Mini-Metal Detector

by Dave Goodman

- ★ 25mm search range dependent upon size of object.
- ★ Finds nails, water and gas pipes in walls and plasterboard.
- ★ Complements the Live Wire Detector.
- ★ Simple to build and use.

If you have ever had to fit cupboards or shelving to partition walls then you will know how "hit and miss" it can be when trying to find the studding. Several methods of assisting with the task exist, such as elaborate relative density measurement systems or the much simpler proximity detector or metal detector. The Maplin Mini-Metal Detector can detect the presence of ferrous or various non-ferrous metals within the search area, such as iron wall board nails or brass screw heads or it could even detect the absence of metal in seemingly solid door sills on a car!

Along with the Live Wire Detector project, the Mini-Metal Detector is a must for DIY'ers of all ages or just for the fun of having built a very simple project with a multitude of uses.

How it Works

In the circuit diagram of Figure 1, it can be seen that IC1 is the main device, around which most of the other components are configured. The chip is somewhat special in that it was developed for just this type of proximity sensing application only. With reference now to Figure 2 block schematic, L1 and C1 form a tank circuit at the oscillator input pin 2. Preset RV1 in the oscillator feedback path determines the operating frequency of this stage, which is close to 400kHz at an amplitude dependent upon the 'Q' of the tank network. If the tank 'Q' drops then the signal reduces in amplitude, although the frequency remains the same. Spurious oscillations and spikes could cause the system to 'lock up', but this is prevented by a transient suppression stage at the input. Metallic objects placed in close proximity to the tank coil produces a change in 'Q' thus causing the peak signal level to drop. The amplitude level could drop too far to allow oscillation to

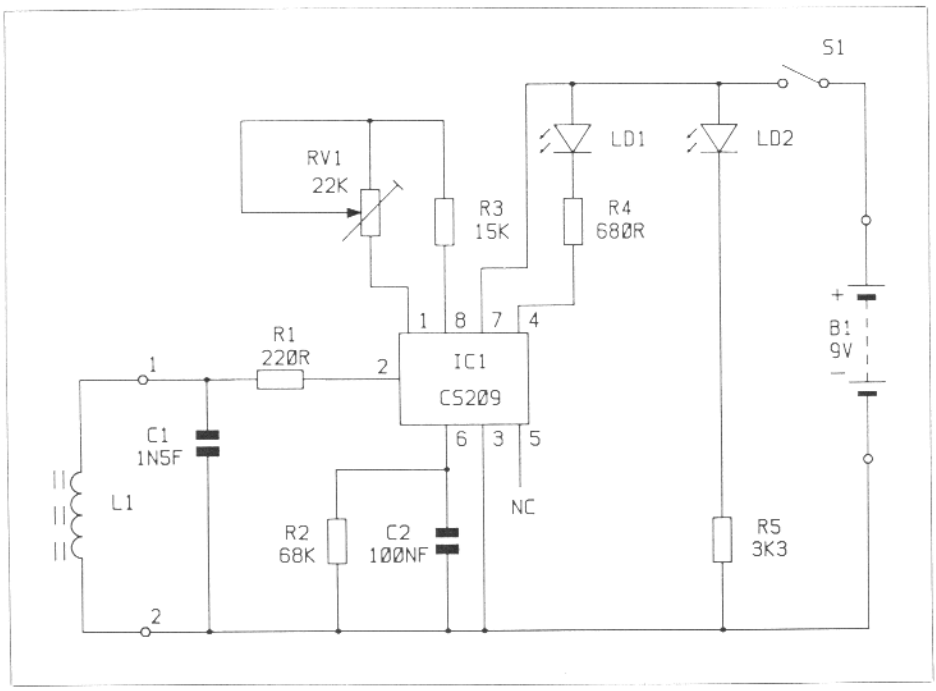
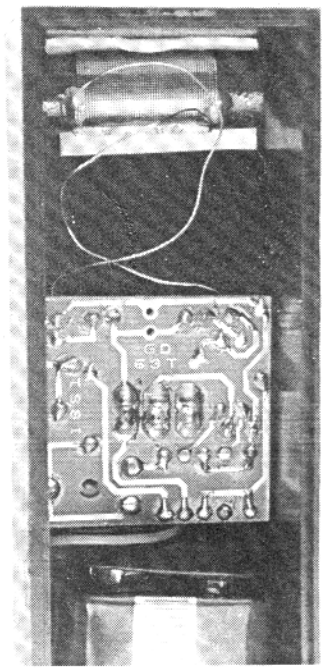


Figure 1. Circuit.



Inside the box.

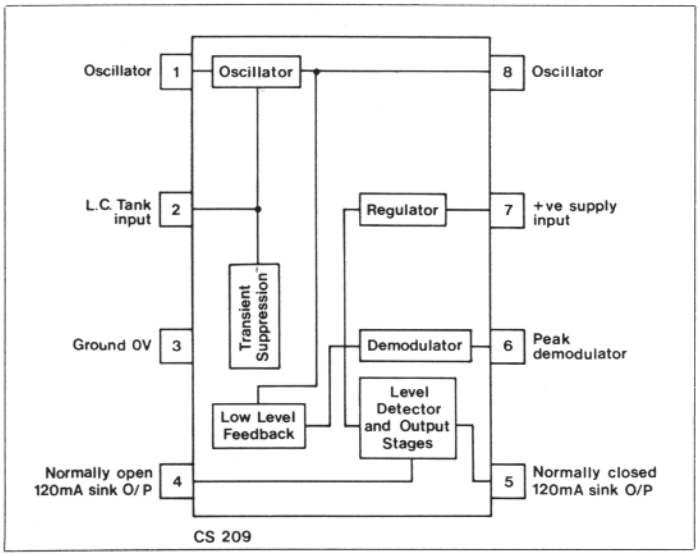


Figure 2. IC Block Schematic.

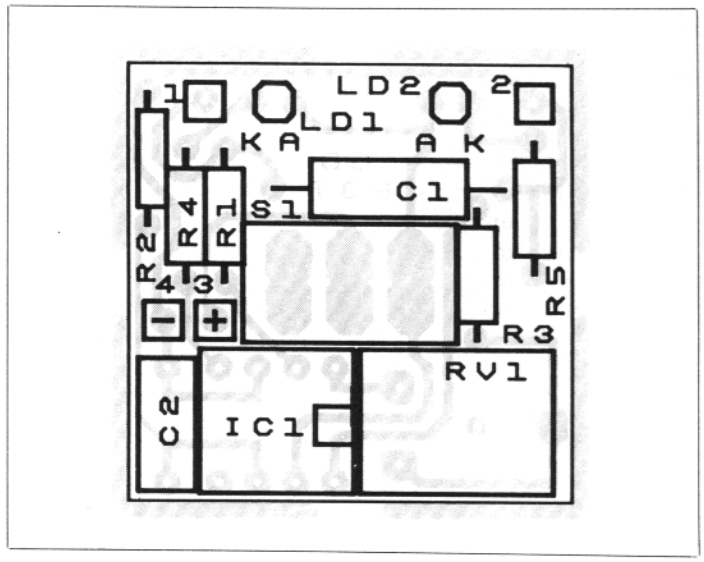


Figure 3. Board Overlay.

continue, therefore during low 'Q' conditions, a variable low level feedback is applied to maintain oscillation. The peak signal 'envelope' has its negative half detected by a peak demodulator which charges C2. R2 acts as a discharge path for C2 and the resulting DC level is compared with a level detector at the output stage. Pin 4 is an open collector output which can be likened to a relay Normally Open contact. When this stage trips, LD1 comes on via R4 and remains on while detection continues. LD2 and R5 indicate power on when on/off switch S1 is operated.

Construction

With reference to Figure 3 and the Parts List, fit the components, with the exception of the slide switch and the coil, as follows: start by fitting each of the resistors, it is important that each of the resistors lies flat on the PCB, otherwise they will foul the slide switch when the PCB is fitted into the box. Solder the components in place and cut off the excess lead-lengths.

Insert capacitors C1 and IC1, than C2 and RV1; C2 is easily broken so be extra careful with the legs when fitting. Now solder all components carefully to the PCB and cut off the excess lead-lengths. Cut the battery clip wires to a length of 50mm (2in.), tin them, and solder them to the PCB (black = $-V_e$; red = $+V_e$) at the positions marked '−' and '+' in Figure 3. Refer to Figure 4 when mounting the LEDs; both LD1 and LD2 are positioned vertically at 90° from the PCB and at a distance of 6mm from board to LED base. Finally, inspect the completed assembly looking for wrong components and poor soldering. It is worth pointing out that most project failures can be attributed to poor quality soldering, and therefore thorough checking of your work is recommended.

Final Assembly

Figures 5 and 6 show the final assembly details. Before mounting the PCB and coil in the box, the switch will need to be fitted into position.

Referring to Figure 6, place the switch in the box so that its lever protrudes through the rectangular cut-out in the case. Insert the M2 bolts through the two

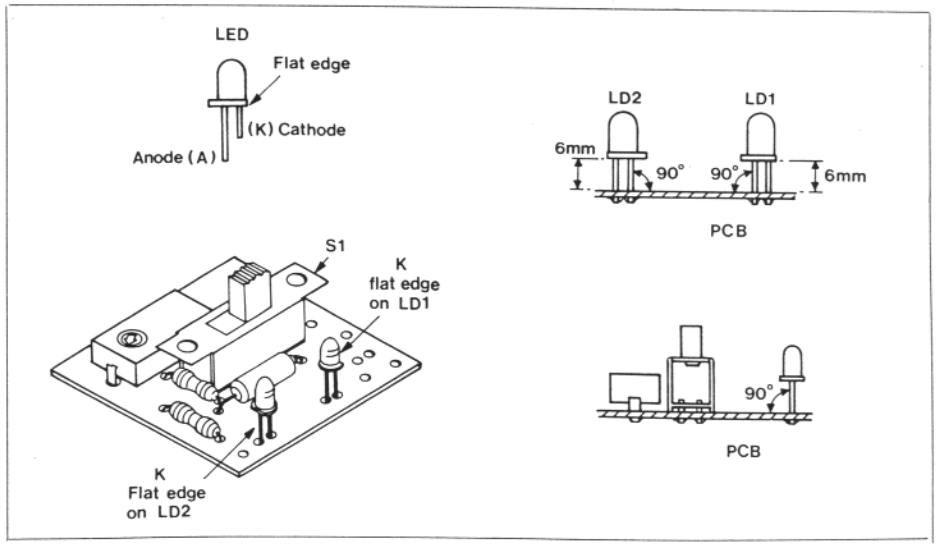
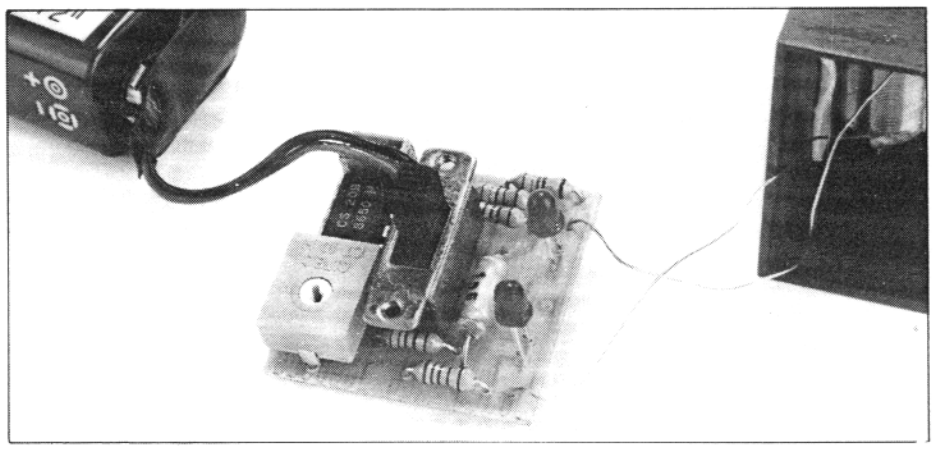


Figure 4. Mounting LD1 and LD2.



The assembled pcb.

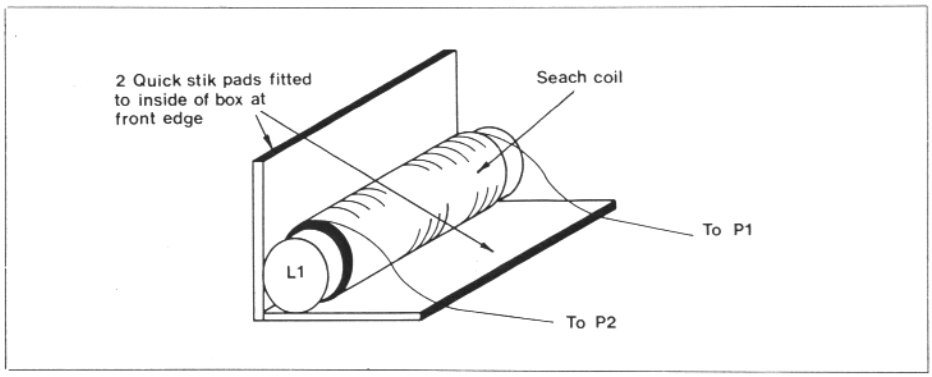


Figure 5. Mounting Search Coil L1.

holes on either side of the switch cut-out, pass them through the mounting holes of the switch and secure the assembly with the M2 nuts. Carefully position the PCB over the exposed switch terminals and locate the LEDs through their respective holes within the case, now push the PCB onto the switch terminals. It must be checked that the board is mounted flush against the switch prior to soldering, otherwise undue strain could be placed on the PCB tracks – the switch effectively holds the PCB in place. Now older the switch terminal to the PCB.

To allow the coil to be fitted, two of the box pillars must be removed, see Figure 6. To secure the search coil, first fit sticky pads onto the inside front and inside top edges of the box. Remove the backing strips and carefully press L1 onto both pads, as shown in Figure 5. Cut the two connecting wires on L1 to about 50mm (2in.) in length, remove the enamel coating and tin each end. Thread the wires through the holes marked '1' and '2' in Figure 6 and solder into place.

The PCB should then be fitted over the switch terminals exposed within the case, making sure that the two LEDs line up with, and protrude slightly through, their corresponding holes in the case. Solder the assembly in place, once it has been ascertained that the PCB is mounted flush against the switch, otherwise undue strain could be placed on the PCB tracks – bearing in mind that the switch effectively holds the PCB in place.

Testing and Use

Fit the battery clip onto a working PP3 battery and operate the slide switch so that either LD2 or both LED's turn on. Insert a trimming tool or small screwdriver into the hole above RV1 and turn

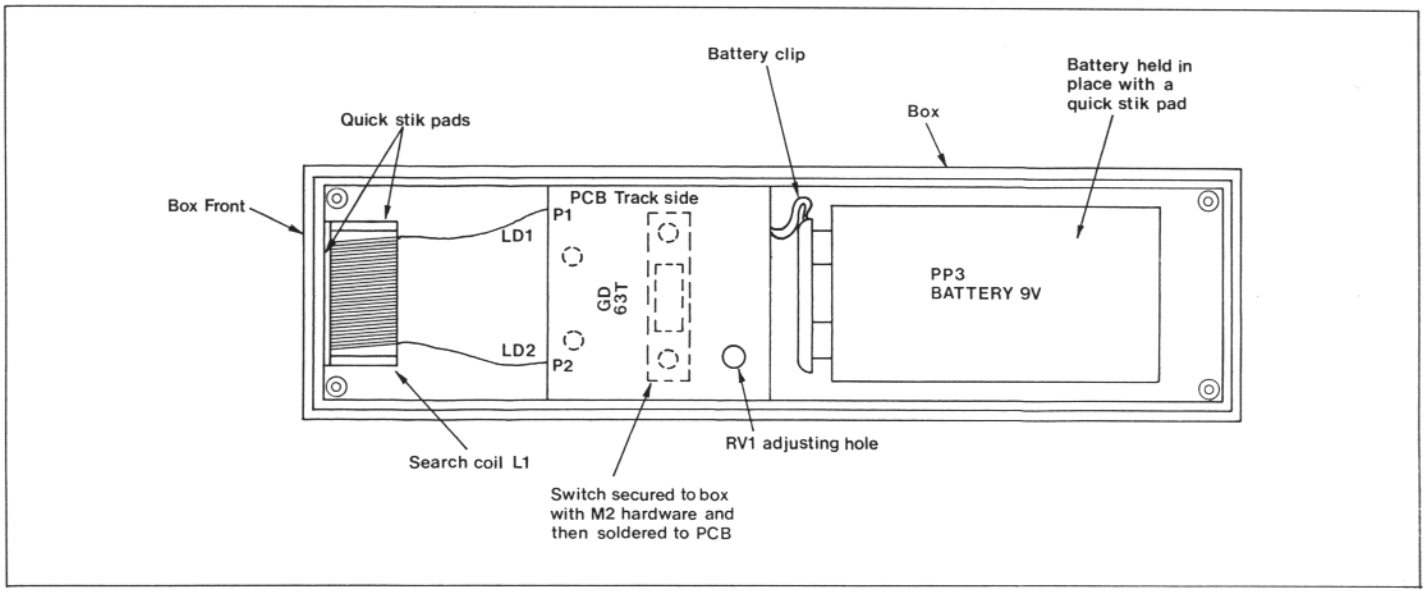


Figure 6. Final Assembly.

the wiper fully anti-clockwise. LD2 only should be on. Now slowly turn RV1 wiper in a clockwise direction until LD1 just comes on and at this point, back off the wiper until LD1 is just turned off. LD2 will stay on all the time while the unit is switched on. Precise setting of RV1 wiper and LD1 will improve the maximum search range, which can be up to 25mm according to the size of the object being monitored.

The third sticky pad may be used for fixing the battery inside the box thus preventing it from bouncing about and causing damage. To complete the project, clip the back panel in place and secure with two screws, at the bottom end of the box only.

To use the Mini-Metal Detector, hold the case with the small front edge pointing at the area to be searched. If very small metallic objects are suspected as being present, such as wire nails and pins in wall boards, then the case will need to be placed directly onto the wall panel. The Mini-Metal Detector will only indicate for metal objects being present and will not identify whether wire and cables are 'live' or connected to mains voltages. For this purpose a matching 'Live Wire Detector' project LK63T is available details of which are found in our Projects Book 14.

MINI METAL DETECTOR PARTS LIST

RESISTORS: All 0.6W 1% Metal Film (Unless Specified)			
R1	220Ω	1	(M220R)
R2	68k	1	(M68K)
R3	15k	1	(M15K)
R4	680Ω	1	(M680R)
R5	3k3	1	(M3K3)
RV1	Hor Encl Preset 22k	1	(UH04E)
CAPACITORS			
C1	1% Polystyrene 1n5F	1	(BX58N)
C2	Poly Layer 100nF	1	(WW41U)
SEMICONDUCTORS			
IC1	CS209	1	(UH59P)
LD1,2	Hi-Bright LED Red Min	2	(WL83E)
MISCELLANEOUS			
S1	Sub-Min Slide	1	(FH35Q)
L1	100μH Search Coil	1	(JC25C)
	Mini Metal Dtctr PCB	1	(GD63T)
	Mini Metal Dtctr Box	1	(JC24B)
	PP3 Clip	1	(HF28F)
	Pozi Screw M2 6mm	1 Pkt	(BF41U)
	M2 Steel Nut	1 Pkt	(JD63T)
	Quickstick Pads	1 Stp	(HB22Y)
	Constructors' Guide	1	(XH79L)
	Leaflet	1	(XT34M)
OPTIONAL			
	Alkaline PP3	1	(FK67X)

A complete Kit of all parts, excluding optional, is available:
Order As LM35Q (Mini Metal Detector Kit)
The following items are also available separately:
Mini Metal Dtctr PCB **Order As GD63T**
100μH Search Coil **Order As JC25C**

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