PE MAGNUM METAL LOCATOR

PART 2... ANDY FLIND

LAST month the general principles of the GEB detector were explained, and construction of a machine began with a p.c.b. comprising power supply, auto-tuning and output stages. This month the remainder of the construction will be covered.

SEARCH COILS

It's best to begin by winding the search coils, which will be required for testing the front-end circuit board at various stages. The Magnum uses a pinpoint coil, for reasons explained last month; these are slightly harder to make than widescans but the results obtainable are well worth the effort. The coil assembly is based on a 10in dia. 'Melaware' plate, made from a very rigid plastic, obtainable from most stores selling picnic tableware.

The inside of the plate is thoroughly roughened with glasspaper to enable glassfibre resin to stick to it, and two 'L' shaped plastic brackets are bolted to the top as in Fig. 6. These were cut from a thick, strong square-shaped clip intended for mounting square section plastic drain pipes to exterior walls, obtained from a local builders' merchants. They are bolted to the plate with 2BA countersunk screws with the heads inside, so nothing protrudes to foul the coils. A hole is drilled just behind one of the brackets to allow a 4-core screened cable to pass through.

The two coils are wound on pins pushed into a suitable board. The larger transmitting coil is made with just five pins positioned as shown in Fig. 7a, on which 60 turns of 32 s.w.g. enamelled copper wire is wound. It can be tied temporarily with a few twists of wire and removed from the pins—this is fiddly but not too difficult—bent to the shape of Fig. 7b, and bound tightly with a spiral of thin bare wire such as 5 amp fusewire, leaving a loop near the lead wires for use as a connection. Remove the temporary ties as the binding proceeds. A strip of aluminium cooking foil is then wrapped over the bare wire to form a Faraday shield, and this is held in place with another tight binding of the bare wire. Note that both wire bindings and the foil *must* have a gap—this is most important, as if the Faraday shield were allowed to form a complete 'turn' around the circumference of the coil it would render it useless.

PICKUP COIL

The pickup coil is made in the same manner, consisting of 200 turns of 36 s.w.g. enamelled copper wire wound around 16 pins placed in a 4in diameter circle. Faraday shielding is fitted as on the transmitting coil, again with the all-important gap.

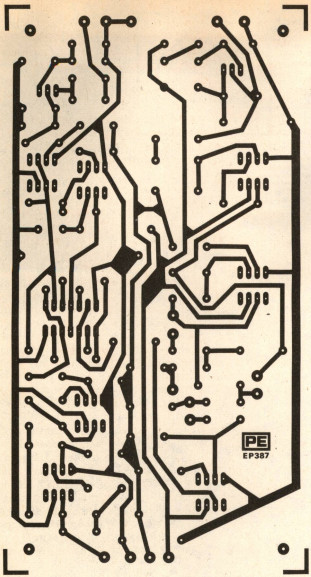
The transmitting coil can now be fixed in place on the former using a small quantity of fibreglass resin. A Holts' 'Fibreglass Repair Kit', obtainable from motoring accessory shops, was used in making the prototype. The coil is best fixed in stages, using clothes pegs and weights to keep it in place as necessary. Apply the resin with a soft brush and have a jar of cellulose thinners handy to dunk the brush into the moment it starts to 'gel'. Push the 4-core screened lead through the hole in the plate, connect the coil leads to two of the cores, and the Faraday shield to the screens. It can be difficult to keep the lead in place whilst the resin sets; one way of doing this is to drill two tiny holes on each side of it and secure it flat against the plate with a couple of twists of thin wire. The pickup coil is not fitted at this stage.

FRONT-END PCB

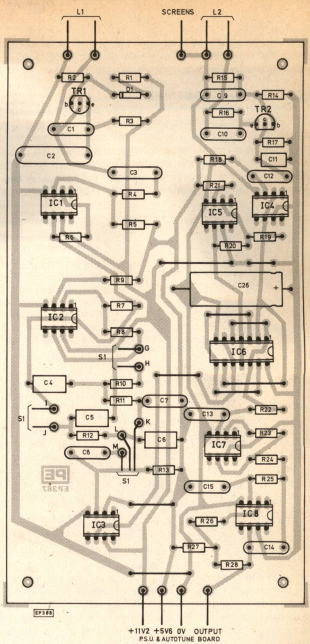
Start building the 'front-end' circuit board by fitting all the links. Then fit R1 to 3, C1, 2, and 26, D1, and TR1. Hook up the transmitting coil and apply power from the supply board. Continue using a resistor in series with the 18 volt battery in case any faults arise during tests, as described last month. The transmit oscillator should now be running, at between 15 and 16kHz. This can be checked by placing a radio tuned to a weak longwave station very close to the coil-faint whistles due to harmonics of the transmitted signal beating with station carries should be present. Faint is the word, however, as the Magnum's oscillator produces a very clean signal. This and other parts of the circuit can be more easily checked with a 'scope of course, but if you have one you'll probably have realised this anyway.

Next fit R4 to 13, C3 to 8 and IC1. Apply power and check that IC1's d.c. output voltage (at pin 6) is equal to 5·6V. Fit IC2, apply power and check IC2's d.c. output is 5·6V. Fit IC3, hook up VR1 across points I and J, VR2 across points G and H, and fit some lengths of wire so that point M may be shorted to points K or L, and short one of these. It doesn't matter which at this stage. Apply power and check that IC3's d.c. output (pin 6) is 5·6V. The output of IC2 should actually be switching from rail to rail at the oscillator's frequency but the average value of output should be 5·6V. A fault will usually result in its being fully driven to one of the supply rails, so this is a useful test. Check that settings of VR1 (M shorted to L) and VR2 (M to K) makes little or no difference to IC3's output voltage.

It might be of interest to explain that in the original design, the pots were connected directly as they are in this test, and a 2-way switch was fitted to M, K and L. This provides 'Ground Reject' (VR2) and 'Discriminate' (VR1). However, on the first beach outing it was found that the 'Beach Effect' could only be rejected with the 'Discriminate' control: a predictable effect since beaches are usually conductive. This prevented the discrimination from being used to reject foil, of which large amounts are to be found on most beaches. To overcome this problem the switching was



FRONT-END BOARD



rearranged to provide a third 'Beach' position, in which VR2 is effectively switched into the discriminate circuit instead of the ground one. Thus VR2 can then be used to reject false signals from wet beaches in the same way as from ground, whilst VR1 can once again be used to check finds as intended.

Continue the construction by fitting R14 to 21, C9 to 12 and TR2. Connect the pickup coil temporarily, apply power and check that the emitter voltage of TR2 is approximately 0·6 volts above the negative rail. Fit IC4, apply power and check IC4's output voltage (pin 6) is 5·6V. Fit IC5, apply power and check that the output of IC5 is also V/2.

Fit R22 to 28 and C13 to 15. Fit IC6, observing the usual CMOS handling precautions for this chip. Place the pickup coil in approximate position over the transmitting coil, apply power and monitor the top end of R22 with a meter. The voltage present should be somewhere between 2 and 8 volts and should alter if VR1 or VR2 (whichever is selected by shorting M to K or L) is moved. Adjust the pickup coil position to obtain 5·6V at the top end of R22. Note that the Faraday shields of the coils shouldn't touch even though they are both connected to the lead screens: if they touch on both sides they can form a 'shorted turn' in the middle of the assembly. Small pieces of card should be placed between them to prevent this from happening.

Fit IC7, check it's output is the same as that at the top of R22, i.e. 5·6V. Fit IC8. Check 5·6V is still present at IC7 pin 6—if not adjust coil position. Then check that 5·6V is also present at the output of IC8. This completes the construction of the front-end p.c.b.

HARDWARE ASSEMBLY

The rest of the hardware can be constructed next. This is made mainly from $\frac{3}{4}$in diameter plastic plumbing pipe and fittings, assembled as shown in Fig. 8. It's simply glued and pushed together, making a very presentable handle and stem in a surprisingly short time. Wood dowelling is inserted at strategic points of the stem to prevent it from flattening when bolts are passed through it and tightened. The search coil is fixed by a length of studding passing through the two brackets and the end of the stem, with a wingnut at each end, so that it's tilt may be easily adjusted by the user. The control box base is secured to the shaft with two bolts, and the tuning button is fitted into the end of a bicycle handlebar

grip which is then pushed onto the plastic pipe, threading the wires through the pipe to emerge through a small hole close to the control box.

CONTROL BOX ASSEMBLY

The electronics now have to be assembled into the control box. The top should be cut to accept meter, pots and switch in the layout shown in Fig. 9. Note that the top only fits the base one way round before starting this! A pattern of holes can be cut in one of the aluminium side panels to act as a speaker fret, the speaker being glued into place. A clip to hold the three PP3 batteries is fashioned from sheet

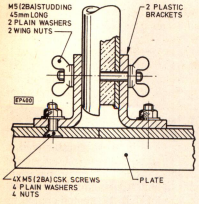


Fig. 6 (left). Search plate mounting assembly

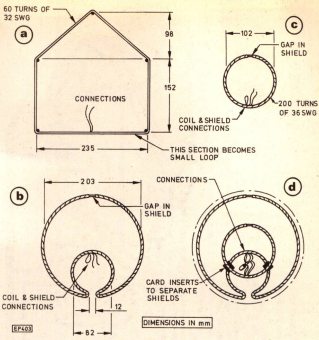
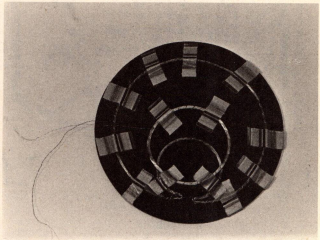


Fig. 7 (right). (a) Winding the transmitting coil; (b) Transmitting coil bent to shape; (c) Pick-up coil; (d) Positioning the coils

aluminium and wood and bolted to the same panel, and to the ends of the bolts a piece of Veroboard is attached to act as a connecctng block for the leads from the batteries and tuning button. Four 4BA bolts passing up through the base of the box act as stand-off pillars on which the two p.c. boards are mounted one above the other, the front-end board being uppermost.

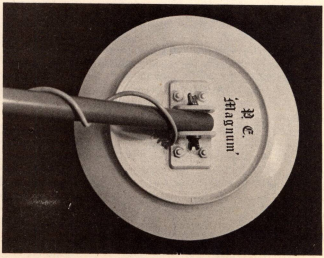
The best way to make all the connections to the boards is with ribbon cable, soldering this to them before fitting them into the case and noting the poit to which each coloured wire goes. A headphone socket is optional: if required it may be connected as shown in Fig. 5. 'R' will have to be selected for the phones to be used, in the prototype a value of 100 ohms was found to be suitable. A 5-pin DIN plug and socket was used for the coil lead, whilst not strictly necessary this does allow for experimenting with different coils at a later date.

The box specified is supplied with feet which were discarded, the securing bolts being shortened a little to compensate.



SETTING UP THE SEARCH COILS

When all the components have been wired up the final tricky part has been reached; the setting up of the search coils. This must be done with metal parts such as the securing bolt and wing nuts in place, though there is no need to have the coil assembled to the stem. There should be no large metal objects close to the coil during this stage. This might also be a good time to mention that the machine can be affected by line timebase radiation from 625-line TV sets, so if you get a 'mushy' sound or a pulsed audio effect from it, check this first. Coil adjustment is actually not as critical as it is for a normal IB machine, but there is a best point and for a GEB machine it is the position where absolute minimum residual amplitude output (and maximum phase shift effect) is obtained from the pickup coil. (Conventional IBs usually work best with a slight 'offset' from absolute null.) This cannot be monitored with the phase sensitive detector in the machine itself, so the circuit of Fig. 10. should be lashed up and connected to IC4 output (top end of R19) and used with



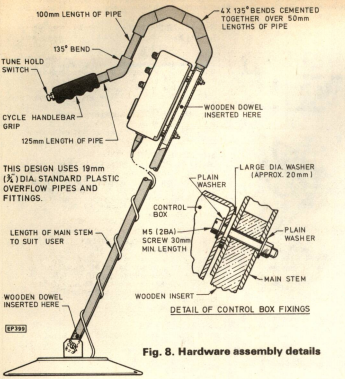


Fig. 8. Hardware assembly details

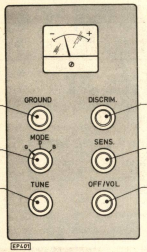
consists of adjusting the pickup coil position for absolute minimum output from the amplitude monitoring test circuit, use resin to stick it down in stages, rechecking the adjustment at each stage. Final fine trimming can be done with only a small section of the pickup coil still moveable.

After the positioning of the coils has been completed the coils can be given a coat of resin, followed by a layer of chopped strand glassfibre mat and more resin, which produces a search head assembly that is neat, tough and totally waterproof. One word of caution; don't use more resin than you have to or the finished head may be heavier than necessary.

FINAL ASSEMBLY AND TESTS

All the test components can now be removed and the machine finally assembled and tested. If you've never used a GEB machine before, you're in for some pleasant surprises.

On switching on, the meter should self-zero within a couple of seconds and the tuning control should then be set just below the threshold of the audio tone. The sensitivity of this machine is quite incredible; on most inland sites you'll probably need to keep the sensitivity control set to around mid-point. With the switch in 'Ground' position, a point can be found on the 'Ground' control where moving the head to and from the ground has no effect whatever—on one side of this point there will be positive ground effect, on the other negative, so it's not difficult to find. Adjusting this control for wet beaches is the same, except that the switch should be set to 'Beach'.



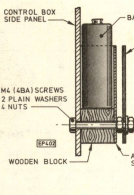


Fig. 9 (left). Control fascia; (above) Detail of battery mounting

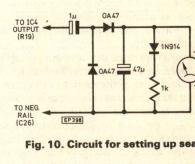


Fig. 10. Circuit for setting up search coils

the 1 volt range of a testmeter to facilitate setting up minimum amplitude.

Set VR1, VR2 and VR3 to mid-point. Switch to 'Discriminate' and switch on. The meter monitoring amplitude will probably indicate full scale. Carefully adjust the pickup coil position until the reading falls—this may take some patience as it's easy to push the coil right past the null position without noticing it if you're too hasty. Remember to keep those Faraday shields apart! Once you have the coils somewhere near the null, try presenting metal objects to the coil whilst watching the centre-zero meter. A non-ferrous object such as a copper coin should cause it to rise, whilst a ferrous object such as a nail should cause a fall. If the opposite happens the phase of the pickup coil must be reversed, either by turning it over or by reversing its lead connections.

Once correct coil phase has been established setting up

Once an object has been located, the machine should be switched to 'Discriminate' and the nature of the object determined. A certain amount of ground effect will be apparent in this mode, depending upon the actual terrain being searched. Ferrous objects produce a negative response at all settings of the discrimate control, but as this control is advanced so the machine will begin to reject small pieces of silver paper, then larger pieces, thick foil, and finally pull rings. It should be noted that in the pull-ring reject setting, however, it will also reject silver coins up to about 10p size. All discriminators suffer from this problem; but the ability to reject scrap iron and foil without difficulty is an absolute boon. Some practice with assorted objects—coins, nails and scraps of foil etc., is recommended before setting forth with this machine.

The tuning 'Hold' button will be found necessary for discriminating and for pinpointing the exact position of finds.

So, Good Hunting! Don't forget you need a licence for your detector; application forms for this can be obtained from: The Home Office, Radio Regulatory Dept., Waterloo Bridge House, London SE1.

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