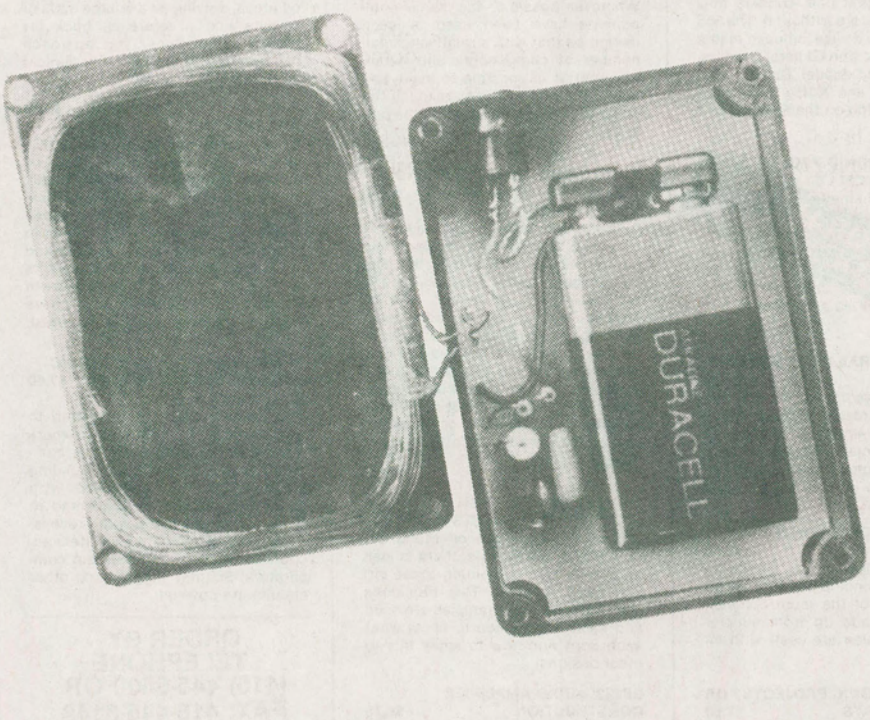
Simple Metal Detector

Find buried treasure and avoid nailing through the water pipes with this simple but effective metal detector.

KEITH BRINDLEY



Although this metal detector is certainly small, it does require a few extras. You don't need a car battery for power, a backpack (to put it all in) and a six foot dipole antenna to make the project work, but you do need a small transistor radio. The metal detector works by transmitting a weak radio wave carrier signal around itself, which has to be picked up with a nearby radio.

The carrier signal main frequency is in the vicinity of the lower end of the longwave band (around 120kHz) and is of sufficient strength to interfere with a radio within about a foot or so. The interference is heard as a whistle from the radio's loud speaker. As the whistle changes frequency, you know the metal detector is approaching a metal or metal-like object.

Sensitivity is pretty good considering how simple the project is. With a remote pickup coil metals can be detected from a distance of six inches or so. Even when the pickup coil is mounted on the project's case (as ours is) metals can be detected from around three or four inches.

How It Works

The circuit is a Colpitts oscillator, formed around transistor Q1 which is connected to a common base amplifier. Positive feedback is applied from the collector to the emitter via the AC potential divider formed by the series connected capacitor C2 and C3.

Capacitors C2 and C3 also form one arm of a parallel LC circuit. The circuit's resonant frequency is given by the relationship

$$f = \frac{1}{2\pi\sqrt{(LC)}}$$

and is around 120kHz. Conversely, we can calculate from the relationship that the coil inductance is around 0.88mH. Try it for yourself.

Coupled in this way, the transmitter amplifier becomes a weak radio transmitter, transmitting a carrier wave frequency of around 120kHz. Now this is actually slightly below the frequencies which are normally found on the radio dial (usually 550kHz to 1600kHz). This means that if the metal detector's transmitted carrier were pure, radios could not be used to pick up the oscillations. Fortunately, oscillations are not of a pure sine wave nature, so many harmonics of the resonant frequency are also formed, going right up through the long and medium wavebands and beyond.

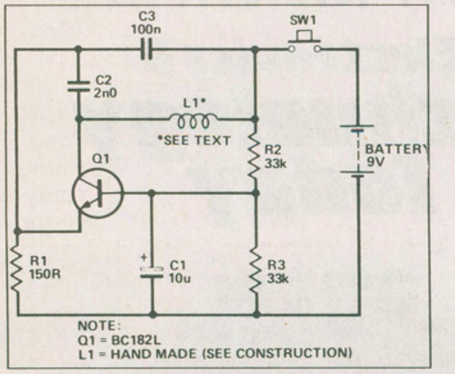


Fig.1 Circuit diagram of the metal detector.

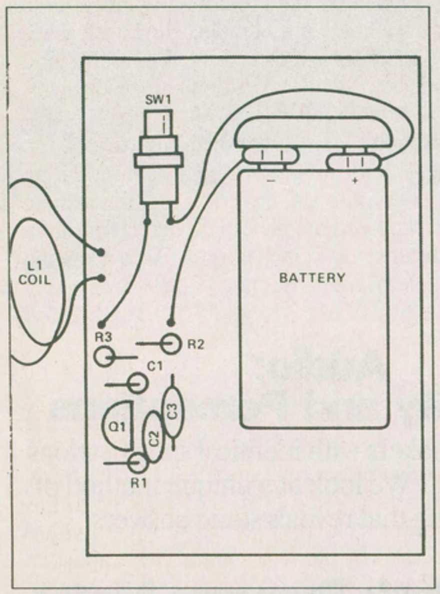


Fig.2 The component overlay for the metal detector PCB.

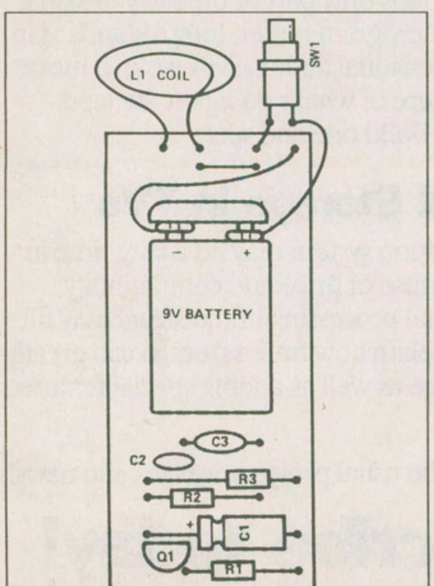


Fig.3 Stripboard component overlay. Note there are no track cuts required for this design.

The project functions as a metal detector simply because the actual inductance of the resonant frequency's coil varies with the proximity of local metallic bodies. Ferromagnetic bodies particularly concentrate the magnetic flux within the coil, so increasing the coil's inductance and lowering the resonant frequency of the oscillator.

A local transistor radio is used to pick up the weak carrier signals produced by the metal detector, along with a carrier wave of another radio transmission (of a broadcast nature). The two carriers heterodyne (interfere) to produce an audible beat frequency from the transistor's loud speaker. The beat tone is stable, until a metal object approaches the detector's coil. Then the coil's inductance varies, causing the resonant oscillation frequency to vary and in turn causing the beat tone to vary. So the user hears, simply by a change of the beat's tone pitch, that the coil is somewhere near a metal object.

Construction

Two ways are suggested to build this project – either on PCB or stripboard. Both methods are straightforward and apart from a few points are more or less self-explanatory.

On PCB, construction needn't follow any particular order, although it's probably best to leave the transistor until last. Whatever, go easy on the heat. Solder only one leg of each component at a time, then leave the component to cool before moving on to solder the next leg.

On stripboard it's probably best to stick to a conventional order, still maintaining heat precautions. Insert and solder the single wire link, followed by resistors, capacitors, and the flying leads to peripheral components. Lastly, insert the transistor Q1 and, when you've made it, the coil.

Whichever construction method you choose, check that no unwanted solder links or bridges are present between component leads.

The coil L1 needs to be wound. First, find a former on which to wind it – something of an external circumference of about 220mm, although this measurement is by no means critical. For reference, we used the widest part of a 250ml. bottle of baby lotion. Alternately, a piece of thick card about 110mm long could be used to hand-wind the coil. Make 100 turns of 30swg enamel- covered copper wire, leaving sufficient ends to connect between the coil's final position and the PCB.

When you've wound the coil, fasten it together in two or three places around its circumference with tape and slip off its winding former. Adjust its shape to suit.

Before you solder the ends of the coil into the PCB, make sure you scrape off the enamel from the copper wire for about 5mm from each end so they can be soldered. If you are using polyurethane coated insulated copper wire, there is no need to scrape off the insulation as the copper is self-fluxing on application of heat from a soldering iron.

Any suitable size box can be used to house your project, although the PCB is exactly the right size to fit the box used. The only real precaution you need to take is to mount the coil on the outside of the case (if it's on the inside its inductance is fixed primarily by the PCB and associated components, not by metals you wish to detect) or better still, remotely.

Setting Up

Setting up is simplicity itself. Turn on your radio and, while you press the metal detector's push-button on/off switch, adjust the radio's frequency tuning control until you hear a whistle. When you release the push-button the whistle should stop. If not, the whistle isn't caused by the metal detector and you should readjust the radio's frequency tuning control.

Test the metal detector by moving it closer to metal. The whistle from the radio will change frequency. ■

PARTS LIST

Resistors

(all 1/4W, 5%)

R1 .... 150R
R2,R3 .... 33k

Capacitors

C1 .... 10u 16V axial electrolytic
C2 .... 2n2 ceramic
C3 .... 100n ceramic

Semiconductor

Q1 .... BC182L or 2N3904

Miscellaneous

SW1 .... Push-to-make
L1 .... Handmade coil

PCB; case; 9V battery and clip; 30swg enamel covered copper wire for coil L1.