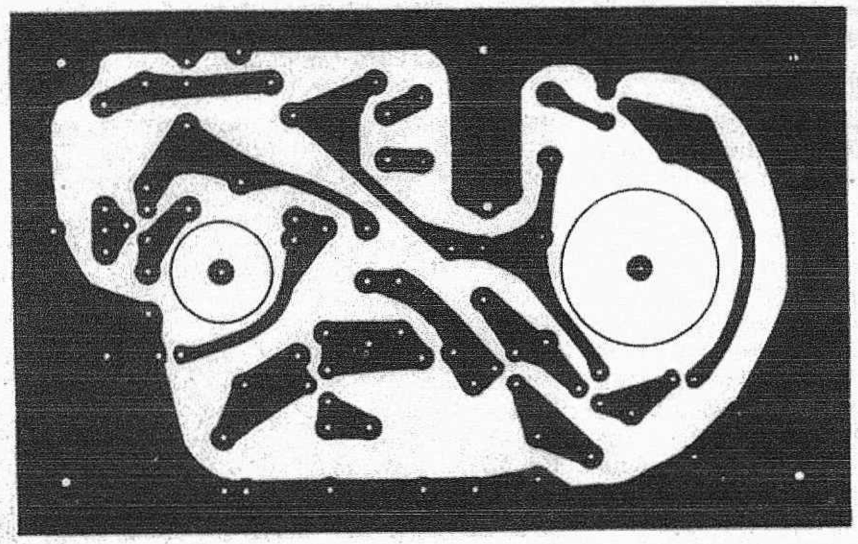


Fig. 2. Actual size drawing of foil side of printed circuit (left) will help you make your own board. Parts are installed on the plain side of the board as shown above. Figure 4 shows parts assembled on board.

Fig. 3. Part of the speaker and coil L1 pass through the circuit board and must be carefully positioned to fit properly. The speaker is not bolted and can be shifted.

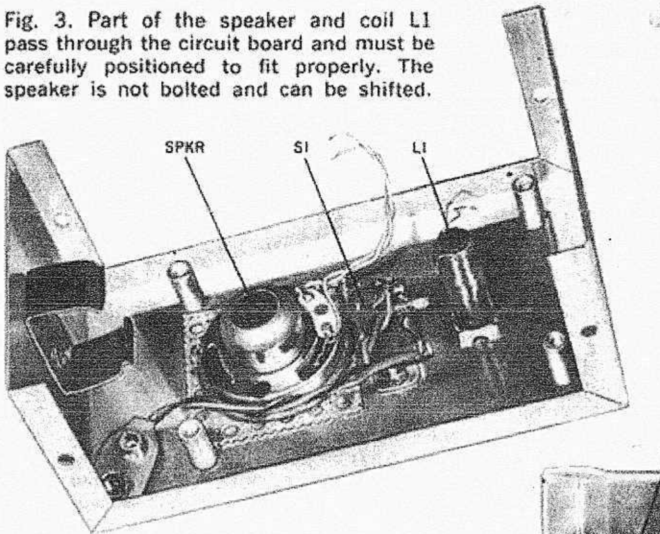
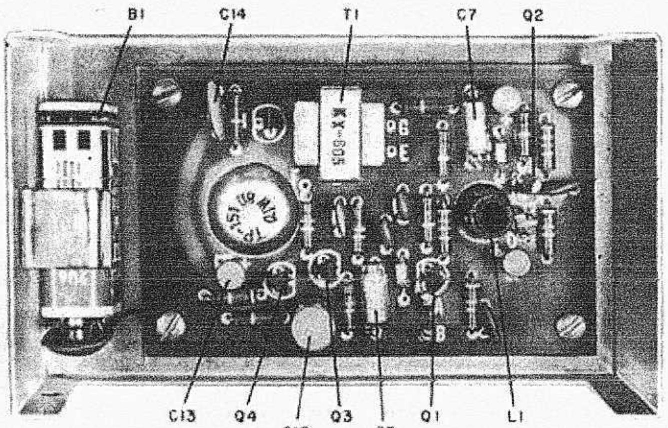


Fig. 5. Clean, firm assembly of internal as well as external components and other hardware means clean operation. Any variations due to movement of parts can cause false readings.



board (Fig. 5) and connect *L1* to the eyelets at points *C* and *D* on top of the board.

The Search Loop. This important part of the locator can be made in several ways. Of the two presented here, the copper tubing search coil shown in Fig. 6 is more rugged, but the plastic tubing loop will work well and is much easier to build.

To make the copper coil, obtain a piece of 1/4" *soft* copper tubing 42 inches long and bend it into as smooth a circle as possible. (Be sure it is straight when you buy it—and bend it around a cylindrical object a little less than a foot in diameter.) Leave a quarter-inch gap between the ends. Drill a 1/8"-hole on the inside of the circle opposite the gap.

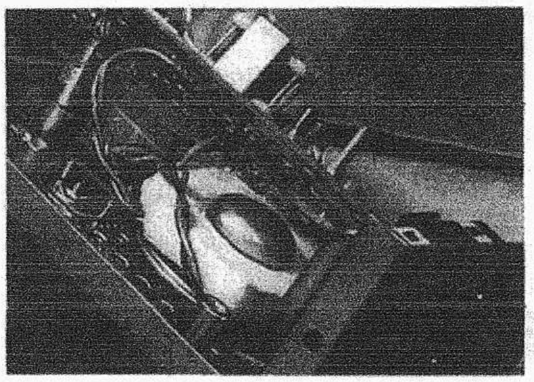


Fig. 4. A "doughnut" of foam rubber or plastic placed around the speaker holds it securely in its correct position when circuit board is installed.

Then take a hacksaw and split the tubing around its outside wall. (Cut through the outside wall only, not completely through the tube.) The edges of the cut can be smoothed with a small file. Solder about 6 inches of insulated hookup wire to one end of a 50' length of No. 24 enameled magnet wire, and slip a piece of insulating tubing over the connection. Thread the insulated wire through the 1/8"-hole in the tubing from the outside (through the slot) and leave about an inch or two of insulated wire inside the split loop.

Now wind 14 turns of wire inside the copper tube through the saw slot, being careful not to pull the 1/4" end gap together. Cut the magnet wire and solder another piece of hookup wire to that end. Insulate the connection and thread the hookup wire through the hole in the tubing. Finally, paint the coil of wire inside the copper shield with coil dope or white glue.

You can make the plastic loop (Fig. 6) in much the same way. Slip a 2" length of 3/8" plastic tubing over the ends of the

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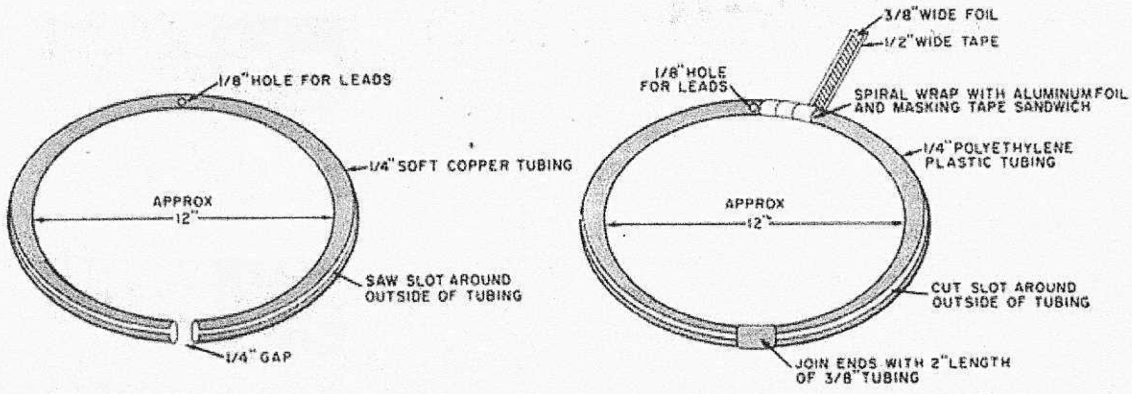


Fig. 6. Loop housing made of copper is shown above, and plastic tubing at right, above. If plastic is used, a metal outer covering can be made from aluminum foil. In either case, there must be a gap.

¼" plastic tubing to hold the ends in place. Then cut or drill a hole on the inside of the loop opposite the gap, and split the outside of the loop with a knife. Cut out a 1/16" strip all the way around the outside.

Make up the magnet wire as described for the copper loop and wind the search loop with 14 turns. Cement the turns together. Since the plastic loop does not shield the coil—as does the copper loop—it must be shielded before mounting.

You shield the plastic loop by cutting a piece about ⅜" wide from the end of a roll of aluminum foil. Stick the foil to a piece of ½" plastic masking tape, leaving a border on each side. Then strip the insulation off of about half of a 6" piece of *stranded* hookup wire, and place the bare portion between the foil and tape at the beginning of the spiral roll.

Now, starting at the point where the connections come out of the loop, spiral-wrap the tape-foil sandwich around the coil form. When you have gone all the way round, tear the foil off and go round

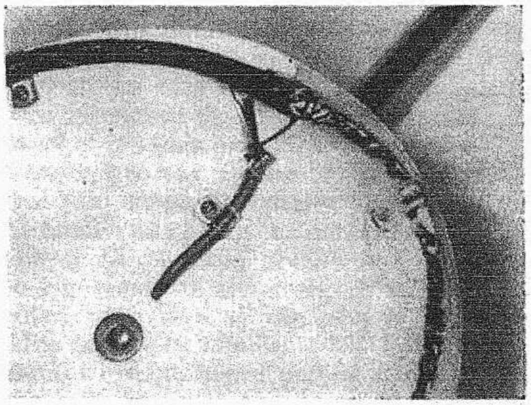
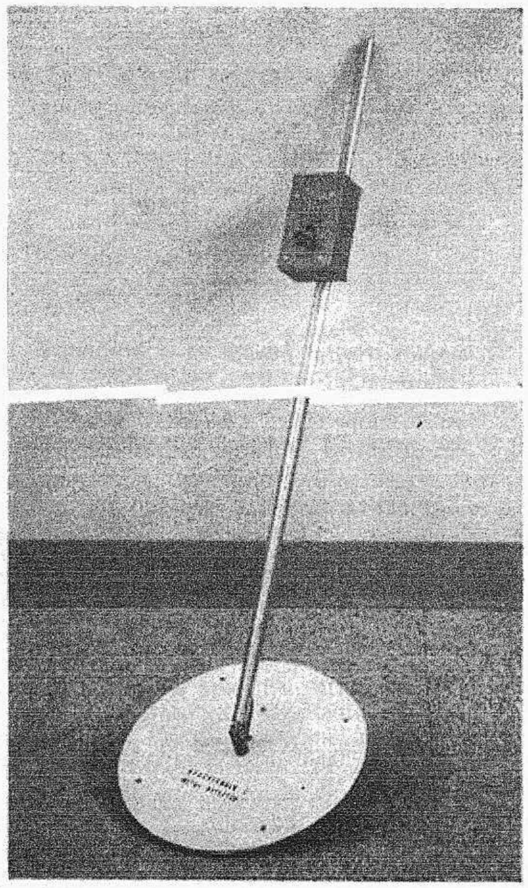


Fig. 7. Plastic-covered loop must be securely positioned. Use plastic cable clamps and putty or cement to hold the entire loop on the plywood board.



Completed "Beachcomber" is ready to "look for" buried treasure. Adjust loop so it is parallel to the ground while you hold unit at comfortable angle.

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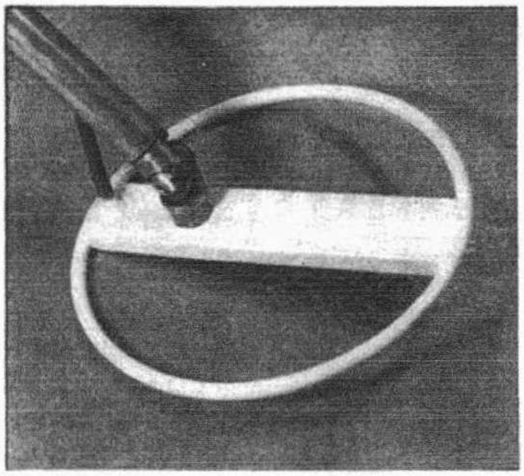

The copper tubing loop assembly is rigid enough to permit the use of a small wood brace for assembly. Some weight reduction can be gained in this manner.

again with the masking tape only, to hold everything firmly in place. *Note that the foil must not form a continuous loop.* Do not let the end of the foil—where you stop—touch the beginning of the winding.

The finished loop is mounted with plastic cable clamps to a 1/4" plywood base (see Fig. 7). Use at least four clamps. The plastic loop must be potted in place on the plywood base with water putty to make sure it won't move or bend.

Finishing Touches. The handle on the Beachcomber can be any convenient length of 3/4" aluminum tubing, and it can be fastened to the plywood base with a universal elbow made for 3/4" tubing. (These items were obtained by the author off a "do-it-yourself" rack in a local hardware store. If you have trouble finding them, the handle can be made of wood. Even an old hoe handle will do.)

Connect the two ends of the loop to the two wires and the shield to the shield braid of a two-conductor shielded cable long enough to run up the handle to the control box. Screw the bottom of the box to the handle and bring the cable through a hole in the bottom of the box to a three-lug terminal strip, which can be mounted with one of the screws that hold the box to the handle.

Connect circuit board points *A* and *B* to the loop wires at the terminal strip with about 3 to 4 inches of hookup wire twisted together. Clip in the battery, put the box together, and you're ready to go.

Using the Detector. The Beachcomber is simple to use and—with a little practice—you should be able to find buried metal easily. The first thing to do is to set the tuning control to produce a beat note. Since the adjustment range of the coil is very wide, you should be able to get a beat note even if your search coil is not identical to the one shown.

If you are not sure whether the circuit is operating, hold a transistor radio near the detector while you turn the tuning control. You should be able to get a strong signal near the low end of the broadcast band somewhere in the tuning control's range.

Place the search loop flat on the ground and adjust the tuning to give a low beat note. Raising the loop 4 to 6 inches above ground should not change the beat note very much. To search, you simply hold the coil near the ground and swing it from side to side, parallel to the ground. If you hear a change in the pitch of the beat note, move the coil slowly around the area to get an idea of the exact location and size of your find.

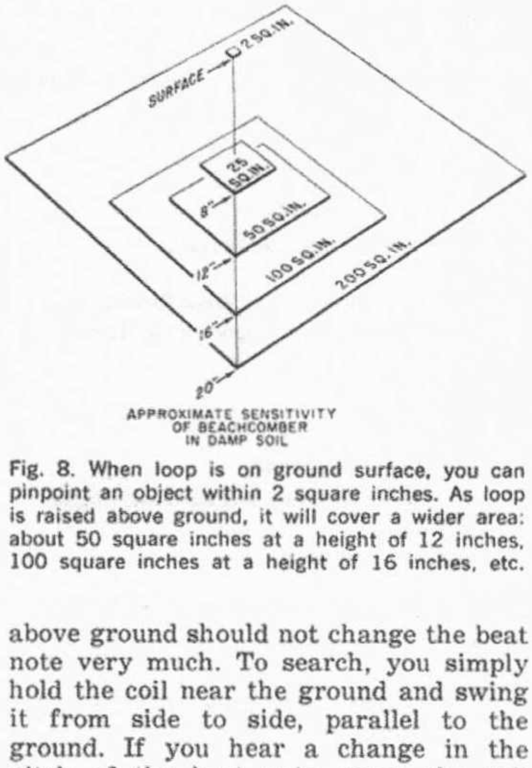

Fig. 8. When loop is on ground surface, you can pinpoint an object within 2 square inches. As loop is raised above ground, it will cover a wider area: about 50 square inches at a height of 12 inches, 100 square inches at a height of 16 inches, etc.

The change in beat note will depend on the size of the buried object and its area as seen from straight above. Thus, while you can easily find a coffee can lid buried flat, you might miss it if it were buried on edge. Figure 8 should give you a good idea of the results you can expect with the detector.

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