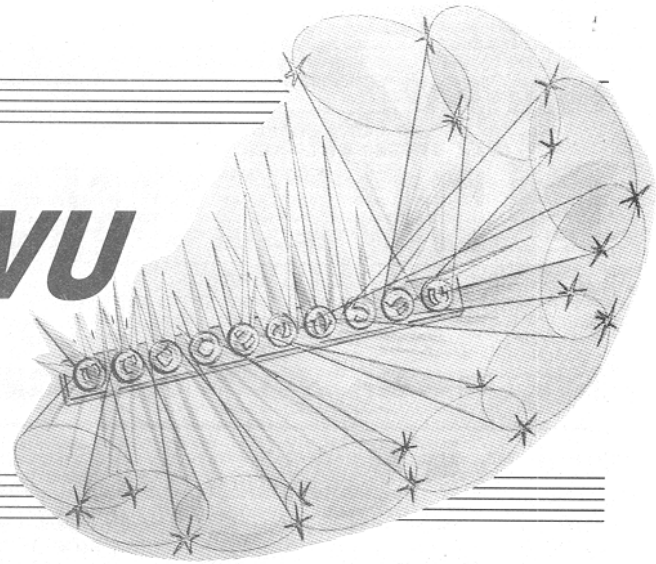
Constructional Project

GINORMOUS VU METER

PAUL STENNING



Add brilliant individuality to your disco display - ten or more lights flashing, ascending, cascading, in harmony with the mood and strength of the music. It's a sight to be seen!

RECENTLY, while rummaging in the loft, the author found the circuit diagram of one of his favourite home-made lighting effects units, a large VU meter. It dated back to when he and a friend ran a small mobile disco. The friend was the DJ, while author dealt with the technical side, building most of their equipment to keep costs down. Feeling prompted to rebuild it, bringing it up-to-date in the process, resulted in this Ginormous VU Meter!

ORIGINALITY

Seven lamps were controlled by the original unit, using individual comparators, whereas the Ginormous VU Meter design controls ten lamps and uses a bargraph driver chip. The effect is emphasized by reducing the difference between the bottom and top lamps, giving a more dramatic effect than a conventional VU meter. In addition, the scaling is linear, rather than the logarithmic scaling normally used.

The Effects potentiometer on the controller sets the level in a similar manner to a recording level control. Normally, this would be set so that the top light comes on at the loudest peaks in the music. However, it may be turned down to give a more romantic atmosphere when playing slower records. Once the desired effect is obtained, it is maintained by an automatic level control circuit, despite variations in volume and music style. This allows the DJ to concentrate on playing the music rather than fiddling with the lighting effects.

Low cost home disco lighting effects use a built-in microphone to pick up the sound. This arrangement is prone to picking up extraneous noises unless it is placed very close to the speakers. This effects unit, though, connects directly to the speaker terminals of an amplifier, eliminating the problem. A transformer is used to isolate the amplifier from mains circuitry.

The input impedance is about one kilohm (1k), which will impose no significant additional load on the amplifier. A high power amplifier is not necessary – by changing one component value the output from a domestic stereo system playing at a sociable volume can be accommodated. Each lamp output can drive up to 250W of lights, giving a total of 2·5kW! In practice, much smaller lamps would be used, 25W per channel being typical. Suggestions for constructing a suitable light box are given later.

Zero crossing control is used to minimize radio frequency interference (RFI). Note that the outputs are only suitable for resistive loads such as normal tungsten lamps. Inductive loads such as pin-spots and similar lights containing transformers are not suitable.

WARNING

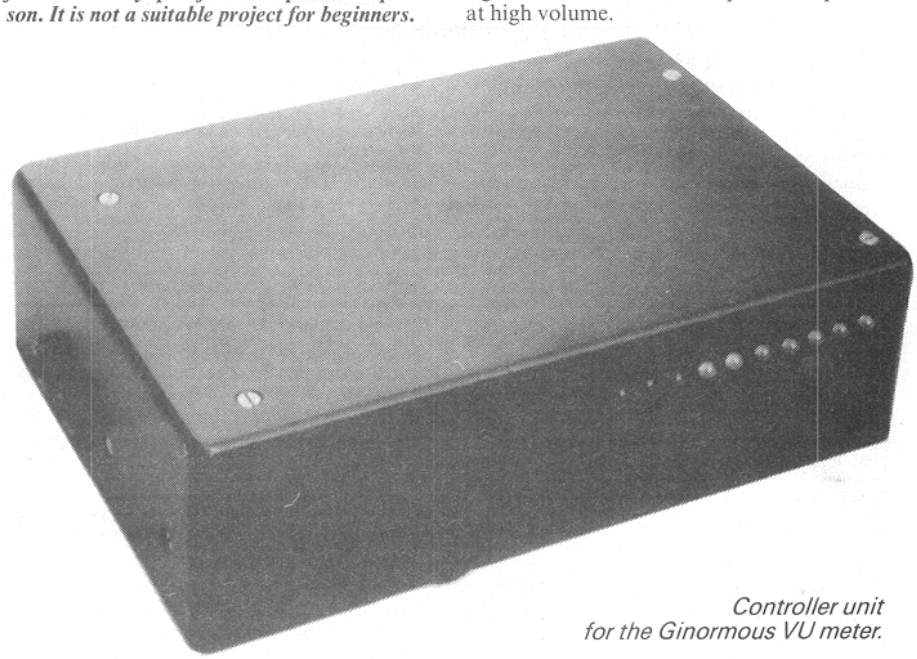
This design operates at lethal mains voltages. If you are in any doubt about your ability to construct it safely, seek assistance from a suitably qualified or experienced person. It is not a suitable project for beginners.

HOW IT WORKS

The circuit diagram for the music level detection and control stages is shown in Fig. 1. Mains transformer T1 is used to isolate the circuit from an audio amplifier. Audio matching transformers are available, but these are not generally designed to isolate mains voltages, and are normally more expensive. Although a mains transformer does not have a particularly flat frequency response, it is good enough for this application. In addition, the transformer reduces the signal to a more manageable level.

The signal from an amplifier delivering hundreds of watts could be about 30V to 60V r.m.s., which is excessive for op.amp circuitry. The transformer used here has a turns ratio of about 10:1, which reduces these voltage levels to a more manageable 3V to 6V. On a domestic stereo amplifier producing maybe between 2V and 10V r.m.s. there will still be between 0·2V and 1V signal level available.

Resistors R1 and R2 form an attenuator to reduce the signal still further, to a level suitable for the input of op.amp IC1. The value of R1 can be adjusted to suit the audio power levels normally encountered. A value of 470k is ideal for domestic use if you wish to remain on speaking terms with the neighbours! If other members of the household do not appreciate your taste in music, it may be better to reduce it to about 220k. On the other hand, 2M2 is about right for use with a 100W power amplifier at high volume.



Controller unit for the Ginormous VU meter.

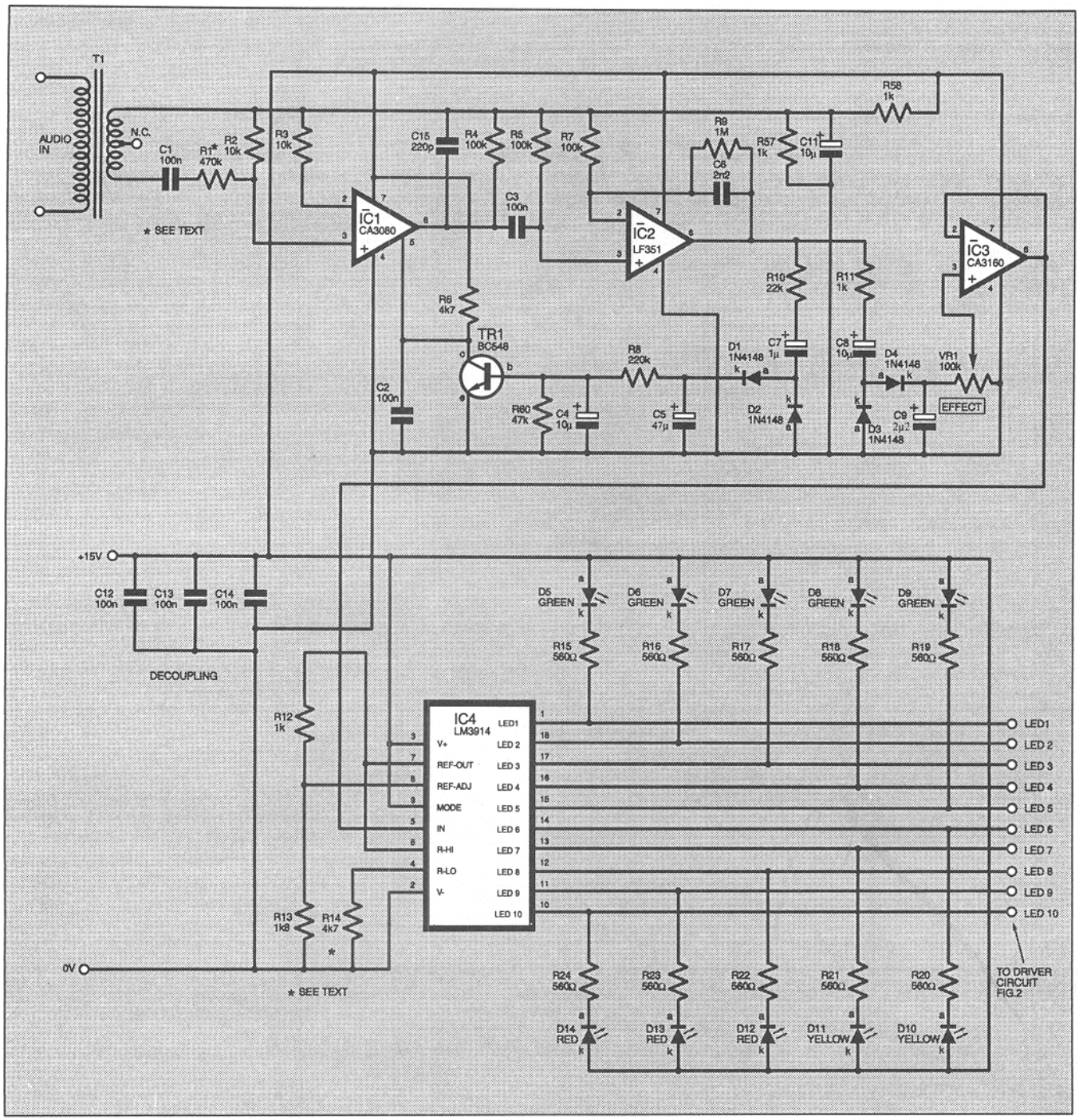


Fig. 1. Music level detection and control stages circuit diagram.

If the value of R1 is too high, there will be insufficient signal for the automatic level control to operate and the effect will vary as the volume is adjusted. If the value is too low, the automatic level control will be saturated and all the l.e.d.s will remain on with virtually no variation. The automatic level control has a wide acceptance range so the precise value is not at all critical.

TRANS-CONDUCTANCE

A transconductance amplifier type CA3080 is used for IC1. The gain of this device is controlled by the current flowing into the control node, pin 5. Resistor R4 is the output load, which converts the output current into a voltage. Capacitor C15 reduces the impedance of the load at higher frequencies, reducing noise and giving some high frequency roll-off. Resistors R2 and R3 bias the two inputs, pins 2 and 3, to the mid-rail supply voltage. Inevitably, there will be some small d.c. offset at the output of IC1, particularly at higher gains. This is blocked by capacitor C3.

If experimenting with the CA3080 device, note that it can easily be damaged by overdriving the control input. The input is connected directly to the base of an internal transistor. Connecting it directly to a low impedance voltage above about 0·6V, or allowing more than about 5mA to pass into it, will destroy the transistor.

A conventional op.amp is used for IC2 and is configured as a non-inverting amplifier with a gain of about ten at lower frequencies. Capacitor C6 progressively reduces the gain at higher frequencies. This is intentional since the effect works better at lower frequencies – in particular the bass beat. The value of C6 may be adjusted to suit individual preferences and music styles.

RECTIFICATION

The output of IC2, pin 6, feeds a rectifier circuit comprising diodes D1 and D2. Capacitor C7 is a d.c. blocking component and C5 is the smoothing capacitor. The latter charges at a rate set by resistor R10 and discharges at the rate set jointly by the paths through R60, R8 and the base of transistor TR1. The component values are arranged to give a gentle attack and slow decay characteristic.

Resistor R6 passes sufficient current to bias IC1 control pin 5 to give maximum gain when transistor TR1 is turned off. If the signal level on the output of IC2 is too great, the output from the rectifier network will rise, causing TR1 to conduct. This diverts current from the control pin of IC1, reducing the gain. This automatic level control circuit will maintain a virtually consistent output level from IC2 despite a large change in audio input level. From measurements taken, a variation of at least 30dB can be accommodated, as proved over many years.

The output of IC2 also drives another rectifier circuit comprising resistor R11, capacitors C8 and C9, and diodes D3

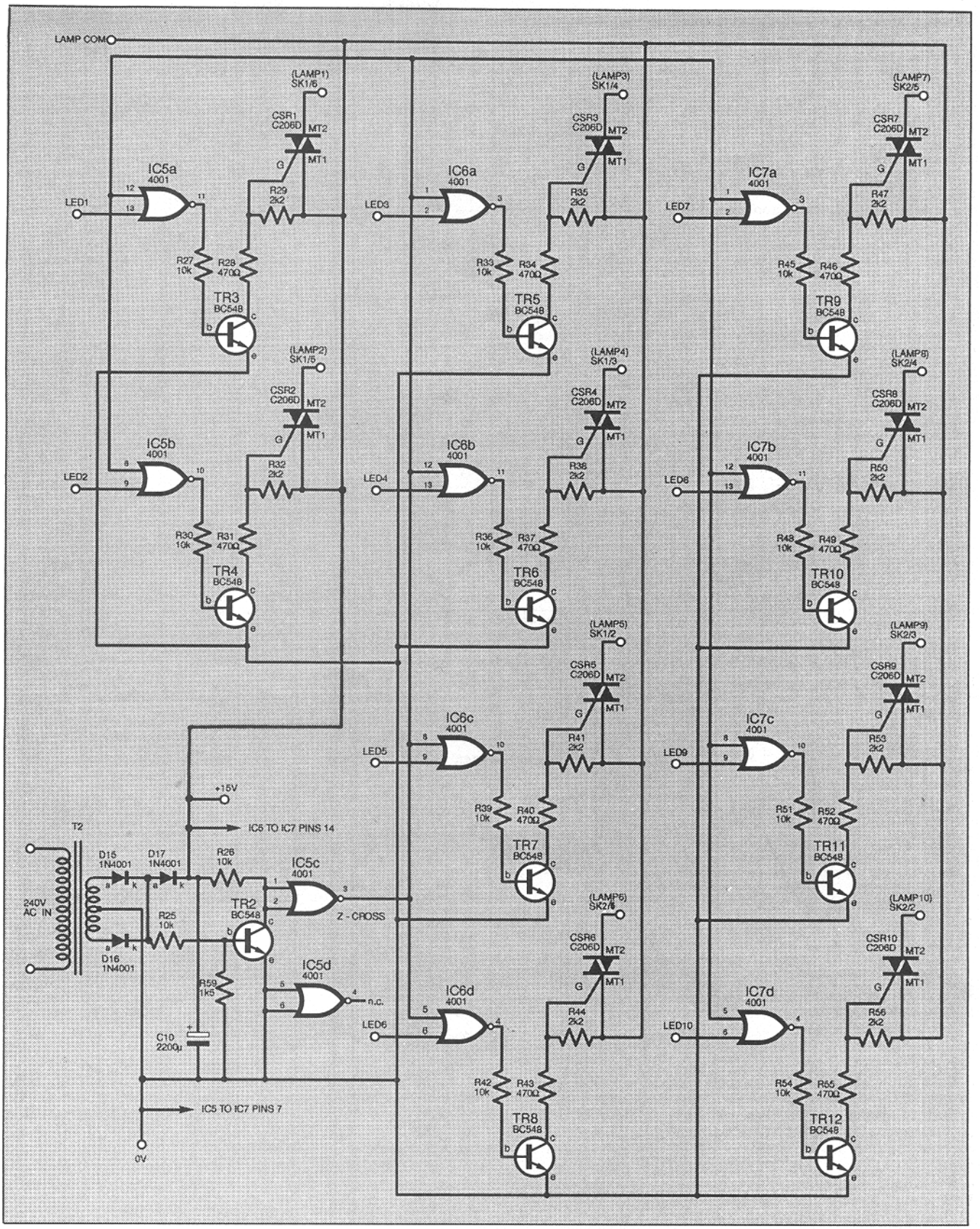


Fig. 2. Circuit diagram for the ten lamp drivers.

and D4. This circuit has a much faster response, due to the low values of R11 and C9. Potentiometer VR1 provides the discharge path for C9. A portion of the d.c. level from this rectifier is tapped off by the wiper of VR1 and buffered by op.amp IC3. A CA3160 op.amp was chosen because its output can be driven to within 0·1V of the positive and negative supply rails.

Mid-supply rail reference voltage for all three op.amps is provided by potential divider R57 and R58, decoupled by C11.

BARGRAPH DRIVER

The output voltage from IC3 is taken to input pin 5 of IC4. This chip is an LM3914 linear 10-channel l.e.d. bargraph driver. A chain of resistors within IC4 provides separate reference voltage levels to 10 comparators. As the input voltage level rises, the comparators are tripped in ascending order, turning on the respective l.e.d.s D5 to D14.

Although current drive to the l.e.d.s is internally regulated, ballast resistors R15 to R24 have also been added in series with the l.e.d.s. If the resistors were omitted the outputs would still drive the l.e.d.s correctly, but the voltage on the output pins would vary from +14V to +11V, which is insufficient variation to drive the inputs of the digital chips in the next stage.

The resistors drop an additional 8V approximately, giving a level which is low enough to register as a logic 0, whilst

allowing the current regulation to operate. As a bi-product, the resistors also reduce the power dissipation within IC4. An output is low when the appropriate l.e.d. is lit.

The l.e.d. sink current is controlled by the voltage reference circuit and is about ten times the current flowing from the Ref-Out pin into resistor R13. In this case the reference voltage is set to 3·5V and the reference current is 1·3mA, giving an l.e.d. current of about 13mA.

The reference voltage is applied across the internal divider resistor chain. The bottom of the chain is lifted above 0V by the addition of R14. This reduces the dynamic range required, enhancing the effect. The value of R14 may be changed to suit personal preferences and the style of music played. Modern dance music has a low dynamic range for which the value of 4k7 is about right. For music from the 60s or 70s, 1k5 would be more suitable. If a selection of music styles is regularly played, 3k3 would be a good compromise. Alternatively, R14 could be replaced by a 10k potentiometer, adjusting it appropriately.

LAMP DRIVERS

Details of the ten lamp driver circuits are shown in Fig. 2. As the circuits are identical, only one is described in detail, that around IC5a, transistor TR3 and triac CSR1:

When lines LED1 and Z-CROSS are both low, the output of NOR gate IC5a will be high. Via resistor R27, this turns on transistor TR3, which drives the gate of triac CSR1. Since the Z-CROSS line is low for only a brief period as the mains cycle passes through 0V, the triac can only be switched on at this point.

Once the triac is on, it will remain on until the current passing through it drops below a minimum holding value. With a resistive load, this occurs as the mains cycle approaches the next zero crossing point. Thus the load is driven for complete half cycles. No switching occurs at points in the cycle where the switched current would be high.

Because the triac is triggered only momentarily at the zero crossing point, the output is not suitable for driving inductive loads. With an inductive load the current and voltage are out of phase, so this simple triac driving arrangement will not operate correctly. Since the unit is only intended to drive normal lamps, this restriction should not cause any problems.

The Z-CROSS signal is derived from mains transformer T2. Diodes D15 and D16 provide full wave rectification, feeding into smoothing capacitor C10 via diode D17. The positively rectified ripple voltage at the junction of the three diodes is attenuated by the resistor chain R25 and R59 and fed to the base of transistor TR2. The transistor is turned off when the voltage at the junction of the diodes is below about 3V. Resistor R26 is the collector load for TR2 from which the triggered output voltage is inverted by NOR gate IC5c.

NOR gate IC5d is unused and so its input pins 5 and 6 are connected to 0V.

CONSTRUCTION

All components except for the transformers are mounted on a single-sided printed circuit board (p.c.b.) which is available from the *EPE PCB Service*, code 956. Component positioning and track layout details for the board are shown in Fig. 3 and Fig. 4.

Components should be assembled in ascending order of size, or convenience. Use sockets for all the i.c.s., but do not insert the i.c.s until after thoroughly checking the entire assembly. Don't forget to fit the ten wire links. Veropins or similar should be used for all off-board connections.

The leads of the l.e.d.s should be left at a suitable length to allow the faces of the components to protrude through holes in the panel of the chosen case. The "k" on the component overlay indicates the cathode of the l.e.d.; usually marked by a flat on the side of the l.e.d.

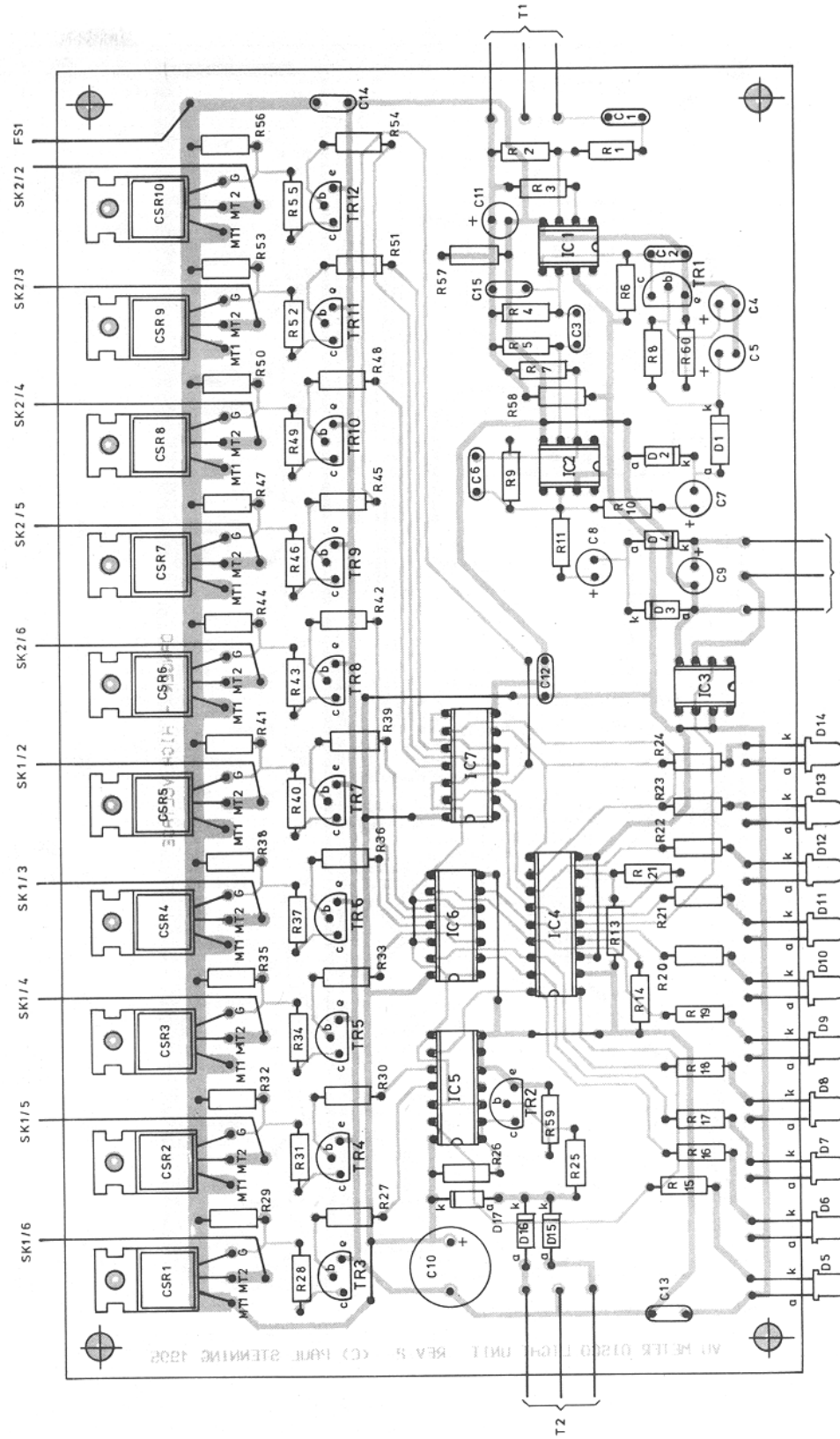


Fig. 3. Component layout for the Gigantic VU Meter p.c.b.

Potentiometer VR1 may be mounted directly onto the p.c.b. or connected to it by short lengths of insulated wire. On the overlay, the centre pin is the wiper, the left pin is the anti-clockwise end of the track and the right pin is the clockwise end.

Triacs CSR1 to CSR10 should be secured to the p.c.b. with M3 or 6BA nuts and bolts. No heatsinking is required. The heavy mains carrying p.c.b. tracks should be *reinforced* with solder or tinned copper wire of about 20 s.w.g.

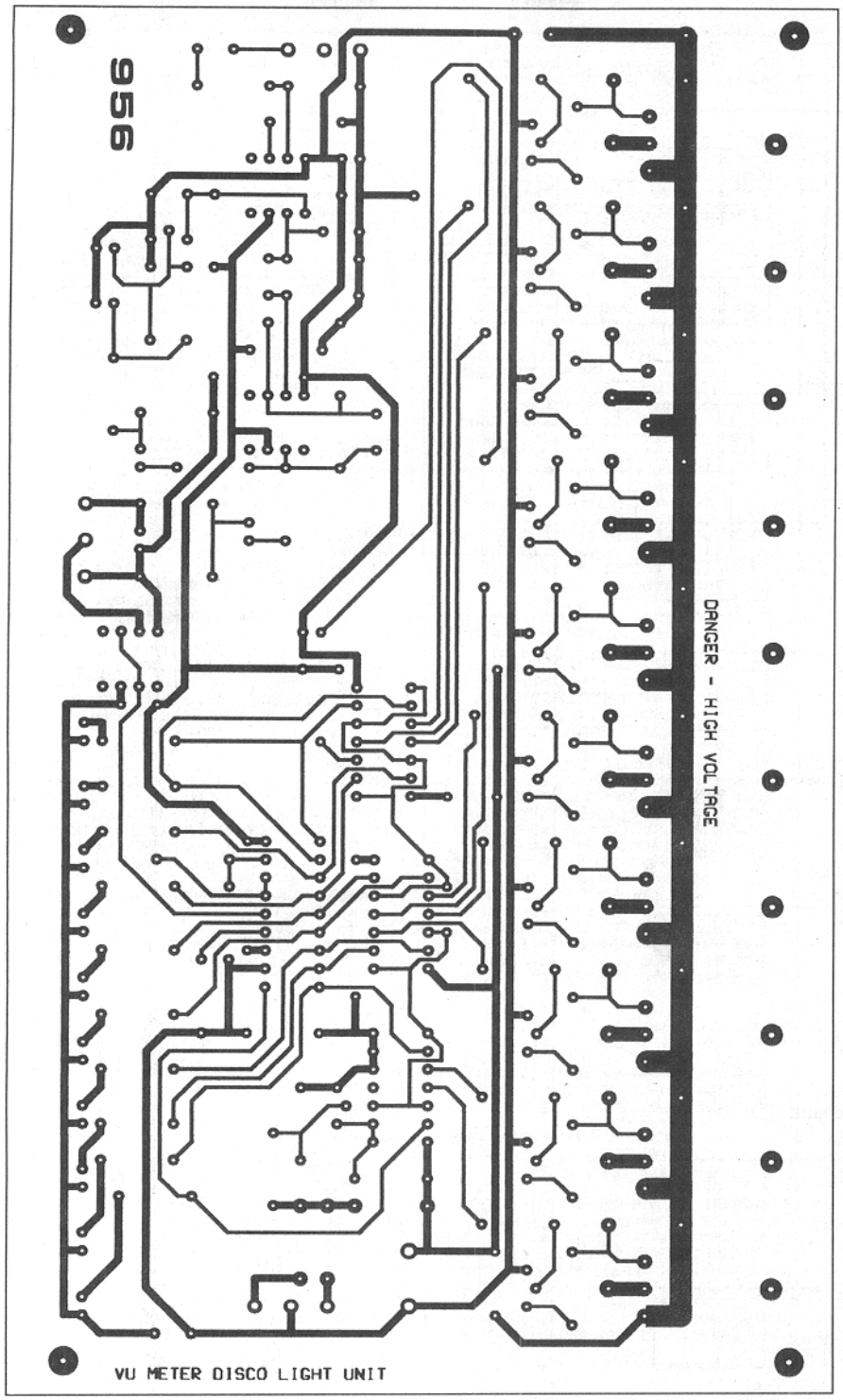


Fig. 4. Full size copper foil track master layout.

When construction is complete, carefully check the entire assembly, especially the area around the triacs, for short circuits and bad joints, etc. Short circuits could cause a nasty mess when the mains is applied!

CASING IT

Once the p.c.b. is finished it should be mounted in a suitable case with the transformers etc. The author's model was housed in a case measuring 221mm × 150mm × 63mm. For professional use, a *sturdy* metal case should be used if the unit is to survive for any length of time – disco equipment leads a rough life! Even for home use, a metal case should be used for safety. Plastic cases are not recommended for this unit. Potentiometer VR1 should have a metal shaft, and a metal knob for strength.

However, a significant amount of money could be saved by building the controller into the light box – saving the cost of a case, some connectors and multicore mains cable.

CONNECTIONS

Interwiring details are shown in Fig. 5. Mains wiring **MUST** be carried out with wire rated at a *minimum* of 6A. The insulated cores stripped out of mains cable will probably be suitable.

Bulgin 8-pin connectors are recommended for the lamps. These are commonly used for disco lighting. Their advantage is that either the plug or socket may be safely Live when de-mated. They are also fairly difficult to break, which is good to know when accidentally dropping a speaker cabinet! Nearly all professional disco controllers and light boxes are fitted with Bulgin P552 sockets.

COMPONENTS

Resistors

R1	470k (see text)
R2, R3, R25 to R27, R30, R33, R36, R39, R42, R45, R48, R51, R54	10k (14 off)
R4, R5, R7	100k (3 off)
R6, R14	4k7 (2 off)
R8	220k
R9	1M
R10	22k
R11, R12, R57, R58	1k (4 off)
R13	1k8
R15 to R24	560Ω (10 off)
R28, R31, R34, R37, R40, R43, R46, R49, R52, R55	470Ω (10 off)
R29, R32, R35, R38, R41, R44, R47, R50, R53, R56	2k2 (10 off)
R59	1k5
R60	47k

All 0.25W 5% carbon film or better

See SHOP TALK Page

Potentiometer

VR1	100k lin. (see text)

Capacitors

C1 to C3, C12 to C14	100n polyester, (6 off)
C4, C8, C11	10µ radial elect. 25V (3 off)
C5	47µ radial elect. 16V
C6	2n2 polyester
C7	1µ radial elect. 63V
C9	2µ2 radial elect. 63V
C10	2200µ radial elect. 16V
C15	220p ceramic plate

Semiconductors

D1 to D4	1N4148 diode (4 off)
D5 to D9	green l.e.d. (5 off)
D10, D11	yellow l.e.d. (2 off)
D12 to D14	red l.e.d. (3 off)
D15 to D17	1N4001 1A rectifier diode (3 off)
TR1 to TR12	BC548 *npn* transistor (12 off)
CSR1 to CSR10	C206D triac (10 off)
IC1	CA3080 op.amp
IC2	LF351 op.amp
IC3	CA3160 op.amp
IC4	LM3914 bargraph driver
IC5 to IC7	4001 quad 2-input NOR gate (3 off)

Miscellaneous

SK1, SK2	8-way Bulgin P552 sockets (2 off)
SK3, SK4	0·25in mono plastic jack sockets (2 off)
T1	12V/0V/12V mains transformer, 100mA
T2	12V/0V/12V mains transformer, 250mA

Printed circuit board, available from the *EPE PCB Service,* code 956; 8-pin d.i.l. socket (3 off); 14-pin d.i.l. socket (3 off); 18-pin d.i.l. socket; case (see text); knob; panel mounting 20mm fuse holder; 20mm anti-surge fuse (see text); 3-core mains cable; 3-way mains terminal block; cable clamp; solder tag; nuts, bolts; solder, etc.

Approx cost guidance only **£47** *excl. case and light box*

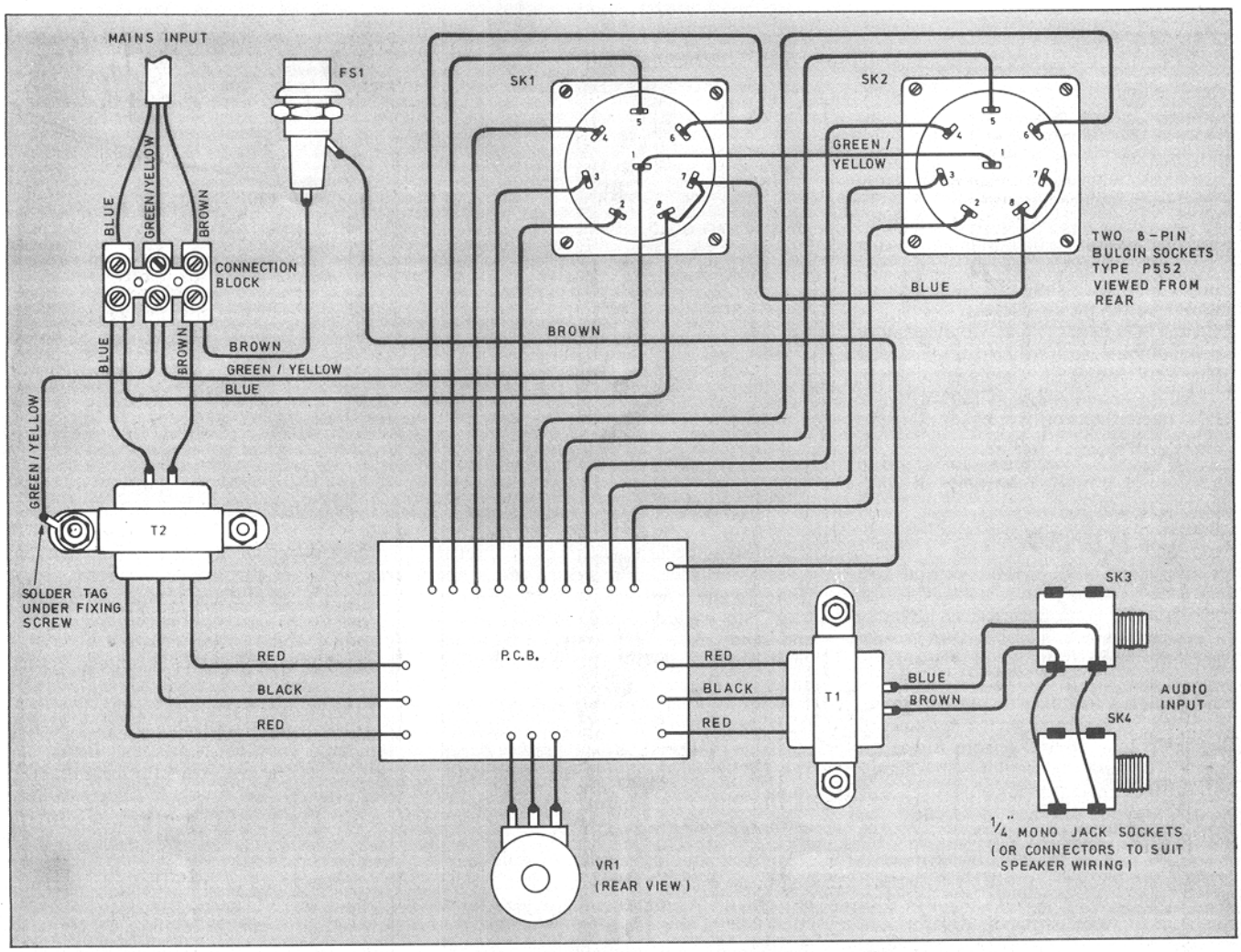


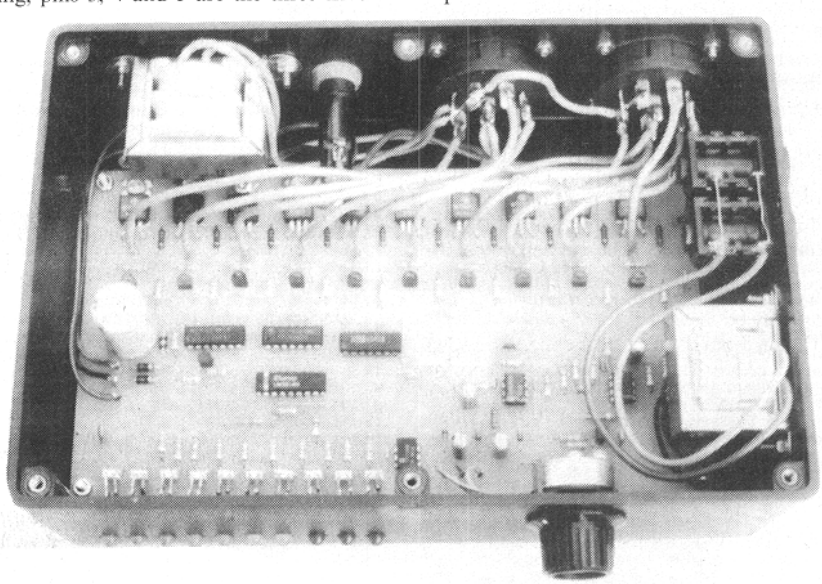
Fig. 5. Interwiring details between the p.c.b. and off-board components.

Connection leads have Bulgin P551 plugs on each end, and are wired for four channels using seven-core cable.

There are normally two sockets on the light boxes (wired in parallel), so a number of light boxes may be connected in a chain, with the controller at one end. This is an extremely flexible method of arranging things, since all the leads are the same, and any controller can be connected to any light box.

The standard wiring for these connectors is pins 7 and 8 for common (Neutral) and pin 1 for Earth. Pins 7 and 8 are linked in every connector, and a single wire is used in the connection leads. For three-channel lighting, pins 3, 4 and 5 are the three Live connections. With four channels, pin 2 is also used. Pin 6 is normally unused or carries a permanent Live feed for motors etc. In this design, pin 6 is used for a further channel so that the ten channels may be carried on two connectors. Although this is slightly non-standard, no harm will be caused if the wrong light is connected to the wrong controller. Standard four-channel leads can be used if they are made up correctly (with pin 6 connected).

An insulating boot should be pushed onto the back of the fuseholder, which should be fitted with an anti-surge fuse. The fuse value should be chosen to suit the total current of all lamps connected, provided that wiring is adquate for the current.



Two standard mono jack sockets are used for the audio input. These **MUST** be the plastic bodied type so that no connection is made between the speaker wiring and the Earthed case (to prevent hum loops or damage to the amplifier). Two sockets are connected in parallel so that the unit may be connected between the amplifier and speakers using two leads. This arrangement is also fairly standard with disco equipment. Use 6A wire for the links between the two sockets as they have to carry the full speaker current. If existing equipment uses a different type of connector for the speaker wiring (such as 3-pin Cannon) these can be fitted instead.

Speaker leads have to handle significant current and should be made using round 2-core 6A mains cable (flat cable kinks too easily). The use of orange cable intended for garden power tools is recommended so that it can be readily distinguished from other audio cables fitted with jack plugs. Use metal jack plugs – the plastic ones break far too easily.

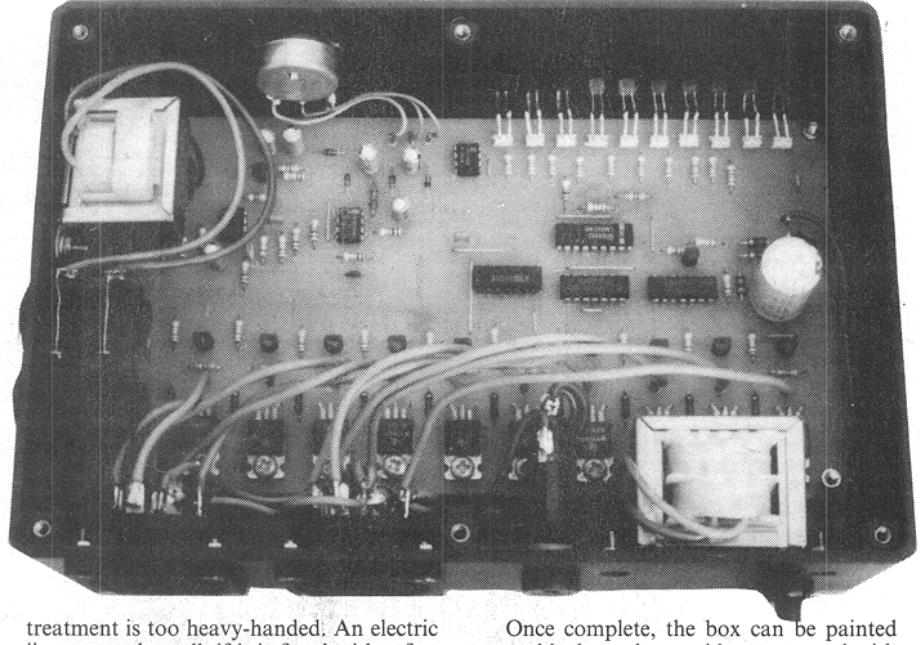
Since all the controllers will normally be stacked up in one place, a number of short speaker leads are useful for linking them together. The above information assumes that this controller is being used with professional disco equipment.

More detail has been given than is strictly necessary to build the controller in the hope that it will be of use to those readers who may be just starting to run a small mobile disco. If this unit is being built solely for home entertainment, any type of connector can be used as long as it is suitably rated for the voltages and currents involved.

TESTING

Initially, the unit should be tested with the lamps disconnected. *Do not fit the fuse in the fuseholder yet*. Set potentiometer VR1 fully clockwise and connect the unit to the mains and amplifier. When playing some music, the l.e.d.s should flash in a manner similar to a VU meter. Reduce the setting of VR1 such that the top l.e.d. lights only occasionally. Now alter the volume on the amplifier. After a second or so (while the automatic level control sorts itself out) the l.e.d.s flashing should revert to the same level.

Switch off and fit the fuse. Connect lamps to the outputs and switch back on. **The whole p.c.b. is now Live, so do not touch it!** The lamps should flash in time with the l.e.d.s on the appropriate channel. If the light box has not yet been assembled, it may be easier to connect a table lamp to each output in turn **(switching off while changing the connections).**



LIGHT BOX

Construction of the light box depends to a great extent on the resources available and your ability. The suggestions given here may be used as a guide. If a mobile disco is being run, the light box should be made fairly solid. It will get a battering – no matter how gentle its treatment is planned to be. There will be evenings when it is necessary to clear everything up and get out within ten minutes, because the landlord or whoever wants to lock up and go home!

First decide whether a vertical or horizontal light box is wanted. If a disco is being run and a vertical arrangement is chosen, two units will probably be needed to keep the setup symmetrical – which of course costs twice as much. Also bear in mind that vertical boxes could be somewhat unstable and prone to being knocked over, unless they are made fairly wide, deep and heavy. The controller will drive two light boxes without problems.

Alternatively, if the disco is stereo, two controllers could be made (possibly in one case with a dual potentiometer), to drive each light box separately. In this case it may be necessary to reduce the value of capacitor C6 to allow more mid-range through, otherwise the two units will appear to be doing the same thing!

A horizontal light box could be positioned centrally, above or below the disco name sign. The disco name could even be put on the front of the light box, killing two birds with one stone! Make sure the chosen box fits the transporting vehicle!

PERSPECTIVE

Whichever way it is intended to be mounted, basically the need is for a box divided into ten equal rectangular sections. Each division must be large enough to house the lamp without it touching the partitions, or overheating its surroundings. The front of the case is covered with translucent acrylic sheet (Perspex) to diffuse the light and protect the lamps. The Perspex should be at least 40mm away from the lamps for this to be effective. Buy the Perspex first, and hold it near a lamp to establish the best distance.

Translucent Perspex may not be the easiest product to find locally – try looking in *Yellow Pages* under "Plastics – Suppliers" or "Plastics – Film and Sheet". To save money, try to get an off-cut and trim it to size, or make the box to suit.

Perspex can be cut with a normal woodworking saw if GREAT care is taken. Beware that it is prone to cracking if treatment is too heavy-handed. An electric jig-saw works well, if it is fitted with a fine blade. In any event, get a second person to help hold it steady, and progress slowly and gently. The Perspex should be about 2mm undersize on all sides so that it is not under any stress.

If professional lettering of the disco name on the front of the box is wanted, try the "Sign Makers" section of *Yellow Pages*. The service can probably be obtained for about twice the cost of a plain sheet.

CHIPBOARD

The box should be made of solid chipboard, or even blockboard if it needs to be really substantial (and heavy). Corner joints should be made by gluing and screwing the chipboard onto battens. Dividers can be made with plywood, about 6mm thick. This is thick enough to fix into place with glue and small nails. The corner joint battens and the dividers should be recessed about 15mm from the front of the case to allow room for the Perspex to be inset.

Strips of 12mm quarter-round timber or similar can be fixed to the case in front of the Perspex to hold it in place. Use screws from the outside of the case for this, and no glue – the Perspex needs to be removed to change the lamps.

The back of the box should be wide enough to hold the bayonet-cap lamp batten holders, allowing about 15mm each side for ventilation. If the dividers stop about 20mm from the back, this will allow room for the wiring between the lampholders.

Air-flow sockets should be fitted through the back panel wherever there is room, and the rear connections covered with a generous quantity of insulation tape. This prevents an electric shock should someone poke their fingers through the ventilation gap.

Once complete, the box can be painted matt black on the outside, or covered with black vinyl sheet if preferred. A few corner protectors will prevent the chipboard from chipping, and a handle or two in the right place can be very useful. The inside should ideally be painted gloss white.

The lamps should be the normal coloured round type, like those used on the larger outdoor Christmas lights. A rating of 25W will generally be suitable, and will not get too hot. Larger lamps such as 40W or 60W could be used if more light is wanted – but there will be more heat too!

Colours could be used that give the impression of a VU meter: five green, two yellow and three red, for example. Or ten randomly coloured lamps could be used. Take spare lamps with you – discos with blown bulbs look most unprofessional!

SUGGESTIONS

A few more suggestions: How about building a horizontal 20-lamp box, with the light effect coming in from the ends or out from the middle? This could look good with a name sign. How about a rectangular box with ten triangular sections each having a corner meeting at the bottom middle, in a fan effect? Or there could just be a row of R60 coloured spot lamps on an overhead gantry. Do something individual and get noticed!

One final suggestion – on a safety matter again. Buy residual current circuit breakers (RCCBs or RCDs) and plug them into the wall sockets where the inevitable multitudes of four-way trailing extension leads are connected. These could prevent an electric shock if some wally smashes a lamp or spills a pint of lager into the equipment. It does happen! □