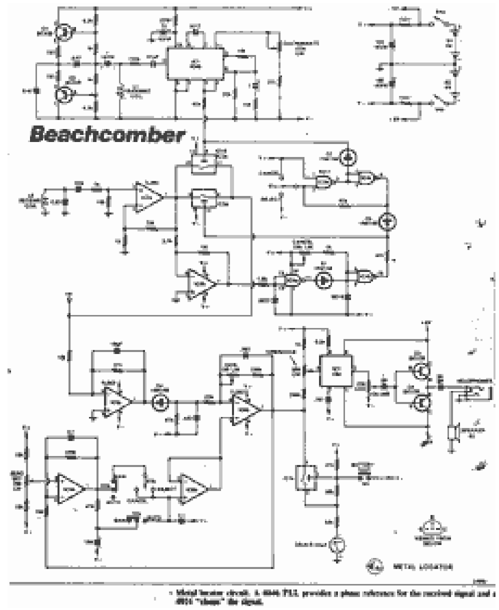
BEACHCOMBER Metal Detector



BEACHCOMBER by COLIN DAWSON

Here's a chance to build a metal locator with discriminate control and automatic zeroing. It even has a cancelling facility. With a special moulded plastic case and preassembled search coil, the Beachcomber is a snack to build and it looks superb. It is sensitive and accurate — ideally suited to finding coins and medals.

Now that the dust has settled from the last gold rush, we can all sit down and offer some rational thought about the business of striking it rich. Even the most optimistic treasure hunter would have to concede that most of us are never going to see a "Hand of Fate" on the end of our shovel. For those intent on an early retirement, money would be better spent on Lotto than a metal locator!

Granted, gold is still lying around by the bucketful for those with dedication enough to retrieve it. Trouble is, most of it is in pieces that you could lose on a pin head.

If you're intent on using a metal locator, a far more rewarding ambition would be to find coins, rings, watches, medals and other relatively common items. Even this modest ambition is likely to be more rewarding in terms of satisfaction than financial gain — but any amateur prospector will tell you that they only do it for "fun" anyway!

Of course the amount of fun derived from using a metal locator is rather minimal if the machine has inadequate performance. In this respect, we think that the Beachcomber should prove quite satisfying. It has a search coil that can locate "small items quite accurately and there are front panel controls for most aspects of its operation.

The Beachcomber has no less than six potentiometer controls and two switches. Initially, the novice operator may well be confused but operation is really quite simple once the technique is mastered. The versatility of the machine is improved through the inclusion of these controls which compensates for the extra time spent in learning to use it.

Let's take a quick look at what all the controls are. The front panel is divided into three zones — Meter, Audio and Mode. Let's start with the Mode section. This contains the Discriminate and Cancel pots. These control the degree of metal discrimination and ground cancel respectively. For readers unfamiliar with these expressions, they are explained later.

Selection between Discriminate and Cancel modes is made by a thumb switch mounted in the handgrip. Operating this switch, which is a momentary contact type, also resets the meter needle to zero. This brings us to the Meter section of the front panel which includes the Gain Control and Zero Set. The Gain function simply determines the sensitivity of the meter (this also incorporates the power on/off switch).

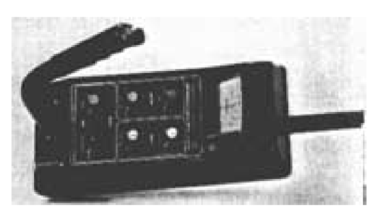
The Zero Set control is a means of controlling the point to which the meter needle actually resets when it is zeroed. In most cases, this will be adjusted so that the meter (a centre zero type) is centre scale. There are good reasons, however, why this will not always be ideal — but more about this later.

The Audio section contains the Volume and Threshold controls. Volume is self explanatory; while the Threshold setting determines the amount of meter deflection that must occur before any sound is produced. The sound is related to meter deflection in frequency — greater deflection leads to increased frequency.

The only remaining control is the second switch. This switches the Beachcomber to either automatic or manual mode. In the manual mode the meter is zeroed through the operation of the thumb switch as previously described. In the automatic mode, the meter is continually zeroed automatically. The response of this function is damped so that the meter can still register a find. It takes about one second for the meter to zero from full scale.

Modes of operation

Operation of the circuit can not be explained quickly, but a brief overview of the main "blocks" would be advisable at this, stage. Referring to the circuit diagram, circuitry immediately to the left of the transmit coil is the oscillator. Through inductive coupling, this signal also appears in the receive coil. Any metal brought into the magnetic field of the search head causes a change in both amplitude and phase of the received signal.



The received signal can be processed in two ways, depending on whether "Discriminate" or "Cancel" has been selected. In any case, the signal is rectified and subsequently fed to the meter driving section of the circuit (IC6a). Other circuitry in this region of the diagram is related to meter zeroing, both manual and automatic.

Shown to the right of this block is the audio section of the circuit, centred on IC7.

OK, so that's the circuit at a glance — now let's get down to details.

How it works

The transmit oscillator is based on one BC338 NPN transistor (Q1) and one BC328 PNP transistor (Q2). Oscillating at a frequency of about 9kHz. it produces a very nearly sinusoidal signal of up to 25V peak to peak.

Notice thai the biasing resistors for the two transistors are not identical — one has a 4.7kft resistor in place of an 8.2k. enables the oscillator to operate down to lower voltages than would be possible with perfectly symmetrical biasing. The resulting asymmetry of the transmitted signal is only slight and of no consequence.

Although the oscillator signal is also fed to the 4046 phase locked loop, we need not consider this aspect for the moment. Turn instead to the receive circuitry. To couple the receive coil signal most efficiently at the designed operating frequency, it is connected across a 0.22mkF capacitor. This yields a nominal received signal of 70mV peak to peak at the coil.

The 022mkF capacitor and 1k resistor which couple the received signal to IC2a form a high pass filter. The nominal 3dB point is at about 8kHz.

IC2a is a TL062 op amp, set up as a non-inverting amplifier having a gain of . Actually, all of the op amps in this circuit are TL062s, the low power version of the TL072 dual op amp. It only uses about 200mkA per amplifier as compared to 1.4mA for the TL072s. With six op amps in the circuit, this certainly leads to worthwhile battery savings.

When metal is introduced into the magnetic field of the search head, the phase of the received signal changes with respect to the transmitted signal./FONT>

This phase effect is more pronounced for ferrous metals than non-ferrous. With respect to the amplitude, the ferrous materials will cause a small decrease whereas non-ferrous will cause an increase. In some cases, the amount of increase is quite substantial.

To take advantage of these characteristics, the discriminate mode must be sensitive to both phase and amplitude changes. This means that the received signal can not simply be rectified and used to directly drive the meter. Instead, it is "chopped", and only about half of the waveform is processed. To sense phase changes, the chopping must be performed by some control signal having the same frequency as the received signal but with independent phase relationship. This is achieved by a rather interesting means.

Notice that the output of IC2a (pin 1) is connected to two other ICs. Consider firstly 1C3, the quad bilateral switch. Each of the four "gates" in this package has a pair of in/out pins, as well as a control pin. When the control pin is taken high, a low resistance path is provided between the two in/out pins. Analog signals of either polarity can be passed between these pins. Actually, two such gates are used to control the output of IC2a — IC3a and IC3b,

Only one of these gates will be on at any given time, depending on whether Discriminate Or Cancel has been selected. IC3a is on for Discriminate and IC3b on for Cancel. Control of these two gates is achieved by a latch consisting of ICs 4c and 4d. Sla. which selects the mode, is a momentary-contact type — hence the necessity to use a latch.

The control pins for ICs 3a and 3b (pins 6 and 12) are connected to the latch circuitry through diodes D2 and D3. The polarity of these diodes is such that the latch can disable either of the CMOS switches but can not actually turn them on. This function must be performed by other circuitry connected to the CMOS switch control pins.

In the case of IC3a, the "on" state of the switch is controlled by 1C1. the 4046 phase locked loop. In fact, it is pin 4 — the VCO output of IC1 — which controls the "on" state of IC1.

The VCO (voltage controlled oscillator) is connected so that it is operating at the same frequency as the transmit oscillator. It must, however, be made to operate at different and adjustable phase angles to the transmit oscillator. This is an essential requirement of the Discriminate function.

Recall that IC1 has a connection to the transmit oscillator output (pin 14). In fact, this connection is made through an RC attenuator consisting of the lOOk resistor and 47pF capacitor. These components reduce the oscillator signal to a level the CMOS 1C can safely handle.

The received input signal and VCO signals are "compared" in a phase comparator. This generates an "error" voltage which is fed back to the VCO input, altering its frequency to match the input signal. In fact, the error voltage is a series of pulses which vary in width according to the frequency difference. These pulses are filtered before being fed into the VCO input (pin 9), so that the error voltage is DC.

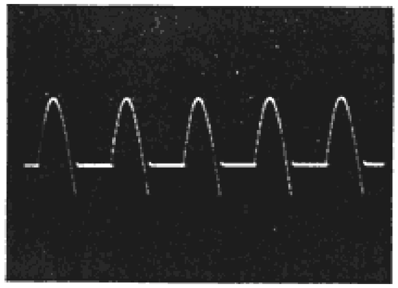
Actually, two phase comparators are available in the 4046. The comparison occurs between the input signal and the VCO output. When phase comparator 2 is used, the VCO operates at the same frequency and in phase to the input signal. Phase comparator 1, which is used in this circuit, only maintains the two signals at the same frequency and a constant phase relationship. This does not mean "in phase" (ie 0° phase angle) — just a constant phase angle.

In fact, when the VCO is operating in the centre of its frequency range, the phase angle will be 90°. This relationship alters to 180° at the extremes of the frequency range.

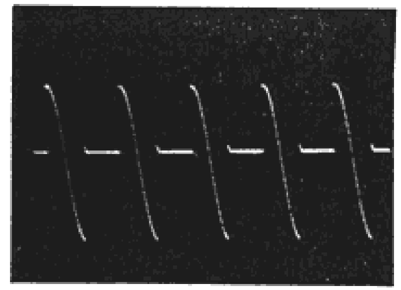
The range of frequencies over which the VCO can operate is not unlimited. In fact, external components are used to set a definite limit. A capacitor connected between pins 6 and 7 (.0012mkF in this case), in conjunction with a resistor from pin 14 to ground, sets the upper frequency limit. In our circuit, this resistor is actually a 27k) resistor in series with a 100k pot. Another resistor can be connected between pin 12 and ground to set the lower VCO limit, although this option is not used in our circuit.

Photographs showing waveform at test point. CRO setting is 50µs and 0.5V/division.

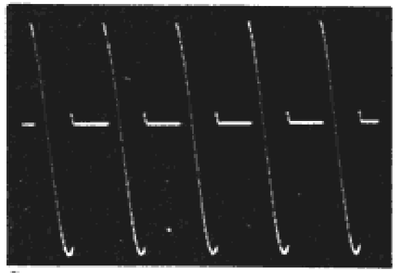
DISCRIMINATE MODE



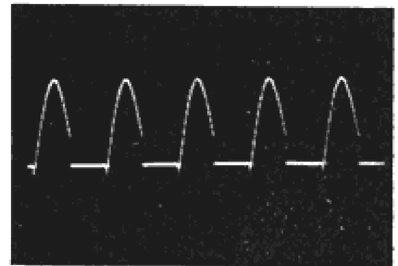
Control at minimum setting.



Control at maximum setting.

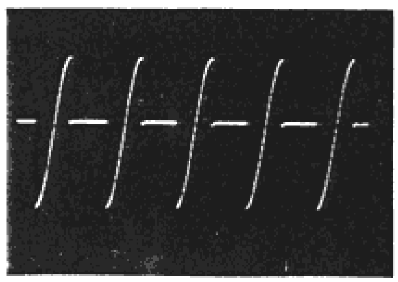


Control at maximum with non-ferrous metal near search head.

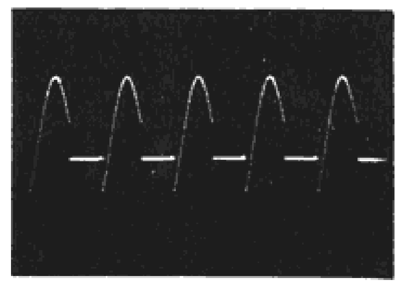


Control at maximum with ferrous metal near search head.

CANCEL MODE



Control at minimum setting.



Control at maximum setting.

With the component values shown, the upper limit for the VCO is set at less than 10kHz with the Discriminate pot set to maximum resistance. This limit increases to about 45kHz with the pot set to its minimum resistance.

Now it becomes apparent that altering the setting of the Discriminate control results in the VCO output shifting in phase with respect to the transmit oscillator. Since the VCO output also gates the received signal by means of IC3a, we now have a means of sampling a specific portion of the return signal waveform. This is the basis of the Discriminate mode of operation.

Now consider the Cancel circuitry. This is, fortunately, rather less complicated. The received signal is still chopped by a CMOS switch (IC3b), but there is no phase detection. The Cancel mode is only sensitive to amplitude changes.

The control signal is now derived from the received signal rather than the transmitted signal. IC2b applies a gain of 370 to the output of IC2a. This high gain ensures that IC2b's output (pin 7) is a square wave, irrespective of the sine wave amplitude appearing at IC2as output (pin 1).

Feeding the output of IC2b into the filter consisting of the 1.5k resistor and .0022/iF capacitor produces a slight delay in triggering of IC4a.

The square wave output of IC4a feeds through D1 into a small value capacitor (.0018mkF). The polarity of Dl is such that only the negative pulses are fed to the capacitor to discharge it. On positive pulses Dl is reverse-biased and the capacitor charges via the lk resistor and 25k) Cancel pot connecting it to the positive supply rail. The rate of charging depends on the setting of the pot.

The waveform appearing at the capacitor is used to trigger IC4b. This means the output of IC4b is a series of positive pulses with duration determined by the Cancel control.

The output of IC4b is connected through a 47k resistor to the control (pin 12) of IC3b. It is therefore the gating signal for this CMOS switch. Bear in mind that this gating signal is only effective when Cancel has been selected and D3 is reverse biased. Otherwise, D3 will clamp pin 12, IC3b high — irrespective of the condition of IC4b's output.

The extent to which the Cancel mode can operate in the Beachcomber is limited by the search coil. This coil is unshielded and therefore subject to ground capacitance effects. In some situations this tends to swamp the inductive response of the coil and the Cancel circuitry cannot compensate sufficiently. To review quickly, we have the situation where the signal available to the meter driving circuit can be derived from either a phase and amplitude sensitive detector (IC3a) in the case of Discriminate, or an amplitude-only detector (IC3b) in the case where Cancel is selected.

The chopped signal, as derived from IC3, is immediately amplified by IC5a. This is a simple inverting amplifier having a gain of about 2.5. Its output (pin 7) is fed into a capacitor via D4. The capacitor used here (.033mkF) has a 47k bleed resistor across it which sets the "normal" level across it to a convenient voltage.

The voltage appearing across the .033mkF capacitor ultimately determines the amount of meter deflection, although it must first be amplified. This is the ???oose of IC6a. This provides a gain of Up to 41, depending on the setting of the 1M gain potentiometer.

Notice that the non-inverting input (pin 5) of IC6a is not connected to the 0V rail as we might normally expect. Instead, the voltage reference for this pin is derived through the meter zero circuitry. This senses the amount of offset appearing at the output of IC6a (and therefore at the meter) by means of IC5b.

To activate the meter zero circuitry, S1 must be operated. As we have already seen, Sla will select the mode of operation but, simultaneously, S1b will be causing the zero circuit to operate. Assuming that S2 is in the manual position, S1b would then connect the output of IC5b to the non-inverting input (pin 3) of IC6b, thus charging the 0.1mkF capacitor.,An amount of offset is p??y produced at the output of IC6b which is in proportion to the amount of offset in the meter.

Notice also that the output of IC6b is connected back to the input of IC6a. Since IC6a originally produced the meter offset, a correction voltage is now applied to its non-inverting input which exactly compensates for that offset. The meter will then be zeroed.

Because IC6b has the 0.1mkF capacitor connected to its non-inverting input, it functions as a sample and hold. Even after S1 is released, the correction voltage is "held" in the 0.1mkF capacitor. Of course, this correction voltage is only applicable at the time of S1's operation. Any offset produced after this time will result in meter deflection — until such time as S1 is operated again and the circuit zeroed.

In this way, any meter deflections resulting from changes in the controls (such as a mode change) or environmental conditions can immediately be nulled. Once zeroed, the meter will deflect in the normal way should a "find" be made.

So far, we have assumed that S2 is in the manual zero position. Should it be selected to the automatic position, two changes occur. Firstly, the path from IC5b to IC6b via S1 is broken. This prevents S1 from activating the zero mechanism. Secondly, an alternate path from IC5b to IC6b is provided. This path is via the 47k resistor and 100mkF capacitor. These components now provide a permanent path for the zero signal so that it is effective continuously.

A delay is thus provided by the 47k resistor and the 100mkF capacitor so that any "find" will not be instantly nulled. The meter will deflect for about one second before zeroing is effective. Note that if the circuit is held over a "metal object for more than one second in this mode, the meter will still zero.

The unfortunate consequence of this characteristic is that if the metal is now removed, a secondary meter deflection will result. This deflection is in the opposite direction to the initial deflection — in other words, a metal which was initially rejected will now produce a brief accept signal. The simple way to avoid this problem is to make sure that the circuit does not have time to zero over any piece of metal.

The 25Omh Meter Zero pot sets the point to which the meter will return when it is zeroed. By altering the reference voltage appearing at the non-inverting input (pin 3) of IC5b, it alters the circuit's response to any given offset. This must be adjusted while S1 is operated, otherwise the altered zero point will not become apparent until the next time S1 is operated. Normally, the zero point will be set for zero meter deflection (centre scale), but this is by no means essential. The meter could be zeroed to a position left of centre or even full scale left.

This would provide greater resolution for metals in the accept region. Additionally, the audio section, which produced a frequency in proportion to the meter deflection, could be made to operate with improved resolution by this means.

A CMOS switch (IC3c) is included in the circuit between the output (pin 7) of IC6a and the meter. During normal operation, the 47k resistor connected to the control of this switch (pin 5) ensures that it is on, ie low resistance from pin 4 to 3. This permits normal meter operation. If, however, the battery test switch (S3) is operated, pin 5 of IC3c will be pulled low, switching it off.

Simultaneously, S3 will provide a connection for the meter to the negative supply rail through the 68k resistor.

The meter is now measuring the negative supply rail. No facility to test the positive supply rail has been provided, but the current drain on the two rails is equal. This means that both battery packs will drain at the same rate — only one of them need be tested.

In our Beachcomber, the meter has full scale readings of ± 30. New batteries produced a deflection of around 27. When the reading fell to below 20, the batteries were due for replacement. Other meters may have different scales which will necessitate calibration with known reference voltages. The batteries can be regarded as flat when the supply has fallen to +- 4V, measured after the 150Omh resistors.

Only the audio section of the circuit remains to be described. This is reasonably straightforward. It is based on an LM566 VCO (IC7). Only two external components are needed to set the normal operating frequency of this device, a capacitor and a resistor. We have chosen .001mkF for the capacitor (connected to pin 7) and 8.2k for the resistor (connected to pin 6). A control voltage applied to pin 5 shifts the normal frequency over a large range.

In this circuit, the control voltage is taken from the output of IC6a and therefore varies in proportion to the meter offset. The 25ki Threshold control is used to calibrate the audio section so that no noise occurs until metal is detected. Initally, only a low "ticking" will occur. With increasing meter deflection, this will rise to a low growl and finally a humming sound. The audio detection circuitry is most sensitive when in the "ticking" range.

As the LM566 cannot drive the speaker directly, a buffer section has been included. This consists of Q3 (BC338 NPN) and Q4 (BC328 PNP). Drive for these transistors, taken from the square wave output of IC7 (pin 3), passes through the 25k Volume pot.

Space is provided in the Beachcomber case for a headphone socket. This must be wired so that the stereo headphone speakers are in series.

The positive and negative supply rails are connected to their respective battery terminals through 150omh resistors. The purpose of these resistors is mainly to reduce the supply to the CMOS ICs. With new batteries, the total supply voltage would be about 19V but, in most cases, the CMOS ICs are designed to operate with a maximum supply of 15 V. With the 150Omh resistors in circuit, the supply is reduced to around ±6.2V for a total of 12.4V — well within the CMOS range.

The 150ft resistors also reduce the current drain — particularly in the early part of the battery cycle where it might otherwise be excessive. Note that the resistors should not be omitted or substituted — the Discriminate control would not have the correct range of adjustment.

The audio section of the circuit is operated directly from the batteries. This section, which is quite rugged enough to withstand the higher voltage, has a fairly heavy current drain once the audio threshold has been exceeded. This would lead to severe fluctuations in the circuit voltage if we attempted to operate the audio section through the resistors.

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Construction

The special moulded plastic case, centre zero meter and search head assembly used in the Beachcomber are available from all Jaycar stores.

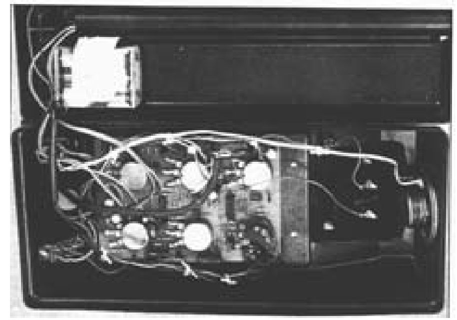
By using these ready-made parts, you will be able to get a really attractive project without investing too much effort. Begin construction by cutting the pot shafts down to size. The pots will all be mounted on the PCB later — it is very much more awkward to cut the shafts then. For the particular knobs we used, 10mm shafts were needed. A few other tasks should be completed

PARTS LIST

1 moulded plastic case (see text)
1 meter to suit case (50mkA-0-50mkA)
1 search head assembly
1 PCB, 143X101 mm, code 84md12
1 DPDT momentary contact switch
1 DPDT slider switch (Jaycar cat 0821 or equiv.)
1 SPST momentary contact switch 1 6.5mm stereo phono socket

1 50mm 8 Omh speaker
6 knobs to suit potentiometers
2 6 X AA cell battery holders 2 screws (to suit slider switch) 25 PCB pins

Beachcomber Inside view of the Beachcomber



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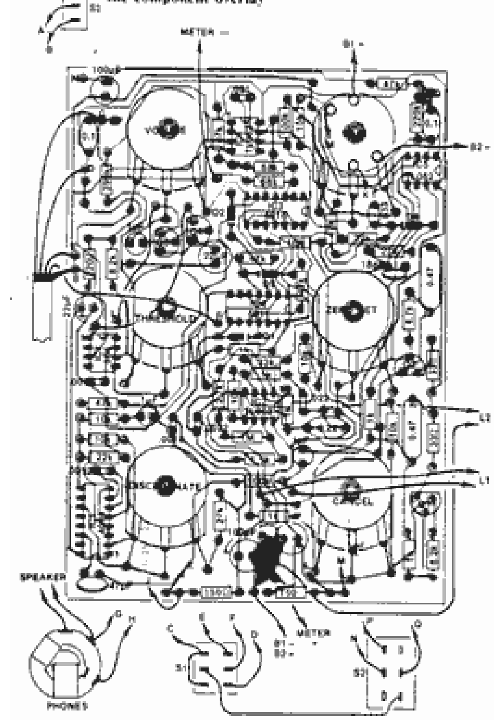
Semiconductors

2 BC338 NPN transistors
2 BC328 PNP transistors
1 4046 CMOS phase locked loop
1 4016 CMOS quad bilateral switch
1 4011 CMOS quad NAND gate
3 TL062 dual op amps
1 566 function generator
4 1N4148 diodes

Capacitors

3 100mkF/16V electrolytics
1 22mkF/16V electrolytic
1 22mkF/16V bipolar electrolytic 3 VF/16V electrolytics
2 0.47mkF metallised polyester (greencap)
1 0.22mkF greencap
2 0.1 mkF greencap
1 .033mkF greencap
1 .022mkF greencap
1 .0022mkF greencap
1 .0018mkF greencap
1 .0012mkF greencap
2 .001 mkF greencap
1 47pF ceramic
1 18pF ceramic

the component overlay



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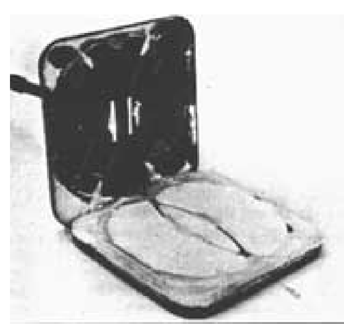
Resistors (1/4 W, 5%)

1 X 1M
1 X 390k
1 X 220k
2 X 100k
2 X 68k
6 X 47k
1 X 33k
2 X 27M
1 X 22k
1 X 15k
6 X 10k
2 X 8.2k
1 X 4.7k
1 X 2.7k
1 X 1.5k
5 X 1 k
1 X 220 Omh
2 X 150 Omh
2 X 33Omh



Inside the search head. The transmit and receive coils overlap by about 25mm.

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Potentiometers

1 X 1M log switchpot

1 X 10Ok linear
1 X 25k log
3 X 25k linear.

Miscellaneous

Hook-up wire
5-core cable (see text)
machine screws
solder

before assembling the PCB. Drill a series of holes in the front of the case to form a speaker grill, then glue the loudspeaker in place. Also check that S2 (the Auto/Man, switch) aligns properly with its mounting holes. We found that the mounting holes — just to the left of the handle — needed to be enlarged just a

???ch. Now mount the Scotchcal front panel and label adjacent to S2. Finally, drill a hole in the end of the handgrip to mount S1.

Now you're ready to start work on the PCB. It measures 143 x 101mm and is coded 84md12. PCB pins will have to be used for this project — it is not practical to make connections any other way. The pins should be inserted before any other components — there are 25 in all.

Next should come the links. There are six mounted on the PCB — leave the four insulated links running between PCB pins until the wiring-up stage.

Now mount the rest of the components. Although the pots should be left until last, each one will connect to the board by means of three short pieces of tinned copper wire. These should be soldered in place now.

Two sets of pot nuts are required for this project. One set fixes the pots to the ???B and the other clamps the pots to the case. Having taken care of this last aspect, turn now to the wiring.

S1 is mounted in the handle and a total of 5 connections must be made to it. We used a 55cm length of 4-core shielded cable, but ordinary hook-up wire is probably quite adequate. In any case, leave some extra length to permit the hand grip and S1 to be removed if necessary.

It is essential that the two coils in the search head are connected with the correct polarity. Transposing the connections for one coil will mean that the received signal is out of phase with the oscillator. This, of course, would play havoc with the phase sensing circuitry. One of the insulated wires connecting to each coil has a black stripe on it. Connect this to V- for the transmit coil and 0V for the receive coil.

The only components mounted in the bottom half of the case are the batteries. Make sure that the wires connecting to them have plenty of spare length to

Operating instructions

1. Auto/Man to Man.
2. Volume to max.
3. Threshold to min.
4. Discriminate to max.
5. Cancel to min.
6. Switch on, leave Gain at min.
7. Press the thumb switch to the right and hold.
8. Adjust Zero Set to centre the meter needle.
9. Adjust Threshold so that the sound is just stopped.
10. Release the thumb switch.
11. Put a $1 coin or other test item on the ground.
12. Move the search head from side to side as you slowly approach the coin.
13. Replace the coin with steel washer, nut or similar item:
14. Reduce the Discriminate control in steps and repeat (12).
15. Press the thumb switch to the left.
16. Replace coin and repeat (12) whilst making adjustments in steps to the Cancel control.
17. Replace the coin with the washer.
18. Repeat 16.
19. If the meter drifts from zero during any of the steps (when no metal is present), reset it by operating the thumb switch (right if in Discriminate mode, left for Cancel).

This should give you some idea of the responses you can expect from the Beachcomber. Generally, it is preferable to use the Discriminate mode rather than Cancel as a slightly greater sensitivity is provided. Always use the lowest practical gain setting. Higher settings will increase the chances of an erroneous detection. One other point — remember to switch the Beachcomber off while digging to conserve the batteries.

facilitate disassembly of the case. The battery pack holders already fitted to the case were intended for larger battery packs. A piece of styrofoam under each one will help to hold the smaller 9V packs in tightly.

Before switching on, set the Discriminate and Cancel controls to the full anti-clockwise position, volume to minimum, Threshold to minimum, Zero Set to about half range and S2 to Man. Now switch on and set the gain to about half range. Switch S1 to the left — the meter should deflect. Adjust the Zero Set and ensure that the meter responds. If not, there is a fault.

Now release S1 and make an adjustment to the Cancel control. The

meter indication should change as the control reaches the extreme of adjustment. If not, try adjusting the Discriminate control. If the meter responds to this, S1 is installed "back-to-front". Either rotate it in the handle or transpose its V + and V - connections.

Assuming that normal responses have so far been obtained from the machine, operate S1 to the right and repeat the zeroing test. Release the switch and adjust the Discriminate control — again, check for some meter deflection.

So far so good? Then turn the volume up to maximum and increase the Threshold through its full range. The sound should range from the aforementioned ticking to a squeal. At this stage you might also want to try the Beachcomber out with a pair of headphones (the internal speaker should be silenced when you insert the headphone jack). You will need to turn the volume down when using the. headphones.

Now for the clincher. Set the Discriminate control to maximum and zero the meter (S1 to the right). Put a coin on the ground where you can be certain that there are no buried metal objects. If you can't guarantee this last requirement then put the coin on a large cardboard box instead of the ground. Move the search head back and forward over the coin, steadily decreasing the height until meter deflection occurs.

Depending on the gain setting, this should happen somewhere between about 2cm and 15cm. Try decreasing the amount of Discrimination. The coin should always register, although the sensitivity may decrease with lower discriminate settings.

Replace the coin with a similarly-sized ferrous object. This should register as an accept with the Discriminate control at minimum and a reject with the control at maximum. Somewhere between these extremes, the ferrous object should be completely ignored.

You could now try the automatic zeroing — select S2 to the Auto position. Repeat the Discriminate test with the coin, but keep the search head moving over it. A brief meter deflection should occur at each pulse. Now try with the ferrous object. The negative meter deflection will still occur — but so too will a brief "shadow" pulse in the positive direction. This is unavoidable, but by moving the search head fairly briskly, the effect will be minimised.

Be sure to develop a reasonable level of familiarity with the machine before taking it out in the field. Practice with coins, rings, aluminium ring-pulls and other items which you are likely to encounter. Bury some of them at depths up to 5cm.

There are some important limitations which you should be aware of. Because of the search coil configuration, the Beachcomber is more suitable for hunting small items such as coins. These can usually be detected with a fair degree of accuracy because the true "search" area of the head is a narrow strip (no more than 2.5cm) running most of the length of the head on its for-aft axis. Outside of this region, readings are not valid.

In fact, to either side of the "hot spot", negative detection areas exist. These will cause a smaller deflection of the meter in the opposite direction.

Hence for a typical find, the meter will respond with a small negative deflection, followed by a large positive deflection, , before swinging negative again.

The Beachcomber is not capable of discriminating against large ferrous objects. Large, in this case, refers to any object which is significantly larger than the "hot spot" of the coil. In practice, this is not a serious limitation. Clearly, any object which causes massive deflections of the meter should be regarded with suspicion, particularly if it is buried deeper than a few centimetres.

With respect to mineralised ground, the Locator will generally operate with reduced sensitivity. The worst case is wet sand at the beach. Only very shallow items can be expected to register. Note that where the soil is uniformly mineralised — as distinct from fluctuating — the Discriminate mode will probably yield slightly improved sensitivity. The Cancel mode is mainly of use where the soil tends to vary with each step.

Troubleshooting

If your Beachcomber refuses to cooperate, and there is no fault in the wiring or soldering, here are some troubleshooting procedures which may help. Firstly, if you have an oscilloscope the accompanying waveform photographs can be referred to. These show the correct waveforms at the test point — the outputs of IC3a and IC3b.

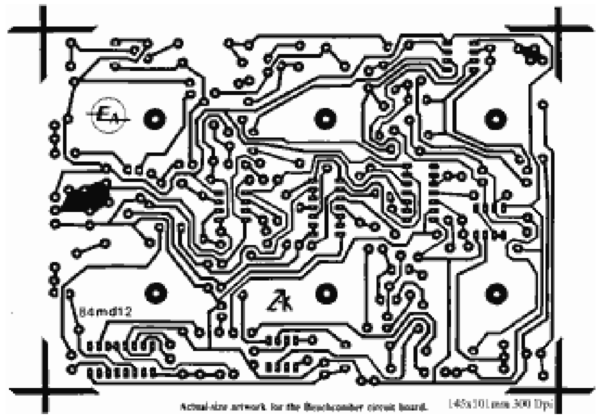
If you do not find very similar waveforms, this is cause for concern. A sine wave or a square wave is most definitely wrong. The distinctive chopped signal should be evident. If only the sine wave appears, there is no gating signal. Determine whether this is so for both Discriminate and Cancel modes. If a square wave appears at the test point, then no received signal is reaching IC3. This could point to a fault in either the receive circuitry of the oscillator.

Assuming that the correct waveform appears at the test point, any problem would most likely be in the meter zero circuitry. This can most easily be checked with the receive coil disconnected. Operate S1 and alter the setting of the Zero Set control.

If there is no response when S1 is operated, check that some voltage is actually being applied to pin 3 of IC6b. If not, trace back through the wiring to IC5b (pin 1 initially, then pin 2). If S1 causes meter deflection but the Zero Set doesn't change it, check the voltage at pin 3, IC5b. This should alter in response to the Zero Set.

If you have only a multimeter, disconnect the transmit coil. The voltage at pin 1 of IC2a should now be very near to 0V. The voltage at the test point should also be 0V in the Discriminate mode, irrespective of the setting of the Discriminate pot. In the Cancel mode, check that the voltage at pin 7, IC2b is also 0V. If pin 10 is low then no conclusive measurement can be made at the test point.

Where there appears to be a problem in selecting or changing the mode, measure the voltage at pin 4, IC4c. This should be high when Cancel is selected — it should stay high, even after S1 is released. Pin 4 should stay low when Discriminate is selected.



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