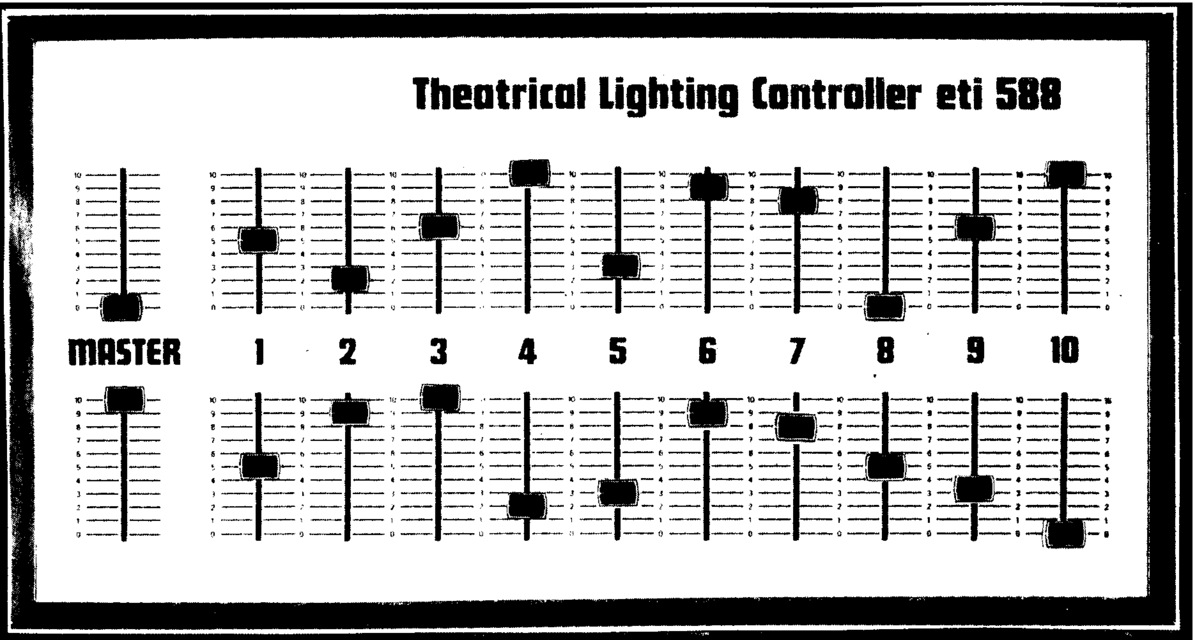
STAGE DIMMER

A comprehensive unit designed to handle up to 20A per channel with **emphasis upon ease of construction and versatility** in operation

SINCE THE EARLY DAYS of the theatre the need for lighting has been all-important Just as Important has been the need for control of that lighting. This ranges from very crude Initially to very sophisticated today oftem with a computer doing the controlling in the creation of special moods and effects.

The first types of dimmer used of which there are still some examples in older theatres, was a variable resistance type which used either a variable or switched power resistor in series with the load With small loads a wire wound resistor or a carbon pile was used while larger loads used a tank of saline solution with a central electrode which was raised or lowered in the liquid, effectively changing the resistance This type of dimming, while reasonably effective, dissipated a lot of power which made life uncomfortably hot for the operator, since to minimise mechanical linkages the dimmers themselves were often in the control room.


Theatrical Lighting Controller eti 588
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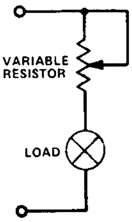
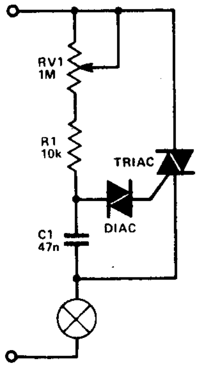
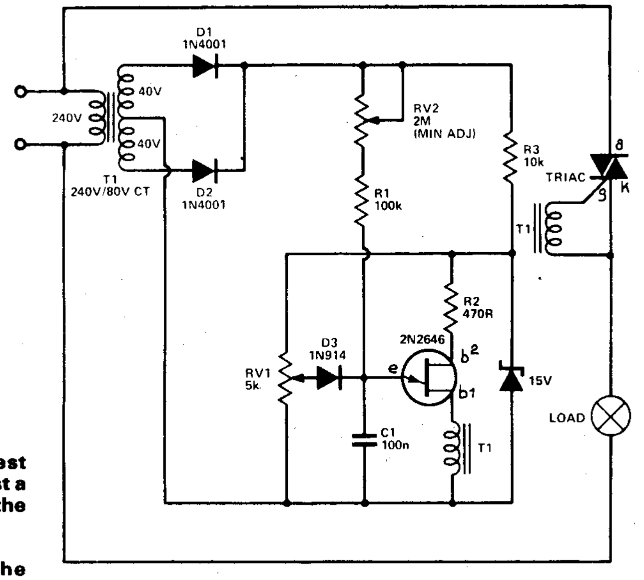






Electronics

With the advent of electronics, life was a little bit easier. The use of phase controlled dimming using thyratrons and later SCRs and Triacs reduced the heat dissipation dramatically (if you'll excuse the pun) and also allows the control to be physically separate from the dimmer. Besides being easier for the operator performances were greatly enhanced by the much better control available.

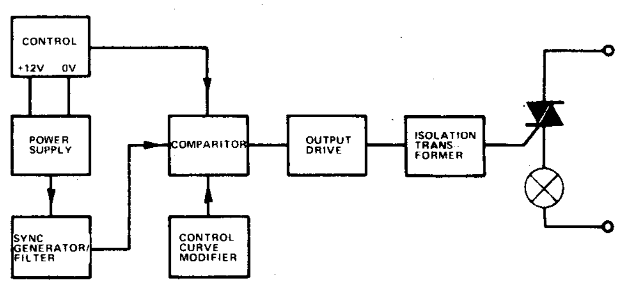
Today the use of phase control is almost universal as it is simple, reliable and cheap. Another method in use today is by magnetics; this type has the advantage of generating no RFI but unfortunately is expensive.

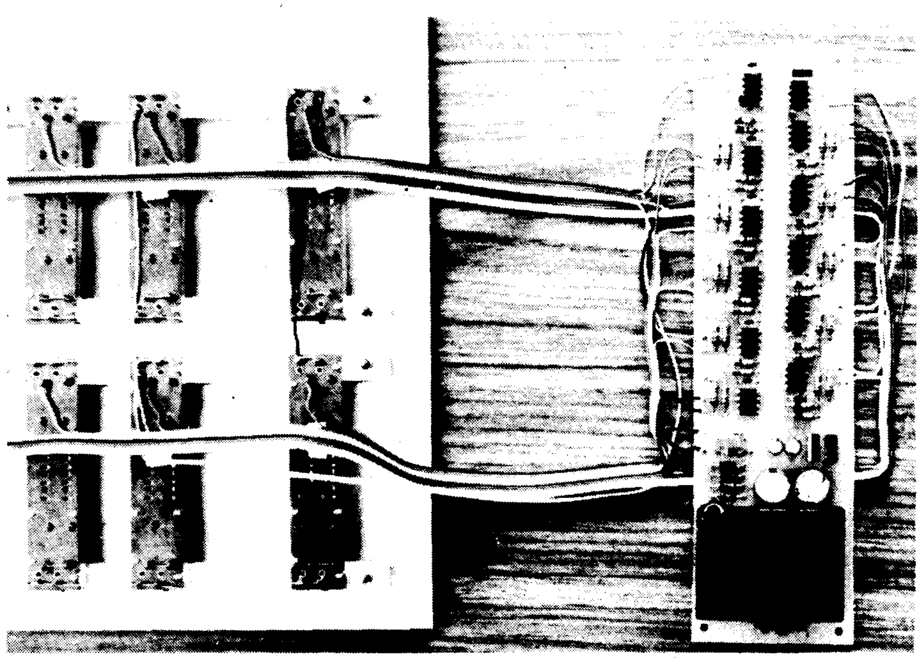
The problem of RFI is common to all phase control circuits, but can usually be reduced to acceptable levels by the use of a choke and several capacitors. For RFI the choke need not be very large, but one other effect of phase control is the audible rattling of the lamp filament (especially with the larger globes) which is due to the sudden application of power, and the magnetic field so produced, each half cycle. This can be cured by reducing the rate of the rise of current by using a larger choke.

Fig 1. (Far left). The earliest type of dimmer employing just a variable resistor controlling the load.

Fig 2. (Left). Common! The most usual kind of light dimmer in use today.

Fig 3. (Right). A more refined realisation of the art, which at least has the control isolated!





Type Casting

We have given some schematic diagrams of types of dimmers which have been used previously. Fig. 1 is the oldest type comprising simply a variable resistor in series with the load. The second (Fig. 2), probably the most common type in use today (mainly in homes) is very simple but lacks the versatility needed for theatrical work.

The third type (Fig. 3) is in common use and while still very simple does have many good features. These include having the control potentiometer isolated from the mains voltage and also a modified control curve to give a better input-output voltage relationship. Synchronization is referred to the zero crossing of the mains voltage, making the unit more suitable for driving inductive (fluorescent) loads; this also eliminates hysteresis which occurs with the simple dimmers.

The dimmer to be described here is more complex than most but a great deal of effort has been taken to ensure that *all* problems have been solved. A low pass filter, with phase ▶

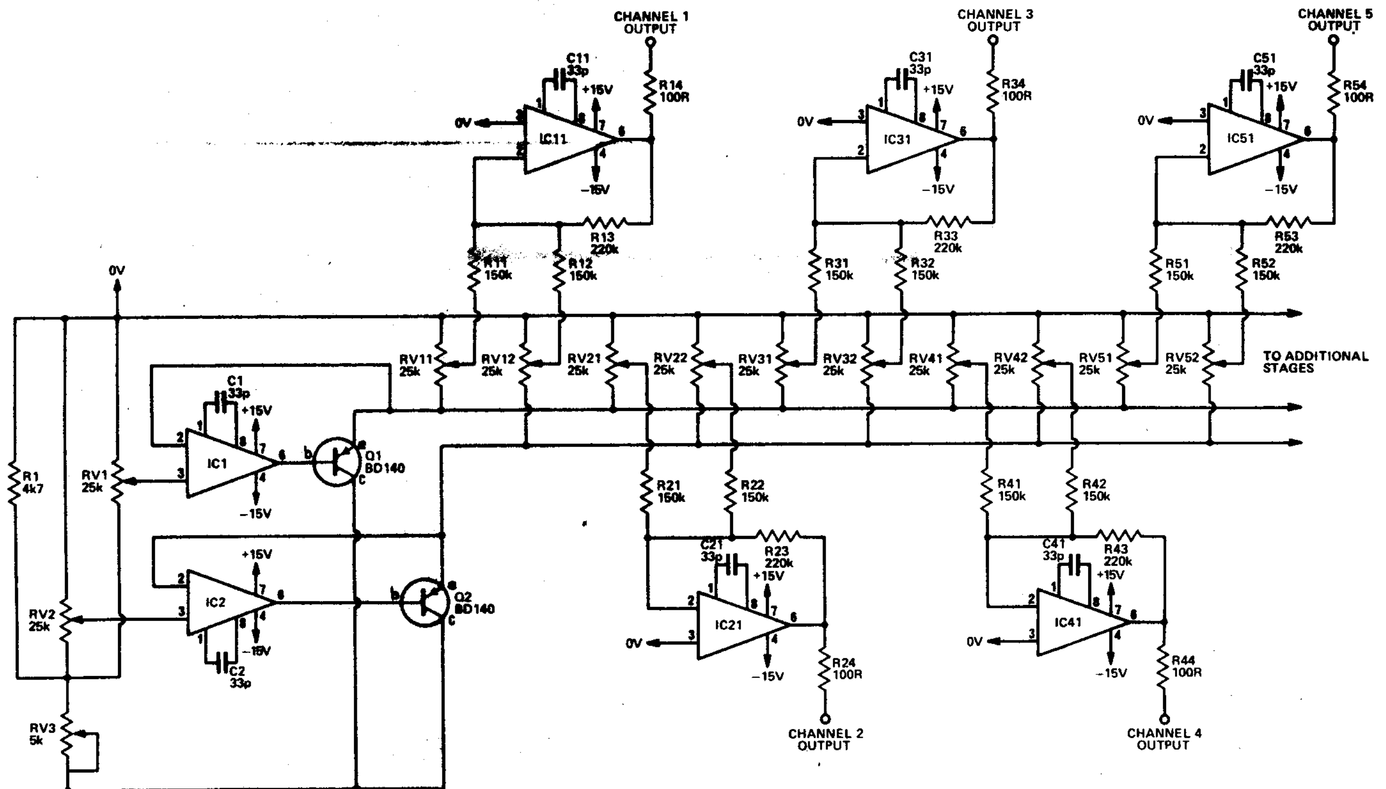


Fig 4. The circuit of the control desk sections.

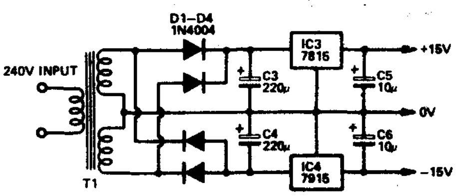


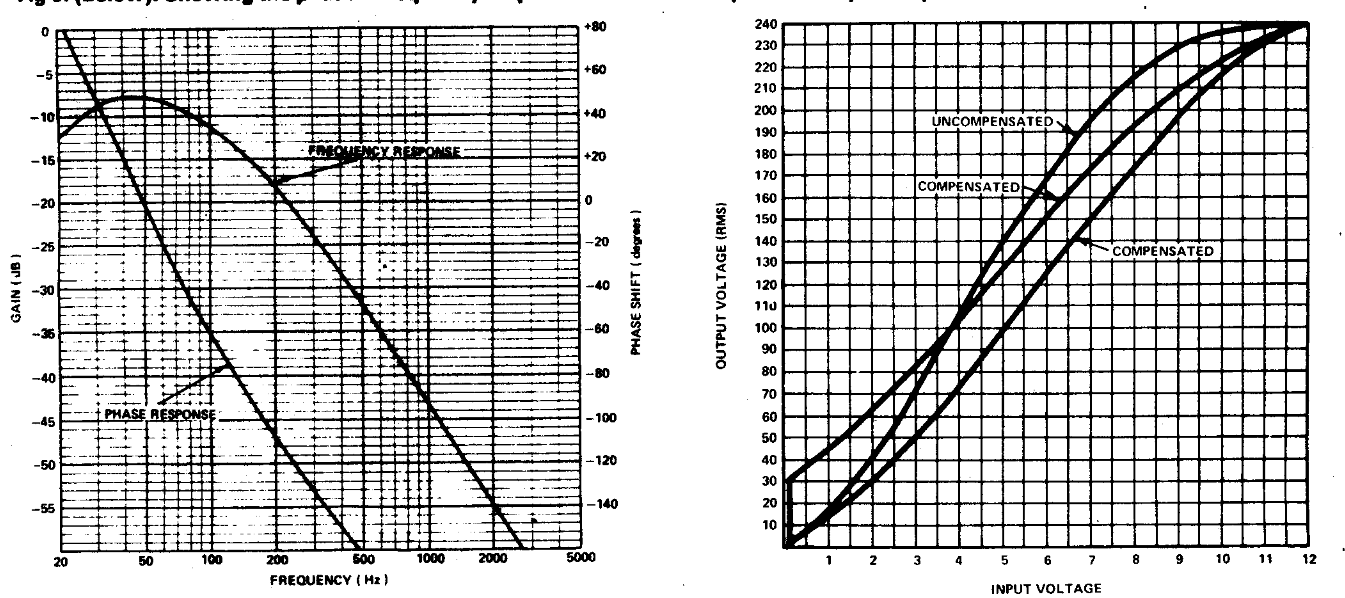
Fig 5. Power supply circuit

HOW IT WORKS - CONTROLLER

There are two controls for each dimmer along with two master controls. The master controls vary the voltage on the individual level control potentiometers from 0 V (no light) to —8 volts (full light). Normally one master will be at maximum and the second at zero. The outputs of the two controls for each dimmer are added by an operational amplifier, referred to 0 V. As one set of potentiometers has 0 V on both of its ends it can be varied without changing the output allowing it to be set for the next scene. By varying the master controls together, but in opposite directions, the complete lighting set up can be smoothly varied from one scene to the next.

As we need + 12V out to drive the dimmers the supply voltage of the control desk is ± 15 volts.

Fig 6. (Below). Showing the phase v frequency responses effect of compensation upon response



PARTS LIST

Resistors all ½W 5%	
R1	4k7
R11,12,21,22,31 32,41,42,51,52, 61,62,71,72 81,82,91,92,101,102	150k
R13,23,33,43,53 63,73,83,93,103	220k
R14,24,34,44,54, 64,74,84,94,104	100R
POTENTIOMETERS	
22 off	25k 1in. 60mm slide
RV3	5k trimmer
CAPACITORS	
C1,2	33p ceramic
C3,4	220u 50V
C5,6	10u 25V
C11,21,31,41	33p ceramic
C51,61,71,81	33p ceramic
C91,101	33p ceramic
SEMICONDUCTORS	
IC1,2	301A
IC3	7815
IC4	7915
IC11,21,31,41 51,61,71,81 91,101	301A
Q1,2	BD140
D1-D4	1N4001
MISCELLANEOUS	
Transformer	30V
Box and front panel	5W
Knobs to suit	

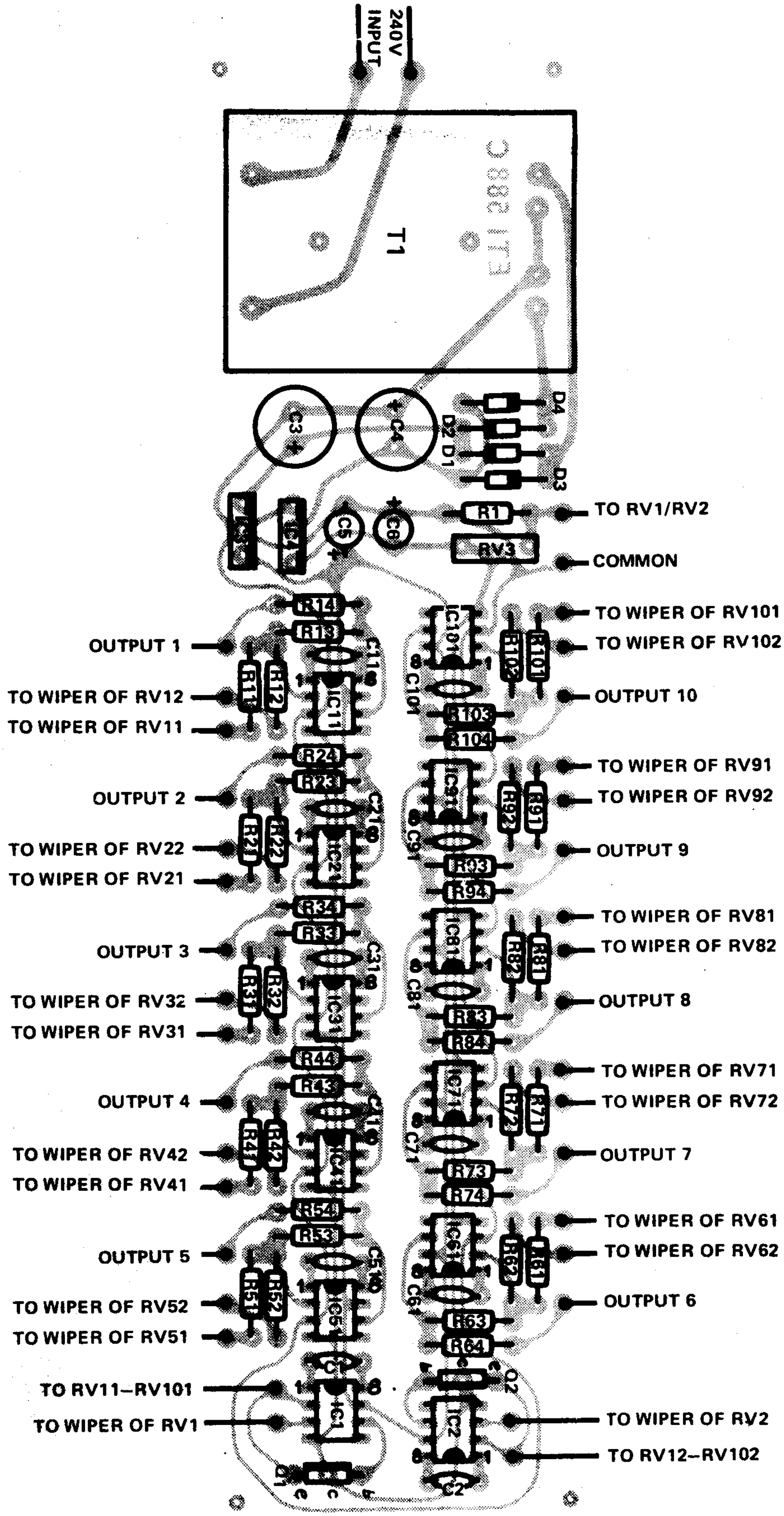


Fig 7. (Right): Component Overlay for the Controller Module.

BUYLINES

Apart from the pulse transformer T1 — for details of which see Table One — none of the components in this (admittedly huge) project should tax your local supplier overmuch. If you send us an SAE we will send you the foil patterns for the PCBs used here, as they were simply too big to print full size.

Any 400V ten or twenty amp triac will probably serve if you can't find the specified type easily.

correction, is used to ensure accurate synchronization. The control curve is' also modified to give a subjectively more linear response and it has the ability to drive a fluorescent load without requiring a ballast resistor. Both the maximum and minimum light levels are adjustable without interaction giving reliable and predictable output. This is especially necessary if a dimmer fails for some reason and is replaced by a spare unit.

The Protection racket

The protection of SCRs and Triacs, especially Triacs, is usually difficult as they tend to fuse faster than the fuse purportedly protecting them. The use of a cheap Triac which requires an expensive fuse to protect it is false economy. We have used a large rugged Triac (40 A device for the 20 A dimmer) which allows economical fuses to be used, especially for the 10 A version.

On the control side we will be describing a panel with two sets of long sliders per dimmer with two master controls which allow the next scene to be set up then faded in when required. A igital memory which can 'prereca d' scenes and recall them on demand may be published later.

Dimmer Module – Construction

Assemble the boards with the aid of the overlay. The heatsink should be drilled and tapped for the triac to allow easy replacement if ever necessary. Note that the mounting of the fuse is different for the 10 and 20 A dimmers.

The choke is bolted onto the PCB using the long clamping bolts, preferably using rubber grommets in the holes in the board (they may have to be drilled out to do this). The leads from the choke should be bent such that they go into the holes provided without going near the mounting bolts which are at earth potential. The leads can now be soldered (both sides on the 20 A unit).

The pulse transformer can now be added according to Table 1 Be careful when winding this transformer not to damage the insulation on the wire as there is 240 V between windings. We also recommend some epoxy between the transformer and the board.

The printed circuit boards for the two versions of the dimmer board are identical in layout and differ only in that the connector end of the 20 A board is double sided to present a greater area of contact with the connectors.

Controller-Construction?

The component numbering system used on the controller drawings is designed to indicate which channel a particular component is part of. The printed circuit board drawing for the dimmer board is too large to publish in the magazine at full size; however, the pattern is available from our offices for the cost of an SAE – a large SAE!

If the dimmer modules are not required to be connected through sockets, the total cost can be reduced by connecting directly to the modules and mounting them in a box. In the 20 A unit the heavy wires should be bolted on to the appropriate pads to ensure contact to both sides of the board.

One more modification to the control desk is the addition of a black-out switch which allows all lights to be blacked out without moving the master control. This is simply done by switching the supply voltage on the master potentiometers from the 8 V supply as set by RV3 to OV. RV3 should be adjusted such that with one master at maximum, the second at minimum and one individual control at maximum that' its output voltage should be + 10 volts.

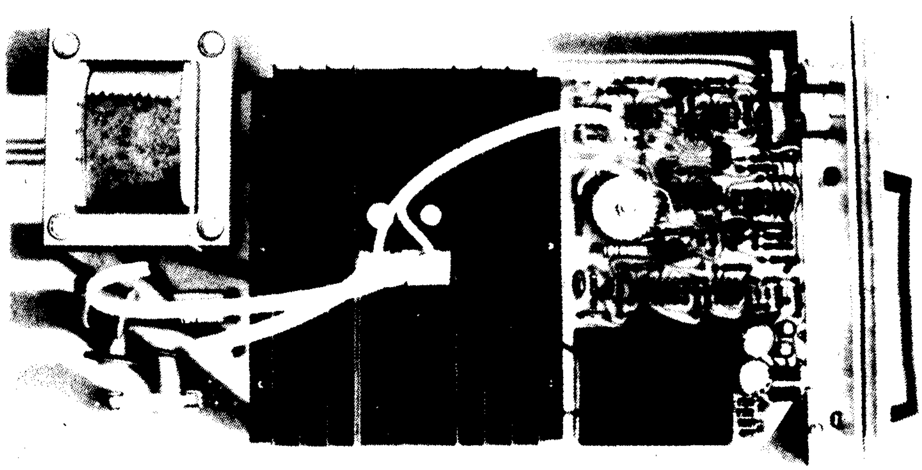
Setting up

With the dimmer module the trim potentiometer has to be adjusted so that the output pulse from IC7 occurs at the very end of each half cycle. This is easiest set using an oscilloscope although an approximate setting can be made without one.

If the dimmer is connected up to a reasonably heavy load and adjusted for about 1 / 3 level it will probably be found that with RV3 at one end the light level is not stable and tends to flash. This is caused by the sync pulse occurring after the end of the half cycle and the trigger pulses from the previous half cycle triggering the next. The trim potentiometer RV3 should be turned back about ¼ turn from the position at which this effect stops.

Max and Min

When adjusting the maximum and minimum levels the minimum should be adjusted first. Note that the control potentiometer must be slightly up off zero to get any light and minimum should be adjusted at this point. The maximum should be adjusted with both the master and individual control at maximum and set to the point where the light level is just starting to drop. ▶



Shown above is a completed dimmer module

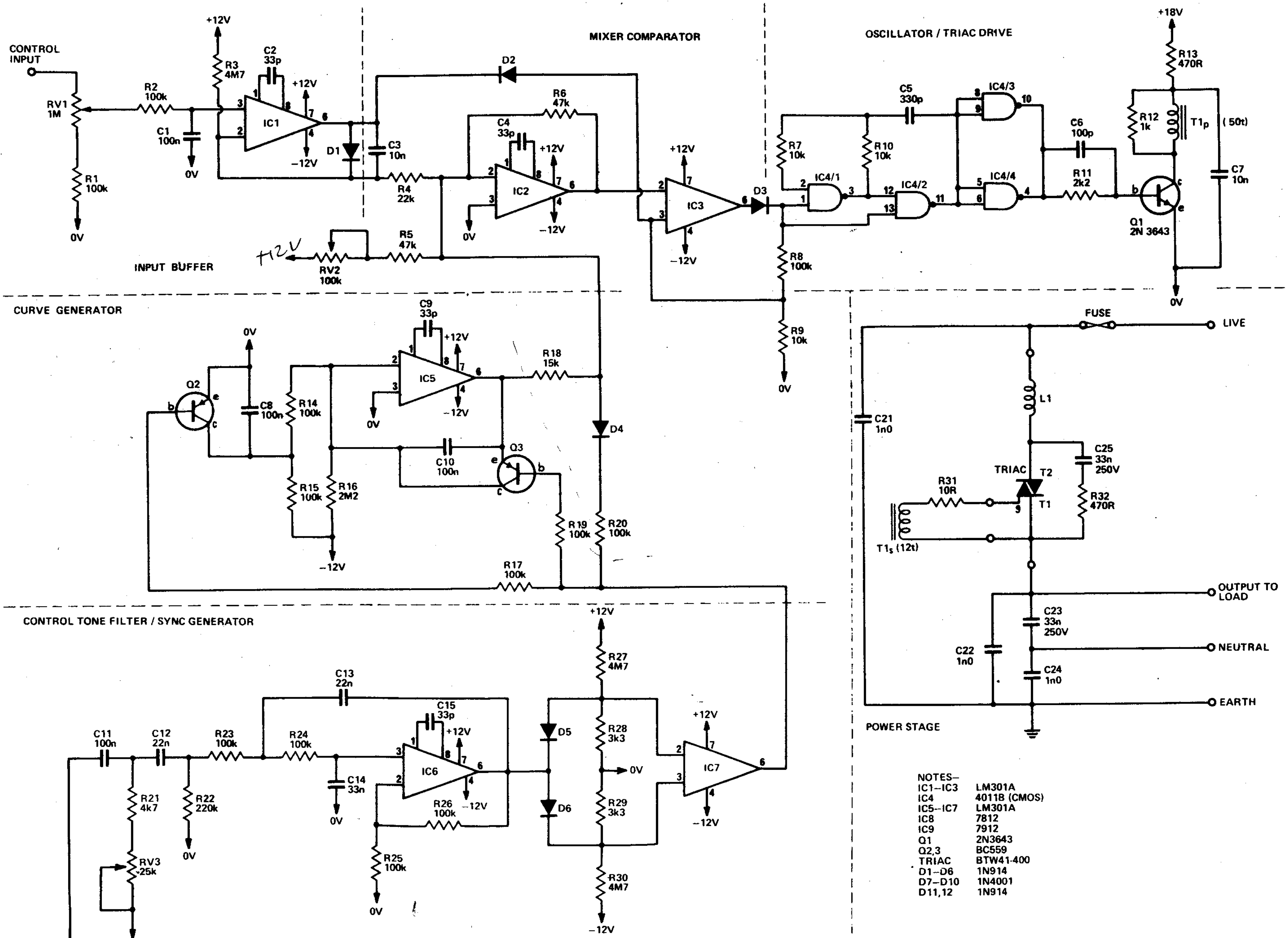
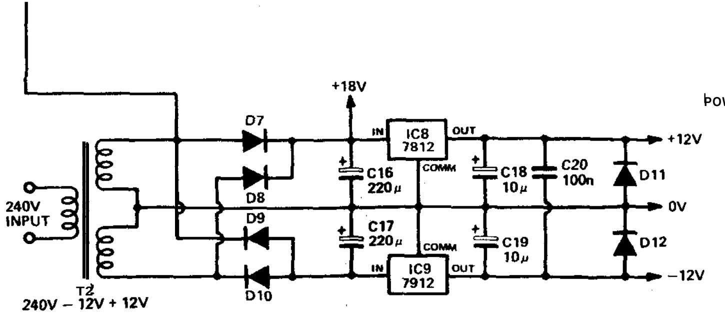


Fig 8. Circuit diagram of the light dimmer module and its power supply (below).



POWER SUPPLY

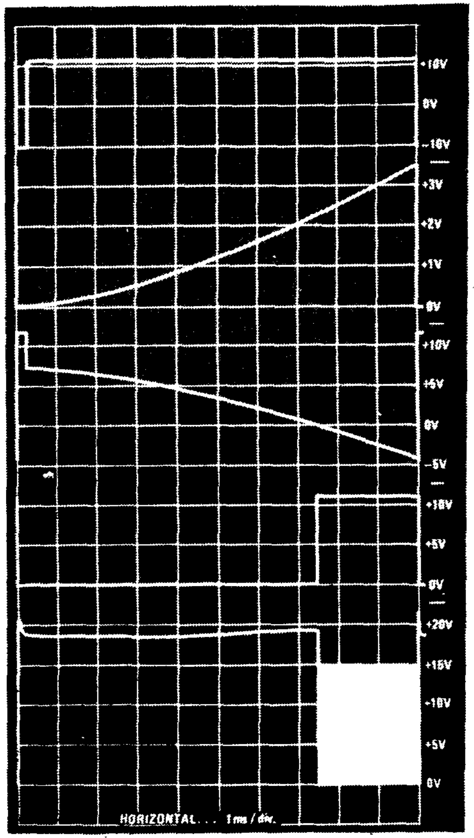


Fig 9. Waveforms shown are: pulse (IC7), curve generator (output IC5). mixer output (output IC2). oscillator output (IC4). transformer drive, (Q1).

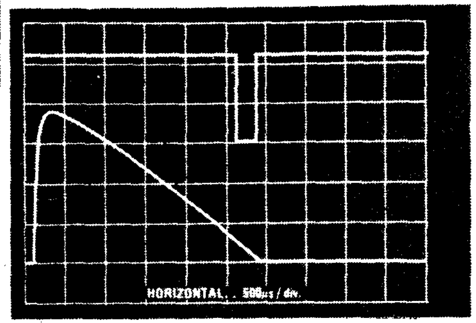


Fig 10. Relationship between the end of half cycle and the **pulse.**

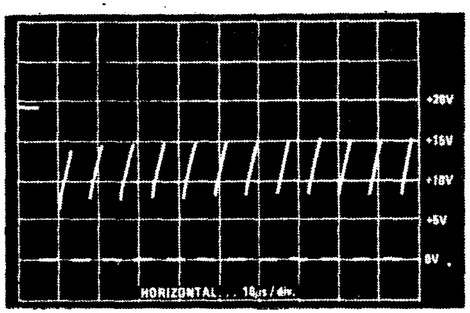


Fig 11. An expanded view of the drive waveform showing Q1

HOW IT **WORKS**
DIMMER MODULE

To help explain the operation the circuit can oe broken into seven sections.

1. Power supply

This is a simple full wave rectifier which gives about ±18 V after being filtered by Cl6 and C17. Using 3 terminal regulators this is reduced to ±12 volts which is needed for the circuitry.

2. Control tone filter and sync generator

As the name implies this removes the control tones that the supply authority superimposes on the mains voltage. These are normally about 1050 Hz and can cause problems by upsettmg synchronization of dimmers. The filter is a low pass type comprising IC6 and associated components. As filters always alter the phase relationship this is corrected using phase shift networks. Cll/R21 and C12/R22. Potentiometer RV3 is used to ensure the phase shift is zero (at 50 Hz) with normal component variations. If the output of IC6 is between +0.6 volts and -0.6 volts neither D5 nor D6 will be forward biased sufficiently to change the input voltages to 1C7 so its output will be -10 volts. As the output voltage of 1C6 is a 'clean' 50 Hz sine wave of about 6 volts amplitude this will only occur at a small region about the zero crossing point. At all other times the output of IC7 will be + 10 volts. The result is a negative pulse, about 250 μS wide at the zero crossing point of the 50 Hz.

3. Curve generator

This produces the output shown in Fig. 6. When the sync pulse occurs, transistors Q2 and Q3 discharge capacitors C8 and Cl0. Immediately on release of the sync pulse the output of IC5 begins to ramp up slowly due to R16 charging ClO. However, while initially the voltage across R14 is zero and therefore does not affect the charging of ClO. as C8 begins to charge due to R15 its effect becomes more and more dramatic. A curve is necessary as it gives a better input/output voltage relationship but the curve must be reproduceable hence the circuit used.

4. Input buffer

This serves two purposes; firstly, it allows a megohm input impedance and secondly it detects when the input voltage falls below 0.1 volt and turns the dimmer output completely off. This allows the minimum light control to be turned up to give a better control range, ie with the filaments just glowing, yet have them off if the control voltage is reduced to zero.

If the voltage is aboveO.l volt, the diode Dl will lift the voltage on pins of 1C1 to equal that of the input on pin 3. However if the voltage falls **below this** level, the voltage on pin 2 will remain at about 0.1 volt due to R3 and the output of IC1 will go to about -10 volts.

5. Mixer-comparator

IC2 mixes the input voltage, the output of the curve generator the sync pulse and the minimum adjustment potentiometers. This gives the waveform shown in Fig. 2 with the input voltage and the minimum adjustment only **moving the** curve up and down without altering the shape. When the output of IC2 falls below zero volts the output of IC3 goes from -10 V to +10 volt with D3 and R8/9 providing about 1 volt of positive feedback. The voltage has to rise to above 1V to force the output back to -10 volts. The diode is necessary to ensure that the voltage at the input of the oscillator IC4 remains within the supply voltage of the IC (+ 12 V, 0 V).

6. Oscillator/ **triac** drive

A CMOS osci[illegible] IC4 is used to drive Q1 which supplies [illegible] energy for the pulse transformer Tl. The oscillator will only operate when the control inputs (pins 1 and 13) are + 10 V. The frequency is controlled by C5 and is set at about 150 kHz. Resistor R13 provides current limiting for the pulse trans former while R12 prevents the reverse voltage damaging Ql if the load on the secondary load (the triac) becomes disconnected.

7. Power stage

This is simply a triac with a choke in series to prevent both RF1 and 'filament rattle' **and a** fuse to protect against short circuits Capacitors are also used as bypasses to help prevent

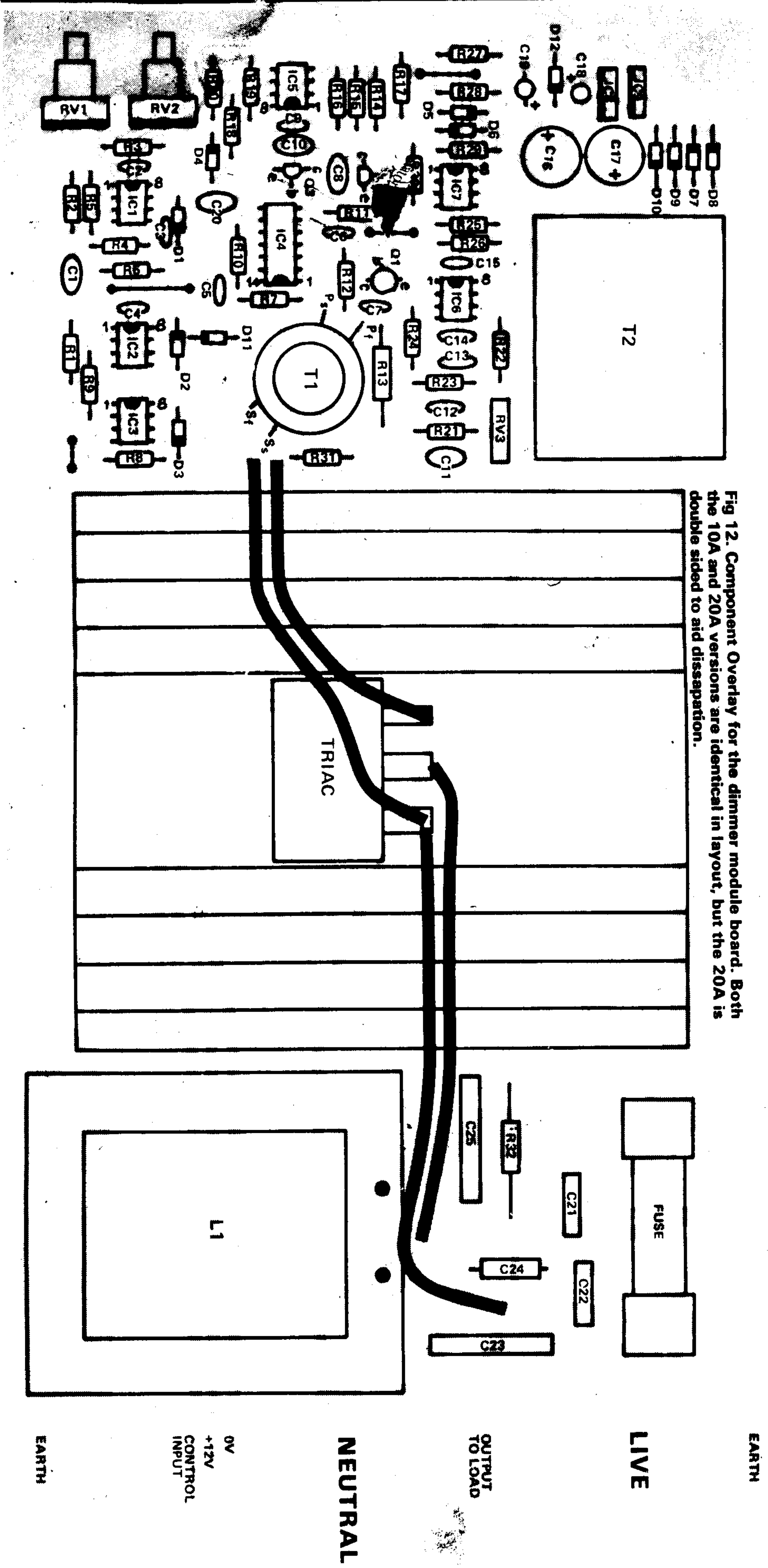


Fig 12. Component Overlay for the dimmer module board. Both the 10A and 20A versions are identical in layout, but the 20A is double sided to aid dissapation.

PARTS LIST

RESISTORS all ¼W 5%

R1,2,8,14,15, 17,19, 20,23-26,	100k
R3,27,30	4M7
R4	22k
R5,6	47k
R7,9,10	10k
R11	2k2
R12	1k
R13	470R 1W
R16	2M2
R18	15k
R21	4k7
R22	220k
R28,29	3k3
R31	10R
R32	47R 1W

POTENTIOMETERS

RV1	1M linear
RV2	100k linear
RV3	25k trimmer

CAPACITORS

C1,8,10,11,20	100n polyester
C2,4,9,15	33p ceramic
C3,7	10n polyester
C5	330p ceramic
C6	100p ceramic
C12,13	22n polyester
C14	33n polyester
C16,17	220u 25V
C18,19	10u 25V
C21,22,24	1n polyester
C23,25	33n 250V AC

SEMICONDUCTORS

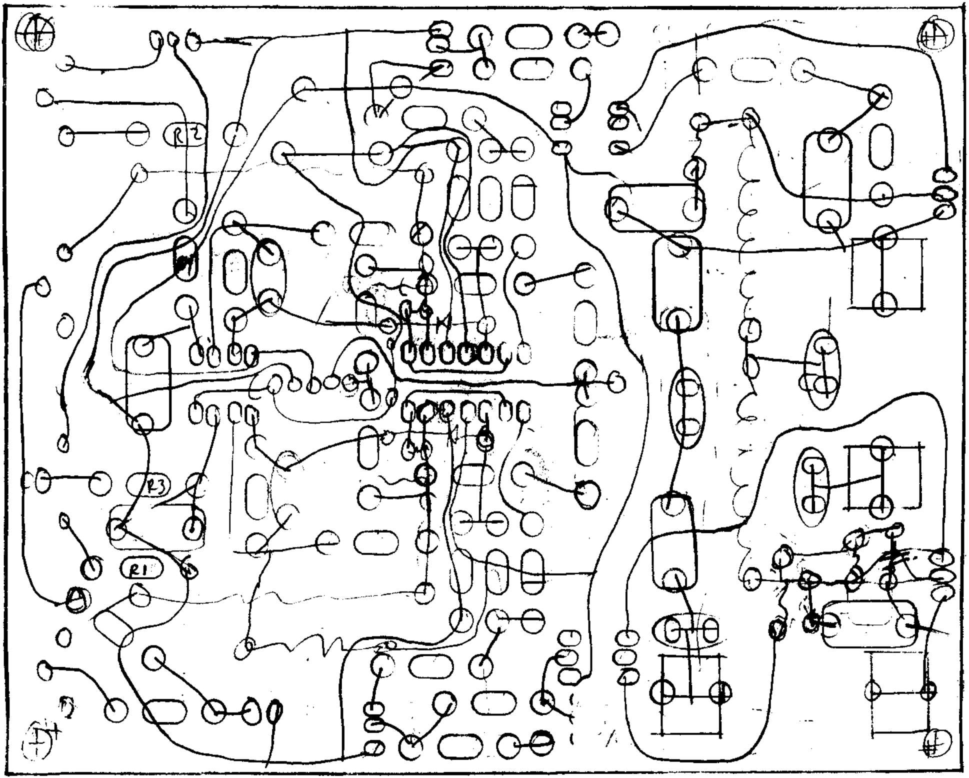
IC1-3,5,6,7	LM 301A
IC4	4011B
IC8	7812
IC9	7912
Q1	2N3643
Q2,3	BC 559
TRIAC	BTW41/400
D1-D6,11,12	1N 914
D7-D10	1N 4001

MISCELLANEOUS

Tl see text, T2 24V, 5VA, heatsink and choke and fuse 10A or 20A to suit, fuse holders.

TABLE ONE

The pulse transformer T1 is the most difficult component in the project to find or produce. Tandy market a 4:1 device and this must be first choice. If this, and all other, commercial units prove elusive — try winding it yourself onto an ferrite ring of about 2in outside diameter, using 50 turns and 12 turns for the windings to obtain the required ratio. Some experimentation may be needed here in order to get the triac to fire properly, and we do not recommend you try this unless you have wound coils previously.


R2
R3
R1