Bodywork Checker

Don't go out and buy a second-hand car without building this handy little gadget. It'll point out any problems under the paintwork. Design by Rory Holmes. Development by Tony Alston.

THE PURPOSE OF THIS project is to help the selective second-hand car buyer detect the amount of body-filler used under well-disguised repair jobs. The unit gives a two-state indication of metal or plastic, ('OK' or 'BAD' respectively).

Our metal detector uses a capacitive sensing principle, which will detect the presence of any conductive object. Because of this the circuitry is much simpler and more reliable than metal detectors working on an inductive principle. It is also more suitable in this type of application where large areas of metal must be checked.

In use the device is switched on and lightly run over the car panels; if it runs over an area of body-filler the 'BAD' light will come on, otherwise it should read 'OK'.

Construction

The case is the most important part of this project as it is also part of the electronic sensing circuit. Take a careful look at the photographs of the finished project and you can clearly see the sensor area at the bottom rear of the case. First cut a rectangular hole (30x35mm) about 8mm from the bottom edge of the case and 14mm from either side; make sure to clean off any burrs from the hole. A piece of single sided copper clad board (24x30mm) is used for the sensor plate. This is centrally glued (copper side out) to a piece of plain plexiglass or similar material (35x45mm). This assembly is then glued to the case from the inside, so that the copper clad board will then be flush with case surface.

A small hole is drilled through to the copper side of the sensor plate and a short length of insulated wire, long enough to reach the main PCB, is soldered to the copper surface of the sensor plate.

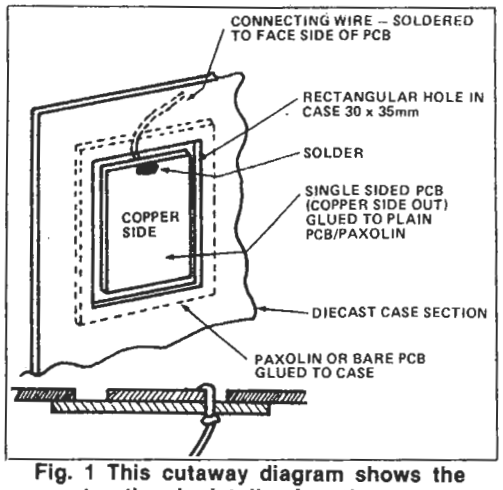
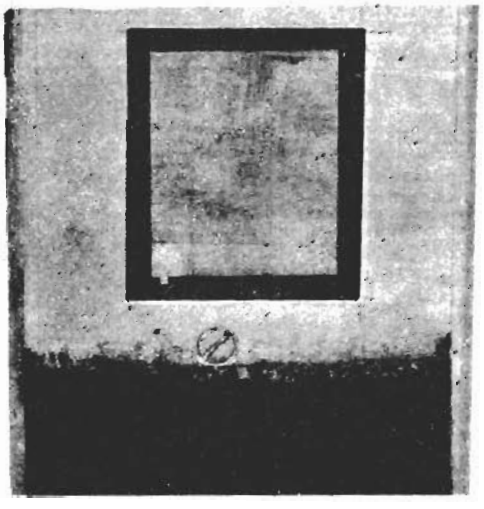


Fig. 1 This cutaway diagram shows the constructional details for the sensor plate.



With the protective felt peeled back to reveal the sensor, you can see how the fixing screws should be countersunk so they lie flush.

The components can now be assembled and soldered to the main PCB as shown on the overlay diagram, making sure to correctly orientate D1, D2, IC1 and IC2 and the LEDs. Make sure to fit the link adjacent to IC1.

A short length of insulated wire is connected from the PCB to a solder tag fixed to the case; make sure this is a good connection as it forms part of the detecting circuit. The connecting lead from the sensor plate is soldered to the main PCB as indicated. A further insulated lead is taken from this same point on the PCB and held against the side of the case by a piece of insulating tape to form a capacitive trimming circuit (see photograph and refer to the setting up procedure). The LEDs are directly mounted on the PCB and appropriate holes are drilled in the front case panel to allow these to pass through.

In the internal shot, note how the trimming wire is taped to one side of the case.

Finally, a piece of felt cut to size is then glued to the rear of the case, covering the sensor plate; this prevents the case from scratching the car bodywork and upsetting your friendly second-hand car dealer!

Setting Up

Setting up the circuit is straightforward; PR1 controls the detecting sensitivity and PR2 the metal/plastic switching threshold. When altering the presets bear in mind that replacing the case lid will slightly offset the adjustments, so replace the lid after each adjustment to check the effect.

Start with maximum sensitivity, i.e., set PR1 to its full resistance (counterclockwise). Then place the case, sensor side down, onto a non-conductive object. With the lid off, PR2 can now be adjusted until the switching threshold is found. When the 'OK' LED is on, back off preset PR2 until it just extinguishes and the 'BAD' LED comes on (indicating no metal). The unit can now be placed against a metal surface and the 'OK' LED should re-light.

The trimming wire capacitively couples a small degree of HF voltage into the detector, effectively altering the switching threshold. Its effect can be varied by trimming the length. By experimenting with this if necessary, together with PR1 and PR2, a suitable switching action can easily be found.

Note that the human body is a fairly good conductor; you can prove this by holding your hand against the sensor, when the 'OK' LED should come on. This resulted in one member of staff wandering round the office, checking out the female employees and reassuring them that all was well.

HOW IT WORKS

CMOS inverter gates IC2a and IC2b form a high frequency oscillator of about 150 kHz. This signal is connected directly to the case, which in turn is capacitively coupled via the sensor to the high-impedance detector circuitry based around IC1. This unusual way of screening the circuit prevents the user's hand from affecting the capacitance between the detector input and the 0V ground rail.

D1, D2, C1, and PR1 rectify the signal from the sensor and pass this voltage to the positive input of the op-amp, which is configured as a simple comparator. PR1 is used to set the input impedance and hence the sensitivity of the sensor. PR2 sets the switching threshold voltage on the non-inverting input to the comparator. When the coupling capacitance is increased, due to a conductive object lying across the case and sensor, the high frequency signal strength arriving at the detector will increase, raising the voltage on pin 3 of the comparator above the threshold, and switching the output from pin 6 fully positive.

IC2c, d are connected as a Schmitt trigger with R4 supplying positive feedback. This sharpens up the switching action coming from the comparator and further provides suitable drive signals for the two LEDs. These drive signals are buffered and current-limited by IC2e,f which power the LEDs. When metal is detected LED2 is lit and LED1 is off; the converse is true if metal is absent.

PARTS LIST

Resistors (all ¼W, 5%)	
R1	22k
R2	8k2
R3	100k
R4	8M2
Potentiometers	
PR1	4M7 miniature horizontal preset
PR2	47k miniature horizontal preset
Capacitors	
C1	4n7 disc ceramic
C2	470p polystyrene
Semiconductors	
IC1	CA3140
IC2	4069B
D1,2	1N4148
LED1,2	5mm red LEDs
Miscellaneous	
SW1	miniature rocker switch

Battery and clip; diecast case.

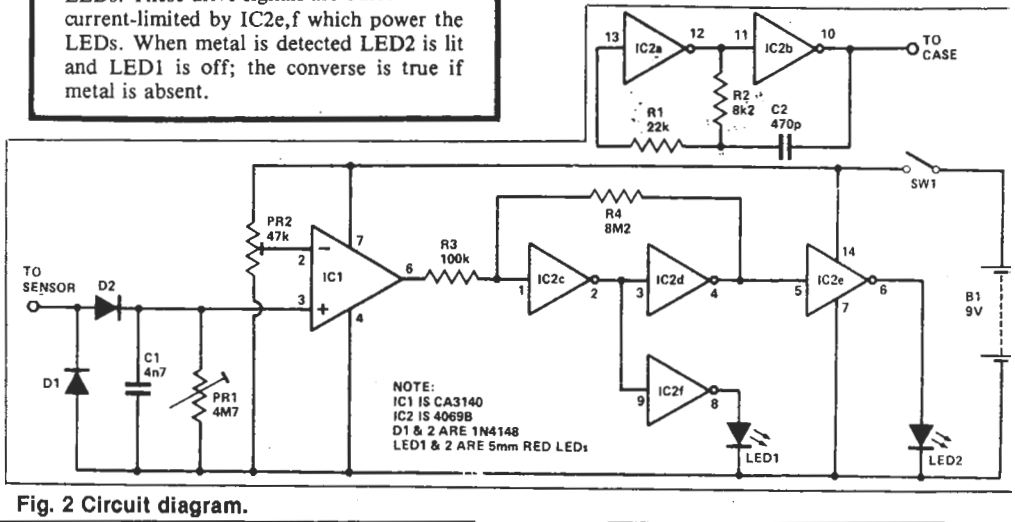


Fig. 2 Circuit diagram.

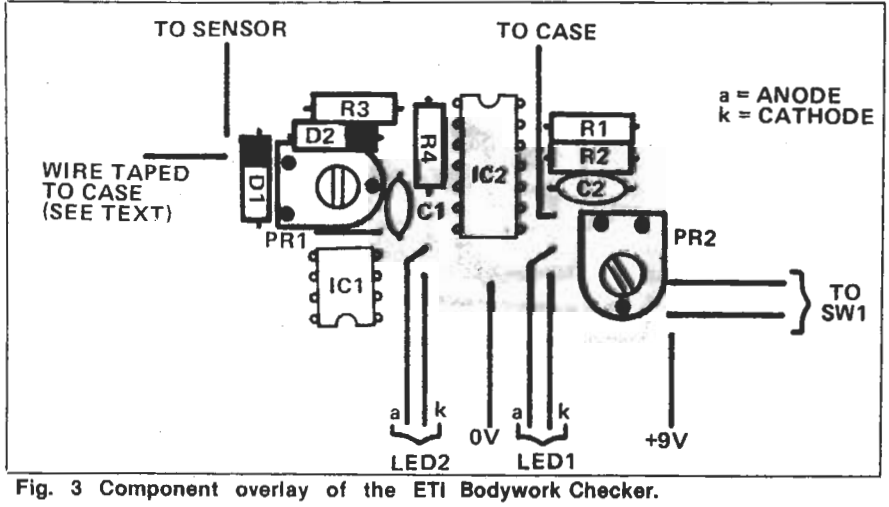
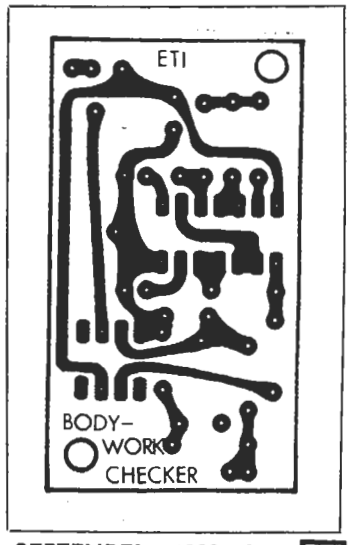


Fig. 3 Component overlay of the ETI Bodywork Checker.



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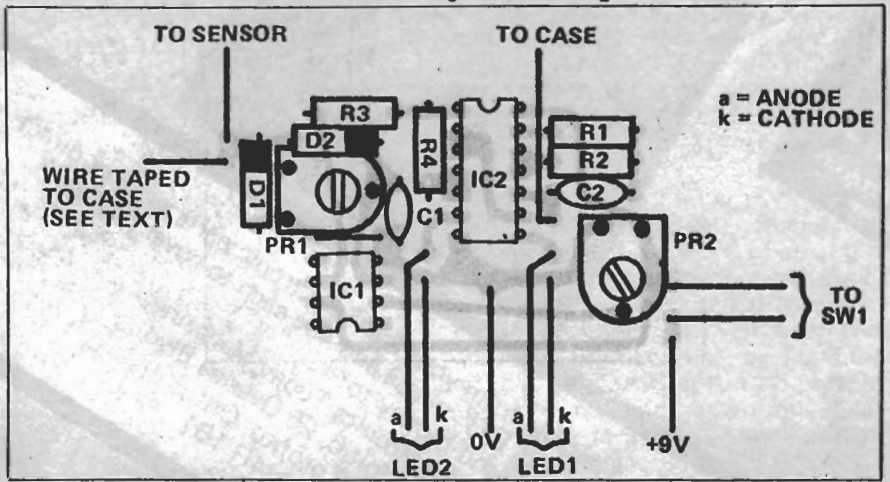

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