LOFT GUARD

TERRY de VAUX-BALBIRNIE

Has the light been left switched on?

HAVING a permanently-wired mains light in the roof space is handy, especially if you keep a lot of useful material up there. Unfortunately, it is all too easy to leave it switched on as any user will testify.

Once the hatch is closed, there is no external sign that the light is on. It could then remain like that until the next visit – possibly several weeks or even months later. In the meantime, a significant amount of electricity would have been wasted.

SELF-CONTAINED

The Loft Guard is built as a small, battery-powered unit which is left in some suitable position inside the loft. It protects against leaving the light switched on by sounding a loud warning after 8 minutes or other preset time. This can be heard through the ceiling even with the loft hatch closed and alerts the next person passing by underneath it.

In the prototype model, the specified operating time was found to be sufficient. If you happen to be working for a long time in the loft, a Reset pushbutton switch on top of the unit may be operated every so often to reset the circuit and hold the sounder off for a further set time interval. This switch may also be used after it has begun to sound to stop it.

If you habitually spend long periods up there, it would be possible to increase the operating time and details for doing this are given later. Similarly, you could shorten it if required.

CHECKOUT

Before beginning construction work, check that the loft space is reasonably dark when the light is switched off. Make sure you will be able to site the unit where light from the lamp will reach it and, at the same time, above some place where the sound will readily attract attention – for example, near the top of the stairs.

Of course, the unit could be used in other similar situations. For example, to guard against a cupboard light being left switched on inadvertently. You could even site the buzzer remotely if required.

The standby current requirement of the prototype unit is less than 100μA. Using the specified 9V battery pack, consisting of six AA alkaline cells, a life of at least one year may be expected.

However, this will depend on how many times and for how long the buzzer sounds. While actually operating, the current rises to some 10mA. You could use a PP3 battery but the life would be correspondingly shorter.

CIRCUIT DESCRIPTION

The Loft Guard circuit works by sensing the change in illumination as the loft light is operated. Switching it on triggers a timer which holds the sounder off for the preset delay period. If the light is switched off during that time, the circuit will automatically reset ready for the next time.

The complete circuit diagram for the Loft Guard is shown in Fig.1. It will be seen that operation depends on the action of two integrated circuits. The first of these, IC1, is an operational amplifier (op.amp) responsible for the light-sensing aspect while the other, IC2, carries out the timing.

Looking at IC1 first, the inverting input (pin 2) is maintained at one-half of supply voltage (nominally 4·5V) due to the potential divider action of equal-value resistors R1 and R2. The non-inverting input (pin 3) has a voltage applied to it dependent on the values of the resistors in another potential divider.

In this case, its top arm consists of preset potentiometer, VR1, connected in series with fixed resistor R3 and the lower one, light-dependent resistor (l.d.r.) R4.

As the illumination of the l.d.r. sensitive "window" is reduced, the resistance of the device increases. In total darkness the specified l.d.r. will have a resistance in excess of 5MΩ. Even when there is a small amount of light, it will exceed 1MΩ.

In tests on the prototype in the author's loft, the "light" resistance was found to be

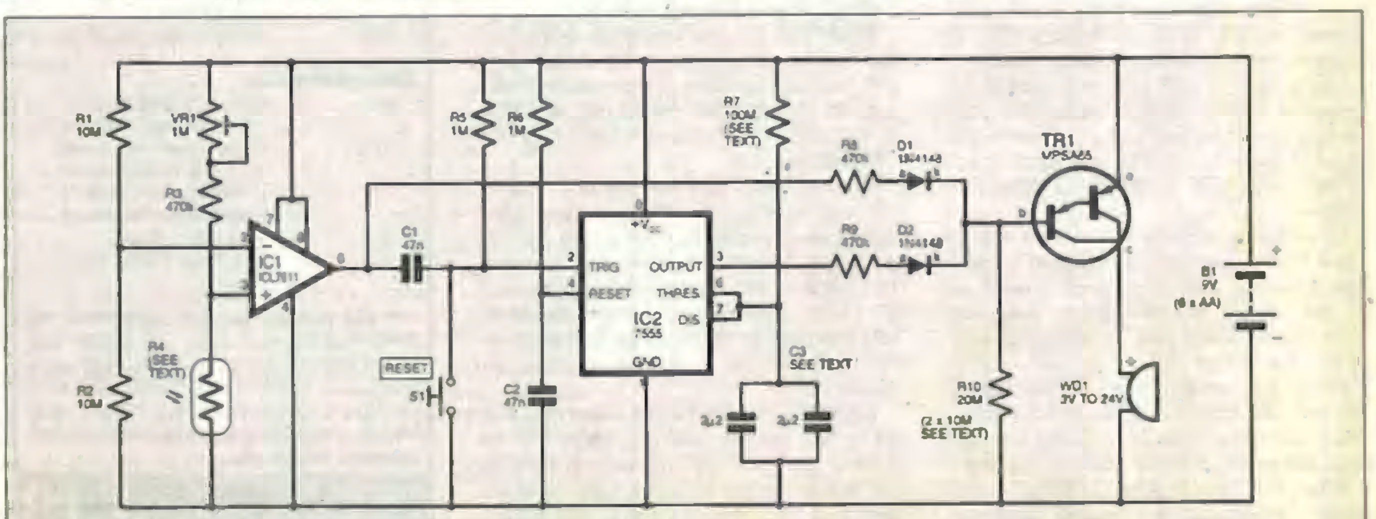


Fig.1. Complete circuit diagram for the Loft Guard.

some 100kΩ. Of course, in any particular situation this value will depend on the relative positions of the unit and loft light, plus also the power rating of the bulb and other factors. The point is that there is a wide difference between the l.d.r. "dark" and "light" resistance.

MORE OR LESS

Suppose preset VR1 is set to a value of 300kΩ. This is added to resistor R3 to give the resistance of the top arm of the potential divider – that is, 770 kilohms.

Under standby ("dark") conditions the resistance of the l.d.r. will exceed this value. This will result in a voltage greater than 4·5V appearing across it and hence at IC1 pin 3. When the loft light is on, the resistance of the l.d.r. will be less than 770 kilohms and the voltage at pin 3 will fall below 4·5V.

When the voltage at the op.amp non-inverting input (IC1 pin 3) exceeds that at the inverting one (that is, under "dark" conditions), the op.amp output, pin 6, will be high. When it is less ("light" conditions), it will be low. At the end of construction, preset VR1 will be adjusted so that this happens under the actual conditions prevailing in the loft.

Note that both op.amp inverting and non-inverting voltages are derived from potential dividers connected across the power supply. As the battery ages and the available voltage falls, the relative state of the inputs will remain unchanged. The circuit will therefore still work correctly. Of course, the battery pack will eventually develop insufficient terminal voltage to operate the buzzer satisfactorily and it will then need to be replaced.

Now look at IC2. This is an i.c. timer configured as a monostable. It may be activated by a *low* pulse applied to the trigger input (pin 2) – while high there is no effect.

Once triggered, the output (pin 3) goes high and remains like that until the circuit times out. The operating period depends on the value of capacitor(s) C3 and resistor, R7. The higher the value of either or both of these components, the greater the timing will be in proportion.

HIGH VALUES

Resistor R7 has a very high resistance (100 meg.) and the specified component may not be available to all readers. It could be made up from lower values connected in series and more will be said about this later.

Capacitor C3 will probably consist of two separate components connected in parallel (as shown in the Fig.1.) to provide the required capacitance. The suggested value (2·2μF) will give a combined effect of 4·4μF.

Of course, you could use a single 4·7μF, two 4·7μF or even one or two 10μF capacitors providing they were small enough to fit the circuit board layout. Such an arrangement would give a correspondingly longer time period.

Using the values shown in the circuit diagram, the timing will be about 8 minutes. It could be reduced by using a single capacitor having a lower value if required.

When the l.d.r. is dark – that is, under standby conditions, the op.amp output at pin 6 will be high and there will be no effect on IC2. However, when the output goes low (i.e. when the light is switched on), a low pulse is transferred, via capacitor C1, to IC2 trigger input (pin 2). The monostable then begins a timing cycle.

The purpose of capacitor C1 is to allow only a short pulse to pass. This is because if IC2 pin 2 was maintained in a low state continuously, the monostable would never time out since it would remain triggered. While on standby, resistor R5 maintains the trigger input in a high condition and this prevents possible false operation.

KEEP IT UP

The reset pin of IC2 (pin 4) needs to be kept high to enable operation of the monostable and this is the purpose of resistor R6. However, to allow the circuit to settle down when switched on and to prevent possible false triggering, it is held low for a short time using capacitor C2.

During this time the monostable is disabled and nothing can happen. The capacitor soon charges through resistor R6 and allows pin 4 to go high.

Pushbutton (Reset) switch S1 may be operated momentarily at any time to begin a new timing cycle and so hold the warning buzzer off. This works by taking the trigger input low for an instant.

While IC2 output is high (that is, during the course of timing), the base (b) of Darlington transistor TR1 will also be made high (close to positive supply voltage) via resistor R9 and diode D2. Under standby conditions, the l.d.r. R4 will be in near-darkness and IC1 pin 6 will be high. This also provides a high state at TR1 base through resistor R8 and diode D1.

Since TR1 is a *pnp* transistor rather than the more usual *npn* type, such a high state will maintain the base at near emitter voltage and so hold it off. No current will flow in the collector circuit and buzzer, WD1, will remain silent.

Suppose some light reaches the l.d.r. R4, IC2 will be triggered and a timing cycle will begin. Op.amp IC1 pin 6 will go low but this will have no effect on transistor TR1 because this state is blocked by diode D1 which is now reverse-biased. However, TR1 base will be kept high by the high condition of IC2 pin 3 and the buzzer will remain off.

When the monostable has timed out, IC2 pin 3 will go low and this state will be blocked by diode D2. Assuming light is still falling on the l.d.r., TR1 base will no longer be made high by either path R8/D1 or R9/D2. This allows it to go low via resistor R10 and the device is turned on

COMPONENTS

Resistors

R1, R2	10M
R3, R8, R9	470k (3 off)
R4	miniature light-dependent resistor, 5MΩ dark resistance. (5mm dia. – see text)
R5, R6	1M (2 off)
R7	100M cermet film (or 3 off 33M – see text)
R10	10M (2 off – see text)

All 0·25W 5% carbon film, except R4 and R7

See SHOP TALK page

Potentiometer

VR1	1M sub-min preset, vert.

Capacitors

C1, C2	47n min. metallised polyester, 5mm pin spacing (2 off).
C3	2μ2 min. metallised polyester, 5mm pin spacing (2 off or as required – see text)
Test capacitor (see text)	100n min. metallised polyester, 5mm pin spacing

Semiconductors

D1, D2	1N4148 signal diode (2 off).
TR1	MPSA65 *pnp* Darlington transistor
IC1	ICL7611 micropower op.amp.
IC2	7555IPA low-power timer

Miscellaneous

S1	miniature pushbutton switch, push-to-make
WD1	Audible warning device 103dB output at 1m minimum, 10mA d.c. operation maximum
B1	9V battery pack (6 x AA cells), with holder

Printed circuit board available from the *EPE PCB Service*, code 249; plastic box, size 138mm x 76mm x 38mm internal; 8-pin d.i.l. i.c. socket (2 off); plastic stand-off insulators (3 off); PP3-type battery connector; small fixings; multistrand connecting wire; solder, etc.

Approx. Cost Guidance Only **£19** *excl. batteries* (remember, it is *pnp* transistor!). Collector current then flows and the buzzer operates.

The fact that TR1 is a *Darlington* transistor results in it having an exceptionally high current gain. Only a very small base current (a fraction of a microamp) is therefore sufficient to operate the buzzer hence the very high value of resistor R10. Remember, the flow of current is in the opposite sense for a *pnp* transistor compared with *npn*.

KEEPING IT DOWN

It is essential that the continuous current requirement of the circuit is kept very low to minimise battery drain. This is achieved by choosing very low power integrated circuits.

Also, the resistors in the potential divider chains are made very high. If the loft is reasonably dark under standby conditions, the resistance of the l.d.r. will also be high and this reduces still further the current flowing through the series arrangement of VR1, R3 and R4.

To be effective, the buzzer must be of a very loud type yet have a current requirement of 10mA maximum. The specified unit (103db at 1m) was found to work very well.

CONSTRUCTION

The Loft Guard circuit is constructed on a small printed circuit board (p.c.b.) and the topside component layout and underside track master details are shown in Fig. 2. This board is available from the *EPE PCB Service*, code 249. All components are mounted on this except the battery holder, buzzer and pushbutton reset switch.

Commence board construction by drilling the three mounting holes in the positions indicated. Follow by soldering the i.c. sockets in position (do not insert the i.c.s at this stage) then all other components except capacitor(s) C3, light-dependent resistor R4, the diodes and transistor. *On no account solder the i.c.s direct to the board – it would be very easy to damage them.*

Note, resistor R10 (20MΩ) consists of two individual 10MΩ units connected in *series* using the pads indicated (both positions are labelled R10). If the 100MΩ cermet film type resistor specified for R7 is not available, connect three 33MΩ resistors in series instead using the pads provided on the p.c.b. – the three positions are labelled R7.

The photographs show the single specified resistor being used. This is soldered directly between the pads connecting IC2 pins 6, 7 and 8 – they are labelled "x" in Fig.2. If you can find no other way of doing it, you can connect ten 10MΩ resistors in series, zig-zag fashion, and connect the ends of the "chain" to the "x" pads.

Connect a 100nF "test" capacitor to either C3 position. This will provide an operating period of around ten seconds which will be more convenient for testing purposes than the full operating time.

Solder the l.d.r. in position using the full length of its end leads for the moment. If the specified *miniature* type of l.d.r. is not available the larger ORP12 type could be used. However, it would take up more space and would need a certain amount of adjustment to its position.

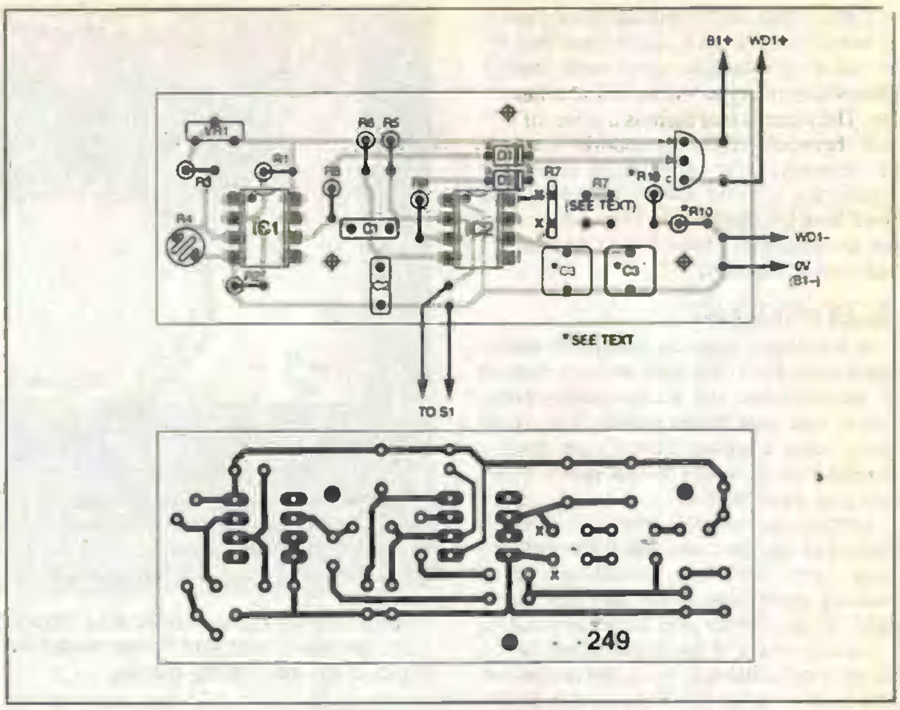
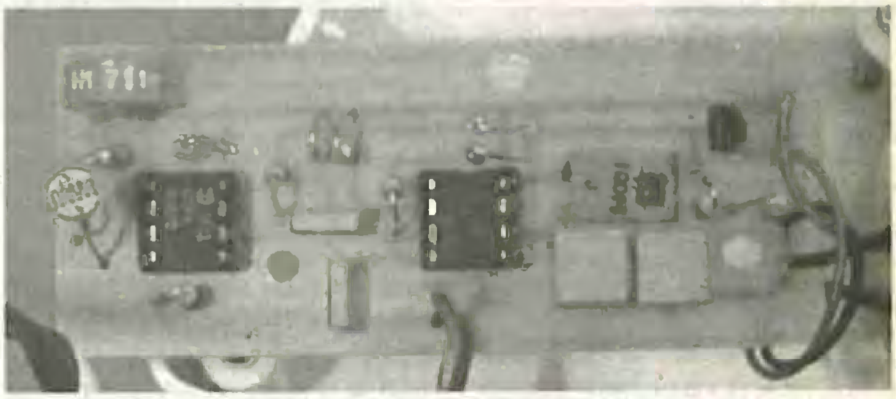


Fig.2. Printed circuit board component layout and full size copper foil master pattern.



Components mounted on the completed circuit board. Note that a single cermet film resistor has been used for R7 (see text).

POLARITIES

Now solder the polarity-sensitive components in place. These are the two diodes and Darlington transistor TR1. When soldering the diodes note that the cathode (k) end has a black band. When mounting the transistor, take care to place it as shown in the photographs with the flat face to the *left*.

Solder the battery connector wires to the p.c.b. If the battery holder has tag connections instead of being the more usual PP3 type, use short pieces of stranded wire instead. Connect pieces of light-duty stranded connecting wire for the Reset switch S1 and solder the buzzer leads to the WD1 pads – the red one is the *positive* lead.

Insert the i.c.s in their holders, with the correct orientation. These are both CMOS devices and could possibly be damaged by static charge which may exist on the body. To avoid possible problems, touch something which is earthed (such as a metal water tap) before unpacking them and handling their pins.

TESTING

Most readers will wish to carry out a basic test before mounting the circuit board in its box. This will allow any errors to be corrected more easily. It would be a good idea to tape over the hole in the buzzer for the moment to reduce the sound output because it is very loud!

Cover the l.d.r. with a piece of black p.v.c. tape to simulate placing it in darkness (or be ready to work in darkness). Adjust preset VR1 to approximately mid-track position and connect the batteries. Keep the switch wires separated so that the bared ends cannot touch.

Working on an insulating surface (such as wood or plastic) to prevent short circuits at the p.c.b. tracks, place the AA cells in the holder and connect it up. Peel back some of the p.v.c. tape to allow some light to reach the l.d.r. – the buzzer may give a momentary "chirp" which may be ignored.

After about ten seconds or thereabouts (remember, the timing has been reduced) the buzzer should sound. If you re-cover the l.d.r., it should stop immediately. Similarly, if you touch together the switch wires, it should stop.

If you have problems making it work, make sure the l.d.r. window really is covered to exclude *almost all* light – some types of black tape are far from opaque. If necessary, carry out the test in a dark cupboard. It is not satisfactory to cover the l.d.r. window with a finger!

If all is well, disconnect the battery holder and remove the i.c.s, again observing the anti-static precautions mentioned earlier. De-solder the buzzer wires and test capacitor C3.

With the required timing in mind, decide on the value of the capacitor, or capacitors needed for C3 and solder them in place. Note that an *electrolytic* capacitor would not be satisfactory here due to its inherent high leakage current.

BOXING UP

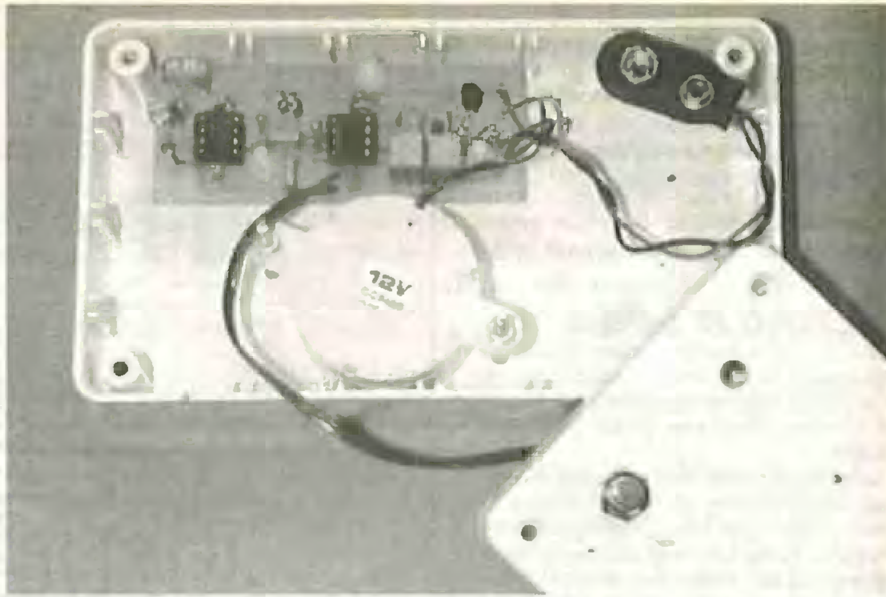
You are now ready to mount the circuit board in its box. This must be large enough to accommodate the p.c.b., battery pack, buzzer and pushbutton switch. You could use a more compact case if you used a smaller type of battery but, remember, this will give a shorter life.

Arrange the internal components on the bottom of the box and mark through the p.c.b. and sounder mounting holes. Remove everything again and drill these holes. Drill a further hole rather larger than that in the centre of the buzzer itself for the sound to pass through. Note that the buzzer will be mounted so that the sound is directed *downwards* (see photograph). This will allow the maximum amount of sound to pass through the ceiling.

Mount the p.c.b. temporarily on plastic stand-off insulators. You may wish to mark the position of preset VR1 on the side of the box so that a hole may be drilled to allow it to be adjusted more easily.

Measure the position of the l.d.r. "window" (top surface) and mark this on the lid of the box. Drill a clearance hole for it. With the lid in place, and the l.d.r. protruding, measure how much the end leads need to be shortened so that the window will be level with the face of the box.

Remove the p.c.b. and adjust the l.d.r. soldered joints to give the correct clearance. It would be a good idea to leave the leads a little on the long side because they can be bent slightly at the end to make small adjustments to the height.



Positioning of components and circuit board inside the prototype case. Note the l.d.r. "window" hole and Reset switch position in the lid. The space to the right of the p.c.b. is for the battery holder.

Drill a hole in the lid for the Reset switch and attach it. Solder the switch wires leading from the p.c.b. to its terminals. Drill the hole for VR1 adjustment if this is needed. Shortening the buzzer wires as necessary, solder them back to the p.c.b. pads. Insert the i.c.s again taking precautions against static charge build-up.

Mount the p.c.b. and attach the buzzer using a pair of long, thin bolts. Do not forget to remove any tape which was used to reduce the sound output, during testing, before attaching it. Insert the AA cells and secure the battery holder to the base of the box using a small bracket if necessary.

Place the lid temporarily in position but do not secure it yet. Adjust the l.d.r. end leads as necessary so that the window is level with the top face of the box (see photograph). Take care that they cannot touch one another and cause a short-circuit.

FINAL CHECKS

Test the circuit under real conditions. Try the unit in different positions in the loft to find the best one. Leave preset VR1 adjusted as far clockwise as you can (as viewed from the top edge of the p.c.b.) consistent with correct operation. When satisfied with the performance, secure the lid.

Check that the sound can be heard below the unit when the loft hatch is closed. You could remove a small amount of roof insulation from around the case to allow the sound to pass through more efficiently but this was not found necessary with the prototype.

It is suggested that the unit be allowed to sound every now and again to check the efficiency. When the buzzer can no longer be heard as it should, the batteries should be replaced. □

SHOP TALK

with David Barrington

PIC Micro-Probe

The component listing for the *PIC Micro-Probe* calls for a piece of "i.c. holder" type stripboard, with a central channel, devoid of copper, running across the copper tracks. This will cost you around £5, but for just under £2 you can use a piece of standard stripboard and cut away the copper tracks as necessary. The rest of the components should be readily available.

The PIC used in this project should be the 10MHz version. For those who want a "plug-in and go" preprogrammed PIC16F84, one is available from **Magenta Electronics** (☎ *01283 565435* or ***http://magenta2000.co.uk***) for the inclusive price of £5.90 (overseas readers add £1 for postage). For those who wish to program their own PICs, the software is available from the Editorial Offices on a 3·5in. PC-compatible disk, see *EPE PCB Service* page 937. If you are an Internet user, it can be downloaded *Free* from our FTP site: **ftp://ftp.epemag.wimborne.co.uk/pubs/PICS/microprobe**.

Magnetic Field Detector – Starter Project

Just a couple of pointers regarding purchasing of components for the *Magnetic Field Detector*, this month's starter project. The first concerns the 100μA "centre zero" meter, some readers may have difficulty in locating one. The meter used in the prototype came from **Maplin** (☎ *01702 554000*), code RW98G.

If you have trouble tracking down the UGN3503U Hall effect sensor, the above company list one as order code GX09K. They also supplied the OP77G precision op.amp, code UL05F. The alternative TL071CP low-noise op.amp should be stocked by most of our component advertisers.

Ginormous Stopwatch – Giant Display

This month we complete the *Stopwatch* project with the construction of a *Giant Digital Display* module. Most of the component supply "bugs" were ironed out last month.

The high voltage 4N25 opto-coupler, code AY44, and the ULN2003 Darlington array, code AD93B, are listed by **Maplin**. The BD681 Darlington transistor may be hard to find, but the suggested alternative TIP141 and TIP142 should be readily available. Note the differing pinouts for the TIP devices (Fig.2 last month).

Ready programmed PICs are available from the author for the sum of £10 each (for either the Display module or Stopwatch) or £50 for six in any combination, with free postage to anywhere in the world. *Payments should be made out to Mr. N. Stojadinovic.* His E-mail address is: **vladimir@u030.aone.net.au** or write to: **Mr. N. Stojadinovic, PO Box 320, Woden ACT, 2606, Australia**.

A programmed PIC16C54 is also available from **Magenta Electronics** (☎ *01283 565435* or ***http://magenta2000.co.uk***) for the inclusive price of £5.90 (overseas readers add £1 for postage). For those who wish to program their own PICs, the software is available from the Editorial Offices on a 3·5in., PC-compatible disk, see *EPE PCB Service* page. If you are an Internet user, it can be downloaded *Free* from our FTP site:

ftp://ftp.epemag.wimborne.co.uk/pubs/PICS/stopwatch.

The two printed circuit boards are available from the *EPE PCB Service*, code 247 (Digit) and 248 (Port Conv.).

Loft Guard

Most of the components called-up for the *Loft Guard* project should be readily available from your usual supplier. The only problems that are likely to crop up may be finding the high value resistors.

The *single* 100 megohm resistor (R7) was only found listed under the "cermet film" range stocked by ***Electromall*** (☎ *01536 204555* or RS ***http://rswww.com***), quote code 158-222. As the article points out, you could use three 33 megohm resistors (in series); the p.c.b. is also designed to accept these. This resistor (33M) came from the **Maplin** "high voltage" metal film range, order code V33M.

Note that to make up the 20 megohm resistor (R10) you will need two 10 meg types. Once again, the "series" pads have been included on the p.c.b.

The last mentioned company also supplied the miniature light-dependent resistor (l.d.r.), code AZ83E, and the high power warning buzzer, code FK84F. Although most of our components advertisers should be able to offer something similar. You could, of course, use the good old standard ORP12 l.d.r. if you wish.

Even though the semiconductors are specific versions, they should be in plentiful supply. The p.c.b. is available from the *EPE PCB Service*, code 249.

Teach-In 2000

If you have only just picked up on our new *Teach-In 2000* series with this issue, and being a newcomer to electronics, you may feel a bit apprehensive about ordering the various parts for the demonstration "exercises". Fear not, some of advertisers have put together component and hardware packs specially for the new series. A few more will be added as the series progresses, but we do not expect that to be until at least part seven.

To date, participating advertisers are as follows and readers are advised to contact them for more details:

ESR Electronic Components (☎ *0191 251 4363* or web ***http://www.esr.co.uk***) Hardware/Tools and Components Pack.

Magenta Electronics (☎ *01283 565435* or ***http://www.magenta2000.co.uk***) – Multimeter and Components Kit 879.

FML Electronics (☎ *01677 425840*) – Basic Components Sets.

N. R. Bardwell (☎ *0114 2552886*) – Digital Multimeter special offer.

PLEASE TAKE NOTE

Demister One-Shot — Nov '99

Page 844 Fig.4. On the p.c.b. component layout diagram, the "body" outlines of capacitors C1 and C2 should be transposed – see photograph at top of page 845. The electrolytic, shown as a circle, should connect to the IC1 pin 8 copper track (+) and the common GND track (–). The actual annotations are correct.