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|---|---|---|---|---|
| 242 | 0·3 | 0·15 | 1·70 | 0·40 |
| 213 | 1 | 0·50 | 2·32 | 0·70 |
| 71 | 2 | 1 | 2·51 | 0·90 |
| 18 | 4 | 2 | 3·24 | 1·43 |
| 68 | 3 | 1·5 | 3·15 | 1·43 |
| 85 | 5 | 2·5 | 5·52 | 1·43 |
| 70 | 6 | 3 | 6·26 | 1·43 |
| 108 | 8 | 4 | 7·36 | 1·73 |
| 72 | 10 | 5 | 8·05 | 1·65 |
| 116 | 12 | 6 | 8·57 | 1·90 |
| 17 | 16 | 8 | 10·53 | 2·05 |
| 187 | 30 | 15 | 17·62 | 2·45 |

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SEC: 0V 12V 15V 0V 5V 9V 15V
VOLTS AVAILABLE 3 → 15 — 0 — 15

| TYPE | AMPS 15v | AMPS 30v | PRICE £ | P/P £ |
|---|---|---|---|---|
| 112 | 1 | 0·50 | 2·47 | 0·95 |
| 79 | 2 | 1·0 | 3·16 | 0·95 |
| 3 | 4 | 2 | 5·64 | 1·43 |
| 20 | 6 | 3 | 6·59 | 1·73 |
| 21 | 8 | 4 | 7·80 | 1·73 |
| 51 | 10 | 5 | 9·68 | 1·90 |
| 117 | 12 | 6 | 10·97 | 2·05 |
| 88 | 16 | 8 | 14·65 | 2·20 |
| 89 | 20 | 10 | 16·93 | 2·35 |
| 90 | 24 | 12 | 18·84 | 2·55 |
| 91 | 30 | 15 | 21·56 | 2·65 |
| 92 | 40 | 20 | 30·08 | 3·50 |

**25/50V RANGE PRI 120/220/240V**
SEC: 0V 20V 25V 0V 8V 15V 25V
VOLTS OUT 5 → 25 — 0 — 25

| TYPE | AMPS 24v | AMPS 50v | PRICE £ | P/P £ |
|---|---|---|---|---|
| 102 | 1 | 0·50 | 2·88 | 1·43 |
| 103 | 2 | 1·0 | 3·60 | 1·43 |
| 104 | 4 | 2 | 7·04 | 1·73 |
| 105 | 6 | 3 | 8·33 | 1·90 |
| 106 | 8 | 4 | 11·18 | 1·90 |
| 107 | 12 | 6 | 14·79 | 2·20 |
| 118 | 16 | 8 | 20·49 | 2·55 |
| 119 | 20 | 10 | 24·52 | 2·55 |
| 109 | 24 | 12 | 29·39 | 3·50 |

**30/60V RANGE PRI 120/220/240V**
SEC: 0V 24V 30V 0V 10V 18V 30V
VOLTS 6 → 30 — 0 — 30

| TYPE | AMPS 30v | AMPS 60v | PRICE £ | P/P £ |
|---|---|---|---|---|
| 124 | 1 | 0·5 | 2·92 | 1·43 |
| 126 | 2 | 1 | 5·78 | 1·43 |
| 127 | 4 | 2 | 7·13 | 1·73 |
| 125 | 6 | 3 | 10·73 | 1·90 |
| 123 | 8 | 4 | 12·28 | 2·20 |
| 40 | 10 | 5 | 15·55 | 2·20 |
| 120 | 12 | 6 | 17·72 | 2·35 |
| 121 | 16 | 8 | 25·09 | 2·65 |
| 122 | 20 | 10 | 29·07 | 4·00 |
| 189 | 24 | 12 | 33·51 | 4·60 |

**48/96V RANGE PRI 120/220/240V**
SEC: 0V 36V 48V 0V 36V 48V
VOLTS 12 → 48 — 0 — 48

| TYPE | AMPS 48v | AMPS 96v | PRICE £ | P/P £ |
|---|---|---|---|---|
| 430 | 1 | 0·5 | 4·14 | 1·43 |
| 431 | 2 | 1 | 7·22 | 1·73 |
| 432 | 4 | 2 | 11·87 | 2·05 |
| 433 | 6 | 3 | 14·47 | 2·20 |
| 434 | 8 | 4 | 18·43 | 2·45 |
| 435 | 10 | 5 | 26·16 | 2·65 |
| 436 | 12 | 6 | 32·75 | 4·00 |
| 437 | 16 | 8 | 35·77 | 4·60 |

**AUTOTRANSFORMERS 240/220—115V**
65VA — 10KVA
0V 115V 220V 240V

| TYPE | VA | PRICE £ | P/P £ |
|---|---|---|---|
| 25 | 65 | 3·82 | 1·10 |
| 64 | 80 | 4·40 | 1·10 |
| 4 | 150 | 5·64 | 1·43 |
| 69 | 250 | 7·13 | 1·73 |
| 53 | 350 | 8·97 | 1·90 |
| 67 | 500 | 11·09 | 2·20 |
| 83 | 750 | 12·42 | 2·20 |
| 84 | 1000 | 16·88 | 2·65 |
| 95 | 2KVA | 31·26 | 4·00 |
| 73 | 3 | 61·27 | 4·75 |
| 57 | 5 | 87·42 | 6·60 |
| 101 | 10 | 159·45 | 13·00 |

**CASED AUTOTRANSFORMERS**
240V LEAD IN:115V 2PIN SOCKET OUT

| TYPE | VA | PRICE £ | P/P £ |
|---|---|---|---|
| 56W | 20 | 5·52 | 0·58 |
| 64W | 80 | 7·63 | 1·43 |
| 4W | 150 | 9·63 | 1·73 |
| 69W | 250 | 11·98 | 1·90 |
| 67W | 500 | 18·67 | 2·20 |
| 84W | 1000 | 26·90 | 2·65 |
| 95W | 2000 | 48·45 | 7·00 |
| 73W | 3000 | 69·18 | 8·00 |

**LINE ADJUSTMENT AUTOTRANSFORMERS**
0 200 210 220 230 240 250

| TYPE | VA | PRICE £ | P/P £ |
|---|---|---|---|
| 415C | 50 | 2·13 | 0·58 |
| 416C | 100 | 3·13 | 1·10 |
| 417C | 200 | 3·65 | 1·43 |
| 418F | 350 | 5·63 | 1·43 |
| 419F | 500 | 6·13 | 1·73 |
| 420E | 750 | 7·60 | 1·90 |
| 421F | 1000 | 10·55 | 2·05 |

**MAINS ISOLATORS (SAFETY SCREEN)**
PRI 120/220/240V SEC 60V 55V 0V 55V 60V 60V 55V 0V 55V 60V

| TYPE | VA | PRICE £ | P/P £ |
|---|---|---|---|
| 149F | 60 | 7·35 | 1·73 |
| 150F | 100 | 8·61 | 1·73 |
| 151F | 200 | 12·15 | 2·05 |
| 152F | 250 | 14·75 | 2·20 |
| 153F | 350 | 18·22 | 2·55 |
| 154F | 500 | 22·70 | 2·65 |
| 155F | 750 | 32·08 | 7·00 |
| 156F | 1000 | 41·26 | 7·00 |

**MAINS ISOLATORS (SAFETY SCREEN)**
PRI 380/415/480V SEC 60V 55V 0V 55V 60V 60V 55V 0V 55V 60V

| TYPE | VA | PRICE £ | P/P £ |
|---|---|---|---|
| 243F | 60 | 7·35 | 1·43 |
| 244F | 100 | 8·61 | 1·73 |
| 245F | 200 | 12·15 | 2·05 |
| 246F | 250 | 14·75 | 2·20 |
| 247F | 350 | 18·22 | 2·55 |
| 248F | 500 | 27·70 | 2·65 |
| 249F | 750 | 32·08 | 7·00 |
| 250F | 1000 | 41·26 | 8·00 |

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| TYPE | VA | mA | PRICE | P/P |
|---|---|---|---|---|
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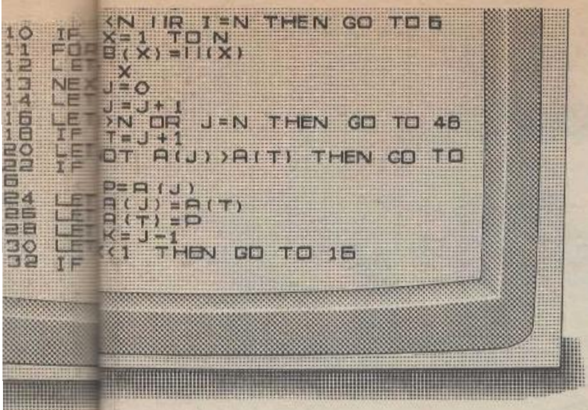


# If you own a Sinclair ZX80...

The new 8K BASIC ROM used in the Sinclair ZX81 is available to ZX80 owners as a drop-in replacement chip. (Complete with new keyboard template and operating manual.)

With the exception of animated graphics, all the advanced features of the ZX81 are now available on your ZX80 – including the ability to drive the Sinclair ZX Printer.

# Coming soon– the ZX Printer.

Designed exclusively for use with the ZX81 (and ZX80 with 8K BASIC ROM), the printer offers full alphanumerics across 32 columns, *and* highly sophisticated graphics. Special features include COPY, which prints out exactly what is on the whole TV screen without the need for further instructions. The ZX Printer will be available in Summer 1981, at around £50 – watch this space!


# 16K-BYTE RAM pack for massive add-on memory.

Designed as a complete module to fit your Sinclair ZX80 or ZX81, the RAM pack simply plugs into the existing expansion port at the rear of the computer to multiply your data/program storage by 16!

Use it for long and complex programs or as a personal database. Yet it costs as little as half the price of competitive additional memory.


**New, improved specification**

- Z80A micro-processor – new faster version of the famous Z80 chip, widely recognised as the best ever made.
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- Up to 26 FOR/NEXT loops.
- Randomise function – useful for games as well as serious applications.
- Cassette LOAD and SAVE with named programs.
- 1K-byte RAM expandable to 16K bytes with Sinclair RAM pack.
- Able to drive the new Sinclair printer (not available yet – but coming soon!)
- Advanced 4-chip design: micro-processor, ROM, RAM, plus master chip – unique, custom-built chip replacing 18 ZX80 chips.

**How to order your ZX81**

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| | Mains Adaptor(s) (600 mA at 9 V DC nominal unregulated). | 10 | 8.95 | |
| | 16K-BYTE RAM pack(s). | 18 | 49.95 | |
| | 8K BASIC ROM to fit ZX80. | 17 | 19.95 | |
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# *Projects... Theory...*

# *and Popular Features...*

FUND RAISER

Everyone enjoys a flutter, and there's always some good cause in need of a fund raiser. The modern art of electronics has its part to play here, for it enables the updating of traditional fairground or bazaar amusements, making them suitable for voluntary neighbourhood events—indoors or out.

Our all-electronic version of that old favourite the *Wheel of Fortune* operates either from a 12 volt car battery or directly from the mains. It is quite portable so if the need arises it can be rapidly transferred to that alternative indoor venue which prudent fête organisers always announce on their bills, in recognition of the vagaries of the British summer.

CHILD PROOF

The child-proof medicine container does not always live up it its name. Little fingers often discover the secret of the safety bottle cap and, hey presto, the lid is off before a parent is alerted as to what is going on.

Locking the medicine cabinet is one sure way of preventing such hazards, but for family reasons this is not always desirable. Another way to thwart an infant's explorations in a danger area is to fit a simple alarm device that sounds off whenever the cabinet door is opened. This is just one example of possible uses for the *Door Alarm* described this month.

MATTER OF TIME

How many beats to the bar? Soft or hard boiled? Two well known instruments that cater for these rather different needs have their electronic counterparts in this issue.

The *CMOS Metronome* produces a steady ticking which is often preferred by musicians to the tick-tock of the traditional clockwork driven beat-marker. The *L.E.D. Sandglass* uses a column of lights to register the passage of time from two minutes to four-and-a-half minutes, in half-minute intervals.

MORSE PRACTISE

Are some CB Breakers getting the Amateur Radio bug, as well? At any rate, the number of Licensed Amateurs is increasing and a demand for a learning aid such as our *Morse Practise Oscillator* is apparent. A fact underlined by those readers who complained about the omission of this project from last month's issue. We apologise for the error in mentioning the Morse Practise Oscillator on the July cover and so inadvertently raising expectations not fulfilled by the actual contents. The one-month delay in waiting for this project we trust will not have cooled anyone's ardour to acquire an Amateur Radio Licence.

Fred Bennett.

***Our September issue will be published on Friday, August 21. See page 543 for details.***

# Everyday ELECTRONICS

VOL. 10 NO. 8 AUGUST 1981

## CONSTRUCTIONAL PROJECTS



## GENERAL FEATURES



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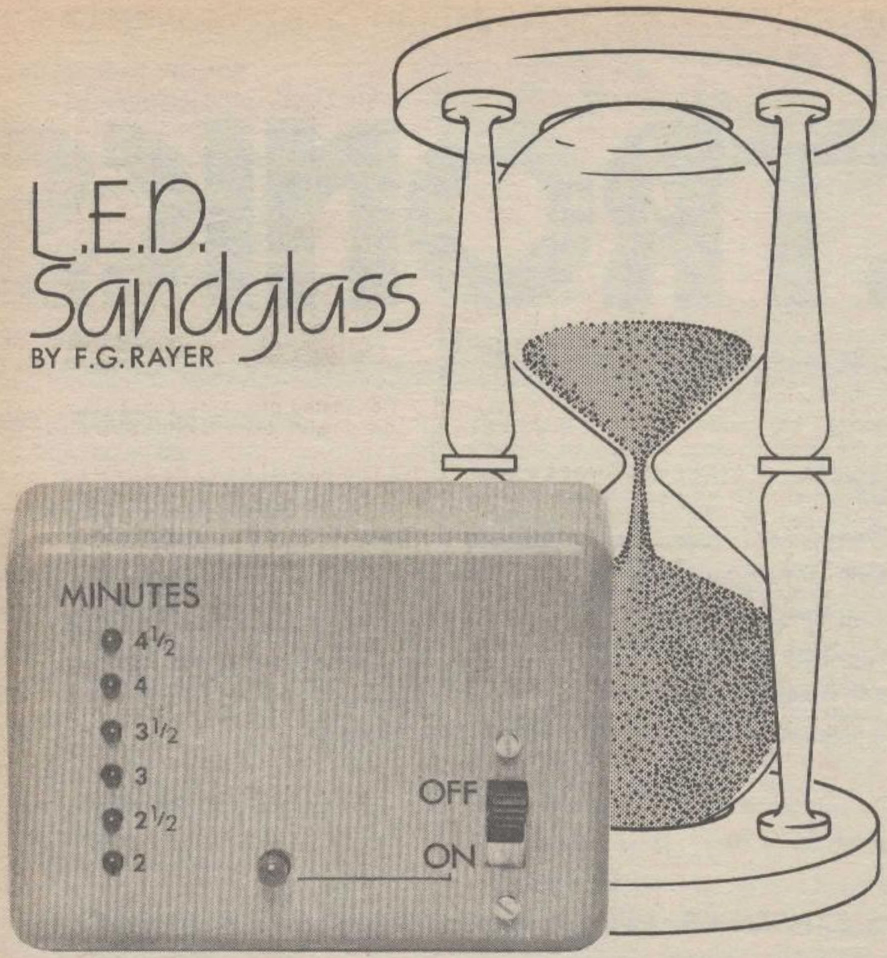
# L.E.D. Sandglass

BY F.G. RAYER




THE unit described in this article was designed to be an electronic replacement for the conventional sand-in-glass type of egg timer, but it could also find other applications for short duration timing in and around the home.

Rising illuminations in a column of six light emitting diodes shows times in half-minute intervals from 2 minutes (for lightly boiled small eggs) to $4\frac{1}{2}$ or 5 minutes for hard boiled eggs.

The way in which time is passing is indicated by the position of an illuminated l.e.d. stepping along the column. This is different from many other egg timer projects in that the display indicates the position reached in the timing cycle.

## CIRCUIT DESCRIPTION

The circuit diagram is shown in Fig. 1. Pulses are generated by TR1, a unijunction transistor. C1 charges up via R1 and VR1 and when a certain threshold voltage is reached, the capacitor rapidly discharges into the emitter of TR1 and through b1 into R3. The result of this is the generation of a narrow voltage pulse at b1. As soon as C1 is discharged, it begins to charge up again to repeat the process. The result is a train of pulses.

VR1 is a preset which allows the repetition rate to be adjusted. These pulses are produced for as long as the unit is turned on.

IC1 is a binary counter where pulses reaching its input, pin 14 are counted, and the number received outputted in binary at pins 12, 9, 8 and 11. IC1 counts up to ten and then returns to zero and repeats; it may be manually reset by briefly putting S1 in its upper position.

IC2 is a decimal decoder, accepting a binary input and decoding this to cause one of its outputs to be logic 0 with the remainder at logic 1. Which output is "on" is decided by the binary count at its input, pins 3, 6, 7 and 4.

The four least significant outputs are not used since they correspond to time intervals of zero to $1\frac{1}{2}$ minutes assuming the pulses are arriving at a rate of one every half-minute. The result of the input pulses therefore is to cause the l.e.d.s D1 to D6 to successively turn on every half minute from two minutes after initialisation.

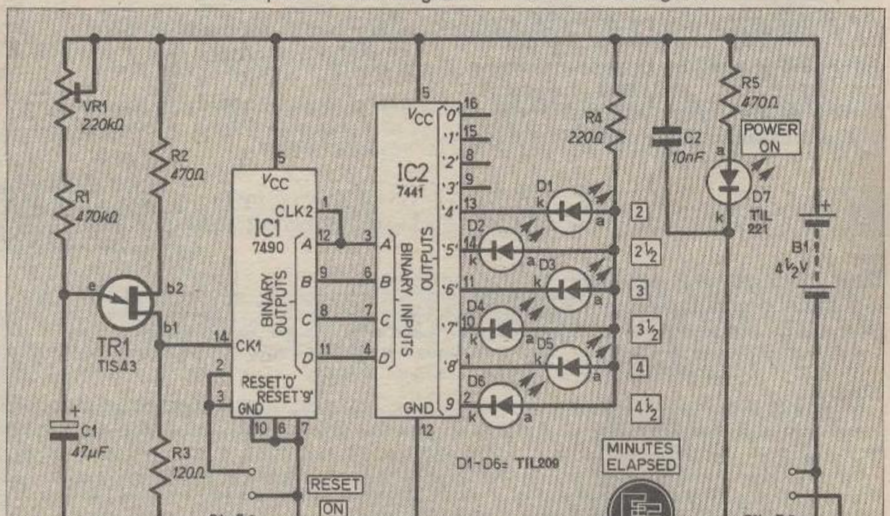
Each l.e.d. remains lit for half a minute and extinguishes when the next one lights up. Time passing is thus shown at half minute intervals against a scale on the case.

A further green l.e.d., D7, lights when the unit is switched on and thus functions as a power-on indicator.

Control is by S1, a three-position slide switch. Both sections are shown off in Fig. 1. At S1b, both centre and on positions close the battery circuit. S1a only closes the reset circuit (grounds pins 2 and 3) of IC1 in the fully up position. In use, the switch is moved from OFF to RESET and back to ON to start timing. This ensures that IC1 is always started in the state corresponding to the "0" output of IC2, to allow correct indication by the l.e.d.s.

The l.e.d. connected to IC2 comes on after $4\frac{1}{2}$ minutes, and remains on for a half minute. It thus extinguishes at 5 minutes. If it is preferred for this l.e.d. to remain on, a diode may be connected, anode to positive of C1,

The complete circuit diagram of the L.E.D. Sandglass.



## COMPONENTS

**Resistors**
R1 470kΩ
R2 470Ω
R3 120Ω
R4 220Ω
R5 470Ω
All ¼ watt carbon ± 5%

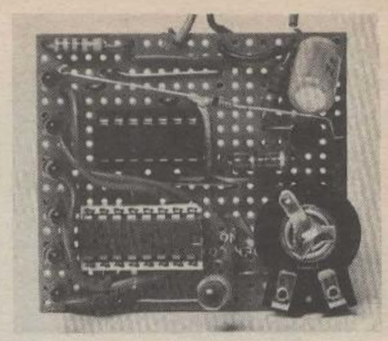
See **Shop Talk** page 535

**Capacitors**
C1 47μF 6V elect. radial leads preferred
C2 10nF ceramic or plastic

**Semiconductors**
TR1 TIS43 *n*-channel unijunction transistor (E5567 and UT46 also suitable)
IC1 7490 TTL binary counter
IC2 7441 TTL decimal decoder
D1-D6 TIL209 0·15in. red l.e.d. (6 off)
D7 TIL221 0·2in. green l.e.d.

**Miscellaneous**
VR1 220kΩ horizontal skeleton preset
B1 4·5V type 1289
S1 2-pole 3-position slide switch
Stripboard: 0·1 inch matrix size 21 strips by 19 holes; i.c. sockets: 14-pin d.i.l., 16-pin d.i.l.; short length of brass strip for making battery connectors; plastic case, size 100 × 75 × 45mm (approx.)

**COMPONENTS approximate cost £5·50**



Completed prototype board shown fitted with extra diode—see text.

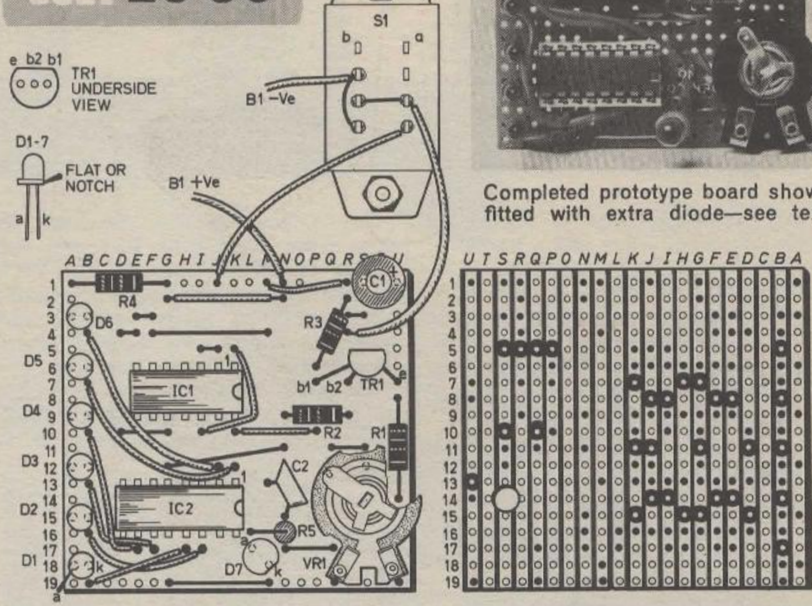



Fig. 2. The layout of the components on the topside of the stripboard and underside view showing breaks and connections to be made.

cathode to IC2, pin 2. Then when the $4\frac{1}{2}$ minute l.e.d. lights, C1 will no longer charge, and pulses will cease.

## BOARD ASSEMBLY

The board used in the prototype was 0·1 inch matrix stripboard size 21 strips by 19 holes. The layout of the components on the board topside are shown in Fig. 2, together with the breaks to be made on the underside. Check that each point really is completely cut, and that fragments of foil do not touch adjacent strips.

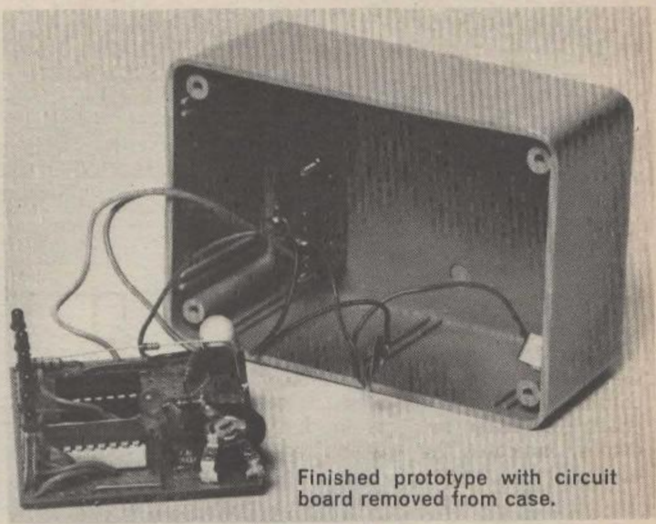
If necessary, check polarity of the l.e.d.s in advance, with a 5V or similar supply and 470 ohm resistor. Set them in line at the same height on the board. The cathode is usually marked by means of a notch on the body alongside this terminal.

A hole centrally under VR1 allows this to be adjusted by means of a small screwdriver.

Several different types of unijunction were found to work satisfactorily. If base 1 pulses do not step-on the counter slightly increasing the value of R3 can be expected to correct this.

External connections consist only of those to battery and switch. S1b is for the negative line, and S1a must complete the reset line IC1 only after S1b is closed, or the count may start with other outputs to give an erroneous timing interval.

One way to set VR1 is to clip a voltmeter across R3, and adjust for pulses at 30 second intervals. After switching on, a meter test should show pins 15, 8 and 9 on IC2 going low at half-minute intervals, followed by the l.e.d.s stepping on at this rate.



Finished prototype with circuit board removed from case.

## CASE

A plastic box approximately 100 x 75 x 45mm will take the board and battery. The l.e.d.s emerge through holes drilled in the case top. Exact drilling can be easily arranged by marking through a spare piece of 0·1in board. A scale marked for 2, $2\frac{1}{2}$, 3, $3\frac{1}{2}$, 4 and $4\frac{1}{2}$ minutes should be made to fit alongside the appropriate l.e.d.s. Letraset was used on the prototype and protected by a spray of varnish.

Logic i.c.s in the 7400 series, as used here, normally operate from 5V. This may of course be used. A 4·5V supply was found satisfactory, but 6V must not be employed, unless a series diode (IN4001, IN4148 for example) is put in the positive battery lead to drop 0·6 volts making the supply 5·4 volts. This is acceptable by 7400 series logic i.c.s. ⌑

# MORSE PRACTISE OSCILLATOR

**by F. G. Rayer**

THE USE of Morse code is one of many Scout activities and a knowledge of the code is also necessary to obtain an Amateur Class A licence. This unit is suitable for practise alone, with a companion or with a group. It is designed for mains running but a battery supply is a practical alternative.

## UNIJUNCTION

Referring to the circuit in Fig. 1, TR1 is a unijunction transistor connected as a relaxation oscillator. Frequency is determined by C1, R1 and VR1 and the output appears at base 1 of the transistor. The frequency may be varied by changing the time constant of the *RC* combination (C1, R1 and VR1), and this is achieved by varying the value of VR1.

The output of this oscillator is taken from base 1 of TR1 and fed via C2 to the volume control VR2. This varies the input to IC1, an audio power amplifier. Little need be said about this stage as all signal processing is carried out inside the chip.

The audio output appears at pin 8 and is fed via C5 directly to the loudspeaker. Although any impedance up to 50 ohms is specified greatest volume is obtained with the lower impedance types—say eight or even four ohms.

**COMPONENTS approximate cost £9·50 excluding case**

## POWER

For battery running a 12 volt supply is suitable. Positive is taken to point *A* on Fig. 1 and negative to point *B*. An on-off switch could be included in the positive battery lead.

Where mains running is envisaged, T1, D1, D2 and C6 will be included. Double-pole switching is provided by S1. This is the ON/OFF switch. Mains power is stepped down to low voltage by T1 and then rectified by D1 and D2 and smoothed by C6 to provide a d.c. voltage rail.

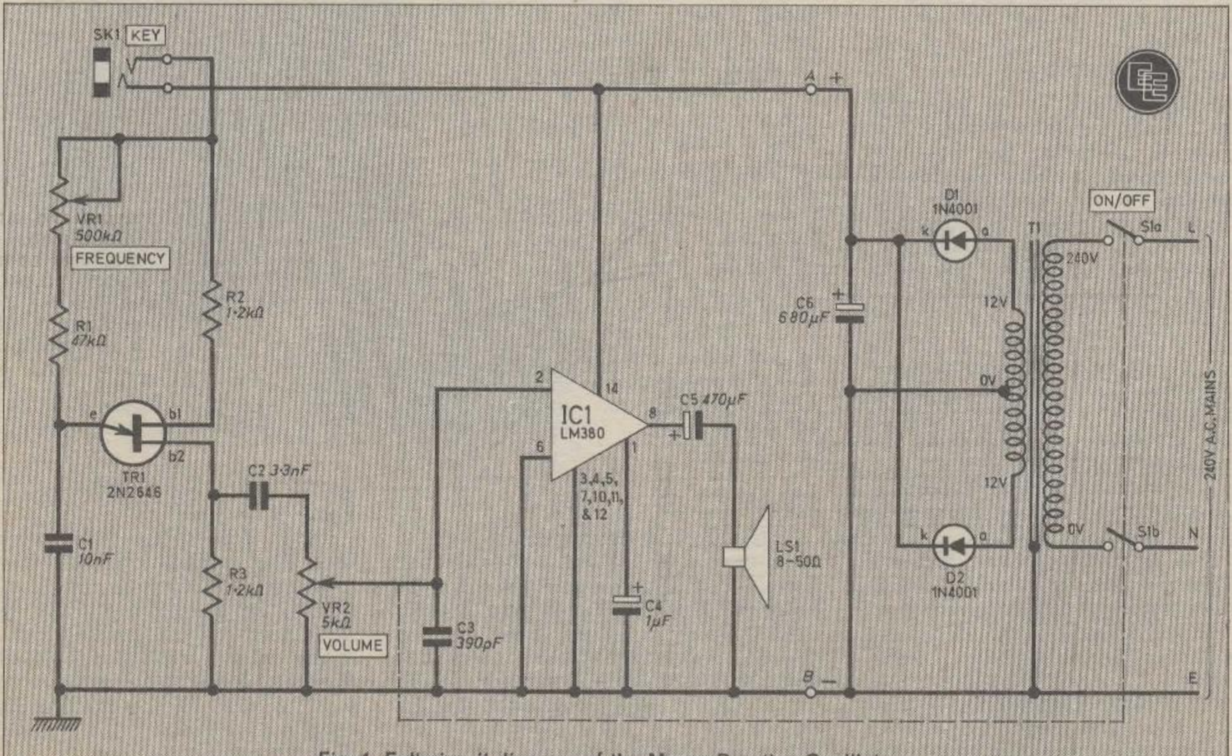



Fig. 1. Full circuit diagram of the Morse Practise Oscillator.

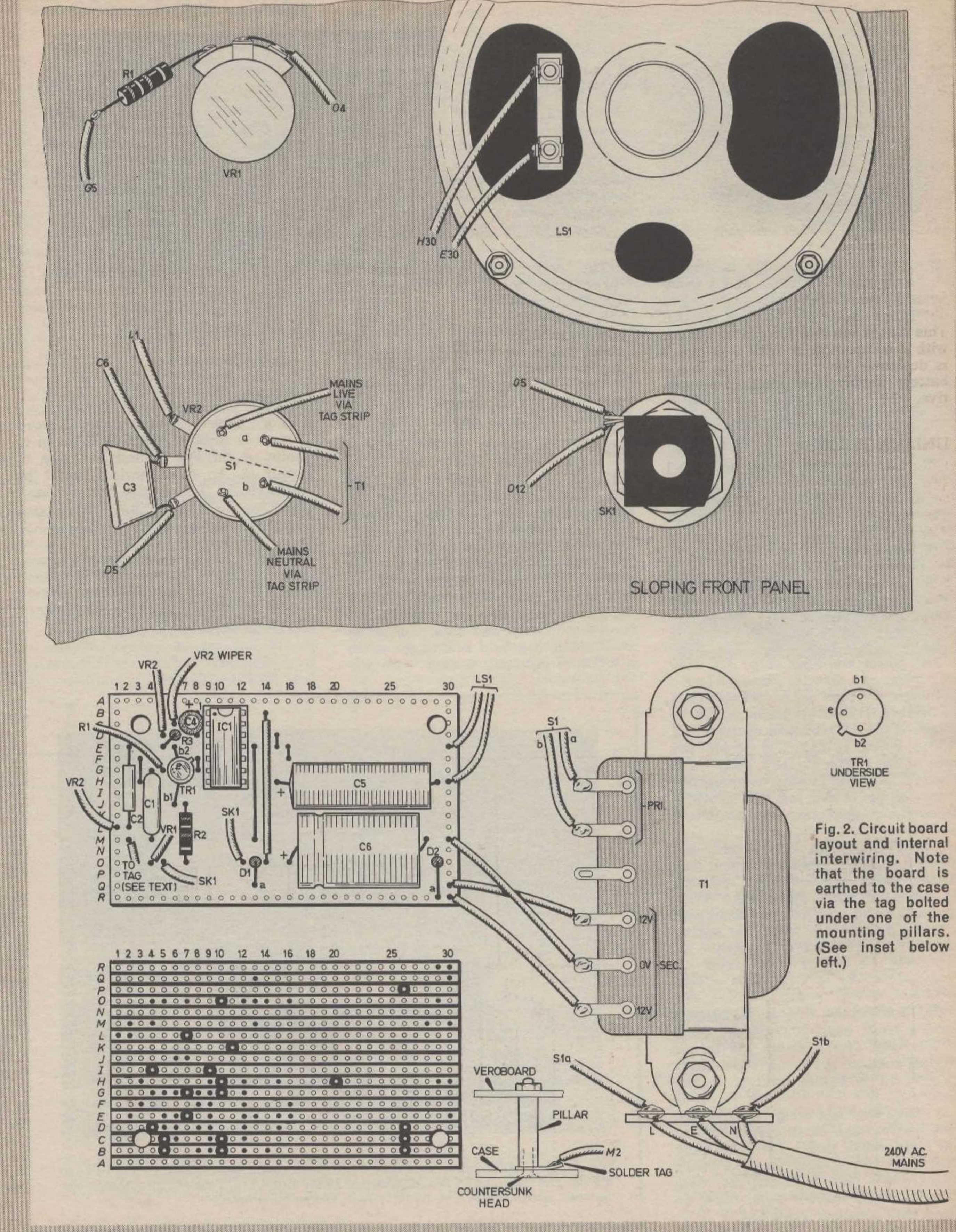



Fig. 2. Circuit board layout and internal interwiring. Note that the board is earthed to the case via the tag bolted under one of the mounting pillars. (See inset below left.)


## CONSTRUCTION starts here

### CIRCUIT BOARD

The majority of components are mounted on a piece of 0·1 inch matrix stripboard, size 18 strips by 30 holes according to the layout in Fig. 2. The breaks are made in the copper strips with either a spot face cutter or a small twist drill. Check that the breaks are clear of fragments and that there are no short circuits between adjacent strips.

The power amplifier chip, IC1, may be soldered directly into place although a 14-pin d.i.l. socket would be preferred. Flexible leads should be attached for the off-board connections.

The board is mounted inside the case with 6BA nuts, bolts and spacers. One bolt is used as an anchor point for the solder tag that provides an earthing connection between board and case.

The other fixing bolt should not provide a short circuit between any copper strips and the case. This can be arranged by breaking the strips round the bolt position and placing an insulating washer between the spacer and the underside of the board.

### CASE

The unit is built into an aluminium sloping front case, 200×150×150mm in size, and Fig. 2 shows the layout and all connections inside. The transformer, T1 is bolted directly to the case.

A three-way tag strip anchors the live, neutral and earth conductors of the main cable, and a three-pin plug with a 1A fuse should be used. Don't forget that any hole in the case through which cables pass, must be fitted with a rubber grommet.

Before commencing assembly, the front panel of the case should be drilled to take the socket, loudspeaker and two variable resistors.

A large cutout is needed for LS1 and this is best achieved using a chassis punch although drilling a ring of small holes to make a cutout and then filing the edges to a smooth finish may work.

Note that the jack socket, SK1, should be an all-plastic type so that neither of its contacts are short-circuited to the case when mounted in position.

Other boxes or cases may be used, either of metal (in which case the case must be earthed), or insulating material. A case could easily be constructed of thin wood.

Setting up is very simple. After checking all aspects of construction thoroughly, plug in a Morse key, turn the unit on and listen. With the key held down, adjust the potentiometers for the required frequency (VR1) and volume (VR2).

### MORSE CODE

Morse code consists of long and short sounds obtained by pressing the key and is written as dashes and dots, with a dash the length of three dots.

However, when learning the code, it should be thought of as a series of "dits" and "dahs" rather than dots and dashes. This is because a sense of rhythm is necessary for sending and receiving Morse and this cannot be achieved if the code is thought of as a series of dots and dashes.

## COMPONENTS

See Shop Talk page 535

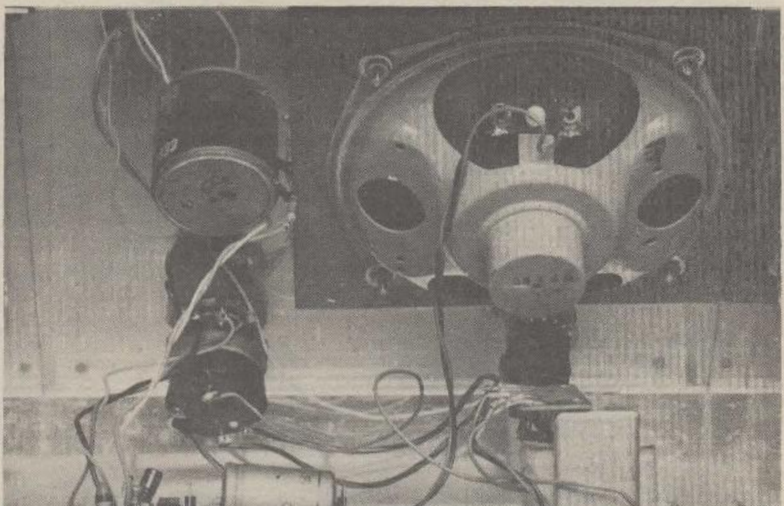
**Resistors**
R1 47kΩ
R2 1·2kΩ
R3 1·2kΩ
All ¼W carbon ±5%

**Potentiometers**
VR1 500kΩ lin. carbon
VR2/S1 5kΩ log. carbon with d.p.d.t. mains switch

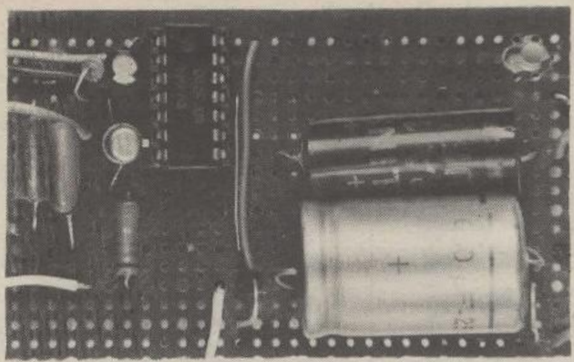
**Capacitors**
C1 10nF C280 polyester
C2 3·3nF polystyrene
C3 390pF polystyrene
C4 1µF 25V elect.
C5 470µF 25V elect.
C6 680µF 40V elect.

**Semiconductors**
TR1 2N2646 unijunction with *n*-type base
IC1 LM380 N-14 audio amplifier i.c.
D1, 2 1N4001 1A, 50V rectifier diodes (2 off)

**Miscellaneous**
T1 mains primary/12-0-12V, 100mA secondary
LS1 loudspeaker, 8 to 50 ohms impedance
SK1 fully-insulated mono jack
Aluminium sloping front case, 200 × 150 × 150mm, H. L. Smith or similar; stripboard, 0·1 inch matrix, 18 strips × 30 holes; knobs (2 off); 3-core mains cable; interconnecting wire; 6BA nuts, bolts and spacers to mount board; solder tag.



Interior view of the completed unit. The circuit board is mounted on the base of the case to the left and the transformer to the right. Front panel components can be seen above these. The panel in fact, slopes backwards.



Top view of the completed circuit board.


Without this rhythm, character recognition when receiving becomes very difficult and your sending style may well become stilted.

The alphabet and numbers are given in Table 1 and can be memorised a few at a time. Always practise by making the sounds with an oscillator, such as the unit described here, rather than trying to write down dots and dashes. It is convenient if two or more persons learn together or you could try to enlist the aid of someone who already knows the code.

A useful solo reading exercise would be to listen to the slow Morse transmissions which are available, or by making tape recordings from the unit.

## LETTER SQUARE

If you are going to make these recordings, it is necessary to adopt random letters, or the memory will fill in too much material. For this purpose, squares such as the one on the right can be constructed and can be read vertically, left to right, right to left and diagonally.

Note that you have to hang the odd letter underneath the square because, of course, there are 26 letters in the alphabet and these won't form a perfect square.

When recording, place the microphone near the loudspeaker and set the input level so that the recorder is not overloaded. After recording for ten minutes or so, play back to

*A typical letter square*

| | | | | |
|---|---|---|---|---|
| A | T | H | E | Q |
| U | I | C | K | B |
| R | O | W | N | F |
| Y | D | G | J | L |
| M | P | Z | S | V |
| | | X | | |

develop your reading skills. It is best to form each letter quickly (though correctly of course) and leave longer spaces between letters. The actual sound will then be more nearly the same as that obtained when working at higher speed.

Table 1

### INTERNATIONAL MORSE CODE

| | | | |
|---|---|---|---|
| A | di-dah | N | dah-dit |
| B | dah-di-di-dit | O | dah-dah-dah |
| C | dah-di-dah-dit | P | di-dah-dah-dit |
| D | dah-di-dit | Q | dah-dah-di-dah |
| E | dit | R | di-dah-dit |
| F | di-di-dah-dit | S | di-di-dit |
| G | dah-dah-dit | T | dah |
| H | di-di-di-dit | U | di-di-dah |
| I | di-dit | V | di-di-di-dah |
| J | di-dah-dah-dah | W | di-dah-dah |
| K | dah-di-dah | X | dah-di-di-dah |
| L | di-dah-di-dit | Y | dah-di-dah-dah |
| M | dah-dah | Z | dah-dah-di-dit |
| 1 | di-dah-dah-dah-dah | 6 | dah-di-di-di-dit |
| 2 | di-di-dah-dah-dah | 7 | dah-dah-di-di-dit |
| 3 | di-di-di-dah-dah | 8 | dah-dah-dah-di-dit |
| 4 | di-di-di-di-dah | 9 | dah-dah-dah-dah-dit |
| 5 | di-di-di-di-dit | 0 | dah-dah-dah-dah-dah |

*Note*
One "dah" should be equal to three "dits" in length
The space between parts of the same letter should be one "dit" in length
The space between characters in a word should be three "dits" in length
The space between words should be two "dahs" in length.

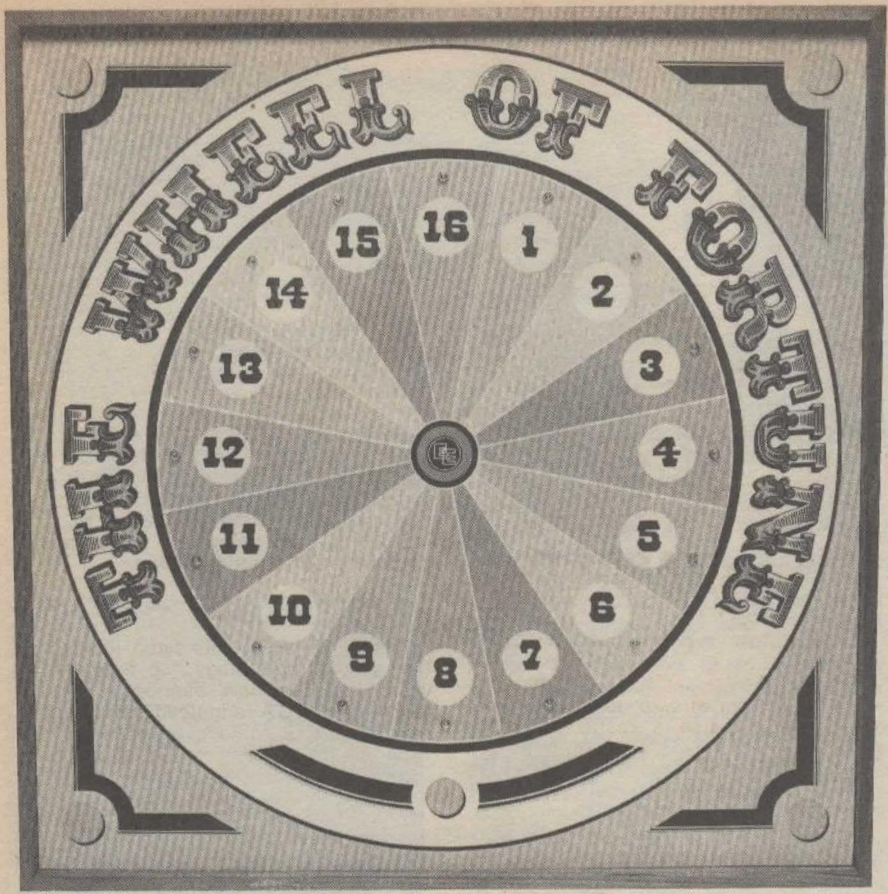
## MORE PRACTICE

It is also easy to make 6 by 6 letter squares, putting in those letters which present the most difficulty twice, or including numbers.

When the code is thoroughly known by this means, it is best to move on to some other means of practising Morse reading, such as listening to the R.S.G.B. Slow Morse transmissions, or joining a reputable amateur radio club.

Sending is generally much easier than reading, and can be practised alone. Have a comfortable desk or table, so that the arm can rest on it, with finders curved over the key.

Practising for short periods several days a week is much better than long periods at wide intervals. It will be found that fluency and speed slowly increase. Once again an amateur radio club will help. ⌑




By C. J. Bowes

The gambling device known as the Wheel of Fortune has been in existence for many years, and is a popular attraction at many garden fêtes and fairs, often in its original form of a wheel fitted with a pointer which is spun and then allowed to come to rest opposite a number of positions around the perimeter, thus indicating the winner.

The mechanical device suffers from the main drawback of being somewhat difficult to read since it often comes to rest between two numbers. Attempts to overcome this electronically have usually suffered from the problem of the devices being somewhat predictable, since they use time delays of various forms which tend to have a fairly constant delay period.

The design described in this article overcomes the former problem by using lights for a display, so arranged that only one can be on at a given time. A random number generator is used to determine the outcome of the display long before it stops. This makes the game completely unpredictable.

## MAINS OR BATTERY

The machine has been designed for use either from an internal mains powered supply when available, or, from 12 volt batteries for use when remote from a mains socket. The d.c. current consumption of the device is approximately 250mA with the specified lamps, thus making its operation from lantern batteries feasible, although a car battery can also be used.

## CIRCUIT DESCRIPTION

The complete circuit is shown in Fig. 1. and for ease of description can be split into the following sections: (1) power supply (2) random number generator (3) display decoder driver circuit.

The power supply is a conventional 12 volt d.c. power supply except for the inclusion of the external d.c. socket SK1 and the position of the smoothing capacitor, C7.

The mains connection is made to a chassis mounted plug so that the mains lead may be removed when the unit is in operation from a battery supply. Mains voltage is first transformed down to 9V a.c. by the mains step-down transformer T1 and is then rectified by the rectifier bridge D1-4 and smoothed by C7 to give 12V d.c. S2 is a double-pole switch arranged so as to act as an on/off switch in either battery driven or mains driven modes.

SK1 is a two-pole switched (normally closed) jack socket which acts as a battery input socket and at the same time disconnects the output of the rectifier bridge from the rest of the circuit when an external battery is plugged in. Capacitor C7 is placed after this socket in order to provide decoupling for the logic circuitry in the battery power option.

## RANDOM NUMBER GENERATOR

The random number generator consists of a source of high speed pulses fed into a counter and read by a latch which is operated by the START switch, S1. When this is released the binary number at its input is latched in and determines the number at which the display will eventually stop.

The counter is deliberately fed with high speed pulses in order to ensure that the number generated is random, with no chance of it being predetermined by the operator.

IC1a is half of a 556 timer (operating as a 555 timer) and is connected in the astable mode to provide pulses at a rate determined by R1, R2 and C1. The values given produce a square wave output at a frequency of approximately 1kHz. These pulses are fed into IC2a, which is half of a 4520 dual binary counter. This counts through the binary numbers for 0 to 15 before returning to 0 again and repeating the process.

The output from the counter is fed to the data inputs of IC3, a quadruple latch in a rather unusual manner. The reason for this is purely to make the manufacture of the printed circuit board easier. This is possible since the object of the circuit is purely to generate a random number and hence an accurate output corresponding to the number generated in the counter is not necessary. In fact this process, and similar connections made later in the circuit for the same reasons, increases the randomness of the result.

There are two control inputs on IC3, $E_0$ and $E_1$, and these are connected so that a falling edge applied to pin 6 causes the data at the inputs to be latched in to appear at the outputs.

As shown, pin 6 is held low by the action of S1a, a normally closed section of the start switch. In this condition the last data present on the data input lines (pins 4, 7, 13 and 14) are held in the latch. When the switch is pressed, the voltage on pin 6 is pulled up to logic 1 by the pull up resistor R3. In this condition the changing data input to the latch appears on the output pins of the device.

When S1 is released S1a closes again and the voltage on pin 6 is

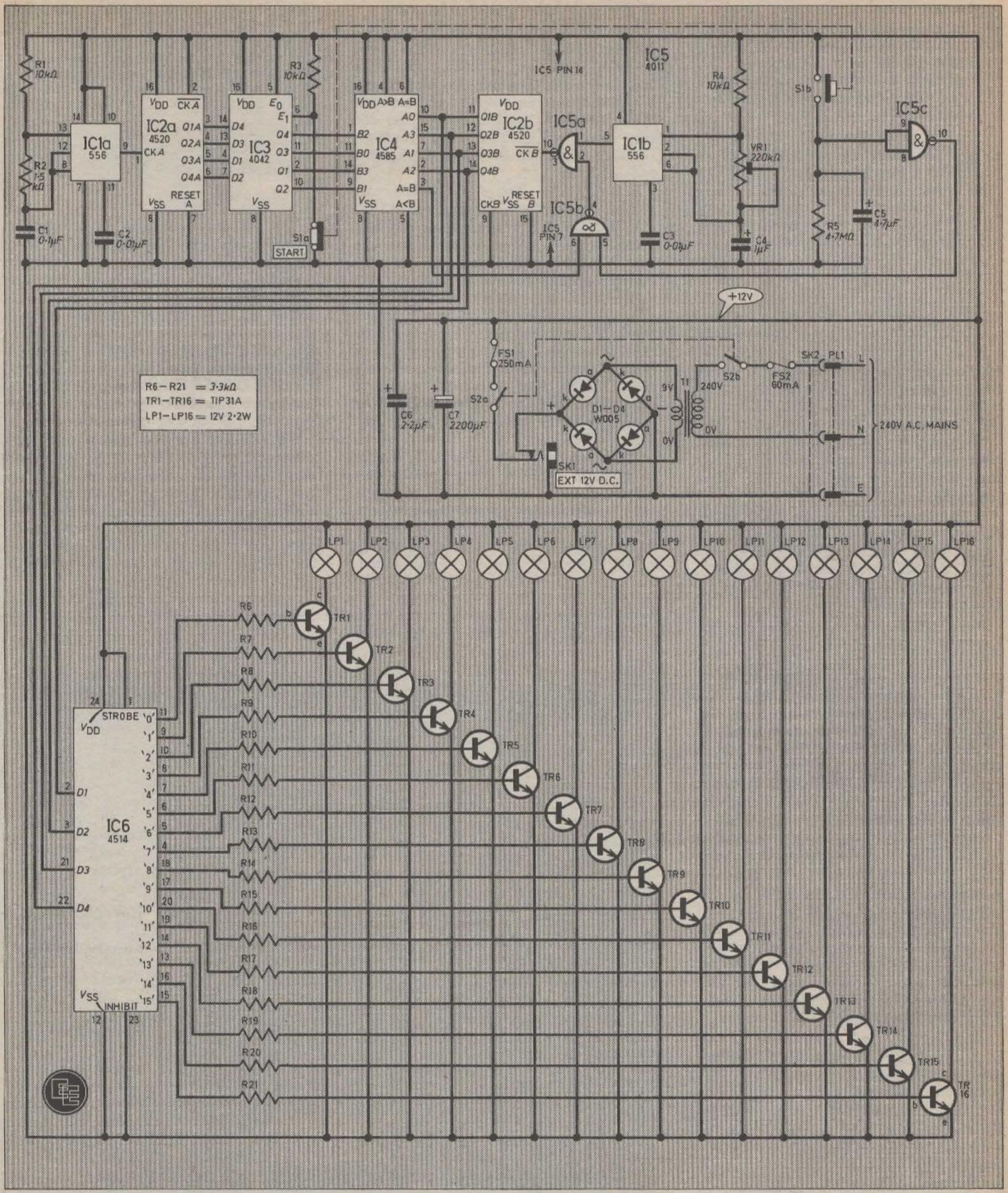



Fig. 1. The complete circuit diagram for the Wheel of Fortune.

returned to logic 0 producing a falling edge. The data presented to the latch by the counter at this instant is then held in the latch to determine the stopping position of the display.

## MAGNITUDE COMPARATOR

This latched information reaches one set of inputs on IC4, a 4-bit magnitude comparator i.c. The other set of inputs to IC4 are derived from a second pulse source and counter, IC1b and IC2b respectively. The output from IC2b is also decoded by IC6 to sequentially switch on the ring of display lamps.

A slow running astable circuit is constructed using the other half of the 556 timer (IC1b) the speed of which is set by R4, VR1 and C4. VR1 is included in order to set the speed at which the display pulses round to a suitable rate.

The output from IC1b reaches one of the two clock inputs to the counter IC2b via a two-input NAND gate IC5a. The other input to this gate determines whether or not the pulses reach the counter. This control signal is derived from a comparator output gated with the output from a simple *RC* timer circuit.

IC4 compares the values of two 4-bit binary numbers and gives outputs showing whether the number on input *A* is larger, smaller or equal to the number on input *B*. In this application the device is wired so that it gives an output when the two numbers are equal, pin 3 provides this. A logical 0 is produced until the numbers are equal where a logical 1 is outputted. This provides one input for IC5b.

In both cases the actual bit position of the numbers inputted to IC4 are wired in a manner which facilitates ease of printed circuit board design, and actually increases the randomness of the final result.

## RC TIMER

The simple timer circuit consists of a resistor-capacitor arrangement, R5 and C5, which is charged up by the closing of the normally open contacts of switch S1b. Whilst the switch is operated the capacitor is charged up to +12V. When the switch is released capacitor C5 begins to discharge through resistor R5.

The output of the circuit is fed to an inverter made up of a two-input NAND gate (IC5c) with its inputs connected together. This gives a logic 0 output while C5 voltage is above 2V and provides a sharp edged output, as opposed to the more gently sloped output of the time delay circuit, when the charge level falls below 2V. The component values shown, give a time delay of approximately 22 seconds.

Thus at the start, just after S1 has been released, the input to IC5b from the timer is at logic 0 with the input from the comparator being at logic 0 for most of the time, changing to logic 1 when the two comparator inputs are equal. Therefore pulses are fed to the counter IC2b for at least 22 seconds. The next logic 1 from IC4 pin 3 after the timer times out (produces a logic 1) inhibits the pulses from being passed on to the counter. This stops the display from being moved on. The display then remains at the position set by the random number generator until S1 is again operated.

## DISPLAY DECODER/DRIVER

The binary coded number generated by the display counter (IC2b) is fed to IC6 which is a 4514, one-of-sixteen decoder. This decodes the binary number from the counter and uses the information to switch one of its sixteen output lines from logic 0 to logic 1 as appropriate to the information fed into it.

Each of the output lines are connected to a driver transistor (TR1-TR16) via a 3·3 kilohm base resistor. The presence of a logic 1 voltage (+12V) causes the transistor to turn on and the associated lamp in the transistor collector line to be lit.

In this part of the circuit it is important that the data lines are connected in the correct sequence and this is facilitated by locating the decoding and driving circuitry on a separate printed circuit board; C6 is placed on this board to provide adequate decoupling.

The display of the device is a ring of sixteen filament lamps which are switched on in sequence in a clockwise pattern around the board for a period of time. The display is merely cosmetic since the position at which it will stop has been predetermined.

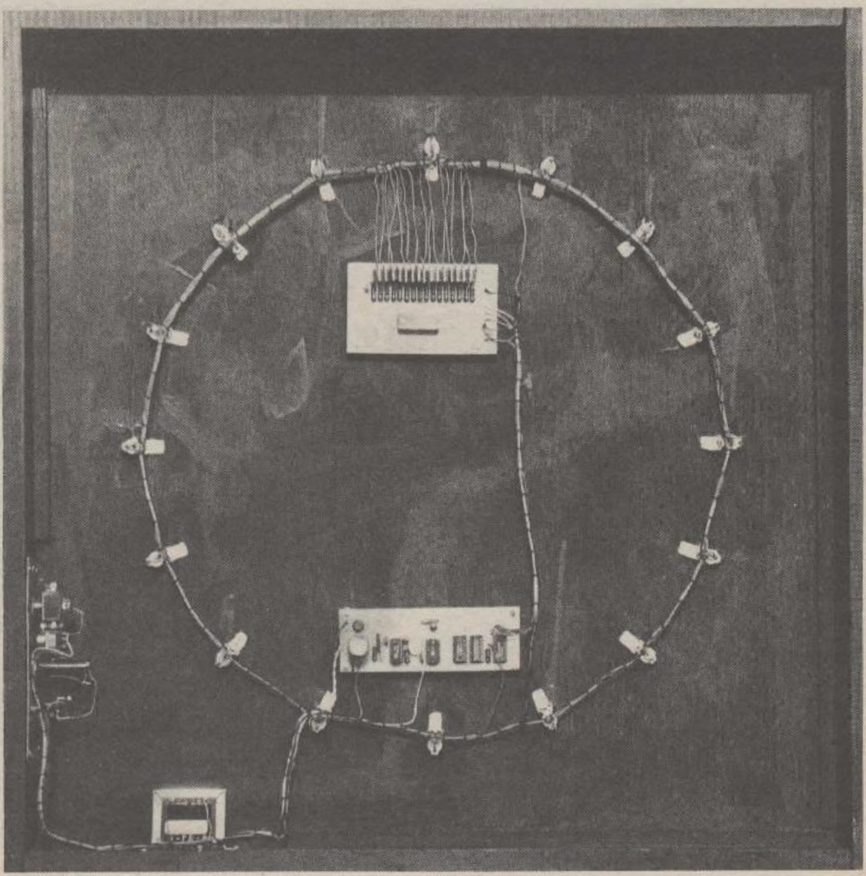
# CONSTRUCTION starts here

## DISPLAY PANEL

The display consists of a square panel containing a circle divided into sixteen segments, each one of which contains a filament lamp (in holder) arranged in a circle. The lamps are wired to the display printed circuit board, which is mounted on the back of the display panel. This is in turn connected to the second p.c.b. containing the logic circuitry. The controls are mounted on a panel inset into the side of the case.

The letters and designs of the display could be painted or applied directly to the display panel after this has been suitably treated, but a better alternative we suggest would be to produce the design on paper or card and glue this to the panel when the unit is complete. In this way the

View into the back of the completed prototype wheel showing looming of all lamp and other wiring in the system. You can see the mains inlet panel sited at bottom left.



# THE WHEEL OF FORTUNE

## COMPONENTS

See Shop Talk page 535

**Resistors**
R1 10kΩ
R2 1·5kΩ
R3 10kΩ
R4 10kΩ
R5 4·7MΩ
R6-R21 3·3kΩ (16 off)
All ¼W carbon film ± 5%

**Capacitors**
C1 0·1μF ceramic disc
C2 0·01μF ceramic disc
C3 0·01μF ceramic disc
C4 1μF 16V tantalum bead
C5 4·7μF 16V tantalum bead
C6 2·2μF 16V tantalum bead
C7 2200μF 16V elect. radial leads

**Semiconductors**
D1-D4 W005 bridge rectifier 1A 50V
TR1-TR16 TIP31A silicon *npn* (16 off)
IC1 NE556 dual timer i.c.
IC2 4520 CMOS dual binary counter
IC3 4042 CMOS Quad *D*-type latch
IC4 4585 CMOS 4-bit comparator
IC5 4011 CMOS Quad 2-input NAND gate
IC6 4514 CMOS 4-to-16 decoder

**Miscellaneous**
LP1-LP16 12V 2·2W m.e.s. bulbs (16 off)
T1 mains primary/9V 0·5A secondary
SK1 standard jack socket with n.c. switched contact
SK2 mains chassis mounting
PL1 to suit SK2
S1 d.p.d.t. miniature momentary action push switch
S2 d.p.s.t. toggle
FS1 250mA 20mm
FS2 60mA 20mm
Single-sided p.c.b. sizes 135 × 53mm and 105 × 69mm; 20mm panel mounting fuseholders (2 off); m.e.s. lampholders and mounting brackets (16 off each); d.i.l. sockets for i.c.s: 24-pin (1 off), 16-pin (3 off), 14-pin (2 off); 4BA fixings for lampholders and p.c.b.s including spacers; aluminium for control panel; wood, sizes to suit.

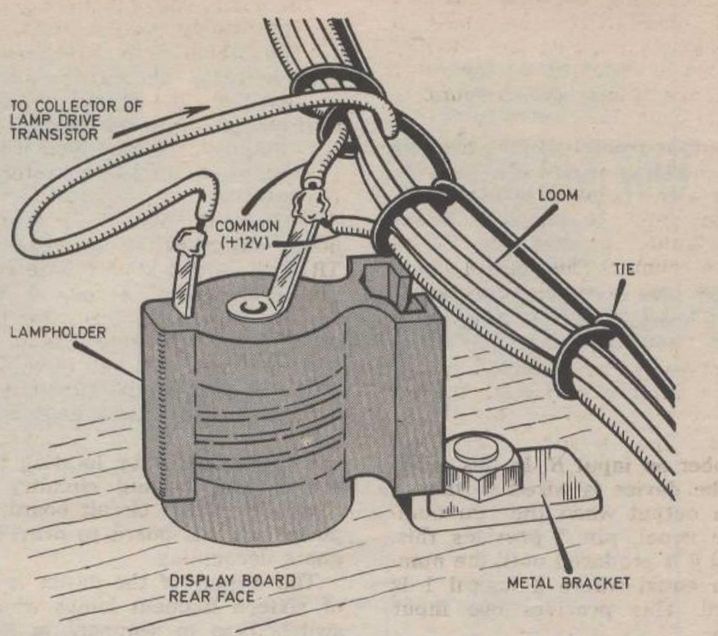



Fig. 2. Details of wiring for a lampholder. This is repeated for all sixteen lampholders. The wire running from these to the display board should take the shortest route through the loom.

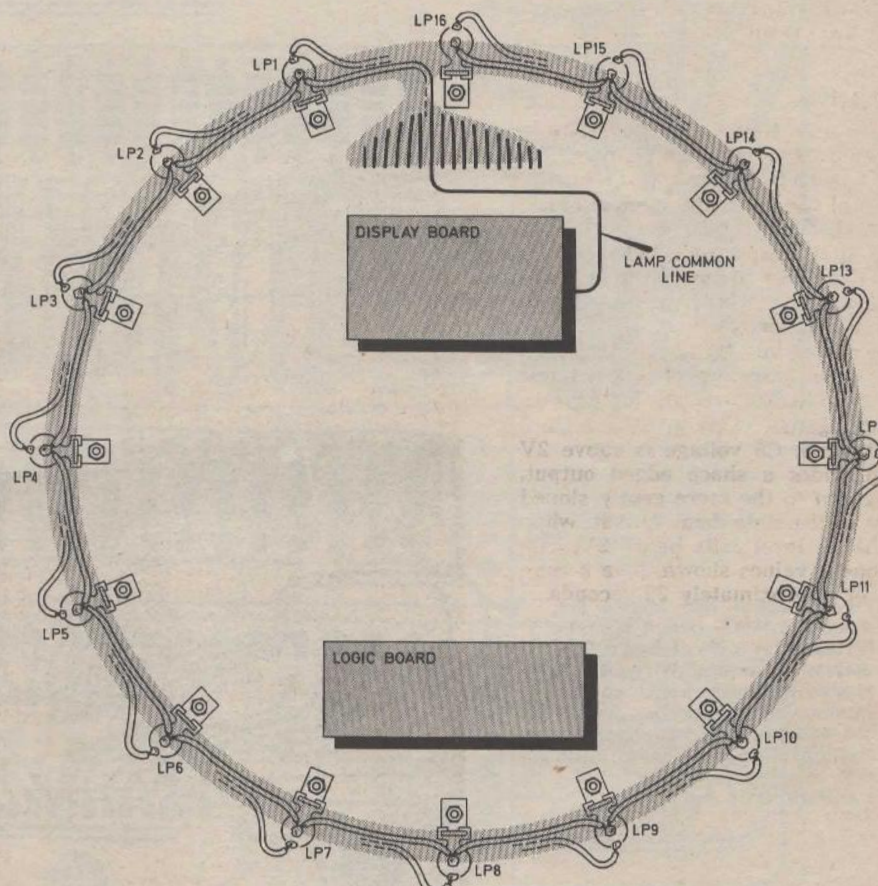
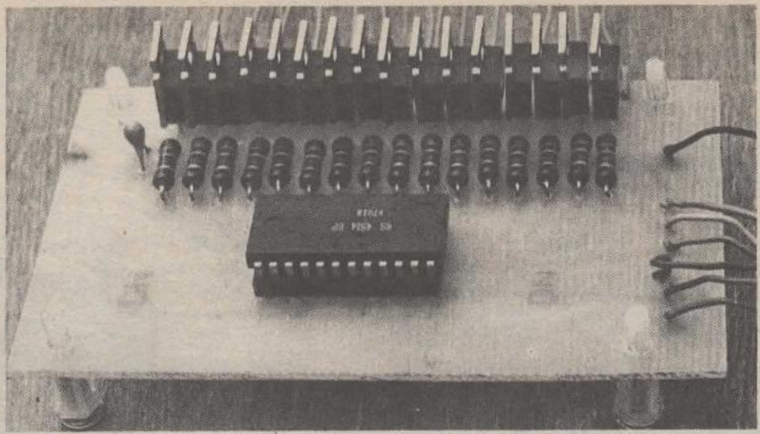
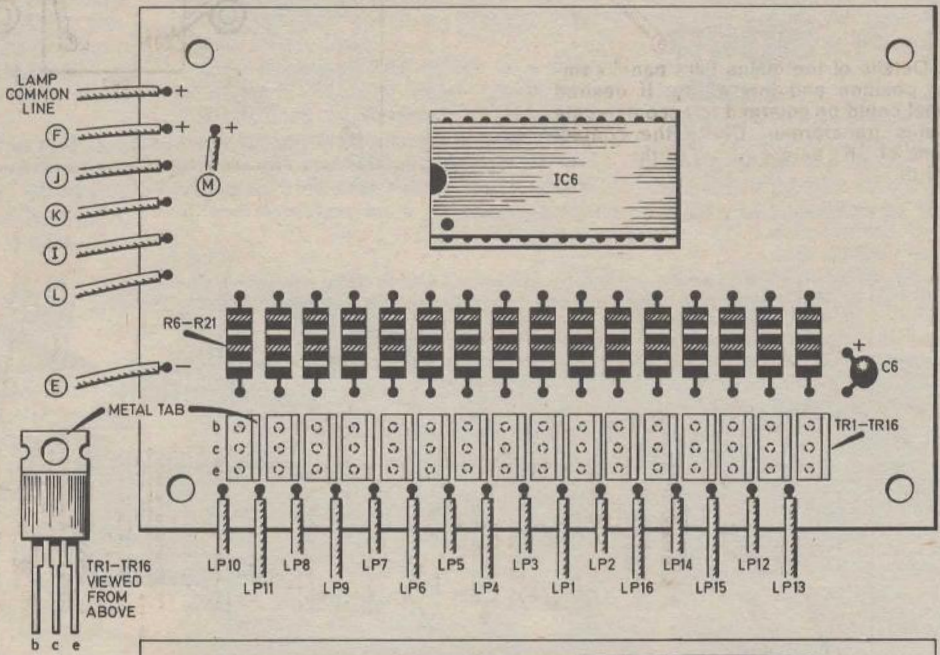



Fig. 3. Arrangement of the lampholders fitted to the display panel. The tinted ring represents the loom shape of all wires connecting to the display board.

# THE WHEEL OF FORTUNE



Close-up view of the display board in position. Note that plastic supports have been used for mounting the board to the panel. This allows easy removal if necessary.



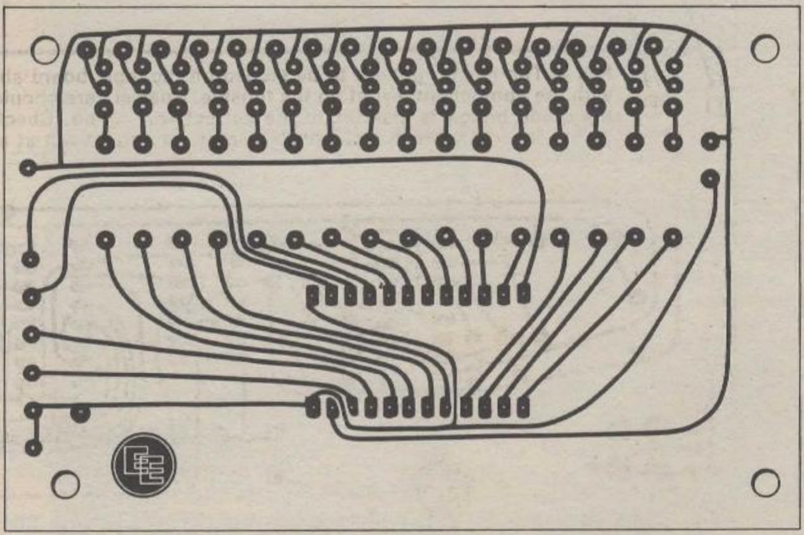



Fig. 4. Lower half shows the master printed circuit pattern (actual size) to be etched on the display driver board. The black areas represent the copper tracks. Upper drawing shows the layout of the components on the topside of this board. Note the orientation of the output transistors, C6 and IC6.

**COMPONENTS**
**approximate cost £28**
excluding cabinet

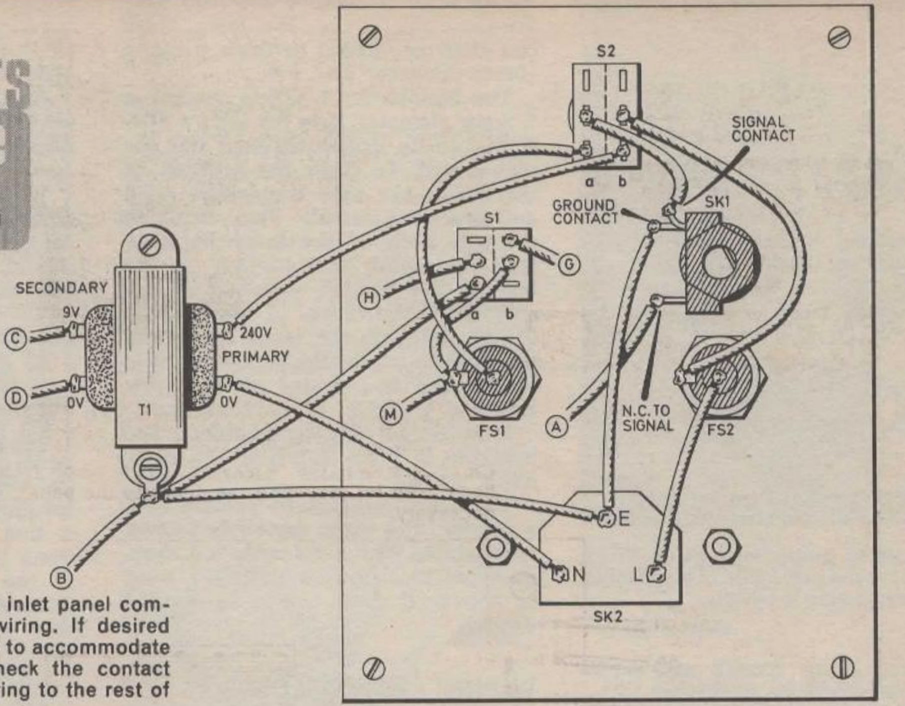



Fig. 6. Details of the mains inlet panel component position and interwiring. If desired the panel could be enlarged to accommodate the mains transformer. Check the contact functions of SK1 before wiring to the rest of the circuitry.

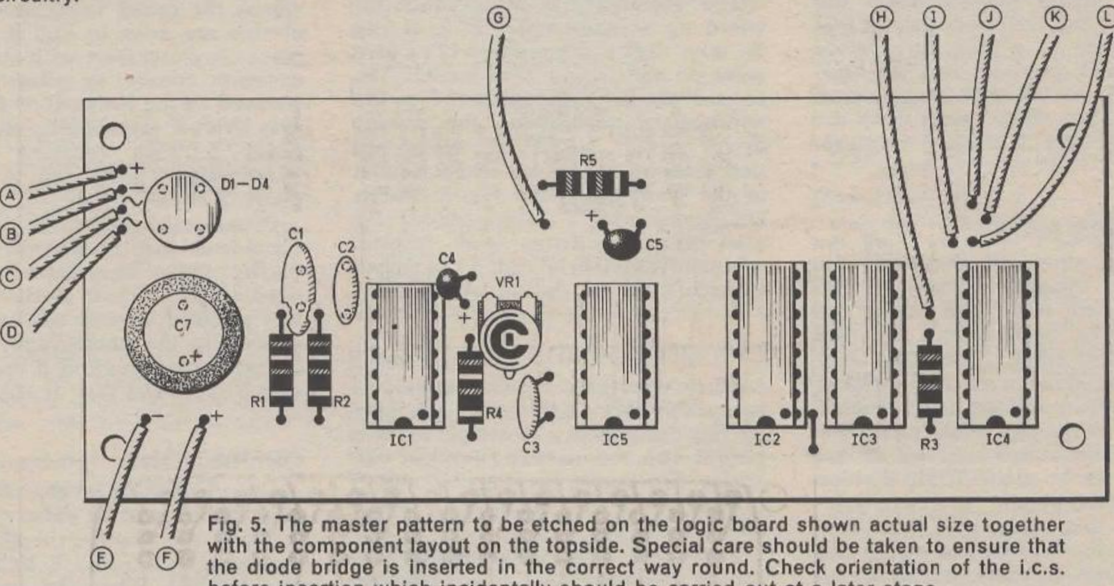
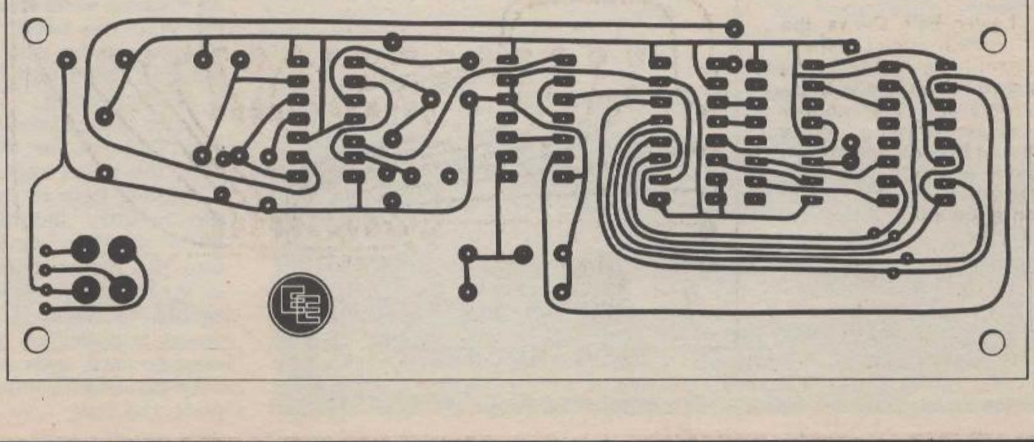
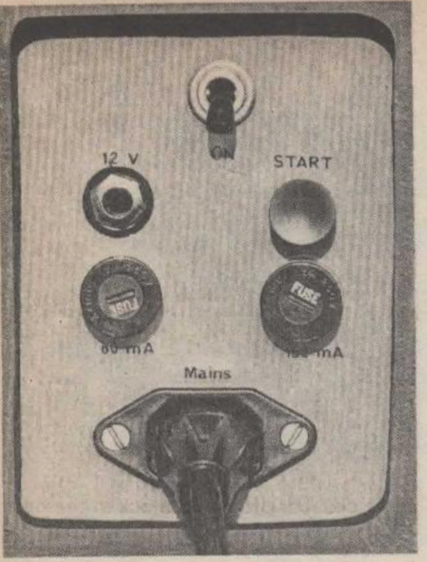



Fig. 5. The master pattern to be etched on the logic board shown actual size together with the component layout on the topside. Special care should be taken to ensure that the diode bridge is inserted in the correct way round. Check orientation of the i.c.s. before insertion which incidentally should be carried out at a later stage.






The completed mains inlet panel fitted beneath a cut-out in the side of the cabinet with the mains plug inserted.

lampholder fixing screws and p.c.b. fixing screws will be concealed.

In the version illustrated on the front cover, the coloured display was on card glued to a 90 x 90cm piece of 6mm thick plywood and the case was made from 150 x 18mm veneered chipboard, but these sizes may be altered to suit individual requirements.

## PREPARING PANEL

Find the centre of the board by joining the opposite corners of the square to each other and taking the centre as the point where the two diagonal lines cross. Using this point as a centre, draw a circle of radius to suit lamp positions from centre. The circle marks the points where the holes for the lamps will be drilled and needs to be divided into sixteen equally spaced points.

To do this place a protractor centred on the intersection of the two diagonal lines to mark off angles of 22·5, 45 and 67·5 degrees in each of the quadrants. Extend each of these angles from the centre until the lines intersect the circle. The lamp holes can then be drilled through using a 10mm diameter drill bit.

The lampholder brackets require a 3·5mm diameter hole (to take a 4BA screw) to be drilled through the display board. To mark the position of this hole make up a lampholder, bulb and bracket assembly. Place the bulb through each of the lamp holes in turn and mark the position of the hole in the bracket where this coincides with the radius to the position of the hole for the lamp. The holes required to mount the p.c.b.s can also be marked and drilled at the same time.

Next fit all the lampholders and brackets in place and also the p.c.b. fixing screws.

The board can then be painted with a primer, and when dry rubbed down and painted with gloss colours, letters, numbers and designs that you want to appear if these are to be applied directly.

## WIRING LAMPHOLDERS

The lampholders should each be wired up as shown in Fig. 2. It can be seen that a common (+12V) wire joins up one tag on each holder. The second tag is to be connected to the appropriate position on the display driver circuit board. All wires are tied to form a circular loom as seen in the photograph and Fig. 3. Different colour wire is recommended for ease of construction and tracing. Alternatively labels can be attached to each free end during wiring up.

## CIRCUIT BOARDS

The electronic construction is reasonably straightforward, with most of the components mounted on two p.c.b.s. The foil patterns for the two p.c.b.s are shown as Figs. 4 and 5 together with the component layout on each topside.

These are single-sided boards and can be produced fairly easily. Because of the close packing of some of the tracks it is best to use either a photographic process or etch resistant transfers and track tape in preference to hand drawing the design with an etch resistant pen.

Because of the use of CMOS devices all the i.c.s except for IC1 should be mounted using sockets. The use of a socket for IC1 is also recommended.

With the exception of the i.c.s the components can be mounted in any convenient order, but the boards should be fully completed, checked for solder bridges and later connected to the rest of the circuitry before the i.c.s are inserted.

## WIRING UP

Lay the two p.c.b.s in situ on the panel and interwire and connect to the ring of lamps according to the information in Figs. 3, 4 and 5. Form a tied loom for interboard connections for neater appearance as seen in the photograph. Connect the remainder of the wires to the boards that are to run to the mains input panel. The boards may now be fastened in position.

The next stage of construction involves the mains inlet panel. Details of this are seen in Fig. 6. This is a piece of aluminium with fixing holes at each corner to allow it to be screwed to the inside face of the case side over a rectangular cut-out. The panel is thus recessed and this affords some protection to the components here.

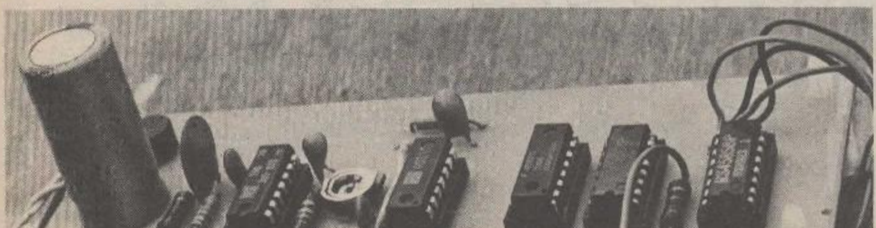
Prepare the panel, fix the components and wire up according to Fig. 6. The mains transformer should be sited close by. and in the prototype was screwed directly to the case side as seen in the photograph. With this complete and checked it may now be wired up to the rest of the circuitry.

## OPERATION

Upon switching on the unit the display should start to pulse round until it reads the number in the random number latch (often 0 lighting position 1, LP1). When the START switch is pressed the display will pulse round at a speed determined by the setting of VR1 for about 22 seconds and will eventually stop at a number, remaining there until the START button is again pressed.

After the device has been tested and VR1 set for the required pulse rate, the panel should be enclosed in a suitable case to prevent damage to the circuitry and to avoid the possibility of stray fingers being poked into the mains driven power supply. A square framework with back panel should be made so that the display panel is recessed. Finally glue the display card artwork in place, suitably varnished for protection, to complete the unit. ⌑

The completed prototype logic board.




**By Dave Barrington**

## Special Offer

Reading the May/June Newsletter put out by J. Bull (Electrical) Ltd., I was reminded that just about one year has elapsed since Mr. Jessie Bull moved his long established business from West Croydon on the southern edge of the London conurbation out to Haywards Heath in the Sussex countryside.

These Newsletters always provide a "good read", being packed with intriguing electrical items generally of a manufacturers' surplus nature. As likely as not there will be listed the kind of electrical equipment required to provide the motive power or muscle for some electronic project featured in EE.

In this latest newsletter the "opening offer" is really something extra-special, and not likely to be repeated. Mr. Jessie Bull informs his readers that he is approaching retirement, and after more than 30 years in the controlling director's chair now wishes to hand over to a younger man. An opportunity that will surely be seized upon by some enterprising fellow, with the requisite capital of course!

These bi-monthly news-sheets are available free to readers (mention EE).

## Project Kits

A piece of news which may be of interest to advertisers and shops is the announcement from the Hobby Products Division of OK Machine & Tool (UK) Ltd., that they are looking for distributors of their range of Electronic Kits.

The kits usually retail for between £5·99 to £8·60 and include such projects as dice, roulette and reaction tester. For further information write to OK Machine & Tool (UK) Ltd., Dept EE, Dutton Lane, Eastleigh, Hants, SO5 4AA.

Another good selection for constructional/educational kits is the excellent range of Chip Shop Kits from Electroni-Kit.

There are twenty kits all told and cover such subjects as a light sensitive switch, transistor tester, lie detector and transistor radio. All projects are transistor based, include loudspeaker, were required, and come with an attractive plastics case for the finished model.

The kits seem excellent value for money and range from £3 to £5. For details of nearest stockists contact Electroni-Kit Ltd., at Dept EE, Rectory Court, Chalvington, Sussex, BN27 3TD.

## TEST PROBE

A multiple tester with l.e.d. and neon indication for checking a.c./d.c. voltages from 4·5V to 415V is one of the many ranges of new Probe Checkers from Steinel K.G.

The Hobby Check will indicate a.c. voltages in three steps, 110V, 240V and 415V, via three neons inset in the indicating handle probe. The direct current polarity indication is by two l.e.d.s, only one illuminating to indicate the polarity at the handle tip. Alternating current is present when both l.e.d.s appear to be on.

Information on the complete range of Probe Checkers can be obtained from Steinel K.G., Dept EE, Unit 9, Armoury Road, Trading Estate, Small Heath, Birmingham B11.

Hobby Check from Steinel K.G.

## Best Seller

It must be very gratifying to component suppliers when orders for their catalogues pour in. But should stocks become exhausted before a new batch can be obtained from the printer, delight must change to chagrin if it becomes necessary to return money to would-be purchasers. This is the predicament Marshalls found themselves in recently. However, June Marshall informs us that a new supply of catalogues is now in their hands and she would like us to pass on her company's apologies to any temporarily disappointed customers.

## Closing the Door

Things happen suddenly in business. We were just examining a new summer edition of the Doram catalogue when the news reached us that the Dutch owners of Doram Electronics have decided to close down this UK based firm. It is a sad end to a business originally set up by Electrocomponents, the parent company of RS Components Ltd., to cater for the hobbyist.

Manager Mike Hutchinson tells us that enquiries about outstanding orders should be addressed directly to Doram Electronics Ltd., De Boer Elektronika, Kleine Berg 41, Eindhoven, Holland, 5611 JS.

## CONSTRUCTIONAL PROJECTS

### Simple pH Meter

Problems may be encountered when trying to locate a supplier for the NE536 i.c. in the *pH Meter* although it is available through any stockist of Mullard products. Pin for pin equivalents are the CA3140T or the LF356T although these have not been tried in the prototype.

Perhaps of more importance is the probe. Readers who are associated with Educational establishments should be able to obtain a suitable item from the equipment suppliers Griffin and George. However this is a strictly trade-only company and do not supply direct to the public.

Other sources of supply are Hogg Laboratory Supplies, Sloane St, Birmingham, B1 3BW, who have a suitable probe priced £21 including postage and packing. This company hopes to have some cheaper probes in stock in the near future.

There is also Castle Laboratories, 7 Guest Rd, Barnsley, S. Yorks, S75 2SR, who can supply probes that have passed their recommended shelf life for £6·75. They also have a "no-quibble" replacement guarantee.

### Metronome

Few difficulties should be encountered when ordering components for the *CMOS Metronome*. Virtually any loudspeaker of suitable size can be used so long as its impedance is not less than about 35 ohms. The case used in the prototype was a Bimbox type 2005/15 made by Boss Industrial Moulding Ltd and available from most component suppliers, although virtually any small plastics box will do just as well.

### Door Alarm

Two items may cause a few problems with the *Door Alarm*. The key switch is one although a suitable item is available from Maplin, order number FH40T. The other item is the bleeper. In fact any solid-state 6V warning device will do here although many of these devices are not particularly loud and perhaps would not be much good as an alarm. Marshalls sell a 6V buzzer which they claim has a "very loud note" although in our prototype we fitted a buzzer from Tandy, type number 273 049.

### L.E.D. Sandglass

It is expected that the three-position slide switch in the *L.E.D. Sandglass* will be difficult to locate. Constructors may obtain this from T. Powell. See their advertisement for full address. The remainder of the components should be readily available.

### Wheel of Fortune

No buying problems are envisaged for the *Wheel of Fortune*. The mains transformer fitted in the prototype had a secondary rating of 500mA but any rating down to 250mA will be suitable. Resistors, capacitors, bridge rectifier and transistors should be in strict accordance with the parts list otherwise they may not fit the p.c.b.s.

### Morse Practise Oscillator

Any one of a number of morse keys can be used in the *Morse Practise Oscillator* and several advertisers such as Home Radio, Watford, and Maplin carry stocks.

# DISCRETE SEMICONDUCTORS EXPLAINED

## PART THREE BY J.B. DANCE

THIS MONTH we will discuss other devices containing *pn* junctions together with heat and voltage sensitive devices.

### THE UNIJUNCTION DEVICE

The **unijunction transistor** (sometimes known as the **double base diode**) has the structure shown in Fig. 3.1. A bar of lightly doped *n*-type silicon has base connections at each end and part of the way along this bar, nearer to base 2 than to base 1, a pellet of *p*-type silicon is used to form a rectifying contact. This electrode is known as the emitter and forms the single junction from which the device derives its name.

The circuit symbol for a unijunction device is shown in Fig. 3.2. It is also possible to obtain unijuction devices with the opposite polarity to that shown in Fig. 3.1 (although they are not so common). In this case the silicon bar is of *p*-type material and the emitter pellet of *n*-type. The symbol for the complementary devices has the arrow pointing in the opposite direction to that shown in Fig. 3.2. This discussion relates to devices with the Fig. 3.1 polarity.

The action of the unijunction transistor is illustrated in Fig. 3.3. The bar of silicon is equivalent to the resistors *R2* and *R1* in series so that when a voltage of $V_{BB}$ is applied between the two bases, the potential at point *A* becomes equal to $R1/(R1+R2)$ times $V_{BB}$. The factor $R1/(R1+R2)$ is known as the **intrinsic stand-off ratio** $\eta$.

When the potential applied to the emitter is less than $\eta \times V_{BB}$ no conduction occurs in the emitter circuit, since the junction is reverse biased. As the emitter potential increases above this value, however, conduction occurs and the device is rapidly switched on.

When the junction conducts, holes are injected from the emitter into the silicon bar and move towards base 1.

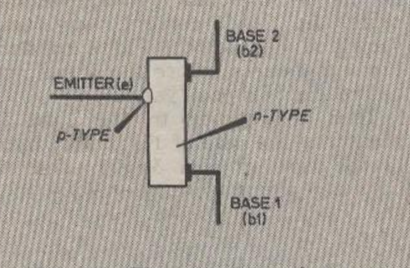



Fig. 3.1. The structure of a unijunction transistor.

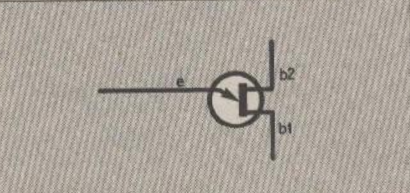



Fig. 3.2. Symbol for a unijunction transistor.

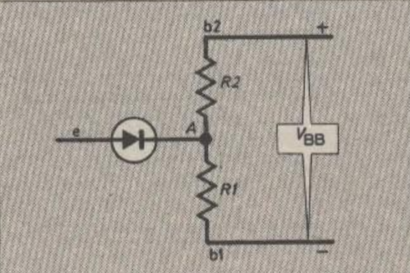



Fig. 3.3. Equivalent circuit for a unijunction device.

Electrons are injected from base 1 to maintain neutrality. There are now plenty of charge carriers in this region and the resistance falls very rapidly between base 1 and the emitter. This causes a large drop in the effective resistance *R1* of Fig. 3.3 and hence a fall in the potential at point *A*. This in turn gives rise to more emitter current and switching by this positive feedback effect.

### PRACTICAL OSCILLATOR

Unijunction transistors enable the very simple type of relaxation oscillator shown in Fig. 3.4 to be constructed. This is the basis of most unijunction oscillator and timer circuits.

The capacitor *C1* charges through *R1* until the emitter potential is adequate to cause the unijunction device to be switched to conduction *C1* then discharges through the emitter circuit and R3 until conduction ceases.

The frequency of oscillation is determined mainly by the product of *C1* and *R1* and can be up to about 100kHz. Positive going output pulses can be obtained from across *R3* which are suitable for firing a thyristor device.

If the value of *R1* is too low, it will pass enough current to keep the circuit conducting so that it will not switch back to the off state. Similarly, the value of *R1* must not be too high or the unijunction will not be switched to conduction.

### WIPER CONTROL

A practical application for a unijunction oscillator circuit shown in Fig. 3.5 is for a delayed, single sweep car windscreen wiper control. The ON/OFF switch S1 ganged with the potentiometer enables firing pulses to be fed to (D2) a C122D thyristor at intervals between about 1 second (determined by R1) and 1 minute (determined by the setting of VR1). This closes the relay and the relay contacts are used to cause the wiper motor to operate. The self-parking switch then closes, the C122D conduction ceases and the wipers park at the end of their single sweep.

The exact connections depend on the type of wiper motor, but VR1 can be adjusted to suit all weather conditions and to automatically keep the windscreen clear without the wiper blades scraping on a nearly dry windscreen.

## THE THYRISTOR

The **thyristor** or **silicon controlled rectifier** (s.c.r.) is a *pnpn* device as shown in Fig. 3.6. When a firing pulse is fed to the **gate** circuit, this initiates conduction from the **anode** to **cathode**. Conduction in the main anode-to-cathode circuit continues until the anode-to-cathode current falls below a certain minimum value (known as the **holding current**) required to maintain conduction.

The thyristor then remains nonconducting until a further firing pulse is applied to its gate electrode. Thyristors are widely used in series with a load across an alternating current mains supply, as shown in Fig. 3.7, since gate pulses can then be used to fire the thyristor into conduction at a desired point in the mains cycle. Switching to the off state is automatic as the alternating waveform from the mains passes through its zero voltage point.

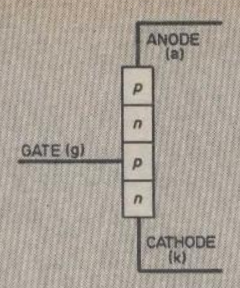


Fig. 3.6. The structure of a thyristor.

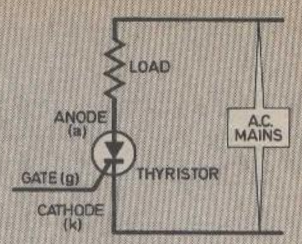


Fig. 3.7. Basic circuit for a.c. power control in a load using a thyristor.

## ALTERNATING WAVEFORM

In Fig. 3.8 we see the alternating mains waveform. If pulses are applied to the thyristor gate electrode of Fig. 3.7 each time the positive half cycles of Fig. 3.8(a) reach their peak, the current in the load will have the waveform shown in Fig. 3.8(b). The current flows in the load only during the part of each positive half cycle after the peak voltage is reached.

If the gate triggering pulses are now applied somewhat earlier in each of the positive half cycles, one obtains the load current waveform shown in Fig. 3.8(c), where conduction commences before the waveform has reached its peak value.

Thus the power to the load is greater in the case of Fig. 3.8(c) than in the case of Fig. 3.8(b). Thus a thyristor circuit can be used to control the amount of power supplied to an electric motor.

The thyristor chosen for use in the type of circuit shown in Fig. 3.7 must have a breakover voltage high enough to prevent the device from switching to conduction under the applied anode-to-cathode voltage when no gate pulse is being fed to the device. Thus the breakover voltage of the selected thyristor should exceed the peak value of the alternating mains voltage ($\sqrt{2}$ times the r.m.s. value).

Some types of thyristor can be turned off by suitable pulses applied to their gate electrodes. The silicon controlled switch is similar to the thyristor except that there are two gate electrodes, one gate being connected to each of the inner layers of the structure shown in Fig. 3.6.

## THE TRIAC

The thyristor will conduct only in the one direction in which the conventional current passes from the

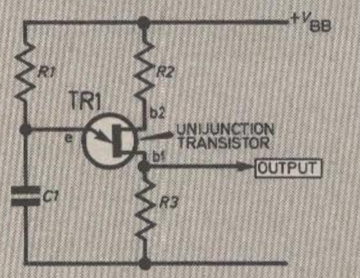


Fig. 3.4. A unijunction relaxation oscillator circuit.

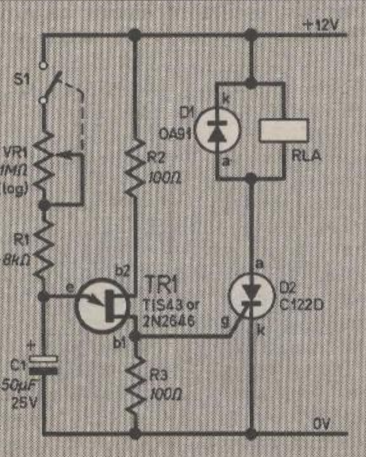


Fig. 3.5. Windscreen-wiper control circuit using a unijunction device.

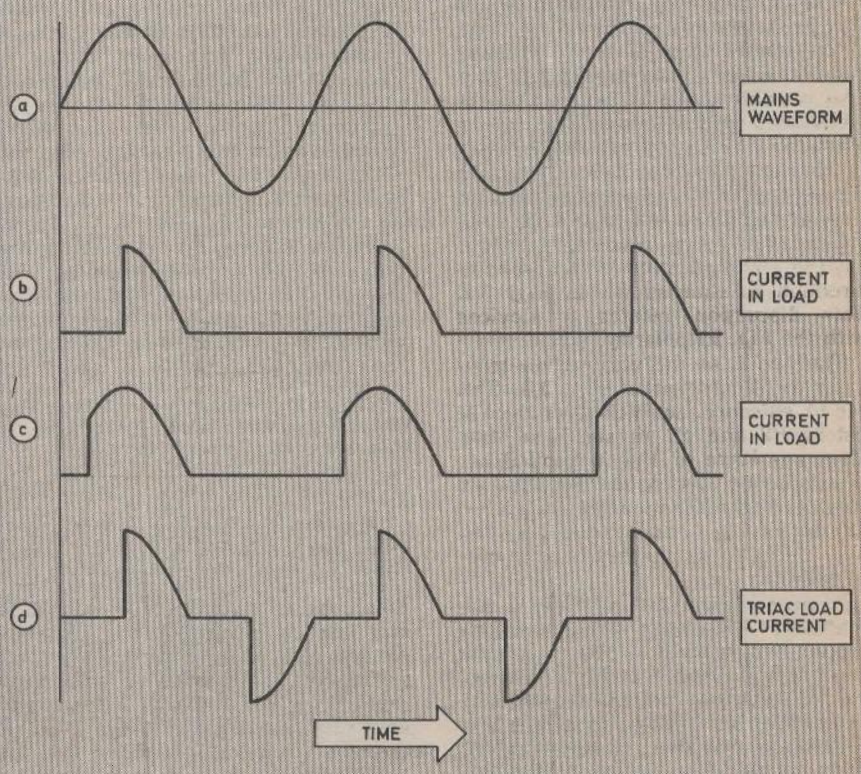


Fig. 3.8. Load current and mains waveforms in thyristor and triac control circuits.

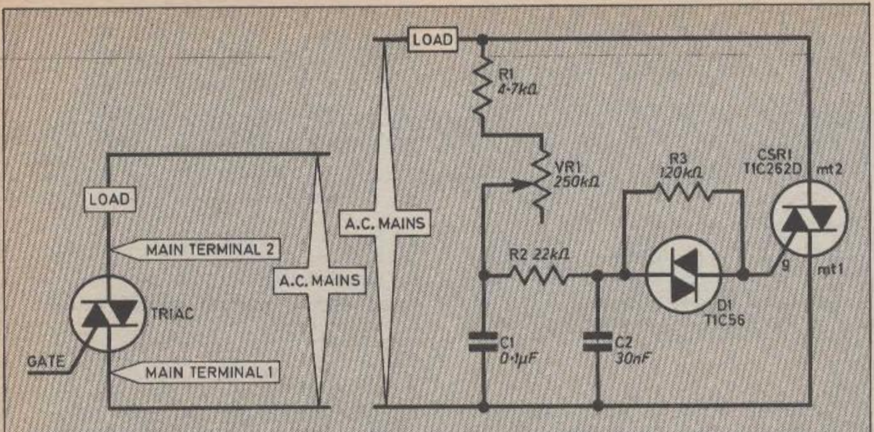



Fig. 3.9. Basic circuit for a.c. power control in a load using a triac.

Fig. 3.10. Power control using a diac to control a triac

anode to the cathode. It is obvious from Figs. 3.8(b) and 3.8(c) that the use of a thyristor in series with a load across the a c. mains will greatly reduce the maximum power in the load. Even if the current flows for the maximum time of each full positive half cycle, the power will be reduced to one half of what it would be without the thyristor.

One solution to this problem is to employ two separate thyristors, one of which conducts during each alternate half cycle of the mains supply. However, it is usually more convenient to employ a device known as a **triac.** This is very similar in operation to a thyristor, but can conduct in either direction. The circuit symbol for a triac is shown in Fig. 3.9. It is a *pnpn* device like a thyristor. Conduction is initiated by means of a pulse to the gate electrode and the device then continues to conduct until the current falls below the holding current for the particular triac concerned. Fig 3.8(d) shows the waveform of the load current in the triac circuit Fig. 3.9 when the gate pulse is applied each time the half cycle of the mains supply voltage reaches its peak.

Apart from the gate, the electrodes of the triac are the **Main Terminal 1** and the **Main Terminal 2** which are abbreviated mt1 and mt2 respectively. Triacs can be turned on by gate pulses of either polarity.

## THE DIAC

A practical circuit designed by Texas Instruments for controlling the power developed in a load is shown in Fig. 3.10. Apart from the triac, this circuit employs a small *pnpn* device known as a **diac.** The diac automatically switches to conduction when the voltage across it becomes greater than a certain value known as the breakover voltage for the device concerned. The circuit in Fig. 3.10 is suitable for resistive but not for inductive loads, since in the latter type of load the current and voltage are out of phase in the load.

The resistor-capacitor network in the circuit of Fig. 3.10 ensures that smooth control can be obtained at all angles of phase delay. However, R2, R3 and C2 can be omitted and the left hand side of the diac connected to the junction of VR1 and C1.

## THERMISTORS

**Thermistors** are rods, discs, beads or a similar block of a semiconductor material with two leads attached. The material is made by sintering certain mixtures of **metallic oxides** (such as nickel, cobalt, iron, manganese), so the material is very different from previous semiconductors.

The resistance of a thermistor changes with temperature. The resistance of most thermistors falls rapidly with increasing temperature, but **positive temperature coefficient types** known as p.t.c. thermistors are also available whose resistance increases with increasing temperature.

Thermistors can be used in the **externally heated mode** in which they sense the temperature of their environment and provide an appropriate electrical signal. For example, they can be used in circuits to provide a warning when the external temperature falls below freezing point or some other value.

In other applications they are **self-heated.** For example, they may be connected in series with a tungsten filament lamp to prevent the initially high peak current which can cause lamp failure. When the circuit is switched on, the thermistor is at room temperature and has a relatively high resistance. However, the current flowing through the lamp and the thermistor warms the latter and its resistance falls to a small value so that the lamp reaches it full brilliance within a short time.

Thermistors are also used in the self-heating mode in much more complex equipment to provide a delayed turn-on of the power. They have the advantages of being small, simple, reliable and rugged and are available with resistances of less than one ohm up to about one hundred megohm.

The variation of resistance with temperature may be expressed as the ratio of the resistance of the thermistor at 0 degrees Celsius to that at 50 degrees Celsius, but for thermistors intended for use in the self-heating mode, it is often convenient to specify the performance as the resistance at 25 degrees Celsius and the resistance when carrying a certain current at a specified ambient temperature.

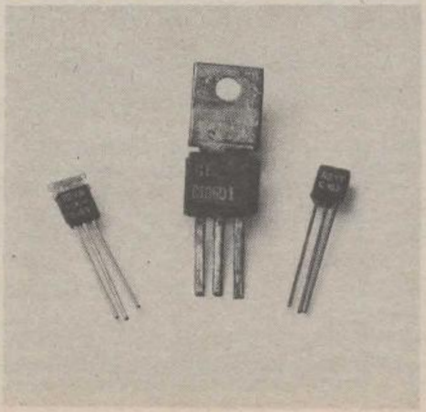
## RESISTANCE

The resistance of a thermistor, $R$, is an exponential function of temperature and is given by the equation:

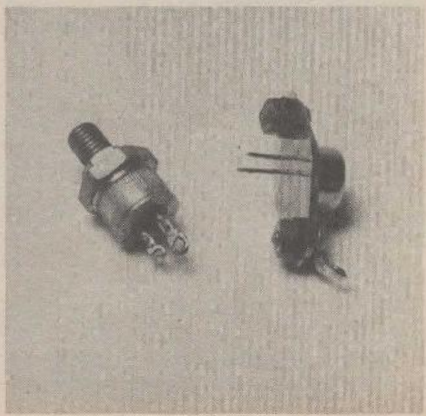
$$R = Ae^{bT}$$

where $A$ and $b$ are constants, e is the natural number 2·718 and $T$ is the absolute temperature. In practice this means that the resistance can change by about 6 per cent for each degree Celsius change at room temperature. For comparison, one may mention that the resistance of plati-

Plastic packaged thyristors and triac. The device in the centre is a 4A power thyristor and to the left is a low power triac.



Power thyristors. On the left is a stud mounting type. The one on the right is mounted like a power transistor



num changes by only 0·36 per cent per degree Celsius.

Thus thermistors can be used to provide large output changes when the temperature alters. Thermistors may be used at temperatures from a few degrees above the absolute zero up to about 300 degrees.

Positive temperature coefficient thermistors are used in warning and trip circuits for detecting excessive temperature rises in industrial equipment, such as electric motors.

## TRANSIENT SUPPRESSORS

Large transient voltages of very short duration (microseconds) appear on electrical power lines, on telephone lines, and so on. They arise in various ways such as atmospheric electrical discharges and the switching of inductive loads. Transient peaks of 1kV can occur on 240V domestic mains supplies, smaller transients occurring more frequently than the larger ones.

The effects of such transients range from "clicks" in audio equipment to the faulty operation of computers. Large transients can damage semi-

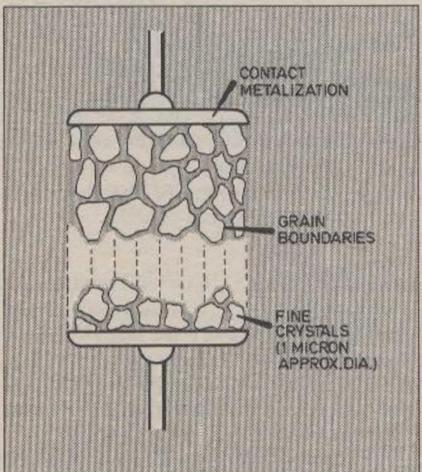
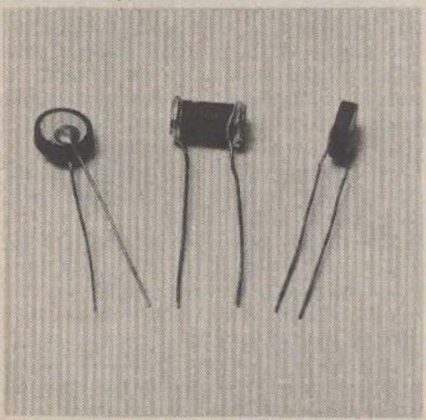



Fig. 3.11. Structure of a zinc oxide Varistor.

**Rod and disc thermistors. A rod type is shown in the centre and two views of the same disc type are shown on either side.**



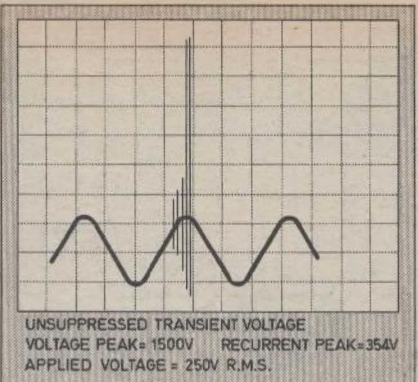



Fig. 3.12. Transient pulses on a waveform.

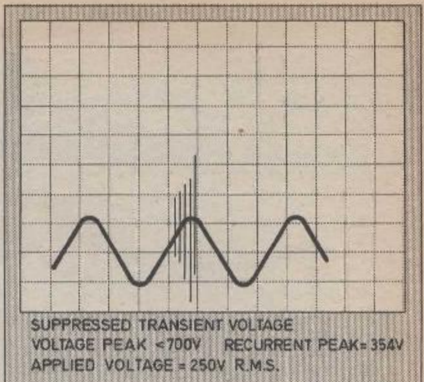



Fig. 3.13. Transient pulses after suppression.

conductor devices because their ratings are exceeded for a very short time.

Most of the large semiconductor manufacturers produce transient suppression semiconductor devices. One type of suppressor is the well-known **Varistor** which has a resistance which falls rapidly with increasing voltage. Such a device can be soldered across the line to be protected and will short-circuit any transient voltage peaks whilst leaving the normal wanted voltages unaffected.

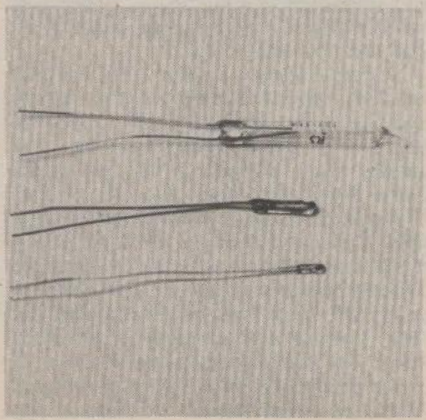
Another type of widely used device is a specially designed Zener diode which will break down in the presence of an over-voltage and thus short it out. No matter which type of device is to be used, it is vital that it acts very quickly before equipment can be damaged.

The non-linear current-voltage relationship in a Varistor may be expressed in the form:

$$I=KV^{a}$$

where $I$ is the current, $V$ is the voltage and $K$ and a are constants. In the case of a metal, a resistor or other material obeying Ohm's Law, a=1, but in Varistors the higher the value of a, the better the transient limiting.

**Glass bead thermistors. At the top is the popular RA53 type, and below that is a miniature and then subminiature type.**



Silicon carbide "Metrosil" devices have values of a of about 4 to 5, some selenium devices have values of about a=10, whilst zinc oxide Varistors and Zener diodes have values for a of at least 30.

## ZINC OXIDE

International General Electric of the USA introduced a range of **zinc oxide varistors** some years ago and in 1978 introduced their improved GE-MOV II range, while International Rectifier produced their "Zenamic" range and somewhat similar products are available from Iskra, Matsushita, Siemens and Thomson-CSF.

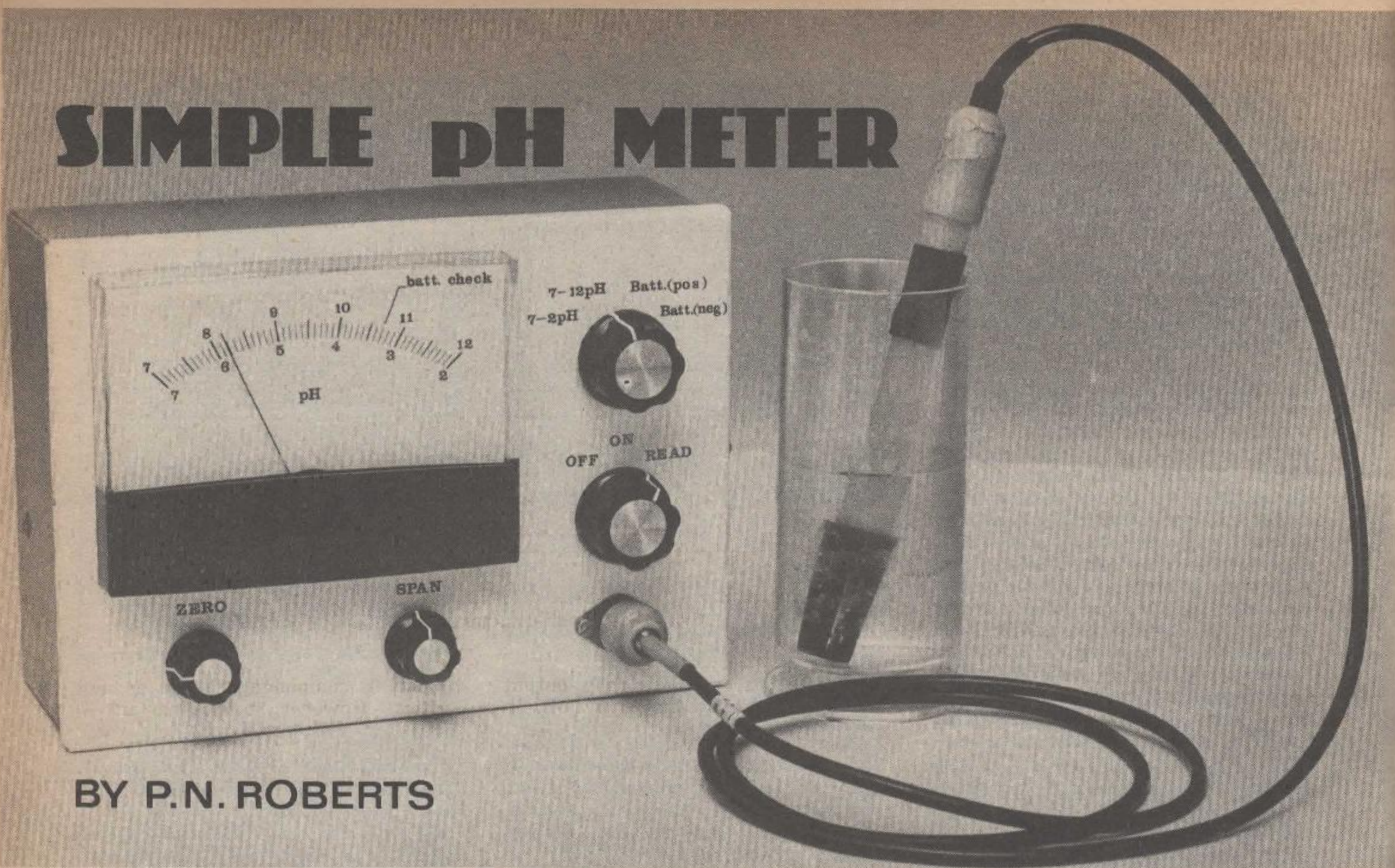
As shown in Fig. 3.11, a zinc oxide Varistor contains small crystals of this material between two parallel plates. The high resistance at the surfaces of the grain boundaries results in a voltage drop of some 3V across each grain, the properties of the devices being due to charge tunnelling through the grain boundaries.

Fig. 3.12 shows transient voltages on a line and Fig. 3.13 the same voltages after suppression by a zinc oxide Varistor. Each type of Varistor will suppress only those transients which have a high enough voltage to render the device resistance relatively low. It follows that a device designed for 240V a.c. mains suppression will not provide good suppression on, say, 150V a.c. lines. Siemens offer devices for use at normal operating ranges of 14V to 1000V r.m.s. or 18V to 1465V d.c., time for operations, 25ns.

In addition to voltage rating, a zinc oxide Varistor should be chosen so that it can absorb the transient peak energy. The volume of a Varistor determines its energy rating and the current rating is determined by the area of its disc. International General Electric offer devices with energy ratings from 0·13J to 600J with peak current ratings of 40A and 25kA respectively.

**Next month: Optoelectronics**

# SIMPLE pH METER




BY P.N. ROBERTS

THE INSTRUMENT to be described was originally designed for use in determining the alkalinity of photographic colour developers and, although somewhat rudimentary, it has proved more than adequate for this task. As such, it offers a simple means of more generalised pH measurements for those readers who are now taking an active interest in electrochemistry.

## THE MEASUREMENT OF pH

Before describing the instrument, a simple explanation of the term "pH" and how it is defined will clarify the principles by pH measurement.

As the result of the phenomenon known as dissociation, all solutions contain a certain equilibrium ratio of hydrogen ions ($H^+$) and hydroxyl ions ($OH^-$). The product of the hydrogen ion concentration and the hydroxyl ion concentration is always the same.

In an acid solution there are more hydrogen ions than hydroxyl ions. The degree of acidity can therefore be defined in terms of the hydrogen ion content of the solution.

The value of acidity, that is the pH, is expressed as:

$$pH = -\log_{10}(H^+)$$

where ($H^+$) represents the hydrogen ion concentration in gram-ions per litre of solution.

As pure water contains $10^{-7}$ gram-ions/litre, it can be seen that the pH of pure water is 7·0. If the pH is less than 7·0, the solution is acidic. Conversely, values greater than 7·0 indicate an alkaline solution. It should be noted that the pH of a given solution can be very dependent upon temperature.

## PROBES

The theory behind the operation and design of the various types of pH probe is a science in its own right but in simple terms it can be regarded as a voltage cell with the solution under test acting as the electrolyte. The voltage output and the polarity will be dependent upon the hydrogen ion concentration, that is the acidity of the solution under test.

Unfortunately, unlike the normal electric cell or battery, the probe is unable to supply sufficient current to deflect a conventional moving coil meter. Any attempt to do so could cause permanent damage to the probe.

Any pH meter is therefore basically a high input impedance circuit driving a moving coil meter. As the minimum acceptable input impedance is typically 500 megohms, an f.e.t. input 741 type op-amp will provide a suitable basis for such an instrument.

Conveniently, the voltage output from the probe results in a linear pH scale and it is therefore a relatively simple matter to modify the meter to read directly in terms of pH.

## GENERAL DESCRIPTION

The instrument is intended for use with a full range (2 to 14pH) "combination electrode" type of probe. As such, it has been kept as simple and inexpensive as possible commensurate with an adequate reading accuracy.

One simplification is to dispense with the temperature compensation normally incorporated in a commercial instrument. As the meter can be easily calibrated at the envisaged solution temperatures, this is a minor inconvenience.

A physical limiting factor on reading accuracy is the scale length of the meter. As long scale meters are difficult and expensive to obtain, a simple changeover switching arrangement is used to effectively double the scale length of a normal meter. This uses the inherent characteristics of the probe whereby the voltage polarity changes at 7·0pH.

The meter thus has two scales, 7 to 12pH and 7 to 2pH. With this arrangement the direct reading accuracy is 0·1pH which allows interpolation to within 0·05pH. If readings in excess of 12·0pH are required, then there is no reason why an alternative scale range shouldn't be adopted.

As the current drain of the circuit is only a few milliamps, the instrument is battery powered to obviate the expense of a mains supply. A battery check circuit has been incorporated.

## CIRCUIT OPERATION

The circuit of the simple pH meter is shown in Fig. 1. The probe is connected via a co-axial socket SK1 and switch S1 which also acts as the ON/OFF switch. The op-amp IC1, is connected as a voltage follower, the output being fed to the meter ME1 via the potentiometer VR2 and switch S2. VR2 is the SPAN control which sets the meter deflection for a given probe output.

The operation of S2 is such that in position 1 the meter is connected so that it reads 7 to 2pH. Position 2 reverses the meter polarity so that it reads 7 to 12pH. Positions 3 and 4 monitor the state of the batteries via R1 or R2 as appropriate. The batteries can be checked with or without the instrument being switched on, thus giving a better indication of their condition.

Variable resistor VR1 is the ZERO control. At first sight such a control may appear redundant. However, although in theory the probe output should be exactly zero at 7·0pH, in practice there will be a small voltage present. This is due to the probe construction and internal geometry.

In this particular application it is a convenient and perfectly satisfactory method to use the off-set control of the op-amp to set the instrument zero.

The intermediate switch position for S1 is quite important as it allows the op-amp to stabilise while the input is still grounded. It is only necessary to briefly hesitate in this position before switching through to the read position.

The larger sized PP6 batteries are used for B1 and B2. With the use envisaged, they should give a working life of some 200 hours.

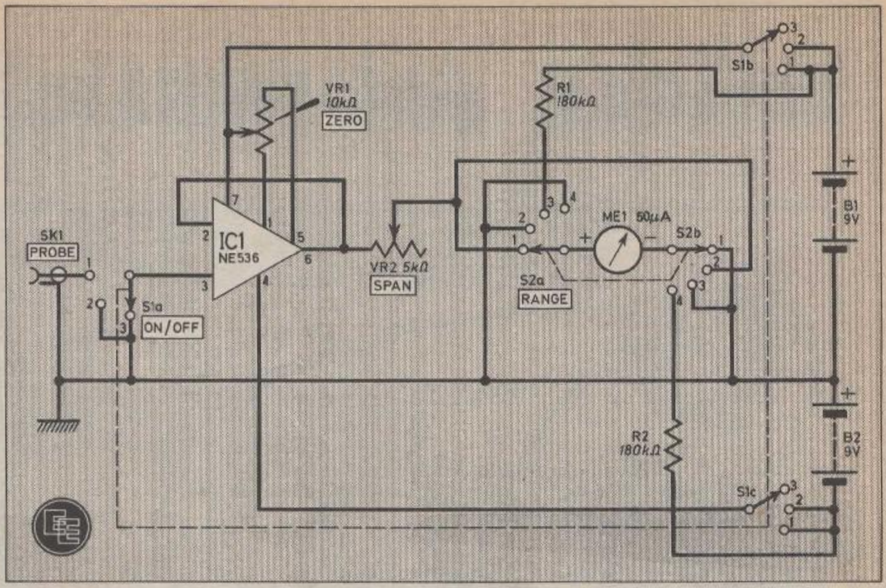



Fig. 1. Full circuit diagram of the Simple pH Meter.

## COMPONENTS

**Resistors**
R1, 2 180kΩ ¼W carbon ± 5% (2 off)

**Potentiometers**
VR1 10kΩ carbon lin.
VR2 5kΩ carbon lin.

See Shop Talk page 535

**Semiconductors**
IC1 NE536 f.e.t. input op-amp, TO-99 metal can

**Miscellaneous**
ME1 50μA d.c. f.s.d. moving coil meter
S1 three-pole, three-way rotary
S2 two-pole, four-way rotary
SK1 Co-ax socket to suit probe
B1, 2 9V, PP6 type (2 off)
Aluminium case, 150 × 100 × 50mm; stripboard, 0·1 inch matrix, 20 holes by 7 strips; battery connectors (2 off); 8-pin d.i.l. i.c. socket; knobs (2 off); interconnecting wire.

***Probe***
A suitable probe for this unit is the B17 DA type from Griffin and George (Gallenkamp). For readers not able to order from this company suppliers of other Full Range Combination Electrode type probes are listed in Shop Talk on page 535.

**Guidance only Approx. cost £12·00** excluding probe

## CONSTRUCTION starts here

## HOUSING

The complete instrument is contained in an aluminium box measuring 150×100×50mm, and the full layout is shown in Fig. 2. Because there are so few components involved, there is no need for a circuit board as such. A small piece of 0·1 inch matrix stripboard is attached to the meter terminals to provide a convenient mounting point for the op-amp. To avoid possible damage due to static charges, handling of the op-amp was kept to a minimum by using an i.c. socket.

Actual component layout is not critical. However, it is important to note that the limiting factor on the input impedance will depend on the insulation properties of the components, stripboard, and so on, rather than on the op-amp itself.

Every attention should be taken to ensure that the items used in the input circuit are of a high quality in this respect. The two resistors are wired directly onto the switches before final interwiring is completed.

In this context, if the instrument is likely to be stored in a relatively damp environment, it is recommended that the assembled stripboard be given a protective coating of polyurethane varnish.

With the type of meter as used in the prototype, the scale plate is easily removed for modification to read directly in terms of pH.

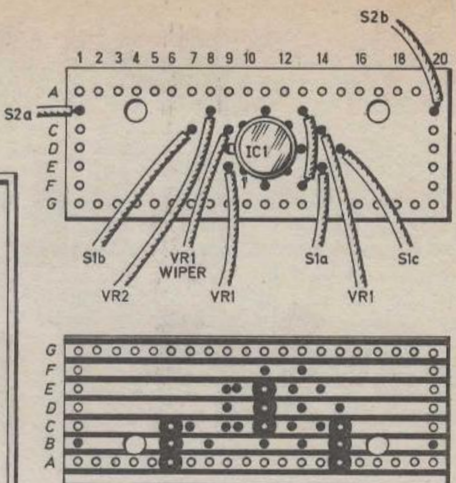
The battery check mark is also incorporated at this stage. The resistors R1 and R2 have been chosen so that fresh batteries will give approximately full scale deflection with a meter having an internal resistance of 1000 ohms. The value of R1 and R2 can be changed in direct proportion for meters having a different internal resistance. The minimum acceptable voltage is marked at 75 per cent of f.s.d.

## CALIBRATION

To calibrate the instrument it is necessary to obtain at least two buffer solutions. These solutions are formulated to provide an accurate and stable value of pH at a given temperature.

Every care should be taken in the preparation of the solution be it from a tablet or a sachet of powder. During subsequent use, avoid any con-

# SIMPLE pH METER



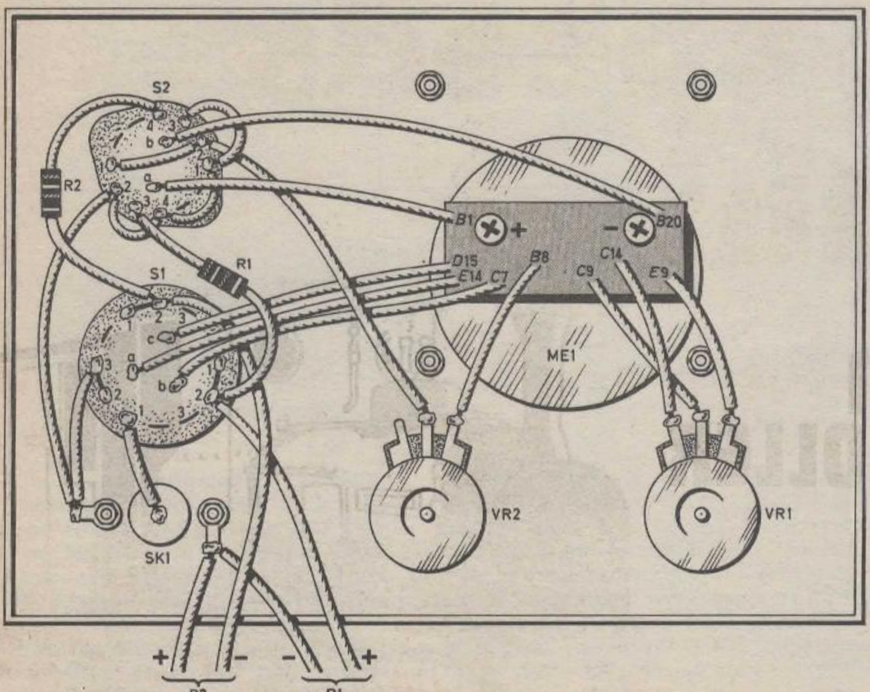




Fig. 2. Diagram above shows circuit board layout, and full interconnections can be seen on the left. Note that there are no obvious connections to the meter. In fact contact is made between the meter terminal posts and the underside of the stripboard at positions B4 and B17 when the board is fastened in place on the back of the meter. When completed the whole of the circuit board, the switches and potentiometers and associated wiring should be sprayed with a moisture repellant protective coating, such as polyurethane varnish to keep the damp out.

tamination of the solutions. This includes the indiscriminate carrying over of water used for rinsing the probe.

For setting the instrument to zero, a 7·0pH buffer solution is the obvious choice. When choosing a second buffer to adjust the SPAN control, maximum accuracy will be achieved by selecting a value close to that of the anticipated measurement. Ideal as this may be, there could be difficulty in obtaining other than a 9·0pH buffer.

Before any calibration is undertaken, it is essential to ensure that the meter is mechanically at zero when the instrument is switched off and is in the preferred operating position, that is vertical or horizontal.

Select the 7 to 12pH range, connect the probe and place it in the 7·0pH buffer. Switch the instrument to read (S1 set to position 1) and use the ZERO control to set the meter needle to the 7 on the scale. As a cross check, temporarily switch the instrument to the 7 to 2ph range. The needle should not move if the zero has been set correctly.

Switch the instrument off and remove the probe from the buffer. Rinse it carefully in distilled water and, having drained off the excess water, transfer it to the 9·0pH buffer solution. Turn S1 to position 1 again and adjust the SPAN control until the meter reads the correct value.

In theory, on the assumption that the probe output is symmetrical about 7·0pH, the instrument is now calibrated on *both* of the ranges.

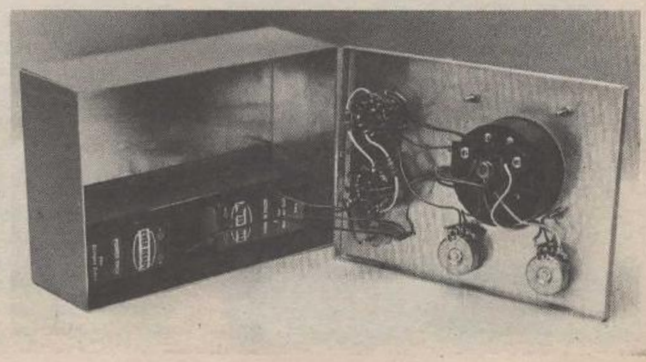
In practice, however, errors of up to 0·1pH have been noted when using the 7 to 2pH range after calibrating on the 7 to 12pH range. When more precise measurements are required the 7 to 2pH range should be calibrated separately using a 4·0pH buffer solution.

## OPERATION

Any measurements are now simply a matter of placing the probe into the solution to be checked. There are, however, one or two points to observe. The switch S1 should never be switched to the read position unless the probe is connected and immersed in a solution. Because there is virtually no warm up drift, there is no advantage in leaving the instrument in the on position between measurements. Accordingly, it is best switched off to avoid draining the batteries.

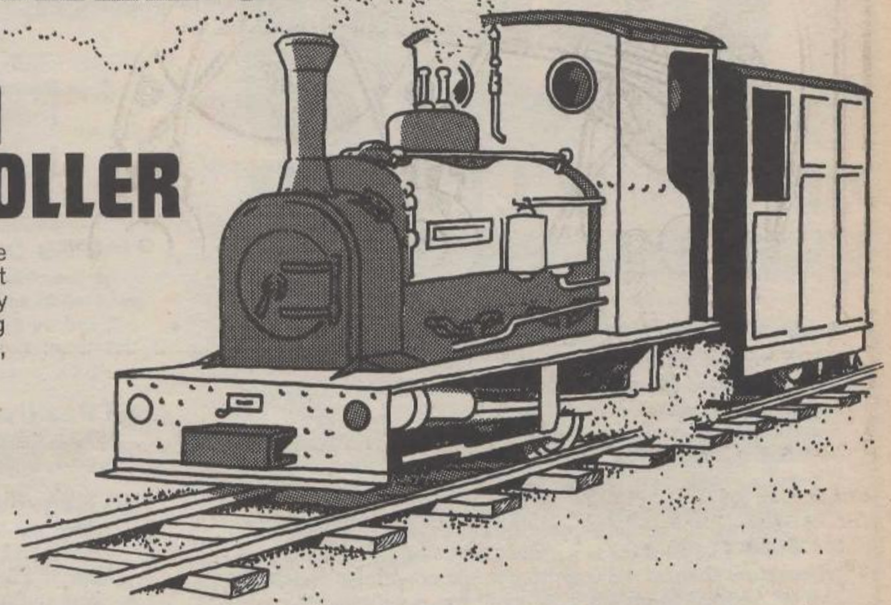
The pH probe is a fairly delicate item and normally comes with a plastic shroud to provide a measure of protection—even so it should not be used as a stirrer! To prolong the life of the probe it is important that the instructions be observed.

Some readers may experience difficulties if the equipment becomes damp. In the author's experience a few hours in a warm dry place, like an airing cupboard soon cures the trouble. ⌑



Interior view of the completed prototype. The two PP6 batteries can be seen secured in place under an aluminium strip in the rear of the case. Compare this photo with the diagram in Fig. 2.

# A smoother ride at all speeds with this



## MODEL TRAIN SPEED CONTROLLER

Uses a pulse-width-modulation technique to maintain a smooth, steady ride even at low speeds. Features include a continuously variable speed control, automatic starting and stopping to give realistic performance, brake and accelerator controls.

## AUDIO COMPRESSOR -MIXER

A wide compression range of around 30dB is available and can be used either for instantaneous short term compression or for automatic level control in tape recording. It also has application in suppressing the level of music whilst speech announcements are superimposed. Provision for mixing microphone and high level (music) signals is included.

## ANTI - THEFT DEVICE

Protection for any number of displayed goods by a simple loop linking all items. Strident alarm sounded if this is interfered with.

## 0-12V POWER SUPPLY

A well smoothed and regulated output adjustable from zero to 12 volts. Incorporates audio alarm which sounds when the selected current limit (40, 100 or 400mA) is approached.

**Everyday ELECTRONICS**

**SEPTEMBER 1981**
**ISSUE ON SALE FRIDAY, AUGUST 21**

# INTRODUCTION TO LOGIC

**PART 4 BY J. CROWTHER**

## THE TRANSISTOR AS A SWITCH

For an *npn* silicon transistor to conduct its base must be 0·6 volts above the emitter voltage. If the voltage between the base and the emitter is less than 0·6 volts the transistor will not conduct. Therefore it can be seen that a transistor can be switched *on* and *off* by two voltage levels, above and below 0·6 volts. These two voltage levels are referred to as **logic 1** for on (a result), and **logic 0** for off (no result).

If these two voltage levels were too close together, for example 0·5 and 0·7 volts, there is a chance that, due to tolerance and temperature changes the transistor would not always switch on and off, so logic levels are usually not too close together, logic 1 may be 6V and logic 0 below 0·25V with nothing inbetween.

Consider the circuit shown in Fig. 4.1.

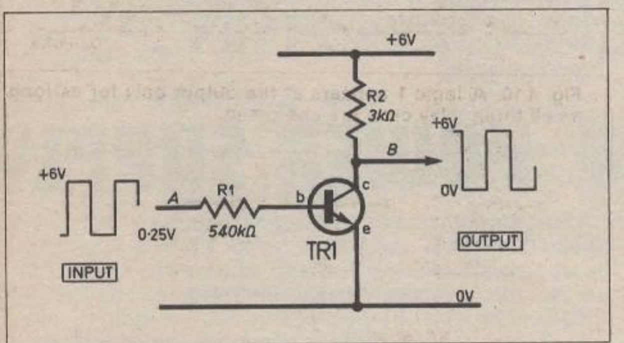



Fig. 4.1. Using the transistor as a switch.

If 0·25 volts is applied to the base at *A*, the transistor would not conduct, no current would flow through the 3 kilohm resistor, so there is no volts drop across it and the output at *B* would be 6 volts. This is equivalent to the switch being on and giving a result—logic 1.

Now suppose 6 volts were applied to the base at *A*, the transistor would start to conduct. The voltage between the base and the emitter would now be 0·6 volts giving a voltage drop of (6—0·6) volts across the 540 kilohm resistor. The base current $I_b$ would now be equal to:

$$I_b = 5{\cdot}4V/540k\Omega = 0{\cdot}01mA$$

If the $h_{FE}$ (gain) of the transistor was 200, the collector current would be $I_b \times h_{FE} = 0{\cdot}01 \times 200 = 2mA$. This would give a voltage drop across the 3 kilohm resistor of $3k\Omega \times 2mA = 6$ volts and the output would fall to zero, equivalent to a switch being off and giving no result—logic 0.

Therefore it can be seen that a transistor can be switched on and off by a squarewave pulse of two voltage levels as shown in Fig 4 2.

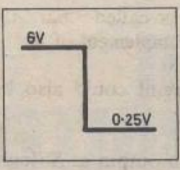



Fig. 4.2. The transistor in Fig. 4.1 will be switched on by 6V level and off by the 0·25V level.

## TYPES OF LOGIC

In practice it does not really matter which voltage level is referred to as logic 1, so long as the transistor switches on and off, and we know which level the designer has used and we use the same. For convenience in design two types of logic are possible:

### (1) Positive Logic

Where the positive half of the wave form is referred to as logic 1, and gives a result, see Figs. 4.3 and 4.5.

### (2) Negative Logic

Where the negative half of the wave form is referred to as logic 1, and gives a result, see Figs. 4.4 and 4.6.

Positive logic is the more common and is used in all E.E. projects and features.

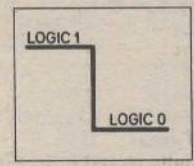



Fig. 4.3. Positive logic.

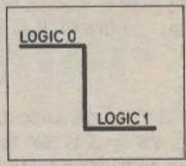



Fig. 4.4. Negative logic.

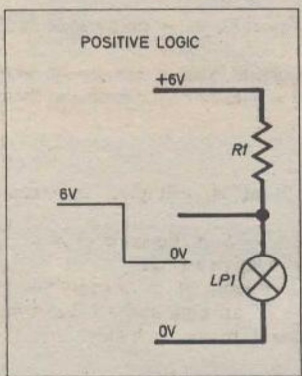



Fig. 4.5. High level lights lamp to give result.

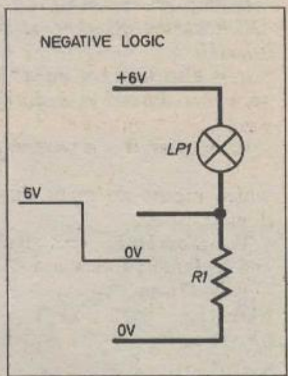



Fig. 4.6. Low level lights lamp to give result.

## BOOLEAN ALGEBRA

George Boole (1847) invented a system of algebra now called **Boolean algebra** with its own special rules, to look into a two state system, his two states being *true* and *false*. This system was later adapted to deal with the two states of a switch, on and off.

Consider a relay as a switch (see Fig. 4.7), and let $A$ be the input to the coil of the relay, and $S$ the output from the main contacts.

Let $A$ be the supply to the relay (logic 1), if $A$ were applied to the coil the relay would close giving an output at $S$.

In Boolean this is written as:

$$A = S$$

which means an input at $A$ (logic 1) gives an output (logic 1). at $S$, and represents a normally open switch or relay.

A line above a letter, for example $\overline{A}$, is called "bar $A$", "$A$ bar" or "not $A$", and is said to be the **complement** of $A$.

Therefore $\overline{A}$ means no pulse at $A$ or logic 0.

The Boolean equation for the above circuit could also be written as:

$$\overline{A} = \overline{S}$$

which means no pulse at $A$ (logic 0) gives no output at $S$ (logic 0), which is also true for the above circuit.

Therefore $A = S$ is the same as $\overline{A} = \overline{S}$ which shows that in Boolean a "bar" can be added to both sides of an equation and it still remains true, providing the bar covers all the terms on each side of the equation.

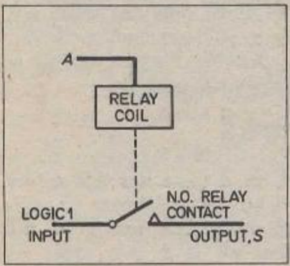



Fig. 4.7. Energising relay coil causes logic 1 to appear at the output.

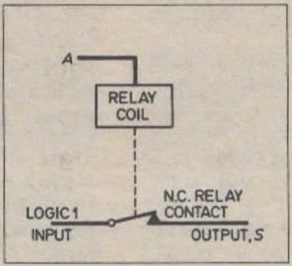



Fig. 4.8. Energising the relay coil causes logic 1 to be removed from the output.

*example*

$AB = S$ is the same as $\overline{AB} = \overline{S}$

but, $AB = S$ is not the same as $A\overline{B} = \overline{S}$.

Now consider a relay which is normally closed as in Fig. 4.8.

A supply or logic 1 applied to the coil at $A$ will open the relay, and there will be no output (logic 0) at $S$.

In Boolean this is written as: $A = \overline{S}$

which means an input at $A$ (logic 1), gives no output at $S$ (logic 0).

It is also true for the above circuit, that if no supply were applied to the coil at $A$, the relay would remain closed and there would be an output at $S$.

In Boolean this is written as:

$$\overline{A} = S$$

which means no input (logic 0) at $A$, will give an output (logic 1) at $S$,

Therefore in Boolean algebra $\overline{A} = S$, is the same as $A = \overline{S}$, and represents a normally closed relay or switch.

This shows that in Boolean algebra it is permissible to transfer a "bar" from one side of an equation to the other providing the "bar" covers all the terms on each side.

*example*

$\overline{AB} = S$ is the same as $AB = \overline{S}$

but, $\overline{A}B = S$ is not the same as $AB = \overline{S}$.

**Note**

Boolean equations are normally written to give an output.

*examples*

$A = S$ and $\overline{A} = \overline{S}$.

## SWITCHES IN SERIES

Consider the circuit in Fig. 4.9.

To get an output at $S$, relays $A$ and $B$ must both be energised.

In Boolean this is written as $AB = S$. $A$ times $B$ in Boolean means $A$ AND $B$.

Therefore $AB = S$ means an input (logic 1) at $A$, AND an input (logic 1) at $B$ will give an output (logic 1) at $S$, and represents two normally open switches in series.

Boolean algebra is not limited to two elements.

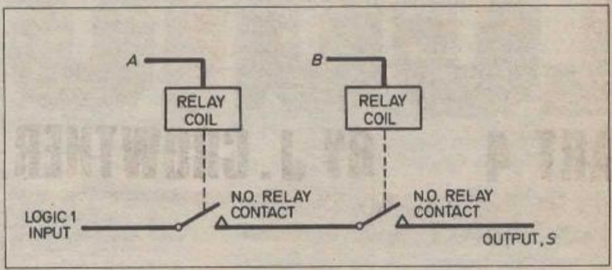



Fig. 4.9. Both relays need to be energised to produce a logic 1 at the output.

*example*

In a three-element system, $ABC = S$ means to get an output we must have $A$, AND $B$, AND $C$, and it represents the state in Fig. 4.10.

Also $A\overline{B}C = S$ means to get an output we must have $A$, AND NOT $B$, AND $C$, and it represents the circuit shown in Fig. 4.11.

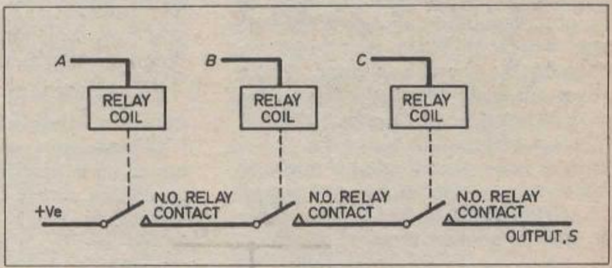



Fig. 4.10. A logic 1 appears at the output only for as long as all three relay coils are energised.

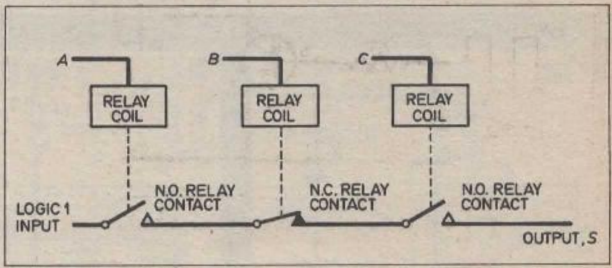



Fig. 4.11. A logic 1 results at output when first and last relays only are energised.

**Answers to Exercises in Part 3**

3.1. (*a*) 00000011 (*b*) 11111101 (*c*) 00010000 (*d*) 11110000 (*e*) 01111111 (*f*) 11111111

**TO BE CONTINUED**

# BACK TO BASICS

## More About Amplifiers

IN the previous article we saw that the active devices (transistors) in amplifiers can be regarded as means of controlling the amount of current drawn from the battery.

Now, the current from a battery can flow only in one direction. It is d.c. (direct current), not a.c. (alternating current). Transistors are also d.c. devices. But most of the signals which have to be amplified are a.c. ones. (Engineers say "a.c. signals" even if they are talking about signal voltages rather than signal currents.)

How can a d.c. device like a transistor amplify an a.c. signal?

### WOBBLING D.C.

The answer (hinted at in an earlier article) is first to set up the circuit so that a steady current (d.c.) flows through the transistor. The effect of applying an a.c. signal of small size is to make the steady current increase when the a.c. goes one way and decrease when it goes the other way. In other words, the a.c. signals put a "wobble" on the d.c. through the transistor.

The resulting wobbling d.c. is exactly the same thing as would be produced by mixing up a genuine small a.c. signal with a larger d.c. flow. When two things are indistinguishable there is a good chance that they are truly identical. This is the case with our wobbling d.c. in the transistor. It really is a mixture of a.c. and d.c.

Common sense suggests that it might be possible to unscramble the two and extract the a.c. part by itself, to feed to some other circuit such as another stage of amplification.

### BIASING

Before we look at how to do it, we must first think about how to set up the circuit so that the required steady d.c. flows.

Practical transistor amplifiers are more complicated than the simple circuits in the last article because they contain extra components for setting up the steady currents. This setting-up process is called **biasing**, and in the case of a bipolar transistor (i.e. a *pnp* or *npn* transistor as opposed to a **field effect transistor**) biasing takes the form of feeding a steady trickle of d.c. into the base-emitter region of the transistor.

A common arrangement is shown in Fig. 3.1a. Here R1 is the biasing resistor. A small current flows from the battery through R2 then R1, then the base, the emitter and to the other side of the battery to complete the circuit.

This **base bias current** causes a much larger (typically 100 times larger) collector current to flow (also through R2, then collector and emitter and back to battery).

Fig. 3.1b repeats the same circuit in a shorthand form which you will come across often. The battery is not actually drawn in, and connection to the common side of the circuit is indicated by an "earth" symbol.

The method of biasing a field effect transistor depends on what sort it is.

**Enhancement mode** f.e.t.s have to be turned on in much the same way as bipolar transistors, except that they draw no input current to speak of and are therefore turned on by a voltage rather than a current.

**Depletion mode** f.e.t.s pass current even when unbiased. In their case a negative bias is often required to reduce the standing current to what is reasonable for the job.

### INTERSTAGE COUPLING

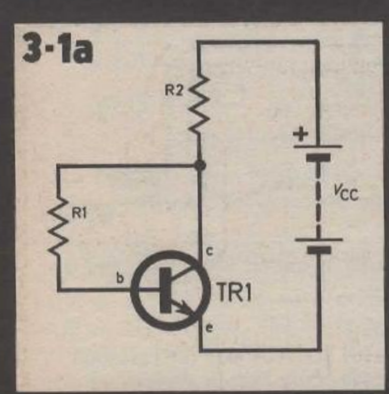
The a.c. part of the current in a transistor may be very small indeed. This is because the a.c. signal may be very small. The aerial of a sensitive radio receiver may deliver only a few millionths of a volt or a few billionths of an ampere. A typical transistor may amplify these signals a hundredfold, but they are still pretty small compared with the steady voltages and currents in the circuit.

If these steady quantities were passed on to the next transistor they might well overload it. So what is required is some sort of filter to allow only the small a.c. signals to pass on while excluding the d.c. voltages and currents. Such a circuit is called an **a.c. interstage coupling**.

### CAPACITORS

One way of separating a.c. from d.c. is to use a **capacitor**. A capacitor is a device which can store an electric charge. Capacitors take many shapes and forms but the essence of them all is a thin sheet of insulating material sandwiched between two metal plates. This is reflected in the symbols for capacitors, which show the plates sideways on, with a gap in between to represent the insulator.

In practice the "sandwich" is often rolled up to save space, and encapsulated for protection, giving a component with two leadouts, one connected to each plate.



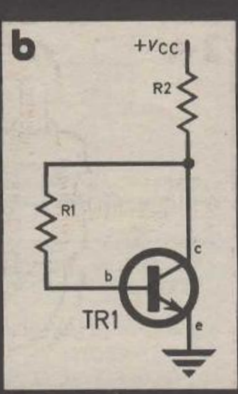




Fig. 3.1. (a) A transistor with d.c. biasing via R1. (b) The same arrangement drawn in a slightly abbreviated fashion.

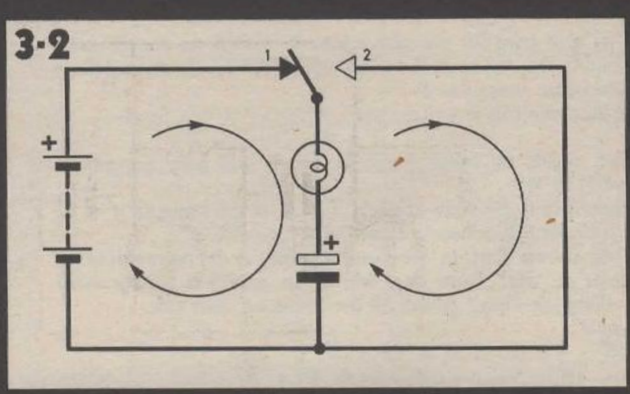



Fig. 3.2. Showing the charging and discharging of a capacitor. Note the direction of current flow as shown by the arrows.

*A FOUR-PART INITIATION COURSE FOR NEWCOMERS*

**3**

# By George Hylton

It is obvious that the insulating material (known as the **dielectric**) must prevent d.c. from flowing through the capacitor. However, if a battery is connected to a capacitor there is a momentary flow of current as the capacitor charges. Then no further current flows because of the dielectric.

If the battery is taken away the capacitor remains charged up to the battery voltage. It can be discharged by connecting its leadouts together. There is then a momentary rush of current in the opposite direction to the original inflow of charge. (Don't try it! The outflow may be violent enough to damage the capacitor itself.)

## CHARGING AND DISCHARGING ACTION

Charging and discharging can in principle be demonstrated by the circuit of Fig. 3.2, which contains a battery, a capacitor, a lamp and a **changeover switch**. I say "in principle" because unless the capacitor is capable of holding enough charge to light the lamp no sign of the circuit operation will be visible.

With the switch contact at position "1", the capacitor charges, and if the inrush of current is big enough the lamp flashes momentarily then goes out. The capacitor is now charged, and if the switch is changed to position "2", it discharges through the lamp (which limits the current) and the lamp flashes again momentarily.

The arrows show which way the current flows round the circuit in each case. During charging, current flows downward through the lamp. During discharging, it flows up.

## A.C. PASSES THROUGH CAPACITOR

If the switch is moved repeatedly from one position to the other the lamp receives a succession of current impulses and flashes each time, the current through it flowing first one way then the other and so on. This is an alternating current and to all intents and purposes it flows through the capacitor as well as the lamp. But no d.c. flows through the lamp, as is proved by the fact that it does not stay lit when the switch is left in position "1".

Evidently a.c. can flow through a capacitor but d.c. cannot. This is just what we need for separating a.c. from d.c. in our amplifier circuits.

## TWO-STAGE AMPLIFIER

A practical bipolar transistor two-stage amplifier using capacitors for a.c. coupling of the stages is shown in Fig. 3.3. Here resistances R1 and R3 are for biasing. An a.c. input signal causes a small current to flow to and fro through C1. It also flows through the base and emitter of the first transistor, TR1. An amplified version of this current flows from the collector to and fro through C2 and thence to the base-emitter circuit of the second transistor TR2. Further amplified, it flows via C3 to whatever circuit follows.

## STEERING THE CURRENT

Without R2, all the collector current of TR1 would pass uselessly through the battery instead of the a.c. part passing via C2 to TR2. So the job of R2 is to steer the a.c. to where it is wanted. Current always takes the easiest path. If R2 is big enough (electrically, that is) most of the a.c. goes to TR2.

This can be illustrated by analogy with water flow (Fig. 3.4). A current of water flows into a branching arrangement of pipes. More water flows through the thick lower pipe than the thin upper one because the thin pipe has more frictional resistance because of its smaller cross sectional area. The thick pipe represents the easy path for the current via C2 while the thin pipe represents R2.

When an electric current has a choice, more flows through a low resistance than through a high one. For obvious reasons resistances connected in the same configuration as the two pipes are said to be connected "in parallel".

## NOISE

If TR1 amplifies by a hundred time and TR2 by a further hundred the overall amplification is by $100 \times 100 = 10{,}000$. By "cascading" stages of amplification in this way enormous amounts of amplification are in theory obtainable. In practice, however, all this amplification cannot be used and three or four stages can reach the useful limit of about a million times.

The reason for this disappointing result is that all circuits contain **noise**, that is unwanted voltages and currents. Noise gets amplified along with the signals and if too strong it just obliterates them.

**Continued next month**

Fig. 3.3. A two-stage amplifier. The coupling capacitors C1, C2 and C3 allow the a.c. input signal to pass but are a barrier to the steady d.c. supply applied to the transistors.

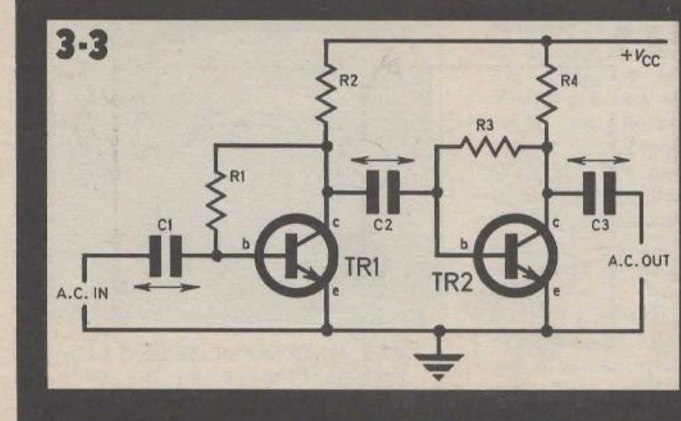
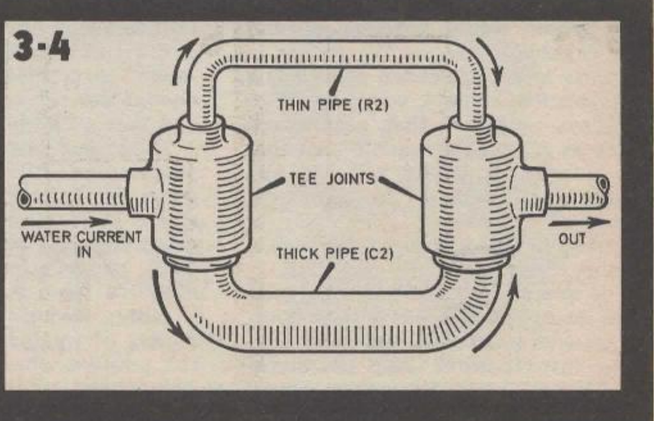



Fig. 3.4. Water flow in a system of pipes provides an analogy with electric current flow in circuits composed of high and low resistance paths.



# DOOR ALARM

D.J.EDWARDS

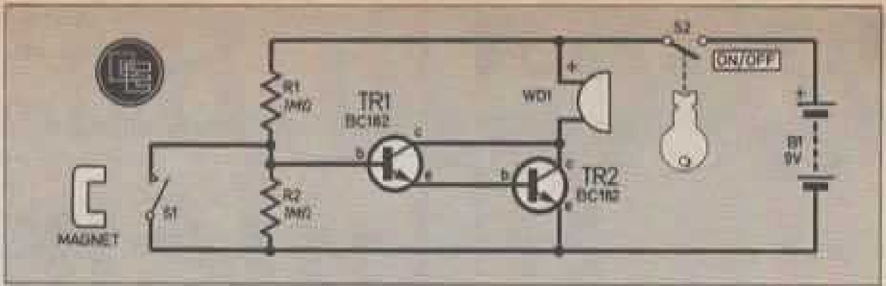



Fig. 1. Complete circuit diagram of the Door Alarm. S1 is a magnetically operated dry-reed switch.

## A self-contained unit for use with all kinds of doors.

EVERY YEAR countless children are poisoned by medicines left unsecured in bathroom cabinets and unattended on dressing tables. Even when they are put away, parents often underestimate the ingenuity of little children in finding out how to open cabinets and cupboards that most people would consider beyond their capabilities.

Clearly what is needed is either a stout lockable cabinet, very expensive nowadays, or failing that, a cupboard placed as far out of reach as possible with a warning device to alert the parents immediately to any unauthorised tampering. The project described in this article is just such a warning device.

It is completely self-contained and could do equally well as a shop doorbell or even a cordless burglar alarm.

The current drain when the alarm is set is a trivial 9$\mu$A ensuring a long battery life. When triggered this rises to approximately 80mA which is high for a PP3 but no-one is going to have this alarm on for long!

### DARLINGTON PAIR

The heart of the unit is TR1 and TR2 which have been arranged as a Darlington pair, that is they can be regarded as one transistor with a very large current gain ($h_{FE}$ of TR1 multiplied by the $h_{FE}$ of TR2). The complete circuit is shown in Fig. 1.

In the "alarm set" condition (unit switched on and reed switch S1 held closed by the magnet) the transistors are off due to the fact that the base of TR1 is short-circuited to the negative rail.

When the magnet is moved away from the reed switch ("alarm triggered"), the reed switch goes open circuit allowing the base of TR1 to rise to +4·5V (set by the potential divider action of R1 and R2). TR1 switches on, which switches on TR2 causing TR2 collector voltage to fall and allowing current to flow through the buzzer, WD1.

## CONSTRUCTION starts here

### PLASTICS BOX

For practical reasons it is important to use as small a case as possible and a full layout is shown in Fig. 2. Make sure that the front is big enough for the buzzer and the switch and that a PP3 battery will also fit in.

The circuit board consists of a very small piece of 0·1 inch stripboard 12 strips by 6 holes and can be fixed where it is most convenient. In the prototype this was attached to the front panel using double-sided self-adhesive foam strip.

Before fixing the buzzer, drill a matrix of small holes in the panel in the position where it is going to lie. This is to let the sound out. The buzzer can then be glued in position.

Finally the reed switch, S1 should also be secured inside the case with epoxy resin close to one of the case sides such that when the case is mounted in its final position the exterior magnet will be able to operate the reed switch successfully.

A keyswitch for S2 is imperative in the unit so as to prevent a child (or burglar) switching the unit off quickly.

### INSTALLATION

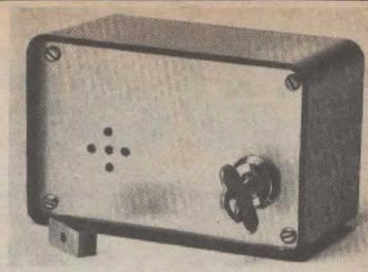
The unit should be installed somewhere on the cabinet or other door such that when the door is closed, the fixed magnet holds the reed switch closed and the alarm is off. When the door is opened the reed switch opens and sounds the alarm.

Other possible methods of mounting would be to have the whole unit inside the door with just the bezel of S2 showing on the outside, or to cut away part of the door leaving the whole of the front panel visible.

The magnet will of course be mounted somewhere on the interior

View of the rear of the front panel showing circuit board and other components.

# DOOR ALARM



## COMPONENTS

See **Shop Talk** page 535

**Resistors**
R1, R2 1MΩ (2 off)
both ¼W carbon ± 5%

**Semiconductors**
TR1, 2 BC182 *npn* silicon (2 off)

**Miscellaneous**
S1 reed switch with one set of normally open contacts
S2 s.p.s.t. key operated switch
WD1 6V solid state warning device
B1 9V, PP3 type battery
Plastics case, with aluminium front panel, 100 × 64 × 50mm; stripboard 0·1 inch matrix, 12 strips by 6 holes; suitable magnet to operate S1; battery clip; double-sided self adhesive foam strip; interconnecting wire.

**Approx. cost Guidance only £6**

of the cabinet such that it keeps S1 closed when the door is closed.

In the case of access door, the magnet will need to be embedded in the framework.

Try to place the magnet as close as possible to the position of the reed switch in the case. Magnets come in all shapes and sizes, and it should not be too difficult to find a small one, with a hole in its centre by which it can be screwed in position.

If the unit is to be used in a shop to attract the shop keeper's attention a resistor will need to be inserted in series with the buzzer to reduce the current consumption and the volume. Use a 1 kilohm preset potentiometer to set this value. ⌑

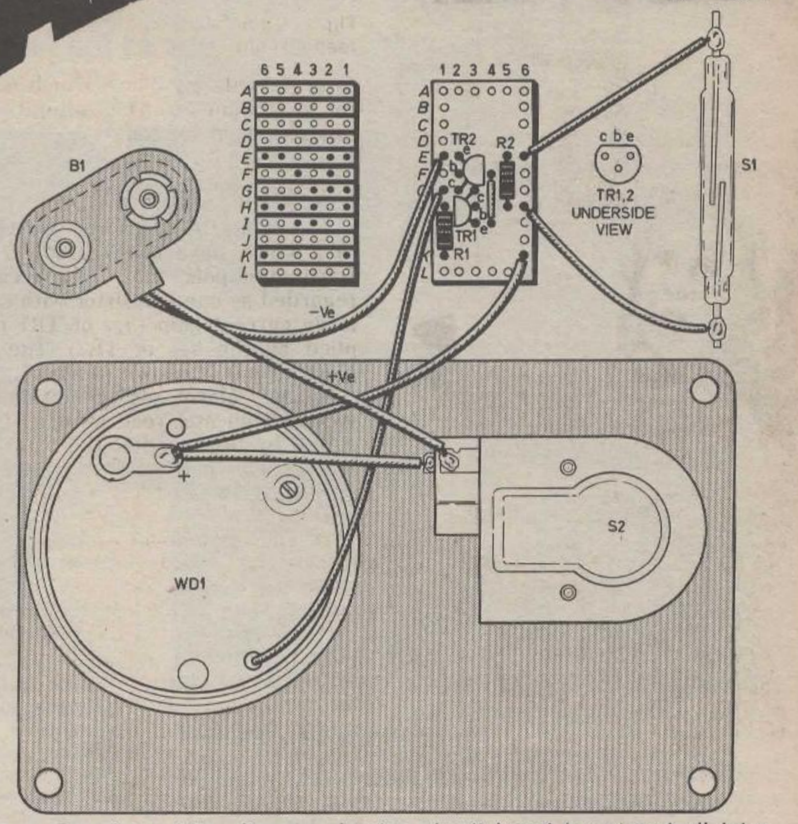



Fig. 2. Complete wiring diagram showing circuit board layout and all interconnections. Note that S1 should be glued to the case side so that it will be as near to the operating magnet as possible when the alarm is in the "set" condition.

## JACK PLUG & FAMILY...

BY DOUG BAKER

# Everyday News

## SILICON CHIPS OR FISH AND CHIPS

*Micro-electronics comes to the Hotel and Catering Industry*

The Hotel and Catering industry is often regarded as very conservative in this country—especially so when it can draw on a vast number of low paid workers.

However it seems that no company can avoid the effects of modern technology and micro-electronics has made such advances in the hotel and catering trades that there is now a special exhibition and conference called, appropriately enough, Electronic Hotel.

*The Plantime Electronic Restaurant Management System*

This exhibition, held at the West Centre Hotel, Fulham, serves to bring together manufacturers offering electronic equipment or services to the trade and these suppliers can really be divided into two camps—those who supply computer based accounting and management systems, and those who supply electronic entertainment packages.

As with most data-processing systems, the computer based hotel management equipment can be made as comprehensive as you like. For instance you could start with simple front desk register which would store and process fairly rudimentary information about each guest, and then expand this to take in annual accounts, staff salaries, restaurant and bar stock control, and so on, ad infinitum.

A typical system for a 20-bed hotel might cost about £300 per month to hire although this price would depend very largely on the size of the hotel and the degree of sophistication required.

In fact this year's exhibition was dominated by computer equipment suppliers, due, no doubt, to the fact that many manufacturers regard this as a key growth area, a point made by the organisers when they said that they wanted to bring together suppliers of equipment and "the hoteliers and restaurateurs who are having to learn as much about the silicon chip as they are about potato chips."

Apart from a multitude of front-desk systems, one rather eye-catching exhibit was the Plantime Electronic Restaurant Management Scheme illustrated above. Apart from aiding stock control and accounting, it also means that the chef is actually going to cook what the waiter ordered and not what he thought the waiter ordered—a bit of an improvement on "two number threes and a number five with rice" shouted down the service lift shaft.

On the entertainment side it seems that the video revolution has begun to catch up with the hotel trade. Systems are now available that allow the hotelier to show feature films on the in-house TV system in addition to ordinary TV programmes. Teletext and Viewdata are also trying to make an impact although progress is slow—even though June was national Teletext month.

So—all in all the hotel and catering trade are being computerised one way or another. Let's hope it results in better personal service and the end of that exasperating "waiting for chips."

## Robots on the March

An industry expert has forecast a market in the UK and EEC of 2,000 robots a year by 1984. Many British firms are entering the market with Japanese partners manufacturing under licence or in joint ventures. Hall Automation, the all-British robot manufacturer, contends that the Japanese can teach them little or nothing, a view also shared by the British Robot Association who claim there is no need to depend on imported technology. The joint venturers, mainly engineering rather than electronic companies, say they have no intention of spending money on "re-inventing the wheel".

**Steam locomotives could be back again in the United States before long. American Coal Enterprises (ACE) of Ohio is building a steam prototype locomotive, the ACR 3000 with micropressor control. With electronic monitoring and control, combustion thermal efficiency in the fire-box can be improved by a factor of two or three. Such a system, however, would be commercially viable (compared with diesel or electric traction) only because of the availability in the USA of cheap coal.**

**The explosive growth of personal computers continues. Apple claim over 200,000 systems sold worldwide and the new Commodore VIC 20 is selling at the rate of 10,000 systems a month in Japan alone. The VIC 20 follows on from the Pet which has clocked up 44,000 sales in the UK. The VIC 20 offers both colour and sound, large memory and full range of peripherals. It should be available in UK stores by October and Commodore expect UK sales to average about 1,000 a week.**

## —ANALYSIS

### THE SURVIVOR

When you next switch on your TV, and before you become absorbed in the programme, spare a thought for the curious story of the cathode ray tube on the faceplate of which your TV picture is almost miraculously traced out.

You may imagine you are looking at a modern invention but you would be quite wrong. The cathode ray tube is in fact the earliest of all electronic devices. Sir William Crookes observed electrical discharges in exhausted glass tubes as early as 1879 and it was largely through his experiments and with similar crude forms of cathode ray tubes that J. J. Thomson, nearly 20 years later in 1897, was able to prove conclusively the existence of the electron.

Thomson's work led directly to the invention of the thermionic valve, first the diode by Ambrose Fleming, soon followed by the triode invented by Lee de Forest which he patented in 1907, and it was the thermionic valve which gave birth to the electronics industry.

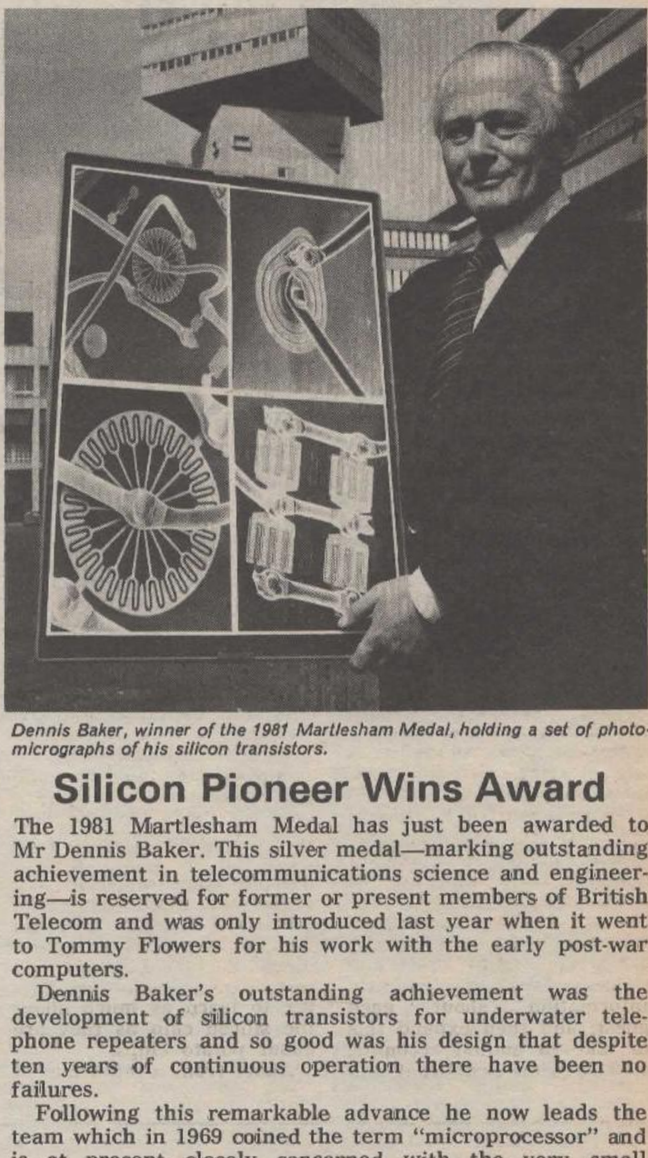
Except for the generation of large amounts of power in industrial radio frequency heating, and in the output stages of radio and TV transmitters, the thermionic valve is all but dead, having been supplanted by the solid state device. But the cathode ray tube, even older than the valve, is the one great survivor from the earliest days.

Naturally there have been many dramatic improvements over the years. Early TV picture tubes and oscilloscope tubes of the 1930's look very dated today. And now, despite the addition of colour and other technical advances, the cathode ray tube is basically the same as ever.

Far from disappearing, the cathode ray tube is more in demand than ever with a great new mass market in word processors. Every office as well as every home will have the small screen.

The first working oscilloscope using a cathode ray tube is attributed to Karl Fedinand Braun of the University of Strasbourg. He made it in 1897, the same year as Thomson discovered the electron. Such old timers weren't so dim!

**Brian G. Peck**



*Dennis Baker, winner of the 1981 Martlesham Medal, holding a set of photomicrographs of his silicon transistors.*

## Silicon Pioneer Wins Award

The 1981 Martlesham Medal has just been awarded to Mr Dennis Baker. This silver medal—marking outstanding achievement in telecommunications science and engineering—is reserved for former or present members of British Telecom and was only introduced last year when it went to Tommy Flowers for his work with the early post-war computers.

Dennis Baker's outstanding achievement was the development of silicon transistors for underwater telephone repeaters and so good was his design that despite ten years of continuous operation there have been no failures.

Following this remarkable advance he now leads the team which in 1969 coined the term "microprocessor" and is at present closely concerned with the very small geometry of the integrated circuits for System X.

Mr Baker's favourite hobby is repairing and restoring clocks and watches so this 4 inch diameter medal which he received at a special ceremony in London, will make a handsome addition to his mantlepiece.

### Time Gentlemen Please

*BBC technology responsible for the BBC2 logo and clock is to be made available to other broadcasters. It will be manufactured by McMichael Ltd under licence from the BBC and will allow other organisations to benefit from this advanced technology.*

*The equipment, which is all electronic, was developed by Richard Russell of the BBC's Engineering Designs Department. It was designed to replace a whole host of slide scanners, mechanical clocks and the like and is far more reliable, not to mention cheaper.*

*It can produce static logos such as the Open University Symbol, and simple animated logos, quite apart from the TV clock.*

### SONY TRIUMPH

Sony's ferrochrome audio cassette tape has been chosen as an international standard. It is the first time a Japanese tape has been selected as a world reference for other manufacturers.

### INFO TECHNOLOGY

Information technology is now absorbing about half the energy of the newly associated National Enterprise Board and the National Research Development Corporation. NEB financial expertise will be married to NRDC technology management. The two organisations are operating in parallel pending a full merger and will be called the British Technology Corporation.

**Electronics easily dominated the world of invention last year according to the annual report of the Comptroller General of Patents, Trade Marks and Designs. Microprocessor applications were top and fibre optic technology and applications were a strong feature.**

**Over 300,000 video recorders were delivered in the UK in 1980. Most went to TV rental companies for hire to clients.**

**Biggest volume manufacturer would appear to be Sony who plan to manufacture 1·5 million units this year.**

# Semiconductor News

## BREAKTHROUGH IN THERMAL IMAGING

A major advance in thermal imaging technology has just been announced by **Mullard** with the introduction of the **SPRITE** (Signal Processing In The Element) detector. This is a new kind of mercury cadmium telluride infra-red detector designed expressly for high performance thermal imaging systems. According to the manufacturers it represents an extremely important advance—if not the most important recent advance—in thermal imaging technology.

The basic difference between this device and previous imaging systems lies in its manner of use. In the old fashioned type of system separate imaging elements are laid side by side in a line and their output is sampled one by one along the line. In order to achieve this, the array needs to be connected to pre-amplification, time delay and summation circuitry—all very costly and complicated.

The SPRITE system is fundamentally different in that it consists of a single strip of photo-sensitive material with just three connections. Two of these are to provide a bias current and the third is a readout connection. When infra-red light falls on any part of the strip, excess current carriers are generated in that region. These drift towards the readout connection at a velocity that depends on the characteristics of the strip material and the magnitude of the bias current. There is no need for time delay and summation circuitry, cutting down on associated circuit components, and the reduction in the number of package connections greatly improves noise performance.

In manufacture, the SPRITE detector will incorporate not one but eight infra-red sensitive strips. This allows its advantages to be exploited in serial-parallel scanning systems and up to eight lines can be scanned simultaneously. The detector is designed for operation in the 8 to 14 micron wave band and like similar detectors needs to be cooled to 77 degrees Kelvin and so is mounted in a Dewar encapsulation.

### MOTOROLA/PHILIPS/ SIGNETICS PACT

In an era of cut-throat competition, two of the world's major electronics manufacturers have agreed to a five-year pact for the development of 16-bit microprocessors.

The Semiconductor Group of **Motorola** and a team of **Philips** and **Signetics** have jointly announced an agreement under which they will jointly develop both hardware and software for Motorola's **M68000** microprocessor family.

The aim of the agreement is to produce an enriched family of integrated circuits and software tools and create the industry's strongest 16-bit product line.

The two companies will produce pin-for-pin compatible products as well as developing new ones which may be manufactured by both participants and by the end of 1983 they hope to have added twelve or more new M68000 designs to the family portfolio.

Strangely enough, while the agreement covers product development, manufacturing, marketing and sales will be conducted competitively.

### CUSTOM L.C.D.

Not so much a new product, more a new service is how you would describe the new facilities being offered by **Hamlin Electronics** for custom built l.c.d. displays.

Panel sizes up to 152 x 76mm are available and a variety of annotations and symbols can be produced. Bar graphs, arrows, units and monetary symbols are just some of the features that can be built in and there is also a wide choice of display fluids for even the most stringent applications.

### FLASH CONVERTER

Described as a "major accomplishment in i.c. design", **TRW LSI Products** have just announced their new 9-bit A/D convertor, the **TDC 1019J**. This new single chip "flash" converter operates at 20 megasamples per second by accepting an analog input from 0V to 2V and comparing it with an internal voltage reference before activating a pre-set proportion of its 511 differential comparators.

The comparator's action is followed by a 511:9 encoder which supplies a digital input to a 9-bit latch providing complementary ECL outputs. From these a CONVERT signal produces a digital output at rates from d.c. to 20 megasamples per second, all without any external sample and hold circuitry.

The inputs can handle signals with frequency components as high as 7MHz making the device ideal for use is such applications as TV special effects equipment. The analog video signal is converted to digital format and back using A/D and D/A converters to permit storage of digitalised video in semiconductor memory and generation of effects such as shrinking, fades, mirror imaging and freeze frames.

Commonly used 8-bit equipment limits the number of usable conversion passes to about ten whereas this 9-bit device allows anything up to twenty passes before distortion is visible.

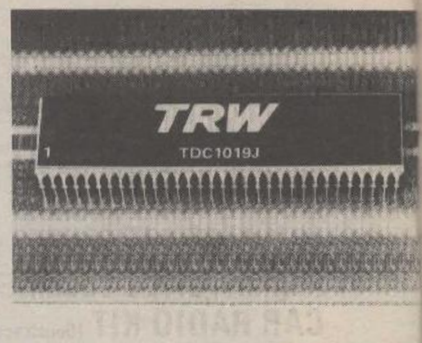
The TDC 1019J is housed in a 64-pin d.i.l. package and is available now at a cost of £330.

### CHANNEL PLATES

The latest addition to the range image intensifier products marketed by **Mullard** is the **G12** range of micro-channel plates (MCPs) which have microchannel diameters of 12·5 microns and are available in three different diameters.

MCPs are used principally as the amplifying heart of modern image intensifier tubes and also find applications in research as well as in commercial mass spectrometers and fast CRT tubes.

This new range has an improved spatial resolution compared with the 25 micron series they will eventually replace. Gain is typically 1000 when biased with 1000V although much higher gains can be achieved using matched pairs.




### BOOST FOR PLASTIC POWER TRANSISTORS

No fewer than twelve new families have been added to **Mullard**'s range of amplifying and switching power transistors, all in the company's TO-220 encapsulation. Current ratings range from 1A to 15A and maximum voltage is 140V. Switching speeds are more than adequate for modern power control systems.

The new components are numbered **BDT29**, **BD239**, **BDT31**, **BD241**, **BDT41** and **BD243** with complementary *pnp* types one number larger (BDT30, and so on). All the BDT types are European equivalents for types in the TIP series and their type numbers are consequently related.

### ADD-ON FOR LOW LEVEL LIGHT TV CAMERA

The latest addition to the range of **Mullard** image intensifier products is an add-on module designed to fit onto any closed circuit TV camera fitted with a C-mount lens incorporating a $\frac{2}{3}$ inch camera tube. This converts the camera into a low light level TV camera (LLLTV).

The basis of the module is the Mullard **XX1500** image intensifier. This has a gain of 70,000 and is effective below starlight level. The makers claim that this outperforms other LLTV systems and is considerably cheaper than a standard LLTV camera. The add-on unit plus CCTV camera costs around £3,000.

Obvious applications include security surveillance, especially where standard TV lighting would be inappropriate, home video where bright lamps are impractical and nature photography.

# DIY MUSIC & EFFECTS KITS

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Automatically gives Wah or Swell sounds with each guitar note played.
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Modulates the attack, decay and filter characteristics of a signal from most audio sources, producing 8 different switchable sounds that can be further modified by manual controls.
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## GUITAR FREQUENCY DOUBLER
Produces an output one octave higher than the input. Inputs and outputs may be mixed to give greater depth.
Kit order code SET 98 £10·55

## GUITAR MULTIPROCESSOR
An extremely versatile sound processing unit capable of producing, for example, flanging, vibrato, reverb, fuzz and tremolo as well as other fascinating sounds. May be used with most electronic instruments. Some SW's not incl. in kit—see list for selection.
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## GUITAR OVERDRIVE
Sophisticated versatile fuzz unit incl. variable controls affecting the fuzz quality whilst retaining the attack and decay, and also providing filtering.
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## GUITAR PRACTISE AMPLIFIER
A 3 watt mains powered amplifier suitable for instrument practise or as a test gear monitor. Drives 8 or 15 ohm speakers (not incl. in kit).
Kit order code SET 106 £18·72

## GUITAR SUSTAIN
Maintains the natural attack whilst extending note duration.
Kit order code SET 75 £11·77

## PHASER
An automatically controlled 6 stage phasing unit with internal oscillator. Depth can be increased with extension.
Main kit code SET 88 £18·34
Extension kit EXT 88 £7·31

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Includes manual and automatic control over the rate of phasing & vibrato. Capable of superb full sounds. A separate power supply is included.
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As the name implies! Order code SET 91 £11·68

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Provides switched selection of 4 preset tonal responses.
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A variable siren generator that can produce British & American police sirens, Star-Trek red alert, heart beat monitor sounds, etc.
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## FUNNY TALKER
Incorporates a ring modulator, chopper & frequency modulator to produce fascinating sounds when used with speech & music.
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## WIND & RAIN EFFECTS
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## P.E. MINISONIC SYNTHESISER
A very versatile 3-octave portable mains operated synthesiser, with 2 oscillators, voltage controlled filter, 2 envelope shapers, ring modulator, noise generator, mixer, power supply and sub-min toggle switches to select the functions. A case is excluded, but the text gives comprehensive constructional details.
Kit plus keyboard & contacts SET 38 £169·69

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**NEW KIT MAKE-UP —SEE BELOW**

## 128—NOTE SEQUENCER
Enables a voltage controlled synthesiser, such as the P.E. Minisonic, to automatically play pre-programmed tunes of up to 32 pitches and 128 notes long. Programs are initiated from the 4-octave keyboard and note length and rhythmic patter are externally variable.
Kit plus keyboard & contacts SET 76 £114·09

## 16—NOTE SEQUENCER
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A very advanced unit using sophisticated I.C. techniques instead of noise-prone mechanical spring lines. The basic delay range of 24 to 90MS can be extended up to 450MS using the extension unit. Further delays can be obtained using more extensions.
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Extension kit EXT 78 £45·94

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Compatible with the Formant and most other synthe sisers.
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Converts saw-tooth waveform into sinewave, mark-space sawtooth, regular triangle, or squarewave with variable mark-space. Ideally one should be used with each synthesiser oscillator.
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## BASIC COMPONENT SETS
Include specially designed drilled & tinned fibreglass printed circuit boards, all necessary resistors, capacitors, semiconductors, potentiometers, and transformers. They also include basic hardware such as knobs, sockets, switches, a nominal amount of wire and solder, a photocopy of the original published text, and unless otherwise stated, a robust aluminium box. Most parts may be bought separately. For fuller kit and component details see our current lists.

Kits originate from projects published in PE, EE, and Elektor.

## RHYTHM GENERATORS
Two different kits—The control units are designed around the M252 and M253 rhythm-gen chips which produce pre-programmed switch-selectable rhythms driving 10 effects instrument generators feeding into a mixer.
12-Rhythm unit SET 103-253 £64·10
15-Rhythm unit SET 103-252 £57·26

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A high specification stereo mixer with variable input impedances. Specs given in our lists. The kit excludes some SW's—see lists for selection. The extension gives two extra channels.
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Full level control on left and right or each channel, and with master output control and headphone monitor.
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Enables stereo live recordings to be made without the 'hole in the middle' effect. Independent control of each microphone.
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## HEADPHONE AMPLIFIER
For use with magnetic, ceramic or crystal pick-ups tapedeck, or tuner, and for most headphones. Designed with RIAA equalisation.
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## VOICE OPERATED FADER
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Produces controllable pulse widths from 100NS to 2Sec. Variable frequency range of 0·1Hz to 100KHz.
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Allows audio signals to be injected into circuits under test, and for tracing their continuity. Includes frequency & level controls.
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A 4-digit counter for 1Hz to 99KHz with 1Hz sampling rate.
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Controls up to 750 watts in 0·5sec steps up to 10 minutes, with built-in audio alarm.
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# RADIO WORLD

## By Pat Hawker, G3VA

### Summer storms

Unusually severe thunderstorms early in June brought almost an inch of rain lashing down over much of southern England: the weather forecasts, the day before, stated, a trifle blandly in the circumstances, "sunny with showers . . . outbreaks of rain".

The public believes that the Government department that most consistently gets its forecasts wrong is the Meteorological Office from its headquarters in Bracknell, despite all the enormous advances in the use of large number-crunching computers, cloud-cover satellite pictures, balloons, unattended sensors linked only by telemetry, and the like. In defence, the Met men always point out (with justification) that the short-term prediction of rain is the most tricky thing to forecast correctly . . . and that forecasts are now very much better than they used to be.

The Met Office now has the support of a worldwide communications network capable of passing enormous amounts of data and facsimile weather maps. This operates under the aegis of the World Meteorological Organization (WMO) representing some 150 countries and one of the very few international bodies to have its own international radio callsign prefixes (C7A to C7Z).

The main trunk circuit stretches right round the globe relaying messages by means of automatic computer-type switching centres. Paris, Bracknell, Washington DC, Tokyo, New Delhi, Moscow, Cairo, Prague, Offenbach (Germany) are all on the weather hot line and there are many regional circuits: Paris for example is not only on the main trunk circuit but has direct links with Rome, Oran, Dakar, Casablanca, Madrid, Brussels, Zurich and so on.

Many ground stations in different parts of the world receive information from weather satellites and in Europe form part of the European Space Agency's "Ethernet" system.

### All that data

The scale of the WMO operation is indicated by some recent French figures: Paris transmits and receives about 20-million characters of data and about 230 graphical documents *every day*. Links between national and international switching centres operate at the high speed of 9600 bits per second, with the main trunk route mostly 2400 bit/s duplex channels. For the spur links, microprocessor-controlled teleprinters are increasingly being used and both analogue and digital facsimile systems are in use.

Much of this worldwide network has been established during the past 10-15 years and follows an appeal to the United Nations by President Kennedy in 1961 for further co-operative efforts between all nations in weather prediction and eventually weather control—though the prospect of "weather control" is fraught with problems.

International co-operation goes back a lot further. In 1873 some 32 countries meeting at Vienna set up the International Meteorological Organization to supplement an even early European storm warning system. The IMO formally became the WMO in 1951.

### The business of weather

Weather forecasting and its supporting technology has become big international business. British radio firms have sold both line and radio systems to many countries: weather data is passed by single-sideband telephony transmitters in many countries in the Middle East and Africa. Some of the elaborate satellite and balloon experiments have had large budgets.

Accurate rainfall predictions require not only massive computers but also enormous numbers of observations to feed into the voracious memories. Forecasters would like to have stations at 25-mile intervals reporting conditions at around ten vertical levels and thousands of free-floating balloons reporting temperature, humidity, pressure and wind data at heights up to about 50,000ft, though the full implementation of such systems is still some way off. Satellite weather photographs have proved one of the most useful and spectacular new forms of technology.

### Weather at war

Not everybody realises that the Met Office, with an annual budget of around £50 million, is part of the Ministry of Defence. Similarly, the French bureau was set up after 400 sailors were lost at sea when a violent storm destroyed part of the French fleet during the Crimean War.

In World War II, in the UK weather forecasts were kept secret and both sides expended time, effort and lives in order to provide their airmen with forecasts of weather conditions likely to be encountered over enemy territory.

The Germans set up a number of secret weather ships and stations in the North Atlantic, including some in Greenland, though these were usually rapidly detected by the Allies through interception of the radio communications.

The RAF was provided with daily forecasts of weather conditions over Europe, partly based on information passed to the Met Office from the British Secret Service who had an effective clandestine h.f. radio link with a group of experienced weather men within the Belgian Resistance—a service that kept going virtually throughout the Occupation despite all the efforts of the German direction-finding teams.

### Record entry for RAE

Despite all the talk of examination-less Citizens Band (or perhaps because of it), the number of candidates who sat for the Radio Amateurs Examination in May reached the remarkable figure of about 5,500 so it seems certain that many new callsigns will soon be heard on the amateur bands. Early this year licences in the G6-three-letter sequence began to be issued to Class B (v.h.f.) stations and many of these can now be heard on 144MHz.

### *Satellite confusion*

The publication by the HMSO of the 100-page booklet *"Direct Broadcasting by Satellite"* (£4·50) represents many months of study by the Home Office of the various options that are opening up. But unfortunately, although the report itself is clear and readable, many of the media comments on the report have added to the confusion in the mind of the public.

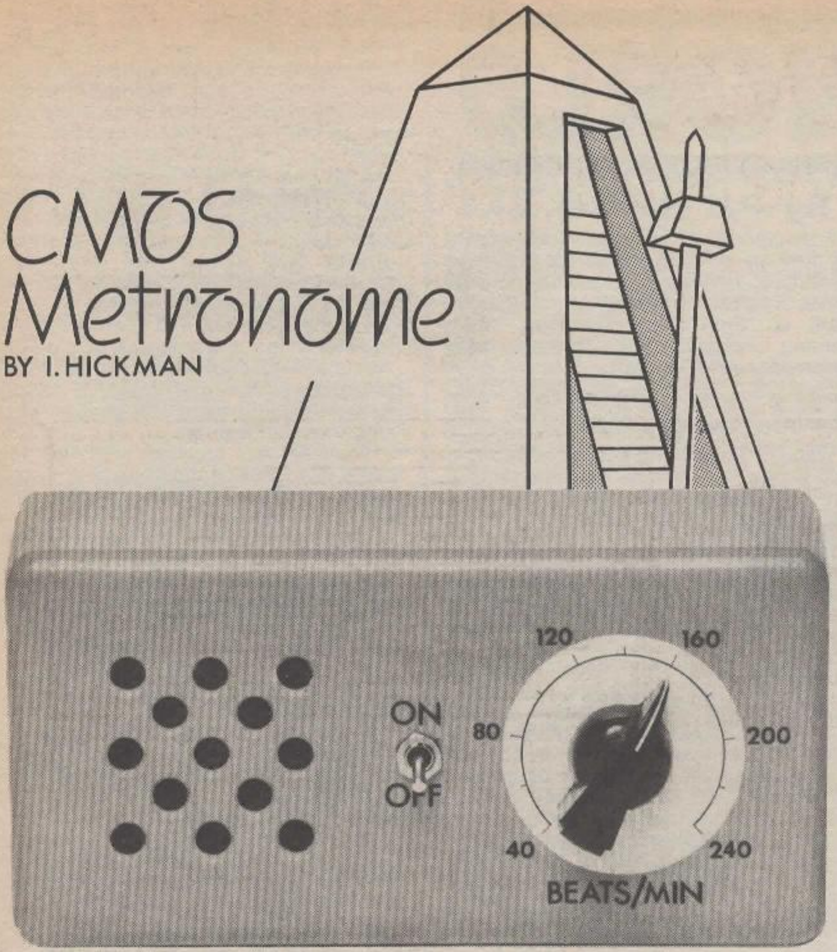
It has not always been appreciated that the study was concerned with *direct* broadcasts to the home, using transmitters (about 150 to 250 watts output) sufficiently powerful to be picked up on small dish aerials of 1-metre diameter or less. It was not concerned with the use of *distribution* satellites (typically 5 to 10 watts output) such as those now widely used in North America and elsewhere for the distribution of television programmes to cable operators or terrestrial transmitters.

The difference is an important one in terms of the technology and the costs since current distribution satellites can carry some 30 different programmes whereas so far nobody has put up a direct broadcast satellite (DBS), even experimentally, with more than two programme channels. A multichannel DBS needs a good deal of electrical power, calling for very large solar panels to give perhaps a 5 or 10kW and there are still questions of reliability in connection with high-power travelling wave tubes.

Then again many commentators noted that the report was generally in favour of an early project but failed to note the qualifications of Mr William Whitelaw, the Home Secretary. He wrote: *"The Government believes that a positive approach to the challenge is the right one . . . we are prepared to give serious consideration to the option for as early a start as possible with perhaps one or two television channels and possibly other information services. . . . This approach would need to be consistent with, and indeed build on, our existing broadcasting arrangements and institutions. In particular, any new DBS services would need to be subject to the same programme standards as apply to existing broadcasting services. . . ."*

# CMOS Metronome

BY I. HICKMAN




THE author's daughter was recently advised that she should use a metronome, as her violin playing—whilst creditably in tune—was distinctly wayward as far as keeping time goes.

Now a *real* metronome, the good old-fashioned wind-up clockwork type, is pretty expensive nowadays—it can cost you £20 or more. Further, despite the attractiveness of its polished wooden case, its beat tends to be uneven especially at the slower settings, and particularly so if not standing on an exactly level surface.

The beats themselves are not exactly identical, tending to sound like "tick - tock - tick - tock", which is fine for march time and common time but decidedly off in waltz time. So for this and other (financial?) reasons the author decided to make an electronic metronome.

Numerous designs for electronic metronomes have appeared in the past. Some were masterpieces of ingenuity using only a couple (or even just one) transistor, while others seemed unnecessarily complicated with flashing l.e.d.s as well as an audible output, or facilities for emphasing the first beat of the bar.

The design presented here however is very straightforward, and consequently it is easy to understand how it works. It is also simple to get going and there is no adjustment or setting up.

## LOGIC GATES

The circuit diagram of the metronome is shown in Fig. 1, and may be explained as follows. IC1a and b are two of the gates of a CD4011 CMOS quad 2-input NAND gate i.c., used as inverters. They form an oscillator running at just over 2kHz—the best frequency for audibility of the metronome's beat.

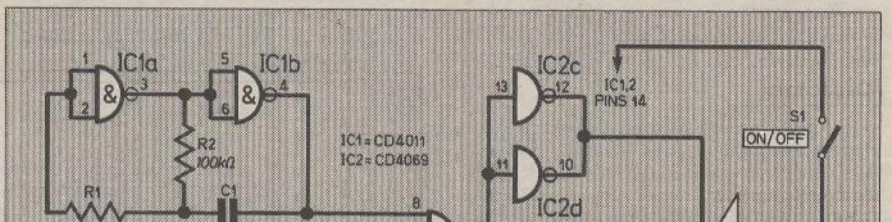
Gates IC2a and b are two of the inverters in the CD4069 CMOS i.c. and form another oscillator whose frequency is adjustable from four beats a second, that is 240 beats a minute, down to a sixth of this speed by means of the 500 kilohm potentiometer VR1. the squarewave output of this oscillator is differentiated by C4 and R5 to give narrow positive-going spikes of peak amplitude equal to the supply voltage, which is obtained from the ever popular PP3 9V type battery.

These positive spikes briefly enable NAND gates IC1c and IC1d resulting in antiphase 2kHz square waves appearing at pins 10 and 11. These are buffered by the remaining four sections of the hex-inverter and drive the directly coupled 40 ohm loudspeakers. Thus 9V appears at one terminal of the loudspeaker and 0V at the other, and then vice versa at a 2kHz rate, giving an 18V peak to peak speaker drive waveform.

## SPEAKER IMPEDANCE

The quoted 40 ohm resistance of the speaker is of course the d.c. value; at a frequency as high as 2kHz its impedance has risen dramatically. Consequently the complete circuit draws less than 2·5mA from the battery, which should therefore last a long time if the metronome is not accidentally left on.

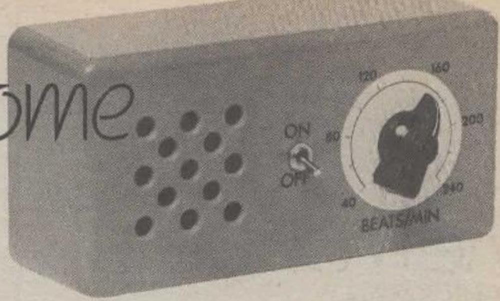
Fig. 1. Complete circuit diagram of the CMOS Metronome.



This is not likely to happen anyway, as its steady ticking, whilst not annoyingly loud, is all pervasive and can be heard all over a quiet house!

Note that by gating both IC1c and d, both terminals of the loudspeaker are at the same potential (0V) between ticks. This enables it to be direct coupled as shown without drawing any standard current, and also avoids the annoying click which is produced when the speaker's drive voltage is not symmetrical about its quiescent level.

# CMOS Metronome

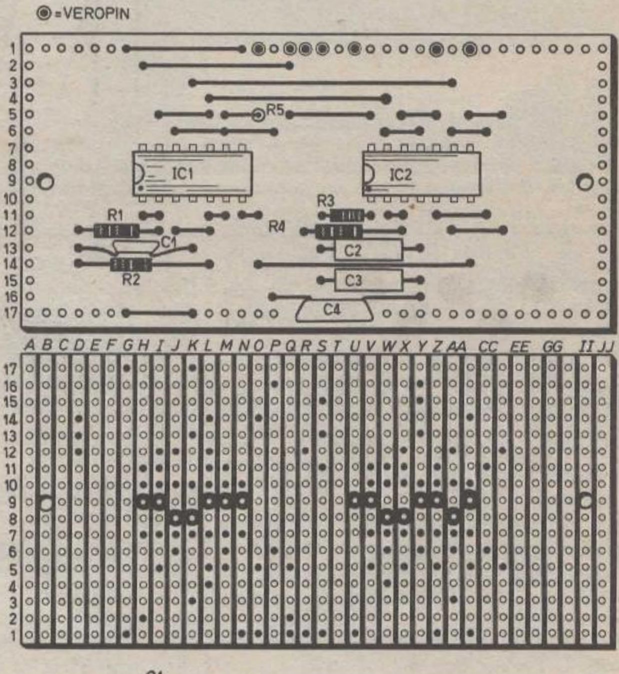



## CONSTRUCTION starts here

### PLASTICS BOX

The author constructed the metronome in a bright orange plastic box about 40 x 80 x 160mm as shown in Fig. 2. Behind the holes drilled for the speaker grille, a piece of perforated zinc, sprayed matt black, was glued into place using an ABS adhesive.

When this was dry, the speaker was glued into place similarly. All the components except the battery (which was mounted under a tin retaining



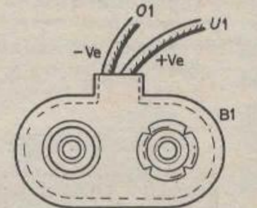




Fig. 3. Stripboard layout. When soldering in the CMOS i.c.s make sure that you use a properly earthed soldering iron to minimise damage due to static electricity. A suitable alternative would be to use i.c. sockets although you may then have to allow for an extra row of holes on each side of the i.c. as some sockets are quite wide. You can also see that there are a large number of wire links. Care should be taken to get these in the correct positions. All connections to off-board components are made using Veropins positioned along the top of the board.

## COMPONENTS

**Resistors**
R1 1M Ω
R2 100kΩ
R3 10MΩ
R4 100kΩ
R5 1MΩ
All ¼W carbon ± 5%

See Shop Talk page 535

**Capacitors**
C1 1nF ceramic
C2, 3 0·47μF polyester (2 off)
C4 10nF polyester

**Semiconductors**
IC1 CD4011 CMOS quad 2-input NAND gate
IC2 CD4069 CMOS hex inverter

**Miscellaneous**
VR1 500kΩ carbon lin. potentiometer
S1 s.p.s.t. toggle
LS1 miniature loudspeaker, 25-40 ohm coil impedance
B1 9V, PP3 type
Plastics case, 160 × 80 × 40mm; 0·1 inch matrix stripboard, 36 strips by 17 holes; interconnecting wire; 6BA nuts, bolts and spacers (2 off each) for mounting board; control knob; battery connector.

**COMPONENTS approximate cost £7**

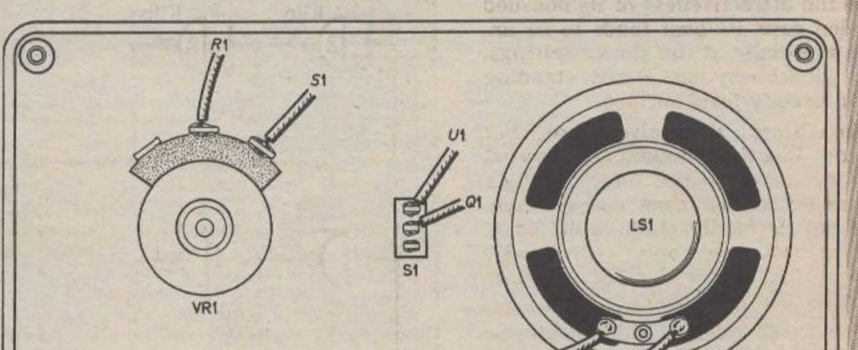
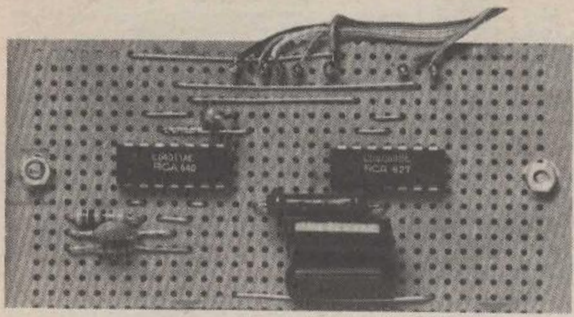
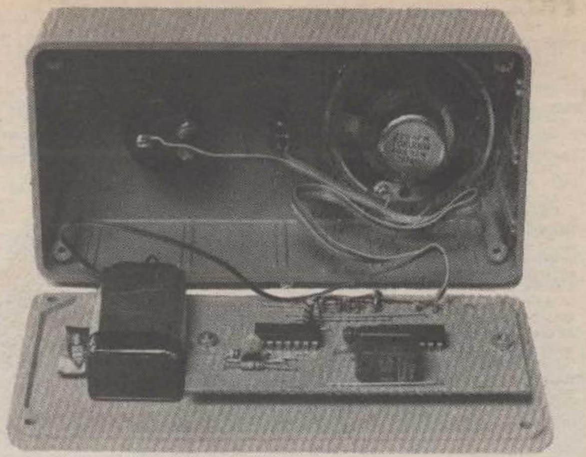



Fig. 2. Front panel layout showing relative positions of off-board components and connection points on stripboard.



Close up view of the prototype circuit board. The final layout in Fig. 3 differs from this because all underside links have been brought out on top of the board and components re-arranged so that they are not one on top of the other.



The assembled unit showing the rear of the front panel and mounted components and the circuit board and battery mounted in position on the rear panel of the case.

strap), S1, and VR1 (which are on the front of the box) were mounted on a piece of 0·1 inch matrix stripboard 17 holes by 36 strips (see Fig. 3).

The copper tracks run across the width of the board and of course the 7 tracks that run under each i.c. must be broken to avoid shorting opposite pins on the two sides of each pack. Take care when mounting the i.c.s or use slimline i.c. sockets.

It is well worth taking a little care with the construction as this always pays off in the long run. In particular, a length of colour coded ribbon cable makes a very neat job of the interconnections from front panel components to circuit board.

Use enough to allow the back of the box carrying the circuit board and battery to come well clear of the box for battery replacement. The spare cable folds neatly away inside the box when assembled. The circuit board is held in place using 6BA nuts, bolts and spacers.

## MODIFICATIONS

There is plenty of scope for tailoring the circuit to your liking. For instance, increasing C4 to 22nF will give a beefier "pip", whilst at 47nF the sound is more like a "bleep".

The value in Fig. 1 gives quite a good imitation of the tick of a traditional clockwork metronome. Capacitor C3 can be omitted—a useful economy—if R4 is changed to 180kΩ and VR1 to 1MΩ, and almost certainly any impedance speaker from 25 to 80 ohms would work satisfactorily.

The final touch is to mark the beat rate in beats per minute on the front panel using dry transfer lettering. For various settings of VR1 count the beat rate and mark it on the front panel as appropriate. There is little variation of beat rate with battery voltage down to 6V.

Below this the speed of the beat rate departs more markedly from the indicated tempo until at about 3V the circuit ceases to function altogether. ⌘

# LETTERS

## False Alarm

I would like to make a point concerning the *Ultrasonic Burglar Alarm*. It may be that I haven't understood it properly, but if there is a switch off delay on entering the room of say 10 to 20 seconds, then surely it would be possible for an intruder to pass through the guarded area (say a hallway), in this short period undetected.

A. J. Burt
New Eltham, London SE9

*The delay referred to will activate the system as soon as the intruder enters the guarded area, but the alarm will not sound until about 15secs. have elapsed, whether the intruder is in the area or not.*

*Another delay built into this project is a short period between initialising the system and it becoming operative. This is to allow the operator to set the alarm and then leave the room without triggering it. Of course if an intruder happens to be already in the area before the alarm is set, and if he is aware of what is happening and can take advantage of it, then he may well be able to pass through this guarded area undetected.*

## Buffered Reaction

The 13-year old son of an office colleague ordered a kit for the *Reaction Tester* (Nov. 80) and when he assembled it the result was disappointing. The result was that "dad" came to me. I found that one of the i.c. pins had curled up without entering the socket, and that was cured in 30 seconds flat. However the lamps did not cease on D18 but kept on cycling. I found that the current being drawn from the output pins of the 4017 i.c. was only a little over 1mA but that even this was seriously pulling down the output voltage so there was insufficient to activate the enable line to pin 13 via D7. My temporary suggestion was to insert a BC107 transistor as a buffer for D18 with a 10 kilohm resistor in the base lead. This achieved successful working. I am not sure why this problem has arisen. Would a buffered output 4017 have been better?

J. W. Robson
Newcastle upon Tyne

*An interesting point. The use of a buffered 4017 would not make any difference as the term "buffered" simply means that the terminal pins are protected against static discharges. It is possible that there may be an un-noticed high resistance path to earth from pin 9 of IC3 or components may be right at the edge or out of tolerance resulting in a high current drain. Changing D7 to a germanium type would help although the insertion of a buffer transistor is the more elegant solution.*

## Wrong Number

Being an 82-year old pensioner interested in electronics I thought I would interest myself in the Logic series, something new to me. I carried out all the exercises but came unstuck on exercise number 1.4d on page 333 in the May issue. It appears to me that the question is either a misprint or I am in error.

The answer given on page 405 in the June issue is 887 and the binary number should be 1101110111 whereas your number is 11011101111 which in my reckoning is 1911. Working back from 887, I came up with 1101110111.

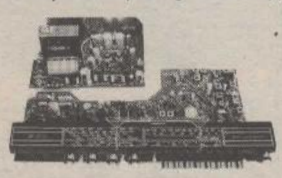
W. G. Chastney
Norwich, Norfolk

*Mr Chastney is of course quite right. The binary equivalent of 887 is 1101110111. You can take your pick as to whether the question is wrong and should have been 1101110111 or the answer was wrong and should have been 1775 (that is 1024 + 512 + 128 + 64 + 32 + 8 + 4 + 2 + 1) and not 1911. We apologise for this mistake.*

## B.K. ELECTRONICS—A SOUND CHOICE

**STEREO CASSETTE TAPE DECK MODULE**

Full record and play-back facilities. Supplied as one complete unit for horizontal installation into cabinet or console of own choice. Brand new, ready built and tested. Smart silver and black finish. **Features:** Three digit tape counter, Auto stop, Six piano type keys, Record, Rewind, Fast Forward, Play, Stop and Eject. Automatic record level control. Main inputs plus secondary inputs for stereo microphones. **Input sensitivity** 100mV to 2V. **Output level** 400mV nominal. **Wow and flutter** 0·1%. Ideal for hi-fi, disco and computer applications etc. Easily connected. **Dimensions**—top panel 5½" × 11½". Supplied complete with circuit and connecting diagrams. Power supply required—18V DC at 300mA. **PRICE £26·70** + £2·50 post and packing. Power supply kit (including transformer) £3·00.



**G.E.C. TUNER AMPLIFIER CHASSIS—AM/FM**

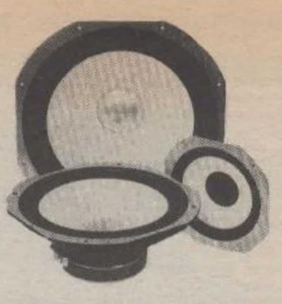
Originally designed for installation into a music centre. Supplied as two separate fully built and tested units which are easily wired together. Circuit diagram and inter-connecting wiring diagram supplied. **Rotary controls**—tuning, volume, balance, treble and bass. **Push button controls**—mono, tape, disc, A.F.C., F.M. (VHF), L.W., M.W., S.W. **Power output**—7 watts RMS per channel into 8 ohms. **Tape sensitivity** Output typically 150mV. Input 300mV. **Disc sensitivity** 100mV (Ceramic cartridge). **Stereo Beacon indicator** LED or bulb. **Dimensions**—Tuner 2¾" × 15" × 7½". Power amp. 2" × 7½" × 4½". **PRICE £23·50** + £2·50 post and packing.

**NEW RANGE QUALITY POWER LOUDSPEAKERS (15", 12" and 8").** These loudspeakers are ideal for both hi-fi and disco applications. Both the 12" and 15" units have heavy duty die-cast chassis and aluminium centre domes. All three units have white speaker cones and are fitted with attractive cast aluminium (ground finish) fixing escutcheons.

**15" 100 watt R.M.S.** Impedance 8 ohm, 2" aluminium voice coil. Resonant Frequency 20Hz. Frequency Response to 2·5KHz. **Price £32 each.** £2·50 Packing and Carriage each.

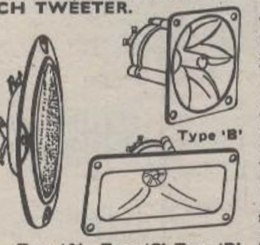
**12" 100 watt R.M.S.** Impedance 8 ohm, 2" aluminium voice coil. Resonant Frequency 25Hz. Frequency Response to 4KHz. **Price £23·70 each.** £2·50 Packing and Carriage each.

**8" 50 watt R.M.S.** Impedance 8 ohm, 1" aluminium voice coil. Resonant Frequency 40Hz. Frequency Response to 6KHz. **Price £8·90 each.** £1·25 Packing and Carriage each. Other units available.



**PIEZO ELECTRIC TWEETERS—MOTOROLA**

Join the Piezo revolution. The low dynamic mass (no voice coil) of a Piezo tweeter produces an improved transient response with a lower distortion level than ordinary dynamic tweeters. As a crossover is not required these units can be added to existing speaker systems of up to 100 watts (more if 2 put in series). **FREE EXPLANATORY LEAFLETS SUPPLIED WITH EACH TWEETER.**




**Type 'A'** 3in round with protective wire mesh. Ideal for bookshelf hi-fi speakers. **Price (Type 'A') £3·45 each.**

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# For your ENTERTAINMENT

**By BARRY FOX**

## Developing a Flat Screen TV

The recent announcement of a £5 million, four year, investment programme in the production of the Sinclair flat screen TV tube and Microvision pocket f.m. radio/television receiver prompts a look at the whole business of flat screen TV. It's always been a designer's dream to produce a TV set which can hang on a wall like a picture. Obviously an ordinary cathode ray tube can never be made flat enough to achieve this. The electron beam would have to scan over an angle approaching 180 degrees and this is electronically impractical.

## Projection Systems

Since the 30's TV designers have achieved a flat screen effect by projection techniques. In most systems a small picture tube, with a very bright picture, is incorporated in a lens-mirror system which projects an enlarged image of the tube picture on a flat, or slightly curved, screen. This is how large pictures were achieved before large c.r.t.'s were practical.

In the USA and Japan there is now a new generation of large screen TV receivers, which look like ordinary sets, but in fact incorporate a projector which beams the picture onto the rear of a translucent screen. More commonly, however, projection is from the front onto a reflective screen.

To achieve a bright, colour picture three separate tubes are used, rather than a single conventional shadowmask tube. One tube reproduces only the red component of the picture, the second tube reproduces green and the third tube reproduces blue. The projection optics combine the red, green and blue images on the screen to produce a full colour picture. But you always need to use a projector in addition to the screen. Sometimes, as in a rear projection system, the projector is combined in the same cabinet as the screen. Sometimes the projector is disguised as a coffee table in front of the screen. But either way the end result is a cumbersome arrangement.

## Matrix System

The long term answer to flat screen television is to use a matrix of light emitting cells instead of a cathode ray tube. In its simplest form, as already used in some vast sports arenas, the light cells are electric lamps. Many thousands of lamps are arranged in a grid of lines like a TV screen raster and their brilliance of illumination is continually modulated by a current which scans the grid.

In theory this replicates the effect of an electron beam scanning the phosphor screen of a TV tube. But in practice there are very real problems. Electric lamps have thermal inertia. You can't switch them on and off instantly. So the image smears on movement.

Neon lamps can be switched more quickly but they are very dim. It's also a very expensive business to build a matrix from large numbers of electric lamps, and they keep burning out so that maintenance is like painting the Forth Bridge. Also definition tends to be very coarse. So all over the world the race is on to find a matrix of fast acting light cells which can be made small enough to give reasonable definition.

## Japanese Approach

At the 1980 Electronics Show in Tokyo, Toshiba showed a prototype pocket TV with a two inch screen made from a liquid crystal display matrix. The tiny screen contained 52800 individual picture elements, arranged in a matrix of 220 × 240 rows. The picture, in black and white only, was dim and disappointing with smearing on motion.

In the research laboratories of NHK, the Japanese radio station which is loosely equivalent to the BBC, I saw two prototype flat screen colour systems. The smallest, a ten inch diagonal display panel is formed from 36480 oblong gas discharge cells arranged with colour phosphors in a matrix of 95 × 384 rows.

The gas discharge cells generate ultra-violet radiation which excites phosphors to emit visible light of the three primary colours, red, green and blue. The pictures were only moderately bright and of only reasonable colour rendition. Definition is coarse because the picture is effectively formed from only 12,160 elements.

The flat screen is also accompanied by a large stack of outboard electronics. Likewise the NHK 16 inch diagonal screen needs a substantial amount of additional electronics.

This uses a matrix of 240 × 320 cells and the phosphors are arranged as dot clusters rather than oblong strips. NHK engineers are the first to admit that both definition and brilliance must be improved before the system is workable.

Reducing the outboard electronics to manageable size is simply a matter of a large scale integration, and although expensive this presents no real practical problems. It's clear that NHK is looking ahead, perhaps to the next decade, and the production of a high definition wall screen built up from a matrix of microscopically fine multi-coloured light emitting cells.

## American Answer

In the US, RCA has been looking at flat screen technology for the last 35 years but has now abandoned matrix techniques. RCA is instead developing a four inch thick cathode ray tube. In fact each of these tubes are really only a part picture tube.

A large TV screen is built up from a parallel series of long thin strips, each formed from an individual c.r.t. The electron beam is fired from guns at one end and turned through 90 degrees onto a phosphor screen by a series of deflector grids. Colour is achieved by normal shadowmask technique and multi-coloured phosphors.

The company claims that it will be able to produce a 50inch diagonal tube, made up from one inch wide individual tubes. This, says RCA, will be available towards the end of the decade.

## Sinclair Recipe

In the UK, Sinclair is adopting a line more closely resembling the RCA approach than that being followed in Japan by NHK and Toshiba. The Sinclair tube, which measures around 4 × 2 × ¾inch in total size and has a 3 inch diagonal viewing screen, is made from a flat sandwich of two glass plates.

An electron beam fired from a gun at one end is bent, as in the RCA tube, through 90 degrees to strike a phosphor screen on the back plate. The image produced is viewed through a transparent tin oxide electrode on the front plate.

To keep power consumption of the scanning circuits down, the displayed image is of squashed aspect, rather like a cinemascope image on film before it is expanded by the special projection lens used for such films. A Fresnel lens on the front plate of the Sinclair tube restores the image to its normal 4 × 3 aspect ratio.

Although Sinclair has only recently disclosed these technical details, even fuller facts have actually been readily available through published patents for some time. For instance, French patent application number 78/14732, published under number 2 391 556, was available for anyone to read in the British Patent Office Library as far back as April 1979!

A recent press conference given by Sinclair did however clear up some other matters. Those who had studied the patents could not for instance see how the tube could possibly be made large, to produce reasonable size pictures. It also seemed impractical to convert the tube to colour, and still keep the cost down.

It now emerges that Sinclair plans to produce large screen pictures by using the tubes in a projection mode. Three tubes, one for red, one for green and one for blue, will be incorporated in an optical system to project a picture of up to 50 inches in size on a wall screen.

Even a 9inch picture in a portable set can, it is claimed, be most economically produced by using three tubes, a projection lens, and a back-projection screen. Only time will tell whether this extraordinary claim is justified.

## Production and Reliability

In the meantime, Sinclair is to start producing tubes and Microvision receivers, at the Timex Corporation's watch plant in Dundee. Over half the £5 million financial backing comes, one way or another, from the British tax payer. Although the investment is spread over the next 3 or 4 years, it is hoped soon to be producing tubes at the rate of one million a year.

Sinclair Microvision flat screen sets should start appearing in the shops for around £50 next year. These will be usable anywhere in the world except France, which is out of line with other TV standard systems on just about every count, for instance the sound is a.m. rather than f.m.

If all goes well around 1,000 people will eventually be employed by Timex on the project. It's obviously in the national interest, therefore, that all goes well!

Sinclair claims that the company's early bad reputation for poor reliability of product, for instance calculators and digital watches, has been overcome with the ZX80 computer "We have not been too proud to take a lesson from the Japanese" he says.

Quality control requirements on the raw components have tightened by a thousandfold but there are still a couple of question marks. Firstly the ZX80 is made for Sinclair by the Tek Group, not Timex. The latter company has already been named as the manufacturing base for the Nimslo 3-dimensional snapshot camera and for this is receiving £3 million in Government cash.

Much has been heard of this gadget, which is supposed to enable the home photographer to produce 3-D snapshots for not much more than the cost of ordinary photography. But so far nothing has been seen of a saleable product.

Incidentally Nimslo, like Sinclair, have been reticent over technical details concerning their products. But again, full details are already on the public record. US patent 3 852 787, for instance, gives a detailed break down of Nimslo 3-dimensional technology. Anyone calling at the foreign section of the British Patent Office Library can look at a copy, free of charge.

## Looking for a Market

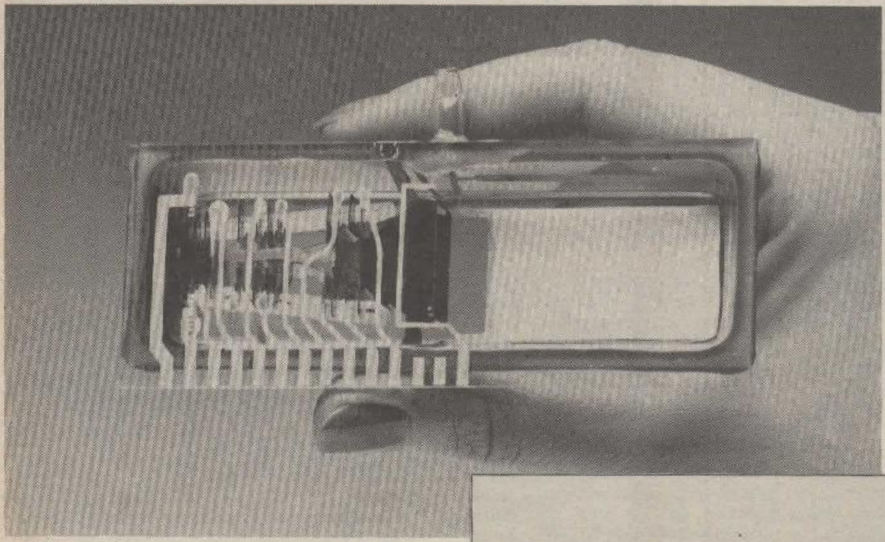
Rather more important is the question of who actually *wants* a pocket TV set with a tiny black-and-white screen which they can carry round the world. Of course, some gadget-hungry executives will buy one simply because it is cheap and makes a good talking point.

In reality anyone who can afford to travel round the world can also afford to stay in a hotel and most modern hotel rooms have a TV set, usually a large screen colour receiver. And whereas it may be nice to listen to the sound from a radio or cassette recorder while on the move, or as aural wallpaper for work or play, any TV set (whether it's large screen colour or pocket sized flat black-and-white) needs watching. Also, however small the Microvision set may eventually be, it still needs a long aerial to receive pictures off-air.

At the London press conference Clive Sinclair showed an impressive looking pocket Microvision and pictures of this set were widely publicised by the media. In fact this set was a dummy. The only *working* system was a prototype, several years old, which sat on a large box of outboard electronics served by a long telescopic aerial. And it's pictures were certainly nothing special.

No one doubts Clive Sinclair's genius for innovation. And it may well be that the flat screen Microvision comes off the Timex production lines as cheaply and as reliably as he predicts. But no one can really predict whether sales will keep up with production.

Flat screen Microvision is a product looking for a market. As the British tax payer is contributing heavily to the development of that product—and 1,000 jobs hang on the results—we can only hope that the market is there.



**First prototype of the Sinclair flat-screen tube produced at St. Ives, Cambridge.**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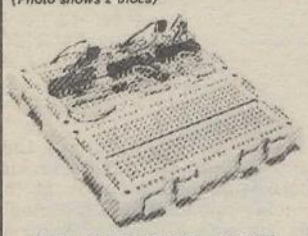

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# SQUARE one FOR BEGINNERS

HAVING looked at the more common forms of non-polarised, fixed value capacitors last month, we now turn our attention to **polarised** types.

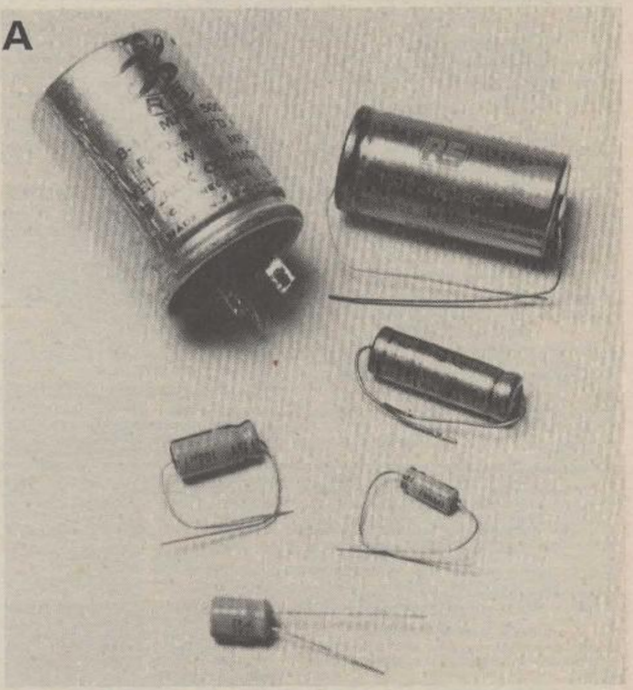
They are called polarised simply because it is essential to connect them up the correct way round as marked on the circuit diagram otherwise they will not work and may well fail with spectacular if not dangerous results.

The value of a capacitor depends on two factors—the size of the conductive plates and the nature of the dielectric. If you wish to obtain a very large value of capacitance and at the same time keep the physical size of the component manageable then it is necessary to use the dielectrics produced in a polarised capacitor.

Here a **metal foil** forms one of the plates. This is coated with an oxide which forms the **dielectric**. Another metal foil is separated from the first by a layer of porous paper impregnated with an **electrolyte** (hence the term **electrolytic**) and this combination forms the other plate. The action of the dielectric is maintained by making sure that the current always flows from the coated plate to the other. If this direction is reversed then the oxide layer breaks down and the component fails.

Recent advances in foil material have resulted in the **tantalum** capacitor becoming available.

A



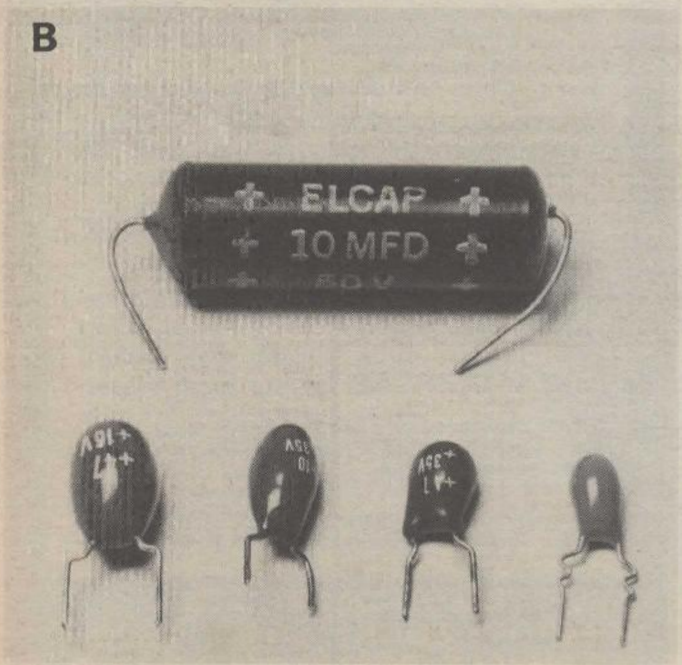
**A** A selection of electrolytic capacitors. It can be seen that they are all in metal containers. This is to make construction easier as the actual casing of the capacitor often forms the negative connection. In fact this point can often be used to identify the different connections on an unknown capacitor. Remember however that there is usually a plastic coating on most capacitors for insulation purposes and some more modern electrolytics might be housed in plastic casings.

The most annoying drawback of electrolytics is their trend to instability. If one of these capacitors is left unused for a long time, it undergoes a process of **deformation**. Although it soon recovers when used again, it may fail if subjected to its maximum working voltage when re-used for the first time, a point worth remembering when a project doesn't work. Even "new" components may have been on the shelf some months.

On a more practical note, the tolerance of these capacitors is generally very wide, often +50, −25 per cent and the **leakage current,** that is the d.c. current flowing between the plates, is also high. Typical uses include smoothing in power supplies and interstage coupling in audio amplifiers.

Three case styles are common. The first, reserved for very high values and voltage ratings consists of a metal can with solder tags at one end as seen in the top left of the photo. Sometimes you find two or three capacitors actually inside the same container, as in this case, hence the three tags. Then there are **axial** types, that is with one wire coming from each end. These come in many sizes. Finally there is the **radial** type with both wires coming from the same end. These are often referred to as p.c.b. types. Each connection is identified as + or −. Usually only one is marked and it may be either one. Remember that the capacitor must be connected the right way round. Once again there is a trade off between value and voltage rating when it comes to case size.

B




**B** Having said that all electolytics have a + and − terminal and must be connected the correct way round, we can now contradict ourselves and say that in certain applications a **non-polarised capacitor** can be used. One of these is shown at the top of the photograph. It is distinguished by the fact that both ends are marked with + signs.

These devices differ in construction from a polarised electrolytic in that both plates inside the capacitor are made from metal foil coated with an oxide layer. These are then separated with the usual porous paper impregnated with electrolyte. Because of this construction method, non-polarised types are about twice as big as a comparable polarised type of the same value and voltage rating.

The most common application of this type of capacitor is in crossover networks for hi-fi speaker systems. These components suffer from the same tolerance and leakage problems as polarised types and are rarely used in other applications as it is possible to obtain other types of non-polarised capacitor that have the far superior leakage and tolerance characteristics necessary in other types of circuit.

Along the bottom of the photo we can see a row of tantalum bead capacitors. Although these are still polarised capacitors and therefore need connecting correctly, they offer distinct advantages over standard electrolytic types. The most striking feature is their size, the biggest being only the size of a man's little finger nail. They offer superior tolerances, typically ± 20 per cent and leakage current is less than one third of that of a comparable standard type. Of course all these advantages have to be paid for and tantalum capacitors tend to be anything up to three times the price of a comparable standard electrolytic.


## Cheeky

Just imagine how a poor shop keeper feels after a particularly bad week, when someone enters his establishment and brightly informs him, "I have just bought this £300 music centre from Sparkos up the road, but he hasn't the right plug for it, so he sent me to you".

A few months ago I had another customer who I think would take first prize for cheek. We had a sale on at the time and as the sale items were displayed in a separate room, it was necessary just to keep an eye on them, which unfortunately stopped us working.

This particular nuisance would stand and read the books for 20 minutes and finally buy something for 10p. He would then bring it back next day and want to change it. But it was his final effort that staggered me.

He had previously bought a small packet of bargain resistors for 20p. Next day he came in with the packet and a list of three resistors he required for a project. He asked me if I had them and I got them out. It was only then that his plan became clear. He was going to empty the packet on the counter, see if any colours matched up and if they did he knew he wouldn't have to buy them, in other words he just wanted to borrow them!!

I said to him "Why don't you buy a colour code calculator?" He asked me how much they were and I said 25p. He then asked me the price of the three resistors, I said 18p so he said "In which case I'll take the resistors." Collapse of poor old Young!

## Burning Matters

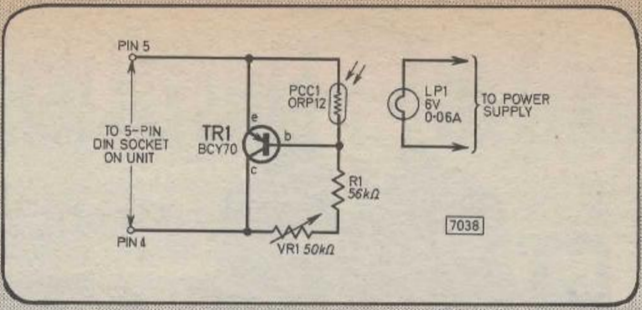
One of my many weaknesses is buying new fangled gadgets, especially if they are electronic. My automatic kettle was supposed to switch off automatically when it boiled, thus avoiding a room full of steam and finally a burnt-out element. Oh! it switched off all right. I would then heat the tea pot, put in the tea and attempt to switch it on again by pushing in the button. After almost breaking my thumb, I would give up and boil the water on the gas.

The one time I gave up completely in disgust and went away, the kettle obviously felt ashamed of itself and said, "I'm not fit to be an automatic kettle" promptly switched itself on again, filled the kitchen with steam and burnt out the element!!

Then the other day, I saw one of these new toasters that are timed with a chip, I just had to have one. I suppose Dr. Johnson would have called it, "The triumph of hope over experience." Well, I was fed up with toast that was either black or white. I've got to admit this is an improvement. My toast is now black one side and white the other. Well readers, I suggest you buy a good old fashioned toasting fork.

# CIRCUIT EXCHANGE

## OPTO-ALARM ADDITION FOR INTRUDER ALARM

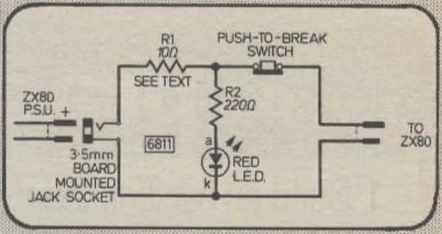



I built the intruder alarm published in your magazine (May 1979) and it proved highly successful. With this circuit, it can also be used as a very sensitive opto-alarm, as well as the loop switches. No modification is necessary to the original unit, the new wiring being connected to the parallel loop. The light source can be powered by battery, or from the intruder alarm power supply. The light source and PCC1 should be shielded from ambient light (mine were mounted inside two cigar tubes).

From the diagram, it can be seen that PCC1, R1 and VR1 form a potential divider chain. VR1 "trims" R1. With PCC1 illuminated from the light source, it exerts a low resistance; since this is lower than R1 and VR1 combined, the transistor does not conduct. Should the light beam be broken, PCC1 will then have a very high resistance, allowing current flowing through R1 and VR1 to turn TR1 on. The transistor then effectively "shorts" across the two terminals (4 and 5) "closing" the normally open loop, and so sounding the alarm.

Paul Hemingway
Hull, North Humberside.

## ZX80 P.S.U. IMPROVEMENT




My circuit should help to prevent the very common ZX80 fault of over heating. Many of your readers with a ZX80 may have problems with loading and saving due to the main circuit board getting too hot. The heat comes from the voltage regulator, the heatsink fitted can't disperse all the heat so it heats up the board.

The computer needs about 10 volts, my Sinclair p.s.u. supplied 18 volts. The resistance needed to reduce the voltage can be calculated, in practice a resistance of 10Ω works best.

One watt resistors were used in the circuit but got rather hot. A strip of aluminium foil was placed around the ceramic area of the resistor R1 to help keep it cool. If 3 watt resistors are to hand they can be used. Of course resistors with integral heatsink would be ideal, these are rather expensive.

A normal 0·2in red l.e.d. was used to show when the ZX80 is on. All the components were mounted on 0·1in stripboard. A push to break switch was mounted to allow instant clearing of memory.

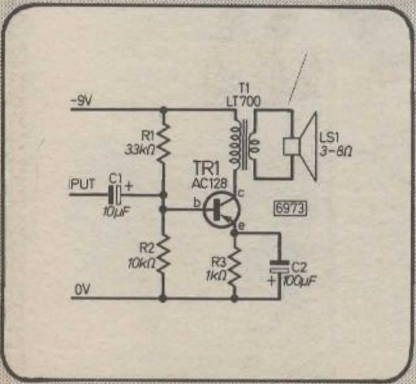
A. R. Jones,
Loughborough,
Leicester.

## CRYSTAL EARPIECE AMPLIFIER

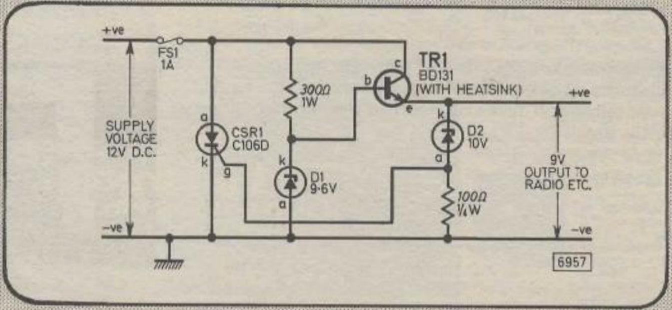
I have designed a crystal earpiece amplifier. The circuit is connected to the crystal earpiece output socket of a piece of equipment and the gain of the transistor TR1 was found sufficient to drive a small loudspeaker via the output transformer.

The circuit could be used in many other projects, including the output stage of a simple radio tuner.

P. Patel,
Hornchurch,
Essex.




## 12V TO 9V CONVERTER WITH OVERLOAD PROTECTION




I enclose a circuit diagram for a simple device I built to step down the 12V d.c. supply from a car battery to 9V d.c., often used by portable radios. This is very useful for people who own cars with no installed radio, and also for campers.

It is a very simple circuit, which as well as stepping the voltage down, also blows the fuse FS1 via the thyristor CSR1 if anything goes wrong with the rest of the circuit; this prevents the load from becoming damaged.

M. D. Farrimond,
Eaton, Norwich.

CIRCUIT EXCHANGE

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| 2N3706 | 0·12 |
| 2N3708 | 0·12 |
| 2N5294 | 0·38 |
| 2N5296 | 0·48 |
| 2N5298 | 0·38 |
| 2SC1306 | 1·25 |
| 2SC1307 | 1·85 |
| **I.C.'s** | |
| MC1307 | 1·00 |
| MC1350 | 1·00 |
| MC1495 | 3·00 |
| SN76003N | 1·65 |
| SN76023N | 1·35 |
| SN76033N | 1·35 |
| SN76131N | 1·30 |
| SN76227N | 1·05 |
| SN76660N | 0·60 |
| TA7205AP | 1·95 |
| TAA661B | 1·20 |
| TBA120S | 0·70 |
| TBA540 | 1·25 |
| TBA5500 | 1·55 |
| TDA1004A | 2·20 |
| UPC575C2 | 2·95 |
| TA7205P | 1·95 |
| TBA810S | 1·60 |
| UPC566H | 2·95 |
| UPC1001H | 3·95 |
| UPC1025 | 2·50 |
| UPC1156H | 2·15 |
| UPC13635C | 3·95 |

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| | | | | | |
|---|---|---|---|---|---|
| AC107 | 25 | BC107B | 11 | BC173 | 09 |
| AC125 | 30 | BC107C | 12 | BC174 | 15 |
| AC126 | 22 | BC108 | 10 | BC175 | 35 |
| AC127 | 22 | BC108A | 11 | BC177 | 14 |
| AC128 | 20 | BC108B | 11 | BC178 | 14 |
| AC128K | 37 | BC108C | 12 | BC179 | 14 |
| AC132 | 28 | BC109 | 10 | BC180 | 12 |
| AC141 | 28 | BC109A | 11 | BC181 | 10 |
| AC141K | 40 | BC109B | 11 | BC182 | 10 |
| AC142 | 26 | BC109C | 12 | BC182L | 10 |
| AC142K | 40 | BC113 | 16 | BC183 | 10 |
| AC176 | 24 | BC114 | 17 | BC183L | 10 |
| AC176K | 40 | BC115 | 18 | BC184 | 10 |
| AC187 | 25 | BC116 | 19 | BC184L | 10 |
| AC187K | 40 | BC116A | 20 | BC186 | 15 |
| AC188 | 25 | BC117 | 20 | BC187 | 18 |
| AC188K | 40 | BC118 | 17 | BC207 | 11 |
| ACY17 | 50 | BC119 | 29 | BC208 | 11 |
| ACY18 | 50 | BC120 | 35 | BC209 | 12 |
| ACY19 | 50 | BC125 | 25 | BC212 | 10 |
| ACY20 | 50 | BC126 | 30 | BC212L | 10 |
| ACY21 | 50 | BC132 | 18 | BC213 | 10 |
| ACY22 | 50 | BC134 | 18 | BC213L | 10 |
| AD130 | 75 | BC135 | 18 | BC214 | 10 |
| AD140 | 70 | BC136 | 20 | BC214L | 10 |
| AD142 | 85 | BC137 | 20 | BC225 | 26 |
| AD143 | 85 | BC138 | 28 | BC226 | 36 |
| AD149 | 70 | BC139 | 32 | BC237 | 13 |
| AD161 | 40 | BC140 | 25 | BC238 | 14 |
| AD162 | 40 | BC141 | 28 | BC239 | 15 |
| AD161/162 M/P | 30 | BC142 | 25 | BC251 | 15 |
| AF114 | 50 | BC143 | 25 | BC251A | 16 |
| AF115 | 50 | BC144 | 40 | BC261 | 18 |
| AF116 | 50 | BC145 | 46 | BC300 | 30 |
| AF117 | 50 | BC147 | 09 | BC301 | 28 |
| AF118 | 65 | BC148 | 09 | BC302 | 29 |
| AF124 | 50 | BC149 | 09 | BC303 | 28 |
| AF125 | 50 | BC150 | 20 | BC304 | 28 |
| AF126 | 50 | BC151 | 22 | BC307 | 13 |
| AF127 | 50 | BC152 | 20 | BC327 | 12 |
| AF139 | 50 | BC153 | 25 | BC328 | 13 |
| AF239 | 42 | BC154 | 19 | BC337 | 13 |
| AL102 | 1.90 | BC157 | 10 | BC338 | 13 |
| AL103 | 1.80 | BC158 | 10 | BC384 | 14 |
| ASY26 | 50 | BC159 | 10 | BC440 | 30 |
| ASY27 | 50 | BC160 | 26 | BC441 | 30 |
| ASY28 | 50 | BC161 | 38 | BC460 | 32 |
| ASY29 | 50 | BC167 | 11 | BC461 | 32 |
| AU104 | 1.90 | BC168 | 10 | BC477 | 20 |
| AU110 | 1.90 | BC169 | 10 | BC478 | 20 |
| AU113 | 1.90 | BC169C | 11 | BC479 | 20 |
| BC107 | 10 | BC170 | 09 | BC546 | 10 |
| BC107A | 11 | BC171 | 09 | BC547 | 10 |
| | | BC172 | 09 | BC548 | 10 |

| | | | | | |
|---|---|---|---|---|---|
| BC549 | 11 | BD200 | 99 | BF163 | 30 |
| BC550 | 14 | BD201 | 80 | BF164 | 50 |
| BC556 | 14 | BD202 | 80 | BF165 | 50 |
| BC557 | 13 | BD201/202 M/P | 1.70 | BF167 | 24 |
| BC558 | 13 | BD203 | 80 | BF173 | 24 |
| BC559 | 14 | BD204 | 80 | BF176 | 36 |
| BCY30 | 80 | BD203/204 M/P | 1.70 | BF177 | 24 |
| BCY31 | 80 | BD205 | 80 | BF178 | 25 |
| BCY32 | 85 | BD206 | 80 | BF179 | 30 |
| BCY33 | 80 | BD207 | 80 | BF180 | 30 |
| BCY34 | 80 | BD208 | 80 | BF181 | 30 |
| BCY70 | 14 | BD222 | 47 | BF182 | 30 |
| BCY71 | 15 | BD225 | 47 | BF183 | 30 |
| BCY72 | 15 | BD232 | 85 | BF184 | 22 |
| BCZ10 | 70 | BD233 | 85 | BF185 | 22 |
| BCZ11 | 70 | BD234 | 55 | BF186 | 26 |
| BCZ12 | 70 | BD235 | 55 | BF187 | 26 |
| BD106 | 50 | BD236 | 58 | BF188 | 32 |
| BD115 | 50 | BD237 | 65 | BF194 | 10 |
| BD116 | 50 | BD238 | 65 | BF195 | 10 |
| BD121 | 65 | BD239A | 50 | BF196 | 12 |
| BD123 | 65 | BD240A | 50 | BF197 | 12 |
| BD124 | 75 | BD239A/240A | 1.00 | BF198 | 15 |
| BD131 | 35 | BD240 | 45 | BF199 | 15 |
| BD132 | 35 | BD241 | 45 | BF200 | 30 |
| BD131/132 M/P | 80 | BD506 | 38 | BF222 | 90 |
| BD133 | 40 | BD508 | 38 | BF224 | 20 |
| BD135 | 35 | BDX32 | 2.20 | BF240 | 17 |
| BD136 | 35 | BDY11 | 1.30 | BF241 | 18 |
| BD137 | 35 | BDY17 | 1.80 | BF244 | 28 |
| BD138 | 38 | BDY20 | 80 | BF257 | 30 |
| BD139 | 38 | BDY55 | 1.40 | BF258 | 30 |
| BD140 | 38 | BDY56 | 1.60 | BF259 | 35 |
| BD139/140 M/P | 80 | BF115 | 25 | BF262 | 60 |
| BD155 | 60 | BF117 | 50 | BF263 | 60 |
| BD175 | 60 | BF118 | 75 | BF270 | 36 |
| BD176 | 60 | BF119 | 75 | BF271 | 31 |
| BD177 | 68 | BF121 | 50 | BF273 | 36 |
| BD178 | 68 | BF123 | 60 | BF274 | 38 |
| BD179 | 75 | BF125 | 50 | BF324 | 35 |
| BD180 | 75 | BF127 | 60 | BF336 | 34 |
| BD185 | 68 | BF152 | 25 | BF337 | 34 |
| BD186 | 68 | BF153 | 25 | BF338 | 38 |
| BD187 | 75 | BF154 | 22 | BF371 | 26 |
| BD188 | 75 | BF155 | 35 | BF457 | 37 |
| BD189 | 78 | BF156 | 28 | BF458 | 37 |
| BD190 | 78 | BF157 | 28 | BF459 | 38 |
| BD195 | 90 | BF158 | 28 | BF594 | 30 |
| BD196 | 90 | BF159 | 28 | BF595 | 28 |
| BD197 | 95 | BF160 | 28 | BF596 | 28 |
| BD198 | 95 | BF162 | 24 | BFR39 | 24 |
| BD199 | 99 | | | BFR40 | 25 |
| | | | | BFR41 | 25 |
| | | | | BFR50 | 25 |

| | | | | | |
|---|---|---|---|---|---|
| BFR52 | 25 | MPSA05 | 20 | TIP30A | 40 |
| BFR62 | 24 | MPSA06 | 20 | TIP30B | 42 |
| BFR79 | 28 | MPSA55 | 20 | TIP30C | 44 |
| BFR80 | 28 | MPSA56 | 20 | TIP31 | 38 |
| BFW10 | 55 | ND120 | 18 | TIP31A | 40 |
| BFX29 | 25 | OC19 | 85 | TIP31B | 42 |
| BFX30 | 30 | OC20 | 1.85 | TIP31C | 44 |
| BFX84 | 24 | OC22 | 1.50 | TIP32 | 38 |
| BFX85 | 26 | OC23 | 1.50 | TIP32A | 40 |
| BFX86 | 26 | OC24 | 1.35 | TIP32B | 42 |
| BFX87 | 26 | OC25 | 1.00 | TIP32C | 44 |
| BFX88 | 26 | OC26 | 1.00 | TIP41A | 44 |
| BFX90 | 55 | OC28 | 90 | TIP41B | 46 |
| BFY50 | 20 | OC29 | 95 | TIP41C | 44 |
| BFY51 | 20 | OC35 | 90 | TIP42A | 44 |
| BFY52 | 20 | OC36 | 90 | TIP42B | 46 |
| BFY53 | 20 | OC41 | 20 | TIP42C | 48 |
| BFY90 | 80 | OC42 | 22 | TIP2955 | 80 |
| BIP19 | 38 | OC44 | 24 | TIP3055 | 50 |
| BIP20 | 38 | OC45 | 20 | TIS43 | 22 |
| BIP19/20 M/P | 30 | OC70 | 24 | TIS90 | 20 |
| BRY39 | 39 | OC71 | 15 | TIS91 | 22 |
| BSX19 | 20 | OC72 | 24 | TIS92 | 22 |
| BSX20 | 20 | OC74 | 26 | UT46 | 20 |
| BSX21 | 21 | OC75 | 30 | ZTX107 | 10 |
| BSY95 | 13 | OC76 | 35 | ZTX108 | 10 |
| BSY95A | 13 | OC77 | 50 | ZTX109 | 10 |
| BU105 | 1.60 | OC79 | 40 | ZTX300 | 12 |
| BU105/02 | 1.95 | OC81 | 22 | ZTX301 | 12 |
| BU204 | 1.40 | OC81D | 24 | ZTX302 | 16 |
| BU205 | 1.40 | OC82 | 24 | ZTC303 | 16 |
| BU208 | 1.90 | OC82D | 30 | ZTX304 | 20 |
| BU208/02 | 2.25 | OC83 | 26 | ZTX330 | 15 |
| GP300 | 40 | OC84 | 38 | ZTX500 | 13 |
| MJ480 | 95 | OC139 | 80 | ZTX501 | 12 |
| MJ481 | 1.05 | OC140 | 80 | ZTX502 | 16 |
| MJ490 | 95 | OC169 | 80 | ZTX503 | 12 |
| MJ491 | 1.15 | OC170 | 80 | ZTX504 | 25 |
| MJ2955 | 90 | OC171 | 80 | ZTX531 | 25 |
| MJE340 | 50 | OC200 | 46 | ZTX550 | 25 |
| MJE370 | 55 | OC201 | 95 | 2N388 | 36 |
| MJE371 | 60 | OC202 | 1.20 | 2N388A | 56 |
| MJE520 | 45 | OC203 | 85 | 2N404 | 20 |
| MJE521 | 65 | OC204 | 90 | 2N404A | 24 |
| MJE2955 | 90 | OC205 | 1.15 | 2N524 | 40 |
| MJE3055 | 65 | R2008B | 2.50 | 2N527 | 50 |
| MJE3440 | 52 | R2010B | 2.80 | 2N598 | 40 |
| MP8113 | 52 | TIC44 | 29 | 2N599 | 46 |
| MPF102 | 60 | TIC45 | 35 | 2N696 | 24 |
| MPF104 | 35 | TIP29 | 30 | 2N697 | 24 |
| MPF105 | 35 | TIP29A | 55 | 2N698 | 30 |
| | | TIP29B | 42 | 2N699 | 32 |
| | | TIP29C | 44 | 2N706 | 10 |
| | | TIP30 | 38 | 2N706A | 12 |

| | | | | | |
|---|---|---|---|---|---|
| 2N707 | 48 | 2N2714 | 22 | 2N3823 (FET) | 60 |
| 2N708 | 14 | 2N2904 | 24 | 2N3903 | 12 |
| 2N711 | 30 | 2N2904A | 26 | 2N3904 | 12 |
| 2N717 | 30 | 2N2905 | 24 | 2N3905 | 12 |
| 2N718 | 25 | 2N2905A | 26 | 2N3906 | 12 |
| 2N718A | 50 | 2N2906 | 18 | 2N4058 | 12 |
| 2N726 | 29 | 2N2906A | 20 | 2N4059 | 14 |
| 2N727 | 29 | 2N2907 | 20 | 2N4060 | 14 |
| 2N743 | 20 | 2N2907A | 22 | 2N4061 | 12 |
| 2N744 | 20 | 2N2903 | 15 | 2N4062 | 12 |
| 2N914 | 20 | 2N2924 | 15 | 2N4220 (FET) | 35 |
| 2N918 | 30 | 2N2925 | 15 | 2N4284 | 28 |
| 2N929 | 20 | 2N2926G | 10 | 2N4285 | 28 |
| 2N930 | 18 | 2N2926Y | 09 | 2N4286 | 28 |
| 2N948 | 40 | 2N29260 | 09 | 2N4287 | 28 |
| 2N1131 | 24 | 2N2926R | 09 | 2N4288 | 28 |
| 2N1132 | 24 | 2N2926B | 09 | 2N4289 | 28 |
| 2N1302 | 25 | 2N3010 | 20 | 2N4290 | 28 |
| 2N1303 | 28 | 2N3011 | 20 | 2N4291 | 28 |
| 2N1304 | 28 | 2N3053 | 22 | 2N4292 | 28 |
| 2N1305 | 28 | 2N3054 | 45 | 2N4293 | 28 |
| 2N1306 | 35 | 2N3055 | 42 | 2N4860 (FET) | 60 |
| 2N1307 | 35 | 2N3402 | 21 | 2N4923 | 65 |
| 2N1308 | 40 | 2N3403 | 21 | 2N5135 | 10 |
| 2N1309 | 40 | 2N3404 | 29 | 2N5138 | 10 |
| 2N1599 | 35 | 2N3405 | 42 | 2N5172 | 14 |
| 2N1613 | 28 | 2N3414 | 16 | 2N5194 | 56 |
| 2N1711 | 30 | 2N3415 | 16 | 2N5245 | 40 |
| 2N1889 | 45 | 2N3416 | 29 | 2N5294 | 50 |
| 2N1890 | 45 | 2N3417 | 29 | 2N5296 | 50 |
| 2N1893 | 40 | 2N3614 | 1.00 | 2N5448 | 12 |
| 2N2147 | 75 | 2N3615 | 1.05 | 2N5457 (FET) | 32 |
| 2N2148 | 70 | 2N3616 | 1.05 | 2N5458 (FET) | 32 |
| 2N2192 | 38 | 2N3646 | 09 | 2N5459 (FET) | 35 |
| 2N2193 | 38 | 2N3702 | 09 | 2N5551 | 36 |
| 2N2194 | 38 | 2N3703 | 09 | 2N6027 (P.U.T.) | 34 |
| 2N2217 | 25 | 2N3704 | 09 | 2N6121 | 70 |
| 2N2218 | 25 | 2N3705 | 09 | 2N6122 | 70 |
| 2N2218A | 28 | 2N3706 | 10 | 2N6289 | 70 |
| 2N2219 | 28 | 2N3707 | 10 | 2S301 | 50 |
| 2N2219A | 30 | 2N3708 | 09 | 2S302 | 43 |
| 2N2220 | 20 | 2N3708A | 09 | 2S302A | 43 |
| 2N2221 | 20 | 2N3709 | 09 | 2S303 | 56 |
| 2N2221A | 22 | 2N3710 | 10 | 2S304 | 71 |
| 2N2222 | 20 | 2N3711 | 10 | 2S305 | 80 |
| 2N2222A | 20 | 2N3771 | 1.40 | 2S306. | 80 |
| 2N2368 | 18 | 2N3772 | 1.60 | 2S307 | 80 |
| 2N2369 | 14 | 2N3773 | 2.20 | | |
| 2N2369A | 14 | 2N3819 (FET) | 18 | | |
| 2N2411 | 25 | 2N3820 (FET) | 45 | | |
| 2N2412 | 25 | 2N3821 (FET) | 60 | | |
| 2N2646 | 47 | | | | |
| 2N2711 | 22 | | | | |
| 2N2712 | 22 | | | | |

## DIODES

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| AA119 | 08 | BB104 | 30 | BY176 | 75 | OA79 | 10 |
| AA120 | 08 | BAX13 | 07 | BY206 | 30 | OA81 | 10 |
| AA129 | 09 | BAX16 | 08 | BY210/600 | 09 | OA85 | 10 |
| AAY30 | 09 | BY100 | 22 | BYZ10 | 45 | OA91 | 07 |
| AAZ13 | 15 | BY101 | 22 | BYZ11 | 45 | OA91 | 07 |
| AAZ17 | 15 | BY105 | 22 | BYZ12 | 40 | OA95 | 07 |
| BA100 | 10 | BY114 | 22 | BYZ13 | 40 | OA182 | 13 |
| BA102 | 20 | BY124 | 22 | BYZ16 | 41 | OA200 | 08 |
| BA144 | 09 | BY126 | 11 | BYZ17 | 36 | OA202 | 08 |
| BA148 | 15 | BY127 | 12 | BYZ18 | 36 | IN34A | 07 |
| BA154 | 12 | BY128 | 16 | BYZ19 | 36 | IN60 | 06 |
| BA155 | 14 | BY130 | 17 | OA5 | 60 | IN914 | 04 |
| BA156 | 14 | BY133 | 21 | OA10 | 35 | IN916 | 05 |
| BA173 | 15 | BY156 | 08 | OA47 | 08 | IN4148 | 04 |
| BA248 | 16 | BY164 | 51 | OA70 | 08 | IS44 | 05 |

## 74 SERIES TTL

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 7400 | 14 | 7437 | 30 | 7485 | 95 | 74153 | 65 |
| 7401 | 12 | 7438 | 30 | 7486 | 28 | 74154 | 1.00 |
| 7402 | 12 | 7440 | 15 | 7489 | 1.95 | 74155 | 70 |
| 7403 | 12 | 7441 | 60 | 7490 | 36 | 74156 | 70 |
| 7404 | 13 | 7442 | 60 | 7491 | 75 | 74157 | 70 |
| 7405 | 13 | 7443 | 1.00 | 7492 | 50 | 74160 | 90 |
| 7406 | 28 | 7444 | 1.00 | 7493 | 36 | 74161 | 90 |
| 7407 | 28 | 7445 | 90 | 7494 | 75 | 74162 | 90 |
| 7408 | 20 | 7446 | 90 | 7495 | 65 | 74163 | 90 |
| 7409 | 20 | 7447 | 65 | 7496 | 65 | 74164 | 1.00 |
| 7410 | 13 | 7448 | 65 | 74100 | 1.10 | 74165 | 1.00 |
| 7411 | 20 | 7450 | 15 | 74104 | 50 | 74166 | 1.00 |
| 7412 | 22 | 7451 | 15 | 74105 | 50 | 74167 | 2.30 |
| 7413 | 30 | 7452 | 15 | 74107 | 32 | 74174 | 90 |
| 7414 | 50 | 7453 | 15 | 74110 | 46 | 74175 | 80 |
| 7416 | 28 | 7454 | 15 | 74111 | 60 | 74176 | 85 |
| 7417 | 28 | 7460 | 15 | 74118 | 96 | 74177 | 85 |
| 7420 | 14 | 7470 | 32 | 74119 | 1.20 | 74180 | 90 |
| 7421 | 32 | 7472 | 28 | 74121 | 36 | 74181 | 2.30 |
| 7422 | 24 | 7473 | 32 | 74122 | 46 | 74182 | 65 |
| 7423 | 28 | 7474 | 30 | 74123 | 60 | 74184 | 1.35 |
| 7425 | 28 | 7475 | 44 | 74124 | 60 | 74190 | 1.00 |
| 7426 | 30 | 7476 | 35 | 74136 | 65 | 74191 | 1.00 |
| 7427 | 28 | 7480 | 48 | 74141 | 60 | 74192 | 95 |
| 7428 | 34 | 7481 | 95 | 74144 | 2.50 | 74193 | 1.00 |
| 7430 | 14 | 7482 | 70 | 74145 | 80 | 74194 | 90 |
| 7432 | 28 | 7483 | 68 | 74150 | 1.00 | 74195 | 90 |
| 7433 | 36 | 7484 | 95 | 74151 | 65 | 74196 | 95 |

## CMOS

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| CD4000 | 18 | CD4021 | 1.05 | CD4042 | 78 | CD4081 | 26 |
| CD4001 | 19 | CD4022 | 95 | CD4043 | 88 | CD4082 | 26 |
| CD4002 | 20 | CD4023 | 23 | CD4044 | 88 | CD4085 | 90 |
| CD4006 | 92 | CD4024 | 70 | CD4045 | 1.50 | CD4093 | 70 |
| CD4007 | 22 | CD4025 | 20 | CD4046 | 1.10 | CD4501 | 28 |
| CD4008 | 80 | CD4026 | 1.50 | CD4047 | 95 | CD4502 | 1.20 |
| CD4009 | 40 | CD4027 | 48 | CD4048 | 65 | CD4503 | 70 |
| CD4010 | 48 | CD4028 | 80 | CD4049 | 45 | CD4506 | 70 |
| CD4011 | 22 | CD4029 | 1.00 | CD4050 | 45 | CD4507 | 60 |
| CD4012 | 22 | CD4030 | 55 | CD4052 | 80 | CD4508 | 2.95 |
| CD4013 | 45 | CD4031 | 2.00 | CD4054 | 1.25 | CD4510 | 99 |
| CD4014 | 84 | CD4034 | 1.95 | CD4055 | 1.25 | CD4511 | 1.15 |
| CD4015 | 84 | CD4035 | 1.20 | CD4056 | 1.35 | CD4516 | 1.10 |
| CD4016 | 42 | CD4036 | 3.30 | CD4068 | 25 | CD4518 | 1.00 |
| CD4017 | 80 | CD4037 | 95 | CD4069 | 25 | CD4520 | 1.00 |
| CD4018 | 85 | CD4038 | 1.15 | CD4070 | 29 | CD4528 | 1.10 |
| CD4019 | 45 | CD4040 | 95 | CD4071 | 25 | CD4531 | 1.50 |
| CD4020 | 99 | CD4041 | 78 | CD4072 | 25 | CD4561 | 1.00 |

## VOLTAGE REGULATORS

| | |
|---|---|
| MVR7805-MVR7824 | all 59p Ea. |
| MVR7905-MVR7924 | all 63p Ea. |
| 78LO5-78L24 | all 28p Ea. |
| 79LO5-79L24 | all 55p Ea. |
| LM309K | 1.25 |
| LM320 15v 12v, 15v 24v | 95p Ea. |

## 74 LS SERIES TTL

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 74LS00 | 13 | 74LS78 | 46 | 74LS165 | 1.20 | 74LS279 | 85 |
| 74LS01 | 13 | 74LS83 | 68 | 74LS166 | 1.70 | 74LS280 | 2.40 |
| 74LS02 | 15 | 74LS85 | 75 | 74LS168 | 1.80 | 74LS283 | 85 |
| 74LS03 | 15 | 74LS86 | 38 | 74LS169 | 1.90 | 74LS290 | 90 |
| 74LS04 | 15 | 74LS90 | 38 | 74LS170 | 2.50 | 74LS293 | 1.00 |
| 74LS05 | 22 | 74LS91 | 1.30 | 74LS173 | 95 | 74LS295 | 1.90 |
| 74LS08 | 21 | 74LS92 | 68 | 74LS174 | 95 | 74LS298 | 1.50 |
| 74LS09 | 21 | 74LS93 | 58 | 74LS175 | 95 | 74LS299 | 3.50 |
| 74LS10 | 20 | 74LS95 | 95 | 74LS181 | 2.70 | 74LS323 | 3.50 |
| 74LS11 | 22 | 74LS96 | 1.10 | 74LS183 | 2.80 | 74LS324 | 1.90 |
| 74LS12 | 26 | 74LS107 | 40 | 74LS190 | 95 | 74LS325 | 3.00 |
| 74LS13 | 34 | 74LS109 | 70 | 74LS191 | 95 | 74LS326 | 3.20 |
| 74LS14 | 50 | 74LS112 | 38 | 74LS192 | 95 | 74LS327 | 3.10 |
| 74LS15 | 34 | 74LS113 | 86 | 74LS193 | 90 | 74LS348 | 1.90 |
| 74LS20 | 18 | 74LS114 | 38 | 74LS194 | 95 | 74LS352 | 1.50 |
| 74LS21 | 26 | 74LS122 | 38 | 74LS195 | 85 | 74LS353 | 1.50 |
| 74LS22 | 32 | 74LS123 | 60 | 74LS196 | 1.00 | 74LS365 | 45 |
| 74LS26 | 38 | 74LS124 | 1.60 | 74LS197 | 85 | 74LS366 | 55 |
| 74LS27 | 35 | 74LS125 | 45 | 74LS221 | 1.00 | 74LS367 | 63 |
| 74LS28 | 35 | 74LS126 | 45 | 74LS240 | 1.60 | 74LS368 | 80 |
| 74LS30 | 18 | 74LS132 | 60 | 74LS241 | 1.60 | 74LS373 | 1.45 |
| 74LS32 | 22 | 74LS136 | 50 | 74LS242 | 1.60 | 74LS374 | 1.45 |
| 74LS33 | 34 | 74LS138 | 60 | 74LS243 | 1.60 | 74LS375 | 1.10 |
| 74LS37 | 28 | 74LS139 | 68 | 74LS244 | 1.50 | 74LS378 | 1.20 |
| 74LS38 | 28 | 74LS145 | 1.15 | 74LS245 | 2.20 | 74LS386 | 75 |
| 74LS40 | 25 | 74LS147 | 2.00 | 74LS247 | 1.20 | 74LS393 | 1.10 |
| 74LS42 | 55 | 74LS148 | 1.60 | 74LS248 | 1.20 | 74LS395 | 2.00 |
| 74LS47 | 72 | 74LS151 | 70 | 74LS249 | 1.20 | 74LS398 | 2.70 |
| 74LS48 | 80 | 74LS153 | 68 | 74LS251 | 1.20 | 74LS399 | 2.00 |
| 74LS49 | 90 | 74LS155 | 65 | 74LS253 | 90 | 74LS490 | 1.40 |
| 74LS51 | 24 | 74LS156 | 80 | 74LS257 | 90 | 74LS670 | 2.50 |
| 74LS54 | 28 | 74LS157 | 60 | 74LS258 | 1.10 | | |
| 74LS55 | 28 | 74LS158 | 60 | 74LS260 | 85 | | |
| 74LS63 | 1.40 | 74LS160 | 85 | 74LS259 | 1.50 | | |
| 74LS73 | 30 | 74LS161 | 75 | 74LS261 | 4.00 | | |
| 74LS74 | 30 | 74LS162 | 1.00 | 75LS266 | 72 | | |
| 74LS75 | 38 | 74LS163 | 90 | 74LS273 | 1.65 | | |
| 74LS76 | 42 | 74LS164 | 90 | 74LS275 | 3.50 | | |

### COMPUTER I.C.s

| | |
|---|---|
| 2114/250 | 1.90 |
| 2708 | 3.50 |
| 2716 | 4.40 |
| 4116 | 1.85 |

## LINEAR I.C.'s

| | | | | | |
|---|---|---|---|---|---|
| CA270BE | 95 | LM324N | 48 | 72709 | 46 |
| CA280Q | 85 | LM337T | 1.35 | 709P | 35 |
| CA3011 | 98 | LM339N | 65 | UA710C | 40 |
| CA3014 | 1.75 | LM348N | 90 | 72710 | 30 |
| CA3018 | 65 | LM380 | 85 | UA711C | 32 |
| CA3020 | 1.75 | LM381 | 1.45 | 72711 | 32 |
| CA3028 | 80 | LM382N | 1.20 | UA723C | 45 |
| CA3035 | 2.30 | LM384 | 1.45 | 72723 | 45 |
| CA3036 | 1.00 | LM386 | 85 | UA741C | 24 |
| CA3042 | 1.60 | LM387 | 1.10 | 72741 | 24 |
| CA3043 | 1.85 | LM1458 | 42 | 741P | 17 |
| CA3046 | 70 | LM3900 | 58 | UA747C | 60 |
| CA3052 | 1.60 | LM3909N | 70 | 72747 | 60 |
| CA3054 | 1.10 | LM3915N | 2.20 | UA748 | 35 |
| CA3075 | 1.50 | LM3914N | 2.20 | 748P | 35 |
| CA3080 | 65 | LM3911N | 1.20 | SN76013N | 1.60 |
| CA3081 | 1.50 | LM3916 | 2.45 | SN76023N | 1.65 |
| CA3085 | 95 | MC1304 | 1.90 | SN76110 | 1.50 |
| CA3089 | 2.00 | MC1310P | 1.45 | SN76115AN | 1.90 |
| CA3090 | 3.60 | MC1312 | 1.70 | SN76660N | 90 |
| CA3123E | 1.50 | MC1350 | 1.20 | TAA550B | 35 |
| CA3130E | 90 | MC1352 | 1.40 | TAA621 | 2.00 |
| CA3140E | 48 | MC1469 | 2.70 | TAA661B | 1.50 |
| LF351N | 55 | MC1496 | 90 | TAB100 | 1.30 |
| LF353N | 88 | NE555 | 20 | TBA120B | 70 |
| LF356N | 90 | NE556 | 55 | TBA540 | 1.40 |
| LH0042CH | 2.25 | NE565 | 1.20 | TBA641A | 2.20 |
| LM301A | 25 | NE566 | 1.50 | TBA800 | 85 |
| LM304 | 1.60 | NE567 | 1.70 | TBA810S | 95 |
| LM308 | 75 | 72702 | 46 | TBA820 | 70 |
| LM309K | 1.25 | UA703C | 25 | TBA920Q | 2.50 |
| LM311 | 65 | UA709C | 25 | TCA270S | 1.40 |
| LM317H | 2.50 | | | ZN414 | 90 |
| LM318H | 1.95 | | | ZTK338 | 15 |

## SILICON RECTIFIERS

| | | | | | |
|---|---|---|---|---|---|
| **200mA** | | IS020 100v | 10 | IN5408 1000v | 25 |
| IS920 50v | 06 | IS021 200v | 11 | **6 Amp** | |
| IS921 100v | 07 | IS023 400v | 13 | BYX38-300 | 45 |
| IS922 150v | 08 | IS025 600v | 14 | BYX38-600 | 60 |
| IS923 200v | 09 | IS027 800v | 16 | BYX38-300R | 45 |
| IS924 300v | 10 | IS029 1000v | 20 | BYX38-600R | 60 |
| **1 Amp** | | IS031 1200v | 25 | **10 Amp** | |
| 1N4001 50v | 04½ | | | IS10/50 50v | 30 |
| 1N4002 100v | 05 | **3 Amp** | | IS10/100 100v | 35 |
| 1N4003 200v | 06 | IN5400 50v | 11 | IS10/200 200v | 40 |
| 1N4004 400v | 06 | IN5401 100v | 12 | IS10/400 400v | 50 |
| 1N4005 600v | 07 | IN5402 200v | 14 | IS10/600 600v | 60 |
| 1N4006 800v | 07 | IN5403 300v | 15 | IS10/800 800v | 70 |
| IN4007 1000v | 08 | IN5404 400v | 16 | IS10/1000 1000v | 85 |
| | | IN5405 500v | 17 | | |
| **1.5 Amp** | | IN5406 600v | 18 | IS10/1200 1200v | 95 |
| IS015 50v | 09 | IN5407 800v | 22 | | |

## BRIDGE RECTIFIERS

| | | | | | |
|---|---|---|---|---|---|
| **1 Amp RMS** | | **2 Amps RMS** | | **6 Amps RMS** | |
| BR1/50v | 20 | BR2/50v | 35 | BR6/50v | 75 |
| BR1/100v | 22 | BR2/100v | 40 | BR6/100v | 80 |
| BR1/200v | 25 | BR2/200v | 44 | BR6/200v | 88 |
| BR1/40v | 29 | BR2/400v | 50 | BR6/400v | 95 |
| | | BR2/1000v | 65 | | |

## THYRISTORS

| | | | | | |
|---|---|---|---|---|---|
| **1 Amp TO39 CASE** | | THY5A/100v | 45 | THY5A/400vP | 50 |
| THY1A/50v | 34 | THY5A/200v | 50 | THY5A/600vP | 60 |
| THY1A/100v | 38 | THY5A/400v | 57 | THY5A/800vP | 70 |
| THY1A/200v | 42 | THY5A/600v | 60 | | |
| THY1A/400v | 50 | THY5A/800v | 75 | **10 Amp – TO48** | |
| THY1A/600v | 65 | | | THY10A/50v | 45 |
| THY1A/800v | 78 | **5 Amp - TO66** | | THY10A/100v | 50 |
| BT101/500R | 80 | THY5A/50v | 36 | THY10A/200v | 55 |
| BT102/500R | 80 | THY5A/100v | 45 | THY10A/400v | 60 |
| BT106 | 1.25 | THY5A/200v | 50 | THY10A/600v | 80 |
| BT107 | 93 | THY5A/400v | 57 | THY10A/800v | 1.10 |
| BT108 | 98 | THY5A/600v | 60 | | |
| 2N3228 | 70 | THY5A/800v | 75 | **16 Amp – TO48** | |
| | | 2N3525 | 77 | THY16A/50v | 65 |
| **3 Amp – TO66** | | BTX30/50L | 40 | THY16A/100v | 80 |
| THY3A/50v | 35 | BTX30/400L | 70 | THY16A/200v | 90 |
| THY3A/100v | 37 | BT116 | 1.50 | THY16A/400v | 1.20 |
| THY3A/200v | 40 | C106D | 38 | THY16A/600v | 1.50 |
| THY3A/400v | 50 | BTY79/400R | 95 | THY16A/800v | 2.00 |
| THY3A/600v | 60 | | | | |
| THY3A/800v | 75 | **5 Amp – TO220 PLASTIC** | | **30 Amp – TO94** | |
| | | THY5A/50vP | 35 | THY30A/50v | 1.30 |
| **5 Amp – TO64** | | THY5A/100vP | 45 | THY30A/100v | 1.50 |
| THY5A/50v | 36 | THY5A/200vP | 47 | THY30A/200v | 2.95 |
| | | | | THY30A/400v | 4.00 |
| | | | | THY30A/600v | 4.20 |

## TRIACS

| | | | | | |
|---|---|---|---|---|---|
| **2 Amp – TO39** | | **4 Amp – TO202** | | **6 Amp – TO220** | |
| TR12A/100v | 30 | TRI4A/400v | 55 | TRI6A/100v | 45 |
| TR12A/200v | 42 | | | TRI6A/200v | 52 |
| TR12A/400v | 50 | **8 Amp – TO220** | | TRI6A/400v | 60 |
| | | TRI8A/400v | 64 | | |
| **10 Amp – TO48** | | | | **12 Amp – TO220** | |
| TRI10A/100v | 55 | **10 Amp – TO220 – PLASTIC** | | TRI12A/400V | 70 |
| TRI10A/200v | 80 | TRI10A/400P | 68 | **DIACS** | |
| TRI10A/400v | 90 | | | BR100 | 20 |
| | | | | D32 | 20 |

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