MAPLIN PROJECTS BOOK ONE

COMBO AMPLIFIER
UNIVERSAL TIMER
TEMPERATURE GAUGE
PASS THE BOMB
SIX VERO PROJECTS

Electronics
THE MAPLIN MAGAZINE

This project book completely replaces issue 1 of 'Electronics', which is now out of print. Other issues of 'Electronics' will also be replaced by project books as they, too, become out of print.

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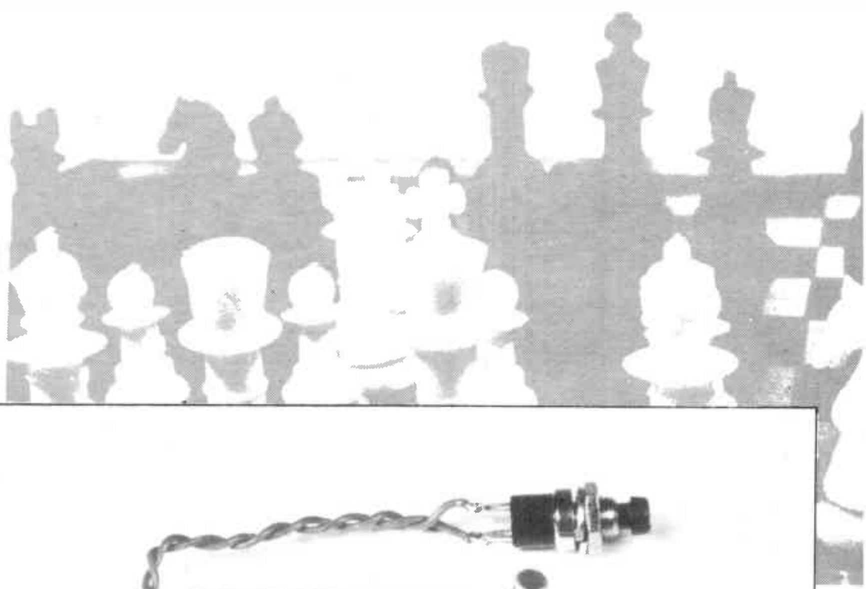
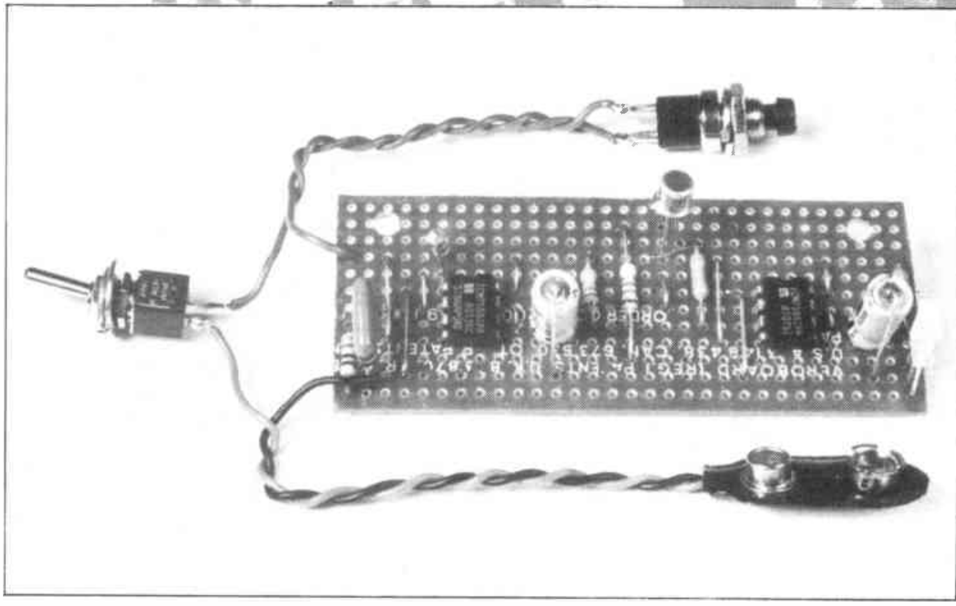
GAMES TIMER

★ Make your board games more exciting with this easy-to-build timing device





There are a number of games where the players make their moves in turn, and progress can be rather slow and tedious if no limit is set on the time available for each move. Chess, Scrabble, and draughts are three examples of popular games which fall into this category. Imposing a time limit on moves in games of this type can make them much more interesting and exciting with the more skilful player still ultimately winning and the outcome of the game being unaffected.

This simple games timer has a three colour LED indicator which is green at switch-on, and remains in this state for about 15 seconds. After this time it changes to orange to indicate that the available time is running out, and after about a further 10 seconds it changes to red to indicate that the allotted time has run out. If the display reaches the red state either the player must make his or her move immediately or some form of penalty (such as a missed move) must be imposed, as preferred. Once the player has made his or her move, or the display has reached the red state, the timer is reset by momentarily operating a push button switch.

The Circuit

The circuit is based on two 555 timer devices, one being used to drive each section of the LED indicator. Both are used in the monostable mode. The ICM7555 (CMOS) version of the 555 is employed in this design because this gives a reduction in current consumption of about 16mA when compared to the standard device, and enables a small 9 volt battery to be used as an economic power source for the unit. The circuit diagram of the Games Timer is shown in Figure 1.

IC1 is used to drive the green section of LED indicator D1, and at switch-on this must immediately switch on its section of the LED and keep it switched on for a period of about 25 seconds. R1 and C1 are used to generate a negative trigger pulse when power is initially connected to the circuit so that a positive output pulse is immediately produced from the output at pin 3 of IC1. This pulse drives the green section of D1 via current limiting resistor R3. R2 and C2 are the timing components which control the length of the output pulse, and the pulse length is approximately 1.1CR seconds. This gives a nominal pulse duration of 24.2 seconds, but this is likely to be marginally increased in practice due to slight leakage in C2. Much larger errors can occur due to the tolerances of IC1 and the timing components, but fairly large errors in the pulse length are of little importance since they will advantage or disadvantage all players by the same amount.

The red section of D1 is driven via an inverter stage from IC2. The red section must be switched on after about 15 seconds in order to mix with the green section to give the orange display, and it must remain on until the unit is reset so that a red indication is given when the green section switches off after about 25 seconds.

IC2, like IC1, is triggered at switch-on by the pulse produced by R1 and C1, and its output pulse duration is set at approximately the required time by using suitable values for R4 and C3. The red section of D1 will not light up during this time since with IC2's output high

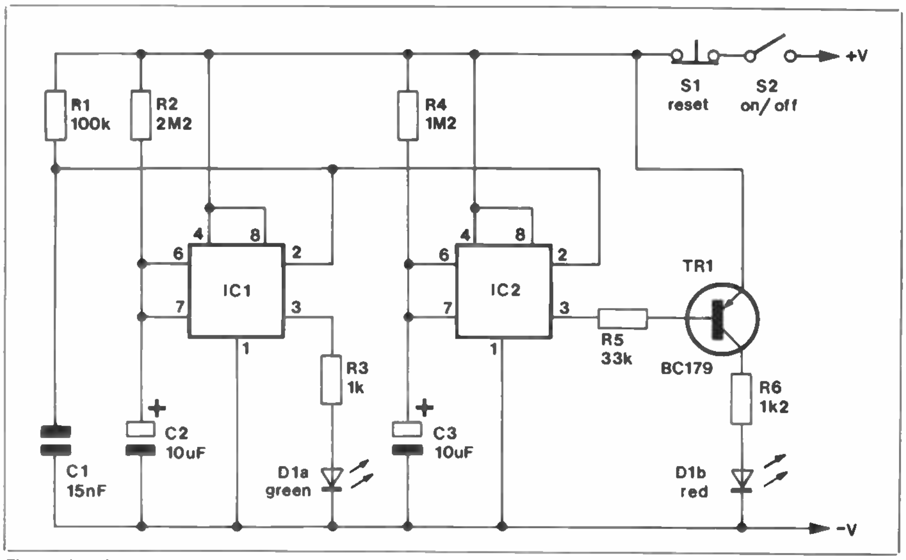


Figure 1. Games timer circuit diagram.

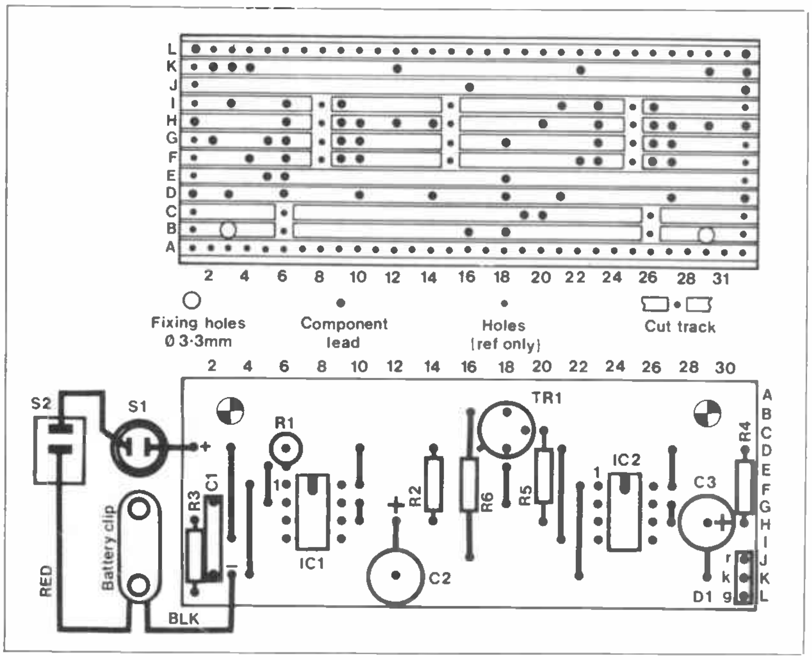


Figure 2. Veroboard layout for the games timer.

PARTS LIST FOR GAMES TIMER

Resistors — all 0.4W 1% metal film except where specified

R1	100k	(M100K)
R2	2M2	(B2M2)
R3	1k0	(M1K0)
R4	1M2	(B1M2)
R5	33k	(M33K)
R6	1k2	(M1K2)

Capacitors

C1	15n polyester	(BX71N)
C2,3	10u 25V electrolytic 2 off	(FB22Y)

Semiconductors

IC1,2	ICM7555	(YH63T)
TR1	BC179	(QB54J)
D1	2 colour common cathode LED	(QR54J)

Miscellaneous

S1	Push-to-break, release to make type	(FH60Q)
S2	Sub-min SPST toggle type	(FH97F)
	Veroboard	
	PP3 battery	
	PP3 connector	(HF28F)
	Case	
	Wire	

TR1 will be cut off and no significant current will be supplied to D1b. At the end of the pulse TR1 is biased into conduction by the base current it receives from IC2 by way of R5, and TR1 then drives D1b on via current limiting resistor R6. D1b remains on until the circuit is reset by briefly operating S1 so that the supply is momentarily cut off and the two timer ICs are retriggered as the supply is restored. If S1 is operated before IC2 and (or) IC1 reach the end of their timing periods, any charge on C2 or C3 will be rapidly lost through IC1 and IC2 so that the subsequent timing run correctly starts with zero charge on the timing capacitor and the unit operates properly.

Construction

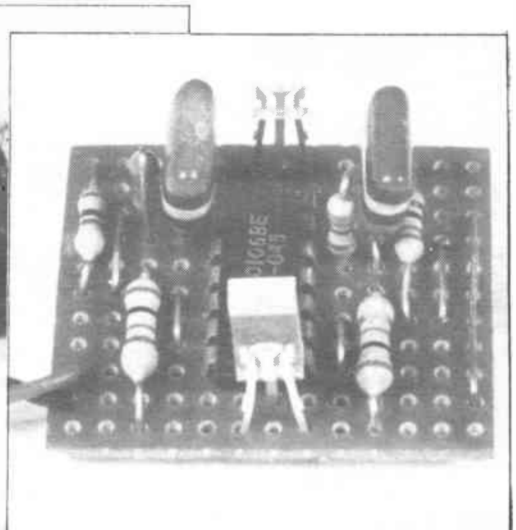
The timer is built on a 0.1in. pitch Veroboard which has 31 holes by 12 copper strips, and full details of this are given in Figure 2. Construction of the unit is quite straightforward, and although IC1 and IC2 are CMOS devices they do not need the normal CMOS handling precautions since the ICM7555 device has internal protection circuitry which gives complete protection against damage by static charges. There should be no difficulty in fitting the board, battery, and other components into a small plastic case measuring about 115 x 75 x 40mm (e.g. case type PB1).

The times provided by the unit using the specified timing component values might be inappropriate for some games, but within reason the times can be changed to suit individual requirements. Both ICs require a timing resistance of about 91k per second of output pulse. Of course, IC2's timing components govern the time for which a green display is obtained, and it is the difference in the pulse lengths of IC1 and IC2 that gives the orange display time. The display goes red after a time equal to the pulse length of IC1.

Robert Penfold ■

MULTI COLOUR PENDANT

Look to the future with this unusual Electronic Jewellery project



This simple item of electronic jewellery can be constructed as either a pendant or a brooch, as preferred. An attractive effect is obtained by the use of two multicolour LEDs, and one of these flashes through its various states (red, green, yellow, and off) at a rate of a few Hertz. The other LED lights up with the complementary colour of the first

LED, so that it flashes green instead of red, red instead of green, off instead of yellow, and yellow instead of off.

The Circuit

Figure 1 shows the full circuit diagram of the LED pendant, and this uses two oscillators of the type used in the Colour Snap Game described elsewhere in this issue; therefore the oscillator operation will not be considered here.

One oscillator is used to drive the red section of D1 by way of current limiting resistor R2, and the other oscillator drives the green section of D1 via R5. The two oscillators have different timing resistor values and therefore operate at slightly different frequencies. This means that sometimes only the red section will be switched, at other times only the green one, and at other times neither or both will be switched on, depending upon what the two output states happen to be at that particular instant. This results in D1 being pulsed through its four possible states at a rate of a few Hertz.

D2 is also driven from the two oscillators, but via an inverting buffer stage so that if the red section of D1 is switched on, the red section of D2 is switched off, and vice versa. Similarly, if the green section of D1 is switched on, the green section of D2 is switched off, and vice versa, giving the complementary LED colours.

Two of the Schmitt Triggers in the 40106 device are not used in this circuit, and their inputs are connected one to each oscillator output so that they are not left floating and vulnerable to damage by static charges. The oscillator outputs are used merely because these are convenient from the constructional point of view.

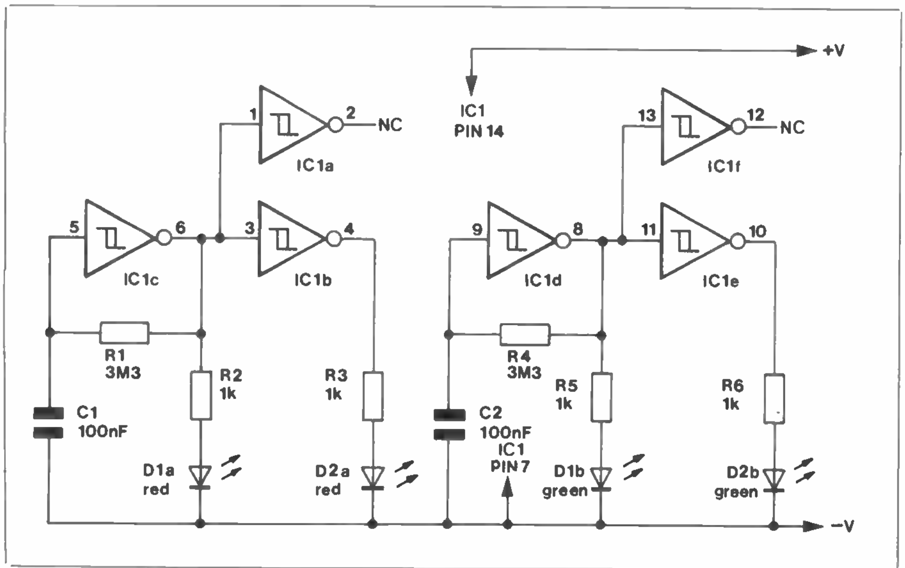


Figure 1. LED pendant circuit diagram.

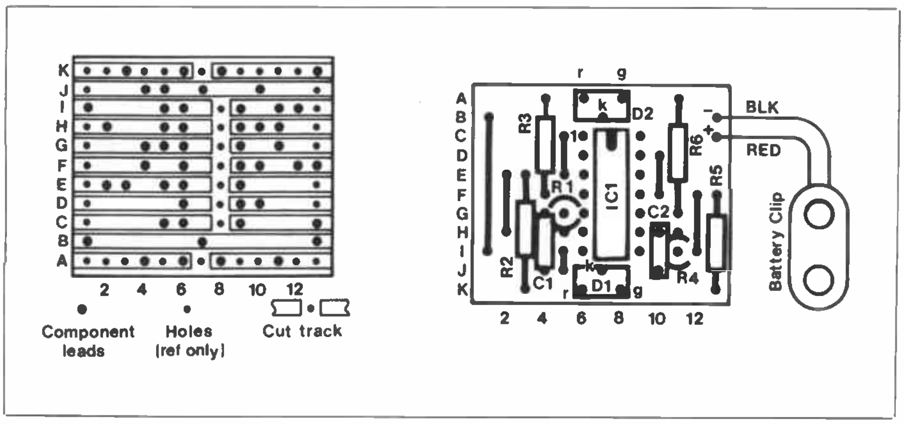


Figure 2. Veroboard layout for the pendant.

PARTS LIST FOR LED PENDANT

Resistors			
R1	3M3		(B3M3)
R2,3,5,6	1k0	4 off	(M1K0)
R4	4M7		(B4M7)
Capacitors			
C1,2	100n polyester	2 off	(BX76H)
Semiconductors			
IC1	40106BE		(QW64U)
D1,2	Two colour LED	2 off	(QR54J)
Miscellaneous			
	Veroboard		
	PP3 battery		
	PP3 battery connector		(HF28F)
	Case		
	Wire		

Construction

The pendant can be constructed on a small 0.1in. matrix Veroboard panel measuring just 11 copper strips by 13 holes using the layout illustrated in Figure 2. IC1 is a CMOS integrated circuit and so the normal MOS handling precautions should be employed.

The board and PP3 size battery could be housed in a small ready made case, but ideally a small home constructed case should be used as this can be given the smallest usable dimensions. It is not essential to mount the battery in the pendant, and it could be fitted separately and connected to the main unit via thin insulated leads. With this method it would be possible to encapsulate the unit in clear resin if desired. If the unit is to have an internal battery and the smallest possible size is desired, a small 6 volt camera type battery (such as a PX28 or equivalent) could be used as the power source, although this would be a relatively expensive method of powering the unit and it would be necessary for the constructor to devise a battery holder and connector. It would also be necessary to reduce R2, R3, R5 and R6 to 680 ohms in value in order to maintain reasonable LED current and brightness. This modification can also be made if a 9 volt supply is used and a brighter display is required.

In order to make the unit as small and neat as possible it is not fitted with an on/off switch, and it is switched off simply by removing the battery.

Robert Penfold ■

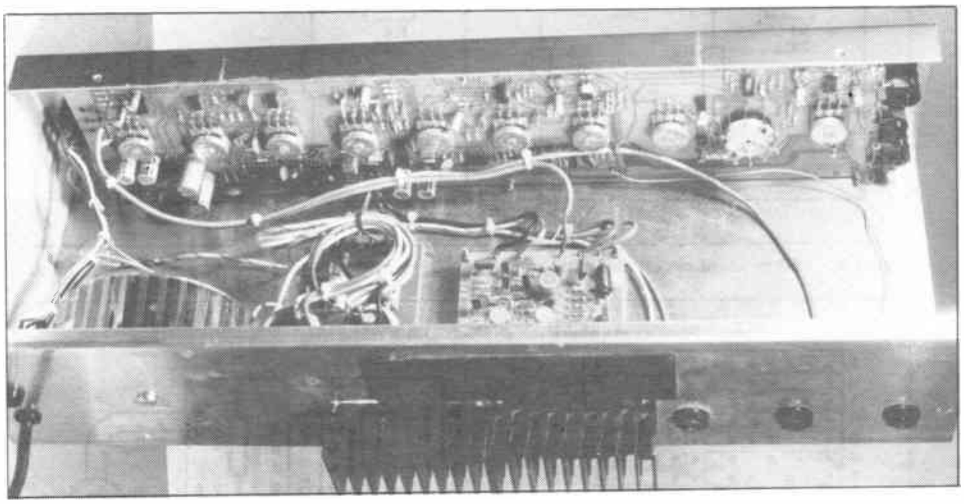
COMBO AMPLIFIER

by Dave Goodman

- ★ **120 watts of reliable MOSFET power**
- ★ **Built-in flanger effect**
- ★ **Two inputs for guitars, keyboards or microphones**
- ★ **Five step equaliser on channel A**
- ★ **Bass and treble controls on channel B**
- ★ **Low noise BIFET preamplifier**

This is an easy to build portable amplifier for all stage musicians requiring high power, reliability and versatility. A choice of equalisation methods is given on the two input channels, allowing a wide range of sounds in conjunction with the built in flanger.

Sockets are provided for feeding a slave, PA amplifier or tape recorder, and for using alternative speakers. The amplifier gives 75W into an 8 ohm speaker, or 120W into a 4 ohm speaker or combination of speakers.



Inside view of the amplifier chassis.

Input Circuitry

IC1 forms the input stage of channel A. RV1, R2 and R3 adjust stage gain from below unity up to x20, and C2 removes any HF noise and unwanted RF signals. Input levels of 10mV up to 10V can be accommodated into 47k input impedance. Amplified signals from the volume control RV2 are processed by the filtering stages of IC2a and b. Selective feedback paths, determined by SW1a and b and C6 to C15 produce up to 10dB boost and cut at the centre frequencies 150Hz, 250Hz, 500Hz, 1.5kHz, 2.5kHz under the control of RV3.

Processed signals from IC2b are routed through bi-lateral switch IC3 and R26 to output mixer IC6b. IC3 can be viewed as an electronic switch, being 'on' when the control gates (pins 5, 6, 12, 13) are high, and 'off' when the control gates are low.

TR1 is normally biased off by R12, connecting IC3 pin 12 to the +7.5V supply through R11 and holding the switch 'on'. IC3 pin 13 will also be positive, connecting IC3 pins 5 and 6 down to the -7.5V rail. The two switches comprising IC3 pins 3/4 and 8/9 will therefore be open circuit.

Turning on TR1 by connecting pins 5 and 6 with the foot switch will reverse the quiescent condition of IC3. IC3 pins 10/11 will be open, pins 1/2 will be open, pins 3/4 and 8/9 will be closed. IC2b output will then be routed to the flanger effects circuitry and back to the output mixer IC6 via IC3 pin 8/9 and R27.

Channel B input IC4 is the same as channel A input stage. Signal processing, from volume control RV5 is achieved using a conventional Baxandall active tone control circuit. RV6 determines boost and cut of bass frequencies up to +12dB at 100Hz, and RV7 gives boost and cut of treble up to +12dB at 10kHz. C22 and C26 remove any instability at extreme boost settings and channel output is direct to the final mixer via R25.

RV8 is the master volume control supplying the power amp stage from IC6b output. IC6a is a unity gain buffer stage, supplying the slave output at a low impedance, and is not affected by the master volume control.

Flanger Circuit

The flanging effect can be switched in or out of circuit silently with the use of an external foot switch, as previously described. Flanging is similar to phasing, and here, the heart of the system is a TCA 350Z 'bucket brigade' device. Signals are applied to a low pass filter, IC7a and IC7d. All frequencies are reduced in amplitude at -24dB per octave above 4kHz. This is necessary to ensure that mixing of input and clock signals does not produce a distortion effect known as 'aliasing'. The TCA 350Z (IC12) delays input signals; the delay period is not fixed, but sweeps up and down at a rate set by triangle waveform oscillator IC9 and IC10.

IC9 is a Schmitt trigger and IC10 is an integrator. RV10 determines the rate of oscillation which is variable from zero to 10Hz. IC11 is a CMOS oscillator, current controlled from D4 and D5, and its range of oscillation is variable from 15kHz up to 0.75MHz.

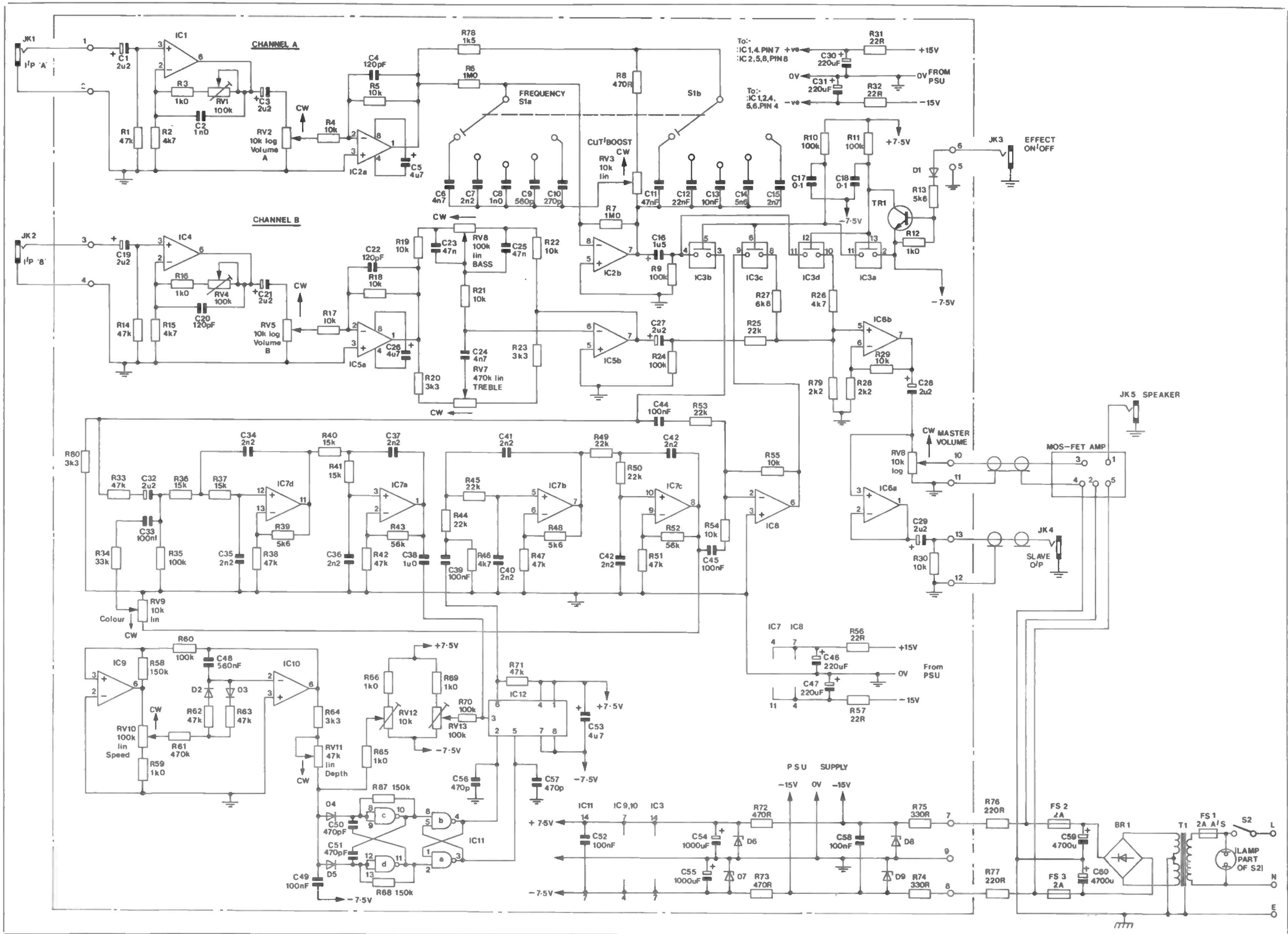


Figure 1. Circuit of the control board.

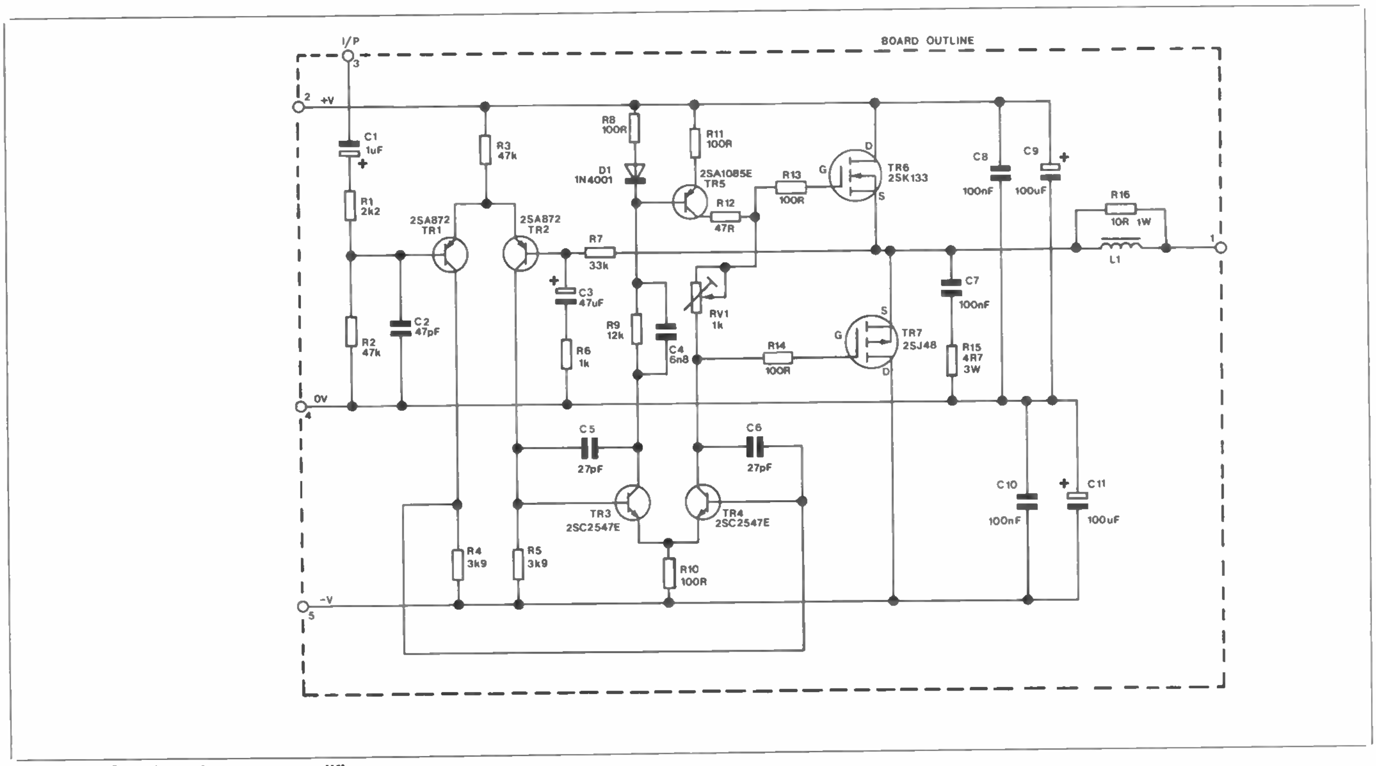


Figure 2. Circuit of the power amplifier.

The slow running triangle wave ramps the fast running square wave oscillator up and down depending on the depth control RV11. The minimum fast running oscillator frequency is preset by RV12. Antiphase square wave signals are applied to the two clock inputs, pins 2 and 5 of IC12.

We now have our low pass filtered audio signal being delayed by IC12 for time periods between 300uS and 6mS. The delay line output stages must be biased into class A operation, and preset RV13 should be adjusted for a symmetrical signal at pin 6 of IC12 — equivalent to 8 volts between pins 3 and 7 of IC12. Obviously, an asymmetrical output will give a distorted sound, so ensure accurate adjustment of RV13.

IC7b and c are, again, low pass filters and they serve to restore the 'stepped' waveform from IC12 by removing the clock signal and amplifying the delayed audio signal. The delayed signal is mixed at IC8 with a percentage of the original unaltered signal. The flanging effect is enhanced by introducing feedback from IC7c output via RV9, R34 and C33 back into the input filters. IC8 output is connected via IC3 pins 8/9 and R27 to the output mixer, IC6b.

R31, 32 and C30, 31 decouple the ±15V supply to IC7 and 8. R72, 73, C54, 55, D6, 7 connect ±7.5V to IC9, 10, 11, 12. C58 removes any RF present at the supply input, and R74, 75, D8, 9 regulate the ±50V from the power amp supply. This degree of supply rail isolation and de-coupling is necessary to maintain a low noise level throughout the pre-amp circuitry.

The power amplifier stage is the MOSFET amplifier published in Electronics & Music Maker, June 1981. The

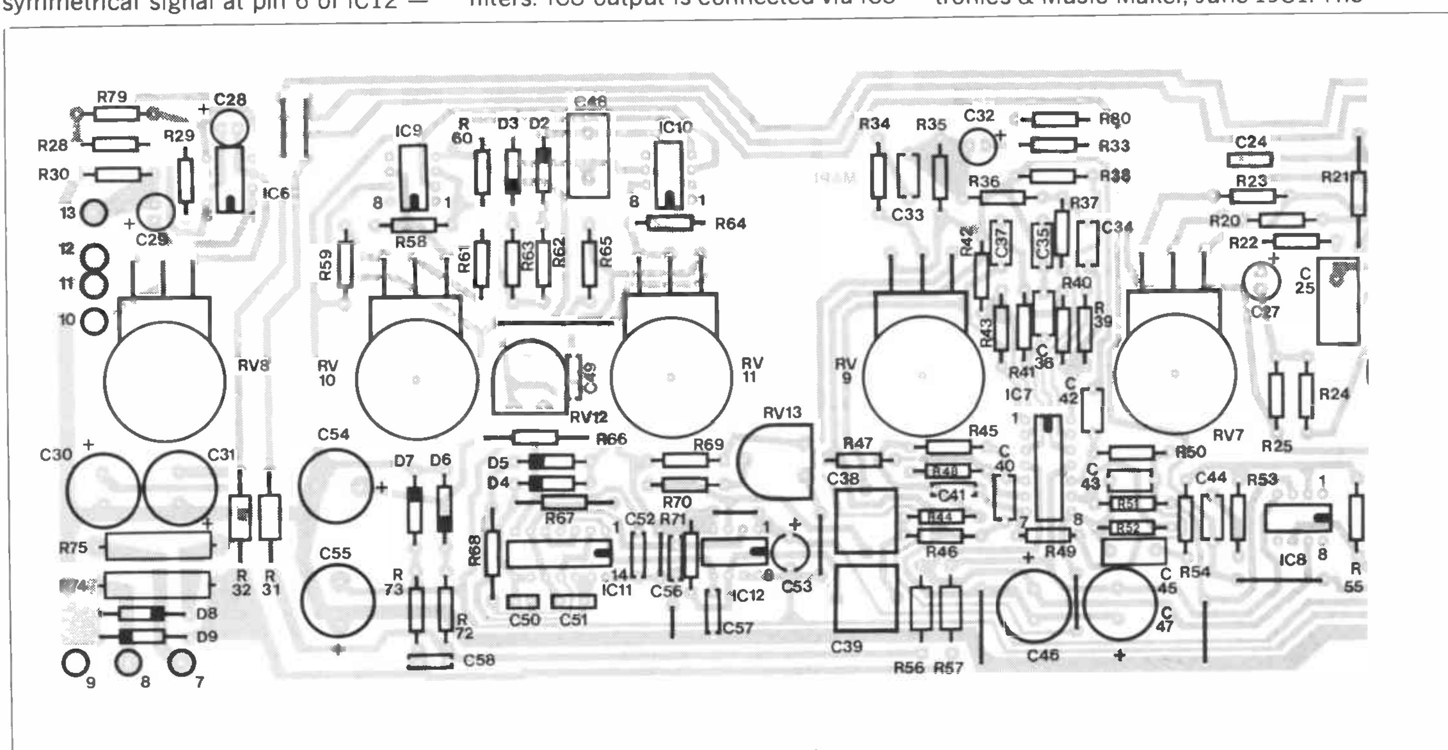


Figure 7. Control PCB.

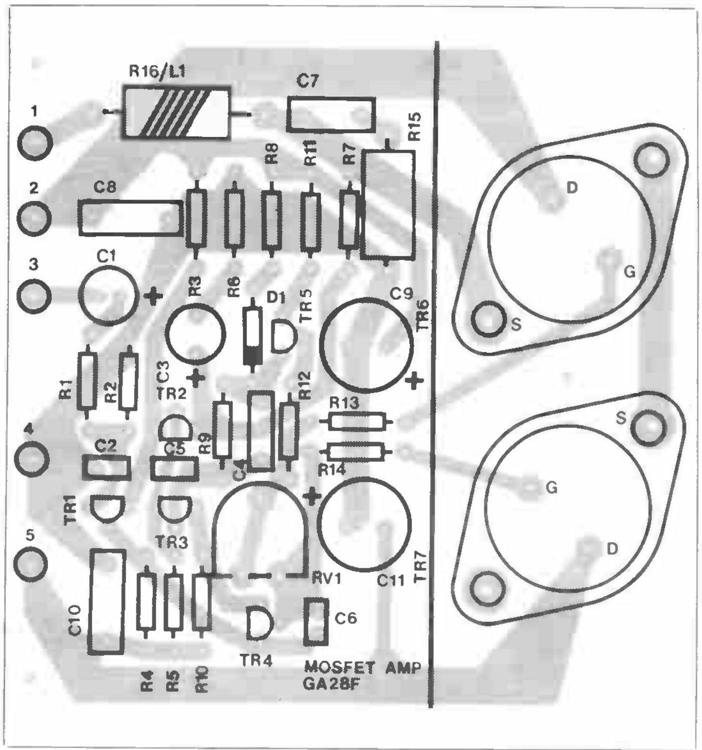


Figure 3. Power amp. PCB.

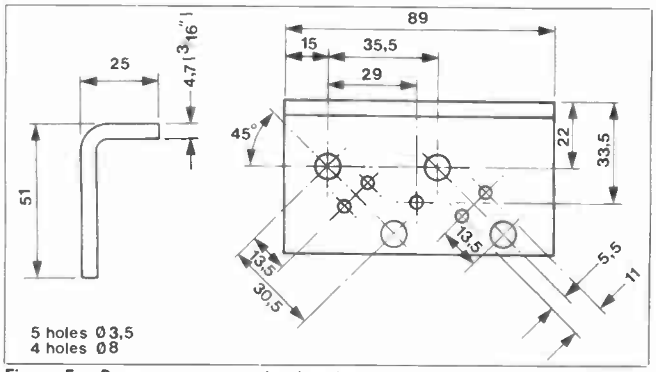


Figure 5. Power amp. mounting bracket.

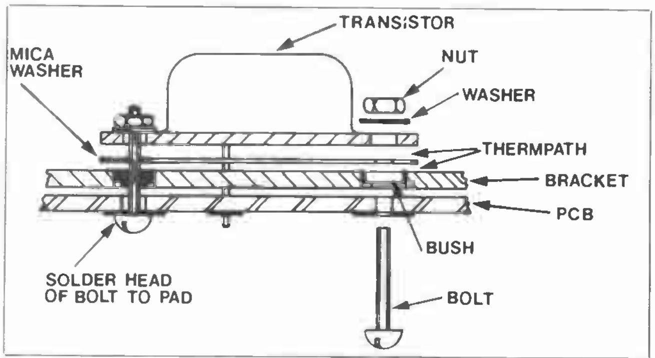


Figure 6. Power MOSFET mounting details.

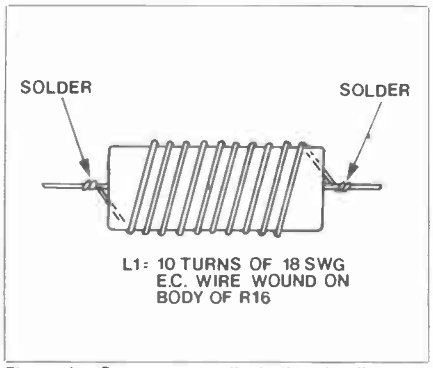


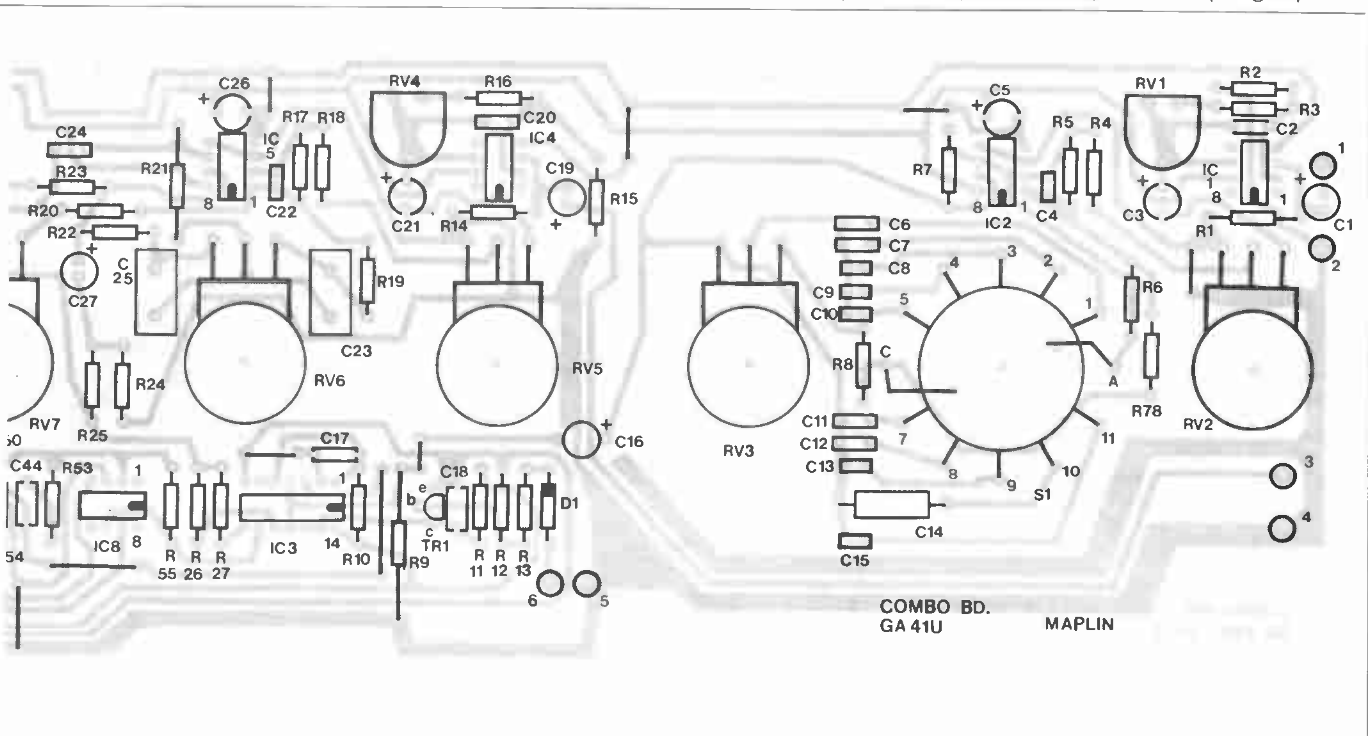
Figure 4. Power amp. coil winding details.

details are reprinted here for convenience.

Circuit Description

TR1 and TR2 form a stable, differential input buffer amplifier, the bias current for each transistor being set to 0.5mA. The 2SA872 transistor is used because it has a very low noise output but can handle high voltages. TR3 and TR4 form a 'current mirror' to give a high open-loop voltage gain. TR5 acts as a constant-current load and this low-noise, high-gain, class A amplifier stage is all that is required to drive the power MOSFETs TR6 and TR7. The transistors in the driver stage need to have a high voltage durability, high F_T and low C_{ob}. They also have to supply sufficient power to charge and discharge the gate-to-source capacitance of the power MOSFETs. In this case a bias current of around 50mA is sufficient to ensure adequate power is available at all frequencies and power levels.

The input impedance of the amplifier is set by R2 to 47k, and C2 bypasses any RF signals present at the input. The amplifier has a gain of 33, and this is set by R7 and R6, via decoupling capacitor



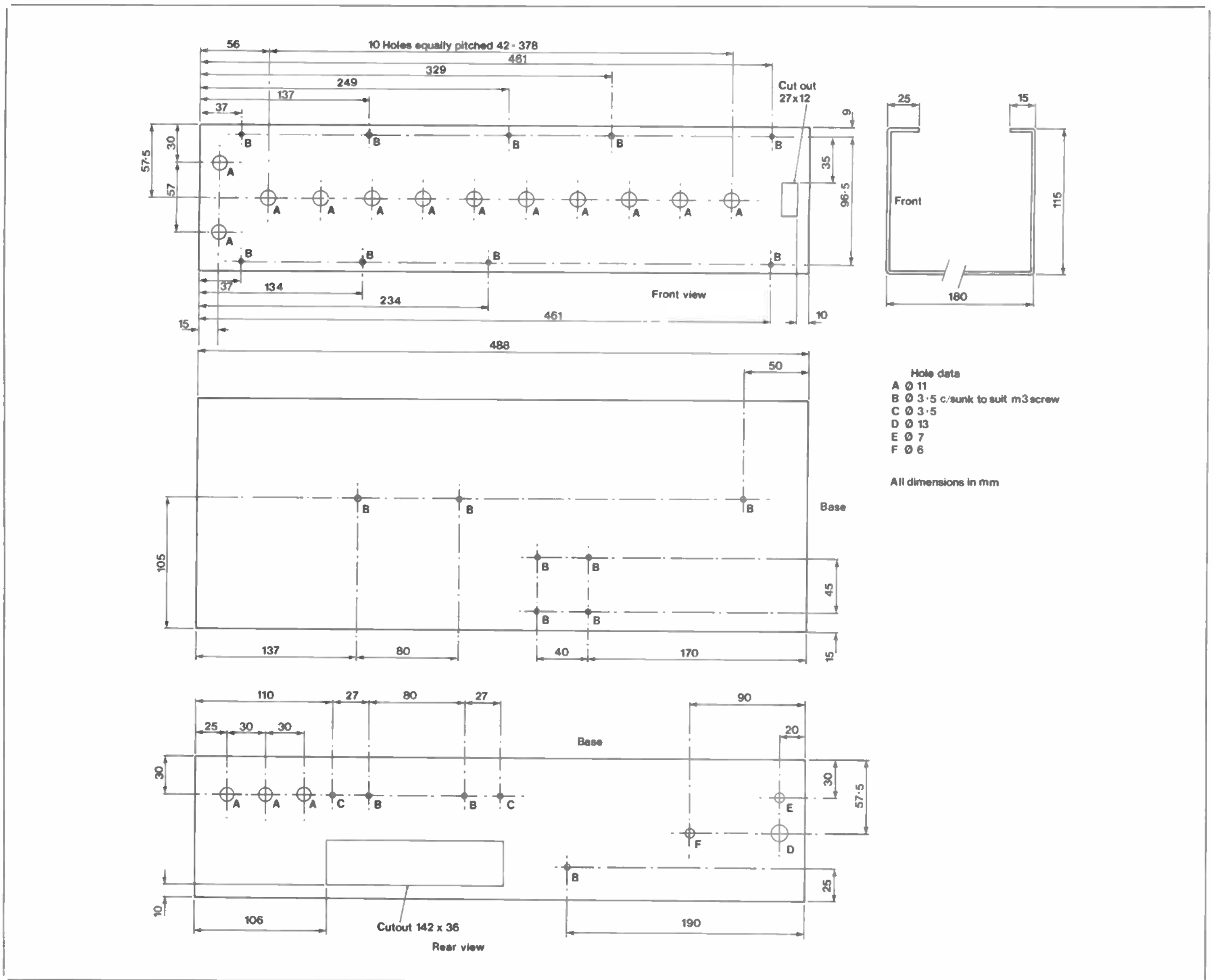
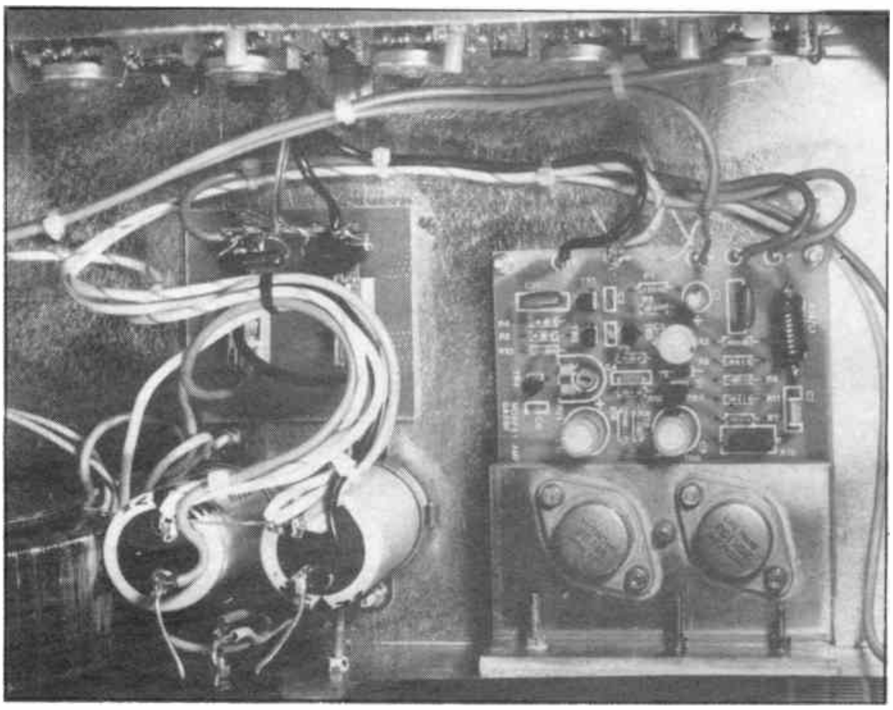


Figure 8. Metalwork details.

C3, R13 and R14 improve the stability at high frequencies by reducing the effective gate load capacitance. C7 and R15 are a Zobel network which, in conjunction with R16 and L1, ensures excellent stability into reactive loads at high frequencies.

Construction

Fit the five Veropins, labelled 1 to 5, to the PCB and solder. Fit and solder diode D1 taking care that it is the right way round. Fit and solder all the resistors *except* R16, and all the capacitors, taking care with the polarity of the electrolytic ones, C1, C3, C9 and C11 (refer to Figure 3). Scrape or burn the enamel off one end of the piece of enamelled copper wire and solder it to one lead of R16, close to the body of the resistor. Now wind the wire tightly around the resistor ten times to form L1, as shown in Figure 4. Do not cut the wire, but hold it tightly and scrape off the enamel where it will touch the other lead-out wire of the resistor, then wrap it around the lead and solder. Fit this composite component to the PCB and solder. Fit and solder the preset to the PCB, then the transistors (TR1-5).



Power amp, capacitors and tag board mounted in chassis.

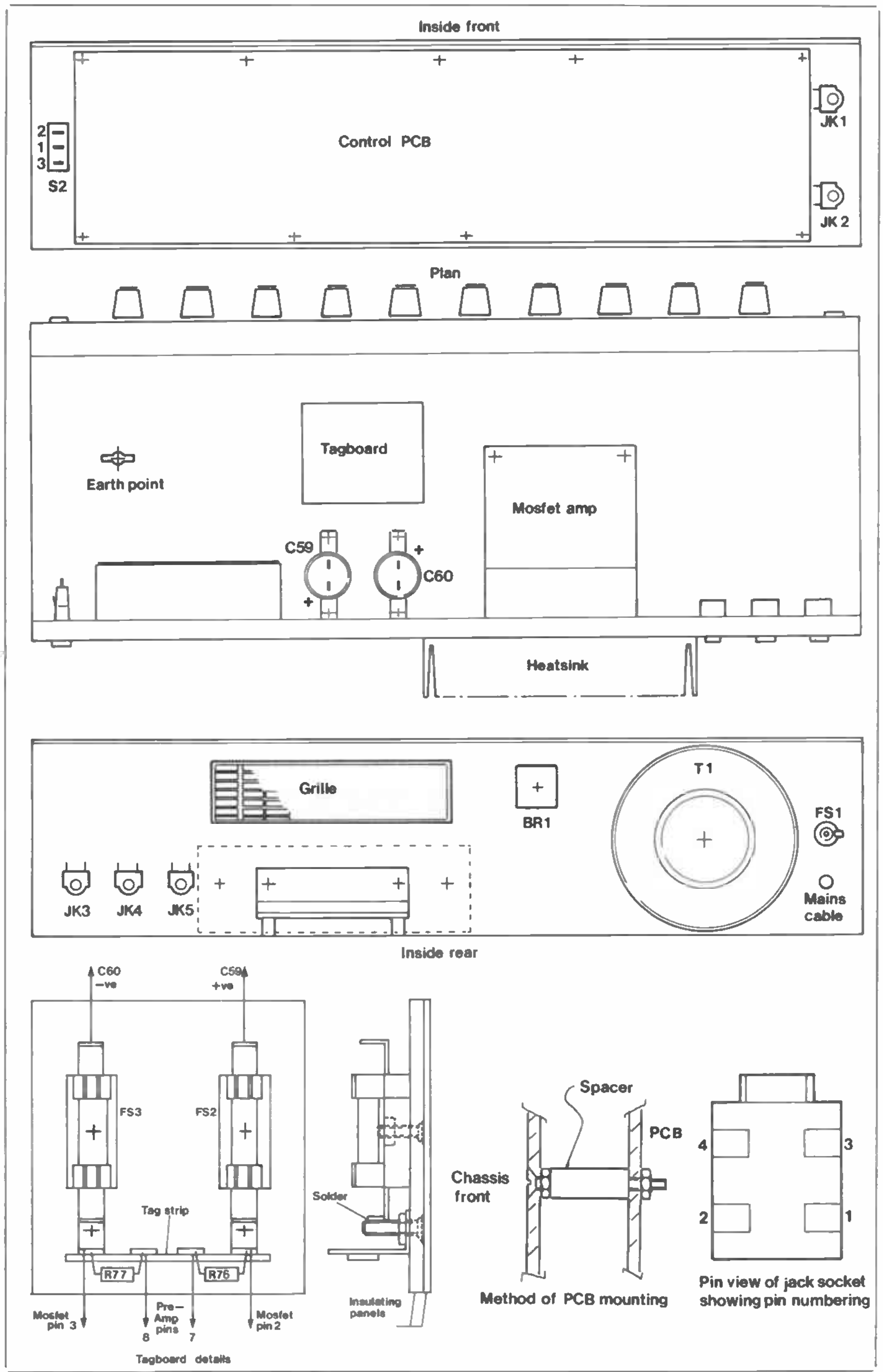
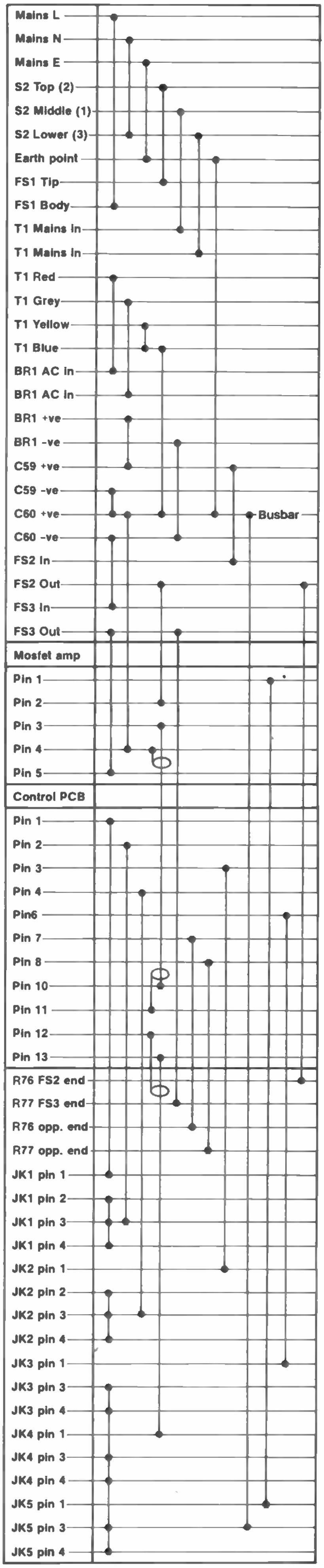


Figure 9. Chassis assembly layout.

Make the heatsink bracket shown in Figure 5. (Note that this is available ready-made, and is included in the kit supplied by Maplin Electronic Supplies Ltd.) The mounting bracket fits to the component side of the PCB as shown in the photograph. Align it with the holes in the PCB and put one bolt through the centre hole from underneath using a 6BA nut, bolt and shakeproof washer. Referring to Figure 6, place a nylon bush in each of the four large holes in the bracket, smear both faces of both mica washers with Thermpath silicone grease and place these in position. Mount the two power MOSFETs, ensuring that TR6 (2SK133) is fitted closest to the coil L1. Put in the 6BA bolts to hold the transistors from underneath and secure them using nuts and shakeproof washers. Solder the bolt heads to the track on the PCB. Finally solder the drain and gate pins to the PCB and re-check all component positions, polarisations and solder joints.

Setting Up

With no speaker connected and fuses not inserted, check that the voltage across C12 is approximately 48V (±5V) and that the voltage across C13 is the same. Switch off and short C12 and C13 in turn with a resistor (e.g. one of the test resistors). Now connect FS2 and FS3, via 100R 5W resistors, to pins 2 and 5 respectively. Connect 0V to pin 4. Check with a multimeter set to the highest resistance range, that there is no connection between the MOSFET cases and the mounting bracket. Turn RV1 fully clockwise.



Wiring schedule.

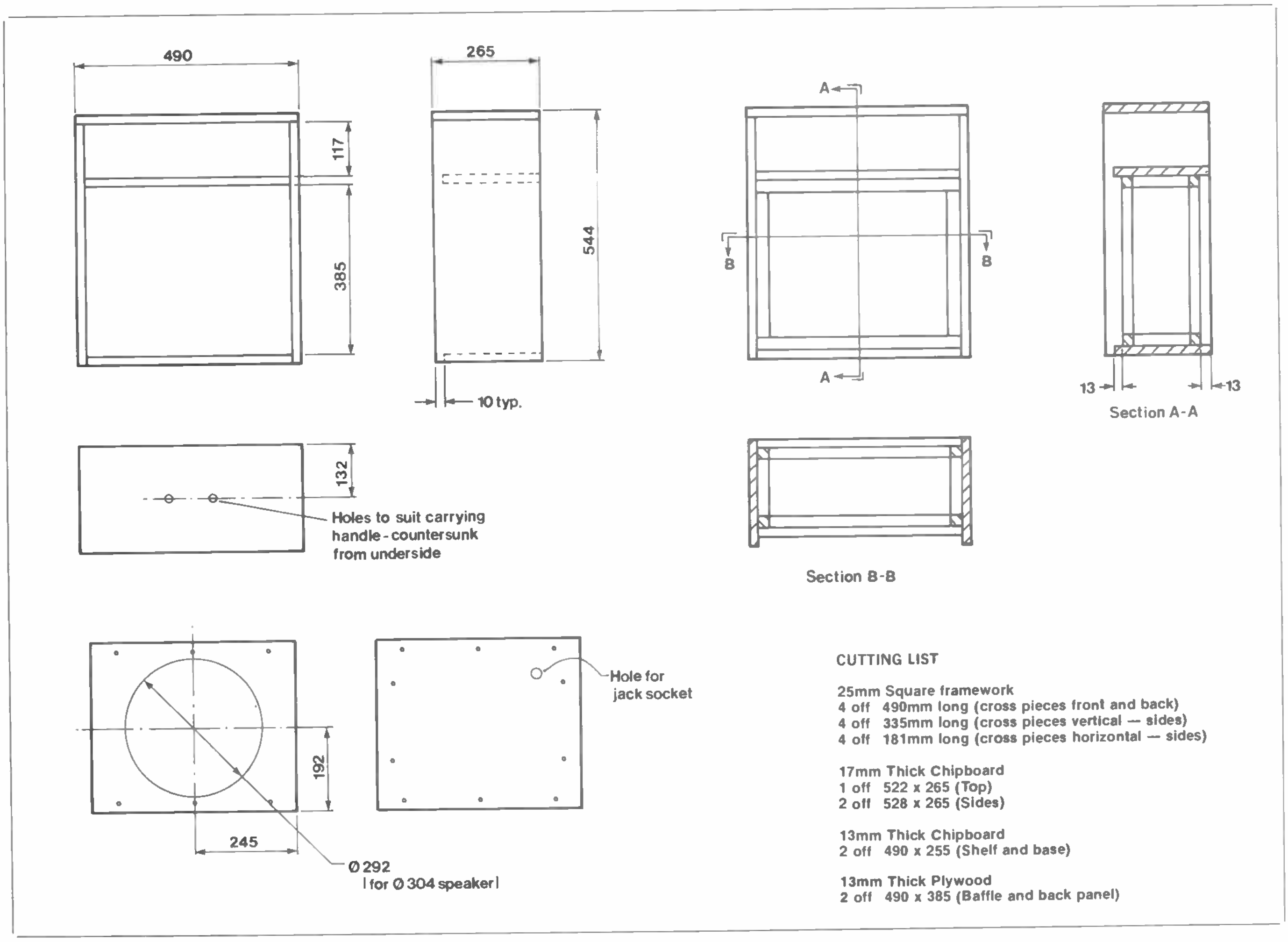


Figure 10. Cabinet construction details.

Insert 500mA fuses for test purposes as FS2 and FS3 and switch on again. If either fuse blows or any component gets excessively hot switch off immediately. If all is well, connect a DC voltmeter between pin 1 and pin 4. The meter should read about 0V (not more than ±100mV). Switch off and remove the two 100R resistors. Connect FS3 directly to pin 5 and connect a multimeter switched to about 100mA DC between FS2 and pin 2 (+ve lead to fuse and -ve lead to pin 2). Switch on again and rotate RV1 slowly until the meter reads 50mA. Leave for 10 minutes and re-adjust.

Switch off, disconnect the meter and connect FS2 direct to pin 2. Replace FS2 and 3 with 2A types.

Control PCB Assembly

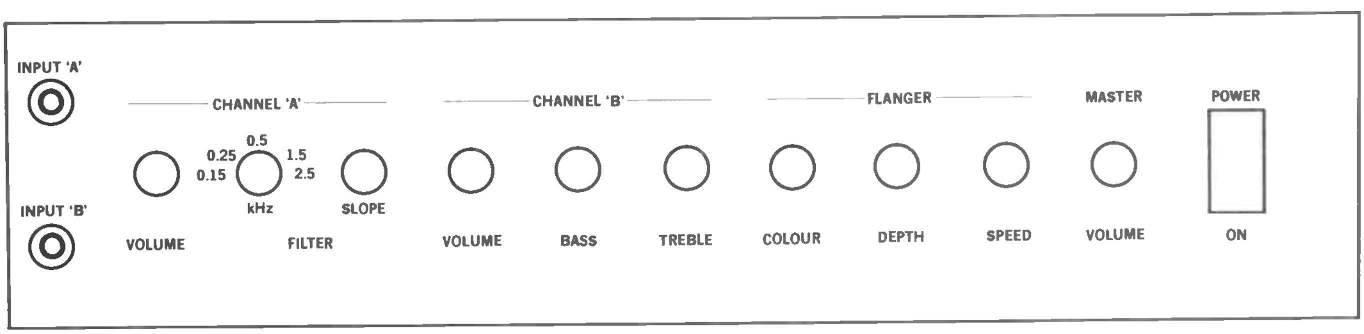
Fit all links first, and then the resistors and capacitors. Electrolytic and tantalum capacitors are polarised, and attention should be paid to their + signs. Fit diodes, transistors and ICs using IC holders if preferred. Lastly, fit the rotary pots and SW1. The rotary switch fits into a locating hole which lines up the switch tags to their appropriate holes on the PCB. Connect pins 1 to 5 and pins 7 to 11 to the PCB; pins 6 and 12 are not used. The switch is a 6 way type and can be adjusted for 5 way with the lug washer on the spindle; the lug should go into the slot marked with a '5' moulded into the switch body. Wire pins A and C to the PCB. The 9 potentiometers are wired to the holes adjacent, either direct or by using Vero pins (1mm type). After soldering and cutting all component wires, scrub the PCB with paint thinners and sponge, to clean off flux, and check for shorts etc. Double check all components. A ±15V supply can be attached for testing the pre-amp circuitry before assembly in the chassis.

Chassis Assembly

C1 and C2 come with their own mounting clips which are fixed with 4 x ½" 6BA countersunk bolts, nuts and washers. BR1 is also mounted with a ½" 6BA countersunk bolt, nut and washer. T1 is supplied with mounting pads, nuts and bolts. The 2 fuse holders FS2 and 3 are fitted to a paxolin panel (for insulation) using ¼" 6BA bolts, and the 4 way tag strip is soldered to the holders.

Resistors R1 and R2 are mounted to the tag strip — see Figure 9 — and then wired to the Combo pre-amp PCB + and - inputs.

The MOSFET amplifier bracket is smeared with Thermpath and bolted to the back panel with 6BA bolts. The front



Front panel.

COMBO PARTS LIST

Resistors — all 0.4W 1% metal film unless specified

R1,14,33,38,42, 47,51,62,63, 71	47k	10 off	(M47K)
R2,15,26,46	4k7	4 off	(M4K7)
R3,12,16,59,65, 66,69	1k0	7 off	(M1K0)
R4,5,17,18,19, 21,22,29,30, 54,55	10k	11 off	(M10K)
R6,7	1M0	2 off	(M1M0)
R8,72,73	470R	3 off	(M470R)
R9,10,11,24,35, 60,70	100k	7 off	(M100K)
R13,39,48	5k6	3 off	(M5K6)
R20,23,64,80	3k3	4 off	(M3K3)
R25,44,45,49, 50,53	22k	6 off	(M22K)
R27	6k8		(M6K8)
R28,79	2k2	2 off	(M2K2)
R31,32,56,57	22R	4 off	(M22R)
R34	33k		(M33K)
R36,37,40,41	15k	4 off	(M15K)
R43,52	56k	2 off	(M56K)
R58,67,68	150K	3 off	(M150K)
R61	470k		(M470K)
R74,75	330R 3W wirewound	2 off	(W330R)
R76,77	220R 3W wirewound	2 off	(W220R)
R78	1k5		(M1K5)
RV1,4,13	100k horiz. preset	3 off	(WR61R)
RV2,5,8	10k log. pot.	3 off	(FW22Y)
RV3,9	10k lin. pot.	2 off	(FW02C)
RV6,10	100k lin. pot.	2 off	(FW05F)
RV7	470k lin. pot.		(FW07H)
RV11	47k lin. pot.		(FW04E)
RV12	10k horiz. preset		(WR58N)

Capacitors

C1,3,19,21,27, 28,29,32	2u2 63V PC electrolytic	8 off	(FF02C)
C2,8	1n0 ceramic plate	2 off	(WX68Y)
C4,20,22	120pF ceramic plate	3 off	(WX57M)
C5,26,53	4u7 35V tantalum	3 off	(WW65V)
C6	4n7 monolithic ceramic		(YY07H)
C7	2n2 monolithic ceramic		(YY25C)
C9	560pF ceramic plate		(WX65V)
C10	270pF ceramic plate		(WX61R)
C11	47nF monolithic ceramic		(YY10L)
C12	22nF monolithic ceramic		(YY09K)
C13	10nF monolithic ceramic.		(YY08J)
C14	5n6 polystyrene		(BX40T)
C15	2n7 ceramic plate		(WX73Q)
C16	1u5 35V tantalum		(WW61R)
C17,18,33,44, 45,49,52,58	100nF disc ceramic	8 off	(BX03D)
C23,25	47nF polycarb	2 off	(WW37S)
C24	4n7 polycarb		(WX76H)
C30,31,46,47	220uF 16V PC electrolytic	4 off	(FF13P)
C34-37,40-43	2n2 polycarb	8 off	(WW24B)
C38	1u0 polycarb		(WW53H)
C39	100nF polyester		(BX76H)
C48	560nF polycarb		(WW50E)
C50,51,56,57	470pF ceramic plate	4 off	(WX64U)
C54,55	1000uF 16V PC electrolytic	2 off	(FF17T)
C59,60	4700uF 63V can electrolytic	2 off	(FF28F)

Semiconductors

IC1,4,8	LF351	3 off	(WQ30H)
IC2,5,6	LF353	3 off	(WQ31J)
IC3	4016BE		(QX08J)
IC7	LF347		(WQ29G)
IC9,10	uA741C		(QL22Y)
IC11	4011BE		(QX05F)
IC12	TCA350Z		(YY79L)
TR1	BC548		(QB73Q)
D1-5	1N4148	5 off	(QL80B)
D6,7	BZY88C7V5	2 off	(QH11M)
D8,9	BZX61C15V	2 off	(QF57M)
BR1	PW06		(WQ58N)

Miscellaneous

	MOSFET amplifier kit		(LW51F)
S1	2-pole 6-way rotary, make before break		(FH43W)
	Combo PCB		(GA41U)
T1	35-0-35V 160VA toroid		(YK21X)
	Chassis fuseholders	2 off	(RX49D)
	Panel fuseholder		(RX96E)
FS1	2A 20mm antisurge fuse		(WR20W)
FS2,3	2A 20mm fuse	2 off	(WR05F)
S2	SPST rocker with neon		(YR68Y)
JK1,2	Chrome bezel jack socket	2 off	(BW78K)
JK3-6	¼" jack socket	4 off	(HF90X)
	L Knobs	10 off	(YG40T)
	Red knob caps	3 off	(QY04E)
	White knob caps	7 off	(QY05F)
	2E heatsinks (see text)	2 off	(HQ70M)
	Jack plugs	3 off	(HF85G)
	Footswitch		(FH92A)
	Footswitch box		(LH09K)
	Loudspeaker 12"		(XQ81C)
	Front panel		(XG03D)
	Handle		(FW82D)
	Ventilation grille		(FX06G)
	4-way tag strip		(FL28F)
	Grommet		(FW59P)
	6BA x 1" countersunk bolts	10 off-1 pkt	(BF13P)
	6BA x ½" countersunk bolts	11 off-2 pkts	(BF12N)
	6BA nuts	27 off-3 pkts	(BF18U)
	6BA washers	27 off-3 pkts	(BF26D)
	6BA x ½" spacers	8 off-1 pkt	(FW35Q)
	Jack socket mounting plate		(HH23A)
	Cabinet cloth	2m	(RY05F)
	Speaker fabric	½m	(RY01E)
	Wire	as required	
	Screened cable	1m	(XR13P)
	Mains cable	as required	(XR03D)
	Chassis (see Fig. 8)		

A complete kit of all parts, excluding the chassis, woodwork and cloth is available. **Order As LW92A (Combo-Amp kit)**

of the PCB is supported using 1" countersunk bolts and ½" 6BA spacers.

If it is intended to use less than 8 ohm loads on the power amp, heatsinks are advisable. Two extra holes are shown for mounting 2 x 2E (HQ70M) heatsinks.

Additional cooling is catered for by cutting a slot in the back panel, above the power amp. A Cool Grille (FX06G) can be accommodated in the dimensions shown in the chassis diagram.

Control PCB Mounting

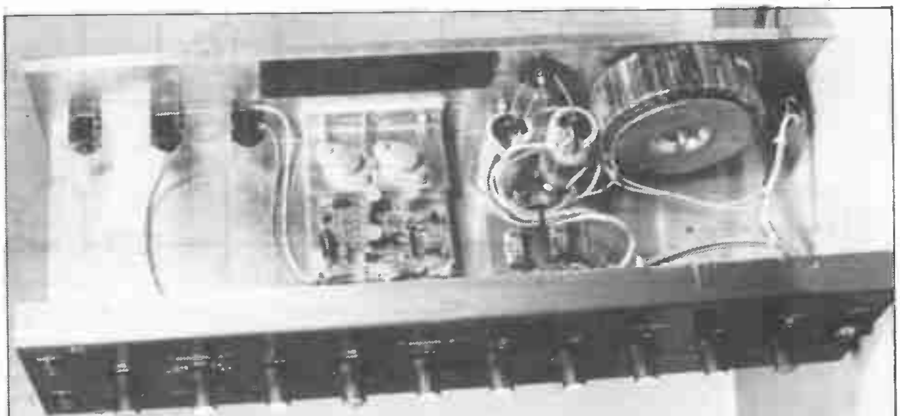
The chassis front panel has 6 countersunk holes. Fit 6 x 1" bolts and tighten with 6 x 6BA nuts. Place 6 x ½" 6BA spacers over the bolts and fit the Combo PCB over the bolts and spacers. Use 6 x 6BA nuts and washers to hold it down (note orientation of the PCB).

Fit the chrome bezel jack sockets to the front panel, and the mains neon switch.

Cut the rotary control spindles to size and fit the knobs; use red caps for the volume controls, white caps for the others.

The control PCB output, pin 10, is connected to the power amp input using screened cable. Connect the cable screen to the power amp 0V pin and the control PCB 0V pin. The C1/C2 0V bus bar is wired to the power amp 0V and this also supplies the control PCB 0V. Do not connect pin 9 to the 0V rail sepa-

Continued on page 62



Inside rear of chassis.

PASS THE BOMB!

by Alan Davies

- ★ **Make your party go with a BANG!**
- ★ **Explosive fun for young and old**
- ★ **Low cost novel construction**

Are you bored with some of the traditional party games — 'musical chairs', 'pin the tail on the donkey', 'blind man's buff' etc? Well, here's The Bomb which, while perhaps not quite as exciting as 'postman's knock', gives an electronic 'facelift' to that old party favourite 'pass the parcel'.

For those unfamiliar with this game, one version of it is as follows: those playing sit in a circle just far enough away from one another to be able to pass an object round the ring. This usually takes the form of a 'parcel'. The package is only passed round while some music is playing. When the music stops, the person holding the parcel has to drop out of the game or 'lose a life' (it may be agreed that when a small number of people are playing that each has say three 'lives'). As each person drops out, the circle of people closes in and the process of passing the parcel continues. The winner of the game is of course the person left in at the end of the game when everyone else has had to drop out.

This works well but does have some disadvantages: a piano or record player is required in the room to be able to play at all and of course someone must play the piano or switch the music on and off. This can also create problems if the provider of the music is accused of cheating by stopping the music when the parcel is with a particular person — strictly not in the party spirit!

But all of this is in the past! No more music needed, no more gamesmanship — enter The Bomb!

This is an entirely self-contained unit which consists of a loud alarm and a circuit for varying the time period between soundings. When The Bomb is primed by pressing the priming button

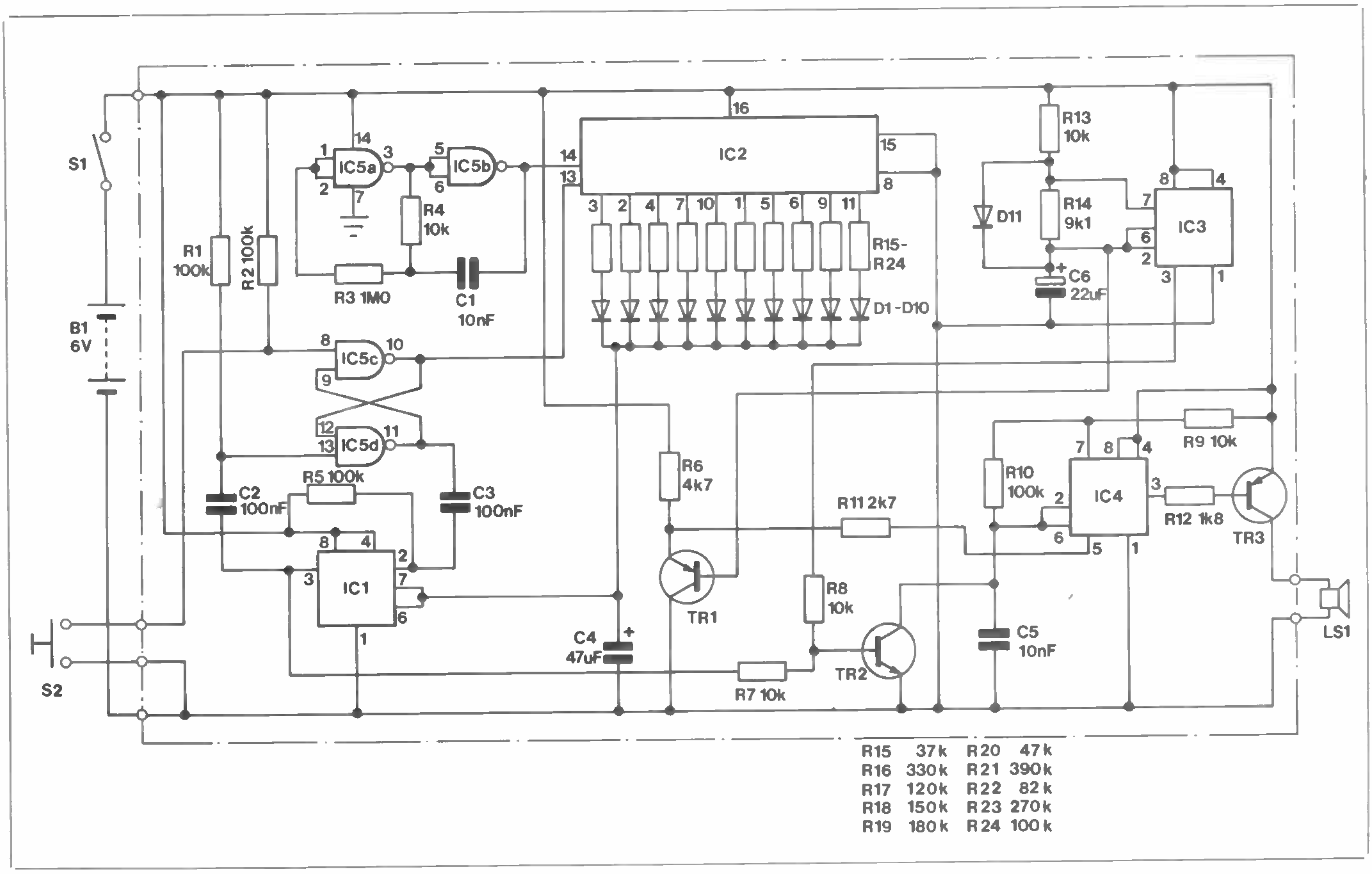


Figure 2. Circuit diagram of The Bomb.

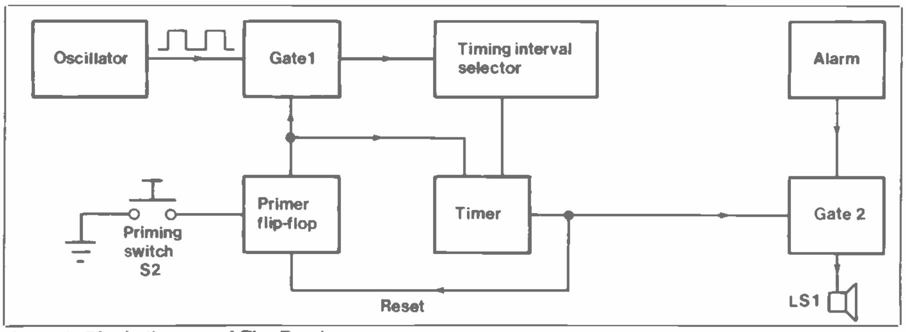


Figure 1. Block diagram of The Bomb.

the alarm ceases to sound and the game begins. The Bomb is passed around from player to player until it 'goes off' (the alarm sounds) in someone's hand. This person then has to drop out and the game continues until one player remains — the winner!

Principle of Operation

With reference to the block diagram, Figure 1, it will be seen that The Bomb consists of two main sections: timing and alarm.

During a timing period (when the alarm is off) the output from the timer switches gate two off preventing the alarm signal reaching the loudspeaker. As soon as the timing period is over, gate two is switched on and the alarm sounds. Whilst the alarm is sounding a clock waveform produced by the oscillator is allowed through to the timing interval selector via gate one. The timing interval selector consists of a ten-stage counter one of whose outputs is 'high' at any one time. As the priming button is pressed to initiate a new timing cycle, gate one is switched off and the timer itself is triggered and produces a timing period dependent upon which output of the timing interval counter was 'high' at the moment the priming button was depressed.

The oscillator clock rate is sufficiently fast (kHz) that it is impossible to predict where the counter in the timing interval selector will stop and hence which one of ten timing periods will have been selected when the priming button is pressed. The timing periods range from 3-25s approximately.

Circuit

The Bomb circuit diagram is shown in Figure 2. The clock oscillator is formed using two of the NAND gates in IC5, a and b. These are wired as inverters and form an RC oscillator with R3, R4 and C1. Since R3 is much larger than R4 the approximate frequency of the oscillator is given by:

$$\frac{0.455}{R4xC1} \text{ i.e. } 10kHz.$$

The squarewave output from this oscillator is fed into the clock input (pin 14) of IC2 which is the ubiquitous 4017 — a 5-stage Johnson counter with ten decoded active 'high' outputs.

The remaining two NAND gates of IC5, c and d, are configured into an RS flip-flop (see Figure 5). When the priming button S2 is pressed a 'low' is produced on pin 8 of the IC. This causes pin 10 to go 'high' and pin 11 to go 'low'. (Further depressions of S2 will have no further effect — this means that once The Bomb is primed no one can cheat by resetting it to the start of its timing cycle by pressing S2 as it is passed around). The 'high' produced on pin 10 stops the 4017 from counting as it is connected to the clock inhibit input of the IC (pin 13). In this way one of the 4017 outputs is selected to charge up C4 (a low leakage tantalum lead capacitor) via one of the resistors R15-R24. Diodes D1-D10 ensure that all the charging current goes into C4 and that some is not taken to ground via a parallel combination of the remaining nine unselected resistors. (Remember all but the selected output of the 4017 IC are at logic '0' which equals ground potential.)

This resistor-diode-capacitor network is connected to the timing pins of IC1 — another popular chip the 555 timer.

This IC is triggered by a falling edge waveform on pin 2 which is generated by the RS flip flop, R5 and C3. The resistor capacitor network ensures that a 'low-going' pulse is produced which resets 'high' (due to R5) despite the output of the flip flop remaining 'low'. If pin 2 of IC1 were continually 'low' then it would not function as desired.

The sequence of events thus far then is: IC2 counting and alarm sounding — S2 pressed — flip-flop activated — timer triggered — timing period selected (counter stops) — alarm stops.

Whilst IC1 is timing its output, pin 3 is 'high'. This is used to switch off the alarm circuit which comprises IC3 and IC4 (both 555 timers) with their associated components. The timing capacitor of IC4 (C5) is shorted to ground using TR2 as a switch (a 'high' on the base input = switch ON, low resistance; a 'low' on the base input = switch OFF, very high resistance).

When IC1 comes to the end of its period, pin 3 goes 'low' which resets the 'priming' flip-flop via C2 and R1, which generates a low going pulse on pin 13 of IC2.

The 'low' on IC1 pin 3 also switches TR2 off allowing the alarm to sound once more. Thus a complete cycle has been generated and The Bomb awaits re-priming via S2.

The alarm circuit itself comprises timer IC4 configured as an astable oscillator with a basic frequency:

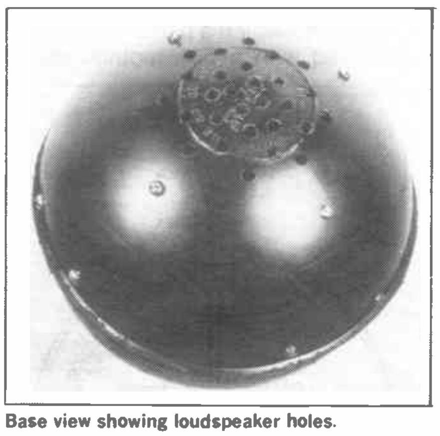
$$f = \frac{1.46}{(R9+2R10)C5} \simeq 700Hz$$

This frequency is modulated via TR1 at pin 5 by a ramp waveform generated at pins 2 and 6 of IC3. The sound is further enhanced by switching it on and off using the square wave produced at pin 3 of IC3 to turn TR2 on and off. TR2 thus serves a dual purpose — that of totally switching the alarm off and that of modulating the sound the alarm produces.

Construction

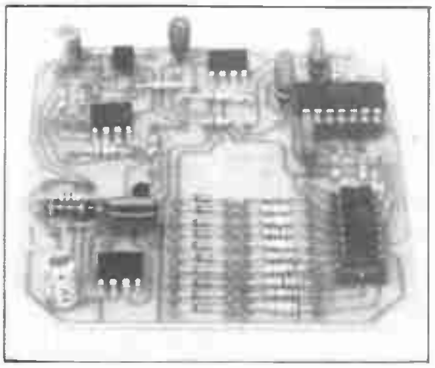
The printed circuit board with component overlay is shown in Figure 3. It is recommended that IC sockets be used at least for the CMOS chips IC2 and IC5 and if desired for the 555 timers.

Begin assembly by soldering the two wire links as shown and then insert the resistors followed by the capacitors. The diodes should be fitted next taking care to assemble them the correct way round as per the band on the casing. Now solder the transistors in place also taking care with their correct orientation. Next solder the battery connections ensuring that the polarity is correct. The two off board switches S1 and S2 and the loudspeaker may then be soldered allowing approximately 6" lengths of wire.


Base view showing loudspeaker holes.

Before inserting the ICs into their holders connect the batteries up to the board and check that the correct power supply voltage is reaching the appropriate pins on each socket. Finally, disconnect the batteries and check for any solder bridges on the track side of the PCB. The ICs may now be inserted and the circuit tested.

Switch on and wait for the alarm to sound. Reset the circuit by depressing S2 and wait for the alarm to sound again. Do this a few times checking against your watch that a varying period of time elapses between S2 being pressed and the alarm sounding. If all is well you may then proceed to fit the unit into a case.



Assembled PCB of The Bomb.

As may be noticed from the photographs the prototype was fitted into a plastic lavatory cistern float which may be obtained from most ironmongers. A black one is ideal although another colour could be painted but is liable to scratching due to the excessive handling which the final device undergoes. Two basic types are available, the main difference being the position of the threaded section. This is either internal or external as shown in Figure 4, which also gives the internal layout of The Bomb. The construction is the same for both types except where stated.

If a float is used first cut the float in half along the 'equator' as shown in Figure 4 keeping the screw thread entry point as the 'North Pole'. This cutting operation can be difficult. The best method is to drill a few small diameter holes e.g. 1mm close together along the seam and then enlarge these laterally into a slit into which a pad saw (keyhole saw) fitted with a fine toothed blade

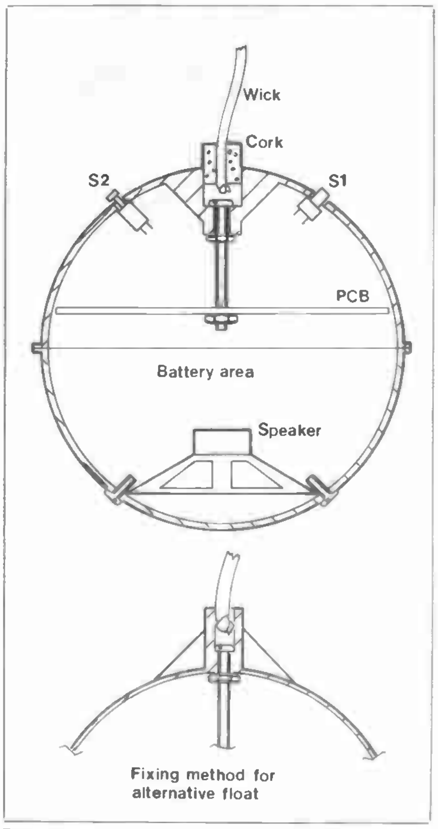


Figure 4. Internal layout of The Bomb.

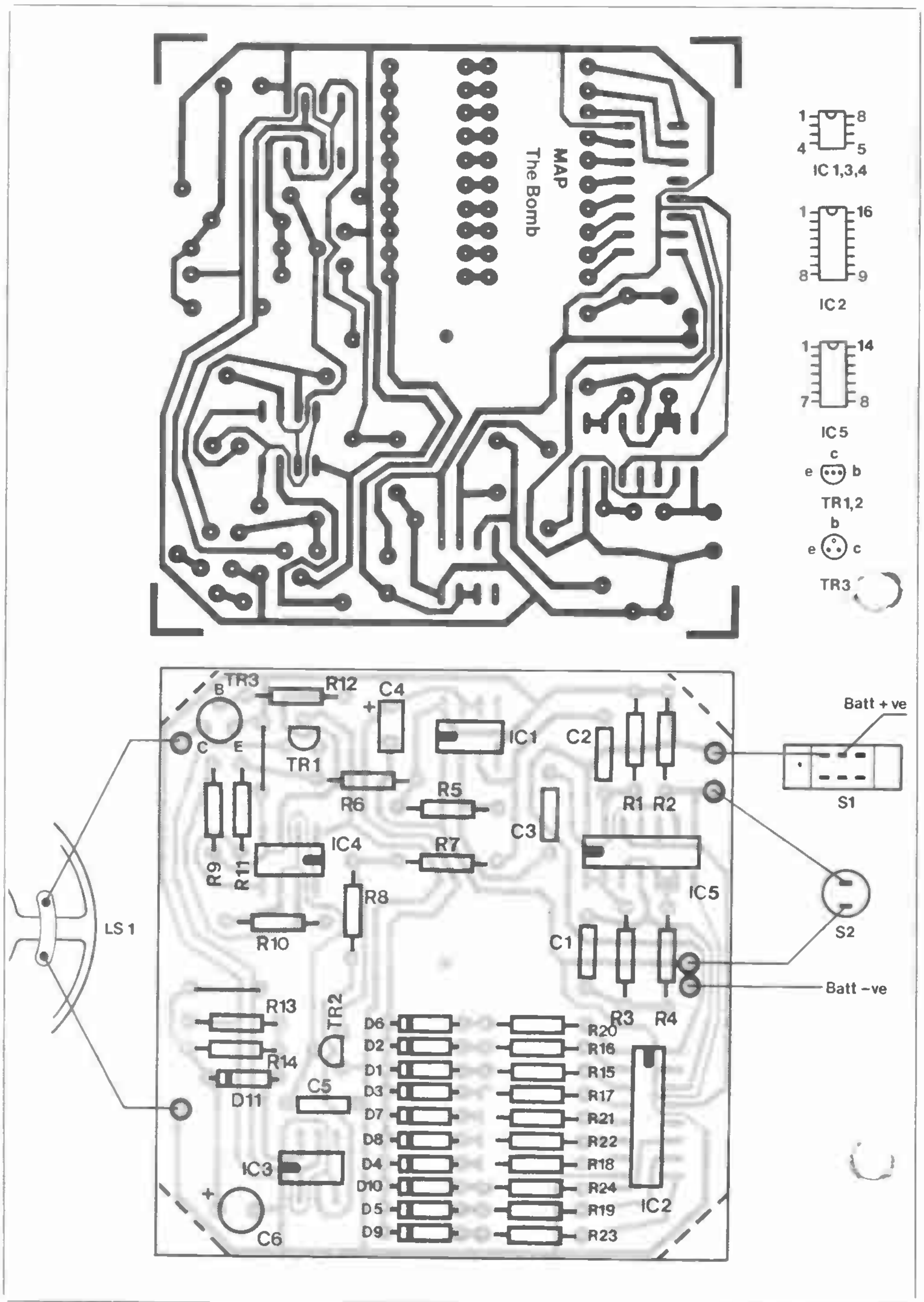


Figure 3. PCB track layout, component overlay and wiring.

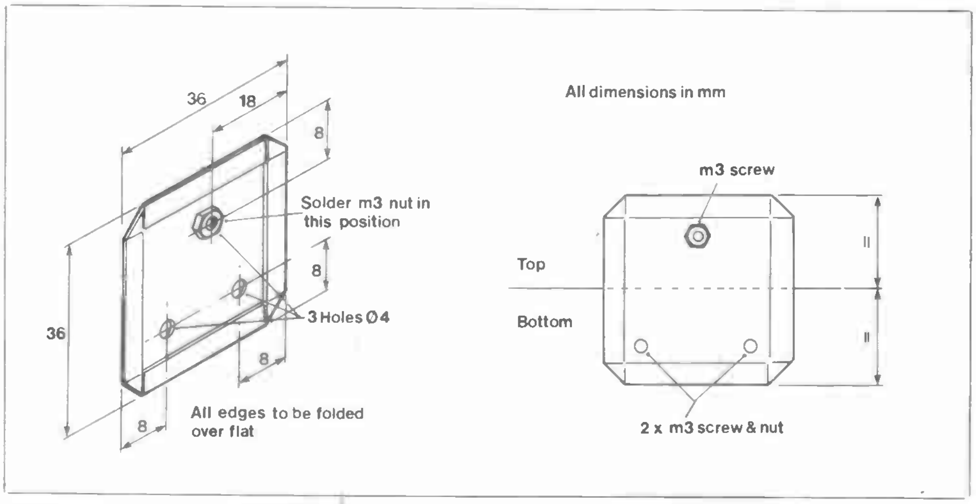


Figure 5. Mounting bracket template.

may be inserted. Proceed to saw carefully around the float.

Having obtained the two halves, take the one with the screw thread and drill a ⅛" dia. hole through the screw thread entry point as shown. The 2" M3 bolt is inserted into the hemisphere which is used to secure the PCB. In order to get the PCB to fit into the hemisphere it will be necessary to pare off the corners along the lines shown on the component overlay Figure 3.

Now take the other hemisphere and drill the 8BA mounting holes for the loudspeaker and also a pattern of holes which allow the sound out.

In order to join the two hemispheres together whilst still retaining access to change the batteries, occasionally it will be necessary to cut out three pieces of thin tin-plate according to the template in Figure 5 from, for example, a can of beans — washed first unless you want a stink Bomb! This is a delicate operation if injury is to be avoided and if some young constructors are contemplating building The Bomb it is advisable here to ask an adult to do this stage for you. Having cut these out each one should be drilled with three 4mm diameter holes and a M3 nut should be soldered on to the reverse side of hole A in each case (also shown in Figure 5). If the nuts are plated it will be necessary to remove plating prior to soldering.

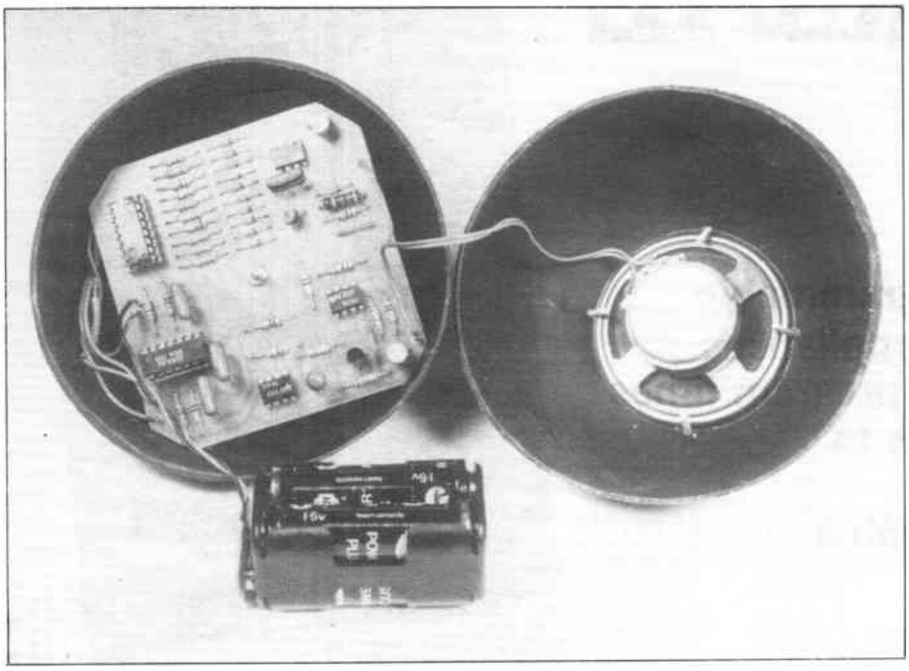
These three pieces of tinplate are placed along the rim of the low hemisphere at 120° intervals and are secured in place with two 6BA nuts and bolts passing through holes 'B' and 'C' in each case.

Holes are now drilled in the upper hemisphere in order to correspond with hole 'A' in each of the three tinplate pieces. The upper and lower hemispheres may now be joined together by passing three 6BA bolts through the plastic of the top hemisphere and screwing them into the nuts on the reverse side of hole 'A' in each piece of tinplate.

Switches S1 and S2 are secured in place in the top hemisphere in the positions shown in Figure 4. Holes will, of course, have to be cut to accommodate these.

The final touch is added to the design by incorporating a mock 'fuse' which is a short length of white shoelace. If a float with an external threaded section is used this can simply be glued in place. However, for a float with an internal threaded section the hole should be drilled out so that a cork, with the shoelace located through the centre, can be inserted.

All the parts of the unit may now be assembled into the two hemispheres. The batteries sit on top of the loudspeaker as shown in the photographs. Ensure that the circuit board mounting bolt is inserted into the top hemisphere before the mock 'fuse' is glued into place.



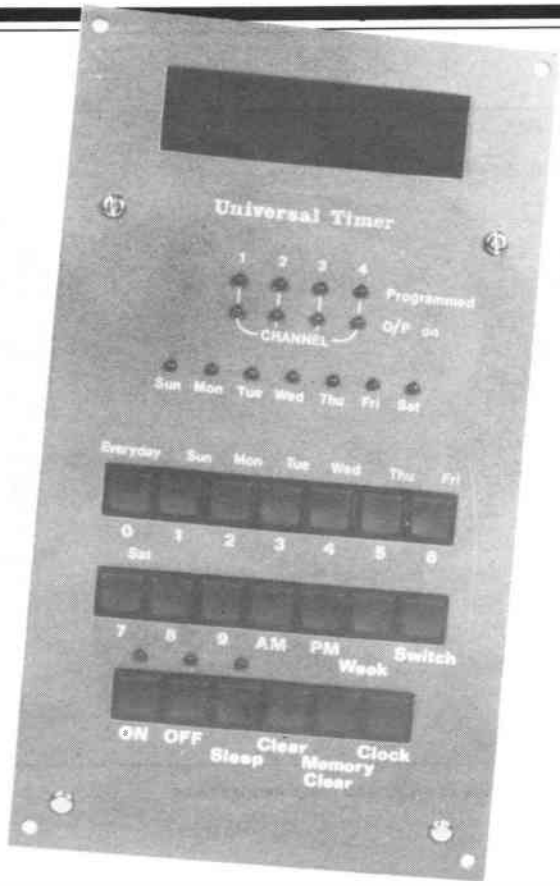
Internal view of upper and lower hemispheres.

PARTS LIST FOR THE BOMB

Resistors — all 0.4W 1% metal film			
R1,2,5,24	100k	4 off	(M100K)
R3	1M		(M1M0)
R4,7-10,13	10k	6 off	(M10K)
R6	4k7		(M4K7)
R11	2k7		(M2K7)
R12	1k8		(M1K8)
R14	9k1 ½W		(S9K1)
R15	39k		(M39K)
R16	330k		(M330K)
R17	120k		(M120K)
R18	150k		(M150K)
R19	180k		(M180K)
R20	47k		(M47K)
R21	390k		(M390K)
R22	82k		(M82K)
R23	270k		(M270K)
Capacitors			
C1,5	10n polyester	2 off	(BX70M)
C2,3	100n polyester	2 off	(BX76H)
C4	47u 10V tantalum bead		(WW75S)
C6	22u 16V PC electrolytic		(FF06G)
Semiconductors			
D1-11	1N4148	11 off	(QL80B)
TR1	BC214L		(QB62S)
TR2	BC184L		(QB57M)
TR3	AC126		(QB01B)
IC1,3,4	NE555	3 off	(QH66W)
IC2	4017BE		(QX09K)
IC5	4011BE		(QX05F)
Miscellaneous			
LS1	8 ohm 0.2W min. loudspeaker		(WB09K)
S1	Single pole sub. min. slide switch		(FF77J)
S2	Push switch		(YR67X)
	14 pin DIL socket		(BL18U)
	16 pin DIL socket		(BL19V)
	PCB		(GA58N)
	Bolts 6BA ½ in.	9 off	(BF06G)
	Nuts 6BA	9 off	(BF18U)
	Bolts 8BA ½ in.	6 off	(BF09K)
	Nuts 8BA	2 off	(BF19V)
	Case		
	Batteries		
	Wire to suit		

UNIVERSAL TIMER

by L. Harrold



- ★ **Comprehensive programmable control for 4 mains appliances**
- ★ **Storage for up to 18 program times**
- ★ **Safe low voltage links to controlled points**
- ★ **Relay outputs can switch other circuits**

This Universal Timer can be used to control up to 4 mains appliances, switching them on and off at various times throughout the week. Typical applications for the timer would be switching on electric blankets, controlling the heating, recording radio programs when out, or controlling the lighting when on holiday to give the impression that the house was occupied. The timer uses the Texas Instruments TMS 1121 IC, which contains a real time clock which displays the time of day, AM or PM and the day of the week; plus a 4 bit micro-computer which can be programmed to control the 4 outputs. It is possible to store up to 18 daily or weekly program times in the memory. The commands can be ON, OFF or SLEEP; the SLEEP command turns the switch on for 1 hour and then off. The programs are entered by push buttons on the front panel and can be of 2 types:

1. Fixed time programs. These are stored in the memory and executed at the same time every day or every week.
2. Interval programs. These are executed after a certain time has elapsed, say in 2 hours time. These programs are executed once and then deleted from the memory.

It is possible to display the programs that are stored in the memory and to delete them. In addition it is possible to switch the outputs directly from the keyboard. The front panel has a 4 digit LED display showing the time and 7 red LEDs, one for each day of the week. There are 4 green LEDs, one for each output, which light when the corresponding output is on. The 4 program LEDs and the 3 other command LEDs are used during programming and to display the programs in the memory.

The Circuit

The mains voltage is stepped down to 12 volts, rectified by BR1 and smoothed by C1. REG 1 and associated components C2, C3, R1 and R2 provide a regulated supply of 9 volts which is fed to the IC pins 20 and 4. The push buttons are connected as a 7x3 matrix which is scanned by the TMS 1121, pins 21 to 27, and pins 5 to 7 detect any buttons that are pressed.

The IC has an internal oscillator whose frequency is determined by R5 and C6, and is approximately 300kHz. Pins 10 to 17 are the multiplexed outputs for the 7 segment and LED displays; these are connected via the emitter followers TR4 to TR11 to drive the display. Pins 21 to 27 are digit and LED select outputs, and are connected via transistor inverters to the LED displays. Pins 22 to 26 use Darlington pairs, as the load on these pins is greater. Pins 28 and 1 to 3 are the 4 output control pins, and are connected via transistors to the 12 volt relays and LED indicators. Diodes D11 to D14 protect the transistors from inductive flyback voltages from the relays.

The TMS 1121 clock is synchronised to the mains frequency which is fed via R3 and TR1 to pin 8. This is normally 50Hz, but if you wish to use the timer on a 60Hz supply, the strap should be wired across the Veropins connecting D3 to pin 27 of the IC. When the circuit is first powered up, C5 charges up via R4, TR2 and TR3; this inhibits the 50Hz input and initially holds pin 9 high. Pin 9 is the initialise pin which resets the clock to 12.00 PM on Sunday and erases all programs from the memory.

Construction

The majority of the components are mounted on 2 PCBs (Figures 2 and 3), which connect together via three 10 way connectors. The timer main board is a single sided board and has 9 wire links to be made. The 1 watt resistors R22 to R29 get quite hot, so they should be mounted about ⅛" off the board to allow the air to circulate underneath them. Capacitors C4 and C5, and the regulator REG 1, should be mounted and bent over onto their sides before soldering. Capacitor C1 is mounted off the end of the board as shown in Figure 6. The 12 Veropins should be inserted from the component side of the board to allow the wires to be connected underneath the board.

The terminals for the connectors should be crimped and soldered onto 20 SWG wire, and then inserted into the housing and cut off about ¼" long; see Figure 7. When all 10 terminals have been made the whole socket can be soldered onto the board. Sockets 1, 2 and 3 should be mounted the right way round, since their holes are offset from the wires. The PCB legend shows the correct orientation.

The other components mount fairly easily, and it is only necessary to check that the diodes and transistors are of the correct type and are the right way round. The transistors should be pushed down so that their tops are about ⅜" above the board.

The LEDs, 7 segment display and push buttons are mounted on the timer switchboard PCB. This is double sided, and there are 76 track pins to be inserted to connect the two sides of the board. These should be inserted from side 1, pressed well down, and then soldered on both sides. The push switches can now be mounted together

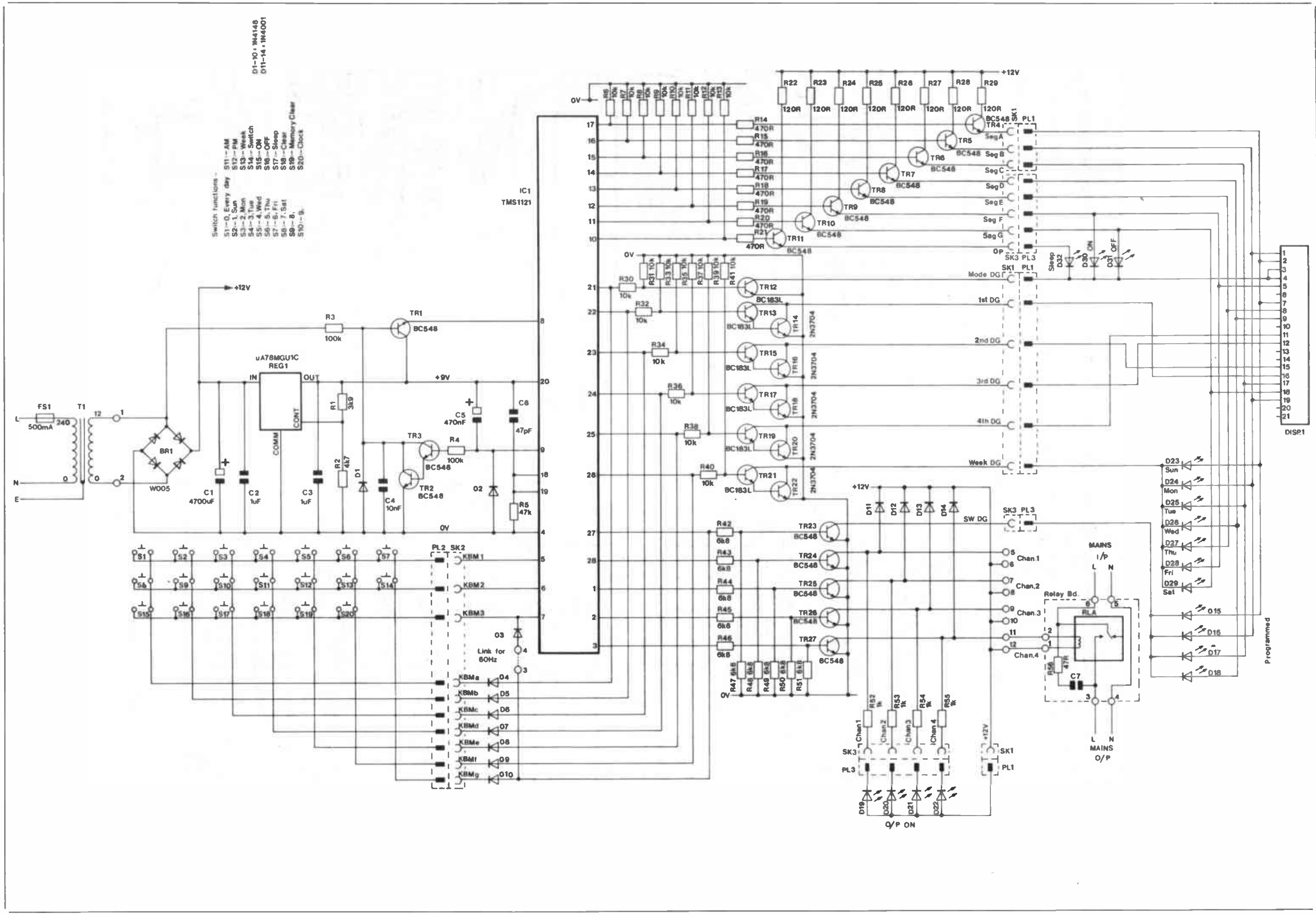


Figure 1. Circuit diagram of the Universal Timer.

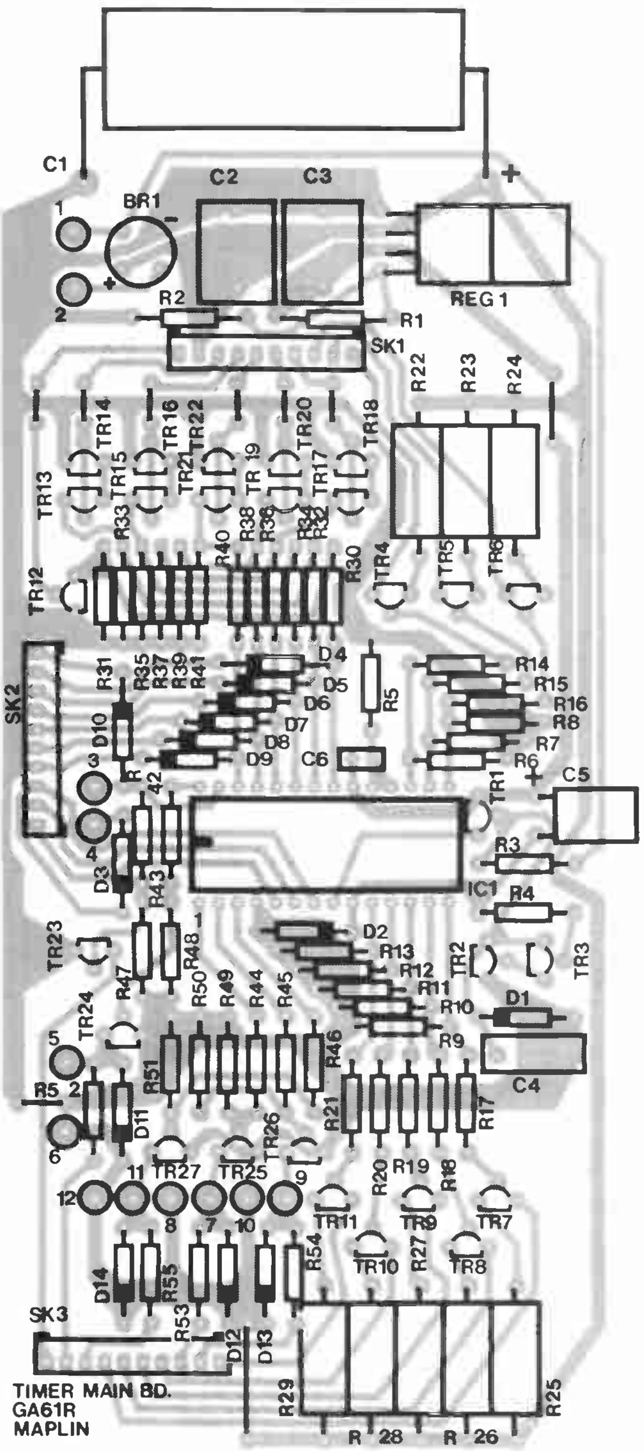
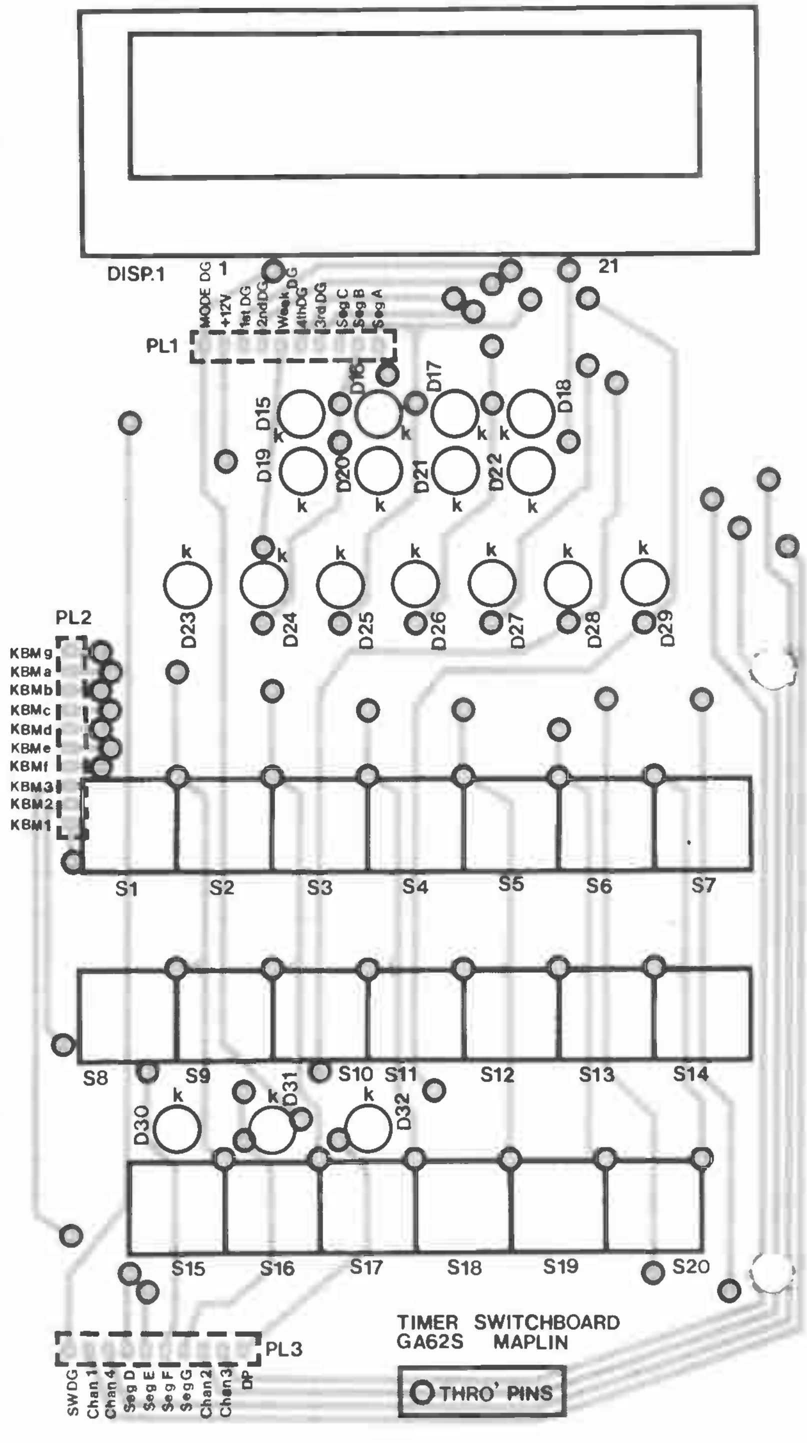


Figure 2. Main PCB.



NB: PL1,2&3 are mounted on rear

Figure 3. Switch PCB.

with the 10 way plugs, which go on the opposite side of the PCB.

The 7 segment display is placed on top of the PCB and there are 15 connections to pin through the two boards; at least three of these should be Veropins to provide the necessary support to the display. The rest can be wired through, which makes it easier to replace the display if necessary.

The four nuts, washers and spacers should be bolted to the front panel, and the red filter glued into place. If the LEDs are now inserted into the board, but not soldered, the front panel can be slid over the switchboard and secured with four more nuts. The LEDs are then pushed through the holes in the front panel and soldered. Note that the two top rows of four LEDs are inserted the opposite way round to the rest.

The transformer secondary can now be wired to the Veropins on the main board, and the primary connected to the mains lead via the fuseholder. The mains earth wire should be connected to a tag bolted to the transformer frame. The circuit should be powered up without the TMS 1121 in the socket, and the voltage between pins 20 and four measured as nine volts. If this is correct, switch off and allow the power supply to discharge before plugging the IC in.

The relay boards are designed to be situated near the appliance to be controlled, with a pair of low voltage wires connected back to the main board. The relay boards can switch a 2kW resistive load at 240 volts, and have a suppressor circuit fitted.

If the main circuit board or the relay boards are housed in metal cases, these should be connected to the mains earth, as well as the front panel.

Programming

The programs are entered via 17 of the 20 push buttons on the front panel. Most of the number buttons have two or three functions; when they are pressed, the number entered is shown on the seven segment display. If the SWITCH button is pressed immediately after a number button, the number is entered as the number of the switch to be controlled (1-4 only) and is displayed on the 'channel' LEDs. If the WEEK button is pressed immediately after a number button, the number is entered as the day of the week (1-7 only) and is displayed on the 'day of the week' LEDs. The other buttons used in programming are AM, PM, ON, OFF and SLEEP. The CLOCK button displays the clock, MEMORY CLEAR clears all the programs out of the memory, and the CLEAR button clears the display so that new digits can be entered if you make an error.

Setting the clock

When the circuit is first powered up, the clock is automatically set to 12.00 pm on Sunday with all the switches off and no programs stored in the memory. The CLOCK button must be pressed to start and display the clock. To set the clock the following sequence must be entered:
1. Day of the week followed by the WEEK button.
2. AM or PM.
3. The time e.g. one, zero, zero, eight for 10.08.
4. The CLOCK button.

The clock is not actually started until the last button is pressed, so that the time can be accurately set. The timer will convert times from the 24 hour system to the 12 hour system for both clock setting and programming. If a 24 hour time is entered, 12 hours will be subtracted from it, but the AM/PM selection is not altered; therefore AM/PM must still be entered correctly.

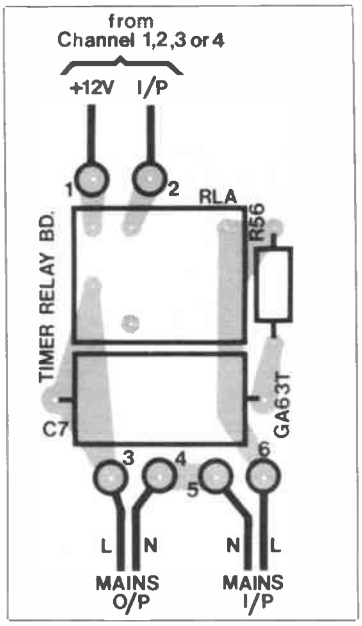


Figure 4. Relay PCB.

Errors

If you make a mistake entering items 1 or 2, just press the CLOCK button and start again. If you make a mistake entering the time, just enter zero followed by the proper time. As the time is entered, the digits shift from right to left as with a calculator; this means that the old time will shift off the display and the correct time will be entered. A display of 99.99 occurs if the key sequence is incorrect or a program is attempted with an invalid time, and a display of 88.88 occurs if an attempt is made to store more than 18 programs.

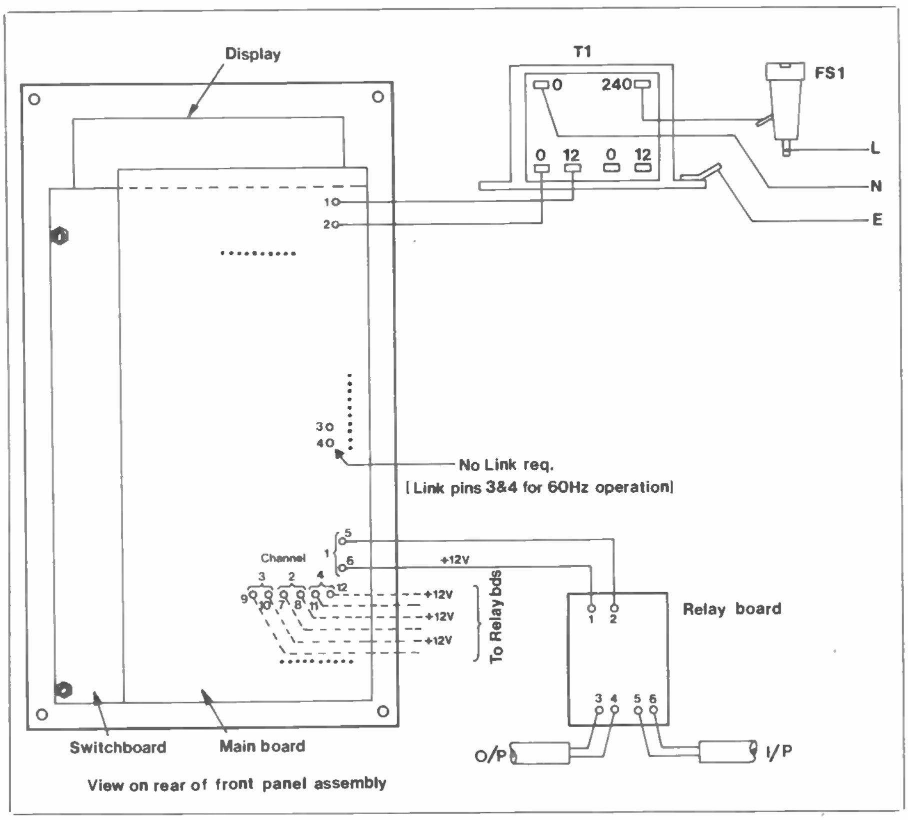


Figure 5. Wiring details.

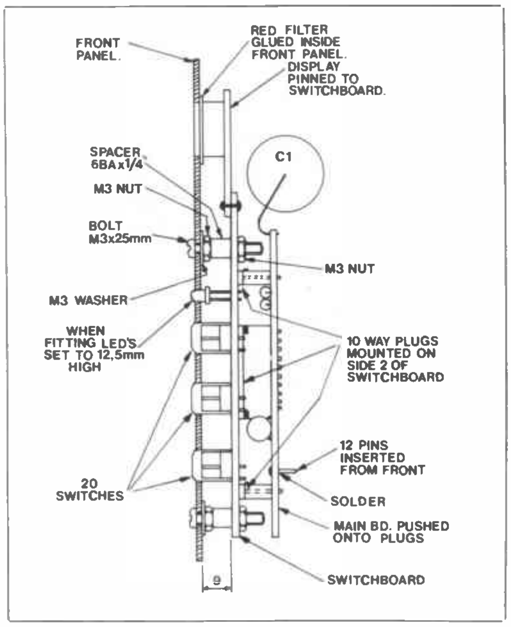


Figure 6. Assembly details.

Fixed time programs

To enter a fixed time program the following sequence must be used:
1. Number of the switch to be controlled followed by the SWITCH button.
2. Day of the week followed by the WEEK button.
3. AM or PM.
4. The time you want the command to be executed.
5. The command. (ON, OFF or SLEEP).

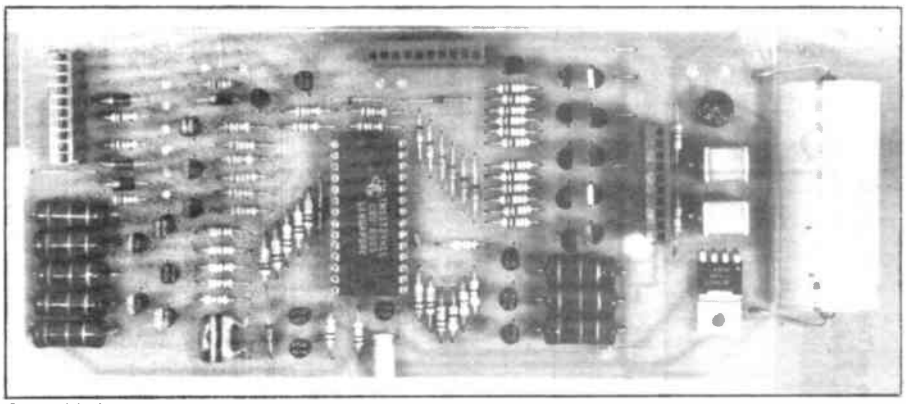
For example the following sequence: 1, SWITCH button, Monday, WEEK button, PM, 5, 1, 0, ON would turn on switch 1 every Monday at 5.10 in the afternoon. The day of the week can be any day (Sunday to Saturday) or every day; in this case the 'Everyday' button is pressed instead. Once a command button is pressed the program is stored in the memory. Any mistakes you have made should be corrected (as described previously) before this button is pressed, as it is more difficult to alter the program once it is stored in the memory.

If you wish to enter another command for the same switch on the same day, it is not necessary to enter the whole sequence again; you can just enter parts 3, 4 and 5. This must immediately follow the first sequence without pressing the CLOCK button in between. A succession of short sequences may follow each other to program several actions of one switch on one day.

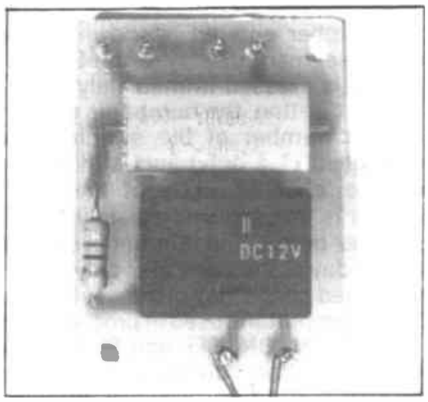
Interval programs

To enter an interval program the following sequence must be entered:
1. Number of switch to be controlled followed by the SWITCH button.
2. The time interval.
3. The command (ON, OFF or SLEEP).

For example the following sequence: 3, SWITCH button, 2, 1, 0, ON would turn switch 3 on, 2 hours and 10 minutes after the ON button was pressed. Once this had been executed the program would be deleted from the



Assembled main board.



A relay board.

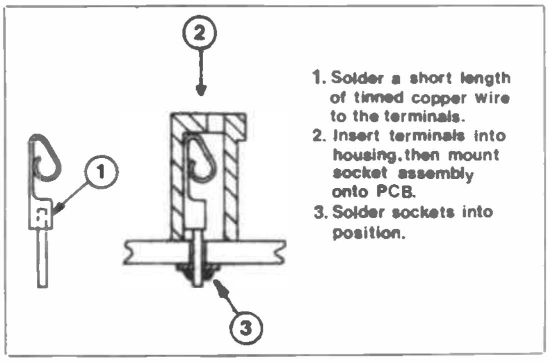
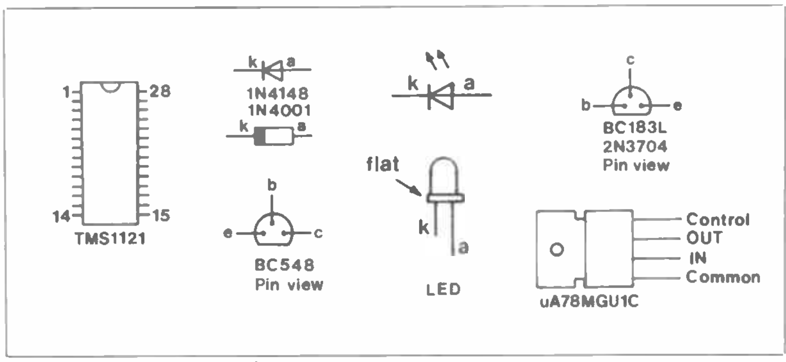


Figure 7. Minicon terminal assembly.



Semiconductor pin connections.

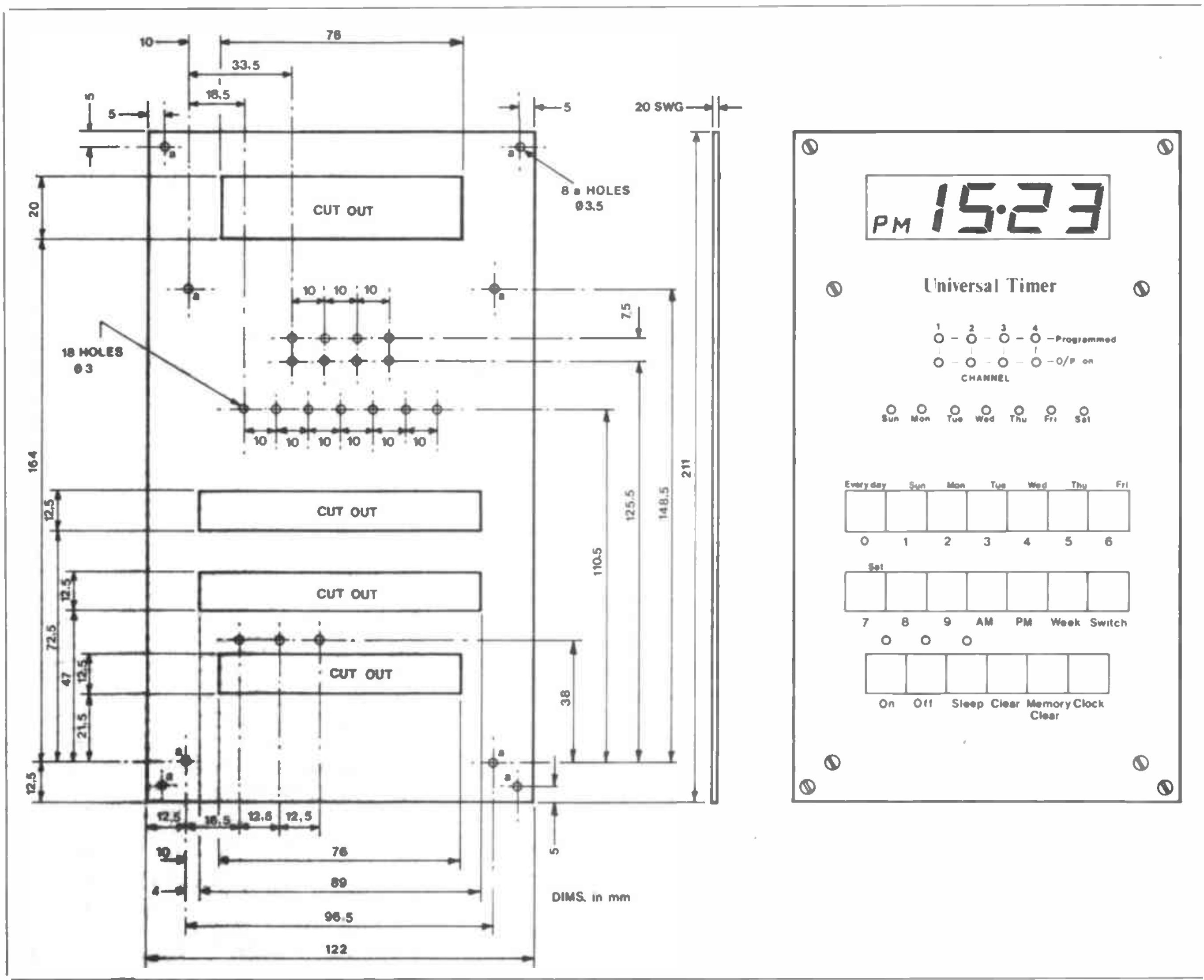


Figure 8. Front panel dimensions and lettering.

☆UNIVERSAL TIMER (LW94C) ☆MODIFICATION☆

The Universal Timer PCB (GB62S) has been modified to accept two standard double digit displays instead of the four way display originally used – which is now unobtainable. The AM/PM mode now consists of two separate red LED's positioned to the left of the display.

Due to this modification there have some changes to the parts list viz:

R28,29 120R 1W (C120R) replaced by 150R 1W (C150R).
D33,34 2 off Mini red LED (WL32K) added.
DISP1 Multiplex common cathode display (HQ36P) is replaced by 2 double digit type C displays (BY68Y)
Track Pins (FL82D) 2 packets off, increased to 3 packets

Assembled switch board.

memory. As with fixed time programs, a short key sequence may be used for a succession of programs, as long as the switch being controlled is the same; in this case you just enter parts 2 and 3. The maximum time for any interval is 11 hours 59 minutes.

Direct switch control

A switch may be operated directly from the keyboard by entering the following sequence:
1. Number of the switch to be controlled, followed by the SWITCH button.
2. Command (ON, OFF or SLEEP).
The command is executed immediately and not stored in the memory.

Program display

It is possible to display the programs stored, either for a particular day or for a particular switch. To display programs for a particular switch:
1. Press the number of the switch followed by the SWITCH button.
2. Press the SWITCH button again.
The programmed time is displayed and the LED indicators show the day of the week, the number of the switch and the command. However, if the command is SLEEP and the command is being executed (i.e. the program is being displayed during the 'on' period of 1 hour), the display will show the 'off' time and the OFF LED will be lit. If the program is displayed before the command is executed, the SLEEP LED will light and the display will show the time entered for the command.

Every time the SWITCH button is pressed twice, the next program for that particular switch will be displayed. Both fixed time and interval programs (before execution) can be displayed. When an interval program is displayed, the time shown is the programmed time of its execution and not the time interval that was entered at the time of programming.

To display programs for a particular day:
1. Press the appropriate day switch followed by the WEEK button.
2. Press the WEEK button again.
The first program for that day is displayed. Every time the WEEK button is pressed twice, the next program for that day will be displayed.

Programs that were entered with the 'Everyday' button will not be shown if you are displaying programs for a specific day; these must be displayed separately using the 'Everyday' button instead. When there are no more programs left, the display is blanked. If you carry on displaying programs the sequence will be displayed again.

Deleting programs

All programs may be cleared from the memory by pressing the MEMORY CLEAR button. To clear all programs for a particular switch:
1. Press the number of the switch followed by the SWITCH button.
2. Press the MEMORY CLEAR button.
To clear all programs for a particular day:
1. Press the switch for that day followed by the WEEK button.
2. Press the MEMORY CLEAR button.
Programs that were entered using the 'Everyday' button must be cleared using this button instead of the day of the week.

Overlapping programs

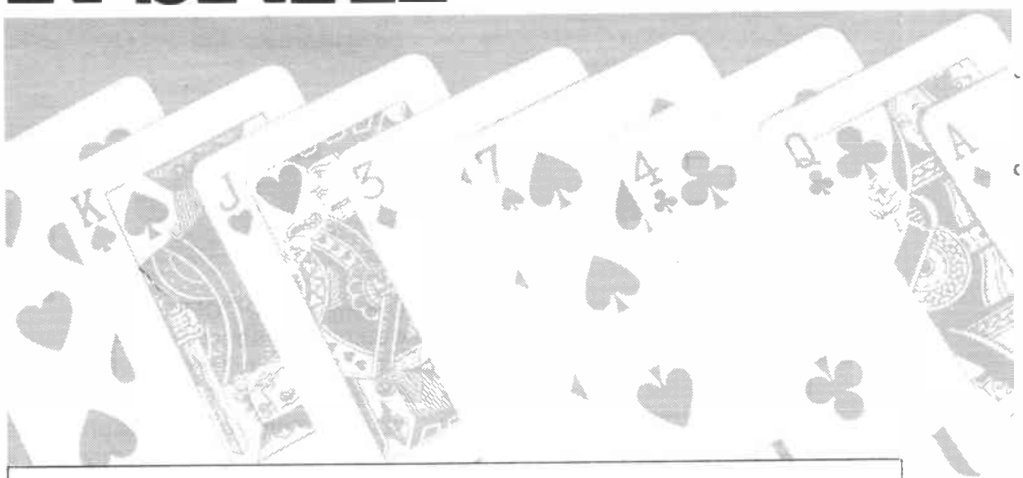
If several programs are entered for the same switch and for the same time, all of them are ignored except for the last one entered. This can be used as follows:
Enter 4, SWITCH, Everyday, WEEK, PM, 6, 4, 5, ON.
Enter 4, SWITCH, Sat, WEEK, PM, 6, 4, 5, OFF.
Enter 4, SWITCH, Sun, WEEK, PM, 6, 4, 5, OFF.
All three programs are entered into the memory, but the last two will override the first one on Saturday and Sunday, the result being that switch four will turn on at 6.45 pm every day of the week except Saturday and Sunday. Note that the 'Everyday' program should be entered before the other two programs. ■

UNIVERSAL TIMER PARTS LIST

Resistors — all 0.4W 1% metal film unless specified			
R1	3k9		(M3K9)
R2	4k7		(M4K7)
R3,4	100k	2 off	(M100K)
R5	47k		(M47K)
R6-13,30-41	10k	20 off	(M10K)
R14-21	470R	8 off	(M470R)
R22-29	120R 1W	8 off	(C120R)
R42-51	6k8	10 off	(M6K8)
R52-55	1k0	4 off	(M1K0)
*R56	47R ½W		(S47R)
Capacitors			
C1	4700uF 25V axial electrolytic		(FB96E)
C2,3	1u0 polycarb	2 off	(WW53H)
C4	10nF polyester		(BX70M)
C5	470nF 100V PC electrolytic		(FF00A)
C6	47pF ceramic		(WX52G)
*C7	100nF suppression cap.		(FF56L)
Semiconductors			
TR1-11,23-27	BC548	16 off	(QB73Q)
TR12,13,15,17, 19,21	BC183L	6 off	(QB56L)
TR14,16,18,20, 22	2N3704	5 off	(QR28F)
REG 1	uA78MGU1C		(WQ78K)
BR 1	W005		(QL37S)
IC 1	TMS 1121		(YY88V)
D1-10	1N4148	10 off	(QL80B)
D11-14	1N4001	4 off	(QL73Q)
D15-18, 23-32	Mini LED red	14 off	(WL32K)
D19-22	Mini LED green	4 off	(WL33L)
DISP 1	Multiplex common cathode display		(HQ36P)
Miscellaneous			
T1	Transformer 12V 1A		(YK28F)
S1-20	Click key black	20 off	(HY34M)
PL1-3	Minicon plug 10 way	3 off	(HQ85G)
SK1-3	Minicon housing 10 way	3 off	(FY94C)
	Minicon terminal	30 off	(YW25C)
*RLA	10A mains relay, 12V coil		(YX97F)
	28 pin DIL socket		(BL21X)
FS1	20mm 500mA fuse		(WR02C)
	Panel fuseholder		(RX96E)
	Timer mains PCB		(GA61R)
	Timer switch PCB		(GA62S)
	*Timer relay PCB		(GA63T)
	Front panel		(GA64U)
	M3 bolts x 25mm		(BF53H)
	M3 nuts		(BF58N)
	M3 washers		(BF62S)
	6BA spacers x ¼"		(FW34M)
	Red filter		(FR34M)
	Veropins 2145		(FL24B)
	*Veropins 2141		(FL21X)
	Track pins	2 packets	(FL82D)

*These items are used on the relay PCBs. Quantities shown should be multiplied by the number of channels required (except for the Veropins).
A complete kit of all parts except those marked with an asterisk is available.
Order As LW94C (Universal Timer Kit)

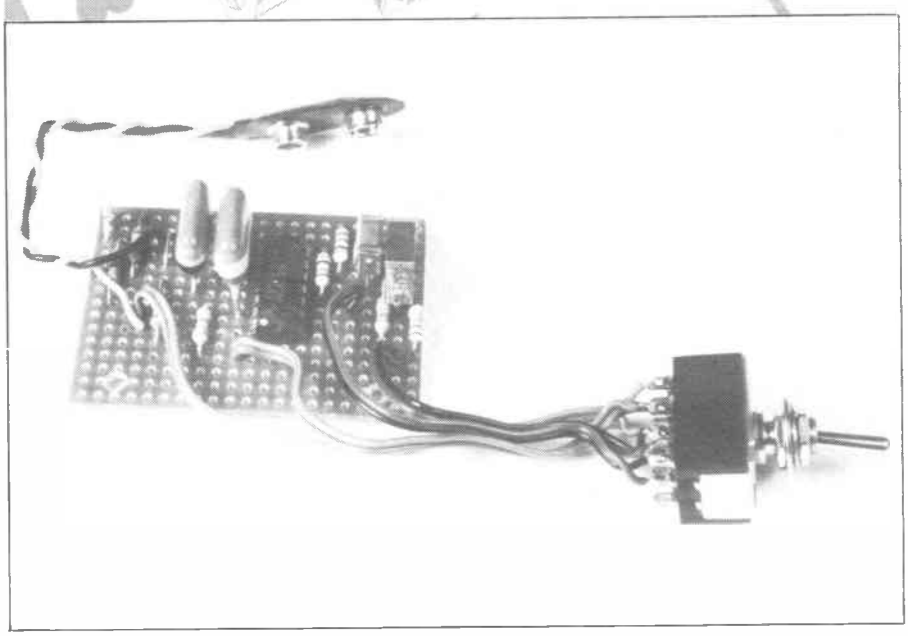
COLOUR SNAP GAME



★ Novel variation on this familiar card game

This electronic game is in essence the same as the popular card game of "snap", but rather than cards there are two LED indicators which flash through their four possible states (red, green, yellow and off) at a fairly fast rate, but not so fast as to make it difficult to see this action clearly. The two indicators are controlled by separate circuits and do not flash in unison. There is a switch which "freezes" the action if it is operated, and the purpose of the game is simply to operate the switch when both LEDs are in the same state. If the competitor is successful this will be indicated by both LEDs being in the same state when flashing action ceases. It does not matter which particular state this happens to be; it just needs to be the same for each LED.

It may sound very easy to accomplish this, but it should be borne in mind that it can take a short while before a "snap" occurs, and there is no way of knowing what state the LEDs will be in when a "snap" does occur. Also, at most the LEDs will only remain in the same state for a fraction of a second. To be successful at this game you therefore require both good concentration and quick reactions. The game can simply be played one round at a time, or, for example, the object of the game could be made to score ten "snaps" in as few attempts as possible.



The Circuit

Figure 1 shows the circuit diagram of the game, and this is based on a 40106BE device which is a CMOS hex Schmitt trigger. The Schmitt triggers are inverting types with built-in hysteresis. Thus, if the input starts at zero volts and is gradually taken higher in voltage, at a certain input voltage the output will trigger from the high state (virtually the positive supply potential) to the low state (little more than the negative supply voltage). The input voltage must then be reduced quite substantially in order to trigger the output back to the high state again. The hysteresis is incorporated in Schmitt triggers to prevent instability, but para-

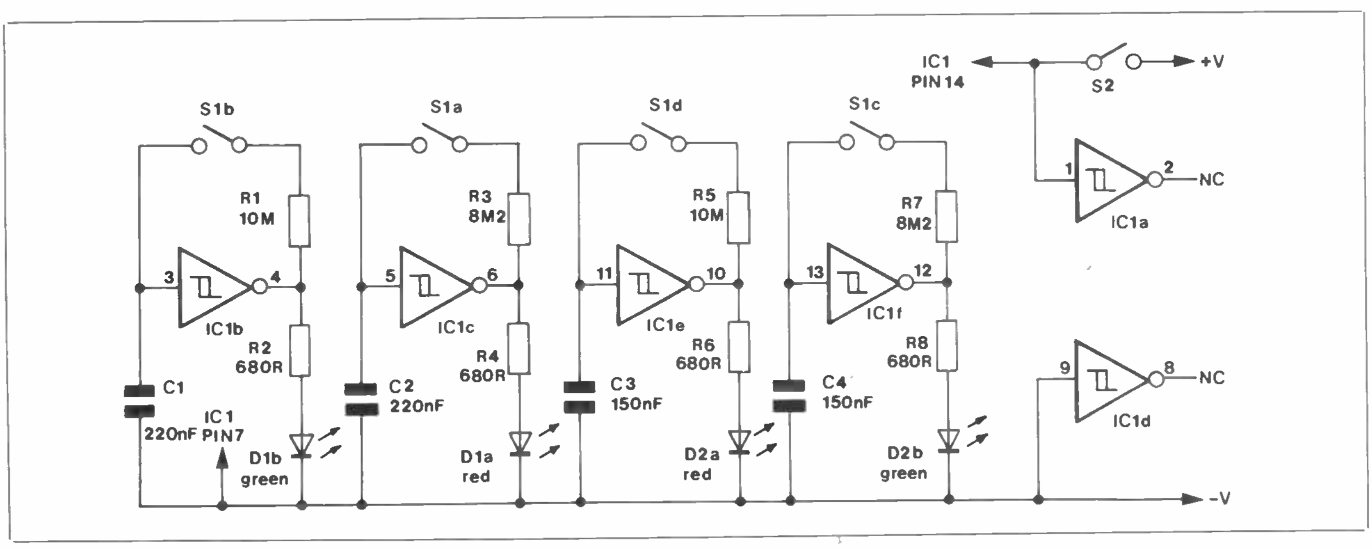


Figure 1. Circuit of the colour snap game.

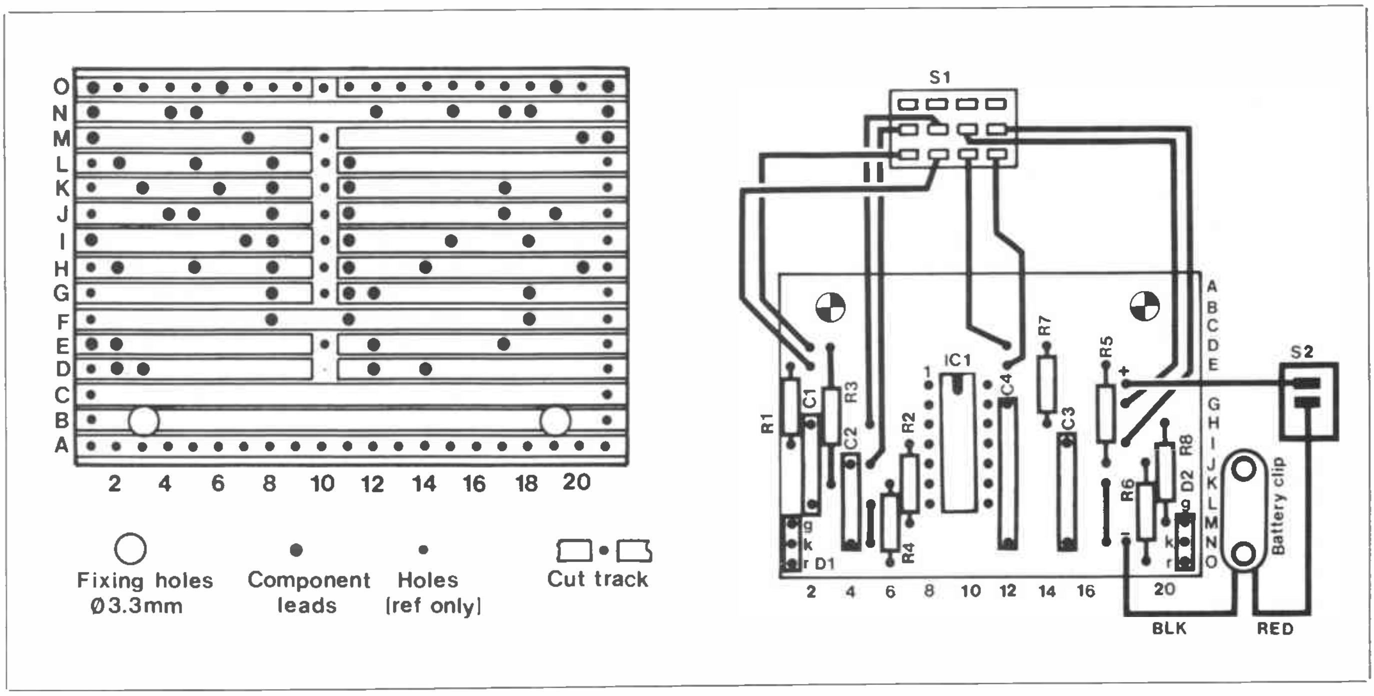


Figure 2. Veroboard layout for the snap game.

doxically it enables an inverting Schmitt trigger to be used in the very simple oscillator configuration which is employed here.

Four oscillators are used, one to drive each LED section, and all four oscillators use the same configuration. Each oscillator operates at a different frequency so that each LED runs through its four states in a pseudo random fashion. It is not a true random sequence since the pair of oscillators driving each LED will eventually arrive simultaneously back in their original states and the sequence will then be repeated. This is not likely to be apparent to an observer though, since the sequence of each LED is quite long.

Each oscillator requires just two components apart from the Schmitt trigger; a resistor connected between the input and output, and a capacitor connected from the input to the negative supply rail. At switch-on the capacitor charges from the output of the Schmitt trigger via the resistor until the output switches to the low state. The capacitor then discharges through the resistor and the output of the Schmitt trigger until the output switches back to the high state again. The capacitor then starts to charge up again, and continuous oscillation is produced. Each oscillator drives a separate LED section via a current limiting resistor (R2, R4, R6 and R8).

Two of the Schmitt triggers are not needed and the inputs of these are tied to one of the supply rails in order to prevent spurious operation and possible damage to IC1. Apart from this the unused triggers are ignored.

The display is "frozen" by opening S1 so that the charge and discharge paths of the capacitors are broken, and the charges on the capacitors hold the triggers in whatever state they happened to be in at the instant S1 opened. As a CMOS IC has been used the input impedance of each Schmitt trigger is extremely high, and the charges on the capacitors leak away at a rate which is too slow to be of consequence. In order to set the unit operating again it is merely necessary to close S2.

PARTS LIST FOR COLOUR-SNAP GAME

Resistors			
R1,5	10M	2 off	(B10M)
R2,4,6,8	680R	4 off	(M680R)
R3,7	8M2	2 off	(B8M2)
Capacitors			
C1,2	220n carbonate	2 off	(WW45Y)
C3,4	150n polyester	2 off	(BBX77J)
Semiconductors			
IC1	40106BE		(QW64U)
D1,2	Two colour LED	2 off	(QR54J)
Miscellaneous			
S1	4-pole miniature toggle type		(FH08J)
S2	SPST miniature toggle type		(FH97F)
	Case		
	Veroboard		
	PP3 battery		
	PP3 battery connector		(HF28F)
	Wire		

Construction

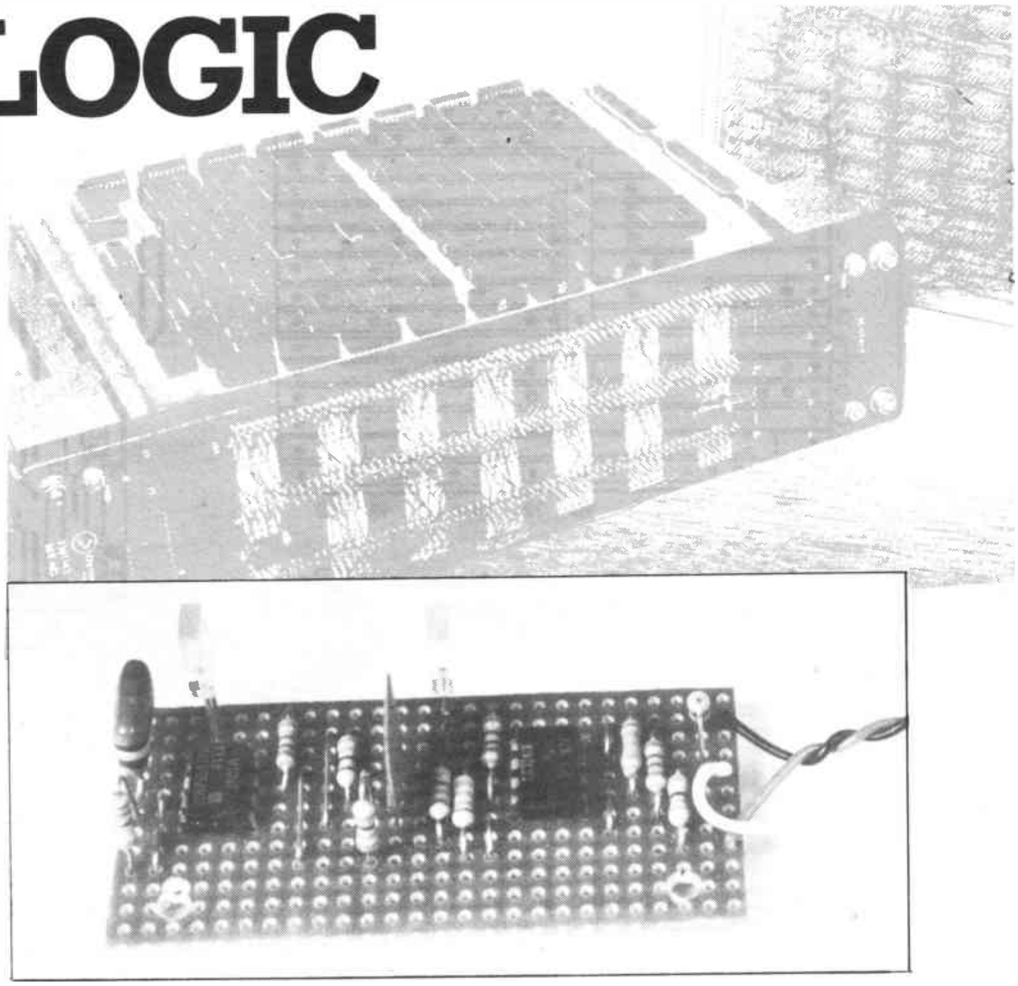
A Veroboard having 21 holes by 15 copper strips accommodates most of the components, and the component layout plus the positions of the ten breaks in the copper strips are shown in Figure 2. This also shows the wiring to the off board components. As IC1 is a CMOS device it requires the usual MOS handling precautions if the danger of damage by static charges is to be eliminated. Connect this component last of all and leave it in its protective packaging until then. Handle it as little as possible, and either solder it in place using an iron having an earthed bit or use an IC socket.

If desired, the game can be made a little less difficult by using capacitors having slightly higher values than the specified components. On the other hand, if the game seems to be too easy after it has been in use for some time, slightly reducing the values of the capacitors will increase the difficulty factor of the game.

Robert Penfold ■

CMOS LOGIC PROBE

★ Build this practical, low cost test instrument



CMOS logic integrated circuits are extremely versatile devices which are used a great deal in modern electronic circuits. Like any logic circuits, those which employ CMOS devices can be difficult to test using an ordinary multimeter as both static and pulsing voltages are involved. A voltage reading of half the supply potential could be a static voltage and indicative of a fault, or it could be produced by a high frequency squarewave signal giving an average voltage of half the supply voltage with no fault present in this part of the circuit.

Ideally an oscilloscope should be used for testing this type of equipment, but where this is not possible for some reason a logic probe makes an excellent alternative. This simple logic probe is intended for use with CMOS logic circuits, is powered from the circuit under investigation, and has a current consumption of only around 0 to 20mA (depending on the supply voltage and logic state indicated by the probe). The logic state detected by the unit is indicated by a two-LED display: one of the display LEDs is a multicolour type and the other is an ordinary green type. The following table shows the display obtained from various input signal conditions.

Input state	D1	D2
Low	Green	Off
High	Red	Off
Intermediate	Yellow	Off
Pulsing fast	Yellow	On
Pulsing slowly	Red/Green	Slowly Pulsing

When the input is pulsing at high speed it is possible that D1 will be red or green instead of yellow, and this simply indicates that the mark-space-ratio of the input signal is far from being one-to-one. D1 will be red if the input is high for the majority of the time, or green if it is predominantly low. If the input is pulsing slowly, unless the pulses are extremely brief, D1 will be seen to switch from red to green and so on in sympathy with the input signal.

The Circuit

Separate stages are used to drive the two indicator LEDs, a dual operational amplifier being used to drive D1 and a 555 monostable driving D2. Figure 1 shows the circuit diagram of the CMOS Logic Probe.

Both sections of IC1 are used as voltage comparators rather than operational amplifiers, and these each have one input connected to a reference voltage and the other taken to the input of the probe. The unit must indicate a high input state if the input voltage is more than about 70% of the supply voltage, and a low input state if the input is at less than about 30% of the supply potential. R3 to R5 form a potential divider which gives reference voltages of approximately 30% and 70% of the

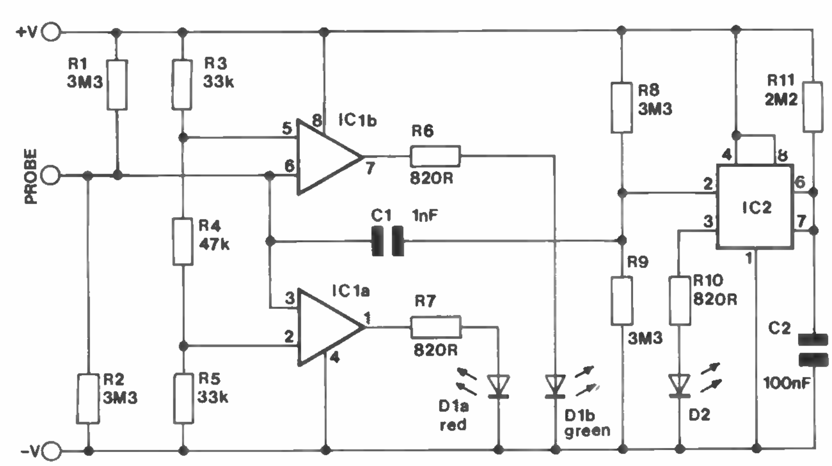


Figure 1. Circuit diagram of CMOS logic probe.

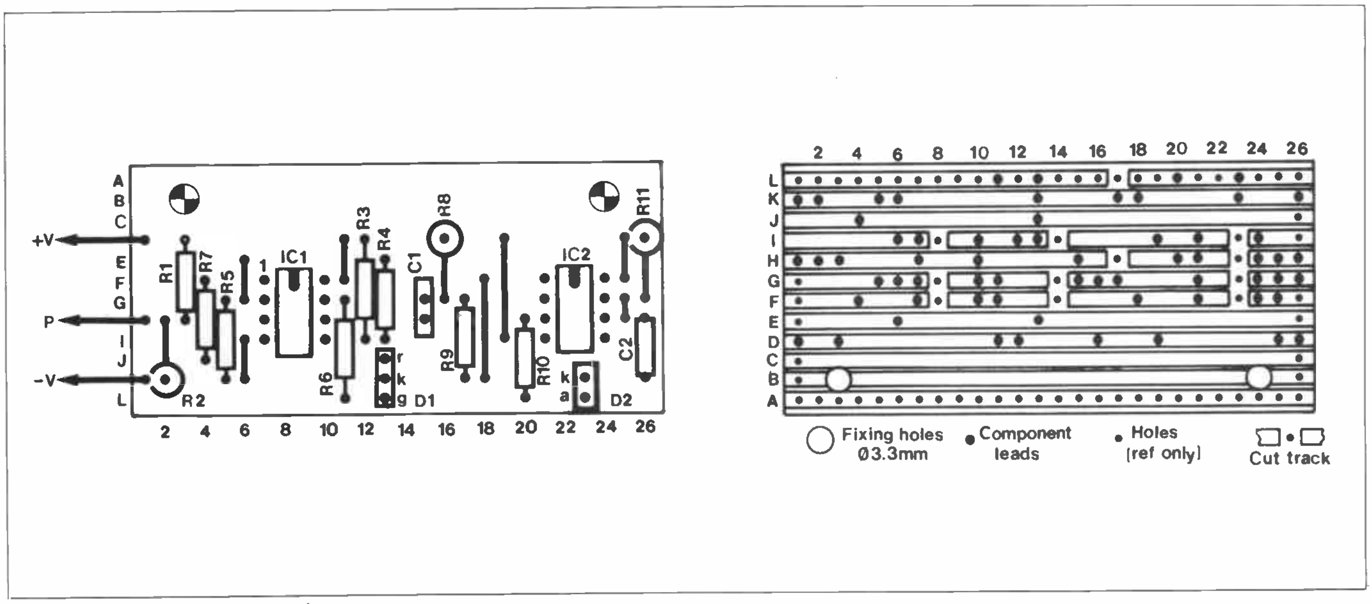


Figure 2. Veroboard layout for CMOS logic probe.

supply voltage.

If the input is low, IC1a's non-inverting input will be at a higher potential than the inverting input so that the output goes high and switches on D1b. IC1b has the opposite input states so that its output goes low and D1a is switched off. This gives a green indication from D1. With the input in the high state IC1a's inverting input is taken to a higher voltage than the non-inverting input, causing the output to go low and switch off D1b. IC1b's non-inverting input will now be at a higher voltage than the inverting input, causing IC1b's output to go high and switch on D1a so that a red indication is obtained from D1.

If the input is between the two logic states the outputs of the two comparators will both assume the high state so that the red and green sections of D1 switch on to produce a yellow display. R1 and R2 bias the input between the two logic levels so that the unit will indicate a fault condition (with D1 in the yellow state) if the input is taken to an open circuit test point.

This section of the circuit does not enable the user to differentiate between a static level between the two logic states and a high frequency pulse signal, since the latter will cause both sections of D1 to switch on in turn and give the impression of a yellow display due to the switching action being too fast to be seen. This is overcome by applying the input signal to the trigger input of a 555 monostable. Normally R8 and R9 hold the input of IC2 above the trigger threshold, but if there is a pulsing input signal it will be coupled to the input of IC2 by C1 and on negative transitions IC2 will be activated. LED indicator D2 is then switched on for about 0.25 seconds each time IC2 is triggered, but with a high frequency input signal the circuit will be retriggered almost as soon as each output pulse ceases, and D2 will appear to light continuously. C1 blocks steady state inputs so that IC2 is not triggered, except possibly for a single triggering when the input is taken to a new logic state, with a consequent brief flash from D2.

PARTS LIST FOR CMOS LOGIC PROBE

Resistors — all 0.4W 1% metal film except where specified			
R1,2,8,9	3M3	4 off	(B3M3)
R3,5	33k	2 off	(M33K)
R4	47k		(M47K)
R6,7,10	820R	3 off	(M820R)
R11	2M2		(B2M2)
Capacitors			
C1	1n ceramic plate		(WX68Y)
C2	100n polyester		(BX76H)
Semiconductors			
IC1	CA3240E		(WQ21X)
IC2	ICM7555		(YH63T)
D1	Common cathode 2 colour LED		(QR54J)
D2	Green Rectangular LED		(YY46A)
Miscellaneous			
	Small case		
	Veroboard		
	Pair of crocodile clips		(HF25C)
	Wire		

Construction

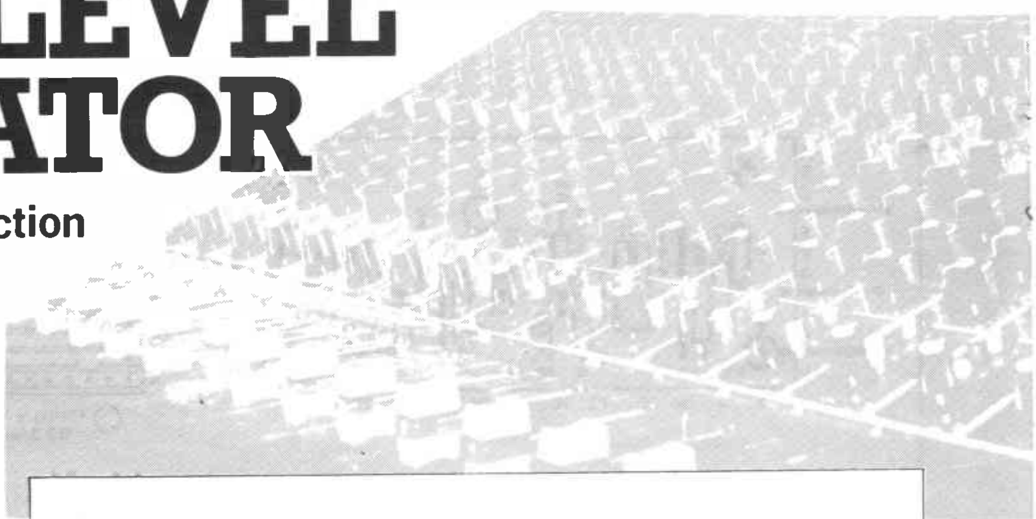
The Veroboard layout for the CMOS Logic Probe is shown in Figure 2 and this is based on a board having 12 copper strips by 26 holes. Construction of the board is quite straightforward apart from the fact that IC1 is a MOS device, and the normal MOS handling precautions must be taken with this device. IC2 is a CMOS device but due to its internal protection circuitry it does not require any handling precautions.

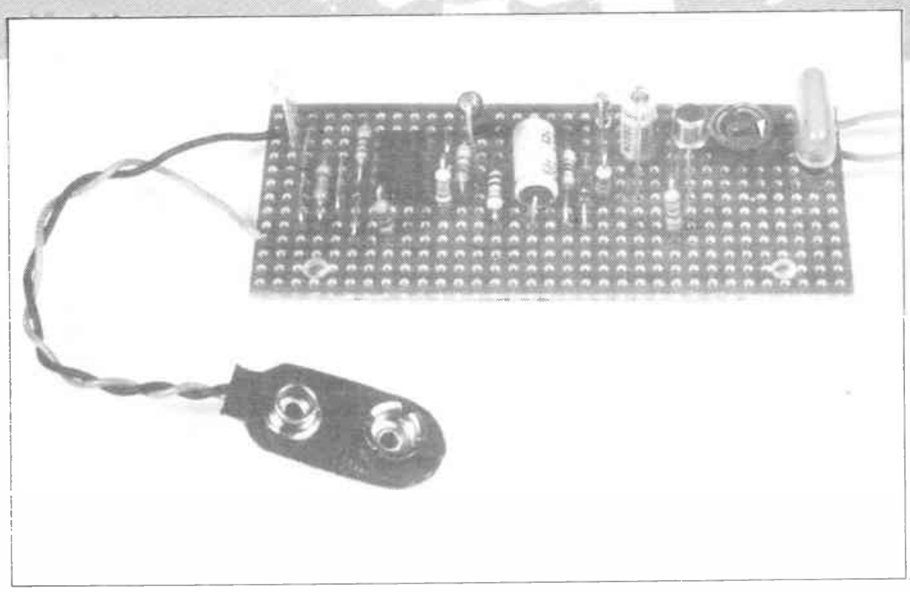
In use the unit will probably be most convenient if it is fitted in a small case that can be comfortably hand-held. The probe tip, which can simply consist of a long M3 bolt, is fitted at the front end of the case and the two display LEDs are mounted off-board at the rear end of the case. The case is drilled to take the two supply leads, and these are about half a metre long and terminated in crocodile clips to permit easy connection to the circuit under test. The crocodile clips are different colours (red for the positive lead and black for the negative one) so that the two leads are easily identified.

Robert Penfold ■

PEAK LEVEL INDICATOR

★ **Instantaneous detection of signal overload**





The shortcomings of average reading VU meters are well known, and the most important of these is their inability to respond properly to signals having a high peak but low average level, so that a low reading is obtained and overloading often occurs in consequence. In order to avoid this it is common for VU meters of the average reading type to be backed-up by a peak level indicator, and this is usually in the form of a LED indicator which flashes on if the peak signal level exceeds some predetermined level.

This simple peak level indicator circuit can be used in conjunction with an average reading VU meter which does not already have the back-up of a peak reading device of some kind, or it could be used in situations where the cost of a VU meter is not justified. It has a multicolour LED indicator which is green for levels below 0dB, yellow for levels between 0dB and +6dB, and red for levels over +6dB. The circuit has fast attack and slow decay times, like professional peak reading meters.

The Circuit

Figure 1 shows the complete circuit diagram of the Peak Level Indicator, and the unit breaks down into three main sections; a preamplifier, a smoothing and rectifier circuit, and the display driver circuit.

The display driver circuit is based on IC1 and is very similar to part of the CMOS Logic Probe circuit which is described elsewhere in this issue. It will not, therefore, be described in detail here. The two circuits differ only in that this one requires stabilised reference voltages so that variations in the supply voltage do not affect the calibration of the unit. R5 and D3 are therefore used to stabilise the voltage fed to the potential divider chain (R6 to R8) which provides the two reference voltages. R6 is merely included to reduce the reference voltages and thus increase the sensitivity of the circuit.

The input signal could be applied direct to the input of the driver circuit, but this would give low sensitivity, and the rapidly fluctuating input level would give unclear results from the LED indicator as it rapidly switched through its various colours. TR1 is therefore used as a common emitter amplifier

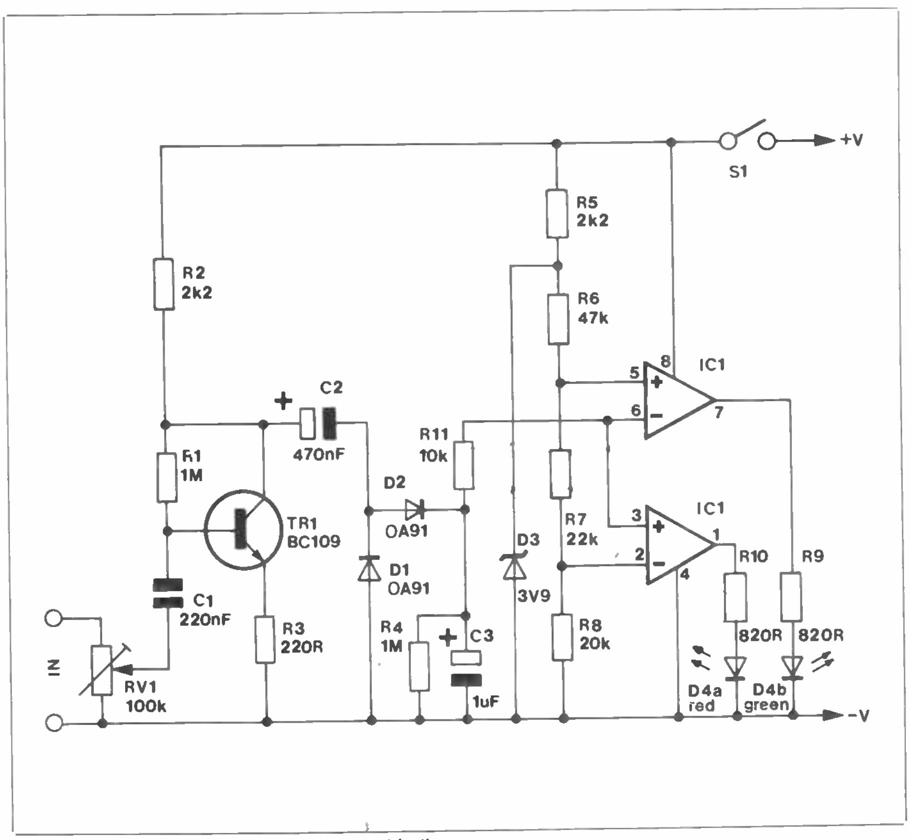


Figure 1. Circuit diagram of the peak level indicator.

having a voltage gain of about ten times (20dB) to boost the sensitivity of the circuit. RV1 is a preset input attenuator which is used to set the sensitivity of the unit at the correct level. At maximum sensitivity only about 100mV RMS is needed at the input to drive D4 to the red state, and this should be more than sufficient for any normal application of the unit. The input impedance of the unit is quite high at about 50 to 100k (depending on the setting of RV1) and it should not have any detrimental effect on the main equipment. Due to the use of a substantial amount of negative feedback over TR1 it does not require a stabilised supply as its voltage gain is largely unaffected by variations in the supply voltage.

C2 couples the output from TR1 to a conventional rectifier and smoothing circuit which consists of D1, D2, R4 and C3. This circuit has a fast attack time so that the circuit responds properly to transients, but a slow decay time so that the display reverts to green slowly and unambiguous results are obtained. The rectifier circuit introduces a degree of non-linearity between the input signal level and the DC voltage fed to the display driver, but the two reference voltages in the display driver circuit compensate for this and ensure good accuracy.

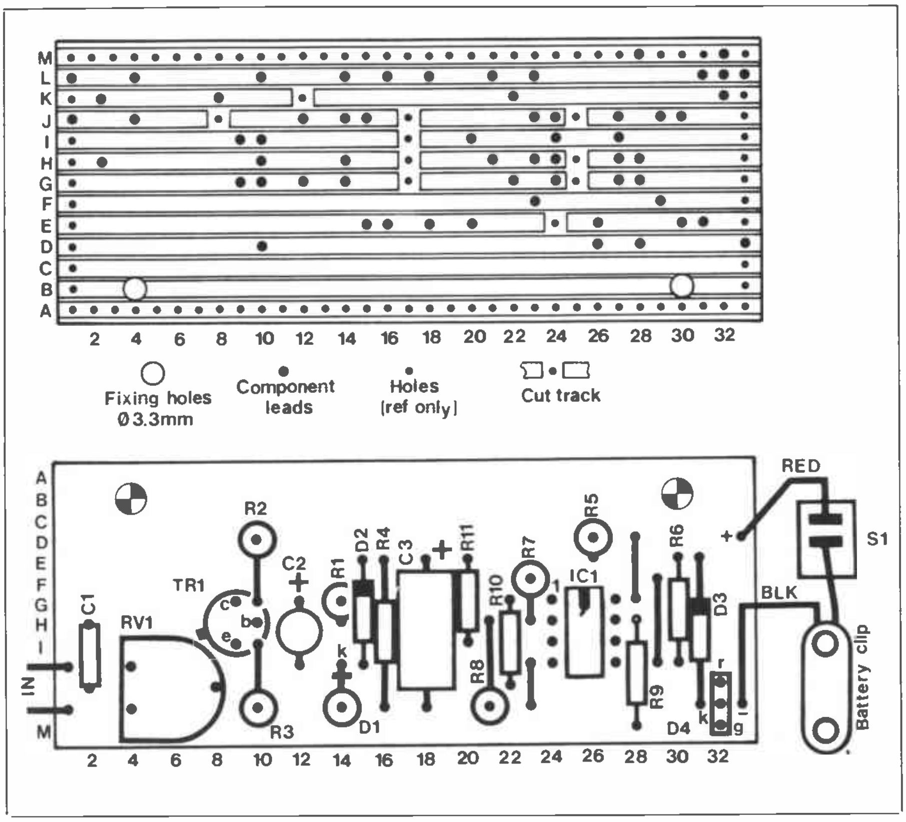


Figure 2. Veroboard layout for peak level indicator.

Construction

The Veroboard layout for the Peak Level Indicator is shown in Figure 2 and requires a board having 33 holes by 13 strips. IC1 is a MOS device and the normal MOS handling precautions should be taken when dealing with this device. Note also that D1 and D2 are germanium devices which are more susceptible to damage by heat than silicon types. Take care not to overheat these two components when soldering them into place.

The unit can either be built as a self contained device with its own on/off switch and battery supply, or it might be possible to fit it into the main piece of equipment (although this should only be tried by those with sufficient experience to tackle the job confidently). If the indicator is built as a self contained unit the input leads should be taken to a two way audio connector mounted on the front panel. The input signal is then coupled to this socket via a suitable screened lead. The unit can be powered by a PP3 size battery, but as the current consumption is about 10 to 20mA it would be better to use a larger type such as a PP7 or PP9 if the unit is to receive a great deal of use as this would give lower running costs.

If the unit is built into the main item of equipment it will probably be possible to power it from the supply of this equipment. A supply potential of around 9 to 12 volts is required. The point from which the input signal is obtained will obviously depend on the precise nature of the equipment with which the indicator is used, but if it is used with equipment having a VU meter it will probably be possible to obtain a suitable signal from the meter's terminals.

Calibrate the unit by first adjusting RV1 fully clockwise, and then applying a steady input signal to the main equipment and adjusting the controls to give a 0dB signal level. RV1 is then adjusted just far enough in an anti-clockwise direction to cause D4 to switch from green to yellow.

Robert Penfold ■

PARTS LIST FOR PEAK LEVEL INDICATOR

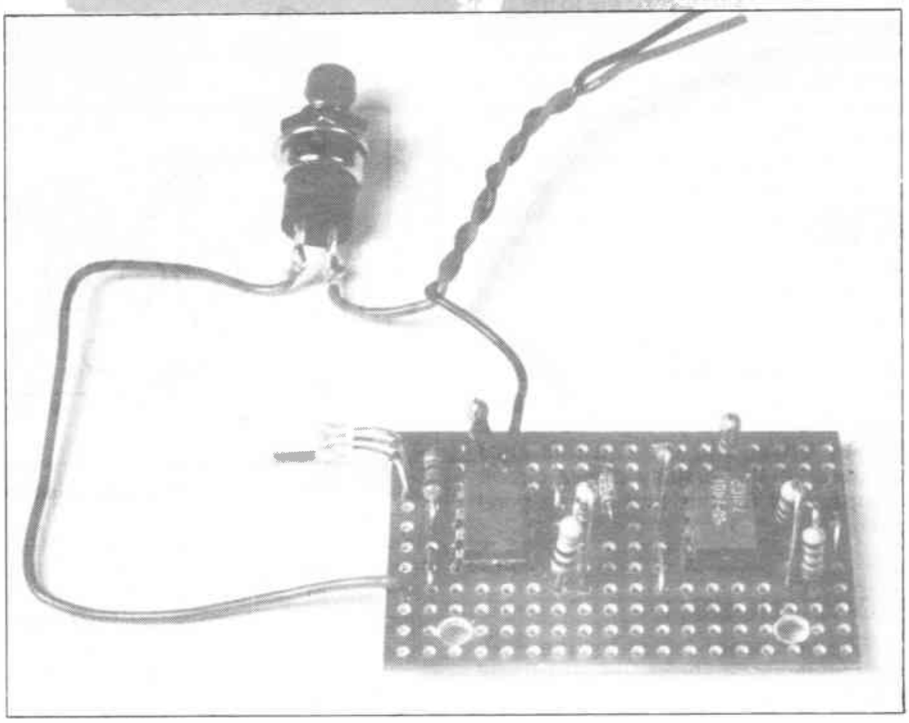
Resistors — all 0.4W 1% metal film except where specified			
R1,4	1M0	2 off	(M1M0)
R2,5	2k2	2 off	(M2K2)
R3	220R		(M220R)
R6	47k		(M47K)
R7	22k		(M22K)
R8	20k ½W 5%		(S20K)
R9,10	820R	2 off	(M820R)
R11	10k		(M10K)
RV1	100k 0.1W hor. preset		(WR61R)
Capacitors			
C1	220n polyester		(BX78K)
C2	470n 50V PC electrolytic		(YY30H)
C3	1u 63V electrolytic		(FB12N)
Semiconductors			
D1,2	OA91	2 off	(QH72P)
D3	BZY88C3V9		(QHC4E)
D4	Multicolour LED		(QR54J)
IC1	CA3240E		(WQ21X)
Miscellaneous			
S1	S.P.S.T. miniature toggle		(FH97F)
	Case		
	Veroboard		
	PP3 battery		
	PP3 battery connector		(HF28F)
	Wire		

CAR BATTERY MONITOR

★ Check your battery condition instantly

This circuit, in common with the other five in the series which are featured in this issue, uses a multi-colour LED. These are a fairly new development and will probably be unfamiliar to most readers, but they are basically little more than a red LED and a green LED in a single encapsulation. The type used in this series of projects have a common cathode connection and separate anode leadout wires, as can be seen from the leadout diagram of Figure 1. The light output of the component is viewed via a diffuser so that with both the red and green sections operating at once the two colours mix and a yellow output is obtained (or orange if the red light level is stronger than the green one). By operating just one section a red or green output can be obtained, and these LEDs are therefore capable of producing three colours.

This first project is a battery state indicator for use with 9 volt battery operated equipment, although it can easily be modified for use with a 12 volt car battery if preferred. If the battery is reasonably fresh and has a potential of about 8.2 volts or more the LED gives a green indication. If the battery is nearing exhaustion but is still usable, and has a potential of between about 7.5 and 8.2 volts a yellow indication is produced by the LED. A battery voltage of between about 5 volts and 7.5 volts produces a red light from the LED and indicates that the battery is overdue for replacement. Below about 5 volts the battery is inadequate to operate the device and the LED will fail to light at all!



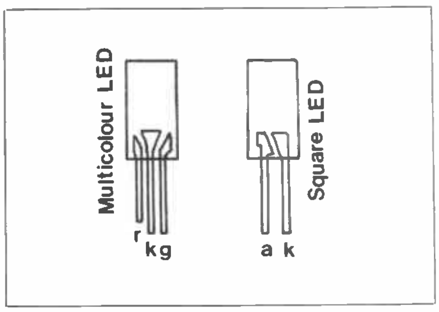


Figure 1. Multicolour LED leadouts.

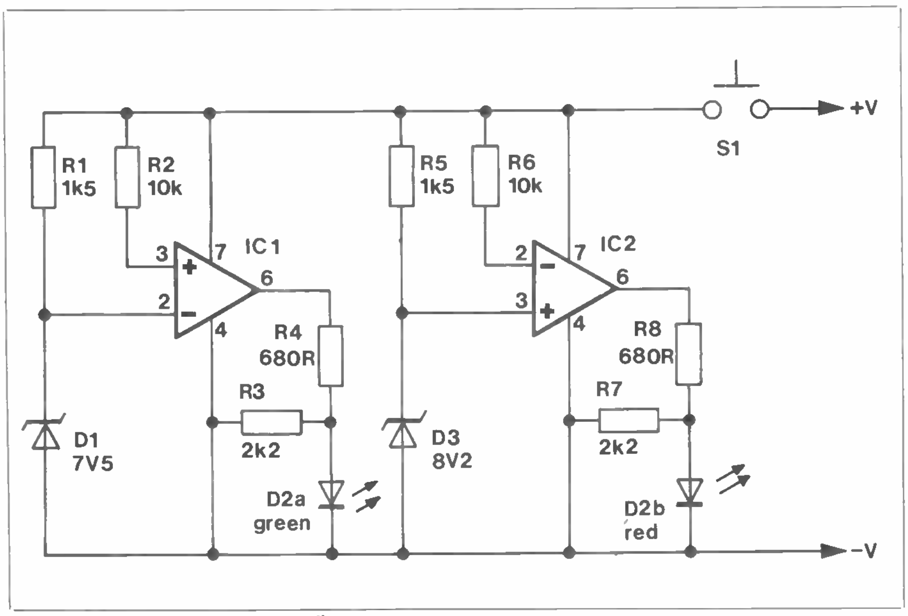


Figure 2. Battery monitor circuit diagram.

The Circuit

Figure 2 shows the circuit diagram of the Battery Monitor, and this is based on two 741C operational amplifiers which are used as voltage comparators in this application.

The green section of LED indicator D2 must switch on only if the supply voltage is above 7.5 volts since it should be off for voltages below this level when the red section alone must be switched on. D2a is driven from the output of IC1 by way of R4 and will be switched on when IC1's output goes high. The inverting input of IC1 is held at 7.5 volts by the zener stabiliser circuit which consists of R1 and D1, and the non-inverting input is taken to virtually the

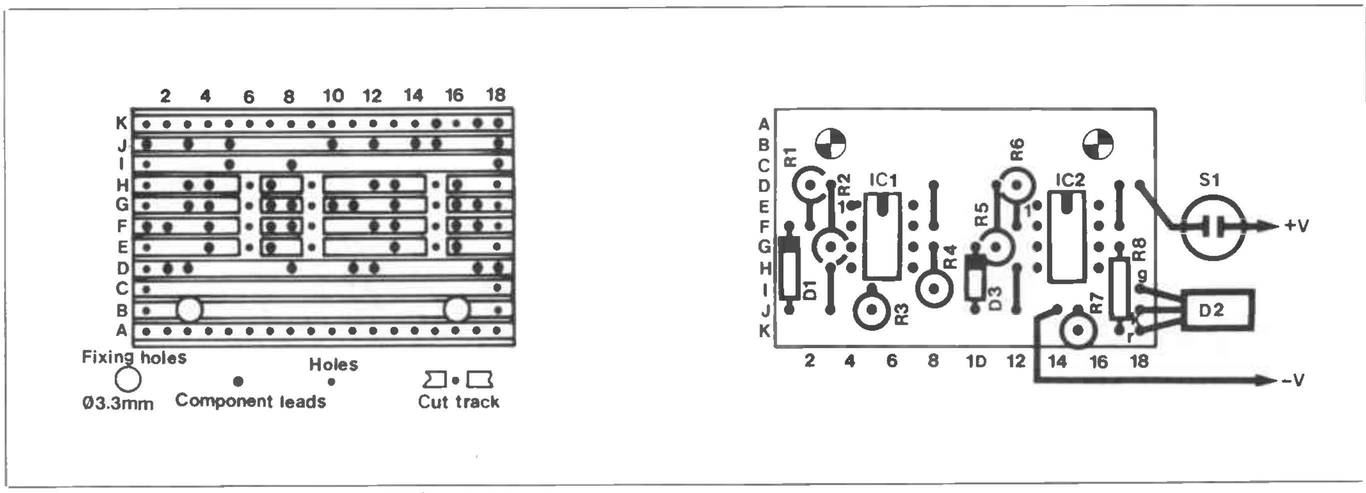


Figure 3. Veroboard layout for the battery monitor.

positive supply voltage due to the coupling through R2. Thus, assuming the supply voltage is more than 7.5 volts, IC1's non-inverting input will be at a higher voltage than the inverting input so the output goes high and switches on D2a. If the supply potential falls below about 7.5 volts D1 no longer conducts significantly and has no effect on the circuit. As the voltage drop through R1 is less than that through R2, due to the higher value of the latter, the inverting input is at the high voltage. This results in the output going low and D2a switching off. R2 ensures that the voltage fed to D2a with IC1's output in the low state is not sufficient to cause D2a to operate at low brightness, which it might otherwise do.

It is necessary for the red section of D2 to switch off if the supply voltage is over about 8.2 volts, as only the green section is then needed. This is achieved using a circuit which is virtually the same as that used to control the green section of D2. Zener diode D3 has an operating voltage of 8.2 volts rather than 7.5 volts so that the threshold voltage of this section of the circuit is set at the required level. Also, the inputs of IC2 have the opposite method of connection to those of IC1 so that with the supply voltage above the 8.2 volt threshold level the inverting input is the one at the higher voltage. The output therefore goes low and D2b is switched off. If the supply potential falls below 8.2 volts the input states are reversed, IC2's output goes high, and D2b is switched on.

The circuit has a current consumption of around 10mA which could result in a serious reduction in battery life if it were to be left operating all the time the main equipment was switched on. It is therefore connected to the supply lines via push button switch PB1, and this is briefly operated in order to test the battery's condition. This method gives a negligible increase in the battery drain.

Construction

Like all six projects in this series, the Battery Monitor is constructed on a 0.1in. matrix Veroboard, and in this case a board measuring 11 copper strips by 18 holes is required. Cut out a board of this size using a hacksaw and then file the sawn edges to a neat finish. Next drill the two 3.3mm diameter mounting holes (which accept M3 or 6BA fixings) and make the twelve breaks in the copper strips at the points indicated in the layout diagram which is shown in Figure 3. There is a special tool available for making the breaks in the strips, but they can also be made using a modelling knife or a small twist drill.

Next solder the components and link wires into place, leaving the two integrated circuits and LED until last. The link wires are made from 22 swg tinned copper wire, and these can simply consist of pieces of wire trimmed from the component leadout wires.

Ideally the unit should be built into the main piece of equipment, and this will probably not be difficult in many instances. However, it can be built as a separate unit if necessary, and connected to the main unit via a twin insulated lead.

If the unit is required as a car battery monitor it is merely necessary to change D1 to a 10 volt component (a BZY88C10V) and D3 to a 12 volt component (a BZY88C12V). The LED will then be red for supply voltages below about 10 volts, yellow for voltages between approximately 10 and 12 volts, and green for supply potentials in excess of about 12 volts. PB1 is not essential if the unit is used as a car battery monitor since the current drain of the circuit is insignificant when compared to the high charge capacity of a car battery.

Robert Penfold

PARTS LIST FOR BATTERY MONITOR

Resistors — 0.4W 1% metal film			
R1,5	1k5	2 off	(M1K5)
R2,6	10k	2 off	(M10K)
R3,7	2k2	2 off	(M2K2)
R4,8	680R	2 off	(M680R)
Semiconductors			
IC1,2	741C (8-pin DIC)	2 off	(QL22Y)
D1	BZY88C7V5		(QH11M)
D2	Two colour LED		(QR54J)
D3	BZY88C8V2		
Miscellaneous			
PB1	Push to make non-locking switch		(FH59P)
	Veroboard		
	Wire		

Jack Plugs

Many high quality mono jack plugs are held together by a nut screwed to the top of a shaft connecting directly to the tip. After much use this nut tends to work loose, eventually resulting in the loss of the tip from the plug. It is well worth dismantling all plugs of this type and re-assembling them with a drip of Loctite Torqueseal on the screw thread. This prevents the nut from working loose and saves the cost of a new jack plug every time the tip is lost.

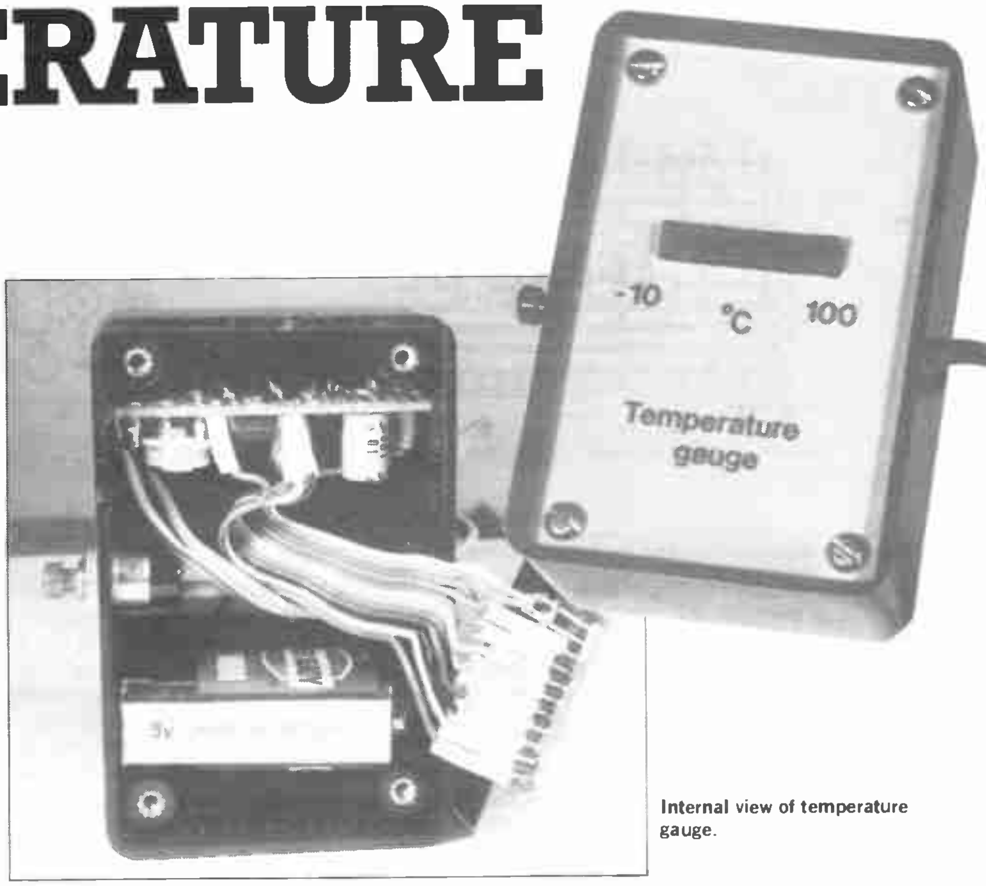
Construction tip: Lettering front panels

It is very hard to remove a rubdown letter from an anodised panel without either scratching the panel, or leaving a slight dark area. If the panel is sprayed with a couple of coats of suitable varnish prior to lettering, subsequent removal of letters becomes much easier. After lettering, the panel is finished in the usual way; the final version is often more scratch resistant than the normal method because the lettering is sealed between two layers of varnish.

TEMPERATURE GAUGE

by Ian Miller

★ **Temperature range -10°C to 100°C**
★ **Indication by multi-colour LED array**
★ **100°C warning**



Internal view of temperature gauge.

This thermometer gives a visual indication of temperature in approximately 10°C intervals from -10°C to 100°C. It uses the LM335Z temperature sensor and the LM3914 bargraph display driver. The latter converts the sensor's output to drive LED indicators which are formed in a block display.

The design presented is for a general purpose temperature gauge, being hand-held with the sensor on a flying lead. However, in response to many requests, information for adaptation to a car thermometer is given.

Circuit

The circuit, which is mounted on a piece of Veroboard measuring 10 strips by 20 holes, is shown in Figure 1. The LM335Z sensor, IC1 acts similarly to a zener diode where the breakdown voltage is directly proportional to the absolute temperature. It gives an output of 2.63V at -10°C and 3.73V at 100°C and has three terminals: +ve, -ve and adjust. The adjust is used for calibration purposes but as it is accurate to 2°C without calibration this facility is not used.

The sensor requires a current of between 400uA and 5mA. This is supplied via the 10k resistor R1 which is connected to the 9V supply.

The LM3914 bargraph display driver IC2 has a buffer input stage, a potential divider chain, comparator and a precise 1·2V reference source. The resistor chain divides the input voltage from the sensor to drive the LEDs wired to the outputs. The driver is used in the dot mode where the outputs are sequentially switched 'on' with an increasing input voltage.

The total voltage change of the sensor is 1·1V which is close enough to the 1·2V reference source to make the biasing circuit fairly simple. The zener diode D1 reduces the 9V supply to 2·7V and is connected to the low reference terminal, pin 4 of IC2. The 5k preset RV1 is used to adjust this voltage to exactly 2·63V, the minimum temperature sensor output, at calibration.

The high reference terminal pin 6 is connected to the 1·2V reference source pin 7 and through R2 to the low reference pin 4. Thus the total sensor range is divided across the resistor chain of IC2 so that at -10°C the first output is 'on' and at 100°C the tenth output is 'on'.

The outputs of IC2 are connected directly to the display LEDs except the tenth which is taken to IC3, an LM3909 LED flasher. This drives two LEDs, D11 and D12 which are the 100°C warning indication. The frequency of oscillation of the flasher is determined by the capacitor C1.

All the LEDs are the rectangular type and in the version built D1 to D4 are green, D5 to D9 red and D10 to D12 yellow, thus signifying the change from cold to warm to hot. These colours are a matter of choice; you may have your own ideas for a particular application.

The gauge is powered by a single PP3 9V battery which is wired via the push button switch S1. This switch is biased 'off' so that as a hand-held device the push button must be held in whilst monitoring a temperature.

Construction

Begin construction by mounting all

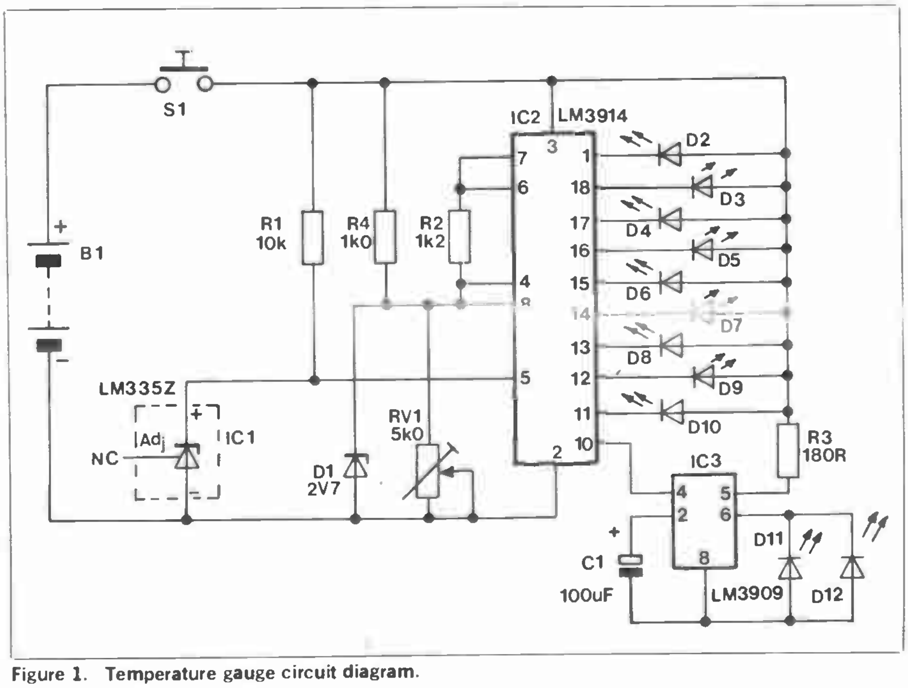


Figure 1. Temperature gauge circuit diagram.

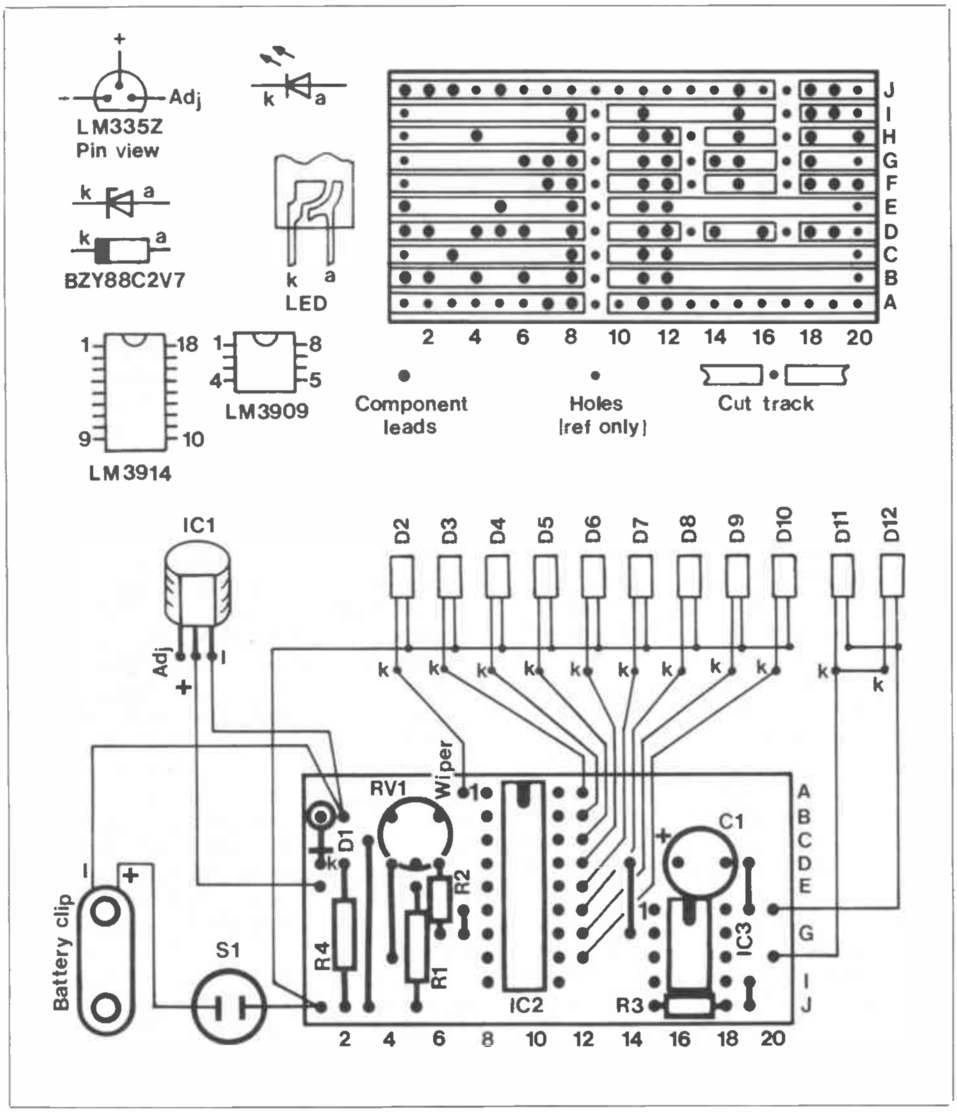
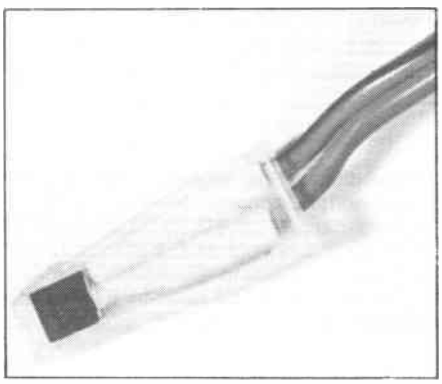


Figure 2. Temperature gauge layout and wiring diagram.

PARTS LIST FOR THE TEMPERATURE GAUGE

Resistors — all 0.4W 1% metal film unless specified		
R1	10k	(M10K)
R2	1k2	(M1K2)
R3	180R	(M180R)
R4	1k0	(M1K0)
RV1	5k cermet preset	(WR41U)
Capacitors		
C1	100u 10V PC electrolytic	(FF10L)
Semiconductors		
D1	BZY88C2V7	(QH00A)
D2-5	Shape LED R1 green 4 off	(YY46A)
D6-9	Shape LED R1 red 4 off	(YY45Y)
D10-12	Shape LED R1 yellow 3 off	(YY48C)
IC1	LM335Z	(YY73Q)
IC2	LM3914	(WQ41U)
IC3	LM3909	(WQ39N)
Miscellaneous		
S1	Push switch	(YR67X)
B1	PP3	
	Box	(WY00A)
	Veroboard	(FL06G)
	Vero pins	(FL24B)
	Battery clip	(HF28F)
	Ribbon cable 10-way 1m	(XR06G)



Temperature gauge sensor.

the components on the Veroboard according to the layout shown in Figure 2. Take care with the orientation of IC2 and 3. Having decided upon the colour display you require glue the LEDs together using a contact adhesive to form a solid block.

A plastic box with an aluminium front panel is used, type M4003. Cut a 27 x 5mm slot in the front panel 32mm from the top edge. Insert the LED block into the slot with the low temperature LEDs at the left and glue them in place.

Mount the push button midway along one of the long sides of the box. Directly opposite this drill a hole for the flying lead.

The battery and connector will conveniently locate at the bottom of the box if two sets of vanes are removed from one side with a modelling knife.

To form the sensor, solder and sleeve the flying lead as shown in the wiring diagram, Figure 2 using small twin cable. Cut a square hole the same size as the sensor's flat face in a push-on connector cover. Insert the sensor so that the flat face is exposed and, if liquid temperatures are to be measured, seal the sensor in place with an epoxy adhesive. However, ensure that the exposed face remains clean so that the reaction time of the sensor is not lengthened.

Finally wire all the components according to Figure 2 using a small length of ribbon cable for the LEDs. The Veroboard slots into the top set of box vanes.

Calibration

Connect a voltmeter to the input and 0V terminals and insert the sensor into the freezer compartment of a fridge. When the voltmeter registers 2·63V adjust the preset RV1 so that D1 is just 'on'.

Check this setting at the high temperature end by holding the sensor over the spout of a boiling kettle, when the voltmeter registers 3·73V LEDs D11 and D12 should be flashing.

Adaptation to a car thermometer

This can be carried out in various ways but in all cases the sensor must be attached to the water cooling system. The simplest method of doing this is to glue the sensor to the thermostat housing. Another way would be to obtain an old car temperature element, which would replace the one at present in the car's engine and drill a hole along its centre large enough for the LM335Z. Glue the LM335Z in place and swop elements.

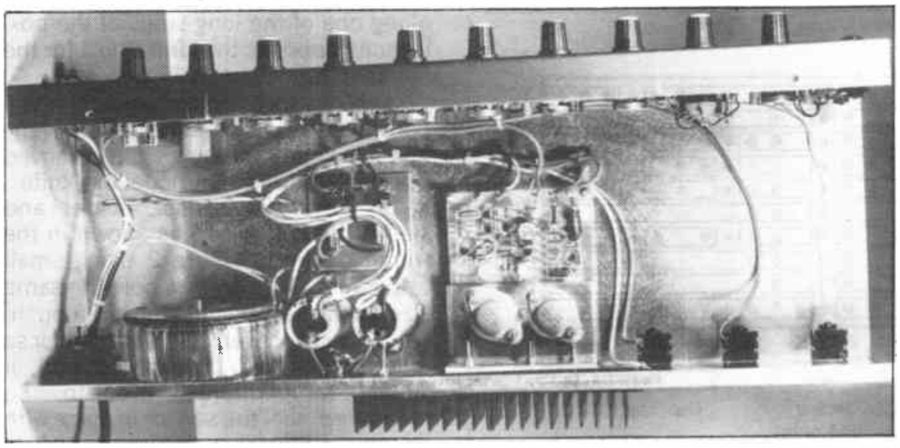
Now carry out one of the following methods of adaptation:

(1) Having mounted the sensor, change the push button switch for an on/off type and use the gauge as previously described.

(2) As above, but instead of using the battery the supply is taken from the car's 12V supply via the ignition switch, thus eliminating the on/off switch.

(3) As in (2) but instead of using the LED block use a single digit 7-segment display with a diode encoding matrix as used on the Digital Petrol Gauge featured in the July issue of E&MM. Note that in this circuit the LED flasher is retained but drives two ordinary LEDs for the 100°C warning.

Combo-Amplifier *(continued)*



Completed wiring in chassis.

rately or earth loop hum will result.

The slave output pin should be wired with screened wire to the slave jack socket. Do not connect the screen at the jack socket end. Combo pin 6 (effect switch) is wired to the footswitch jack socket using hook up wire. The bus bar supplies the 0V on all three jack sockets as in the chassis layout diagram.

The front panel input sockets are wired directly to the inputs and 0V pins on the control PCB. Screened wire is not necessary as the run is only about 1" long.

Cabinet Construction

16mm (⅝") and 12mm (½") chipboard and 12mm (½") plywood is used in the construction of the cabinet. Material thicknesses vary and it is important to keep to the cabinet inside measurements when marking out.

Cut out the five basic cabinet sections. Drill the top panel to accommodate a suitable carrying strap. The panel inside face will need the holes countersunk so that the nuts lie flush.

Use a good wood glue on the joints, and pin them (or use clamps) ready for drilling and screwing down. Use 1¼" No. 8 screws and countersink the outside of all holes. Note that the shelf and base panels fit flush with the back edges, while the front edges are set back by 10mm.

Before fully tightening all screws, fit the front baffle board, after cutting a hole to suit the loudspeaker to be used. A 292mm (11½") hole is required for a 12" loudspeaker. Mark off the speaker mounting holes, drill and counterdrill the holes to counter sink the mounting bolts. 1" x 2BA bolts usually suffice for this job.

Screw into the baffle board edges, through the cabinet sides. Ensure that the board is flush with the shelf front edge and base front edge. Tighten down all cabinet screws, and leave the assembly for the glue to dry.

Cut the 1" (25mm) square wood to make a framework fitting inside the cabinet. Again, 1" prepared wood can vary considerably in thickness, so take this into account before cutting to size. Twelve pieces will be needed for the frame. Glue and screw the frame along the baffle edge (inside), but ensure the outer edge (back) framework is set back enough to accommodate the back panel (12mm).

Radius the front edges of the cabinet, and smooth all surfaces with a Surform and glass paper. The cabinet can then be covered using a suitable impact adhesive and cloth backed PVC material. About 2 metres of 0.5 metre wide material will be required. Cover the cabinet top with impact adhesive and lay the cloth centrally on to the glued surface. Smooth the cloth over the top completely. Remove the cloth and leave for two minutes — no more. Re-lay the cloth and stretch it gently, smoothing out any creases. Repeat this action for the sides; trim the corners and glue the cloth over the edges and into the cabinet about 25mm.

The baffle can be covered with a suitable speaker material, glued (very conservatively) and laid over. Cut the edges with a sharp scalpel type blade.

The shelf and base front edges can be covered with aluminium angle trim. The two sides of the baffle board can be fitted with our mixer trim channel.

Fit four plastic feet (or castors) to the base. Drill a hole in the back panel and cut out to accommodate a jack socket mounting plate. Wire the socket to the loudspeaker and screw the back panel into place. Fit the carrying strap to the top panel, and ensure the nuts are fully recessed.

If our chassis is to be used, slide it into the shelf area, up to the angle trim (if used) or to within 25mm of the shelf front edge. Cut two pieces of channel trim to fit horizontally along the chassis front, top and bottom. This serves to cover the PCB mounting screw heads. Glue the channel to the cabinet top and shelf. Finally, screw in two small wood blocks behind the chassis to keep it in position. ■

Car Lights Reminder

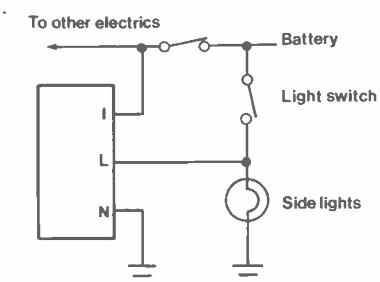
P. Glover, Ockbrook, Derby

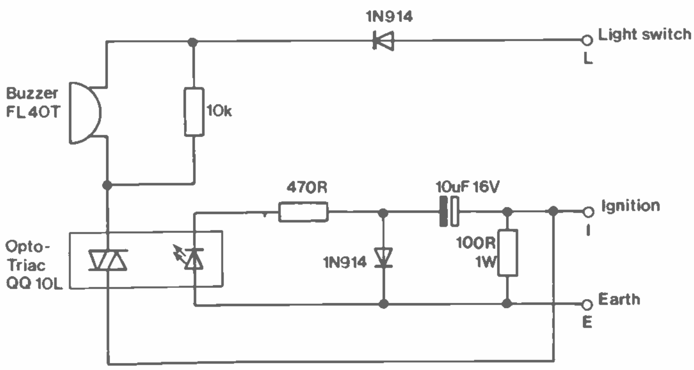
This circuit will produce an audible alarm if the lights are left on when the ignition is switched off. If the lights are turned on when the ignition is off the alarm will not sound.

With the ignition on the capacitor charges via the diode. If the ignition is switched off the capacitor discharges through the LED in the opto triac. With the lights on there will be a voltage present across the triac so that it will trigger and sound the buzzer.

The circuit can be reset by turning the lights off for a short moment, which allows the triac to switch off and not switch on again.

The circuit is connected to the car via three wires; to the ignition switch, light switch and earth as shown in the circuit diagram.



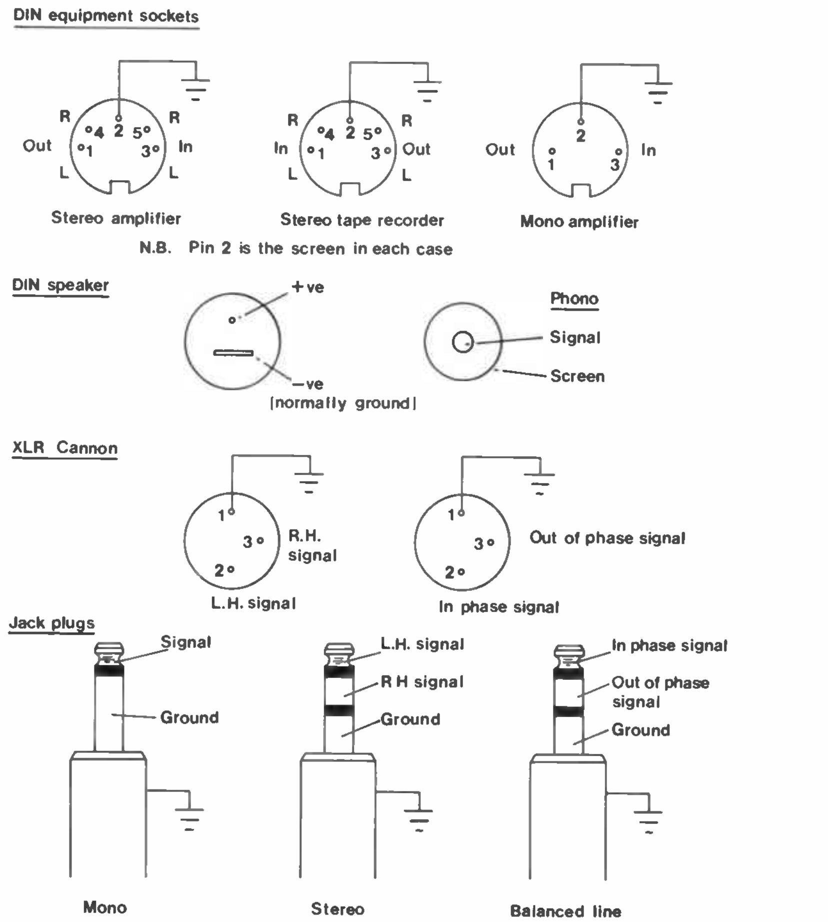


Audio Lead Connections

Every time an audio lead is made up, particularly those using DIN plugs, the question of which wire is which occurs. The lead is invariably made up wrongly, necessitating alteration afterwards with the end result that the lead is not as neat or reliable. This Circuit Maker guide should help avoid this, hopefully all the common lead connections for audio use are covered.

One useful tip is for dealing with 5-pin DIN leads for interconnecting tape recorders and amplifiers. The problem is that although a tape recorder may be connected directly to an amplifier using a straight through lead (pin 1 to 1, 4 to 4 etc), connection of two tape recorders requires a back to front or 'mirror' lead (pin 1 to 3, 4 to 5 etc). This implies that any lead set must have a collection of straight and mirror leads. It is, however, much easier to wire all leads straight through and make an adaptor using a DIN plug and socket wired in mirror form about 6" long. Any straight lead may be then transformed to a mirror lead with the adaptor, thus saving the "is it mirror or straight?" question.

It is also useful to own a channel reverse adaptor for when problems occur in one channel. The channels can then be easily reversed until the cause of the problem is isolated (pin 1 to 4, 4 to 1 etc).



Novel sound to light

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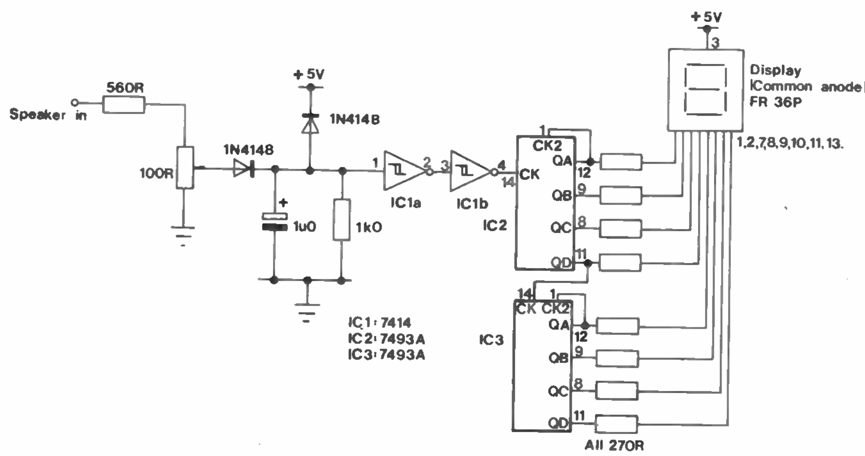
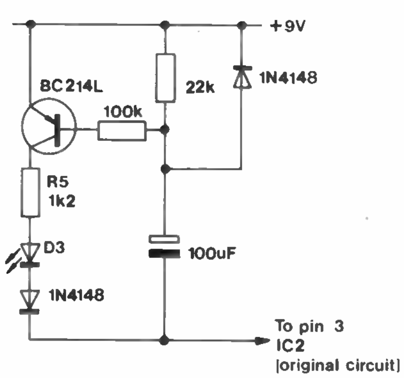
This small unit provides a pseudo random pattern on a LED seven segment display which changes in time with a musical input. The actual display is driven from two 7493 counters connected in series, the outputs being connected to each segment and the decimal point via 270R resistors. In this way, as the counters are clocked up to a maximum of 256, each number will correspond to a different pattern. The clock is derived directly from a loudspeaker output and, after being rectified and smoothed by the capacitor, it is squared up by the Schmitt trigger gates. Note the addition of a diode to the +5V rail; this must be included in case high amplifier levels are used. The potentiometer acts as a level control and should be adjusted for the most pleasing effect.



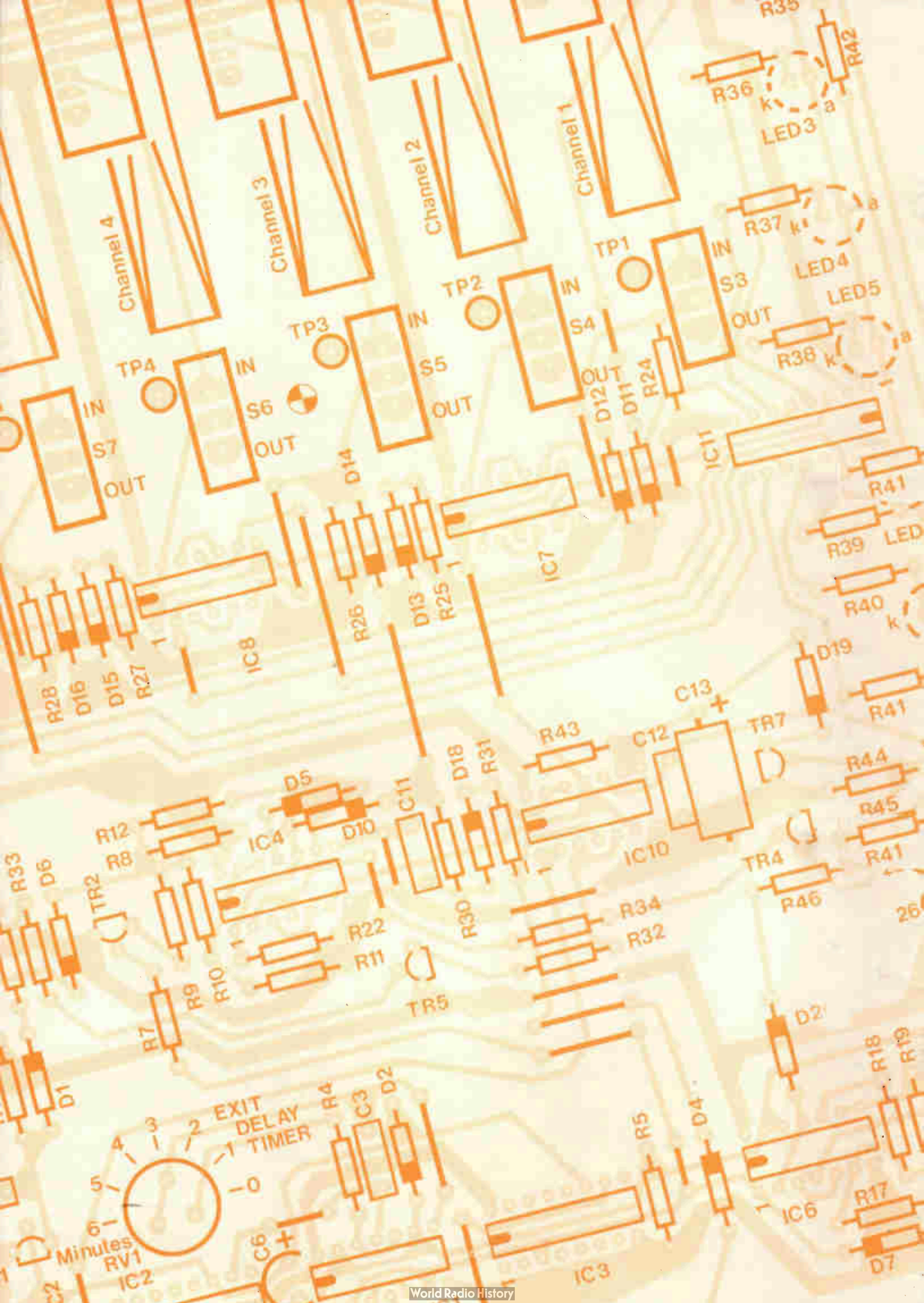
Car Race Starter Power Saver

One of the main reasons the E&MM Car Race Starter (August 1981) uses up power is because the red 'start' LED remains on once the race has started and people are too busy controlling cars to think about turning the unit off. The circuit may be modified such that the red LED lights to full brightness as soon as the flashing and buzzer stops, as in the original but over the next six seconds fades away leaving a standing current of only 6mA (or 1mA if the dual CMOS 555 version is built — see other Circuit Maker: Car Race Starter Mods). Needless to say this offers a considerable saving over five minutes!

The circuit shown replaces the LED and resistor which were connected from pin three of IC2 in the original (D3 and R5). During the timing cycle pin three is high, and so the 100uF capacitor is fully discharged since the same voltage is present on both plates. Obviously the LED does not light and the entire circuit may be said to be non-functional. Once pin three falls towards 0 volts at the end of the timing cycle the voltage at the top end of the capacitor will also fall since it is still discharged. This turns on the transistor and the LED lights. The capacitor will start to charge up, and as it does so the transistor will become progressively less 'on' until the LED goes out, leaving only a small leakage current.



It has been found necessary to add the extra diode in series with the LED when using some 555's to prevent the LED glowing. This seems well worth adding at the same time.


R35
R42
R36
LED3
Channel 1
Channel 2
Channel 3
Channel 4
R37
LED4
LED5
R38
TP1
TP2
TP3
TP4
IN
S3
OUT
IN
S4
OUT
IN
S5
OUT
IN
S6
OUT
IN
S7
OUT
D12
D11
R24
IC11
D14
R41
R39
LED
R40
IC7
D13
R25
R26
IC8
R28
D16
D15
R27
D19
C13
R41
TR7
R43
C12
D18
R31
R44
D5
C11
R45
R12
IC4
D10
IC10
R41
R8
R33
D6
TR2
TR4
R46
R34
R32
R22
R11
R30
R9
R10
R7
TR5
D2
R18
R19
D1
EXIT
DELAY
TIMER
R4
C3
D2
R5
D4
Minutes
RV1
IC2
C6
IC3
IC6
R17
D7
C2