Metal Locator

For discriminating treasure hunters, we present the Shadow metal locator from Altek, featuring deep-seeking VLF and discriminating operation.

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The design of professional quality metal detectors is a specialist field which up until now the commercial manufacturers have kept very much to themselves. This design incorporates many of the latest techniques in push button VLF discriminators which have hitherto been the subject of well guarded trade secrets. The detector performs as well as commercial models costing over £200.

It uses a ready made search head, as a home-made one would have no hope of giving the results needed for a design of this nature (would you use a home-made speaker with your hi-fi?). The search head from Altek enables depths of over 12” for a single coin to be achieved.

Construction

The use of sockets for IC1 and IC5 is not recommended due to the increased risk of leakage currents in the push button circuitry. C12 is a very critical component. Its value is not too important but it must be of the highest quality, have low dielectric absorption and high resistance. Polycarbonate types were used, but polystyrene would be equally suitable.

To keep the design as tidy as possible 20 way ribbon cable is used to connect the board to the controls. As each colour appears twice they are differentiated by indicating from which side of the ribbon they come - either white or black (the colour of the wire at the edge of the ribbon). Circuit pins are used at all other connection points so that wires can be attached after the board is installed in the case.

Setting Up

When construction is complete and the detector appears to function it is necessary to make sure that the Rx coil has been properly connected. Due to the way the head is aligned it is not possible to check it until this stage.

Hold the head away from all metal and set the controls as follows: MODE and GROUND fully anticlockwise. ALL OTHERS at mid-rotation. Depress the tuning button and hold it in, rotate the TUNE control until the meter needle is approx mid scale. Release the button and bring the head close to a metal object - the meter should be deflected to the right. If it goes left, reverse the wires from the Rx coil (see diagram).

Use

Using the detector and interpreting the results is very much a matter of experience but the following notes will help.

Tuning

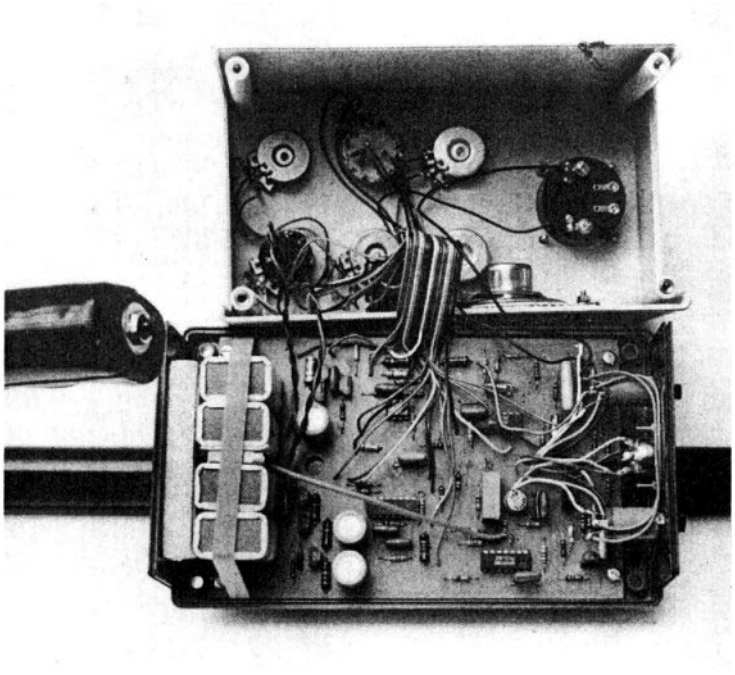
To adjust, the push button must be depressed. When tuned to your satisfaction release the button. If the tuning point drifts then it can be brought back simply by pushing the button for a second or two. When first switched on the memory retune hutton will be needed every few seconds but as thermal equalibrium is established it will be needed less often.

Sensitivity

It is not necessary to set the sensitivity to maximum to achieve the greatest depth. Amplification is so great that a maximum setting may bring on instability. Experiment intelligently with it - mid-rotation is about right.

Ground

This only works in the VLF mode. Its setting is quite critical. First set the tuning with the head away from the ground. Move the head down to the ground and observe the meter. If it swings left - rotate GROUND clockwise, if it swings right - turn anticlockwise. Hold the head away from the ground and depress the button to reset the tuning. Repeat this procedure until the meter does not deviate when the head is lowered. A slight misadjustment is tolerable but if it is turned too far clockwise the detector will work in “reverse”. When VLF is selected the detector is in its most sensitive mode.



Connections from the PCB are taken to the top panel controls by 20 way ribbon cable.

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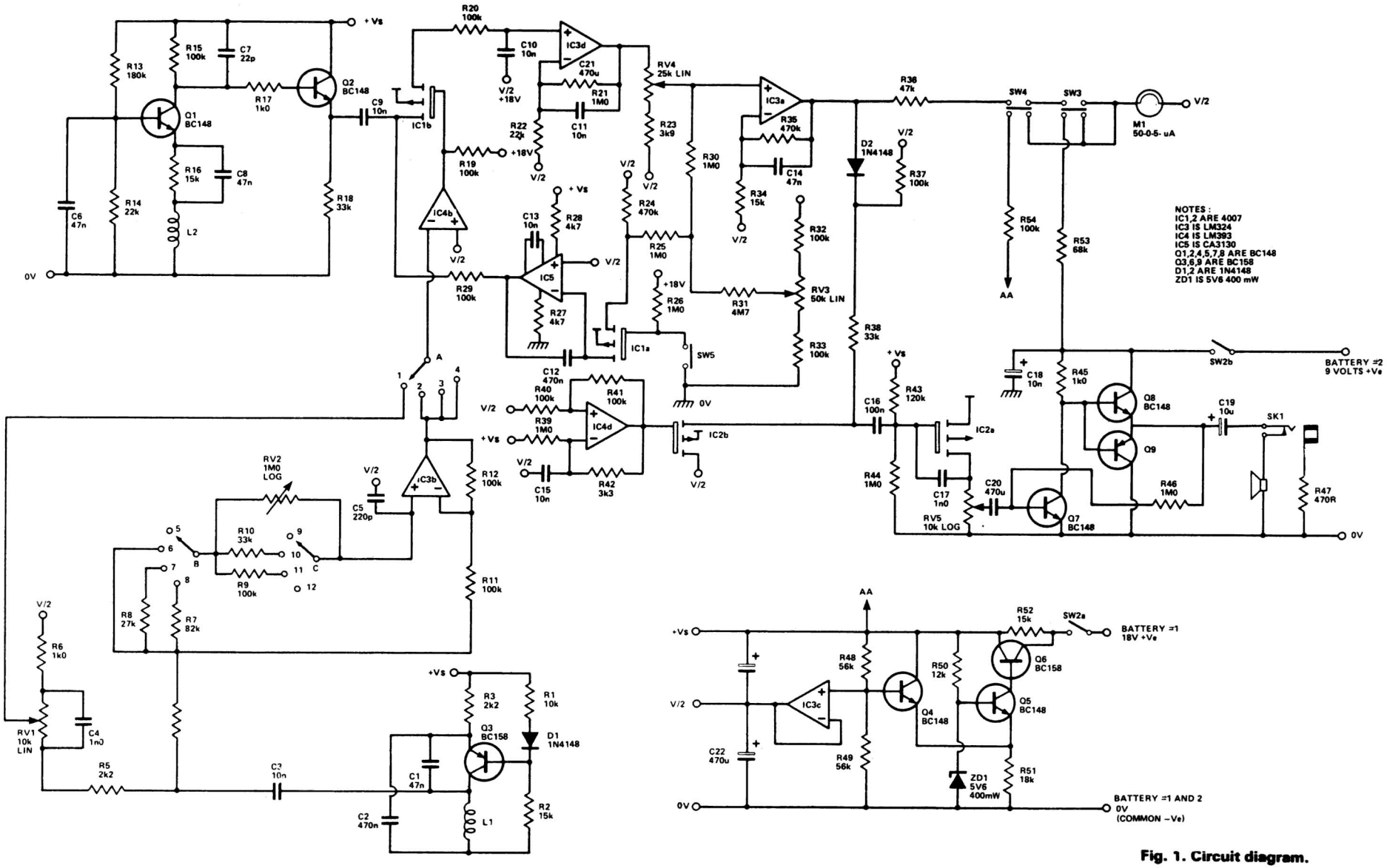

Fig. 1. Circuit diagram.

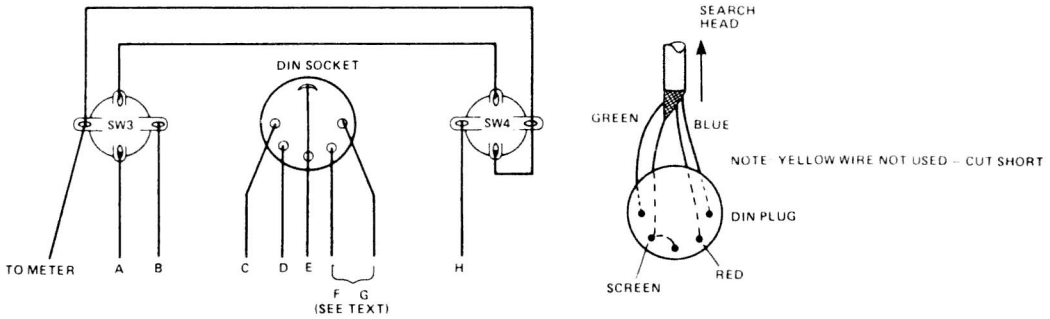

Fig. 2. Connection details for DIN plug and socket and SW3, 4. Note the tag lengths on SW3, 4.

Discrimination

It only functions when a TR mode is selected. The degree of discrimination is controlled jointly by the MODE (coarse setting) and the DISCRIMINATION (fine setting) controls. Together they set the point at which the resistance of the target causes a left or right deflection on the meter. The circuit in this design is very good indeed. It is possible to differentiate between a can ring pull and a gold ring, for example. However, the discrimination control reduces sensitivity slightly. It is best to use a detector of this type in VLF mode until a target has been found and then use discrimination to determine its Iikely value!

Finally we ought to point out that in the UK It is necessary to obtain a licence before using a metal detector. This is not necessary elsewhere. Application forms can be obtained from: Home Office, Radio Regulatory Dept., Waterloo Bridge House, London S.E.1.

HOW IT WORKS

L1 and L2 are the Tx and Rx coils in the search head. The signal to drive L1 is produced by Q3 and associated components which generate a sine wave of approx. 16 kHz. Part of this signal passes via C3 to the phase shift section which produces a reference signal for the phase comparator. When the VLF mode is selected, RV1 (ground control) and C4 provide a variable phase advance of O - 180 degrees.

The suitably modified signal is squared up by the precision voltage comparator IC4b and applied to the gate of the phase comparator IC1b. Meanwhile, the signal picked up by L2 passes through Ql and Q2 which amplify, but do not distort or shift the phase, and meet the reference signal at IC1b.

The signal emerging from IC1b is a DC signal upon which is superimposed an AC component corresponding to the phase coincidence of the reference and received signals. This is integrated by IC3d and a portion of the emerging DC signal is tapped off by the sensitivity control RV4. This is further amplified by IC3a and applied to the meter and, via D2, to the audio gate lC2b.

Audio is generated by an astable formed from the remaining half of the voltage comparator IC4a and, after being gated by lC2b, is amplified by IC2a, Q7, Q8 and Q9. RV5 is the volume control.

IC5 and IC1a form the heart of the push button tuning system. Part of the voltage from RV4 is added to a voltage determined by the position of the slider of RV3 and applied to the source of IC1a. When the tuning button is depressed, the normally high source to drain resistance falls and allows current to flow through the FET and build up as a voltage across C12. IC5 inverts and buffers the voltage to provide a DC bias for the phase comparator. The change of bias at IC1b in turn affects the DC conditions at IC1a (via IC3d and RV4). In other words a negative feedback loop is established whenever the tuning button is pressed. Within a second or two the new DC levels settle down and the button is released. The system is then maintained by the charge held on C12.

The power supply to the audio section is unstabilised, but due to the sensitive nature of the DC levels in the control section, stabilisation is required there. ZD1 provides a voltage reference for the differential amplifier formed by Q4 and Q5, which control the series pass element Q6. R52 allows a small current to Q4 and Q5 at switch on to ensure that Q6 starts conducting. The base of Q4 must always be at 50% of the stabilised supply (R48 = R49). This point is buffered by IC3c used in the voltage follower mode to source the V/2 supply. C21, C22 and C20 are decoupling components. Special attention has been given to cutting down the current consumption. The control section only takes 5.5mA and the audio section less than 2mA when silent or when using headphones.

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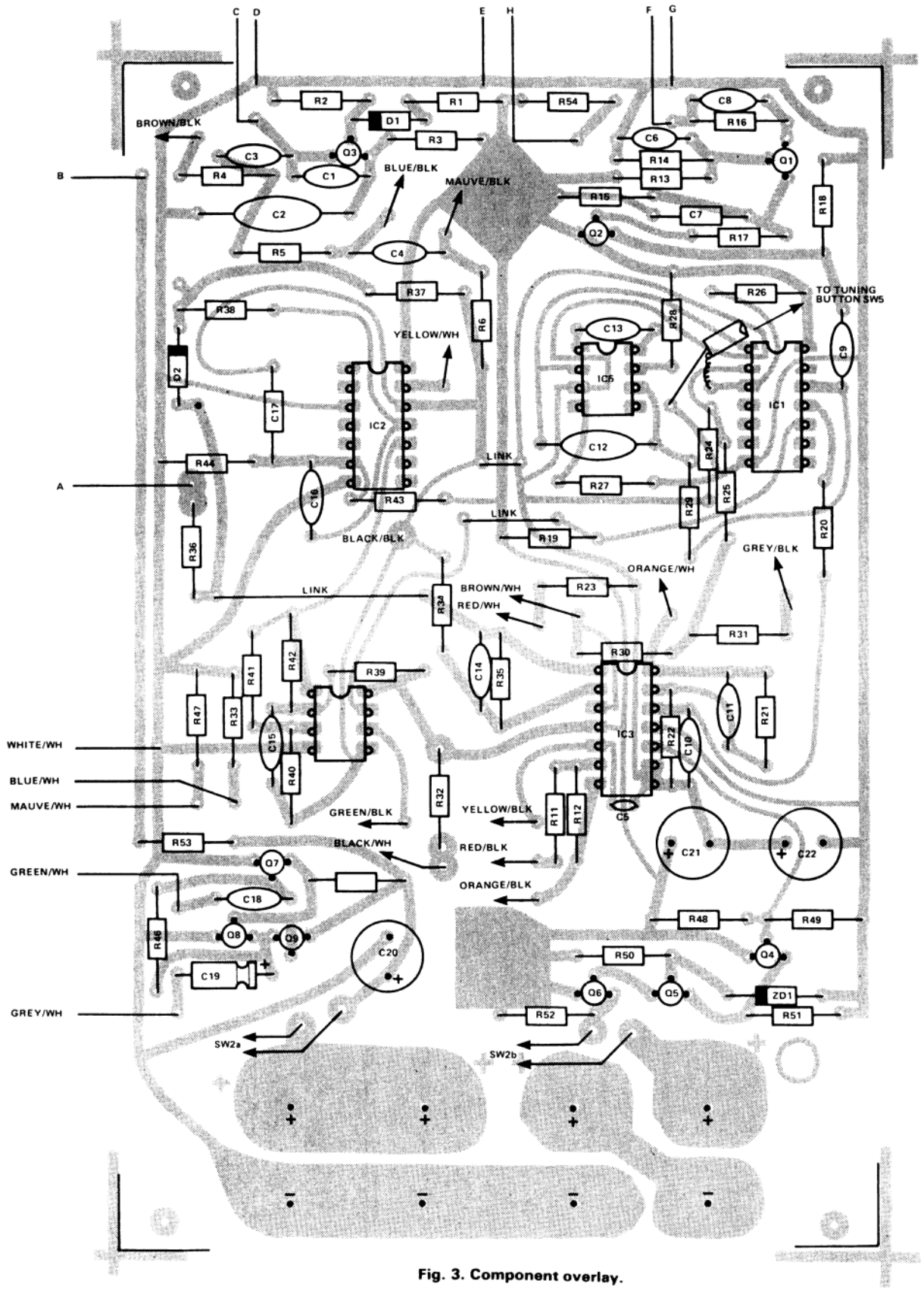

Fig. 3. Component overlay.

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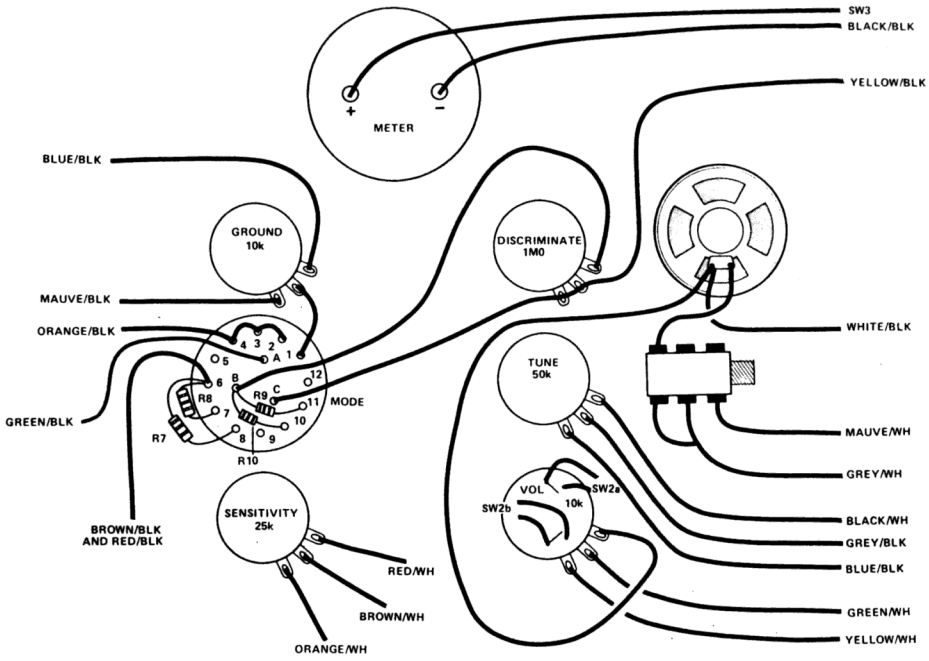
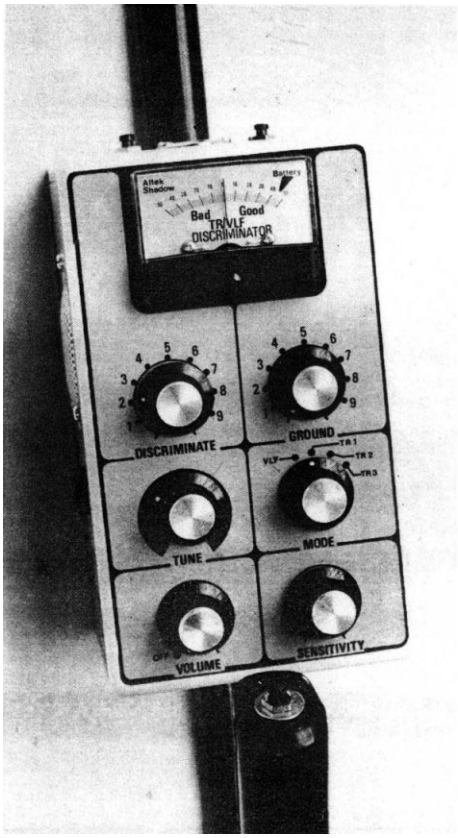


Fig. 4. Connections to controls on the front panel.

CONNECTION DETAILS FOR CONTROLS, METER, SPEAKER AND JACK SOCKET



PARTS LIST

Resistors All 1/4W, 5%

R1	10k
R2,16,34,52	15k
R3,5	2k2
R4,51	18k
R6,17,45	1k0
R7	82k
R8	27k
R9,11,12,15, 19,20,29,32, 33,37,40,41, 54	100k
R10,18,38	33k
R13	180k
R14,22	22k
R21,25,26,30, 39,44,46	1M0
R23	3k9
R24,35	470k
R27,28	4k7
R31	4M7
R36	47k
R42	3k3
R43	120k
R47	470R
R48,49	56k
R50	12k
R51	18k
R53	68k

Potentiometers

RV1	10k lin
RV2	1M0 log
RV3	50k lin
RV4	25k lin
RV5	10k log

Capacitors

C1,6,8,14	47n polyester
C2	470n polyester
C3,9,10,11, 13,15,18	10n polyester
C4,17	1n0 polystyrene
C5	220p ceramic
C7	22p polystyrene
C12	470n polycarbonate
C16	100n polyester
C19	10µ 25v electrolytic
C20,21,22	470µ 16v electrolytic

Semiconductors

IC1,2	4007
IC3	LM324
IC4	LM393
IC5	CA3130
Q1,2,4,5,7,8	BC148
Q3,6,9	BC158
D1,2	1N4148
ZD1	5v6 400mW

Miscellaneous

50-0-50 µA meter, 8R 2-1/4" speaker, 1/4" stereo jack socket, 6 knobs, 2 double pole c/o push buttons, single pole make push button, 3p 4W rotary switch, 5 way 180° latching DIN plug and socket, PCB, search head, shaft and handle, case to suit, 4 pairs PP3 battery connecting studs, 20 way ribbon cable.