# EVERYDAY ELECTRONICS

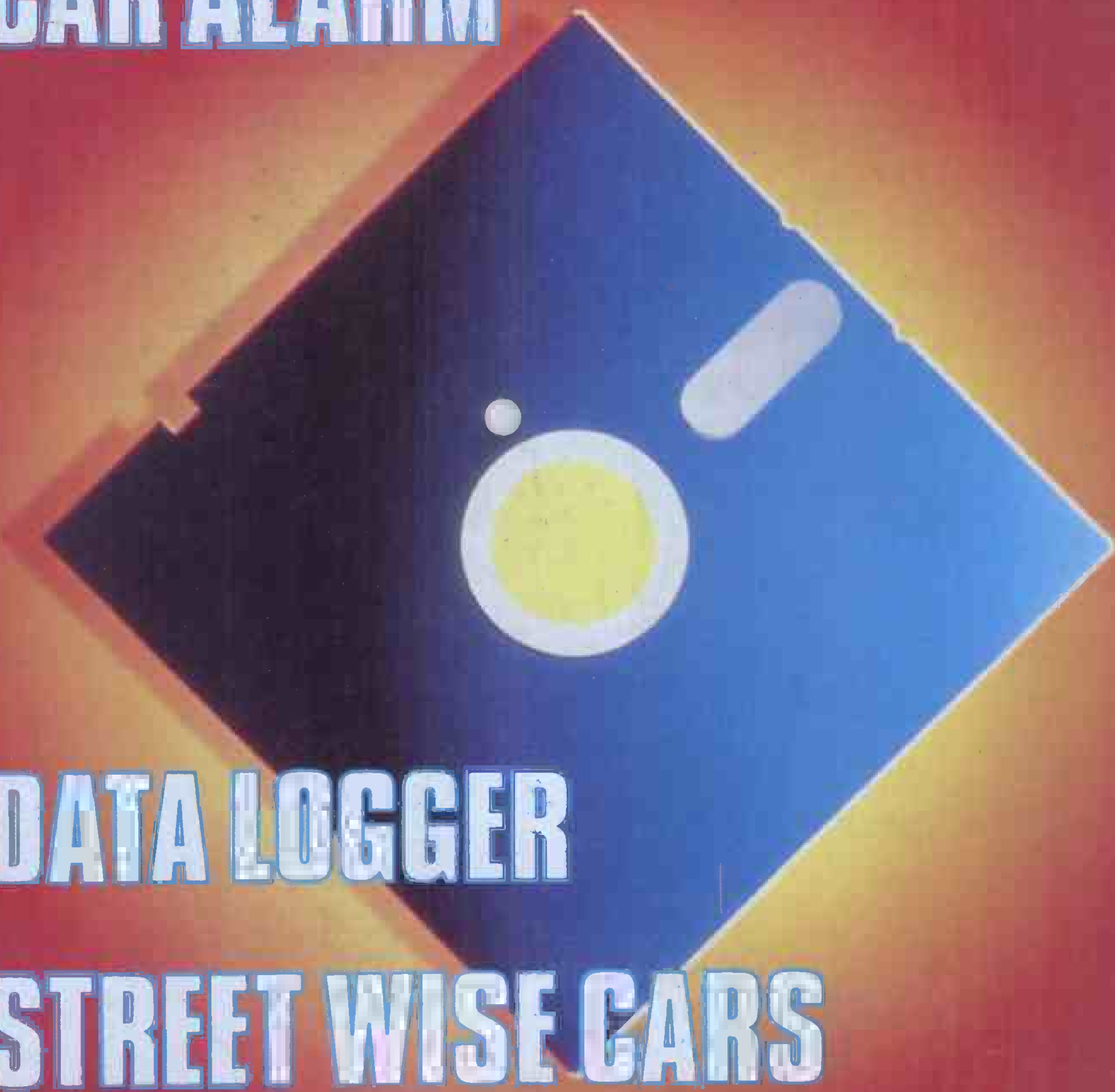
AUGUST 1988

INCORPORATING ELECTRONICS MONTHLY

£1.30

## SUN TAN TIMER

## CAR ALARM



## DATA LOGGER

## STREET WISE CARS

The Magazine for Electronic & Computer Projects

VOL 17 No 8 AUGUST '88

# EVERYDAY ELECTRONICS

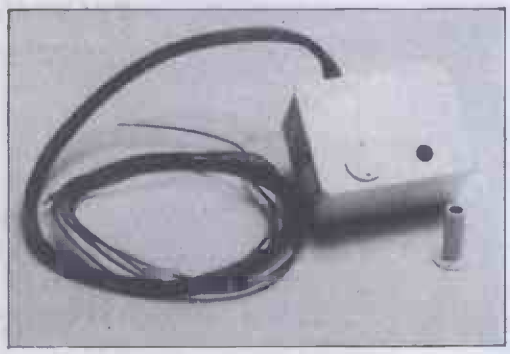
INCORPORATING ELECTRONICS MONTHLY

ABC

The Magazine for Electronic & Computer Projects

ISSN 0262-3617

PROJECTS . . . THEORY . . . NEWS . . .
COMMENT . . . POPULAR FEATURES . . .

## Projects



## Series



## Features





*Our September '88 issue will be published on Friday, 5 August 1988. See page 445 for details.*

ILP AMPLIFIERS FROM JAYTEE

# The UK Distributor for the complete ILP Audio Range

## BIPOLAR AND MOSFET MODULES

**The unique range of encapsulated amplifier modules with integral heatsink.**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| HY30 | 15W | Bipolar amp | £11.30 | HY248 | 120W | Bipolar amp (8ohm) | £24.15 |
| HY60 | 30W | Bipolar amp | £11.30 | HY364 | 180W | Bipolar amp (4ohm) | £36.00 |
| HY6060 | 30W | Stereo Bipolar amp | £23.65 | HY368 | 180W | Bipolar amp (8ohm) | £37.55 |
| HY124 | 60W | Bipolar amp (4ohm) | £18.50 | MOS128 | 60W | Mosfet amp | £40.70 |
| HY128 | 60W | Bipolar amp (8ohm) | £18.50 | MOS248 | 120W | Mosfet amp | £46.35 |
| HY244 | 120W | Bipolar amp (4ohm) | £24.15 | MOS364 | 180W | Mosfet amp | £75.75 |

## POWER SUPPLIES

**Comprising toroidal transformer and DC board to power the ILP amplifier modules.**

| | Application | | | | |
|---|---|---|---|---|---|
| PSU30 | Pre-amplifier | £ 9.75 | PSU532 | MOS128 (2) | £25.40 |
| PSU212 | 1 or 2 HY30 | £17.70 | PSU542 | HY248 | £25.40 |
| PSU412 | HY6060, HY124, 1 or 2 HY60 | £19.95 | PSU552 | MOS248 | £27.45 |
| PSU422 | HY128 | £22.00 | PSU712 | HY244 (2) | £29.20 |
| PSU432 | MOS128 | £23.00 | PSU722 | HY248 (2) | £30.20 |
| PSU512 | HY244, HY128 (2) | £24.40 | PSU732 | HY364 | £30.20 |
| PSU522 | HY124 (2) | £24.40 | PSU742 | HY368 | £32.20 |
| | | | PSU752 | MOS364, MOS248 (2) | £32.20 |

## PRE-AMP and MIXER MODULES

**These encapsulated modules are supplied with in-line connectors but require potentiometers, switches etc. Individual data sheets on request.**

| | | |
|---|---|---|
| HY6 | Mono pre-amp with bass & treble | £ 9.25 |
| HY7 | Mono mixer 8 channel | £ 8.75 |
| HY8 | Stereo moxer 5 channel | £ 8.75 |
| HY9 | Stereo pre-amp | £ 9.30 |
| HY11 | Mono mixer 5 channel with bass & treble | £ 9.75 |
| HY12 | Mono pre-amp 4 channel with bass, mid & treble | £ 9.30 |
| HY13 | Mono VU meter driver | £ 8.75 |
| HY66 | Stereo pre-amp with bass & treble | £15.00 |
| HY67 | Stereo headphone driver | £16.60 |
| HY68 | Stereo mixer 10 channel | £11.30 |
| HY69 | Mono pre-amp 2 channel with bass & treble | £15.40 |
| HY71 | Dual pre-amp | £14.95 |
| HY73 | Guitar pre-amp with bass & treble | £15.00 |
| HY74 | Stereo mixer 5 channel with bass & treble | £15.95 |
| HY75 | Stereo pre-amp with bass, mid & treble | £15.40 |
| HY76 | Stereo switch matrix | £19.50 |
| HY77 | Stereo VU meter driver | £14.35 |
| HY78 | Stereo pre-amp | £14.70 |
| HY83 | Guitar pre-amp with special effects | £18.95 |
| B6 | Mounting board | £ 1.15 |
| 866 | Mounting board | £ 1.75 |

## LOUDSPEAKERS

| | | |
|---|---|---|
| 312B | 350W 12" Bass loudspeaker | £78.65 |
| 312WB | 200W 12" Wideband bass loudspeaker | £78.65 |

## POWER SLAVES

**These cased amplifiers are supplied assembled and tested in 60 and 120 watt Bipolar or Mosfet versions.**

| | | | | | |
|---|---|---|---|---|---|
| US12 | 60 watt Bipolar (4ohm) | £75.00 | US32 | 60 watt Mosfet | £99.95 |
| US22 | 120 watt Bipolar (4ohm) | £83.75 | US42 | 120 watt Mosfet | £108.35 |

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VISA

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K503 100 Wirewound Resistors ~~£2.00~~ **£1.00**
K547 100 Zeners ~~£4.50~~ **£2.00**

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Z578 30×30mm 16R 0.4W ~~60p~~ **3 for £1**

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Z660 8-24V in 5V 2A out ~~£5~~ **£2.50**
Z975 14V 600mA ~~£6.50~~ **£3.25**

**Amplifier Panels:**
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Z915 Stereo 1W amp ~~£3.50~~ **£1.75**
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## NEW THIS MONTH

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**Z4081 CB Aerial eliminator.** Black steel case 77×70×30 for using car radio aerial with CB. Has 2×500pF trimmers, switches, coil etc +2 leads approx. 2m long. Originally £7.95 Our price £2.00

**Z4080 AM/CB converter.** Enables all CB channels to be picked up on MW. 85×70×50mm **£4.50**

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**Z4057** Mains Lead, 2m long grey 3 core 6A lead with 13A plug fitted with 5A fuse. **70p; 10+ 55p; 100+ 40p**

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★ Large tube solder

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**Z4071 MAP LIGHT**—In car use with magnet and magnifier, curly lead and plug. **£1.95**

**Z345 OPTICAL SHAFT ENCODER.** Similar to RS631-632, but 80% cheaper! **£8.50**

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**Z347** 4 x LM358 op amps surface mounted on ceramic substrate, easily removed. **5 panels for £1**

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**REPRINTS: If you do not have the issue of E.E. which includes the project, you will need to order the instruction reprint as an extra: 80p each. Reprints are also available separately–Send £1 in stamps.**

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# NEXT MONTH

## *POWER CONTROLLER*

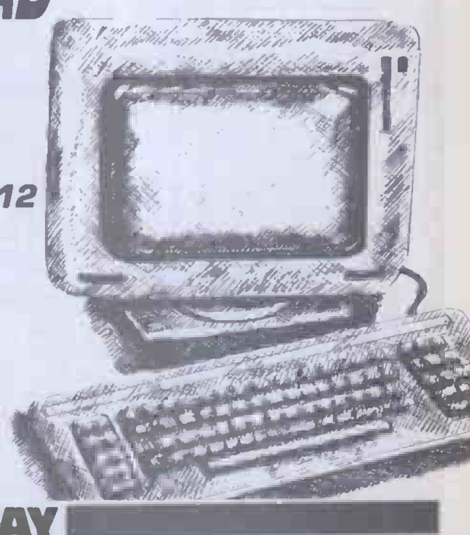
***The article describes the construction of a multi-purpose phase-control power controller, based around a fully-integrated thick film triac and trigger circuit.***
***Also included is a very effective suppression circuit which eliminates nearly all RFI.***

## BREAKING GLASS ALARM

**By sensing the ultrasonic sounds generated when glass is broken this unit provides unique protection for any window or glass covered area.**

## *PIO FOR THE AMSTRAD*

***A simple parallel interface board for the PCW8256/512 which provides two 8 bit wide input/output ports.***



**EVERYDAY ELECTRONICS**
**SEPTEMBER ISSUE ON SALE AUGUST 5**

# EVERYDAY ELECTRONICS

INCORPORATING ELECTRONICS MONTHLY

**The Magazine for Electronic & Computer Projects**

**VOL. 17 No. 8** **August '88**



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## PROJECTS . . . PROJECTS . . . PROJECTS . . .

WE publish six or seven projects in nearly every issue of *Everyday Electronics*—that's over 70 projects a year—yet if we ask readers how many of our designs they build we find the average is about one project per reader, per year. Of course some of you build 10 or 15 but many build none at all. However what we do find is that the circuits and data are used for other purposes.

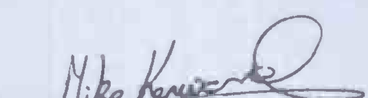
Many readers are learning electronics and, while they build up experimental circuits, like those in *Exploring Electronics*, they do not yet build full projects. They may well read the articles describing particular projects to gain knowledge from the circuit descriptions etc., and they will often go on to build equipment later; having had their appetite whetted by various articles.

There is of course another band of readers who, one might say, are "dreamers", and those who read everything avidly, work out how they can build their own pet design but never actually do it. Then there are readers who never make any of our projects, but use the basic circuit ideas to build their own project idea.

Whatever band you fall in, whether you build up any circuits or not, I hope you all get enjoyment from our hobby and of course from reading *EE*.

## DREAMER!

I suppose I could be classed as a "dreamer". Some of the projects we publish have been designed because they were items I wanted to build. I must say that while I have helped my children build the odd design I have not actually built any that I planned to in the last couple of years. Still, one day . . .



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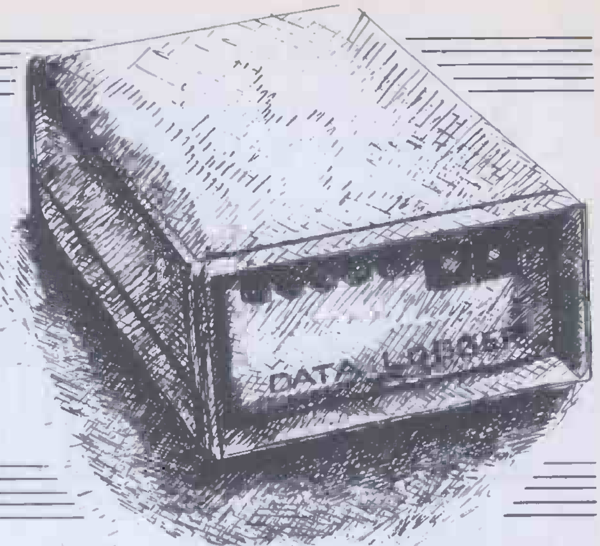
Constructional Project

# DATA LOGGER



J. PHELAN

*A battery powered data logger which can be used anywhere to record 16K bytes (or more) of data over a period of up to 450 hours. Data can later be dumped into a computer for analysis.*

DATA logging is the recording of data over a period for subsequent analysis. If for example a person wished to check on the operation of a home central heating system, they could arm themselves with a thermometer and a notepad and measure and record the temperature at various places throughout the building. This of course would have to be continued over a long enough period to ensure that the building had been subjected to a normal range of temperatures, it would, therefore, entail recording temperatures over at least a day. This data could then be plotted as a graph so that the performance of the system could be gauged.

The interval between readings would have to be sufficiently short to record normal fluctuations, but not so short that unmanageable amounts of data would be generated, so the person taking the measurements would not get a lot of rest. This is an example of one kind of data logging, but there are many other situations where data must be collected over a period and where the environment is more hostile. Clearly data logging is an activity where automation is called for.

## AUTOMATIC DATA LOGGERS

Automatic data loggers usually consist of some form of transducer to convert the parameter being logged into electrical signals and a system for recording these signals. The recording medium generally used until quite recently was magnetic tape as this has an enormous capacity compared to most other media. In the last few years though, because of the ever increasing capacity of silicon memory devices coupled with their falling prices, there has been a movement away from magnetic tape to solid-state memory. Solid-state loggers have the advantage of being robust because they have no moving parts, and can interface easily with computers for subsequent data dumping and analysis.

Although solid-state loggers have a long way to go before their memory capacity reaches that of magnetic tape, they are quite suited to situations where the amount of data to be recorded is in the order of thousands to tens of thousands or perhaps even hundreds of thousands of readings. Once the requirements reach the mega-reading point, magnetic tape wins hands down. Some solid-state loggers have been designed with sufficient intelligence to process the data as it is being received and are able to optimize their available memory space.

The logger described in this article has been designed with low cost and low power consumption in mind. It can be used to record a variety of parameters and one analogue circuit will be described later in the text. The logger has been designed to interface with the BBC and the AMSTRAD PC1512/IBM computers and data collection programs for these are available.

The logic has been implemented in CMOS in order to keep the power consumption as low as possible and the analogue to digital converter and RAM's, which are the most power hungry devices in the circuit, are switched off when not actually doing a conversion. The memory capacity can be increased from the basic 16K bytes to 72K bytes. The circuit is shown in Fig. 1.

## MASTER TIMING GENERATOR

The timing for the whole system is provided by a 32,768Hz watch crystal which, along with a 4060 binary divider and oscillator, forms the master clock. The basic crystal frequency of 32,768Hz is divided by 214 by the dividers in the 4060, giving a final output frequency of 2Hz. Unfortunately, 32,768Hz has to be divided by 215 to give the required frequency of 1Hz, but a suitable divider is not available, so the output of the 4060 has to be further divided by two to give 1Hz. This is done by feeding the signal to the clock input of a 4013 D-type flip-flop. The data input of this flip-flop is connected to its Q output thus causing the device to toggle with each 2Hz clock pulse and providing a 1Hz signal from the Q output.

The 1Hz signal is passed to two 4522 programmable, 4-bit BCD down counters which are connected to form a divider whose output can be switched between one pulse per second and one pulse per 99 seconds. The four parallel inputs to the counters which are tied to $V_{ss}$ through the resistors contained in the single-in-line resistor network, R2, are also connected to the switches S1 and S2. These are BCD switches, so they present the BCD value of their settings to the parallel input lines. Thus if a switch is set to position 5, then the D1 and D3 inputs to the counter would be taken to $V_{dd}$.

The 4522 counters IC7 and IC8 are connected together like conventional ripple counters in that the Q4 output of the first stage is connected to the clock input of the second stage. But in addition these counters have a decoded zero state output to provide the divide by *n* function. For multi-stage applications, the zero output is used in conjunction with the cascade feedback (CF) input.

The zero output is normally at a logic "0" level during counting and will go to a "1" state only when the counter is at its terminal count (0000) AND its CF is at logical "1" level. Thus, CF acts as an active low inhibit for the zero output. The zero output of the first counter is connected to the parallel enable pins of both counters and when it goes high it will load the counters with the BCD value on the switches S1 and S2. The zero output of the second counter is connected to the CF input of the first counter.

Consider the situation when the first counter is at a count of 1 and the second is at 0. Because the second counter is at 0 AND its CF input is high (tied to $V_{dd}$, its zero output will be high. This high level is applied to the CF input of the first stage. If now one clock pulse occurs, the first counter will reach 0 and because its CF input is high, its zero output goes high and presets both counters with the BCD value on the switches (say, for example 15). The counters are thus set to the required count and because the first counter is no longer at 0, its zero output goes low again.

Incoming clock pulses will continue to decrement the first counter until it again reaches 0, but this time its CF input is being held low because the second counter is at 1 (and so its zero output is low). Thus the zero output of the first counter will remain low and will not preset the counters this time round. The next clock pulse will decrement the first stage counter from 0 to 9 and the

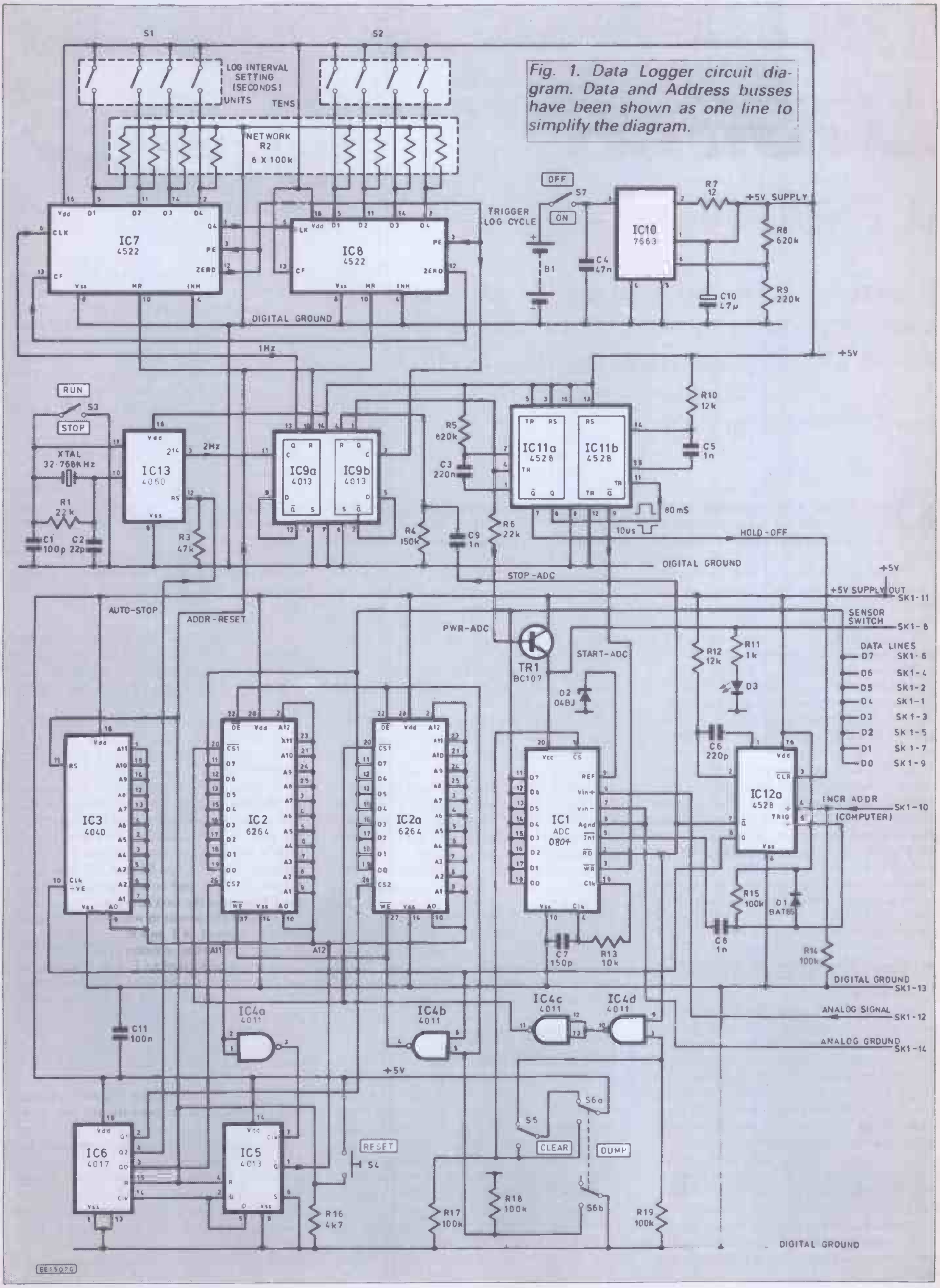



*Fig. 1. Data Logger circuit diagram. Data and Address busses have been shown as one line to simplify the diagram.*

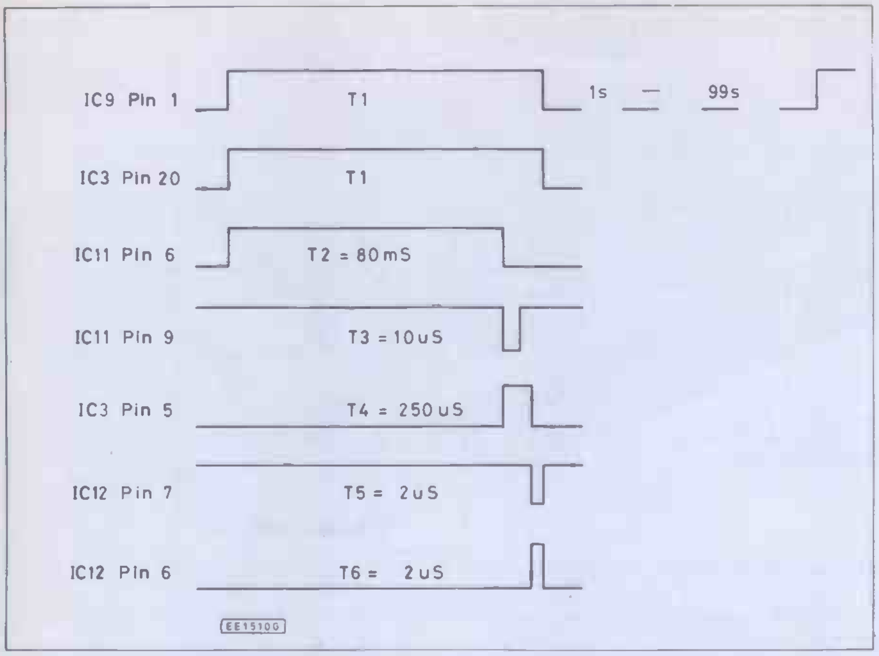



*Fig. 2. Timing diagram of the Data Logger.*

count ripples through to the second stage taking it to 0. After a further 9 clock pulses, stage one reaches 0 again and as both counters are now at 0, they are preset once more with the value on the switches. The two stage counter can thus divide the incoming rate from one pulse per second to one pulse per 99 seconds as determined by the switch settings.

The output of the programmable divider stage is the signal which triggers the subsequent operations of the logger. It is fed to the clock input (pin 3) of IC9b which is a 4013 D-type flip-flop. This device triggers on the rising edge of the clock signal and because the D input is connected to the $\overline{Q}$ output this causes the flip-flop to toggle and its Q output to go high.

Looking at the timing diagram in Fig. 2 the output of IC9 Q output is shown in trace (1) as T1. This Q output is connected to the positive edge triggered input of the monostable, IC11a, and through R6 to the base of the transistor TR1 which is the power switch for the ADC. Thus when the Q output goes high, the transistor is switched on and powers the ADC as shown in (2) of the timing diagram. As a visual indication of this "on-time", the l.e.d. (D3) is also powered during time period T1. The timing components C3 and R5 connected to pins 1 and 2 of the monostable give a timing period of 80mS, shown as T2 in line (3) and this provides a delay to allow the ADC time to power up properly before it is required to do a conversion.

After the 80mS delay, the falling edge of the pulse from the Q output of IC11a triggers the next monostable IC11b which is connected as a negative edge triggered device. The timing components C5 and R10 on pins 14 and 15 give this monostable a period of 10$\mu$S. This negative going pulse from $\overline{Q}$, trace (4), is fed to the $\overline{WR}$ input of the ADC and triggers the convert cycle.

## ANALOGUE TO DIGITAL CONVERTER

The ADC0804 is a CMOS 8-bit successive approximation ADC converter. It has an internal clock oscillator and the components C7 and R13 determine the period of this oscillator. The components chosen give an oscillator frequency of around 600kHz. The time to do a conversion is related to the clock frequency and is about 120$\mu$S at the chosen frequency. The voltage on the REF input determines the full scale sensitivity of the ADC and it must be held at half the required full scale voltage, i.e. holding it at 2 volts gives a full scale reading (an output of 11111111) with a 4 volt input.

As the measurement accuracy depends upon the accuracy of this reference voltage, it must be derived from a stable accurate source. In this case it is provided by a bandgap diode, D2. This diode is designed to be used as a precision reference device, it has low temperature drift, good regulation, and will operate from currents as low as 15$\mu$A. Its reference voltage is specified as being between 1.24 and 1.28 volts with a typical reference voltage of 1.26 volts. This is ideal for this application giving the ADC a full scale sensitivity of approximately 2.5 volts.

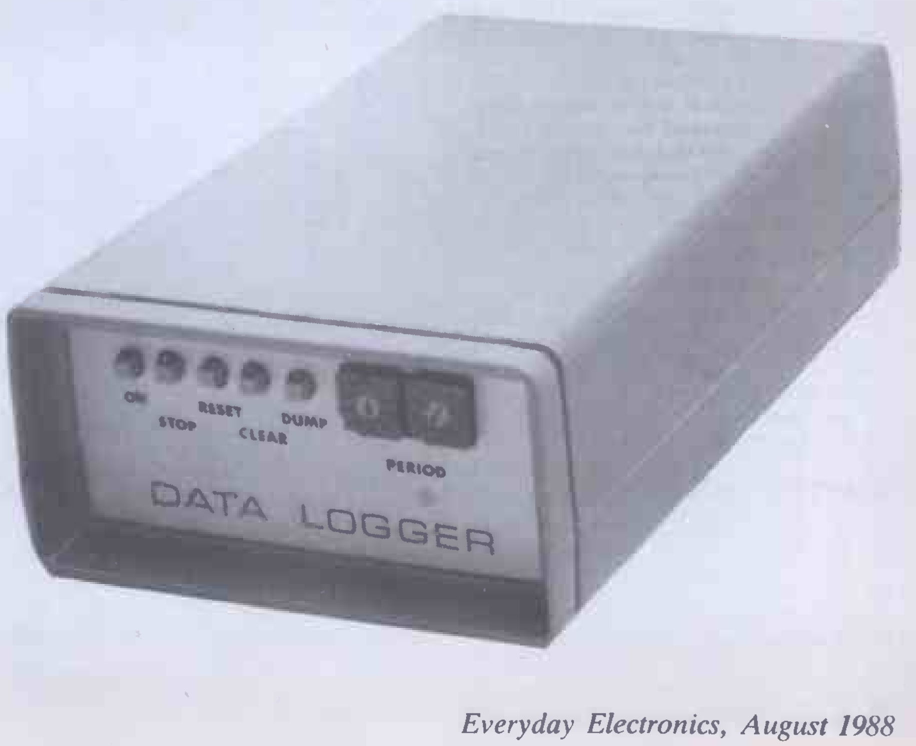
A successive approximation ADC works by comparing the input voltage to successive test voltages until a match is found. The input is tested using a binary search method where each successive test decides if the input is above or below the test voltage. Subsequent test voltages are generated according to the result of the previous test. The first test decides if the input is in the upper or lower half of the range of the ADC and the next test decides if the input is in the upper or lower half of the range found by the previous test.

In an eight-bit ADC, this process repeats eight times with each "approximation" getting nearer to the input voltage until the test voltage matches the input voltage. At each step the result of the test generates a bit of the final binary output, (input higher 1, lower 0), beginning with the most significant bit. Eight bits give a resolution of 1 in 256, so if the full scale input voltage is 2.5 volts, one bit represents approximately 10mV.

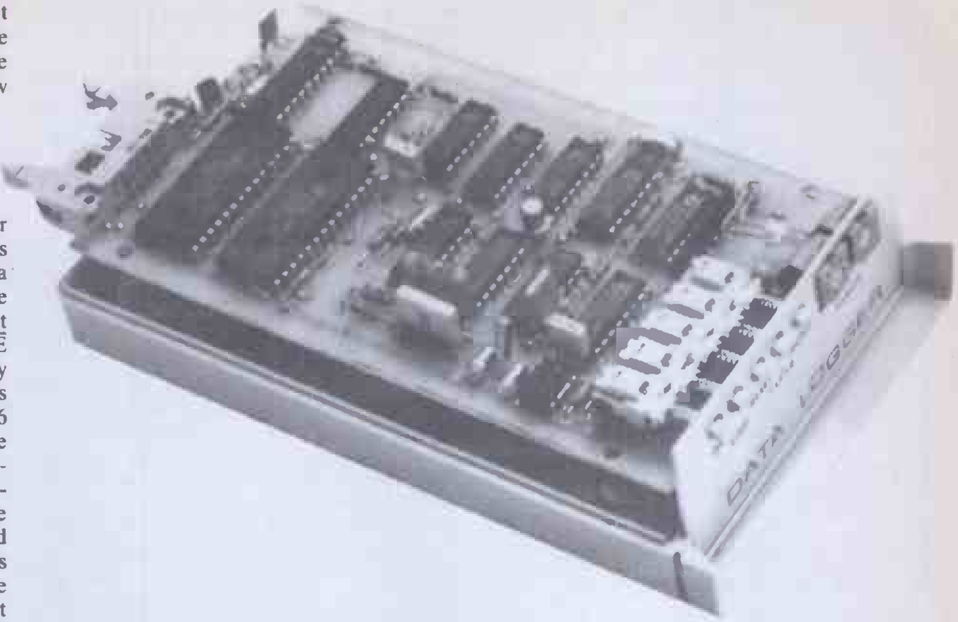
In order for the ADC to begin a conversion, it is necessary for $\overline{CS}$ and $\overline{WR}$ to be low. $\overline{CS}$ is held low by resistor R17 and when $\overline{WR}$ is driven low by the 10$\mu$S negative going pulse from the monostable IC11b, a conversion begins and $\overline{INT}$ goes high. At the end of the conversion period, the $\overline{INT}$ output of the ADC goes low and triggers monostable IC12a. This monostable whose period is determined by C6 and R12, creates timing periods T5 and T6, traces (6) and (7) in Fig. 2. The pulse from $\overline{Q}$ drives the $\overline{RD}$ input of the ADC low and causes it to output data on the data bus.

The pulse on the $\overline{Q}$ output of the monostable is also applied to pin 9 of NAND gate IC4d. Because pin 8 of IC4d is held high through the "clear" and "dump" switches, S5 and S6, the negative going pulse on pin 9 causes the output of the gate to go high. This positive going pulse is then inverted by NAND gate IC4c and drives the $\overline{CS1}$ pins of the RAMS low.

At the same time that the above is happening, the Q output of IC12a goes high for 2$\mu$S and this drives pin 6 of IC4b high. The other input to this gate is held high through R18, so the output of the gate on pin 4 goes low for 2$\mu$S, thus providing a write pulse at the $\overline{WE}$ pins of the RAM's. In this way the ADC data is written to the memory. The Q output of monostable IC12a also goes to pin 10 of the 4040 address counter, IC3, and causes the counter to increment on the trailing edge of the write pulse and thus gener-



ating the next RAM address. The $\overline{Q}$ output of IC12a is also coupled through C9 to the reset input of IC9b and the rising edge of the 2µS pulse resets IC9a, puts its Q output low and so powers down the ADC.



## MEMORY ADDRESSING LOGIC

The 4040 is a twelve-stage binary counter and its function is to provide the address lines for the RAMs. It is reset at the start of a run and as explained above, the falling edge of the pulse from IC12 steps it on to the next address. As this occurs at the end of the $\overline{WE}$ pulse (see timing diagram) the data is safely written into the RAM before the address changes. The 4040 provides 212 or 4096 addresses and drives A0 to A11 of the RAM's. The top address line for the memories A12, is supplied by the D-type flip-flop, IC5. Its clock input line is driven by the output of gate IC4a which is the inverted address A11 from IC3 and its Q output is used as A12 for the RAMs. Address line A11 goes high half way through the count range of IC3 and low again at its last address. This falling edge after inversion, triggers IC5 and its Q output goes high (A12). On A11's next negative transition, A12 goes low and the $\overline{Q}$ output of IC5 clocks the decade counter IC6.

The first two outputs of IC6, Q0 and Q1 are connected to the positive true chip select inputs, CS2 of IC2 and IC2a respectively. As this counter, like IC3 is reset at the start of a run, the Q0 output is high and this enables IC2. After clocking once, the Q0 output goes low and Q1 output goes high thus enabling IC2a. If this counter is clocked again, Q1 will go low and Q2 will go high and this line which is connected to the reset line of the 32kHz oscillator IC13, will end the logger's run. Thus the logger will use all of its memory, but cannot overwrite previously written data. If the logger is to be expanded, up to nine of the outputs of IC6 could each enable an 8K RAM chip (the tenth being used for automatic stop), thus giving a maximum memory capacity of 72K.

## COMPUTER INTERFACE

The logger interfaces to the computer using eight data lines, one control line and a ground line–ten in all. The decision to transfer data in parallel fashion rather than use serial RS232 or RS422 was taken in order to minimize component requirements and as a consequence minimize power consumption. To transfer data serially would require a parallel to serial converter such as a UART and output drivers as well as several extra logic devices to control the operation. On the other hand, parallel data transfer uses the minimum of extra components.

Originally it was hoped that the computer could do all the controlling of data output and input to the logger, but some common computers such as the BBC provide only ten interface lines, eight of which are required to carry the data. This leaves insufficient control lines to select the various required functions, so the logger has been provided with several switches to enable the user to select the operation required before running the computer program.

## SWITCH OPERATION

The operation of the switches is quite straightforward. The reset switch resets the flip-flops, the programmable counters and the address counters. It is obviously important that the address counter IC3 is reset so that it starts by pointing to the first RAM address. Equally important is to ensure that flip-flop IC5 is reset, because it provides the top address line, A12 and must not begin a run out of step with the address counter. The RAM selector IC6 must also start from zero as it decides which memory chip data will be stored in.

The clear switch is used to enable the computer to write zeros to all memory locations before a run is begun. This helps find the end of the log when the data has been dumped to the computer. If the memories are not cleared after power is applied, then they will contain random data. This is no problem for the logger during the run, because it overwrites each memory location with good data. The problem comes at the end of the run, as there can be some uncertainty about which is the last data point.

Although the user will have a good idea of

## COMPONENTS

**Resistors**

| | |
|---|---|
| R1 | 22M |
| R2 | 8×100k s.i.l. |
| R3 | 47k |
| R4 | 150k |
| R5 | 820k |
| R6 | 22k |
| R7 | 12 |
| R8 | 620k |
| R9 | 220k |
| R11 | 1k |
| R10, R12 | 12k (2 off) |
| R13 | 10k |
| R14,R15,R17 | |
| R18,R19 | 100k (5 off) |
| R16 | 4k7 |

**Capacitors**

| | |
|---|---|
| C1 | 100p |
| C2 | 22p |
| C3 | 220n |
| C4 | 47n |
| C5,C9 | 1n (2 off) |
| C6 | 220p |
| C7 | 150p |
| C8 | 1n |
| C10 | 47µ tantalum 16V |
| C11 | 100n |

**Semiconductors**

| | |
|---|---|
| IC1 | ADC0804 |
| IC2 | 6264 (2 off) |
| IC3 | 4040 |
| IC4 | 4011 |
| IC5, IC9 | 4013 (2 off) |
| IC6 | 4017 |
| IC7, IC8 | 4522 (2 off) |
| IC10 | 7663 |
| IC11, IC12 | 4528 (2 off) |
| IC13 | 4060 |
| TR1 | BC107 |
| D1 | BAT85 |
| D2 | 04BJ |
| D3 | l.e.d. |

**Switches**

| | |
|---|---|
| S1,S2 | p.c.b. vertical mounting miniature BCD switches (RS 334 937)–2 off |
| S3,S7 | latching pushbutton d.p.d.t (RS 333 726) –2 off |
| S4 to S6 | momentary action sub miniature pushbutton d.p.d.t. (RS 333 701) 3 off |

**Miscellaneous**

| | |
|---|---|
| X1 | 32,768Hz crystal |
| SK1 | 14 way p.c.b. mounting socket |

Case 155×92×45 mm with battery compartment; p.c.b; software–see *Shop Talk*; battery.

Shop Talk

See page 490

*Approx. cost Guidance only* **£40** *plus case and software* how many data points the logger will have recorded, from the sampling rate and the log duration, unless he has been very accurate with timing the duration there will be some uncertainty about which point is the last one. If the memories are all cleared before a run begins, then, providing the logger is not recording zero at the end of its run (a fairly unlikely situation), it will be obvious where the log ends.

Normally the pin 8 input to IC4d is tied to +5V through the clear switch and dump switch, but when the clear switch is operated, pin 8 is pulled to 0V through R19. This forces the output of the gate to go high, which in turn causes the output of IC4c to go low. This low level signal is applied to the negative true $\overline{CS1}$ inputs of the memory chips IC2 and IC2a. At this point, the clearing program is run on the computer and this puts all data lines low and pulses the increment address line. This pulse causes IC12a to generate a 2μS pulse as in the logging mode and the signal from the Q output generates a $\overline{WE}$ pulse through IC4b. This pulse writes zero data into the memory location addressed by the address counter and the trailing edge of the pulse causes this counter to increment to the next address. The computer repeats this process for the appropriate number of times, (16384 times for the basic memory size) so that all memory locations are cleared. At this time the clear switch can be returned to the normal position and the logger is ready to run.

The dump switch is required to dump logger data to the computer. It, like the clear switch also breaks the +5V line to the gate IC4d and so enables the $\overline{CS1}$ lines of the RAMs, but it also, through its second pole, grounds one of the inputs to IC4b, pin 5 and thus forces the output of the gate to the high state. This inhibits IC4b from generating the $\overline{WE}$ pulses and thus ensures that the memories cannot be written to.

The same switch pole also grounds the $\overline{OE}$ lines of the memories and thus allows them to output data on their data lines. The computer program now puts the data lines of its port into the input state and again pulses the Increment Address line the appropriate number of times as it did when clearing the RAM. After each pulse, the data from the RAM location being addressed is output to the computer and is stored for later analysis.

The last remaining switch apart from the power switch is S3, the Stop/Run switch. It is connected to one of the input pins of the oscillator/divider, IC13. In the run position, the oscillator formed by C1, C2, R1, X1 and IC13 runs at 32.768kHz, but in the stop position, pin 11 is grounded and this prevents oscillation. Also when the logger reaches its last address, the reset (RS) input to the logger is pulled high by the Q2 output from IC6 and so stops the oscillator.

## POWER SUPPLY

The 7663 voltage regulator (IC10) was chosen mainly due to the fact that its operating current is typically less than 4μ A over an input voltage range of between 1.6V and 10V. It is a CMOS fabricated device hence the usual precautions should be observed with regard to input voltage and output current ratings. The input voltage (designed for use with a PP3 battery) must not exceed 10V and the 47n capacitor between pins 8 and 4 is absolutely necessary to limit the input rate-of-rise to around 2V/μ S. If this capacitor is omitted, the 7663 could be damaged during power-up. The output voltage is derived from an internal bandgap- type voltage reference of 1.3V, with the actual voltage value calculated using the formula,

$$(R8+R9)/R9\times 1.3V, \text{ giving us } 5V.$$

Note that R8 and R9 have a total resistance of 840k which, being reasonably high, help to keep the total quiescent current low. The "sense" pin of the 7663 is used to detect excessive current drain from the output, $V_{out}2$, by causing the device to shutdown if its voltage falls more than 0.7V below that of the $V_{out}2$. The maximum output current is thus set by the formula,

$$I_{max}=0.7V/R7$$

The power consumption for the circuit is very low in the quiescent state, about 147μA, rising to 2.3mA when the logger is powered up. The time during which the circuit is powered up is very small, being only 80mS per sample, thus the average power consumption when sampling is kept low.

To calculate the battery life of the logger, we must find the total energy required for the circuit during a run. The worst case run in the basic logger with 16K RAM would be with a sampling rate of 99 secs. The time to use every memory location would be 99×16,384=1,622,016 seconds, or 450 hours. During this time the logger would go through its cycle of being in the quiescent state (99 secs), powering up (80mS) and saving the data to the memory (2μS). Thus to find the total energy required during the run, we must sum the energy required by all the individual parts of the cycle.

The first energy requirement and the most significant, is for the quiescent state, which is 147μA for approx 450 hours=66.15mA hrs. The second requirement is the powered up state which would be 2.3mA for a total of 0.364 hours=0.84mA hrs. The last requirement is for the RAMs which consume the very large current of about 80mA, but only for a total time of 0.03 secs=0.0006mA hrs. Therefore, the total energy required by the circuit over the 450 hour run will be just under 67mA hrs. This is well within the capacity of a PP3 battery which is rated at something like 90mA hrs. As 450 hours represents almost 19 days of continuous logging, battery life is very reasonable.

## CONSTRUCTION

The logger is built on a double-sided printed circuit board which measures 140×79mm, the layout of the board is shown in Fig. 3. There are no special problems in constructing the board, but bear in mind that the integrated circuits are CMOS and as such are prone to damage by static charges. The i.c.'s may be soldered in place or mounted on sockets, but if they are to be soldered in, ensure that a fine tipped soldering iron is used and that it is well earthed so that no static charge can build up on the tip.

Sockets have the big advantage that an i.c. can be removed or replaced very easily should something go wrong with the circuit and the p.c.b. suffers no damage. But regardless of whether or not sockets are used, all passive components should be mounted on the board before the CMOS devices are mounted, as this lessens the chance of damage by heat or static.

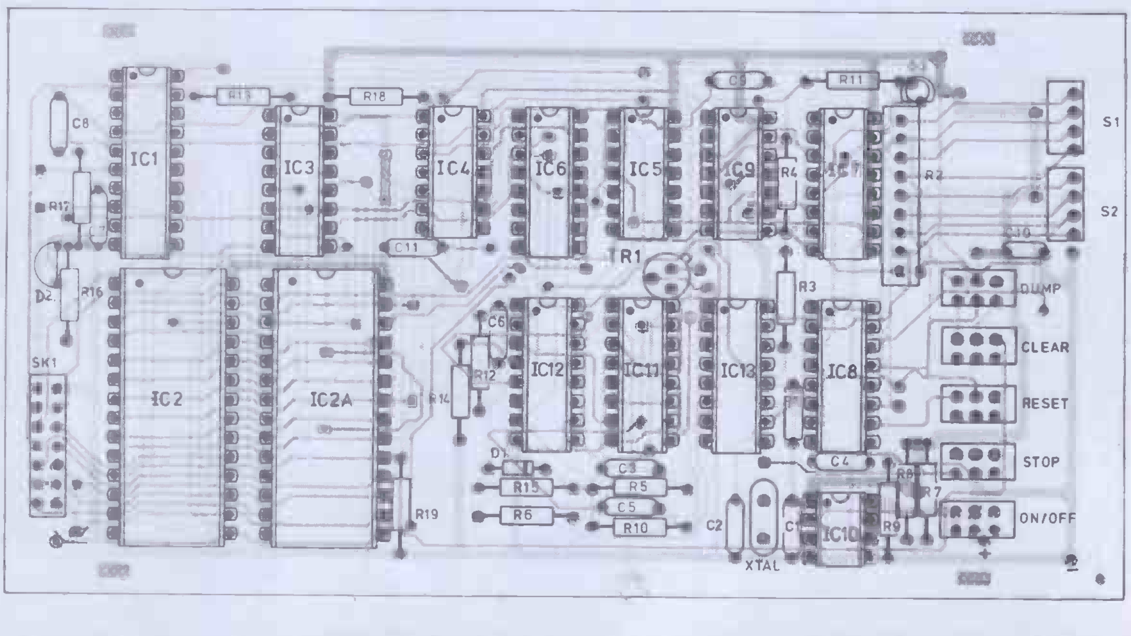



*Fig. 3. Double sided p.c.b. of the Data Logger. See photos for positioning of D3. All pin throughs should be soldered in first. Make sure that no tracks are bridged with solder—a very fine soldering bit is required—as is a steady hand. Due to the complexity of the board no p.c.b. masters have been given here.*

## TESTING THE P.C.B.

Before plugging the logger into a computer port or using an input sensor device it is suggested that the following quick checks and measurements be made first to eliminate any faults which may have arisen during construction.

1. Measure output from 7663 (5V) and ensure that it is present at all i.c.s except the ADC0804.

2. Release the stop buttom : check for the 2Hz signal at IC13 pin 3 and 1Hz signal at IC9 pin 13.

3. Set the BCD switches to various sample time periods while monitoring IC9 pin 1. This output should switch at the preset rate of the BCD switches–if not a more detailed check should be made at each stage of ICs 7 and 8.

4. Now that the basic "cycle start pulse" is available the timing diagram should be examined and compared with actual pulses on the p.c.b. before proceeding to the next stage.

5. Ensure that the outputs of IC3 are incrementing after each clock pulse, obviously only the lower few can be checked even at the fastest sample rate. (We shall look at all the addresses incrementing later).

6. The input pins of the RAMS i.e. $\overline{CS1}$, CS2 and $\overline{OE}$ should operate as dictated by the "Clear and Dump" buttons with $\overline{WE}$ (pin 27) receiving a $2\mu S$ negative going pulse.

7. The ref. voltage of IC1 should be 1.2V but remember this is only present when the ADC is on.

8. Finally check that the RESET button activates all reset inputs used.

## AMSTRAD/IBM INTERFACING

The logger input/output, SK1, can be directly connected to the parallel port of a BBC computer providing a suitable lead is made. However, when an AMSTRAD or IBM computer is to be used, a simple interface must be built. The reason for this is that the printer port of these machines provides 8 output lines, 4 control lines and 5 "status" lines.

The interface enables the "status" lines to be used as inputs for the data and the software accesses the data from the logger in two parts, the lower 4 bits are read first, then the upper 4 bits are read next. The logic for this is taken care of by the interface which uses two "HC" TTL ic's and is powered directly from the logger. Data and a p.c.b. are available for this if necessary–see *Shop Talk*.

## COMPUTER TESTING

1. Using the "read" function of the menu check that each address of the RAMS are being incremented, this includes the output of IC5 which generates A12.

2. Also check that Q0, Q1 and Q2 of IC6 are changing state after each RAM has been completely read. Remember when Q2 goes high the logger will be stopped during normal "logging" operation.

## USE OF SOFTWARE

Software is available for the BBC model B and the AMSTRAD PC1512/IBM computers. The following describes the use of the BBC software (the programs for the other computers provide similar functions but differ slightly in operation). Since the software is "menu" driven no real problems should arise, however, we shall run through a typical set-up procedure to familiarize you with the procedure.

1) Connect computer interface lead to SK1..

2) Insert program disk and load by SHIFT-BREAK keys.

3) Switch on the logger and press "stop" button.

4) Select the WRITE function with CLEAR option from the menu. Press the logger "Reset" button then hold in the "Clear" button and press the space bar on the keyboard. The computer now write zeros to the logger memory.

5) Disconnect the cable from SK1 and connect the sensor device to be monitored. Select the sample period and release the "Stop" button. When the logger has finished its recording–put the logger into "Stop" mode, disconnect the sensor and connect the computer lead.

6) Select the READ function from the main menu. Once again the logger "Reset" button must be pressed before holding the "Dump" button. Press the spacebar to start the reading process, it takes about 5 seconds to read the data. All the recorded data is now in the computer memory so the logger can now be switched off.

The software provides many useful functions for saving, accessing and analysing the information which has now been stored in your computer's memory.

**Saving data** : The data is stored on disk under a file number which is incremented automatically each time the "Save routine" is used.

**Accessing Data** : Any file can be recalled by simply typing the file name/number while in the "Load routine".

**Analysis of data** : One quick method of analysing the data is to use the "Screen Plot" programme. Probably the most useful aspect of this is the capability to plot the data either as a condensed plot encompassing the total recorded data or to plot an expanded version which gives a detailed graph of those events of particular interest. The latter method allows the user to choose any part of the complete plot without laboriously stepping through all the data.

## CASE CONSTRUCTION

The p.c.b. for the logger was designed to be mounted in the box shown in Fig. 4. In order to do this properly a few minor modifications were necessary to the "non-battery" half of the case which, if carried out in the following order, should present no problems.

1. Cut away the existing p.c.b. mounting guides which are located vertically on each side of the case.

2. Cut away the existing mounting pillars until the tapped brass bushes are free. Keep these for use later.

3. Continue reducing the height of the pillars until three of them are 15mm long and the one next to the 14 way socket is 5mm long.

4. After positioning the p.c.b. the hole for the 14 way socket can now be marked and cut.

5. Press the brass bushes into the remaining pillars and glue if necessary.

6. Using longer screws and suitable spacers the board will be held firmly in the case when closed.

7. The holes for the front panel should now be marked and drilled depending on your own intended use for the logger. For safety reasons i.e. to avoid accidental pressing of switches, the switches have been purposely recessed from the front of the case allowing "screwdriver" access only. However, there is sufficient room between the switches for push buttons to be used.

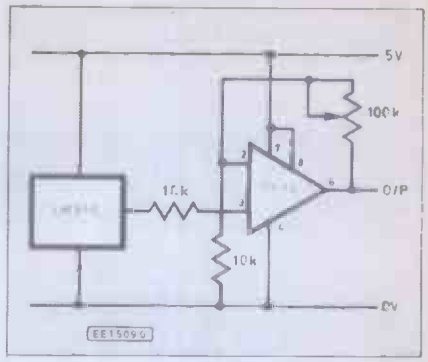



*Fig. 5. Suggested circuit for a temperature sensor for the Data Logger.*

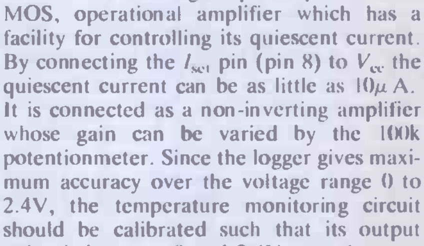
## TEMPERATURE MONITORING

One of the simplest and possibly most interesting domestic uses for the logger would be a "central heating monitor". The suggested circuit Fig. 5 only requires two cheap integrated circuits (cost approximately £4) and can be constructed easily on Veroboard since component layout is relatively unimportant.

The LM35DZ is a precision temperature sensor which operates in the range 0 to 1000 degrees centigrade. Its output voltage changes linearly by 10mV for each "one degree" change in temperature and is accurate to+or–0.4 degrees C at normal room temperature. Hence, it can be readily seen that its output swing for the full temperature range is 0 to 1V.

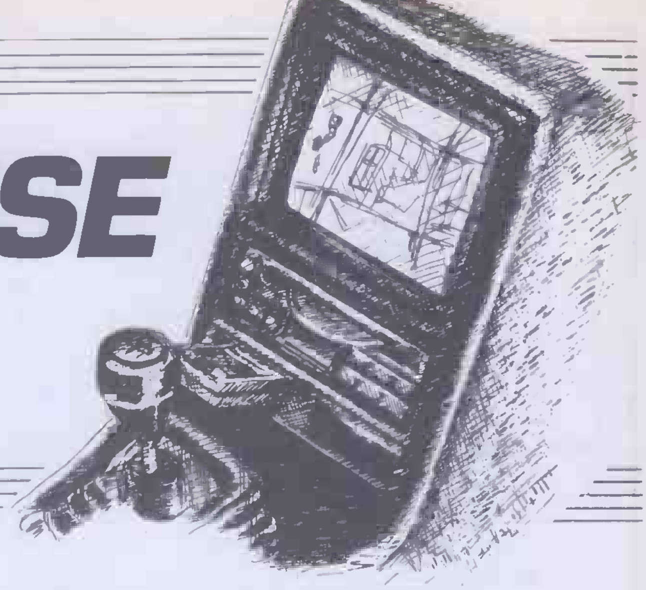
The 7611 is a high input impedance, C-MOS, operational amplifier which has a facility for controlling its quiescent current. By connecting the $I_{set}$ pin (pin 8) to $V_{cc}$ the quiescent current can be as little as $10\mu A$. It is connected as a non-inverting amplifier whose gain can be varied by the 100k potentionmeter. Since the logger gives maximum accuracy over the voltage range 0 to 2.4V, the temperature monitoring circuit should be calibrated such that its output swing is between 0 and 2.4V over the temperature range to be monitored. When using this circuit to monitor room temperatures it is suggested that the calibration be made between 0 and 300 degrees C hence giving a digital accuracy of about 8 counts per degree.

The measured current consumption of the temperature monitor circuit was $73\mu A$, hence it can be powered directly from the 5V unswitched supply of the logger. However, for longer battery life it is more useful to use the switched output of the logger which, because of its 80mS duration, allows the temperature sensor output time to stabilize before a reading is taken by the Logger. □



Special Feature

# STREET-WISE CARS



IAN GRAHAM

## Electronic navigation aids for motorists in the 1990's

MOTORISTS should find it more difficult to get lost in the 1990's thanks to electronic navigation systems. Several car manufacturers and electronics companies have already demonstrated prototypes.

The most basic systems rely on the accuracy of an electronic compass and sensors on the car's wheels to calculate how far the car has travelled and in which direction. The car's position is displayed on a television monitor screen on the dashboard. For safety's sake, the screen is disabled while the car is moving and information is presented to the driver via a computer-generated voice.

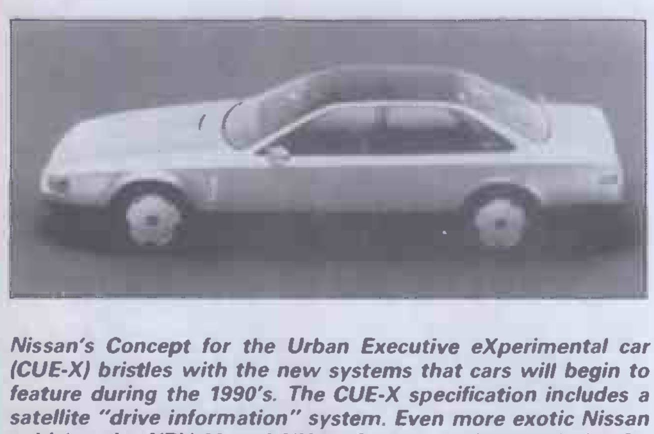
This type of self-contained system suffers from the problem of accumulated error. It can't be 100 per cent accurate in every respect. Tiny errors inevitably creep into the system's calculation of the car's position. These errors pile up and if nothing is done to correct them, they eventually reach the point where the positional plot is so inaccurate as to be meaningless.

The electronic compass works by detecting the direction of the Earth's magnetic field. But the field is changed by any large chunks of iron nearby. The iron in manhole covers, reinforced concrete and bridges, for example, will upset the electronic compass and lead to false positioning. Even passing cars cause problems–a serious disadvantage to a car-borne system! Fortunately, the on-board computer that calculates the car's position can be programmed to ignore rapid and short-lived fluctuations in the received magnetic field due to nearby iron-rich objects.

### SATELLITE NAVIGATION

The American *Navstar Global Positioning System* (GPS) offers a way of improving accuracy. Eighteen satellites orbit the Earth at a height of 20,000 kilometres. At any given time, four satellites should be within "sight" of a receiver on the ground. Information transmitted by the satellites will enable the receiver to calculate its position in longitude, latitude and height to within 10 metres and time to within the microsecond accuracy of an atomic clock.

But that's not the whole story. It's all very well knowing how far a car has travelled and in which direction, or, with the help of satellites, the precise latitude and longitude of the car within a few metres, but that doesn't give the driver any information whatsoever about which road the car is driving along and where it leads. To be of practical use to the driver, the position calculation has to be related to a street map overlaid with "ye olde worlde" pre-computer street names.



***Nissan's Concept for the Urban Executive eXperimental car (CUE-X) bristles with the new systems that cars will begin to feature during the 1990's. The CUE-X specification includes a satellite "drive information" system. Even more exotic Nissan vehicles–the NRV-11 and NX-21–feature navigational aids for the driver. Photo: Nissan.***

Even in a small country, the system needs a truly enormous memory in which to store all the streets of all the country's towns and cities. And, with route-planning, information about locations miles apart have to be accessible from the memory very rapidly indeed. The optical Compact Disc (CD) turns out to be the most efficient way of storing and retrieving the information.

### LASER MAPS

A standard one-hour CD stores music as a series of digital pulses. The analogue (constantly varying) waveform of the music source is converted into these pulses by sampling it 44,100 times every second. Each sample or "snapshot" of the music is then converted into a 16-bit binary number (1100101011010111, for instance). This pattern of zeroes and ones is transferred onto the disc permanently by burning it into the disc by laser.

As all music is recorded in stereo now, the disc has the capacity for two independent one-hour channels. It can, therefore, hold:

$$(3600 \times 44100 \times 16 \times 2) \text{ bits of information}$$

or over five thousand million bits of information (3600 seconds in an hour, 44,100 samples per second, 16 bits per sample, two channels). That's equivalent to approximately 150,000 A4-size pages of text.

The immense storage capacity of the system is difficult to grasp. If Britain's entire road network down to street name level was converted into CD format, a single one-hour disc would be only half full. Any part of the disc, and therefore any part of the map stored on it, is accessible to the system computer within a fraction of a second.

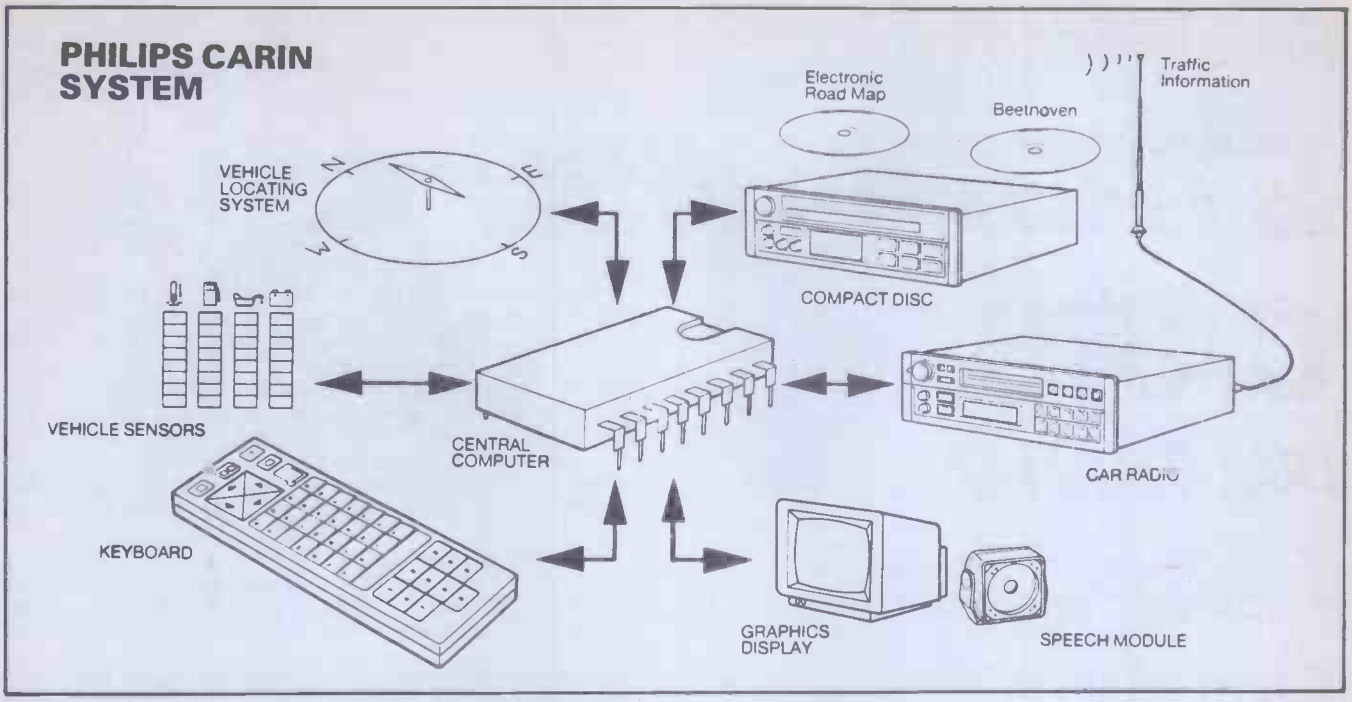
### ROUTE PLANNING

The Carin car information and navigation system designed by Philips shows a plot of the car's position on a small television screen on the dashboard. The screen will only operate when the car is stationary. Carin also helps motorists to plan routes. When the driver enters the start point and destination on the system's keyboard, the on-board computer works out the most efficient route.

As the driver sets off, the computer monitors the car's progress and tells the driver where to turn left or right by means of a speech synthesiser. Research in Britain indicates that if drivers were directed by a navigational computer instead of finding their way by the most familiar routes and landmarks, they would make savings in fuel and time of approximately 20 per cent.

### RADIO UPDATE

The advantages of directing a driver along a particular route by computer to save fuel and time are entirely lost if the road is closed because of a traffic accident or there is a 10 mile tail-back on the motorway because of road surface repairs. Test broadcasts of a radio system that could solve these problems are already under way in Europe.



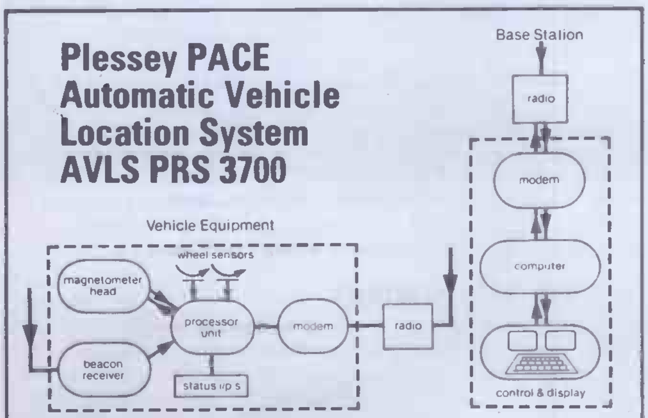

*Philips' Carin car information and navigation system.*
*The system brings together information from an electronic compass, laser discs, radio and vehicle sensors to provide valuable information about the vehicle's position and the most efficient route from start-point to destination.*

Eleven European countries have so far agreed to adopt the BBC's Radio Data System (RDS). In the same way as teletext signals are broadcast with television programmes to supply extra information to the viewer, RDS signals carrying extra information are broadcast with radio programmes.

As a result of the proliferation of radio stations, it can be very difficult to find one particular station amongst the many,or to identify the station that the radio is already tuned into. A small liquid crystal screen on an RDS receiver shows the name of the station. As the radio is tuned through the waveband, the station names on the screen change. The RDS radio also receives a continually updated time-check and so the radio doubles as an accurate digital clock that need never be set or corrected.

One aspect of the projected development of RDS is very relevant to car navigation. Local road and traffic reports will be transmitted via RDS. Philips Carin navigation system will be able to decode traffic information received by RDS and if necessary use it to modify the car's planned route. If, for example the road ahead is closed for some reason, Carin will plan an alternative route and advise the driver of the changes by its speech synthesiser.

Later, other sensors on the car will be able to feed information into



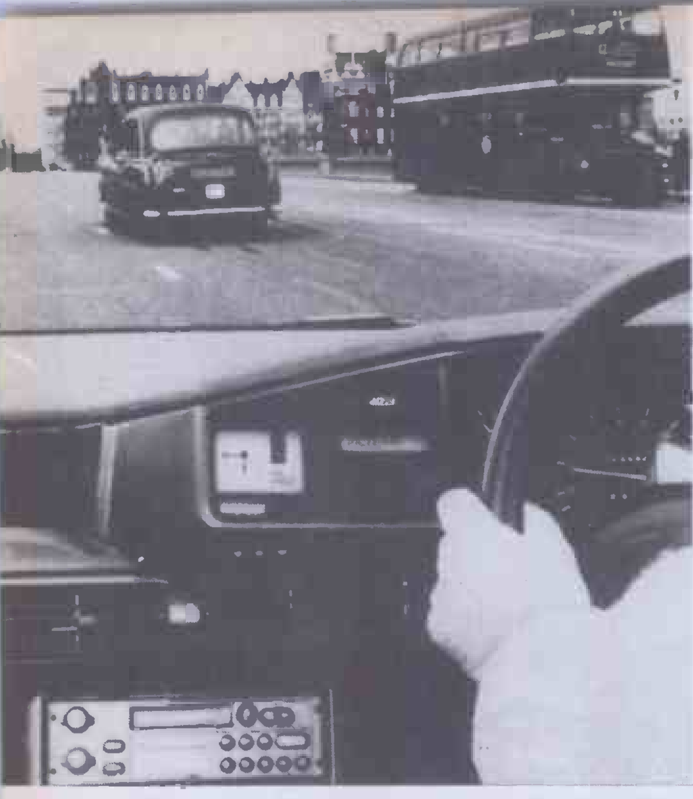

**Data Summary**
**Vehicle Location Unit**

| | |
|---|---|
| Navigation Accuracy | in the order of 2% of distance travelled |
| Resolution | 10 metres (opt 100 metres) |
| Status Inputs | 16 max |
| Data Outputs | –Vehicle Identification<br>–Northings co-ordinate<br>–Eastings co-ordinate<br>–Direction<br>–Status<br>–Distance Travelled<br>–Beacon update |
| Data Rate | 1200 bauds |
| Dimensions | 180 x 120 x 70mm |
| Power Supply | Nominal 12V vehicle supply 500mA |
| Temperature | −10° to +70°C |

**POSITION BEACON**

| | |
|---|---|
| Frequency | In 150 MHz or 450 MHz ranges |
| Nominal Power | 0.3mW |
| Transmission Range | 25 metres (50% CEP) |
| Data Outputs | Location co-ordinates |
| Power Supply | Battery/Solar/Mains as required |
| Temperature | −10° to +60°C |

*Plessey's PACE Automatic Vehicle Location System.*
*Information about each vehicle's location provided by in-car sensors updated by roadside radio beacons is transmitted to a central base station.*



A car fitted with the Autoguide navigational system developed by the Transport and Road Research Laboratory and now operational in Westminster, London.

the system. The system's voice will be able to advise the driver to fill up with fuel or that the engine is overheating, or of the presence of ice on the road. Sensors on the steering wheel will respond if a driver appears to be suffering from drowsiness and the computerised voice will alert the driver.

## VEHICLE LOCATION

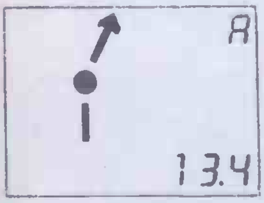
Turning the idea of vehicle positioning on its head, a similar system might be used to show a central base station where a vehicle is, rather than to advise the driver on position and route. Plessey has developed a vehicle location system with this in mind.

Police, ambulance, fire brigade, taxi and courier services generally have to rely on voice communications with their vehicles to monitor the vehicles' locations. Plessey's PACE system shows a street map of the operational area with continually updated plots showing vehicle locations without any need for repeated interrogation of the drivers.

Each vehicle is fitted with sensors to monitor its speed and direction travelled from its known start-point, as in the basic car navigation system. As the system is subject to errors for the reasons explained earlier, it is reset from time to time by radio signals transmitted from short-range (25 metres) radio beacons sited by the roadside.

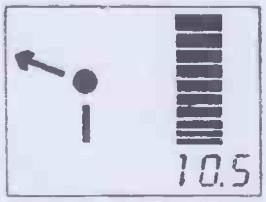
At the base station, the operator can select either an area or specific vehicles. The map and vehicle positions are then shown on a television monitor screen. The system also has a "free-hand" facility, allowing the operator to add notes to the map on traffic conditions, road-works etc.

Similar systems also have an emergency call feature. If a vehicle crew needs urgent help, perhaps as a result of a traffic accident or an attack on a wages courier, they can throw an alarm switch, which instantly sounds an alarm at the base station and presents the operator with a distinctive visual alarm on the screen. The appropriate assistance can then be called in, without delay.

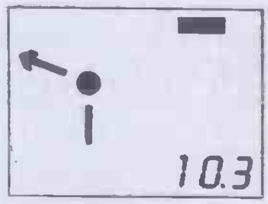



Compass direction and crow-fly distance to destination


Follow road ahead even if it twists and turns

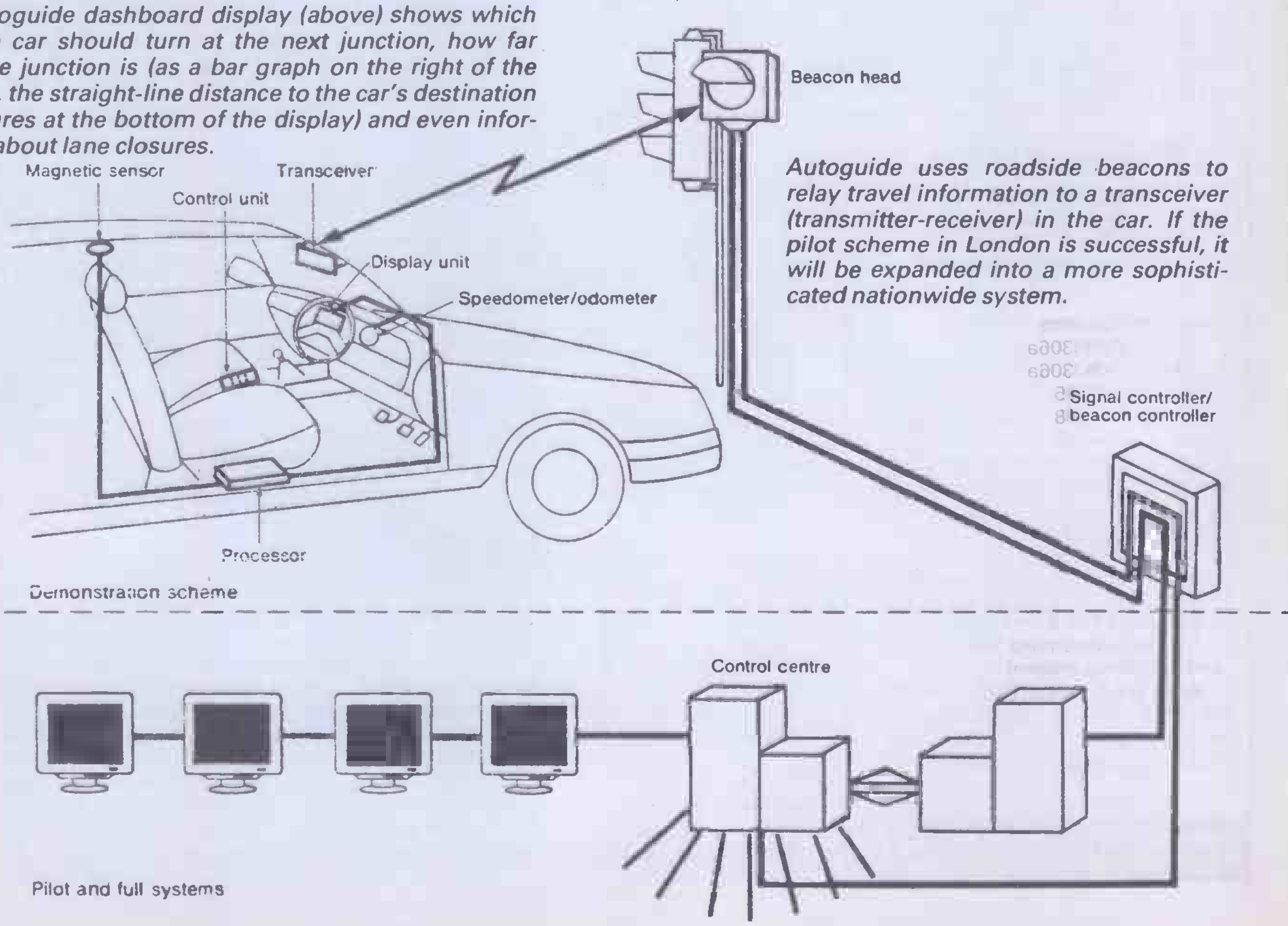



Initial indication of turn: distance shown on bar-graph



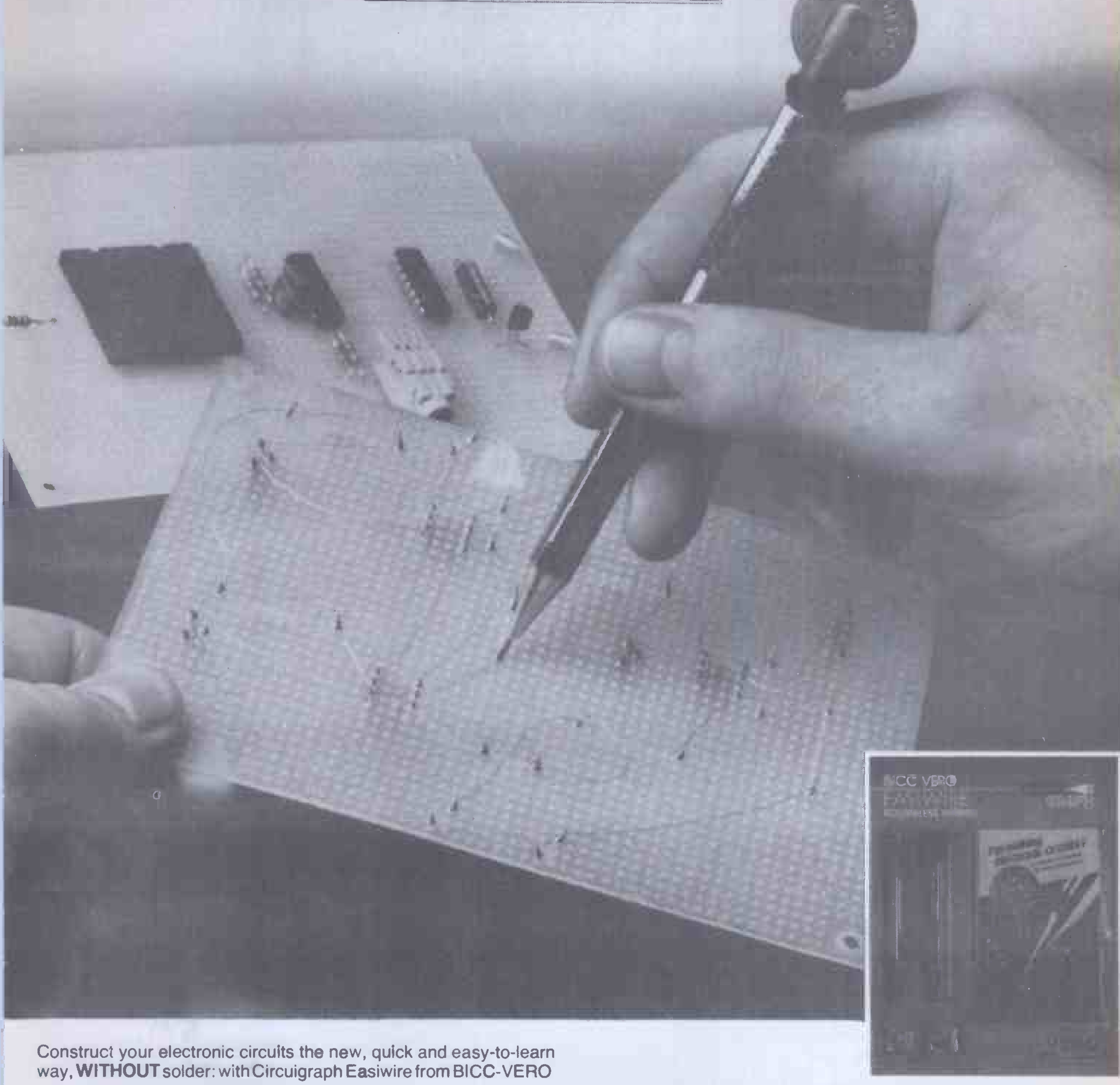

Turn left: distance remaining

*The Autoguide dashboard display (above) shows which way the car should turn at the next junction, how far away the junction is (as a bar graph on the right of the display), the straight-line distance to the car's destination (the figures at the bottom of the display) and even information about lane closures.*




*Autoguide uses roadside beacons to relay travel information to a transceiver (transmitter-receiver) in the car. If the pilot scheme in London is successful, it will be expanded into a more sophisticated nationwide system.*

# SOLDERLESS WIRING
# EASIWIRE

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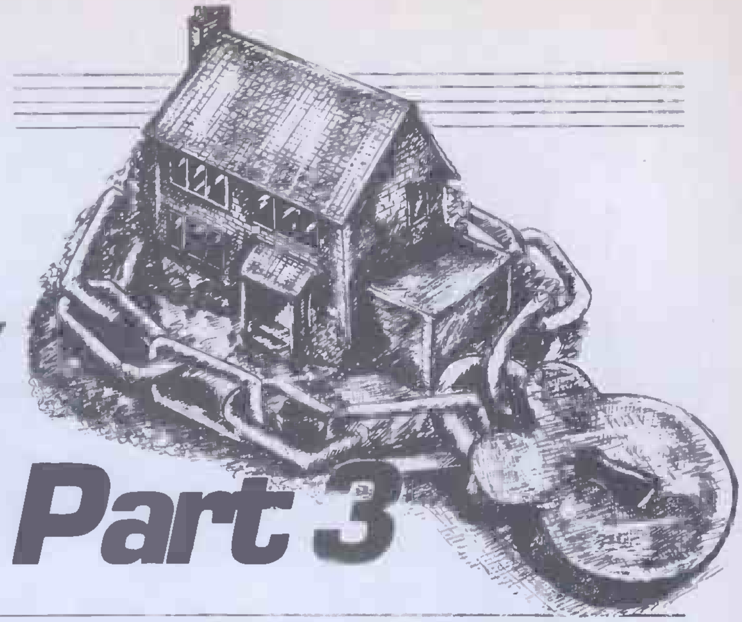
Constructional Project

# HOME SECURITY SYSTEMS Part 3



OWEN BISHOP

## Part 3 Smoke Detector and Temperature Monitor

*In this series our main concern will be securing the home against intruders, but we shall also describe devices for securing it against fire. The system is modular, so that you can adapt it to your needs.*

THIS month we describe a Smoke Detector, which gives an alarm when the fire is getting under way, and also a Temperature Monitor which, with suitable placing of the sensor, is able to monitor likely trouble-spots and sound the alarm *before* the fire starts.

Both of this month's circuits are intended for operation in conjunction with the security system described in Part 1. However, they can drive a siren directly, so are equally suitable as stand-alone devices.

### SMOKE ALARM

The smoke alarm circuit (Fig. 3.1) closes a relay switch when it detects small quantities of smoke in the air. The red light from an l.e.d. (D1) is directed at two light-dependent resistors (R5, R6) placed about 3cm away. The circuit is contained in a tubular enclosure which assists in conducting smoke past the l.d.r.s and also excludes most of the light from external sources. The l.d.r.s are positioned so that they are more-or-less equally illuminated by the l.e.d. The circuit is in a balanced quiescent condition and the relay switch is open. Changes in external illumination may reach the l.d.r.s, but they are affected *equally* so the circuit remains balanced.

When smoke first enters the enclosure, it rises and swirls around the space between the l.e.d. and the l.d.r.s. The smoke is denser in some regions than others particularly when the smoke *first* enters the enclosure. The l.d.r.s are no longer equally illuminated. At one moment R5 receives more light than R6; an instant later R6 receives more than R5. The circuit alternates rapidly between one unbalanced state and the other.

In the balanced condition, the output of the op. amp is approximately mid-way between the two supply rails, i.e. it is +6V. As illumination varies, the potentials at points A and B vary. R4 is connected to the +12V rail while R7 is connected to the 0V rail. The l.d.r. sensors therefore act in opposite directions. A partial reduction in the light reaching R5 causes the output of the op. amp to fall below 6V, while a partial reduction of light to R6 causes the output to rise above 6V. A change in the amount of light reaching both R5 and R6 cancels out and the output remains close to +6V.

The effect of smoke is to cause the output of IC1 to fluctuate rapidly above and below +6V. The oscillating voltage passes across C1 and is fed to a *diode pump*, consisting of D2 and D3. The positive-going voltages from the pump are used to charge C2. The charge normally leaks away through R11 but a rapid pumping action, resulting from the detection of smoke, causes the charge on C2 to rise steadily. When this has risen to a sufficient level, a base current flows to TR1, turning it on. The relay coil is energised and the relay switch closes.

The relay switch may be wired as one of several parallel switches in the "mat" loop of the security system (Fig. 3.2). Thus, the alarm system is triggered when the switch closes. In practice, the spikes generated on the supply line when the relay coil is activated usually cause the circuit to go into permanent oscillation at this stage. The relay switch closes and opens regularly about twice a second. This oscillation is of no consequence as it only occurs *after* smoke has been detected.

### SMOKE ALARM CONSTRUCTION

The Smoke Alarm is constructed on a narrow piece of stripboard, cut to fit into the tubular enclosure (Fig. 3.3). For the enclosure, use a length of plastic water pipe (the type used for bath waste pipes etc.).

The circuit-board is mounted within the tube on two bolts (Fig. 3.3). Fig. 3.4 shows the component layout. The leads of the l.e.d. (D1) are bent so that the diode is parallel with the plane of the board. The l.d.r.s are positioned so that their receptive

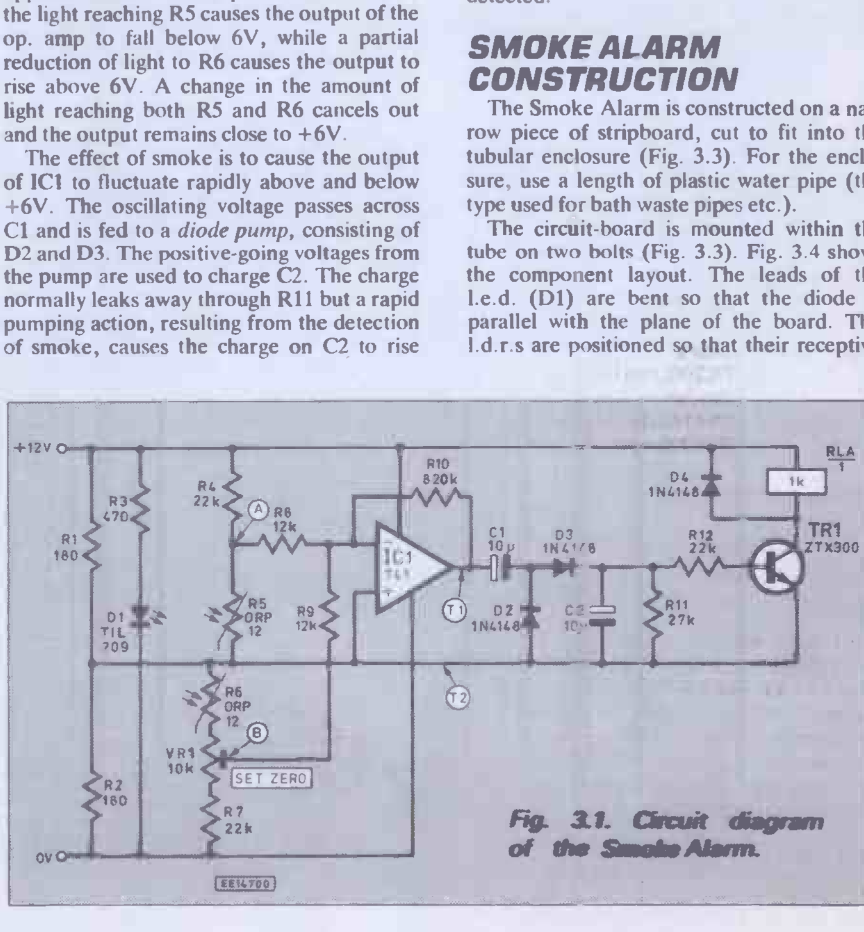



**Fig. 3.1. Circuit diagram of the Smoke Alarm.**

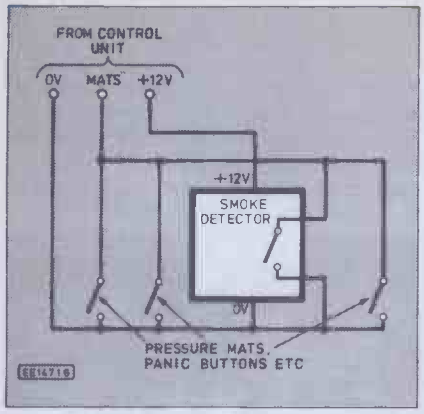



Fig. 3.2. Wiring the Smoke Alarm to the "Mats" circuit.

surfaces face towards the l.e.d. Resistors R8 and R9 are small and lie close to the board, so they do not obstruct the light from the l.e.d.

The pin-out of the d.i.l. relay used in the prototype is shown in Fig. 3.5. You may need to modify the strip-board layout if a different type of relay is used. If the relay you are using incorporates its own protective diode, D4 may be omitted.

## COMPONENTS

**SMOKE ALARM**

Shop Talk

See page 490

**Resistors**

| | |
|---|---|
| R1, R2 | 180 (2 off) |
| R3 | 470 |
| R4, R7, R12 | 22k (3 off) |
| R5, R6 | ORP 12 light-dependent resistor, or similar (2 off) |
| R8, R9 | 12k (2 off) |
| R10 | 820k |
| R11 | 27k |

All ¼W carbon

**Potentiometer**

| | |
|---|---|
| VR1 | 10k horizontal sub-miniature preset |

**Capacitors**

| | |
|---|---|
| C1, C2 | 10µ, elec.16V or 25V |

**Semiconductors**

| | |
|---|---|
| D1 | TIL209, red l.e.d., or similar |
| D2 to D4 | 1N4148 diode (3 off) |
| TR1 | ZTX300 *npn* transistor |

**Integrated circuits**

| | |
|---|---|
| IC1 | 741 op.amp |

**Miscellaneous**

RLA1 6V or 12V relay, normally open, in d.i.l. package (NEC type PG1A-12, etc.)

2.5mm matrix stripboard (11 strips×48 holes): 1mm terminal pins (6 off); 8-pin d.i.l. i.c. socket; 14-pin d.i.l. i.c. socket (or as required for RLA1); materials for enclosure and mounting (see text); connecting wire; fixings; etc.

Approx. cost Guidance only **£6**

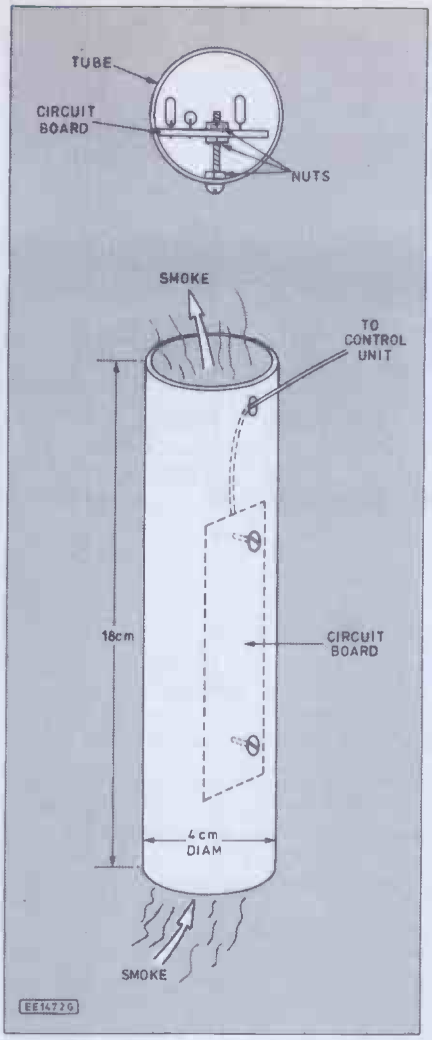



Fig. 3.3. Mounting of the Smoke Alarm.

## TESTING AND SETTING UP

When assembled, the circuit is first tested by connecting a voltmeter between the two test-points T1(−) and T2(+). It is best if testing is done in a dimly-lit corner of the room. Switch on the power; the l.e.d. lights. The meter may show any value, possibly with its needle below the zero mark (or a negative reading, if you are using an autoranging digital meter). Adjust until the reading is close to 0V (from now on voltages are measured relative to the +6V line).

It should prove easy to balance the circuit. If this is not possible with VR1 turned fully in either direction, check all connections, and the soldering of the joints. Replacing R7 with a resistor of lower or higher value may also solve this problem. With the circuit balanced, place a thin sheet of transparent polythene (from e.g. a polythene "food bag") in between R6 and D1; the meter reading

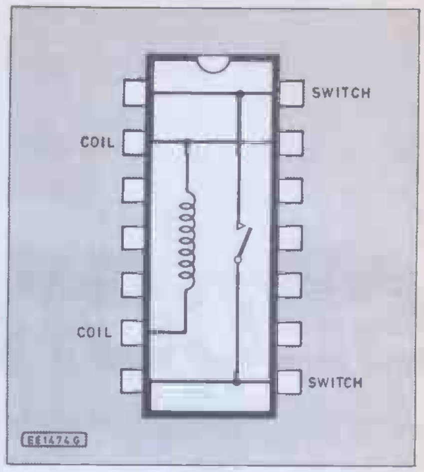
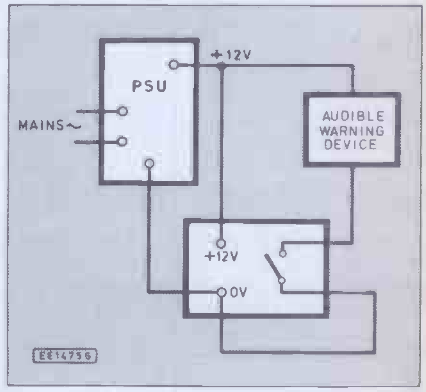



Fig. 3.5. Relay connections for the PG1A-12.

Fig. 3.6. Using the Smoke Alarm on its own.



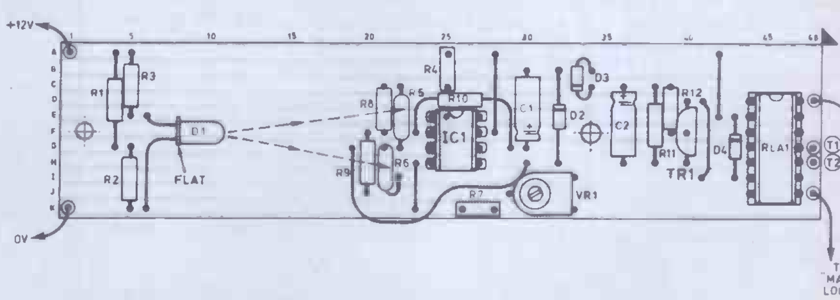
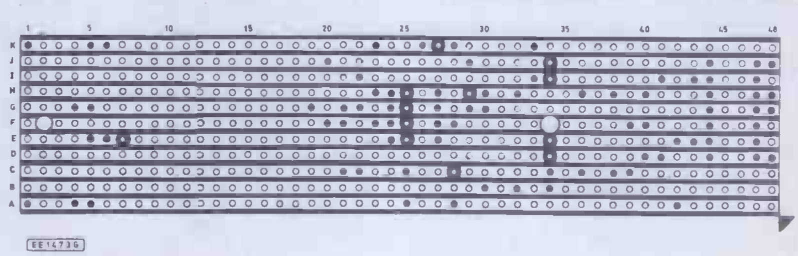
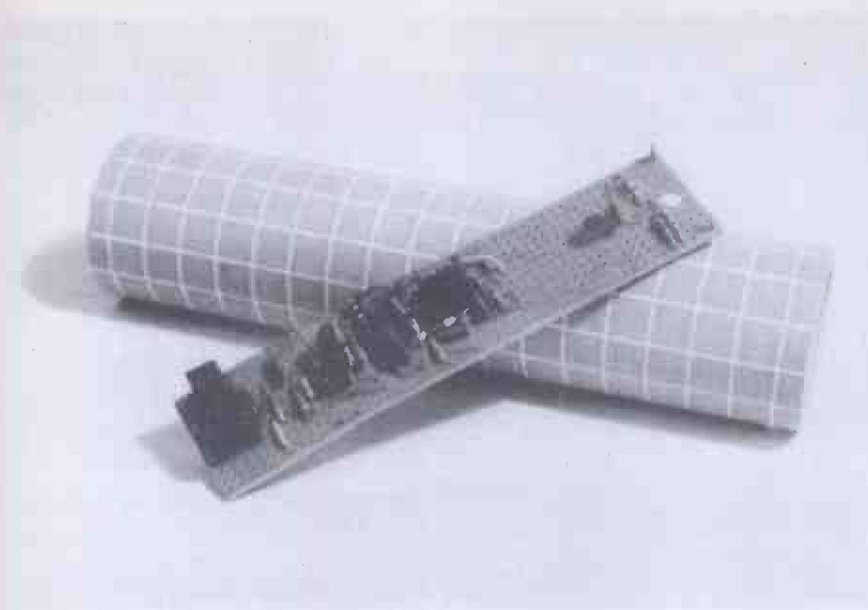




Fig. 3.4. Stripboard layout and wiring for the Smoke Alarm.





should rise to 4V or more. Place the polythene in front of R5; the reading should fall to −4V or less.

Assuming that all appears to be operating properly, set up the circuit for smoke detection as follows. Slide the circuit-board inside the enclosure so that the l.e.d., l.d.r.s and i.c. are inside the tube but VR1 is just outside. Connect the meter to T1 and T2 as before. Switch on the power. You may find that VR1 needs further adjustment and the large change of light level brought about by enclosing the circuit will probably throw the circuit out of balance. Incidentally, it is not essential to balance the circuit at exactly 0V. A fraction of a volt on the positive side is near enough.

Fix the tube temporarily in a vertical position with its lower end a few centimetres above the bench. Cut a strip of fairly thick cardboard about 2cm wide. Set light to one end of it, then blow out the flame to leave the end of the strip smouldering. Hold this below the enclosure so that the smoke rises through it. As the smoke reaches the l.d.r.s the meter reading should fluctuate irregularly between about +3V and −3V.

Remove the smouldering card and extinguish it carefully. Now connect the meter to the two relay switch terminals (positions D48 and J48, Fig. 3.4). Switch the meter to a resistance range. It should read "infinity" because the switch is open. Light the card again and hold it below the tube. After about a second the needle should swing sharply to "zero", showing that the relay switch has closed. Once triggered by smoke, it may oscillate between "infinity" and "zero", as explained previously.

Next, solder connecting wires to the terminals to instal the detector in the security system. It can of course also be used as an independent unit if required (see Fig 3.6). The circuit requires only 60mA. A low-power battery eliminator makes an ideal power source.

## MOUNTING

For maximum effect, the detectors should be mounted above any potential source of fire (such as a central-heating boiler) and close to the ceiling. For general fire-detection in a house, mount it at the top of the stairs. If you require maximum security, instal several detectors in various key parts of the house.

Fig. 3.2 shows that the 0V line of the "mats" loop may be used as a return power line. Only a single 12V supply line is required between the control unit and the detector; this line could be used to supply several detectors. The remaining connections are made to the nearest part of the "mats" loop.

The unit may be given a less utilitarian appearance by covering the piping with a decorative material such as "Contact", or similar wallpaper to that on the mounting surface. It is important that the upper and lower ends of the tube should be unrestricted to allow the smoke to enter and leave freely. If desired, a circular piece of coarse-gauge wire mesh can be pressed into each end of the tube to prevent insects from entering and possibly triggering the alarm. Do not use fine-gauge mesh as this unduly restricts the entry of smoke.

The device is not greatly affected by changes in ambient illumination, and is almost immune to the *slow* changes of natural daylight. Nevertheless, it is best positioned at a reasonable distance from lighting fittings or where direct daylight and sunlight can reach it.

## TEMPERATURE MONITOR

The Temperature Monitor is an easily-constructed inexpensive device so it is feasible to have several monitors scattered at strategic positions in the house. The prototype has the temperature sensor mounted inside the case, with holes drilled to allow air to circulate. This version, therefore, monitors air temperature. Suitable positions for this device include the room in which the central heating boiler is situated, any rooms in which there are exposed flames, the head of the stair-well, children's rooms, the garage or workshop.

The device is best mounted near the ceiling and, if possible, immediately above any likely source of fire. Alternatively, the sensor may be mounted outside the case, connected by a pair of thin wires. It is then possible to strap the sensor to surfaces that are likely to become overheated when a fire is imminent. Such surfaces include chimney ducts, and the ducts of air extractor fans. The device has other less dramatic applications, such as warning when the greenhouse is too hot in the summer months.

## TEMPERATURE MONITOR CIRCUIT

The temperature sensor is a thermistor (R1 in Fig. 3.7). The VA1056S is a negative temperature coefficient thermistor, with a resistance of about 47k at 25 degrees C. Its resistance falls as ambient temperature increases. The VA1056S is normally marketed as a rod, but sometimes is available in disc form. Either type is suitable for this project.

As Fig. 3.7 shows, the thermistor and VR1 form a potential divider. As temperature rises, the decreasing resistance of the thermistor causes a rise in potential at the base of TR1. TR1 and TR2 together form a Schmitt trigger. When the temperature is below danger level, TR1 is off and TR2 is on. The current flowing through TR2 lights the l.e.d. D1, which acts as a pilot lamp to indicate that the monitor is active. As soon as the temperature reaches the danger level, as determined by the setting of VR1, TR1 is turned on and TR2 is turned off. Because this is a Schmitt trigger, there is a sharp "snap" action. Once it has occurred, it cannot be reversed by any slight decrease in temperature.

The output from the trigger circuit is at the collector of TR2. This is connected by resistor R6 to TR3, which acts as a simple switching transistor, controlling the relay RLA1. When temperature is below the danger level, TR2 is on, so the potential at its collector is low and TR3 is off. The relay is not energised and its contacts are open.

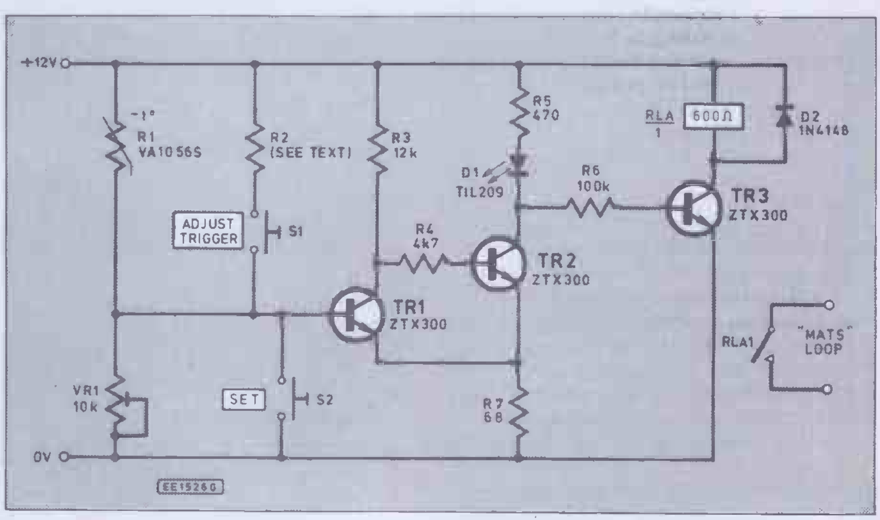



Fig. 3.7. Temperature Monitor circuit.

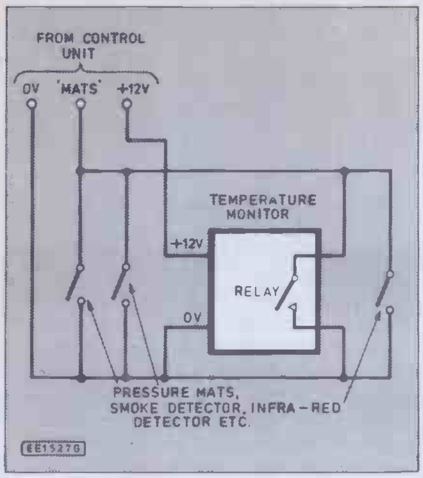



*Fig. 3.8. Wiring the monitor into the "Mats" circuit.*

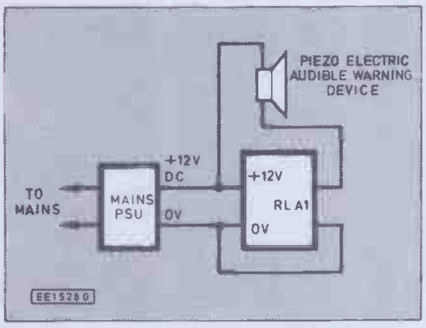



*Fig. 3.9. Using the Temperature Monitor on its own.*

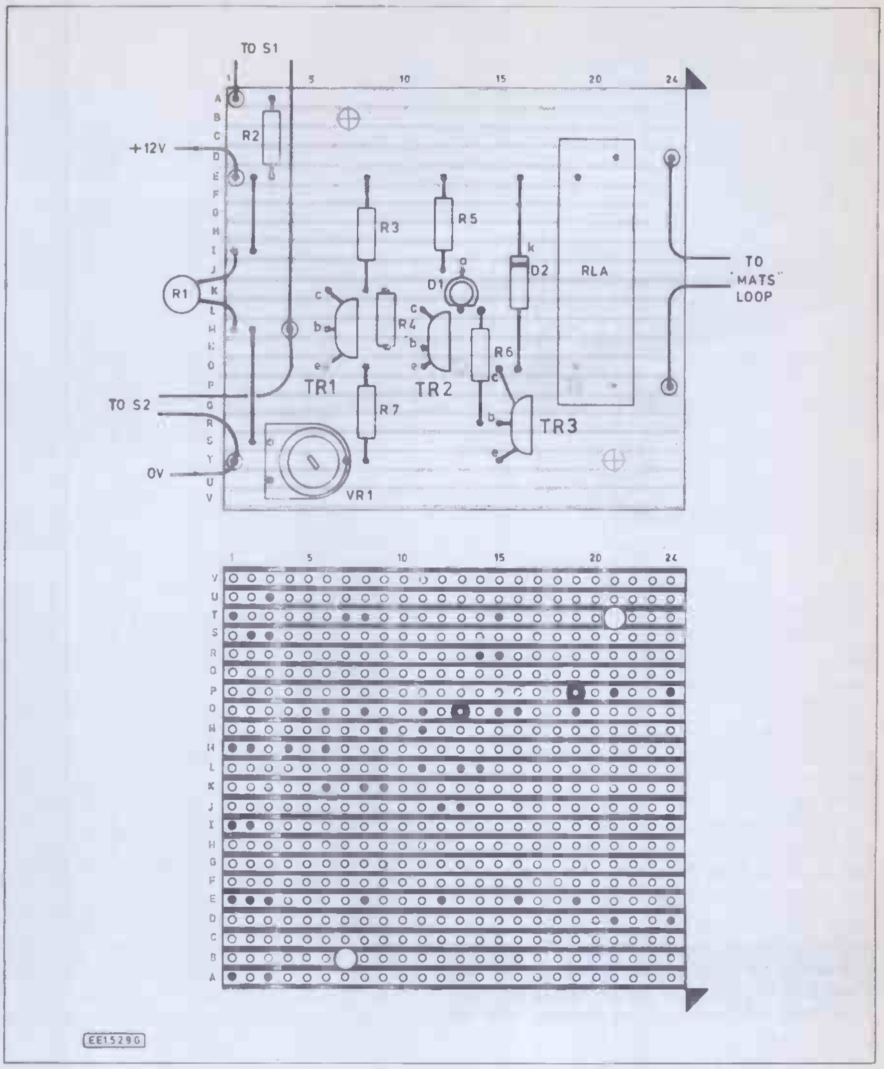



*Fig. 3.10. Stripboard layout and wiring for the temperature monitor.*

However, when the temperature is at or above the danger level, TR2 is off, the potential at its collector is high, TR3 is on, the relay is energised and its contacts are closed.

## CONNECTION

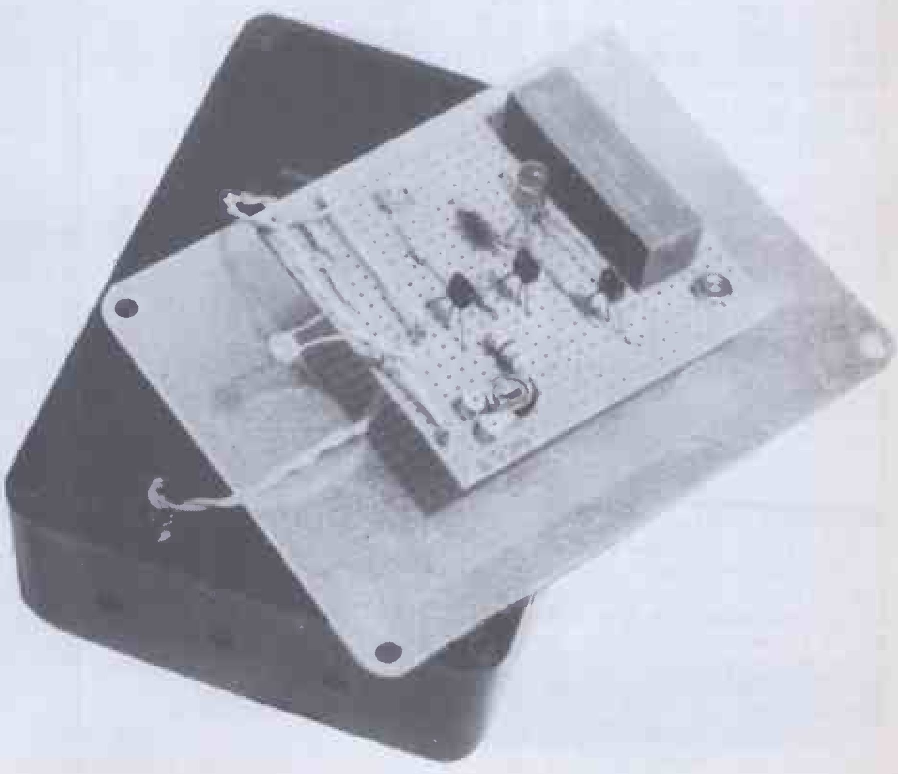
The relay can be wired into the "mats" loop of the security system (Fig. 3.8), in parallel with the pressure mats, other temperature monitors or the smoke alarm. Triggering of any *one* of these devices causes the alarm to sound. Alternatively, it can operate independently, with its own siren (Fig. 3.9).

If the monitor is operated as part of the main security system, it obtains its power from the main power supply circuit. For economy of wiring, the 0V terminal of the circuit may be connected to the return line of the pressure mat wiring, as Fig. 3.8 shows. If the monitor is operated independently (Fig. 3.8), a low-current 12V power pack is used. A variety of "battery eliminator" devices are available cheaply and are ideal for this purpose. The quiescent current is only a few milliamps, so battery power may be considered.

## CONSTRUCTION

The stripboard layout is shown in Fig. 3.10. The components are assembled on the board as shown, keeping the leads of R1 and D1 long. The leads of R1 are long so that the thermistor is well clear of the board, to allow maximum ventilation. The leads of D1 are long so that the l.e.d. can project through the hole cut for it in the case. If R1 is to be mounted off the board, insert two terminal pins at I1 and M1, and wire the thermistor to these.

The value of R2 depends upon the temper-



ature at which the monitor is to be triggered. To work out what this is to be, we need to know the value of R1 at that temperature. One way of discovering this is to heat R1 to the specified temperature and measure its resistance. Another way, adequate for this purpose, is to calculate the resistance from a value known at some other temperature. The equation for calculating this is:

$$R_{T1}=R_{T2}.e^{(B/T1-B/T2)}$$

$T_1$ and $T_2$ are the two temperatures concerned. Note that these are in *Kelvin*, which is 273 greater than the temperature in degrees Celsius. B is the temperature characteristic of the thermistor (=)3925 for the VA1056S) and *e* is the exponential factor (=2.7183). Given that this thermistor has a resistance of 47k at 25 degrees C, its resistance at other temperatures may be calculated, as shown in Table 3.1.

**TABLE 3.1.**

| Temperature (°C) | Resistance of R1 (kilohm) | Parallel resistor, R2 (kilohm) |
|---|---|---|
| 25 | 47 | - |
| 30 | 38 | 180 |
| 35 | 31 | 100 |
| 40 | 25 | 56 |
| 45 | 21 | 39 |
| 50 | 17 | 27 |

## COMPONENTS

### TEMPERATURE MONITOR

**Resistors**
R1 VA1056S n.t.c. thermistor
R2 see text
R3 12k
R4 4k7
R5 470
R6 100k
R7 68
All ¼W carbon unless otherwise specified

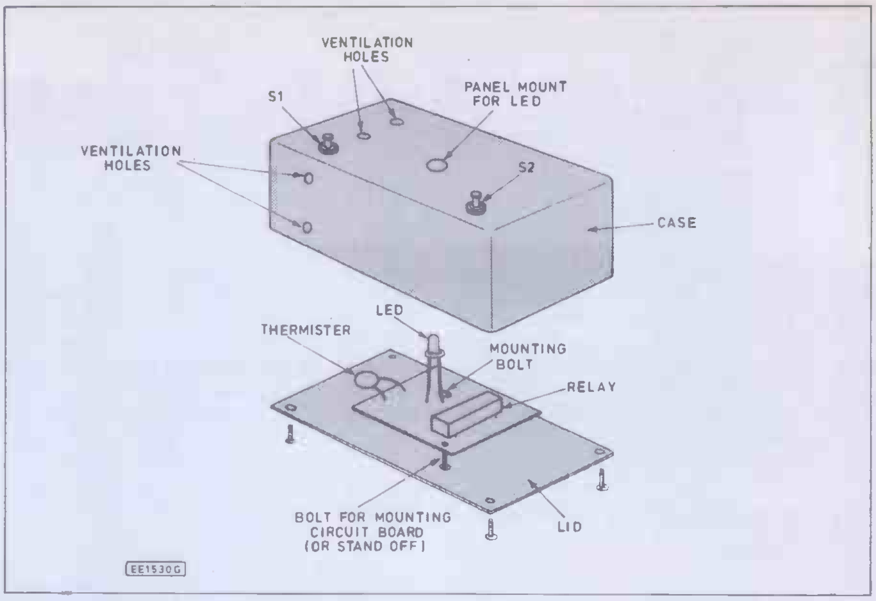
Shop Talk See page 490

**Potentiometer**
VR1 10k sub-miniature horizontal carbon preset

**Semiconductors**
D1 TIL209 or similar light-emitting diode
D2 1N4148
TR1 to TR3 ZTX300 *npn* transistor (3 off)

**Miscellaneous**
S1, S2 push-to-make push-buttons (2 off)
RLA1 p.c.b. mounting 12V reed relay, normally open contacts; stripboard 2.5mm matrix (22 strips by 24 holes); 1mm terminal pins (6 off); case standoffs or bolts with nuts for mounting board (2 off); mount for l.e.d.

*Approx. cost Guidance only* **£7**




The second column of the table tells us the resistance of R1 at the temperature at which we wish it to trigger the alarm. The tolerance of thermistors is only ± 20 per cent, so these are approximate values only. To adjust the trigger circuit we switch in another resistor (R2) in parallel with R1, so the the *combined* resistance of R1 and R2 at 25 degrees C equals what the resistance of R1 *alone* would be at the required triggering temperature. These values (in the third column of the table) have been calculated and taken to the nearest E12 preferred value. If you require more precision, the formula for the calculation is:

$$R=\frac{47\times R_T}{47-R_T}$$

Where $R$ is the required resistor and $R_T$ is the resistance of R1 at the triggering temperature, as taken from the second column of the table.

## SETTING UP

We assume that you are adjusting the circuit in a room at a temperature of about 25 degrees C, so that the resistance of R1 is close to 47k. Press S1 to bring R2 into the circuit in parallel with R1. Hold S1 while you rotate VR1 to reduce its resistance (turn it anticlockwise) until the l.e.d. comes on. Then turn VR1 *slowly* in the opposite direction until the l.e.d. *just* goes off. This sets VR1 so that the circuit will trigger the alarm at the required temperature. Release S1. Now press S2, to set the circuit; the l.e.d. comes on. To check circuit operation, heat the thermistor (hold a hot soldering iron a centimetre beneath it). In a few minutes the l.e.d. goes off and the relay closes. When the thermistor has cooled, the circuit is set by pressing S2 again.

Once the circuit is adjusted, no further adjustments to VR1 should be made. However, by pressing S1 at any time, the circuit is triggered and the alarm sounds. In this way S1 may be used to sound the fire alarm manually. Fig. 3.10 shows the circuit in its case, with two push-buttons of equal size. If you prefer, S1 can be a much larger button, connected to the main circuit by leads. It may be mounted conspicuously in an accessible position and marked "Fire". □

**Next month**: An Infra Red Beam Alarm.

# Robot Roundup

## NIGEL CLARK

THE dream continues. Despite years of false dawns and dashed hopes there are still people looking to create robot butlers and gardeners to take away all those unpleasant menial tasks that take up so much time, leaving us intelligent human beings to concentrate on the more important things in life.

At the moment there is a Government-sponsored team hard at work with a budget of between £30,000 and £40,000 to find uses for robots in the home. It is described as a feasibility study but the press release from the Department of Trade and Industry, which announced the group's formation, seemed convinced that robot servants were more than feasible.

"The department is setting up a group of industrialists and academics who will develop intelligent robots for use in, and around, the home." No doubt there. However, I am less than convinced.

I began writing about small robots almost five years ago when home robots, led by Nolan Bushnel's Androbot, were about to become the next new high technology success story after the home computer. It did not happen. The attempt became bogged down under the weight of expectations which the Androbot could not fulfil.

**EXPECTATIONS**

Robots, unfortunately, do not come as something totally new to be looked at and assessed on their merits. The dream of the robot servant has been around for centuries in all the media. No writing or film about the future would be complete without its robot, Robocop being one of the latest in a long line.

When someone tries to sell a robot for the home it has to compete with those expectations, which are totally unreal on the basis of present technology. It is a problem which both IGR, with its buggy, and Spectravideo, with its RobotArm, came up against when they tried selling into the home.

To be fair they, as did Bushnell, appreciated the problem enough to try to alter people's perceptions. Bushnell tried to convince people to part with the best part of £1,000 for a robot which had no pretensions about being useful but was clearly stated to be a toy. The others considered creating games which could be played by the robots. IGR closed down and Spectravideo now supplies most of its arms to Logotron and Resource as part of their educational arm package.

Their efforts were of little use against the myths which the setting up of this group seems determined to perpetuate. It is not that the area it is covering cannot make use of robots. As a way of creating and developing an interest in a wide range of technologies small robots are ideal. However, statements like "new technologies will make certain types of domestic robot a reality" do little to encourage reasonable expectations of what is going to be achieved.

**DOMESTIC AND LEISURE**

The DTI's intentions are admirable. The domestic and leisure group was set up as part of the department's larger Advanced Robotics initiative. It began a couple of years ago with the aim of developing and integrating artificial intelligence, computing and robots with traditional engineering techniques. A national research centre is being set up in Salford–an announcement is likely soon–to be a focus for work in advance robotics.

Nine areas were chosen for work, and feasibility studies have been undertaken in seven of them, only the domestic and agriculture areas remain to be assessed. The next stage is for industry, educational establishments and the Government to get together to consider undertaking further development of some areas which have been highlighted. That stage is being undertaken by the tunnelling group.

To date the work has been concentrated on how robots can help in hostile environments, such as fire fighting and nuclear installations. The work for the home has only recently started.

Although the domestic and leisure feasibility study has yet to be started the group has already been considering a guidance system, which could be used in a security robot to patrol the home, detecting out-of-place or missing items and intruders.

**SECURIBOT**

While not as ambitious as the robot servant dream of the DTI press release, the problems facing a home securibot can give a good insight into the problems faced by any robot expected to work in the home. In their existing or prospective industrial uses robots operate in a structured environment which allows the number of different situations with which the robot has to contend to be limited, simplifying its operation considerably.

There are well-known stories of paint sprayers which have continued spraying although there is nothing there. They could not sense the absence of the part to be sprayed because under normal conditions the part would be in place. To add a sensor with the necessary feedback for the odd occasion when something went wrong was seen as an unnecessary complication.

The home is far from being a structured environment. In all the best unordered houses items move from day to day, hour to hour. Unless the securibot is not to be continually complaining that something is missing it would be necessary to make sure that everything was kept in one place or that the robot would have to develop some intelligence to allow it to recognise items in different places in a reasonable amount of time. Both solutions pose problems in being excessively restricting or being highly complex and, therefore, expensive.

In addition artificial intelligence is not yet developed enough to allow the robot to react with any kind of speed. For example there are many ways of recognising a chair, depending on the direction from which it is approached and on the other items in the room. For the robot to decide what object it was sensing it would have to sort through all its memory which could take some time. It is here that the initiative could flounder.

The DTI is only fully financing the feasibility stage. Further work must have 50 per cent of its funds from industry. It is doubtful whether industrialists would be willing to fund artificial intelligence research, which has shown itself to be a very long-term project, even if there was a possible product at the end of it.

I hope that I am wrong. I hope that people with the imagination and creativity of Richard Greenhil and Dave Buckley, both former IGR people, and Jim Whiting, of the outrageous robotic sculptures, can come up with robots which will catch the popular imagination. However, I remain sceptical.

*IGR's Buggy for which Games were being written*

# b...Beeb...Beeb...Beeb...Be

HAVING spent the last three articles dealing in detail with EPROM programming using the BBC computer, this month we will consider a few more lightweight aspects of the BBC machines.

## Geriatric BEEBS

Although it may not seem like it, the BBC model B has been a popular computer for what must be around five years now. It was probably at its most popular in the first one or two years of production, which means that a large percentage of the BBC computers currently in use are around three to five years old. Fortunately, these computers are quite strongly built, and they should last a good many years. My BBC model B has received a great deal more use than certain other computers in my possession which are literally falling apart! My model B looks its age, but is still in fairly solid condition.

A lot of the components in these computers are "off the shelf" types, and the circuit board is not one of those that is populated by little more than half a dozen special chips. The special components that are used in the design still seem to be available from the larger BBC retailers, and will presumably continue to be available for some time to come. It is well worth keeping BBC computers in serviceable condition for as long as possible, as replacing one with a Master 128 would be quite costly.

An Archimedes computer with the right add-ons will also act as a suitable replacement for a BBC model B, but this option is even more costly. At least the BBC line of computers is continuing, and they have not gone the way of many model B contemporaries which are now little more than dim memories.

## Keyboard

A problem I have experienced with my BBC computer, and one that is apparently not uncommon, is the unit producing a blank screen and a continuous tone from the speaker at switch-on. Sometimes the problem manifests itself in the form of either no characters or the wrong characters being produced on the screen when the keyboard is used! Both problems are usually intermittent, and the computer may perform flawlessly for some time and then give repeated difficulties.

The problem seems to be due to the ribbon cable used to connect the keyboard assembly to the main printed circuit board. I suppose it is more accurate to say that it is the multiway connectors that give the problem. These are of a type much used in home computers, and it seems likely that similar problems with other computers are not uncommon. The root of the trouble seems to be nothing more than bad connections betwen the plugs on the circuit boards and the sockets on the ribbon cable. Although the connectors may be firmly locked together, there may still be a poor electrical contact between the two.

Just removing the cable and then plugging it back in place again seems to cure the problem. Presumably this scrapes the contacts of the connectors against one another and cleans them off to some extent. In the interest of good long term reliability it is a good idea to remove and refit the cable a few times, and to give all four connectors a quick spray with contact cleaner.

It is easy enough to see why a poor connection to the cable would prevent the keyboard from functioning properly, but why would it prevent the computer from completing its start-up routine and providing the usual initial screen message? Well, virtually all computers go through some form of checking routine at switch-on.

The IBM compatible I use for word processing etc. actually goes through quite a long checking sequence each time it is switched on, and gives on-screen reports about the memory, display driver, keyboard, etc. The BBC model B seems to go through some form of start up routine of this type, but in the event of a fault being detected it just seems to hang-up, rather than giving an on-screen error message. The keyboard seems to be included in its start-up checking routine.

A strange phenomenon I have noticed over the years is that the actual potential of the +5 volt supply seems to have been gradually reducing. It eventually fell to below 4.5 volts (as read on three different multimeters) and I was resigned to the fact that a replacement power supply module would probably be required. However, after a short circuit on the +5 volt supply due to a faulty add-on device the supply voltage seems to have been restored to its full rated potential! I must admit that I have no idea why there should have been the gradual fall off in the supply voltage, or the sudden recovery. Any ideas anyone? *(Possibly something to do with electrolytic leakage? Ed.).*

## Regulation Efficiency

A well known shortcoming of the BBC computers is the noise problems associated with the four analogue inputs of the analogue port. Separate digital and analogue ground terminals are provided, but use of the analogue ground terminals seems to no more than marginally reduce the problem. The problem is reputedly one with the NEC μPD7002 analogue to digital converter chip and not a computer design fault.

I have tried adding decoupling capacitors to give reduced noise, but have met with no real success. The only way of obtaining improved performance seems to be to take several readings and then use some system of averaging to counteract the random variations introduced by the noise. Where speed is not a problem this can be quite effective. The more readings used in each averaging calculation the better. The potential 12 bit of the converter can probably never be fully realised in practice, but you can get quite close. Acorn only claim 10 bit accuracy for the converter incidentally.

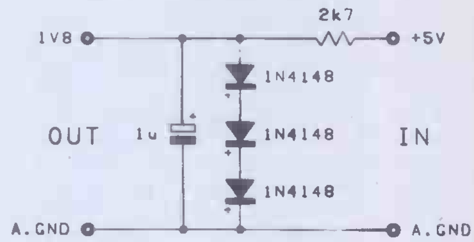



*Fig. 1. The voltage regulator used in the BEEB's A/D converter.*

A less well known problem with the analogue port is a lack of accuracy and stability in the 1.8 volt reference source. This reference voltage is generated by a simple diode shunt regulator, as shown in Fig. 1. This relies on the fact that about 0.6 volts is produced across a forward biased silicon diode. Three diodes in series, therefore, give an output voltage of approximately 1.8 volts. This is a rather crude form of regulator when compared to the high quality types used in some other analogue to digital regulator circuits. The actual reference voltage can vary significantly from its nominal 1.8 volt level, and it is also apt to drift significantly.

One cause of the problem is that the exact voltage developed across a forward biased silicon diode varies somewhat from one component to another. The main problem is that this voltage is temperature dependent. In fact diodes are often used as temperature sensors. The variation in voltage is not very large, and is generally no more than a reduction of about 3 millivolts per degree Centigrade. With three diodes in series this becomes some 9 millivolts per degree Centigrade. This represents about 0.5 per cent per degree Centigrade, which is substantially higher than the resolution of the converter (even when making some allowance for the noise problem). The temperature inside the computer can rise substantially in the half hour or so after switch-on, and the reference voltage can drop substantially as a result of this.

Measurements made on my BBC Model B showed an initial reference voltage of 1.927 volts, with a fall of about 1 per cent in the space of a few minutes after switch-on. It then fell by a further 1 per cent over the next 25 minutes or so, and continued to fall at a slower rate for some time thereafter. After a couple of hours the reference voltage had fallen by over 3 per cent. Remember that in percentage terms the resolution of the converter is better than 0.01 per cent (even allowing for the reduced resolution caused by the noise problem).

For some applications any drift is of no importance. This really means applications where the analogue inputs are fed from a potential divider circuit connected between the reference source and analogue ground. Any change in the reference voltage is precisely matched by a change in the full scale sensitivity of the converter. The net result of this is no change at all in the readings obtained. Where any drift becomes important is in applications that have the analogue port measuring a voltage produced by some add-on device. A lot of the published designs which utilize the analogue port of the computer fall into this category.

It would be quite possible to remove the existing regulator components and replace them with a more efficient circuit. The three diodes, load resistor, and decoupling capacitor (which will probably be a tantalum bead type) are situated between the $\mu$DP7002 integrated circuit and the 15 way D connector of the analogue port. However, I am not keen on making internal modifications to commercial equipment, even if it is well out of the guarantee period.

An alternative is to have an external voltage regulator circuit in any add-on to the analogue port which requires a high degree of accuracy. The key to success is to have the new reference generator produce a voltage that is somewhat lower than the normal reference level. The three diodes are then cut off and have no effect on the external regulator circuit. This still leaves the load resistor, but this does not need to be a problem.

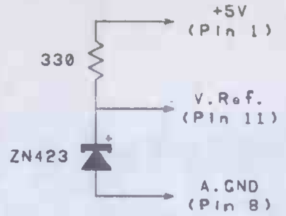




*Fig. 2 (left). An add-on regulator circuit.*

*Fig. 3 (right). Pinout details of the ZN423.*

A circuit for an external reference voltage generator is shown in Fig. 2. This looks like a conventional Zener diode shunt regulator circuit, but in this case the Zener is actually a high quality Ferranti voltage regulator device which has a nominal avalanche voltage of 1.23 volts. It has excellent stability and accuracy. The internal 2k7 load resistor of the computer is no problem as the ZN423 needs to pass a current of 10 milliamps or so in order to work efficiently. This requires the use of a fairly low value load resistance, which is formed by the parallel resistance of the internal 2k7 resistor and the external 330 ohm component.

The ZN423 has good temperature stability, and if it is mounted in an external unit it will presumably be subjected to a very restricted range of ambient temperatures anyway. Results using this device certainly seem to be very good, with negligible drift.

Note that the ZN423 does not have the usual Zener diode tubular type encapsulation. It is contained in a sort of two lead TO-18 style case, similar to the encapsulation used for the popular BC109 series of transistors. Leadout details for the ZN423 are shown in Fig. 3.

An important point to bear in mind if you use this regulator circuit is that the full scale sensitivity of the converter is changed from 1.8 to 1.23 volts. If necessary, potential dividers can be used ahead of the analogue inputs to reduce their full scale sensitivity back to about 1.8 volts. However, in most cases it will probably be possible to adjust the add-on used with the port to suit the lower full scale value, or some minor changes to the software might be sufficient.

# FOR YOUR ENTERTAINMENT

**BY BARRY FOX**

## Hear, Hear!

We all know that everything goes wrong in the end. I heard recently of a couple of unusual equipment breakdowns. The first concerned David Steel who recently retired from leadership of the S.D.P.

During the BBC's coverage of the last election, David Steel was in Wales while a reporter in London asked him awkward questions. As is usual in these cases, Steel was wearing a small earpiece. As the questions became more awkward, Steel's earpiece stopped working. So he couldn't hear the questions and couldn't be expected to answer them.

Over the next few weeks, the BBC got letters from all round the world, from firms making earpieces which were claimed to be more reliable, but the BBC was confident that it did not need to buy any new earpieces. Engineers had checked David Steel's earpiece directly after the aborted interview, and found it to be working perfectly well. As far as the viewers were concerned, David Steel was the innocent victim of equipment that went wrong.

Roger Cook's radio programme specialises in telephoning shady businessmen and taping their responses. Those who slam down the 'phone or shout abuse come off badly. So do those who expose themselves to Cook's questions.

Even the BBC engineers setting up Cook's 'phone link had to admire the cheek of one con man who found a neat new way round the problem.

He had been told that Roger Cook wanted to interview him by telephone, and said "yes that would be fine–I've got nothing to hide or be ashamed of– I'll make a point of being in and keeping the telephone line clear".

When the BBC made the connection, the con man answered the telephone. "Hello" he said helpfully. Then he just continued saying "Hello", over and over again, complaining that he could not hear Roger Cook at the other end.

Finally he said "We seem to have been cut off", and hung up. When the BBC tried to 'phone back, all they got was an engaged tone. This went on for several hours. As a BBC engineer put it "We could hardly broadcast an engaged tone in reply to Cook's questions".

Later that day the con man administered the *coup de grace*. His secretary 'phoned the BBC from another number, saying that her boss was awfully sorry, he'd been trying to get through to Roger Cook all day to record the interview, but had failed–and he had now had to leave town for an appointment. Was there some other time they could arrange to talk?

Although the BBC engineers were convinced that there never had been anything wrong with the line, there was no way they could prove it and the interview had to be abandoned.

## More news on video

The new Super-VHS system improves picture clarity by raising the frequency of the f.m. video carrier and increasing its modulation bandwidth. This makes the system capable of resolving over 400 vertical lines, compared to around 240 lines for standard VHS. What has never previously been made clear, however, is that raising the video carrier loses 6dB of signal and widening it loses 2dB, meaning an unacceptable reduction of signal-to-noise ratio from 47dB (for standared VHS) to 39dB (for Super VHS).

To recover this lost 8dB, S-VHS relies on better tape (a gain of 2dB), better heads (another 2dB) and modified pre-emphasis circuitry (another 4dB).

However, there are still two insuperable snags. Altering the carrier and emphasis means that tapes recorded in S-VHS mode will not play back on a standard machine. The pictures on screen are torn and barely recognisable. If film companies want to support S-VHS with pre-recorded videos, they must thus be prepared to put out each film, in two versions, standard and super, but it is unlikely they will do so. Even in Japan there are still only two or three titles to choose from.

The other snag is that the improved line resolution is only obtained if a "component" signal is fed from the video recorder to TV set, with colour and black and white information kept separate. If the signal from an S-VHS recorder is fed to a TV set in normal "composite" format, there is a loss of at least 100 lines of resolution. This is why there is already a new generation of sets on sale in Japan, with S-connectors which keep the colour and black and white information separate.

So far there are no S-connector sets available in Europe but they are expected to appear on the market by Christmas along with the first S-VHS recorders. Anyone who uses an S-VHS machine with a conventional TV set or video monitor will see nowhere near the full picture improvement that the new format offers. Inevitably this will cause confusion amongst the public and trade unless manufacturers take the time and trouble to explain and demonstrate the S-VHS system properly.

# TIME SWITCH SUN TAN TIMER

GARY CALLAND

*Sleeping in the noonday sun is much safer with our automatic timer. The basic circuit is also used for a very versatile mains timer unit.*

On the few days that summer actually comes to Britain and a strange warm orange disc is sighted in the sky, the immediate reaction is to rush out and try and capture as much sunshine as possible. This usually fails to have the desired effect of you becoming instantly bronzed, and often results in a sore reddening of the skin, and in extreme cases, blistering, which can make things like sleeping and walking painful exercises.

A more serious result of too much sunlight is sunstroke. Many people enjoy a good snooze in the sun, but some, having overslept wake up feeling ill, suffering from sunstroke and this can lead to hospital treatment. These misfortunes could be avoided if there was a device to let you know when you have had just the right amount of sunlight to develop a tan but not enough to cause damage.

Such a device now exists in the form of the sun alarm. This compact lightweight pocket-sized project sounds a penetrating alarm, piercing enough to wake anyone from the deepest slumber when it has received a set amount of sunlight. This set amount is fully adjustable to allow for any sort of skin type and so that built up tolerances to sunlight acquired after several days in the sun can be compensated for.

## HOW IT WORKS

The sun alarm can be split into three basic sections (Fig. 1). Firstly, a light controlled oscillator produces pulses at a frequency which depends upon the intensity of sunlight falling upon it. The stronger the light, the higher the frequency.

This oscillator is based around IC1a (Fig. 2) a single Schmitt trigger NAND gate. The frequency of oscillations depends upon C1 and the combined resistance of TR1 and VR1. The resistance of the photo transistor (TR1) falls with increasing sunlight which increases the frequency. VR1 forms a sensitivity control so that the combined resistance can be varied. Oscillations are only produced however when there is a high on pin 9 of IC1a i.e. a low is present on the input pins of IC1b, a second Schmitt trigger NAND gate.

The pulses are then sent to the second part of the circuit to be counted. This consists of IC2, a 14 stage binary counter and IC3, a dual 4 input AND gate IC. The top 7 stages of the binary counter are effectively added together by the AND gates to give a high on pin 1 of IC3 after 16,256 pulses have been counted.

This high is converted into a low by IC1b and so IC1a stops producing pulses. This high also switches on the final part of the circuit, and the audio alarm section. This consists of the two remaining Schmitt trigger NAND gates belonging to IC1. IC1c oscillates at about 5Hz set by C2 and R1 when a high is present on pin 2. This switches on and off IC1d which is set to oscillate at 2kHz by R3 and C4 to produce a pulsed tone from the ceramic resonator.

When a low is present on pin 2 of IC1c the NAND gate does not oscillate, however the output is high which would switch on IC1d. To prevent this C3 and R2 are placed between them both to block this voltage. These also produce a small beep when the alarm is switched on. C5 eliminates any noise spikes on the power lines which may interfere with the circuit operation.

## CONSTRUCTION

The compactness of the sun alarm has been achieved by using two lids from the smallest Verobox available, bolted together to form a case measuring only 50×72×10mm. Inside one of the lids lies a tight fitting p.c.b. which accommodates all the components except for the batteries (Fig. 3). These 1.5V watch batteries lie at the bottom of the case in a space specially cut out of the p.c.b.

Construction should begin with the p.c.b. Firstly solder in the two links, the resistors, the preset resistor and the capacitors, noting their polarity. The phototransistor should be soldered leaving about 2 to 3mm between its

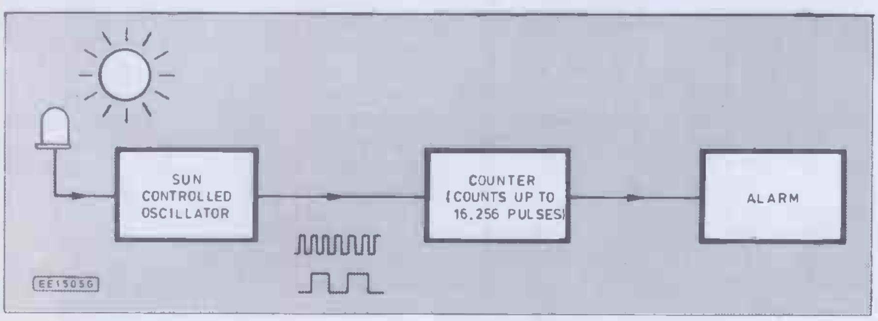



*Fig. 1. Block diagram of the Sun Tan Timer.*

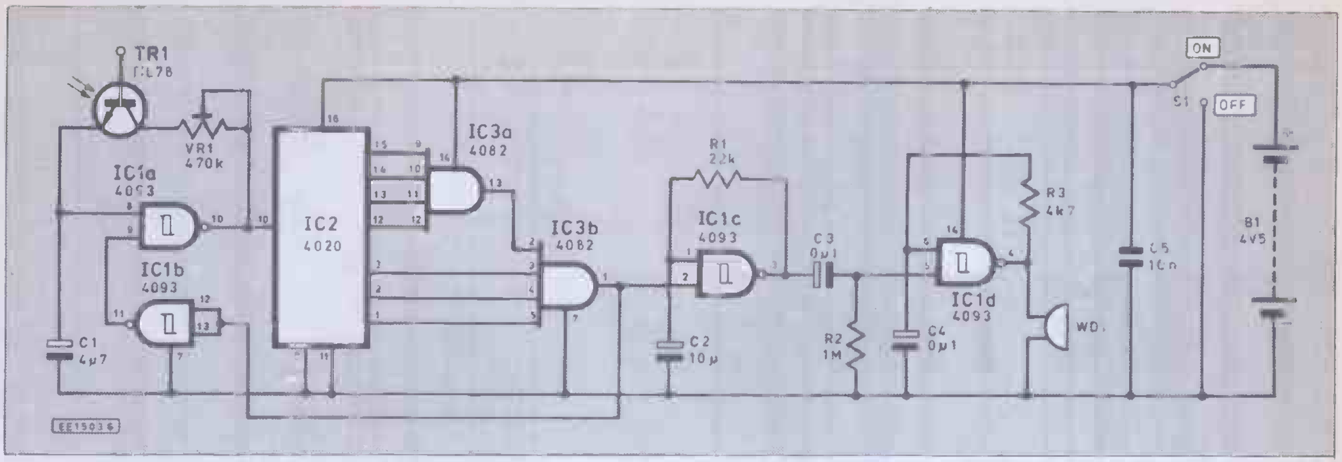



Fig. 2. *Circuit diagram of the Sun Tan Timer.*

base and the board so that it doesn't suffer from heat damage when soldering.

It is important to remember that due to the size of the case, the circuit board with its components should be as thin as possible. As a result all component leads should be cut as close as possible to the circuit board to avoid solder "blobs" and the capacitors should be bent over to lie flat against the p.c.b.

It is also for this reason that i.c. sockets could not be used, and the i.c.'s are soldered directly onto the board. This should be done carefully to avoid damage due to heat and it may be wise to earth yourself so that static electricity will not damage these CMOS devices as well. If all is well, the minature slide switch and ceramic resonator can be soldered in place and glued onto the p.c.b.

Attention is now turned to the case and battery mounting details. The three batteries are connected together in series by using strips of tin glued to both case lids. Alternatively, they could be soldered together with wire to produce a more permanent arrangement. Whichever method is chosen, it is important that the sides of the batteries do not touch and so they should be separated by small strips of cardboard or plastic.

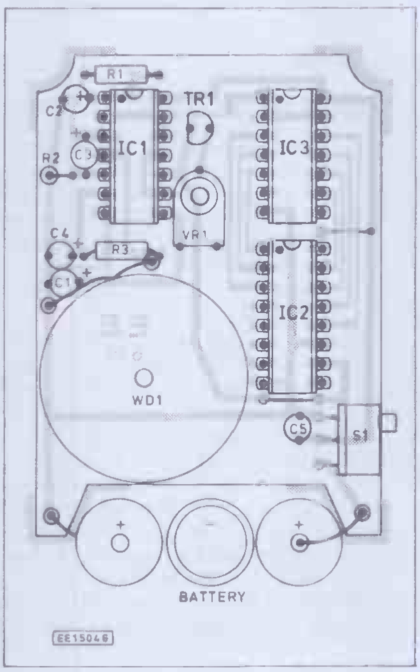
Finally, cut a hole in the side of the case for the slide switch, and drill holes for the phototransistor, the preset resistor and for the ceramic resonator. The project is completed by bolting the case together with 12mm 6BA bolts and lettering with rub down letters.

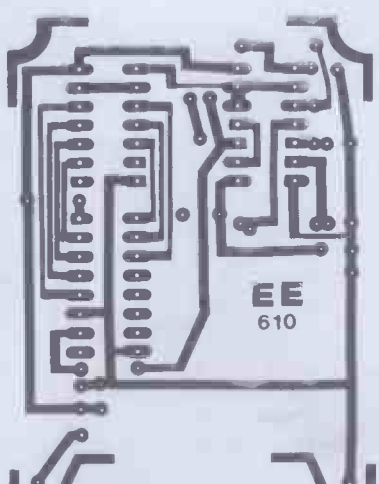
## IN USE

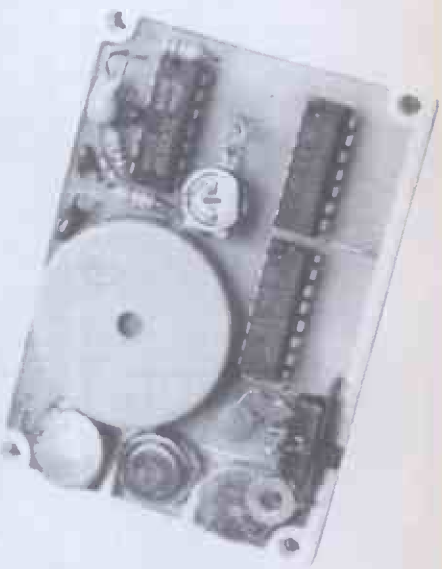
When the sun alarm is switched on it should produce a beep to let you know it works. To test the alarm, place it under a bright light with the sensitivity turned fully to the left. This is the minimum setting and the alarm should sound after about 20 to 30 mins.

When actually in use, the correct setting for the sensitivity control depends upon the

*Fig. 3. Printed circuit board layout and wiring for the Sun Tan Timer.*



## COMPONENTS

**SUN-TAN TIMER**

**Resistors**
R1 22k
R2 1M
R3 4.7k
All ¼ watt ±5%

**Potentiometer**
VR1 470k horizontal preset

**Capacitors**
C1 4μ7 tant
C2 10μ tant
C3 0μ1 tant
C4 0μ1 tant
C5 10n ceramic

**Semiconductors**
IC1 4093 quad 2 input NAND Schmitt trigger
IC2 4020 14 stage binary counter
IC3 4082 dual 4 input AND gate
T1 TIL78 IR phototransistor

**Miscellaneous**
Vero boxes 7249×25mm (2 off– see text); 1.5V watch batteries type AG12 (3 off); ceramic resonator type PB2720; s.p.d.t. miniature slide switch; 12mm 6BA nuts and bolts (4 off); p.c.b. available from the *EE PCB Service*, order code EE610.

*Approx. cost Guidance only* **£9**

user and is found by trial and error. To help, the further to the right the control is turned, the higher the dose of sunlight you will be allowed. It is also possible to pause the sun alarm in the middle of a sun bathe if the user goes in for some reason. Simply turn the alarm over so that it is facing the ground and this will virtually stop the counter, holding it ready to continue when turned back.

The sun alarm draws just 12μA and so it should last through many summers before the batteries need to be changed, especially considering how often the sun actually comes out during summer. So to those who have successfully completed the sun alarm, happy sunbathing.

# USEFUL TIMER CIRCUIT

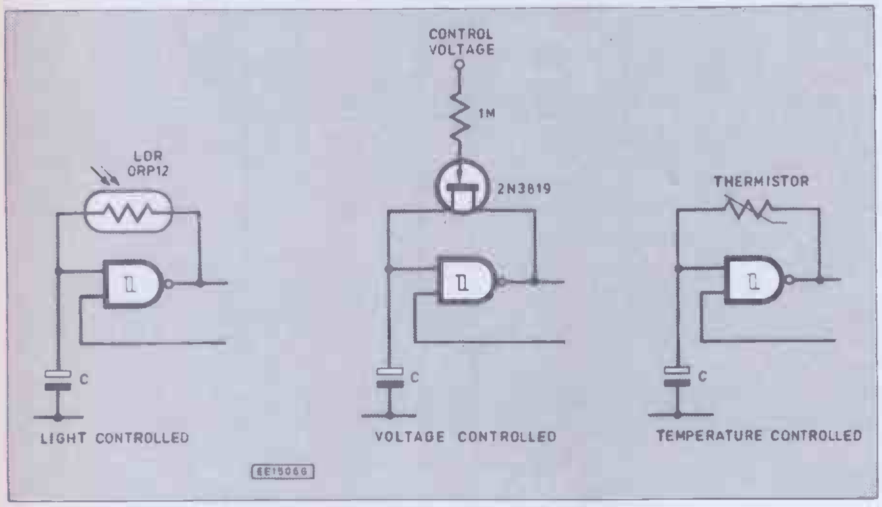



*Fig. 4. Various inputs for the timer circuit.*

After the circuit for the Sun Tan Timer was conceived, it became obvious that this circuit could easily be changed from a light controlled timer to a temperature controlled timer or a timer controlled by any variable which can be represented by a resistance. See Fig. 4. The circuit is also extremely useful as a general purpose timer which can be set from several seconds to many hours by simply changing the value of a fixed resistor. The timer circuit can easily be added to circuits where a time period greater than that obtainable from the 555 timer i.c. is required.

Some of these ideas are illustrated by this Time Switch project which has hundreds of uses and which demonstrates how adaptable the timer circuit can be.

The time period is fully adjustable from 20 minutes to about 7 hours, but, if desired, virtually any length of time from seconds to tens of hours could be set by simply changing a couple of components on the circuit board.

It is also an easy matter to combine two or more timer circuits so enabling a mains appliance to be switched on after a length of time, and then switched off again after a different length of time. In fact, the timer circuit is so cheap and versatile that the possibilities are endless.

The number of uses for the Time Switch are equally endless and rabge from burglar deterrents, as the time switch could be used to switch lights on and off in an empty house to give the impression of occupancy, or to provide a sleep facility for T.V.'s and radios, so that you can doze off to sleep listening to or watching a late night show, without the fear of the radio or T.V. waking you up at some unearthly hour in the morning. In fact after building the Time Switch you will wonder what you ever did without it.

## Circuit Description

Mains electricity is transformed by T1 (Fig.5) and rectified and smoothed to give 8V d.c. by D3, D4 and C2 respectively. This either powers, through a 100mA fuse, the timer circuit or the l.e.d. in the opto-switched triac IC4, depending upon the position of S2.

When the switch S2 is in the latter position the l.e.d. in IC4 is on and this switches on the internal triac. This triac can only drive loads drawing less than 100mA and is inadequate for most household equipment. Hence, the triac is used to switch on a higher power triac, CSR1 via R4 and R5. So when the timer circuit is not required power is supplied to the load.

When the timer circuit is switched on, l.e.d. D1 is illuminated, via a current limiting resistor R2, to show that this is so. Also, pulses are produced from the oscillator as described for the Sun Tan Timer and this produces pulses with a period T given by:-

$$T = \frac{1}{2}RC1$$

where R=R1+VR1. Hence, altering the value of VR1 alters the pulse frequency, and thus the time period . Eventually IC1b stops pulses from being produced by IC1a and so the timer circuit is frozen with a high on the output pin after a time period of length

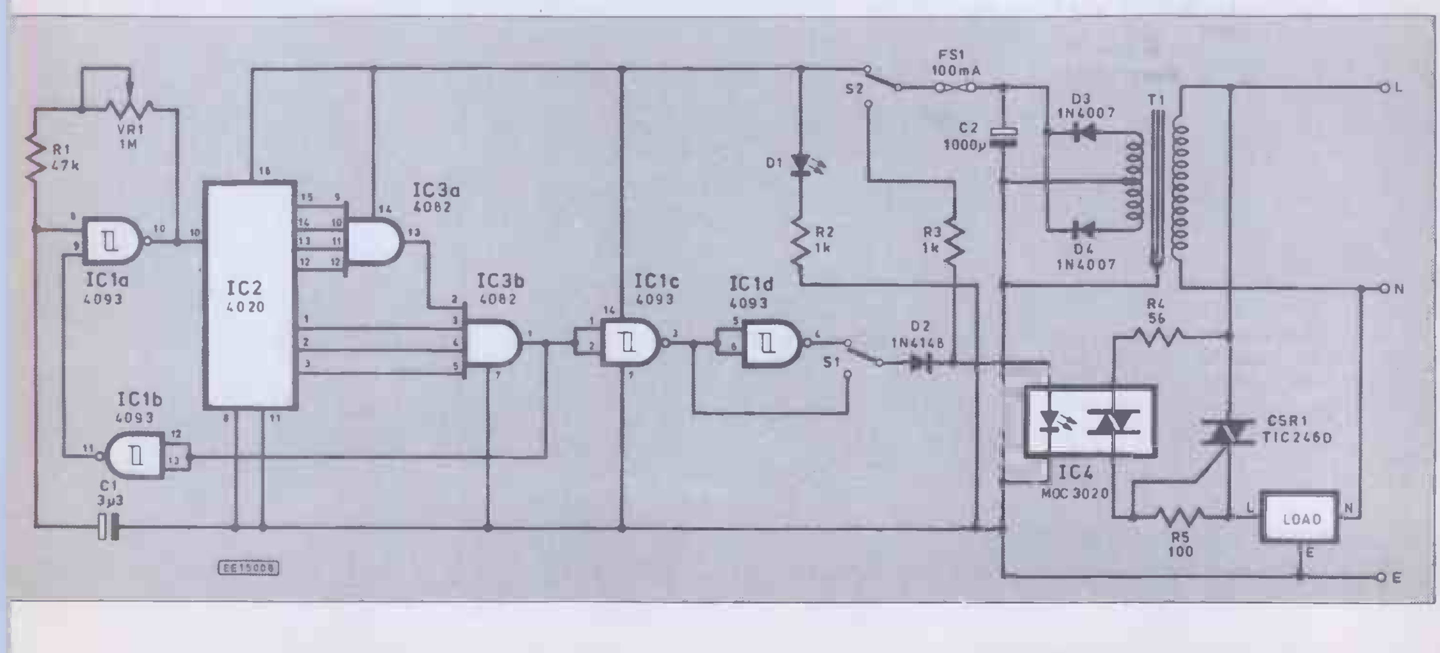
$$T = \frac{16256\ RC}{2} \text{ or } 8128RC \text{ in seconds}$$

Switch S1 selects whether the output from IC1c or IC1d is fed to the opto- switched triac l.e.d. via D2. If IC1c is selected, then the opto-switched triac l.e.d. is switched off and hence the load is switched off, after the set time period. If IC1d is selected the opposite happens, and the load is switched on after the set time period.

## Construction

Virtually all the components fit onto the p.c.b. to simplify construction as much as possible (see Fig. 6). After holes for mount-

*Fig. 5. Circuit diagram of the Time Switch.*



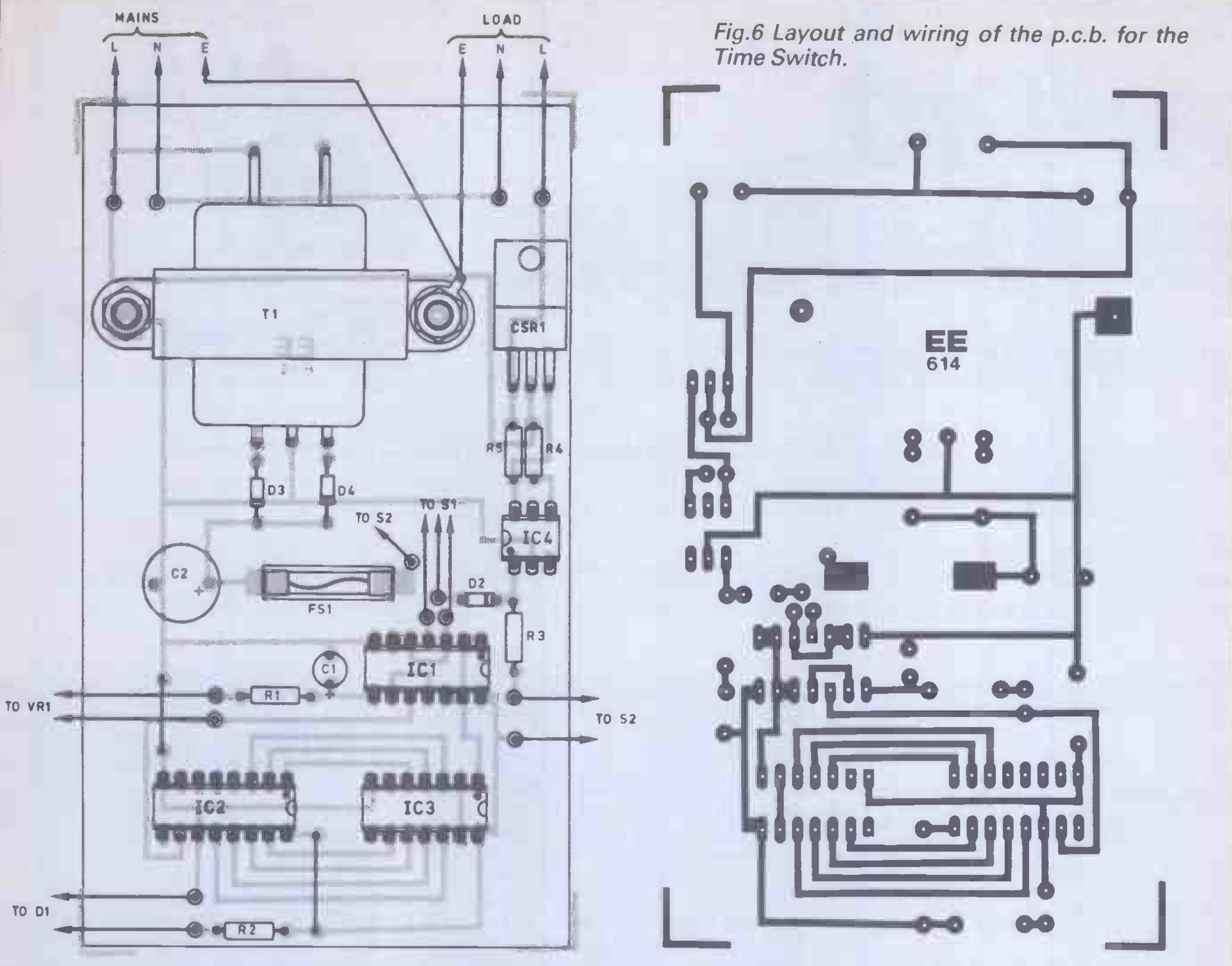



*Fig.6 Layout and wiring of the p.c.b. for the Time Switch.*

# COMPONENTS

## TIME SWITCH

**Resistors**

| | | | |
|---|---|---|---|
| R1 | 47k | R4 | 56 |
| R2 | 1k | R5 | 100 |
| R3 | 1k | All ¼ watt ±5% | |

**Capacitors**

| | |
|---|---|
| C1 | 3μ3 elect. |
| C2 | 1,000μ elect. |

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See page 490

**Potentiometers**

VR1 1M lin.

**Semiconductors**

| | | | |
|---|---|---|---|
| | | D1 | red l.e.d. |
| IC1 | 4093 | D2 | 1N4148 |
| IC2 | 4020 | D3 | 1N4007 |
| IC3 | 4082 | D4 | 1N4007 |
| IC4 | MOC3020 | CSR1 | TIC246D |

**Miscellaneous**

T1 6–0–6V 100mA transformer

20mm fuse clips (2 off); 100mA 20mm fuse; s.p.d.t. switches (2 off); knob; 13 amp mains socket; 14 pin i.c. socket ( 2off); 16 pin i.c. socket; case 145×95×55mm; p.c.b. wire etc. available from the *EE PCB Service*, order code EE 614.

*Approx. cost Guidance only* **£18**

ing the transformer and terminal block have been drilled, the components may be inserted.

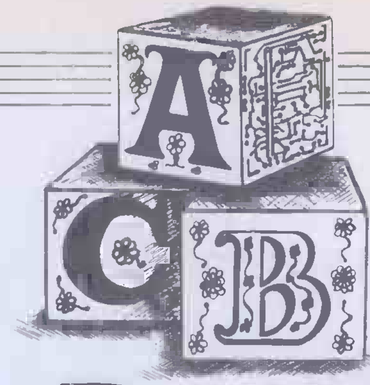
Start with the two links and resistors followed by the capacitors and semiconductors. Ensure all polarized components are inserted in their correct positions according to the overlay, i.e. sockets may be used for the CMOS devices to avoid damage through heat and static electricity.

Insert the fuse clips and mount the transformer using 6BA bolts and solder in its leads. Finally bolt on the two terminal blocks and the p.c.b. is complete. All the other components are mounted on the case lid. The case used measures 145×95×55mm and is ideal for the project. A 13 amp mains socket is mounted to the left of the case lid to leave space for fixing the two switches S1, S2, the timer control variable resistor VR1 and the power on l.e.d. D1 to the right.

The mains cable enters through a rubber grommet in the side of the case and is prevented from being pulled out by tying a cable tie around it inside the case. After the p.c.b. is wired up to the case components, the time switch is ready for use.

**Note:** The Time Switch can only switch loads which draw less than two amps. For greater currents a higher power triac should be used for CSR1. Also for high currents the triac should be mounted on a heat sink to prevent overheating. □

# Constructional Project



# AUDIO MINI-BRICKS

## Part 3


JOHN BECKER


*A planned series of audio building "bricks" that can be connected together in numerous different ways to produce all kinds of sound effects. These basic building modules are examined in detail and, with one exception, all the circuits use identical i.c.s and a master printed circuit board.*

*The circuits are all self-contained and you can select whichever circuits you want to build. All projects are suited to assembly by novice and experienced constructor alike.*

THIS month we investigate frequency doubling and explore the effects that may be obtained from an Envelope Shaper.

### FREQUENCY DOUBLING

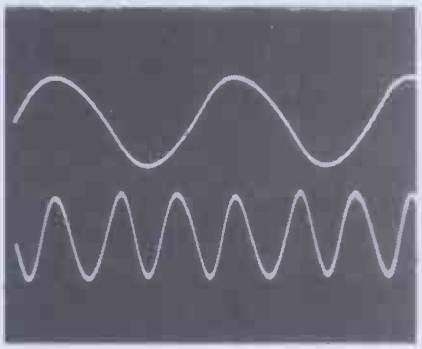
One attribute of a Ring Modulator is its ability to double an input frequency. This is done by feeding the signal to both inputs simultaneously (see Fig. 3.1). The output then contains a frequency one octave above the original, though the result is not as harmonically clean as a true octave increase would be. Frequency doubling with ring modulation is shown in photograph 8.

Considerably more complex equipment is needed to achieve a true octave increase. The effect is similar to using a fuzz unit and when used with simple musical notes is quite acceptable for stage use in a group.

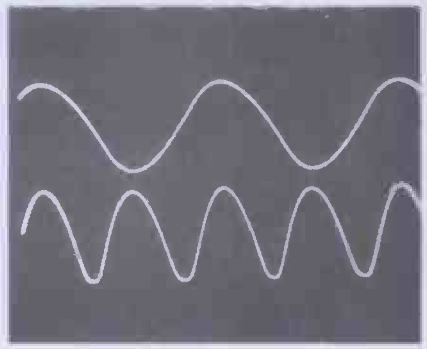
A very different way that frequency doubling can be produced is shown in Fig. 3.2. The effect is similar to the ring mod method, but its advantage is that it does not need a separate modulating oscillator.

An audio signal waveform consists of peaks and troughs. In the circuit shown, IC2a is a buffer through which the original signal passes. It is then split. Due to the action of diodes D3 and D4, the troughs and peaks respectively go to the inverting and non-inverting inputs of IC1a.

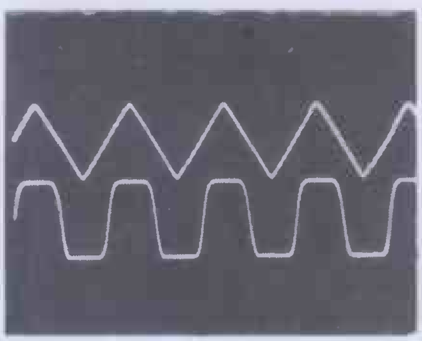
At its output the two signals are combined, but the troughs have become peaks and are slotted in between the original peaks. The number of peaks per second has thus been



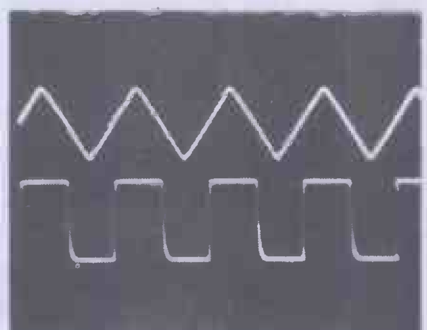
**8–Frequency doubling with Ring Mod.**



**9–Frequency doubled with circuit Fig. 3.2. Upper trace original signal.**



**10–Overloading TCA (IC1) input–note rounded corners.**



**11–Appearance of conventional overloading–sharp corners.**

*Fig. 3.2. Circuit diagram for a Freqency Doubler.*

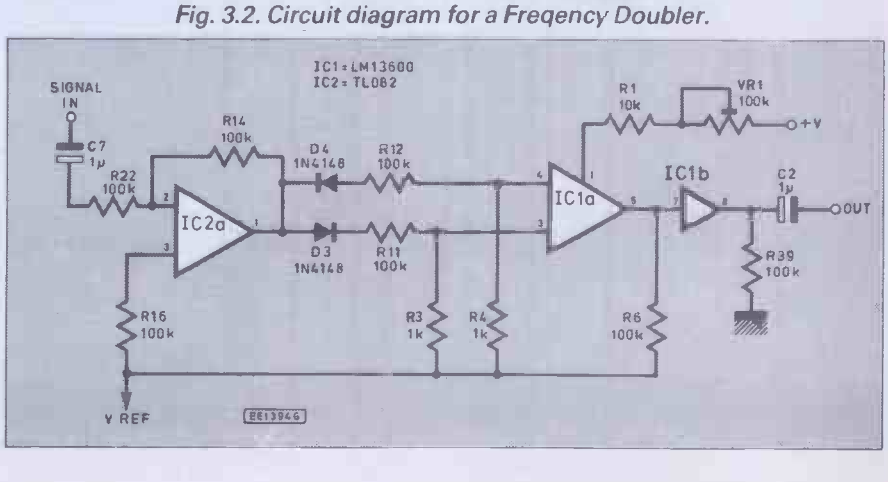
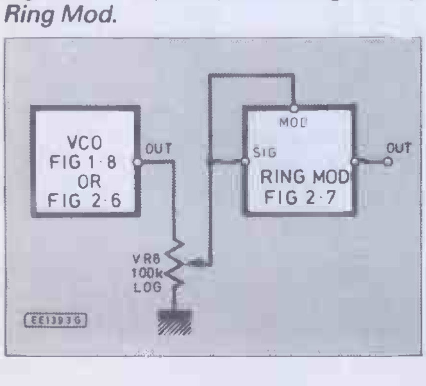



*Fig. 3.1. Frequency doubling using Ring Mod.*



doubled, and the frequency raised by an octave. The output is buffered by IC1b, and preset VR1 is used to restore the level to its original volume.

Waveform showing the frequency doubled by using circuit diagram Fig. 3.2 is shown in photograph 9. The upper trace is the original signal.

## CONSTRUCTION —PLAN D

The printed circuit board component layout for the Frequency Doubler (Plan-D) is shown in Fig. 3.3. Only half of the board is used, and the other half can be used for some of the other simple circuits from this series.

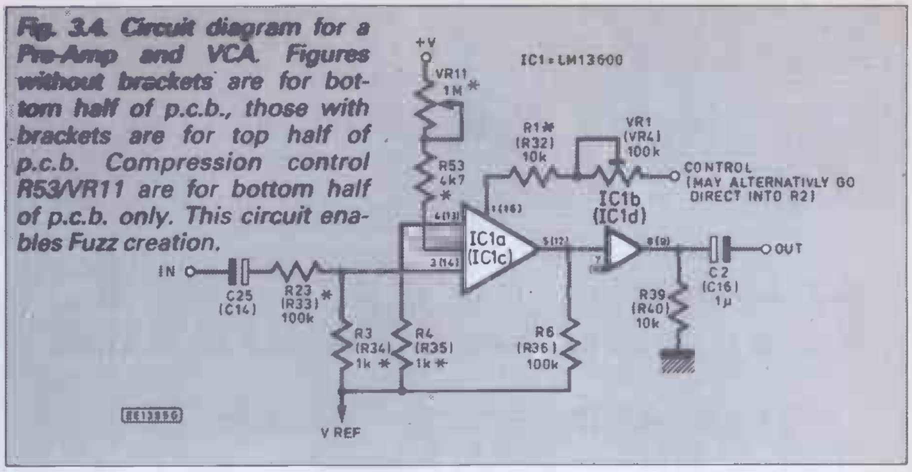



*Fig. 3.4. Circuit diagram for a Pre-Amp and VCA. Figures without brackets are for bottom half of p.c.b., those with brackets are for top half of p.c.b. Compression control R53/VR11 are for bottom half of p.c.b. only. This circuit enables Fuzz creation.*

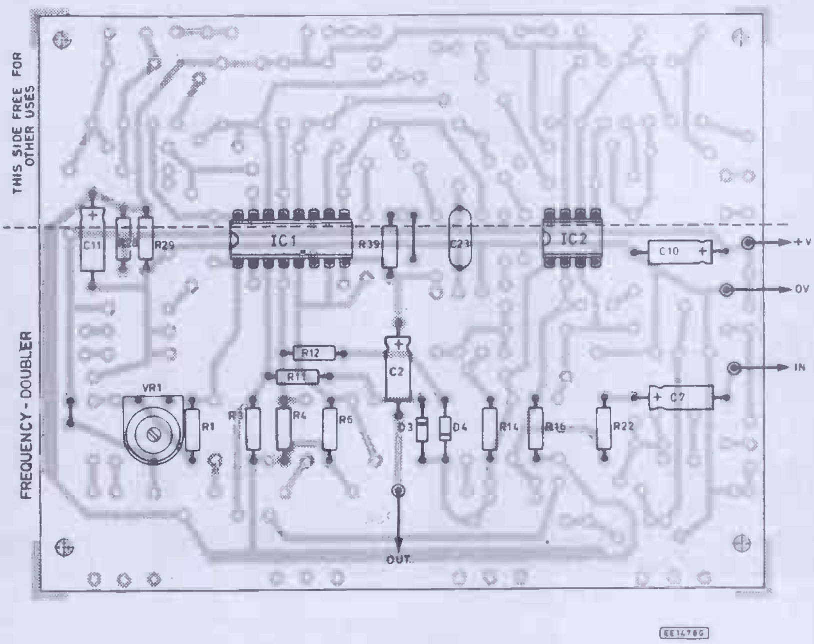
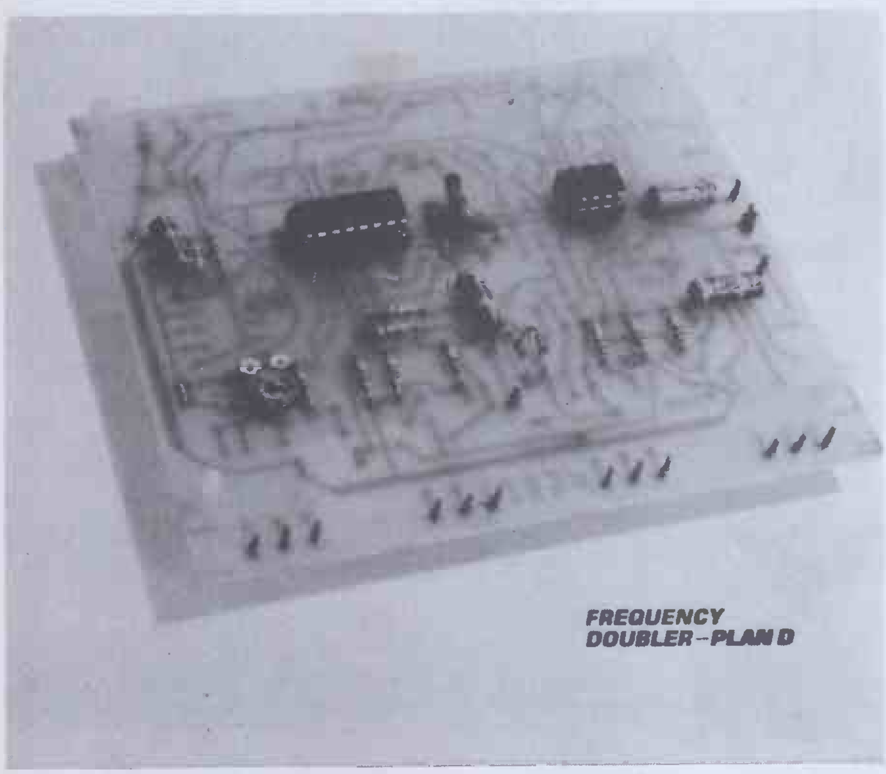



*Fig. 3.3. Printed circuit board component layout for the Frequency Doubler-Plan D. A full size copper foil master pattern appeared in Part One (June '88).*



FREQUENCY DOUBLER—PLAN D

## PRE-AMP AND VCA

One fundamental use of a TCA is in the role of a voltage controlled amplifier (VCA). Fig. 3.4 shows a typical configuration and is notated so that the circuit can be put on either side of the p.c.b. as space permits.

In its basic form, the signal level that appears at the output of IC1a depends on the current flowing into the control node and upon the value of resistor R6. In most instances when IC1a feeds directly into the buffer IC1b, a value of 100k for R6 is usually a reliable choice.

## COMPONENTS

**FREQUENCY DOUBLER (As in Fig. 3.2)**

Shop Talk
See page 490

**Resistors**

| | |
|---|---|
| R1, R39 | 10k (2 off) |
| R3, R4 | 1k (2 off) |
| R5, R11, R12 | |
| R14, R16, R22 | 100k (6 off) |
| R28, R29 | 4k7 (2 off) |

All 0.25W 5% carbon

**Potentiometers**

| | |
|---|---|
| VR1 | 100k skeleton |

**Capacitors**

| | |
|---|---|
| C2, C7, C10 | 1μ elec. 63V (3 off) |
| C11 | 22μ elec. 16V |
| C23 | 100n polyester |

**Semiconductors**

| | |
|---|---|
| D3, D4 | 1N4148 (2 off) |
| IC1 | LM13600 transconductance op. amp |
| IC2 | TL082 dual BIFET op. amp |

**Miscellaneous**

Printed circuit board, 255a; p.c.b. clips (4 off); 8-pin i.c. socket; 16-pin i.c. socket; connecting wire and solder, etc.

*Approx. cost Guidance only* **£14**

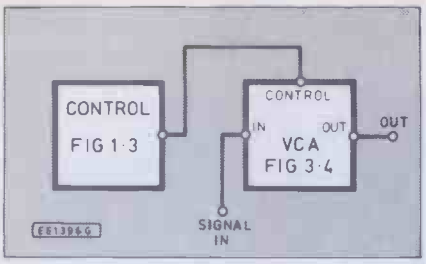



*Fig. 3.5. Control of VCA*

## TREMOLO AND WOBBLE-WAH

Tremolo can be given to a signal by controlling a VCA with a VCO, Fig. 3.6 shows an example of this, using either of the VCOs in Fig. 1.8 and Fig. 2.6 as the modulator.

Potentiometer VR12 controls the depth of modulation. With the wiper fully down, maximum modulation occurs. With the wiper at the positive end, it ceases, allowing the original signal through at full strength.

Modulated Wah-Wah is produced in a similar fashion. The modulator remains the same, but the signal goes through the VCF instead of the VCA. Some quite fascinating "bubbly" wah-wah sounds can be produced by varying the modulation rate and depth.

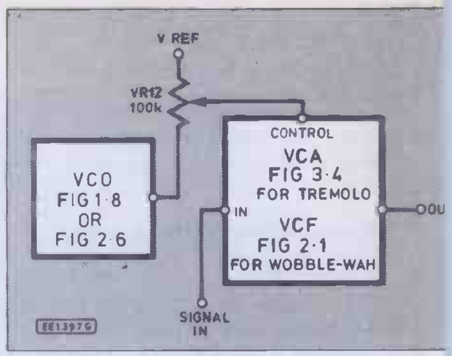



*Fig. 3.6. Arrangement for Tremolo-/Wobble-Wah.*

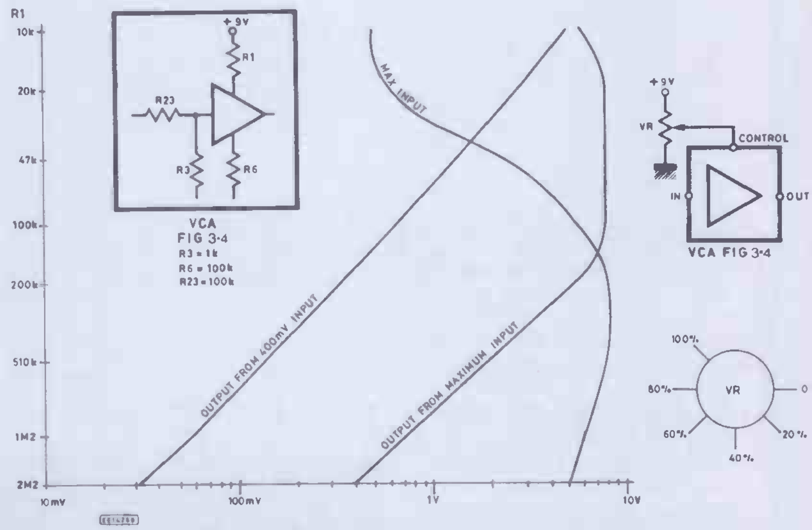
## GAIN

The gain can be doubled by doubling the value, but at the risk of a slight increase in noise levels. Reducing it will drop the gain, but increase current consumption.

The usual way to control the gain is by varying the current into the control node. Since gain occurs through the TCA it can be used as a pre-amplifier for low level signals. It can also be used as a volume control and Fig. 3.5 shows a typical method.

The relationships between the control resistance plotted against input and output levels is shown in Graph 5. As will be seen, the most linear response is obtained from an input around 400mV. For inputs higher than this, if linearity right across the control resistance scale is required either increase resistor R23 or decrease resistor R3. In the latter case resistor R4 should be decreased to the same value.

With the values shown linearity is retained for control resistances above 200k when the input is at maximum of 9V. The rather odd looking curve shows the maximum input level that can be used with different control values without distorting the output.




*Graph 5. VCA response showing the relationship between the control resistance plotted against input and output levels.*

## COMPRESSION

For high level input signals, the response can alternatively be further linearised by using the compression function of the TCA. This is controlled by applying a current via VR11 and R53 (Fig. 3.4) to the linearising input. Its use enables the ratio of resistors R23 and R3 to be reduced.

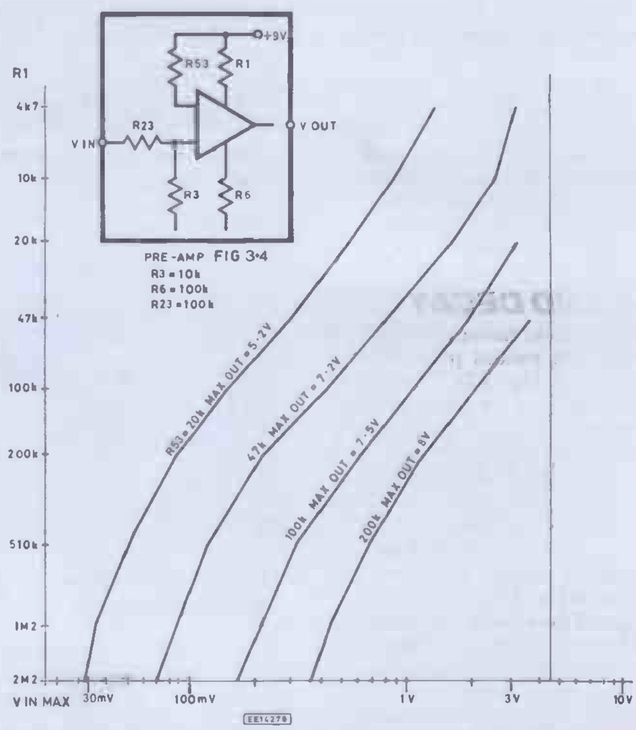
The response curves obtained before distortion occurs at the output is shown in Graph 6. A circuit for automatic signal compression will be described later.

## FUZZ

There are some instances when deliberate signal overdriving is actually required. One such case is in Fuzz production.

Often in fuzz circuits the effect of overdriving a signal results in waveform shapes somewhat squarish in appearance. These can sound rather harsh. Overdriving a TCA by overloading its input produces a smoother fuzz effect. Although clipping occurs, it is tapered and the edges of the waveform are smoothed out. The effect of overloading the TCA input (note rounded corners) is shown in photograph 10 and the effect of conventional overloading (sharp corners) is depicted in photograph 11.

Additionally, as the signal strength decreases, the clipping effect reduces so that the fuzz signal does not just cut straight out in an edgy fashion as with some simple units. For deliberate fuzz creation, resistors R3 and R4 can be increased, to 10k for example, and the compression control VR11 used to set the level at which clippings starts.




*Graph 6. Pre-amp response curves obtained before distortion occurs at the output. Effect of R1 and R53 upon compression with maximum input before distortion.*

## ENVELOPE SHAPER

From the principle of changing amplitude levels with a varying voltage, it is a small step to produce an Envelope Shaper. The term envelope shaper refers to the apparent shape of the overall signal level when viewed on an oscilloscope or plotted on a graph. A waveform of a reverberation envelope from a pulsed input is shown in photograph 12.

It is a simple term, but its implementation has a profound effect on the way that a sound is heard. Varying the way in which the basic sound starts and ends can make all the difference between it sounding like a piano or an organ, an explosion or a distant thunder roll.

Whatever, the signal source, providing the original duration is long enough, the attack and decay characteristics can be modified to change the perceived sound. This is true whether the source is a guitar, synthesiser, simple VCO, or a white noise generator.

A simple Envelope Shaper circuit diagram for setting attack and decay voltage characteristics in response to a trigger pulse is shown in Fig. 3.7. The output controls the way in which a signal passes through a VCA or VCF.

## TRIGGER LEVELS

The input trigger can come from a pulse generating source, or from the push switch S3. When the pulse goes high, the voltage level is applied to one input of IC1a. It also goes via diode D11 to the "Attack" control VR13.

As a potential divider, VR13 sets the voltage passed through diode D2 to resistor R1, so changing the current seen at the control node of IC1a. When the current rises, capacitor C1 charges. An equivalent voltage appears at the output of IC1b.

Once the pulse falls back to zero level, the input at IC1a pin 3 follows suit. Providing a current is maintained at the control node, capacitor C1 will start discharging. The rate is the responsibility of IC2a and the "Decay" control VR14.

The trigger levels are applied to the inverting input of IC2a. With a high level, the output of IC2a is low, but has no effect upon VR14 because of diode D8. When the level falls, so IC2a goes high. Via VR14, the output voltage then maintains the node current. The potentiometer setting can be adjusted to vary the rate at which capacitor C1 discharges.

## ATTACK AND DECAY

The attack and decay timings obtained on the test model with various potentiometer settings is shown in Fig. 3.7a. The timing ranges may be changed by using different values for capacitor C1, though the value shown is suitable for most applications.

The voltage level obtained from IC1b can be reduced by the "Level" control VR15 and sent direct to the control node of a VCA, VCF or VCO. Application of the Envelope Shaper module for normal VCA envelope shaping is shown in Fig. 3.8.

How a triggered siren sweep generator can be produced by controlling a VCO frequency at the same time that its output is passed through an envelope controlled VCA is illustrated in Fig. 3.9. The effect is that the siren starts off at a low level and pitch. Both rise to a maximum, and then fall again.

In Fig. 3.10 this idea is taken a stage further. One VCO is used to modulate another so that the resulting tone sweeps up and down. This is fed to a VCA under control from the Envelope Shaper. When triggered, modulating sirens like those of police cars and ambulances are created, dying away as the Envelope Shaper is released.

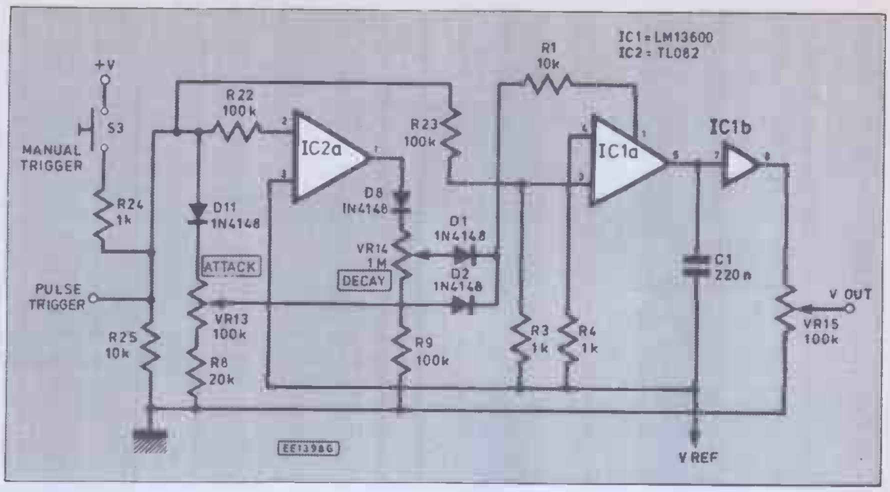



Fig. 3.7.(above). Circuit diagram for the Envelope Shaper.

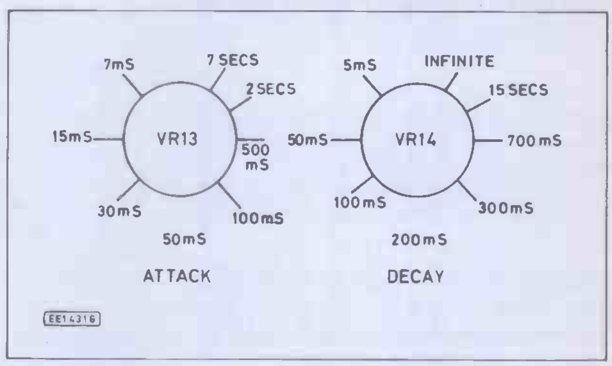
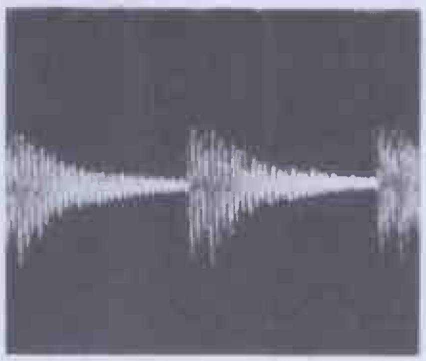



Fig. 3.7a. (right). Envelope Shaper control timings.



12–Reverberation envelope from pulsed input.

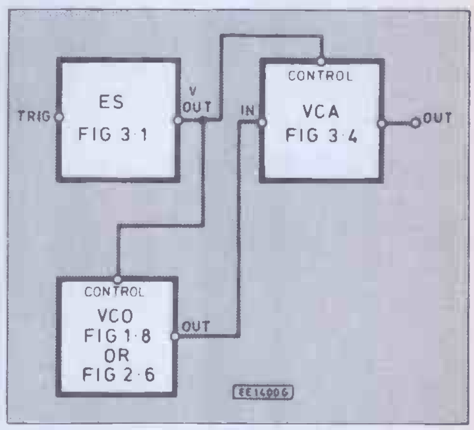



Fig. 3.9. Arrangement for producing a triggered siren sweep generator.

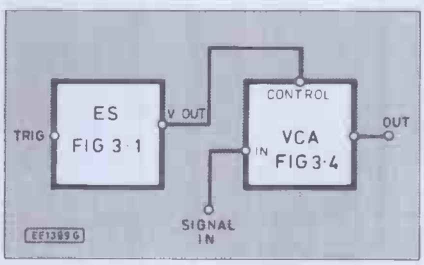
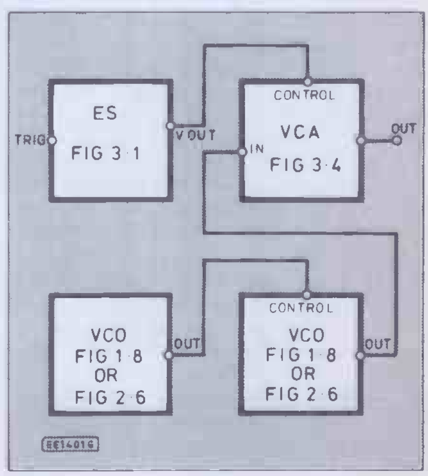



Fig. 3.8. Envelope control of VCA using the shaper (ES).

Fig. 3.10. Producing a triggered modulating siren.



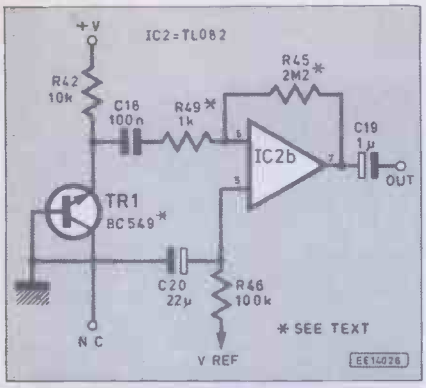
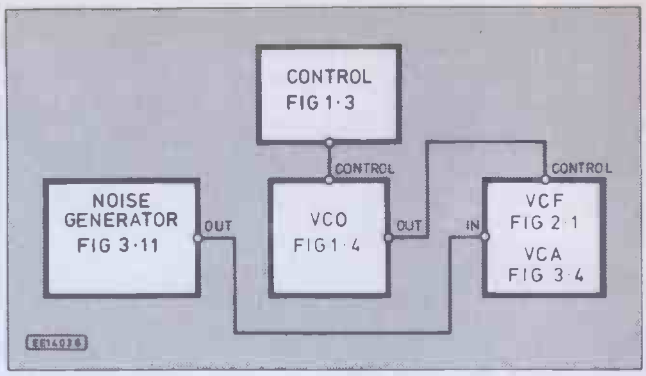
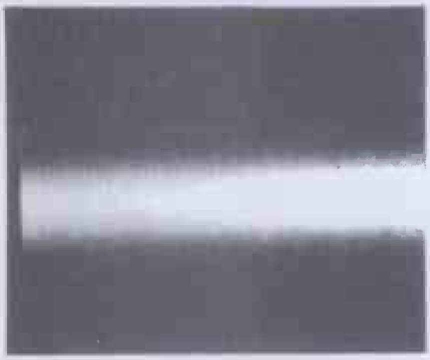



*Fig. 3.11. (left). Circuit diagram for a simple Noise Generator.*

*Fig. 3.12. (right). Producing "sound effects". With a VCA–Steam Engines etc.*



*13–Representation of "white noise".*

## NOISE GENERATOR

An envelope shaper can be used to create many different effects when the sound source comes from a white noise generator. Fig. 3.11 shows a simple noise producing circuit.

Any electronic component tries to produce noise if it can. This is due to electrons bumping around as current flows through it.

When a transistor is reversed biased as in Fig. 3.11 it protests strongly. It does not die, but produces intense white noise that contains frequencies from right across the audio spectrum and beyond. An oscilloscope trace depicting "white noise" is shown in photograph 11.

Virtually any *npn* transistor is suitable. The actual noise level produced though can vary in intensity between different types and even between individuals from the same batch run. The type shown though has been found to be pretty consistent for this sort of application.

The noise is amplified by the high gain stage around IC2b. Gain corrections can be made by varying the values of resistors R45 and R49. The method of calculating gain factors is mentioned in the earlier mixer module section.

## COMPONENTS

### ENVELOPE SHAPER –NOISE GENERATOR

**Resistors**

| | |
|---|---|
| R1, R25, R32, R40, R42 | 10k (5 off) |
| R3, R4, R24, R34, R35, R49 | 1k (6 off) |
| R8 | 20k |
| R9, R22, R23, R33, R36, R46 | 100k (6 off) |
| R28, R29 | 4k7 (2 off) |
| R45 | 2M2 |

All 0.25W 5% carbon

**Potentiometers**

| | |
|---|---|
| VR4 | 100k skeleton |
| VR13, VR15 | 100k mono rotary (2 off) |
| VR14 | 1M mono rotary |

**Capacitors**

| | |
|---|---|
| C1 | 220n polyester |
| C10, C14, C16, C19 | 1µ elec. 63V (4 off) |
| C11, C20 | 22µ elec. 16V (2 off) |
| C18, C23 | 100n polyester (2 off) |

**Semiconductors**

| | |
|---|---|
| D1, D2, D8, D11 | 1N4148 signal diode (4 off) |
| TR1 | BC549 *npn* silicon |
| IC1 | LM13600 transconductance op. amp |
| IC2 | TL082 dual BIFET op. amp |

**Miscellaneous**

Printed circuit board, 255A; p.c.b. clips (4 off); S3 push-to-make switch; 8 pin i.c. socket; 16-pin i.c. socket; knobs (3 off); connecting wire; solder etc.

Approx. cost Guidance only **£16**

Shop Talk

**ENVELOPE SHAPER, VCA AND NOISE GENERATOR**

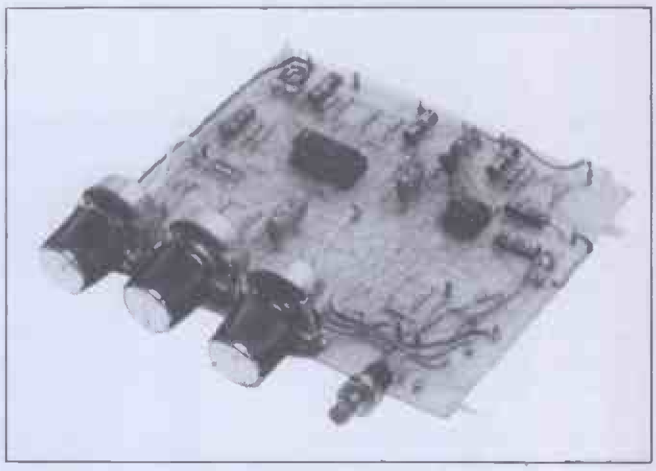
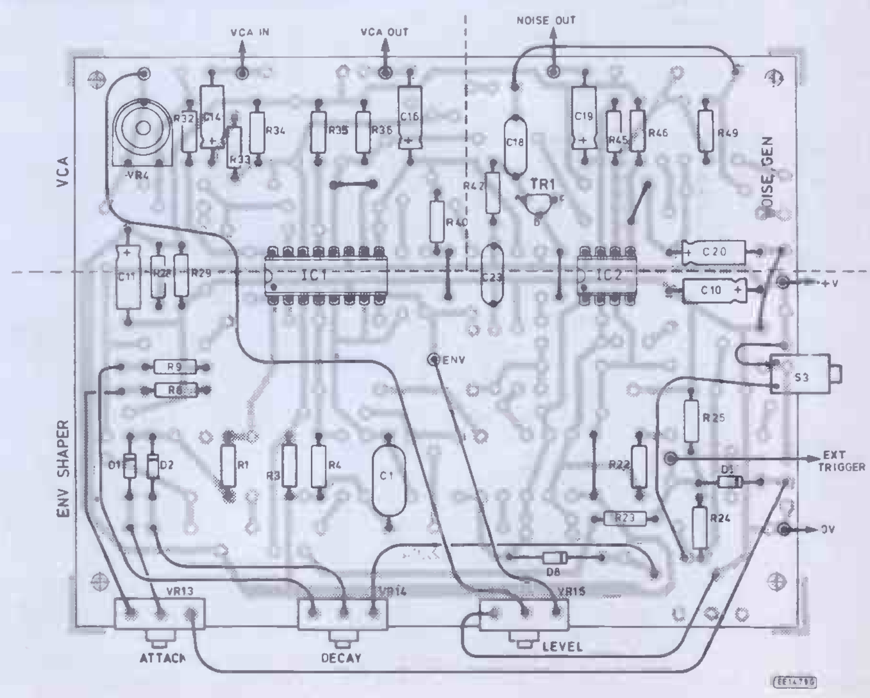


*Fig. 3.15 (below). Component layout for the Envelope Shaper, VCA and Noise Generator board–Plan E.*



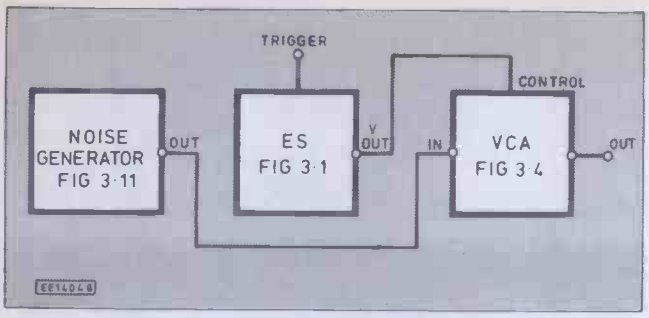



*Fig. 3.13. Arrangement for producing snare drums, cymbals, gun shot effects.*

## SOUND EFFECTS

The noise output can go to either a VCA or a VCF, as shown in Fig. 3.12 . When used with a VCF, the selected noise frequency bands are modified in response to the control signals from a modulating VCO. With a slow modulation rate, sounds like wind, rain and surf can be created. With a VCA instead of a VCF, the "chuff-chuff" sound of steam engines occurs.

The simpler configuration in Fig. 3.13 can be used as a drum. cymbal or gun shot generator, depending on the "attack" and "decay" rates set for the Envelope Shaper. This is an instance when a computer can be used to initiate the triggering, as in Fig. 3.14.

## COMPUTER TRIGGERING

The normal output level from a computer Port will be no more than 5V. It is preferable though for the trigger pulse to be as high as the Envelope Shaper will permit. With a 9V power supply, a 9V trigger level is the optimum. By using IC2a as a comparator, the computer output can be raised to close to this.

A threshold trigger level is set by resistors R15 and R21. This is roughly about 1V. When the computer data level crosses this point, the comparator changes state so producing a level suitable for triggering the Envelope Shaper.

Varying the value of resistor R21 can change the trip point if desired. Do not reduce resistor R15 as this could unnecessarily load the voltage reference line. The computer pulse duration and timing is readily varied under program control.

## CONSTRUCTION —PLAN E

The printed circuit board component layout for the Envelope Shaper, VCA and Noise Generator is shown in Fig. 3.15.(Plan E). The full size copper foil master pattern was published in Part One (June '88).

**Next Month: Pulse Generator, Voice Operated Fader, Autowah and Compressor.**

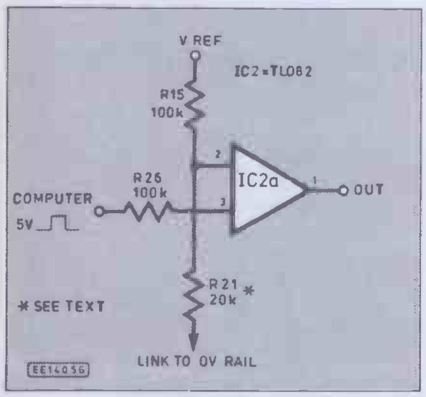
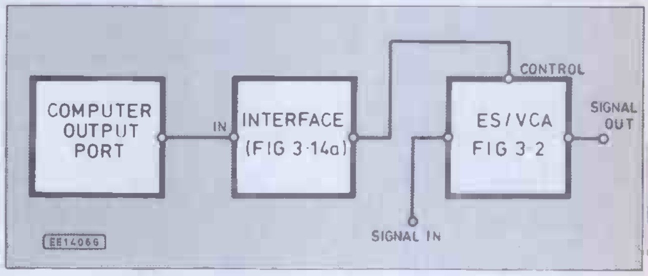
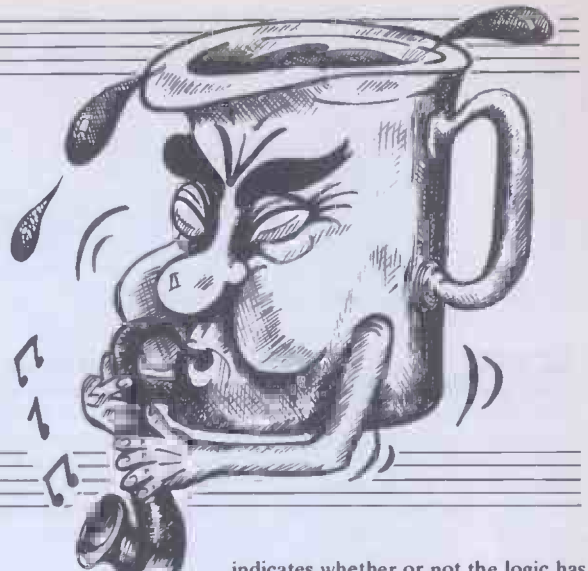



*Fig. 3.14. (a) Interface circuit for control by computer pulse and (b) block diagram for connecting the ES/VCA to allow computer control.*



Constructional Project

# TEA-TUNE



## C. WALKER

*You don't have to be a Chimp to enjoy a good cup of tea.*

Many of us must have been in the situation where a well-deserved cup of tea or coffee, which has been too hot to drink immediately, has been allowed to go cold because the owner has become preoccupied in electronics construction or some other engrossing pastime!

A quick look around shows that there is no commercially available device to alleviate this problem and it therefore seemed a good application for a little electronics design. One of the benefits of electronics as a hobby is that it gives one the opportunity of owning a custom-designed gadget that nobody else could possibly have.

The Tea-Tune is designed to hang on the side of the cup (measuring only 76×50×27mm) where it monitors the drink until the temperature falls below a preset level, upon which it loudly plays a medley of popular tunes. Of course, the device has other applications; being pocket-sized it can be used to monitor and signal a fall in temperature in almost any liquid (fish tanks, photographic processing etc.) or even ambient air temperature, e.g. it could be used as a personal temperature monitor for the elderly—warning of a fall in room temperature below a "safe" level, or as an ice warning etc.

### DESIGN CONSIDERATIONS

In order to be practical the unit must be pocket-sized, reasonably lightweight and easy to use. The thought of a "main unit" and "sensor connected by trailing leads" is cumbersome and awkward, so the Tea-Tune has an attached sensor and the whole unit hangs on the side of the cup without adversely affecting its stability. A low profile on-off switch has been chosen to reduce the possibility of accidental switch-on in a pocket.

The block diagram of the Tea-Tune is shown in Fig. 1. The temperature sensor is a thermistor, used to convert the drink temperature into an electrical voltage, $V_2$. This voltage is compared with a preset reference voltage, $V_1$, and the comparator output is "high" if $V_2 > V_1$, otherwise the output is "low".

The control logic is preset to ensure that the musical buzzer does not sound until the temperature of the sensor has initially exceeded the preset level, and *then* dropped back below it. This is necessary otherwise the buzzer would sound as soon as the device was switched on and continue until the sensor was placed in the hot drink. An l.e.d. indicates whether or not the logic has triggered, i.e. whether the drink is sufficiently hot to warrant monitoring.

### CIRCUIT DESCRIPTION

The complete circuit diagram of the Tea-Tune is shown in Fig. 2. The glass-bead, negative temperature coefficient, thermistor R1 is immersed in fluid, and along with resistor R2 forms a potential divider so that the voltage at the non-inverting input (pin 3) of the voltage comparator, IC1, depends on the temperature of R1. The resistance of R1 decreases with increasing temperature so the voltage at pin 3 falls as the temperature rises.

The reference voltage, derived from preset potentiometer VR1, resistors R3 and R4, is fed to the inverting input, pin 2. As long as pin 3 is at a higher voltage than pin 2, the output of the comparator (pin 1) will be "high" (9V).

As the temperature of R1 increases, the voltage at pin 3 drops until it is less than the voltage at pin 2. Pin 1 then goes "low" (0v). Capacitor C1 helps to remove noise from the thermistor signal whilst C3 stabilises the output from IC1.

The LM392 contains a voltage comparator and op-amp in one package, and has been chosen because of the voltage comparator's ability to drive CMOS logic. The outputs from most op-amps only swing to within about 2V of the supply voltage and this could not guarantee that IC2 was driven properly.

Using the given values for resistors R1 to R4 and preset VR1, the threshold temperature (i.e. the temperature at which the output from IC1 changes state) can be adjusted over a range of about 42°C to 90°C. Constructors wishing to use the device over other temperature ranges may be interested to know that the resistance (in kilohms) of the GL16 thermistor at a temperature 'T' Kelvin (Kelvin=°C+273) is:

$$R_T = 1000 \times e^{\left(\frac{4850}{T} - \frac{4850}{293}\right)}$$

e.g. $R_T$=215k at T=50°C=323°K.

The voltage at pin 3 of IC1 is given by the potential divider formula:

$$V_2 = \frac{9 \times R_T}{(R_T + R_2)} \quad R_2 \text{ in k}\Omega,$$

Therefore, an upper and lower limit for $V_2$ can be found corresponding to the minimum

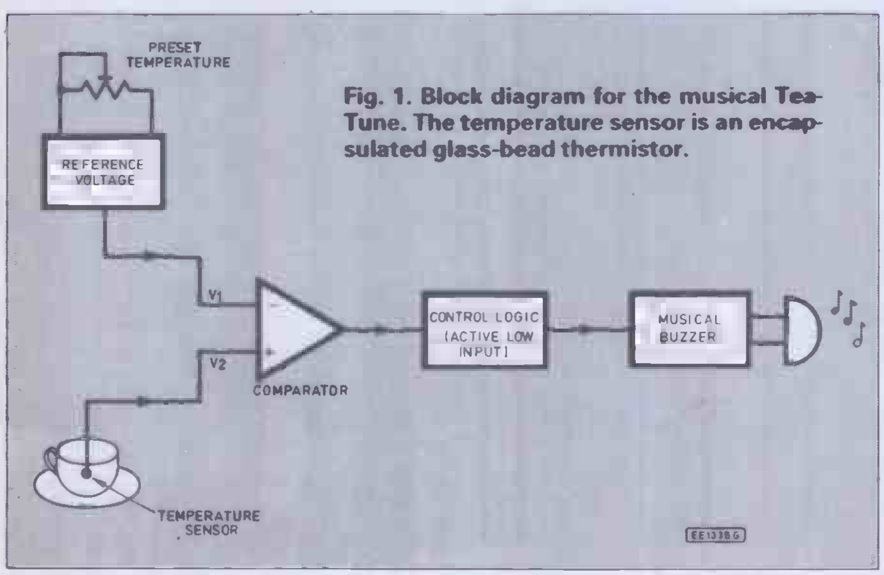



**Fig. 1. Block diagram for the musical Tea-Tune. The temperature sensor is an encapsulated glass-bead thermistor.**

and maximum temperatures, respectively, which one wishes to cover. Resistors R3 and R4 can then be calculated from:

$$R_3 = 500\left(1 - \frac{V_2max}{9}\right)$$

$$R_4 = 500 \times \frac{V_2min}{9}$$

$R_3$ and $R_4$ in kΩ.

and VR1=500−R3−R4 if we set the fact that the combined resistance of R3, R4 and VR1 is 500kΩ.

## LOGIC

The gates IC2c and IC2d form a bistable latch. When thermistor R1 exceeds the preset temperature, IC1 pin 1 goes low. This triggers the bistable whose output (pin 10) goes high. Thus, the AND gate (IC2a and IC2b) has one low and one high input and, therefore, transistor TR2 is turned off, i.e. buzzer WD1 is silent.

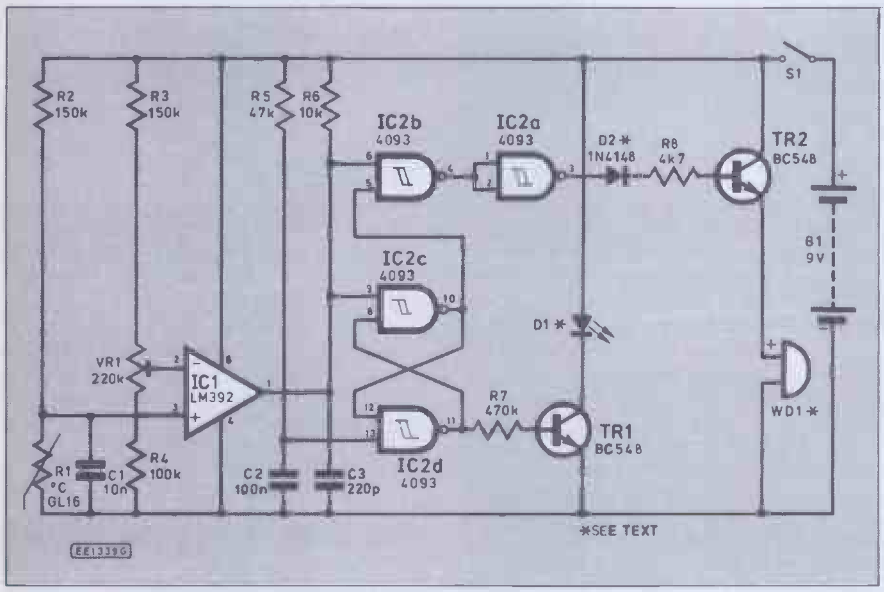



*Fig. 2. Complete circuit diagram for the Tea-Tune. The diode D1 is part of the on/off switch S1. The diode D2 is optional, see text.*

When the temperature drops again IC1 output goes high and both inputs to the AND gate IC2b/a are now high—TR2 switches on and the buzzer sounds. Resistor R5 and capacitor C2 ensure that the bistable is reset when the circuit is switched on. The NAND gates in the 4093 integrated circuit have Schmitt triggers on their inputs—these "clean up" any noisy rising or falling edges from IC1 which may occur as thermistor R1 is slowly changing temperature.

The l.e.d. (D1) is used to indicate the state of the bistable. When the circuit is switched on D1 lights, but should extinguish a few seconds after the sensor is placed in the liquid, showing that the thermistor has exceeded the preset level and the bistable has triggered. If D1 fails to extinguish then the drink temperature is below the threshold level and it should be sent back in return for a fresh cup!

Notice that resistor R7 has been chosen so that no current limiting resistor is needed in series with D1. In the prototype, D1 was an integral part of the on-off switch, S1 for aesthetic reasons.

The output from IC2a (pin 3) is used to turn on transistor TR2 which, in turn, switches-on the musical buzzer WD1. In the prototype, a silicon diode (D2) was placed in the base circuit of TR2 to improve the switching characteristics for the buzzer.

Constructors may find that it can be omitted, depending on the type of buzzer used. However, its presence has no detrimental effect on the circuit and it can be included as a matter of course, if desired.

## CONSTRUCTION

Most of the components are mounted on a single-sided printed circuit board measuring 20×45mm. This board is available from the *EE PCB Service*, code EE609. The master foil pattern is shown in Fig. 3. Construction is straightforward but as the circuit board is so small be sure to use a miniature soldering iron bit.

The printed circuit board component layout for the Tea-Tune is also shown in Fig. 3. Insert the i.c. holder sockets first followed by the resistors and the single wire link—mount all components flush with the surface

## COMPONENTS

**Resistors**
- R1 GL16 glass bead thermistor.
- R2, R3 150k (2 off)
- R4 100k
- R5 47k
- R6 10k
- R7 470k
- R8 4k7

**Potentiometer**
- VR1 220k sub-min. skeleton preset (vert.)

**Capacitors**

Shop Talk

- C1 10n
- C2 100n
- C3 220p

All miniature ceramic.

**Semiconductors**
- D1 Part of S1 or any small l.e.d.
- D2 1N4148 silicon.
- TR1, TR2 BC548 *npn* silicon (2 off);
- IC1 LM392 voltage comparator.
- IC2 4093 CMOS quad 2-input NAND Schmitt trigger

**Miscellaneous**
- S1 Miniature single-pole rocker switch, with integral l.e.d.
- WD1 Musical buzzer. AND piezo-electric Sounder in plastic carrier (see text)
- B1 9V alkaline PP3 with connecting clip.

Single-sided printed circuit board, available from *EE PCB Service*, code EE609; plastic case size 76×50×27mm; thin stranded connecting wire (10/0.1); 8-pin d.i.l. socket; 14-pin d.i.l. socket; ¼ inch diameter rigid plastic tube; ¼ inch bore flexible plastic tube; Plastic Weld liquid.

*Approx. cost Guidance only* **£20**

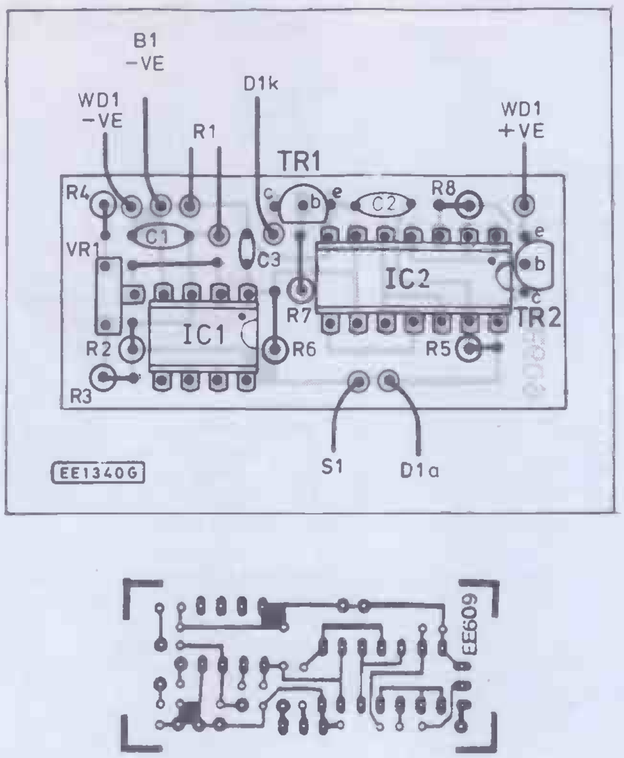



Fig. 3. Printed circuit board (not to scale) component layout and full size printed circuit copper foil master pattern.

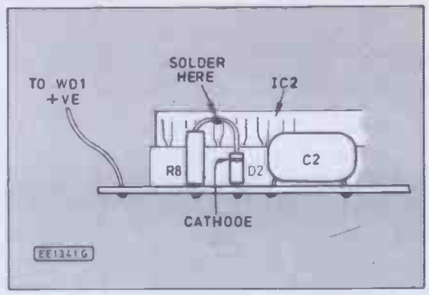



Fig. 4. Suggested method of mounting diode D2 on the circuit board.

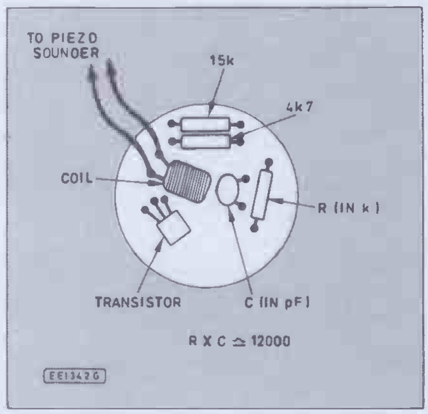



Fig. 5. Modifications to the musical buzzer circuit board.

of the board. Use only ¼W or ⅓W resistors–½W are too bulky.

If diode D2 is to be used it is easiest to insert it now–see Fig. 4. Solder the capacitors in place–C1 and C2 must be miniature ceramic types as the larger versions will not fit in the available space. Next insert both transistors and the preset potentiometer, VR1.

Finally, attach flying leads, about 10cm long, to the board for connection to D1 and switch S1 and solder the negative lead from the battery clip. Fig. 7 shows the interwiring inside the case. Inspect the board for solder bridges between tracks–these can be removed with a solder-sucker or by holding the board upside-down and applying the *clean* soldering iron bit so that the solder runs off the board and down the bit.

The plastic case used has external dimensions 76mm×50mm×27mm (although it tapers slightly) and requires three holes for WD1 sounder, the wires to thermistor R1 and the switch S1 (if a separate switch and l.e.d. is used then also drill a hole for l.e.d. D1).

## SENSOR

The thermistor is mounted in the end of a tube which is also used to hook the unit onto the cup. The tube is ¼" external diameter rigid plastic with internal diameter sufficient

*The completed Tea-Tune showing the modified buzzer in the top left of the lid.*

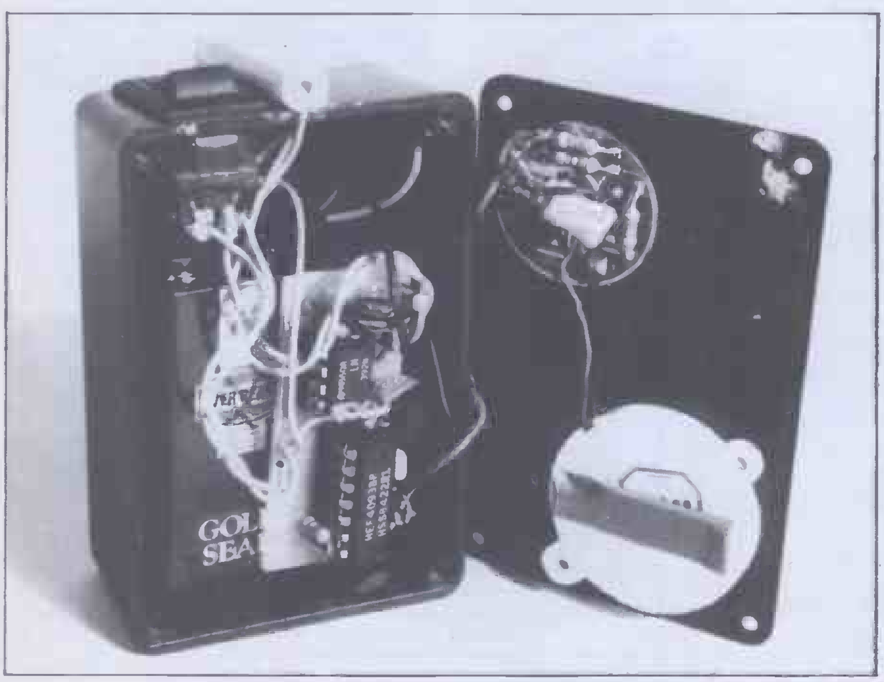
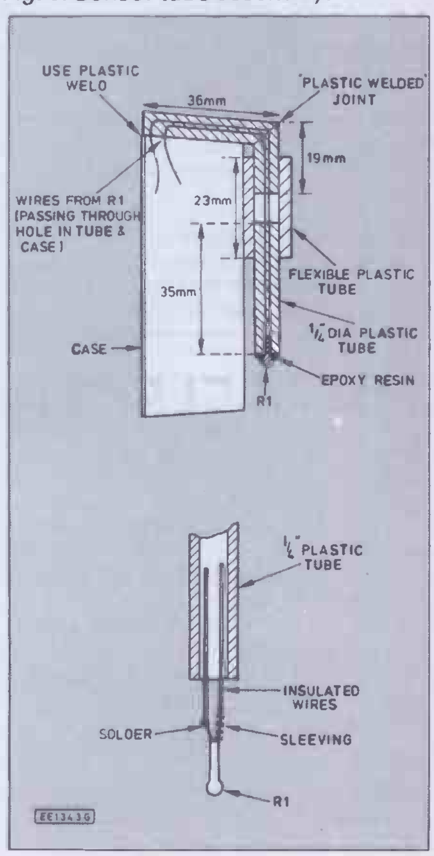


*Fig. 6. Sensor tube assembly.*



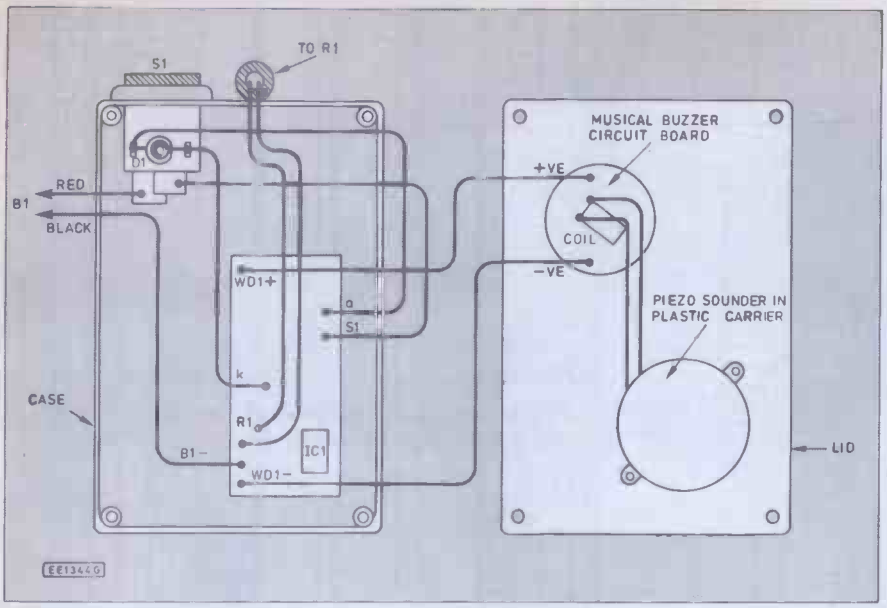



*Fig. 7. Complete interwiring details from the circuit board to the case mounted components.*

to take two thin wires to the sensor. This tube is available from a good model shop or ironmonger. Cut the tube to the lengths shown in Fig. 6.

Although the top two pieces should be cut at a 45 degree angle at the ends, this angle will have to be filed down so that the two tubes join at an angle to match the corner of the case. The strongest way to join the tube is to use "Plastic-Weld" (trichloromethane, from the model shop) which literally welds the pieces together forming a very strong joint. Be sure to thread the wires through before joining—fortunately, "Plastic-Weld" has little effect on the p.v.c. insulation.

A 23mm length of plastic tube with ¼" bore (from homebrew or aquarium shops) is used as a flexible joint in the sensor tube, allowing the device to be hooked onto tapering cups.

Drill or file a small hole on the underside of the top tube to allow the wires to enter the case. Solder the wires to the thermistor, using sleeving to ensure the two connections do not short together. Pull the thermistor into the tube by pulling the wires at the top end, leaving just the tip protruding and seal the end with clear epoxy-resin so that no liquid can enter.

The completed assembly can be attached to the top of the case using Plastic-Weld. Solder the wires from the thermistor R1 to the circuit board.

## MUSICAL BUZZER

Any miniature 9V or 12V solid state buzzer could be used for WD1 but recently available on the market is the musical buzzer which has a repertoire of seven American tunes. These buzzers measure about 28mm diameter and 19mm high and are too large to fit in the case along with the battery. Some modification is therefore required, but this proves well worth while if only for the novelty value.

Carefully prise the top off the buzzer using a screwdriver—take care as the interconnecting wires are very thin. The electronics inside drive a coil which is sometimes magnetically coupled to a metal diaphragm which acts as a sounder, and in other types of buzzer a piezo sounder is connected across the coil.

In either case, remove the circuit board *leaving the coil connected* and remove any sounder which is present. Connect the new piezo sounder across (i.e. in parallel with) the coil. Use a sounder which is mounted inside a plastic carrier as the latter acts as a resonator providing a suprisingly loud output.

After examining a number of these buzzers, it seems as though some of them run more effectively from a 9V battery than do others. All have been successfully modified by altering the values of the three resistors on the buzzer circuit board.

With reference to Fig. 5, two of the resistors lie side by side—the outer one should be a 15kΩ and the inner one 4.7kΩ. The product of the final resistor (in kΩ) and the capacitor (in pF) should be 12000 (e.g. if C=1000pF then change the last resistor to 12kΩ.

Mount the piezo sounder and circuit board on the case lid using adhesive so that they do not foul any components in the case. Connect the buzzer +ve and −ve leads to the circuit board (if your buzzer has two additional leads for "strobing" the tunes, solder these together).

## TESTING AND USE

Set the preset VR1 to midway position and switch on; D1 should light and stay lit. If it does not, check that the correct value capacitors have been inserted in the appropriate positions.

Put some hot water in a cup and hang the Tea-Tune so that the thermistor "probe" (R1) is immersed. If the temperature of the water is above about 75°C then D1 will extinguish after a few seconds. Remove the device from the cup and the buzzer should start playing a tune, and continue until switch S1 is opened. If the buzzer does not "start up" properly then including diode D2 in the circuit (see Fig. 2) should solve this.

Reset the bistable by switching off and then on again and replace the unit on the cup. Check D1 goes off, then allow the liquid to cool naturally and check the buzzer sounds satisfactorily.

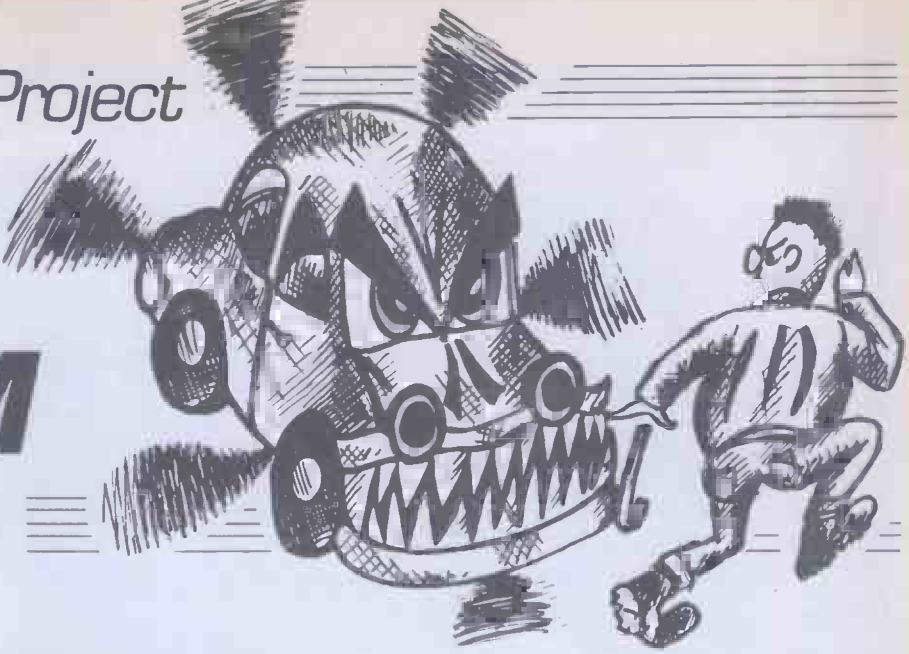
All that now remains is to adjust the preset VR1 so that the device triggers at your favourite drinking temperature; turning it clockwise will reduce this temperature. The sensor tube can be occasionally cleaned by hanging the unit over a cup of clean, hot water.

Put the kettle on! □

Constructional Project

# CAR ALARM

## I. COUGHLAN



*A simple car alarm which employs a magnetic on-off switch, thus avoiding any external fittings.*

THIS car-alarm is totally conventional in that it relies on the vehicle's own courtesy-light switches closing a circuit to detect an intruder; and when the alarm is tripped, the horn, or other device, will sound. There's nothing unusual in that. What is unusual is the method used to arm and disarm the system.

### REED SWITCH

While most systems use a conventional keyswitch, mounted on one of the car's external panels, this system uses a reed switch, mounted inside the car, just behind the windscreen. The owner carries a small magnet, fixed to his keyring, and uses it to operate the reed switch. In this way, the problems associated with keyswitches are avoided, i.e. corrosion, vandalism, and the determined thief with a large screwdriver.

The magnetically-operated approach may not seem very secure, but the system's security lies in the concealment of the reed switch—behind the tax-disc, for example—and in the fact that car thieves don't carry magnets around with them. If you're still not convinced, the alarm could be used to supplement a conventional system.

### CIRCUIT

The circuit (Fig. 2) is designed around a CMOS device, a CD4093, which is a quad 2-input NAND with Schmitt inputs. A Schmitt trigger has a decidedly non-linear transfer-function, as shown in Fig. 1. The input voltage is shown on the horizontal axis, while the output is on the vertical axis. Note that, since NAND is an inverting function, the diagram has also been inverted, to make it clearer.

When the input is at 0V, the output is at V+. As the input voltage reaches $V_2$, the output will fall quickly to 0V, and will not return to V+ until the input voltage has fallen below $V_1$. This "hysteresis" is typically one-third of V+, and since in this design V+ is 12 volts, the hysteresis is about 4 volts. The Schmitt trigger is an incredibly versatile building block, and can be used for eliminating contact-bounce, building a simple oscillator, pulse generation, and many more.

In this design, one of the four NAND gates within the 4093 is used as an oscillator,

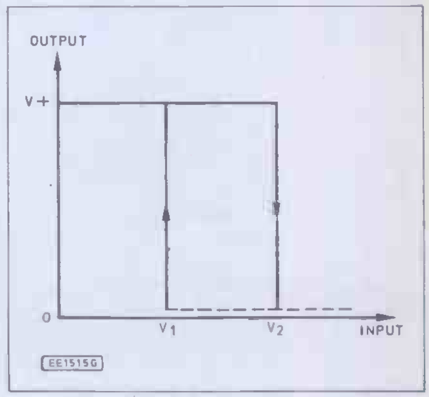



Fig. 1. Schmitt trigger action

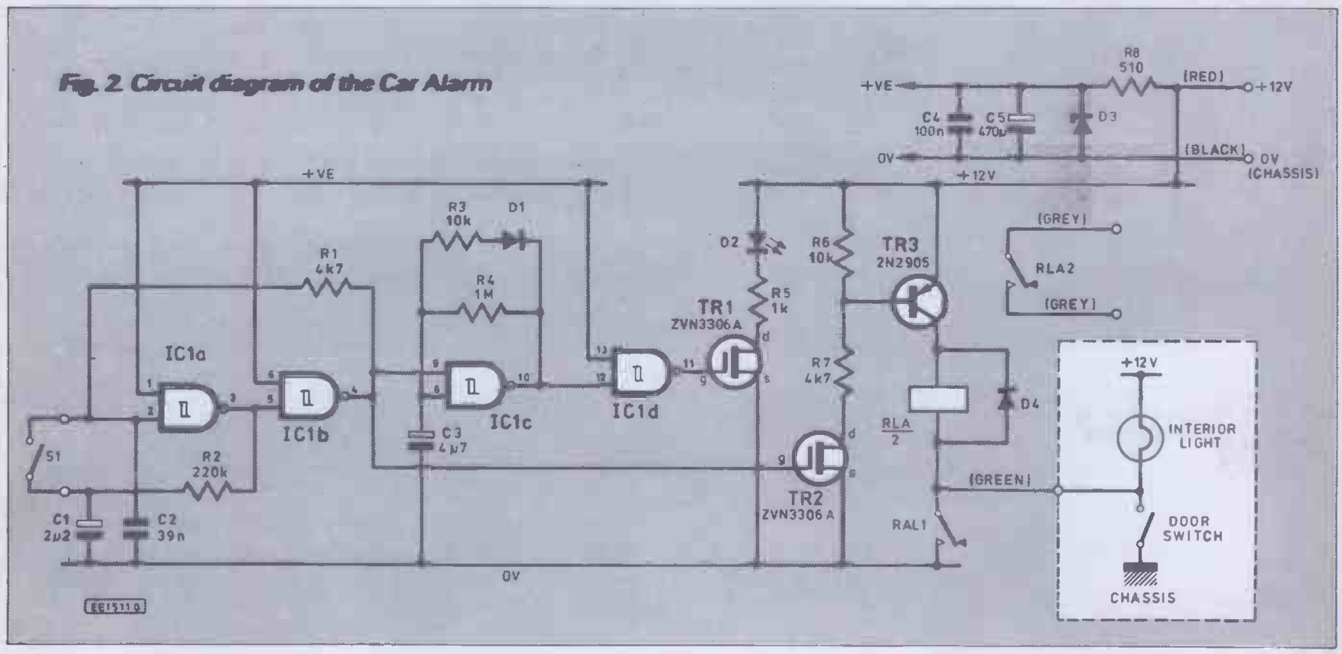



Fig. 2 Circuit diagram of the Car Alarm

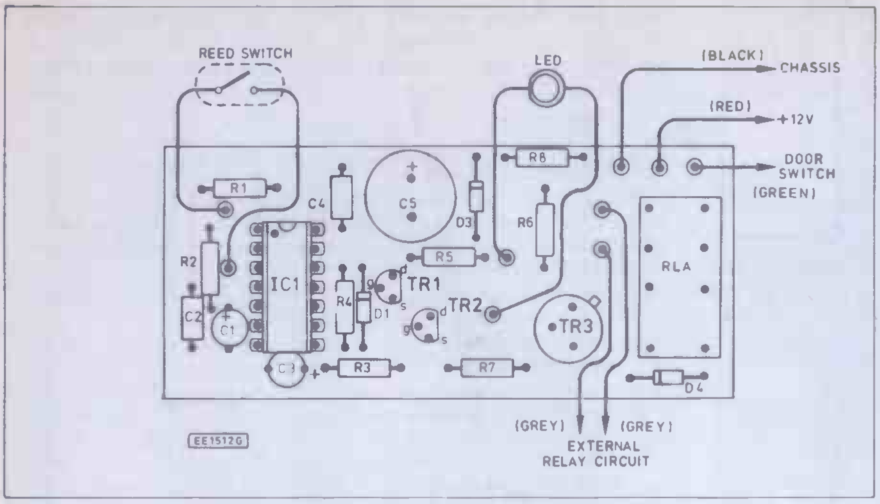
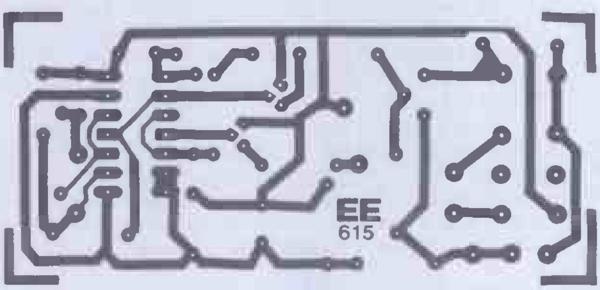



*Fig. 3. Layout of the p.c.b.*




## COMPONENTS

**Resistors**
R1 4k7
R2 220k
R3 10k
R4 1M
R5 1k
R6 10k
R7 4k7
R8 510
All ¼W carbon

Shop Talk
See page 490

**Capacitors**
C1 2μ2 Tantalum bead
C2 39n multilayer
C3 4μ7 Tantalum bead
C4 100n multi layer
C5 470μ radial elect. 25V

**Semiconductors**
TR1 ZVN3306a
TR2 ZVN3306a
TR3 2N2905
D1 1N4148
D2 1N4148
D3 15 volt ½W Zener
D4 0.2 inch red l.e.d. with clip
IC1 CD4093B

**Miscellaneous**
RLA relay 12V BT-47 type
S1 flush-mounting reed switch and operating magnet
Box; p.c.b., available from the *EE, PCB Service*, order code EE 615; insulated wire; sleeving; Veropins; grommet; fixings etc.

Approx. cost Guidance only **£11.50**

two are used as a bi-stable latch, and one as a simple inverter. Let's look at the latch first.

As is usual when considering the operation of a circuit with more than one possible state, we have to start somewhere, so we'll assume that the latch is in the "reset" state, represented by a logic 0 on pin 4 of the i.c. S1 is the reed switch, so we will further assume that the operating magnet is nowhere near the switch, and it is therefore open.

The logic 0 on pin 4 will pull pin 2 to a logic 0 via R1. This in turn will cause pin 3 to be at a logic 1. Pin 5 will also be at a logic 1, and this will maintain pin 4 at a logic 0. The circuit is therefore stable in this state, and will not change unless acted upon by some external influence. Remember that pin 3 is at a logic 1: this will charge-up C1 via R2. In other words, C1 will have a potential equivalent to a logic 1.

When the reed switch is closed, by bringing the magnet close, the positive end of C1 will be connected to pin 2, overriding the effect of R1. Now, pin 3 will be at a logic 0, pin 4 at a logic 1, and the circuit is once more stable. When the switch is opened again, R1 will maintain pin 2 at a logic 1. The logic 0 on pin 3 will this time discharge C1, so that the next time the switch is closed, pin 2 will be forced to logic 0, tripping the latch into changing states again.

Capacitor C2 serves to suppress any voltage pulses that may be present on the wiring from the reed switch, which may otherwise change the state of the latch. To summarise, then, pin 4 will toggle between a logic 1 and a logic 0 each time the reed switch is operated.

## OSCILLATOR

The oscillator is formed by IC1c and its sole purpose is to make an l.e.d. flash to indicate the status of the alarm. If the alarm is in the "disarmed" state, pin 9 will be at a logic 0, held there by the output of the latch circuit. This causes pin 10 to be at a logic 1 and the oscillator will not operate. IC1d inverts the logic 1, so TR1 is turned off, and so too is the l.e.d.

When the alarm is "armed", pin 9 will be at a logic 1, enabling the oscillator. Ignore for a moment R3 and D1. Whenever pin 10 is at a logic 1, C3 will be charged-up via R4; and when the voltage on the capacitor reaches "$V_2$", as described earlier, the Schmitt trigger will trip, causing pin 10 to go to a logic 0. This will of course discharge C3 via R4. When the voltage on the capacitor falls below "$V_1$", pin 10 will go to logic 1, and the cycle will repeat, and continue to do so as long as pin 9 is at a logic 1.

Resistor R3 and D1 serve to shorten the discharge time of C3, while leaving the charge time unaffected. The mark-space ratio of the oscillator is therefore changed from being 1:1 to a series of short pulses separated by long spaces. This has the effect of making the l.e.d. flash briefly once every second or so.

Transistor TR2 will be turned on whenever the alarm is "armed", and therefore TR3 will also be on, pulling the top end of the relay coil to +12 volts. The other end of the coil is connected to the car's courtesy-light circuit. Normally, then, the relay will be de-energised.

When a door is opened, the bottom end of the relay will be pulled to 0V, by the door switch, energising the relay. One of the relay's contacts is used to maintain current through the coil even if the door is then closed. The other contact is used to operate the car's horn, or alternatively it may be used to operate some other audible alarm, such as a siren.

Note that the relay contacts are rated at just over 1 amp, so do not attempt to drive the horn directly. If your car does not have a horn relay, then it will be necessary to fit one, and use the relay within the alarm to operate it. Once tripped, the alarm can only be reset by operating the reedswitch.

CMOS devices are quite happy to operate with a supply voltage of up to 15 volts, so no attempt has been made to regulate the car's supply. It is filtered, however, by C4, C5 and R8, and clamped to 15 volts by D3.

## CONSTRUCTION

Construction is very straightforward, but give some thought to fitting the system to your car. The prototype has everything in the one box, with the reed switch and l.e.d. side-by-side. The constructor may feel that the l.e.d. advertises the location of the reedswitch, and may prefer to mount them separately. If so, keep the reed switch close to the electronics, and mount the l.e.d. remotely. Commence construction by pressing Veropins through the board (Fig. 3) for the flying leads to connect to. Fit the resistors and capacitors to the p.c.b. followed by the i.c. socket (if used) then the relay and semiconductors.

The transistors in the prototype were mounted on bases, but these are not essential, and neither is the small heatsink clipped to TR3. The reed switch has four wires coming from the back; using a multimeter, identify the pair that close when the magnet is brought into contact, and cut back the other two. Drill the holes in the box, and fix the reed switch and l.e.d., then wire them to the p.c.b.

The alarm is now complete and ready for testing. Apply 12V to the appropriate wires, and check that the alarm can be armed and disarmed using the magnet. Using a multimeter, check that the relay contacts are open, and then, with the system armed, touch the green wire to 0V. The relay should operate

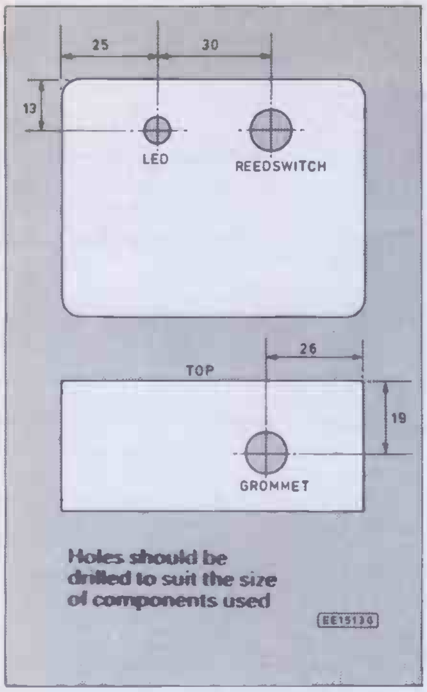



*Fig. 4. Case drilling details*

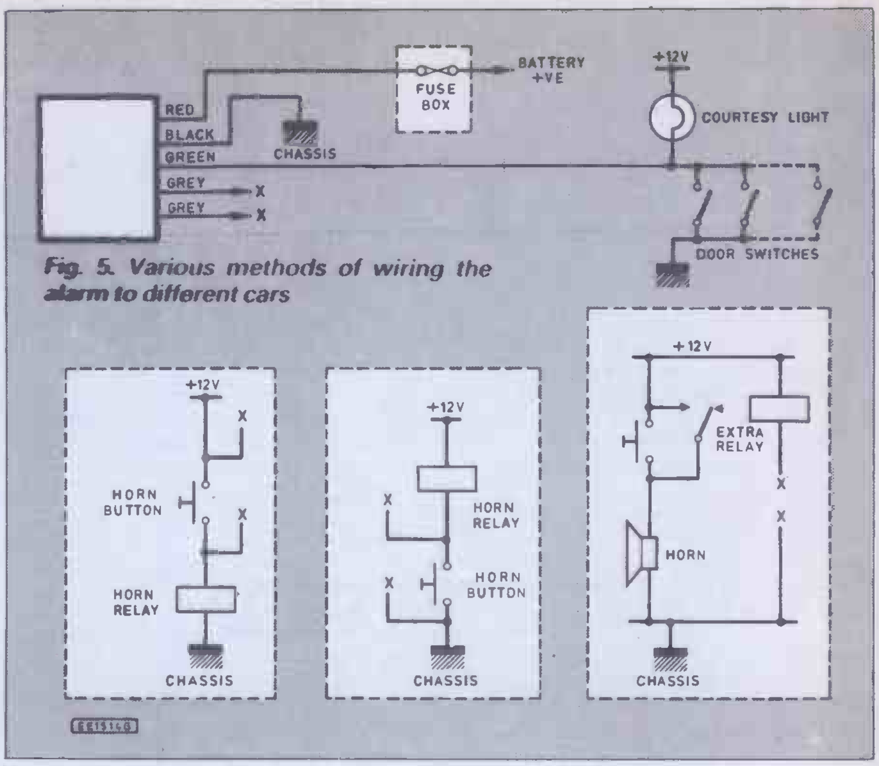



***Fig. 5. Various methods of wiring the alarm to different cars***

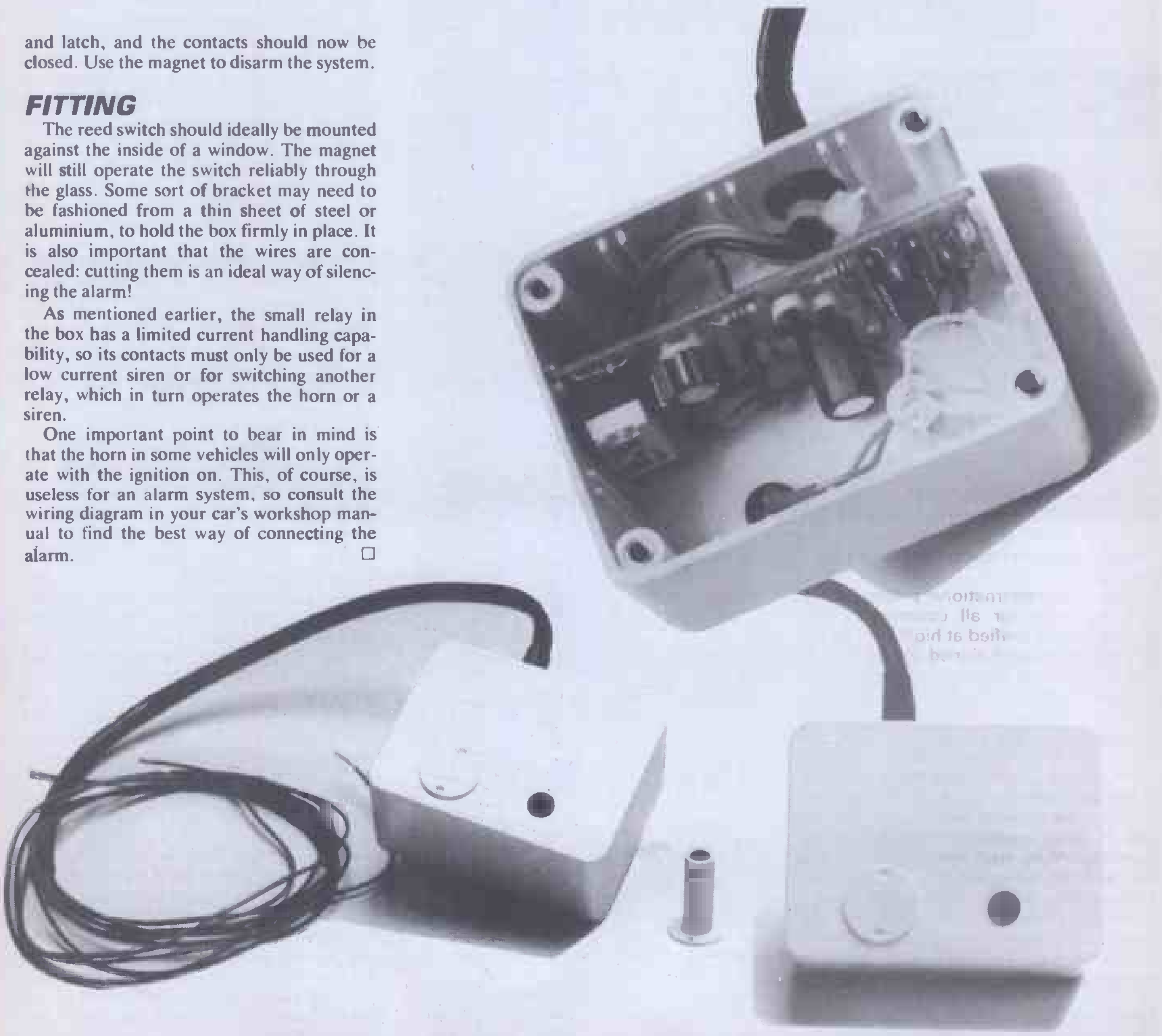
and latch, and the contacts should now be closed. Use the magnet to disarm the system.

## FITTING

The reed switch should ideally be mounted against the inside of a window. The magnet will still operate the switch reliably through the glass. Some sort of bracket may need to be fashioned from a thin sheet of steel or aluminium, to hold the box firmly in place. It is also important that the wires are concealed: cutting them is an ideal way of silencing the alarm!

As mentioned earlier, the small relay in the box has a limited current handling capability, so its contacts must only be used for a low current siren or for switching another relay, which in turn operates the horn or a siren.

One important point to bear in mind is that the horn in some vehicles will only operate with the ignition on. This, of course, is useless for an alarm system, so consult the wiring diagram in your car's workshop manual to find the best way of connecting the alarm. □



# ...REPORTING AMATEUR RADIO...

**TONY SMITH G4FAI**

**RSGB HONOURED**

HRH Prince Philip, Duke of Edinburgh, has graciously accepted the Radio Society of Great Britain's invitation to open its 75th Anniversary three-day Convention and Exhibition, open to non-members, at the Birmingham NEC on Friday 15th July.

Details of the Society's celebrations were given in our May issue, and up- to-date information can be obtained from the RSGB, Lambda House, Cranborne Road, Potters Bar, Herts EN6 3JE.

**SKITREK**

There is now more information to hand about the USSR/Canada Polar Bridge Skitrek Expedition which I mentioned last month. The expedition started out at 0731 GMT on March 3rd, composed of a group of nine Russians and four Canadians, intending to make geometrical, glacial and meteorological observations on the journey. Experiments were also to be conducted in physiology and biochemistry to determine the limits of human endurance and social isolation. The expedition's leader, Dr. Dmitri Shparo, is a radio amateur, as are several other team members.

The main Canadian base station was located at Resolute Bay, Cornwallis Island, using the amateur call-sign CI8C. This was manned by teams of volunteer amateur operators in two-week shifts and a Soviet amateur was due to join the Canadians at CI8C during the last six weeks of the expedition.

A Soviet and a Canadian amateur were operating EXOCR, the Soviet base station at Sridney Island, while a similar pair operated 4KOD a second Soviet base station on North Pole 28, the floating Russian scientific base near the Pole. Amateurs around the world followed the progress of the expedition simply by listening in to its daily signals and to the "instant position reports" from the satellite digitalker.

This unique international project, using amateur radio for all communications purposes, was ratified at high level by an historic agreement signed jointly by senior officials of the Soviet Ministry of Communications, the Canadian Department of Communications, the Chairman of the Radio Sports Federation of the USSR and the President of the Canadian Radio Relay League. Incidentally, the first of the Russian floating stations, back in 1937/8. had a radio operator who was also a radio amateur. This was Ernst Krenkel, RAEM, who operated from the pole with the call-sign UPOL, and became perhaps the best-known Soviet amateur of all time. Regular readers of *Reporting Amateur Radio* may recall that I mentioned Krenkel's autobiography, *RAEM is my call-sign*, in the May 1986 column.

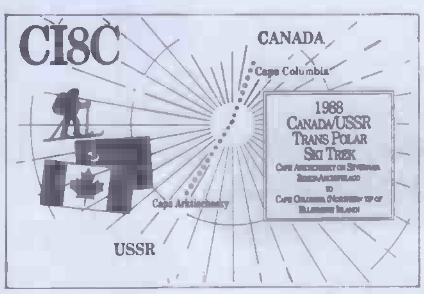
**WORLDWIDE BEACON NET**

If you monitor 14.100MHz, any time of day or night, you should hear one or more of nine worldwide beacon stations providing useful information for amateurs about the prevailing propagation conditions on the 20 metre band. Within a space of ten minutes it is possible to assess what radio paths are currently open to, and the possibility of satisfactory communication with, other countries on that particular band. These beacons are provided by the Northern California DX Foundation, NCDXF, a registered charity founded in the USA in 1972 to assist worthwhile international amateur radio and scientific projects with funding and/or equipment.

The beacons come "on-air" sequentially at one minute intervals. Each transmission lasts 58 seconds. This contains the call-sign of the station in Morse code, for identificaiton purposes, and four nine-second dashes each one-tenth of the power of the previous dash. The first is 100 watts, and the subsequent dashes are 10, 1 and 0.1 watts. These dashes provide an indication of the level of power required by the receiving station to achieve two-way communication with that part of the world where the beacon is situated. The beacons also tell a short-wave listener if the band is sufficiently "open" for a satisfactory listening session.

All the beacons use Kenwood TS-130 amateur radio transmitters with fixed frequency control. A quartz clock controls the timing of each transmission and the variations in power levels are controlled by a microprocessor. The sequence of transmissions, station by station, starts at New York on the hour and circles the world every ten minutes.

Apart from monitoring conditions, the beacons provide a time/frequency check; a means of comparing the performance of antennas or receivers; and an opportunity for amateurs to carry out propagation studies, e.g. comparing actual conditions with published forecasts or known sunspot conditions. In 1983, radio amateurs around the world were asked to continuously monitor the beacons for an hour before, and an hour after, a total solar eclipse in the area of Indonesia. Reports of radio reception from different global areas were then sent to the San Francisco State University to assist in assessing the effect of the eclipse on radio propagation conditions.




QSL card for contacts with station CI8C.

Details of the beacons are as follows:

| Time | Station | Location |
|---|---|---|
| 0000 | 4U1UN/B | United Nations, N.Y. |
| 0001 | W6WX/B | Stanford University, California. |
| 0002 | KH60/B | Honolulu. |
| 0003 | JA21GY | Tokyo. |
| 0004 | 4X6TU/B | Tel Aviv University. |
| 0005 | 0H2/B | Helsinki Tech. University. |
| 0006 | CT3B | Madeira. |
| 0007 | ZS6DN/B | Transvaal, South Africa. |
| 0008 | LU4AA | Argentina. |

**OTHER FUNCTIONS**

Apart from providing the beacon system, NCDXF gives financial assistance to DXpeditions, i.e. groups of amateurs who take radio equipment to isolated parts of the world where there is normally no radio activity. Such expeditions are usually very expensive to mount and attract thousands of contacts over the air, all requiring QSL cards to be printed and despatched afterwards. Without the help of the NCDXF many of the regular DXpeditions which set out each year could not take place.

Invested funds and contributions from members provide an income in excess of $10,000 a year to spend on Foundation supported or assisted DX and scientific activities. Everyone in the governing body and the support groups is an active amateur. All give their services free of charge and no officer, adviser or consultant receives salary or compensaton in any form. I hope to report on other activities of this remarkable organisation from time to time in the future.

**ISWL '87**

The International Short Wave League was for many years before its demise a popular organisaton for short-wave listeners. It was reformed last year as ISWL '87 with many of the original founder members still involved in it.

The league offers its members SWL contests and awards. Its monthly journal, *Monitor*, contains information and articles on broadcast as well as amateur band listening. Members are allocated an individual identification number consisting of their country prefix followed by a series of numbers, and can use the League's QSL bureau to handle their QSL cards.

ISWL nets are held by licensed members on the 80 metre band, on single sideband, and can be heard on Tuesdays at 7 p.m. (3.700MHz) and Saturdays at 10 a.m. (3.685MHz). If you have s.s.b. capability on your receiver you are invited to listen to these nets. Further details about ISWL '87 are available from Mr. J. May, 10 Clyde Crescent, Wharton, Winsford, Cheshire. CW7 3LA.

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**The books listed have been selected as being of special interest to everyone involved in electronics and computing. They are supplied by mail order direct to your door. Full ordering details are given on the last book page.**



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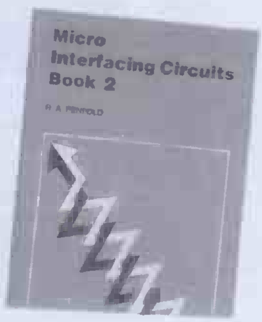


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**Michael Tooley BA**
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Specifically, this book aims to provide the reader with a unique collection of practical working circuits together with supporting information so that circuits can be produced in the shortest possible time and without recourse to theoretical texts.
Furthermore, information has been included so that the circuits can readily be modified and extended by readers to meet their own individual needs. Related circuits have been grouped together and cross-referenced within the text (and also in the index) so that readers are aware of which circuits can be readily connected together to form more complex systems. As far as possible, a common range of supply voltages, signal levels and impedances has been adopted.
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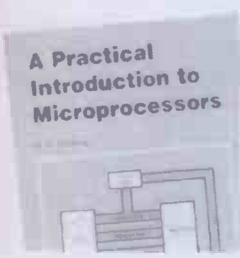



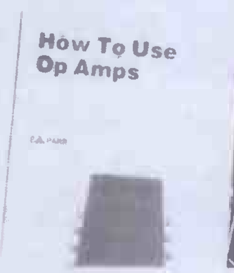


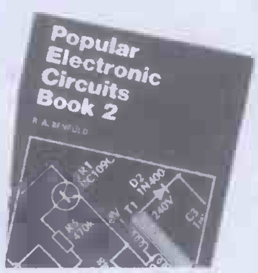


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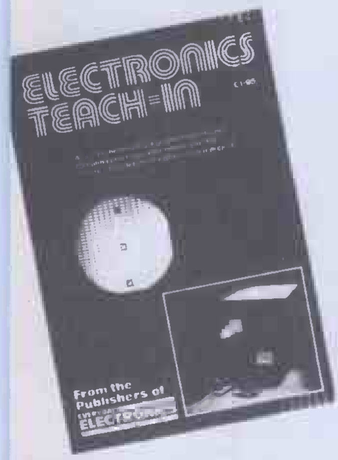


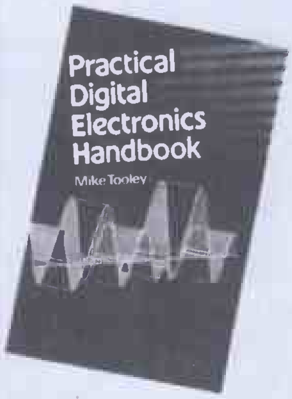


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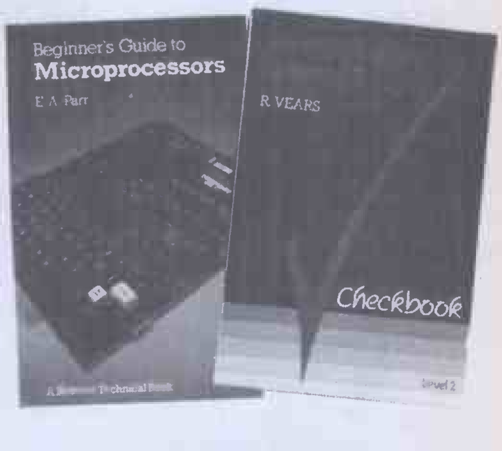


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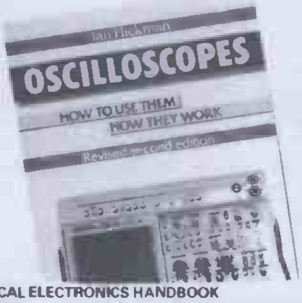


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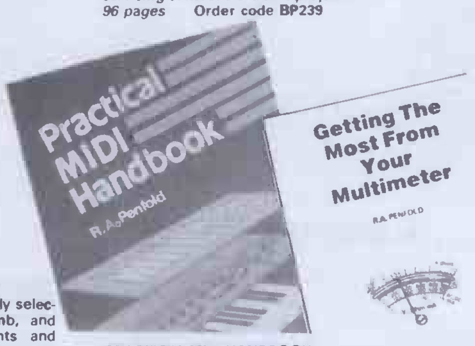


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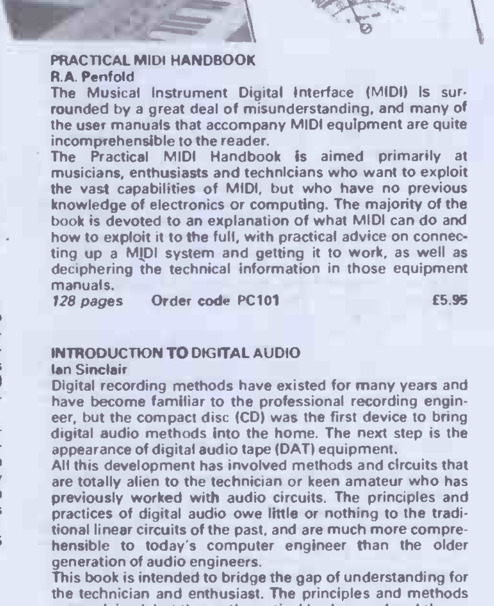


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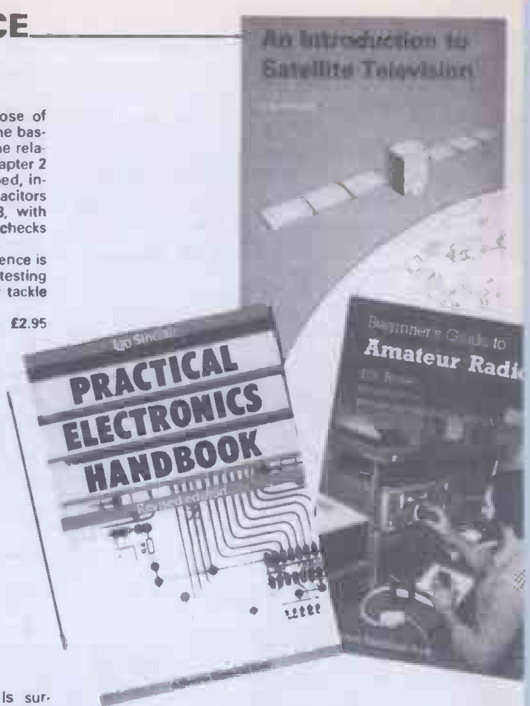


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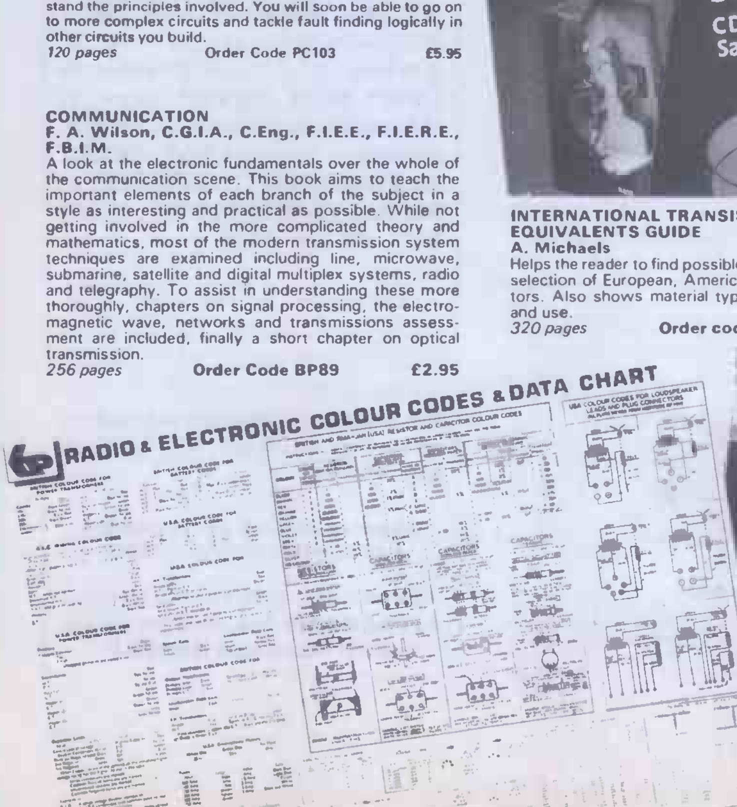


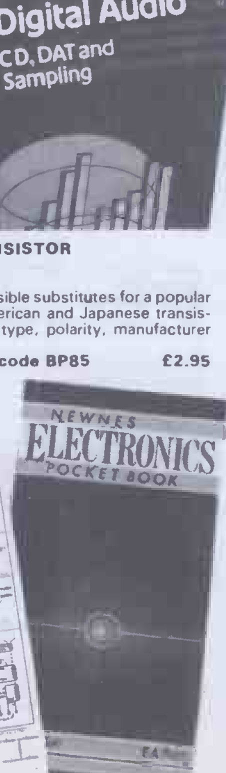


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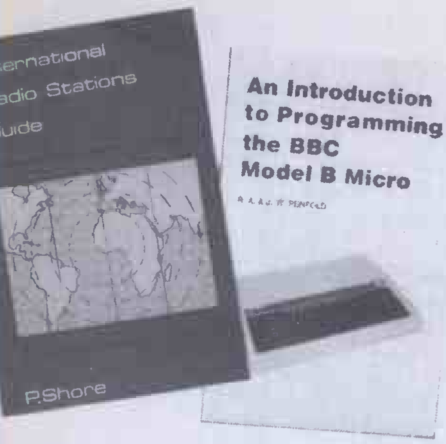
## RADIO/TELEVISION

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No previous knowledge of microprocessors or machine code is assumed. Topics covered are: assembly language and assemblers, the register set and memory, binary and hexadecimal numbering systems, addressing modes and the instruction set, and also mixing machine code with BASIC. Some simple programming examples are given for 6502-based home computers like the VIC-20, ORIC-1/Atmos, Electron, BCC and also the Commodore 64.
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# exploring electronics

OWEN BISHOP

This series is designed to explain the workings of electronic components and circuits by involving the reader in experimenting with them. There will not be masses of theory or formulae but straightforward explanations and circuits to build and experiment with.

## Part 26—More uses for diodes

THIS month we have two more applications for that simplest of components, the semiconductor diode. As in last month's investigations we need a circuit that generates an alternating voltage.

For this purpose we use the 555 timer i.c. connected as an astable multivibrator (April 1987). With the values of resistors R3, R4 and capacitor C1 shown in Fig. 26.1, the frequency is about 10kHz. The explanation of this is given in the previous part.

In the description all voltages are measured with reference to the mid-voltage point, the junction of resistors R1 and R2. Thus the positive and negative terminal of the 6V battery are referred to as −3V and +3V.

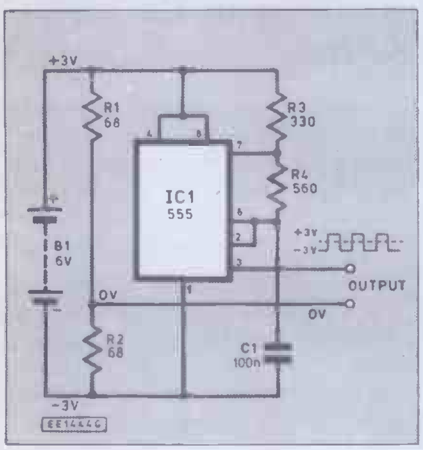



*Fig. 26.1. Pulse generator and potential divider circuit diagram.*

### DIODE-CAPACITOR LADDER

If you look carefully at the circuit diagram for the Diode/Capacitor Ladder in Fig. 26.2, you will see that this ladder is really a series of diode pumps connected one above the other. Capacitor C2 and diodes D3, D4 and C4 make up a diode pump like the one shown in Fig. 25.4 of last month's article.

An alternating voltage applied to capacitor C2 pumps electrical charge through diode D2 to plate C of capacitor C3. This action causes the potential across C3 to rise. The potential across C3 also falls as current is drawn by external circuits or your voltmeter.

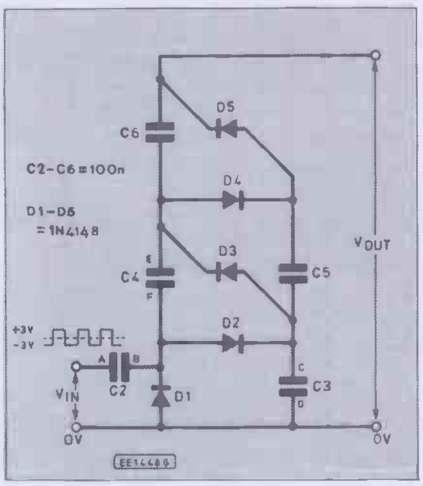



*Fig. 26.2. Circuit diagram for the Diode-/Capacitor Ladder.*

This rise and fall of potential across capacitor C3 pumps a charge through diode D3, charging plate E of capacitor C4. But the potential of plate F of C4 is already being raised owing to the fact that it is connected to plate B of capacitor C2. Thus the rise in potential of plate E is the rise in plate C *plus* the rise in plate B. This effect continues all the way up the ladder.

In essence we have a stack of diode pumps each raising the potential of the ones above, like acrobats climbing onto each other's shoulders. The potential at the output can reach several times the supply voltage. The diode-capacitor ladder acts as a *voltage multiplier*.

#### CONSTRUCTION

To demonstrate this effect connect up the two circuits as shown in Fig. 26.3. Make sure that all diodes are the right way round, as indicated by the band at one end.

To check that the pulse generator is working, connect a crystal earphone betwen socket *B*11 and *E*26. You will hear a high-pitched tone since the circuit is oscillating at about 10kHz. Measure $V_{OUT}$, as shown by the connections in the breadboard layout. Also measure the voltages at the lower "rungs" of the ladder (at sockets L18 and L22).

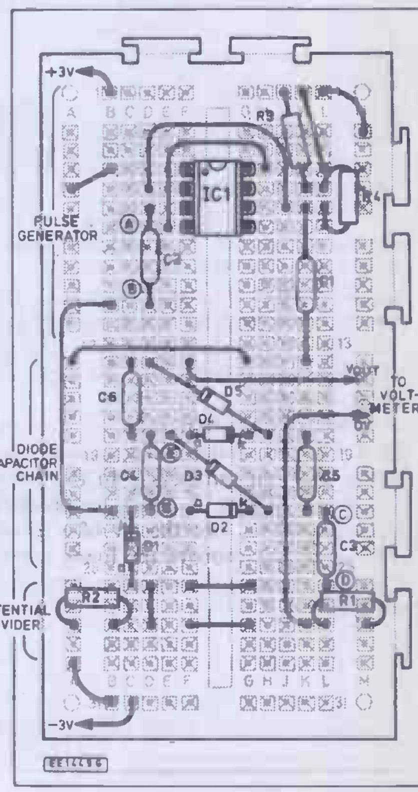
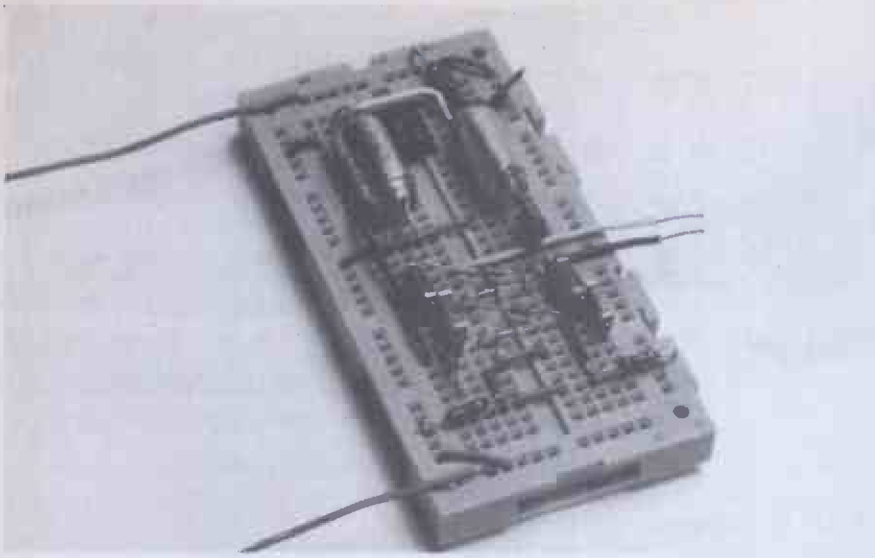



*Fig. 26.3. Demonstration breadboard component layout for the Diode/Capacitor Ladder, including the pulse generator.*

The ladder could have many more rungs, generating high voltages from a low-voltage source. Of course, we do not get something for nothing. Though the voltages produced may be high, the



current available is smaller than that obtainable directly from the source (the timer i.c. (Fig. 26.1)).

If anything other than a small current is drawn, the voltage drops substantially. The voltage multiplier circuit has its uses for generating high voltages from low ones. Such circuits are used to operate devices that are normally mains powered (e.g. a caravan lamp), from a low-voltage, high- current source (e.g. a car battery).

A photo-flash requires a high voltage for its xenon tube. You have probably heard the high-pitched whine as the flash is charging. This is the high-frequency astable used to drive the pumping action. A low-voltage battery, connected to a diode-capacitor ladder produces what is required.

A large current is required to power the flash, but only for a very short time. The solution to this is to make the final capacitor in the chain a large one. The circuit has to run for a few tens of seconds to charge this up before enough charge has accumulated in this capacitor to fire the flash.

Other devices that may be powered by a diode-capacitor chain include laser tubes and "air-purifiers". In the latter the high voltage is used to produce streams of ions into the air of a room. This is said to improve the living conditions in a room and make the occupants feel fitter.

## TEMPERATURE SENSOR

One of the characteristics of a diode that we have mentioned before is that there is a voltage drop across a diode when it is carrying current. Unlike the voltage drop across a resistor, which increases in proportion to the current (i.e. *Ohm's Law, V=IR*), the voltage drop across a diode is independent of current. This *forward voltage drop* $V_F$, is in the region of 0.7V for a silicon diode.

A simple circuit for measuring $V_F$ is shown in Fig. 26.5. We have used five diodes in series so that a total $V_F$ is approximately 3.5V. This makes it easier to measure the drop with an inexpensive voltmeter.

The resistor R1 limits the current flowing through the diodes to about half a milliamp, not only preventing the diodes from becoming burnt out, but also preventing them from being heated appreciably by the current passing through them.

Connect a voltmeter between the $V_{OUT}$ terminal and 0V. This measures the total forward voltage drop of the five diodes. Now put the circuit in a warm place–in front of a radiant electric fire for example, or on top of a central heating radiator. Read the voltage after a minute. What change has occurred in $V_{OUT}$?

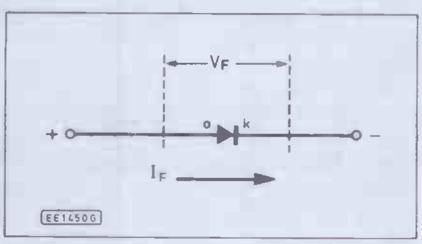



*Fig. 26.4. Forward current ($I_F$) and forward voltage drop ($V_F$) of the pn junction in a forward-biassed diode.*

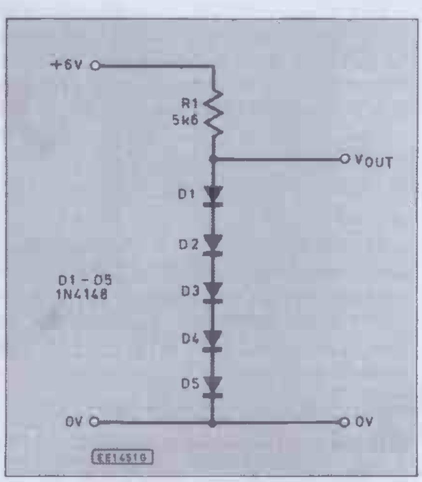



*Fig. 26.5. Measuring forward voltage drop of diodes.*

## COMPONENTS

### DIODE-CAPACITOR LADDER

**Resistors**

| | |
|---|---|
| R1, R2 | 680 (2 off) |
| R3 | 330 |
| R4 | 560 |

All 5% carbon 0.25W%

**Shop Talk**

See page 490

**Capacitors**

| | |
|---|---|
| C1-C6 | 100n polyester (6 off) |

**Semiconductors**

| | |
|---|---|
| D1-D5 | 1N4148 (or similar) diodes (5 off) |
| IC1 | 555 timer i.c. |

**Miscellaneous**

Breadboard (e.g. Verobloc); 8-pin i.c. holder; B1 6V battery and connector; connecting wire and Voltmeter, set to 10V d.c. scale.

### TEMPERATURE SENSOR

**Resistors**

| | |
|---|---|
| R1 | 5k6 |

0.25W 5% carbon

**Semiconductors**

| | |
|---|---|
| D1-D5 | 1N4148 (5 off) |

**Miscellaneous**

B1 6V battery and connectors; Breadboard (e.g. Verobloc); Voltmeter set to 10V d.c. scale.

*Approx. cost Guidance only* **£5** *(excluding meter)*

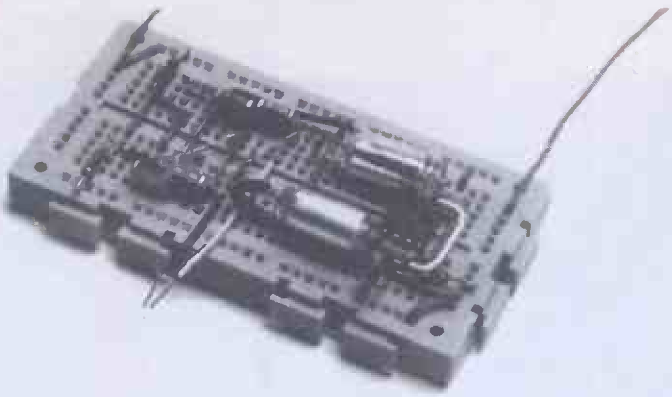
Next put the circuit in a cold place, such as a freezer. Read the voltage after a minute. What change has occurred in $V_{OUT}$?

Put the circuit back on the workbench. Read the voltage after a minute. Does $V_{OUT}$ return to its original value?

This investigation shows that $V_F$ is dependent on temperature. Precise measurement shows that the change is about 2mV per Kelvin (or per degree Celsius). $V_F$ ranges from about 0.75V at 0°C to about 0.55V at °C. This is obviously a property that has many applications.

Another temperature-dependent device that we have studied in this series is the *thermistor* (Part 4, October 1986). In this device it is the *resistance* that varies with temperature.

Thermistors are useful in circuits which are to be triggered into action at a



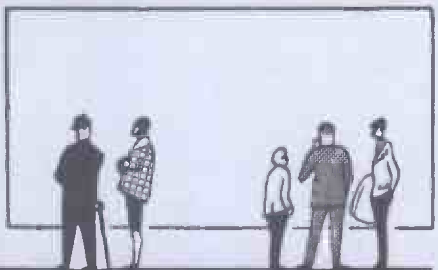
*single* pre-set temperature, but they are less useful as sensors for circuits intended to *measure temperatures* in a given range. This is because the change in resistance of a thermistor is not *linear*. That is to say, a graph of temperature plotted against resistance is not a straight line. This makes it hard to design an instrument that shows temperature on an evenly-graduated scale.

By contrast, the change in forward voltage drop of a diode *is* linear, at least over a wide range of temperatures of everyday interest (i.e. from just below freezing point to just above boiling point). This makes the diode a useful temeperature sensor. Of course, it is not the diode as such that has this useful property. It is the *pn junction* of the diode that is the site of the effect.

Other devices with *pn* junctions (for example, junction transistors) have the same property. In particular, a number of i.c.s have been designed that rely on this property. They included a *pn* junction as sensor and may also incorporate an amplifier to increase the effect of temperature and other circuitry to make the device easy to use.

**Next Month: Field Effect Transistors.**

# SHOP TALK

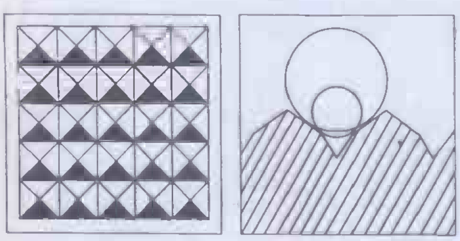


BY DAVID BARRINGTON

### Guide Lines

We have it on good authority from our resident artist, that drawing straight lines "free hand" is to be avoided at all costs. This could soon change with the receipt of the latest Quickliner drawing aid sheet from **Commotion**.

The worksheet is placed on top of the plastic type material, which is covered in a grid pattern of tiny pyramid shaped "pimples". A pencil point is pressed into the grooves formed by the pyramids and, with moderate pressure, it is claimed you are able to draw "straight" lines across the worksheet. Printed angle lines in the top right corner of the liner enable the drawing to be set up vertically and horizontally on the page.



Provided you represent resistor symbols as rectangles, the drawing sheet is useful for producing block, circuit and wiring diagrams.

Available in sheet form or with a clipboard, details of prices and further information on Quickliner may be obtained from **Commotion Ltd., Dept EE, 241 Green Street, Enfield, Middlesex, EN3 7TD. ☎ 01 804 1378.**

### Catalogues Received

We have just received news of the contents of the new *1988 Bi-Pak Bargain Catalogue* and for anyone just starting out in electronics this catalogue lists an excellent range of "Paks" that should appeal to the newcomer. Items listed include test meters, audio leads, opto devices and soldering irons.

Copies of the 1988 Bi-Pak Bargain Catalogue may be obtained from **B-Pak, Dept. EE, P.O. Box 33, Royston, Herts, SG8 5DF. (☎ 0763 48851)**, enclose a large self-addressed stamped envelope.

## CONSTRUCTIONAL PROJECTS

### Tea Tune

The glass bead thermistor type GL16 specified in the *Tea Tune* project should be available from most of our advertisers. The price of this device seems to vary from about £4 to just over £6.

The musical buzzer and piezoelectric sounder should be available from **Maplin, Cirkit, Greenweld** and **Marco Trading.** The rigid plastic tubing and glue (Plastic Weld) should be obtainable from most good model shops. The designer's was purchased from EMA Model Supplies of Feltham, Middlesex.

The small printed circuit board for the Tea Tune is available from the *EE PCB Service*, code EE 609.

### Data Logger

There are quite a few components that could be classed as "specials" for the *Data Logger* and cause buying problems.

Most of the semiconductor devices appear to be generally available, but diodes D1 and D2 and the voltage regulator only appear to be stocked by **Electromail (☎ 0536 204555**. These are listed as follows: BAT85, code 300-978; 04BJ, code 283-564; ICL7663, code 630-718.

The Data Logger p.c.b. (£11.75), p.c.b. and case (£18.25), and the interface board (£5.50) are available from **Tayside Microsystems, Dept. EE, 55 Causewayend, Coupar Angus, Perthshire, PH13 9DX.** They also supply the Software–BBC (£15.00), Amstrad/IBM (£25)–for this project. The software is supplied on disc, with full operating instructions.

The crystal is currently listed by **Maplin**, code UJ02C, and is usually recommended for replacement of digital watch crystals.

### Audio Mini-Bricks

The master printed circuit board (£7.90) for the *Audio-Mini Bricks* series of projects is available from **Phonosonics, 8 Finucane Drive, Orpington, Kent, BR5 4ED.**

### Car Alarm

The flush-mounting reed switch and magnet needed for the *Car Alarm* project should be available from **Riscomp (☎ 084 44 6326)**,they stock quite a large range of various types of alarm sensors. The switch is also available as a RS type (337-396) and can be purchased from any RS component supplier.

The f.e.t.s type ZVN3306A are Ferranti devices and are stocked by **Farnell (☎ 0937 61961).** To date this is the only source we have been able to locate.

The printed circuit board is available from the *EE PCB Service*, code **EE615**.

### Suntan Timer

All of the components required to build the *Suntan Timer* are standard devices and should not cause any purchasing problems.

Readers building the Time Switch option should note that it can only switch loads which draw less than 2A. For greater currents a higher rated triac should be selected and be mounted on a suitable heatsink.

The printed circuit board(s) for this project are available from the *EE PCB Service*, see page 493.

We do not expect any component buying problems for the *Exploring Electronics* and *Home Security* projects.
and *Home Security* projects.

# ON SPEC

*a regular feature for the Spectrum Owner...*

**by Mike Tooley BA**

THIS month we shall be devoting the whole of this column to the dual DAC featured in last month's instalment of *On Spec*. We also include a program which will not only allow constructors to put the dual DAC through its paces but can be used in its own right as the basis of a programmable waveform generator.

## DAC Software

We shall assume that readers have been able to follow the simple procedure for testing and adjusting the dual DAC and that both channels are functioning correctly. Programming the dual DAC is fortunately an extemely simple process and only requires a few simple lines of BASIC of the form:

**OUT port.value**

The port addresses (expressed in decimal) for Channels A and B are 63 and 127 respectively. Thus commands of the form

**OUT 63.*nn*** and **OUT 127.*nn***

issued directly from the keyboard will generate voltage levels of *nn*×10mV on Channels A and B respectively. (Note that *nn* must be a positive integer in the range 0 to 255).

Hence, a BASIC statement of the form

**50 OUT 63.100**

will produce an output of 10×10mV (i.e. 100mV) from Channel A, whereas a BASIC statement of the form:

**60 OUT 127.250**

will produce an output of 250×10mV (i.e. 2.5V) from Channel B.

It is important to note that the two DAC channels are entirely independent of one another and that they will continue to produce a desired output value until new data is written to them. As an example, the following routine sets Channel A output voltage to 1.5V, generates a positive going ramp on Channel B (using ten equal steps of 20mV from 20mV to 2V), and then sets Channel A output voltage to zero:

```
10 OUT 63.150
20 FOR x=1 TO 10
30 LET v=x*20
30 OUT 127.v
40 NEXT x
50 OUT 63.0
60 STOP
```

```
  10 REM ******************************************
  15 REM *                                        *
  20 REM *   Everyday Electronics  August 1988    *
  25 REM *  Dual Digital-Analogue Converter Demo  *
  35 REM *                                        *
  40 REM ******************************************
  45 REM Initialise
  50 POKE 23609.50
  55 POKE 23658.8
  60 POKE 23617.0
  70 PAPER 1: INK 7: BORDER 1
  71 BRIGHT 1
  75 LET Z=63
  80 REM Main Program Loop
  81 CLS
  85 PRINT AT 0.0; INVERSE 1;"EVERYDAY ELECTRONICS     ON SPEC"
  86 PRINT "DAC Test Program      Version 1.0"
  87 PRINT
  90 PRINT  INVERSE 1:"SELECT DAC": INVERSE 0:" A or B"
  92 PRINT
  93 PRINT  INVERSE 1:"D.C. LEVEL": INVERSE 0:" L(voltage) "
  94 PRINT  INVERSE 1:"POS. RAMP ": INVERSE 0:" P(voltage) "
  95 PRINT  INVERSE 1:"NEG. RAMP ": INVERSE 0:" N(voltage) "
  96 PRINT  INVERSE 1;"TRIANGLE  ": INVERSE 0:" T(voltage) "
  97 PRINT  INVERSE 1:"SQUARE    "; INVERSE 0;" S(voltage) "
  98 PRINT  INVERSE 1:"QUIT      ": INVERSE 0;" Q"
  99 PRINT : PRINT "All voltages in mV (max. 2550)"
 100 PRINT : PRINT  INVERSE 1:"STATUS": PRINT
 101 IF Z=63 THEN  PRINT AT 16.0:"DAC A selected"
 102 IF Z=127 THEN  PRINT AT 16,0;"DAC B selected"
 104 INPUT "Command ":A$
 105 IF A$="" THEN  BEEP 0.1.0.1: GO TO 80
 106 LET B$=A$(1)
 107 IF B$="A" THEN  LET Z=63: GO TO 80
 108 IF B$="B" THEN  LET Z=127: GO TO 80
 111 IF B$="Q" THEN  GO TO 9000
 112 IF LEN A$<2 OR LEN A$>5 THEN  BEEP 0.1,0.1: GO TO 80
 115 LET V$=A$(2 TO LEN (A$))
 116 LET V=VAL (V$)
 117 IF V<0 OR V>2550 THEN  BEEP 0.1,0.1: GO TO 80
 118 LET V=10*INT (V/10)
 119 LET X=V/10
 123 IF B$="L" THEN  GO TO 2000
 124 IF B$="P" THEN  GO TO 3000
 125 IF B$="N" THEN  GO TO 4000
 126 IF B$="T" THEN  GO TO 5000
 127 IF B$="S" THEN  GO TO 6000
 128 IF B$="Q" THEN  GO TO 9000
 130 BEEP 0.1.0.1: GO TO 80
2000 REM D.C. Level
2010 PRINT
2020 PRINT AT 18,0:"D.C. level = ";V:"mV   "
2030 OUT Z.X
2190 GO TO 100
3000 REM Positive Ramp
3001 PRINT
3002 PRINT AT 18.0:"Positive Ramp: ";V:"mV peak  "
3010 FOR W=0 TO X
3020 OUT Z.W
3030 LET R$=INKEY$
3040 IF R$="Q" THEN  GO TO 80
3050 NEXT W
3060 GO TO 3010
4000 REM Negative Ramp
4001 PRINT
4002 PRINT AT 18.0:"Negative Ramp: ";V:"mV peak  "
4010 FOR W=X TO 0 STEP -1
4020 OUT Z.W
4030 LET R$=INKEY$
4040 IF R$="Q" THEN  GO TO 80
4050 NEXT W
4060 GO TO 4010
5000 REM Triangle Wave
5001 PRINT
5002 PRINT AT 18,0;"Triangle Wave; ";V;"mV peak  "
5010 FOR W=0 TO X
5020 OUT Z.W
5030 LET R$=INKEY$
5040 IF R$="Q" THEN  GO TO 80
5050 NEXT W
5060 FOR W=X TO 0 STEP -1
5070 OUT Z,W
5080 LET R$=INKEY$
5090 IF R$="Q" THEN  GO TO 80
5100 NEXT W
5110 GO TO 5010
5190 GO TO 80
6000 REM Square Wave
6001 PRINT
6002 PRINT AT 18,0:"Square Wave; ";V:"mV peak  "
6010 OUT Z.X
6020 FOR W=0 TO 200
6030 LET R$=INKEY$
6040 IF R$="Q" THEN  GO TO 80
6050 NEXT W
6055 OUT Z.0
6060 FOR W=0 TO 200
6070 LET R$=INKEY$
6080 IF R$="Q" THEN  GO TO 80
6090 NEXT W
6100 GO TO 6010
9000 REM Tidy-up and exit
9010 POKE 23609.0
9020 PAPER 7: INK 0: BORDER 7: BRIGHT 0
9030 CLS
9040 NEW
```

## Demonstration program

Our demonstration program provides constructors with a wide range of options, including generating fixed d.c. levels (with a resolution of 10mV), ramps (both positive and negative going). as well as the production of triangular and square waves of programmable amplitude.

Listing 1 shows the complete demonstration program for the dual DAC. Lines 45 to 75 initialise the system and set Channel A as the default (initially selected) channel. The main program loop starts at line 80 and provides the user with a menu screen from which he or she is able to select the DAC (by typing A or B) and one of five different functions (by typing L, P, N, T, or S followed by a desired voltage expressed in mV). The program can easily be extended to provide additional functions and readers are invited to submit their efforts for incorporation in our *On Spec Update*.

## Output driver

Finally, some constructors may find that the 2.55V maximum output voltage of the dual DAC is a little restricting. If this is the case, Fig. 1 shows how a power operational amplifier can be added to increase the output voltage and current drive capability of the circuit. The 759 can provide up to about

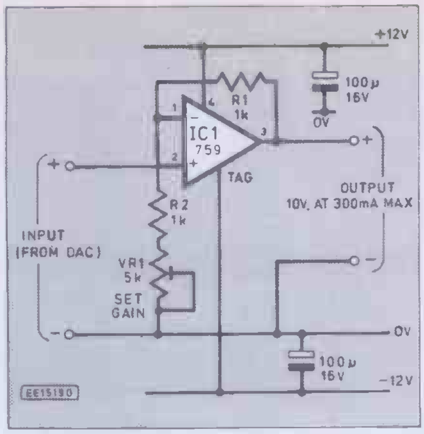



*Fig. 1. Output driver circuit*

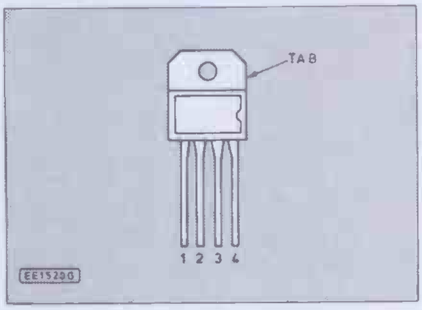



*Fig. 2. 759 pin connections*

300mA output at 10V but will need an efficient heatsink (rated at 10 deg. C/W. or better). The positive and negative supplies should be capable of delivering the maximum load current (i.e. 300mA).

Negative going outputs can be produced by simply connecting the input of the power amplifier circuit to the output of IC2d (rather than IC2c) or IC2a (rather than IC2b). In either case, VR1 is adjusted for the maximum output required (i.e. 10V for a value of *nn* of 255.

## Next month

In answer to several requests from readers, we shall be reviewing the Miles Gordon Technology Plus-D disk interface. We also have details of an address selector which can greatly simplify the problem of address decoding when several of our *On Spec* I/O modules are connected simultaneously. For good measure, we shall include some fast machine code routines for constructors of our dual DAC. In the meantime, if you would like a copy of our *On Spec Update*, please drop me a line enclosing a large (250mm×300mm) stamped addressed envelope. Mike Tooley, Department of Technology, Brooklands Technical College, Heath Road, Weybridge, Surrey, KT13 8TT.

# PCB SERVICE

Printed circuit boards for certain constructional projects (up to two years old) are available from the PCB Service, see list. These are fabricated in glassfibre, and are fully drilled and roller tinned. All prices include VAT and postage and packing. Add £1 per board for overseas airmail. Remittances should be sent to: The PCB Service, *Everyday Electronics* Editorial Offices, 6 Church Street, Wimborne, Dorset BH21 1JH. Cheques should be crossed and made payable to *Everyday Electronics. (Payment in £ sterling only.)*

**Readers are advised to check with prices appearing in the current issue before ordering.**

***NOTE:*** *Boards for older projects – not listed here – can often be obtained from Magenta Electronics, 135 Hunter St., Burton-on-Trent, Staffs DE14 2ST. Tel: 0283 65435 or Lake Electronics, 7 Middleton Close, Nuthall, Nottingham NG16 1BX. Tel: 0602 382509.*

**NOTE: Please allow 28 days for delivery. We can only supply boards listed in the latest issue. Boards can only be supplied by mail order and on a payment with order basis.**

| PROJECT TITLE | Order Code | Cost |
|---|---|---|
| – JUNE '86 – | | |
| Watchdog | 524 | £3.51 |
| Percussion Synthesiser | 525 | £7.06 |
| Personal Radio | 526 | £2.58 |
| – JULY '86 – | | |
| Tilt Alarm | 527 | £2.65 |
| Electronic Scarecrow | 528 | £2.86 |
| VOX Box Amplifier | 529 | £2.93 |
| Headphone Mixer | 530 | £5.71 |
| – AUG '86 – | | |
| Solar Heating Controller | 533 | £4.16 |
| – SEPT '86 – | | |
| Car Timer | 538 | £2.53 |
| Freezer Failure Alarm | 534 | £2.38 |
| Infra Red Beam Alarm (Trans) | 536 | £4.16 |
| Infra Red Beam Alarm (Rec) | 537 | £4.16 |
| Scratch Blanker | 539 | £6.80 |
| – OCT '86 – | | |
| 10W Audio Amp (Power Amp) £4.78 Pair | 543 | £3.23 |
| (Pre-Amp) | 544 | £3.97 |
| Light Rider – Lapel Badge | 540 & 541 | £2.97 |
| – Disco Lights | 542 | £5.12 |
| – Chaser Light | 546 | £4.04 |
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| Modem Tone Decoder | 547 | £3.46 |
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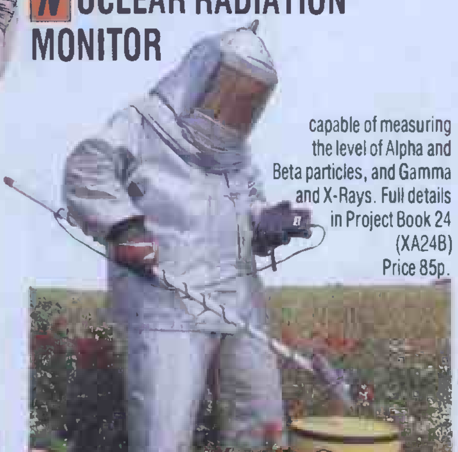

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