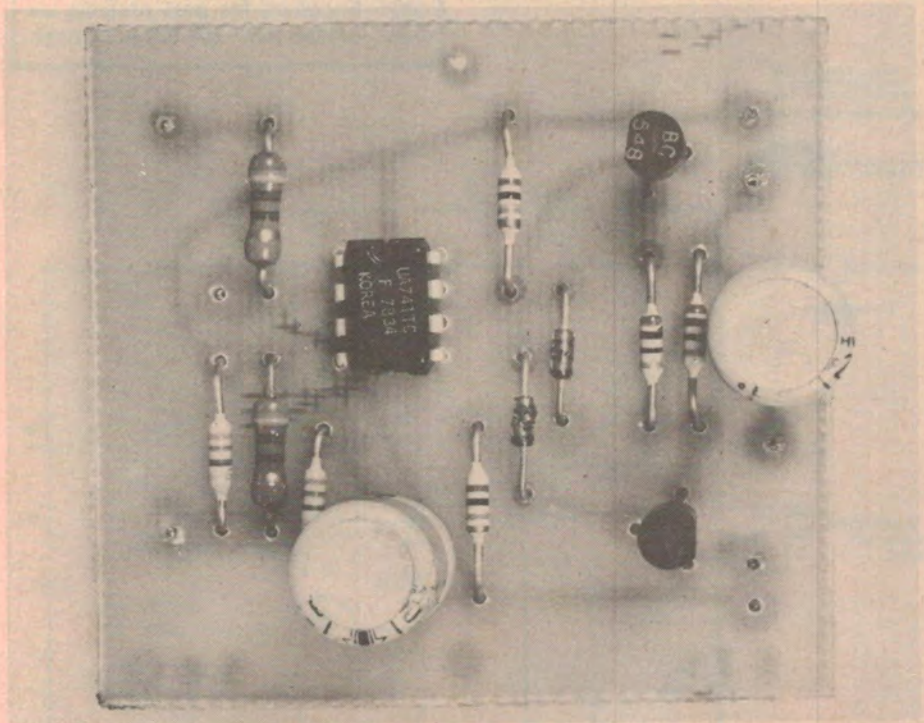
Mains cable seeker

Phil Wait

Finding mains cables hidden in wall cavities would require the X-ray vision of Superman or the divining skills of a 'dowser' . . . unless you had this project.

The sensor used for this project is a "telephone pickup coil" — the black object at the top. The inexpensive magnetic earpiece, below the pickup coil, indicates when you have located a cable.



Construction is very simple — just about foolproof if you use a printed circuit board; see over.

WHETHER YOU'RE engaged on extensive house renovations, or just want to bang in a picture hook, it's not only handy but a decided safety advantage to know where your mains wiring is located in the wall cavity.

After all, you don't want to drill straight into a mains cable and discover it by the shower of sparks . . . do you! It may well be the last thing you ever discover . . .

This simple device picks up the alternating magnetic field radiated by any cable connected to the 50 Hz mains. A simple, inexpensive "telephone pickup coil" is used as the sensor, the 50 Hz signal induced in this is amplified and applied to a small earpiece.

Commencing at any outlet or wall switch, you can trace where the cable runs by passing the pickup coil back and forth over the position where the 50 Hz hum is loudest, moving along the line of the loudest sound. The run of the cable may be marked with tape or whatever suitable method springs to mind.

Design

The design of the Mains Cable Seeker is extraordinarily simple. The pickup coil is a commercially-available unit that consists of a coil of many turns of fine wire wound on a small bobbin which is slipped over a soft-iron 'core'. This is encapsulated in a plastic container having a suction cap on one end. The suction cap enables the unit to be attached to a telephone. However, this feature is not used with this unit.

If the pickup coil is brought near any alternating magnetic field a current will be induced in the windings of the pickup coil and a small signal voltage will appear across the ends of the coil.

The pickup coil is connected to the input of a sensitive audio amplifier which raises the level of the signal such that it will drive an earpiece. ▶

Dowser — user of a "dowsing rod" or "divining rod"; a person who uses a rod, wire etc holding it in a particular way that gives an indication when the user approaches water, metal etc.

The amplifier design used in this project utilises an operational amplifier as a voltage amplifying stage, the output of which drives two transistors operated as a low power output stage. Feedback is applied directly from the output to the input. The resistance in the feedback path determines the gain, and thus the sensitivity, of the whole amplifier. A potentiometer is placed in the feedback path to allow you to vary the gain, depending on the strength of the 50 Hz field picked up from the cable you are tracing.

Construction

For simplicity, and to avoid wiring errors, we strongly recommend you construct this project using the printed circuit board design given here. You can make your own pc board, or buy one ready made. They should be widely available from a number of suppliers.

Commence construction by soldering the resistors and diodes in place. Take care with the orientation of the diodes. Refer to the overlay picture to make sure which way around they go. Next solder the two transistors in place – make sure you get them in their respective positions. Watch the lead orientation. Follow this with the IC making sure you get it the right way round also.

As the two electrolytic capacitors are a little cumbersome in comparison to the other components, they are soldered in last. These too, are polarised components, so watch which way you insert their leads. Refer to the overlay picture.

Once you have the pc board assembled and checked, you can connect the external components and give the project a trial run.

Run wires from the pc board to the input and output jack sockets, to SW1 and RV1 as indicated on the external wiring diagram shown with the pc board overlay picture. The battery connector has one red lead (the positive connection) and one black lead (the negative connection). The *red* lead is soldered to the other pole of SW1 and the black lead is soldered to the '0V' connection indicated (on the pc board).

You are now ready to test the project. Plug in the pickup coil and the earpiece. Turn the unit on, you should hear a click in the earpiece. With an appliance plugged into an outlet and turned on, bring the pickup lead near the appliance's cord and advance the gain control. You should clearly hear the 50 Hz hum in the earpiece when you pass the pickup coil near the cord. Try tracing the hidden wiring a short distance.

If all is well, you can now think about mounting the completed project in a suitable box. One of the commonly-available plastic "zippy" boxes would

HOW IT WORKS – ETI 560

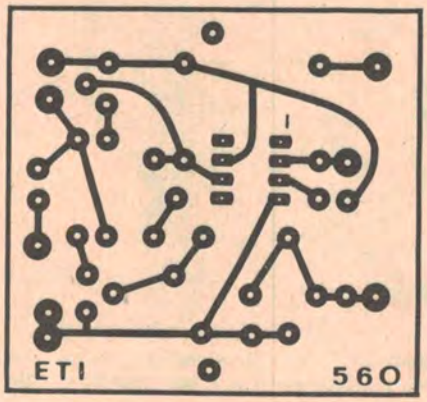
This Mains Cable Seeker works by detecting the weak alternating magnetic field of any current-carrying mains wiring. This signal is amplified to drive an earpiece. A pickup coil consisting of many turns of wire on an iron core is used to locate the field surrounding the mains cable.

The weak signal induced into the pickup coil is first amplified by IC1, a type 741 operational amplifier (op-amp). This IC normally requires to be operated from a dual supply but, in this application, is biased to operate from a single 9 Vdc supply. The non-inverting input of the 741 (pin 3, marked +) is biased to half the supply via a potential divider consisting of R2 and R4. The junction of these two resistors is decoupled for ac by a 100u electrolytic capacitor, C1. The signal from the pickup coil is applied between the half-supply point and the inverting input of the op-amp (pin 2, marked –).

The op-amp, IC1, is arranged here as a variable gain inverting amplifier; that is, the output is out of phase with the input. The output of the 741 (pin 6) drives two output transistors, Q1 and Q2. These are connected as a complementary emitter follower current amplifier, driving the earpiece. Diodes D1 and D2 ensure that the bases of Q1 and Q2 are correctly biased, bias current being provided by R5 and R6. Resistors R7 and R8 are output current limiting resistors, the output being taken from their junction to the earpiece via a dc isolating capacitor, C2.

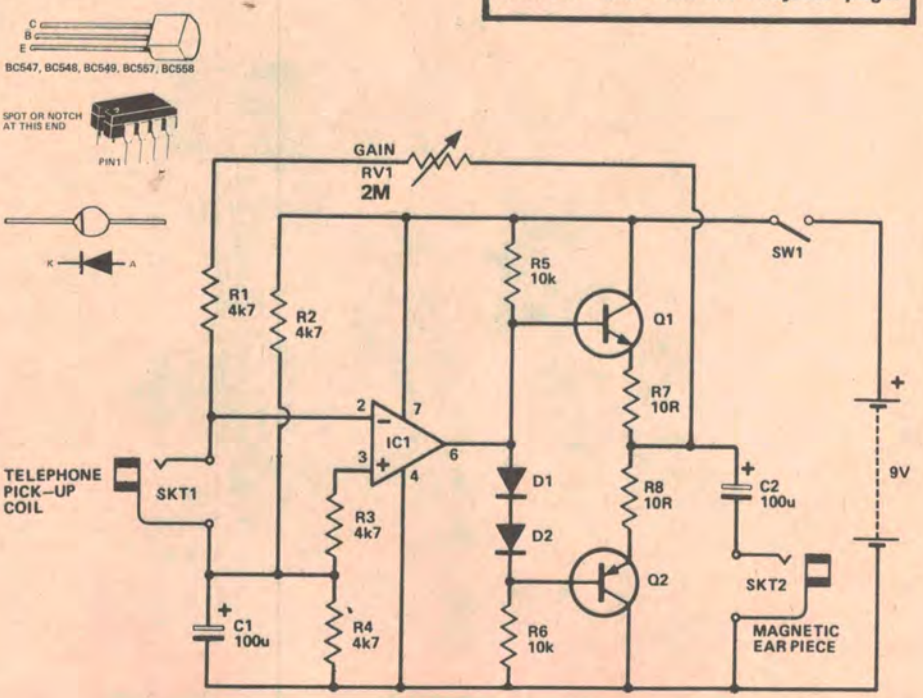
Feedback is taken directly from the output to the inverting input of IC1, via the gain control, RV1 and R1. The value of R1 sets the minimum gain (about unity).

Varying the feedback ratio, by varying R1, varies the gain of the whole amplifier.



READERS PLEASE NOTE

We do not sell kits or components for the projects described in the magazine. To find out who may be stocking kits or components for the projects featured in this issue, please refer to the 'Shoparound' page. Suppliers for past projects are listed on the 'Kits for Projects' page.



be ideal. One of these measuring 130 x 70 x 40 mm will accommodate the pc board, the other components and the battery with ease. However, any similar box would suit, just make sure everything will fit.

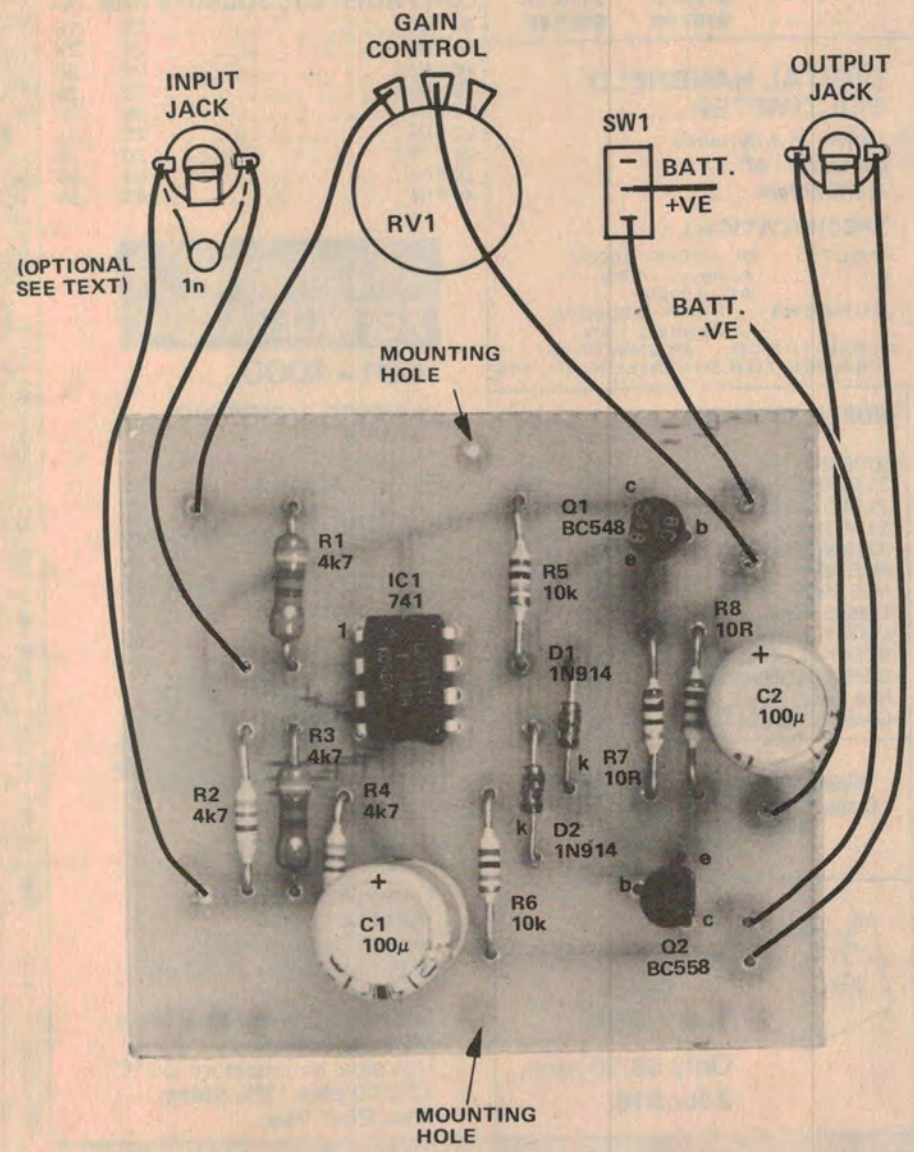
Suggestions

If you experience trouble with broadcast station pickup – where the pickup coil and input lead (and perhaps your body) act as an antenna – solder a 1n (1000 pF) ceramic or greencap capacitor across the input jack connections, as shown in the wiring diagram with the overlay picture.

You can wind your own pickup coil if you wish. We wound one on an 8 mm diameter by 30 mm long steel bolt. You must use a steel bolt. Being a ferro-magnetic material it concentrates the lines of force of a magnetic field in which it is placed, hence you will get greater induction in the pickup coil with a steel bolt than with any other type.

We first wound a layer of sticky tape over the thread of the bolt. A coil of about 300-400 turns of a light gauge enamelled copper wire was then jumble wound on this, then covered with a layer of sticky tape to hold it in place. The wire gauge is quite non-critical. Too heavy a gauge is difficult to handle and you won't fit the required number of turns on a bolt the size we used. Any gauge from, say, 26 to 32 gauge is OK – it doesn't matter if it's SWG or B&S. Any gauge lighter than 32 g tends to break very easily.

The coil/bolt assembly may be encapsulated for protection, or fitted into a small pill bottle or something similar. A length of shielded cable or a twisted-pair wire cable should be used to connect the pickup coil to the input jack. ●



Component overlay and external connection diagram for the project. Follow this carefully.

PARTS LIST — ETI 560

Resistors all ½W, 5%
- R1, 2, 3, 4 ..... 4k7
- R5, 6 ..... 10k
- R7 & 8 ..... 10R

Capacitors
- C1, 2 ..... 100u 16 V electrolytics

Semiconductors
- Q1 ..... BC548, BC108 or similar
- Q2 ..... BC558, BC178 or similar
- IC1 ..... 741 op-amp
- D1, D2 ..... 1N914, 1N4148 or similar

Miscellaneous
- RV1 ..... 2M linear pot
- SW1 ..... SPST toggle switch
- SK1, SK2 ..... 3.5 mm jack sockets
- B1 ..... Type 216 9 V battery

Zippy box to suit, battery clip, ETI-560 pc board, magnetic earpiece, telephone pickup coil or wire and bolt to wind your own.