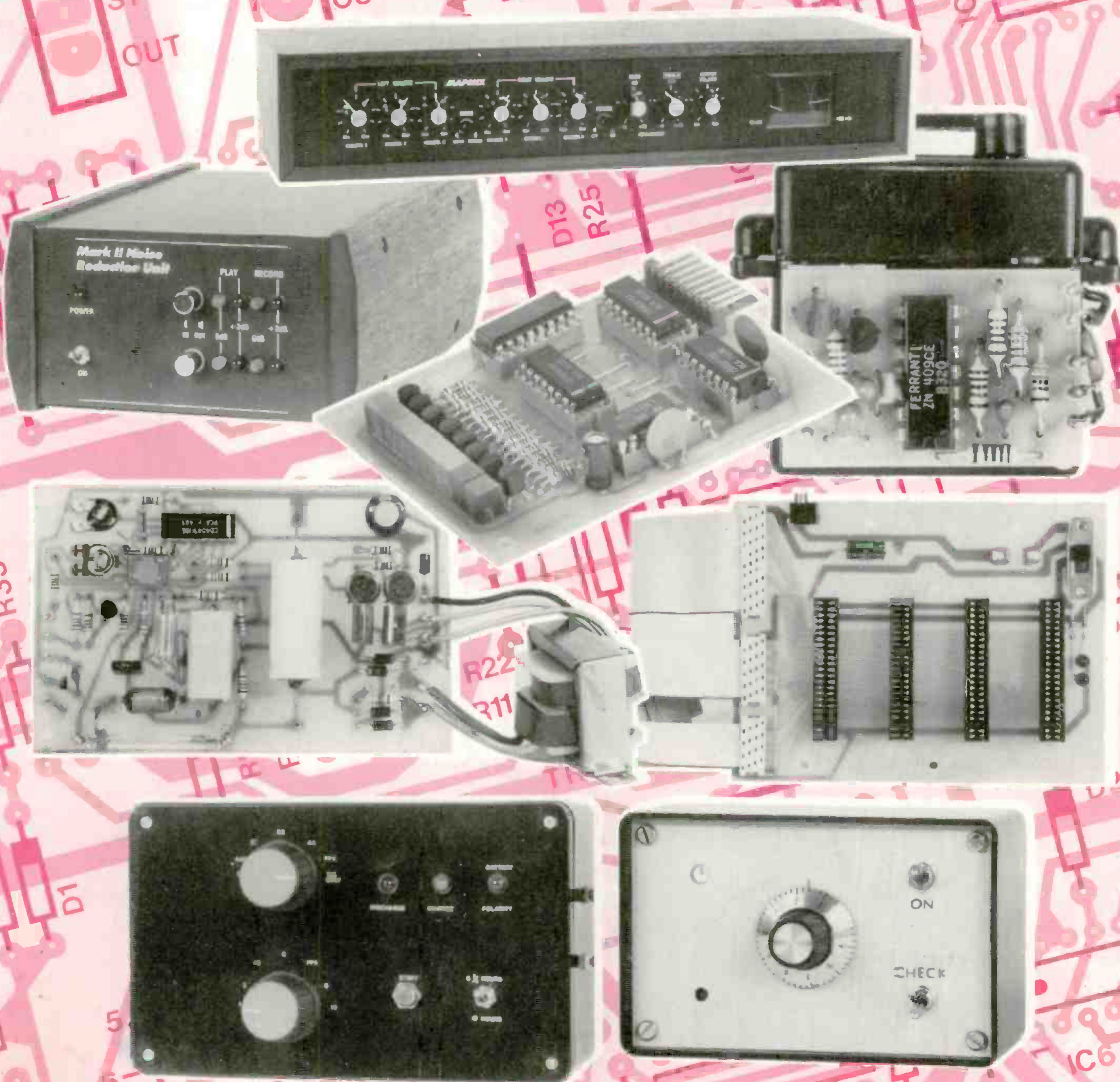
# MAPLIN PROJECTS BOOK ELEVEN

SERVO AND DRIVER MODULE
8 CHANNEL FLUID DETECTOR
NOISE REDUCTION UNIT MK2
MAPMIX
CAUTIOUS NI-CAD CHARGER
MOTHERBOARD FOR BBC 'B'
ANOTHER FIVE BOB'S WORTH
XENON TUBE DRIVER
ENLARGER EXPOSURE METER



Electronics
THE MAPLIN MAGAZINE

# PROJECT BOOK ELEVEN

This Project Book replaces issue 11 of 'Electronics' which is now out of print. Other issues of 'Electronics' will also be replaced by Project Books once they are out of print. For current prices of kits, please consult the latest Maplin price list, order as XF08J, available free of charge.

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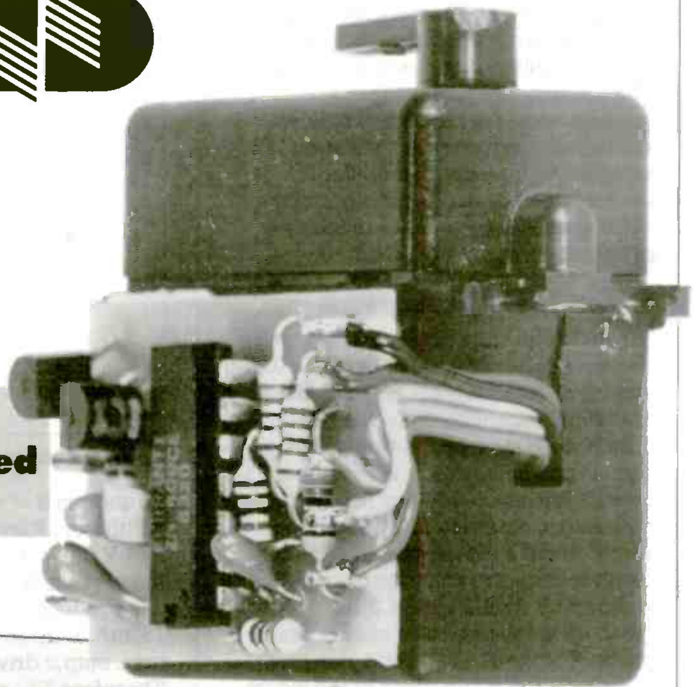
# SERVO AND DRIVER MODULE

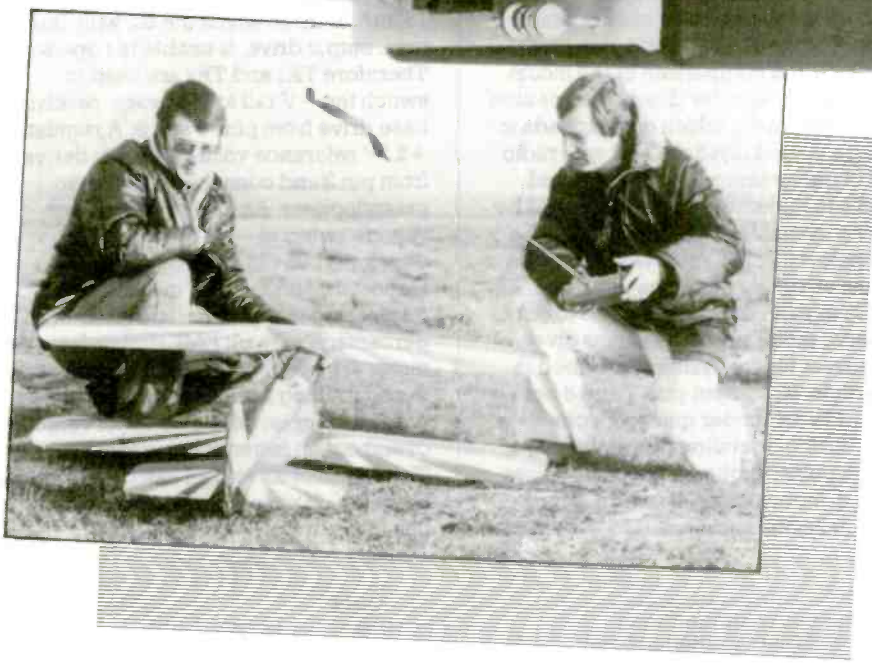


★ **Compact Lightweight Unit**
★ **Easy Construction – Reasonably Priced**
★ **Ideal for Model Aircraft/Boats etc**

## by Dave Goodman

Electro-mechanical interfaces for use in modelling, robotics and control systems can be difficult to produce with any accuracy, especially if facilities or finances are limited; therefore this article describes construction of a complete servo mechanics kit and small driver module (37 x 25mm). The project is easy to build and the cost very reasonable. Both servo and PCB are small and lightweight, these being important criteria for use with such models as aircraft or small power boats, although the PCB is not so small that construction requires a degree in micro-technology!

Robotics 'buffs' could find servo's useful for producing arm lift and rotational movement or perhaps steering control of wheels. The necessary electrical control signals are generated from port scanning routines and FOR–NEXT loops in BASIC, which is quite fast enough for successful operation.



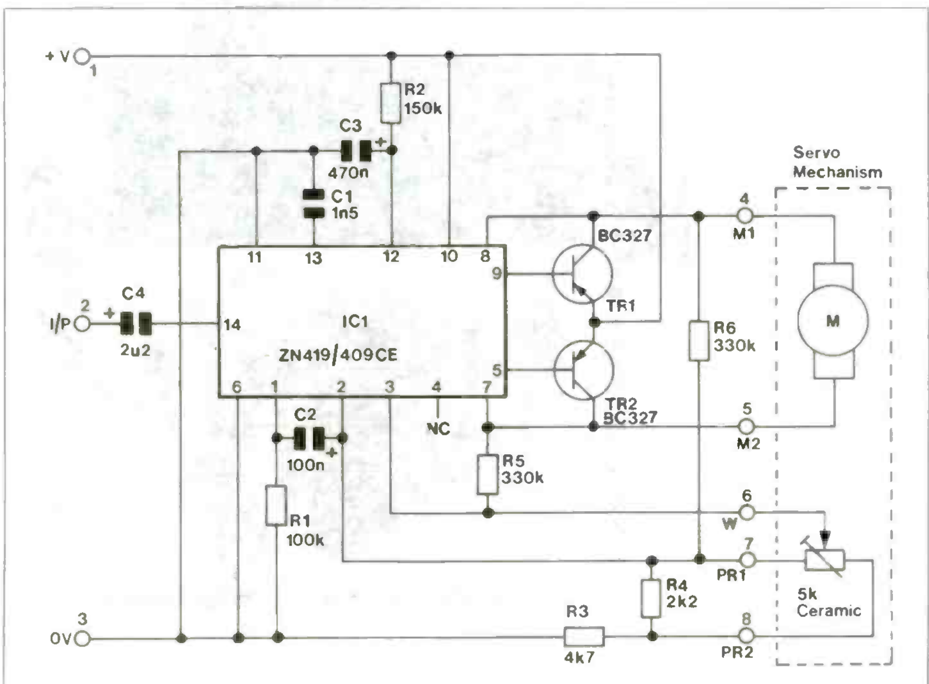



**Figure 1 Circuit Diagram**

## Proportional Control

A servo consists of an electric motor with gear box, rotating arm, for transferring movement, and a feedback potentiometer. Connecting a suitable voltage across the motor causes high speed rotation which is geared down to produce a final drive of one revolution every two seconds – at high torque. The drive arm continues rotating as long as power is applied, this is not the required state of affairs, as positional control of the

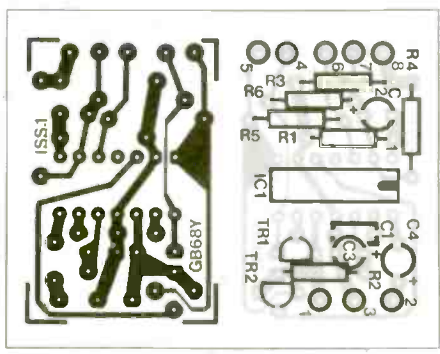



**Figure 2 Artwork & Legend**

arm is necessary. Positional or proportional control is achieved by continuously pulsing the motor in small steps. The gearbox drives the wiper of a potentiometer the resistance of which varies with each step, this variation is sampled by the control module. When the arm reaches the desired position, drive signals to the motor are inhibited, preventing further movement.

## Circuit Description

IC1 requires a positive going, pulse width modulated signal of between 0.5 and 2.5mS repeated every 20mS (50Hz). This 20mS repetition, or frame rate, is standard for most proportional radio control transmitter/receiver systems (Figure 7). Servo arm rotation (of 0 to 180 degrees) is determined by the pulse width, with the centre position (90 degrees) equal to half maximum pulse width, viz. 1.5mS. R1 and C2 are mono-stable timing components which produce a fixed time period, used for reference and comparison of the incoming signal. C1 sets the 'dead band' or area of non-movement, which corresponds to a centre loaded joystick used with radio control transmitters. This area around 1.5mS can be increased or decreased by altering the value of C1, but it should be kept below 2.2nF – otherwise the pulse expansion timing becomes obscured. R2 and C3 expand the control pulse to suit the servo motor used, the values given are correct for the system described in this article. IC1 output pins 7 and 8 both sit at 1.75V DC under quiescent conditions. During operation one of these outputs pulses high and the other pulses low, e.g. increasing pulse width from 0.5mS to 2.5mS causes pin 7 to = 0V (not Q) and pin 8 = +V (Q). Decreasing pulse width from 2.5mS to 0.5mS causes pin 7 to = +V (Q) and pin 8 = 0V (not Q). Putting the servo under a heavy load condition will produce supply current drains of 150mA or more which the IC, with 7mA max. output drive, is unable to cope with. Therefore TR1 and TR2 are used to switch the +V rail to the motor, receiving base drive from pins 5 and 9. A regulated +2.2V reference voltage level is derived from pin 2 and connects to the servo potentiometer. As the wiper moves a voltage swing of +1.7V to +2.2V is developed on pin 3 this modifies the monostable timing thus increasing or decreasing output drive to the motor. A percentage of back EMF signals from the motor are connected via R5, along with the controlling signal, to the monostable reference input; this helps to prevent overshoot on faster servo mechanisms. The values of R5 and R6 can be altered by up to 10%, if necessary, to accomodate this.

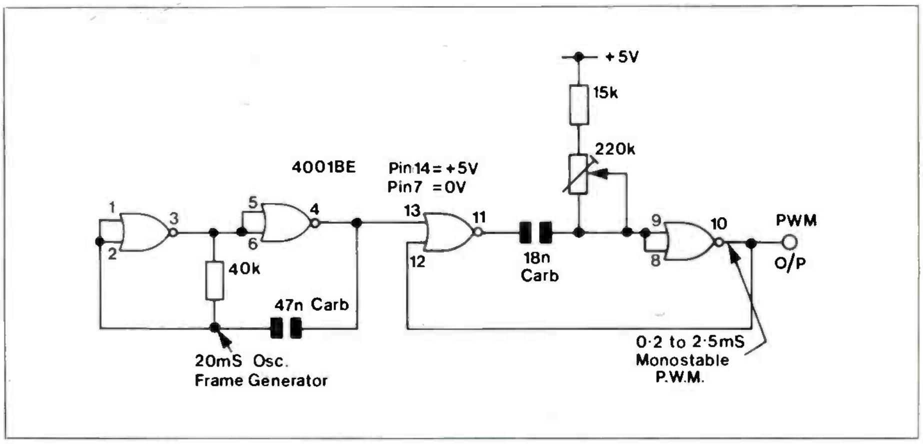



**Figure 3 Test Circuit**

## PCB Construction

Insert resistors R1 to R6 and capacitors C1 to C4. C2 to C4 are polarised types and must be fitted correctly, with the longest lead marked with a + sign to the + sign on the PCB. Insert 8 Vero pins (if required) from the track side of the PCB and press home with a soldering iron. Solder these pins and components

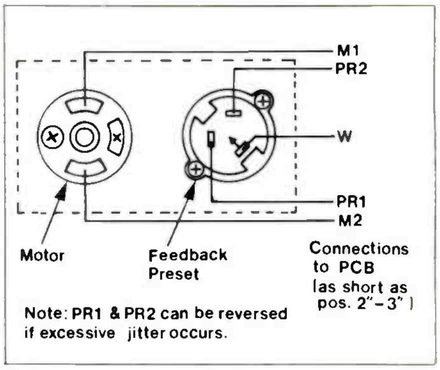



**Figure 5 Servo to PCB Wiring**

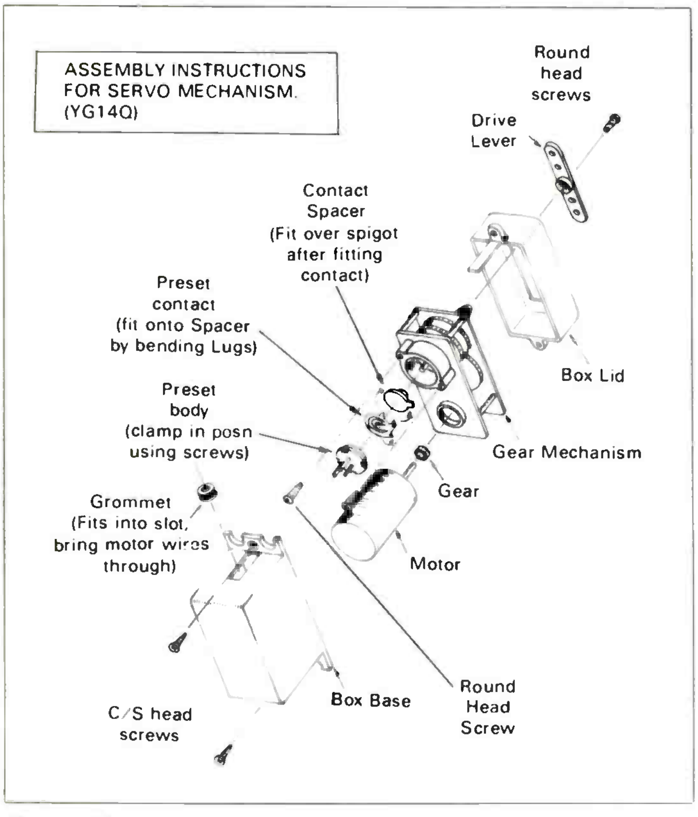
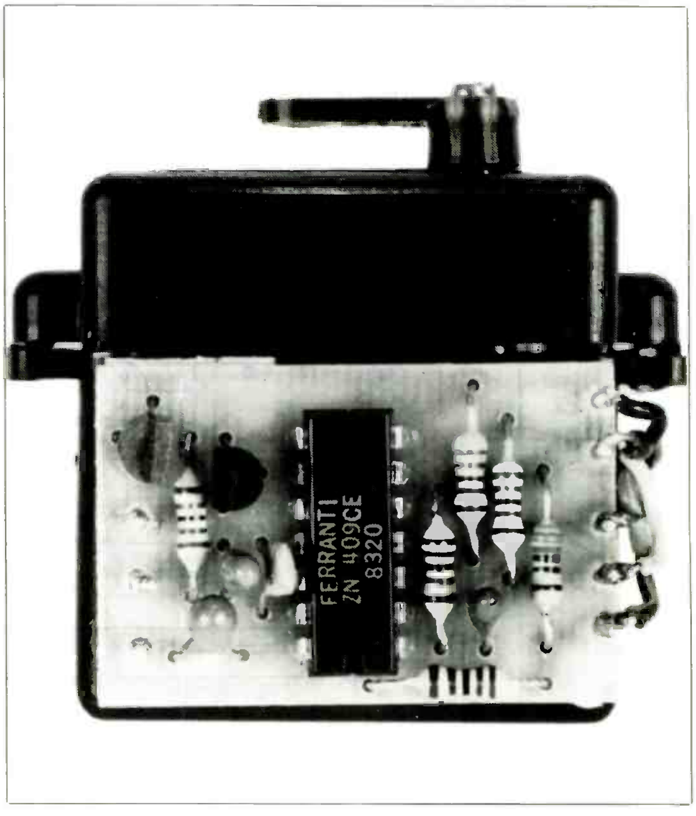



**Figure 4 Mechanics Assembly**



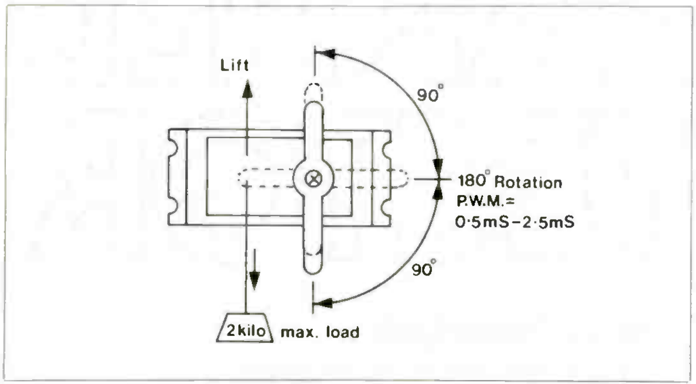



Figure 6 Servo Operation

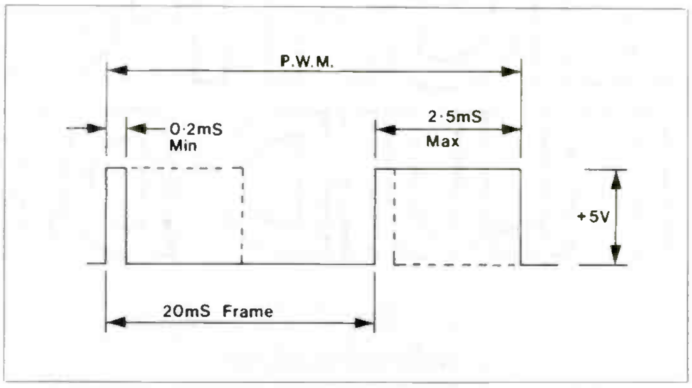



Figure 7 Control Signal

and remove excess wire ends. Fit IC1 and both transistors and carefully solder them in place. Clean the board and inspect for mistakes, short circuits, etc.

## Servo Construction

The diagram in Figure 4 shows the servo assembly, but a few points need explaining in more detail. Snap off one of the contact spacers and remove the casting piece. Fit the brass preset contact over the spacer so that the key fits into the slot. Note that the contact mounts over the face moulded with a small bush protrusion – not the larger bush face! Gently bend both brass lugs over so that the contact is held firmly to the spacer. Next carefully press the assembly onto the gearbox spigot as shown, ensuring that the wiper is facing outwards. This job is a bit fiddly and great care must be taken to avoid damaging the wiper. Place the cermet preset (terminals facing outwards!) over the wiper and line up two of the four available slots with two screw mounting holes. Insert the self tapping cross-head screws and tighten down just enough to grip the preset edges, over-tightening will break the body and obviously should be avoided. Place the small brass gear over the motor shaft and press home. Fit the motor onto the mechanism housing by pushing and twisting, the fit is made tight to prevent the motor from turning when in use.

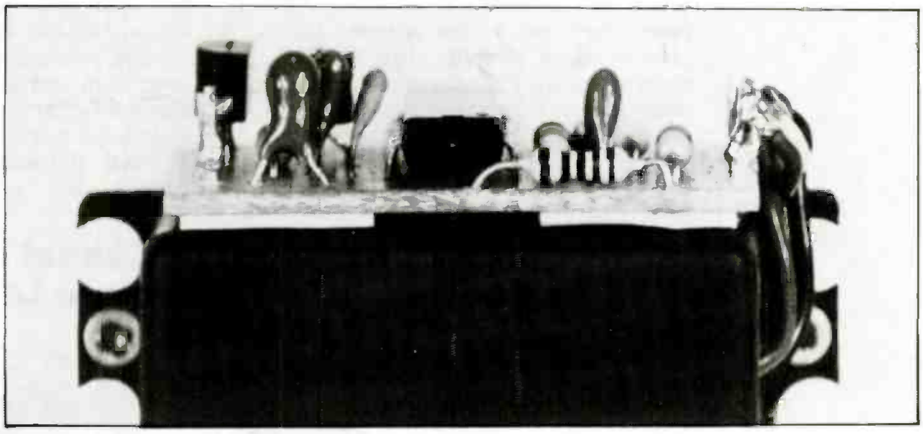
## Servo and PCB Wiring

Figures 2 and 5 show the five connections between the servo and PCB. In fact motor connections M1 and M2 can be reversed as can preset connections PR1 and PR2 although the wiper W connection must be as shown. Keep wiring between the units as short as possible to prevent excessive motor RF from being induced into the preset circuitry, otherwise operation may be erratic. The PCB has been made the correct size for fitting onto the side of the servo box and quick stick pads can be used here to advantage – as shown in the photograph.

## Testing

A suitable +V pulse transmitter/receiver system can be used, or for convenience the test circuit shown in Figure 3 can be constructed – to produce a 20mS frame and variable 0.5 to 2.5mS pulse width, using the values given. A suitable 4.2 to 6.5V supply will be required, such as four AA Ni-Cads or a 126 type dry battery. The power supply used should be capable of delivering up to 1 Amp without the +V rail dropping, otherwise problems will be encountered.

Connect up the supply rails and switch on, a slight 'glitch' may occur, but nothing more. Input the PWM signal and make a return path by connecting the servo ground (0V) to the signal source ground. If using the test circuit (Figure 3) from the same power supply you will require a large de-coupling capacitor fitted across pins 7 and 14 of the 4001 IC, to prevent amplitude modulating the PWM signal; 470uF to 1000uF should suffice. Move RV1 or your transmitter joystick from centre to full clockwise or full anti-clockwise, whereupon the servo arm should follow suit. If the motor drives continuously or jitters excessively, reverse PR1 and PR2 connections. In case of malfunction various voltage levels should be checked with a high impedance voltmeter or oscilloscope, referring to the circuit description as a guide.



## SERVO & DRIVER MODULE PARTS LIST

RESISTORS:– All 0.6W 1% Metal Film

| | | | |
|---|---|---|---|
| R1 | 100k | 1 | (M100K) |
| R2 | 150k | 1 | (M150K) |
| R3 | 4k7 | 1 | (M4K7) |
| R4 | 2k2 | 1 | (M2K2) |
| R5,6 | 330k | 2 | (M330K) |

CAPACITORS

| | | | |
|---|---|---|---|
| C1 | 1n5F Ceramic | 1 | (WX70M) |
| C2 | 100nF 35V Tantalum | 1 | (WW54J) |
| C3 | 470nF 35V Tantalum | 1 | (WW58N) |
| C4 | 2$\mu$2F 35V Tantalum | 1 | (WW62S) |

SEMICONDUCTORS

| | | | |
|---|---|---|---|
| IC1 | ZN419CE | 1 | (YH92A) |
| TR1,TR2 | BC327 | 2 | (QB66W) |

MISCELLANEOUS

| | | |
|---|---|---|
| Servodriver PCB | 1 | (GB68Y) |
| Veropins 2145 | 1 pkt | (FL24B) |
| Servo Mechanism | 1 | (YG14Q) |

A complete kit of parts is available.
**Order As LK45Y (Servodriver Module Kit)**

# EIGHT-CHANNEL FLUID DETECTOR

by Nigel Fawcett

## Introduction

This project, as the title suggests, is a variation of the very popular fluid detector circuit, only here it has been taken a stage further, and has thereby increased the range of applications for such a device. When building a darkroom and workshop into a garage recently, it was deemed necessary to have a sink with hot and cold running water. Getting the water in was no problem, but getting it out again was a different matter. The garage was considerably lower than the house, and did not have immediate access to any main drainage point.

The only solution was to pump the water back up to house level, and thereby into the normal domestic waste system. The waste from the garage sink emptied into an expansion tank of the kind used in central heating systems, and was pumped out again with a self-priming pump purloined from a redundant washing machine. It was here that the need for a fluid detector lay. A means of determining the presence of water was required to switch on the pump. However, it was foreseen that a greater inflow of water than the pump could reasonably handle might occur. To overcome this problem, eight separate channels were incorporated to detect the increasing level of water in the tank, and so indicate the effectiveness of the pump.

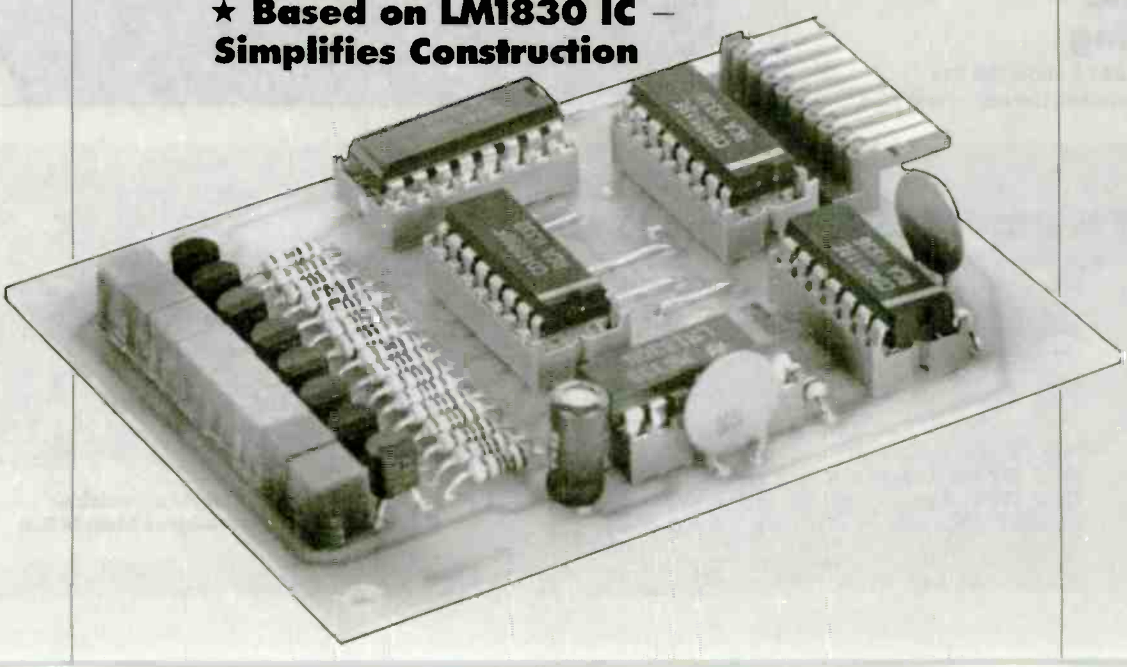
## Circuit Description

At the heart of the circuit (see Figure 1) is the LM1830 fluid detector chip IC2. This is the type of IC commonly found in drinks vending machines, washing machines, and a whole host of other domestic and industrial appliances. It is a well designed IC which includes an A.C. current to the probes to alleviate the problem of plating. The output is also pulsed, and can be used to drive a speaker or LED directly, but in this instance an 'on' or an 'off' condition was required to interface with the CMOS digital part of the design. This is achieved by the reservoir capacitor C4, which smoothes the oscillator output, and the pull-up resistor R2.

The IC detects the presence of water by comparing the resistance across the probes with an internal resistor. One probe is connected to ground, whilst the other is connected to pin 10 of the IC. In this particular design, eight independent probes are connected to the single 8-channel analogue multiplexer/demultiplexer IC1. Each of the channels is scanned approximately once a second, and during the scan time IC2 checks for the presence of water (conductive fluid). If water is detected then the output of IC2 goes high and is written into the latch corresponding to the input channel of the 8-bit addressable latch IC3.

Both IC1 and IC3 have a three bit address bus to select the desired

**★ 8 LED's Indicate Fluid Level or**
**★ Monitor up to 8 Separate Levels**
**★ Based on LM1830 IC – Simplifies Construction**



channel, and the addressing for the chips is provided by half of the dual decade counter IC5. The clock for the counter is formed from two of the dual input NAND gates of IC4, R1 and C1. The other two gates of IC4 and the other counter of IC5 are used to produce a short pulse during each scan cycle, to ensure that data is only written into the output latches when IC2 has had time to sense the fluid and settle down. The outputs from the latch are then used to drive the eight LED's and their associated circuitry. In the application described in the introduction, the LED's for channels 1-6 were green and channels 7 and 8 were red. This provided visual stimulation when things were getting dodgy. In practice the colours chosen will depend on the application (see applications). It should be noted here that a remote lead was taken from channel one output to a separate board which was used to switch the pump on or off.

## Construction Details

All the components are fitted on the printed circuit board (see Figure 2). Start by inserting, and soldering, the wire links and resistors, proceed with the IC sockets, capacitors, PL1, the transistors and LED's, and finally insert the integrated circuits into their respective sockets. Normal MOS handling precautions should be observed with the CMOS integrated circuits, with care to ensure correct orientation. PL1 is a ten pin connector, but only nine pins are required, and in fact there are only nine holes in the PCB, so pin one must be removed from the plug before it can be mounted on the board. This is easily achieved with a small pair of radio pliers.

A twelve volt power supply is required and, although no construction details are described here, many of the circuits shown in back issues of this magazine will reveal a suitable design (i.e. Digital Enlarger Timer/Controller in the June to August 1983 issue, Vol.2 No.7). As far as the construction of a probe is concerned, it would be beyond the realms of practicability to attempt the description of a suitable design, since it depends entirely on the application. The receptacle containing the fluid may be small or large, shallow or deep. There may be one individual container or up to eight separate ones. There may not even be a container at all (see applications). In many applications however, a simple narrow piece of copper strip Veroboard can be employed, using the strips horizontally, choosing appropriate strips for the particular levels, and connecting the ground terminal to the bottommost strip.

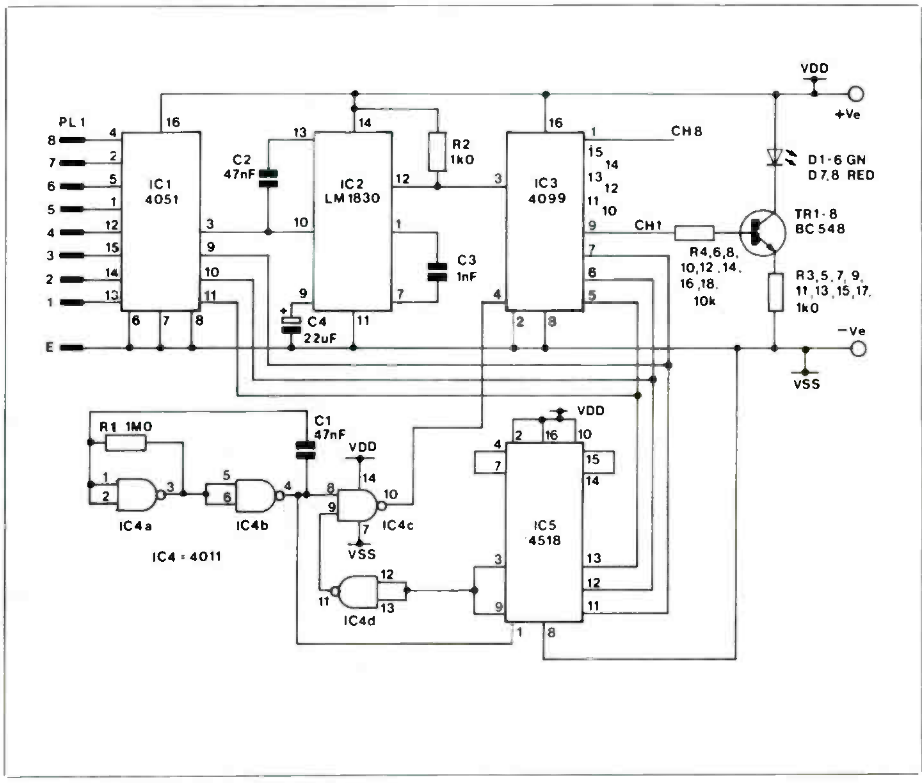



**Figure 1. Circuit diagram**

## Applications

Up to this point, most of the references to utilising this project have revolved around using all eight channels to monitor the fluid 'level' in a container. In the previous paragraph it was suggested that the various channels could in fact be used quite independently or in groups of any number. To explain this further, consider the following three applications for which the circuit has already been gainfully employed. Case one is for use in a car and is really rather a novelty idea. The pupose here is to use the project to give a continuous visual indication of the amount of water in the windscreen washer bottle. When used in this way, the red LED's should be

*Continued on page 11.*

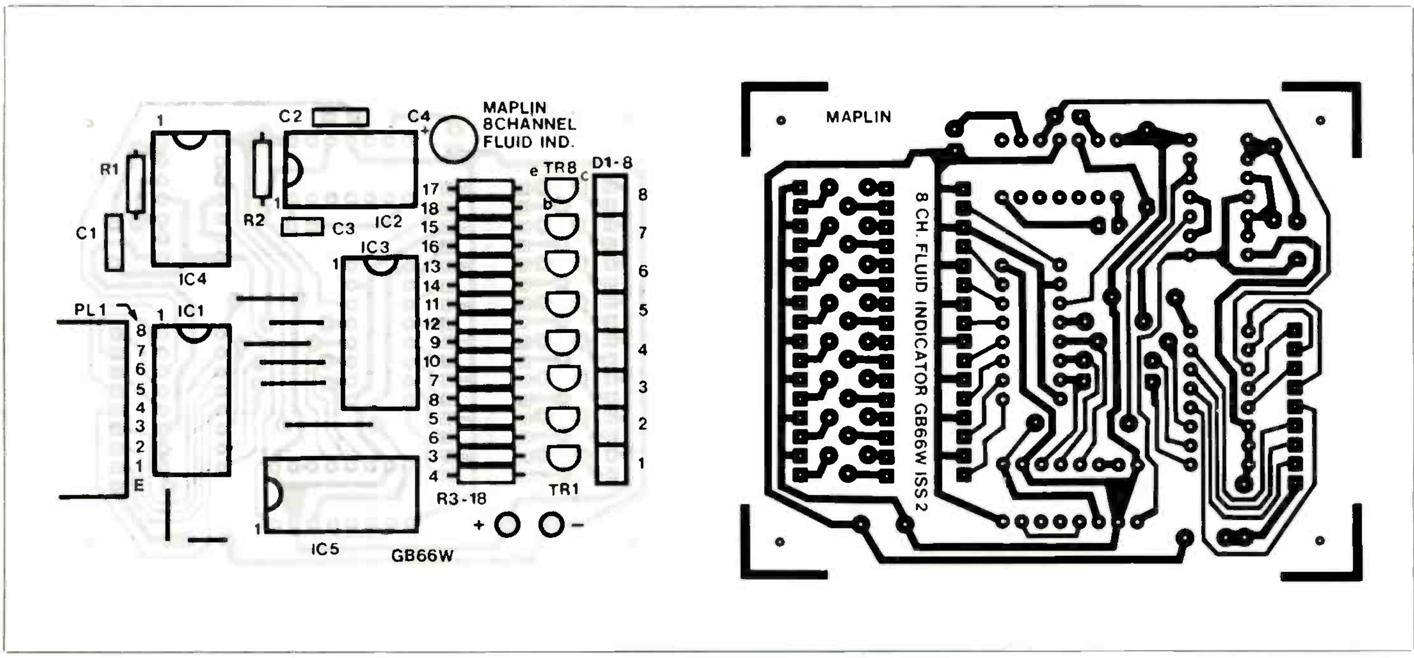



**Figure 2. PCB track & layout**

# NOISE REDUCTION UNIT *Mark 2*


Based on an original design, by Dr. David Ellis

- ★ **Simple Calibration**
- ★ **LED Peak Indicators**
- ★ **Full Hi–Fi Specification**
- ★ **Very Low Distortion Levels**
- ★ **Stereo or Four Channel Operation**
- ★ **30dB Improvement in Signal-to-Noise Ratio**

## Introduction

This improved design for the Maplin/E&MM Noise Reduction Unit utilises fewer components and is easier to construct, yet still offers the same high specification. Calibration has been simplified, no test gear is required, although a distortion analyser will enable the lowest distortion levels to be achieved. (0.06% typical).

The compander PCB's are fully compatible with the original Noise Reduction Unit. The Mark II Unit is designed for stereo (2 channel) operation but power supply outputs via a DIN socket enable two units to be connected together, thus giving 4 channel operation. If required furthur units could be utilised to give more channels.

## N/R Principles

Noise reduction systems reduce the irritating noise of tape hiss and so on by an encode/decode process. Quiet sounds especially those at the top end ot the spectrum, are easily swamped by tape hiss, so an encoder is used to artificially boost these signals before they are recorded. During playback the reverse process decodes the recorded sound back to its original state and rids the music of tape generated noise. Until recently, noise reduction systems have fallen into three distinct types: Dolby B (domestic), Dolby A (professional) and DBX (professional). However there is now a confusing proliferation of other systems offering various degrees of noise supression, including: Toshiba's Adres system, Telefunken's Highcom & Telcom, Sanyo's Super D, Dolby's C & HX systems and Tandberg's Dyneq. If there's any sense in this race to the pinnacle of perfect music reproduction, the hopefully there will be some common standards agreed upon! Table 1 gives the signal-to-noise ratios obtainable from various recording mediums with and without different types of noise reduction.

The various systems available at present basically work on the principle of complementary compression of the on-tape signal and expansion of the off-tape system. Compression involves reducing the dynamic range of the material that is being recorded, thus– with a 2:1 compression ratio, if the input to the compressor increases by 12dB, then the output of the compressor (on-tape signal) will increase by only 6dB. Conversely, expansion involves increasing the dynamic range, so that an increase of 6dB in the off-tape level will result in a 12dB increase in the output from the expander, thereby restoring the original dynamic range of the music. At the same time the noise introduced in the recording chain, particularly tape hiss, is rendered inaudible on expansion since this unwanted signal was not subject to the initial compression treatment and is therefore expanded downwards below the lowest dynamics of the music signal. This process is illustrated in Figure 1.

Another feature of the compression/

| Recording medium | Noise reduction | S/N ratio | Comments |
|---|---|---|---|
| Cassette (Sony TCK55 II) | - Dolby B | 57dB | |
| | + Dolby B | 67dB | Above 4 KHz |
| | + Dolby C | 75dB | Above 1 KHz |
| | + HighCom | 75dB | Above 1 KHz |
| Four-track tape (Teac 3440) | No noise reduction | 55dB | |
| | MarkII unit | 85dB | Above 30 Hz |
| Two-track tape (Studer) | No noise reduction | 70dB | |
| | + Dolby A | 80dB | Above 20 Hz |

**Table 1. Comparison of Noise Reduction Systems**

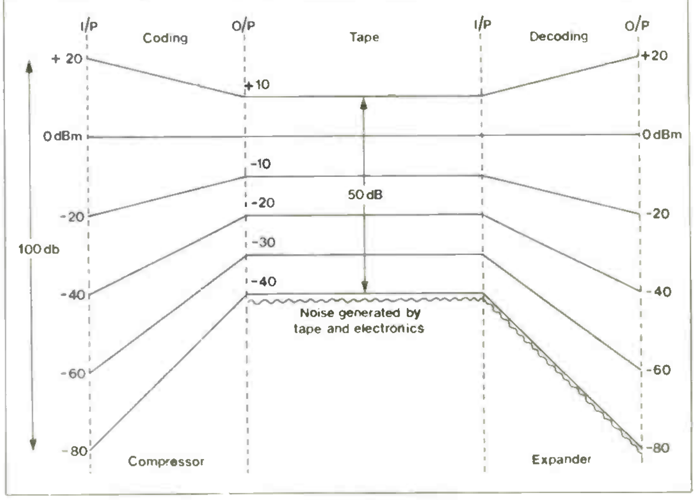



**Figure 1. Operation of a Compression/Expansion System**

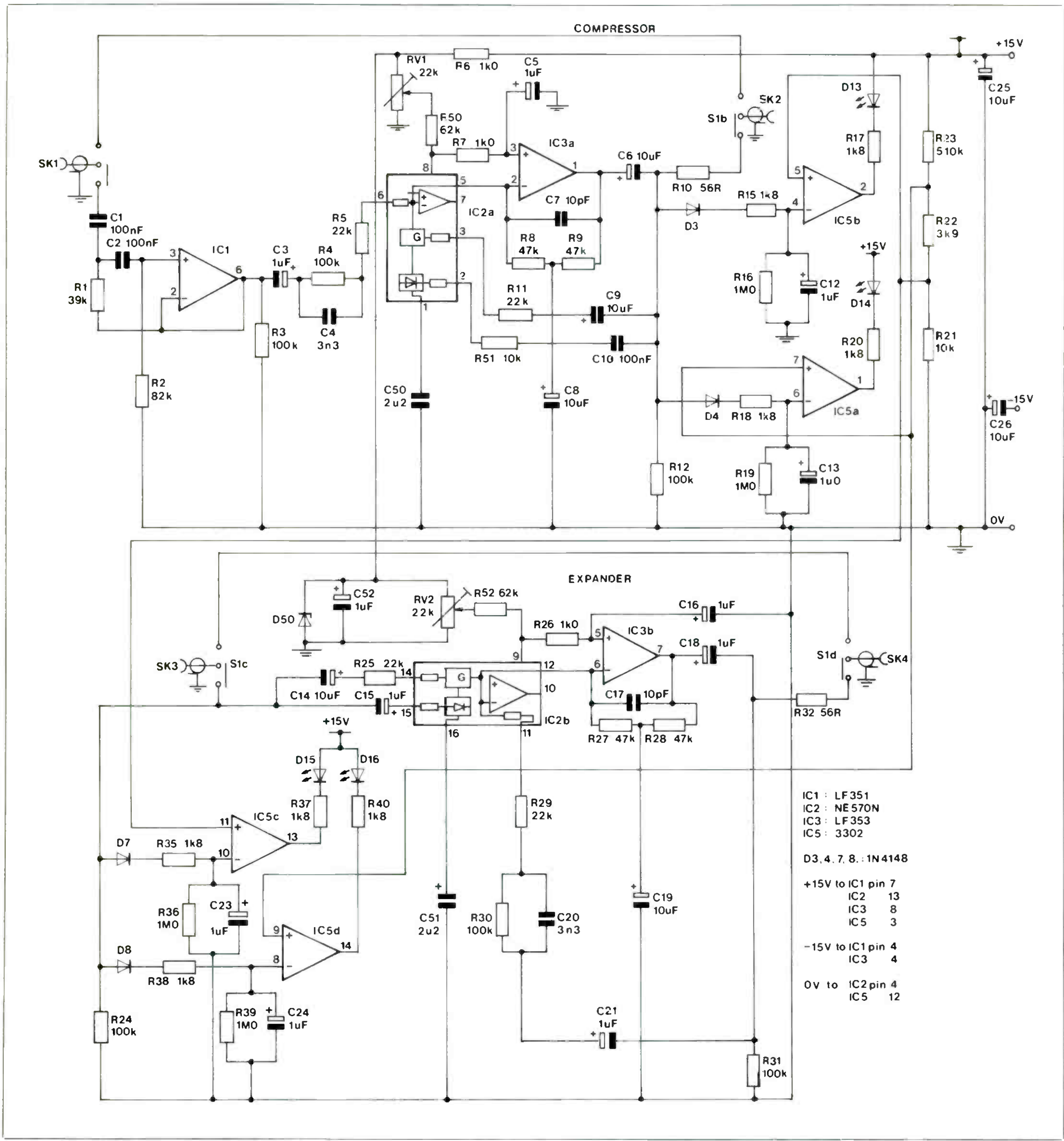



**Figure 2. Circuit Diagram of Compressor/Expander**

expansion process is that it allows the recording of signals with a dynamic range approaching the limits of audibility, i.e.100 to 120dB.

## Circuit

The circuit diagram for the compressor and expander (compander) is shown in Figure 2. The power supply circuit is given in Figure 3.

The compressor input is routed via S1a, either directly to the output in the 'out' position, or to C1 in the 'in' position. IC1 and associated components form a second-order high pass filter with a 12dB/octave roll-off below 30Hz. This removes sub-audible signals (infrasonics) that might be generated from record warps or sub-octave tracking VCO's. The reason for this filtering is that once audio frequencies descend towards DC, the response of tape recorders drops off dramatically, and on playback a signal compressed in response to high level low frequency signals will be expanded, resulting in phantom modulation by the missing low frequency component lost during recording. The output of the filter is AC coupled to a simple RC network (C4, R4) which forms a high frequency pre-emphasis circuit, providing a 12dB treble boost. Without this pre-emphasis and corresponding de-emphasis in the expander, a low level signal may be swamped by high level bass frequencies, typically resulting in a heavy breathing or pumping effect as the expander attempts to adjust the gain accordingly.

The signal is then applied to the NE570 (IC2a) configured as a compressor using an internal variable gain cell and full-wave rectifier, as well as an external output op-amp (IC3a). The variable gain cell is similar to a standard operational transconductance amplifier (OTA), except that, unlike OTA's, it is 'linearised' and therefore insensitive to temperature changes as well as offering low noise and low distortion performance. The signal at the output of IC3a is rectified and the resultant control voltage used to adjust the variable gain cell. By placing the gain cell in a feedback loop with the op-amp, the variable current generated in propor-

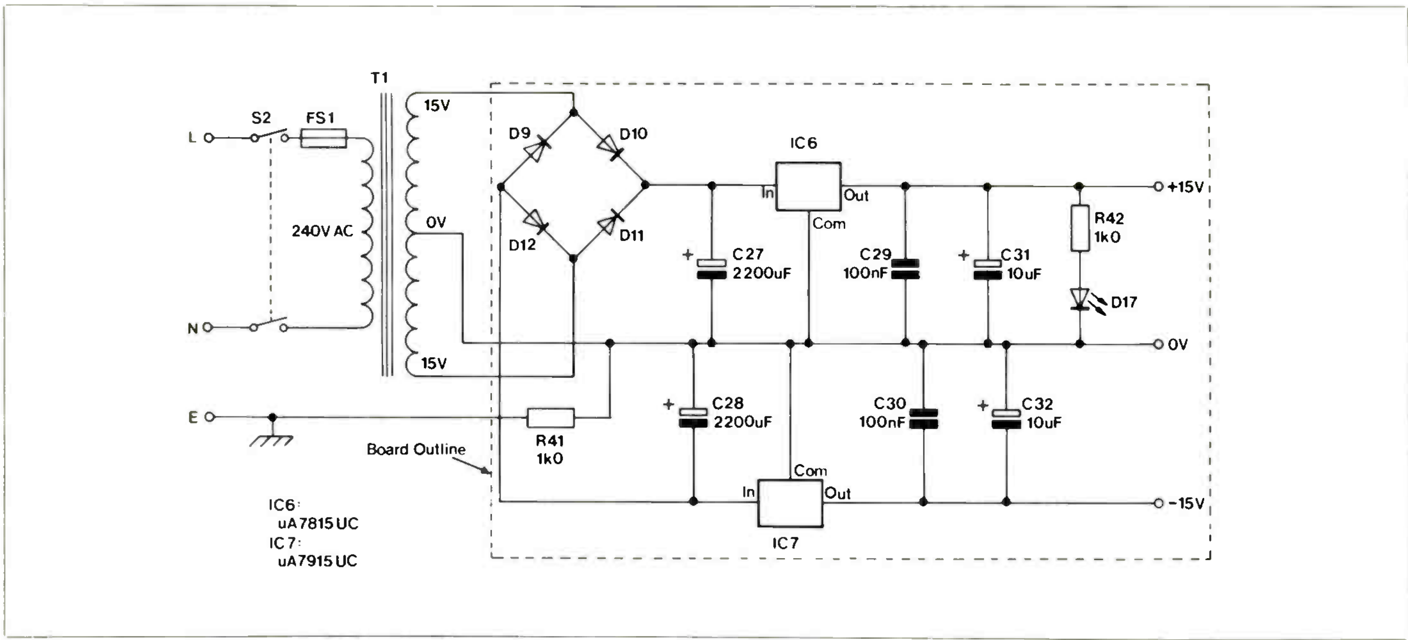



**Figure 3. Circuit Diagram of Power Supply**

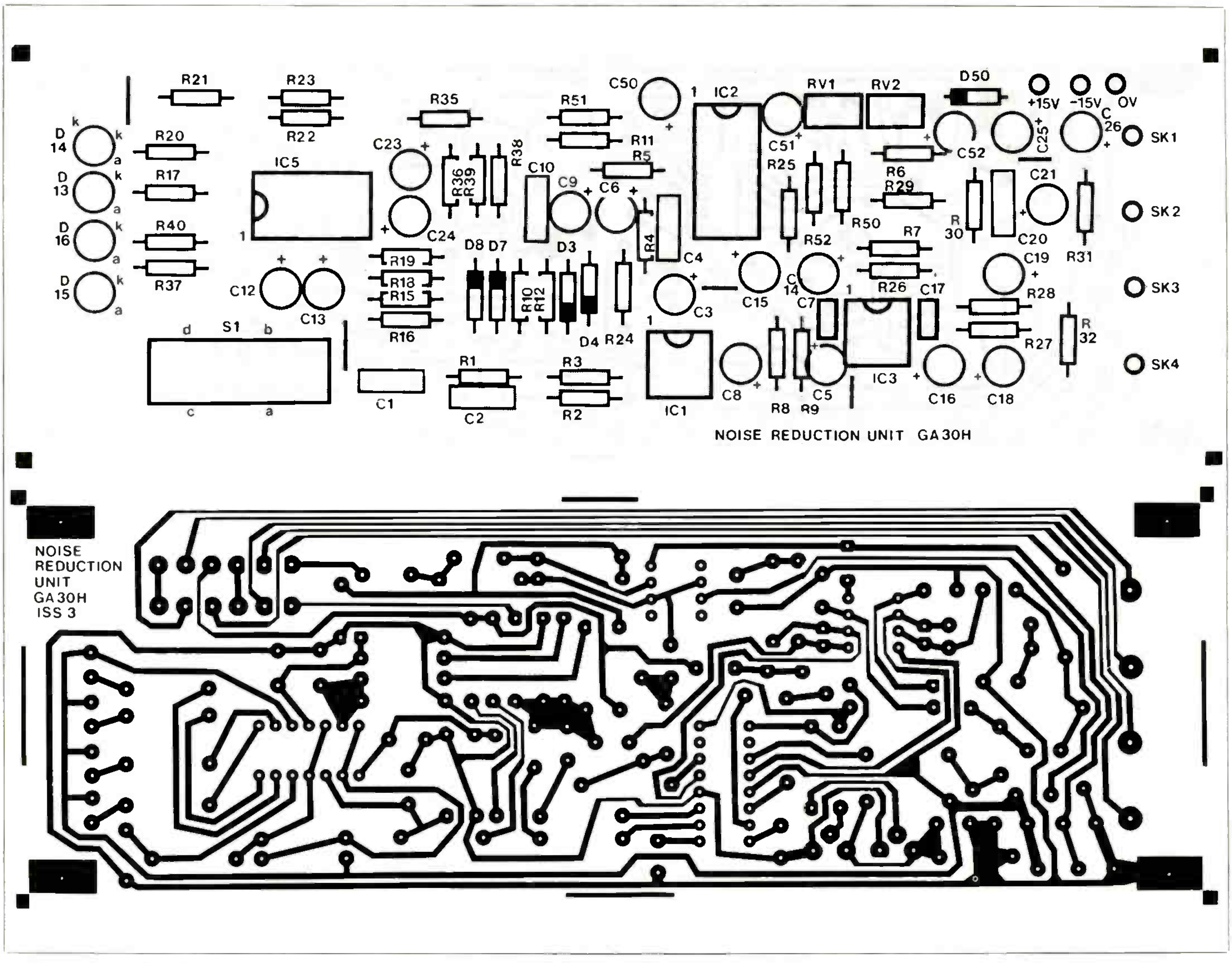
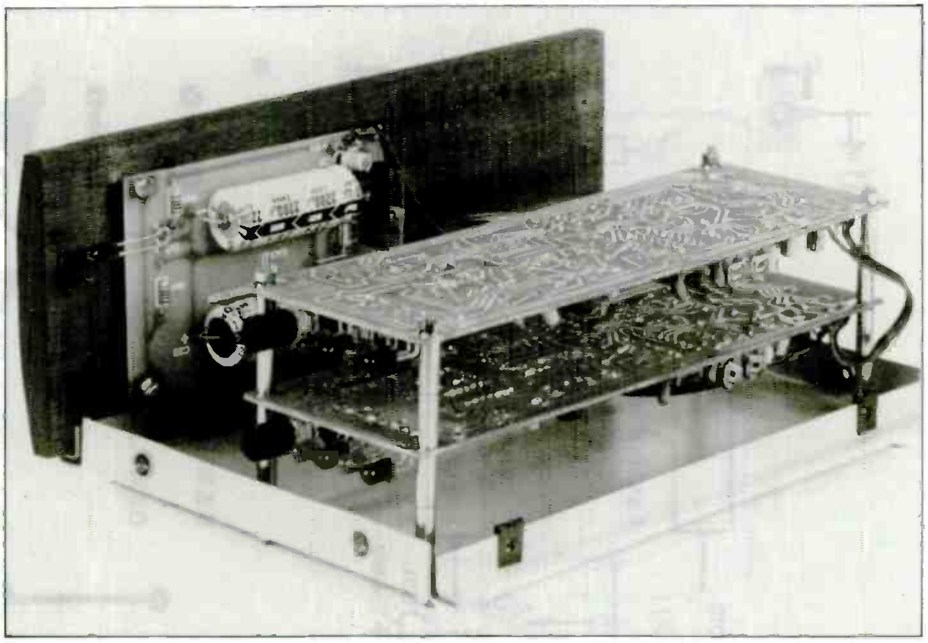



**Figure 4. Compander PCB**

signal which is compared with reference voltages derived from the potential divider network, R21, R22, and R23. The fast attack/slow decay operation of the comparators is determined by C13 and R19. IC5a and b respond to signal levels of, respectively, −3dBm and 0dBm.

The expander configures the other half of the NE570, IC2b, with a different arrangement of the various blocks. Once the off-tape signal has been routed via S1c to C14, the signal is applied to comparators, IC5c & d, to provide an indication of off-tape levels, and simultaneously to the full-wave rectifier and variable gain cell. The rectifier produces a control voltage that is used to adjust the gain cell, with a response time determined by C51. An RC network (R30, C20) is connected in parallel with the op-amp, IC3b, to provide a treble cut a 12dB, therefore de-emphasising the pre-emphasised signal emerging from the compressor via the tape recorder. When tion to the input signal is used to adjust the overall gain of the op-amp. A 6dB increase in output level produces a 6dB increase in the gain of the variable gain cell, since this is effectively an expander inserted in the feedback loop, this results in a 12dB increase in feedback current to the input of the op-amp. Consequently, an increase in input level of 12 dB results in only a 6dB increase at the output of the op-amp, thereby yielding the desired 2:1 dynamic range compression.

The current from the full-wave rectifier is averaged by an external filter capacitor (C50) with the result that the gain control is made proportional to the average value of the input signal. The speed with which this gain adjustment is made determines the transient response of the compressor and is a product of the value of the filter capacitor and an internal 10k resistor. The value of 2.2uF for C50 yields good transient response at average signal levels.



## Op-Amp Slew Rates

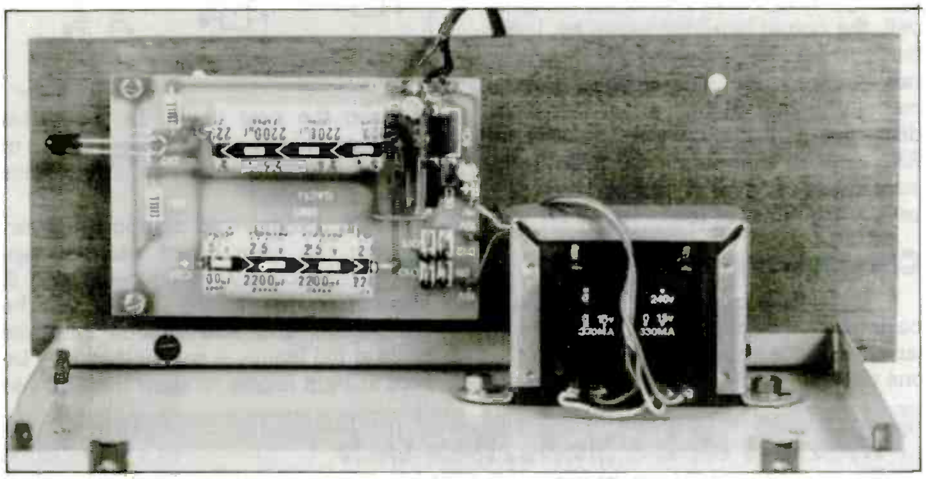
The RCR network (R8, C8, R9) around the op-amp, IC3a, provides DC feedback to bias the output at DC. C7 is an external compensation capacitor to provide stable operation over the audio bandwith. It may seem curious to use an external op-amp when the circuit diagrams indicate that the NE570 has its own. This is because the op-amps in this IC are equivalent to 741 types— with slew rate, noise, bandwidth, and output drive capability that are not really adequate for demanding audio applications. With weak signals, the compressor circuit operates at high gain and the NE570 op-amp runs out of loop gain. Furthurmore, a slew rate of 600mV per micro-second means that high frequencies will suffer. By using a J-FET op-amp, such as the LF351 with a slew rate of 13V per micro-second, these problems are eliminated. Additionally, the output swing can be larger since IC3a is powered by a dual supply rather than from the single-rail supply required by the NE570.

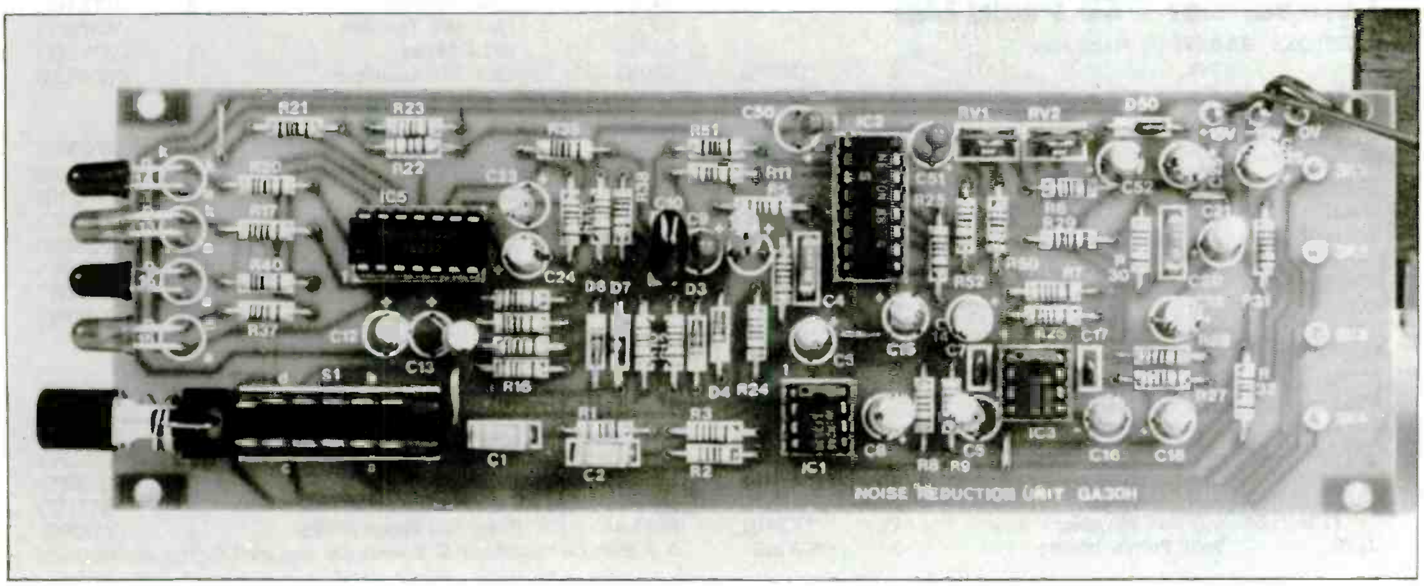
The non-inverting input of the NE570 op-amp is biased by an internal reference voltage of 1.8V. In the case of the external op-amp, IC3a, this is accomplished by tying it to pin 8 via an RC decoupling network (R7, C5) which filters out noise from the NE570 reference voltage. Pin 8 also serves another important function; providing the means for trimming distortion generated by IC2a. Even harmonic distortion is produced by voltage offsets in the variable gain cell, and RV1 enables adjustment of the offsets for minimum distortion.

## Comparator Functions

The function of R10 is to isolate the output of IC3a from the potential capacitive load of a long length of screened cable connected to the compressor output which could lead to oscillation. S1b selects the 'in' or 'out' mode of operation.

Comparators IC5a and b provide an indication of the signal level at the output of the compressor. The inverting inputs receive the half-wave rectified output





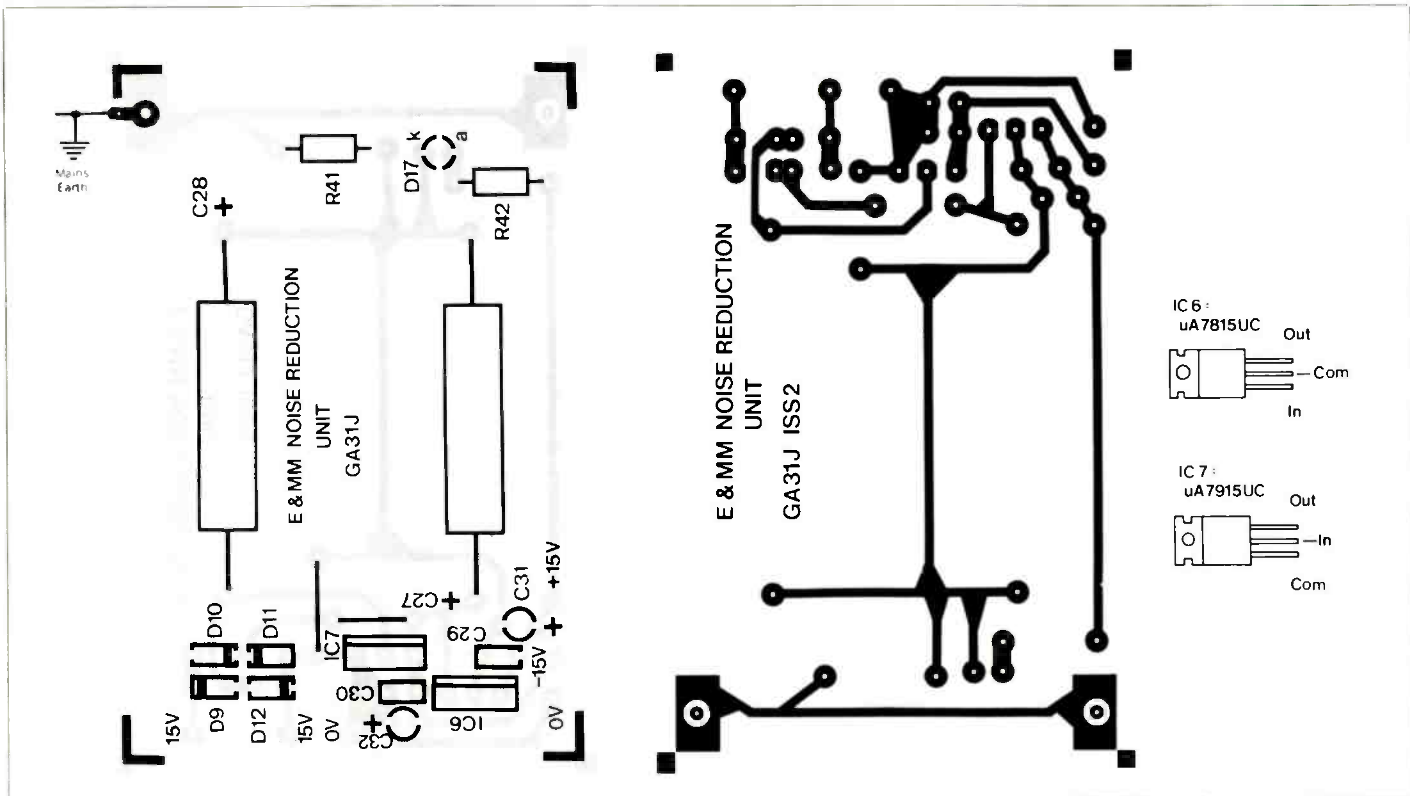
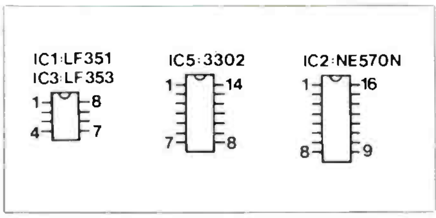



**Figure 5. Power Supply PCB**

the input signal increases by 6dB, the gain cell control current is raised by a factor of 2, resulting in an increase in gain of 6dB. Since the input of the external op-amp, IC3b, is derived from the gain cell, the output level increases by 12dB, thus giving the required 1:2 dynamic range expansion. RV2 enables adjustment of gain cell offsets for minimum distortion, as in the compressor. Finally, R32 isolates the output of IC3b from subsequent screened cable, and S1d selects the mode of use.

## Construction

The unit is designed on a modular basis so that each PCB provides simultaneous compression and expansion for one channel. Single sided PCB's are used




to keep the cost down. In order that decoding should be the exact inverse of coding, it is important that components are well matched.

PCB designs and component overlays for the main board and PSU are given, respectively, in figures 4 and 5. Remember to fit the LED's to the compander and PSU boards with the leads at full length – so that they may be bent at right angles to allow the LED's to protrude through the front panel of the unit. The threaded phono sockets suggested for the unit have the advantage of small physical size and compatability with the connectors normally encountered in Teacs, Revoxes and the like. These sockets are mounted on the rear panel and connections to the signal pins are made via short lengths of unscreened wire from the relevant points on the PCB's. The phono socket earth connections are linked together and connected to the earth (0V) line on each compander PCB – again using short lengths of unscreened wire.

The PSU is utterly standard, though it's important to note that mains earth is connected directly only to the PSU PCB and then indirectly via a 1K resistor (R41)

## Mark II Noise Reduction Unit Compander PCB Parts List

RESISTORS:- All 0.6W 1% Metal Film

| | | | |
|---|---|---|---|
| R1 | 39k | 1 | (M39K) |
| R2 | 82k | 1 | (M82K) |
| R3,4,12,24,30,31 | 100k | 6 | (M100K) |
| R5,11,25,29 | 22k | 4 | (M22K) |
| R6,7,26 | 1k | 3 | (M1K) |
| R8,9,27,28 | 47k | 4 | (M47K) |
| R10,32 | 56Ω | 2 | (M56R) |
| R15,17,18,20,35, 37,38,40 | 1k8 | 8 | (M1K8) |
| R16,19,36,39 | 1M | 4 | (M1M) |
| R21,51 | 10k | 2 | (M10K) |
| R22 | 3k9 | 1 | (M3K9) |
| R23 | 510k | 1 | (M510K) |
| R50,52 | 62k | 2 | (M62K) |
| RV1,2 | 22k Vert S-Min Preset | 2 | (WR72P) |

CAPACITORS

| | | | |
|---|---|---|---|
| C1,2 | 100nF Polycarbonate | 2 | (WW41U) |
| C3,5,12,13,15,16, 18,21,23,24,52 | 1μF 50V Minelect | 11 | (YY31J) |
| C4,20 | 3n3F Polycarbonate | 2 | (WW25C) |
| C6,8,14,19,25,26 | 10μF 40V Minelect | 6 | (YY35Q) |
| C7,17 | 10pF Ceramic | 2 | (WX44X) |
| C9 | 10μF 16V Tantalum | 1 | (WW68Y) |
| C10 | 100nF Mylar | 1 | (WW21X) |
| C50,51 | 2μ2F 35V Tantalum | 2 | (WW62S) |

SEMICONDUCTORS

| | | | |
|---|---|---|---|
| IC1 | LF 351 | 1 | (WQ30H) |
| IC2 | NE 570N | 1 | (QY10L) |
| IC3 | LF 353 | 1 | (WQ31J) |
| IC5 | 3302 | 1 | (QH48C) |
| D3,4,7,8 | 1N4148 | 4 | (QL80B) |
| D13,15 | 0.2in LED Green | 2 | (WL28F) |
| D14,16 | 0.2in LED Red | 2 | (WL27E) |
| D50 | BZY88C3V9 | 1 | (QH04E) |

MISCELLANEOUS

| | | | |
|---|---|---|---|
| | P.C.Board | 1 | (GA30H) |
| | D.I.L. Socket 8 Pin | 2 | (BL17T) |
| | D.I.L. Socket 14 Pin | 1 | (BL18U) |
| | D.I.L. Socket 16 Pin | 1 | (BL19V) |
| S1 | Latchswitch 4-pole | 1 | (FH68Y) |
| | Latchbutton Black | 1 | (BW13P) |
| SKT1-4 | Threaded Phono Socket | 4 | (YW06G) |

*N.B. Two Compander P.C. Boards are required for the Stereo Unit.*

## Power Supply PCB Parts List

| | | | |
|---|---|---|---|
| RESISTORS:- All 0.6W 1% Metal Film | | | |
| R41,42 | 1k | 2 | (M1K) |
| CAPACITORS | | | |
| C27,28 | 2200μF 25V Axial Electrolytic | 2 | (FB90X) |
| C29,30 | 100nF Minidisc Ceramic | 2 | (YR75S) |
| C31,32 | 10μF 40V Minelect | 2 | (YY35Q) |
| SEMICONDUCTORS | | | |
| IC6 | μA7815UC | 1 | (QL33L) |
| IC7 | μA7915UC | 1 | (QL36P) |
| D9-12 | 1N4002 | 4 | (QL74R) |
| D17 | 0.2in. LED Red | 1 | (WL27E) |
| MISCELLANEOUS | | | |
| | P.C.Board | 1 | (GA31J) |

## Miscellaneous Parts List

| | | | |
|---|---|---|---|
| S2 | DPDT Toggle Sub-Min E | 1 | (FH04E) |
| FS1 | 250mA Fuse 20mm | 1 | (WR01B) |
| | Safuseholder 20 | 1 | (RX96E) |
| T1 | Transformer 15V/15V | 1 | (LY03D) |
| | Hook-up Wire | 3m | (BL00A) |
| | Mains Cable Black 3Amp | 2m | (XR01B) |
| | Grommet Strain Relief | 1 | (LR48C) |
| OPTIONAL ITEMS | | | |
| | 3 Pin DIN Socket | 1 | (HH32K) |
| | 3 Pin DIN Plug | 1 | (HH25C) |
| RVA,RVB | 10k Hor S-Min Preset | 2 | (WR58N) |
| | Case | 1 | (XG37S) |
| | Printed Front Plate | 1 | (FJ35Q) |
| | Stick-on-feet | 1 pkt | (FW38R) |

A complete kit of parts (excluding optional items) for a stereo Mark II N/R Unit is available.
**Order As LK38R (Mark II N/R Unit)**

to the 0V line. This should prevent the build up of any hum loop when using the noise reduction unit with earthed equipment. Power line buses are connected from the PSU to each compander PCB.

The power supply and two compander PCB's can be mounted in the optional case using the bolts and spacers, to form a stereo noise reduction unit.The front panel can be drilled using the optional, self adhesive, face plate as a template. If four channel operation is required power supply outputs are connected to a 3 pin DIN socket, a second N/R Unit consisting only of two compander boards can then be connected using a 3 pin DIN plug.

## Setting-up and Use

The unit requires very little setting-up apart from adjustment of RV1 and RV2 which are simply set to mid-travel, thus ensuring a low distortion level of well within 0.1% typical. Furthur adjustment with a distortion analyser will allow minimum levels to be reached (0.06% typical).

If the unit is being used with a mixer and a tape recorder with variable line output, the mixer output is adjusted so that the compressor 0dBm LED's fire at peak sound levels. The record level is set to match the optimum for the tape being used. Playback levels are then adjusted so that the expander 0dBm LED's fire at approximately the same level as the compressor 0dBm LED's. When the noise reduction unit is used with an amplifier or tape recorder where the line output levels are not adjustable the 0dBm LED's should fire at peak sound levels, providing the equipment is to Hi-Fi specification. However, this level isn't critical since the level-adaptive response time circuits take care of possible mistracking, but it does ensure really accurate decoding of the encoded signal.

In order to adjust output levels and avoid overloading the input to equipment not to Hi-Fi standards, it may be necessary to insert preset potentiometers of 10k (RVa & RVb) in the output of the expander and compressor circuits (between R10 & S1b and between R32 & S1d)

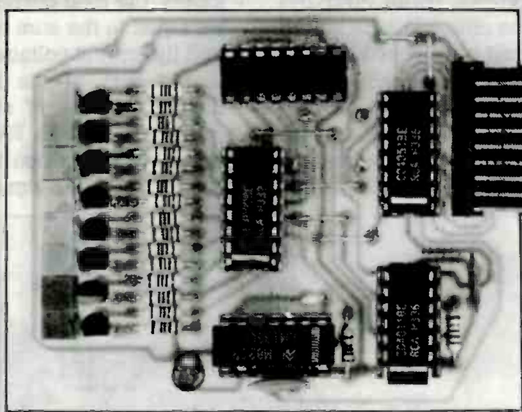
A couple of points to note: the unit will not reduce the noise present in a noisy signal applied to the compressor input (this is territory best served by dynamic noise limiters), and any difference in the signal between compressor output and expander input introduced by the recording process will be exaggerated by expansion, including such horrors as common-or-garden dropouts. Therefore to get the best out of the unit scrupulous attention should be paid to alignment and cleaning of tape heads!

**8 CHANNEL FLUID DETECTOR** *Continued from page 5.*

inserted in the positions for channels one and two, as a warning condition is now required when the water content is getting low. If you are using the idea in an estate car or any other car with a rear window washing facility then use two probes; channels 1-4 for one bottle and channels 5-8 for the other, and this time insert one red LED in channel one and the other in channel five. The strip of Veroboard was found to be ideal in this application.

Case two was for an installation which had a number of large tanks. These gradually drained over a period of time but when they got down to a predetermined level they were to be refilled by opening an electronically controlled valve. Here two channels were used for each tank, one channel opening the valve when fluid dropped below the minimum level, and the other closing the valve when the tank was full. Four tanks were able to be controlled by the one board.

Case three was for use in a nurseryman's greenhouses. The grower in question used mist spayers in his



houses which gave the plants a good spraying whenever the water had evaporated from the surface of the probes, which were placed at regular intervals between the plants. The mist was turned off again when enough water had fallen to bridge the gap on the probe and therefore detect the presence of water again. As he grew a large number of different plants at different temparatures and humidity, he was able to use each channel separately to give individual monitoring and control for all the environments he required.

There are obviously a great many more ways in which this circuit could be used, and these suggestions are only here to demonstrate the wide range of uses in which this project may be put to work.

*Continued on page 16.*


# Mapmix - Six Channel Audio Mixer

by
Dave Goodman

- ★ Twin VU Meters
- ★ Battery Operation
- ★ Master Volume Control
- ★ Switched Mono/Stereo Modes
- ★ Bass and Treble Equalisation
- ★ Six Microphone or Instrument Inputs

## Introduction

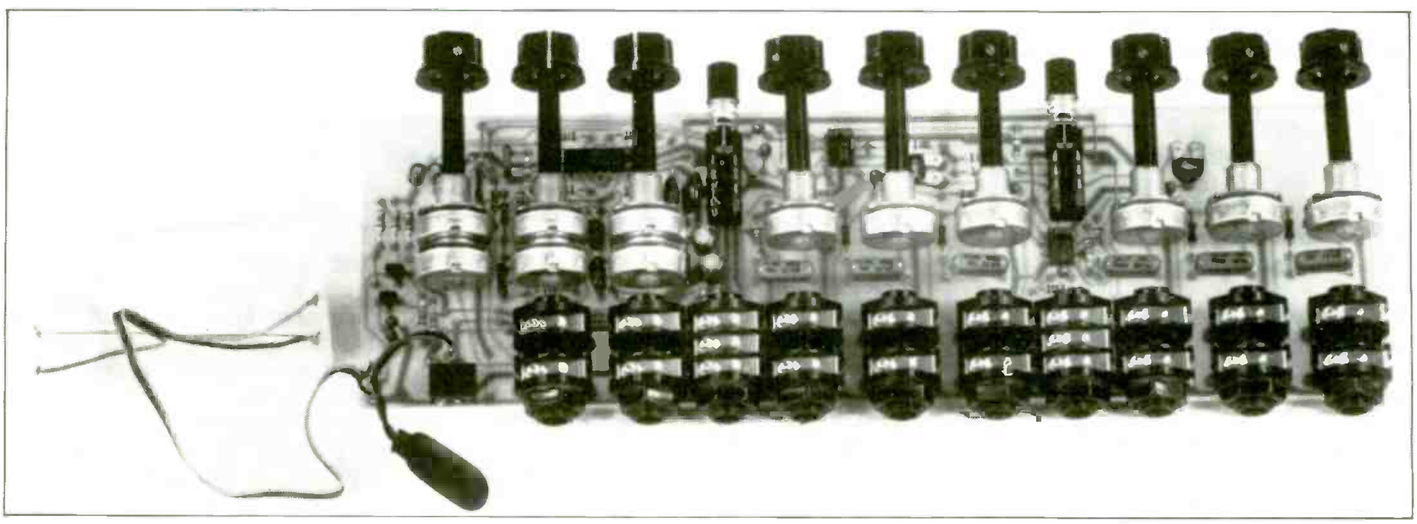
The Mapmix is a versatile six input mixer, in the stereo mode it has three inputs connected to the left channel and three inputs connected to the right channel. For mono use all six inputs are connected to both output jacks via the mode select switch. Both left and right channels have separate post-mix send/receive facilities, for connecting external effects units. Tonal balance can be modified with Bass and Treble controls. The twin VU meter gives an indication of final output levels although it is unaffected by the master volume control, which is connected to the output. All input and output connections are made with standard ¼ inch mono jack sockets, while send and receive connections utilise ¼ inch stereo jack sockets. The unit is powered by a 9V battery – so current consumption has been kept at a very low level, to prolong battery life. However, external DC power supplies can be connected using the 2.1mm power socket.

## Circuit Description

Low power IC's are used to keep power requirements to a minimum – approximately 1.75mA quiescent current at 9V. IC1a and b are configured as virtual earth mixers with inverted outputs and can be referred to as 'adders'. For the left channel, input signals are applied to IC1b via SK1 to 3 with signal attenuation, or volume control, being performed by RV1 to 3. Resistors R1 to 3 and R7 have the same value, a signal applied to SK1 only, will appear at C7 +V in inverted form, but at the same amplitude as the input. Thus the mixer exhibits a unity gain characteristic under this condition. If signals are now applied to all three inputs, the total current flowing in R7 will be equal to the sum of the input current's and the output voltage at C7 will be equal to the sum of the input voltages. For instance, a 100mV signal applied to all three inputs, with RV1 to 3 set to maximum, will produce the sum product of 300mV at C7; the signals being effectively 'added' together.

Blocking capacitors C1 to 3 isolate IC1b from possible DC level changes present at the input jacks; the input impedance of each channel is set by the volume control resistance at 100k ohms. R11 carries the mixer output to the send terminal, this being the 'tip' connection of a stereo jack plug. Without a plug inserted into SK4, the switched connections direct the signal path to S1 and IC2a, another inter-stage unity gain mixer, which re-inverts the input signal and provides a low impedance drive to the tone control stages which follow. S1 is shown operated, which is the mono mode, thus IC2b receives the same input signal as IC2a.

When an external device is inserted into SK4, both 'tip' and 'ring' are disconnected by the internal switching and receive inputs are connected to IC2a via level preset RV10. Effects units such as echo, phase, reverb or perhaps another mixer can be inserted here and mixed



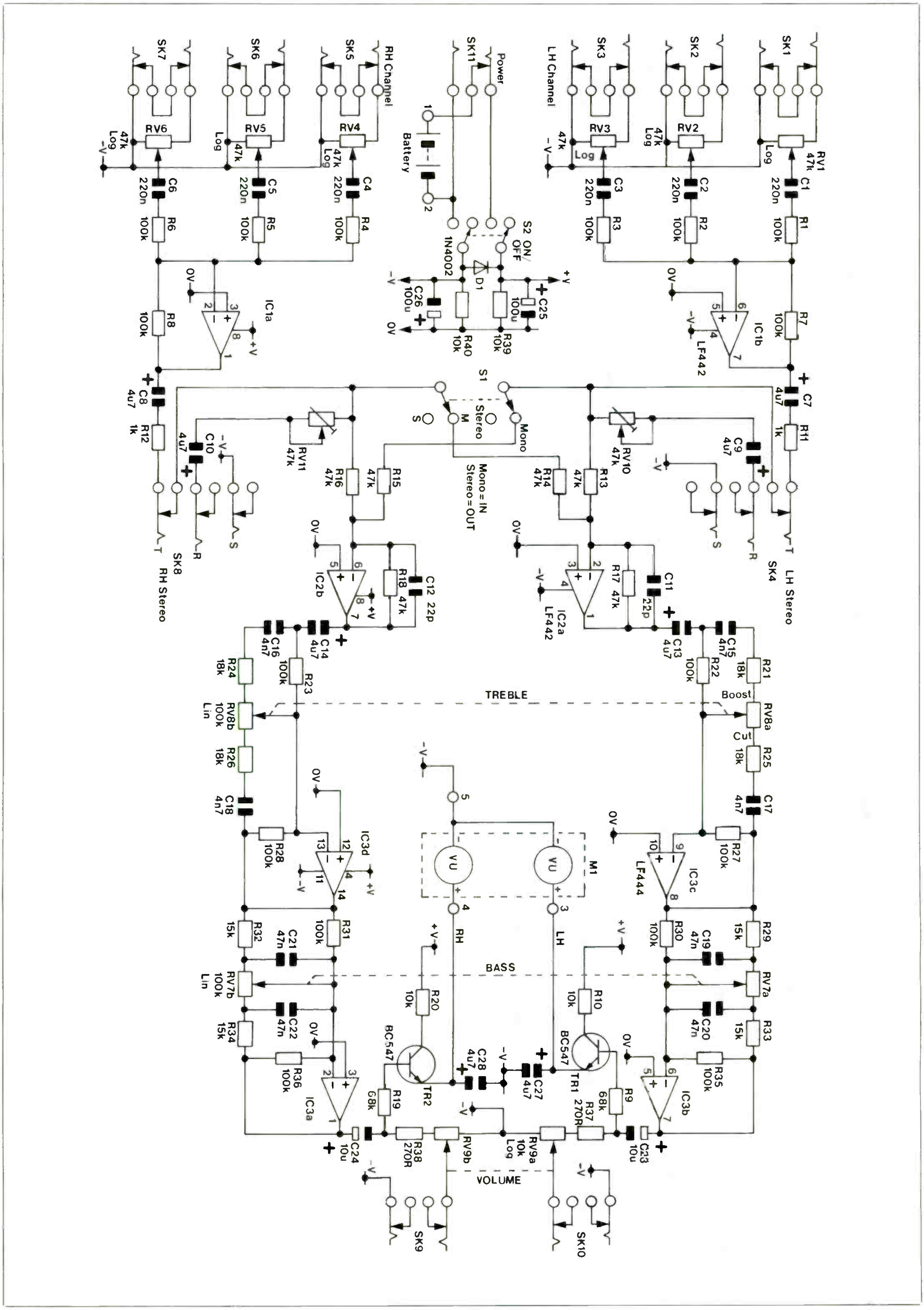
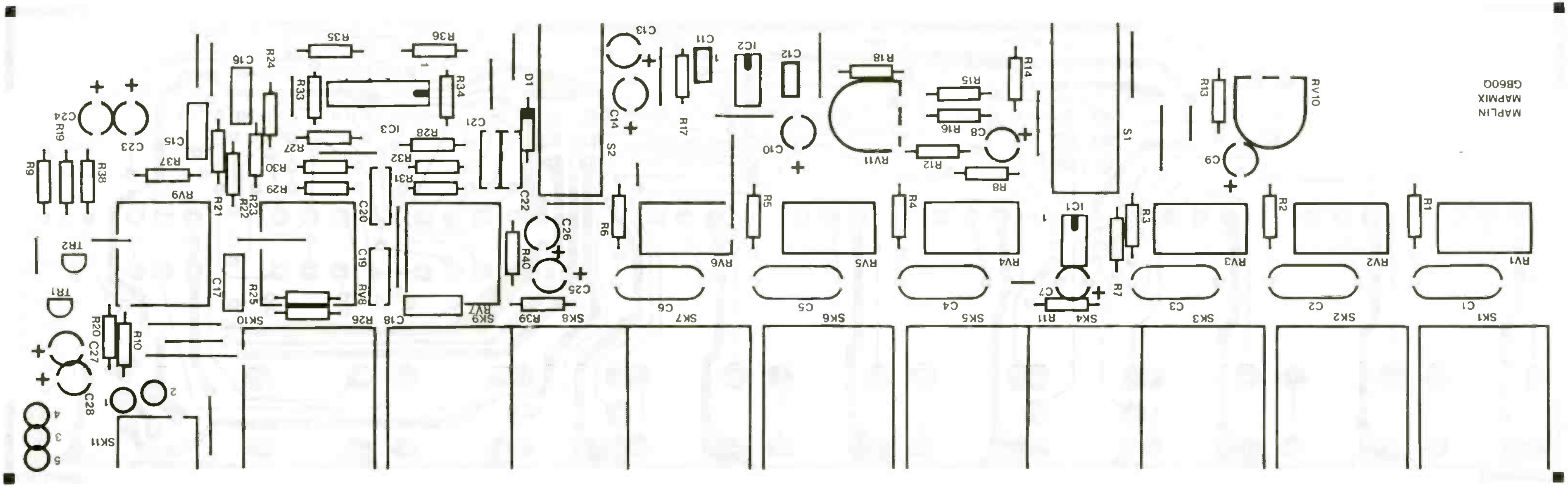



Figure 1 Circuit Diagram



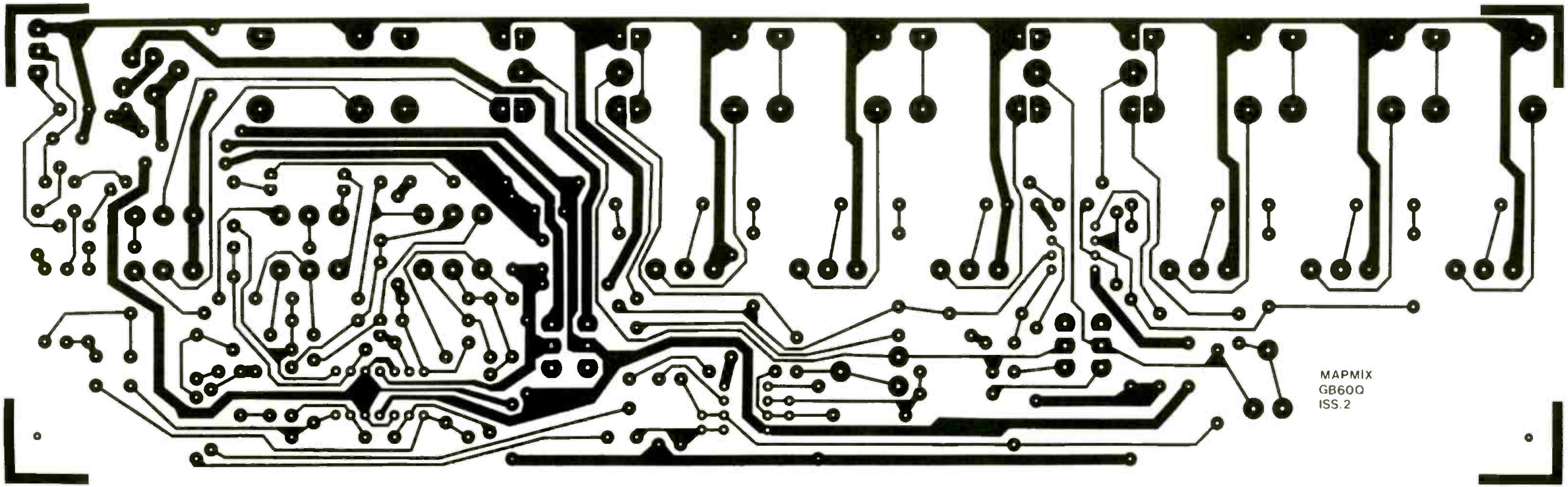



**Figure 2 Artwork & Legend**

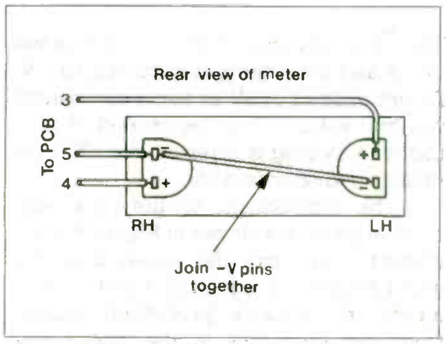



**Figure 3 Meter Wiring**

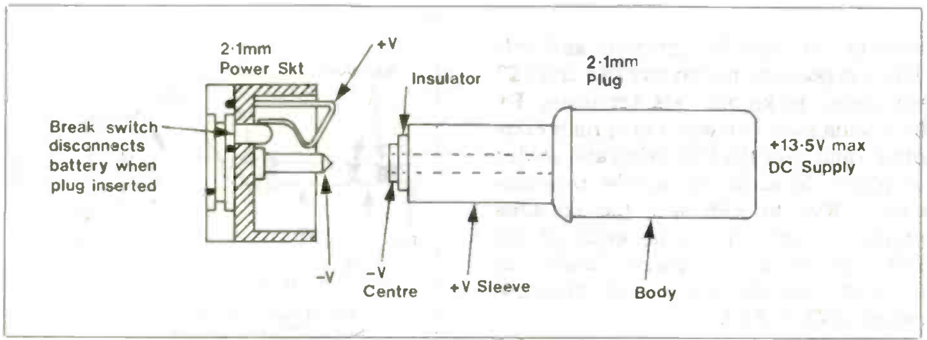



**Figure 4 Power Plug & Socket**

into the rest of the system. IC1a and IC2b function in exactly the same way as previously described for the left channel. Switching S1 out of circuit establishes the stereo mode, where left and right channels become independent of each other.

IC3c and d form the active section of the treble control RV8, which is a dual potentiometer. Both channels, although electrically independent, can be set for flat response by keeping the wipers central. A boost of up to 10dB at 10kHz can be applied by turning the wiper of RV8 clockwise and a cut of 10dB by turning anti-clockwise. Similarly IC3b and IC3a form the active section of bass control RV7, another dual potentiometer. This control gives up to 10dB boost or cut at 40Hz when rotated clockwise or anti-clockwise respectively. Separate active filters are used to keep interaction to a minimum, for improved performance and to lessen the effects of distortion – which can be noticeable in multi-feedback type systems. R37 (38) is located in the output stage to prevent IC3b from drawing excessive supply current if the output connecting cable is shorted out, whilst RV9 (master volume control) is set at maximum. This raises the output impedance slightly, to about 1k ohm, or 10k ohm at low output volume settings – this is, however, adequate for most audio amplifier input stages.

Emitter follower TR1 (TR2) charges capacitor C27 (C28) to produce a mean DC average from the outgoing AC signal, this capacitor also dampens the meter response – otherwise it would be unreadable, with the needle bouncing around on its mountings! Switched potential dividing stages have not been incorporated with the meter, so low level input signals applied to the mixer will not be registered on the scale. Zero on the scale corresponds to approximately 0dB (+or− 1dB) or 775mV at 1kHz applied to one input, maximum volume, mono mode and tone controls set flat. The maximum scale reading corresponds to an output level of 1.6V RMS (4V peak to peak), which is some 2dB down on the absolute signal handling capability of the mixer. Because the input levels can be continuously variable it is possible that signals of a few millivolts to a few dozen volts can be connected to the system. The maximum signal that any one channel can handle is 500mV – with the volume set to maximum and sufficient margin allowed for bass and treble boost. Of course higher input signal levels simply require the volume control to be turned down.

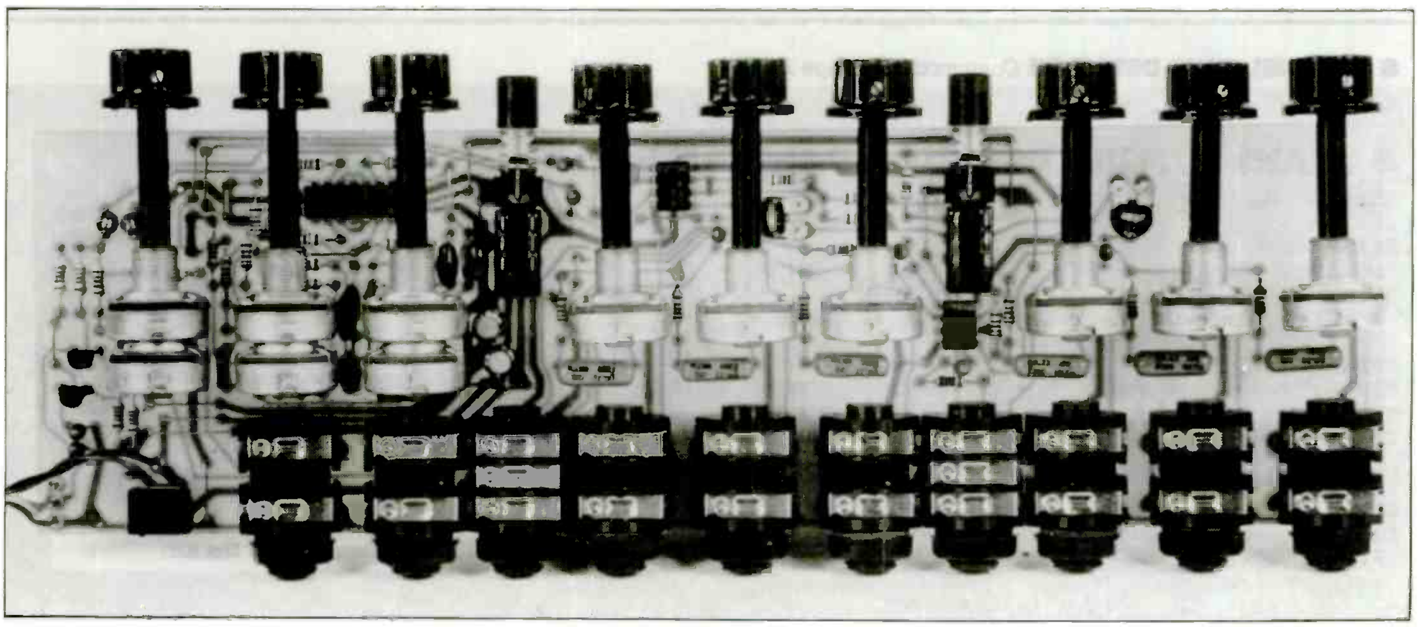
**Prototype Specifications:–**

| | |
|---|---|
| Power Requirement: | 1.75mA with 9V battery (eg PP3). Or fully regulated external PSU – max 13.5V DC. |
| Frequency Response: | 25Hz – 30kHz ±1dB |
| Bass Control: | ±10dB at 40Hz |
| Treble Control: | ±10dB at 10kHz |
| Meter Response: | 50Hz ±1dB |
| LHC/RHC Tracking: | ±1dB |
| Signal To Noise: | Better than 65dB |
| Distortion: | <0.05% at 1kHz – flat |
| Input Impedance: | 100k ohm each channel |
| Output Impedance: | 1k ohm at max. setting |

## PCB Assembly

Refer to the parts list for component values and Figure 2 (legend/overlay) for designations. Begin construction by inserting each of the 25 links, using 24SWG B.T.C. Next insert the 40 resistors into their respective positions, the PCB hole spacing is set at 13mm and each resistor lead must be bent to fit and then pushed firmly onto the board. Mount both 47k presets, RV10 & RV11, and diode D1 making sure of correct polarisation. Now fit IC's 1 to 3, these must be fitted correctly – pin 1 is usually marked with a small hole or indentation, occasionally a 'D' shaped concave slot is cut into one end of the body; if the IC is held with this slot facing to the left, with the pins facing down, then pin 1 is the first on the bottom row.

Solder the part assembled board at this stage and remove all excess wire ends. Next the capacitors can be fitted. C1 to C6 are polyester types and mount in-line across the centre of the board. C7 to 10 and C13,14,27,28 are polarised types with long +V leads and short −V leads, ensure they are mounted correctly to the PCB legend. C23 to 26 are PCB mounting electrolytics, which are of course polarised, only the −V lead is identified so care must be taken to fit these components correctly. Now fit TR1 & TR2 and power socket (SK11) along with the five Vero pins which are inserted from the track side of the PCB, finally solder these components. The ten PC mounting jack



sockets can now be inserted and soldered in position, noting that SK4 and SK8 are stereo jacks with six terminals. Fit both latch switches with the sprung ends protruding over the PCB edge and solder in place. Now fit the single potentiometers RV1 to RV6 with the spindles protruding over the same edge of the PCB and solder in place; finally do likewise with the three dual potentiometers RV7 to RV9.

Closely inspect all solder joints, for excess solder, shorts, dry joints etc, and clean the PCB track with a suitable solvent. Re-check all components, values etc and when satisified connect the PP3 type battery clip with the red (+V) to pin 1 and the black (−V) to pin 2.

If the dual VU meter is being used then it must be wired to the PCB pins 3,4 & 5 (see Figure 3) using hook-up wire. Both −V terminals on the meter movements should be joined together and connected to −V supply pin 5, as shown.

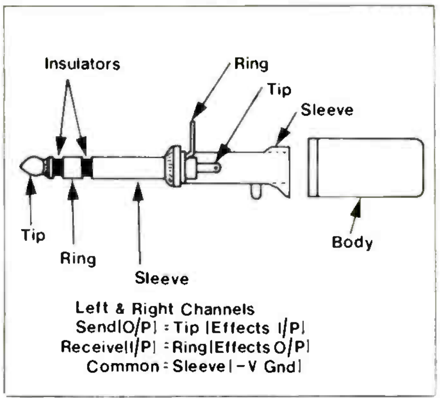



**Figure 5 Stereo Jack Connections**

## Using the Mixer

Details of connection to an external power supply are shown in Figure 4. The inner terminal of SK11 is connected to −V and the outer spring contact to +V. Do not exceed 13.5V as some component working voltages may be exceeded, note that when a plug is inserted into SK11 the battery is disconnected.

The connections to the send and receive jacks are shown in Figure 5, send outputs (tip) carry the signal from the mixer to external equipment and receive inputs (ring) carry processed signals from the equipment to the mixer. The sleeve terminal is for screen connection or earth return.

It should be borne in mind when using the mixer that amplification is low, the unit does not act as a pre-amplifier. Thus when mixing microphone, musical instrument or line output levels, as recommended, an amplifier with integral pre-amp or a power amp and suitable pre-amp should be used.

# MAPMIX PARTS LIST

| RESISTORS:- All 0.6W 1% Metal Film | | | |
|---|---|---|---|
| R1-8,22,23,27,28, 30,31,35,36 | 100k | 16 | (M100K) |
| R9,19 | 68k | 2 | (M68K) |
| R10,20,39,40 | 10k | 4 | (M10K) |
| R11,12 | 1k | 2 | (M1K) |
| R13-18 | 47k | 6 | (M47K) |
| R21,24,25,26 | 18k | 4 | (M18K) |
| R29,32,33,34 | 15k | 4 | (M15K) |
| R37,38 | 270Ω | 2 | (M270R) |
| RV1-6 | 47k Log Pot | 6 | (FW24B) |
| RV7,8 | 100k Lin Pot Dual | 2 | (FW88V) |
| RV9 | 10k Log Pot Dual | 1 | (FX09K) |
| RV10,11 | 47k Hor Sub-Min Preset | 2 | (WR60Q) |
| **CAPACITORS** | | | |
| C1-6 | 220nF Polyester | 6 | (BX78K) |
| C7-10,13,14,27,28 | 4μ7F Tantalum | 8 | (WW64U) |
| C11,12 | 22pF Ceramic | 2 | (WX48C) |
| C15-18 | 4n7F Polycarbonate | 4 | (WW26D) |
| C19-22 | 47nF Mylar | 4 | (WW20W) |
| C23,24 | 10μF 16V Minielect | 2 | (YY34M) |
| C25,26 | 100μF 10V PC Electrolytic | 2 | (FF10L) |
| **SEMICONDUCTORS** | | | |
| D1 | 1N4002 | 1 | (QL74R) |
| IC1,2 | LF442 | 2 | (QY30H) |
| IC3 | LF444 | 1 | (QY31J) |
| TR1,2 | BC547 | 2 | (QQ14Q) |
| **MISCELLANEOUS** | | | |
| SK1-3,5-7,9,10 | PCB Jack Skt Mono | 8 | (FJ00A) |
| SK4,8 | PCB Jack Skt Stereo | 2 | (FJ05F) |
| SK11 | PC Mtg Power Skt | 1 | (RK37S) |
| S1,2 | Soft Latchswitch 2-Pole | 2 | (BW11M) |
| M1 | Dual VU Meter | 1 | (YQ47B) |
| | Small Latchbutton Black | 2 | (BW13P) |
| | Knob K7A | 9 | (YX01B) |
| | Veropin 2141 | 1 pkt | (FL21X) |
| | Battery Clip | 1 | (HF28F) |
| | Mapmix PCB | 1 | (GB60Q) |
| **OPTIONAL** | | | |
| | Mapmix Case | 1 | (XG38R) |
| | Printed Front Panel | 1 | (FJ36P) |

A kit of parts (excluding optional items) is available.
**Order As LK49D (Mapmix Kit)**

**8 CHANNEL FLUID DETECTOR** *Continued from page 11.*

# 8 CHANNEL FLUID DETECTOR PARTS LIST

| RESISTORS: All 0.6W 1% Metal Film | | | |
|---|---|---|---|
| R1 | 1M | 1 | (M1M) |
| R2,3,5,7,9,11, 13,15,17 | 1k0 | 9 | (M1K) |
| R4,6,8,10,12, 14,16,18 | 10k | 8 | (M10K) |
| **CAPACITORS** | | | |
| C1,2 | 47nF Minidisc | 2 | (YR74R) |
| C3 | 1nF Ceramic | 1 | (WX68Y) |
| C4 | 22μF 16V PC Electrolytic | 1 | (FF06G) |
| **SEMICONDUCTORS** | | | |
| D1-6 | Shape LED R1 Green | 6 | (YY46A) |
| D7,8 | Shape LED R1 Red | 2 | (YY45Y) |
| TR1-8 | BC547 | 8 | (QQ14Q) |
| IC1 | 4051BE | 1 | (QW34M) |
| IC2 | LM1830 | 1 | (YY99H) |
| IC3 | 4099BE | 1 | (QW57M) |
| IC4 | 4011BE | 1 | (QX05F) |
| IC5 | 4518BE | 1 | (QX32K) |
| **MISCELLANEOUS** | | | |
| PL1 | RA Minicon Latch Plug 10-Way | 1 | (RK68Y) |
| | DIL Socket 14-pin | 2 | (BL18U) |
| | DIL Socket 16-pin | 3 | (BL19V) |
| | PC Board | 1 | (GB66W) |
| | Strapping Wire | 1 roll | (BL13P) |

A complete kit of parts is available for this project.
**Order As LK48C (8-Channel Fluid Det Kit)**

# -CAUTIOUS- NI-CAD CHARGER

by B. Puttock & D.J. Silvester

## Introduction

The accepted life for most Ni-Cad cells is five hundred charge/discharge cycles, however this sort of life can only be achieved if some care is taken over the treatment of the cells. A number of chargers are available commercially and many High Street shops are now selling both batteries and chargers. These chargers are only able to charge a limited number of cells at one time (usually 4), have a fixed charge time of about 15 hours and no provision for high speed charging of scintered cells.

The overcharging of cells is detrimental to their useful life, most manufacturers state their cells must not be charged for more than 14 to 16 hours at the recommended charge current. However, no commercial charger appears to offer an automatic timing system. Partially used cells are normally treated as though they were completely discharged and will consequently be substantially overcharged by a commercial unit.

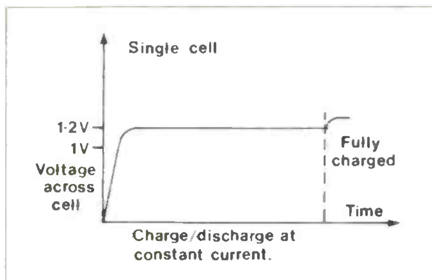
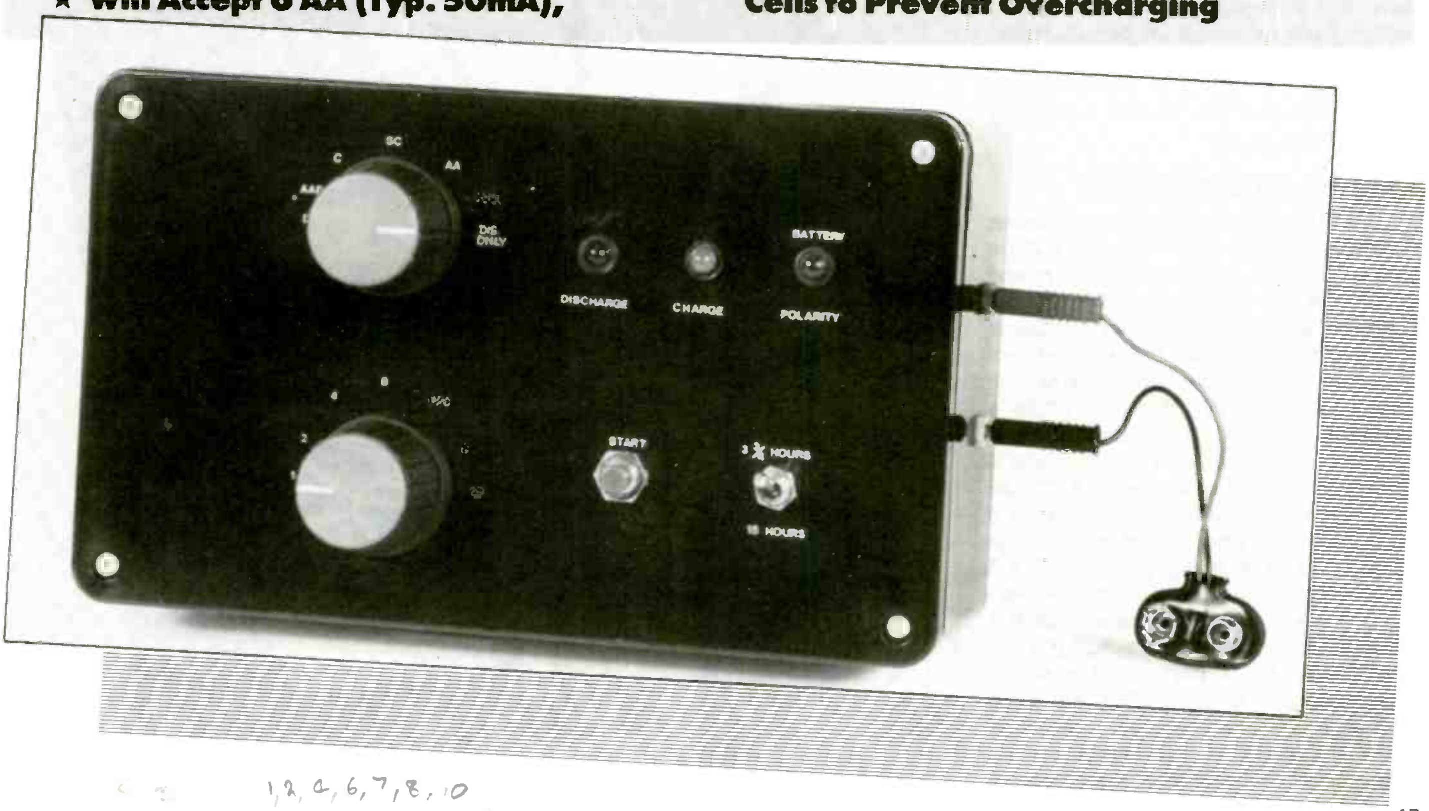



**Figure 1 Single Cell Discharge**

The discharge of a single cell at a constant current is shown in Figure 1. The voltage across the cell remains constant at about 1.2V until the remaining charge is below 10% of the full charge – then the voltage drops rapidly. Recharging the cell raises the voltage across the cell to between 1.3 and 1.4 volts very rapidly, where it remains until the cell becomes overcharged, the voltage then rises slightly before becoming constant again.

In order to charge a variety of batteries this design uses the discharge voltage of 1V per cell to initiate the charge cycle, which is then carried out at constant current for either 3¾ or 15 hours depending on cell type. To satisfy a number of interests, including photography and amateur radio, the unit is able to charge a range of batteries, from a single AA cell to a bank of up to 6 cells – which will provide a 12V supply. Consequently switched reference voltages are used to detect the end of the discharge cycle and various charge rates are

- ★ **Battery Polarity Sensor**
- ★ **Constant Current Charging**
- ★ **Fast Charge for Scintered Cells**
- ★ **Electronic Timing of Charge Cycle**
- ★ **Will Accept up to 6 Cells**
- ★ **Will Accept 6 AA (Typ. 50mA), 6 AAF (Typ. 190mA), 6 C (Typ. 180mA), 3 D (Typ. 380mA), 6 SC (Typ. 130mA)**
- ★ **Trickle Charge to Maintain Cells in Fully Charged Condition**
- ★ **Discharge Facility for Part Charged Cells to Prevent Overcharging**




1,2,4,6,7,8,10

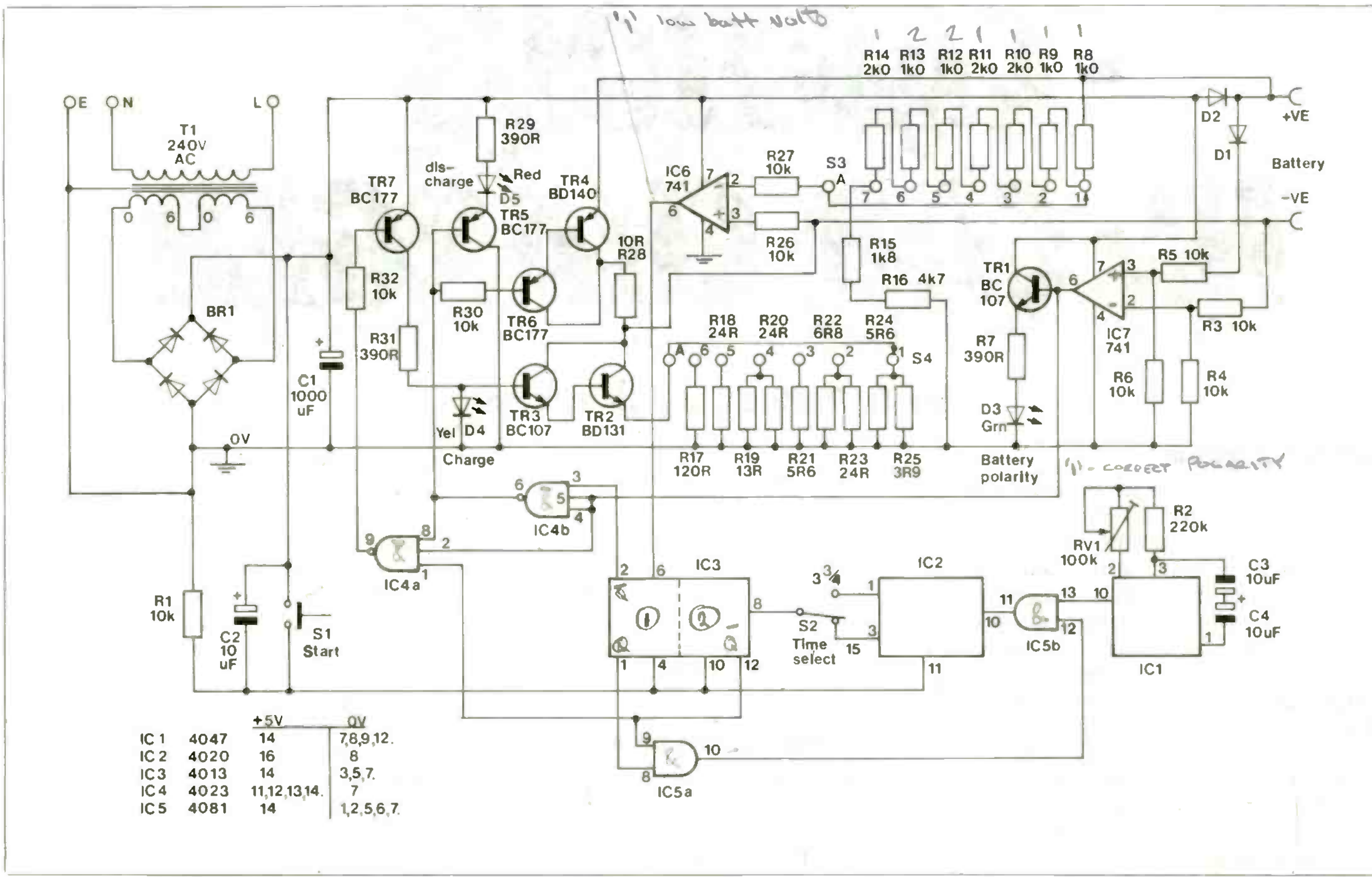


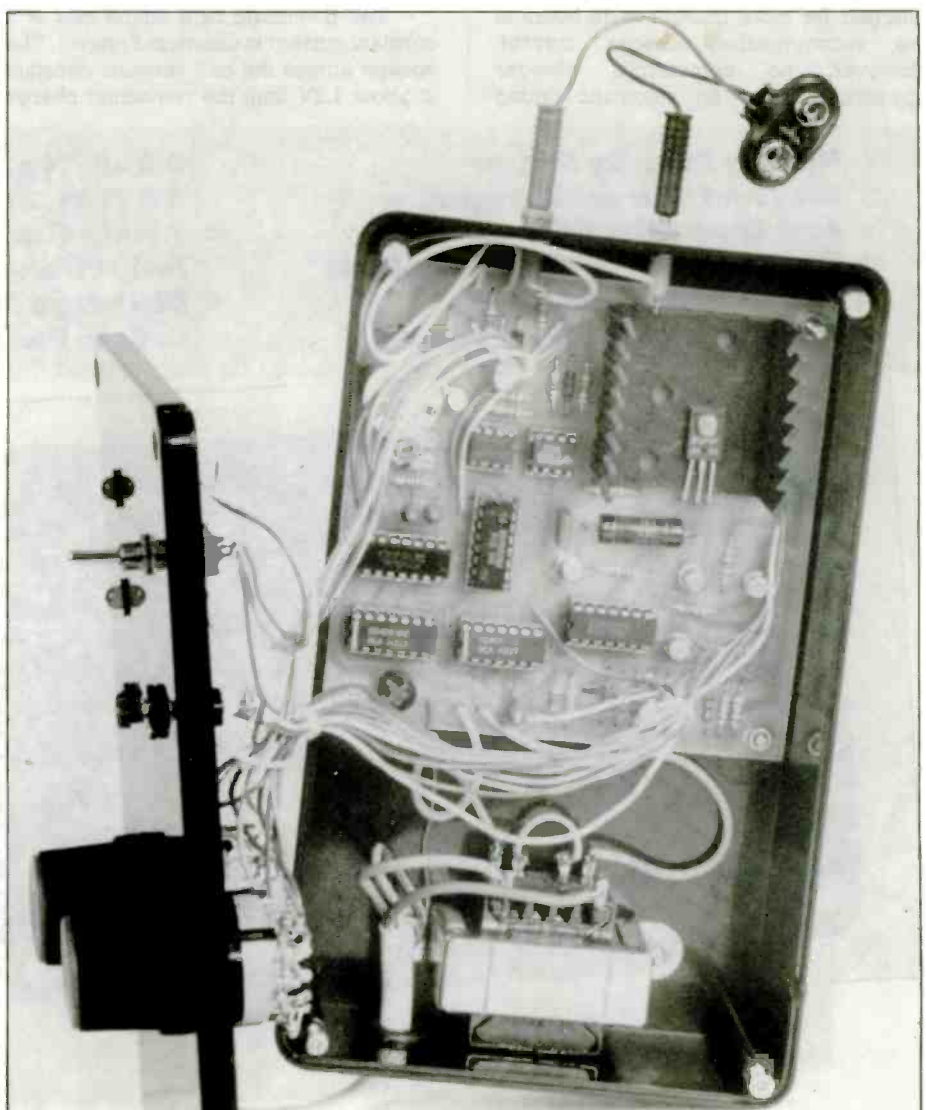

**Figure 2 Circuit Diagram**

offered. A discharge only facility is also offered for cases where a new battery pack is to be made up from old cells in various charge conditions. After discharging each of the cells individually, they can then be recharged as a battery pack so that each of the cells is equally charged.

To accommodate the charging of various types of batteries the output is connected to a PP3 type clip, which can then be connected to the required battery pack (although for certain single cells the connection to the battery holder will need to be soldered). For full details of battery holders see page 42 of the 1986 Maplin Catalogue.

## Circuit Description

T1, BR1 and C1 are used to convert AC mains input to 16.5V DC, the voltage used to drive all of the logic circuitry and to charge the batteries (see circuit diagram Figure 2). The circuit consisting of D1, R3 to R6 and IC7 is used to detect that the battery to be charged is connected correctly. Normally when a battery is regarded as being discharged it in fact still produces a small potential difference across its terminals. R3 to R6 form a potential divider so that if the two battery contacts are shorted together the inputs to the voltage comparator IC7 will be the same, ignoring resistance tolerances. To ensure that in this condition IC7 produces an error signal, i.e. IC7 pin 6 is low voltage, D1 is introduced to unbalance the divider chain. The off-set is extremely low and will be overcome when a battery is connected to the charging terminals in the correct manner.



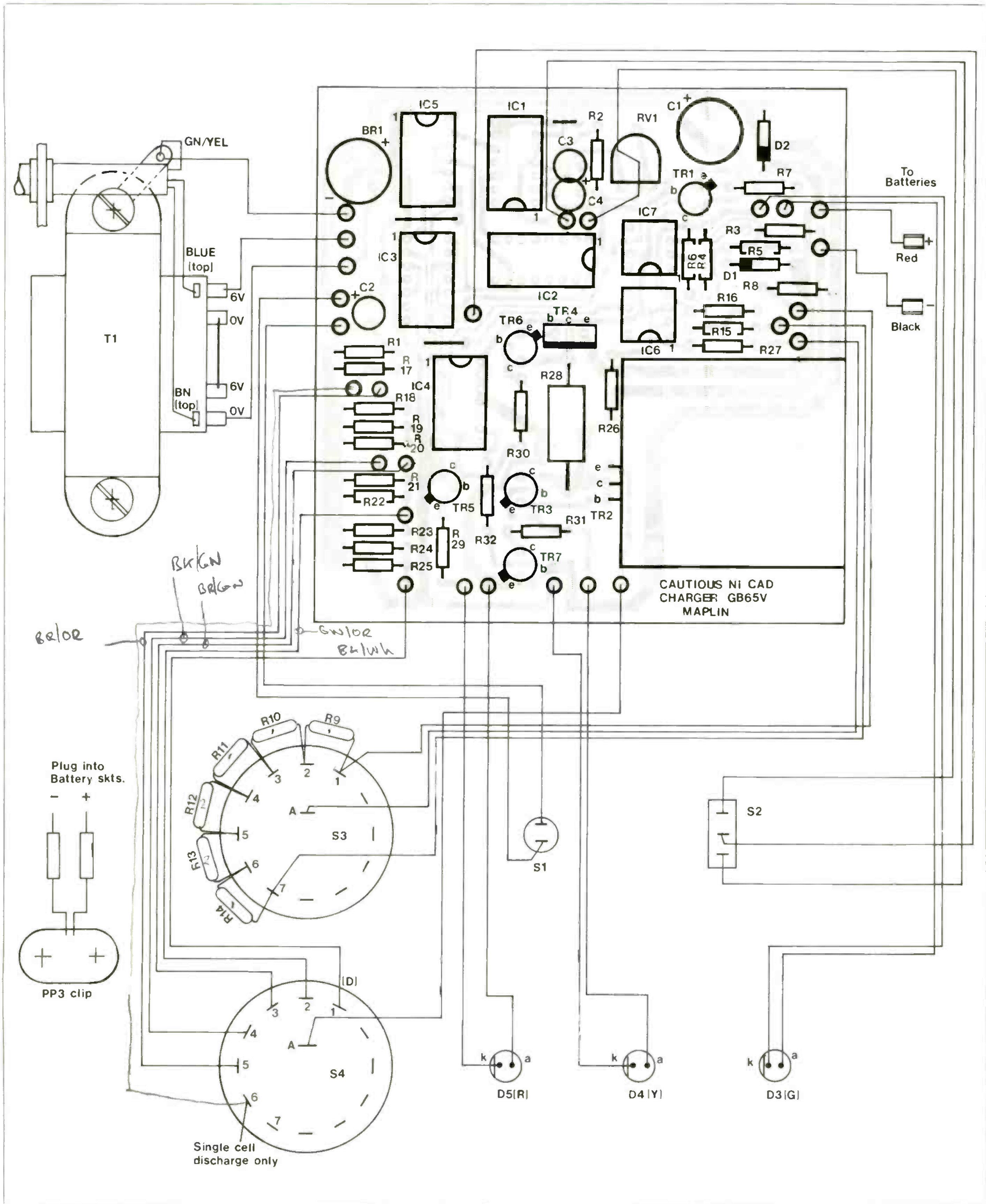
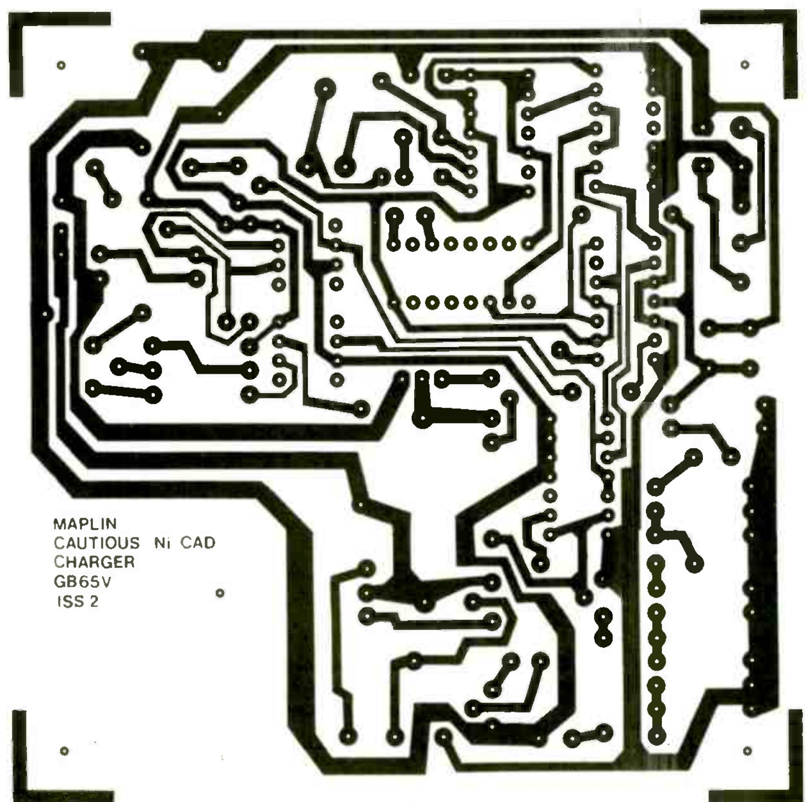



**Figure 3 PCB Track Legend & Wiring Diagram**

IC7 pin 6 will then become high. An incorrectly inserted battery will reinforce the off-set introduced by D1.

TR1, R7 and green LED D3 are used to indicate the voltage level, i.e. logic state, of the output of IC7 – when D3 is illuminated the battery has been inserted correctly. The output from IC7 is also used to disable the charge/discharge logic (IC4a and IC4b) thus preventing damage to an incorrectly inserted battery.

IC6 with its associated resistors R8, R15, R16, R26, R27 and the resistor chain R9 to R14 which is connected onto the switch S3 (see S3 diagram in Figure 2) form a second voltage comparator system. This provides the voltage standard against which the voltage of the battery is checked. The total resistance across the supply is the sum of R8 to R16 which equals 16.5k ohms. The current through the chain is 1mA and therefore a 1k resistor will produce a 1 volt potential difference. Hence position 1 of S3 gives a 1 volt input to IC6 pin 2, against which the battery voltage is compared. Similarly switch positions 2 to 7 give 2,4,6,7,8 and 10 volts respectively, for checking larger battery packs. If the battery voltage is




greater than 1 volt per cell the output of IC6 pin 6 will be low and if less than 1 volt per cell it will be high.

The timing and control logic receive the outputs of IC's 6 and 7 which are used to initiate the charge/discharge operations.

IC1 is a free running multivibrator the output cycle time of which is controlled by the values of R2, RV1, C3 and C4; it requires low leakage non-polarised capacitors across pins 1 and 3, as a high value of capacitance is required in this case, back to back tantalum bead types are used. The resistance needed across IC1 pins 2 and 3 is provided by R2 and RV1, the variable component is used so that the output square-wave from pin 10 can be made as close as possible to 6.59 seconds per cycle – to allow reasonably accurate charge times.

IC2 is a 14 stage binary counter which is used to divide down the 0.152 cycles per second from IC1; the output voltage at pin 1 becomes high after $2^{11}$ input pulses, i.e. 3¾ hours and that at pin 3 high after $2^{13}$ input pulses, i.e. 15 hours. IC5b and the associated logic loop of IC2 and IC3 prevent the timer restarting after $2^{12}$ and $2^{14}$ counts respectively, thus preventing a second charge cycle.

Consider the situation where a partially charged battery is connected to the charger. S3 must be switched to the correct number of cells. S4 must be switched to the charging current required and S2 to the time needed. If the polarity is correct the output of IC6 will be low and as there is more than 1 volt per cell the output of IC7 will be high, which will illuminate D3. The output of IC7 is also connected to IC4a and IC4b, when this output is low the outputs of both IC4a and IC4b are forced high, disabling the charge/discharge circuitry. With a correctly inserted battery IC4a and IC4b are enabled.

Pressing and releasing S1 or switching on the mains supply forces the reset inputs of IC2 and IC3 high and then low again, in a time period controlled by the values of R1 and C2. The outputs $\bar{Q}$ of the dual flip-flop, IC3, become high whilst Q of flip-flop (F/F2) becomes low. This low output passes via IC5a and IC5b to disable the counting of IC2 during the discharge cycle. The $\bar{Q}$ signal of F/F2 passes to IC4b, the output of which forces the output of IC4a high. This then turns off the charge circuit. The low output of IC4b enables the discharge circuit consisting of R28,R29,R30,TR4,TR5 and TR6 thus illuminating the red LED D5.

The discharge circuit remains on until the voltage across the battery drops below 1 volt per cell. This voltage drop causes the output of IC6 to go high thus causing the outputs of F/F2 in IC3 to change.

When $\bar{Q}$ of F/F2 becomes low, the output of IC4b becomes high, disabling the discharge sequence and enabling the charge circuit via IC4a. Since Q of F/F2 becomes high and $\bar{Q}$ of F/F1 is still high, the counting of IC2 is enabled by the high input to IC5b derived from IC5a. IC2 now begins to count the pulses from IC1, with S2 selecting whether the high signal is passed on to IC3 after $2^{11}$ or $2^{13}$ pulses. During this period all inputs to IC4a are high and its output is low, thus turning on the charge circuit consisting of R17 to R25, R31,R32,TR2,TR3,TR7 and illuminating the yellow LED D4. The voltage drop across the illuminated D4 is about 2.4 volts and as each of the base-emitter junctions of TR2 and TR3 produce a voltage drop of 0.7 volts, 1 volt is applied across the switch (S4) selectable resistors, R17 to R25. The range of currents passing through TR2 is quite large and therefore a variable voltage drop actually occurs across the base-emitter junction of this transistor. The values of the resistors are chosen so that a constant current suitable for charging the cell selected, will be passed through themselves, TR2 and the battery.

At the end of the charge time selected by S2 the input of F/F1 becomes high. This causes $\bar{Q}$ to become low and via IC4a turn off the charge system. In addition, via IC5a and IC5b, furthur timing is prevented. The unit now remains in this state and the battery receives a very small trickle charge via R3 and R4. D2 is included so that when the charger is disconnected from the mains the battery cannot discharge through the rest of the circuitry.

## Construction

Before starting the PCB construction the bottom of the box should be marked with the positions of the transformer, the PCB mounting screws, the mains input cable and the charger power output sockets. All these holes should be drilled and the components (excluding the PCB) mounted into position, not forgetting to locate the mains cable through the grommet. Next mark the positions of the 3 switches and the LED's on the lid of the box, drill the holes and mount these components.

Assemble the PC board in the following order: first locate the positions of the IC sockets and carefully solder them onto the PCB. Do not insert the IC's at this stage! Next mount and solder in turn, the resistors and capacitors, the bridge rectifier and the transistors except TR2. Once these components are fitted TR2 can be attached to the heat-sink and the two items screwed to the PCB – after bending the transistor leads to pass through the holes in the board. Finally solder TR2 and fit the wires connecting the PCB to the sockets and transformer, and also the switches and LED's in the lid (see Figure 3, PCB track legend and wiring diagram), then fix the PCB into the box.

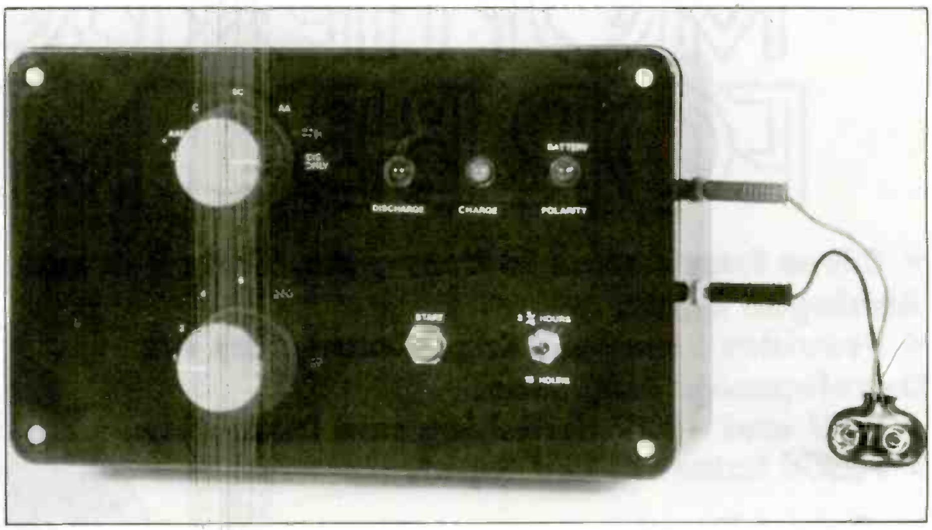
Now wire the switch S3 with the resistor chain as shown in Figure 3, and ensure that 4 switch positions only are available. If not there is a small movable stop under the mounting nut of the switch which should be placed in the position marked 4. Incidentally S4 should rotate through 6 positions and should be adjusted if required. Before testing, all wiring should be checked and the wires between the PCB and other components secured with cable ties.

## Testing

Having completed construction the supply voltage to each of the IC's should be checked – there should be a reading of 16 volts between pin 14 (positive) and pin 7 of IC's 1,3,4 & 5, and between pin 16 (positive) and pin 8 of IC2. For IC6 and 7 the 16 volt supply should be across pins 4 and 7 (positive). If these readings are satisfactory plug in all the IC's.

With the output sockets disconnected, the green and possibly the yellow LED's should light. Shorting the sockets should turn off all the LED's – proving that the polarity checker is working.

Connect a part charged cell to the charger and check that the unit transfers from discharge to charge when the voltage drops to 1 volt and that the charge current is correct for the cell being used. Each time a new size of cell is charged the charge current should be checked.




Finally check that the time for 10 cycles from the output of IC1 (pin 10) is as close to 65.9 seconds as possible. RV1 can be adjusted to alter the cycle time the accuracy of which will obviously affect the charge time.

## Operation

Set S4 to the correct battery type to be charged. Set S3 to the correct number of cells. Set S2, for charge time, to 15 hours – or 3¾ hours for scintered cells. Fit the cells to be charged in the correct type of battery holder and connect to the charger via the PP3 clip. Pressing the start button or switching on the mains supply will initiate the discharge/charge cycle.

When a battery pack is to be made up of cells in varying states of discharge, the cells must first be discharged singly by setting S4 to the discharge only position and S3 to 1 cell. Once the cells are all discharged they can be fitted into the required battery holder for recharging.

## NI-CAD CHARGER PARTS LIST

RESISTORS: All 0.6W 1% Metal Film unless otherwise stated.

| | | | |
|---|---|---|---|
| R1,3,4,5,6,26,27, 30,32 | 10k | 9 | (M10K) |
| R2 | 220k | 1 | (M220K) |
| R7,29,31 | 390Ω | 3 | (M390R) |
| R8,9,12,13 | 1k0 | 4 | (M1K) |
| R10,11,14 | 2k0 | 3 | (M2K) |
| R15 | 1k8 | 1 | (M1K8) |
| R16 | 4k7 | 1 | (M4K7) |
| R17 | 120Ω | 1 | (M120R) |
| R18,20,23 | 24Ω | 3 | (M24R) |
| R19 | 13Ω | 1 | (M13R) |
| R21,24 | 5Ω6 | 2 | (M5R6) |
| R22 | 6Ω8 | 1 | (M6R8) |
| R25 | 3Ω9 | 1 | (M3R9) |
| R28 | 10Ω 7W 5% Wirewound | 1 | (L10R) |
| RV1 | 100k Hor S-Min Preset | 1 | (WR61R) |

CAPACITORS

| | | | |
|---|---|---|---|
| C1 | 1000μF 25V PC Electrolytic | 1 | (FF18U) |
| C2,3,4 | 10μF 25V Tantalum | 3 | (WW69A) |

SEMICONDUCTORS

| | | | |
|---|---|---|---|
| D1,2 | 1N4001 | 2 | (QL73Q) |
| D3 | LED Green | 1 | (WL28F) |
| D4 | LED Yellow | 1 | (WL30H) |
| D5 | LED Red | 1 | (WL27E) |
| TR1,3 | BC107B | 2 | (QB31J) |
| TR2 | BD131 | 1 | (QF03D) |
| TR4 | BD140 | 1 | (QF08J) |
| TR5,6,7 | BC177 | 3 | (QB52G) |
| IC1 | 4047BE | 1 | (QX20W) |
| IC2 | 4020BE | 1 | (QX11M) |
| IC3 | 4013BE | 1 | (QX07H) |
| IC4 | 4023BE | 1 | (QX12N) |
| IC5 | 4081BE | 1 | (QW48C) |
| IC6,7 | μA741C 8-pin DIL | 2 | (QL22Y) |
| BR1 | W005 | 1 | (QL37S) |

MISCELLANEOUS

| | | | |
|---|---|---|---|
| S1 | Push Switch | 1 | (FH59P) |
| S2 | Sub-Min Toggle Switch 'A' | 1 | (FH00A) |
| S3,4 | Rotary Switch 12B | 2 | (FF73Q) |
| T1 | Min Transformer 6V | 1 | (WB06G) |
| | Heatsink Vaned | 1 | (FL59P) |
| | LED Clips | 3 | (YY40T) |
| | DIL Socket 8-pin | 2 | (BL17T) |
| | DIL Socket 14-pin | 4 | (BL18U) |
| | DIL Socket 16-pin | 1 | (BL19V) |
| | Knob K7C | 2 | (YX03D) |
| | Feet Stick-on | 1 pkt | (FW38R) |
| | Grommet Small | 1 | (FW59P) |
| | Tie Wrap 92 | 4 | (BF91Y) |
| | Cable C6A Mains White | 2m | (XR04E) |
| | Wire | 1 pkt | (BL00A) |
| | Veropin 2145 | 1 pkt | (FL24B) |
| | Socket Black 2mm | 1 | (HF44X) |
| | Socket Red 2mm | 1 | (HF47B) |
| | Plug Black 2mm | 1 | (HF38R) |
| | Plug Red 2mm | 1 | (HF41U) |
| | Printed Circuit Board | 1 | (GB65V) |
| | PP3 Battery Clip | 1 | (HF28F) |
| | Bolt 6BA ½in. | 1 pkt | (BF06G) |
| | Nut 6BA | 1 pkt | (BF18U) |
| | Spacer 6BA ¼in. | 1 pkt | (FW34M) |
| | Tag 6BA | 1 pkt | (BF29G) |

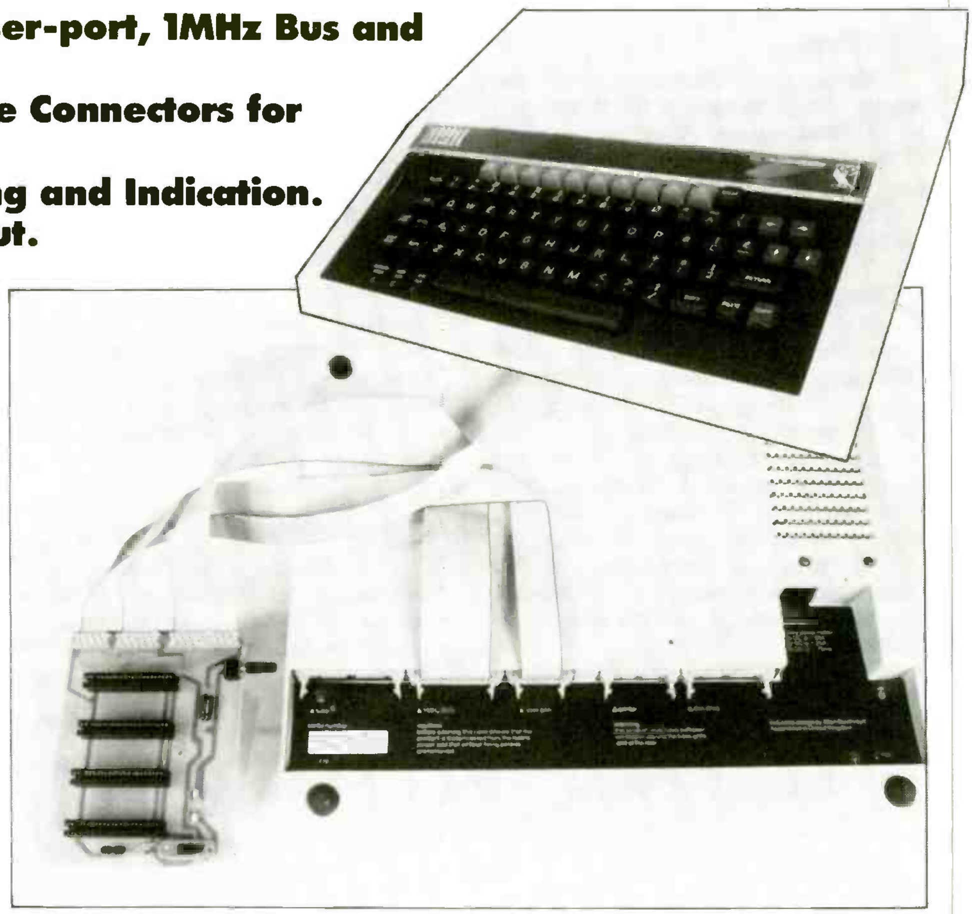
OPTIONAL

| | | | |
|---|---|---|---|
| | Case Verobox 305 | 1 | (LH51F) |
| | Battery Holders – see Maplin Catalogue | | |

A complete kit of parts (excluding the case and battery holders) is available.
**Order As LK50E (Cautious Ni-Cad Charger Kit)**

# MOTHERBOARD FOR BBC MICRO

**★ Gives Easy Access to User-port, 1MHz Bus and Analogue Input.**
**★ Provides Standard Edge Connectors for Development Purposes.**
**★ +5V and +12V Switching and Indication.**
**★ Fused External 12V Input.**



## by Robert Kirsch

The Acorn BBC computer is one of the most popular and versatile of the vast range of microcomputers at present available and is ideally suited for development work. The one drawback is the location of the 1MHz Bus and User Port underneath the computer. This project describes a Motherboard that brings both these ports as well as the Analogue Input out to 4 parallel double sided edge connectors on a board that can be located either in front of or behind the computer when in its working position. Power switching and protection are also provided. Figure 1 shows the circuit diagram and pin functions of the motherboard (only one of the 4 identically connected edge connectors is shown). Note that the pins are configured to keep the individual ports from the computer grouped together with power supplies at either end.

## Construction

The construction of this project is fairly straightforward although care should be taken to ensure the correct polarity of the capacitor C1 and LED1 and LED2. Note also that the location guide on the edge connectors is towards the side of the PCB away from the external power input socket. The headers of the ribbon cables should be carefully inserted through the PCB to prevent bending under any of the pins during insertion. There are three wire links to be provided on the board and these can be made of any odd lengths of tinned copper wire about 24swg. Careful inspection of the completed project is recommended to ensure that there are no short circuits or unsoldered pins before connection is made to the computer.

NOTE: Always turn off the power before any connections are made to the computer ports or cards inserted into the motherboard. With the motherboard connected and no cards inserted the computer should function in the normal manner. This project is the first of several we hope to include for the BBC computer and we would be interested to hear from anyone having projects for the BBC particularly if they could be adapted to use the motherboard system shown here.

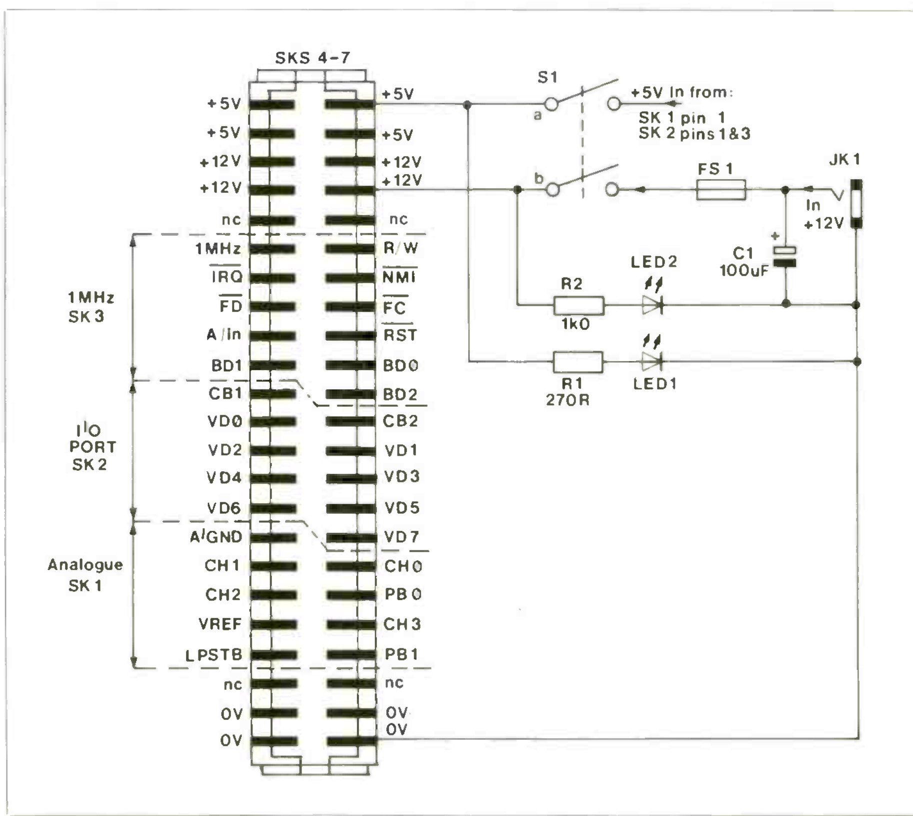



Figure 1. Circuit diagram

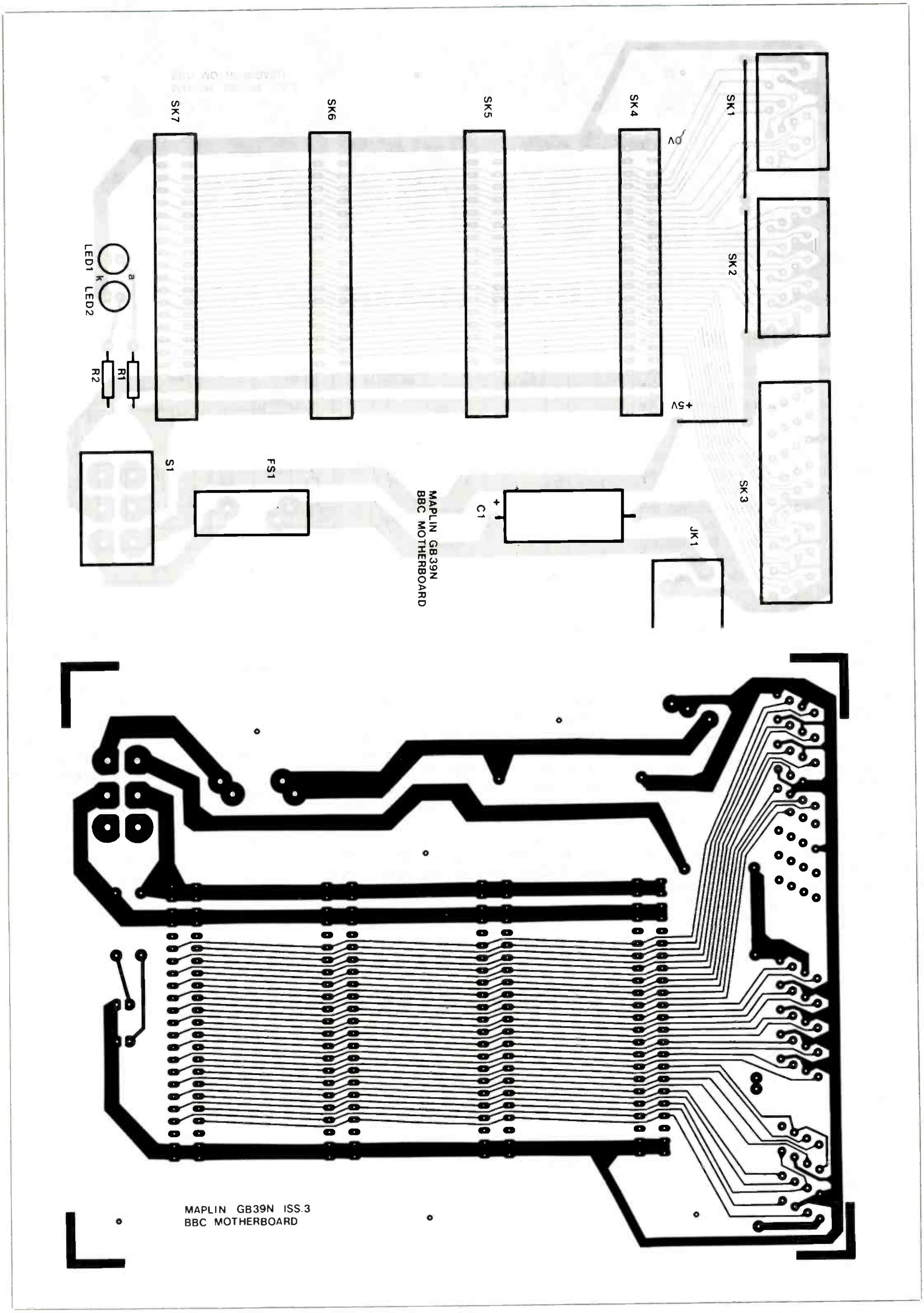



**Figure 2. Track and overlay**

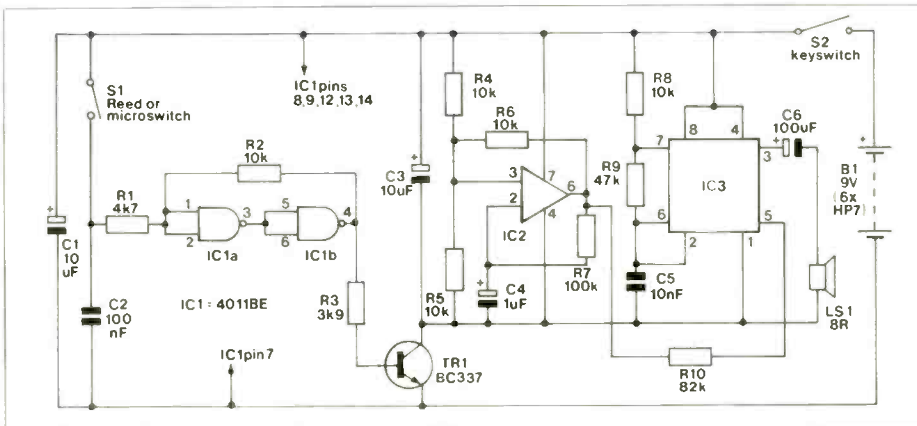
*Continued on page 27.*

# Another FIVE BOB'S WORTH

## DOOR ALARM

### From Robert Penfold

This circuit is a slightly more sophisticated alternative to the popular door-chain alarms. Units of this type have a microswitch that is operated when any tension is placed on the door-chain, and the microswitch in turn operates an audio alarm generator. With this circuit a reed switch or microswitch is directly operated when the door is opened so that the alarm is activated, even if the door is opened by just a few millimetres. Furthermore, once activated, the alarm latches in the ON state so that closing the door again will not silence it.




IC1 is a CMOS 4011BE quad 2 input NAND gate, but in this circuit two of the gates are used as simple inverters and the other two are unused. The two inverters are connected to act as a bistable circuit, and C2 ensures that the output of the bistable always goes low at switch-on. If S1 should close, even momentarily, the output of the bistable will trigger to the high state, and latch in that state. TR1 is then biased hard into conduction, and it provides the alarm generator with virtually the full supply voltage.

The alarm generator is based on IC2 and IC3. The latter is a 555 astable circuit operating at a fairly high audio frequency and having its output coupled to a loudspeaker by C6. The 555 can provide a strong output current into a low impedance load such as LS1, and this gives quite a loud alarm signal.

The alarm is made even more effective by frequency modulating the tone generator. IC2 is a 741C operational amplifier used in a standard relaxation oscillator circuit, and the low frequency square-wave output from pin 6 is loosely coupled to pin 5 of IC3 by R10. This gives an increase in the output frequency of the tone generator when the output of IC2 is low, and a reduction in frequency when it is high, giving a two-tone output signal.

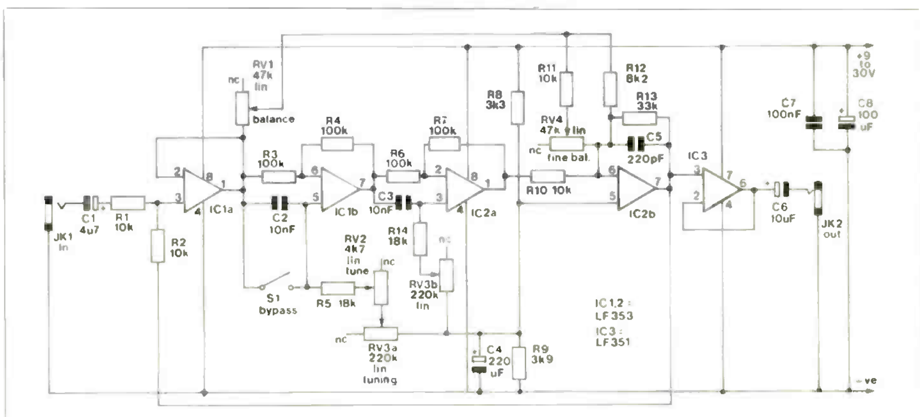
The unit is reset by switching off and then switching on again. On/off switch S2 should ideally be a key-operated switch, and the unit should be housed in a fairly tough case such as a diecast aluminium type, so that there is no quick and easy way for an intruder to silence the unit.

The most convenient type of switch to use for S1 is a reed switch having changeover contacts. The unit can then be arranged so that the activating magnet is next to the switch when the door is closed, but the pair of contacts that provide a normally closed action are used, so that the alarm is not activated. When the door is opened the magnet and reed switch become separated, the contacts close, and the alarm is activated.

As the unit will be left switched on for long periods of time it is obviously essential for it to have a low stand-by current consumption. Under quiescent conditions the only supply current that flows is the leakage currents through C1 and TR1, plus the supply current of IC1. This is not likely to total more than a few microamps, and in practice each set of batteries will give months of use.

## THD FILTER

Equipment for the measurement of total harmonic distortion (THD) tends to be quite complex and expensive. However, anyone who has a high quality (sinewave) audio signal generator and an AC millivoltmeter has the basis of a THD measuring set-up. The only other major item of equipment required is a high quality notch filter, such as the one shown in the accompanying circuit. To measure THD the signal generator is used to supply a sinewave signal to the amplifier under test, and the output of the amplifier is fed to the millivoltmeter via the notch filter. Initially the filter is bypassed and the millivoltmeter is used to measure the output signal level. Then the filter is used to notch out the sinewave signal, leaving



only the noise and distortion, which is measured using the millivoltmeter. The ratio of the output signal to the noise and distortion level gives the distortion factor (which is normally expressed as a percentage). The millivoltmeter can then be used to measure the output noise level of the amplifier. Deducting this from the noise and distortion figure gives the THD level, and again this is normally compared with the output signal level and specified as a percentage.

The filter is based around two phase shifters (IC1b and IC2a). At a certain frequency these provide a 180 degree phase shift, and mixing the phase shifted and unshifted signals at IC2b therefore produces a cancelling effect and a notch in the response of the circuit at this frequency. RV1 and RV4 are adjusted to provide precise cancelling so that a high degree of attenuation is provided. With careful adjustment more than 80dB of attenuation can readily be achieved. IC3 is an output buffer stage.

A problem with this basic filter is that it provides significant attenuation at double the notch frequency, and therefore tends to reduce any second harmonic content that is generated in the amplifier, and consequently a slightly low THD reading is produced. This is overcome by using a small amount of overall negative feedback. This tends to flatten the frequency response of the circuit, but near the centre of the notch the degree of attenuation is far too high for the negative feedback to have any significant effect. R1 and R2 provide the overall negative feedback and give the circuit a nominal voltage gain of unity. The reduction in gain at twice the notch frequency is less than 1dB.

RV3 enables the notch frequency to be varied from about 100Hz to approximately 1kHz, which is the frequency band that is likely to be of prime interest, but the values of C2 and C3 could be changed to provide operation at other frequencies. Changes in the values of these components have an inversely proportional effect on the band of frequencies covered (e.g. a value of 5nF gives coverage from about 200Hz to 2kHz).

RV2 is the fine tuning control, and together with the fine balance control (RV1), need to be adjusted very carefully in order to accurately notch out the fundamental signal. S1 is the bypass switch, and this renders the first phase shifter inoperative so that the notch is eliminated and the fundamental signal can pass unhindered to the output of the unit.

A supply voltage of between 9 and 30 volts is needed, and in order to give optimum large signal handling ability, a high supply voltage is preferable. If a mains power supply is used it should have a low noise and ripple content on its output. Bifet operational amplifiers are used in the filter so that it has minimal noise and distortion levels.

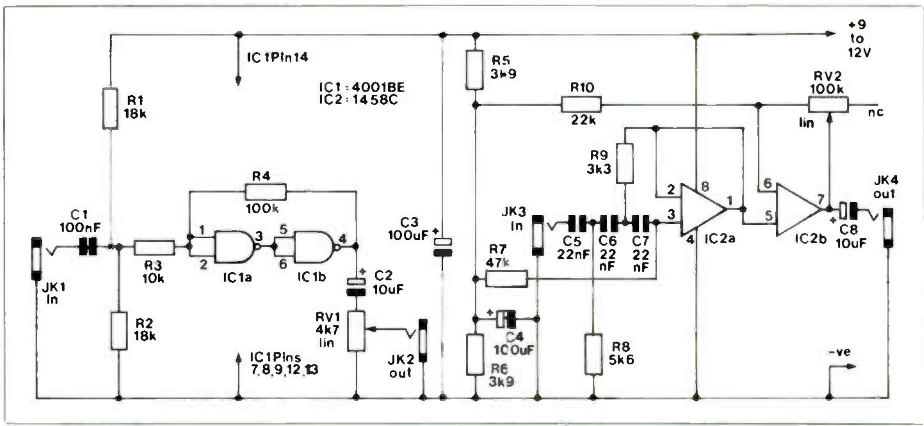
## CASSETTE PROCESSOR

Loading programs from a cassette recorder seems to be a major problem for many home-computer users. While some machines, such as the Dragon 32 or 64, seem to operate well with practically any cassette recorder over a wide range of volume and tone control settings, some others seem to be far less co-operative. There are various ways of processing the output of a cassette recorder to (hopefully) provide more reliable results. The circuit shown here is quite simple and inexpensive to construct, but provides two types of signal processing. Of course, how well (or otherwise) any cassette processor operates depends on the precise nature of the problem, and whether or not the applied processing is appropriate for that problem, but the circuit described here will effect an improvement in most cases.

IC1 is a CMOS 4001BE quad 2-input NOR gate, but here only two of the gates are used, and each of these has its two inputs connected together so that it functions as a straightforward inverter.

The two inverters are connected in series, and R1 plus R2 are used to bias the input to about half the supply voltage. R4 provides DC positive feedback over the circuit, which operates as a sort of Schmitt trigger. The signal from the cassette recorder is capacitively coupled to the input of the circuit by C1, and provided an input of around 1 volt RMS or more is provided, a good quality squarewave signal is produced at the output of the circuit. This type of signal seems to work much better with some home-computers than the direct output from the cassette recorder which has much slower rise and fall times, as well as a higher noise content. RV1 is used to set the output level of the circuit for optimum reliability.

The second processor is based on IC2, and is simply a highpass filter having




a cut-off frequency of about 700Hz, followed by a voltage amplifier stage. The filter is a third order (18dB per octave type), and it removes any 'mains hum' or any other low frequency noise, which can often prove troublesome. Noise of this type can be caused by hum loops, stray pick-up in the connecting leads or the computer itself, and can be very difficult to prevent. However, an active filter of this type should attenuate any low frequency noise to an insignificant level.

With RV2 at minimum resistance, IC2b operates as a unity gain buffer amplifier, but advancing RV2 increases the voltage gain up to a maximum of about 5 times. It can sometimes be beneficial to advance RV2 to the point where the output signal becomes clipped, as this can give a more regular waveshape having a reduced risetime. However, in many cases results will be best with RV2 set for minimum resistance, and it is probably best to initially try out the circuit with RV2 at this setting.

## VOLUME EXPANDER

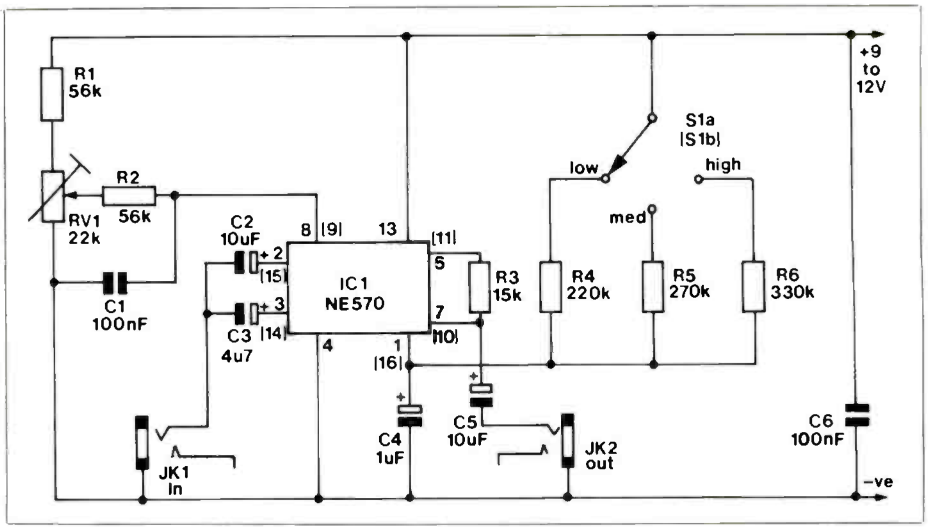
Although modern digital recordings are capable of reproducing the full dynamic range of even the most demanding music, most recordings cannot achieve the required 70dB or so dynamic range. In order to prevent the signal from either dropping down into the background noise level during quiet passages or producing overloading on volume peaks, most recordings have to be subjected to a degree of compression.

A volume expander can be used to increase the dynamic range of a signal, and restore some of the 'impact' that is lost during the recording process. There is no way of exactly counteracting the original compression, since the compression characteristic will vary considerably from one recording to another. However, in many cases the use of a certain amount of volume expansion will provide a worthwhile improvement in results with an apparent increase in the signal to noise ratio as well as the boosted dynamic range.

This volume expander is based on an NE570 compander (compressor-expander) device. This is primarily intended for use in noise reduction systems with one of the identical sections of the device used as a compressor and the other configured as an expander. In this case both sections are used as expanders, with one being used to process each stereo channel. Only one channel is shown in the circuit diagram, but the numbers in brackets show the equivalent pin numbers for the other channel, which is in other respects identical.

There are three stages in each section of the NE570; a voltage controlled gain block, a precision fullwave rectifier, and an operational amplifier. When used as an expander the input signal is coupled to the rectifier and gain block stages by C2 and C3 respectively. C4 is the smoothing capacitor for the rectifier, and this has a value which gives suitably fast attack and decay times, without either being so fast that distortion is caused. The output of the rectifier is used to control the gain block. As the input signal level is increased, the output voltage from the rectifier rises, the gain block provides increased gain, and the expansion is obtained. R3 is used in the bias and feedback circuit of the operational amplifier, which is utilized here as just a buffer at the output.

The NE570 has a 2 to 1 expansion




characteristic. In other words, a rise in the input level of (say) 20dB (10 times) gives a 40dB (100 times) increase in the output. This gives far too much expansion for this application, but a bias register from the positive supply to the smoothing capacitor of the rectifier can be used to give reduced expansion. In this circuit there are three switched bias resistors (R4 to R6). With a maximum input signal of about 500 millivolts rms, these provide expansion levels of about 6, 9, and 12dB. 12dB is about the maximum that can be used in practice without the expansion becoming too obvious.

RV1 is adjusted to minimise distortion, and the NE570 has a typical trimmed THD of only 0.05%. If R1, R2 and RV1 are omitted, the typical THD is still only 0.3%, which is adequate for most purposes. Input levels of up to about 1 volt rms can be handled before clipping occurs.

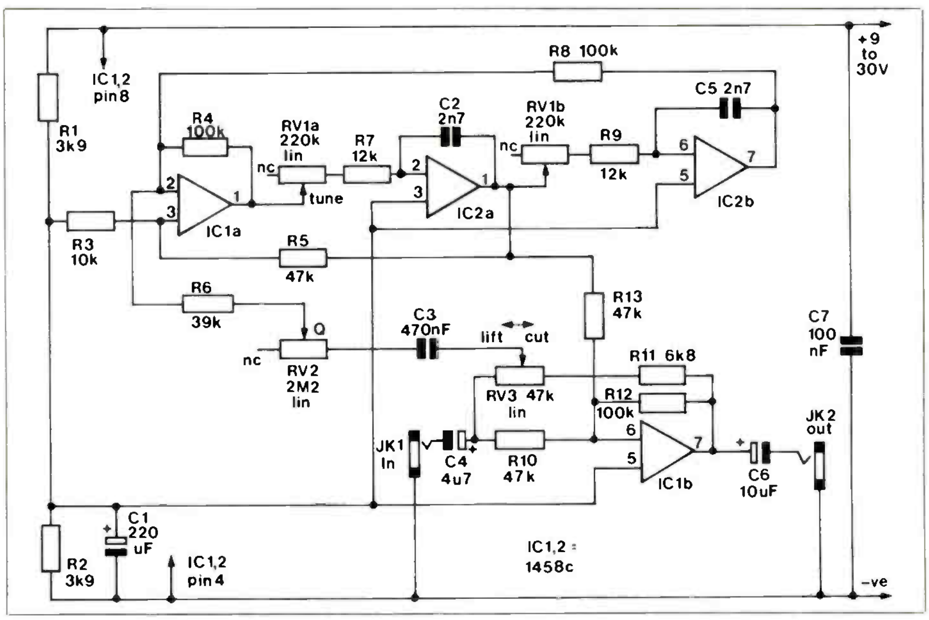
## PARAMETRIC EQUALISER

A parametric equaliser is a versatile form of tone control which is used principally in the production of electronic music, but circuits of this type can also be used in hi-fi systems. Both lift and cut can be provided, like an ordinary bass or treble tone control, but it is a frequency band somewhere in the middle of the audio range that is controlled by this type of filter, rather than one end of the audio spectrum. The centre frequency is tunable (usually over a fairly wide frequency range), and the filter is really a bandpass and notch type, with the type of filtering provided depending on whether the circuit is set for lift or cut. Circuits of this type invariably have variable Q, so that a very narrow range of frequencies, a broad frequency range, or anything in between these two extremes can be controlled.

In electronic music, a parametric equaliser can obviously be used to radically alter the sound of an instrument, and can modify the sound in a variety of ways. When used with a hi-fi system it could be used to counteract a resonance or other irregularity in the frequency response of the system.

Although quite simple, the design featured here has a respectable level of performance with a tuning range which extends from about 200Hz to approximately 4kHz. Up to about 15dB of boost and cut can be provided and the Q can be varied over wide limits.

In common with other designs of this general type, the circuit is based on a state variable filter. This is formed by IC1a, IC2a and IC2b, and it is the bandpass output at pin 1 of IC2a that is utilised here. The frequency of the filter is




governed by the values of C2 and C5, plus the series resistances of R7 plus RV1a and R9 plus RV1b. By making the resistive elements variable, the operating frequency can be adjusted over the nominal range specified above, with minimum resistance corresponding to maximum operating frequency.

The signal is not actually handled directly by the bandpass filter, but instead passes through inverting amplifier IC1b. The bandpass filter is effectively used as a sort of frequency selective network in the negative feedback circuit of IC1b. The point of doing this is that it enables the notch response to be obtained in addition to the bandpass response, with the type of filtering obtained depending on whether RV3 is adjusted for lift or cut. Feedback over the filter (and hence its Q value) is controlled by R5, and R6 plus RV2. The Q can therefore be controlled using RV2, with minimum resistance corresponding to maximum Q (and a narrow response).

The circuit will operate on any supply voltage in the range 9 to 30 volts, but a supply of around 15 to 30 volts is preferable as it enables high output levels to be handled without clipping and serious distortion resulting. Bear in mind that when set for maximum boost the circuit provides a significant amount of voltage gain at the centre of the response, and it is then more vulnerable to overloading.

## DOOR ALARM PARTS LIST

| | | | |
|---|---|---|---|
| RESISTORS:- All 0.6W 1% Metal Film | | | |
| R1 | 4k7 | | (M4K7) |
| R2,4,5,6,8 | 10k | 5 | (M10K) |
| R3 | 3k9 | | (M3K9) |
| R7 | 100k | | (M100K) |
| R9 | 47k | | (M47K) |
| R10 | 82k | | (M82K) |
| CAPACITORS | | | |
| C1,3 | 10uF 35V PC Electrolytic | 2 | (FF04E) |
| C2 | 100nF Polyester | | (BX76H) |
| C4 | 1uF 100V PC Electrolytic | | (FF01B) |
| C5 | 10nF Polyester | | (BX70M) |
| C6 | 100uF 63V PC Electrolytic | | (FF12N) |
| SEMICONDUCTORS | | | |
| IC1 | 4011BE | | (QX05F) |
| IC2 | 741C 8 pin DIL | | (QL22Y) |
| IC3 | 555 | | (QH66W) |
| TR1 | BC337 | | (QB68Y) |
| MISCELLANEOUS | | | |
| S1 | Reed Switch Miniature | | (FX70M) |
| S2 | Key Switch | | (FH40T) |
| B1 | HP7 Battery | 6 | — |
| LS1 | L/S Lo–Z 768 | | (YW53H) |
| | Magnet small | | (FX71N) |

## THD FILTER PARTS LIST

| | | | |
|---|---|---|---|
| RESISTORS:- All 0.6W 1% Metal Film | | | |
| R1,2,10,11 | 10k | 4 | (M10K) |
| R3,4,6,7 | 100k | 4 | (M100K) |
| R5,14 | 18k | 2 | (M18K) |
| R8 | 3k3 | | (M3K3) |
| R9 | 3k9 | | (M3K9) |
| R12 | 8k2 | | (M8K2) |
| R13 | 33k | | (M33K) |
| RV1,4 | Pot Lin 47k | 2 | (FW04E) |
| RV2 | Pot Lin 4k7 | | (FW01B) |
| RV3 | Dual Pot Lin 220k | | (FW89W) |
| CAPACITORS | | | |
| C1 | 4u7F PC Electrolytic | | (FF03D) |
| C2,3 | 10nF Polyester | 2 | (BX70M) |
| C4 | 220uF 63V PC Electrolytic | | (FF14Q) |
| C5 | 220pF 1% Polystyrene | | (BX49D) |
| C6 | 10uF 35V PC Electrolytic | | (FF04E) |
| C7 | 100nF Polyester | | (BX76H) |
| C8 | 100uF 63V PC Electrolytic | | (FF12N) |
| SEMICONDUCTORS | | | |
| IC1,2 | LF353 | 2 | (WQ31J) |
| IC3 | LF351 | | (WQ30H) |
| MISCELLANEOUS | | | |
| JK1,2 | ¼" Jack Socket | 2 | (HF90X) |
| | ¼" Jack Plugs | 2 | (HF85G) |
| S1 | Sub-Min Toggle A | | (FH00A) |

## VOLUME EXPANDER PARTS LIST

| | | | |
|---|---|---|---|
| RESISTORS:- All 0.6W 1% Metal Film | | | |
| R1,R101,R2,R102 | 56k | 4 | (M56K) |
| R3,R103 | 15k | 2 | (M15K) |
| R4,R104 | 220k | 2 | (M220K) |
| R5,R105 | 270k | 2 | (M270K) |
| R6,R106 | 330k | 2 | (M330K) |
| RV1,RV101 | Hor Preset S-Min 22k | 2 | (WR59P) |
| CAPACITORS | | | |
| C1,C101,C6,C106 | 100nF Polyester | 4 | (BX76H) |
| C2,C102,C5,C105 | 10uF 35V PC Electrolytic | 4 | (FF04E) |
| C3,C103 | 4u7F 63V PC Electrolytic | 2 | (FF03D) |
| C4,C104 | 1uF 100V PC Electrolytic | 2 | (FF01B) |
| SEMICONDUCTORS | | | |
| IC1 | NE570 | | (QY10L) |
| MISCELLANEOUS | | | |
| JK1,JK2 | ¼" Jack Socket Stereo | 2 | (HF92A) |
| | ¼" Jack Plug Stereo Plastic | 2 | (HF88V) |
| S1 | Switch Rotary SW3B | | (FF76H) |

## CASSETTE PROCESSOR PARTS LIST

| | | | |
|---|---|---|---|
| RESISTORS:- All 0.6W 1% Metal Film | | | |
| R1,2 | 18k | 2 | (M18K) |
| R3 | 10k | | (M10K) |
| R4 | 100k | | (M100K) |
| R5,6 | 3k9 | 2 | (M3K9) |
| R7 | 47k | | (M47K) |
| R8 | 5k6 | | (M5K6) |
| R9 | 3k3 | | (M3K3) |
| R10 | 22k | | (M22K) |
| RV1 | Pot Lin 4k7 | | (FW01B) |
| RV2 | Pot Lin 100k | | (FW05F) |
| CAPACITORS | | | |
| C1 | 100nF Polyester | | (BX76H) |
| C2,8 | 10uF 35V PC Electrolytic | 2 | (FF04E) |
| C3,4 | 100uF 63V PC Electrolytic | 2 | (FF12N) |
| C5,6,7 | 22nF Polyester | 3 | (BX72P) |
| SEMICONDUCTORS | | | |
| IC1 | 4001BE | | (QX01B) |
| IC2 | 1458C | | (QH46A) |
| MISCELLANEOUS | | | |
| JK1,2,3,4 | ¼" Jack Socket | 4 | (HF90X) |
| | ¼" Jack Plug | 4 | (HF85G) |

## PARAMETRIC EQUALISER PARTS LIST

| | | | |
|---|---|---|---|
| RESISTORS:- All 0.6W 1% Metal Film | | | |
| R1,2 | 3k9 | 2 | (M3K9) |
| R3 | 10k | | (M10K) |
| R4,8,12 | 100k | 3 | (M100K) |
| R5,10,13 | 47k | 3 | (M47K) |
| R6 | 39k | | (M39K) |
| R7,9 | 12k | 2 | (M12K) |
| R11 | 6k8 | | (M6K8) |
| RV1 | Dual Pot Lin 220k | | (FW89W) |
| RV2 | Pot Lin 2M2 | | (FW09K) |
| RV3 | Pot Lin 47k | | (FW04E) |
| CAPACITORS | | | |
| C1 | 220uF 63V PC Electrolytic | | (FF14Q) |
| C2,5 | 2n7F 1% Polystyrene | 2 | (BX61R) |
| C3 | 470nF Polyester | | (BX80B) |
| C4 | 4u7F 63V PC Electrolytic | | (FF03D) |
| C6 | 10uF 35V PC Electrolytic | | (FF04E) |
| C7 | 100nF Polyester | | (BX76H) |
| SEMICONDUCTORS | | | |
| IC1,2 | 1458C | 2 | (QH46A) |
| MISCELLANEOUS | | | |
| JK1,2 | ¼" Jack Socket | 2 | (HF90X) |
| | ¼" Jack Plug | 2 | (HF85G) |

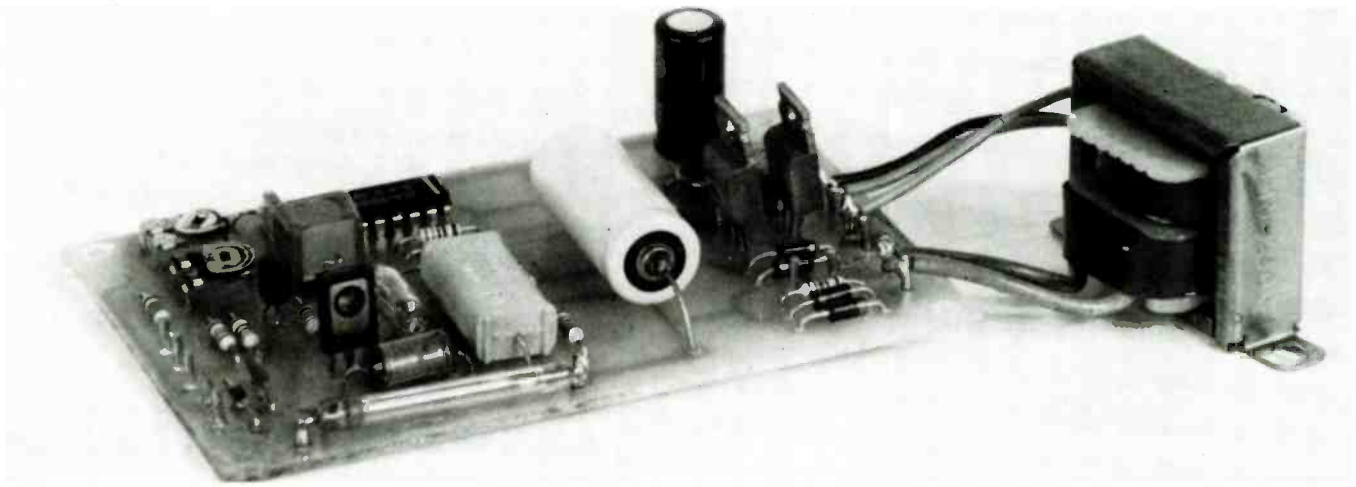
*Continued from page 23.*

## Motherboard for BBC Parts List

| | | | |
|---|---|---|---|
| RESISTORS: All 0.6W 1% Metal Film | | | |
| R1 | 270Ω | 1 | (M270R) |
| R2 | 1k0 | 1 | (M1K) |
| CAPACITORS | | | |
| C1 | 100µF 25V Axial Electrolytic | 1 | (FB49D) |
| SEMICONDUCTORS | | | |
| LED1,2 | LED Red | 2 | (WL27E) |
| MISCELLANEOUS | | | |
| SK1 | Analogue Port Cable | 1 | (FJ24B) |
| SK2 | I/C Port Cable | 1 | (FJ26D) |
| SK3 | 1MHz Port Cable | 1 | (FJ25C) |
| SK4-7 | 2 x 23 Way PC Edgecon | 4 | (RK35Q) |
| FS1 | Fuse 20mm 250mA | 1 | (WR01B) |
| | Fuse Clip | 2 | (WH49D) |
| JK1 | PC Mtg Power Skt | 1 | (RK37S) |
| S1 | DPDT Slide Switch | 1 | (FH36P) |
| | Motherboard PCB | 1 | (GB39N) |
| | Std Power Plug 2.1mm | 1 | (HH60Q) |
| | Strapping Wire 20 SWG | 1 roll | (BL13P) |

A complete kit of the above parts is available.
**Order As LK47B (Motherboard for BBC Kit)**

# Xenon Tube Driver



★ **Driver Module for Xenon Tube**
★ **Complete with Trigger Transformer**
★ **External Triggering or**
★ **Internal Strobe Oscillator**

**by Dave Goodman**

## Introduction

The Xenon Tube, along with the Trigger Transformer required to operate it, are regular subjects of enquiry by many of our readers, therefore to put the books straight, a tube driver module with external triggering and 'on board' strobe oscillator is offered. The module can be used for photography, roadside hazard indication, navigation, distress beacons or perhaps underwater communications, and is ideal for further experimentation. Xenon tubes are glass envelopes filled with a gas which emits blue/white high intensity light when energised. A high voltage potential of 210 to 400V must be applied across both anodes, A1 & A2, (see Figure 4g) which will allow the gas to 'strike' when a 3 to 5kV pulse is applied to the trigger electrode strip, located along one side of the tube. To generate the EHT triggering voltage, a pulse transformer is used which is similar in action to the well known car ignition coil (see Figure 4f), stepping up the primary (B,C) voltage to the required secondary (B,A) voltage.

## Circuit Description

To generate the xenon strike voltage a simple inverter system is employed. Each half of transformer T1 secondary is connected to a power transistor (TR3 & TR4) and the common centre tap is connected to +V supply. By alternately switching each transistor on and off, one half of T1 is grounded at a time, and maximum current flows through each winding in turn. By inductive effect a 50V peak pulse develops between TR3 and TR4 collectors (across T1 secondary)

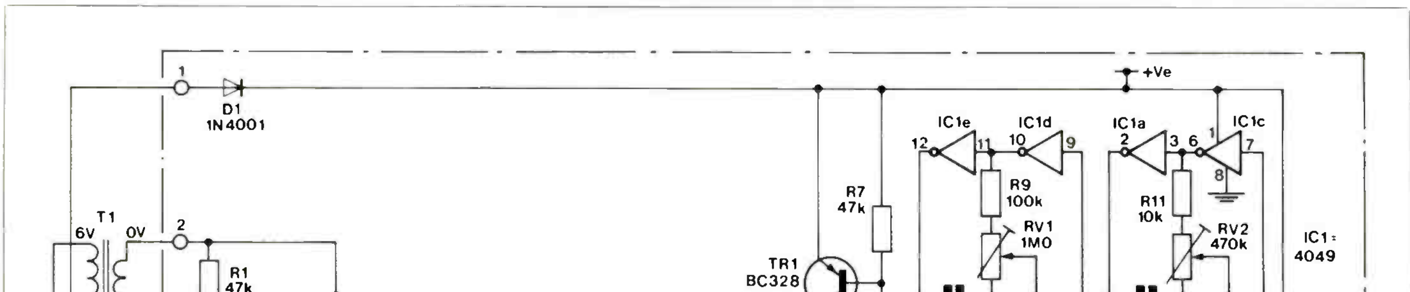
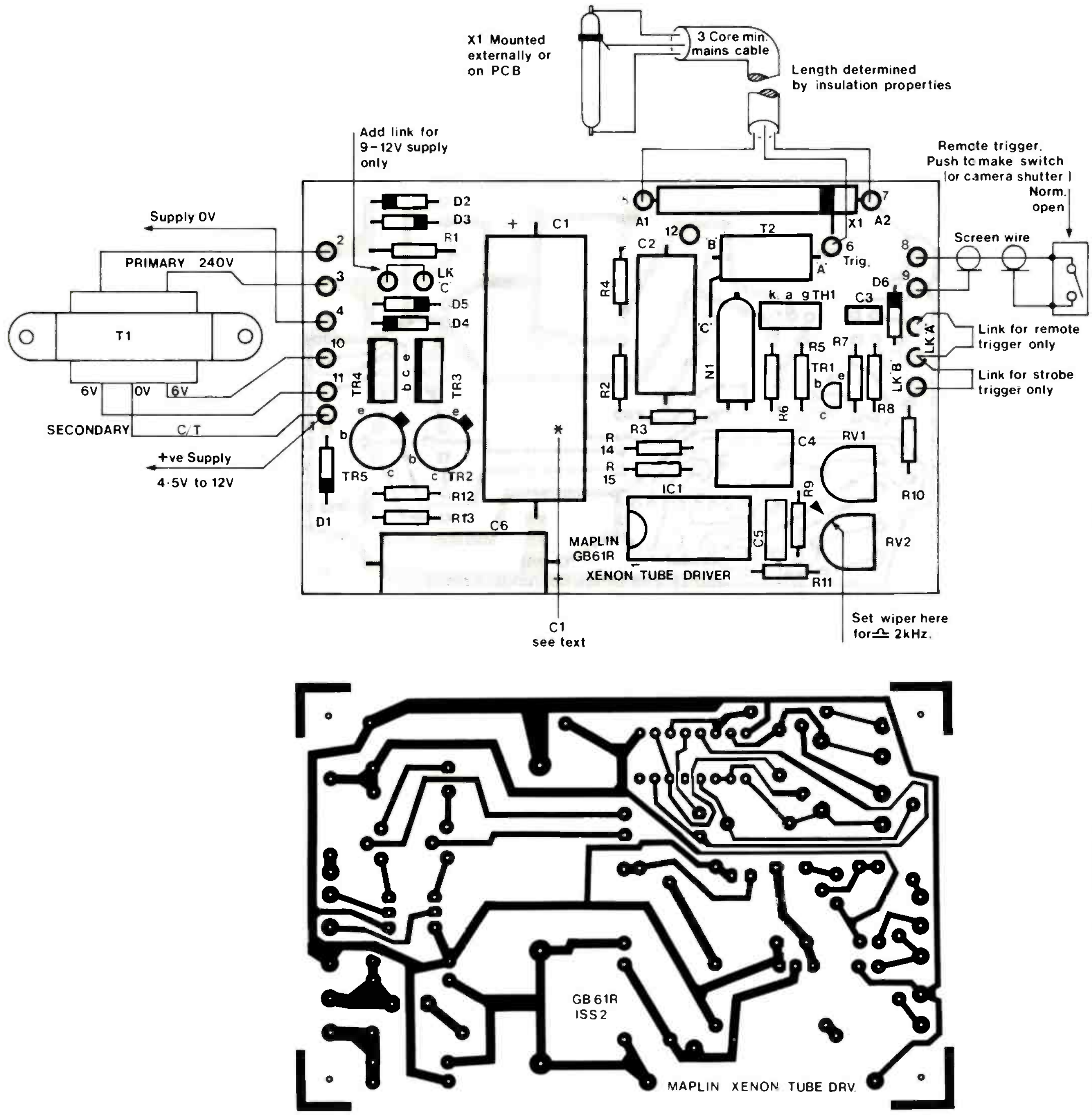



**Figure 1. Circuit Diagram**




**Figures 2 & 3. PCB Track Legend and Wiring Diagram**

which is stepped up by the primary winding approximately 20 times to produce a 1kV peak signal at pins 2 and 3. T1 is in fact a normal 240 to 12V mains transformer connected the reverse way round; instead of applying 240VAC for stepping down to 12VAC, we apply 12VAC and step it up to 240VAC, or in this case 1kVAC.

The alternating signal for switching TR3 & TR4 comes from a CMOS inverter/oscillator IC1a,c and f. IC1c has a variable resistance RV2, and R11 connected across it, which maintain the input voltage level close to the output level on pin 6. If IC1a output, pin 2, is assumed to be low (0V) capacitor C5 will start to charge via RV2 and IC1c pin 7 input will be momentarily pulled low. By inverter action IC1c pin 6 will go high (+V) maintaining IC1a pin 2 in the low state. As C5 charges, the voltage across it increases until a point is reached when IC1c input pin 7 is potentially high enough to flip the output pin 6 low, IC1a pin 2 will then change state from low to high. At this stage the voltage across C5 is reversed and a discharge path via RV2 & R11 gradually drops the potential at IC1c input until the switching level is reached and the oscillation cycle repeats. RV2 determines both charge and discharge times which can be varied from 25uS to 650uS, or between frequencies of 40kHz and 1.5kHz.

IC1f buffers the oscillator and drives the emitter follower driver transistor TR2. With output high, TR3 is turned on, IC1b goes low and TR4 is turned off. When IC1f output goes low TR3 is turned off, IC1b output switches high and TR4 turns on. C6 decouples the +VE rail and D1 helps prevent component damage in the case of supply reversals.

Once oscillation is established, D2 to D5 form a full wave bridge rectifier for charging C1. This capacitor must be of a high voltage rating, in this case 450V working, and to keep the voltage within limits, R1 can be connected across T1 primary by inserting link 'C' if necessary (see Testing).

Neon lamp N1 indicates when the C1 charge voltage is high enough to strike the xenon tube, but as neons normally conduct at around 90V, a high impedance potential divider (R2, R3) is required to set this threshold. Resistor R4 charges a high voltage capacitor, C2 via the pulse transformer primary winding (T2, c & b). By discharging C4 to ground a fast rise-time spike of several hundred volts is generated in the primary of T2 which is stepped up to some 5kV in the secondary winding thus triggering the tube. C1 discharges a high current pulse through the tube to ground and is then re-charged by the inverter.

Connecting link 'A' allows an external make switch to momentarily connect D6 to ground, TR1 base potential is lowered via R7 and R8, TR1 conducts so that a positive gating voltage appears at R5, R6. Thyristor TH1, which can be viewed as a switched diode, conducts and C2 is discharged to ground from the anode to the cathode. Immediately after discharging, C2 re-charges via R4 so that the anode voltage rises positively, under this condition TH1 would remain in a permanently conducting state, even without further control gate signals! This is obviously not what is required and somehow the thyristor must be reset to a non-conducting high impedance state. Fortunately the effect of expanding T2 primary, by discharging C2 through it, results in the coil contracting back again, thus producing a high, negative voltage, spike in the reverse direction. This is applied via C2 to TH1 – taking the anode more negative than its cathode. The conducting state is thus prevented by reverse biasing the anode/cathode junction and TH1 resets to the high impedance state, under gate control.

A second CMOS oscillator runs at a lower frequency than the inverter clock and with link 'B' inserted can be used to strobe the xenon tube from approximately 0.5Hz to 6Hz. If required links A and B can both be fitted for repeat and manual triggering.

## Construction

Refer to the parts list and begin by bending the resistor leads for fitting into the PCB. Do the same with diodes D1 to D6 referring to Figure 4a for orientation. Mount both presets (RV1 & RV2), IC1, TR1 and C1 to C5. Figure 4c, d and e shows lead connections for TR2 and 5, TR3 and 4, also TH1 which must be fitted correctly to the legend. Next fit pulse transformer T2 with the primary lead C exiting on the left towards C2. Now fit vero-pins P1 to 11 from the track side of the PCB and push home with a soldering iron. All components may now be soldered and excess wire ends cut off. Clean the tracks with solvent and a brush, then inspect for solder splashes, dry joints, short circuits etc. Neon N1 can be fitted either way round, but X1 must be

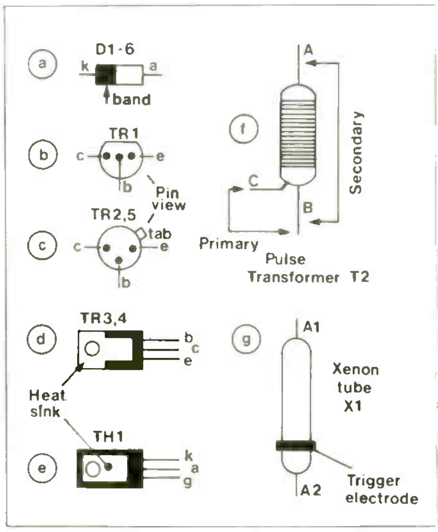



**Figure 4. Component Reference**

fitted with the double wire end to the right of the board. For test purposes carefully solder the anodes A1 and A2 to pins 5 and 7 respectively, and the trigger electrode directly to the component side of the PCB (Figure 3). Mount the min. mains transformer T1 with the primary (thick wires) to pins 2 and 3 and the secondary (three thin wires) to pins 10 and 11. The centre tap (middle wire) connects to pin 1 (+V). Finally re-check the construction and when completely satisfied, proceed with testing.

## Testing

Connect a suitable power supply of from 4.5V to 12V with +V to pin 1 and 0V (–V) to pin 4. Adjust RV1 wiper to about half-travel and RV2 wiper to the arrow on the legend. Turn on the power whereupon a slight buzzing sound should be heard, after a few seconds the neon should start to glow. Now take a length of insulated wire, connect one end to 0V and momentarily touch the other end onto pin 12. The xenon tube should flash and a loud crack may be heard as the air around the tube expands; N1 will go out. If using a 9 to 12V power supply connect link 'C' to prevent excess charge across C1 and connect link 'A'. Re-apply power, wait for the neon to glow, then touch pins 8 and 9 together, once again the tube will flash. Switch off the power, discharge the system by grounding pin 12, remove link 'A' and connect link 'B'. Re-apply power, the tube should flash at approximately 1 second intervals. Adjusting RV1 will vary the flash rate slightly, but not a lot. Switch off the power, discharge pin 12 to ground and remove the +V PSU lead, leave T1 centre tap in place. Now connect an ammeter between the +V supply lead and pin 1 on the PCB, set the range to 0.5 or 1A and switch on. The final current reading will be dependant on the supply voltage, on average it should be around 80mA for a 6 volt supply. Slowly adjust RV2 clockwise or anti-clockwise until the lowest reading is found, link 'B' may have to be removed before doing this check. If a frequency counter or 'scope is available, monitor the inverter clock on IC1 pin 15, it should be close to 2kHz at minimum current setting. Also an oscilloscope connected across C1 with a 10M.ohm probe should read below 450V DC with a 12V supply and link 'C' inserted. Note that link 'C' will not be necessary when using a power supply of 4.5 to 9 volts.

## Strobe Rate Adjustment

Capacitor C1 is supplied as 47uF but may be reduced in value providing its working voltage is kept at 450V or more. Because the inverter source is high impedance, the charge rate for C1 is slower for larger capacitance values and faster for smaller values. The final value chosen will depend upon the use to which the module is to be put. Thus faster strobe oscillator times will require C1 being lower in value, say 10uF or less, to increase the oscillator frequency still further, C5 can be reduced in value.

One major effect of reducing C1 in value is a reduction in discharge current through the tube, hence a reduction in light output, so this must be borne in mind when selecting C1. If it is required to use the 47uF value for C1, but light intensity needs to be variable, link 'C' can be inserted and the value of R1 decreased to suit.

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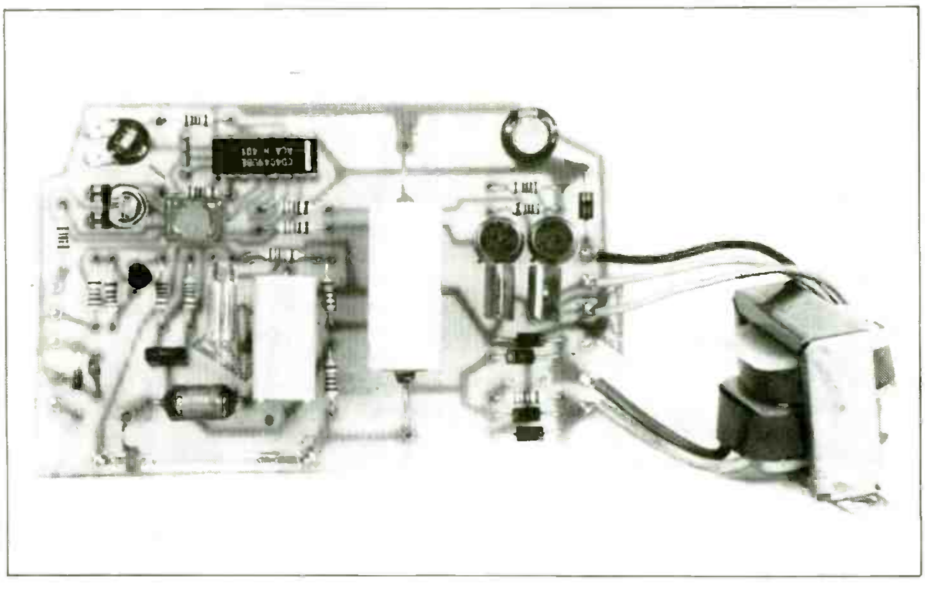
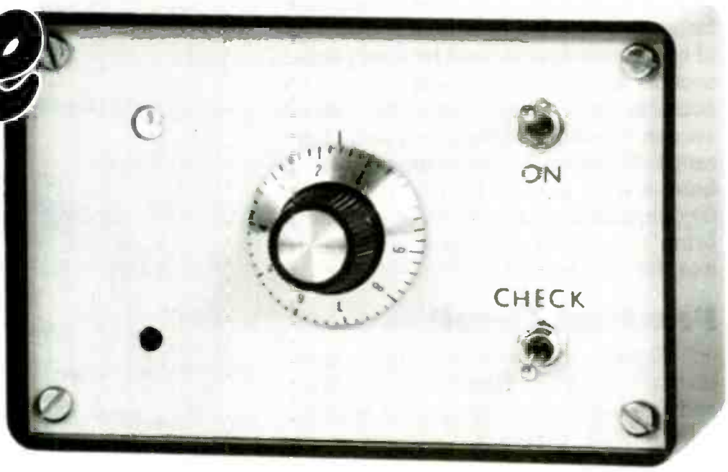


# Enlarger Exposure Meter




★ **Over Six Stops Range**
★ **Simple & Inexpensive Design**
★ **Battery Operated – Low Consumption**

## by Robert Penfold

A common way of determining the optimum exposure when making enlargements is to make a test strip, but it is quicker and more convenient to use an enlarger exposure meter. With the aid of an exposure meter of this type only one test strip needs to be produced for each box of paper. The correct exposure for each negative is then quickly and simply obtained using the meter to indicate the correct aperture.

A unit of this type can be very simple and inexpensive, and the enlarger exposure meter featured in this article certainly falls into this category. It is perhaps a little misleading to refer to it as a 'meter' since it does not actually incorporate a meter movement of any kind. Instead, the unit has a calibrated potentiometer and a LED indicator. A reading is obtained by adjusting the potentiometer to the point where the LED switches on and off, and then taking the reading from the potentiometer's scale. This scale is only in arbitrary units from 0 to 10, but it is perfectly adequate for this application.

The meter has a usable range of six stops or more. It is completely self contained with power being obtained from an internal 9 volt (PP3 size) battery which has a long operating life. A simple battery check facility is included so that misleading results due to an inadequate supply voltage can be avoided.

## Operating Principle

The circuit is based on an operational amplifier which is used as a voltage comparator. Figure 1 shows the basic circuit of the unit.

An operational amplifier amplifies the voltage difference across its two inputs, and at DC it has an extremely high voltage gain of typically about 200,000 times. Therefore, only a very small voltage difference at the inputs is needed in order to send the outputs of the device

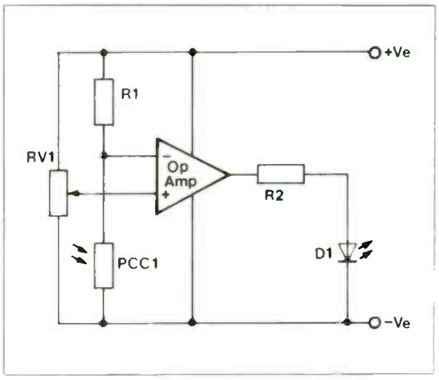



**Figure 1. Voltage Comparator**

fully positive or negative. The output goes positive if the non-inverting (+) input is the one at the higher potential, or negative if the inverting (−) input is at the higher voltage.

The input to the non-inverting input is provided by RV1, which is the calibrated potentiometer. The voltage at the inverting input is produced by the potential divider which is comprised of load resistor R1 and photocell PCC1. The resistance of PCC1 varies in sympathy with the light level to which it is subjected. The higher the light level the lower the resistance of PCC1, and the lower the voltage fed to the inverting input of the operational amplifier. If RV1 is adjusted for maximum slider potential, and then gradually backed off, the output of the operational amplifier will initially be high, but will switch to the low state as the slider voltage falls below the potential produced by the photocell circuit. In other words, by adjusting RV1 to this switch over point its scale reading will reflect (in arbitrary units) the voltage produced by the photocell circuit, and therefore the light level received by the photocell. Due to the high gain of the operational amplifier a high degree of precision can be obtained with this system, and the accuracy is limited largely by the degree of precision with which the potentiometer's position can be read, rather than by any electrical limitations. In fact, in practice the output of the operational amplifier will only be high or low, and it will not be possible to adjust RV1 for an intermediate level.

LED indicator D1 is used to show the output state of the operational amplifier, and this switches on when the output is

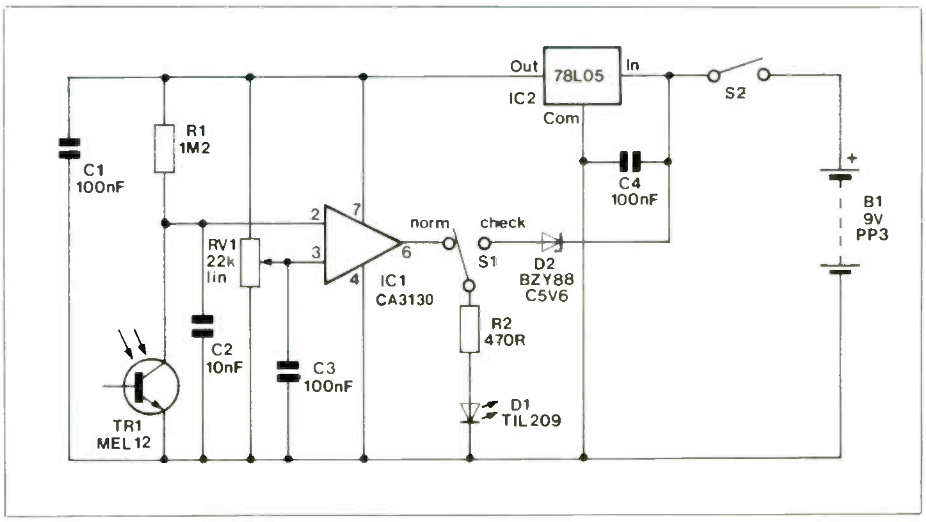



**Figure 2. Practical Circuit**

high. In theory the unit covers an extremely wide light level range, since RV1 can be adjusted to match any voltage produced by the photocell circuit. In pratice the usable light range of the unit is far more restricted as a very wide range of light levels are covered by a very small section at each end of the scale. The scale is only usable over the central section where a comparatively small light range is covered. The range covered here is wide enough for this application though, and the value of R1 is chosen to bring the appropriate light level range into this usable area.

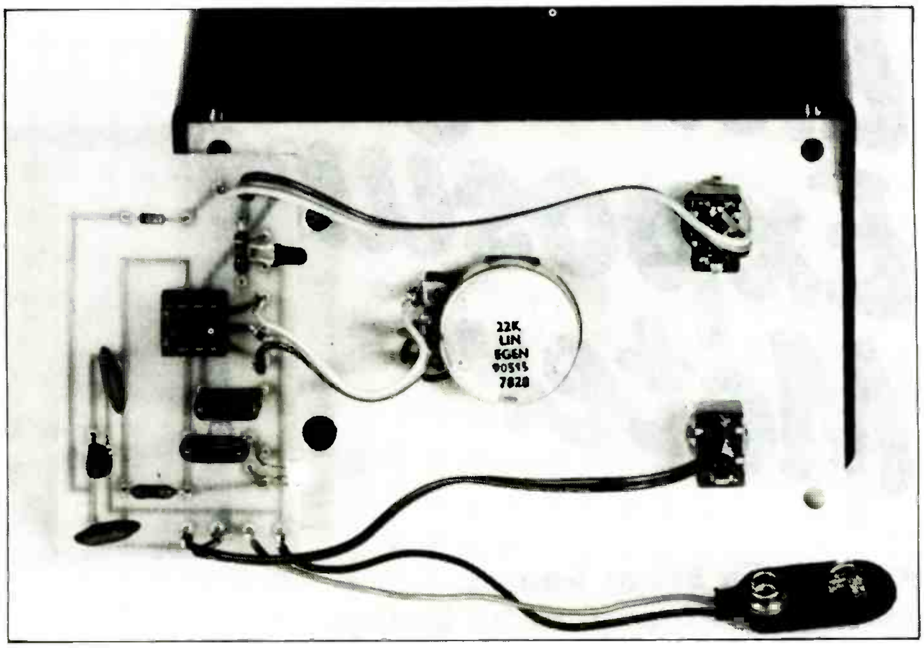
## Practical Circuit

Figure 2 shows the full circuit diagram of the Enlarger Exposure Meter, and this has obvious similarities with the basic circuit. However, there are a few important differences.

One of these is the use of a photodarlington transistor as the photocell, rather than a photoresistor. A photodarlington device has the advantage of a relatively fast response at low light levels and it is also inexpensive. A disadvantage is that is does not provide a true resistance, and changes in the supply voltage may not cause a proportional change in the output voltage of the photocell circuit, This results in changes in supply voltage slightly changing the reading produced by a given light level; a stabilised supply therefore has to be used. IC2 is a small monolithic voltage regulator which gives a well stabilised 5 volt supply that ensures good accuracy and consistent results. The circuit has to operate at very low light levels (far lower than an ordinary exposure meter), and this is reflected in the high value of load resistor R1. IC1 is a MOS operational amplifier which has an extremely high input resistance and operates well at a supply potential of just 5 volts. Most other operational amplifiers will not work in the circuit.

The circuit is very sensitive to stray pick-up of mains 'hum' and other electrical noise, due to the use of the operational amplifier with its full voltage gain. C2 and C3 help to minimise this unwanted pick-up which could otherwise prevent a well defined switch over point from being obtained, and could seriously impair the accuracy of the unit.

A simple battery check circuit is included, and the only additional components used in this are S1 and D2. With S1 in the 'normal' position the LED indicator D1 and its current limiting resistor R2 are connected across the output of IC1 so that the unit functions normally. In the 'check' position the LED indicator circuit is connected across the non-stabilised 9 volt battery supply via zener diode D2. With about 5.6 volts dropped across D2 and just under 2 volts needed across D1 before it will switch on, around 7.5 volts is needed across the battery check circuit before D1 will pass any current at all, and about 8 volts is needed before it will light up reasonably brightly. Therefore, if D2 lights up brightly when S1 is set to the 'check' position the battery voltage is



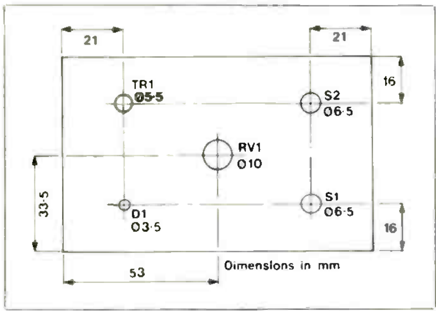



**Figure 3. Front Panel Drilling**

satisfactory. If D1 lights up only dimly the battery is nearly exhausted, and if D1 fails to light at all the battery should be replaced immediately. Incidentally, the battery check facility only functions when the unit is switched on.

The current consumption of the circuit is only about 5 or 10 milliamps (depending on whether D1 is switched on or off) and a small (PP3 size) 9 volt battery is quite adequate to power the unit.

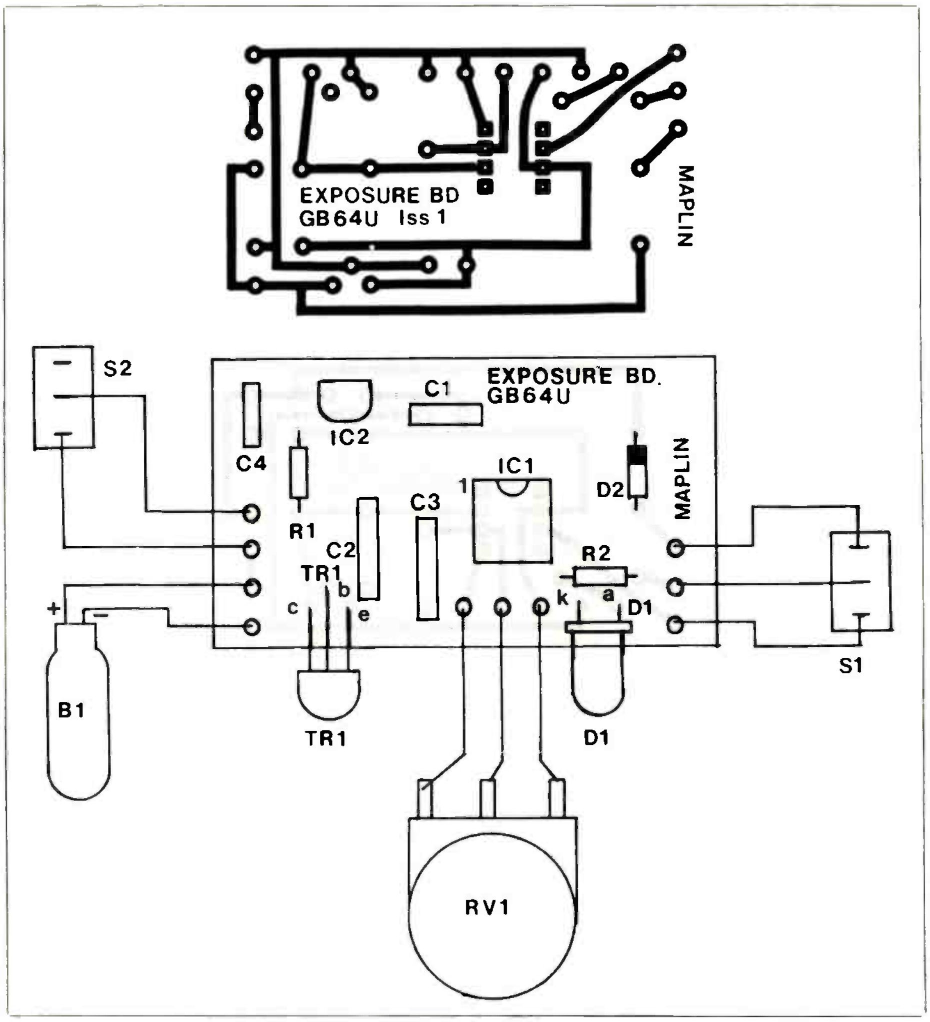



**Figure 4. PCB Layout and Wiring**

## Construction

The recommended case for this project is a plastic type having an aluminium front panel and approximate outside dimensions of 111 by 71 by 48 millimetres. As the printed circuit board has been specifically designed to fit this case it is strongly recommended that this particular type should be used. If all the components are to fit into place properly, especially TR1 and D1, it is essential that the mounting holes in the front panel are drilled in the correct positions. Figure 3 gives drilling details for the front panel, and once again, it is strongly recommended that this layout should be used.

Details of the printed circuit board and wiring are provided in Figure 4. IC1 is a MOS input device and it should therefore be mounted in an 8 pin DIL socket. Do not fit IC1 onto the board until all the other components have been mounted, and leave it in the antistatic packaging until then. Handle IC1 as little as possible. D1 and TR1 are mounted at right angles to the board, and are made to protrude slightly over the edge of the board. When the completed board has been wired up to the rest of the unit it is slotted into the vertical set of guide rails on the extreme left hand end of the case, with the component side of the board facing inwards. With D1 and TR1 suitably positioned they will fit into their mounting holes in the front panel when this is pushed into place.

Either RV1 must be fitted with a calibrated control knob, or it must be fitted with a pointer knob and a scale must then be marked around this. The former is by far the easier option, and is the one adopted for the prototype. An indicator line must be marked on the front panel next to RV1.

## In Use

In use the unit is simply placed on its back on the enlarger baseboard with the photocell facing upwards towards the enlarging lens. In order to find the correct scale setting for a particular box of paper it is necessary to first determine the optimum aperture and exposure times for an average negative. This is done in the usual way by producing a test strip. With the negative and the diffuser in place and the enlarger adjusted for the appropriate aperture, position the exposure meter on the baseboard and adjust RV1 to the switch over point. Make a note of the scale reading and the exposure time on the box of paper.

The procedure for finding the correct exposure for a new negative is then quite straightforward. Place the exposure meter on the baseboard and set it at the reading marked on the box. With the negative and diffuser in position the aperture of the lens is adjusted to bring the meter to the switch over point. This then gives the correct aperture for the exposure time marked on the paper's box. The same exposure time is always used for a given box of paper, and only the aperture is varied to suit each negative.

As the photocell has only a very small sensitive area it is possible to use the unit as a spot meter, reading either a highlight or a shadow tone as desired, or it can be utilized as an integrating meter if a diffuser is fitted under the enlarging lens while metering (as described above). An important point to keep in mind is that a different scale reading for a given box of paper will be obtained for each of these three methods, and if using more than one of these you must note the correct readings for each method on the box (and then be careful to use the right one each time).

The unit should give satisfactory results without any modifications being made, but it is just possible that the range of light intensities that you will use may tend to be in a cramped portion at one end of the scale or the other. If necessary R1 can be raised in value to broaden out the low light level end of the scale, or it can be reduced in value to broaden out the opposite end of the scale.

### ENLARGER EXPOSURE METER

| | | | |
|---|---|---|---|
| **RESISTORS** | | | |
| R1 | 1M2 ⅓W 5% Carbon Film | 1 | (B1M2) |
| R2 | 470Ω 0.6W 1% Metal Film | 1 | (M470R) |
| RV1 | 22k Pot Lin | 1 | (FW03D) |
| **CAPACITORS** | | | |
| C1,4 | 100nF Disc | 2 | (BX03D) |
| C2 | 10nF Polyester | 1 | (BX70M) |
| C3 | 100nF Polyester | 1 | (BX76H) |
| **SEMICONDUCTORS** | | | |
| D1 | Mini LED Red | 1 | (WL32K) |
| D2 | BZY88C5V6 | 1 | (QH08J) |
| TR1 | MEL12 | 1 | (HQ61R) |
| IC1 | CA3130 | 1 | (QH28F) |
| IC2 | μA78L05AWC | 1 | (QL26D) |
| **MISCELLANEOUS** | | | |
| S1,2 | Sub-Min Toggle A | 2 | (FH00A) |
| | Printed Circuit Board | 1 | (GB64U) |
| | Metal Panel Box M4004 | 1 | (WY01B) |
| | Knob F10 | 1 | (RW78K) |
| | DIL Socket 8-pin | 1 | (BL17T) |
| | Wire | 1m | (BL00A) |
| | Veropins 2145 | 1pkt | (FL24B) |
| | Battery Clip (PP3) | 1 | (HF28F) |

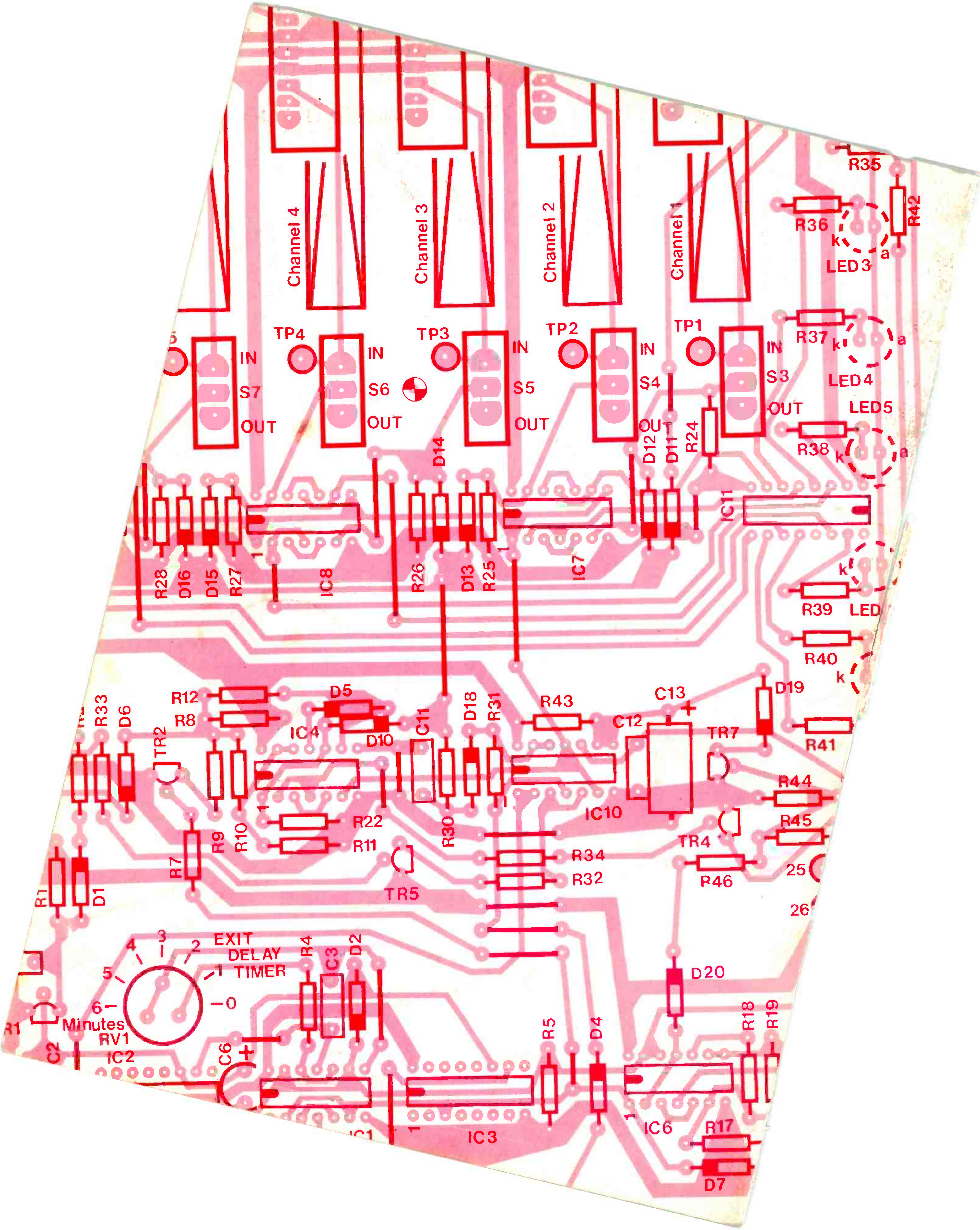
A Kit of all the above parts, including the case, is available.
**Order As LK44X (Enlarger Exposure Meter)**

**XENON TUBE DRIVER** *Continued from page 30.*

### XENON TUBE DRIVER PARTS LIST

| | | | |
|---|---|---|---|
| **RESISTORS: All 0.6W 1% Metal Film unless otherwise stated** | | | |
| R2 | 4M7 ⅓W 5% Carbon Film | 1 | (B4M7) |
| R3 | 2M2 ⅓W 5% Carbon Film | 1 | (B2M2) |
| R4 | 1M0 | 1 | (M1M0) |
| R5,10,11 | 10k | 3 | (M10K) |
| R6 | 4k7 | 1 | (M4K7) |
| R1,7 | 47k | 2 | (M47K) |
| R8,9 | 100k | 2 | (M100K) |
| R12,13 | 1k0 | 2 | (M1K0) |
| R14,15 | 5k6 | 2 | (M5K6) |
| RV1 | 1M0 Hor. Sub-min Preset | 1 | (WR64U) |
| RV2 | 470k Hor. Sub-min Preset | 1 | (WR63T) |
| **CAPACITORS** | | | |
| C1 (See Text) | 47μF 450V Axial Electrolytic | 1 | (FB43W) |
| C2 | 0.1μF Interference Supp. | 1 | (FF56L) |
| C3 | 10nF Disc | 1 | (BX00A) |
| C4 | 1μF Polycarbonate | 1 | (WW53H) |
| C5 | 1nF Polycarbonate | 1 | (WW22Y) |
| C6 | 470μF 16V Axial Electrolytic | 1 | (FB72P) |
| **SEMICONDUCTORS** | | | |
| D1 | 1N4001 | 1 | (QL73Q) |
| D2–5 | 1N4007 | 4 | (QL79L) |
| D6 | 1N4148 | 1 | (QL80B) |
| TR1 | BC328 | 1 | (QB67X) |
| TR2,5 | 2N3053 | 2 | (QR23A) |
| TR3,4 | BD711 | 2 | (WH15R) |
| TH1 | C106D | 1 | (QH30H) |
| IC1 | 4049UBE | 1 | (QX21X) |
| **MISCELLANEOUS** | | | |
| T1 | Transformer 6V Sub. Min. | 1 | (WB00A) |
| T2 | Trigger Transformer | 1 | (YQ63T) |
| N1 | Neon Bulb Wire Ended | 1 | (RX70M) |
| X1 | Xenon Tube | 1 | (YQ62S) |
| | Veropin 2141 | 1pkt | (FL21X) |
| | Printed Circuit Board | 1 | (GB61R) |

A complete kit of parts is available.
**Order As LK46A (Xenon Tube Driver)**


Channel 4
Channel 3
Channel 2
Channel 1
R35
R36
R42
LED3
R37
LED4
LED5
R38
TP4
TP3
TP2
TP1
IN
S7
OUT
IN
S6
OUT
IN
S5
OUT
IN
S4
OUT
IN
S3
OUT
D14
D12
D11
R24
IC11
R28
D16
D15
R27
IC8
R26
D13
R25
IC7
R39
LED
R40
D19
R41
R12
R8
D5
D10
IC4
R33
D6
TR2
C11
D18
R31
R43
C13
C12
TR7
R44
R45
TR4
R46
R22
R11
R9
R10
R7
R30
IC10
R34
R32
TR5
R1
D1
25
26
EXIT
DELAY
TIMER
Minutes
RV1
R4
C3
D2
D20
C6
C2
IC2
R5
D4
R18
R19
IC1
IC3
IC6
R17
D7