Fancy becoming a treasure hunter? Well, start here. We make no wild claims, just give you honest, proven results. Complete and detailed building instructions make this a suitable project for all levels.

HALVOR MOORSHEAD

WE thought very carefully before calling this article the PW Treasure Tracer. Certainly this sounds better than "metal locator" but could we justify the title? We think we can, especially after our test. We found nothing of great value but judging by the results we *could* have, that is, if there had been any there. Even if valuables are not found, certainly a whole lot of extremely interesting items will be and the history of an area of ground will yield up its secrets. However, your chances of finding coins are very good—about 150,000,000 coins are lost *every year* and a high proportion of these must be lost in areas where they can be found using a device of this type.

Not many months ago a hoard of Anglo-Saxon coins was found, using a metal locator, these were later auctioned for £9,000. It shows what can be done.

Metal locators work on a variety of principles and the author has experimented with a number of different circuits. Nearly all rely on the fact that metal objects distort magnetic fields. Complex designs have appeared from time to time making use of various effects—each claiming to be an improvement over others—but the author's experience has not borne out these claims. The principal used here—the Beat Frequency Type—is possibly the oldest and certainly the simplest. It needs only one wound coil, unlike many other circuits, and the sensitivity and results are excellent. We are deliberately not overstating our claims and the only figures for range etc. are those proved by our tests.

The Treasure Tracer comprises two low power r.f. oscillators working at about 130 kHz. One of the oscillators is screened inside the chassis and the frequency can be altered over a fairly wide range to match it close to the other. The second oscillator uses a frequency determined by the inductance of a winding which is used as the search coil.

In the absence of any material which will affect the inductance of this search coil, the oscillator is at one frequency. However when this coil is moved near some metal object, the inductance is altered slightly and the frequency of oscillation is changed. If the oscillators are set closely together an audio beat note is produced (equal to the difference in frequency) which may be amplified to feed a loudspeaker.

Finding a small copper clip (Item 16). The grass guard made from Perspex can be seen fitted under the coil framework.

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Let us assume that the search oscillator is working at 130·0kHz. The reference oscillator is adjusted to say 130·2kHz. The two signals are mixed together producing notes of 130·2−130·0=200Hz. There is also another frequency produced, the sum of the two, 260·2kHz, but this can be ignored.

The presence of a metal object near the search coil will increase the inductance causing the frequency of the search coil oscillator to fall to say 129·8kHz. The beat note will now be 130·2−129·8=400Hz so the raising of frequency of the beat note will thus indicate the presence of a metal object near the coil.

From this theory the Treasure Tracer was built, using a frequency below 150kHz to conform to regulations. Initial tests in the lab showed that the prototype was working reasonably well and that a definite beat note was obtained—but how would it work in practice?

THE TESTS

The first test was arranged at the PW offices. A couple of dozen telephone directories were piled two high (making for a thickness of at least two inches) and coins ranging from $\frac{1}{2}$p to 50p were hidden under certain piles. All coins were found immediately, but there was an extra reading—this turned out to be the wiring under the floor!

These tests in themselves were interesting and we were slightly encouraged but how would the metal locator (for we were still calling it that at this stage) fare in a field test? Only one way to find out—arrange one.

One Monday in late May Eric Dowdeswell (PW Editorial), Peter Metalli (Art Editor), Jack Wood (Photographer) and the author set out for Canvey Island in South Essex to put it to the test.

The weather was fantastic and the beach was far from empty and under the puzzled eyes of day trippers we began our search, panning up and down the beach, just above the water line.

Our hearts fell. For several minutes the whistle remained unaltered. Up and down we panned and gradually we began to think that the journey was wasted. Then suddenly the note changed frequency—a very definite, strong reading. As we dug Jack Wood photographed us and the picture is that used on the cover. A quick dig produced a rusty hinge about three inches under the sand. We must have been unlucky to start with for after our first "find" we got readings every few yards. The items we found on this short stretch of beach and at other locations tried on the test are shown overleaf.

One thing cursed the search—silver paper. We found it everywhere and it accounted for over 75 per cent of all readings. We couldn't ignore these of course, for until we dug we didn't know what was causing the note to change frequency. The silver paper was from ice cream wrappings, cigarettes and sweets and even pieces so small that they were only found after extensive sifting, gave strong readings.

We altered our technique because of the sensitivity of the Treasure Tracer to small objects. As soon as we obtained a reading we carefully located the *exact* position before we began to dig—this could be done within an inch or two. As we dug we put the sand in two piles and checked at intervals with the Treasure Tracer that there was still a reading in the original position. If we had found nothing and the reading had disappeared we checked the two piles of sand. Invariably the metal was found in one of these. Even quite careful digging did not stop us missing several items the first time around.

Our deepest find was at 9in. The strength of the reading confused us at first—it was too strong and over a fairly wide area. The "treasure" turned out to be an aerosol can for retouching cars, a beer can of similar size was found at 4in with less trouble. The reading at 9in. was strong and it would be fair to assume that if the can had been deeper it would still have been found.

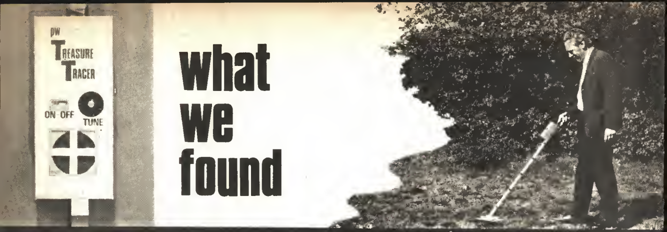
We were very successful near the sea wall where people were sunning themselves but due to the numbers already there we could only try a few yards of this but it was here that we found our only coin—which turned out to be a 1966 penny, badly corroded. We had expected to find more money and because of our failure to do so we arranged a test. One person buried coins of various sizes in a marked off area and we tried to locate them. These tests were successful and convinced us that we could unfailingly find all coins at depths up to four or five inches and larger coins at even more.

n old track. All we found here (items 1 and 26) but such erally be more fruitful.

Money! Right against the sea wall we found our only coin—a 1966 penny, badly corroded.

The one that got away! The tide came in so fast that before we had time to dig out the "find" the water put an end to it.

what we found



1 Cart fitting (?). Found on the old farm road at 2″ down.
2 Boiler clinker (?). Gave strong reading. 1″ down.
3 Sheet metal handle, badly rusted. Found in author's garden at $2\frac{1}{2}$″.
4 Iron Hinge. Our first find, 3″ under the sand.
5 Nail found under the beach, $\frac{1}{2}$″ down.
6 Copper gasket ring (?). Found under the beach at 6″.
7 Shrapnel. Author's garden at 2″.
8 Sharp metal spike. On the beach at 3″.
9 Screw eye (from clothes line ?). Author's garden, 2″ down.
10 Small piece of torn metal. Beach at 3″.
11 Copper tube (squashed). Author's garden, 2″ down.
12 Piece of unidentified iron. Beach at $1\frac{1}{2}$″.
13 File badly rusted. Garden at $2\frac{1}{2}$″.
14 Plant label (?). Zinc, garden at 4″.
15 Shrapnel. Garden at 1″.
16 Copper clip. Beach, found at 3″.
17 Shrapnel, gun metal, beach at 4″.
18 Screw-on bottle top, beach, 1″ down.
19 Shrapnel. Author's garden at 3″.
20 1966 penny. Beach at 3″.
21 Encrusted iron fitting. Under the beach at $1\frac{1}{2}$″.
22 Thin copper tube (squashed). Beach at 2″.
23 Copper tube (squashed). Author's garden at 2″.
24 Piece of cast iron. Beach at 3″.
25 Nail with small piece of wood attached. Beach at 1″.
26 Cart fitting. Old farm road at 4″.
27 Galvanised washer. Author's garden at $3\frac{1}{2}$″. Looked just like a coin until cleaned up.
28 and 29 (not shown) Aerosol can and beer can. At 9″ and 4″.

As we progressed experience enabled us to locate more accurately and our ears became more and more sensitive to changes in the note.

Just one word of caution. The beach will provide finds of all types but be careful near the water's edge. The spray landing on the search coil sent it haywire and searching became almost impossible. Later tests carried out in the light rain proved fruitless for the same reason. Not only does the impact of the spray or raindrop change the note but water trapped in the turns alters the inductance of the coil. As the water evaporates the pitch of the note changes—the effect lasts several minutes during which searching is impossible.

The second part of the test was made on the outskirts of a nearby castle. Not unreasonably the custodians would not let us search in the grounds but recommended trying outside, pointing the way to the original approach roads. A number of items were found, though none of any great age.

The final test was conducted in the author's garden in north-east London. Surprisingly most of the items were found at the same depth under the lawn. When a reading was obtained a circle of turf about 6in. in diameter was cut out, the item was found and the earth replaced, laying the turf back in position; in this way no damage was done to lawn.

The house was built in 1913 and the lawn is probably original. The objects found were probably from the building process, spread out before turfing —though the file was probably lost by some workman long ago.

Some pieces of shrapnel were found. This is not really surprising for at the height of the London Blitz the fire from the anti-aircraft guns was so heavy that shrapnel apparently came down almost like "hail stones," according to a neighbour. Most of the shrapnel was cleared up but quite a lot would have buried itself in the ground.

A grass guard was developed from experience, this can be seen in the photographs. It is a piece of Perspex, 6×6in. fixed to the bottom of the search coil framework to stop blades of grass from touching the coil and so cause the beat note to change.

A total of four hours test searching was carried out to produce the finds shown. In that short period we became very much better at identifying signals and in the end knew exactly where to dig and even how deep we could expect to find the metal object.

HOW TO BUILD THE P.W. TREASURE TRACER

The circuit of Treasure Tracer comprises three distinct sections: the search coil oscillator, the reference oscillator and the audio amplifier.

The search coil oscillator is made around L1 which is wound on a wooden framework shown in Fig. 1. This is made up from two 6in. lengths of hardwood batten with a section of $1\times\frac{3}{4}$in., though this section is not critical. These should be made into a cross by half-lapping as shown and small V shaped grooves cut into the ends. This framework must be rigid and if poor joints are made, these should be firmly glued.

The handle is made up from wood of the same cross section as the coil framework and about 4ft. in length, though this will depend upon the height of the user. The base of this should be cut at 45° and screwed firmly to the coil former. A normal type screw can be used; it will alter the inductance of the coil but as it is a constant it does not affect operation.

A small three way stand off tag strip should be mounted a few inches from the bottom to provide a firm anchorage for the coil wires. A thin enamelled copper wire should be used; the gauge is not too critical and 32 to 38 s.w.g. will do. If the wire has to be specially bought, 36 s.w.g. (as used in the prototype) would be a good choice. The start of the wire should be soldered to one of the outside terminal tags and 48 turns should be wound in the upper grooves, ending by fixing to the centre terminal tag.

The second part of L1 is wound in the lower

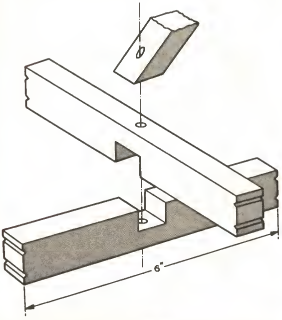
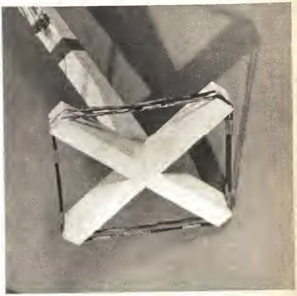


Fig. 1 : The construction of the search coil wooden framework.



The search coil. Note the terminal tag at the top left and the taping of the wires.

grooves, again 48 turns, anchoring at the centre and other outer terminal. Both coils should be wound in the same direction and the centre terminal used only as a convenient centre tap which is needed for the circuit.

All windings should be tight, including the leadups to the terminal tag. Once completed the windings should be taped together at several points to hold them firmly.

It should be emphasised that the successful operation of the Treasure Tracer depends largely on the care taken in the construction of this search coil and loose windings will make operation very difficult and unreliable.

L1 is connected into the collector circuit of Tr1 as shown in the circuit diagram in Fig. 2. C2, shown as a 500pF capacitor, is connected across the coil and this combination will resonate at about 130kHz. The value of C2 and C4 (in the reference oscillator circuit) should be of the same type and reasonably close in value; miniature 5 per cent polystyrene types are very good here and inexpensive. It doesn't matter too much what their values are as long as they are the same, but to stay within the regulation frequency band they should be over 390pF.

The components in the search coil oscillator are connected to form a Hartley oscillator, working at the frequency mentioned. R1 provides the base bias for Tr1 and C1 provides the feedback signal to maintain oscillation.

A low value resistor, R3, is connected in the emitter and this is shared by Tr2 which forms the reference oscillator.

L2 is a standard Denco LW aerial coil which is fitted with the three windings necessary. The main one (between points 1 and 6) is tuned by C4. Another of the windings is arranged to feed back to the base forming a blocking oscillator; this also carries the base bias to Tr2.

The shared emitter resistor R3 means that there is a mixing action in Tr2 and a degree of the search coil oscillator signal is mixed with that of the reference oscillator to make the beat note.

It is necessary to tune one of the oscillators to bring it close to that of the other and here the reference oscillator can be tuned over a wide range by altering the position of the ferrite dust core. The coil should be mounted as shown in Fig. 3 with a small knob fixed to the brass thread attached to the dust core.

The take-off point of the coil comes from the third winding of L2 (between pins 8 and 9). This is d.c. blocked by C5, detected by D1, smoothed by C6 and applied to the base of Tr3.

The signal here will be the beat note or an audio frequency represented by the difference in frequency of the two signals.

The base bias for Tr3 is provided by R5 with R6 acting as the collector load.

Tr4 further amplifies this audio signal and applies it to the 80Ω loudspeaker in the collector. R7 and C7 are included to raise the emitter voltage of Tr4 and to limit the quiescent current. The impedance of the

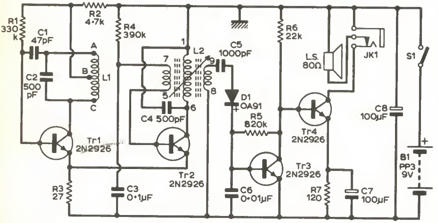


Fig. 2 : The complete circuit for the P.W. Treasure Tracer.

★ components list

Resistors

R1	330kΩ	R5	820kΩ
R2	4·7kΩ	R6	22kΩ
R3	27Ω	R7	120Ω
R4	390kΩ	All ¼W, 5% types.	

Capacitors

C1	47pF	C5	1000pF
C2	500pF†	C6	0·01μF
C3	0·1μF	C7	100μF 6V
C4	500pF†	C8	100μF 25V

† see text

Semiconductors

Tr1	2N2926	Tr3	2N2926
Tr2	2N2926	D1	OA91
Tr3	2N2926		

Miscellaneous

L1—see text and drawings
L2 Denco LW aerial coil, Type 1T
LS 75-80Ω miniature loudspeaker
JK1 3·5mm jack socket with cut-out switch
SW1 On-Off slide switch
B1 PP3, 9V battery
Chassis 6⅜ x 2¾ x 1⅞in., (H. L. Smith Ltd. 287/9 Edgware Road, London W.2.) 60p inc. postage.

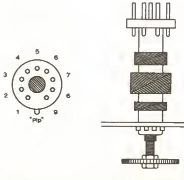


Fig. 3 : The pin numbering and mounting of L2.

loudspeaker can lie between 35Ω and 80Ω and various miniature types with impedances in this range are available. If difficulty is experienced in obtaining one of these, the loudspeaker can be replaced by a transistor output transformer (such as the Eagle LT 700) feeding a lower impedance loudspeaker.

There is a tendency for the two r.f. signals to lock together if they are within a few Hertz of each other. This is not too serious but the inclusion of R2, which drops the supply to Tr1, reduces this tendency. Theoretically the junction of R1 and R2 should be decoupled to the negative line using a $0\cdot1\mu F$ capacitor; this however made no difference in the prototype but may be included if Tr1 fails to oscillate.

Note that the chassis is connected to the positive rail rather than the more conventional negative line. This enables simple fitting of the jack socket, JK1, one connection of which has to touch the chassis.

CONSTRUCTION

The majority of the components are mounted on a small piece of 0·15in. matrix Veroboard, 16 holes by 13 holes and this is shown in Fig. 4.

The chassis used in the prototype, and highly recommended, is available from H. L. Smith Ltd. (see components list) and the bottom of this is drilled as shown in Fig. 5. The three holes in a triangle are fitted with 1in., 4BA screws and the component board is mounted on these, spaced off by means of nuts.

The loudspeaker can be glued in place and the wiring between the Veroboard and the other components is shown in Fig. 6.

The recommended chassis comes with a lipped lid which is screwed to the wooden handle as shown in Fig. 7. A hole ¼in. in diameter is fitted with a rubber grommet to take the wires leading to the search coil L1. Stiff wire should be used to run between the chassis and the terminal tag and this should be firmly taped to the handle as shown in the photographs. A small loop is left before entering the chassis to enable it to be opened.

An internal view of the completed prototype.

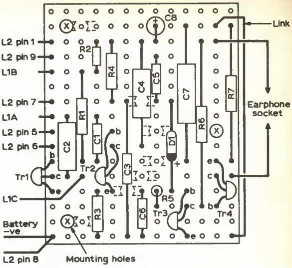


Fig. 4 The component layout on Veroboard.

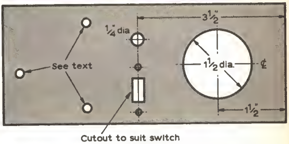


Fig. 5 : The drilling of the bottom of the chassis.

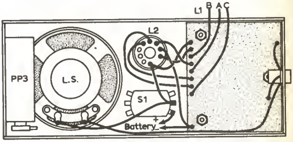


Fig. 6 : The wiring between the component board and the other components.

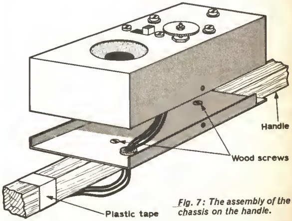


Fig. 7: The assembly of the chassis on the handle.

TESTING

Once all wiring is done a visual check should be made to ensure all is well and this being so, the Treasure Tracer can be switched on.

If all is correct the tuning of L2 will produce two positions where a strong beat note can be heard.

A number of weak signals may be heard at other settings. These are probably caused by radio signals on those frequencies but they are very low compared to the main signals.

The beat note should be set at the lowest stable audio note—probably between 50Hz and 200Hz. When a metal object is brought near L1 the note will either go up or down, depending on whether the search coil oscillator is working higher or lower than the reference oscillator.

By experience it was found that is was better to arrange for the note to go *down* in frequency when a metal object was approached but this is up to the user—a rising note may be preferred.

Certain objects—especially brass—go against the general trend and operate in reverse—causing the note to rise when iron and aluminium cause it to fall.

No volume control is fitted as the output from the loudspeaker is fairly low—about 75mW, though this proved sufficient and was not found too low even by the sea shore. Headphones or earpieces with impedances between 50Ω and 4000Ω all work when plugged into the socket—this automatically cuts the loudspeaker out if wired as shown.

The current consumption is not too high—it should certainly be under 20mA and several hours of searching are possible using the PP3 battery specified.

Before carrying out your first search, eliminate as much movement of the leadup wires as possible by taping them, as even a mild breeze will cause a change in note otherwise.

In testing it will be found that nearly all large objects cause some change in frequency—even laying the coil on the ground— but these changes will be minute compared to that caused by even a small piece of metal.

Do not expect to become an expert in a few minutes. The use of a device of this type needs a degree of skill and it took all of us several hours before we became reasonable at it. Now, after the test, we have used the detector to find a whole mass of new material, including more coins, but this was outside the testing period and the finds were not witnessed so we are not including later items in the list.

Well, where do you search? *Note that there are very heavy penalties for using such a device in areas scheduled as being of historical interest and there have been prosecutions for this.* However there is no need to search in such places and paths or roads that have been in use for centuries are a good place to start; river banks will also prove fruitful.

An excellent small book "A Fortune Under Your Feet" by E. Fletcher elaborates on this and is recommended reading for those encouraged by early results.

If you find something of interest, let us know. We are offering £2 for the most interesting letter we receive dealing with objects found. It doesn't have to be valuable, just as long as it is interesting. ■

I.C. of the Month—*continued from page 310*

two heatsink tabs. If the i.c.'s are to be used to their full 5 watt rating some form of additional heatsinking is needed. This may take the form of directly soldering about two square inches of copper to each tab or alternatively to equivalent area of printed circuit board foil. At any rate, in most applications the full output ratings will not be approached so that the above precautions are necessary only for worst case operating conditions.

View of I.C. showing unusual heatsink tabs and staggered leads.

To find out the maximum output currents that the units can deliver all one has to do is to determine the product of the voltage drop across terminals 2 and 7 of the i.c. and the current drawn, making sure that the answer does not exceed 5 watts.

MAXWELL

by G8DSH