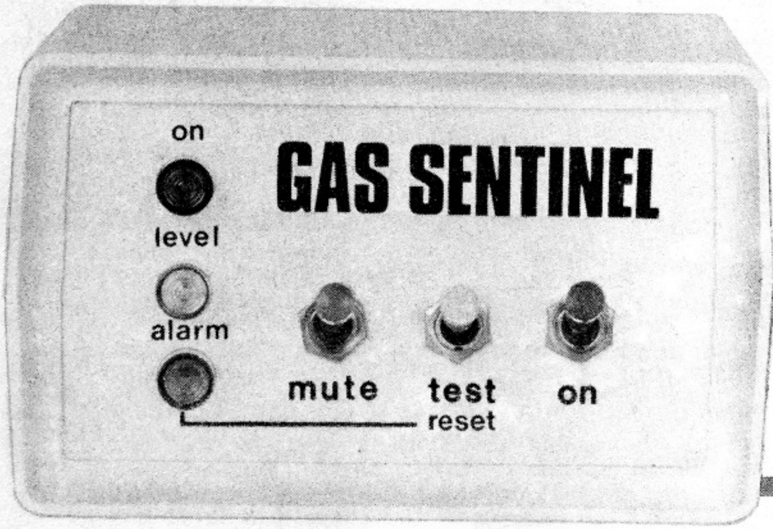
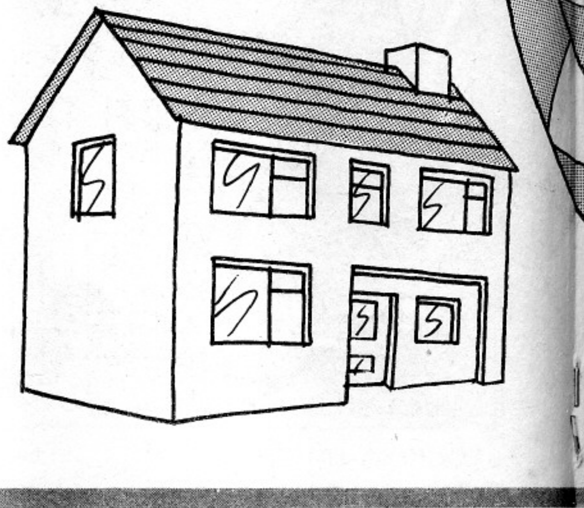




MANY types of gas or fumes, if released and allowed to accumulate, are insidious killers; consequent explosions from large concentrations can wreck property and cause many thousand pounds worth of damage.

A small investment on this project could well prove to be money well spent. Whilst this device obviously cannot prevent leakages arising, it will detect the presence of a surprising variety of fumes and vapours, as well as common smoke, and will then relay a warning signal well before any dangerous accumulations can build up.

The unit has been designed to be flexible in its application and use. It can be either battery or mains powered.

GAS DETECTED

The Gas Sentinel will detect the presence of domestic gas (methane) and Calor Gas (propane) the latter making it eminently suitable for use in boats and caravans when operated from a battery supply. Also, carbon monoxide, a constituent of smoke, will trigger the alarm giving the unit the additional feature of being a fire detector. However, large volumes of smoke are required to trigger the alarm.

REMOTE SENSING

Because the actual sensor is located remotely to the main unit, this means that the sensor can be mounted right in the heart of potential trouble spots (e.g. next to propane cylinders, alongside the gas cooker/fire) whilst the main unit and alarm can be positioned in any convenient place.

The Gas Sentinel employs a solid-state gas sensor device which makes the construction of a low-cost and easy-to-build gas detector a reality for the amateur enthusiast.

THE SENSOR

The sensor used in this project is from the TGS family. The family types differ in operating voltage as well as sensitivity to individual gases. Of these sensors, type TGS813 is used in this application. A diagram showing details of this appears in Fig. 1.

The TGS813 comprises a resin housing measuring 10mm high by 17mm diameter (excluding terminal pins). In the top of the housing is a very fine mesh window, with a smaller mesh window in the base. Stand-offs are moulded into the underside, allowing gas and smoke to pass through the sensor.

Inside the housing is the sensor element, consisting of a ceramic tube with a semiconductor-material coating. Electrodes are taken from the sensor to terminal pins. The sensor is heated by a filament inside the tube; the increased temperature of the semiconductor improves the sensitivity and response time of the unit.

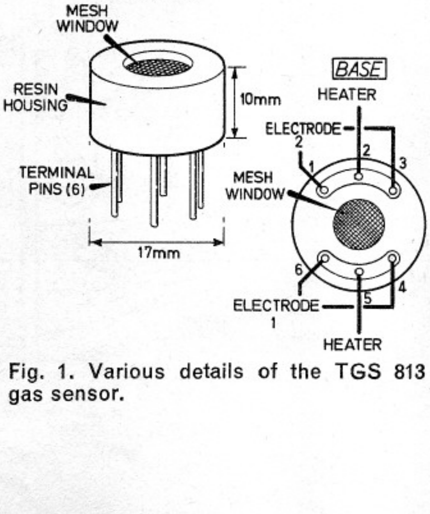


Fig. 1. Various details of the TGS 813 gas sensor.

Connections for the electrodes and filament are taken to six external pins in the base: the sensor must always be used in conjunction with a special socket to which wires may be soldered. The base connections for the device are also given.

For practical purposes, pins 1 and 3 can be considered to be joined together, as can pins 4 and 6.

The maximum permissible circuit voltage is 24V, and the filament is rated at 5V 130mA. Fig. 2 shows how the resistance of the semiconductor element alters with varying concentrations of several gases. The sensor will also respond to accumulations of smoke.

CIRCUIT DESCRIPTION

The circuit diagram of the Gas Sentinel is shown in Fig. 3. Here two

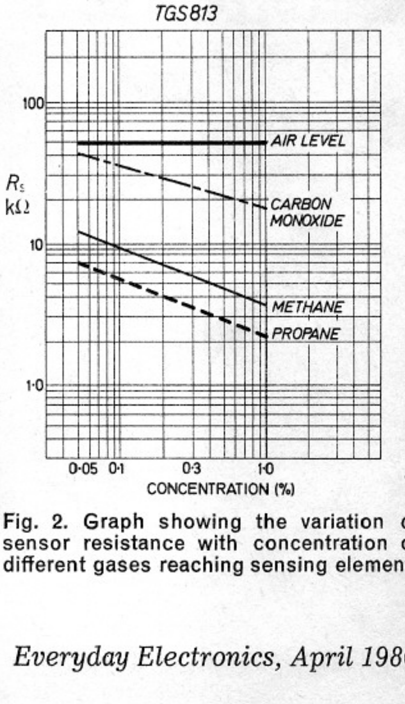


Fig. 2. Graph showing the variation of sensor resistance with concentration of different gases reaching sensing element.

BE ON YOUR GUARD IN THE HOME, BOAT OR CARAVAN

By A. R. Winstanley

power supply options are shown to cater for the environment in which the unit is to be employed. The mains supply is recommended when the unit is installed in the home, whereas the battery version is for use in boats, caravans and other places where mains is not available.

In the mains supply version, mains voltage enters the unit via S1 and FS1 and stepped down in voltage by T1. The resulting voltage (about 9V a.c. is rectified by a bridge rectifier consisting of four diodes encapsulated in one package with four lead-outs. The resultant d.c. is smoothed by C1 to give nominally 12V d.c. which forms the supply rail to the rest of the circuitry.

With the battery supply unit, a 12V battery is used which is switched to the circuit by means of S1 via FSI to provide the 12V d.c. supply at the same point as the mains version.

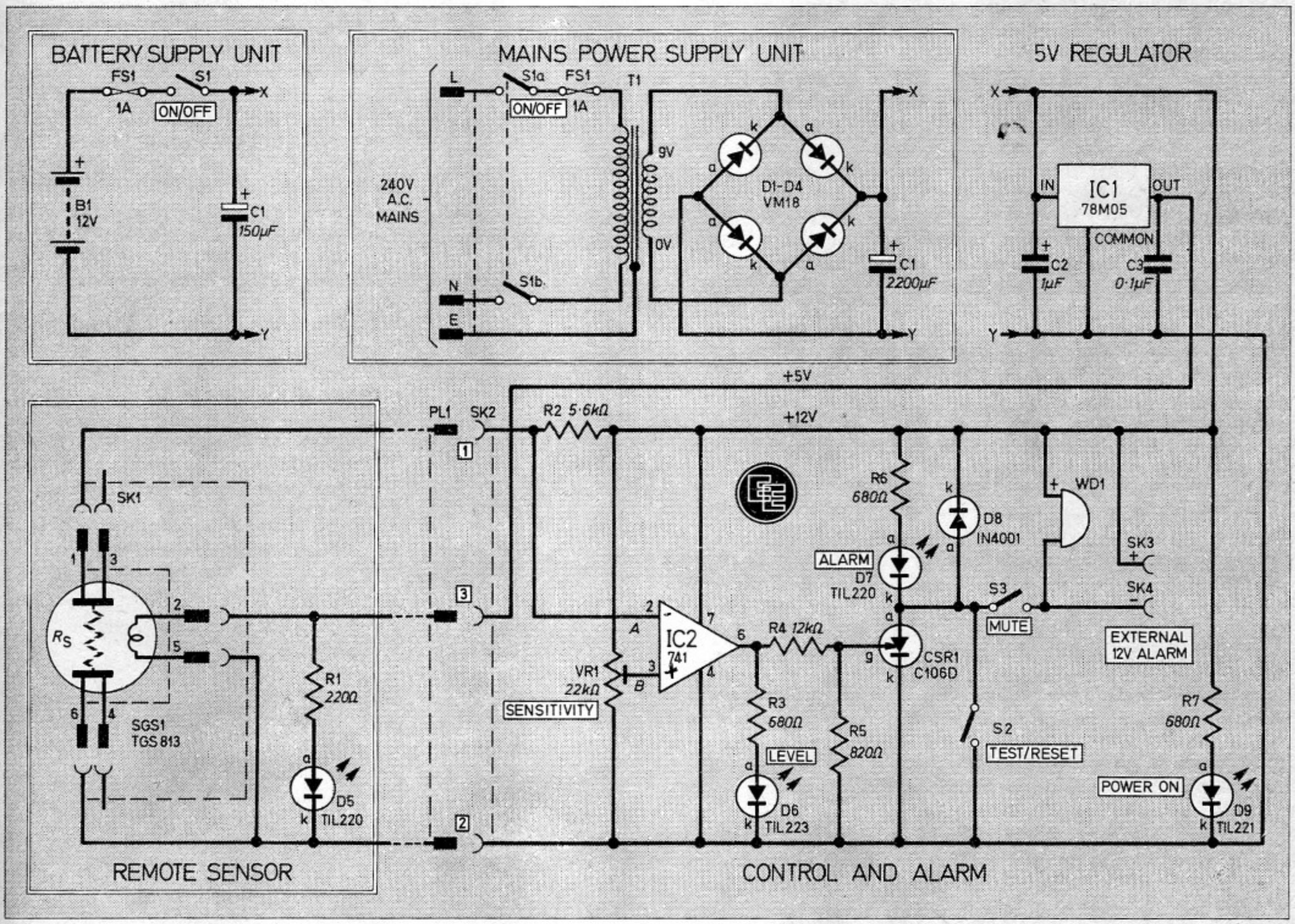
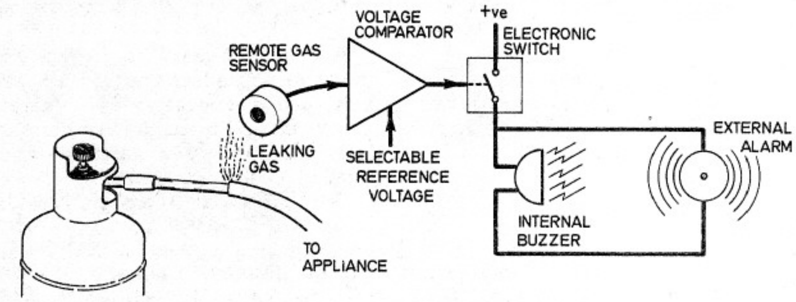


Fig. 3. The circuit diagram of the Gas Sensor with optional power supplies.

HOW IT WORKS



Gas or other toxic vapours reaching the sensing element in the sensor affect its conductivity and causes the voltage level into the comparator to change. When this passes the set reference level, the comparator output turns on the latching electronic switch and sounds the alarms. The alarms continue to sound even if the gas concentration reduces, until manually reset.

The gas sensor itself requires a 5V 150mA supply for its heater filament, and this is provided by IC1, a 5V 500mA regulator fed from the 12V rail. The p.c.b. layout has been devised to suit the μA78M05UC voltage regulator, so if an alternative type is considered the lead-out configuration must conform exactly with that shown.

In the mains version, the 12V supply is unregulated, and in reality measured only 10-11V. The voltage available at the alarm output sockets was only 10V. So if this outlet is used to drive a relay, ensure that it operates at 10V.

Diode D9 indicates that power is being applied to the circuitry and should of course be on all the time that the unit is in use, whether mains or battery supply.

SGS1 is the gas sensor. Its resistive semiconductor element, R_s, forms a potential divider with R2. As R_s decreases, due to an increased concentration of ambient gas levels, the voltage at SGS1/R2 junction will be reduced.

This voltage is referred to the inverting input (pin 2) of IC2, an operational amplifier connected as a simple comparator. A variable resistor VR1 determines the voltage at the non-inverting input (pin 3) of the comparator, and this voltage can be adjusted by rotating VR1 as necessary.

COMPARATOR ACTION

The output voltage of the comparator depends upon the inputs at pins 2 and 3 of IC2. If the voltage at pin 3 exceeds that at pin 2 then the output goes high, being at a voltage almost equal to the positive supply rail. Similarly the output goes low if the two input voltages are reversed.

By varying the setting of VR1, the switching point of IC2 can be adjusted. The effect of this is to alter the SENSITIVITY of the circuit, so that the alarm will sound at a required gas or smoke concentration.

Once pin 6 goes high—the sensor having detected gas at the necessary triggering level—then the LEVEL indicator diode D6 will illuminate to show that the ambient gas level has reached a value determined by VR1. The l.e.d. will extinguish once the level drops again.

When the comparator output switches high, this is fed via attenuator R4 and R5 to the gate terminal of CSR1 causing the thyristor to turn on.

This device normally assumes a high resistance blocking state between anode and cathode, but will be triggered into a conductive state when a suitable signal is received at the gate.

Once conducting, the thyristor completes the circuit to the ALARM l.e.d. and this illuminates.

LATCHING ACTION

The ALARM l.e.d. will continue to glow even if the output of IC2 falls and D6 extinguishes. This is due to the latching action of the thyristor. The main characteristic of a thyristor is that once it is triggered into conduction, it will remain in this state until it is reset.

It can be reset by several methods. If power is removed temporarily from the circuit, once switched back on again it will resume its blocking state. Another means of resetting the thyristor is to short the anode to cathode. This is accomplished by temporarily closing S2. Once opened again, the thyristor will resume its high resistance state, unless a trigger signal is present at the gate in which case the device will conduct once more.

Connected in parallel with the ALARM indicator is a miniature audible warning device, WD1. This consumes only 15mA when operating, and provides an audible indicator that the gas level being monitored by SGS1 has reached the required alarm level.

Provision has been made in this design for an external alarm to be connected at SK3 (+) and SK4 (−). This must be rated at 12V 500mA *maximum* (see later), and can take the form of a lamp, buzzer, relay, or combination of these.

If a relay is used, an e.m.f. suppression diode is required to short out any high reverse voltages which tend to appear across the relay coil just after power is removed from the relay; D8 accomplishes this.

CONTROLS

Switch S2 has a dual function. Apart from resetting the thyristor as described earlier, it will also complete the circuit to the alarm. If closed, therefore, it will cause the alarm to operate, and this is useful in testing the external alarm set-up. S2 is a biased (spring-loaded) type so that it is normally open.

The MUTE switch S3, if opened, silences the internal audible warning device WD1, and also removes power from the external alarm. This is necessary if the gas level is high for a long period of time.

Under these circumstances, the thyristor cannot be reset at S2 until the gas level drops because a constant triggering signal is present at CSR1 gate.

One could switch off the Gas Sentinel altogether, but this will not tell you when the gas level has dropped to below the triggering level. The most convenient course of action is obviously just to silence any audio alarms by opening S3. This will disconnect the external alarm

Rear view of prototype showing inlet/outlet sockets, fuse and internal alarm.

Straight-on view of completed unit.

as well as WD1, but D7 will remain alight. Then the user should wait for D6 to extinguish before resetting the alarm completely at S2. Switch S3 can then be closed once more. In practise this is a very neat solution.

The MUTE switch comes in handy when initially switching on the unit. During warming up, the resistance of the sensor temporarily drops to a low value (2 to 3 kilohms). The op-amp detects this and triggers the alarm. The MUTE switch, if opened while sensor is warming up, will prevent any audio alarm sounding unnecessarily. Warming up, on the prototype, takes about 30 seconds, and the sensor is ready for use once the LEVEL l.e.d. has extinguished, the alarm has been reset and S3 has been closed.

The l.e.d., D5, fitted to the remote sensor case should always be illuminated when the unit is switched on. This shows that voltage is being applied to the filament of the sensor.

PRINTED CIRCUIT BOARD

A professional finish, coupled with higher reliability, is achieved by using a p.c.b. to carry the complete circuit. This also makes for easier construction, and helps to ensure that the circuit will work first time.

The Gas Sentinel circuitry is very neatly accommodated in a Verobox Series II Casebox type 2066. This measures 155 x 92 x 52mm. It has one aluminium front panel which slots into a moulded bezel-type surround.

Any other plastic or metal case of suitable dimensions can be employed, but the specified box lends itself to compact construction and a professional appearance.

The remote sensor is mounted with its socket on a small Verobox type 1413E. This particular case measures 72 x 47 x 25mm and is moulded in black ABS. Again, any other suitable box can be used. Details of construction of this are given later.

CONSTRUCTION starts here

P.C.B. COMPONENT ASSEMBLY

Construction should commence with the printed circuit board. This is shown full size in Fig. 4a. There are a few points to watch concerning what should otherwise be a straightforward assembly procedure. The layout of the components on the top side of the board is shown in Fig. 4b.

If the battery version is to be built, the bridge rectifier should be omitted and the battery supply wired up as indicated in Fig. 4c. Note the value of C1.

IC2 is an 8-pin d.i.l. device and to make later replacement easier, should this prove necessary, it should be mounted in a suitable d.i.l. socket. This also prevents thermal damage arising during soldering.

The bridge rectifier specified here is a VM18 400V 1A type. This is encapsulated in a 4-pin d.i.l. package. Do not attempt to adapt a d.i.l. socket for use here, but solder it straight in, observing the d.c. polarity markings. Any other 1A type can be used if it is physically compatible with the p.c.b. It may be possible to bend the leads of the cheaper W005 device to make it fit the p.c.b., but ensure

COMPONENTS

COMPONENTS approximate cost £13 (battery) £15 (mains) excluding cases

Resistors

R1	220Ω	R5	820Ω
R2	5·6kΩ	R6	680Ω
R3	680Ω	R7	680Ω
R4	12kΩ		

All ¼W carbon ± 5%

Capacitors

C1	150μF 12V elect. *(battery version)*
	2200μF 16V elect. (*mains version*)
C2	1μF 35V tantalum
C3	0·1μF polyester type C280

Semiconductors

D1-D4	VM18 1A 400V bridge rectifier (*mains version*)—see text.
D5	TIL220 red l.e.d.
D6	TIL223 yellow l.e.d.
D7	TIL220 red l.e.d.
D8	1N4001 silicon diode
D9	TIL221 green l.e.d.
IC1	μA78M05 5V 500mA voltage regulator i.c.—see text
IC2	741 differential op-amp 8-pin d.i.l.
CSR1	C106D 4A 400V thyristor
SGS1	TGS813 semiconductor gas sensor (Watford)

Miscellaneous

VR1	22kΩ standard size preset potentiometer
S1	s.p. on/off toggle (*battery version*)
	d.p.d.t. sub-miniature toggle (*mains version*)
S2	s.p.c.o. sub-miniature biased off toggle
S3	s.p.c.o. sub-miniature toggle
FS1	1A 20mm fuse
SK1	TGS 6-pin socket
SK2	3-pin DIN socket
SK3	4mm insulated (red)
SK4	4mm insulated (black)
PL1	3-pin DIN plug to suit SK2
WD1	12V 15mA audible warning device
T1	mains primary/9V 800mA (or 1A) secondary or two 9V 400mA secondaries wired in parallel [latter, type 182 Watford] *(mains version)*

Printed circuit board: 66 × 50mm; 8-pin d.i.l. socket for IC2; 3-core miniature mains wire (connection to remote unit); mains cable (power to unit); small rubber grommet; nuts, bolts, washers; aluminium for IC1 heatsink; cases: Vero series II Casebox (65-2066A) (mains unit), Vero type 301 (74-1413-E) (remote unit); lens clips for panel l.e.d.s 2, red, 1 green, 1 yellow, self adhesive cabinet feet (4 off); 20mm panel mounting fuseholder.

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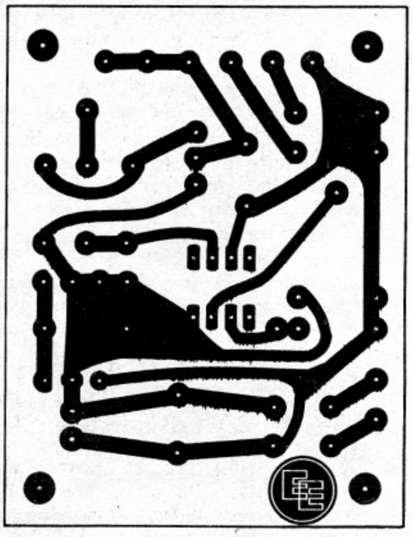


Fig. 4a. The master pattern of the p.c.b. underside shown full size. The black areas represent the copper remaining after etching.

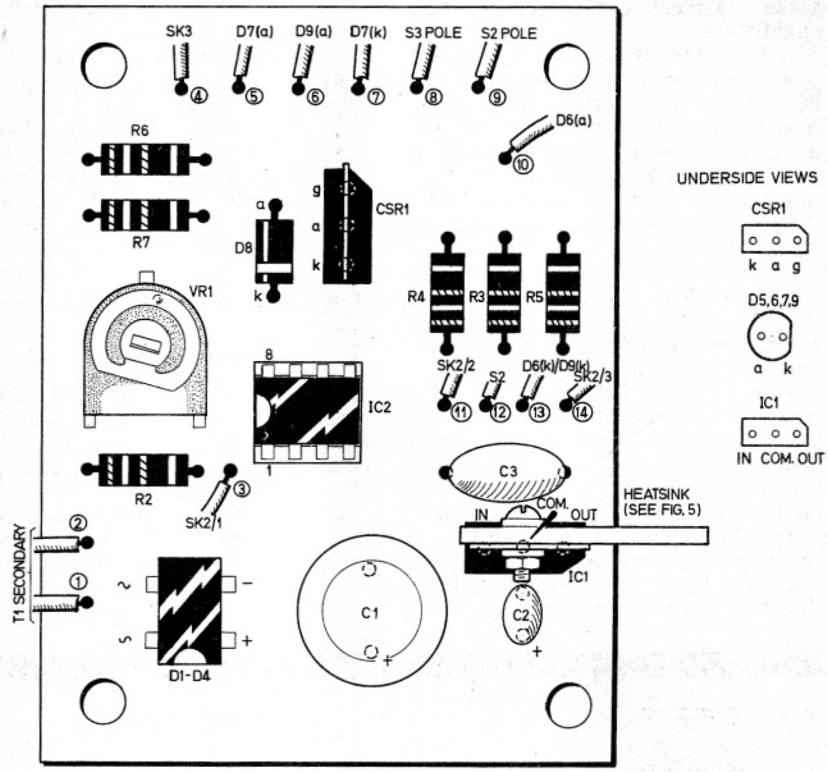


Fig. 4b. The layout of the components on the top of the p.c.b. and wiring details to off-board components.

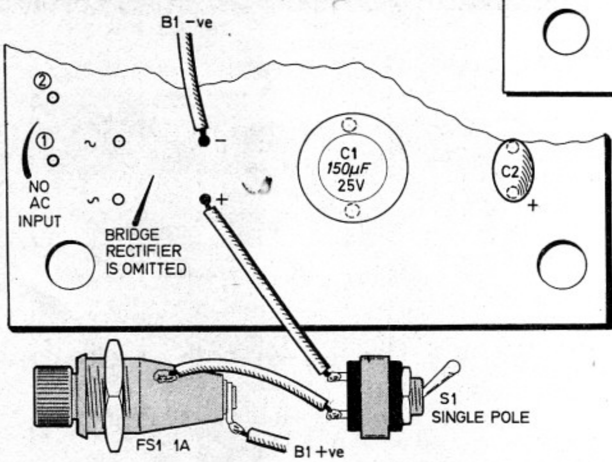


Fig. 4c. Shows modification to board layout, fuse and on-off switch for battery version.

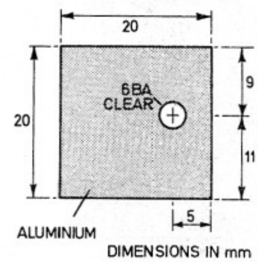
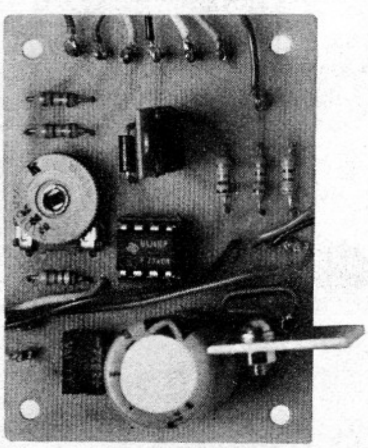


Fig. 5. Dimension and drilling details for the regulator heatsink.



The prototype printed circuit board removed from its case.

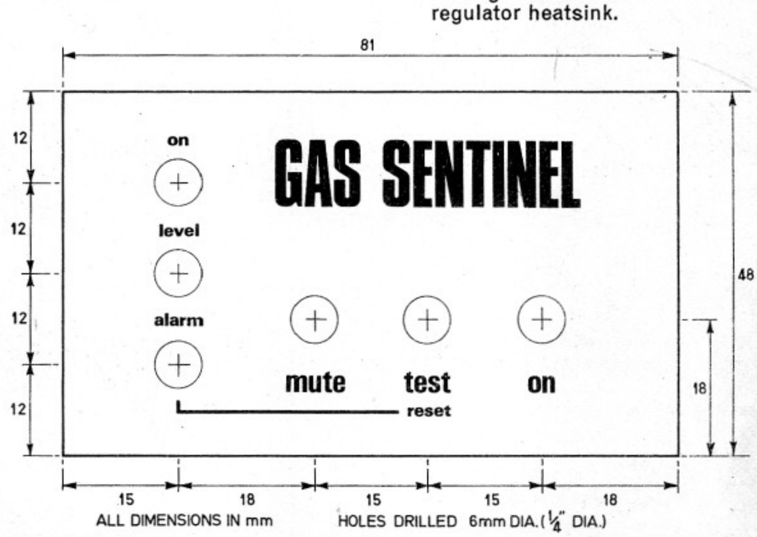


Fig. 6. Drilling information for the front panel, shown actual size for the specified case. Can be used as a template and/or front panel label.

that none of the leads can short circuit. The VM18 was used simply to make the p.c.b. copper track design slightly easier.

It is extremely important that the electrolytic smoothing capacitor C1 is soldered in the right way round. A radial lead (p.c. mounting) type is used, and the negative lead-out is clearly marked. Similarly, the tantalum bead capacitor has its polarity clearly marked, and this must be observed.

VR1 is a standard-sized preset, and not the more usual subminiature component; the one used on the prototype has a plastic knob fitted which helps in adjusting this control.

Care needs to be taken to ensure that the semiconductors are not overheated during soldering. A small heatsink used on the lead being soldered will help prevent any damage arising. Also, note the base connections for IC1 and CSR1. A chamfer on the plastic case identifies the output of the regulator and thyristor gate respectively.

IC1 is best fitted with a small heatsink as seen in Fig. 5 to help dissipate heat generated by the regulator. The heatsink does not require a mica insulation kit. C1 and IC1 are located closely together, but there should be enough clearance between the two. Note, however, that the heatsink is pointing to the perimeter of the p.c.b. and indeed overlaps it.

Check the completed printed circuit board for dry joints, reversed polarities of components, and adjacent tracks which may inadvertently have been abridged with solder.

CASE COMPONENTS

Construction can proceed with the case. With this design, some care needs to be exercised to ensure that everything is going to fit into place. For example, the positioning of the p.c.b. within the case in relation to the switches on the front panel is very important. The components on the circuit board must not touch any of the wiring to the switch tags.

Drill the aluminium panel as illustrated in Fig. 6, and after this the panel may be lettered as desired.

As usual, use small rub-down lettering and then spray on two or three coats of protective lacquer. Take care not to get dust or fluff on to the varnish while it is drying. Alternatively, Fig. 6 may be cut out or copied and glued to the front panel. Now fit the front panel mounted components.

Before finalising the location of the p.c.b. within the case, it would be better to experiment with its position in relation to the mains transformer and assembled front panel. Similar care should be taken to make certain that the transformer will not touch any other parts once the case is closed up. The transformer used in the prototype had dimensions 50 x 42 x 44mm. Also it had two 9V 400mA secondary windings that were connected in parallel. In the diagrams, the secondary has been shown as a single winding having a current rating equal to 800mA.

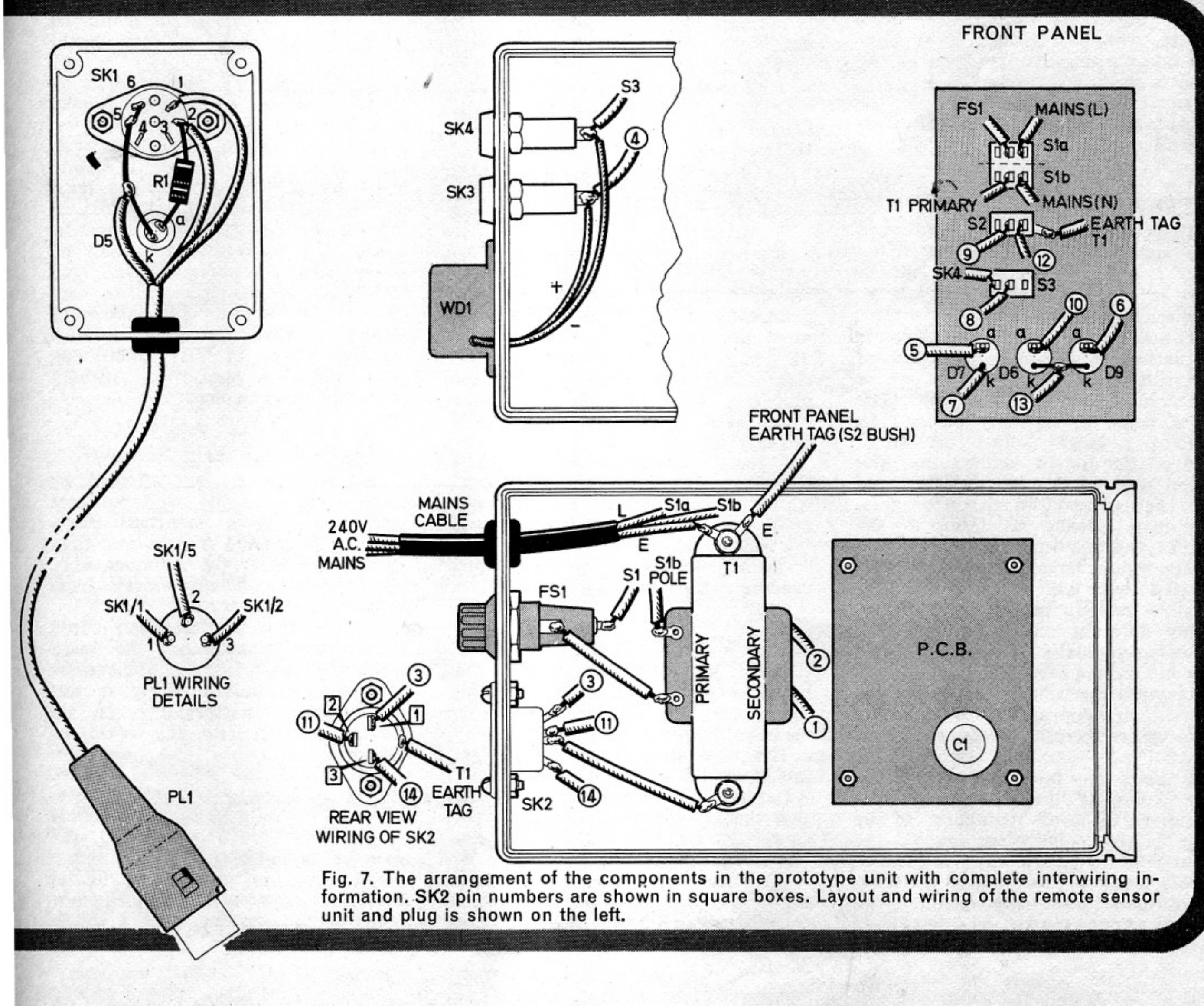
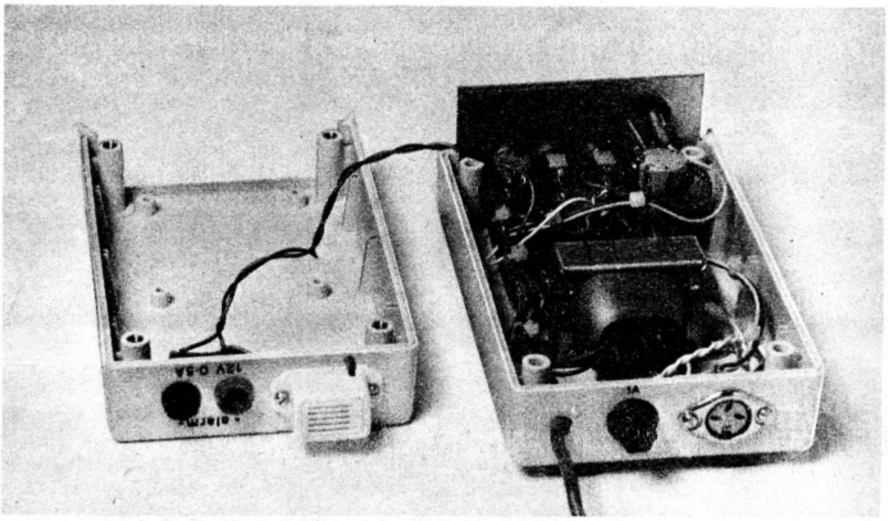


Fig. 7. The arrangement of the components in the prototype unit with complete interwiring information. SK2 pin numbers are shown in square boxes. Layout and wiring of the remote sensor unit and plug is shown on the left.



The completed control unit with top removed to show the close density of components.

On the bottom half of the case at the rear is mounted the 3-pin DIN socket, fuseholder and mains cable inlet; this last hole should have a grommet fitted.

On the top half at the rear there are the two 4mm sockets (SK3 and SK4) plus the audible warning device. The two sockets must clear the transformer completely when the case is fixed together. WD1 requires a small hole nearby to enable the leads to pass through to the terminals of SK3 and SK4.

INTERWIRING

There is quite a lot of interconnecting to be carried out, and Fig. 7 gives details; 3 amp mains wire is suitable for the mains interwiring.

The earth input from the mains is connected to the metal bracket of T1 with a solder tag under one of the transformer mounting bolts. The front panel is similarly earthed by placing a larger solder tag under one of the toggle switch nuts. The metal body of the DIN socket should also be earthed: an earth terminal tag may already be fitted to the socket, and this can be used.

The remainder of the wiring can be carried out with general purpose flexible hook-up wire. Try to use as many different colours as you can, in order to make subsequent checking and tracing easier.

Insulate any connections with p.v.c. sleeving as required. This is especially true of any mains voltage connections.

Readers may have noticed that the appearance of the front panel was improved by using "lens-clips" of the appropriate colour to mount the light-emitting diodes. Also, the rather small tangs of the toggle switches were made more manageable, and more attractive, by employing coloured push-on plastic caps.

REMOTE SENSOR UNIT

The final part of construction is the remote sensor unit; Fig. 8 gives all necessary details. The socket for the sensor requires an 18mm diameter hole to be cut: as this hole will still be visible once the socket is bolted in from behind, the cut-out should be as perfectly round as possible if a pleasing appearance is to be maintained.

In fact a perfect hole can be cut in the ABS plastic case using a Q-Max chassis cutter.

A cable length of 5 metres has proved successful, but it is anticipated that much greater lengths can effectively be used. Miniature 3-core mains cable is suitable for this.

It would be possible to mount the sensor on the main unit itself, thereby dispensing with the need for a remote unit. In this case, you would need to ensure that there is adequate clearance behind the socket once the unit was closed up, and the sensor would need to be mounted on top of the casebox.

A remote sensor, however, enables it to be positioned exactly as required, whilst the control unit can be in some other more convenient position (e.g. the bedside table).

Check over all wiring before proceeding to the next stage.

TESTING AND SETTING UP

Insert IC2 into its socket if you have not already done so. Also plug the sensor into its socket on the remote unit (either way round will do).

The unit should not be plugged into the mains during these tests.

Before switching on, try to test that the completed model is earthed correctly. Using an ohmeter on a low ohms range, check:

(i) The resistance between the earth pin on the mains plug and transformer mounting bracket registers a very low resistance.

(ii) Similarly check that the front panel is correctly and soundly earthed.

Set VR1 to middle position and S3 to MUTE (i.e. S3 open). Plug in and switch on. The green POWER ON l.e.d. should light, as should D5 on the remote unit.

After a few seconds the LEVEL and ALARM l.e.d.s should suddenly illuminate at the same time. This is perfectly in order and is attributable to the sensor warming up. This should be accompanied by the temperature of the sensor cell slowly rising.

Presently the LEVEL indicator should extinguish, leaving the ALARM l.e.d. on. Close S3; this should cause the audible warning device to sound. Then operating S2 (TEST/RESET) should silence the buzzer and extinguish D7 (ALARM).

Pressing S2 again should then operate the alarm circuitry once more, this time in the TEST mode.

One method of testing the sensor (without gassing yourself) is to pour a little lighter fuel or petrol on to a cotton wool pad and place this near to the sensor cell. Depending on the setting of VR1, the alarm should be triggered and the LEVEL l.e.d should illuminate.

The Gas Sentinel should then be operated for a few hours to make sure that everything is in order.

Over a period of about one week the SENSITIVITY control, VR1, should be adjusted until the desired level of sensitivity is obtained. The reason for the extended period of adjusting is that false alarms may initially be given because, for example, very high levels of cigarette smoke may trigger the alarm. This tendency should eventually be cured by altering the setting of VR1 accordingly until maximum sensitivity without false alarms is attained.

LOCATION OF THE SENSOR

The gas sensors are affected by changes in humidity and ambient temperature. It is important therefore to position the remote unit away from direct heat (e.g. radiators, fires, lights, etc.) and also away from steam.

In use it is advisable to check occasionally to see that the mesh window of the sensor has not become blocked with dust or dirt, as this will impair its performance. *Do not clean the mesh with any liquids or aerosols.*

The life of the sensor is claimed to be approaching ten years under normal operating conditions. Should replacement prove necessary, this will be signified by much poorer response of the unit to the "lighter fuel" test mentioned above. Replacement of the gas sensor is a simple matter. ⌑