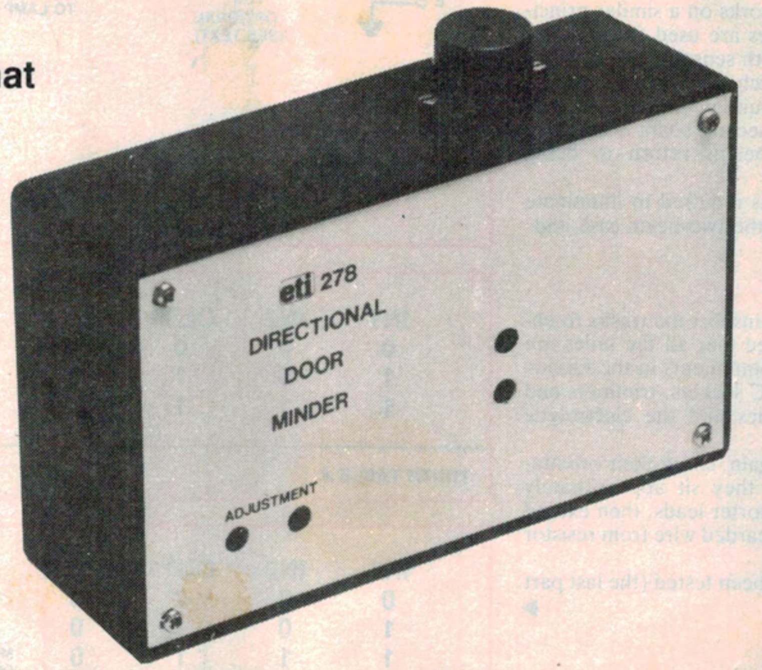
Project 278

DIRECTIONAL DOOR-MINDER

Peter Ihnat



Most electronic door minders function by having a beam of light shining across a doorway interrupted, but are incapable of detecting whether the light beam is broken by a person entering or leaving the room. This project overcomes that problem with the aid of digital logic.

Figure 1a.

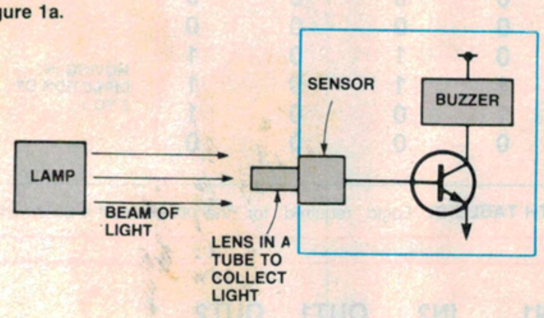
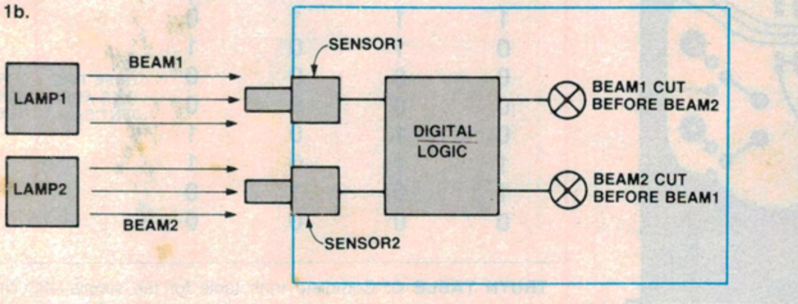


Figure 1b.



HAVE YOU NOTICED how annoying the buzz of a door minder is every time you enter your favourite bottle shop? What's usually more annoying is having the damn thing sound when you leave. Well, this project solves the problem. It will sound a buzzer (flash a light, operate a counter, etc) when a person either enters *or* leaves a room via the door being monitored. In other words, it senses the direction in which the person is moving.

This immediately opens up the field for much experimentation. For example, the circuit could be adapted to operate as an automatic light switch, that is, to switch the light on in a room when someone enters and off when they leave.

Another use would be to count the number of people entering the premises (similar to a turnstile counter). Or, if you really want to be clever, the two previous ideas can be combined so that the light comes on in a room when a person enters and then the circuit counts ▶

Above left.
Simple, Simon. Basic arrangement of a simple door minder. Break the beam and the buzzer sounds.

Left.
The 'directional' method. With two beams, two sensors and a bit of digital logic, one can sense in which direction the beams have been broken.

how many people actually come in. When the same number of people leave, the light switches off (see Ideas for Experimenters, ETI Nov. '82, p.60). But more of this fantasising later; let's look at some background.

Basics

The basic idea behind the operation of a Door Minder is to shine a beam of light across the doorway onto a light sensor which, by means of a simple circuit, controls a relay or transistor feeding power to a buzzer (see Figure 1a). When the beam is interrupted, the buzzer sounds. Simple!

The ETI-278 Directional Door Minder works on a similar principle except that two light beams and sensors are used (Figure 1b). Digital logic combines information from both sensors and, depending on which beam is interrupted first, switches one of the outputs on. Note that once one beam is cut, the circuit latches the appropriate output, which stays latched even if the second beam is now cut. The circuit will reset only when *both* beams return to being uninterrupted.

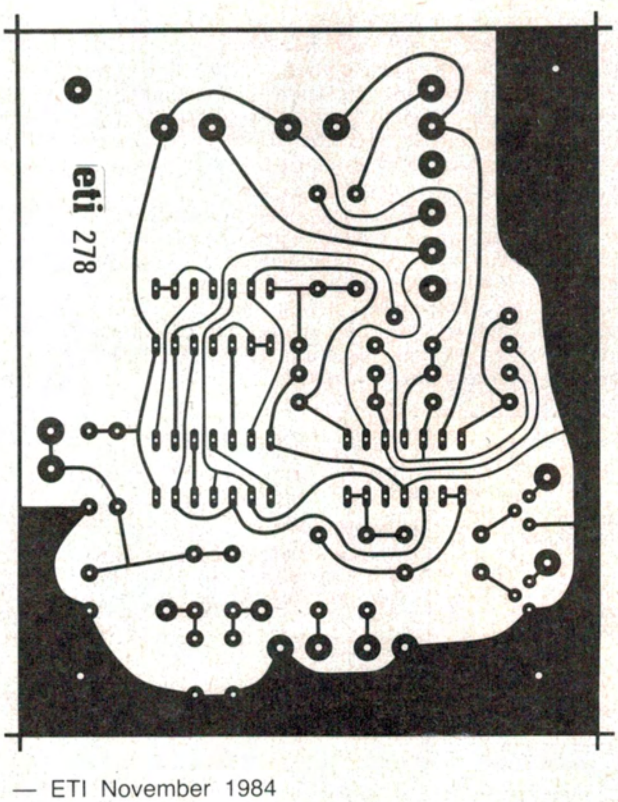
In a practical unit, only one light beam is required to illuminate both sensors. The operation is identical to the two-beam case and much easier to set up.

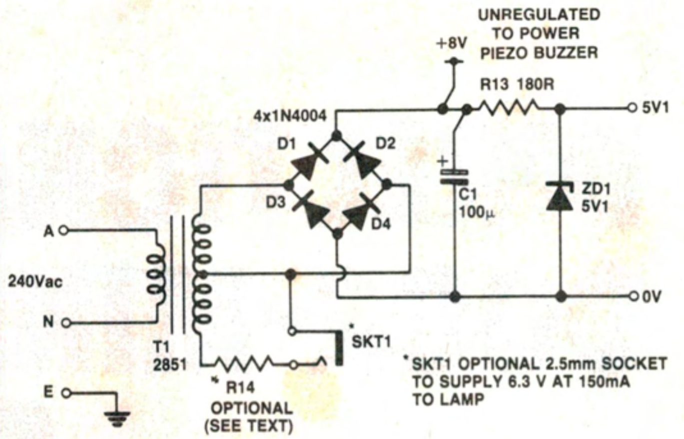
Construction

Begin construction with the pc board. First inspect the tracks to ensure that there are no breaks or shorts. See that all the holes are drilled and of the correct size. Insert the components in the following order — resistors, diodes, capacitors, IC sockets, trimmers and PCB pins. Check the orientation of diodes and the electrolytic capacitors.

The LEDs can now be fitted and, once again, check their orientation with the overlay. On the prototype they sit approximately 13 mm off the board. If your LEDs have shorter leads, then extend them with some lengths of hookup wire (discarded wire from resistor or capacitor leads will do).

Leave the ICs until the power supply has been tested (the last part of construction). ▶





FOR TRUTH TABLE REFER TO TABLE B.

IN1	IN2	OUT1	OUT2
0	0	0	0
1	0	1	0
1	1	1	0

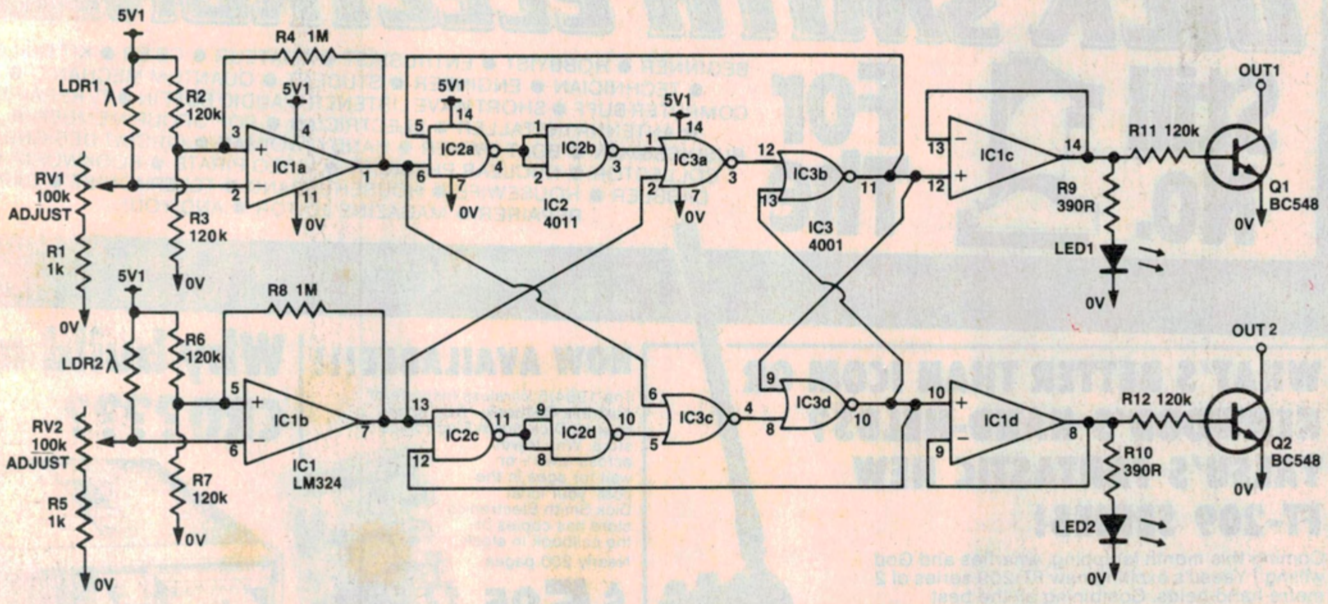
TRUTH TABLE A

IN1	IN2	OUT1	OUT2	
0	0	0	0	MOVING IN DIRECTION OF 1 TO 2
1	0	1	0	
1	1	1	0	
0	1	1	0	
0	0	0	0	
0	0	0	0	MOVING IN DIRECTION OF 2 TO 1
0	1	0	1	
1	1	0	1	
1	0	0	1	
0	0	0	0	

TRUTH TABLE B: Logic required for the operation of a door minder.

IN1	IN2	OUT1	OUT2		
0	0	0	0		
1	0	1	0		THESE TWO LINES ARE IDENTICAL
1	1	1	0		
0	1	0	1	THESE TWO LINES ARE IDENTICAL	
0	0	0	0		
0	0	0	0		
0	1	0	1		
1	1	0	1		
1	0	1	0		
0	0	0	0		

TRUTH TABLE C: Complete truth table for the simple latch circuit.



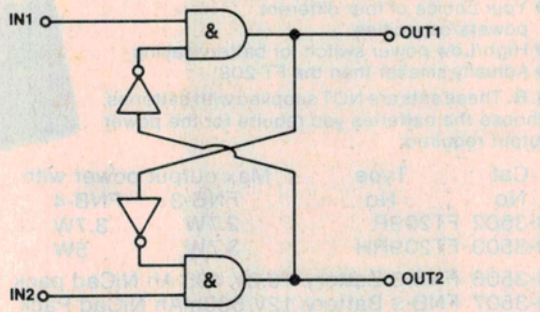
HOW IT WORKS — ETI 278

A general description of the operation of door minders is given in the main text. The circuit itself can be broken up into analogue and digital halves.

The analogue part is identical for both sensors so only one will be described. Sensor LDR1, RV1 and R1 form a voltage divider, the output voltage of which depends on the amount of light hitting the sensor (more light produces a higher voltage). RV1 acts as a calibration control and allows the range of voltage available from the divider to be adjusted.

This voltage is then compared with a fixed voltage (2.5 volts produced by divider R2 and R3) by IC1a which produces an output of 5 volts if the sensor voltage is *less* than 2.5 volts, and 0 volts if *greater* than 2.5 volts. Resistor R4 provides a small amount of hysteresis to avoid false triggering. Its value isn't critical and is normally the lowest value which still allows the device to operate. As a compromise, a value of 1M provides sufficient hysteresis for the current application.

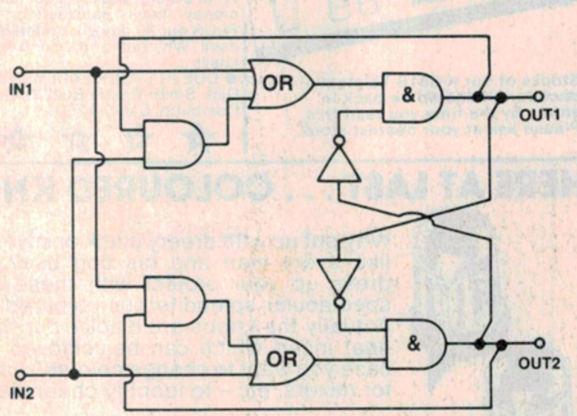
The heart of the unit is the digital section. It logically determines which sensor first "sees" an interruption to its light beam and thus latches one of the outputs *until the interruption is removed.* A latch which almost does the job is produced by interconnecting two AND gates, as shown in the diagram above right.



If both inputs are low (assume this represents light beams uninterrupted), the outputs will be low. If input 1 goes high first (that is, beams are traversed in the direction 1 to 2), the corresponding output (OUT1) will go high and, via the inverter, put a low on the input of the other gate, thereby disabling it. If input 2 now also goes high (both beams interrupted), the circuit will remain latched and ignore that input (see truth table A). The operation is exactly opposite to this if the beams are traversed in the other direction.

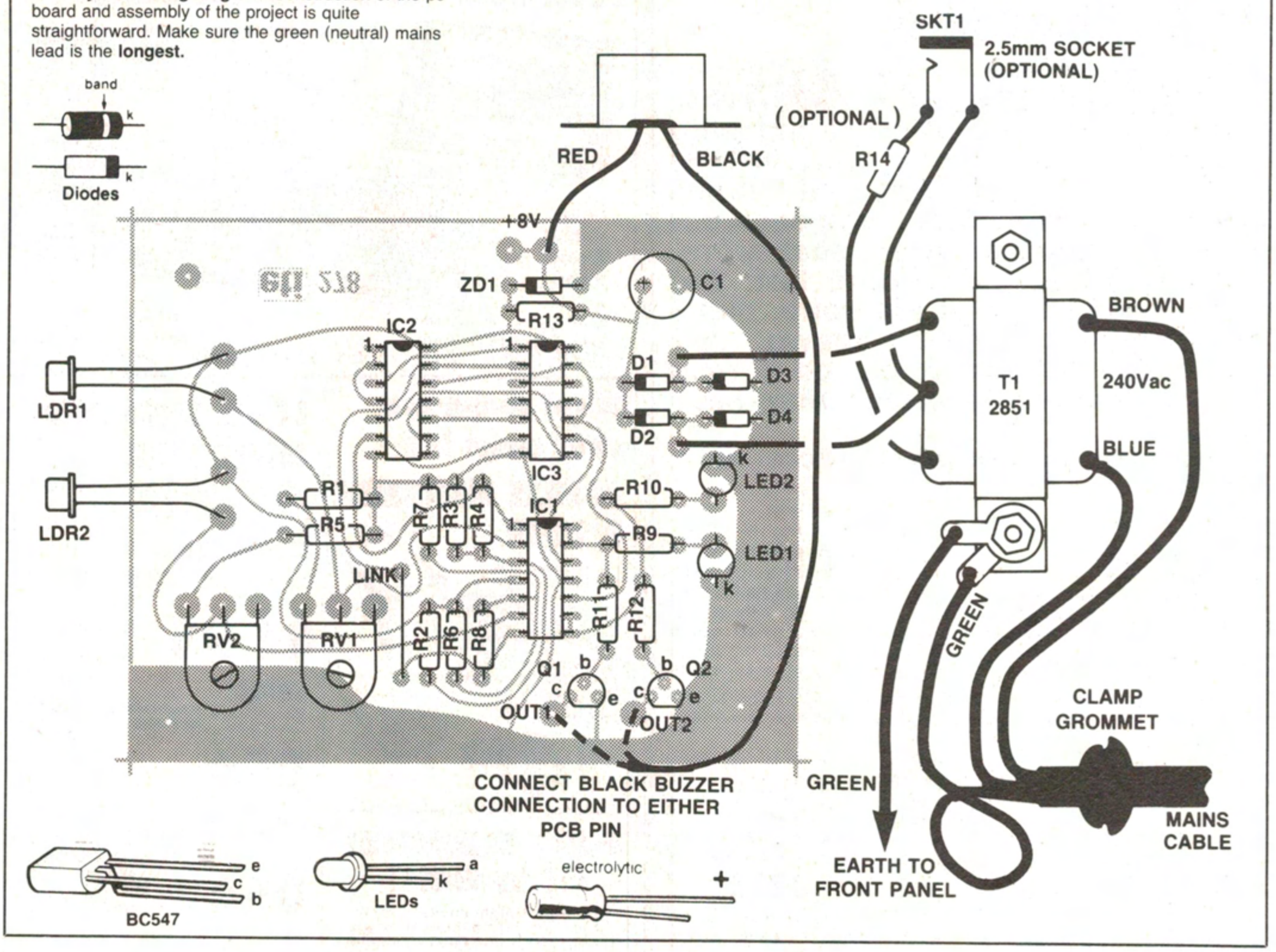
This, however, is not the complete operation. Truth table B shows what a door minder requires if the two light beams are interrupted by an object moving from 1 to 2. Firstly, beam 1 is broken, followed by both beams broken, then only beam 2 broken and, finally, no beams broken. Output, once latched, should remain so until both beams return to being uninterrupted. Truth table C shows all combinations of inputs for the latch circuit described above. Note how lines 4 and 9 differ from those of table B. Extra circuitry is required to overcome this.

The solution to the problem is to operate the latch in the first instance by either input 1 or 2. Then, extra circuitry needs to be activated so that the output remains latched while input 1 *or* input 2 (or both) are present. The circuit shown on the left does this.

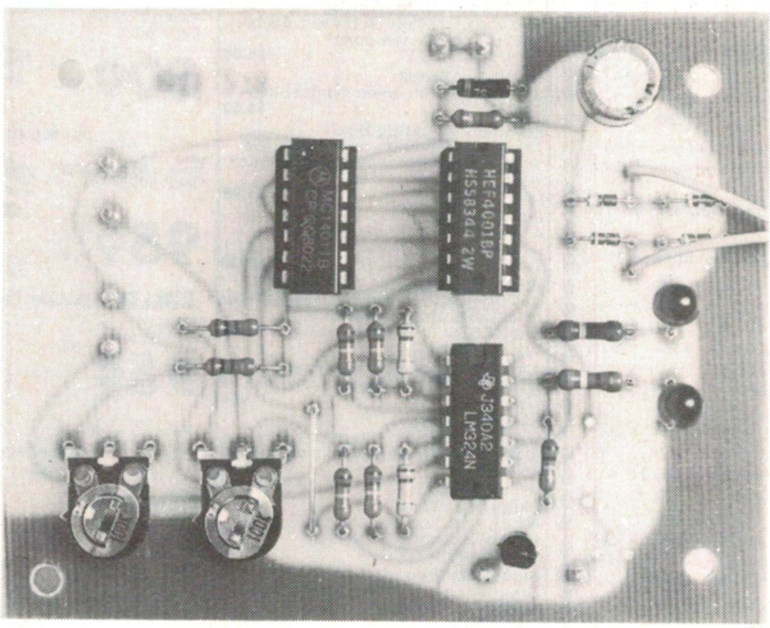


If input 1 goes high first, output 1 goes high, disabling output 2, and feeds back to enable the top left AND gate. Now, as long as any input is high, the top OR gate keeps feeding a high into the latch to keep output 1 high. Both inputs must go low for the circuit to reset.

The circuitry actually used in the current project is identical except that the AND, OR and NOT functions have been implemented with NAND and NOR gates.



Overlay and wiring diagram. Construction of the pc board and assembly of the project is quite straightforward. Make sure the green (neutral) mains lead is the **longest**.



Completed board. The completed board, Note that IC sockets may be used if you wish.

For a guide to components and kits for projects, see SHOPAROUND this issue.

PARTS LIST — ETI-278

Resistors .... all ¼ W, 5%

R1, R5	1k
R2,3,6,7,11,12	120k
R4, R8	1M
R9, R10	390R
R13	180R
R14	optional (see text)
RV1, RV2	100k trimpots

Capacitors

C1	100μ/25 V pc-mount electro.

Semiconductors

IC1	LM324, μA324
IC2	4011
IC3	4001
Q1, Q2	BC547/8/9
D1,2,3,4	1N4002 or sim. 1A diode
ZD1	5V1/1W zener
LED1,2	5 mm red LED
LDR1,2	Light-dependent resistor or cadmium sulphide cell, AL-12 or similar.

Miscellaneous

ETI-278 pc board; Scotchcal front panel; T1 — 2851 transformer (12.6 volt CT output); 50 x 90 x 150 mm zippy box; piezo buzzer; 10 pcb pins; 2.5 mm socket and jack plug (optional); 6.3 volt (or less) lamp (150 mA if powered by 2851 transformer) and reflector (see text); mains grommet and clamp; mains cable and plug; four 25 mm spacers; solder lugs, bolts, etc.

Price Estimate: $23-$30

The sensor unit can be made next (Figure 2). The prototype was made from a short length of 12 x 12 mm maple left over from a previous project, but any opaque material can be used. For example, plastic, aluminium, etc. I cut the maple in half lengthwise and drilled two 6 mm holes about 15 mm apart to hold the LDRs.

The actual LDRs used are a dual unit and I originally tried to use the two halves in the circuit. Unfortunately, one half interacted too much with the other so the idea was abandoned. Luckily, the LDR is quite cheap so it's no disadvantage to use two of them. Note that only one half of the LDR is used (it doesn't matter which).

Since there is no tag or mark to identify the leads of the LDRs, use the following method. If you look into the window of the LDR, it is possible to see where the external leads are connected to the "chip". At each connection, there is a certain pattern of lines. If you look carefully, you will notice that two of the patterns are similar and one is different.

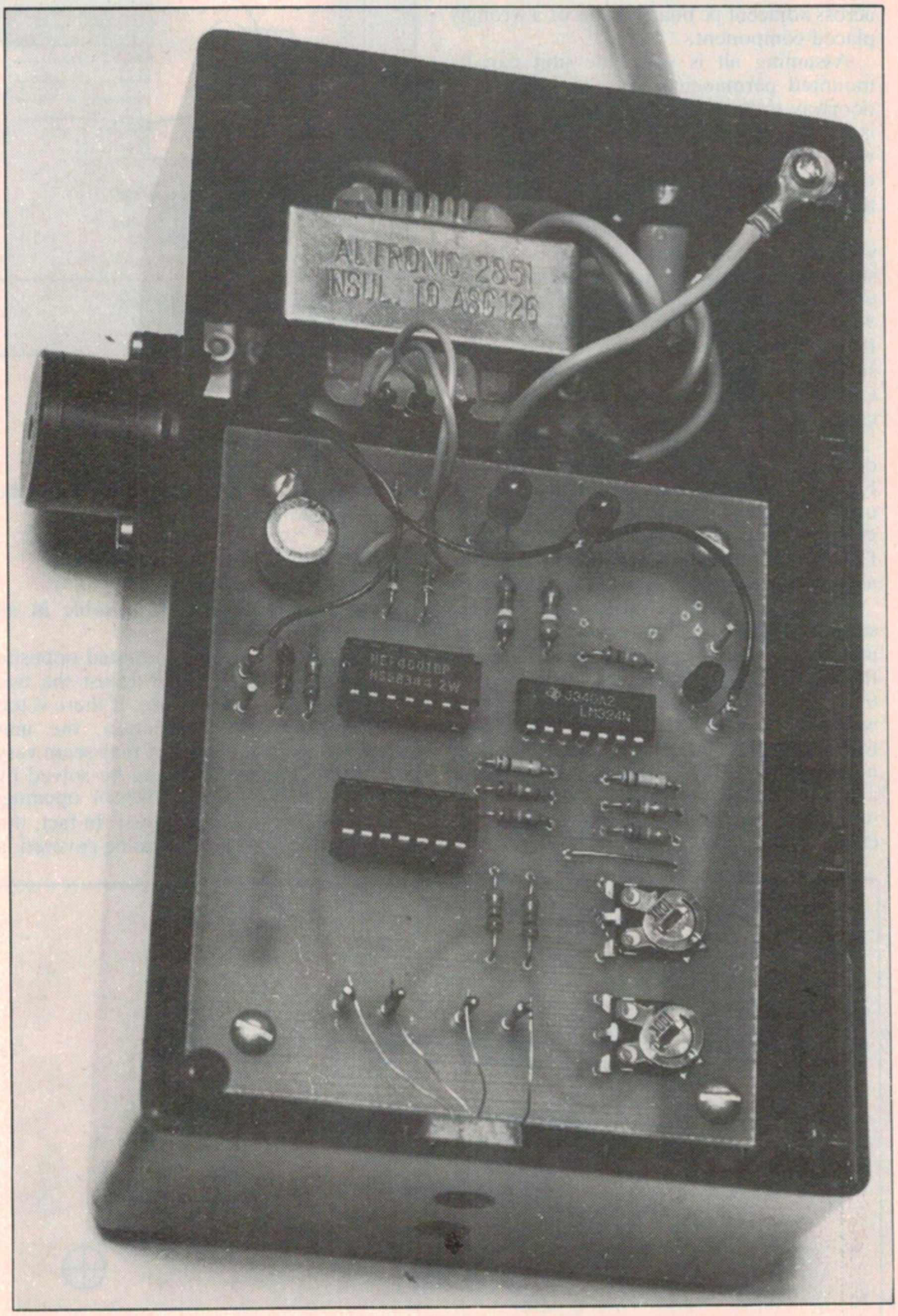
Simply use the lead which goes to the different pattern and one of the other two. Cut the unused lead about 3 mm from the body and, if you like, thread some spaghetti over the other two to ensure they don't short together. Both LDRs can now be glued into the block you drilled before and put aside until dry.

Next, the box. I used a 50 x 90 x 150 mm zippy box for the prototype but any other suitably-sized type may be used. Start by sitting the pc board and transformer inside and mark where mounting holes need to be drilled. Temporarily fit the lid and mark the positions of the two trimmer access holes and the holes for the LEDs; 3 mm holes should be OK for the mounting holes and 5 mm ones for the access ones.

Next, drill two 6 mm holes where the sensor unit is to be mounted and, the hard part, drill and file a hole to hold the mains grommet clamp. Finally, drill three small holes in the top to allow the buzzer to be mounted and its leads to pass through.

The unit can now be assembled. First, strip the mains cable to expose about 60 mm of the three internal cables. Fit the grommet clamp around the cable and push it into place in the side of the box. Solder the blue and brown wires to the 240 V connections of the transformer and bolt it into place. Then mount the pc board into the box on 25 mm spacers and connect the 6.3 V from the transformer to the board. It's now possible to apply power to the unit and check the 5.1 Vdc supply. If all is OK, switch off and plug in the ICs.

To complete the gadget, glue the sensor unit into its correct place, connect the leads to the pc board and mount the buzzer into place. The mains earth wire should be connected to one of the transformer's securing bolts and one of the front panel mounting bolts, as shown in the overlay.



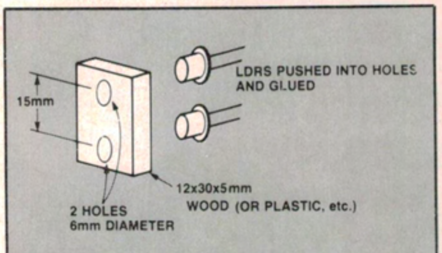


Figure 2. Showing the assembly of the sensors.

Using it

To check the unit, shine a torch onto the sensors and switch the unit on. Start the adjustment procedure with both trimmers turned fully anticlockwise — the LEDs should both be off. Turn one trimmer clockwise until a LED comes on, then back off slightly until the LED just goes out. Repeat for the other trimmer.

Now for the big test. Pass you hand between the torch and Door Minder. When you move your hand back and forth through the beam, first one LED will light and then the other. If not, check for solder splashes ▶

across adjacent pc board tracks or a wrongly placed component.

Assuming all is well, the unit can be mounted permanently on one side of the doorway to be guarded. Double-sided tape is not recommended to hold the unit to the wall. Either use small brackets or drill a couple of holes in a spare area at the back of the box and screw it to the wall.

The buzzer connects between the +8 volts pcb pin and either OUT1 or OUT2, as shown in the overlay. The connection used will depend on whether you want it to sound when a person enters *or* leaves the room. If you like, it's possible to place a SPDT switch between the buzzer, OUT1 and OUT2 to let you switch between the two cases.

The light source on the other side of the door can be created in a variety of ways. Figure 3 shows one possible method which uses the globe and reflector from a very cheap torch available from K-Mart or Coles. Disassemble the torch and fit the reflector and globe in a suitable plastic or wood box.

The globe can be powered by a separate supply or from the transformer in the main unit. If the latter, fit a 2.5 mm socket near the buzzer and connect it to the unused 6.3 V winding on the transformer. Two wires can then be run round the door frame to power the globe. Ensure that it requires no more than 6.3 V at 150 mA. If it runs on a lower voltage then insert R14 in series with the 2.5 mm socket. Its value can be calculated from:

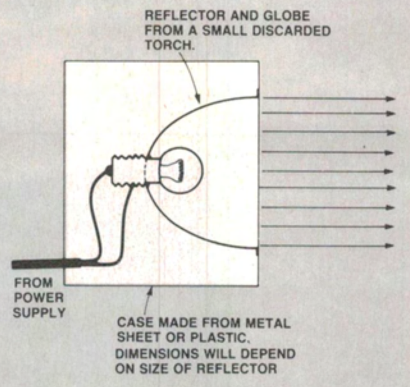


Figure 3. General arrangement of the beam light source.

$$R14 = (6.3 - V_{globe})/I_{globe}.$$

For example, a 2.5 volt, 100 mA globe needs R14 to be

$$(6.3 - 2.5)/100 \text{ mA} = 38 \text{ ohms}.$$

A 1 W resistor should be suitable in all cases.

Once the lamp unit is mounted opposite the sensors, switch on and adjust the two trimmers as described before. If there is too much background illumination, the unit may switch on but not off or may seem very insensitive. The problem can be solved by gluing two tubes into the sensor openings to make them more directional. In fact, if a much larger distance needs to be covered, a couple of small lenses should be used to focus the light onto the LDRs. Some experimentation may be required.

For experimenters

That completes the Door Minder in its basic form. For those readers who like to experiment, here are some tips. Firstly, to avoid running wire around the door frame to power the globe, try mounting the lamp and reflector on the main unit itself (bolt the assembly to the top of the main unit just above the sensors). Then fit a mirror to the other side of the door to reflect the beam back onto the sensors. Although not tried, it should work.

Since a 5.1 V supply is used to power the logic circuitry, the output can easily be made TTL compatible. Connect a couple of 1k pull-up resistors from OUT1 and OUT2 to the 5.1 V supply and two negative-going signals become available to feed a counter, computer or whatever.

If positive-going signals are required, take them from the outputs of IC1c and IC1d. Be careful, though, since these outputs may not swing high enough for some logic circuits due to loading by the LEDs and transistors. If this is the case, simply remove them.

To switch a light on and off, feed the two signals to the *set* and *reset* inputs of a flip-flop. The flip-flop output can then drive a transistor which switches a relay on and off. The possibilities are endless. I'll leave other ideas to your imagination. ●