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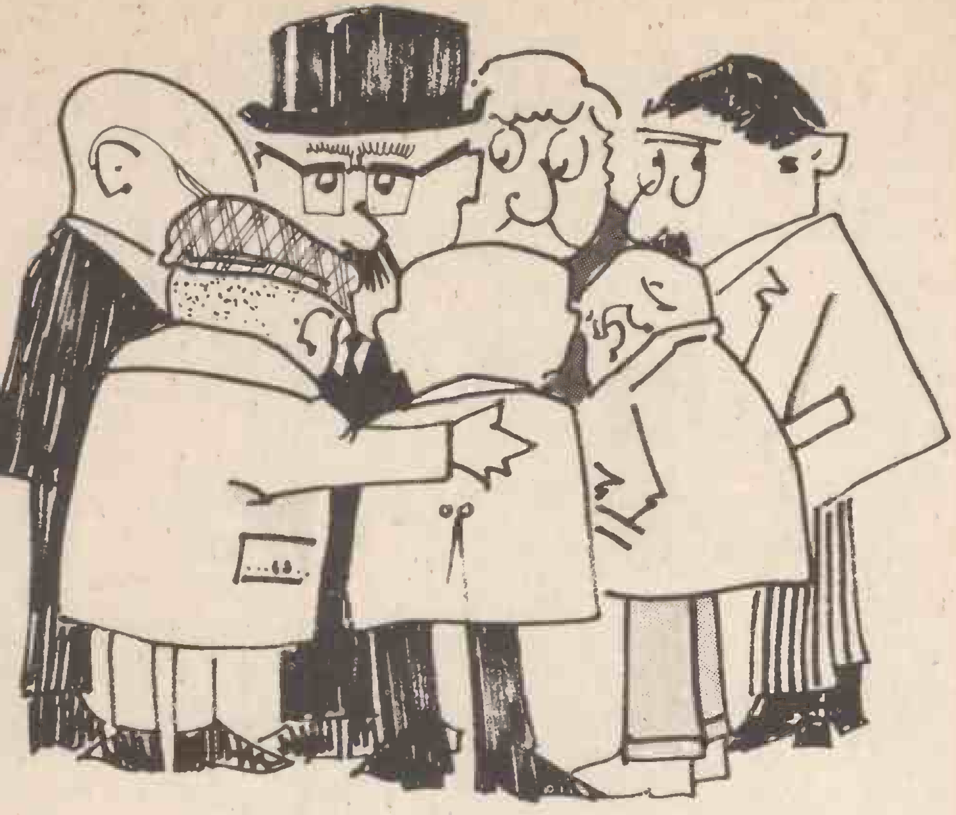

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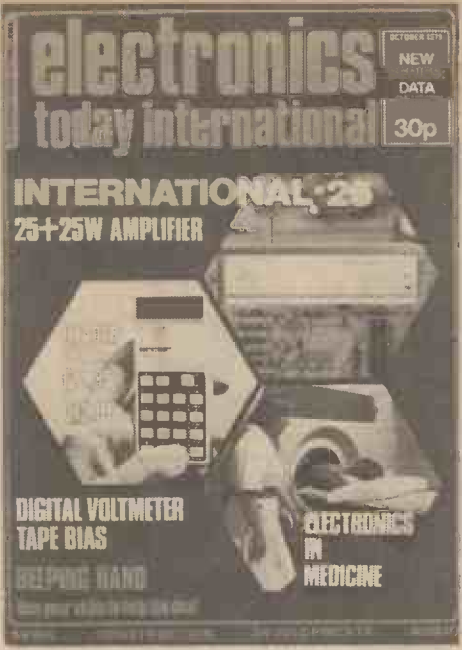

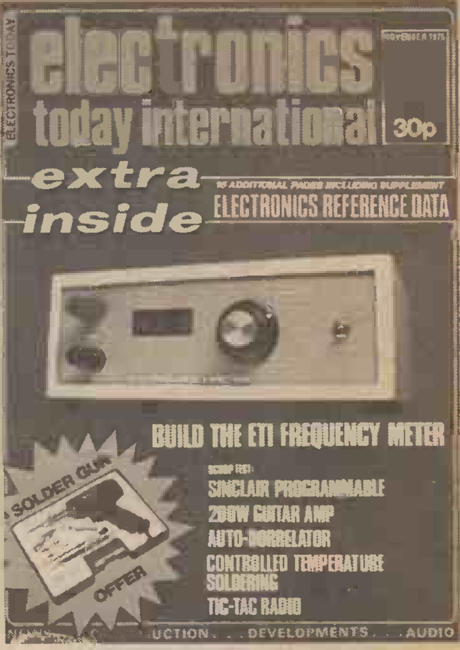

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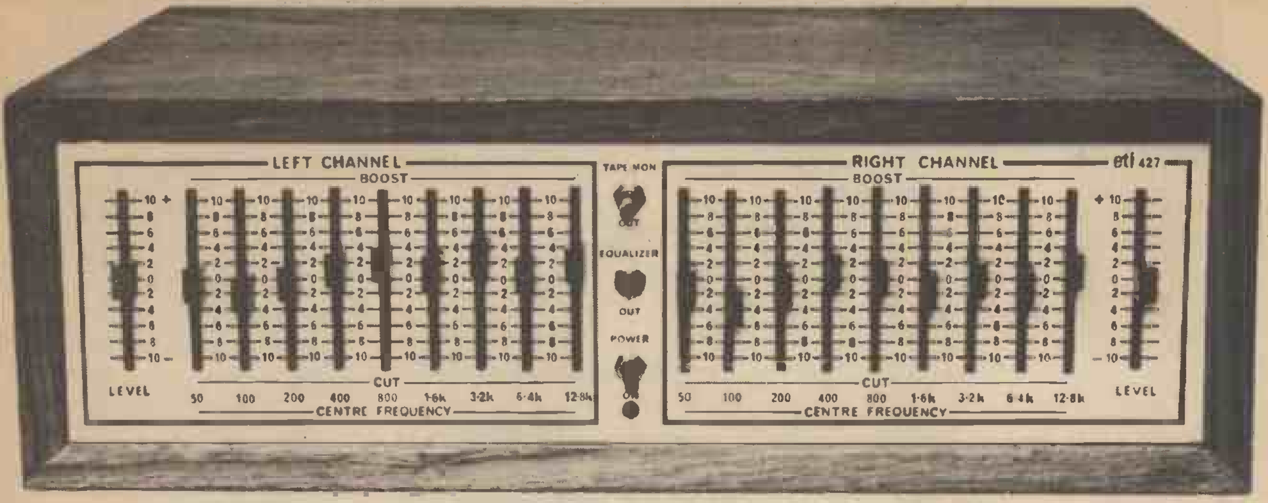


GRAPHIC EQUALIZER

A unit that compensates for speaker and room deficiences.

MANY audiophiles are discovering the advantages of graphic equalizers in domestic as well as professional sound systems. Unfortunately the costs of such units have prevented them becoming as popular as warranted by the many advantages they offer.

The advantages of an equalizer are not generally well known but are as follows.

Firstly an equalizer allows the listener to correct deficiencies in the linearity of either his speaker system alone, or the combination of his speaker system and his living room.

As we have pointed out many times in the past, even the best speakers available cannot give correct reproduction in an inadequate room. It is a sad fact that very few rooms are ideal, and most of us put up with resonances and dips, sadly convinced that this is something we have to live with.

Whilst the octave equalizer will not completely overcome such problems, it is possible to minimize some non-linearities of the combined speaker/room system.

In a concert hall it is also possible to use the unit to put a notch at the frequency where microphone feedback occurs, thus allowing higher power levels to be used.

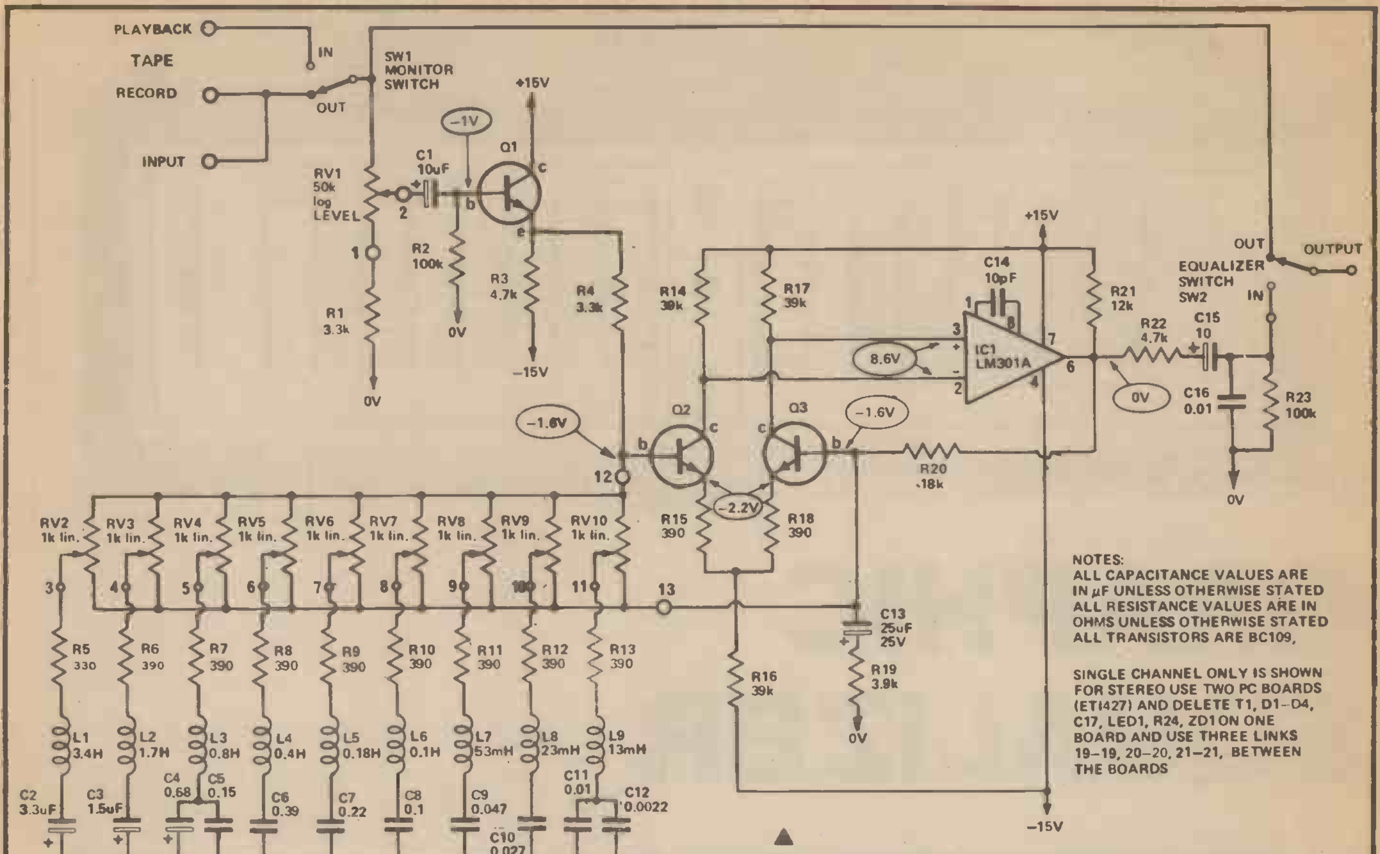
Thirdly, for the serious audiophile, an equalizer is an exceedingly valuable tool in evaluating the deficiences in a particular system. One adjusts the equalizer to provide a uniform response, the settings of the potentiometer knobs then graphically display the areas where the speaker etc is deficient.

There is a snag, however, one must have an educated ear in order to properly equalize a system to a flat response. It is not much use equalizing to your own preference of peaky bass etc in order to evaluate a speaker.

Ideally, a graphic equalizer should

MEASURED PERFORMANCE (of Prototype)

Frequency Response			
Equalizer out		Flat	
Equalizer in and all controls at zero	10 Hz – 10 kHz 1.5 Hz – 30 kHz	±½ dB + ½ – 3 dB	
Range Of Control			
Individual filters		±13 dB	
Level control		+ 14 – 9 dB	
Maximum Output Signal at < 1% distortion		> 6 volts	
Maximum Input Voltage		3 volts	
Distortion at 2 volts out, controls flat	100 Hz < 0.1%	1 kHz < 0.1%	6.3 kHz < 0.1%
Signal to Noise Ratio at 2 volts out (unweighted)		69 dB	
Input Impedance		50 k	
Output Impedance		4.7 k	



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▲ *Fig. 1. Circuit diagram of one channel of the equalizer.*

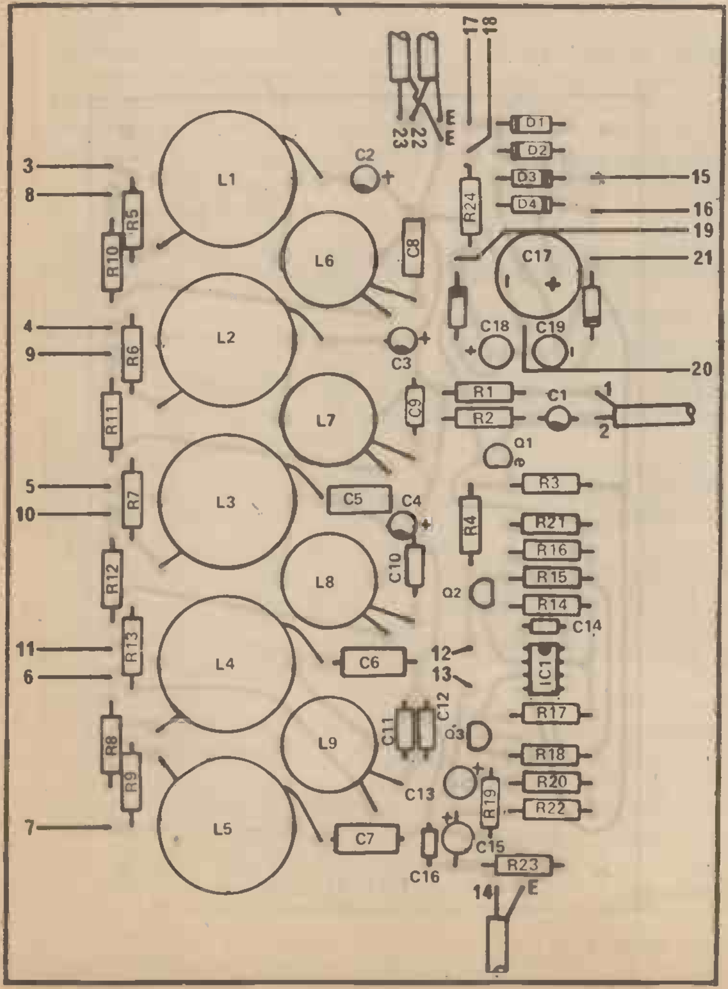


Fig. 2. Component overlay of the equalizer (one channel only)

GRAPHIC EQUALIZER

have filter at 1/3 octave intervals, but except for sound studios and wealthy pop groups, the expense and size of such units are too much for most people.

Recently some excellent commercial units have become available with filters spaced at octave intervals. These are relatively inexpensive and cater for the needs of most professionals and domestic users. Such a unit is the Soundcraftsmen 2012 which we reviewed in February 1975 issue.

The Electronics Today Equalizer has been designed to provide nine filters spaced at octave intervals in each of two channels. It is simple to construct and should be available inexpensively in kit form in the near future.

HOW IT WORKS ETI 427

This equalizer is basically similar to those used in the ETI Synthesizer and master mixer projects with the exception that it has nine filter sections per channel.

The equalizer stage is a little unusual in that the filter networks are arranged to vary the negative feedback path around the amplifier. If we consider one filter section alone, with all others disconnected, the impedance of the LCR network will be 390 ohms at the resonant frequency of the network. At either side of resonance the impedance will rise (with a slope dependant on the Q of the network which is 2.5) due to the uncancelled reactance. This will be inductive above resonance and capacitive below resonance. We can therefore represent the equalizer stage by the equivalent circuit below.

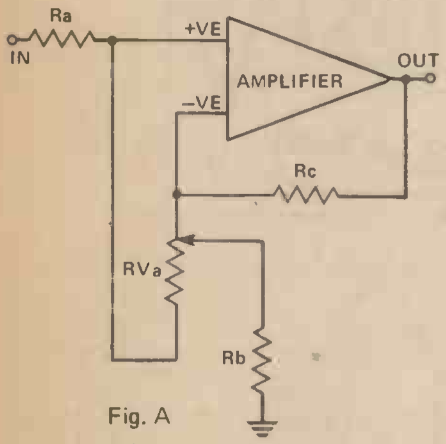


Fig. A

It must be emphasized that this equivalent circuit represents the condition with one filter only, at its resonant frequency. Additionally letters have been used to designate resistors to avoid confusion with components in the actual circuit.

With the slider of the potentiometer at the top end (Fig. A) we have 390 ohms to the 0V line from the negative input of the amplifier, and 1 k between the two inputs of the amplifier. The amplifier, due to the feedback applied, will keep the potential between the two inputs at zero. Thus there is no current through RVA. The voltage on the positive input to the amplifier is therefore the same as the input voltage since there is no current through, or voltage drop across resistor RA.

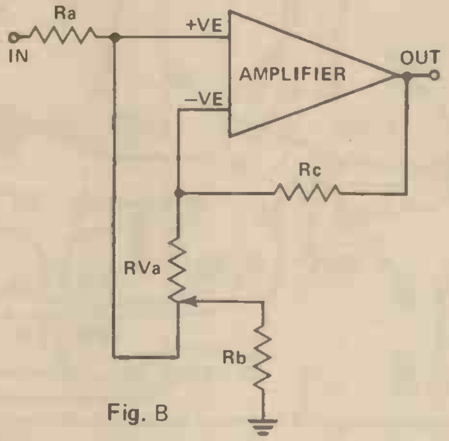


Fig. B

The output of the amplifier in this case is approximately the input signal times (3300 + 390)/390 giving a gain of 19 dB. If the slider is at the other end of the potentiometer, (Fig. B), the signal appearing at the positive input, and thus also the negative input, is about 0.11 (390/(3300 + 390) of the input. There will still be no current in the potentiometer and in RC, thus the output will be 0.11 of the input. That is, the gain will be -19 dB.

If the wiper is midway, both the input signal and the feedback signal are attenuated equally, and the stage will have unity gain.

With all filter sections in circuit the maximum cut and boost available is reduced, but ±14 dB is still available.

Reverting back now to the actual circuit, the amplifier consists of IC1, Q2 and Q3. The transistors help to reduce the effect of the noise in the IC and add gain at the high-frequency end. This additional gain is required because the negative feedback, due to the potentiometer between the two inputs, causes high-frequency roll off. This does not affect operation of the unit provided the open-loop gain is above 60 dB over the entire audio range. An overall closed-loop gain of about 15 dB is maintained by R20/R19 with the filter potentiometer at mid position.

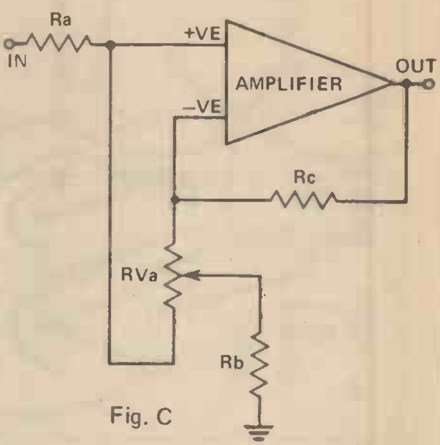
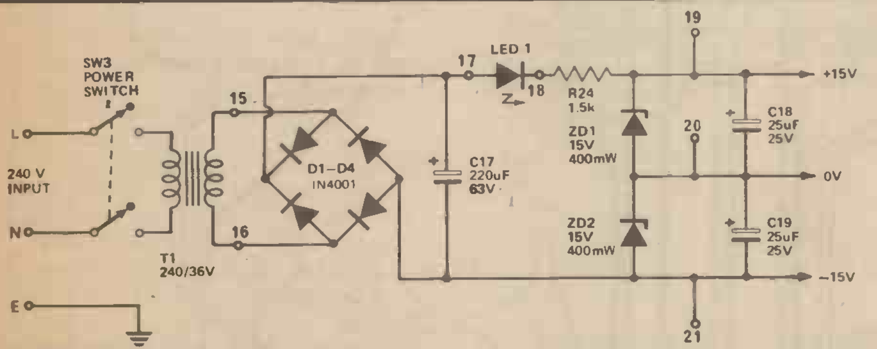


Fig. C

The output of the amplifier is decoupled to the output of the unit via C15, and C16/R22 provide a cutoff above 30 kHz.

The input signal is buffered by Q1 because the equalizer stage requires a low impedance signal source for correct operation. Potentiometer RV1 provides level control with 0 to -23 dB range which, combined with the equalizer characteristic, results in an overall level range of + 14 to -9 dB.

The power supply used is a simple, full-wave bridge filtered by C17. Plus and minus supplies are derived by means of two 15 volt zeners in series fed via R24. The front-panel power indicator is an LED connected in series with the dropping resistor R24.



Circuit diagram of the equalizer power supply.

CONSTRUCTION

All components, with the exception of the transformer and the slide potentiometers, are mounted on two printed circuit boards — one for each channel. Whilst the layout is not critical, any alternative construction method could be used, we strongly recommend the use of printed-circuit boards to ease construction and eliminate a possible source of faults.

The components should be assembled to the boards with the aid of the overlay Fig. 2. Carefully check polarities of ICs, capacitors and transistors, etc, before soldering in place. Attach lengths of wire and Coax of adequate length to the board before mounting in position by means of 13mm spacers.

Due to the close spacing used for the slide potentiometers it is necessary to mount the 9.6 mm spacers, to the potentiometer support-bars, before mounting the potentiometers. Use 6.4 mm long countersunk screws for this purpose.

The potentiometer assembly, and all other external components, (switches etc) can now be assembled to the chassis and the unit wired as shown in the interconnection diagram.

The circuits used have very high gains and it is necessary to take precautions

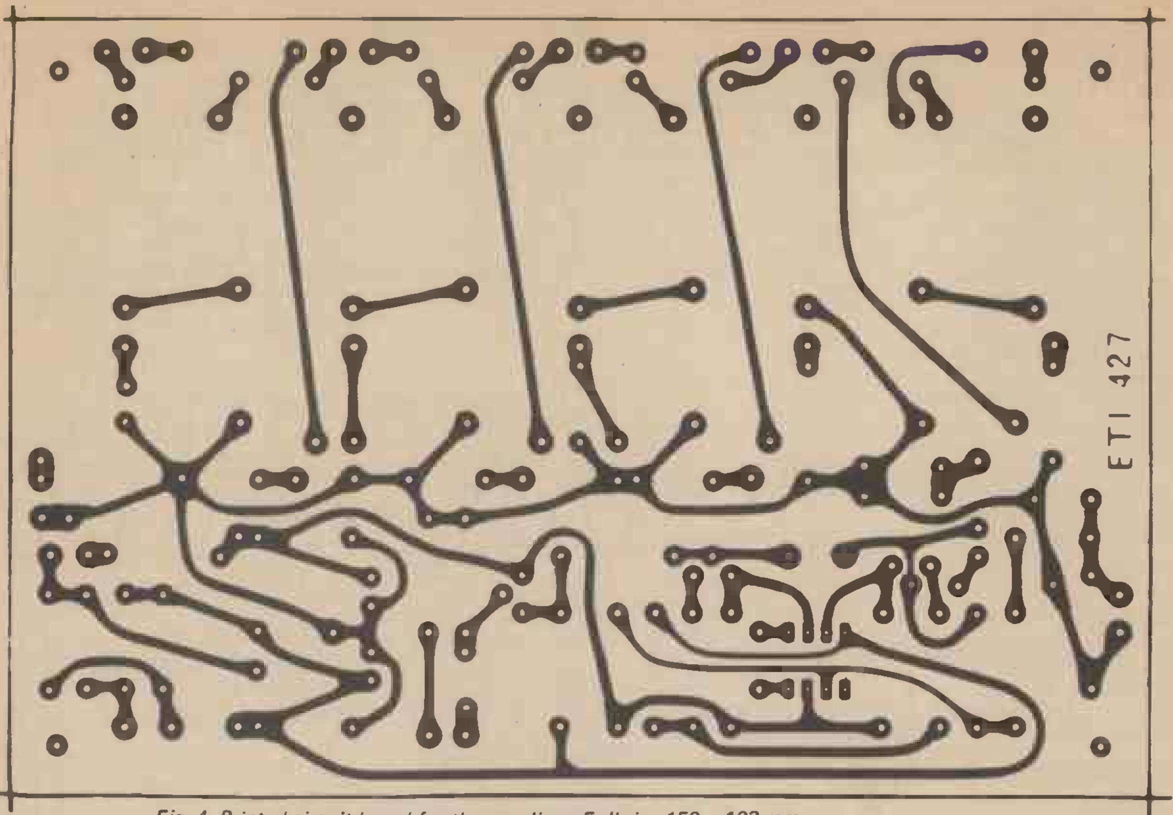
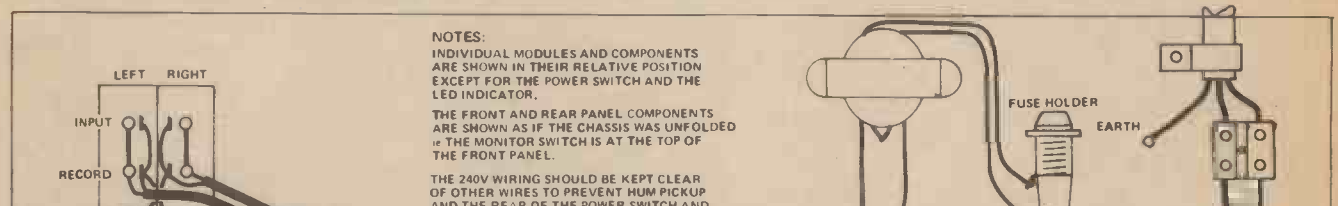


Fig. 4. Printed circuit board for the equalizer. Full size 152 x 103 mm.



NOTES:
INDIVIDUAL MODULES AND COMPONENTS ARE SHOWN IN THEIR RELATIVE POSITION EXCEPT FOR THE POWER SWITCH AND THE LED INDICATOR.

THE FRONT AND REAR PANEL COMPONENTS ARE SHOWN AS IF THE CHASSIS WAS UNFOLDED ie THE MONITOR SWITCH IS AT THE TOP OF THE FRONT PANEL.

THE 240V WIRING SHOULD BE KEPT CLEAR OF OTHER WIRES TO PREVENT HUM PICKUP AND THE REAR OF THE POWER SWITCH AND THE FUSE SHOULD BE TAPED WITH INSULATION TAPE TO PREVENT PERSONAL CONTACT.

Fig. 3. Interconnection diagram for the unit.

against mains hum-pickup. The transformer should be mounted in the position shown, and the 240 volt wiring, to the front power switch, should be run down the right-hand side of the chassis and along the front, in front of the potentiometer support brackets. If hum pickup does occur, it may be necessary to mount the transformer inside a metal box to shield it.

Due to tolerances of resistors variations in V_{be} of Q2 and Q3 etc, the steady-state output of IC11 may be anywhere within plus or minus one volt of zero.

Hence it is desirable to determine the polarity of the steady state voltage at pin 6 of IC1 in order to determine which way round C15 should be inserted. If the output is positive insert as shown in Fig. 1. Alternatively C15 should be a non-polarized type.

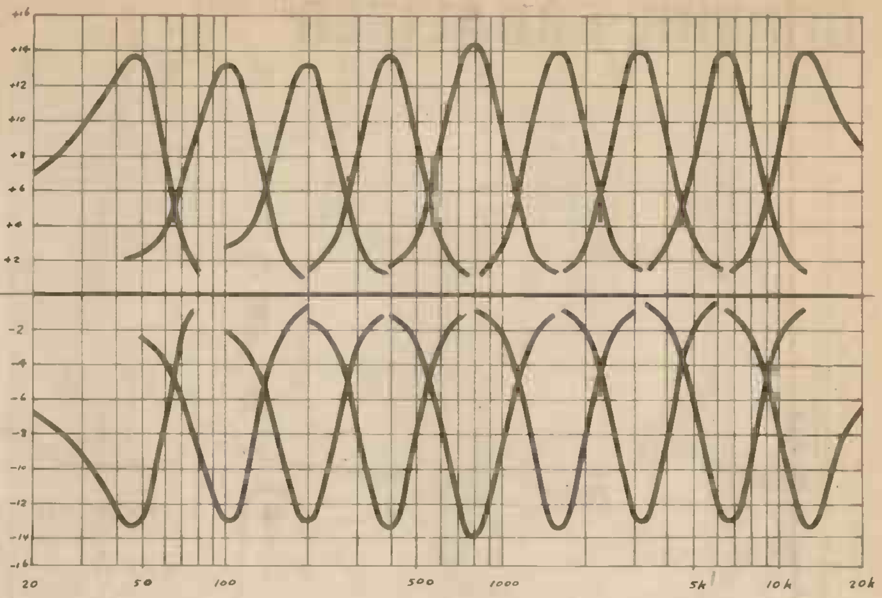


Fig. 5. Individual filter responses for the unit. Boost at top and cut at bottom.

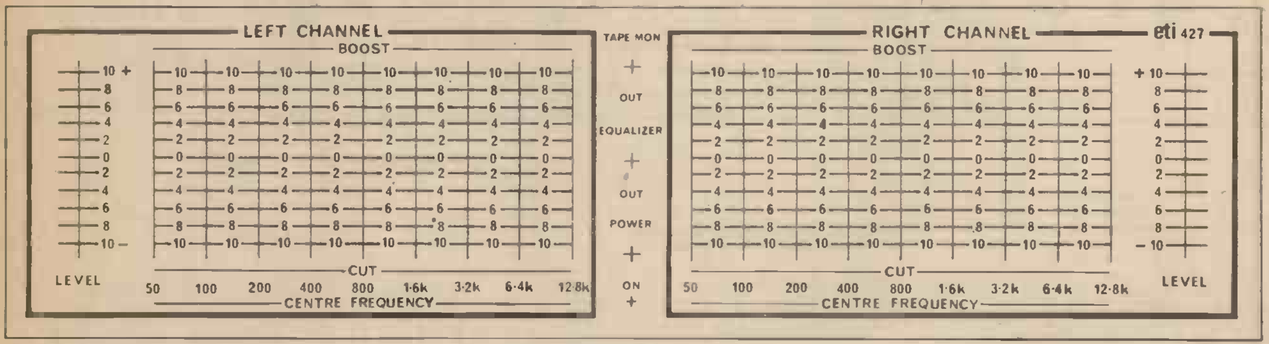
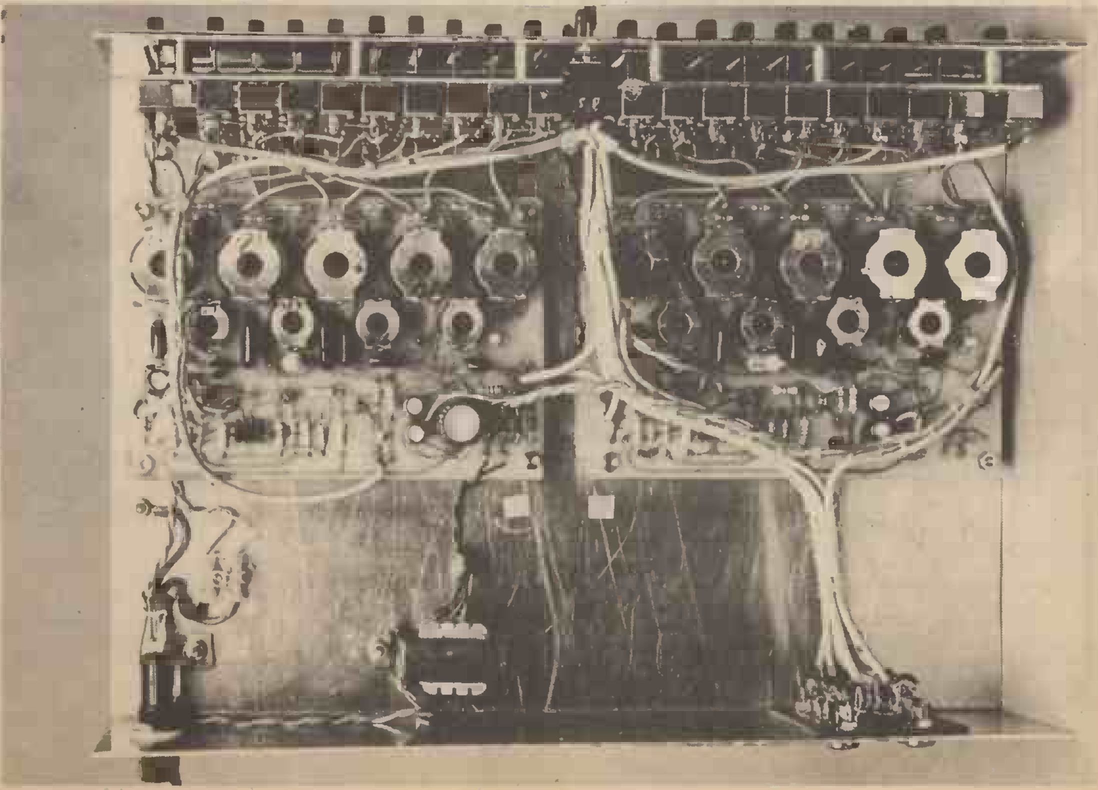


Fig. 6. Front panel artwork for the equalizer. Full size 336 x 88 mm.



Internal layout of the equalizer.

GRAPHIC EQUALIZER

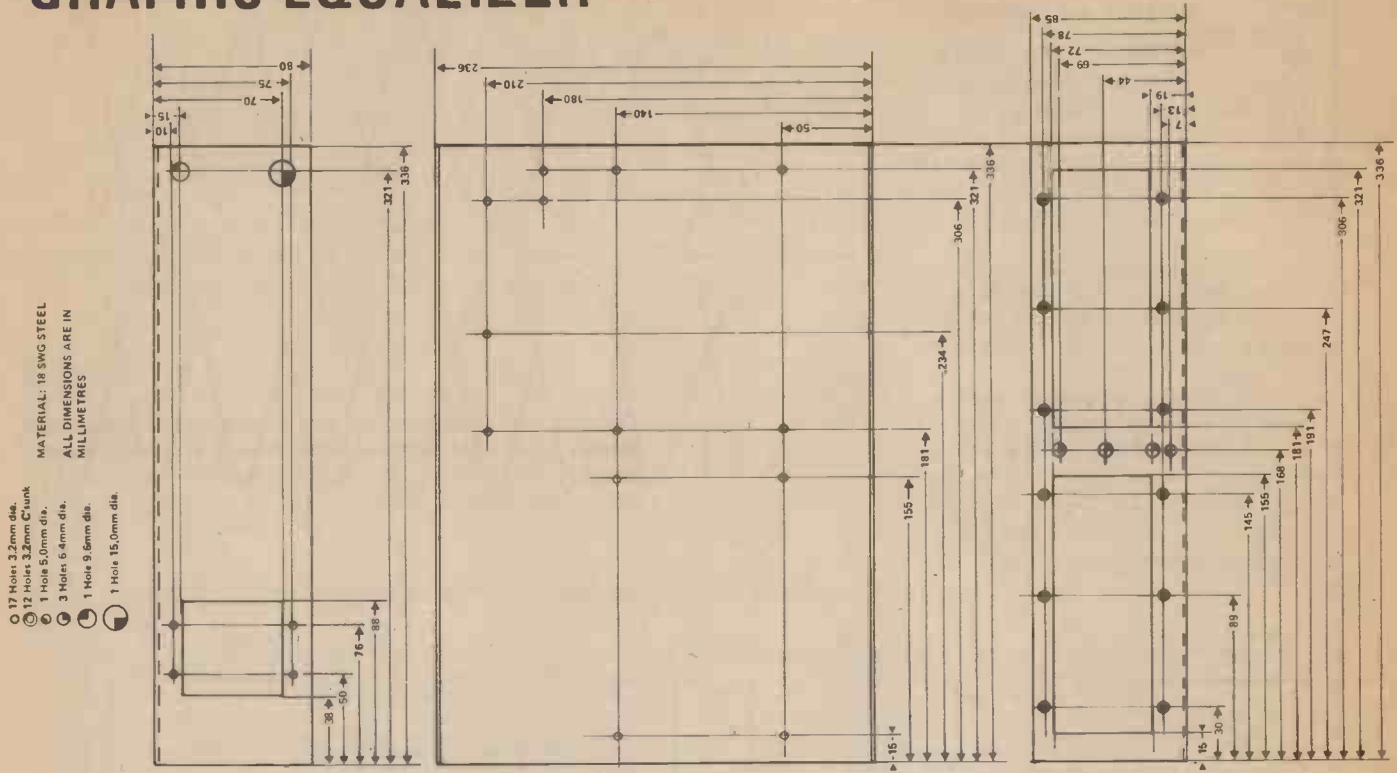


Fig. 7 Detail of the chassis.

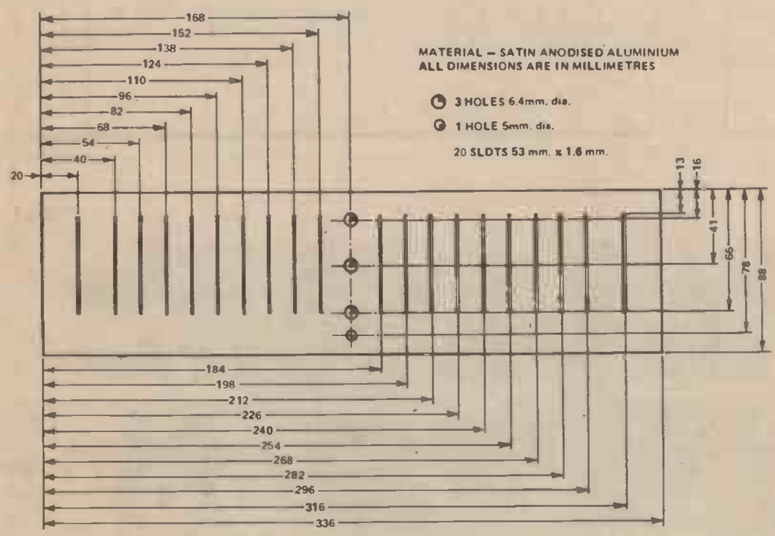


Fig. 8 Metalwork details of the front panel.

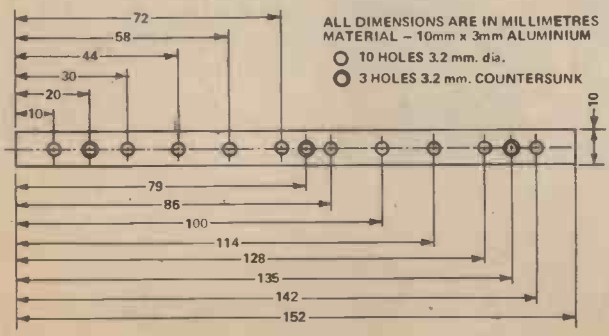


Fig. 9 Drilling details for potentiometer support brackets.

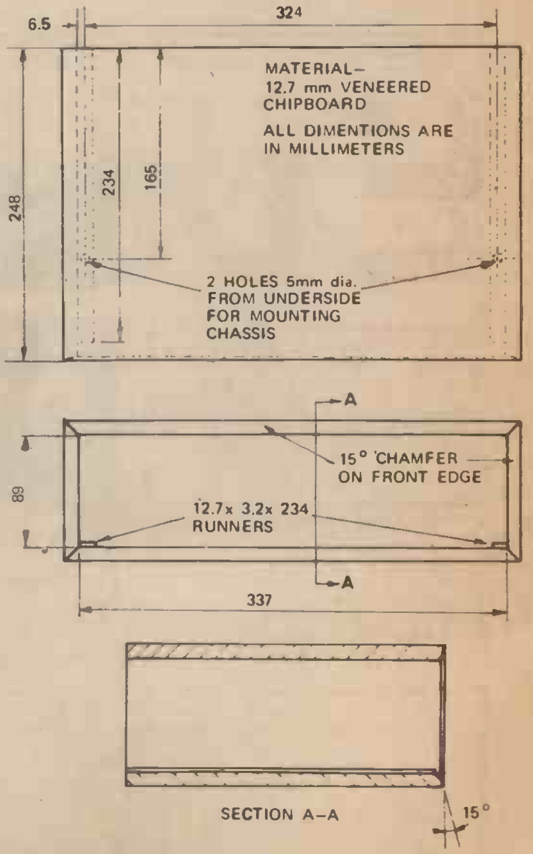


Fig. 10. Constructional details of the cabinet.

PARTS LIST – ETI 427

R5	Resistor	330	½W	5%
R6	"	390	½W	5%
R7,8,9	"	390	½W	5%
R10,11,12	"	390	½W	5%
R13,15,18	"	390	½W	5%
R24	"	1.5k	½W	5%
R1,4	"	3.3k	½W	5%
R19	"	3.9k	½W	5%
R3,22	"	4.7k	½W	5%
R21	"	12k	½W	5%
R20	"	27k	½W	5%
R14,16,17	"	39k	½W	5%
R2,23	"	100k	½W	5%
RV1	Potentiometer 1k lin 45mm slide			
RV2-10	Potentiometer 1k lin 45mm slide			
C17	Capacitor	220µF	63V electrolytic	
C13,18,19	Capacitor	25µF	25V electrolytic	
C1,15	Capacitor	10µF	16V electrolytic	
C2	"	3.3µF	10V tag. tant.	
C3	"	1.5µF	25V " "	
C4	"	0.68µF	25V " "	
C6	"	0.39µF	polyester	
C7	"	0.22µF	"	
C5	"	0.15µF	"	
C8	"	0.1µF	"	
C9	"	0.047µF	"	
C10	"	0.027µF	"	
C11	"	0.01µF	"	
C12	"	0.0022µF	"	
C16	"	0.001µF	"	
C14	"	10pF	ceramic	
L1-L9	Coils from Maplin (see right)			
Q1,2,3	Transistor BC109 or similar			
D1,2,3,4	Diodes IN4001 or similar			
ZD1,2	Zener Diode 15V, 400mW			
LED 1	light emitting Diode			
IC1	Integrated Circuit LM301A			

PC Board ETI 427
For stereo operation double the above components except R24, C17, LED 1, ZD1, ZD2, D1-D4 where only one is required.
Transformer 240V — 36V @ 30mA min.
SW1,2,3 switch DPDT miniature toggle
4-way phono socket, 2 off
Chassis to Fig. 6.
Front panel to Fig. 7 and 8.
20 off knobs for slide pots.
4 pot support rails (Fig. 9)
12 threaded spacers 9.6mm long
8 plain spacers 12.7mm long
24 screws, countersunk head, 6.5mm long to suit spacers
3 core flex and plug
Cable clamp, grommet, terminal block.

The coils and capacitors for this project are available from Maplin Electronic Supplies, P.O. Box 3, Rayleigh, Essex. Maplin also produce a kit of this complete project except for the wooden cabinet.

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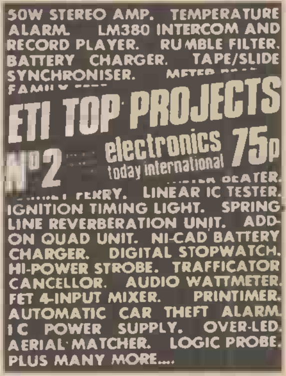
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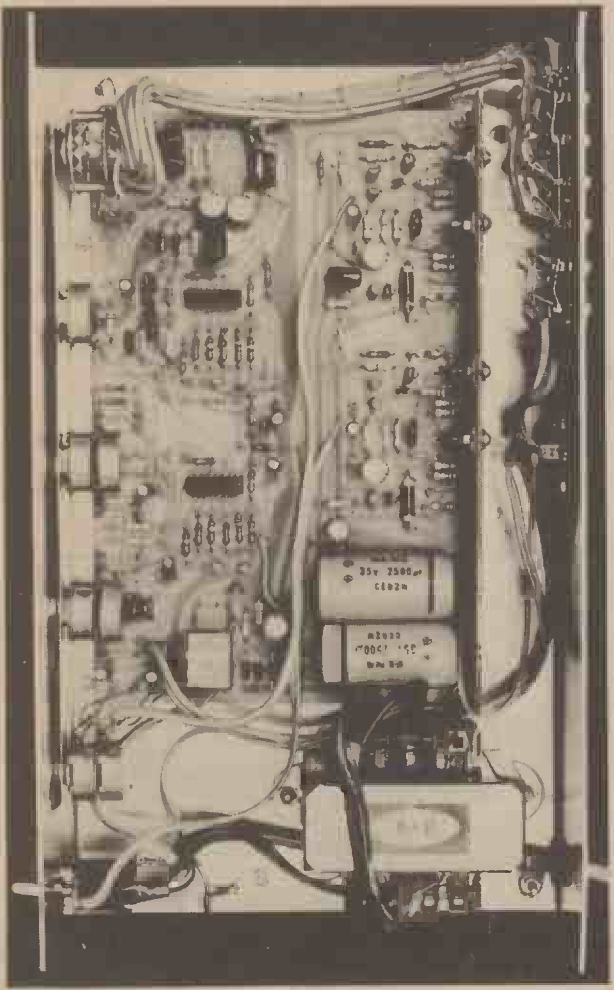

Fig. 1. Internal view of the INTERNATIONAL·25

MEASURED PERFORMANCE OF THE INTERNATIONAL·25

POWER OUTPUT	25 + 25 watts into 8 ohms	
FREQUENCY RESPONSE	+0 – 0.5 dB	15Hz–30kHz
	+0 – 3 dB	6 Hz – 80 kHz
CHANNEL SEPARATION	1 kHz – 46 dB	
HUM AND NOISE (with respect to 25W)		
Phono (10 mV)	67 dB (unweighted)	
Other inputs	68 dB (unweighted)	
INPUT SENSITIVITY		
Phono	2.5 mV	47k
Other inputs	200 mV	47k

TOTAL HARMONIC DISTORTION

Power	Frequency	One channel	Both channels
	100 Hz	0.1%	0.13%
12.5W	1 kHz	0.08%	0.16%
	10 kHz	0.12%	0.17%
	100 Hz	0.14%	0.5%
20W	1 kHz	0.12%	0.6%
	10 kHz	0.17%	0.8%
	100 Hz	0.5%	5.2%
25W	1 kHz	0.6%	4.8%
	10 kHz	0.7%	4.3%

TONE CONTROLS	
Bass	12 dB boost at 50 Hz 12 dB cut at 50 Hz
Treble	9 dB boost at 10 kHz 9 dB cut at 10 kHz
DIMENSIONS	340 x 88 x 210 mm

THE INTERNATIONAL·25 is a twenty-five watt per channel, high quality audio amplifier which is so easy to build that it is likely to set a standard for the amateur constructor which will remain unbeaten for years to come. ETI's top design team used some of the latest devices on the market to achieve this breakthrough.

WHEN designing this amplifier considerable effort was made to achieve several, generally incompatible, aims. These were to design an amplifier that gave high performance, was simple enough for the beginner to build BUT, was low in cost.

Since a high percentage of the cost of an amplifier is in the hardware, (e.g. chassis, potentiometers, switches etc) and this cost does not vary greatly relative to amplifier power output, we aimed at the highest possible power for reasonable cost. Thus the amplifier gives 25 watts RMS per channel which is about as much as can be obtained without component costs increasing dramatically.

To gain the required simplicity we used a single printed circuit board, to hold as much as possible of the electronics, thus keeping external wiring down to a minimum.

The result is a 25 watt-per-channel amplifier which is extremely easy to build and set up, which has a distortion of around 0.1% and costs about the same as a 12 watt per channel kit at present on the market that is much more difficult to build.

The single printed-circuit board

25 STEREO AMPLIFIER

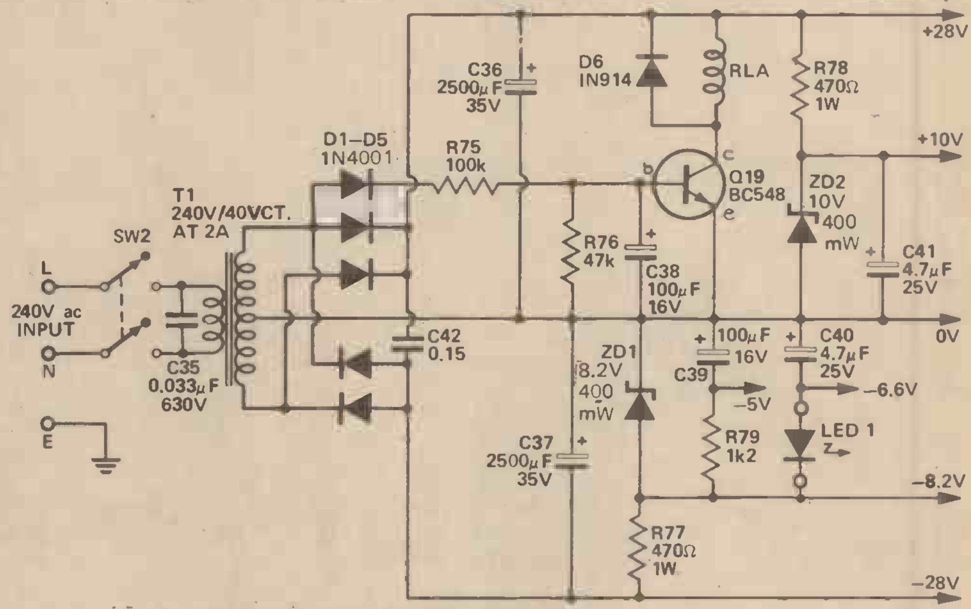

Fig. 2. Power supply of the INTERNATIONAL·25

KIT OF PARTS

A kit of parts for this project is available from Doram Electronics.

construction greatly simplifies things for the beginner. A heatsink is attached to the rear of the board to hold the power transistors, and a bracket at the front holds the potentiometers. Before attaching these brackets assemble the components to the printed circuit board according to the component overlay,

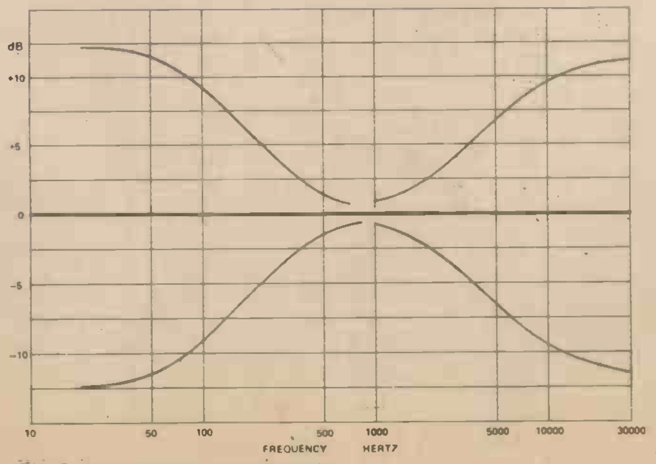

Fig. 3. Tone control characteristics.

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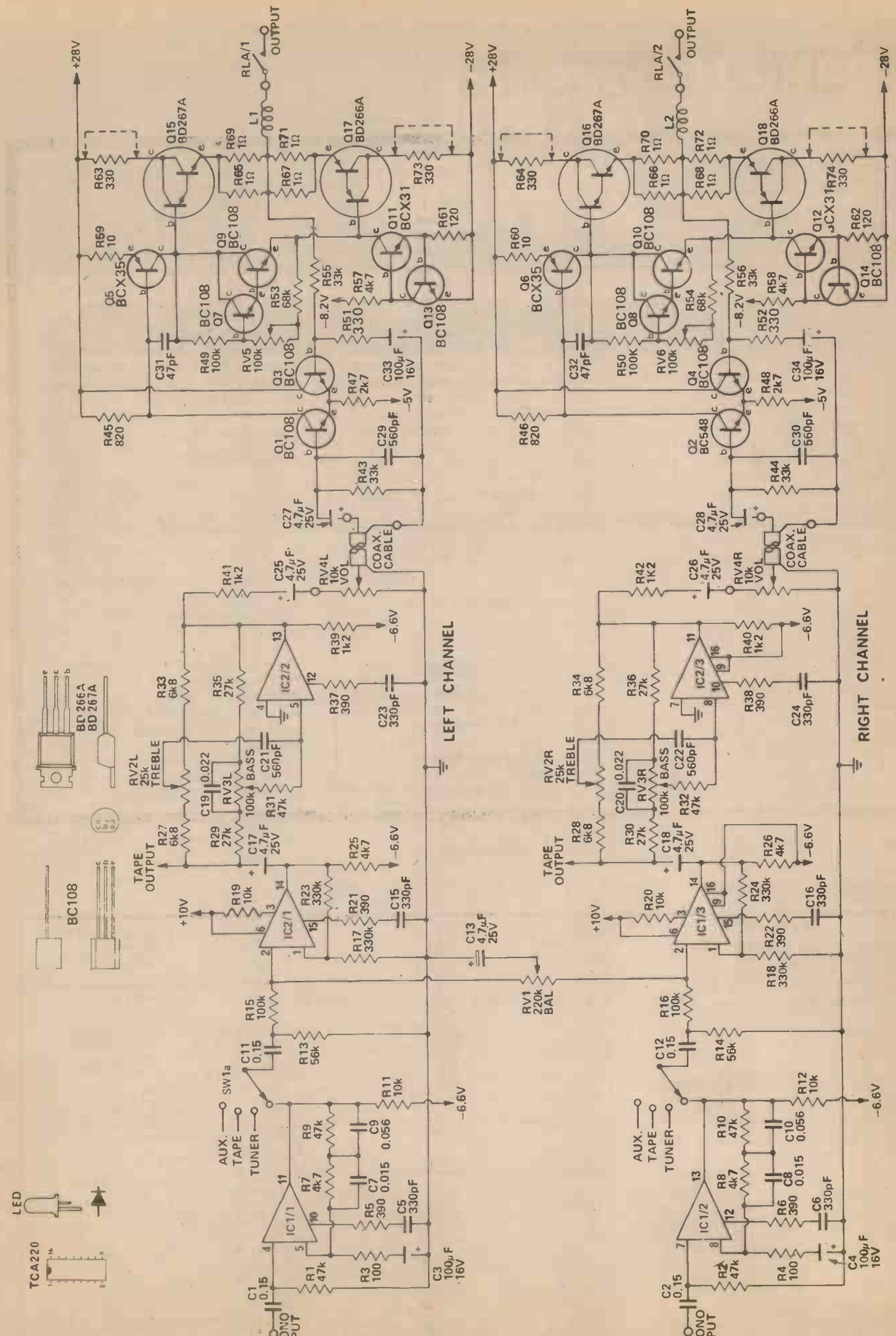

Fig. 4. Circuit diagram of the INTERNATIONAL-25.

INTERNATIONAL-25

HOW IT WORKS – INTERNATIONAL-25

PREAMPLIFIER

In the preamplifier we have used two TCA220 integrated circuits each of which contain three identical operational amplifiers. These work similarly to the conventional op amp like the 709, 741 or 301 except the output is an emitter follower and needs a pull down resistor. Fig. 1. for those interested. Frequency compensation is accomplished by a 390 ohm resistor in series with a 330 pF capacitor connected to the appropriate terminal. The maximum voltage allowed on this IC is 18V. Since the output swing in the positive direction is less than that in the negative direction we have used +10V and −6.6V supplies.

The magnetic pickup used on most good turntables has a low output and also needs equalization to perform correctly. We used part of the TCA 220 (ICI-1 and ICI-2) to amplify this signal (about 60 times or 35 dB at 1 kHz) and to provide the equalization required (+13 dB at 100 Hz and −14 dB at 10 kHz referred to the gain at 1 kHz). The output of this amplifying stage connects to the switch SW1 which selects the desired input. The signal from the cartridge is amplified before the selector switch to improve the signal-to-noise ratio.

After the selector switch we have the balance control (RV1) which attenuates either left or right channel as desired. The signal is then amplified, by a factor of two, to recover what is lost in the balance-control network and also to buffer the signal to give a low impedance output. The output drives the tone-control network and also the tape-output sockets.

The tone-control section uses the last sections of the TCA220 (IC2/2, IC2/3) with the bass and treble controls in the feedback network. These controls provide about 10 dB of boost and cut of both bass and treble. Resistors R27 and R33 set the limit of the treble boost and cut, while C21 controls the actual frequency where the treble control starts. Resistors R29 and R35 control the bass limits while C19 sets the frequency. The output of the stage is connected to the volume-control potentiometer RV4.

POWER AMPLIFIER

The power amplifier is of conventional design using a differential pair Q1 and Q3 followed by a common-emitter amplifier stage, Q5, working at a constant current (5 mA) supplied by Q11 and Q13. The output of Q5 is buffered by the output transistors Q15 and Q17. These are darlington transistors and have a current gain (Hfe) of over 750 at 3A. These transistors are biased on slightly (10 mA) to remove cross-over distortion and the bias is set by measuring the voltage across R63 or 73 (3V) while adjusting RV5. After bias adjustment is completed these resistors are shorted out to allow full power capability. Transistors Q7 and Q9 are physically joined onto Q15 and Q17 to provide accurate temperature indication and to ensure thermal stability.

The gain of the power amplifier stage is 100 and is set by the ratio of R55/R51. The earth reference for the power-amplifier input stage is supplied via the coax cables connecting to the preamplifier.

POWER SUPPLY

The power supply is a full wave rectifier with a centre-tapped transformer supplying ± 28V to the main amplifiers. The supplies for the preamplifier are obtained from a 10 V zener ZD2 and a 8.2V zener ZD1. The actual negative supply to the preamplifier comes via the LED on the front panel and is about −6.6 volts (1.6V across LED). A smooth −5V is also derived from the −8.2V and is used for the differential pair in the main amplifier.

The relay RLA is used to prevent the switch on transient reaching the speakers. After switch on there is a delay due to C38 of about 4 seconds before the speakers are connected. On switch off the delay is only about 1 second.

PARTS LIST

R65, 66	Resistor	1Ω	½W	5%
R67,68	"	1Ω	"	"
R69,70	"	1Ω	"	"
R71,72	"	1Ω	"	"
R59,60	"	10Ω	"	"
R3, 4	"	100Ω	"	"
R51,52	"	330Ω	"	"
R61,62	"	120Ω	"	"
R80,81	"	220Ω	1W	"
R63,64	"	330Ω	½W	"
R73,74	"	330Ω	"	"
R5,6,21	"	390Ω	"	"
R22,37,38	"	390Ω	"	"
R77,78	"	470Ω	1W	"
R45,46	"	820Ω	½W	"
R39,40,41	"	1k2	"	"
R42,79	"	1k2	"	"
R47,48	"	2k7	"	"
R7,8,25	"	4k7	"	"
R26,57,58	"	4k7	"	"
R27,28	"	6k8	"	"
R33,34	"	6k8	"	"
R11,12	"	10k	"	"
R19,20	"	10k	"	"
R29,30	"	27k	"	"
R35,36	"	27k	"	"
R43,44	"	33k	"	"
R55,56	"	33k	"	"
R1,2,9,10	"	47k	"	"
R31,32,76	"	47k	"	"
R13,14	"	56k	"	"
R53,54	"	68k	"	"
R15,16,49	"	100k	"	"
R50,75	"	100k	"	"
R17,18	"	330k	"	"
R23,24	"	330k	"	"
RV1	Potentiometer	220k lin single gang rotary		
RV2	"	25k lin dual gang rotary		
RV3	"	100k lin dual gang rotary		
RV4	"	10k log dual gang rotary		
RV5,6	"	100k trim pot		
C31,32	Capacitor	47pF ceramic		
C5,6,15	"	330pF "		
C16,23,24	"	330pF "		
C21,22	"	560pF "		
C29,30	"	560pF "		
C7,8	"	0.015μF polyester		
C19,20	"	0.022μF "		
C35	"	0.033μF 630 V		
C9,10	"	0.056μF polyester		
C1,2	"	0.15μF "		
C11,12,42	"	0.15μF "		
C13,17,18	"	4.7μF 25V electro		
C25,26,27	"	4.7μF 25V "		
C28,40,41	"	4.7μF 25V "		
C3,4,33	"	100μF 16V "		
C34,38,39	"	100μF 16V "		
C36,37	"	2500μF 35V "		
L1,2	Choke	25 Turns 0.4mm Cu Wire on a 10Ω 1W Resistor		
D1 — D5	Diode	1N4001 or similar		
D6	"	IN914 " "		
LED1				
ZD1	Zener Diode	8.2V, 400mW		
ZD2	Zener Diode	10V, 400mW		
Q1,2,3	Transistor	BC108		
Q4,13,14,19	"	or ZTX108		
Q7,8,9,10	"	"		
Q5,6	"	BCX35		
Q11,12	"	BCX31		
*Q15,16	"	BD267A or B		
*Q17,18	"	BD266A or B		

*insulation washers needed

IC1,2 Integrated Circuit TCA220

RLA Relay 2c/o contacts 1250Ω coil
T1 Transformer 40V cT @ 2A
SW1 Switch Rotary 2 pole 4 position
SW2 Switch miniature toggle 240V
Stereo Phone Socket
Twelve phono sockets
Two 2pin DIN sockets
CHASSIS
HEAT SINK
POT SUPPORT BRACKET
COVER
3 small knobs — 2 large knobs — 4 rubber feet — 2 9.6mm spacers — 3 core flex & plug rubber grommets.

INTERNATIONAL · 25

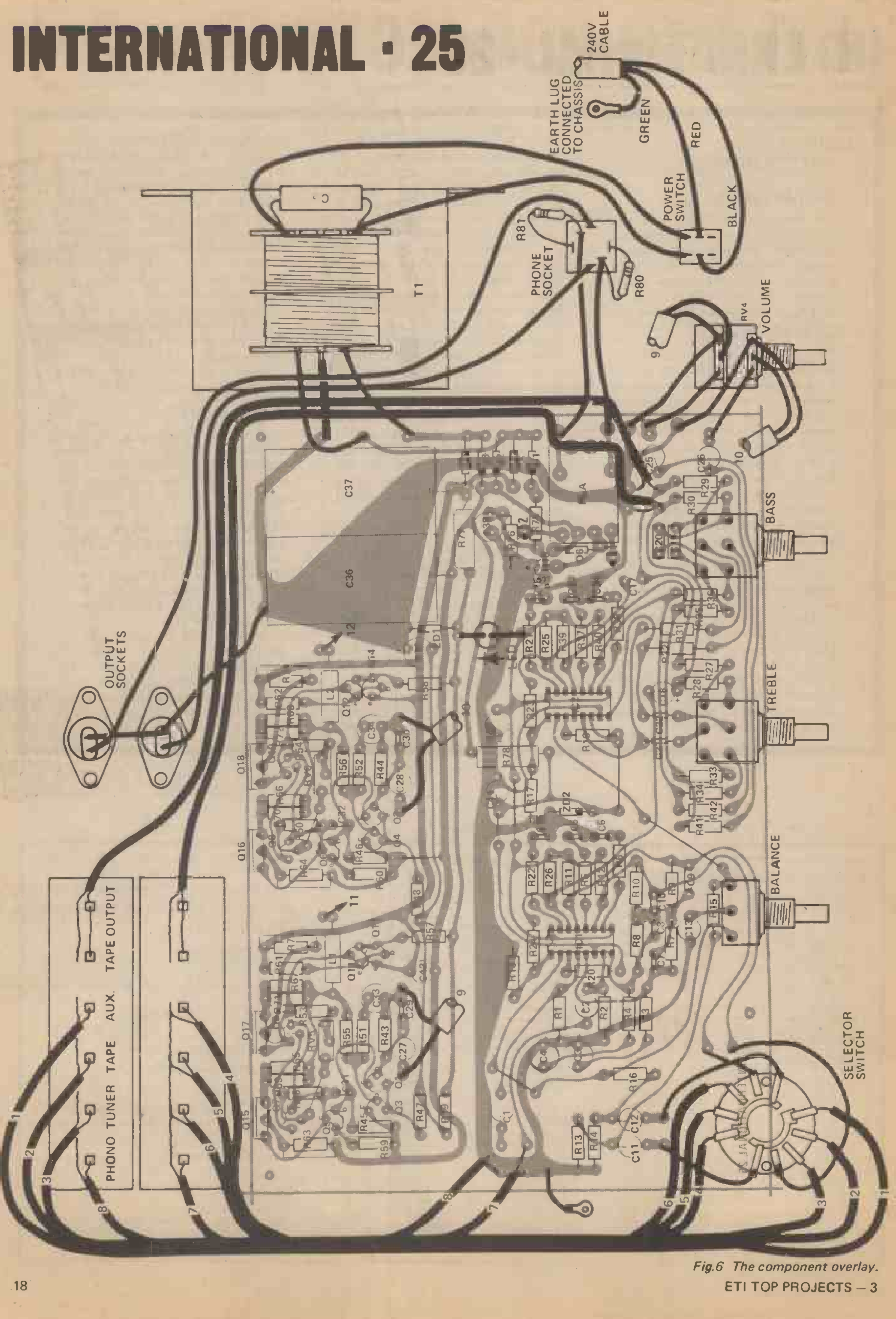

Fig.6 The component overlay.

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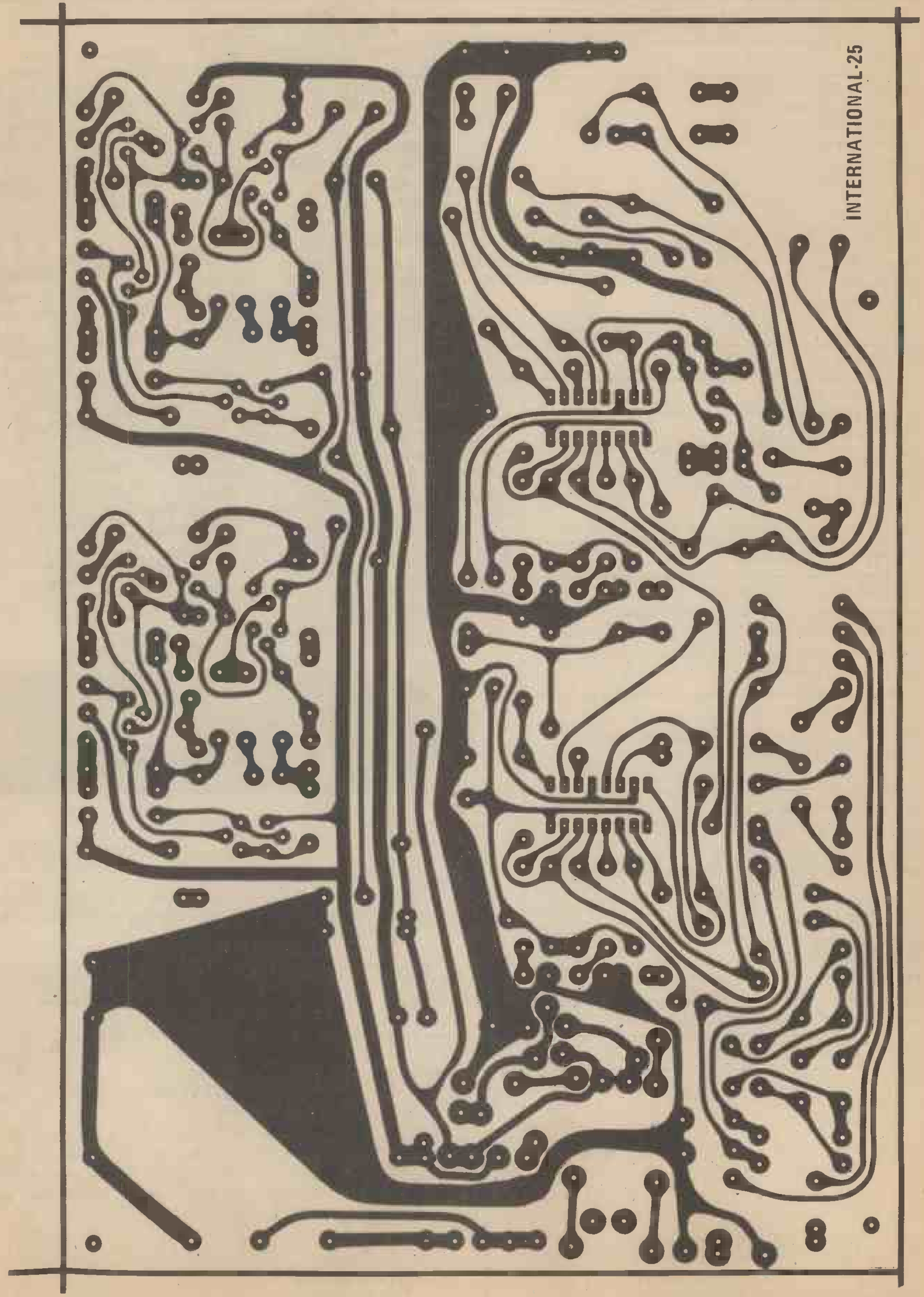
Fig. 5. PCB design for the INTERNATIONAL·25.



The component overlay diagram, Fig. 6, should be used when the components are soldered to the board. Do the linking wires first. There are two links which go under resistors R49 and R50 in the power amplifier and these should be insulated with sleeving. All other links may be tinned copper provided that they are kept straight and flat on the board.

Although the components can' be mounted in any order it is usually easier to mount the smallest (lowest height) components first, ie, resistors and diodes. These should be mounted flush on the surface of the board. The capacitors may now be mounted taking care not to damage the small ceramic capacitors by bending the leads too close to the body of the device. Make sure that electrolytic capacitors are orientated correctly, i.e., the polarity is correct.

The transistors, apart from Q7,8,9,10,15,16,17 and 18 (which are on the heatsink) may now be fitted to the board.

The integrated circuits may now be installed making sure that orientation is correct as indicated by the mark on the IC which is at the pin 1 end. Then mount the relay by passing the pins through the holes provided in the board and then bend the leads flush with the copper and solder them to the tracks.

The chokes L1 and L2 are made by winding about 25 turns of 0.4 mm copper wire (insulated) onto the body of a 10 ohm 1 watt resistor terminating the ends of the wire on the resistor leads. These may now be mounted on the board.

The balance, treble and bass controls should now have lengths of copper wire soldered to each of the terminals. They are then mounted, by passing the leads through the holes in the board, but are not soldered in position as yet. The front bracket should now be attached to the *component* side of the printed-circuit board and the potentiometers mounted to the panel. The leads from the potentiometers should then be drawn through the board as far as possible and then soldered in position. Then mount the heatsink bracket to the rear of the board using 9.6 mm spacers and countersunk screws.

The output transistors have to be prepared in a couple of ways before installation. The leads are too close together, and since they are mounted close to the board the transistors may be damaged if the leads are just pulled apart. Fig.7 shows the lead bending process which should be done carefully with a pair of long nose pliers. After bending, a BC108 should be epoxyed with flat side onto the face of these transistors.

It is preferable to use one of the slow dry epoxies as they appear to withstand the elevated temperature better. If such epoxy is dried in the 100-130° range it will normall dry in about 30 minutes. Before gluing, however, it is best to scratch the type number on to the side of the output transistor to aid later identification.

When dry, the transistors can be mounted using insulation washers and a smear of silicon grease if available. The leads of the BC108 have to be bent out a long way but they should be long enough. If a small soldering iron is used these transistors can now be soldered in without removing the heatsink.

The rotary switch and volume control can now be mounted on to the front bracket. There are four links from the board to the rotary switch as shown in Fig. 9, the rest of the connections going to the rear panel. There are also four links to the volume control and two coax cables which go from the volume control to the main-amplifier inputs.

The chassis can now be assembled by mounting the transformer (terminals on the outside), the front panel, the headphone socket, LED, speaker sockets, the phono sockets, the rubber feet, the grommet for the mains lead and the mains lead itself. The screw for the cable clamp also mounts one of the rubber feet.

The printed-circuit board module can now be temporarily installed. If the potentiometers used have a long threaded portion (this depends on the brand) there may be room for extra nuts to hold the module and front panel on. If not, the nuts will have to be removed and refitted on the outside of the front panel. The module is held in by the potentiometer and by two self-tapping screws into the heatsink from the underside. Due to the variations in alignment of the mechanical parts, the location of the holes in the heatsink cannot be accurately determined. Therefore these holes have been left undrilled and can now be marked through the holes in the chassis. The unit can now be removed to facilitate drilling these holes to a size suitable for the self tappers. Be careful not to damage the printed circuit board, and to remove any shavings during this process.

Connect coax cable from the phono input and the tape output, long enough to reach the rear panel socket. Leads to join the output of the main amplifier to the relay, and leads from the relay long enough to reach the headphone socket can be installed along with the lead from the speaker common and the LED leads. To facilitate the assembly pins should be installed to the board where the transformer is connected.

The 240 V input cable can now be joined to the switch and then to the transformer primary along with the capacitor C35. The earth wire should be bolted directly onto the chassis as shown. To prevent possible personal injury the switch and the transformer primary terminals should be taped up with insulation tape.

Detail of power transistor assembly and installation. Note compensation transistors glued to output transistors (see text) and mica insulators between power transistors and chassis. Care should be taken with cooling Q15 and Q17 (the two transistors on the left). If the amp is likely to be driven hard these will need individual heatsinks.

The leads from the compensation transistors may need careful bending.

INTERNATIONAL · 25

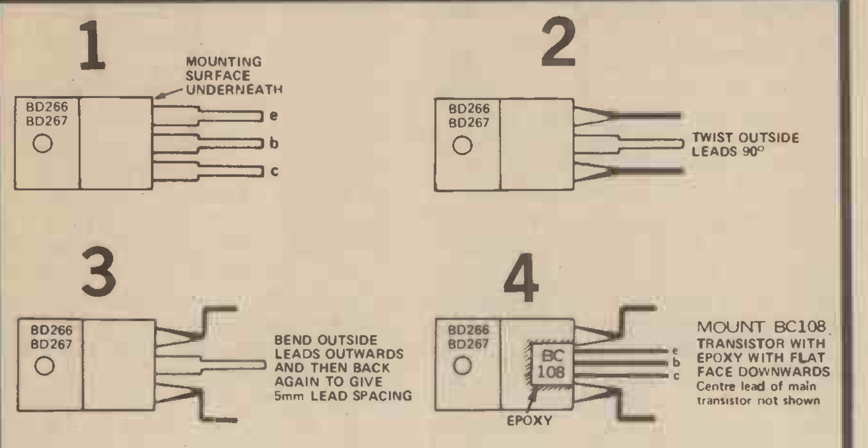


Fig. 7. How to prepare the power transistor leads for installation.

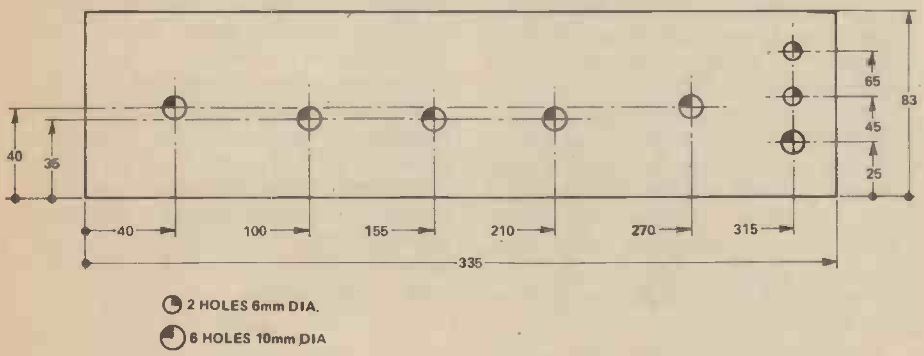


Fig.13. Front panel details.

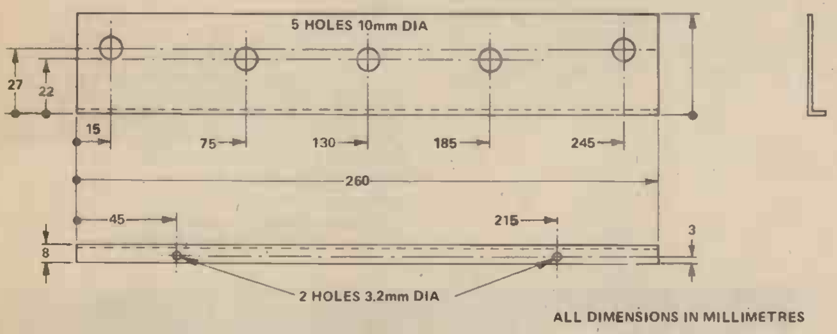


Fig.14. Potentiometer support bracket.

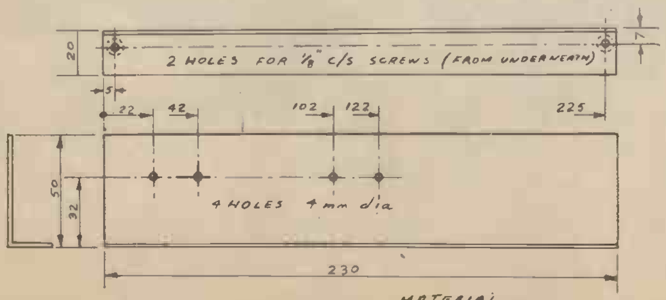


Fig.15. Details of the heatsink bracket.

The printed-circuit board module can now be permanently reinstalled. The transformer secondary can now be connected and the rest of the wiring installed. The headphone socket along with R80 and R81 can be wired according to Fig. 6.

This completes the assembly of the unit which is now ready for testing.

TESTING

Providing all components are in the correct place and all interconnections are correct the only adjustment is that to set the bias current in the output transistors.

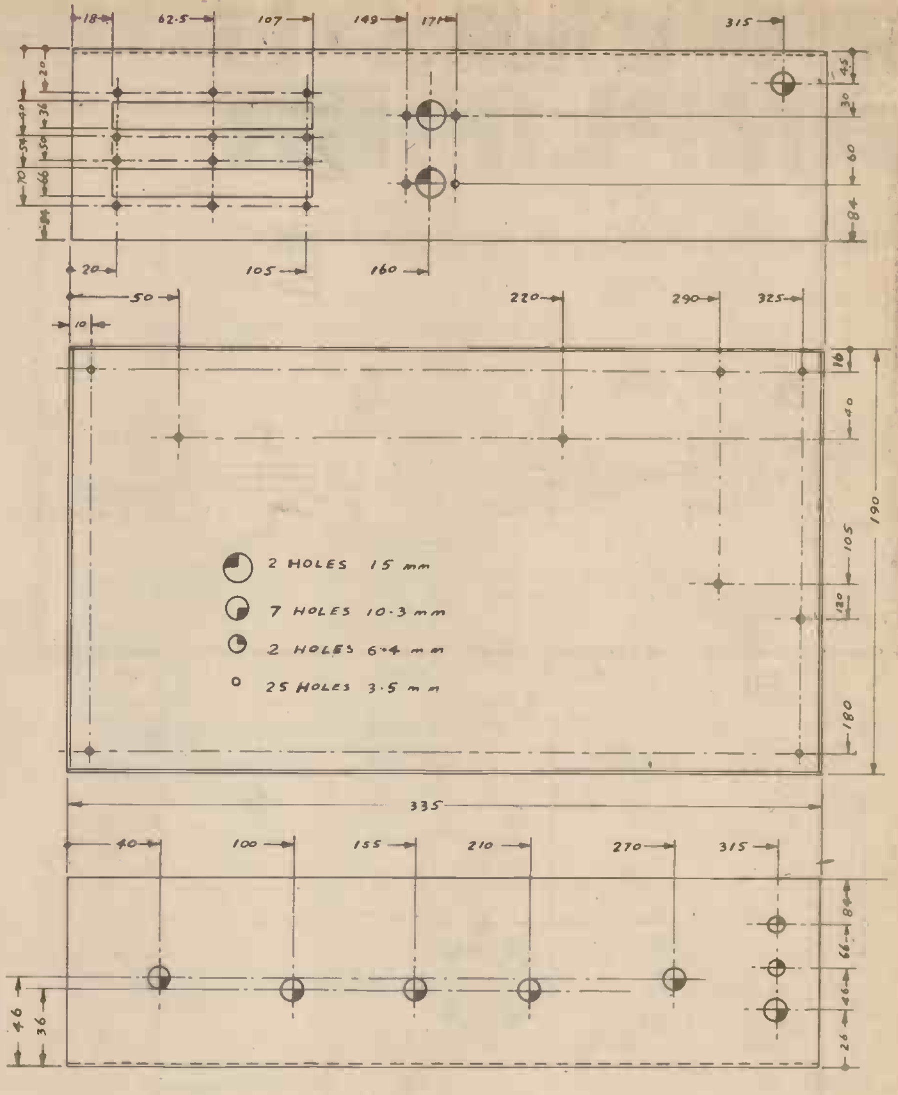
Before switching on rotate the trim potentiometers, RV5 and 6, fully clockwise i.e. toward the transformer. Switch on without speakers connected and measure the voltage across R63 and adjust RV5 to give about 3 volts. Repeat the process with the other channel and R64 and RV6. The resistors R63, 64, 73 and 74 can now be shorted out (after switching off) by short links of wire soldered onto the leads of the resistor.

If a fault exists in the output stage, either a transistor is shorted to the heatsink or the bias setting is faulty etc. In such a case the resistors R63, 64, 73 and 74 will overheat and may burn out. This effectively protects the output transistors. ●

FAULT

PROBLEM
R63 or R73 gets hot (only one)
R63 and R73 gets hot (both)
Bias current not adjustable down to within limits
Bias current too low or zero
Output voltage high (near supply rail)
Output voltage low
Main amplifier has no gain
Main amp appears OK but pre amp does not work

Fig.16. Chassis details



FINDING

POSSIBLE FAULT AND CHECKS

shorted insulation on Q15 or Q17

bias current too high

Q7 and/or Q8 faulty or wrong polarity. Voltage between base of Q15 and base of Q17 should be about 2.3 Volts

check output voltage, if about 0V then possible shorted Q7 or Q8

check current source Q11 is working Voltage across R61 should be about 0.65V. Check voltage across R45 it should be almost 0V (output high) if it is suspect Q5. If not check voltage at base of Q1 and Q3. Q3 should be higher than Q1 if so suspect Q1 or Q3

check voltage across R45 should be about 0.7V if >0.7V suspect Q5. If less than 0.5V measure voltages at base of Q1 and Q3. Q3 should be lower than Q1 if so suspect Q1 or Q3

faulty or disconnected C33, R51 or R53 wrong value

check supply voltages or pin 6 (+10 V) and pins 9 and 16 (–6.6 V) Check output voltage of each individual amplifier. They should all be about 0V if not check components in local area.

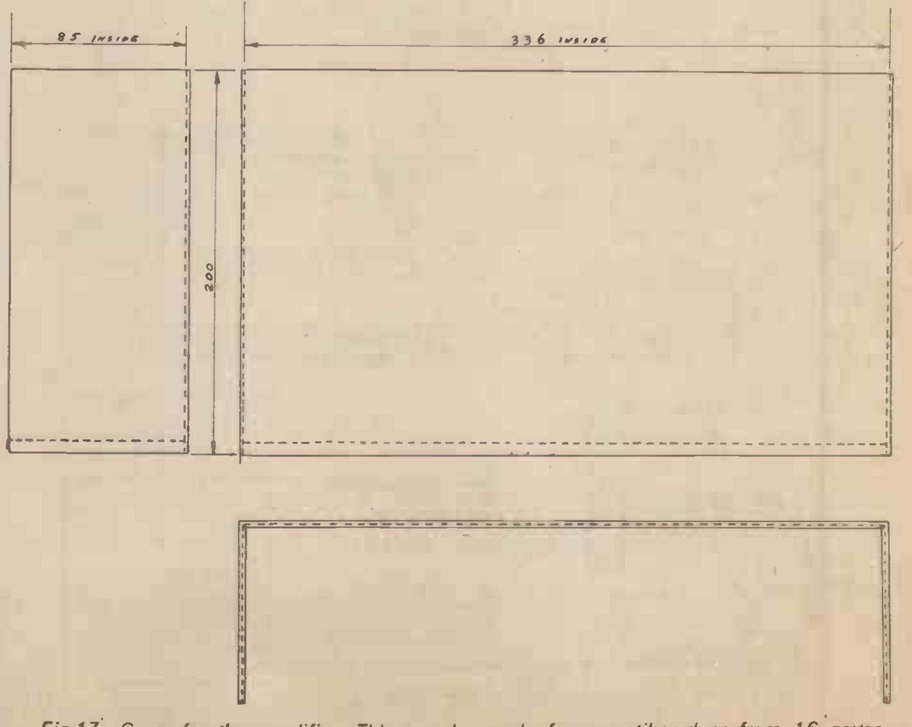


Fig.17. Cover for the amplifier. This can be made from contiboard or from 1,6 gauge aluminium.

SIMPLE STEREO AMPLIFIER

Ideal beginner's amplifier suits simple record players.

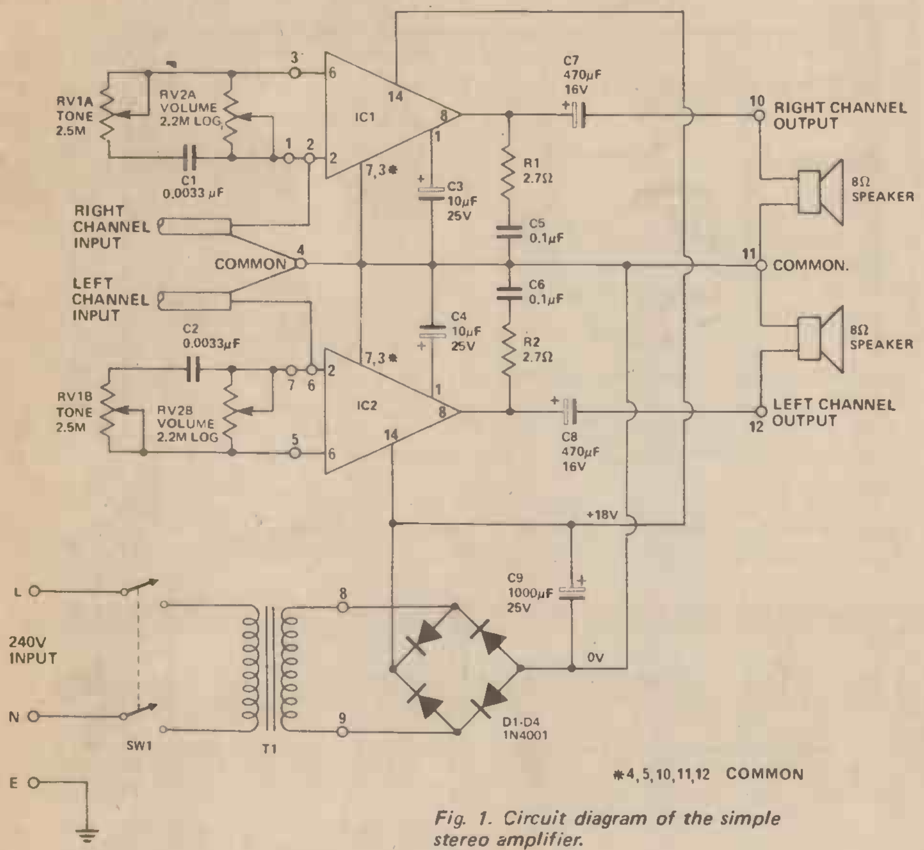


Fig. 1. Circuit diagram of the simple stereo amplifier.

THIS SIMPLE stereo amplifier uses two LM380 IC's and a minimum of external components, it can easily be assembled in only one or two evenings. It is designed to match the *crystal* cartridges found on most simple record players and gives surprisingly good results.

CONSTRUCTION

Check the orientation of the ICs on the PC board with the aid of the component overlay and solder them in position first of all. Next cut four heatsinks from shim copper or tinplate as illustrated in Fig. 3 (a rolled out tin can will do to make these).

Tin the tabs of the heatsinks and solder one to the centre three pins on either side of each IC.

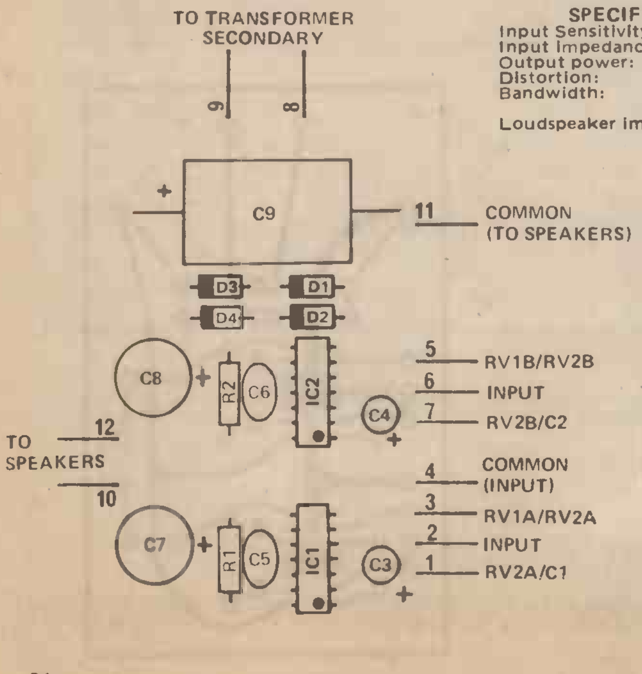
Next mount the four diodes and the electrolytic capacitors, again checking orientation, as these devices are polarity conscious. Use shielded leads for the connections to the pickup cartridge and twisted pairs to the potentiometers.

Mounting position is not critical — a general rule of thumb is to keep input circuitry away from strong ac fields such as found close to power transformers and motors. Keep all leads reasonably short and away from moving parts likely to foul them. Additionally keep the power transformer well away from the pickup arm and its signal leads.

If you mount the volume and tone controls as we have, on a wood base board, solder an earth wire to the cases of the pots. This will stop the amplifier buzzing every time you adjust the controls. ●

SPECIFICATIONS ETI 429

Input Sensitivity:	200mV
Input Impedance:	150k
Output power:	2.5W RMS/channel
Distortion:	0.2%
Bandwidth:	100kHz (tone control flat)
Loudspeaker impedance:	8 ohm or 15 ohm



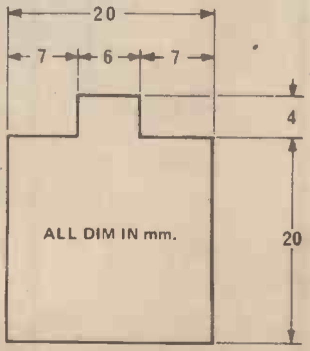


Fig. 3. Dimensions for the IC heatsinks. One is soldered to each side of the IC — to pins 3, 4, 5 and 10, 11, 12.

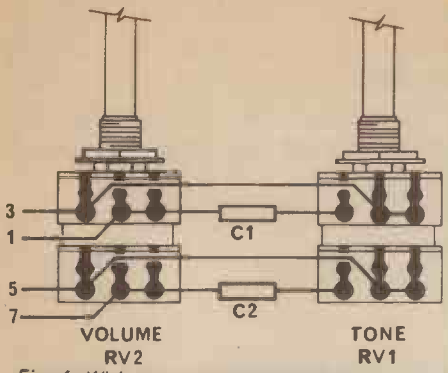


Fig. 4. Wiring to the volume and tone potentiometers.

PARTS LIST ETI 429

R1,R2	Resistor	2.7Ω ½W, 10%
C1,C2	Capacitor	0.0033μF, mylar
C3,C4	"	10μF, 25V electrolytic
C5,C6	"	0.1μF, mylar
C7,C8	"	470μF, 16V electrolytic
C9	"	1000μF, 25V electrolytic
D1,2,3,4	Diode	1N4001
RV1	Potentiometer	2.2M LIN Dual
RV2	"	2.2M LOG Dual
T1	Transformer	240V—12/15V, 500mA
SW1	Switch	DPST 2A 240V
PCB		

Three core mains flex and plug, speakers (8-15 ohm), hookup wire, knobs, 3 way mains terminal strip.

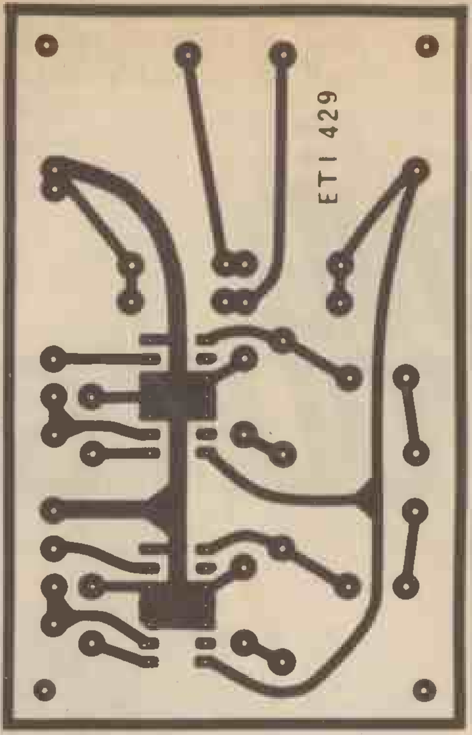
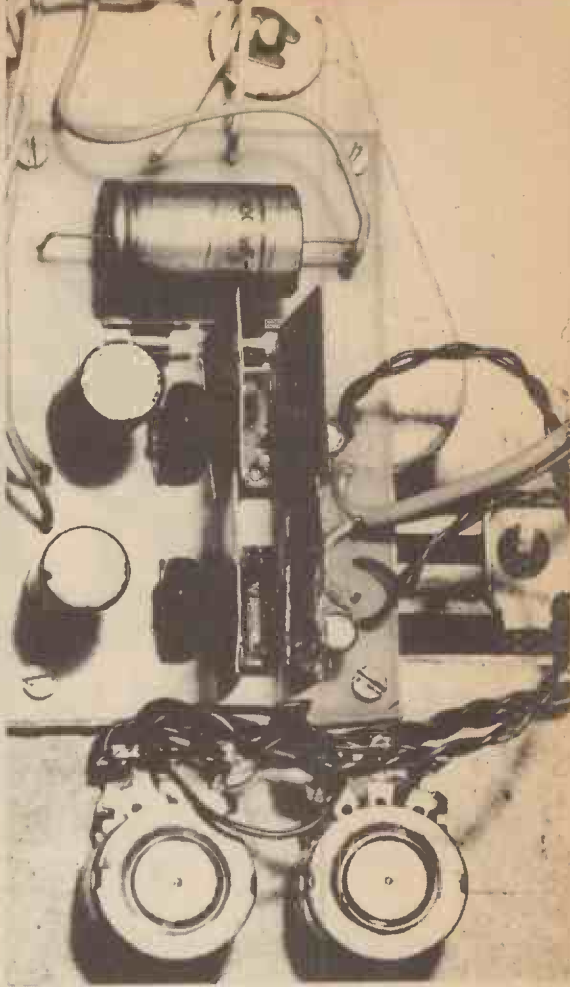


Fig. 5. Printed circuit board. Full size 97 x 61mm.



The completed amplifier fitted below a conventional record player. Transformer (not shown) is mounted well clear of signal leads.

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who's built an ETI Synthesiser....
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NEW SOUND FOR YOUR GUITAR

The normal guitar sound begins with a sharp 'attack'. This device removes the attack effect, producing a completely new and way-out sound, unlike that of any other instrument.

Every musical instrument owes its unique sound to a certain combination of inherent characteristics. For instance, the number of harmonics produced, combined with their magnitudes and phase relationships, play an important role in creating the instrument's distinctive sound.

Another important characteristic is attack time — the speed with which sound is built up after a tone is initiated. Reed instruments such as the clarinet produce sounds which can be described as 'soft' because they have a relatively slow attack, caused by the time it takes for the reed to build up to its maximum vibration. On the other hand, instruments such as the guitar have a very rapid attack because maximum amplitude vibration is started as soon as the string is plucked or struck.

By changing an instrument's attack, we can make it sound different and, at the same time, not like any other instrument. That is what the 'Attack Delay Unit' (ADU) does for the guitar. By slowing down the guitar's attack, a brand new sound can be obtained. The effect can also be produced by recording a guitar passage on tape and then running the tape backwards through the player. Instead of sharp, clean tones, a hard-to-describe 'whoop' is heard for each note played. Although the note is on pitch, it doesn't sound like it belongs to any known musical instrument.

Using the ADU, attack can be delayed for a very short period so that only the sound of the pick hitting the string is eliminated, or it can be delayed so that the 'music builds up over the length of a run. A foot control switch makes it easy to delay particular notes selectively.

CONSTRUCTION. The circuit of the ADU, shown in Fig. 1, is fabricated on a printed circuit board whose foil

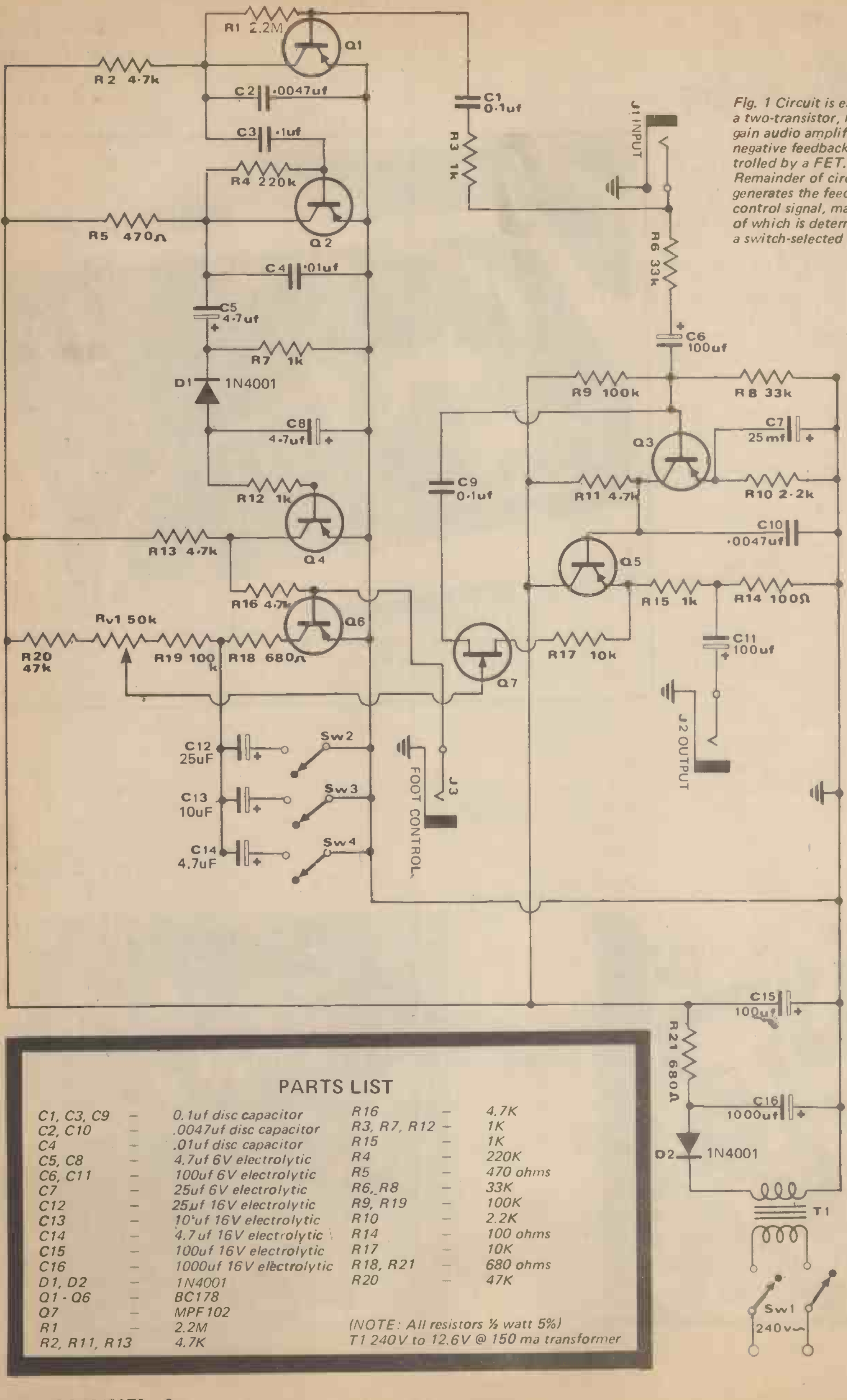


Fig. 1 Circuit is essentially a two-transistor, high gain audio amplifier with negative feedback controlled by a FET. Remainder of circuit generates the feedback control signal, magnitude of which is determined by a switch-selected capacitor.

PARTS LIST

C1, C3, C9	–	0.1uf disc capacitor
C2, C10	–	.0047uf disc capacitor
C4	–	.01uf disc capacitor
C5, C8	–	4.7uf 6V electrolytic
C6, C11	–	100uf 6V electrolytic
C7	–	25uf 6V electrolytic
C12	–	25µf 16V electrolytic
C13	–	10uf 16V electrolytic
C14	–	4.7uf 16V electrolytic
C15	–	100uf 16V electrolytic
C16	–	1000uf 16V electrolytic
D1, D2	–	1N4001
Q1 - Q6	–	BC178
Q7	–	MPF102
R1	–	2.2M
R2, R11, R13		4.7K
R16	–	4.7K
R3, R7, R12	–	1K
R15	–	1K
R4	–	220K
R5	–	470 ohms
R6, R8	–	33K
R9, R19	–	100K
R10	–	2.2K
R14	–	100 ohms
R17	–	10K
R18, R21	–	680 ohms
R20	–	47K

(NOTE: All resistors ½ watt 5%)
T1 240V to 12.6V @ 150 ma transformer

NEW SOUND FOR YOUR GUITAR

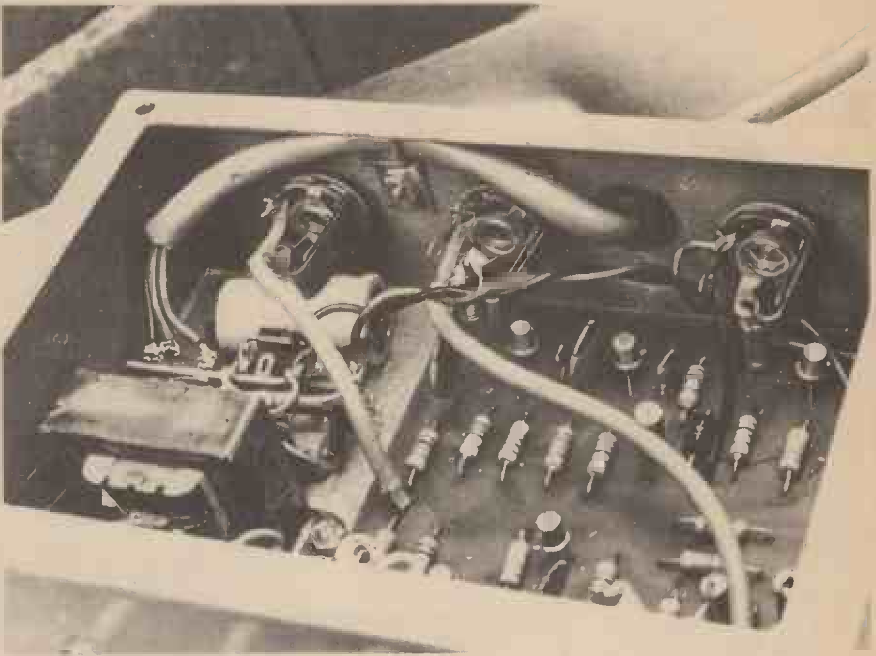
pattern is shown in Fig. 2. Once the board has been made (or purchased), install the components as shown in Fig. 3. Be sure to install the semiconductors and electrolytic capacitors correctly. Use a heat sink (such as long-nose pliers) on the transistor and diode leads while soldering to avoid possible thermal damage. Also, use a low-power (35 watts) soldering iron. Connect sufficiently long leads to the various external connection pads before mounting the board in the chassis.

Almost any type of metal chassis may be used as long as it will hold the PC board, the power transformer and the associated rectifier, and will permit the installation of four switches on the front and three phone jacks on the back.

The choice of switches for S2, S3 and S4 should be made carefully. During use, it may be necessary to manipulate these switches rapidly in various combinations, so they should have large paddle-type handles and operate with a light pressure. Any type of DPST switch rated at 240 volts ac may be used for power switch S1.

Do not ground either side of the ac to the chassis.

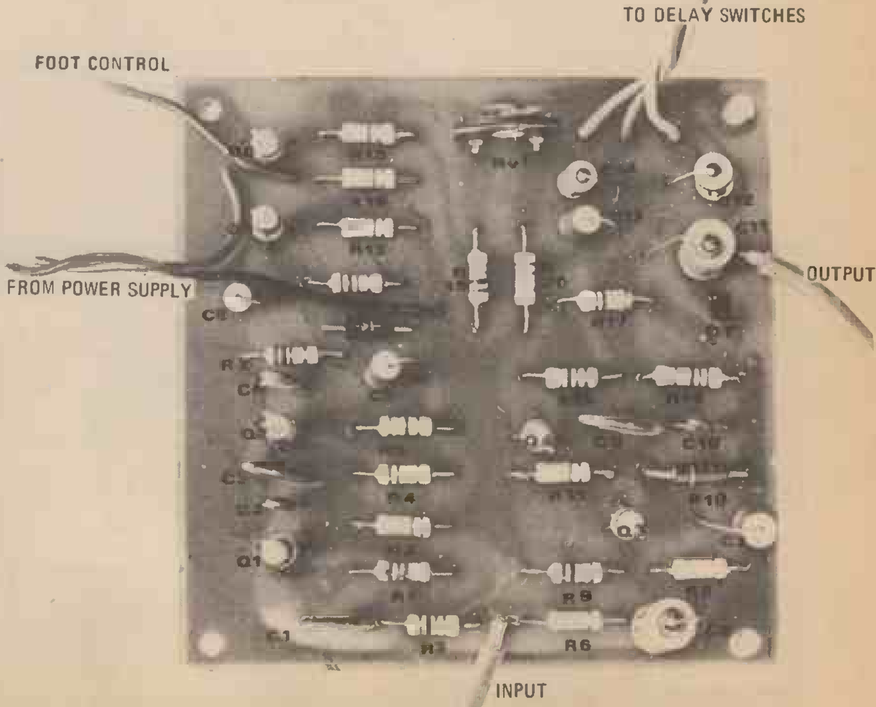
Mount the three capacitor-selector switches (S2, S3 and S4) on the front wall and three phone jacks (J1, input; J2, foot control; and J3, output) on the rear wall.

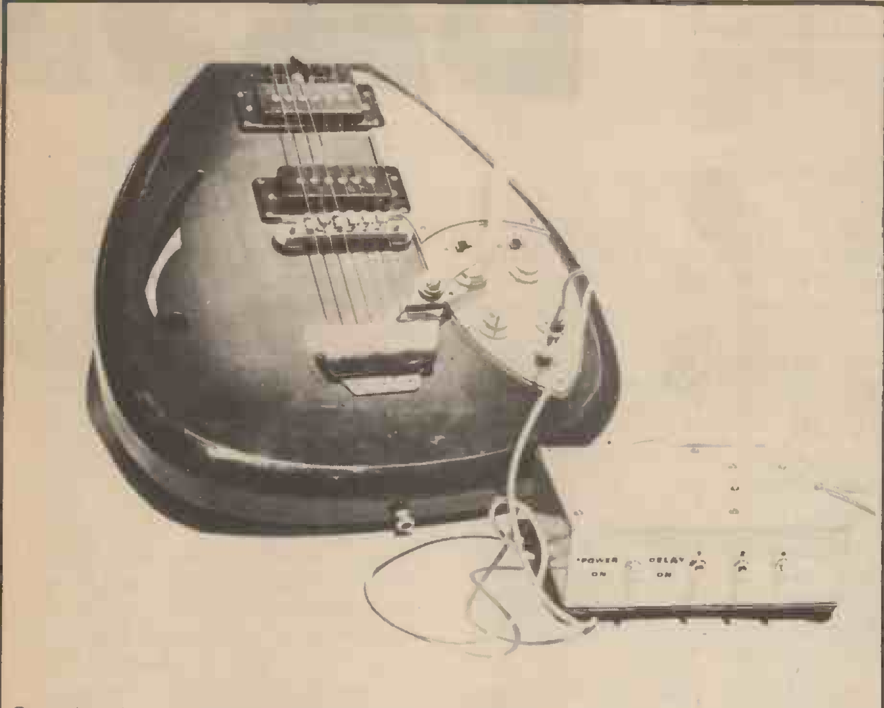


Interior of unit, showing power supply at left, main circuit board at right. Jack sockets for input, output and foot control are seen on rear panel.

FIG. 2 (below, left): Foil pattern of printed circuit board (full-size).

FIG. 3 (below, right). Component layout on printed circuit board.





Completed prototype unit connected to guitar.

Mount the PC board on four ¼" insulated spacers so that RV1 will be accessible from the side. Wire the complete circuit as shown in Fig. 1. Put four rubber feet on the chassis bottom to keep it from slipping around when in use.

SET—UP. Prepare the unit for operation by running a short length of cable from the output of the ADU to your amplifier input and plugging the instrument output into the ADU input. For the time being, do not use the foot control switch. Turn the ADU on and set the delay to 4.

Since a certain minimum signal is required to operate the delay unit, the instrument's gain should be turned up almost all the way and the volume adjusted by using the amplifier's control.

The only thing that needs adjustment in the ADU is potentiometer RV1. At one end of this potentiometer's rotation there is little or no delay in the instrument attack; with the opposite setting, there is no sound for an instant and then the volume will come up full. Between these two extremes are a variety of settings which can be selected strictly as a matter of personal taste. Ideally there should be very little or no sound when the note is first struck, followed immediately by a noticeable increase in volume with a smooth glide to maximum.

OPERATION. The three delay switches on the ADU can be used singly or in combinations to yield up to seven different delays. The numbers above the switches represent some arbitrary unit of delay (which varies with the setting of RV1) and may be added together to get the longer delays. For instance, if switches 2 and 4 are down, the attack delay is 6 times longer than if only switch 1 is down.

Since the ADU requires a short, no-signal dead time for the circuits to reset, all strings on a guitar must be silenced before the next chord or note is struck. If single notes are being played, just lifting the finger from the finger board will ordinarily accomplish the deadening, but for chords with open strings it is necessary to deaden the strings with the palm of the strumming hand. The resetting time is actually very short (in the order of a tenth of a second), so very rapid runs can be played with the delay still occuring on each note.

The foot control switch is a single-pole, single-throw type and can be housed in a sturdy case of metal or a block of wood. The switch can be a push-on/push-off type, but experience has shown that a spring-loaded, normally closed switch works best. With this arrangement, selective delay can be accomplished, by pressing the switch when delay is desired and releasing it to sustain a note. ●

BASS

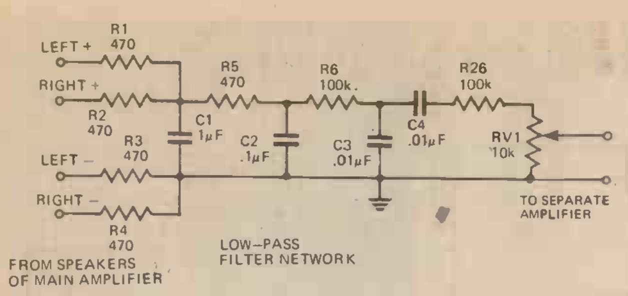


Fig. 1. This filter circuit can be used with an external amplifier.

Many economy hi-fi systems have adequate mid-range and treble response – but sound as if the bottom has fallen out of the amplifier when they come to some good solid bass.

And when you calculate the amplifier and speaker capacity required for realistic bass response you begin to appreciate why.

But all is not lost – for here is a modification that will reproduce the very deepest of bass, at levels practically guaranteed to infuriate your neighbours for life!

Unlike the higher audio frequencies, bass is largely non-directional, and, because of this, the positioning of a bass speaker is not at all critical.

The bass booster described in this project exploits this principle. Whilst in no way affecting the normal output or stereo separation of the existing system the booster effectively combines the bass signals from the left and right hand stereo channels and, following amplification, reproduces them through a common bass speaker.

The system may be used in several different ways.

In its simplest form, the combining filter shown in Fig. 1 is connected to any spare mono or stereo amplifier (rated at 20 Watts or more) and played through a single speaker enclosure that has a good bass response.

In another form the same arrangement is used together with the speaker system specifically designed for bass reproduction (shown in Figs. 6 & 7).

But as few of us have spare high-powered amplifiers lying around waiting for a project like this – we have designed a very simple yet effective amplifier especially for this project. Note, that for this latter arrangement the design of the filter has been changed slightly.

CONSTRUCTION

If the booster is used in its simplest form – using a separate amplifier – the filter should be constructed on a small piece of perforated board or tag strips. The circuit is shown in Fig. 1. The layout is not at all critical.

In the form shown in Fig. 2, the amplifier and filter are constructed as one unit. This complete unit may be mounted within the new bass speaker enclosure (as we did with our

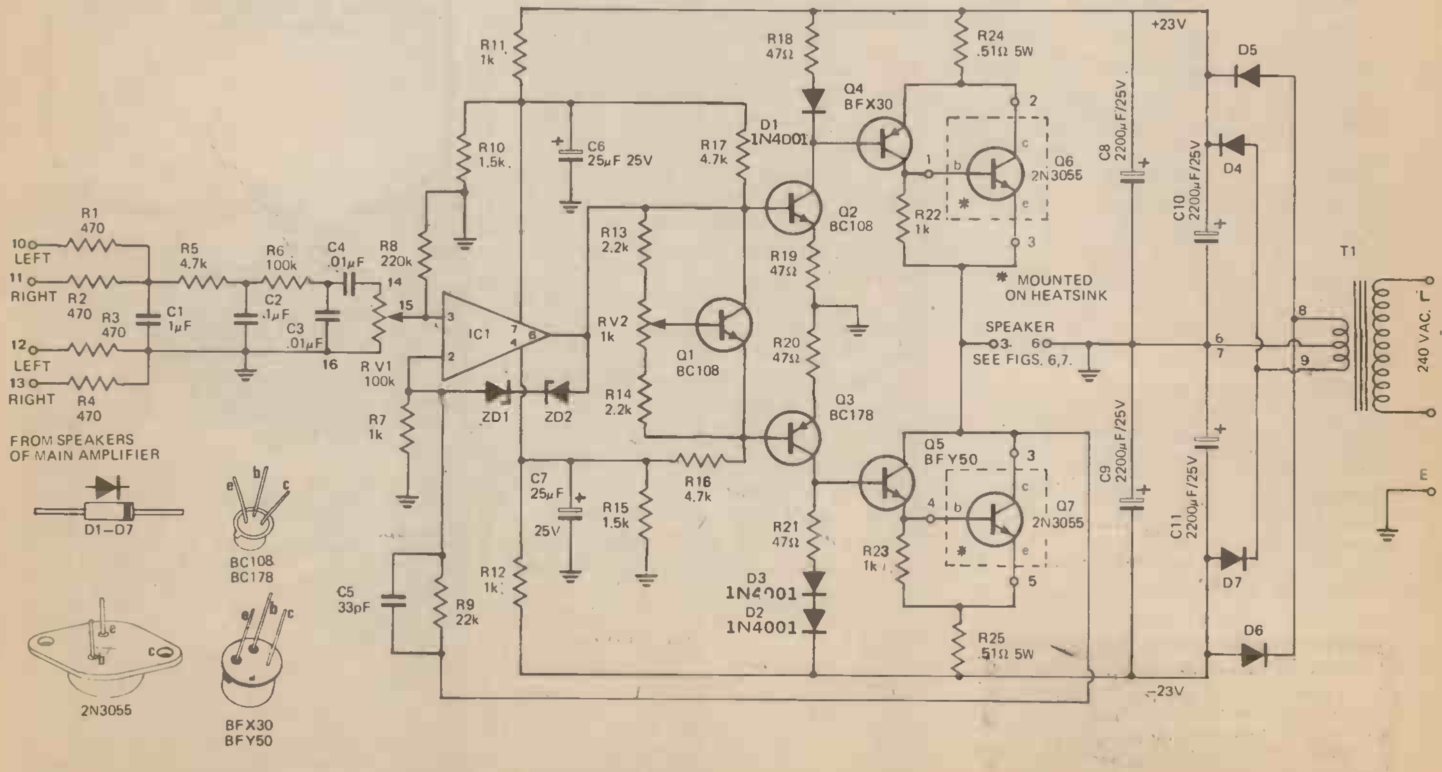


Fig. 2. In this circuit the filter and amplifier are combined as one unit.

BOOSTER

Modify your hi-fi system to provide some real bass performance.

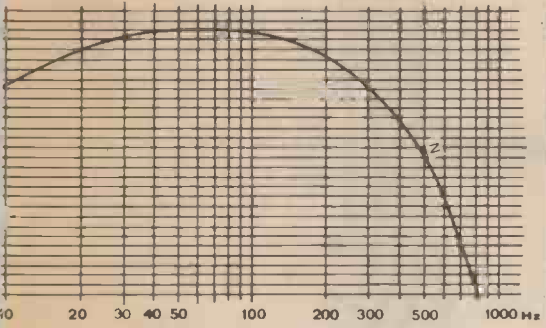


Fig. 3. This curve shows the frequency response of the filter.

prototype unit) or located in any readily accessible place.

Construction of the one-piece unit is quite simple as most components are mounted directly on the printed circuit board — shown full size in Fig. 4. The main power transformer, output transistors and control potentiometer are mounted externally — and connections to and from these components are made via the points numbered on both the component layout diagram (Fig. 5) and the main circuit diagram (Fig. 2).

Make sure that all components are orientated correctly before soldering them into the circuit.

Transistors Q6 and Q7 are mounted on the heatsink — using insulating washers — and connected to pins 1, 2, 3, 4 and 5 as shown in Figs. 2 and 5.

If the amplifier is to be located within the speaker enclosure, the power transformer should be mounted on rubber.

The connections to the inputs and to the volume control should be made using screened cable.

When you are sure that all components have been wired correctly, set the wiper RV2 centre of its travel. Do not connect the speakers at this stage of the operation.

This project is intended primarily to increase the bass response of economy hi-fi systems. There is little to be gained by using this system where adequate bass already exists.

All components can be mounted within the speaker enclosure.

Switch on the main 240 Volt supply and check the voltage across the speaker terminals. This should be less than 200 mV. If it is substantially higher than this, switch off and recheck all connections. (If a voltmeter is not available, connect one side of the speaker to one side of the amplifier and momentarily touch the second amplifier lead to the remaining side of the speaker. If all is well the speaker should remain practically silent or at most produce a slight 'click'. (If the speaker cone tries to fly across the room — then switch off at once and recheck all connections).

Next, if a milliammeter is available, disconnect the lead to pin 2 and measure the current in this lead. Adjust RV2 until the current is approx. 40 mA. If no milliammeter is available, leave RV2 in mid-position.

Connect the leads from the existing speakers to the filter input and connect the bass speaker to the booster amplifier. The power may now be switched on and the complete system checked out. Remember that the sound from the bass booster will be grossly distorted if this unit is used

PARTS LIST ET 407

(combined filter/amplifier)

R1	—	resistor	470	Ω	½W	5%
R2	—	"	"	"	"	"
R3	—	"	"	"	"	"
R4	—	"	"	"	"	"
R5	—	"	4.7k	"	"	"
R6	—	"	100k	"	"	"
R7	—	"	1k	"	"	"
R8	—	"	220k	"	"	"
R9	—	"	22k	"	"	"
R10	—	"	1.5k	"	"	"
R11	—	"	1k	"	"	"
R12	—	"	1k	"	"	"
R13	—	"	2.2k	"	"	"
R14	—	"	2.2k	"	"	"
R15	—	"	1.5k	"	"	"
R16	—	"	4.7k	"	"	"
R17	—	"	4.7k	"	"	"
R18	—	"	47	"	"	"
R19	—	"	47	"	"	"
R20	—	"	47	"	"	"
R21	—	"	47	"	"	"
R22	—	"	1k	"	"	"
R23	—	"	1k	"	"	"
R24	—	"	0.51	"	5W	"
R25	—	"	0.51	"	"	"
RV1	—	potentiometer 100k log				
RV2	—	preset potentiometer 1k linear				
C1	—	capacitor	1	μF	200V	
C2	—	"	0.1	"	100V	
C3	—	"	0.01	"	"	
C4	—	"	0.01	"	"	
C5	—	"	33pF			
C6	—	"	25μF,25V electro-			
C7	—	"	25μF,25V lytic			
C8	—	"	2200μF,25V		"	
C9	—	"	"		"	
C10	—	"	"		"	
C11	—	"	"		"	
Q1	—	transistor	BC108			
Q2	—	"	BC108			
Q3	—	"	BC178			
Q4	—	"	BFX30			
Q5	—	"	BFY50			
Q6	—	"	2N3055			
Q7	—	"	2N3055			
IC1	—	integrated circuit μA 741C— TBA 221				
D1-D3	—	silicon diodes type 1N4001				
D4-D7	—	diodes 100 PIV, 1.6A;				
(PL4002	—	Henry's Radio)				
ZD1	—	zener diode BZYB8 C3V9				
ZD2	—	" " " "				
Transformer		220-250V Primary; 15-0-15V 1·5A Secondary; (MT3AT, Henry's Radio)				
PC	—	printed circuit board ET018				
Heatsink	—	type H11, Henry's Radio				

Insulating kits for 2N3055s
Three core flex and plug
Terminals
Shielded wire etc
Note: C1-C4 — single-ended Polyester, Mullard type C280 or equivalent

PARTS LIST FOR SEPARATE FILTER

R1-R4	—	resistor	470	Ω	½W	5%
R5	—	"	4.7k	"	"	"
R6	—	"	100k	"	"	"
R26	—	"	100k	"	"	"
RV1	—	potentiometer 10k log				
C1	—	capacitor	1	μF	200V	
C2	—	"	0.1	"	100V	
C3	—	"	0.01	"	"	
C4	—	"	0.01	"	"	
Tag strips	—	terminals etc				

(C1-C4 : See Note above)

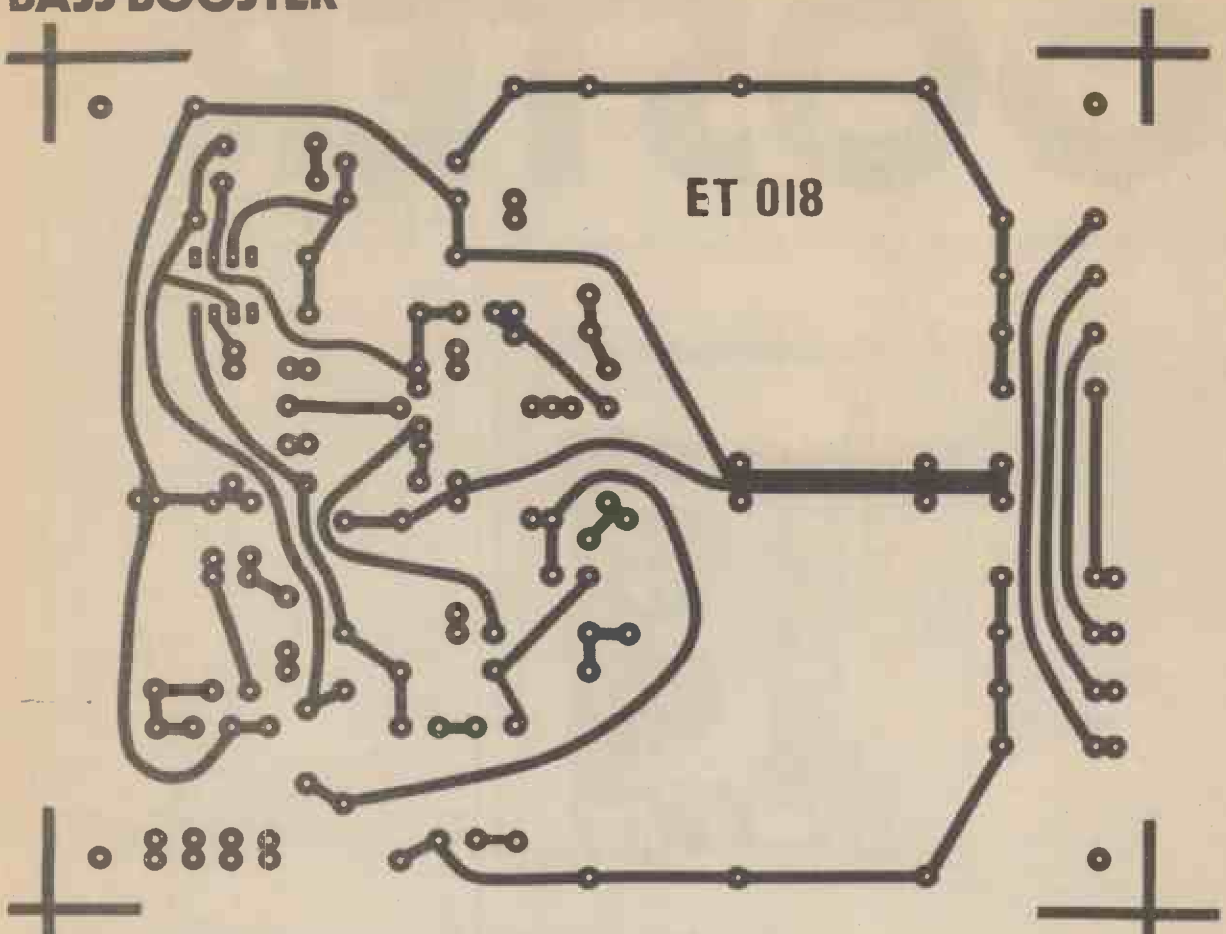


Fig. 4. Printed circuit board – shown full size.

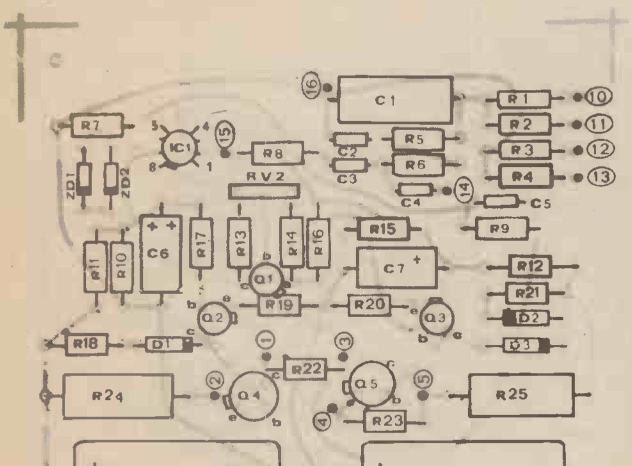


Fig. 5. How the components are located on the printed circuit board.

HOW IT WORKS

The output from each channel of the existing stereo amplifier is combined by resistors R1-R4. Resistors R5, R6 and RV1, together with capacitors C1, C2 and C3 form a low pass filter that has a cut-off frequency around 200 Hz and a final 18 dB per octave slope.

Capacitor C4 provides a high pass filter of approximately (30 Hz to protect the speakers from large transients and dc levels. (The filter shown in Fig. 1 – intended for use with separate amplifiers – has a 20 dB attenuator incorporated before the output potentiometer – this protects the following amplifier against overloads).

The amplifier shown in Fig. 2 has a voltage gain of 23 $\frac{(R9 + R7)}{R7}$, a power output of approx. 25 Watts into four ohms and a frequency response from 0Hz to approx. 50 kHz. However with the input filter incorporated, the frequency response of the amplifier is that of the filter – shown in Fig. 3.

The main voltage gain of the amplifier circuit is provided by IC1, Q2 and Q3, Q4 and Q5 provide the necessary current gain to drive the output transistors Q6 and Q7. Transistor Q1 stabilises Q2 and Q3 while D1 compensates Q4, D2 and D3 compensate Q5 and Q7.

Zener diodes ZD1 and ZD2 protect Q2 and Q3 by limiting the output voltage swing of the IC.

The amplifier described in this project may also be used – without the filter – as a straightforward 25 Watt mono amplifier – in this case diode D2 or D3 (but not both) should be removed from its location on the printed circuit board and relocated on the heat sink.

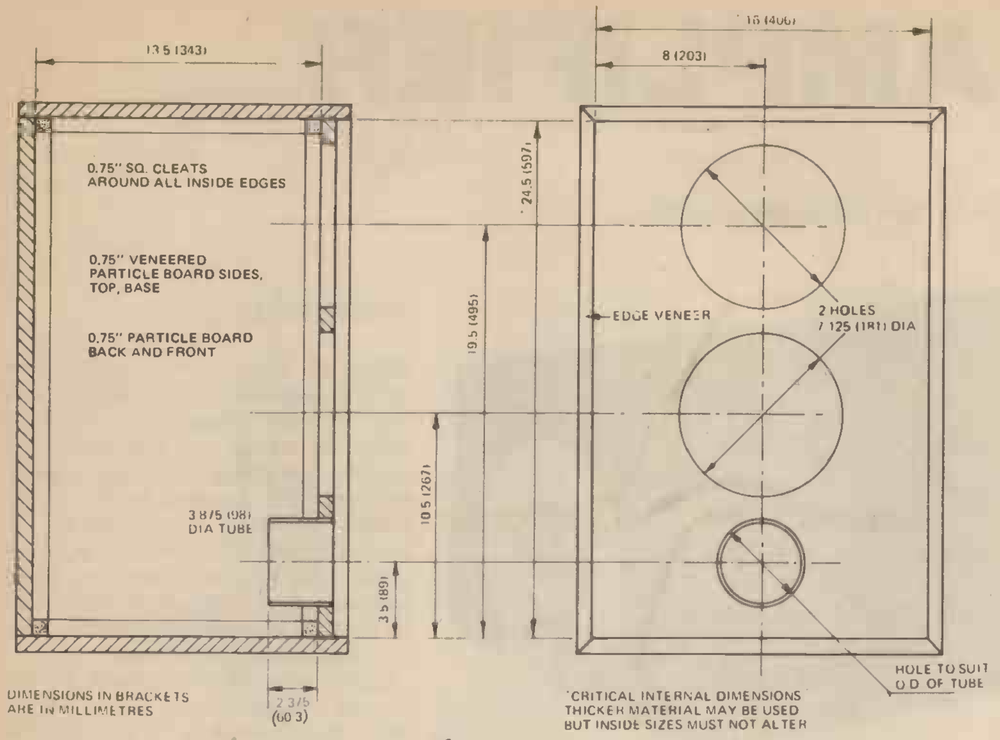


Fig. 6. Constructional details of recommended speaker enclosure.

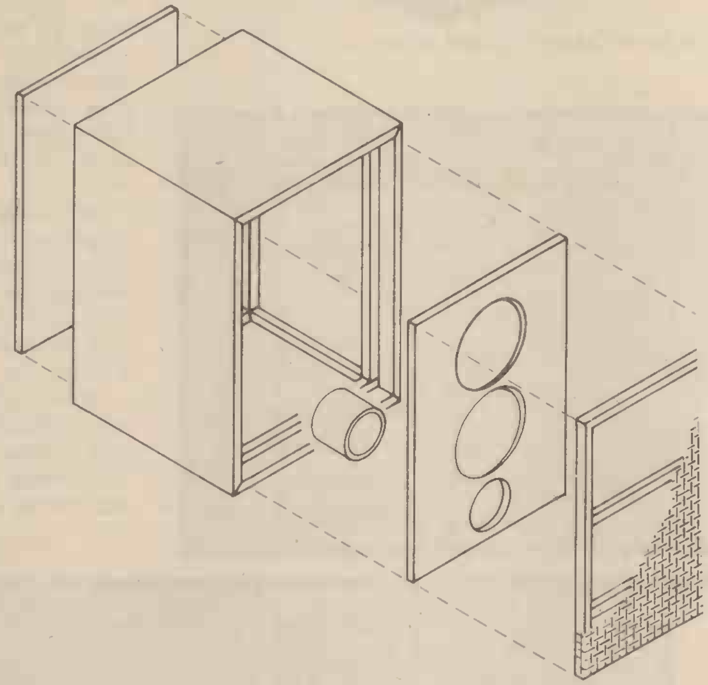


Fig. 7. Exploded view of speaker enclosure.

alone – but when mixed with the sound from the existing two speakers in your stereo system it sounds just great.

BASS SPEAKER ENCLOSURE

The enclosure tested for use with this system is shown in Figs 6 and 7. The speakers used were two 8 ohm Magnavox type 8W connected in parallel, thus having an effective impedance of 4 ohms.

The inside of the speaker enclosure was lined on at least three non-facing surfaces (eg side, top and rear) with absorptive material such as felt. ●

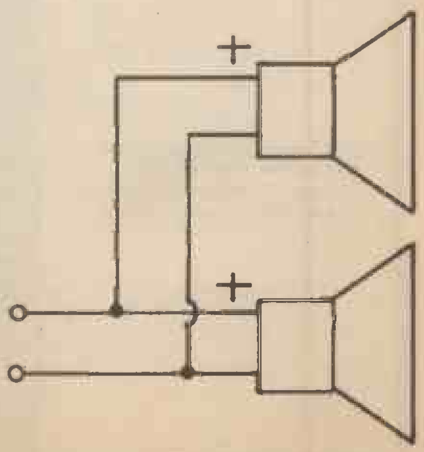
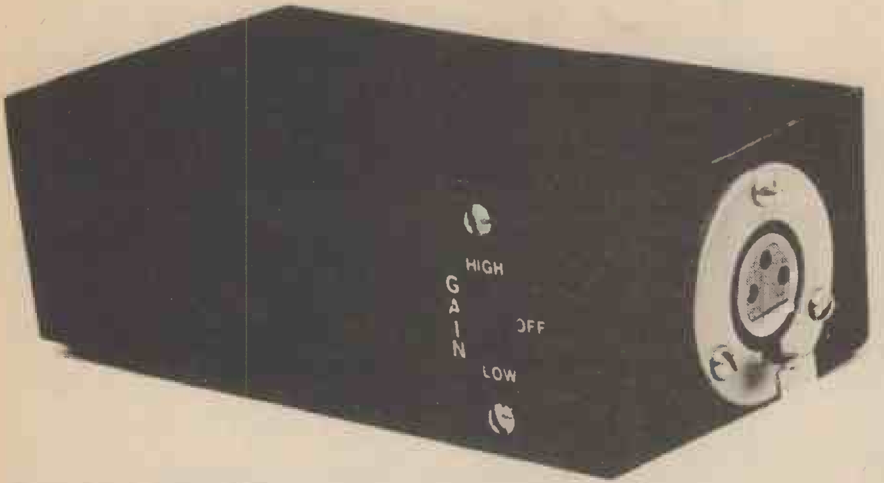


Fig. 8. How the speakers are interconnected.

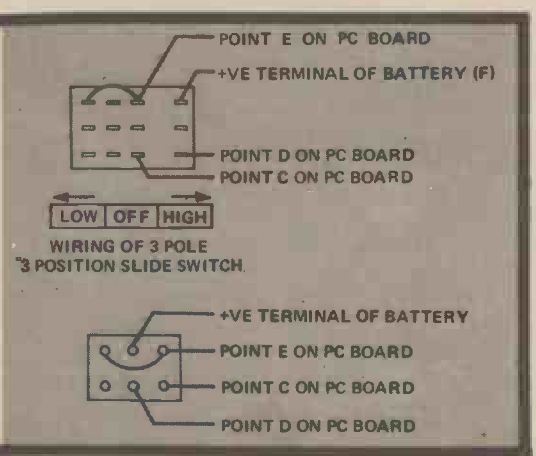
LINE AMPLIFIER

Boost microphone output with this low noise amplifier.



The completed line amplifier. Note the use of Cannon plugs and the gain switch on the side.

Wiring of DPDT toggle switch with centre off position.



PROJECT 430

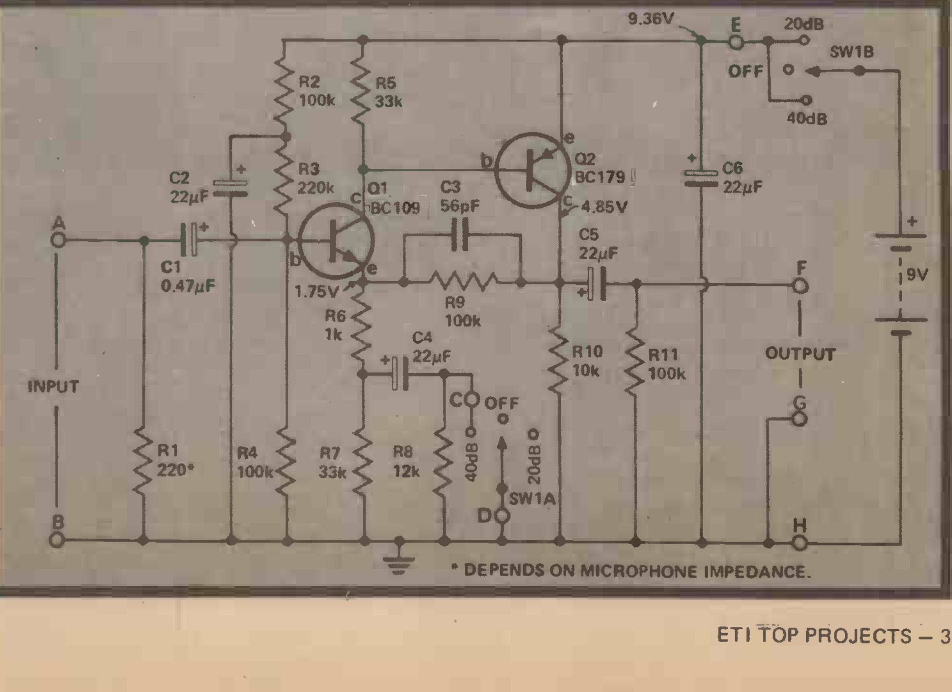
MODERN high quality microphones are low impedance units having a very low output voltage. To minimize noise, picked up on long leads, it is usually necessary to use special balanced and screened leads together with balancing transformers. An alternative approach is to use a low noise amplifier to boost the signal *before* passing it down the cable. The ETI 430 line amplifier, described here, is intended for this purpose.

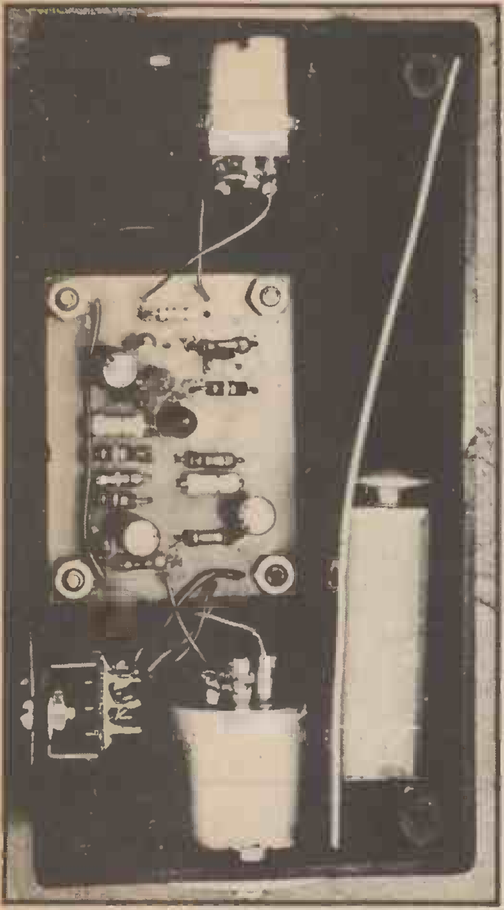
Such a unit, when used with the ETI Master Mixer (described in April, May, June and July 1973) provides either 20 or 40 dB of gain prior to the mixer. This allows the mixer to be used on the low-sensitivity range. Thus the larger signal now available, effectively over-rides the inherent noise of the first amplifier in the mixer.

The overall effect of using such an amplifier is to vastly improve the signal-to-noise ratio of the particular microphone channel and to eliminate the need for an expensive balanced and screened cable and balancing transformer.

To reduce the possibility of mains — hum pickup we have used a small nine volt battery to power the unit. Since the current drawn is a mere 0.5 mA, the battery should last about three to

Fig. 1. Circuit diagram of the microphone line amplifier. Voltages shown are typical and as measured on our prototype.





Internal layout of the line amplifier.

four hundred hours before replacement is required.

The ETI line amplifier can of course be used to great advantage with any recording equipment where low noise operation is necessary. When used with the Master Mixer the low impedance input should be used but the terminating resistor (fitted across the mixer input socket) should be removed so that a 4.7 k input impedance is obtained.

CONSTRUCTION

The circuit is not critical in any way hence, practically any construction method may be used. However, the use of the printed circuit board specified will considerably simplify construction.

We used an unbreakable plastic box (polycarbonate) to house our unit but if the unit is to be used in the proximity of power cables etc it would be advisable to mount the unit in a metal box (diecast or similar). This is especially so if an input impedance above 1 k is to be used as the higher the impedance the more likely is hum pickup.

If Cannon plugs are used, as in our prototype, pins 1 and 2 should be linked and used as the earth line. Pin 3 is then used as the active line.

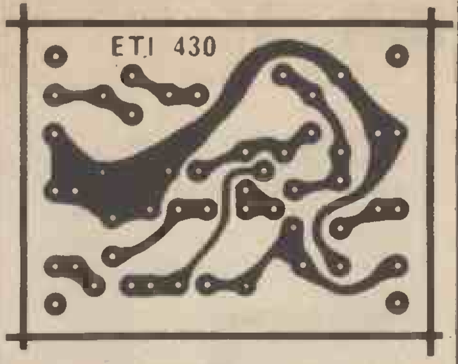


Fig.2. Printed circuit board layout for the amplifier. Full size 55 x 42 mm.

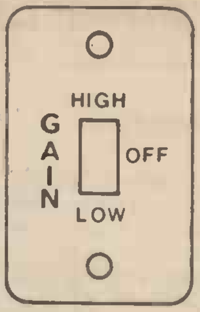


Fig.3. Artwork for the gain switch label. (Shown full size).

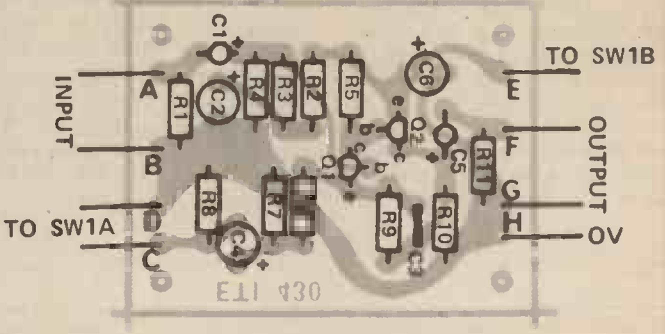


Fig.3. Component overlay. Note particularly the orientation of the transistors and electrolytic capacitors.

MEASURED PERFORMANCE

IMPEDANCE	
Input	selectable up to 68k max
Output	≈ 1.5k
GAIN	
High	40 dB
Low	20 dB
OUTPUT VOLTAGE	
Maximum	3 volts
INPUT VOLTAGE	
Maximum (high range)	30 mV
Maximum (low range)	300 mV
FREQUENCY RESPONSE	
10 Hz – 30 kHz	+0 – 3 dB
EQUIVALENT INPUT NOISE (referred to 1 mW into 600Ω)	
High Range	–110 dBm
Low Range	– 102 dBm

DISTORTION

Output Voltage	100 Hz	1 kHz	6.3 kHz
300 mV	<0.1%	<0.1%	<0.1%
1 V	0.17%	0.2%	0.17%
2 V	0.5%	0.5%	0.5%
3 V	1.75%	1.8%	1.7%

LINE AMPLIFIER

HOW IT WORKS – ETI 430

The line amplifier is basically a two transistor amplifier having a selectable gain of either 20 dB (x10) or 40 dB (x 100).

The input impedance of the amplifier (referring to Fig. 1) is determined by the combined values of R1, R3 and R4 – all in parallel. The parallel impedance of R3 and R4 is 68 k and this is therefore the upper limit of input impedance (R = ∞).

For impedances less than 5 k the values of R3 and R4 may be ignored and R1 is set to the same value as the desired input impedance. Hence the circuit as shown matches microphones having 200 ohm output impedance.

Resistor R2, in conjunction with R3 and R4 determines the dc bias for transistor Q3 whilst capacitor C2 decouples the input bias network from any supply rail noise. The output of Q2 is fed back to the emitter of Q1 thus providing negative feedback which as well as supplying a dc bias, sets the ac gain of the stage.

The gain of the amplifier may be calculated using the following formula (assuming ideal transistors).

$$\text{Gain} = \frac{R9 + R6 + (R7//R8)}{R6 + (R7//R8)}$$

Thus for R8 = 12 k the gain is 11.2 or 21 dB. For R8 = 0 the gain is 101 or 40 dB. The actual gain obtained is slightly lower than this due to the finite betas of the transistors used.

The value of capacitor C3 determines the upper 3 dB point of 30 kHz whilst capacitors C1, C4 and C5 all give individual break points at the low end of 5 Hz, 7 Hz and 1.5 Hz respectively.

PARTS LIST – ETI 430

R1	resistor	selected to suit input impedance
R2,4, 9,11	"	100 k ¼W 5%
R3	"	220 k " "
R5,R7	"	33 k " "
R6	"	1 k " "
R8	"	12 k " "
R10	"	10 k " "
C1	Capacitor	0.47µF 25V TAG
C2,4,5,6	"	22µF 16V electrolytic
C3	"	56pF ceramic
Q1	Transistor	BC109 etc.
Q2	"	BC179 etc.
SW1	Switch	2 pole 3 position slide or 2 pole centre off toggle

PC board ETI-430

Cannon sockets (male and female)

Cord plugs =

Box to suit (preferable metal), 9 V battery and clip input and output sockets etc.

It is reported that as office efficiency allegedly falls when the ambient noise level is ***low*** *due to sounds such as telephone conversations, etc, becoming intrusive and thus impairing the concentration of nearby staff; electronic installations are being advocated to maintain a constant masking background noise . . . other methods might also suggest themselves.*

Simple Loudness Control

This circuit, intended primarily for the experimenter, enables basic loudness control to be added to simple amplifiers.

THERE YOU ARE, sitting in the lounge room enjoying Beethoven's Fifth. All of a sudden your enjoyment is shattered by your wife — who insists that the music is far too loud, the neighbours five doors up are complaining, and the kids can't get to sleep. So reluctantly you turn the volume down — only to find that the music just doesn't sound the same, the bass has dropped-off badly and even the treble seems to be down.

It is to cater for situations like this, that amplifier manufacturers include 'loudness' controls.

'Loudness' is a subjective evaluation, primarily a function of a sound's intensity, but also strongly influenced by frequency. The keyword is of course 'subjective'. That is the response of the ear is non-linear — both to changes in sound level and also frequency.

This is best understood by reference to the standard curves for the *average* ear. These curves, due to Robinson and Dadson, are now generally accepted as being more accurate than the classical ones generated earlier by Fletcher and Munsen (after whom the effect is called).

In essence, loudness controls compensate for the Fletcher Munsen effect, producing what is generally (but by no means universally) agreed to be a subjectively more pleasing sound at low listening levels.

Loudness circuits do this by progressively boosting bass — and to a lesser extent treble — as volume is reduced.

The objection to loudness controls is that the effect is totally artificial — as one moves further away from an original sound source bass and treble *will* be attenuated more than midrange sounds. So if your penchant is listening to orchestras a hundred metres or so away then loudness controls are not for you!

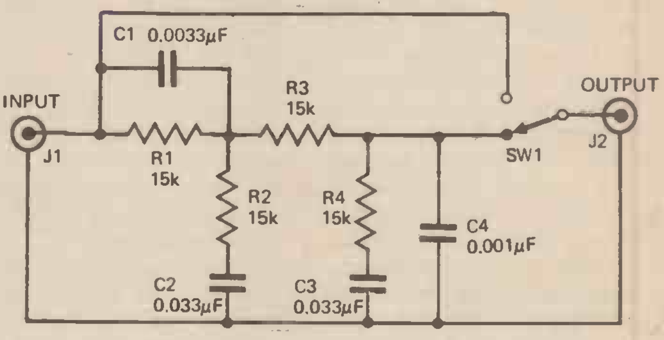


Fig. 1.

PARTS LIST

R1	15k	5%	½ W
R2	15k	5%	½ W
R3	15k	5%	½ W
R4	15k	5%	½ W
C1	0.0033μF		
C2	0.033μF		
C3	0.033μF		
C4	0.001μF		
SW1	DPDT Toggle Switch		

Many modern high quality amplifiers have loudness controls built in. In most instances they are manually switched into circuit when required — in a few amplifiers the circuit is switched in at all times.

Nevertheless there are innumerable older or present-day low-priced amplifiers that are not fitted with loudness compensation — and it is for units such as these that this simple project has been designed.

The device shown in Fig. 1 is for a mono amplifier — two are required for stereo amplifiers. It can be very simply assembled on tag strips or matrix board, and, when completed connected between your pre-amplifier and main amplifier. If yours is an integrated unit it should be readily possible to break into the volume control circuit — just connect the unit in series with the slider terminal of the potentiometer. Screened leads may be necessary if long lengths are required.

We would like to emphasize that this is a 'compromise' circuit. Ideally a loudness control must be designed specifically to suit the amplifier for which it is intended. Also the degree of loudness compensation should be related to the volume control setting.

This latter requirement involves replacing the existing volume control by a suitably tapped potentiometer — a device that is not readily available "off the shelf" — so the circuit shown here introduces a fixed amount of compensation that is adequate for moderate listening levels.

This circuit will suit most amplifiers quite well — and in any case can be adjusted by minor variation of component values if required.

Switch SW1 should be a double-pole double-throw type if stereo operation is required. ●

ELECTRONIC IGNITION SYSTEM

Reliable CDI, tachometer and engine speed limiter — all in one unit!

by Barry Wilkinson.

THE CONVENTIONAL electro-mechanical engine ignition system has been with us virtually unchanged since its development by Charles Kettering over fifty years ago.

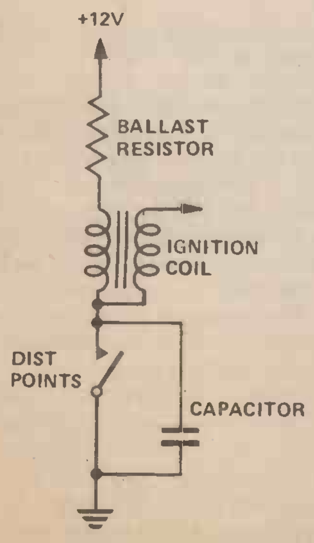
It is simple in concept and fairly reliable in operation, but even if maintained in impeccable working order it's performance is only *just* adequate in vehicles of average performance used in moderate climates.

The Kettering system has characteristics that are very far from ideal. The voltage supplied to the spark plugs, for instance, is low during starting and also at high engine speeds — just when high output is most needed. Contact breaker point and distributor cam wear is quite rapid and cause efficiency to fall off alarmingly.

Even when new, it is rare indeed to find a Kettering system that is working correctly, (that is the reason why many people obtain better results than should otherwise be expected when they fit a CDI or other electronic system to their car).

Now the system's deficiencies have become more serious — our world has too little oil and too much pollution. Good fuel economy and low engine emission have become of greater importance than original engineering cost.

At first sight it seems a relatively simple job to convert a Kettering system to electronic operation. But there is far more to it than that, as many have found to their cost. And whilst there has been a plethora of electronic systems on the market for the past ten years, few indeed can even remotely match the conventional system's reliability.



Normal (Kettering) ignition system.

As recently as August of 1974, one of our leading motoring magazines tested ten electronic systems made by leading European manufacturers. Incredibly, five of those systems failed within an hour and a half of installation! The reasons for the failure of these systems is discussed later in this article.

Nevertheless though, it *is* possible to design and construct sound reliable electronic ignition systems and these do have many advantages over Kettering systems.

At this point we might as well debunk a few myths — and probably lose the odd advertiser or two as well!

Unless your original ignition system is grossly maladjusted, there is no way in the world that an electronic system will improve power or fuel consumption by the 20% plus that many of their manufacturers claim.

What you can *realistically* expect is about three to five per cent better consumption and about the same increase in top end power — especially with small high revving engines. There is rarely any measurable difference with big lazy V8s, except that starting may be easier on cold mornings.

Distributor point life is greatly extended, spark plugs will last longer and the system will remain in tune for much longer periods.

EARLY ELECTRONIC SYSTEMS

The first transistor systems came into use about ten years ago. These were rudimentary systems in which a transistor was used to switch the main current — so that a control current only passed through the contact breaker points.

These systems were effective in that they prevented point burning but were just as adversely affected by high-speed point bounce as the systems they replaced. Apart from that, only low-voltage rating (100 V) transistors were generally available so special high ratio ignition coils were required. These special coils drew heavy current — as much as 12 amps was not uncommon.

The systems just described were not really electronic ignition systems — rather they were transistor-assisted.

CDI

Capacitor Discharge Ignition (CDI) was introduced some three years later.

In this system a capacitor (normally between $1.0\mu F$ and $1.5\mu F$) is charged to 400 V or so, and, when triggered, is discharged into the spark coil thus inducing the required high voltage by transformer action.

CDI systems can be made to work very well indeed, they have excellent characteristics, such as low current drain and almost constant voltage output.

But whilst they *can* be very effective, many CDI systems are very unreliable due mainly to designers not appreciating that many of the components are being run way beyond their design limits.

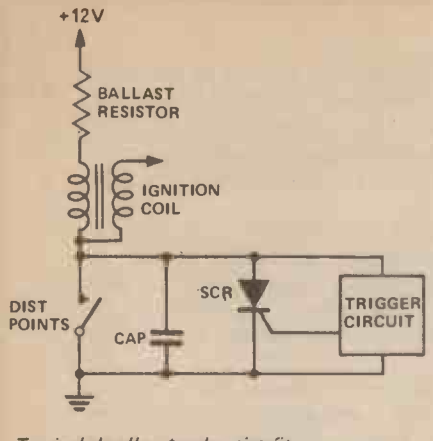
DWELL EXTENDERS

A simple device called a dwell-extender made a brief appearance a few years ago. This operated by using an SCR to 'close' the points about half a millisecond after they opened thus allowing greater current build up in the coil. In effect, dwell extenders extended the 'effective rev range' of an ignition system by about 20%.

At present the transistor assisted system is making a comeback and is just as common as CDI systems. There is also a trend towards breakerless (no contact points) systems — thus eliminating point bounce and ideally ensuring that each cylinder is fired precisely at the correct time — something that rarely happens with Kettering systems due to manufacturing errors in the distributor cam.

THE ETI SYSTEM

Many readers have asked us to design and publish a reliable up-to-date CDI system, so over a period we have investigated very many different types to see which would provide the optimum in performance and cost combined with total reliability.



Typical dwell-extender circuit

Since electronic components can fail suddenly and unexpectedly (usually at the most inconvenient times) we opted out of a contact-breakerless system or any system which could not be changed rapidly back to standard.

This latter constraint ruled out transistor assisted systems since these normally require a low inductance ignition coil which cannot be used with standard points.

Eventually we came back to the CDI technique, but then set about eliminating those aspects of earlier designs that compromised reliability.

Our starting point was to study existing CDI systems — to see just why they fail.

The circuit diagram of a conventional CDI system is shown below.

In this circuit the most likely component to fail is the discharge capacitor since peak currents of 10 to 20 amps flow during each cycle. Few capacitors will withstand this sort of treatment for long. To make matters worse, the charging voltage may under certain conditions reach 500 volts or more. Since 300-350 volts is really all that is required, this higher voltage causes the capacitor to operate at twice the energy density needed — thus stressing the capacitor unnecessarily.

The SCR is also subjected to high current peaks and unless of adequate rating (as few are) it too may soon fail.

The inverter used to provide the high input voltage required by the CDI system is normally a self-oscillating saturating core circuit of the type shown. This type of circuit too has inherent failings. High currents are drawn at the moment of switching, thus causing high peak power dissipation in the transistors themselves, and as the output from the inverter is a square wave the rectifier diodes are subjected to very rapid changes in polarity.

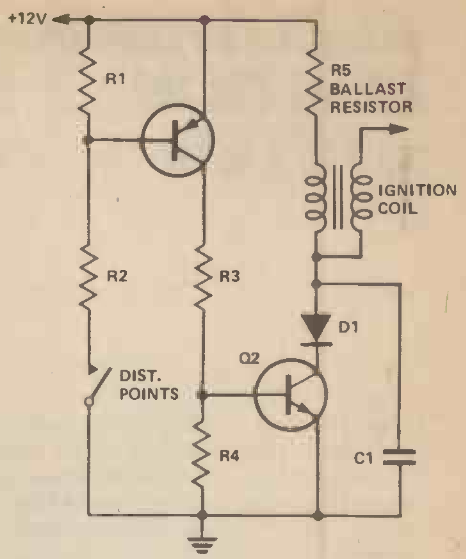
Another failing common to many commercial units is that if the inverter is sufficiently powerful to deliver full power up to 5000 rpm to a V8 engine (i.e. operating frequency of plus 2 kHz) the power dissipated in the diodes may eventually destroy them.

A final most annoying characteristic of otherwise satisfactory CDI systems is the hard-to-quieten whistle from the inverter transformer.

The new ETI unit is more complex than most CDI's currently available — but all the above problems have been eliminated — and it has two further features that make it (we believe) unique.

Besides being a very good CDI unit, the circuit includes a tachometer output and an adjustable rev-limiting circuit.

The tacho has been included because most electronic tachos cannot be used in conjunction with a CDI system (to use the tacho function all that is needed is a suitably calibrated 0—1 mA fsd meter).

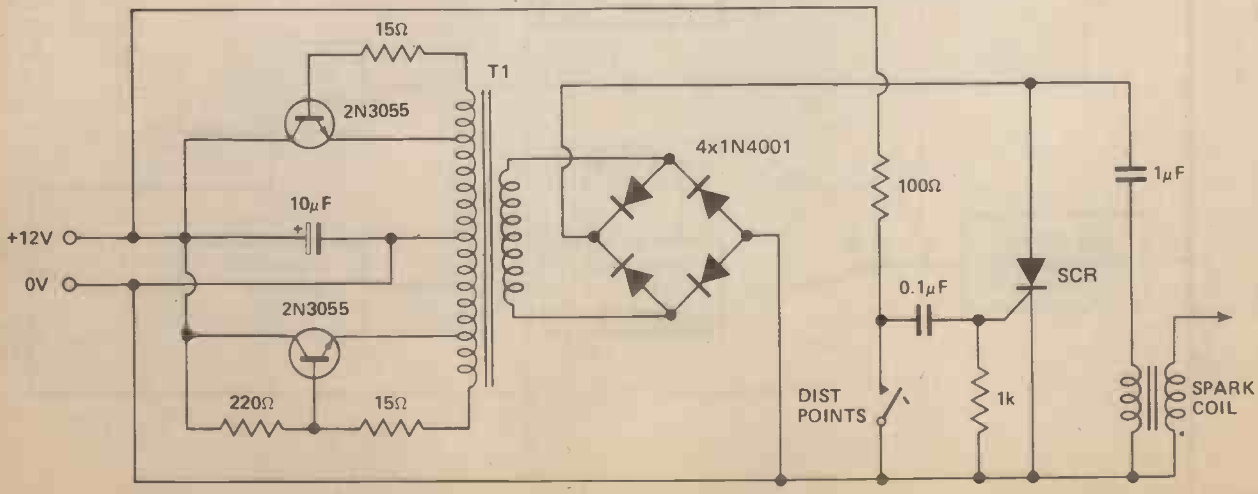


Transistor assisted ignition

The rev limiter circuit is intended for engine overspeed protection only. It is of particular value with sporting cars in which safe engine rpm may be inadvertantly exceeded — and also in high power motor boats which frequently suffer engine damage due to the propellor jumping out of the water, thus unloading the motor sufficiently for engine speed to exceed a critical level.

Engine speed limiters are already fitted to a few vehicles (some Lotus cars for example) but these usually consist of a mechanically controlled electrical ignition cut-out. They work quite reliably but are prone to a 200 rpm or so hysterisis. If they cut out at, say 6500 rpm, then ignition will not be switched on again until the engine speed has fallen to 6300 rpm. In the meantime unburnt fuel has collected in the silencer where it will be ignited (with a bang) when ignition re-occurs.

The ETI electronic unit has virtually no hysterisis and operates smoothly and effectively.



ELECTRONIC IGNITION SYSTEM

The tacho/rev limiting circuit uses a dual timer (556). The first half of this IC operates as a monostable which is triggered when the ignition contact points open. This provides the tacho drive.

When the first delay period ends, the second monostable is triggered and this sets the limiter. If the next pulse from the points occurs before the completion of the second delay, the SCR is inhibited thus switching off ignition until the speed has fallen below the preset limit.

As the limiter has no real hysterisis, the motor will usually fire every second or third cylinder.

Any back firing that may occur takes place in the exhaust pipe near the cylinder head — not in the silencer.

We would like to emphasise once again that the limiting circuit is intended for motor protection only. It should not be used as a road speed limiter or governor.

EARLY IGNITION SYSTEMS

The very earliest gas and oil engines used a flame or hot tube ignition system. The systems were basic yet reliable and effective. When ignition was required, a port in a reciprocating slide valve provided a passage between the burning flame and the mixture in the combustion chamber. Once the mixture was ignited, the port was mechanically closed.

The first electrical ignition system was devised by Sir Dugeld Clerk in the mid-1800's. The principle was similar to that of flame ignition except that an electrically heated platinum wire replaced the flame or hot tube. (This system is described in Sir Dugeld Clerk's classic work 'The Gas, Petrol and Oil Engine, Vol II.)

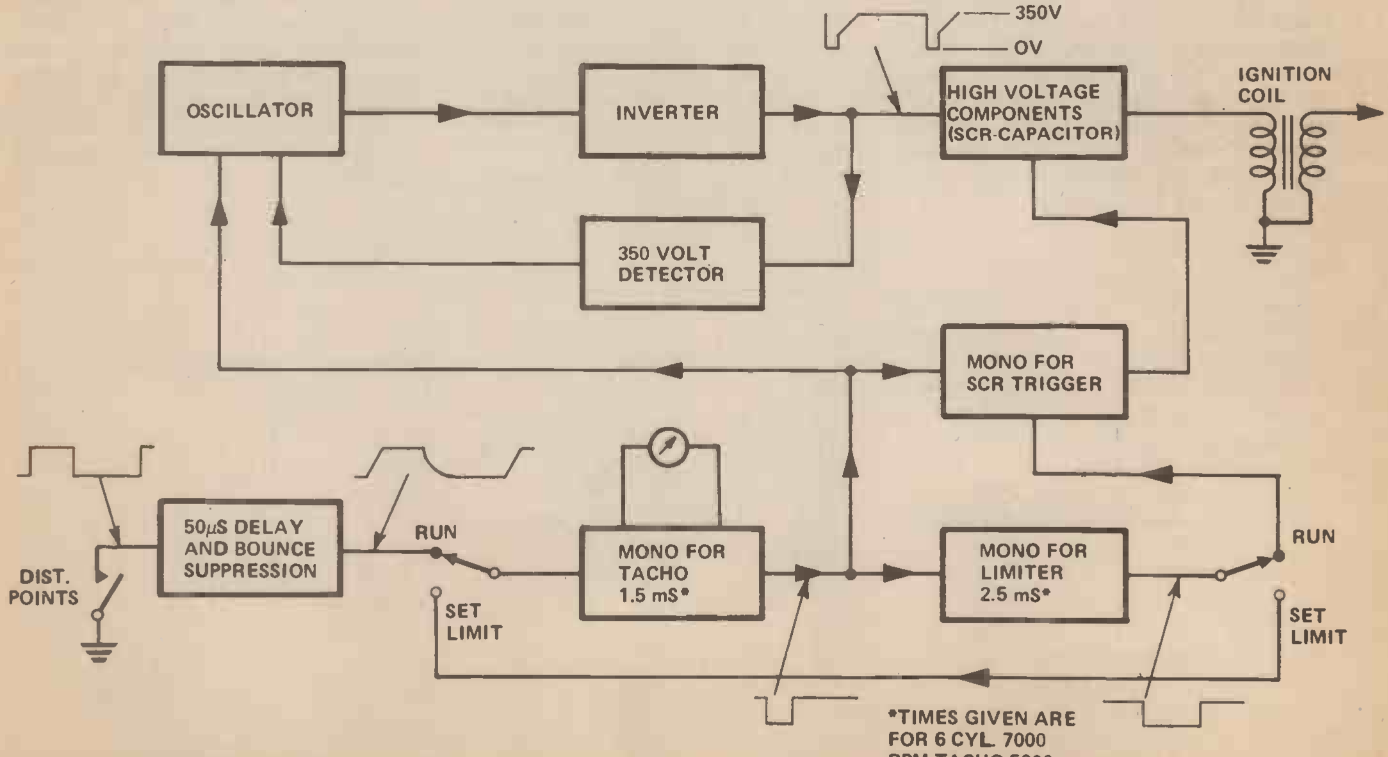
Break-spark ignition was used for a short time in the early days of motoring. In this system, a low voltage generator produces current in an inductive circuit. A spark is established within the combustion chamber at the required moment simply by mechanically separating two normally closed contacts. (This system is still used in a number of slow-speed stationary engines.)

The first high tension spark gap ignition was developed in France by Lenoir in 1860. Ten years before, a French mechanician, Ruhmkorff, had started to produce induction coils on a commercial scale. Lenoir based his system on the Ruhmkorff coil. His circuit was virtually identical to present day practice except that he used a trembler make and break on the primary side of the induction coil, instead of the mechanically operated synchronous switch used today.

The so-called 'trembler' ignition system was fitted to early Model 'T' Fords, and a few other (mainly American) vehicles, prior to 1920 or so. In this system, sixteen or so magnets were located around the engine flywheel. When the flywheel revolved, the magnets caused an alternating flux change in sixteen coils fixed to the engine main flywheel housing.

All sixteen coils were connected in series and provided an ac input to four separate trembler coils which in turn provided a high tension output, via a rotating distributor, to the spark plugs.

The system was not very reliable and later models used an orthodox Kettering system.



*TIMES GIVEN ARE FOR 6 CYL. 7000 RPM TACHO 5000 RPM LIMIT

Block schematic of ETI system.

HOW THE ETI UNIT WORKS

The block schematic drawing shows all functions of the ETI system.

The oscillator is based on a TTL device and runs at approximately 36 kHz. The output is frequency divided down to 9 kHz and can then be gated on or off by either of two control lines.

The output of the oscillator is used to drive an inverter which is simply a set of power transistors driving a centre-tapped transformer (no feedback windings are used).

The output of the transformer is rectified by high-speed diodes to provide about 500 volts with 14 volt input. This output is monitored by a detector. If the voltage rises above 350 volts the oscillator output is gated off which in turn shuts off the inverter. The oscillator restarts when the voltage drops below 325 volts. This circuit ensures that the output voltage (i.e. across the capacitor) is maintained at a constant level for input voltage changes from eight to 16 volts.

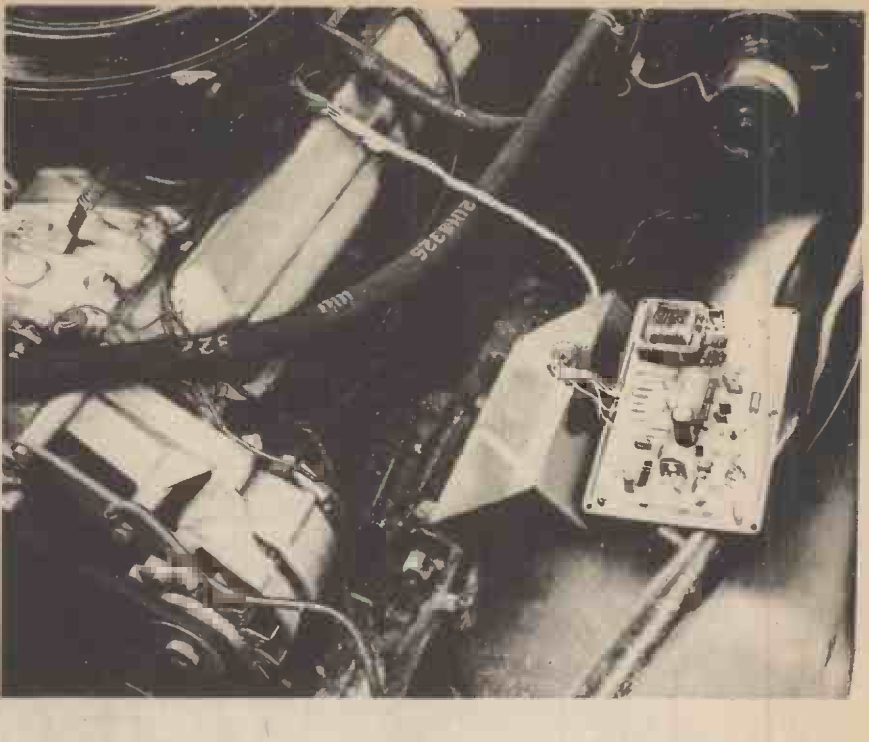
High voltage components consist of a 1μF or 1.5μF capacitor and a 16 amp SCR. Due to the closely controlled drive voltage from the inverter, stress on these high voltage components is greatly reduced.

When the distributor points open, a 50μsec delay is initiated. This approximates the delay inherent in the normal mechanical system, thus the original distributor timing is maintained.

At the end of this 50μsec period, a monostable (half a NE556) is triggered. Its output is used for several purposes. The complete pulse is used to drive the tachometer (1 mA fsd) and the leading edge of the pulse triggers the SCR via a short monostable and signals the oscillator to switch off and remain off for a period long enough for the SCR to discharge the capacitor and turn off again. This prevents the inverter looking into a short circuit.

The trailing edge of this monostable output pulse triggers a second monostable comprising the second half of the NE556. This latter monostable is used for the rev limiting function. If its output has not returned to 'normal' before the contact breaker points re-open, the firing pulse to the SCR will be inhibited.

The rev limiting function is adjusted by simply connecting the output of the second monostable to the input of the first. The tacho meter will now indicate the maximum rpm before limiting occurs. Then, by adjusting the second delay, the desired rpm limit can be set.



CONSTRUCTION

Construction of the unit is considerably simplified by the use of a printed circuit board and this is strongly recommended.

All components should be mounted on the printed circuit board in accordance with the component overlay diagram. Take particular care with the orientation of transistors, diodes, ICs and electrolytic capacitors.

Wiring between the printed circuit board and external components is illustrated in Fig. 5. The switch used in our prototype was mounted internally (it is only used in initial setting up) by soldering it onto the screws which mount the power transistors. If this method of mounting the switch is used, the screws to which it is mounted must be insulated (by insulated mounting washers on both sides of the transistor) from the transistor case. The other two transistor mounting screws should be insulated from the box lid but not from the transistors. When drilling the lid of the box check that the distance

SPECIFICATION

SUPPLY VOLTAGE

Nominal	+ 12 Volts
Maximum	+ 16 Volts

CAPACITOR VOLTAGE

8 to 16 volt input	350 volts (nominal)
POINTS CURRENT	200 mA (non-inductive)

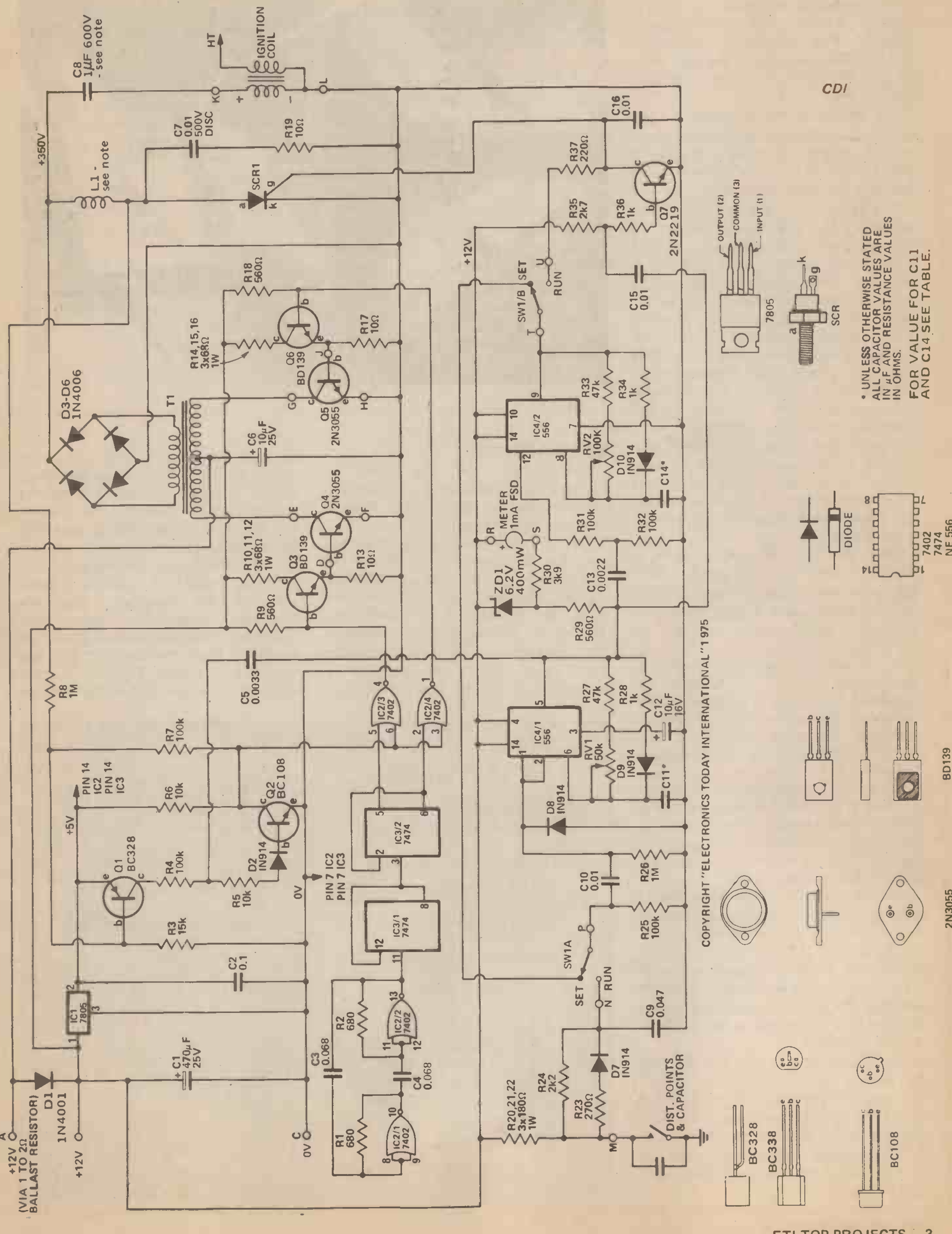
SUPPLY CURRENT*

RPM			CURRENT
8 cyl	6 cyl	4 cyl	
1500	2000	3000	1A
3000	4000	6000	2A
4500	6000	9000	2.8A
6000	8000	12,000	3.2A
7500	10,000		4A
9000			4.4A

* ballast resistor of one ohm

ELECTRONIC IGNITION SYSTEM

CDI



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* UNLESS OTHERWISE STATED ALL CAPACITOR VALUES ARE IN µF AND RESISTANCE VALUES IN OHMS.

FOR VALUE FOR C11 AND C14 SEE TABLE.

between the two mounting screws is the same as the hole spacing on the switch so that it will fit.

To facilitate easy change over, between standard and CDI ignition, an octal plug and socket is used to connect the unit, and a second socket for the standard system. Whilst our prototype may be seen to have both octal sockets mounted on the box, it is recommended that the second socket be mounted by a separate bracket on the car bulkhead, etc, so that the unit may be removed completely if desired without interfering with normal operation of the car.

CALIBRATION

This may be performed in either of the two ways:–

1. Obtain, or borrow, an accurate tachometer (one which will work with CDI systems). Connect and run the motor at a reasonably high rate and adjust RV1 to obtain the same reading as displayed on the master tacho.

2. Build either of the circuits shown in Fig. 4 and use together with a reference from the 50 Hz mains or a separate oscillator. If 50 Hz is to be used the second circuit is preferable as it gives a higher reading on the meter. To calibrate set RV1 such that the appropriate reading is obtained as detailed in the Table below.

Calibration against 50 Hz

	4 cyl	6 cyl	8 cyl
Circuit A	1500	1000	750
Circuit B	3000	2000	1500

If an oscillator is used the calibration may be performed at a point nearer the top end of the meter scale and the frequency to be used calculated as follows:–

$$\text{Input frequency} = \frac{\text{RPM} \times \text{N}^{\text{o}} \text{ of cyl}}{120}$$

(4 stroke only)

Using this method, the power to the inverter may be removed (detach the wire to pin 2 of the socket) which eliminates the need for connecting the ignition coil. Do not run the unit too long in this condition as resistors R10, 11, 12, 14, 15 and 16 run hot in this mode.

To set the rev limit, simply switch SW1 to SET (power should previously have been applied to the unit) and adjust RV2 to the desired limit as indicated on the meter.

HOW IT WORKS ETI 312

The general block diagram and principle of operation was given last month and we now treat this in greater detail.

Integrated circuits IC2/1 and IC2/2 form a multivibrator which runs at about 26 kHz. The output of the multivibrator clocks the D-type flip-flop IC3/1, the D terminal of this IC is coupled to the $\bar{Q}$ output and the result is that the output is half the frequency of the input. This frequency division is necessary to provide an absolutely symmetric square wave which cannot otherwise be guaranteed from the simple oscillator used. The output of IC3/1 is divided again by 2 by IC3/2 reducing the frequency to about 6.5 kHz. The second division is used because we have two flip-flops available in the 7474 package and this allows us to use a higher frequency oscillator and hence smaller values for capacitors C3 and 4.

The Q and $\bar{Q}$ outputs (these are the same frequency but out of phase, (i.e. when Q is high, $\bar{Q}$ is low) are fed to the gates IC2/3 and IC2/4. If the control input (pin 3 and 6) is low these gates simply pass the 6.5 kHz with just a phase inversion. If however the control is high the output of the two gates will be low irrespective of the other inputs.

The output of these gates control Q3 and Q6 which in turn control Q4 and 5. If the gate output is low all current is shunted away from the base of the appropriate transistor turning it and the transistor it controls off. If the output is high this current will turn the transistor on. With the control voltage low the transistors are switched alternatively on and off at the 6.5 kHz rate. If the control is high then all transistors will turn off.

The transistors Q4 and Q5 control the primary of the transformer whose centre tap goes to +12 volts via a ballast resistor. This resistor is either the one fitted in the wiring-loom of the car, or, if not an additional one ohm resistor will need to be fitted. This ballast resistor allows the transistor to fully saturate by limiting the peak current even when driving into the effective short circuit of the discharged capacitor (C8).

The output of the transformer is rectified by D3-D6 and C8 is charged up via the primary of the ignition coil. This current is small (less than 150 mA) and has no effect on operation of the coil. If allowed, this capacitor would charge to about 450 V using a 12 volt input, however, the output voltage is measured and the inverter is stopped when 350 V is reached. Transistors Q1 and Q2 form a schmitt-trigger circuit where Q2 goes high if the voltage on C8 goes above 350 volts and reverts to a low state if the voltage falls below 325 volts. The reference for this circuit is the 5 volts supplied by the 7805 regulator which also supplies the TTL circuitry. This effectively maintains constant voltage on the capacitor over inputs from 8 to 16 volts.

The SCR1 is what actually controls the output to the ignition coil since if it is triggered on it effectively discharges the energy in C8 into the ignition coil primary. The transformer action of the coil gives the required high voltage for the spark plugs. The inductor L1, along with R19 and C7 protect the SCR from voltage transients which could damage it.

When the distributor points open the voltage at point M rises rapidly to +12 volts, whereas, the voltage at point N rises over a period of about 50 µs. When the points close the voltage at point N requires about 0.5 mS to revert to zero. This helps prevent point bounce. With SW1 in the run mode the rising voltage of the points opening is coupled, via C10, to the input of IC4/1. The output of this IC is normally high (+12 V) and if this voltage at pin 2 goes above two thirds of the supply volts the output will be triggered low. It will remain low until the voltage at pin 6 falls below 1/3 supply voltage when the output will revert to high. When the output goes low C11 will be discharged via RV1 and R27. The IC itself draws virtually no current, therefore, the time to reach 1/3Vs is dependent entirely on the value of C11 and the associated resistors. When the output goes high capacitor C11 is charged rapidly by R28 and D9 ready for the next cycle.

The tacho movement is driven by this IC and, every time the monostable is triggered, a 2 mA pulse is passed through the meter. Since the mono is triggered every time the points are opened the current in the meter will be proportional to the engine speed. When running (if possible) at the maximum tacho reading, the mono on time will be equal to the off time corresponding to 1 mA through the meter.

When the output of IC4/1 reverts to the high state it triggers IC4/2 which is a monostable similar to the first half. The output of this also starts at +12V drops to 0V and reverts to +12V again. The output occurs at the end of the output of IC4/1. The SCR is triggered by a monostable formed by Q7. The transistor derives its power, and that used to trigger the SCR, from the output of IC4/2. The input of the transistor, which is normally held on due to R35/36, is controlled via C15 from the output of IC4/1. The sequence of operation is as follows.

When the points open there is a delay of about 50 µs before IC4/1 is triggered. When the output goes low capacitor C15 couples this fall to Q7 turning it off. If the output of IC4/2 is high the SCR will be triggered activating the coil. If however the points have opened before the expiry of the sum of the delays of IC4/1 and IC4/2 there will be no current available to trigger the SCR, since the output of IC4/2 will be 0 V, and no ignition will result until the engine speed drops. Normally however this would only mean one or two cylinders not firing as the motor will slow down rapidly without ignition.

To calibrate the unit we first adjust RV1 so that the tacho reads the same as some known standard (your local garage will have a tacho) then with the motor stopped, but ignition on, switch SW1 to SET. This will cause the tacho to indicate the preset rev limit. Adjusting RV2 will give the desired limit. The indicated reading may be about 100 RPM lower than the actual limit set but for normal use this should be sufficiently accurate.

Also from IC4/1, we have a capacitor going into the schmitt trigger. Transistor Q2 forms a monostable with this capacitor, which switches off the invertor, or at least holds it off, while the SCR is on and therefore prevents the invertor running into a short circuit. This effectively reduces the power drawn from the battery.

ELECTRONIC IGNITION SYSTEM

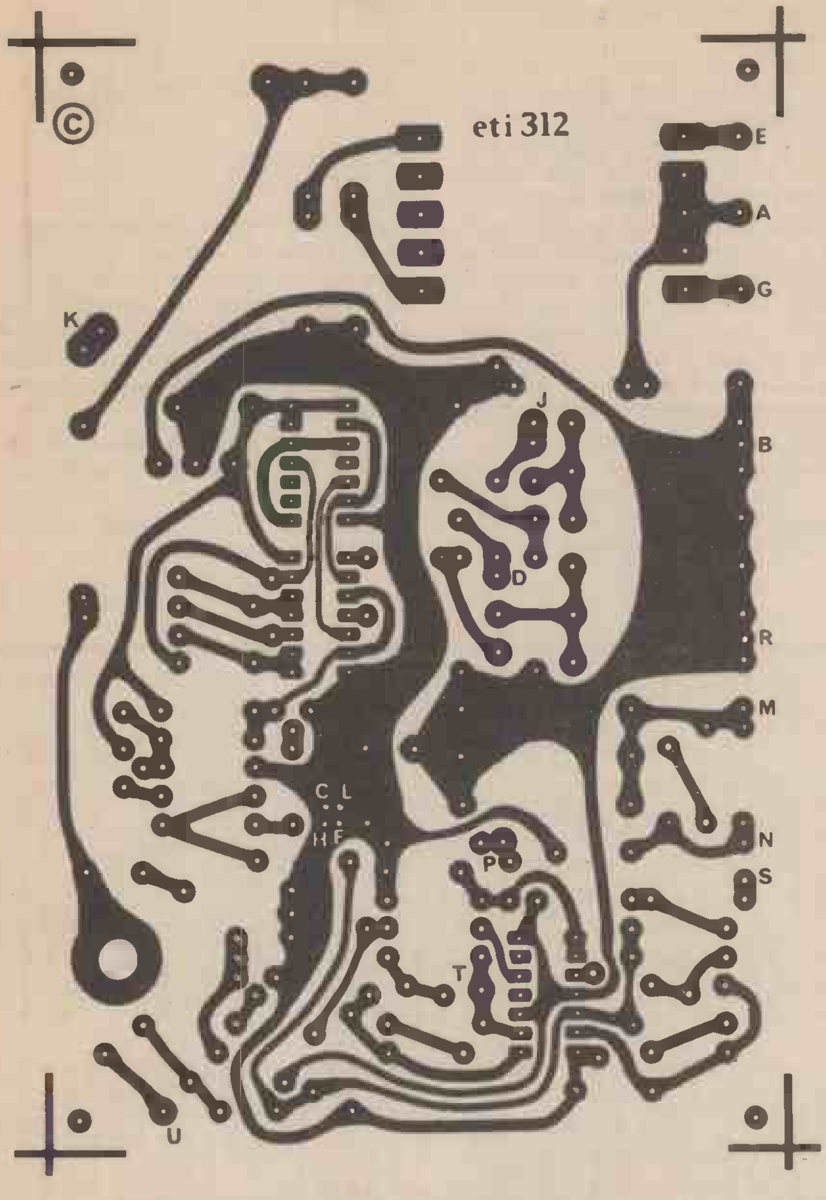


Fig. 2. Printed circuit board layout. Full size 149 x 100 mm.

GETTING HOLD OF THE COMPONENTS

SEMICONDUCTORS

The transistors and ICs are not unusual types and are all listed by more than one mail-order supplier and should present no problem.

The SCR must have a minimum voltage rating of 400V and a current handling capacity of 15A. This is deliberately rated very generously as a failure is more serious in this type of equipment than in some others. A number of companies list SCR's by spec, others use manufacturers codings, however 400V/15A types or better are widely listed.

Diecast boxes are available from Doram (172x121x55mm) and Home Radio (184x114x51mm).

The printed circuit board is available from Ramar or Crofton.

C8 must be a high quality component. If a 1μF is not available two 0.47μF may be used in parallel. Marshalls and Doram however list 1μF capacitors with working voltages over 600V.

Many readers may not wish to wind their own transformers. Two companies market inverter transformers which have very similar electrical, though not physical, characteristics. Henry's Radio reference is IT3AT and Bi-Pre-Pak of Westcliff-on-Sea will supply the inverter transformer used in the previous ETI ignition System.

INSTALLATION

A standard ignition system, illustrated in Fig. 6, usually has a ballast resistor which is either a separate wire-wound resistor, or is built into the wiring loom in the form of a resistive lead. In either case the power for the inverter must be tapped off the *battery* side of this resistor so that a solid +12 volts is obtained. If the resistor is in the wiring loom it may be easier to use another circuit (eg, reversing lights) which is only on when the ignition switch is on.

The connection socket should be wired into the standard circuit as shown in Fig. 7, If the car does not have a ballast resistor, then the power

PARTS LIST ETI

R13,17,19	Resistor	10	½W	5%
R10,11,12	"	68	1W	5%
R14,15,16	"	68	1W	5%
R20,21,22	"	180	1W	5%
R37	"	220	½W	5%
R23	"	270	½W	5%
R9,18,29	"	560	½W	5%
R1,2	"	680	½W	5%
R28,34,36	"	1k	½W	5%
R24	"	2k2	½W	5%
R35	"	2k7	½W	5%
R30	"	3k9	½W	5%
R5,6	"	10k	½W	5%
R3	"	15k	½W	5%
R27,33	"	47k	½W	5%
R4,7,25	"	100k	½W	5%
R31,32	"	100k	½W	5%
R8,26	"	1M	½W	5%

RV1 Potentiometer 50k preset
RV2 " 100k preset

C13 Capacitor 0.0022 μF polyester
C5 " 0.0033 μF polyester
C10,15,16 Capacitor 0.01 μF polyester
C7 Capacitor 0.01 μF 500V disc ceramic
C9 " 0.047 μF Polyester
C3,4 " 0.068 μF Polyester
C2 " 0.1 μF Polyester
C6 " 10 μF 25V electrolytic
C12 " 10 μF 16V pc mounting electrolytic
C1 Capacitor 470 μF 25V pc mounting electrolytic
C8,11,14 See Table

Q1 Transistor BC328 BC178 etc.
Q2 " BC108 etc.
Q3,6 " BD139, BD135 etc.
Q4,5 " 2N3055
Q7 " 2N2219, BC338 etc.

IC1 Integrated circuit 7805C
IC2 Integrated circuit 7402
IC3 Integrated circuit 7474
IC4 Integrated circuit NE556

D1 Diode 1N4001
D2,7,9,10 Diode 1N914 etc.
D3,4,5,6 Diode 1N4006
D8 Diode 1N914
ZD1 Zener Diode 6.2V, 400mW
SCR1 Thyristor 15A, 400V
T1 Transformer — see text
L1 Inductor — see text
PC Board ETI 312
DPDT Slide or toggle switch
Diecast Box, about 7"x5"x2"

2 Octal sockets
1 Octal plug and cover
4 spacers 12mm long plain
8 screws 20mm long screws & nuts
2 insulation kits for 2N3055s
Wire etc.
If the car does not have an internal ballast resistor a 1Ω 20 watt.

M1 1 mA FSD meter scaled to RPM

is taken to pin 1, and a one ohm, 20 W resistor connected between pins 1 and 2. In addition the standard ignition socket should use pins 1 and 3 rather than 2 and 3.

Mount the unit in the coolest possible place whilst at the same time not making the leads too long. The changeover socket should be mounted on the car in close proximity to the unit.

USE OF REV LIMIT

The rev-limiter is designed to prevent engine revving beyond its safe operating speed. IT IS NOT INTENDED TO ACT AS A SPEED LIMITER. Nor should it be regarded as an infallible watchdog. It is intended solely to limit engine speed if the safe limit is exceeded inadvertently.

Clearly some people *will* use the device as a 'continuous limiter' — racing and rally drivers, motor boat race drivers for instance. In such applications no engine damage should occur, but the silencer (if fitted) may be damaged as *some* fuel will be burnt in the tail pipe.

The device should never be used in this manner on the road. It wastes fuel and it is potentially dangerous as there is no reserve power available to cope with possible emergencies.

TABLE I

TACHO Value of C11

Full scale	8 cyl	6 cyl	4 cyl
5000	0.027 μF	0.039 μF	0.056 μF
6000	0.022 μF	0.033 μF	0.047 μF
7000	0.022 μF	0.027 μF	0.039 μF
8000	0.015 μF	0.022 μF	0.033 μF
10 000	0.012 μF	0.018 μF	0.027 μF

REV LIMIT Value of C14

	8 cyl	6 cyl	4 cyl
4000	0.039 μF	0.047 μF	0.082 μF
5000	0.027 μF	0.033 μF	0.047 μF
6000	0.022 μF	0.033 μF	0.039 μF
7000	0.022 μF	0.027 μF	0.033 μF
8000	0.015 μF	0.022 μF	0.033 μF

TABLE 2
Transformer Winding Details

WINDING	TURNS	WIRE SIZE	NOTES
Secondary	600	0.315mm (30swg)	layer wind and use 0.05 mm insulation every 150 turns
	interwinding insulation 0.25mm		
Primary 1 Primary 2	15 15	1mm (20swg) 1mm (20swg)	Bifilar wound (i.e. wind both primaries together as a pair)

The best cores to use for this project are as follows:
CORE: E42 Siferrit E cores, B66241-A0000—R026 or B66244-A0000-R026, two required.
FORMER: Siemens B66242-A0000-M001, one required.
ASSEMBLY: Insert cores into bobbin after winding. Tape them together and then glue (epoxy) the cores onto the bobbin to hold them in position.

The E cores and former are stocked by Electrovalue. An alternative is their ex-stock 47mmx28mm pot core (Ref B65631) with a single section bobbin, (Ref B65632-A0000-M001). The same wire gauge should be used but the primary windings are 10 turns each, the secondary 400 turns. Available from Electrovalue, 28 St. Judes Road, Englefield Green, Egham, Surrey.
CHOKE DETAILS: Approx. 30 turns of 0.315mm (30 swg) single layer wound onto a 1W resistor with a value over 1kΩ (the resistor is only used as an inexpensive former).

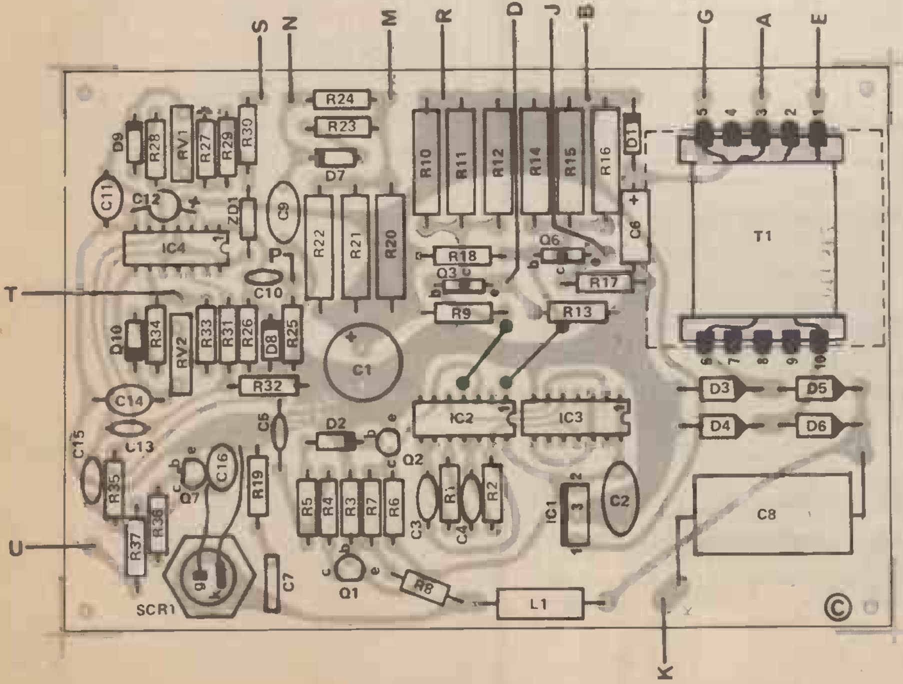


Fig. 3. Component overlay.

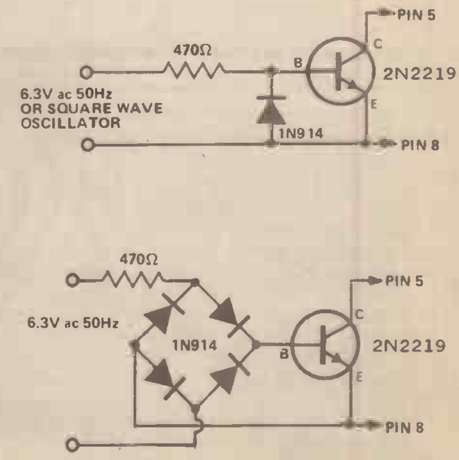
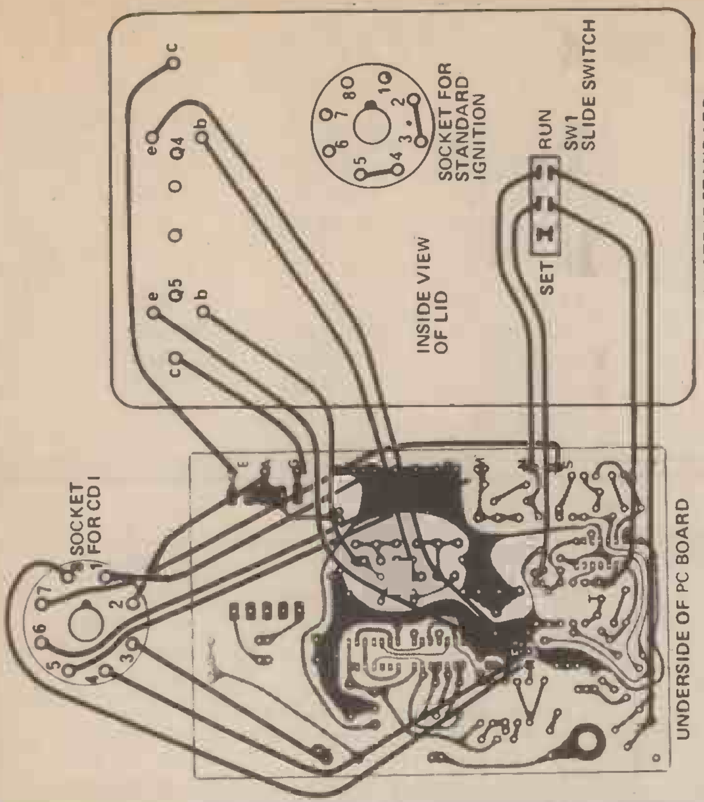


Fig. 4. Two circuits which may be used to calibrate the unit if a reference tacho is not available. The second circuit should be used if a mains transformer is used to supply the 6.3 volts. (See text).

ELECTRONIC IGNITION SYSTEM



* NOTE IF STANDARD SYSTEM DOES NOT USE A BALLAST RESISTOR LINK PIN 1 AND 3 NOT PIN 2 AND 3.

Fig. 5. Wiring diagram — printed circuit board to front panel components.

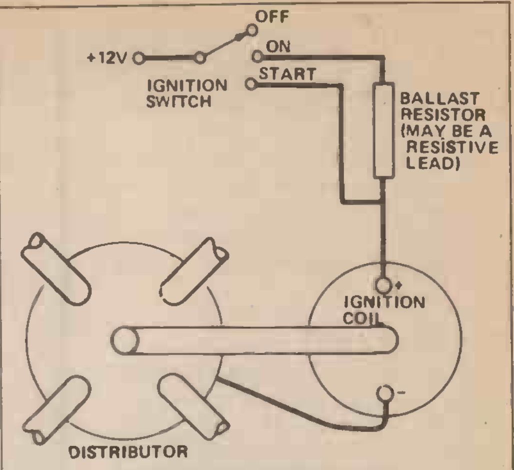


Fig. 6. Standard ignition system.

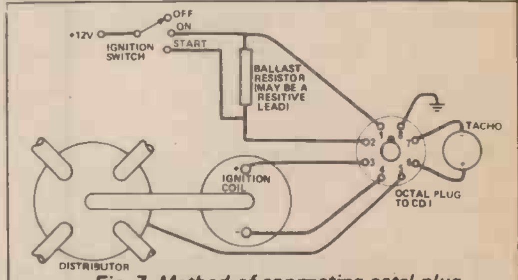
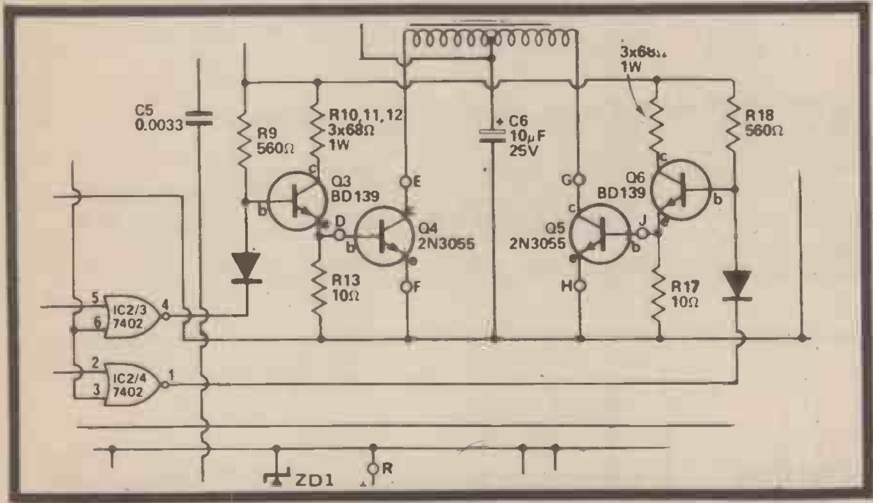
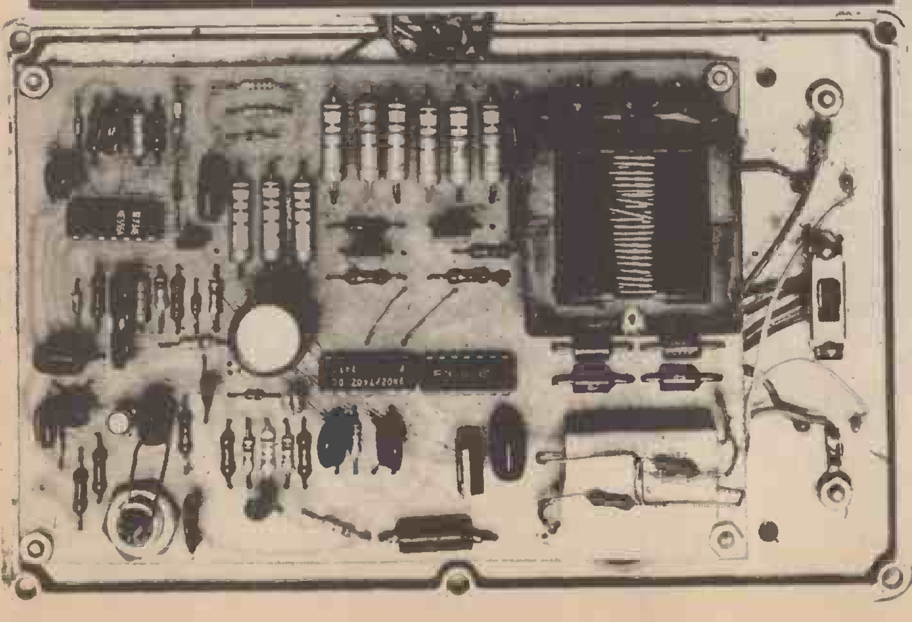


Fig. 7. Method of connecting octal plug into existing ignition system.





MODIFICATION

A few readers have experienced problems with the 7402 blowing up. The failure of this is probably due to the loading in the 1 state by the transistors Q3 and Q6. This can be cured by adding two diodes in series with output of IC2/3 and IC2/4 as shown in the diagram. These diodes should be 1N4005 or germanium transistors used as diodes (bases and collectors strapped together). The use of silicon diodes increases slightly about 150mA, the input current due to not turning off the output transistor as hard. Germanium transistors do not alter it. Germanium diodes have too high a voltage drop at the 20mA required. Adding these diodes reduced the current of the 7402 from 30mA to 19mA in our prototype.

The waveform on the output of IC2/3 and IC2/4 should be symmetrical except that it is being gated on and off due to the regulation.

The modification is shown on the left.

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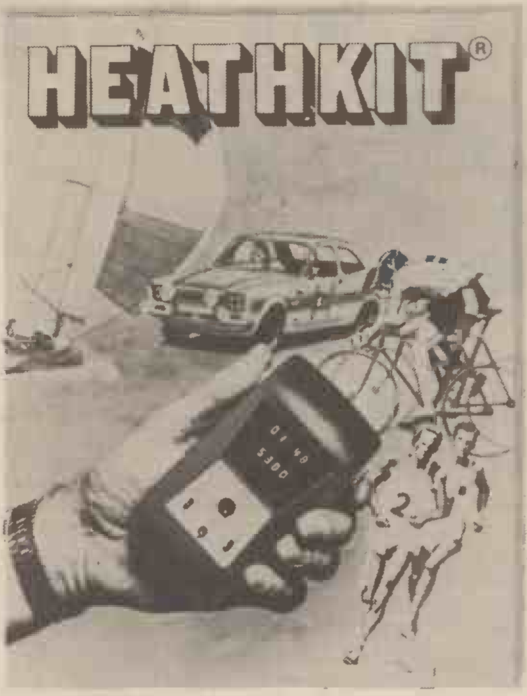

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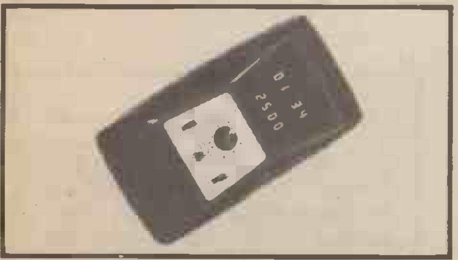

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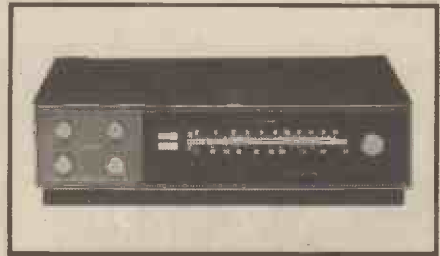

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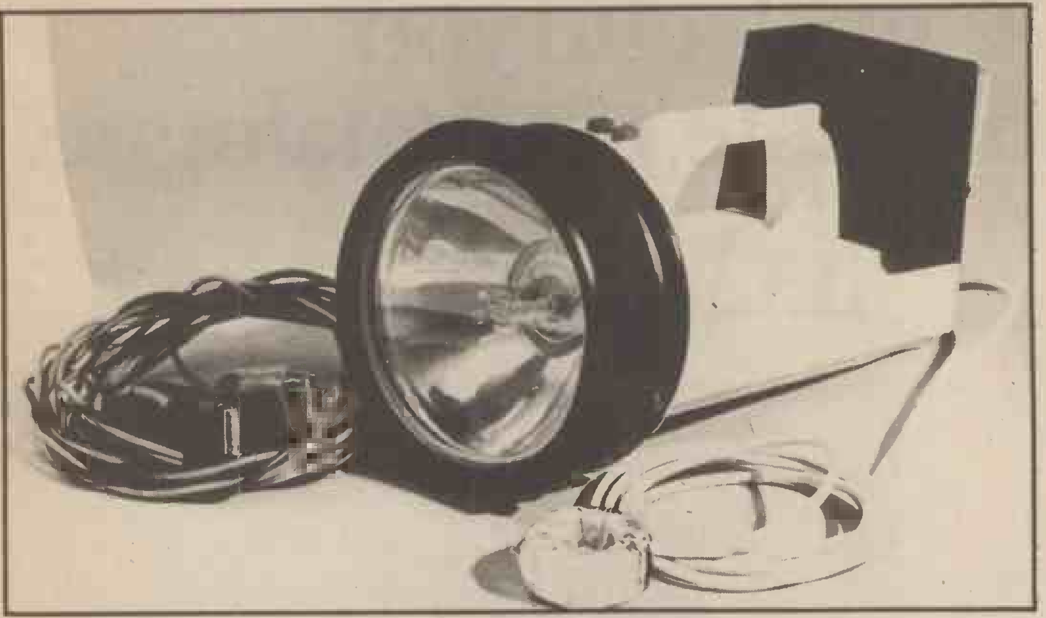
TACHO TIMING LIGHT



Extended circuitry allows timing check over full speed range.

This instrument incorporates a calibrated delay which gives a meter indication of the exact advance of the ignition in degrees — at any engine speed. It has a built-in tachometer so a serious enthusiast could check the complete distributor advance curve.

The use of such an instrument will allow checks on the correct operation of the distributor particularly with respect to mechanical and vacuum advance with increasing RPM.

CONSTRUCTION

The layout and construction of the timing light will vary depending on the housing.

We purchased a cheap torch which takes four HP2 batteries.

Our layout and method of construction can be seen from the illustration but this can readily be varied to suit the housing used.

Most of the electronic components are mounted on a printed circuit board which can be assembled with the aid of the circuit diagram and the component overlay, Fig. 2. Check the polarity of diodes, capacitors and transistors etc before soldering. All external wiring to the PC board is numbered and interconnections from the PC board to external components should be made with the aid of the circuit diagram, note that C4 is mounted on the back of the meter and C12 on the rear of the reflector.

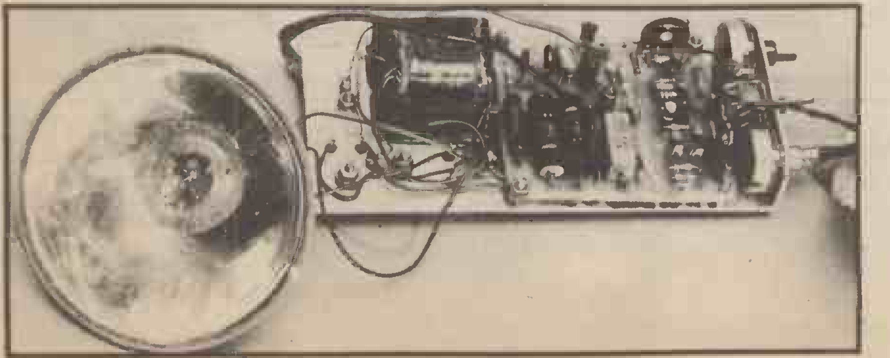
The inverter power transistors should be mounted on, but insulated from, a heatsink made from aluminium sheet of at least 40 square centimetres area.

If the unit will not oscillate, (you will hear a 2 kHz whistle when it is oscillating) try reversing the feedback winding.

The secondary voltage is around 350 volts and care should therefore be taken to insert insulation as specified in Table 1, between the primary and secondary windings in the transformer, and to keep the windings separate on the matrix board.

The reflector of the torch may be modified to house the flash lamp in the following manner.

Remove the existing socket, using a pair of pliers or cutters, and file the



Assembly of the unit may be seen from this photograph.

WARNING

On some cars the fan blades rotate close to or at a multiple of the crankshaft speed. When strobed by the timing light, the fan may appear to be stationary or rotating slowly.

This is common to all strobe light timers and failure to remember this can result in serious personal injury, or a wrecked timing light.

ALWAYS — keep well clear of the fan, or remove the fan belt whilst timing the engine.

opening until it is large enough to accept the flash lamp with about one millimetre clearance all round. Insert the lamp from the front and use modelling clay at the rear of the reflector to hold the lamp and seal the opening. Then pour quick-dry epoxy cement into the reflector until there is sufficient around the base of the tube to secure it in place. Be careful not to get epoxy elsewhere on the reflector. When dry, remove the clay and use more epoxy to fill any recesses in the rear.

If and when the tube is to be replaced a hot soldering iron may be used to destroy the epoxy thus permitting removal.

The discharge capacitor C12 should be mounted on the rear of the flash-tube/reflector assembly as shown in the photograph.

The pick-up coil is wound on a toroidal ferrite core, as shown in the photograph, using screened audio cable as follows. Remove about 0.8 metres of the inner cable from its shield and wind 20 turns of this around the ferrite core. Then solder the end of the inner conductor to the screen thus creating a complete loop.

The coil should also be shielded to prevent the magnetic field around nearby spark-plugs (other than number one plug) from triggering the timing light. To do this we cut strips of aluminium foil about 10mm wide and sandwiched them between two layers of 12mm wide cellulose-tape to produce a continuous strip of insulated foil 1 metre long. A length of wire should be connected to one end so that the strip may be connected to the screen of the coaxial cable. The foil is wrapped around the coil, in a similar manner to the coax, except that the ends of the foil must not touch. Should the ends touch, a shorted turn would be created which would prevent the transducer from operating at all. The coil should be completely covered and will appear as shown in the photograph.

CALIBRATION

Two different methods may be used to calibrate the timing light. In method A, the preferred method, you will need an oscilloscope with a triggered and calibrated time base, and an accurate tacho. In method B you will have to prevail on the local garage to allow you to calibrate your unit against their accurate (?) unit.

Method A.

1. Connect the unit to the engine with the transducer over number 1 spark lead.
2. Switch the timing light to "tacho" mode.
3. Start the engine and adjust the sensitivity control to the minimum setting that allows the meter to move smoothly as engine revs are increased.
4. With the CRO monitor between the common line and the collector of Q4, the voltage should swing from zero to +9 volts and back to zero each time the number one plug fires.
5. Adjust RV2 such that the pulse width at Q4 collector is 1.67 milliseconds.
6. Remove the CRO leads and set the engine revs to 3000 with the aid of the accurate tachometer.
7. Adjust RV4 such that the meter reads 3000 RPM. This completes the calibration.

Method B.

1. Connect both your timing unit and the garage unit to the car.
2. Switch the unit to "timing" mode.
3. Start the engine and set the RPM to 3000.
5. Now using your own unit adjust the sensitivity control as in step 3 method A.
6. Adjust RV1 until the timing marks coincide.
7. Adjust RV4 such that the same reading is obtained on meter M1 as on the garage unit.
8. Switch to tacho and adjust RV2 to read 3000 RPM.

Note that the engine must be held at constant speed throughout this process.

USING THE UNIT

The workshop manual for most cars contains details of the timing changes with respect to engine RPM and vacuum. If an engine is to perform at maximum efficiency these characteristics need to be checked and corrective measures taken if out of tolerance.

To check mechanical advance:

1. Remove vacuum line to distributor.
2. Fit transducer over number 1 spark-plug lead.
3. Switch timing light to "TACHO"
4. Start engine and switch on timing light.
5. Adjust sensitivity such that meter indicates correct RPM over full range without undue jitter.
6. Set the idle speed as specified in manual.
7. Switch to TIMING and set "timing adjust" potentiometer until the flywheel mark corresponds with TDC mark on the crankcase. (If some other mark than TDC is used, simply add the number of degrees the mark is BTDC (before top dead centre) onto the meter reading). If this is less than 2° advance (minimum obtainable with delay) switch SW3 may be used to remove all delay.
8. Switch back to tacho and increase speed to next calibration point as detailed in the manual.
9. Whilst holding engine revs steady at this setting, switch back to "TIMING" and set "TIMING ADJUST" until the marks again coincide. The meter now indicates the number of degrees of advance. Note that engine revs must not change otherwise the reading will be in error.
10. Repeat 8 and 9 for all other specified calibration points.

To check vacuum advance:

The only points on vacuum advance that need checking are the maximum advance with vacuum and that a vacuum is held, ie no leaks in the distributor.

1. With the motor idling check the timing with the vacuum line disconnected.

2. Draw a vacuum in excess of the normal vacuum (sucking the line by mouth will be sufficiently effective) and check the timing advance against that specified in the manual.

3. Hold the vacuum in the line and check that the timing does not shift (due to leak in distributor vacuum mechanism).

If a more accurate check is required the above checks can be done in conjunction with a vacuum gauge.

SPECIFICATION

Energy per flash	**0.2 joule**
Maximum flash rate	**>50/sec (6000 rpm)**
Trigger method	**current transformer on No 1 spark lead.**
Input voltage	**10-14 volts dc**
Timing meter range	**0-50°**
Minimum delay **0° is switchable**	**<4°/1000 rpm**
Maximum delay **50° maximum**	**>40°/1000 rpm**
Tacho meter range	**0-5000 rpm**

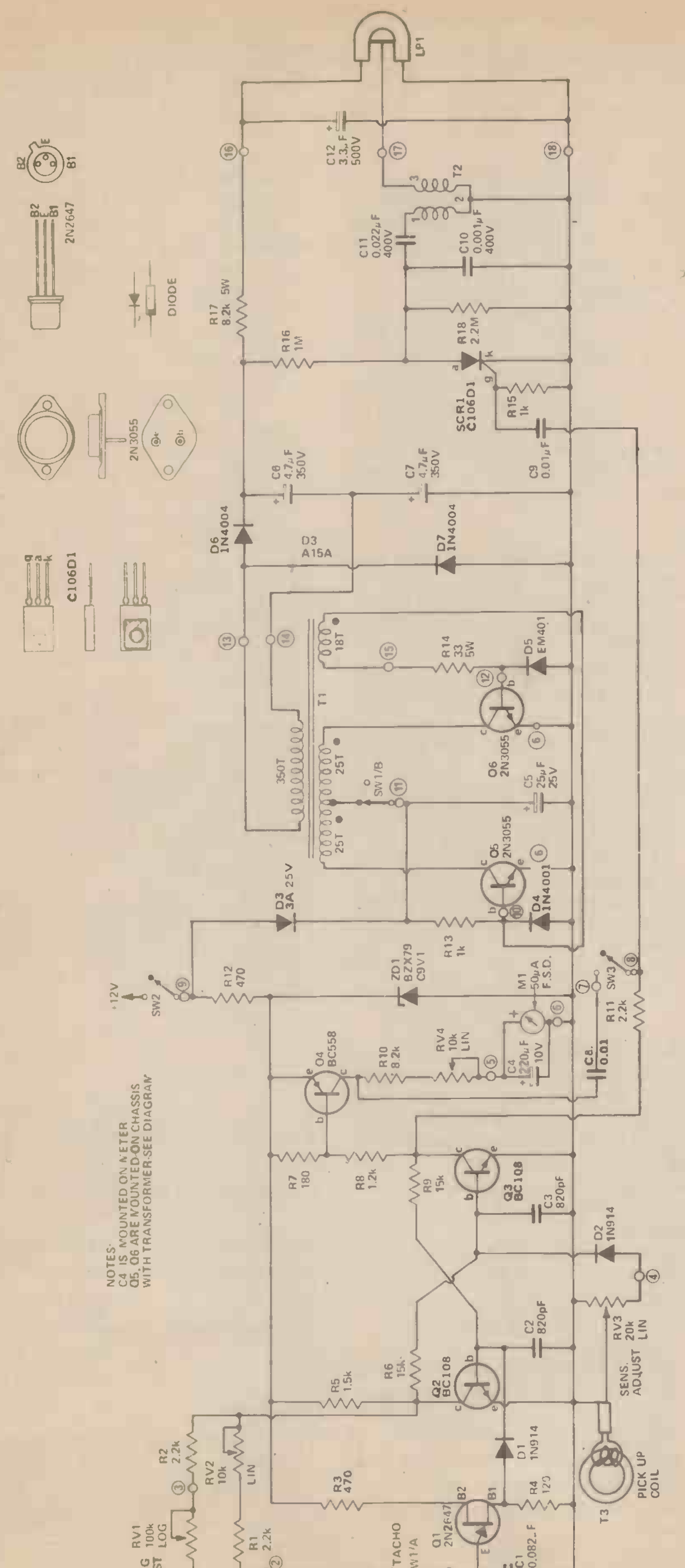
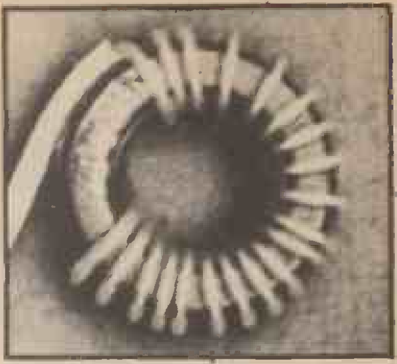


Fig. 1. Circuit diagram of the Tacho Timing Light.



This picture shows how the transducer is wound with the inner core of screened cable. Aluminium foil shielding is wound over the completed coil as detailed in the text.

PARTS LIST
TIMING LIGHT
ETI 311

R14	Resistor	33 5W	5%
R4	"	120 ¼W	"
R7	"	180 ¼W	"
R3	"	470 ¼W	"
R12	"	470 ½W	"
R13,15	"	1k ¼W	"
R8	"	1.2k ¼W	"
R5	"	1.5k ¼W	"
R1,2,11	"	2.2k ¼W	"
R10	"	8.2k ¼W	"
R17	"	8.2k 5W	"
R6,9	"	15k ¼W	"
R16	"	1M ¼W	"
R18	"	2.2M ¼W	"
RV1	Potentiometer	100k log rotary	
RV2,4	"	10k trim type VTU or similar	
RV3	"	20k lin rotary	
C2,3	Capacitor	820pF ceramic	
C10	"	0.001μF 400V polyester	
C11	"	0.022μF 400V polyester	
C8,9	"	0.01μF polyester	
C1	"	0.082μF polyester	
C12	"	3.3μF 500V electrolytic	
C6,7	"	4.7μF 350V electrolytic	
C5	"	25μF 25V electrolytic	
C4	"	220μF 10V electrolytic	
Q1	Transistor	2N2647	
Q2,3	"	BC108	
Q4	"	BC178	
Q5,6	"	2N3055	
SCR1	SCR	2N6240 C106D1	
D1,2	Diode	1N914 or equivalent	
D3	"	3A, 25V.	
D4,5	"	1N4001	
D6, 7	"	1N4004	
ZD1	Zener diode	BZX79C9V1 (9.1V 400mW)	
T1	Transformer	see text	
T2	Pulse Transformer	"	
T3	Pickup coil	"	
LP1	Flash tube		

PC board ETI-311
M1 meter 0.50μA FSD
SW1 Switch 2 pole 2 position.
SW2,3 switch single pole on-off. (There were already incorporated in the torch housing used in our prototype)
reflector, heatsink, housing for electronics.

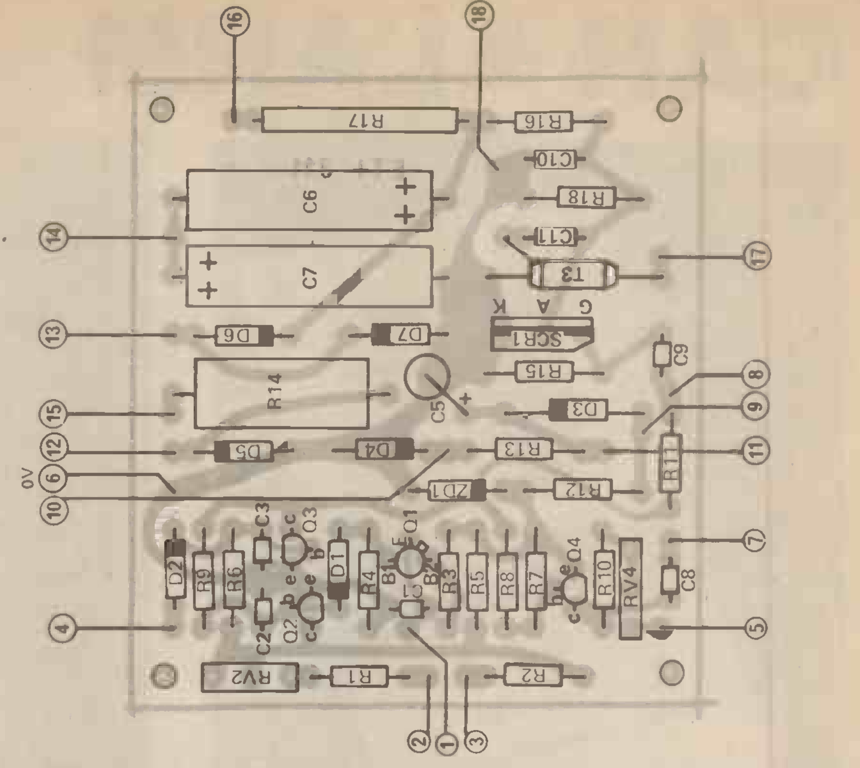


Fig. 2. Compont overlay for the Tacho Timing Light (this drawing has been placed sideways on the page to simplify checking against main circuit drawing).

HOW IT WORKS ETI 311

The flash tube used requires a supply of 300 to 400 volts. This is obtained by stepping up the vehicle 12 volts supply by means of an inverter.

Transformer T1, together with transistors Q5 and Q6 form a self oscillatory inverter. The frequency of operation, about 2 kHz on a 12 volt supply, is primarily determined by the core materials, the number of primary turns and the supply voltage. Protection against reversed-polarity supply leads is provided by diode D3.

The output from the secondary of transformer T1 is voltage doubled by D6, D7, C6 and C7 to provide about 400 volts dc which is fed to the flash tube via R17. Capacitor C12, in parallel with the flash tube, charges to this voltage and thus stores the energy needed for the flash.

Capacitor C11 is also charged up via R16 and the energy stored in this capacitor is used to trigger the flash as follows. When the SCR is triggered by a pulse on its gate it conducts and rapidly discharges C11 through the primary of pulse transformer T2. The pulse of current through the primary of T2 induces a 4000 volt pulse in the secondary winding which fires the flash tube.

When C11 is fully discharged the current through R16 is not sufficient to hold the SCR on and it turns off. Thus the flash is fired at a time determined by timing of the trigger pulse to the SCR.

The pulse from number one spark-plug lead is picked up by transducer T3 and used to trigger a monostable consisting of Q1, 2 and 3. Each time a spark-plug pulse occurs Q3 turns on and Q2 turns off, and remains off for a predetermined time before resetting. Whilst Q2 is off C1 charges via RV1/R2 (or RV2/R1) and when the voltage across it reaches about 6 volts the unijunction transistor Q1 fires, discharging C1, producing a pulse which resets the monostable. By varying the setting of RV1 the time duration of the monostable pulse can be altered.

Transistor Q4 simply inverts the output pulse train from Q3 and drives the meter M1. When Q3 is on Q4 is on and its collector is at +9 volts, and when Q3 is off Q4 is off and its collector at zero volts. Thus capacitor C4 will charge to a voltage which is proportional to the average of the on/off ratio, and this voltage is read by the meter. Zener diode ZD1 stabilizes the supply to Q4 at 9.1 volts.

The output of Q3 (Q4 in the no delay mode) is used to trigger the SCR. Since the SCR requires a positive pulse to trigger it, it will fire when Q3 turns off, that is, at the end of the delay period produced by the monostable. Since the output of Q4 is "inverted", when this output is selected the SCR fires the instant Q3 turns on, that is without any delay.

In the timing mode the delay period is adjustable by means of RV1 so that the timing mark on the flywheel is aligned with that on the block. The meter M1 will then read the number of degrees of spark advance. In the tacho mode the inverter is disconnected to disable the strobe and a preset delay of 1.66 msec is selected. The meter now reads RPM with full scale of 5000 RPM.

The picture shows how the transducer is wound with the inner core of shielded cable. Aluminium foil shielding is wound over the completed coil as detailed in the text.

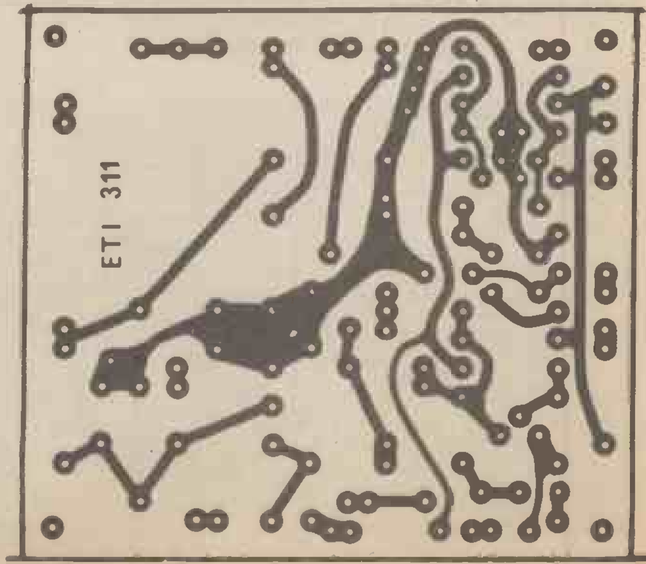


Fig. 3. Printed circuit board dimensions 74mm x 82mm (full size).

GETTING HOLD OF THE COMPONENTS

THE TRANSFORMER

This is available for £2.37 including VAT and postage from RCS, MCQ or Henry's. The RCS transformer will not fit the PCB mentioned below. Winding details were given in our September issue.

THE XENON FLASH TUBE AND TRIGGER TRANSFORMER

These can be bought from Music Craft, 367 Edgware Road, London W2. The ZFT-8B tube is slightly different from the one in our prototype, but the same mounting method will work.

THE PICK-UP COIL

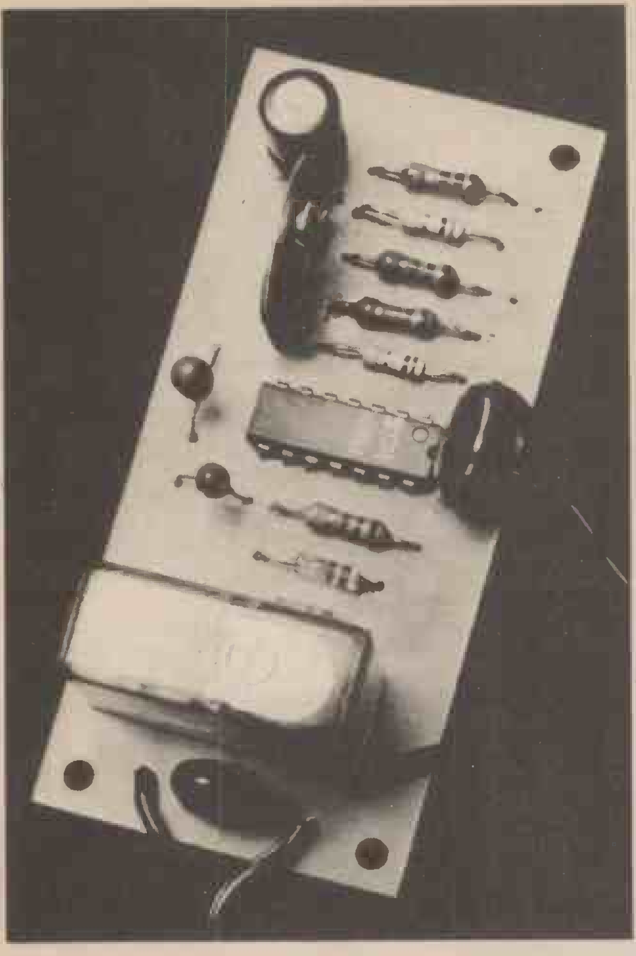
This is made from a ferrite ring with an inside diameter of 1". The Mullard FX1588 will do. Further details are given in the text.

THE PCB

PCB's are available for this project or the simpler version for £1.25 plus 15p P & P, from MCQ. However these are suitable only for the transformers from MCQ or Henry's.

RCS Products Ltd, 31 Oliver Road, London E.17.
Music Craft, 367 Edgware Road, London W.2

CAR ALARM



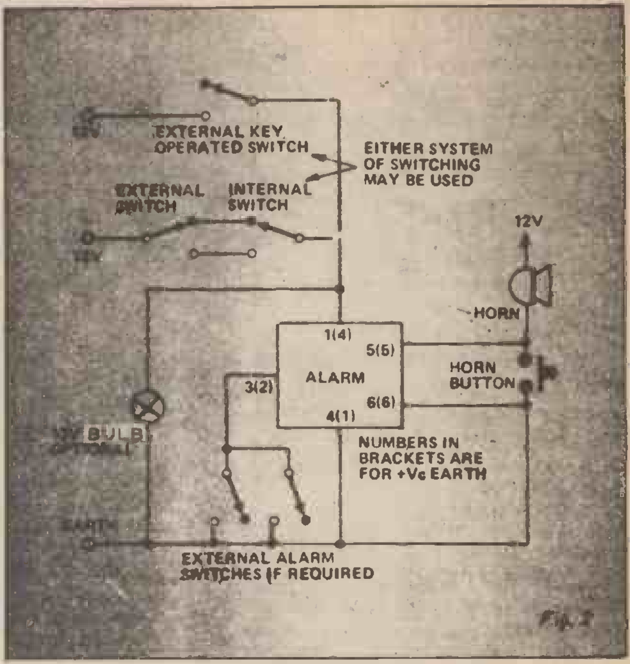


Fig. 2

Protect your car with this simple but effective circuit.

ONE OF LIFE'S more devastating experiences is to walk out of your house in the morning and find that your car has disappeared!

But this need not happen to you, for an effective alarm system, as described here, may be quite easily constructed and installed at low cost.

The ETI 313 car alarm uses one single IC and a minimum of other components. It will, when actuated, blow the horn at one second intervals, and will continue to do so until deactivated by means of a key switch etc.

The alarm is triggered by any drop in the battery supply voltage caused by an increase in loading on the vehicle's electrical system. Thus, if a door is opened, the interior light will be activated and the increase in electrical load will trigger the alarm.

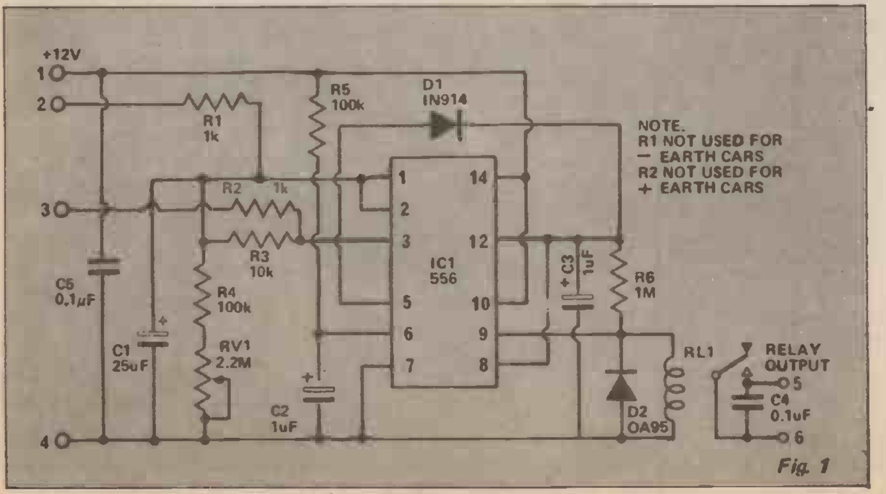


Fig. 1

This operating principle simplifies installation, for practically all vehicles have courtesy lights activated by switches on at least two of the doors — and it is a fairly easy task to install further switches on the other doors if required.

Both the boot and under bonnet areas may be protected in a similar manner — indeed many vehicles have lights already fitted in these areas, if not, it is a simple matter to fit them into the circuit such that they come on when the boot lid etc is opened.

These lights are of course very useful apart from their alarm function, but remember — they must operate at all times, not just when the ignition is on.

The alarm is sensitive enough to be activated by anyone pressing the brake pedal — or even by opening the glove box (where a lamp is fitted of course).

The unit is designed for use with cars having 12 volt electrical systems. It may be used with either positive or negative earth systems without modification.

In addition to the power sensing alarm mode other precautions may be taken by adding further alarm microswitches. For example microswitches may be fitted to the suspension such that if anyone tries to lift the car, in order to tow it away, the alarm will go off. If such switches are used they should be connected between terminal 2 or 3 of the alarm (see Fig 1 and 2), depending on whether the vehicle has a positive or negative earth system, and earth.

CONSTRUCTION

Construction of the alarm is extremely simple and anyone capable of using a soldering iron should not have any difficulty. All components, including the relay, are mounted on a small PC board as shown in the component overlay diagram.

Note the polarity of electrolytic capacitors, the IC and diodes. In particular make sure that the germanium diode D2 is mounted in the correct position and with the correct orientation. When soldering use a small, light-weight iron and preferably small gauge solder. Solder quickly and cleanly. Only apply the iron for sufficient time to cause the solder to flow around the joint. These precautions will ensure that components are not damaged by excessive heat. The unit should then be mounted in a small plastic, or metal, box.

Two different switching systems may be used to enable the alarm. Use either an external key switch mounted in a convenient, but not obviously seen location, or a two way system of concealed switches — one inside and one outside. The switch inside is used to enable the alarm (after opening the door) and the external one to disable the alarm before entering the car. This latter system has the advantage that anyone watching will not see where the external disable switch is located. ●

PARTS LIST — ETI 313

R1,2	Resistor	1k ½watt 10%
R3	"	10k ½watt 10%
R4,5	"	100k ½watt 10%
R6	"	1M ½watt 10%
RV1	Potentiometer	2.2 meg
C1	Capacitor	25μF 25 volt electrolytic
C2,3	"	1μF 25 volt electrolytic
C4,5	"	0.1μF polyester
IC1	Integrated Circuit	NE556

D1	Diode IN914 or similar	
D2	Diode OA95 (must be germanium)	
RL2	Relay 12V 100—470 ohm coil, 6A min. contacts.	
PC board ETI 313		
SW1	Switch	SPST key operated
SW2,3	"	SPDT toggle (see text)
metal or plastic box to suit.		

NOTE: After this article was published, a number of readers experienced problems with the triggering being too sensitive. Two solutions are possible; increasing the value of R4 to 2.2Mohm and changing the value of C5 from 0.1uF to 10uF. On the main circuit, pin 14 of the IC should be shown connected to pin 4, this is correct on the PCB however.

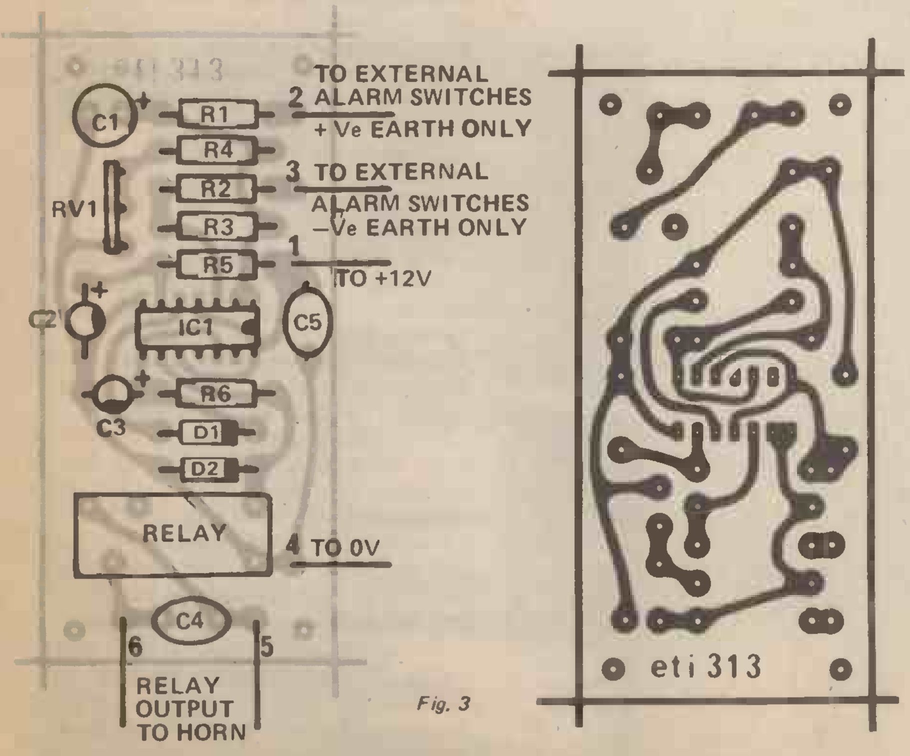


Fig. 3

This PCB will probably have to be altered to suit the particular relay used. (Electrovalue do a 12V 110Ω relay but this will not fit the PCB as shown).

HOW IT WORKS

When a load, especially an incandescent lamp, is switched onto a battery the battery voltage will drop instantaneously and then return to normal. The amplitude and duration of this negative going spike in the supply is dependant on the size of the lamp used but is of sufficient amplitude, even with small bulbs, to trigger an alarm circuit.

The NE556 IC contains two NE555 timer ICs in a single case. One of the timer sections is used to detect the supply spike and to gate on the second timer which produces a one Hz output to the relay and horn.

Each timer section contains two comparators, a LOW comparator set at 1/3 supply and a HIGH comparator set at 2/3 supply. These comparators set a flip-flop which provides an output.

When the power is first applied, the voltage at pin 6 (input to the low comparator) is initially low for about half a second whilst C2 charges via R5. This sets the output of the flip-flop to a high state where it will remain regardless of further excursion in the voltage at pin 6.

The only way that the output may be set low again is for the input to the high comparator (pin 2) to be taken past its threshold. This threshold voltage is available at pin 3, and by using a voltage divider (R3, R4 and RV1) a slightly lower voltage is derived from it. This is used as a reference level to the HIGH comparator input (pin 2) Capacitor C1 is used to bypass any fast transients which may appear at the input (pin 2).

If the supply falls, the voltage on pin 3 will also fall. If it falls below the voltage at pin 2, the output will fall again to a low state and will stay there. The capacitor C1 will also be discharged via pin 1.

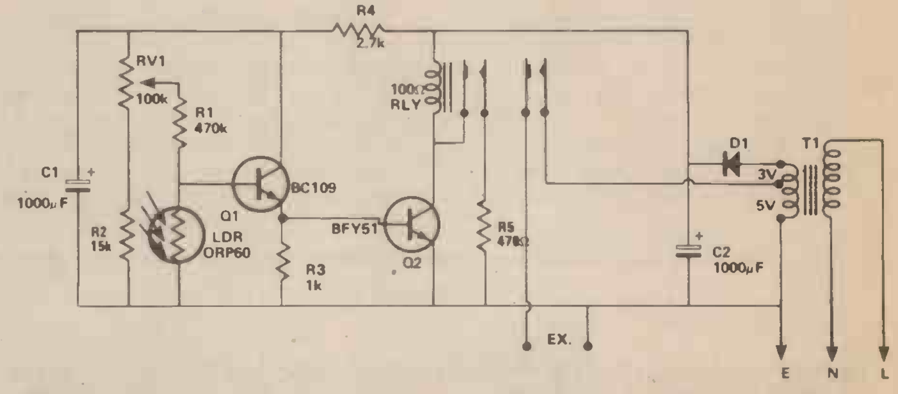
The second half of the IC is connected as a free-running multivibrator having a frequency determined by R6 and C3, of about 1 Hz. If the output of the first stage is high, the diode D1 will force the multivibrator to lock into the low state. When the output of the first stage goes low the multivibrator is freed to oscillate.

This one hertz output switches a relay which in turn controls the horn, or any other suitable device. The diodes across the relay prevent reverse voltages being generated which could damage the IC. This must be a germanium type for correct operation.

AUTO LUME

THIS UNIT is automatically operated by the level of general illumination, or the strength of light falling upon it. The most frequent uses of such a device include operating a child's night light, or switching on a light in a room, when darkness falls, as a deterrent to burglars, when leaving the house unoccupied.

The unit is operated from a.c. mains, and is adjustable to operate over a wide range of light intensities. It switches on an external circuit when light fades below a set level, as in the evening and switches off this circuit when light increases, as with the arrival of morning.



The circuit.

AUTO-LUME CIRCUIT

This is shown in Fig. 1. The resistance of the light-dependent resistor LDR rises as the illumination reaching it falls. This allows the base of Q1 to move positive so that it conducts. Q1 emitter and Q2 base also move positive, so that Q2 collector current rises. This current flows through the relay windings, closing the relay contacts.

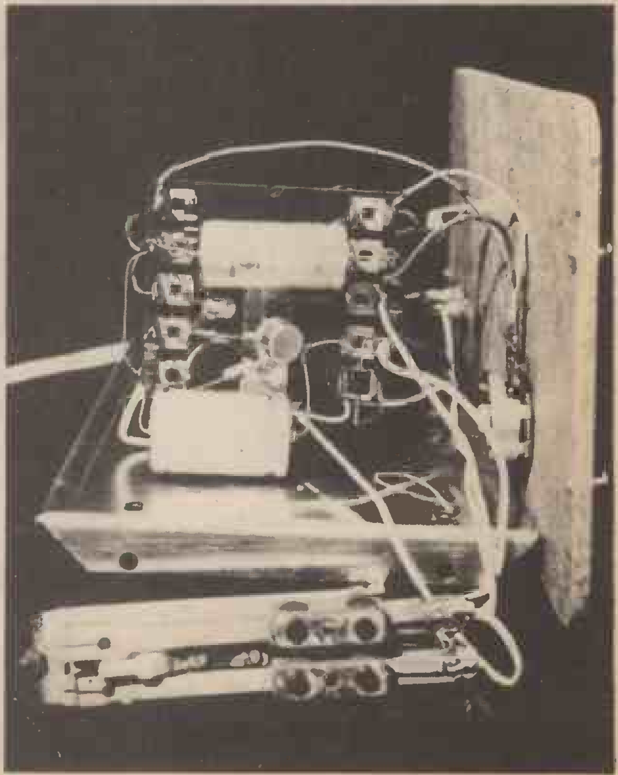
RV1 is the sensitivity control, so that the device can be set to work at the desired light intensity. Spare contacts on the relay close to bring R5 into circuit, providing additional current through the winding. This means that the relay release current through Q2 is lower than the pull-on current, and avoids vibration or flicking on and off of the relay when darkness slowly comes and light has fallen to a level where the unit is about to operate.

A bell transformer or similar transformer T1 provides current, and the operating voltage is not very critical. The second set of relay contacts result in 5V a.c. being available at the extension sockets EX, which does well for a child's night light equipped with a 6V 3 watt or similar bulb. By changing the connections to T1 secondary, 3V or 8V may be obtained instead, if required.

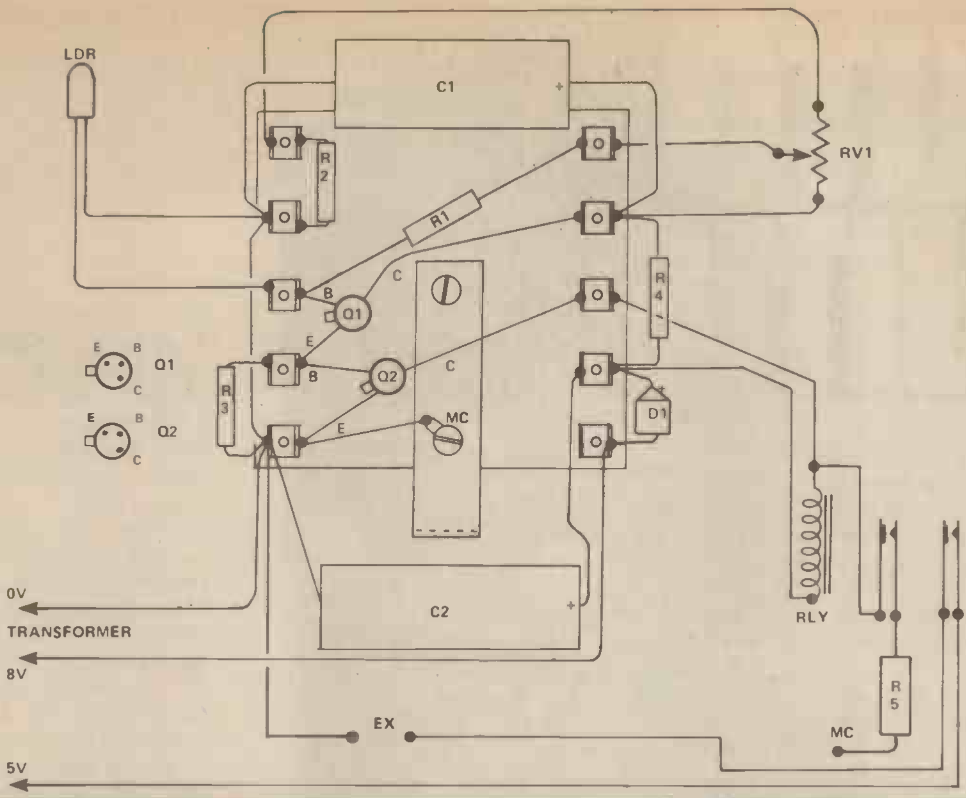
To switch on a mains-voltage lamp, it is necessary either to use a mains-voltage relay here, or to employ the extension circuit to control a relay which in turn switches on the mains-voltage equipment. Normally, however, a 3 watt or 6 watt low voltage lamp will provide enough light for the purposes for which the unit will be used.

TAG BOARD

The small components are assembled on a tag board as in Fig. 2. This also shows the positions of the leads of the semiconductors. A bracket bolted to the board allows it to be mounted vertically, and also forms the negative or metal chassis return.



Layout of the major components.



Positioning of the components on the tag board.

View of the tag board before mounting the relay.

COMPONENTS

R1	470k	¼W
R2	15k	¼W
R3	1k	¼W
R4	2.7 k	¼W
R5	470 ohm	½W
RV1	100k linear pot.	
C1	1000μF	16V
C2	1000μF	16V or 25V
LDR	ORP60	
Q1	BC109	
Q2	BFY51	

Relay, 100 ohm coil, double pole switch.

SR1 Selenium rectifier, 50V 1A or similar.

T1 Bell transformer, 200/250V, 3/5/8V secondary, 1 ampere, or 8VA, or as required for lamp.

Case, internal dimensions approx. 9 x 4 x 4in.

7 x 4in. chassis (Universal Chassis flanged side, Home Radio).

Tag-board, knob, sockets, 3-core mains lead, etc.

Leads run from various tags to the relay and other components, and these connections are most easily added after the board is fitted in position.

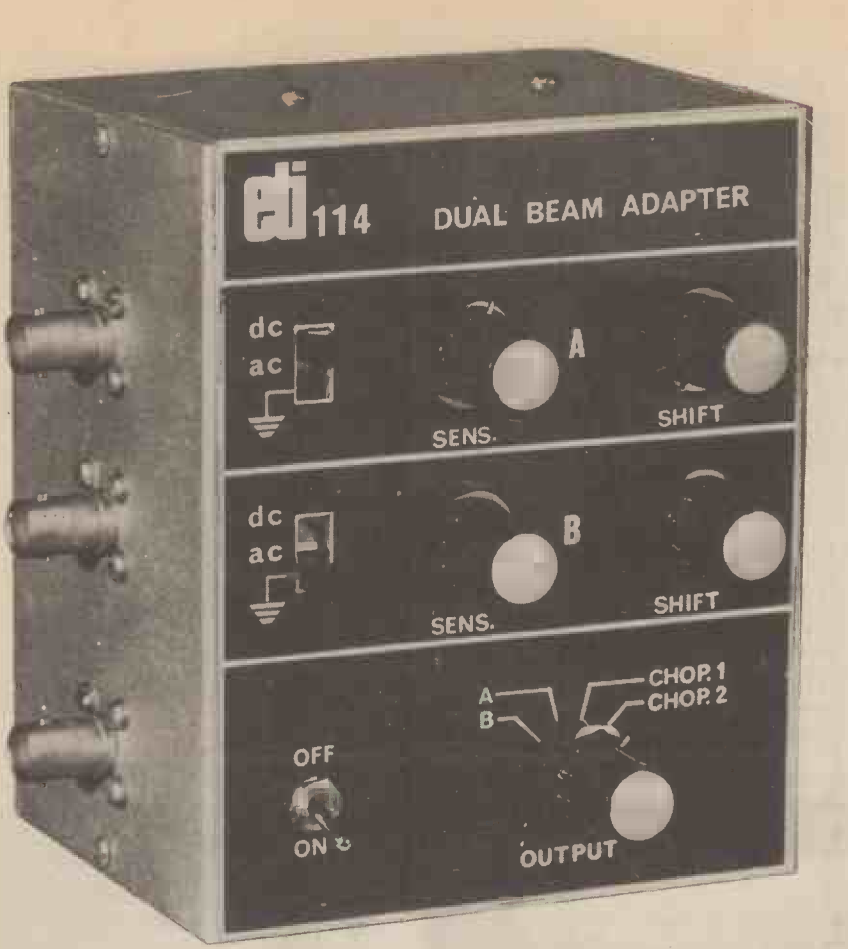
Construction can be completed on a shallow chassis 7 x 4 in. in dimensions, which will take the transformer, tag-board, and relay. The unit illustrated has a 9 x 4 in. panel, fitting a case 9 x 4 x 4 in. The extension circuit sockets, sensitivity control RV1, and LDR are fitted to the panel. The LDR is cemented in a small hole, and its leads are extended to reach to the tags shown. All connections can be seen from Fig. 2.

SETTING UP

The unit and lamp controlled must be placed so that light from the lamp does not operate the LDR. The Auto-Lume is best placed near a window when to be controlled by daylight, or at a position near the room main light, when it is to take over automatically as the room light is switched off. The extension circuit can then run to the bulb to be controlled, situated clear of the Auto-Lume. The disposition of unit and bulb is in no way critical, provided they are sufficiently separated.

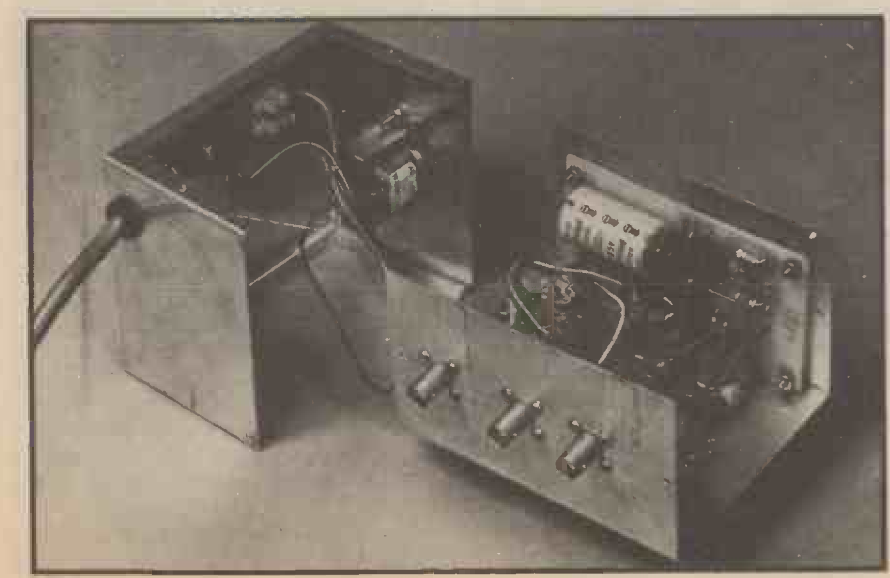
RV1 is then set so that the controlled must be placed so that light LDR is shaded with the hand, and sensitive control over a wide range of illumination values should be obtained.

When a low-voltage 3 watt, 6 watt or similar lamp is to be used with a conventional type table lamp, the latter should be fitted with a small bayonet cap or miniature Edison screw holder to suit, and a mains-type plug should *not* be used for connecting to the Auto-Lume extension sockets. This will avoid any chance of someone eventually plugging the lamp into a mains voltage outlet. Various small night-light lamps and similar lamps can also be easily adapted to take a suitable bulb. ●



DUAL BEAM ADAPTOR

Simple unit converts single beam CRO to dual beam operation.



THE oscilloscope, next to the multimeter, is perhaps the most useful test instrument. Indeed, for any serious experimental work an oscilloscope is indispensable. Unfortunately they are expensive beasts, and whilst an experimenter may well afford a simple, low-frequency single-beam type, a dual-beam version (at £100 or more) is usually beyond his means.

Nevertheless a dual-beam facility is most convenient, for it allows comparison of two different signals, for wave-shape or timing, and makes obvious, differences which otherwise would not be discernable.

The simple dual-beam adaptor described here, whilst not providing *all* the capabilities of an expensive dual-beam CRO, will however, cover most experimenter's requirements.

It is a low cost unit which allows two inputs of similar amplitude to be displayed simultaneously on separate traces. Frequency response of the unit is sufficient to allow observation of signals up to about 1 MHz.

CONSTRUCTION

Most of the components are mounted on a printed circuit board. However, if desired matrix or veroboard may be used.

Be careful to orientate the polarised components correctly, as shown on the component overlay. Wiring to the sockets and switches should be as short as possible. Note that C3 and C4 are mounted on the input switches and C5 is mounted on the output socket.

Our prototype was mounted in a small aluminium minibox as illustrated. As individual requirements will vary, details of front panel layout and metalwork only are supplied.

USING THE ADAPTOR

Connect the output of the adaptor to the input of the CRO. The two adaptor inputs now become A and B trace inputs to the CRO. A triggering signal should be applied direct to the trigger input of the CRO as otherwise the CRO will tend to synchronize to the chop frequency and not to either input signal.

It is preferable that the two input signals have approximately the same amplitude as there is no input amplifier or range selection provided

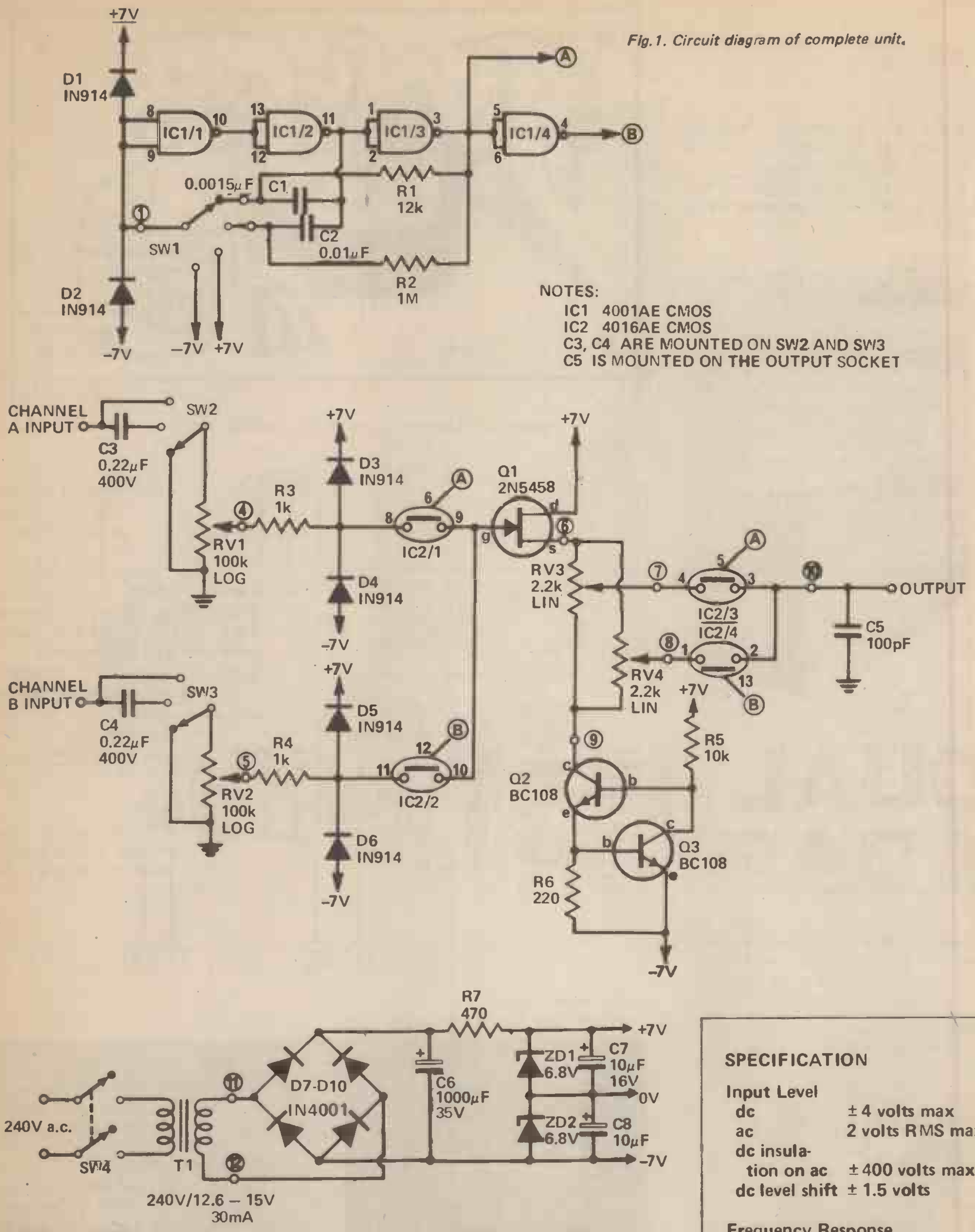


Fig. 1. Circuit diagram of complete unit.

NOTES:
IC1 4001AE CMOS
IC2 4016AE CMOS
C3, C4 ARE MOUNTED ON SW2 AND SW3
C5 IS MOUNTED ON THE OUTPUT SOCKET

on the adaptor. However there is an attenuator provided on each input so that some adjustment may be made.

If only one input is to be applied it is best to switch to that input only thus eliminating the second trace and any cross talk which may occur due to the high input impedances.

Two chopping frequencies are used, having widely different frequencies, so that if the input signal is a harmonic of the chopping frequency, (see Fig. 4) choosing the other chop mode will prevent the chop frequency being visible.

Normally CHOP 1 would be used for high frequency inputs, and CHOP 2 for low frequency inputs. An ALTERNATE mode has not been included (entails obtaining an output

SPECIFICATION

Input Level	
dc	± 4 volts max
ac	2 volts RMS max
dc insulation on ac	± 400 volts max
dc level shift	± 1.5 volts
Frequency Response	
– 3dB point	> 1 MHz
Chopping Frequencies	
A	60 Hz
B	35 kHz
Input Impedance	100 kHz

from the CRO of unknown level and availability) as the CHOP 1 mode is similar and almost as effective.

By means of the two shift controls traces A and B may be separated by up to ±1.5 volts.

HOW IT WORKS – ETI 114

Switches SW2 and SW3 select dc or ac coupling, or input shorted, for channel A and channel B inputs respectively. The signals are applied to the sensitivity potentiometers RV1 and RV2 and then passed to IC2/1 and IC2/2 which select one of the signals as an input to source follower Q1.

Transistor Q1 is supplied with a constant current (approximately 2.7 mA) by transistors Q2 and Q3. Hence, there is about 3 volts across RV3 and RV4, and this is unaffected by changes in input signal level. These potentiometers therefore provide a level-shift facility. When channel A is selected by IC2/1, IC2/3 selects RV3, and when channel B is selected by IC2/2, IC2/4 selects RV4. Thus as each signal has an independant level shift the two traces may be separated when chopped.

The CMOS gates of IC2 are driven by the outputs, A and B, the circuitry associated with IC1. The drive circuit mode of operation is selected by SW1, a four position switch, such that channel A only, channel B only, A and B chopped at 60 Hz or, A and B chopped at 35 kHz may be selected. The operation is as follows.

Integrated circuit IC1 forms a multivibrator which can run at 60 Hz or 35 kHz, or be locked in A-high B-low, or A-low B-high output states. For example, if SW1 selects –7 volts, IC1 pin 10 will be at +7, IC1 pin 11 will be at –7, IC1 pin 3 will be at +7 and IC1 pin 4 will be at –7 volts. The CMOS switches of IC2 will be "on" if the control voltage is at +7 volts and "off" if the control voltage is at –7 volts. Thus when –7 volts is selected by SW1, "A" will be at +7 volts, and IC2/1 and IC2/3 will select channel A. Similarly if +7 volts is selected by SW1, IC2/2 and IC2/4 will select channel B.

If C2 and R2 are selected by SW1 the multivibrator will be free to run at 60 Hz and channels A and B will be alternately selected at this frequency. Similarly if C1 and R1 are selected, channels A and B will be alternately selected at 35 kHz.

The power supply is a simple full-wave bridge type which uses two Zeners to provide the +7 and –7 volt supplies required.

Fig.2. Printed circuit board pattern for the adaptor. (Shown fullsize).

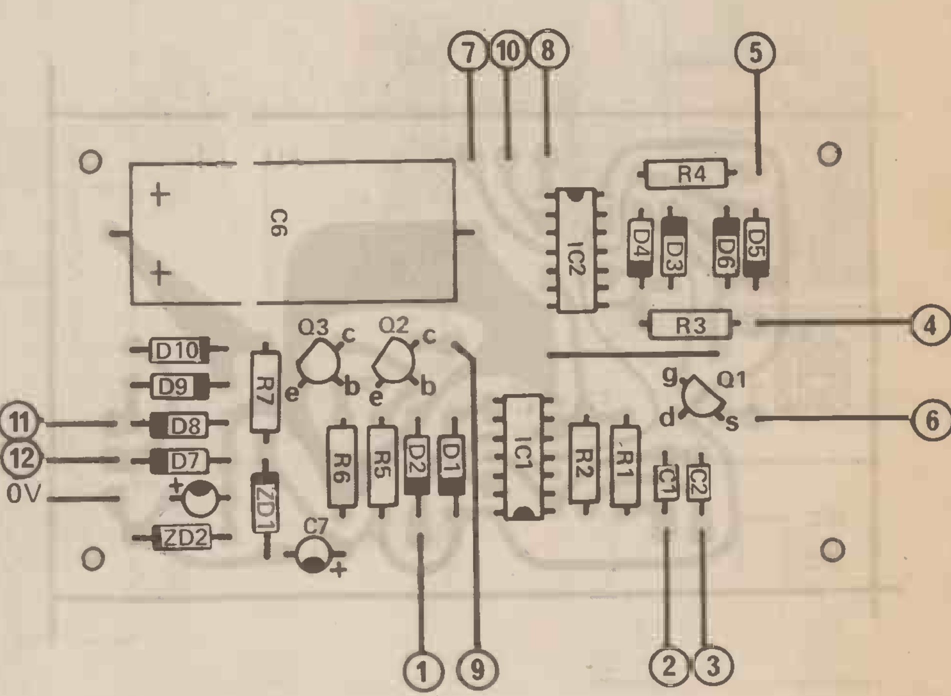


Fig.3. Component overlay.

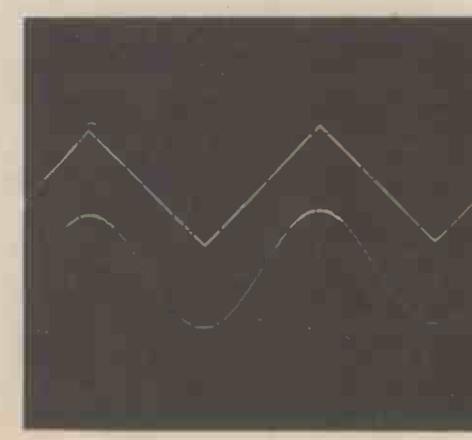


Fig.4a. Two signals, correctly displayed using the dual beam adaptor.

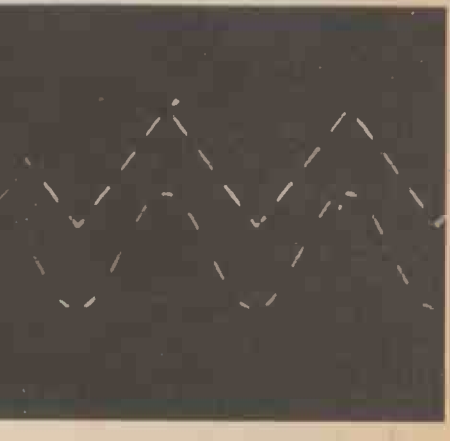
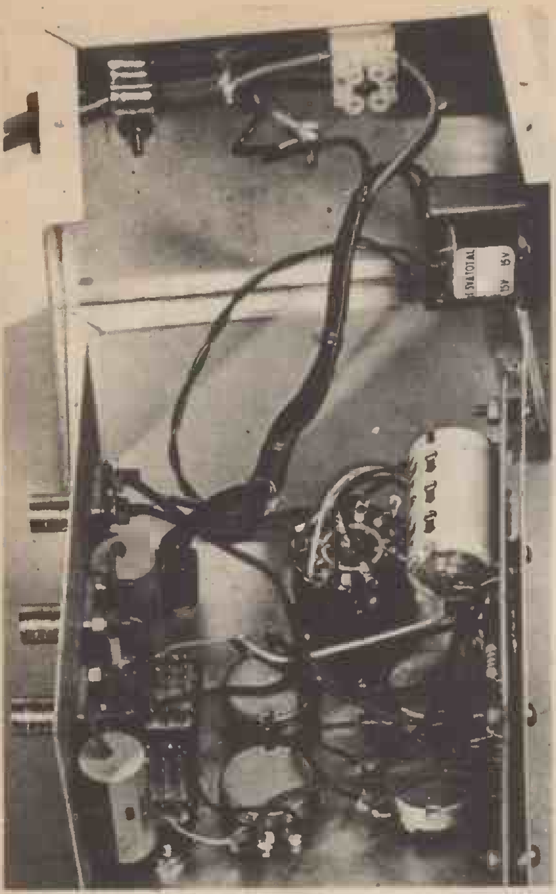


Fig.4b. Use of incorrect chopping frequency for a particular input signal (chop frequency a harmonic of signal) results in above effect. To cure use other chop frequency.



Layouts of components within the unit can be seen from this and accompanying photographs.

PARTS LIST—ETI 114

R6	Resistor	220	½W	5%
R7	"	470	½W	5%
R3,4	"	1k	½W	5%
R6	"	10k	½W	5%
R1	"	12k	½W	5%
R2	"	1M	½W	5%

RV1,2 Potentiometer 100k log rotary
RV3,4 Potentiometer 2.2k lin rotary

C5	Capacitor	100pF ceramic
C1	"	0.0015µF polyester
C2	"	0.01µF polyester
C3,4	"	0.22µF 400V poly.
C7,8	"	10µF 10V electrolytic
C6	"	1000µF 35V "
D1-D6	Diode	IN914 or similar
D7-D10	"	1N4001 or similar
ZD1,ZD2	Zener Diode	BZY88CV8 or similar
Q1	Transistor	2N 5458
Q2,Q3	"	BC108,BC548

' or similar

IC1 Integrated circuit 4001AE CMOS
IC2 Integrated circuit 4016AE CMOS

T1 transformer 12,6V–15V at 300mA
PC Board ETI 114
SW1 switch one pole 4 position rotary
SW2,3 switch 3-position slide switch
SW4 switch 2-pole on-off toggle 240V rated
Metal box 130mm x 105mm x 80mm
3 sockets to suit CRO leads
Knobs for front panel.

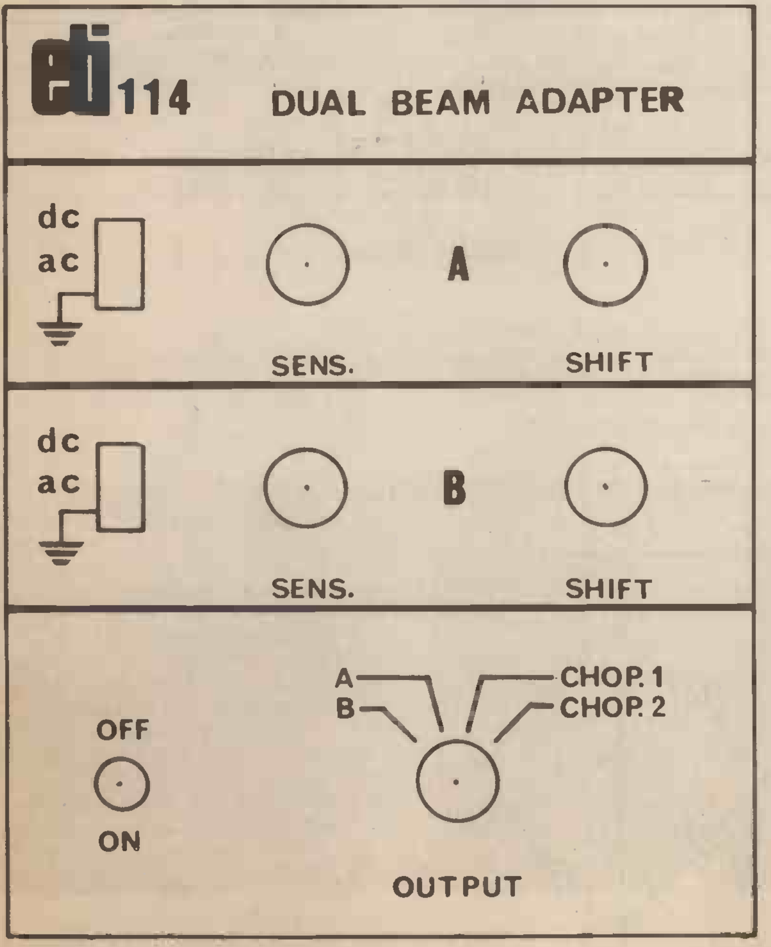
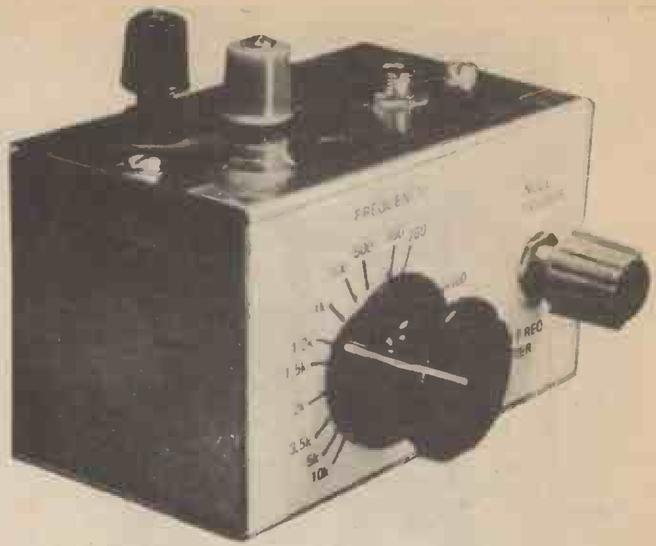


Fig.5. Artwork for front panel of the adaptor.

Audio frequency meter



Simple unit measures frequencies from 50 Hz to 10 kHz

ON MANY occasions it is useful to be able to determine the frequency of an audio signal. Often, the accuracy and expense of a commercial frequency meter is not justified.

This little circuit, using only a few components will provide an indication of frequencies from 50Hz to 10kHz with an accuracy primarily determined by the calibration of the instrument.

The audio signal — of which the frequency is to be established — is fed into the input terminals of the unit and the calibrated dial adjusted until a 'null' is obtained whilst listening to the signal through a pair of headphones, or even a single crystal earpiece.

We suggest that the components be mounted in one of the small aluminium miniboxes which are available readily at low cost. Our prototype unit had a 4" x 2¼" front panel, but a larger box will enable a larger frequency scale to be used hence providing better resolution. Apart from this a larger box will allow input terminals and output socket to be mounted on the front panel together with the frequency-null controls.

Note that the dual potentiometer is a logarithmic type and is wired such that the frequency scale *increases* with anti-clockwise rotation. This results in a more linear scale (less cramped at the high end) than if wired conventionally.

Any type of earpiece or headphone

CALIBRATION CHART

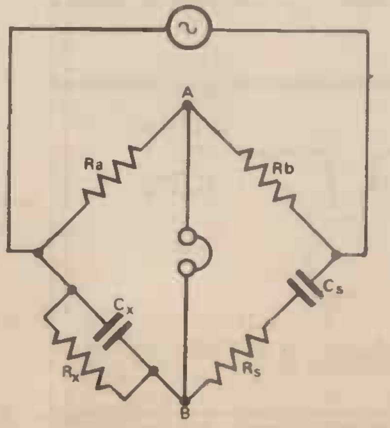
FREQUENCY HZ	RV1 RESISTANCE (one section)
75	21.2 kohm
100	15.9 kohm
150	10.6 kohm
200	8.0 kohm
300	5.3 kohm
400	4.0 kohm
500	3.18 kohm
600	2.65 kohm
750	2.12 kohm
1000	1.59 kohm
1500	1.06 kohm
2000	800 ohms
3000	530 ohms
4000	400 ohms
5000	318 ohms
6000	265 ohms
7500	212 ohms
10 000	159 ohms

HOW IT WORKS

The circuit is that of a Wien bridge which when used for frequency measurement has the form shown below:–

If $C_x = C_s$, $R_x = R_s$ and R [illegible], then

$$f = \frac{1}{2\pi C_s R_s} \text{ or, } R_x = R_s = \frac{10^6}{0.628 f}$$



where $c_x = C_s = 0.1\mu f$. Our calibration chart was calculated from this last formula.

At the frequency where the reactance of C_s equals R_s and also $C_x = R_x$, the series network has an impedance of 1.414R and phase angle of 45%. The parallel network has an impedance of 0.707R and the same phase angle. The signal at point B will therefore be in phase with the input level, but attenuated to 1/3 of that level. If Rb = 2Ra the signal at A will also be attenuated to 1/3 of the input. Thus the bridge is balanced and the signals at A and B will be equal in amplitude and phase and a null will occur at that frequency.

At any other setting of the potentiometer the phase angle and, amplitudes will be such that an increased output is obtained.

The respective sections of the dual gang potentiometer never track each other perfectly and hence RV1 has been included to obtain best null at any point on the scale.

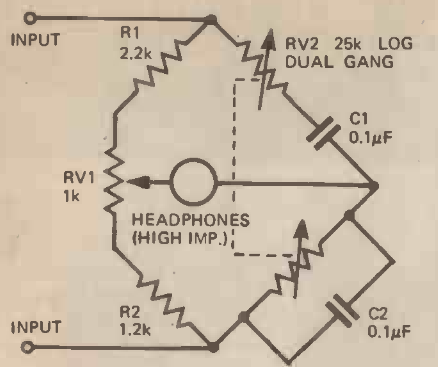
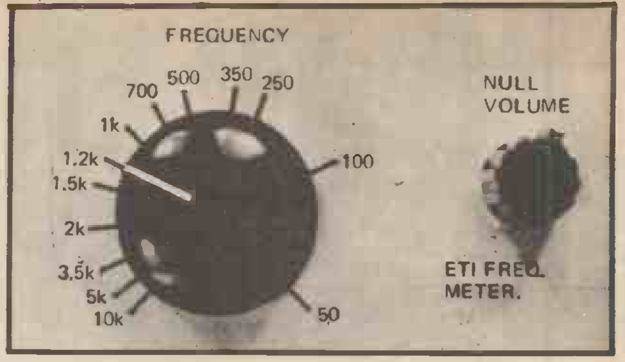
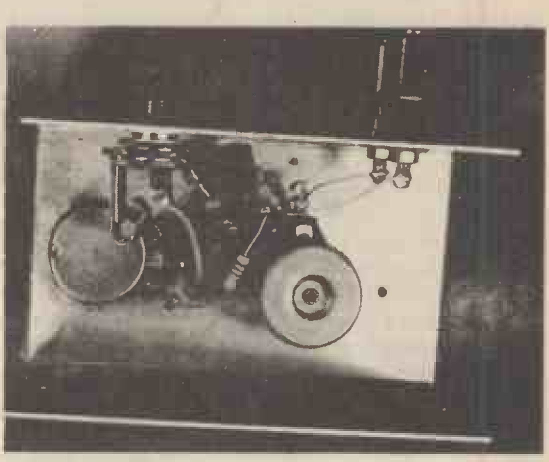


Fig. 1. Circuit diagram of the audio-frequency meter which is based on the Wien bridge.



PART LIST

R1 resistor 2.2 k ohm 5% ½ watt
R2 resistor 1.2 k ohm 5% ½ watt
C1 capacitor 0.1µF 100 volt polyester
C2 capacitor 0.1µF 100 volt polyester
RV1 potentiometer 1 k ohm linear
RV2 potentiometer 25 k ohm log dual gang
Input terminals
Output socket to suit headphones
Metal box
Headphones earpiece or headset preferably high impedance — 1 k ohm or more.



An internal view of the prototype

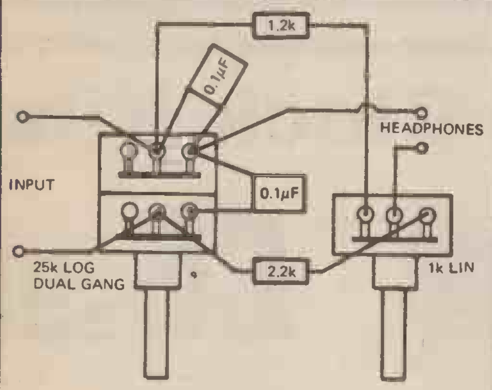


Fig. 2. Follow this diagram to wire the unit.

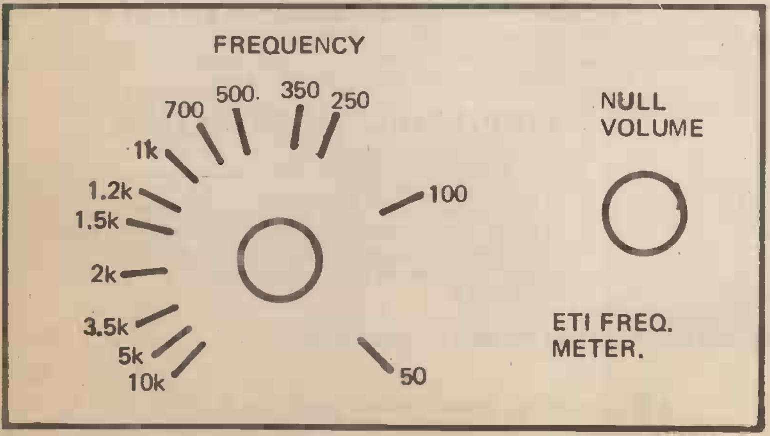


Fig. 3 Front panel of our meter shown for information only — calibration may not suit all potentiometers

may be used to detect the null but best efficiency will be obtained with those having an impedance of around one thousand ohms.

The best way to calibrate your meter is to compare it with a good quality oscillator and mark your scale to suit. Remember that most potentiometers have a manufacturing tolerance of ±20% and hence our front panel drawing may not be correct for your potentiometer.

If an oscillator is not available, but you do have an ohm-meter, then calibration may be carried out by measuring the settings of RV2 (disconnected from the circuit) and marking the scale as shown in Table I.

To use the meter, couple the audio signal into the input terminals and adjust RV2 to a point where the signal drops off. Adjust RV1 to increase the null and RV2 again for the final setting. The frequency of the incoming signal is then read from the front scale. What could be simpler? ●

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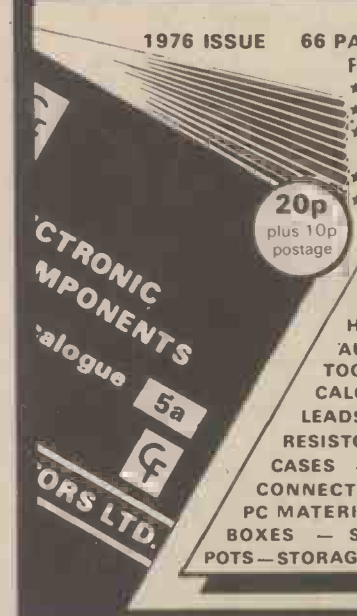

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IMPEDANCE METER

Measure impedance directly with ETI's new impedance meter — checks capacitance and inductance too!

THIS IS an unusual project — in that we started out designing one thing and finished up developing another!

We had intended to design an RLC bridge which is a very useful instrument and perhaps the next most commonly used after the multimeter, signal generator and scope.

But whilst it is useful to be able to measure the value of an individual component, on many occasions we are more concerned with the magnitude of the impedance than we are with the actual value of C or L.

For example assume that we require to know how the impedance of a speaker varies with frequency. Due to the effects of the crossover network it will not be known whether the speaker is inductive or capacitive in the crossover region. Additionally a speaker goes capacitive below its natural resonant frequency. Hence the use of an RLC bridge to plot impedance would be very tedious indeed. We would have to determine whether the speaker was capacitive or inductive, measure the actual value and then calculate the impedance for each point to be plotted.

With the ETI impedance meter impedance can be read *directly* as a function of frequency as shown in Fig. 7.

This is just one example of the many possible applications. In addition the meter may be used to measure component values by simply referring to a reactance chart or doing a simple calculation as detailed below.

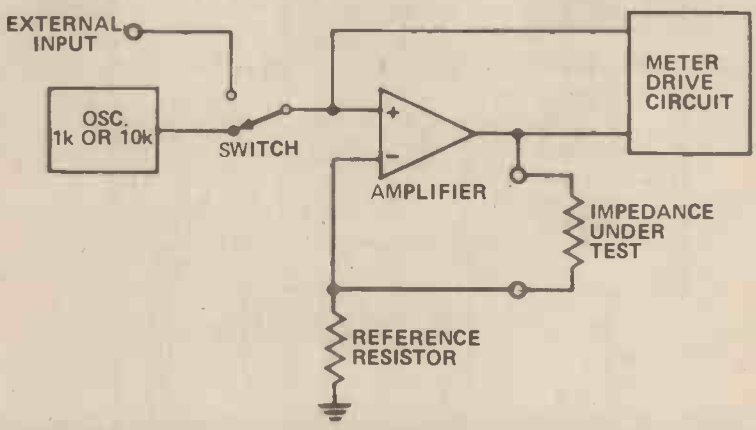
Other applications include measuring the impedances of microphones, filters, transformers and amplifier inputs etc. All can be measured as easily as one would measure a resistor using an ohmmeter. Simply by connecting the device to the input terminals of the meter and making the measurement as detailed in the "How To Use" section.

In most practical applications we require to know the magnitude of the impedance — we do not care whether the device is predominantly inductive or capacitive.

On the rare occasions that we do require to know reactance we can

Fig. 1. Block diagram of the impedance meter shows that it consists of an oscillator an amplifier and a meter circuit.

▼



SPECIFICATION

Impedance measuring range	1Ω – 1 Meg Ω	
Frequency of test	20 Hz – 20 kHz 1 kHz or 10 kHz	external internal
Range of inductance	10μH – 1000 H 20μH – 100 H	external internal
Range of capacitance	100 pF – 1000μF 100 pF – 100μF	external internal

Accuracy ± 5%

Voltage applied to unknown, max 1 V rms

When measuring items which are connected to the mains earth either the item, or the meter, must have the earth removed.

IMPEDANCE METER

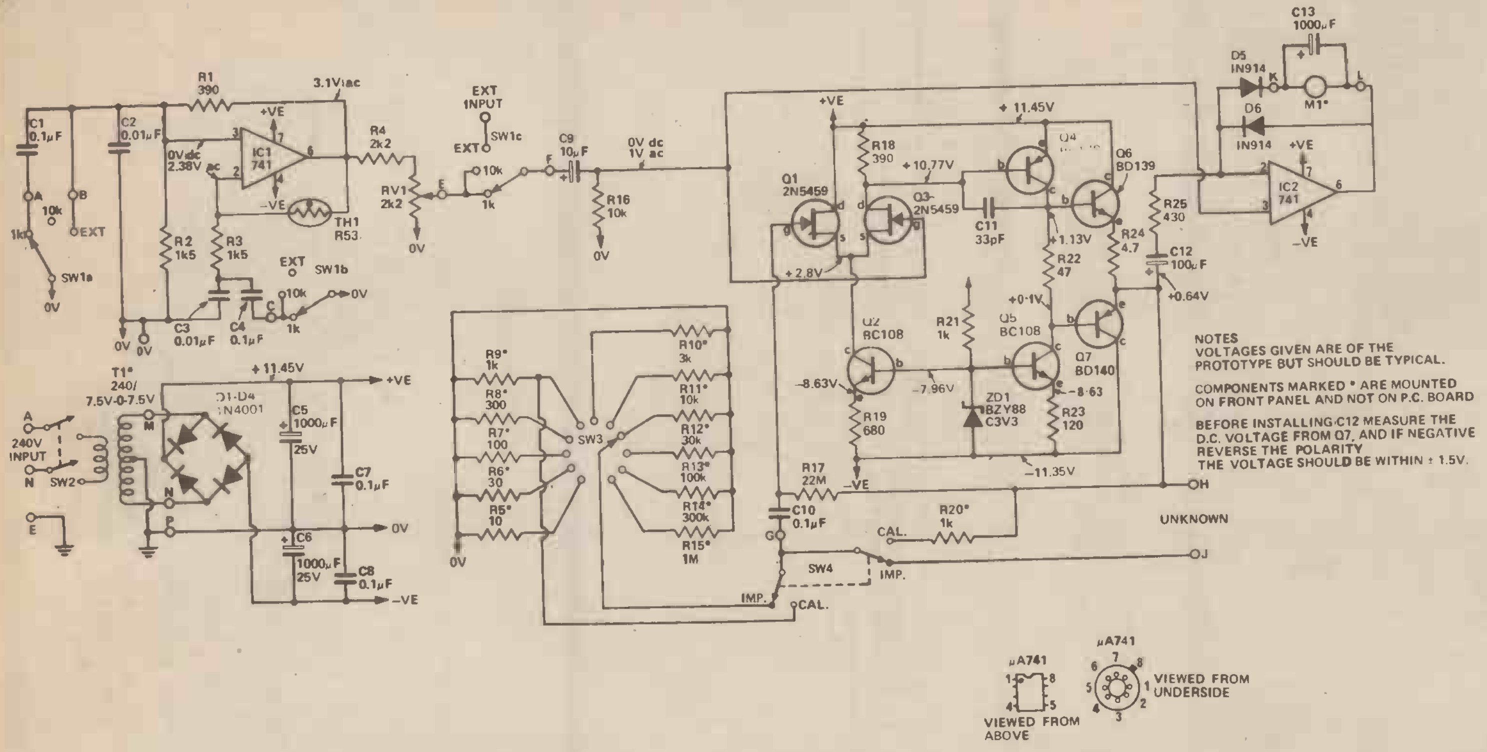


Fig. 2. Circuit diagram of the complete impedance meter.

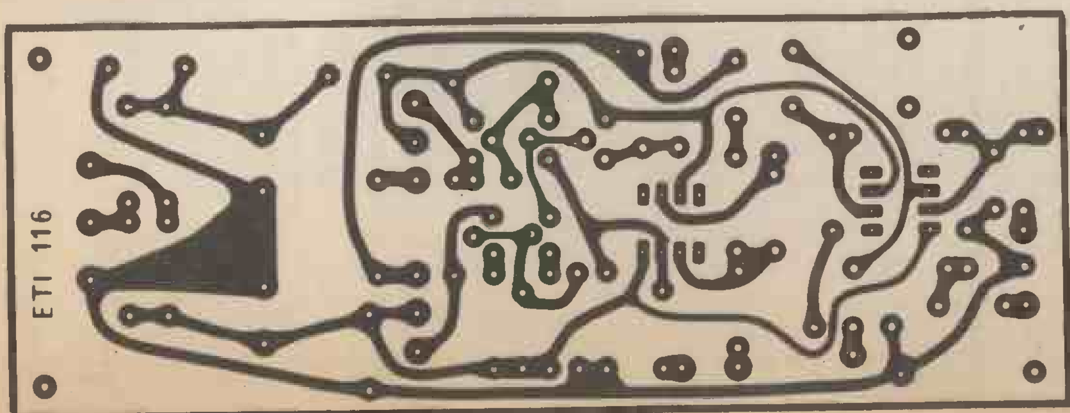


Fig. 3. Printed circuit board layout. Full size. 140 x 62 mm.

measure the dc resistance as well as the impedance and calculate from the formula

$$X = \sqrt{Z^2 - R^2}$$

where X = reactance inductive or capacitive at the frequency used

Z = magnitude of impedance (as measured on impedance meter)

R = dc resistance (as measured by an ohmmeter).

MEASURING CAPACITANCE

The value of an unknown capacitor can easily be determined by measuring the impedance and then using the reactance chart. Or, it may be calculated from the formula

$$C = \frac{1}{2\pi F X_c} \text{ (with capacitors } X_c = Z_c)$$

If the 10 kHz frequency is used this may be simplified to

$$\text{C in microfarads} = \frac{16}{Z_c} \text{ } (Z_c \text{ in ohms})$$

and if 1 kHz

$$C\mu F = \frac{160}{Z_c} \text{ } (Z_c \text{ in ohms})$$

Since the meter can resolve the range 1 ohm to 1 megohm this implies a capacitance range of 16pF to 60μF. But as explained elsewhere stray capacitance limits the lowest capacitance that can be resolved to about 100pF.

MEASURING INDUCTANCE

To determine the value of an unknown inductance the impedance is again measured and the value read off the reactance chart. Alternately the value may be calculated from

$$L = \frac{X_L}{2\pi F} \text{ high Q coils } X_L = Z_L$$

or $$L = \frac{\sqrt{Z_L{}^2 - R^2}}{2\pi F} \text{ (low Q coils)}$$

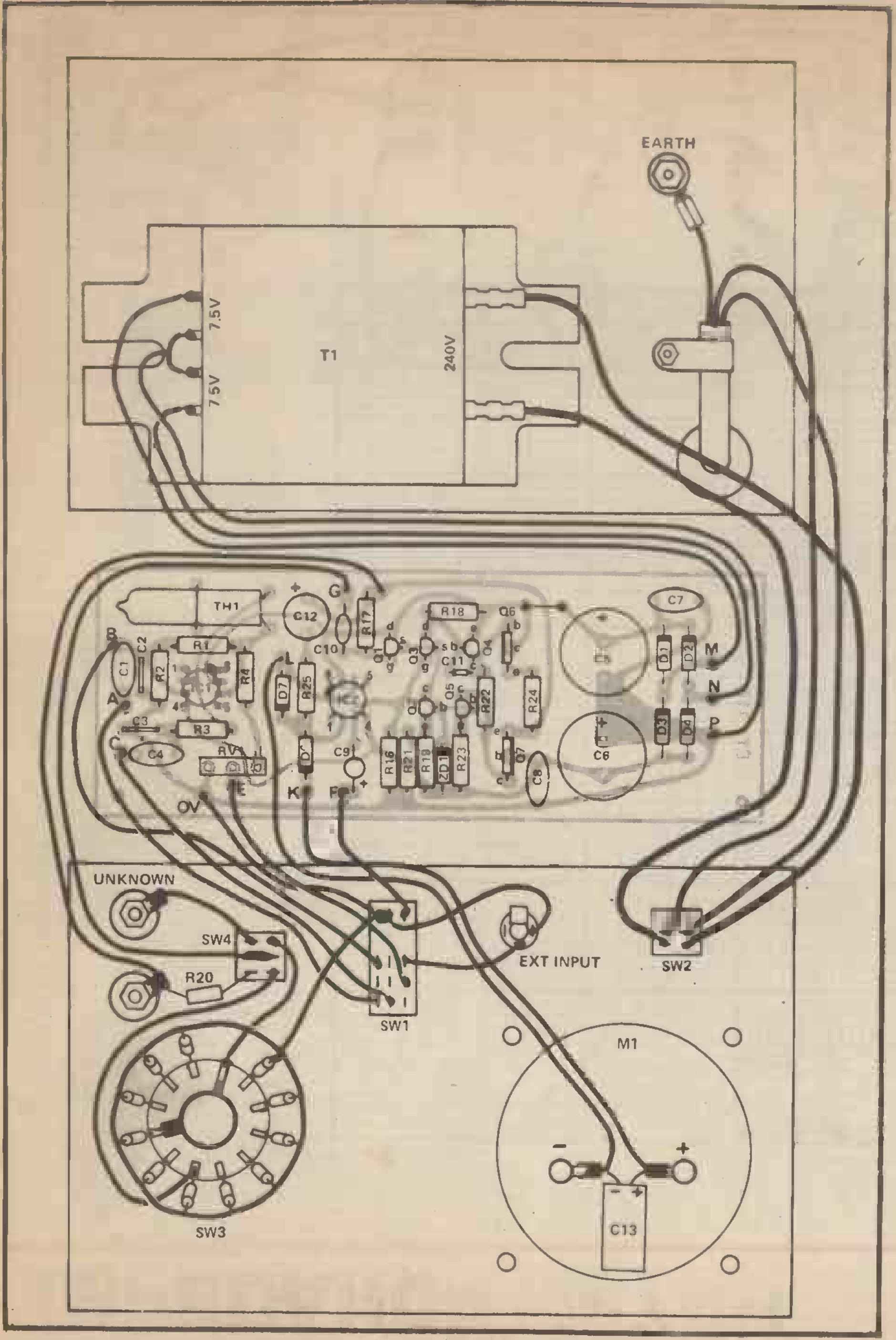


Fig. 4. Component overlay and wiring diagram for the impedance meter.

HOW IT WORKS ETI-116

The basic format of the impedance meter may be seen from the block diagram Fig.1. Firstly, we have an oscillator which may be switched to provide either 1 kHz or 10 kHz. Then we have a differential amplifier with a high input impedance, and lastly a meter drive circuit.

Either output of the oscillator, or an external frequency, as required, is passed to the non-inverting input of the amplifier. The amplifier gain is set by the ratio of the unknown impedance, Z, to the reference resistance, R. Due to feedback, the voltage across R is always equal to the input voltage and, as the amplifier requires no input current, the current through R must also flow through the unknown impedance, Z. The voltage across Z is therefore proportional to its impedance.

The meter circuit measures the output voltage by using the input voltage as a reference. Since the input voltage is equal to the voltage across R, we are effectively measuring the voltage across Z.

Refer now to the main circuit diagram Fig.2. The oscillator is of the Wein bridge type and uses a 741 IC as the amplifier and an R53 thermistor as the stabilizing element. The circuit oscillates at the frequency where the impedance of C2 and C3 is equal to the resistance of R2 and R3 respectively. Therefore, to change frequency, we simply change the values of C2 and C3. The output of the oscillator is attenuated by R4 and RV1 to approximately one volt.

The amplifier has a very high input impedance, can supply about 200 mA into a load, has an open-loop gain of 50 dB and can work into any load including a short circuit (unity gain).

An integrated circuit operational amplifier having the above characteristics (at reasonable cost) is not available, hence, a discrete seven transistor design was used. To obtain the high impedance input a pair of FETs, Q1 and Q3, used as a differential pair, operate with a constant current (4 mA) supplied by Q2. Transistor Q4 is supplied with a constant current of 22 mA by Q5, and Q4, in conjunction with the input pair, supplies the necessary overall gain. Transistors Q6 and Q7 buffer the output of Q4 and Q5 to provide the necessary current drive. The dc bias for the amplifier is provided by R17 such that an output voltage within ±1.5 volts of zero is always obtained.

The meter drive circuitry consists of a 741 IC with a meter, and half wave rectifier in series, connected in the feedback path. A second diode is used to prevent the IC being saturated on the opposite-polarity swing.

The current in the meter is half the current through R25 and, since this is proportional to the difference between input and output voltages of the amplifier, is proportional to the voltage across the unknown impedance. The meter scale is linear and the IC effectively compensates for the diode drop. Capacitor C3 provides the smoothing necessary when working at frequencies less than 40 Hz.

As previously stated the gain of the amplifier is set by the ratio of the unknown impedance 'Z' and the reference resistor 'R', and is equal to

$$\frac{Z + R}{R} \quad \text{(where Z may be complex)}$$

The value of R is switch selectable from 10 ohms to 1 megohm in eleven ranges. In the calibrate mode a 1 k resistor, R20, is substituted for the unknown impedance and the 1 k range selected. This provides a gain of two and thus with one volt in we have two volts out and hence 1 volt into the meter circuitry.

Thus, on calibrate, the output of the oscillator (or the external oscillator level) should be adjusted by RV1 to obtain full scale deflection on the meter. The calibrate position should also be selected before changing the unknown impedance, as an open circuit may damage the meter by driving it well beyond full scale.

IMPEDANCE METER

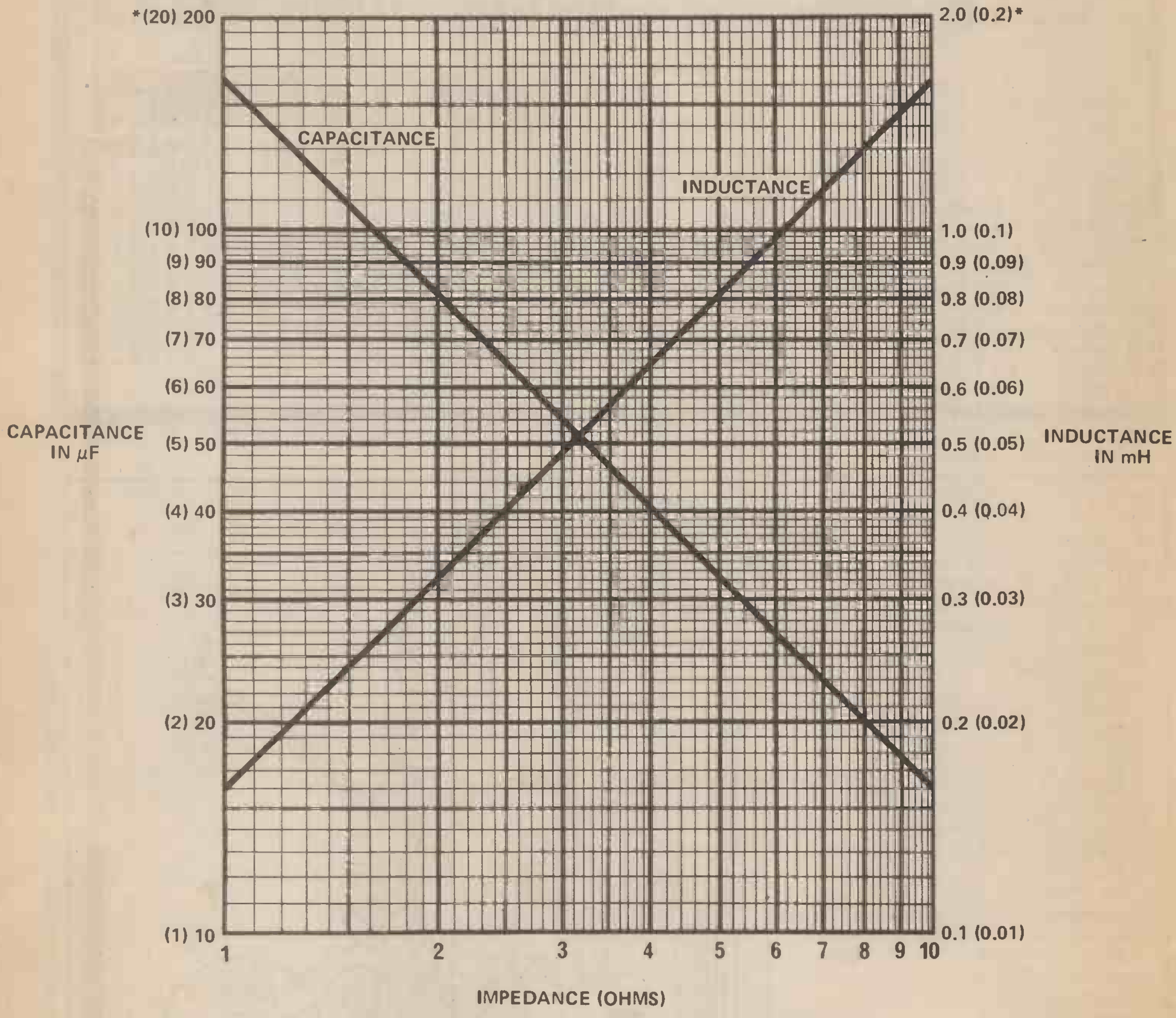
It should be borne in mind that we are determining impedances by using audio frequencies in this instrument hence components such as RF coils may well have a different impedance at RF frequencies (due to skin effect etc) than they do at audio. Additionally iron-cored coils have an inductance dependant upon the measuring frequency and upon dc current flowing. Hence such coils should be measured under conditions as close as possible to those when in circuit. Further the inductance value, as measured, will only be accurate on coils having a Q greater than 10.

If the dc resistance is greater than one tenth of the measured impedance the second formula should be used.

TURNS RATIO

To measure the turns ratio of an unknown transformer simply load the secondary with a value of resistance, R, which causes the impedance Zp (looking into the primary) to drop by 50% from the unloaded value. The turns ratio may then be calculated from

$$\frac{N_1}{N_2} = \sqrt{\frac{Z_p}{R}} \quad \text{(N = number of turns)}$$



FOR IMPEDANCES GREATER THAN 10Ω DIVIDE CAPACITANCE SCALE BY THE SCALING FACTOR AND MULTIPLY THE INDUCTANCE SCALES BY THIS FACTOR. e.g. A CAPACITOR WHOSE IMPEDANCE IS 6000 OHMS (SCALING FACTOR x 1000) AT 1 kHz VALUE IS 27/1000 = 0.027µF

*FIGURES IN BRACKETS ARE FOR 10 kHz

Fig. 5. Reactance chart for determining values of L or C from measured impedance at 1 kHz (10 kHz in brackets).

This calculation is based on the fact that an impedance in the secondary is transformed to an impedance in the primary that is proportional to the square of the turns ratio.

Many other applications can be devised for an impedance meter and the few mentioned here are indicative of the usefulness of such an instrument.

CONSTRUCTION

Any accepted construction method may be used but the use of a printed circuit board will greatly simplify the procedure.

Components should be assembled onto the printed circuit board, with the aid of the component overlay Fig 4, making sure that all polarized components are orientated correctly. Capacitor C12 should not be fitted initially as the required polarity must be determined as follows.

Temporarily connect the transformer to the otherwise completed board and switch on the power. Measure the voltage from the amplifier at point H. This should be within ±1.5 volts of zero. If this voltage is negative reverse the polarity of C12 to that shown on the overlay. If the voltage is positive use the polarity shown. This variation of voltage at point H is due to differences in the FET transistors Q1 and Q3.

Attach wires to all output connections of the printed circuit board allowing sufficient length to terminate them in their respective positions. Instal the board in position using 12 mm long spacers and countersunk screws. Countersunk screws are necessary as they will be covered by the lid of the box. Instal the power transformer and power lead, on the rear panel, together with the power-cord clamp and earth lug. Mount the slide switch to the front panel using countersunk screws.

Resistors R5 to R14 should be mounted on the rotary switch SW3 before mounting it on the front panel. If the 30, 300, 3k etc resistors are not available they may be replaced by a parallel combination; eg 30 ohms is obtained from 33 ohm and 330 ohms in parallel and 3 k from 3.3 k and 33 k in parallel.

The rest of the front panel components, except the meter, (for ease of wiring) should now be mounted together with the escutcheon. The wiring can now be completed and the meter installed and connected.

USING THE METER

The meter should be used in the following manner:–

1. Switch the cal/impedance switch to cal.

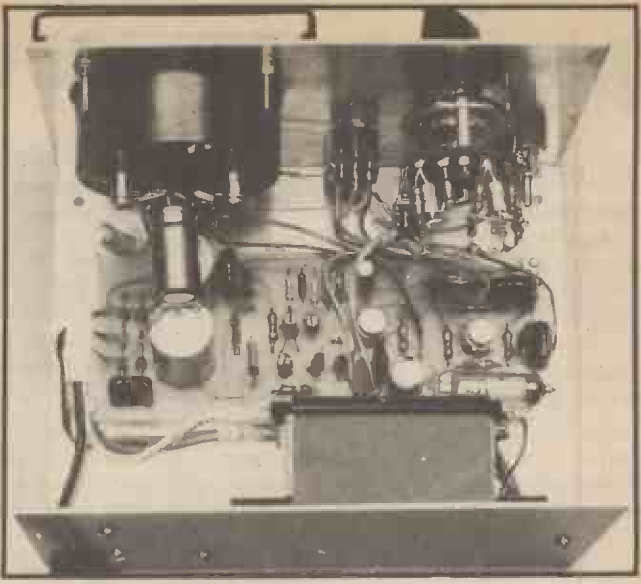


Fig. 4. Internal view of the meter shows how the board and other components are positioned.

2. Switch on power.

3. Select the required test frequency. The meter should read full scale, if not, adjust RV1.

4. If an external oscillator is used set the frequency and adjust oscillator output level to obtain full scale reading.

5. Connect the impedance to be measured.

6. Select the one megohm range.

7. Switch the cal/impedance switch to impedance.

8. Reduce the range, if necessary, to obtain a readable deflection. This reading is the required impedance; eg 0.6 on the 10 k range is an impedance of 6 k.

9. If desired the external frequency may be varied to obtain a plot of impedance versus frequency.

10. Switch back to 'Cal' before removing the impedance being measured.

TABLE 1

Error	Resistance (R2/R3)	Capacitor (C1,C4)	Capacitor (C2,C3)
1%	150k	0.001μF	100 pF
2%	68k	0.0022μF	220 pF
3%	47k	0.0033μF	330 pF
4%	39k	0.0039μF	390 pF
5%	27k	0.0056μF	560 pF
6%	22k	0.0068μF	680 pF
7%	18k	0.0082μF	820 pF
8%	18k	0.0082μF	820 pF
9%	15k	0.01μF	1000 pF
10%	13k	0.01μF	1000 pF

PARTS LIST – ETI 116

R24	Resistor	4.7 ohm	½W 5%
R5	"	10	" " "
R6	"	30	" " "
R22	"	47	" " "
R7	"	100	" " "
R23	"	120	" " "
R8	"	300	" " "
R1,18	"	390	" " "
R25	"	430	" " "
R19	"	680	" " "
R9,20,21	"	1k	" "
R2,3	"	1k5	" "
R4	"	2k2	" "
R10	"	3k	" "
R11,16	"	10k	" "
R12	"	30k	" "
R13	"	100k	" "
R14	"	300k	" "
R15	"	1M	" "
R17	"	22M	" 10%
RV1	Potentiometer	2k2	Trim type
TH1	Thermistor	type R53	
C11	Capacitor	33pF	ceramic
C2,3	"	0.01μF	polyester
C1,4,7	"	0.1μF	"
C8,10	"	0.1μF	"
C9	"	10μF 16V	electrolytic
C12	"	100μF 6.3V	electrolytic
C13	"	1000μF 6.3V	electrolytic
C5,6	"	1000μF 25V	electrolytic
Q1,3	Transistor	2N5459	or similar
Q2,5	"	BC108	"
Q4	"	BC178	"
Q6	"	BD137, BD139	
Q7	"	BD138, BD140	
IC1, 2	Integrated Circuit	μA741C	mini dip or T05
D1-D4	Diodes	1N4001	or similar
D5,6	"	IN914	"
ZD1	Zener Diode	3.3V, 400mW	or simliar
T1	Transformer	240V/7.5-0-7.5V @ 1A	
M1	Meter	0-1mA FSD.	75 x 65 mm
SW1	Switch	three pole three position slide switch	
SW2	"	DPDT 240V toggle switch	
SW3	"	one pole eleven position rotary switch	
SW4	"	DPDT toggle switch	

PC board ETI-116, Metal box, Front panel, small phone socket, pointer knob, 3 core flex and plug, rubber grommet and cable clamp, four 12mm long spacers, two terminals, nuts and bolts etc.

IMPEDANCE METER

FREQUENCY CALIBRATION

The frequency should be within 10% of nominal if specified components are used. However, if a frequency meter is available the network can be trimmed to give the correct readings.

Measure both the 1 kHz and the 10 kHz and calculate the percentage errors. If either or both are low in frequency the resistors R2 and R3 can be paralleled with additional resistors to increase the frequency. Since this will affect both ranges choose the one with the greatest error. Table 1 gives the correct resistance to use.

Re-measure the frequencies. One frequency should now be right and the other high. The capacitors C1 and C4 or C2 and C3 can be paralleled by the appropriate capacitors as selected from Table 1.

LIMITATIONS

Due to stray capacitance, (about 15 pF) associated with the front panel terminals and the switches, the 1 megohm range is useful only up to about 4 kHz. The 300 k range is useful to about 10 kHz.

When measuring series LCR networks (where the impedance rises greatly off resonance) it is usually necessary to parallel a resistor across the network to stabilize it. Once at resonance, the resistor may be removed for the actual impedance measurement. The frequency can now be altered provided that the meter is not allowed to go off scale. The resistor used should be not more than 10 times the value of the network impedance at resonance. ●

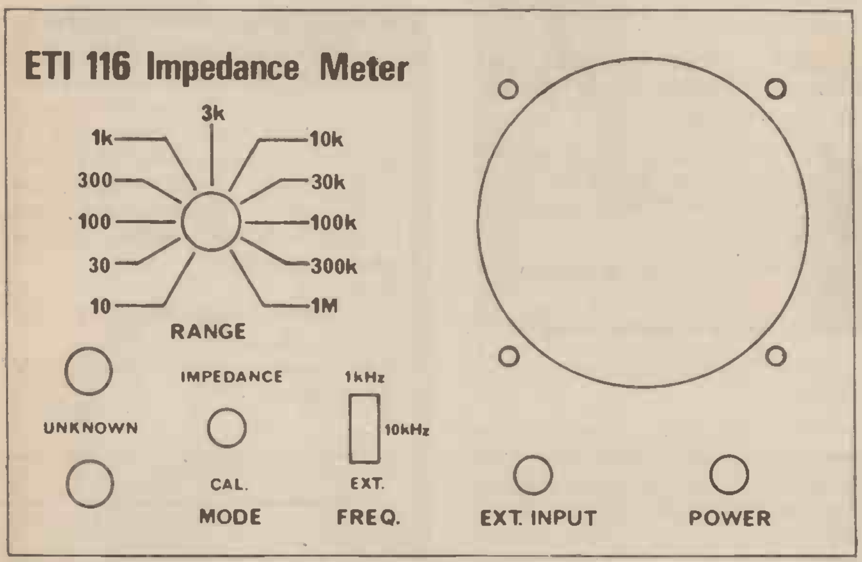


Fig. 6. Layout of front panel. Full size is 152 x 98 mm.

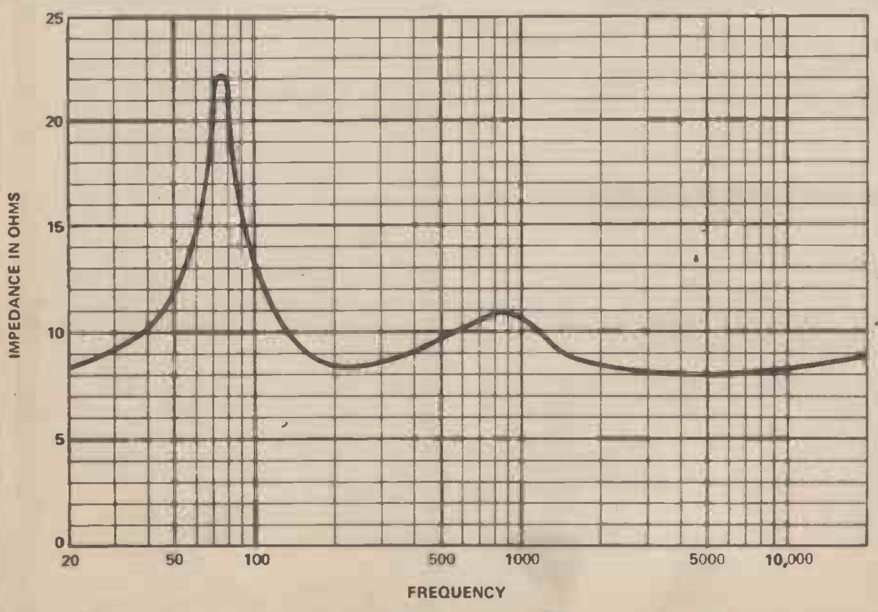
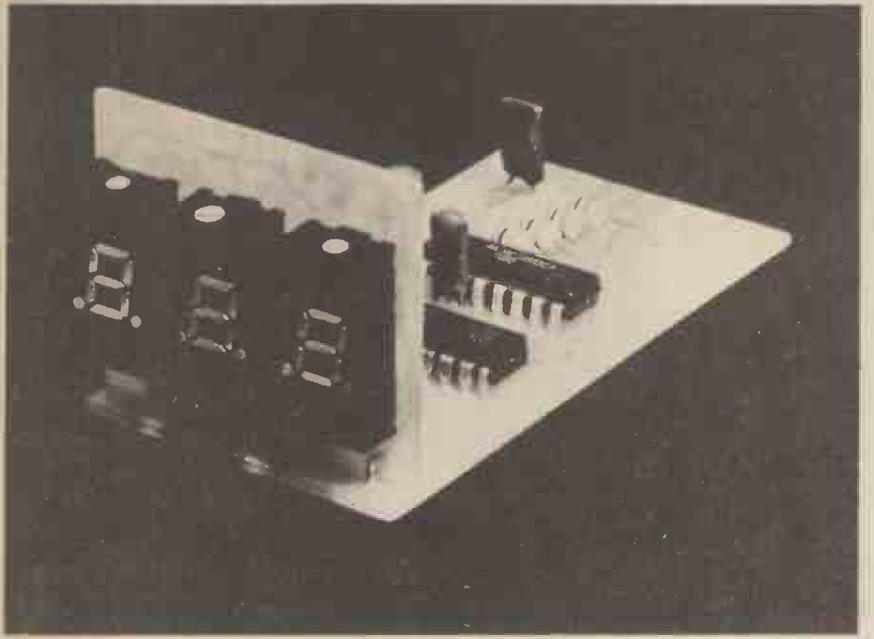


Fig. 7. Impedance-versus-frequency plot for a two-way speaker box. Note the combined speaker/box resonance is 75 Hz. The crossover frequency was 2 kHz. A plot such as this would be extremely difficult to generate using a conventional LCR bridge, but is very simply done using the ETI 116 impedance meter.

DIGITAL DISPLAY

The ETI Digital Display has been used in a number of projects in the magazine including the Digital Voltmeter in this Project Book.



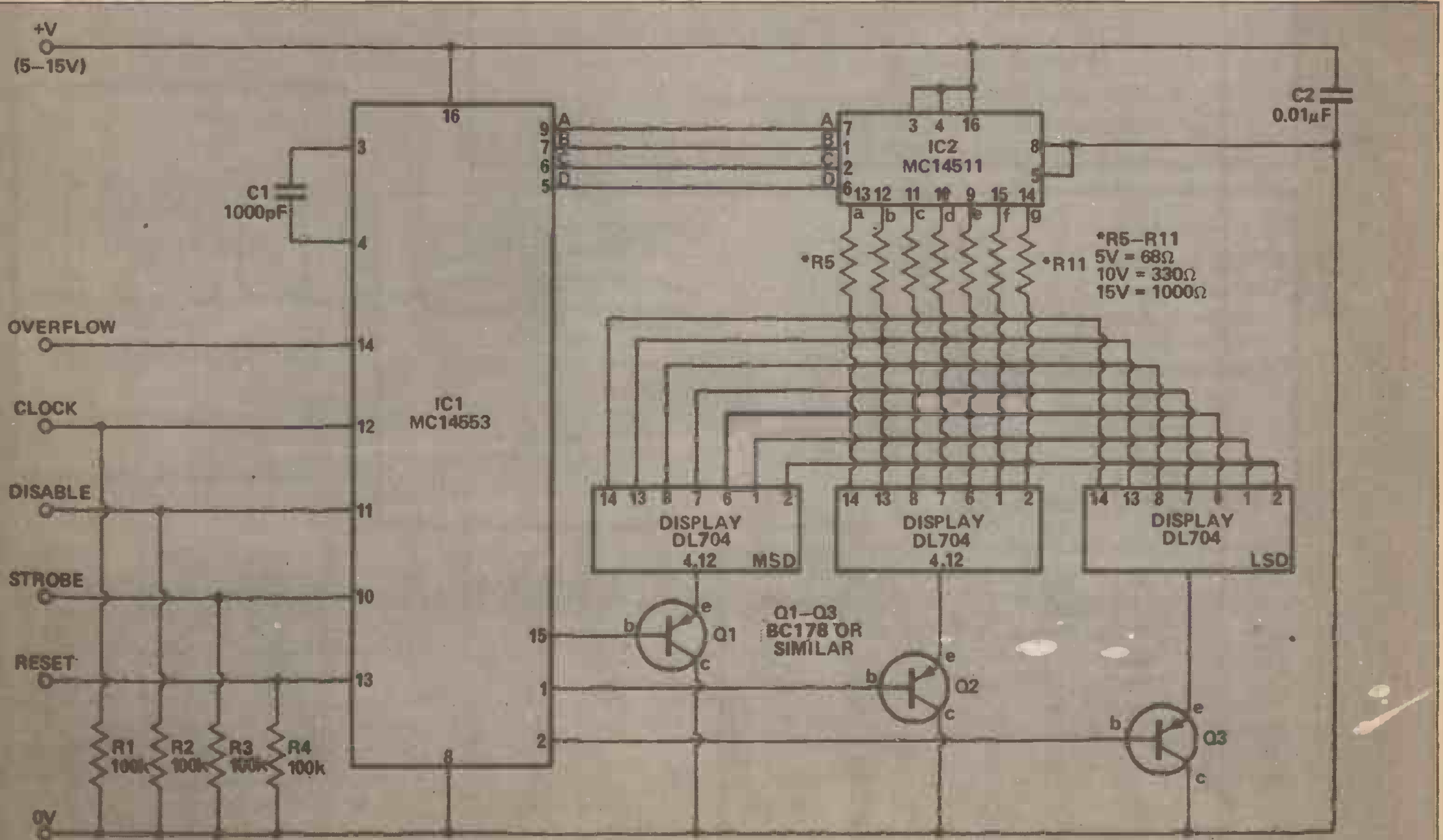
Three digit module for experimenters.

ALL digital instruments have a common assembly in the display system. Again, almost all instruments require decade counters, stores and decoder-drivers for the display.

Normal systems using TTL logic generally have a 7490, a 7475 and a 7447 to drive each 7 segment LED display digit. Hence to build a three-digit display nine ICs are required in addition to three display ICs.

Complex logic functions are available in CMOS which allow a 3 digit display to be built using only two ICs — and such ICs are available at reasonable cost. One of the devices is a three-digit, decade-counter, store and the second is a three-digit decoder-driver. Thus three digit displays can be built which have the following advantages.

1. Small size
2. Low power consumption (120 mA compared to 600 mA in TTL)
3. Wide power supply range (5-15V unregulated).



FOR DECIMEL PT. (RIGHT HAND)
ON DISPLAY CONNECT
PIN 9 TO +V VIA RESISTOR
(OF SAME VALUE) AS ABOVE

Fig. 1. Circuit diagram of the three digit counter module.

DIGITAL DISPLAY

4. Cost about same as TTL but rapidly decreasing.
5. Immunity to noise is greatly improved.

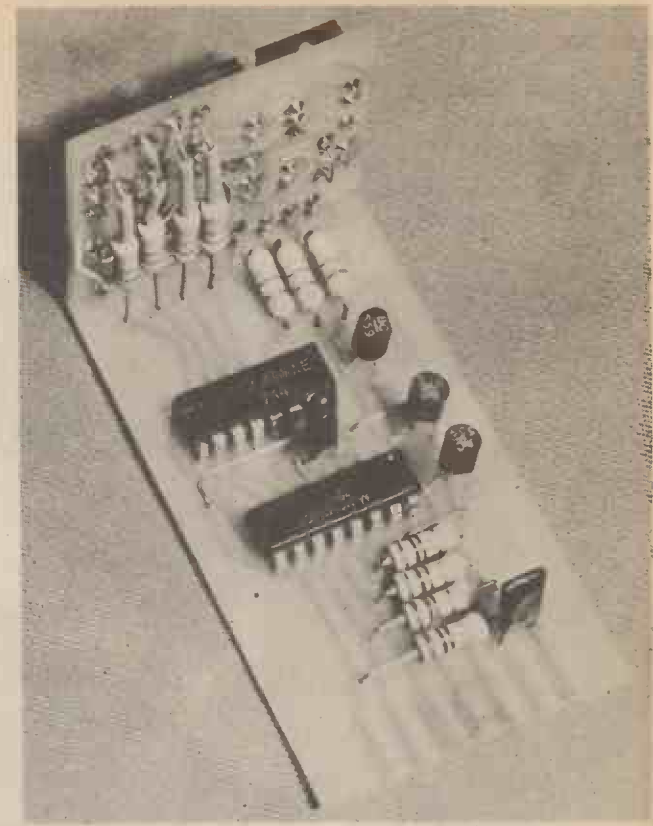
Disadvantages

Maximum frequency about 1 MHz compared to 15 MHz for TTL..

CONSTRUCTION

Construction is quite straightforward especially if the printed circuit boards described are used. Since both ICs are CMOS devices, they can be easily damaged by static charges. Hence they should be handled as little as possible, fitted to the board after all other components and soldered using a minimum of heat.

Using the component overlay assemble the three DL704 displays to the display board (533B). Next solder the links onto the copper-side of the



Rear view of the completed module. Note resistors and links at rear of display board.

PARTS LIST – ETI 533

R1, 2, 3, 4 Resistor 100 k
R5-11 " see text.

C1 Capacitor 0.001 μF Polyester
C2 " 0.01 μF Polyester

IC1 Integrated Circuit MC 14553 (CMOS)
IC2 " " 14511 or 4511 (CMOS)

Q1,2,3 Transistor BC 178 or similar
DISPLAYS DL704 or similar three required
PC boards ETI 533A and ETI 533 B
IC1 and IC2 are available from Marshall's

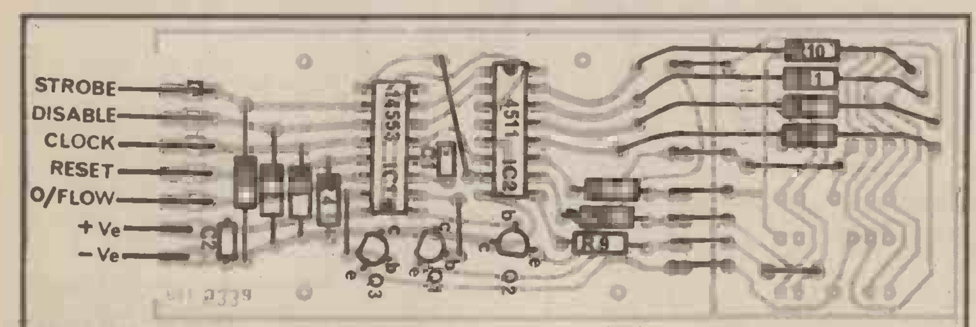


Fig. 2. Component overlay-logic board.

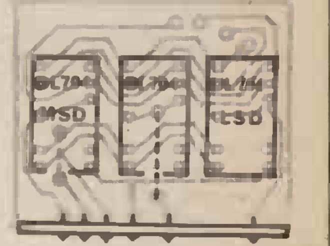


Fig. 3. Component overlay – display board.

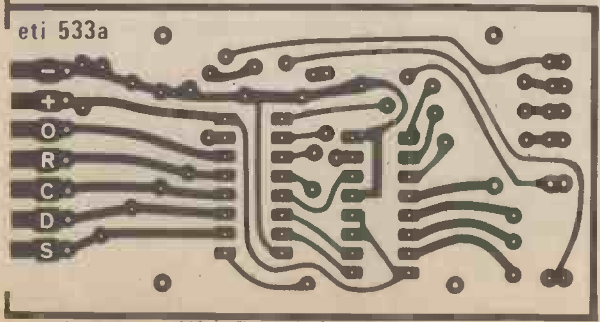


Fig. 4. Printed circuit layout for logic board. Full size 80 x 42 mm.

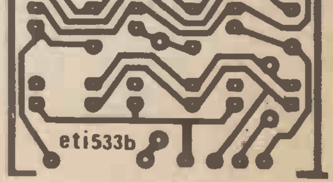


Fig. 5. Printed circuit layout for the display board. Full size 41 x 35 mm.

HOW IT WORKS – ETI533

The heart of the counter is IC1, this LSI CMOS chip contains a three-digit decade counter, three sets of latches, and a three-digit multiplexer with an internal oscillator. C1 is used to set the frequency of this oscillator.

The four input lines to IC1 are used to control the operation of the counter. Since IC1 is a CMOS device R1-4 are used to protect its inputs. Pulses to be counted are fed to the clock input and on a negative transition the value in the counter is increased by one. The schmitt-trigger action of the clock input allows any value of transition time of the input pulse.

The counter operates when there is a low at the disable input (pin 11).

To ensure accurate counting the clock should be low when the disable is brought from a high to a low level. The strobe input controls the loading of the latch. When it is low, data can be accepted for display. However the strobe input has no effect on the counter, i.e, even with the strobe input high, the counter can still be incrementing.

A high on the reset input clears the counters (to a 000 state) and stops the internal multiplexing oscillation of IC2, and so – blanks the display. Returning the reset to a low allows the internal oscillator to start up and all zeros to be displayed. This feature could be used in portable equipment to conserve power.

All inputs are standard CMOS inputs and require a minimum voltage change of from 30% to 70% of supply volts. However it is recommended that a swing from 0V to supply be used to give a satisfactory noise margin. Each input can be considered to be 100k shunted by 8-10 pF. Voltage swing below 0V and above supply are also to be avoided.

The one output available is the overflow (pin 14). This goes positive when the counter is 999 and the clock input is high. When the clock input goes low and advances the counter to all zeros the overflow goes low. This is a CMOS output and will swing between supply rails. It is not recommended that the overflow output be used to drive TTL directly.

The internal multiplexer of IC1 allows considerable saving in parts and board space. It allows a three-digit number to be transmitted over a single set of lines and it does this by leaving each digit on the output lines for a short length of time, before replacing it with the next digit. Then after presenting all the digits once, it starts over again and repeats the operation.

IC2 is a CMOS, latch BCD to seven-segment decoder and driver, however for this application the latch is not used. It converts the 4-bit BCD code into the seven-line code necessary to drive the display segments. It also provides sufficient current to drive the display. Although IC2 is coupled to all three displays, only one display is lit up at any one time. Thus when it is the turn of the most significant digit to be displayed IC1 presents that number to IC2 which decodes the number and presents it to the three displays, but only Q1 is turned on, so only the left most display lights.

Note that IC1 controls which number is being presented and which transistor is turned on. This is called multiplexing. The switching between displays occurs so quickly that to our eyes the light appears continous.

Resistors R5 to R11 limit the current to each LED display to a safe level. Three different values have been given for these resistors. Select the value appropriate to the supply voltage that you decide to use, 68 ohms for 5 V, 330 ohms for 10 V and 1k for 15 V. Transistors Q1, Q2 and Q3 also act as current amps since only a limited amount of current can be taken from IC1.

Any voltage from 5 V to 15 V can be used to supply the counter, however, a supply voltage of 15 V allows the counter to operate at its highest speed.

display board and form them so that they are clear of other tracks by at least one millimeter.

Next fix lengths of tinned copper wire to each of the six holes on the bottom of the display board. Allow approximately 10 mm of wire to extend from either end of the holes. Bend each wire so that they lie parallel and flush to the surfaces of the display board – do not solder as yet.

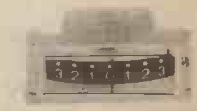
On the main printed-circuit board (533A) fit resistors R7, 8, 9, 12, 3 and 4 and capacitors C1 and C2. Now mate the display board to the main board by inserting each of the previously bent wires into its corresponding pair of holes on the main board.

Apply gentle force to the display board until its bottom edge fits snugly against the main board. Solder each of the wires to both the supply and main boards to make a sound electrical and mechanical support for the display.

Fit R5, 10 and 11 and, taking care to orientate them correctly, fit Q1, 2 and 3 and IC1 and 2.

Lastly check that all components have been correctly fitted and all solder joints are good. If possible get someone else to check your final circuit as a final safeguard. ●

88 92 96 100 104



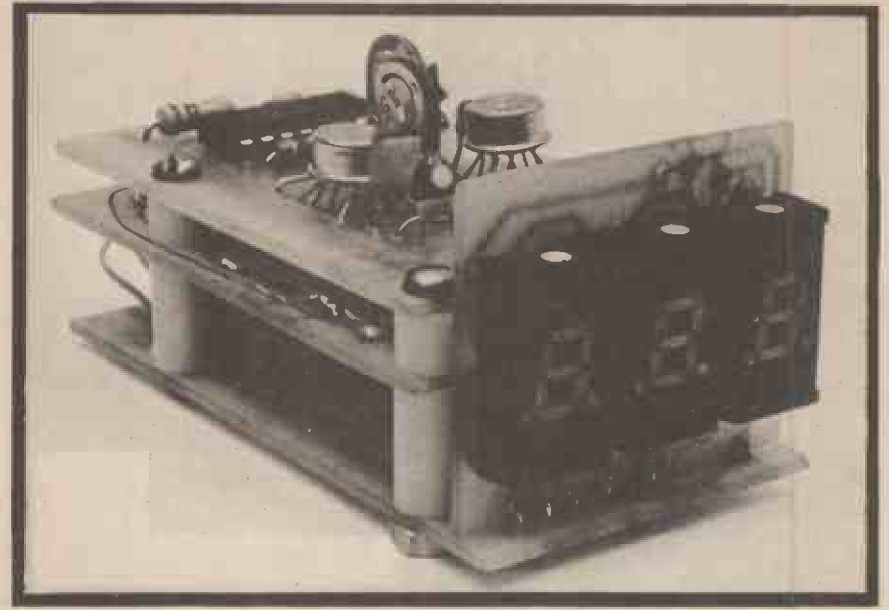
3 2 1 0 1 2 3

DIGITAL VOLTMETER

AN ARTICLE elsewhere in this book details a simple, three-digit display module which is readily adaptable to a wide range of applications and is inexpensive to build. This month we provide details of the first of a series of modules specifically designed to interface with the ETI 533 display module.

The first of these modules is a simple, yet accurate, dc digital voltmeter. Fundamentally we have described it as a single range unit which is economical enough to be mounted within other equipment as a panel meter. However an input switch may be readily added to convert the instrument for use on ranges from one volt dc full scale to 1000 volts dc full scale.

We have not described the mounting of the unit in a cabinet or box as individual requirements will vary widely.



Inexpensive unit uses dual-slope technique

Fig.2. Circuit boards used for the converter.

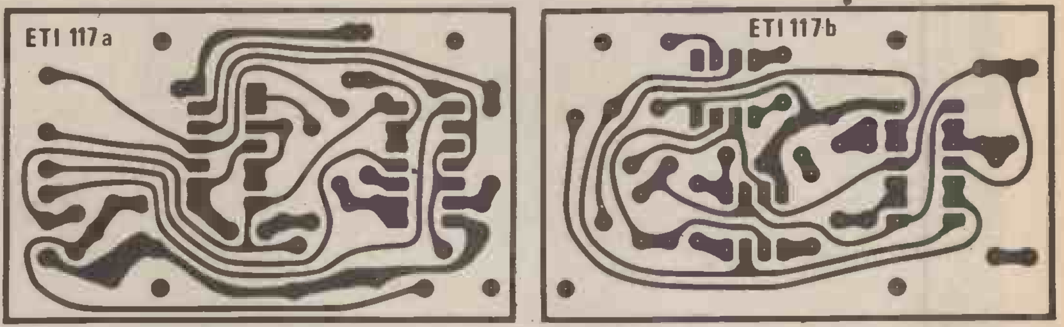


TABLE I

RANGE	VALUE OF R12	
1V	100k	5%*
10V	1M	5%*
100V	10M	5%*
1000V	100M (10 x 10M)	5%*

For multirange meters R12 must be 1% or adjustable.

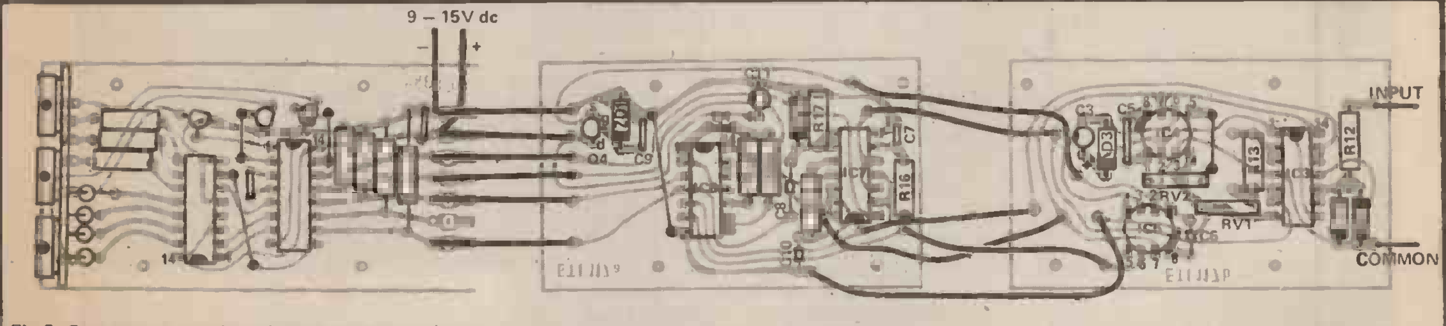


Fig.3. Component overlay of the complete voltmeter.

Fig.4. How the voltmeter appears before final assembly.

MEASURED PERFORMANCE OF PROTOTYPE

Number of digits	3	
Overrange	250% (no indication on first digit)	
Dual polarity	No	
Ranges	1, 10, 100 and 1000 V dc	
Accuracy	As adjusted	
Linearity	±1 digit	
Power supply	9-15 V dc at 120 mA isolated	
Input impedance	100 k/V	
Overrange Protection		
1 V range	100 V	limited by power
10 V range	500 V	dissipation and
100 V range	500 V	voltage rating of
100 V range	2500 V*	R12
	* input switch permitting	
Reference	5.1 volt zener at constant current.	

HOW IT WORKS

The method of analogue-to-digital conversion used is the popular dual-slope integration technique. A general explanation of this method was given last month in our multimeter survey and reference should be made to that article. We chose the dual-slope technique because it is relatively insensitive to component tolerances and gives very linear results with least amount of circuit complexity. The technique was developed by Weston and hence is covered by patents, however, there is nothing to stop individual constructors from using it, nor are there any royalties involved.

The circuit consists of an integrator (IC4 and C3), a comparator (IC5), an input selector (IC3), an oscillator (IC6/1,2,3) an RS flip flop (IC7/1,2), pulse generators for the reset and strobe outputs (IC6/4, IC7/3,4), a voltage reference (ZD1 and constant current source Q1), and (last month's) digital display module.

The 5 kHz output of the oscillator, which runs continuously, is connected directly to the clock input of the display module and the conversion proceeds as follows. Flip Flop IC7/2, drives IC3 such that it selects either the input voltage via R12 or the reference voltage via R13. The state of the flip flop is determined by the output state of the comparator IC5 (output high selects input voltage) and the overflow output from the display module (overflow selects reference voltage). If the input voltage is selected the output of the integrator will fall at a rate dependant on the input voltage, and, if the reference voltage is selected the input voltage will rise at a constant rate.

When the integrator output rises above 5.1 volts the comparator output goes high causing the output of IC6/4 to go low (as pin 5 of IC6/4 is also high). After about 10 μseconds delay, due to R16 and C7, the flip-flop changes state and the output of IC6/4 goes high again Thus a pulse is generated which is used as the strobe to transfer whatever number is in the decade counters into the store, and hence, to the display. The strobe pulse also triggers a 15 microsecond monostable, IC7/3, the output of which is delayed by 10 microseconds and inverted by IC7/4. This new pulse acts as a reset pulse for the counters setting them to zero.

As the flip flop has now reverted to its original state the input voltage is reselected and the integrator commences to ramp down again repeating the cycle.

Whilst the input voltage is selected clock pulses are gated into the counter and after about 200 milliseconds (1000 clock pulses each 0.2 mS) the counter will be full. The overflow thus generated from the display changes the state of the flip flop and the reference voltage is selected. The voltage across the integrator (referenced to 5.1 volts) at this instant will be proportional to the input voltage. With the reference supply connected the output of the integrator will rise at a predetermined rate and on crossing the 5.1 volt reference level the strobe and reset pulses are generated, the flip flop toggled and the process started again.

The time taken to bring the integrator back to the reference level is proportional to the input voltage and hence the number in the decade counter at that instant is the required reading of input voltage.

The only components which are required to have good stability, if accuracy is to be maintained, are R12, R13 and ZD1. All other components, provided their short-term stability is good, can be almost any tolerance. The integrator capacitor, for example, can have any value between 0.5 microfarad and 2.0 microfarads without affecting accuracy. However variations in the value of this capacitor will affect the over-range capability. The clock frequency may likewise be altered without affecting accuracy however, if the time of 1000 clock pulses is a multiple of 20 milliseconds the voltmeter will automatically reject 50 Hz ripple on the voltage being measured. This however was not considered of great enough importance to warrant special adjustment of the clock frequency which is preset by R15 and C4.

The reference supply is a 5.1 volt zener diode and a FET connected as a constant current source. The 5.1 volts is used as the common and hence, the 12 volt supply for the voltmeter must be left floating and must not be connected to ground or to any other equipment.

Due to the simplicity of the circuit there are some features of the instrument which are not desirable but do not greatly affect the operation of the instrument. Firstly there is no over-range indication and thus if 15 volts is applied to the 10 volt range the instrument will read 5 volts. The unit remains accurate (except for the first digit which is lost) until the integrator clips on its negative swing (about 250% of full scale). The other point is that if the input voltage is negative the comparator, IC5, will remain high and no further strobe or reset pulses will be generated. The effect of this is to freeze the display at the last number. This is not normally a problem as the display goes to zero if the input is disconnected.

CONSTRUCTION

The display-counter module ETI 533 should be built first.

Two additional boards are required to complete the voltmeter and the overlays and interconnections are given in Fig. 3. Check that all components, especially the metal case ICs are orientated correctly.

The interconnection wires should be long enough to allow the boards to fold together as shown above. The lower board ETI 533A has the components uppermost, the middle board ETI 117A has the components

DIGITAL VOLTMETER

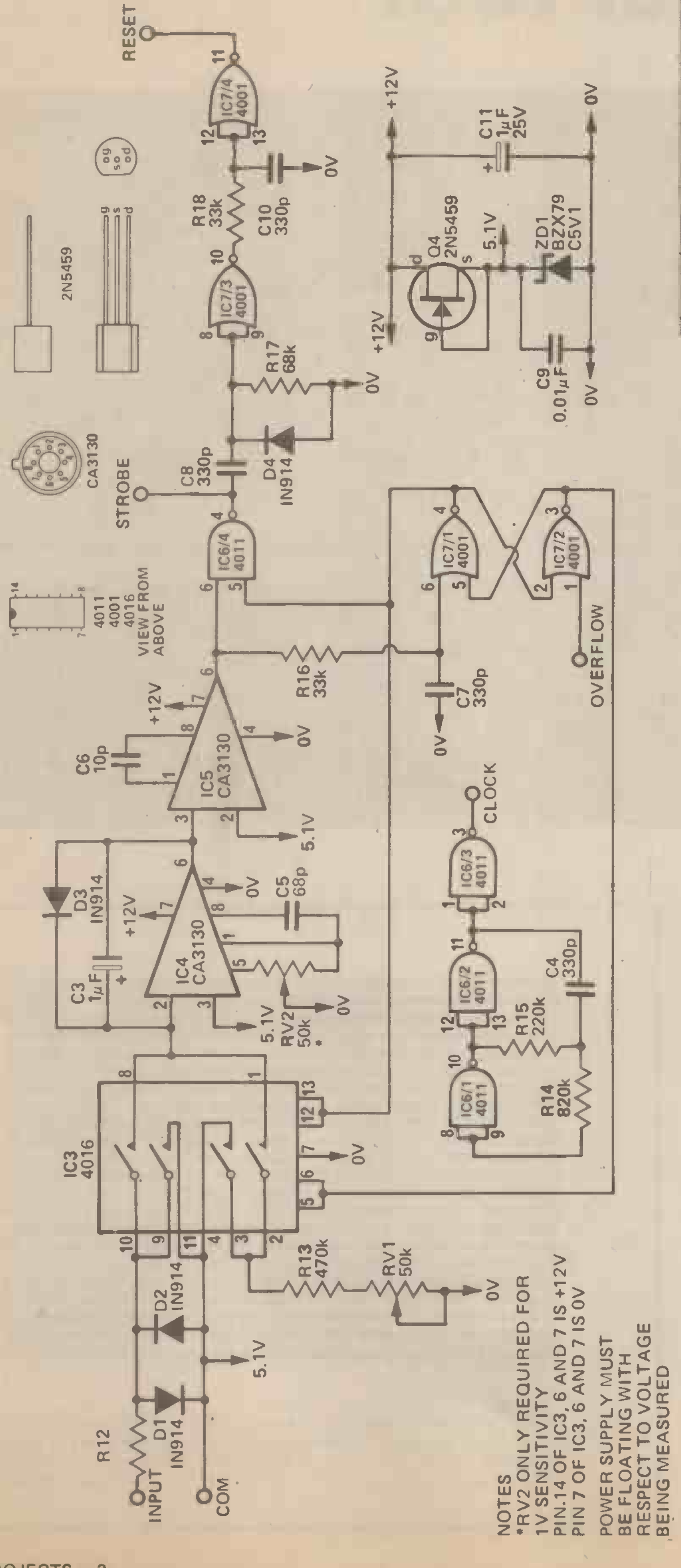


Fig. 1. Circuit diagram of the dual-slope analogue to digital converter. This circuit is used together with the ETI 533 display to make the complete voltmeter.

PARTS LIST

R16,18	Resistor	33k ¼w 5%
R17	"	68k " "
R15	"	220k " "
R13	"	470k " "
R14	"	820k " "
R12	"	See text
RV1,2	Potentiometer	50k Trim type
C6	Capacitor	10pF ceramic
C5	"	68pF "
C4,7,8,10	"	330pF "
C9	"	0.01μF polyester
C3,11	"	1μF 25V Tantalum
D1,2,3	Diode	IN914 or similar
ZD1	Zener diode	5.1V, 400mW
Q1	Transistor	2N5459 or similar
IC3	Integrated circuit	4016 (CMOS)
IC6	" "	4011 (CMOS)
IC7	" "	4001 (CMOS)
IC4,5	" "	CA3130

PC Boards ETI 117A, ETI 117B

Display Board Complete — Project ETI 533

downwards while the top board ETI 117B again has the components uppermost. It may be necessary to juggle the components slightly on the lower two boards to allow them to fit together closely enough. These two boards are spaced apart with 12mm long spacers while the upper two boards are separated by 6mm insulated spacers. A piece of insulation material should be fitted between the top two boards to prevent the solder joints touching.

Power, 9-15 volts dc, is supplied to the lower board while the input connects to the upper board.

The unit can be either installed in a suitable box or within a piece of equipment. If range switches are required simply change the value of R12 as per Table 1.

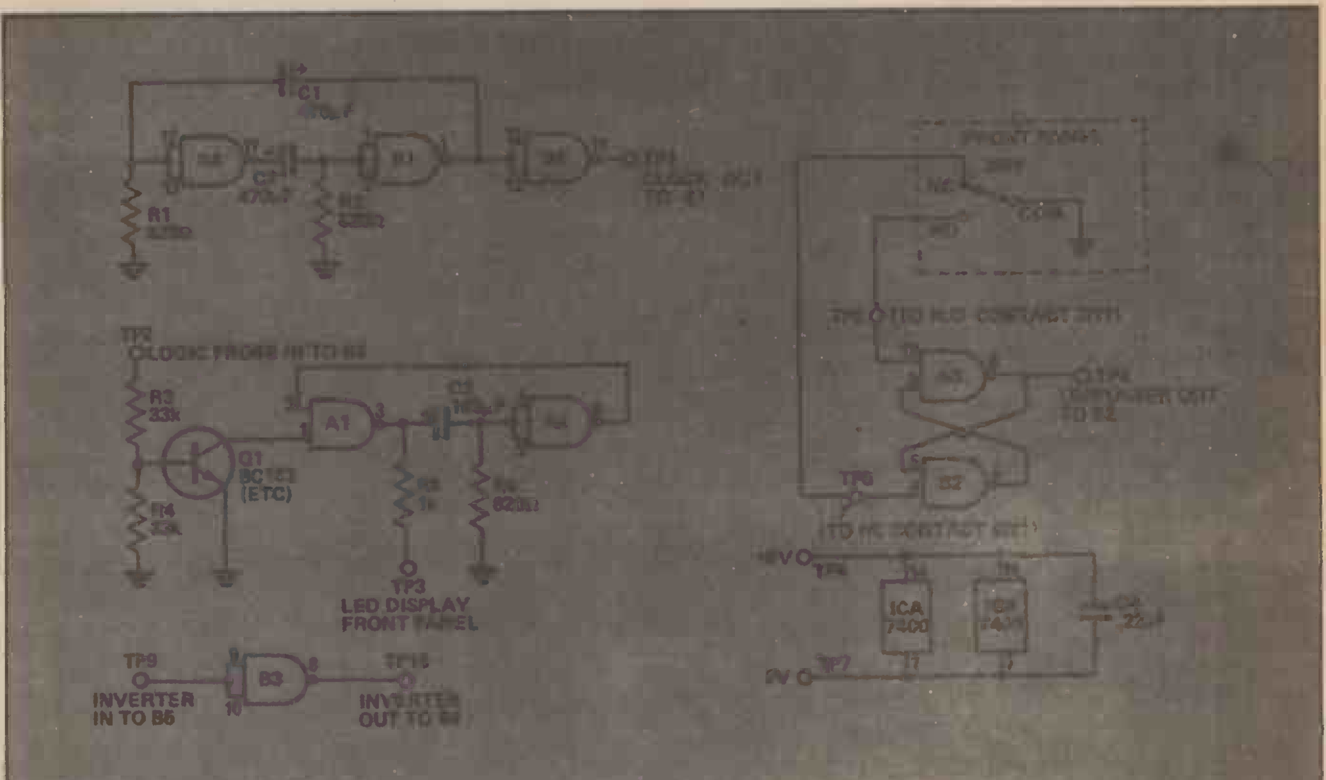
CALIBRATION

Unfortunately to calibrate any voltmeter a known voltage reference or an accurate voltmeter is required for comparison. Two adjustments are provided, one for calibration and the other to compensate for the offset in the integrator IC. For input voltages of 10 V or more the offset potentiometer is not required as the error is within one digit.

This offset potentiometer should be adjusted first by applying a voltage of about one per cent (10 digits) of full scale and adjusting RV2 to give the correct reading. The calibration potentiometer RV1 can now be adjusted by applying an accurately known voltage near full scale.

The meter has a large overrange and voltages up to 250 per cent of full scale can be measured except that the first digit is lost and must be assumed, ie, if you are measuring a car battery on a 10 V range and it reads 3.52 V it is obviously 13.52 V. ●

TTL super test



Circuit diagram of complete unit.

ORIGINALLY conceived as a tester for checking out disposals dual-in-line T.T.L. integrated circuits, this device has also proven effective in the roles of logic trainer, breadboarding unit and digital trouble-shooter.

Two SN7400 quad NAND integrated circuits, together with an NPN bipolar transistor, have been adapted to perform the functions of multivibrator clock-generator, unipulser and pulse lengthener/detector, each function being located on a sub-board and brought out to banana sockets on the front panel.

Three hook probes with banana plug terminations are provided. The use of banana sockets for probe entry frees the probes for use in conjunction with other equipment.

Logical 'I' and 'O' detection is available. Logic indication is by a red LED — alight for TRUE.

A 16 pin dual-in-line socket with base connections fanned to well spaced binding posts (Fig. 3B) is used for the testing of both 14 and 16 pin D.I.L. integrated circuits and also for

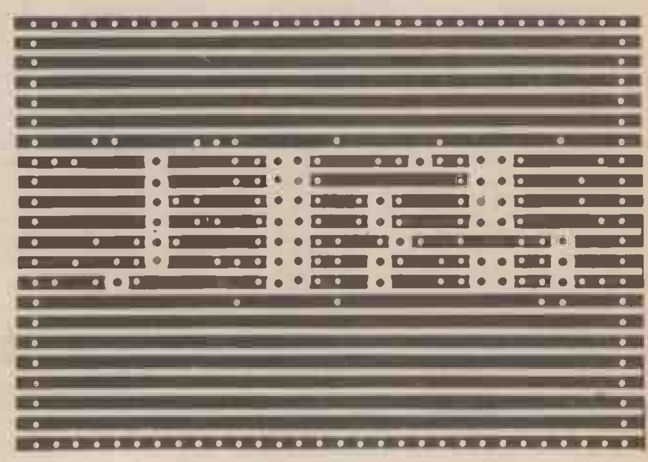


Fig.2. Veroboard pattern for the sub-board. Dimensions are 3.75" x 3.12" X 0.1" pitch. Board is shown here as seen looking down onto the copper side. Cut gaps in copper tracks with the correct tool or a sharp drill. Ensure that the track is completely broken.

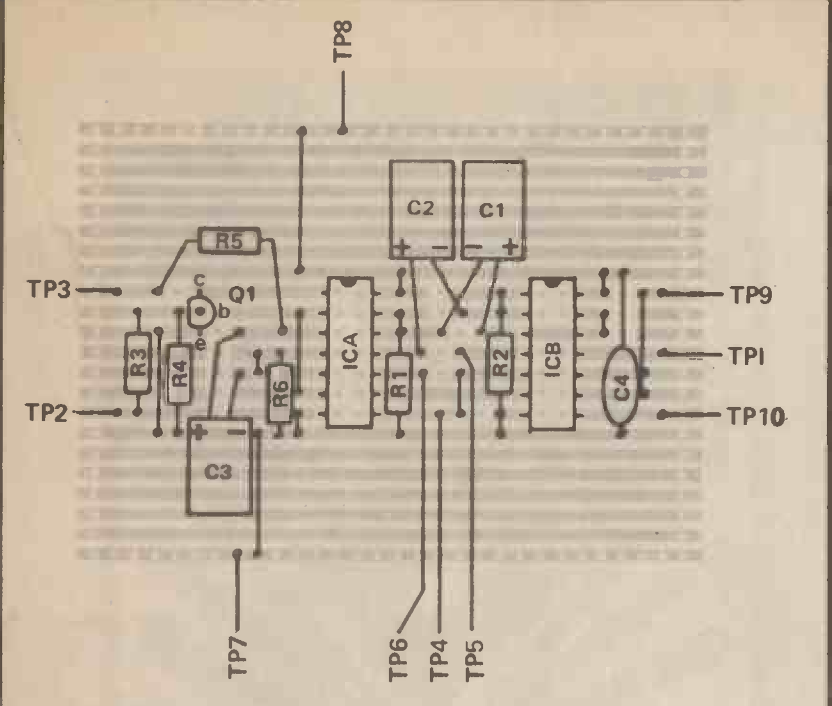


Fig.3. The component overlay.

BCD OPTION

A useful addition to the Supertest project is a BCD readout facility consisting of four LEDs brought out through current limiting resistors to binding posts on the front panel.

The LED's, positioned in line and close together for easy interpolation, are fitted in the positions indicated on the layout diagram, using the islands provided on the front panel for mounting the associated resistors and binding posts. The posts should be clearly labelled ABCD and the LED's defined by their binary weightings of 1, 2, 4, 8.

For those enthusiasts who find continuous operation of the clocking multivibrator objectionable, the clock may be inhibited by isolating pin 1 of gate B1 and connecting this point via a toggle switch to ground. When the ground is removed the clock will operate normally. This switch can be located conveniently inboard of the unipulser switch. With the clock inhibited the clock output at TP1 will be a 'low'.

HOW IT WORKS

MULTIVIBRATOR CLOCK

The clock consists of a multivibrator formed by gates A4 and B1 and associated RC networks. The period of oscillation is about 0.8 seconds and the output is buffered by gate B4 to reduce loading effects.

The clock rate may be varied, if required, by altering the value of both capacitors. It is inadvisable to increase the value of the resistors beyond 2k as this may result in unstable operation.

UNIPULSER

The purpose of the unipulser is to provide a single, bounce-free pulse, at each depression of SW1, for use in testing counters etc.

The two gates A3 and B2 are interconnected to form a switched bistable (RS flip-flop). Normally pin 4 of B2 is grounded via SW1 and the resulting high at pin 6 is coupled directly to pin 9 of A3. As pin 3 of A3 is not connected, A3 sees both inputs as 'high' and its output will be 'low'.

When S1 is depressed pin 10 is earthed and pin 4 goes high. A3 output goes 'high' and this appears at pin 5 of B2. As both inputs of B2 are now high its output will transfer a 'low' to pin 9 of A3 causing its output to be locked into the high state regardless of any further bouncing of the switch contacts which would otherwise provide spurious input pulses to the counter under test.

Releasing SW1 causes the flip-flop to revert to the state where A3 output is low.

PULSE EXTENDER

This simple circuit stretches very short pulses to about 100 milliseconds duration thus allowing them to be detected easily.

The two NAND gates A1 and A2, together with C3 and R6, form a monostable. Initially both inputs of A2 are held 'low' due to R6, its output is therefore 'high'. All inputs of A1 are thus 'high' and its output is 'low'.

If the input of A1 is driven 'low', by a short duration pulse, the output of A1 will go 'high' transferring a high via C3 to the input gates of A2. Output of A2, and A1 input, will go 'low' holding A1 output 'high'. Hence the LED indicator will be alight.

Capacitor C3 now discharges via R6 and after approximately 100 milliseconds the input to A2 will revert to 'low' and hence A2 output and A1 input will go 'high'. If both inputs of A1 are now 'high' (pulse not present) A1 output will go 'low' and the LED will extinguish. However if a pulse is present A1 output will remain 'high' and the LED lit.

As a 'low' is required to gate A1, an inverter is required for logical '1' detection. This is performed by Q1. Q1 also acts as a current amplifier allowing the logic probe to be of reasonably high impedance. Resistor R3 provides a light load, for the disconnected outputs of operating ICs, thus allowing logic levels to be observed. Resistors R3 and R4 also form a potential divider such that Q1 does not draw excessive current at normal logical '0' levels.

INVERTER

The spare NAND gate, B3, is wired as an inverter. This allows inversion of the clock or unipulser outputs or 'low' logic detection using the logic probe.

breadboarding and training purposes.

The front panel is clearly labelled with carefully applied Letraset — lacquered to increase durability — and housed on a small black plastic utility box to give the completed unit a professional appearance.

Thirteen short leads — approximately 230 mm long — twelve terminated with small insulated alligator clips and one with banana plugs, complete the test kit.

The unit is intended to operate from an external power source of 5 V and this is normally provided by the digital equipment under test. But for casual purposes a 6 V lantern battery, connected via two forward biased silicon diodes, is a satisfactory and economical power source. Current drain is about 30 mA.

CONSTRUCTION

Prepare the sub-board from Veroboard by cutting the tracks as shown on page 53 and then commence wiring by fitting the resistors and links. Sleeve any long links with 'spaghetti'. Next mount the ICs taking particular care to orientate the notch (or dot) as shown in the overlay.

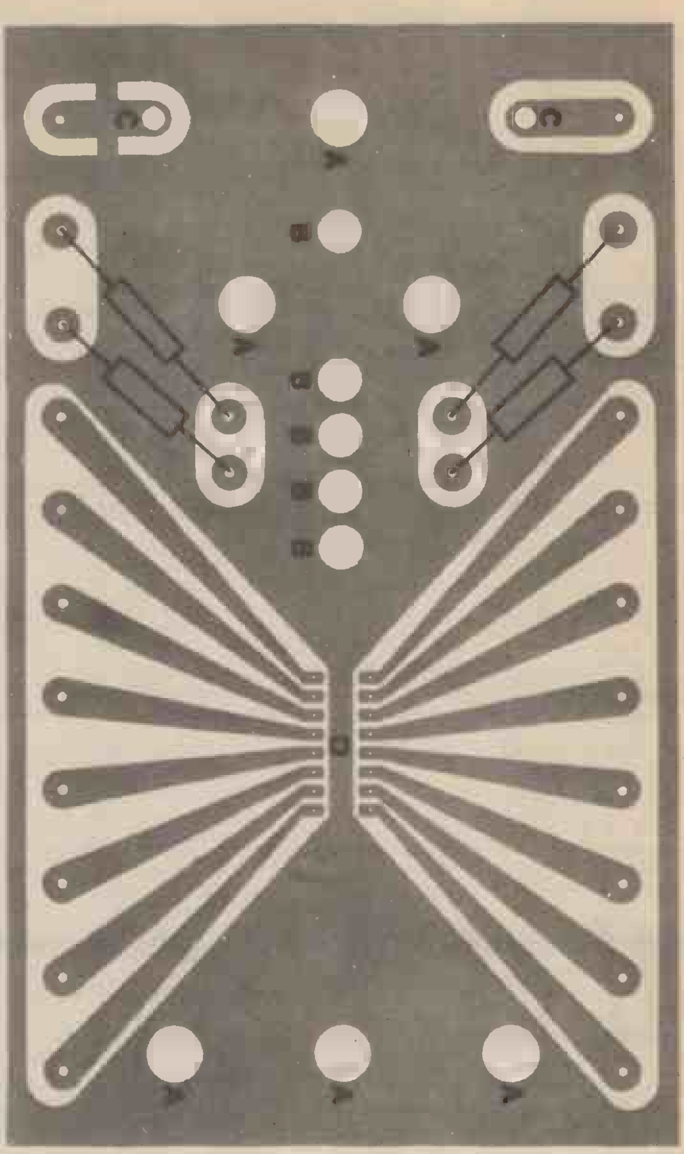
Mount the capacitors and Vero-pin terminal posts taking care to insulate the capacitor leads with spaghetti. As C1 and C2 are physically large, they should be laid on their sides and bound to the board with a length of spaghetti-sleeved wire.

After checking the board for errors, poor solder joints etc, it may be tested by temporarily wiring the LED between TP3 and TP7 — the lead closest to the flat on the LED being connected to the grounded terminal, TP7. The unit is then powered by applying +5 volts to TP8 (zero volts to TP7). The LED should flash briefly on application of power and then extinguish.

Connect TP2 to TP8 — the LED should light and then extinguish when the connection is broken. Observe that there is a pulse stretching action by flicking TP2 against TP8.

Connect TP2 to TP1. The LED should flash regularly at approximately 1 Hz. Now connect TP5 to TP7 and TP2 to TP4 in that order — the LED will be extinguished. Disconnect TP5 and connect TP6 to TP7 — the LED will light. Note that repeated disconnections of TP6 will have no effect on LED indication.

Disconnect TP6 and reconnect TP5 to TP7 — the LED will extinguish. Note that repeated interuptions of TP5 connection will have no effect on LED indication.



Printed circuit layout for modified (BCD) unit (shown full-size). Note resistors. These are 470 ohms (330—1k will do).

Connect TP9 to TP7 and TP2 to TP10 — the LED will be lit. Disconnect TP9 from TP7 — the LED will go out. Now connect TP9 to TP8 — the LED should still be out.

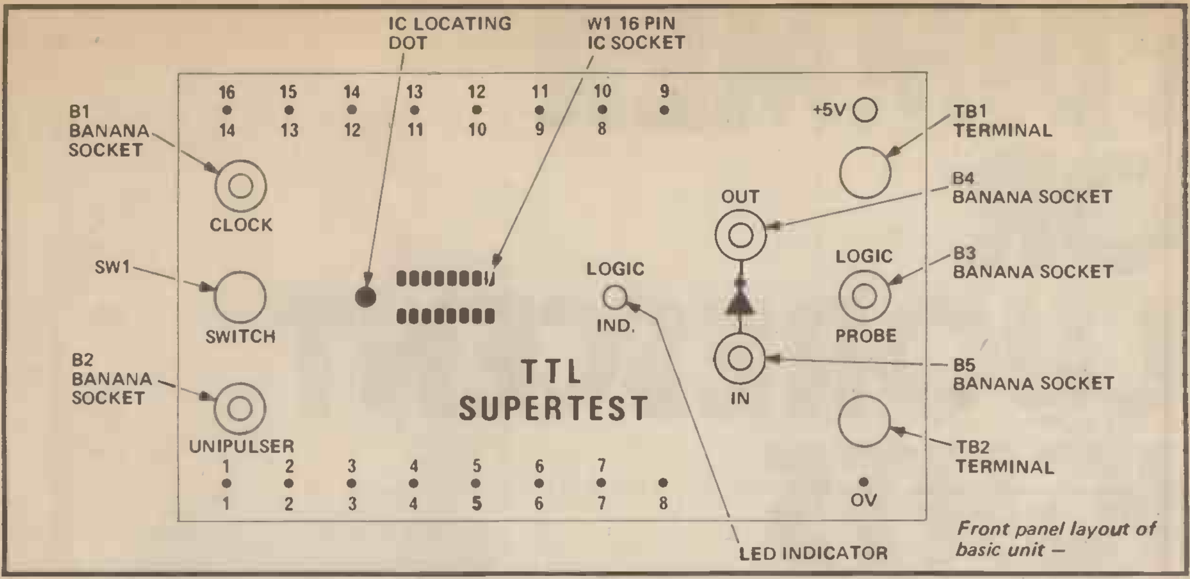
That completes testing of the sub-board. The banana sockets, IC socket, power terminals and unipulser switch should now be fitted to the front panel. Note that the common lead on SW1 is earthed to the panel ground-plane adjacent to the switch body.

Mount the LED using the plastic mounting clip provided, and solder the lead near the flat side of the LED to the ground plane. Take care, when bending the leads from the LED, to hold the wire near the base of LED with long nose pliers. Unless the strain is relieved as above, the leads are prone to break off at the base.

Mount four, half-inch insulated posts to the sub-board with screws and then, using 5 minute epoxy, cement the other end of the pillars to the front panel. When the glue is set unscrew the sub-board so that final wiring may be performed as follows.

Connect TP1 to B1; TP2 to B3; TP3 to LED; TP4 to B2; TP5 to NC SW1; TP6 to NO SW1; TP7 to GND; TP8 to +5 V; TP9 to B5; TP10 to B4.

When all these connections have been made, the sub-board may be reinstalled on the front panel and the whole assembly mounted in the utility box. ●



Front panel layout of basic unit –

PARTS LIST

ICA, ICB Integrated circuit SN7400
Q1, BC108 or similar
C1, C2 Capacitor electrolytic 470µF 16V
C3 Capacitor electrolytic RB 100µF 16V
C4 Capacitor 0.22µF 100V tantalum
R1, R2, R6 resistor 820 ohm ¼W 10%
R5 resistor 1k ¼W 10%
R3, R4 resistor 33k ¼W 10%
TB1, TB2 terminals
W1 DIL IC socket 16 pin
Veroboard .1" matrix, 3¾" x 3 1/8"
PCB, 6" x 3"
Veropins (.1"), 30
SW1 switch DPDT pushbutton, momentary action
LED TIL209
Probes (3 off), self gripping *(Doram)*
Banana sockets
Banana plugs
Crocodile clips, miniature, plastic covered, (24 off)
Solder, hook-up wire, sleeving, epoxy and insulating posts.
Box, 190 x 90 x 50mm, or similar.

A DIMMER FOR FLUORESCENT LIGHTS

This 700VA dimmer ensures smooth and almost flicker-free control of fluorescent lighting

Although not recommended it *is* possible to dim fluorescent lights over a limited range using a dimmer that has been designed for incandescent lighting control.

But it is very probable that there will be severe flickering at low light levels.

Although this flickering can be reduced by various techniques, it is primarily caused by asymmetrical current flow in the tube, i.e. current in one half cycle is greater than current in the other half cycle, and unlike the 100 Hz flicker that is present at all times, asymmetry introduces a 50 Hz component that the eye can follow.

The most commonly used method of light dimming today is phase control, (described in detail in our article A Practical Guide to Triacs — May 1972).

In this method the effective power input to the lamp is adjusted by varying the proportion of each half-cycle of the mains wave-form that is supplied to the load.

Most domestic dimmers sold today use this operating principle and have a circuit basically similar to that shown in Fig. 1.

This circuit will control fluorescent loads fairly well providing the triggering diode is selected for symmetrical operation, but triggering diodes are not generally sold this way and 10% asymmetry is not uncommon. What this means is that the diode will trigger on one half-cycle at say, 32 Volts and on the next half-cycle at 29.5 Volts. And so at low light levels the diode may trigger the Triac only on alternate half-cycles. This causes flicker.

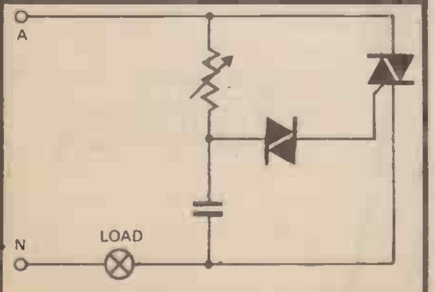


Fig. 1. Many commercially available light dimmers use circuits similar to this.

The same asymmetrical operation will also occur with incandescent loads, but due to the thermal inertia of the filament, the visual effect is much less noticeable.

The dimmer shown in this project overcomes the problem of asymmetry. It provides as nearly as possible an ideal and symmetrical waveform for fluorescent tubes.

Some flickering may still occur at very low light levels because the fluorescent tubes themselves may not be perfectly symmetrical. (The only way to achieve totally flicker-free operation is to use a variable frequency supply. The cost of this method would be enormous).

The maximum loading that can be placed on the dimmer is 700VA. Table 1 shows how the VA rating is calculated. It is also possible to use a combination of both fluorescent tubes and incandescent lamps and in this case the VA rating of the incandescent lamp is simply its normal wattage ie. 100 Watts equals 100VA.

Tube Indicated Wattage	VA Rating
15, 20 or 30	90
40	100
65	180
80	210

CONSTRUCTING THE DIMMER

Construction is fairly simple, but remember that this unit is connected to the main 240 Volt supply and follow our instructions carefully — especially those sections concerning insulation.

The circuit diagram of the complete unit is shown in Fig. 2, and the foil pattern of the printed circuit board in Fig. 3. Metalwork drawings are shown in Fig. 4 and the complete assembly drawing in Fig. 5.

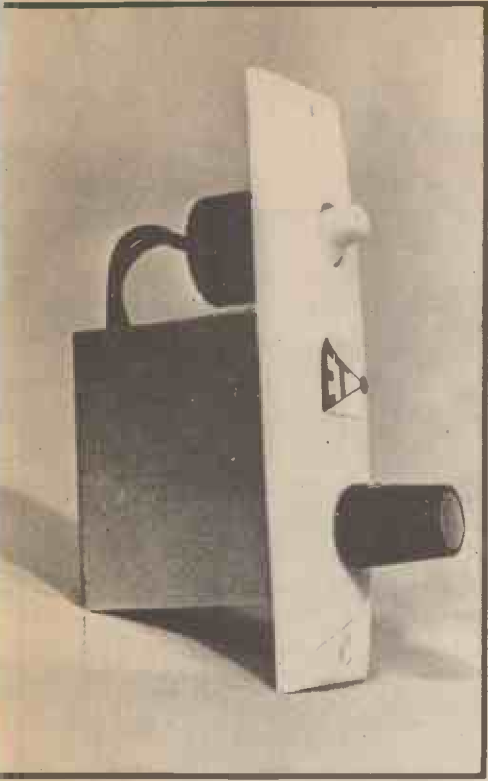
1. Mount the potentiometers on the chassis and cut the shafts to the required length. The minimum adjustment potentiometer should be cut short and slotted so that it may be adjusted with a screwdriver.

Insulated wires should now be soldered onto the respective terminals of the potentiometers ready for later attachment to the printed circuit board.

2. Any 6A or 10A rated triac without built-in diac and with PIV of 400V will do. If you use a triac, such as SC41D, with the case forming the anode, follow the procedure in para 3 to mount the device.

3. Glue a piece of insulating material 0.025" — 0.035" thick and ¾" diameter to the back of the potentiometers.

Before mounting the triac a lead must be soldered onto the top edge (ie nearest the terminals). When doing this, place the triac on a piece of copper or aluminium to act as a heat sink, and use the minimum heat required to make a good joint.



Cut a circle of mica ¾" diameter and 0.002" to 0.005" thick. This may be cut out of a T03 washer if required. Glue this mica washer to the side of the chassis, using epoxy glue. Then glue the Triac to the centre of the mica. The epoxy glue should extend completely over the top surface of the mica to prevent the mica splitting. The new 'five minute' epoxy glue is ideal for this purpose.

4. The rf choke (L1) should now be wound following the details shown in Fig. 6. Then wind the pulse transformer as shown in Fig. 7. Care must be taken with the insulation — there is 240 Volts ac between the primary and secondary winding on this transformer.

5. The components can now be soldered onto the printed circuit board. Locate transistor Q2 so that it is about 3/16" off the board and transformer T1 so that it is about 1/8" off the board. Capacitor C1 is mounted flat on top of the diodes. Fig. 8 shows the location of all components.

6. Glue the choke L1 on top of the 50k potentiometer, and connect one lead to the 'cathode' of the Triac (larger of the two terminals).

7. Connect the lead, which is soldered to the case of the triac, and the second lead from the choke to the appropriate places on the printed circuit board.

8. The printed circuit board should now be mounted on the chassis using 6BA nuts and bolts and 3/16" insulating spacers. Make sure that the board is reasonably level and is not touching the Triac or the chassis.

9. The leads from the secondary of the pulse transformer should now be twisted together. One lead should be connected to the Triac gate and the second lead connected to the Triac 'cathode'.

10. Connect the leads from the potentiometers to their respective locations on the printed circuit board.

11. Insert two short lengths of 23/0076 240 Volt insulated wire through the slot in the chassis and solder one end of each to the appropriate solder lands on the printed circuit board.

12. Place a piece of insulating material over the back of the printed circuit board and fit the cover temporarily in position. When doing this make sure that no bare wires can touch any metal. The dimmer is now ready for testing.

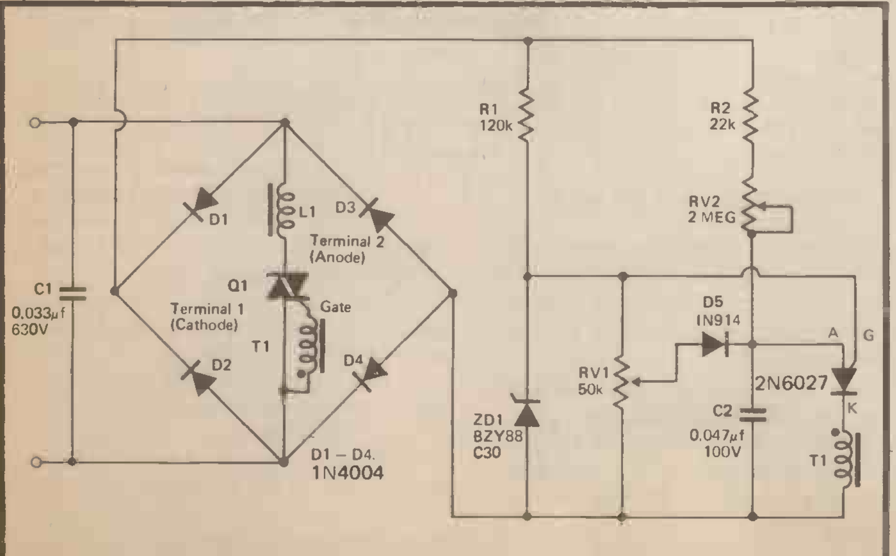
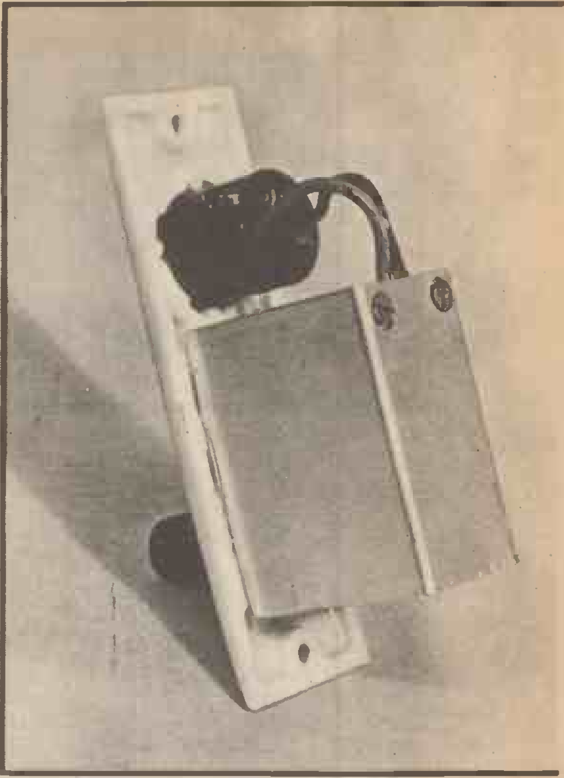


Fig. 2. Complete circuit diagram of the light dimmer.



PARTS LIST
FLUORESCENT DIMMER

C1 — capacitor 0.033 uF, 630V
C2 — capacitor 0.047 uF, 100 or 160V
D1-D4 diodes 1N4004
D5 — diode 1N 914
ZD1 — zener diode BZY 88 C30 or 1N972B
Q1 — Triac type SC41D
Q2 — programmable unijunction transistor type 2N6027
RV1 — miniature potentiometer 50k linear
RV2 — miniature potentiometer 2 Megohm
L1 — choke (see text) wound on ferrite plate 7/8" long x 19mm x 3.8mm
T1 — pulse transformer (see text) wound on Neosid core type 0.159 x 0.375/2 x B6/F14
R1 — resistor 120k, ½Watt, 5%
R2 — resistor 22k, ½Watt, 5%

One on/off switch plate with switch mechanism and one spare terminal. Insulation material 0.025" — 0.035" thick, mica sheet, 6BA x ½" bolts and nuts, 3/16" spacers, insulated control knob, wire, epoxy glue etc. Metal work, printed circuit board ET 011.

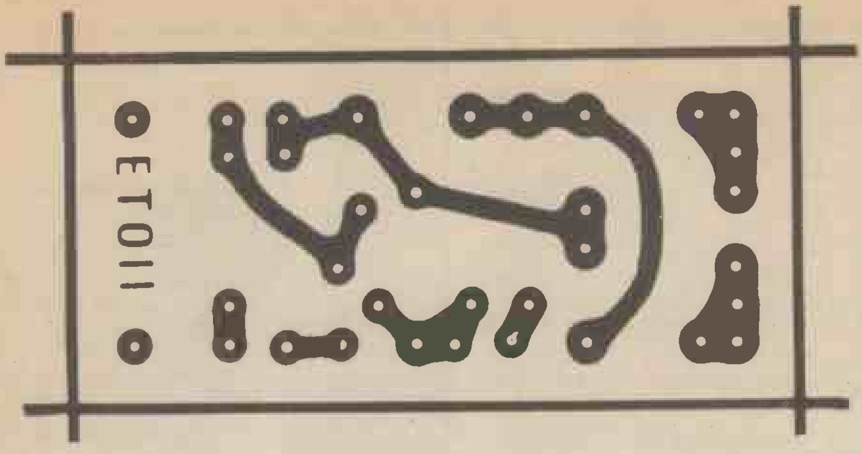


Fig. 3. Foil pattern of the printed circuit board. Note that this is shown here exactly twice full size.

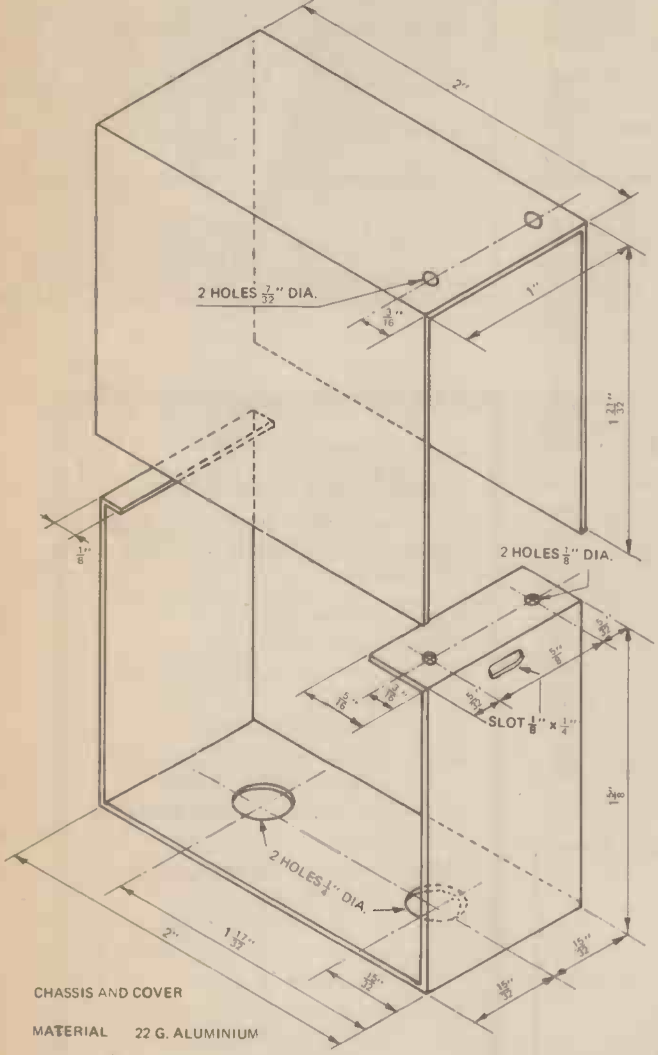


Fig. 4. Details of metalwork.

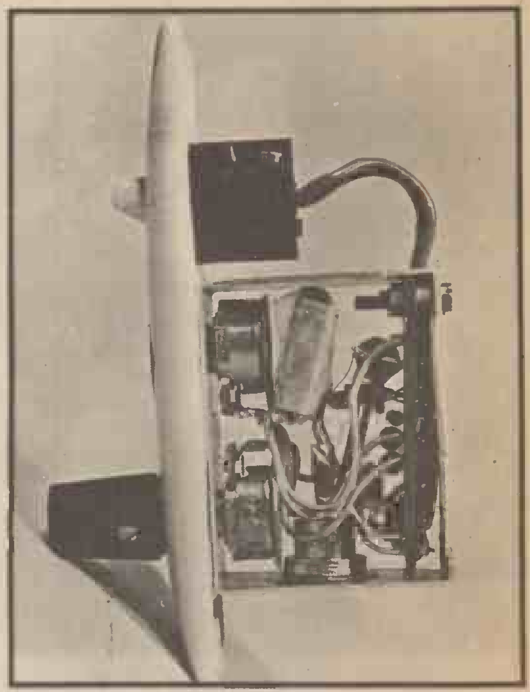
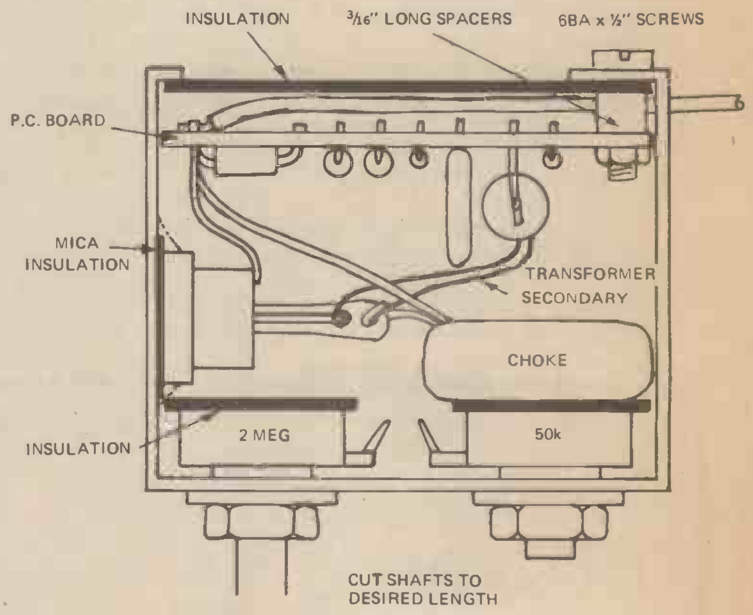


Fig. 5. How the unit is assembled.



TESTING

If a Megger is available, check the insulation by twisting together the two leads from the dimmer and testing between these two leads and the metal chassis. (Fig. 9). A reading of several Megohms should be obtained.

If a Megger is not available then check by using the circuit shown in Fig. 10. The lights should not glow at all — if they do then there is an insulation breakdown within the dimmer. If an isolating transformer is not available the same test can be made by connecting the mains directly to the dimmer via a 15 Watt bulb as shown in Fig. 11.

If the test must be done without using an isolating transformer, place the dimmer on a thick dry newspaper and take extreme care not to touch either the dimmer or the leads whilst power is connected to the circuit.

Having completed the insulation test, connect the dimmer to an incandescent bulb as shown in Fig. 12. Turn both potentiometers fully anticlockwise and switch on the power to the dimmer. The light should not be on, now turn up the minimum adjustment potentiometer until the light just glows. The main potentiometer should now control brilliance up to the maximum level.

If flickering is evident, switch off and reverse the connections from the pulse transformer to the Triac.

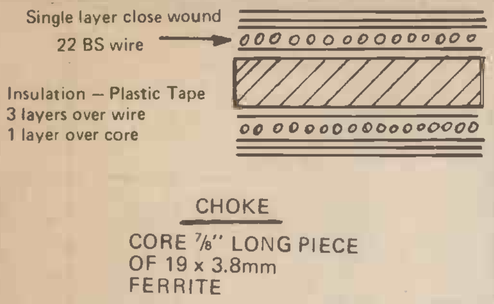


Fig. 6. How to wind the choke.

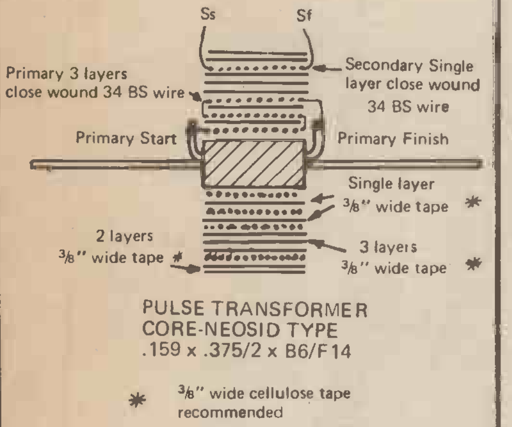


Fig. 7. Details of the pulse transformer – follow the construction exactly as shown.

FIG. 9

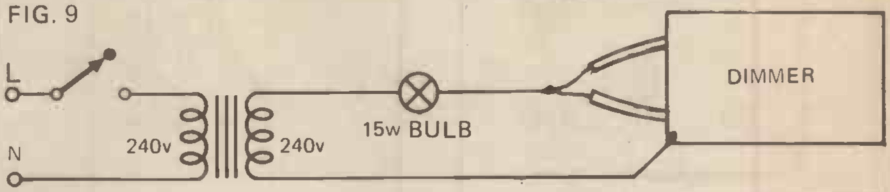


FIG. 10

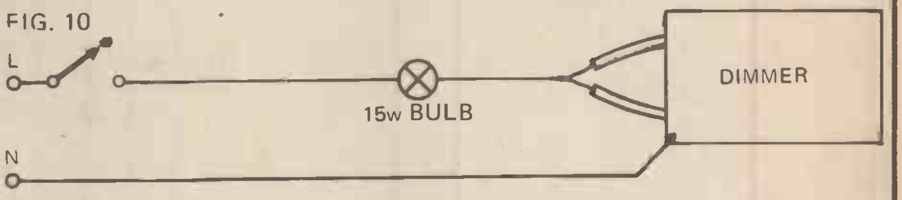


FIG. 11

The unit may now be glued to the front plate and the cover glued onto the chassis (use Araldite or other epoxy glue). Connect the two wires from the dimmer to the switch.

INSTALLATION

Any modifications to the house wiring must preferably be carried out by a qualified electrician and the following notes are intended for guidance only:-

If the dimmer is to be used solely with incandescent loads, all that is necessary is to connect the dimmer in place of the existing wall switch.

If fluorescent lamps are to be used, refer to Fig. 13. This is a composite drawing showing the wiring required for various combinations of fluorescent lamps.

A single fluorescent lamp would be connected as shown in Fig. 13a. If twin tubes are used then Fig. 13b would be applicable. If both single and twin fittings are to be paralleled then use Figs. 13a and 13b.

There may be occasions when it is

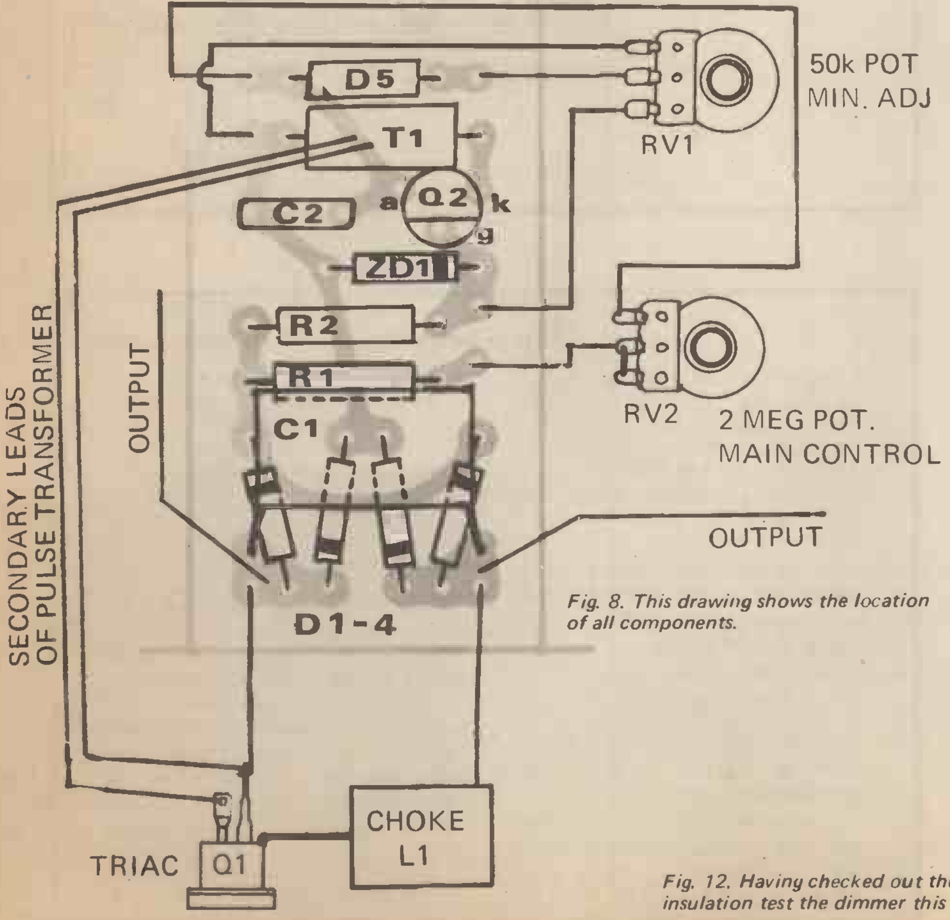


Fig. 8. This drawing shows the location of all components.

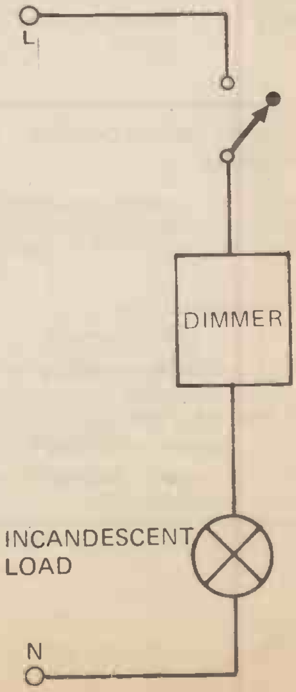


Fig. 12. Having checked out the insulation test the dimmer this way.

A DIMMER FOR FLUORESCENT LIGHTS

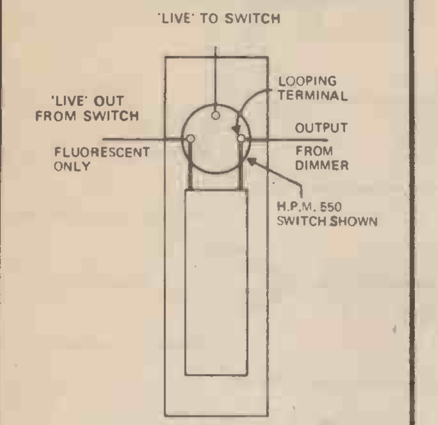


Fig 14. This shows how the dimmer is connected to the lamp switch

necessary to parallel a twin 20 Watt fitting and a single 40 Watt fitting — in this case use Figs. 13a and 13c.

No matter what combination of fluorescent tubes are used it will always be necessary to install the resistor (or incandescent bulb) as shown in Fig. 13 and explained in the fluorescent dimming article.

Again, as explained in the fluorescent dimming article, filament transformers must be used. The correct type of transformer for each application is shown in Table 2.

Filament transformers may be ordered through your parts supplier or through an electrical wholesaler. Our experience is that most companies do not hold them in stock but will willingly obtain them against a firm order. ●

FILIAMENT TRANSFORMERS & BALLASTS

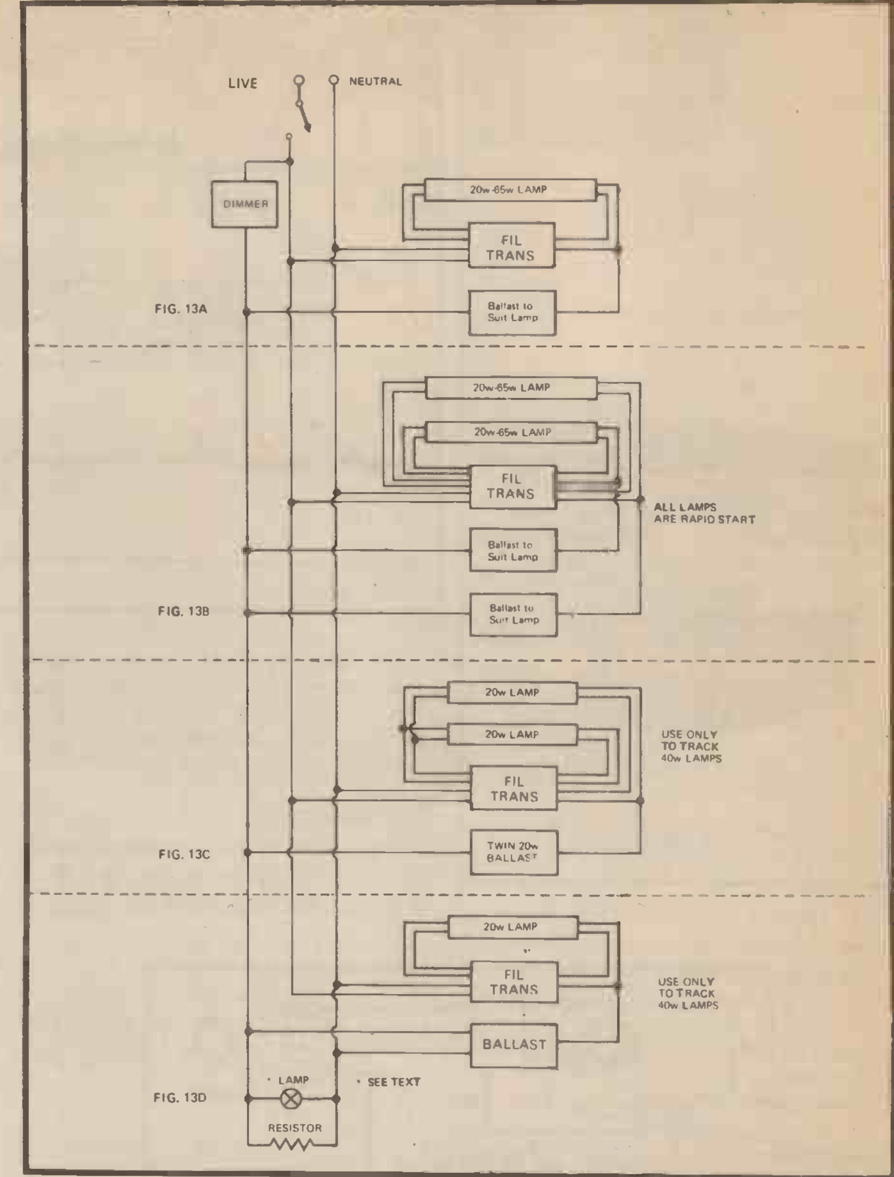
Transtar Ltd, Prince Consort Road, Hebburn, Co Durham stock the following filament transformers and ballasts in one can:

Single rapid-start tubes

20W : A20SCR
40W : A40SCR

Twin rapid-start tubes

2x20W : A20TSCR
2x40W : A40TSCR



HOW IT WORKS

The power circuit consists of C1, L1, and Q1. Q1 is a Triac, which when triggered into conduction, remains so until the current through it falls to zero. The Triac is triggered at any required point during each half cycle to give a chopped sine-wave output.

The purpose of C1 and L1 is to slow down the rise time of voltage and current to reduce radio frequency interference.

The diode rectifier bridge (D1 — D4) supplies unsmoothed 240 Volts dc to the control circuit, where R1 and ZD1 supply 30 Volts to the gate of the PUT (Programmable Unijunction Transistor) Q2.

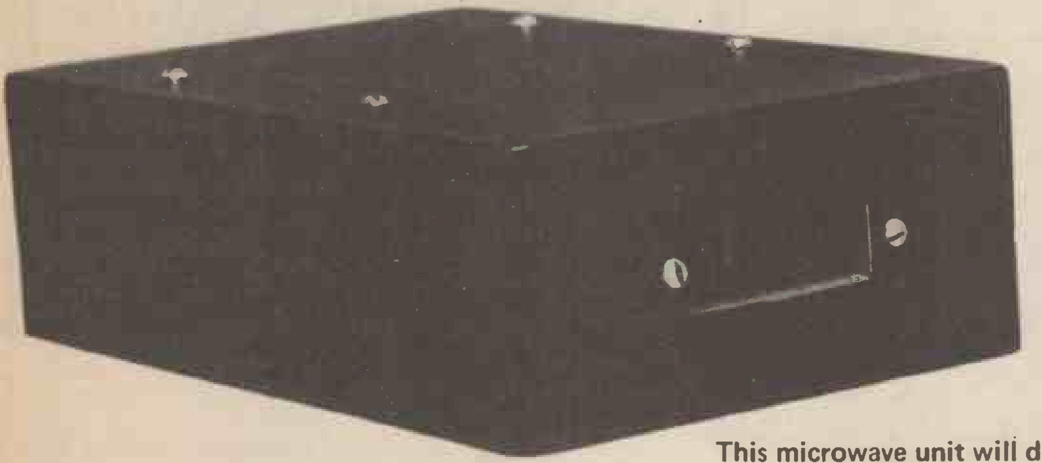
Capacitor C2 is rapidly charged via RV1 and D5 until the voltage set by RV1 is reached. Charging then continues via R2 and RV2. When the voltage across C2 exceeds the gate voltage (nominally 30 Volts) by about half a volt the PUT conducts and discharges C2 into the primary of pulse transformer T1. This causes a pulse of energy to be fed into the gate of the Triac and to trigger it into conduction.

The action of the Triac conducting removes all voltage from the control circuit until the next half cycle of the mains input waveform.

The point in each half cycle at which the PUT (and hence the Triac) is triggered is determined by the setting of RV1 and RV2. The range of the main control potentiometer RV2 may be varied by the preset potentiometer RV1, and so RV1 is used to preset the minimum light level.

This circuit ensures symmetrical firing of each half cycle of the Triac

RADAR INTRUDER ALARM



This microwave unit will detect moving objects at ten metres range.

IN 1963 J B Gunn reported that he had obtained coherent oscillations by applying an electric field to a crystal of gallium arsenide, and that a power of 0.5 watt at a frequency of 1 GHz could be obtained by this means. Since that time a great deal of research and development effort has been devoted to producing a range of solid-state microwave generators with stable and predictable properties.

The Gunn effect oscillator is the first practicable solid-state microwave source. About five times cheaper than an equivalent klystron source (including power supply), the Gunn oscillator, because of its inherent efficiency, reliability and portability is finding wide use in contactless object detection and observation equipment. Applications include intruder detectors in security systems, aids for the blind, motor car anti-collision systems, contactless actuators and speed and rotation measuring equipments.

Microwaves have many advantages over light, infra-red and ultrasonic waves for such duties. Principal among these is the relatively "unpolluted" section of the spectrum in which they operate: few natural phenomena or electrical machines generate incidental microwaves. Additionally, conventional radio-signal processing techniques may be used to improve the signal-to-noise ratio and the immunity to interference.

One of the latest devices to become available in this field, is the Mullard CL8960 radar module. This device is intended for short range doppler radar applications.

In essence it transmits a beam of very high frequency radiowaves — virtually anything intercepted by the beam will reflect some energy back to the unit. If the intercepted object is moving then the reflected energy will be at a frequency slightly different from the transmitted frequency (the difference depends on the speed and direction of the moving object).

Thus if there *is* a difference between the transmitted and the reflected signal frequencies (i.e. a Doppler shift) then, by definition, a moving object must have caused it.

The CL8960 modules consists of a dual cavity and integral aerial assembly. A self-oscillating Gunn diode is mounted in one cavity and a microwave mixer diode in the other.

Hence the unit is self-contained, needing only a power supply and amplifier for the Doppler audio output.

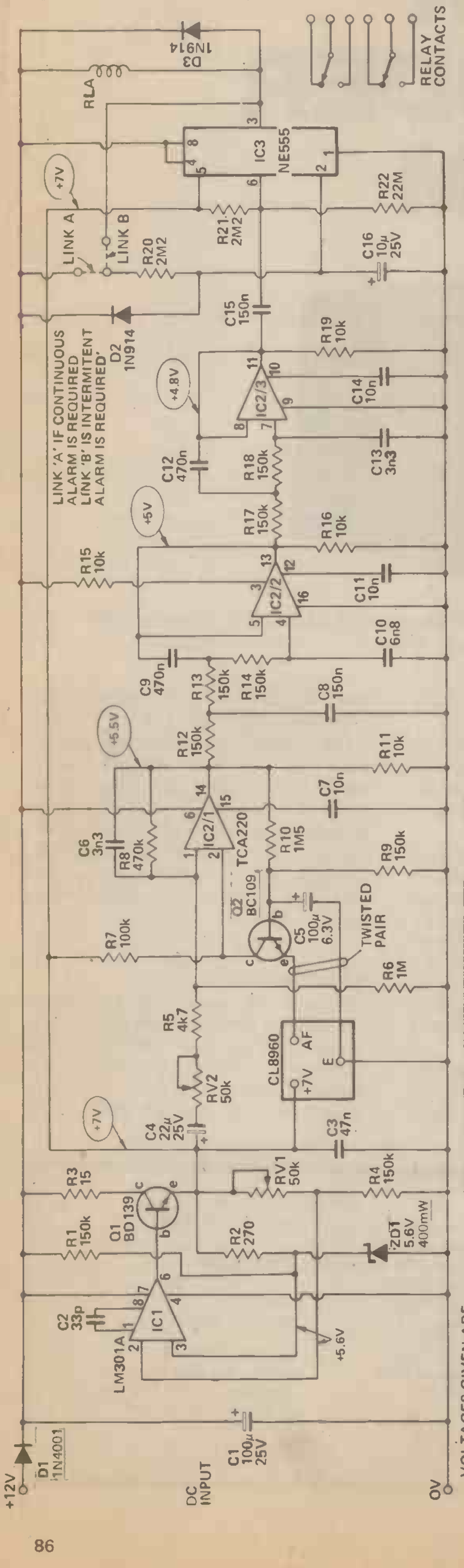
CONSTRUCTION

We did not attempt to miniaturize the unit as ultra-small physical size is unlikely to be required in intruder detection systems. Our prototype was therefore mounted in a 185 x 120 mm diecast box, the side of which makes

SPECIFICATION

Frequency	10.675 — 10.7 GHz
Power Output with 7.0V dc supply	8 mW typical
Beam Width free space	approx 60°
Range	up to 10 metres
Sensitivity maximum	50 μV at 10 Hz
Internal Filter	30 Hz, five pole low-pass
Output	by relay — either latching or 20 seconds on plus automatic reset.
Input	10-15 volts dc at 150 — 200 mA.

RADAR INTRUDER ALARM



VOLTAGES GIVEN ARE OF THE PROTOTYPE BUT SHOULD BE TYPICAL

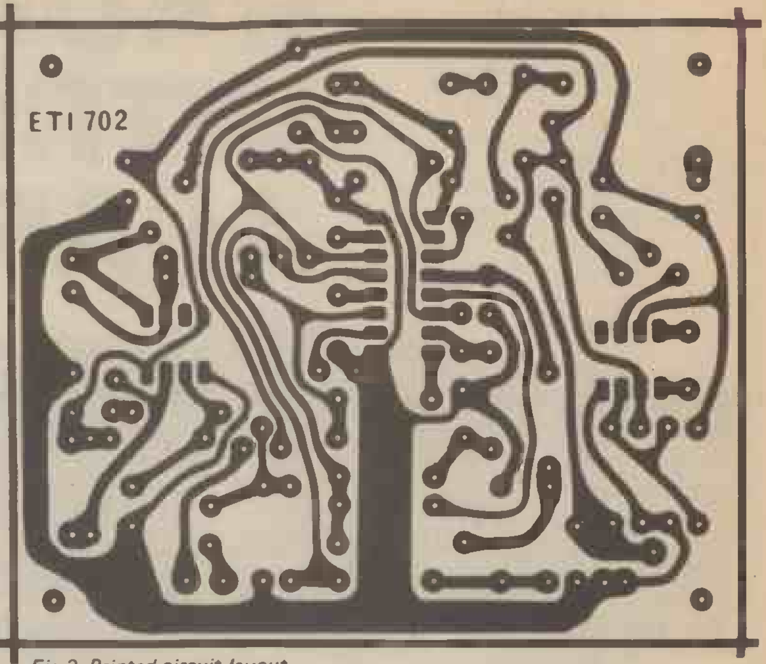


Fig.2. Printed circuit layout.

Fig. 1. (left) Circuit diagram of the radar alarm.

WHERE TO GET THE COMPONENTS

THE CL8960 RADAR UNIT
This module is available from
SASCO LIMITED
P.O. Box 2000,
Gatwick Road,
Crawley, Sussex.
for £20.00 + 8% VAT + 75p postage.

The values of resistors and capacitors now follows our new standard. Examples are given below.

Resistors	Capacitors
2R2 is 2.2 Ω	2n2 is 0.0022µF
2k2 is 2.2k	220n is 0.22µF
2M2 is 2.2M	2µ2 is 2.2µF

an ideal rigid support for the radar module.

Assemble the components to the printed circuit board with reference to the circuit diagram and the component overlay. Take particular care with polarization of components and watch for the differing connections of BC109 transistors (see connections at bottom of circuit diagram). The relay may be mounted by simply glueing it to the side of the box.

Do not remove the shorting strap, between the mixer diode and ground, until the module is completely wired into the circuit. The wires from the printed circuit board to the mixer diode should be twisted to minimize pickup — as there is a very low signal level at this point. After these are connected remove the strap by unwinding the end on the mixer diode with the aid of a pair of long-nose pliers and then disconnecting it from the earth terminal.

SETTING UP

The only adjustments required are the setting of the +7 volts supply for the transmitter and setting the sensitivity control.

Initially the transmitter should be left disconnected and a resistor (100 to 1k ohm) inserted from the +7 V line to ground as a simulated load. Switch on and adjust RV1 to obtain exactly 7 volts output. Use some glue or nail polish to secure the potentiometer in this position, switch off, and reconnect the transmitter.

To set the sensitivity it is advisable

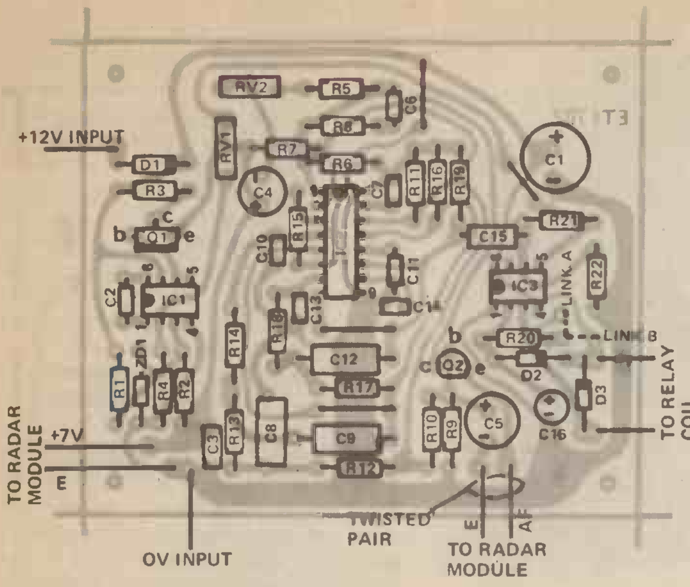


Fig.3. Component overlay.

initially to link the unit for intermittent alarm operation. It may be changed to latching mode later if required. Mount the unit in its normal operating position and adjust the sensitivity such that the desired range is achieved without the unit being over-sensitive. Note that the 10.7 GHz transmitted will pass through timber walls with almost zero attenuation — so movement outside the protected room could set off the alarm if the sensitivity is too high.

This characteristic can be valuable though as it enables the complete alarm to be concealed behind a plastic or wooden screen — or even inside the wall itself if desired.

PARTS LIST – ETI 702

R3	Resistor	15 ohm ½W 5%	
R2	"	270 ohm ¼or½W 5%	
R5	"	4k7	" " "
R11,15, 16,19	"	10k	" " "
R7	"	100k	" " "
R1,4, 9,12	"	150k	" " "
R13,14, 17,18	"	150k	" " "
R8	"	470k	" " "
R6	"	1M	" " "
R10	"	1M5	" " "
R20,21	"	2M2	" " "
R22	"	22M	" " "
RV1,	Potentiometer	50k Trim.	
RV2	"	" "	
C2	Capacitor	33pF	ceramic
C6,13	"	0.0033µF	Polyester
C10	"	0.0068µF	"
C7,11, 14	"	0.01µF	"
C3	"	0.047µF	"
C8, 15	"	0.15µF	"
C9,12	"	0.47µF	"
C16	"	10µF 25V	electrolytic
C4	"	22µF 25V	"
C5	"	100µF 6.3V	"
C1	"	100µF 25V	"
Q1	Transistor	BD139 or similar	
Q2	"	BC109 or similar	
IC1	Integrated Circuit	LM301A	
IC2	" "	TCA220	
IC3	" "	NE555	

D1 Diode 1N4001 or similar
D2,3 Diode IN914 or similar

ZD1 Zener Diode 5.6V 400mW
RLA Relay 185 ohm miniature

Radar Unit CL8960 Mullard — see box on the circuit diagram

Die cast box

Four Screw-type Terminals.

HOW IT WORKS
ETI 702

The intruder alarm consists of four main sections:

1) The Gunn diode assembly and associated power supply.
2) An amplifier for the output of the mixer diode.
3) A 5-pole, low-pass filter.
4) A detector and relay driver.

The transmitter consists of a Gunn diode in a tuned cavity that requires a supply of 7 volts ±0.1V dc at about 140 mA. No other input is required and the diode automatically oscillates at 10.7 GHz. The regulation of this supply is critical as any variation will frequency modulate the Gunn diode. In security applications a 12 volt battery, together with a separate charger. will most commonly be used and the output of such a system will be anywhere between 11 and 15 volts. Hence we have used a series regulator which has a 5.6 volt zener as the reference element. Integrated circuit IC1 compares the zener voltage to the voltage, as set by RV1 and R4, and controls the series transistor Q1 to keep the relationship of output voltage constant with respect to the zener voltage. Thus RV1 controls the output voltage and is set to obtain 7 volts. A diode D1 is used in series with the input to prevent damage due to reversed polarity.

The mixer diode is in a second tuned cavity next to the transmitter and receives two signal sources. The first of these is 'spill" from the transmitter, constituting a local oscillator signal.

The second signal consists of energy reflected from all objects in the target area. If nothing is moving in the area the reflected signal will be of the same frequency as the transmitted frequency – so the output from the mixer will be the transmitted frequency only.

However a moving object in the area will doppler shift the reflected signal. The difference in frequency will be proportional to the objects velocity, in accordance with the following formula.

f = 71.3 V Hz (V = velocity in metres/sec perpendicular to module)

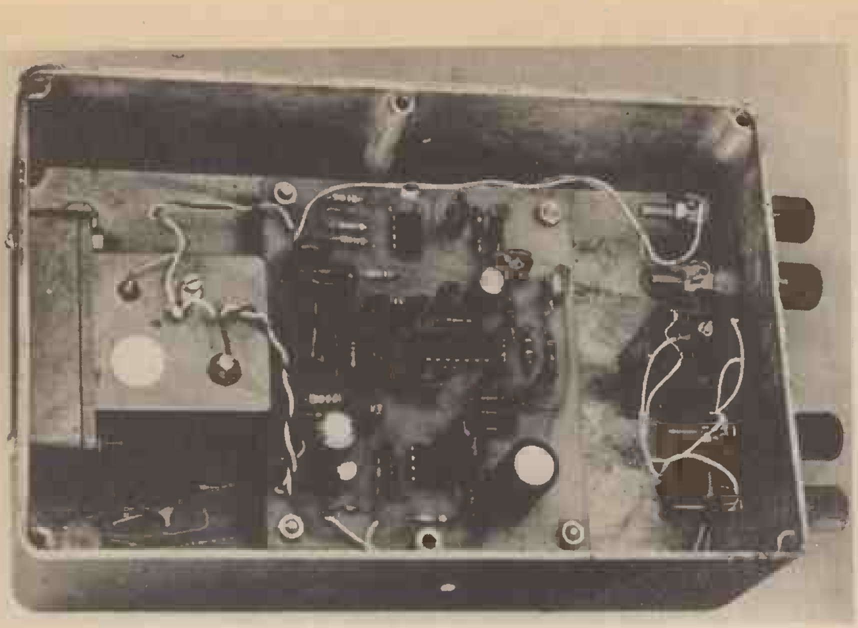
This doppler frequency is amplified by Q2. connected as a common-base amplifier, and again by IC2/1 providing a maximum gain of some 85 to 90 dB.

Approximately 20 dB of gain control is provided by RV2. The collector load of Q2 (R1) provides the 35 micro-amp bias required by the mixer diode and R6, 9 and 10 provide the correct dc conditions for the combination.

The filter consists of two active sections, one three-pole and one two-pole, which together make a five-pole Chebyshev filter. The cutoff frequency is about 30 Hz and the attenuation at 50 Hz is more than 40 dB.

An NE555 timer IC is used as a detector. This IC has two level detectors, one at two-thirds of V_S (input A) and one at one third V_S (input B). However, by connecting the control voltage input (pin 5) to +7 volt these levels will be +7 V and +3.5 V respectively. If input B is less than 3.5 V the output will be high irrespective of input A. If input B is above 3.5 V and input A goes above 7 V, the output will go low until input B again goes below 3.5 V. The voltage at input A is normally held at 6.4 V by R21 and 22 and hence about 600 mV increase is needed to reach the trigger point.

On initial switch on, C16 will be discharged causing the output to be high and the relay unenergized. After about 10 seconds C16 charges to 3.5 volts and this allows input A to assume control of IC3. This initial period is required to prevent false alarms whilst the rest of the electronics stabilizes. If the resistor R22 is connected to the output of the IC (link B) the relay will reset itself after about 25 seconds. If it is retriggered within the next two minutes it will re-latch, however the on time will be less than 25 seconds. If link A is used the initial 10 second delay still occurs, however once activated the alarm will remain on until power is removed.



ABOUT MICROWAVES

Nature and properties

Microwaves, as the name suggests, are high-frequency, short-wavelength electromagnetic waves. Being of short wavelength, their properties lie somewhere between those of normal radio and visible light waves. They can be focussed and directed by comparatively small structures, but being of high frequency they are more easily deflected and attenuated by solid objects. The high quantum energy involved with microwaves means that some precautions are necessary to avoid personal injury.

The microwave region of the electromagnetic spectrum is arbitrarily defined as lying between 1000 MHz (1 GHz) and the far infrared region beginning at 300 GHz. Over this range of frequencies, similar signal generating and processing techniques may be used. The wavelengths involved range from 30 cm to 1 mm, the location of the microwave region of the spectrum.

In most countries, radiation health regulations specify a safe limit of exposure to microwaves of 10 mW/cm^2, however, under normal circumstances a maximum intensity of 1 mW/cm^2 should be regarded as the limit for continuous exposure. The CL8960 output is only 8 mW. There is therefore no danger in using this device.

Guiding and Directing

The high dielectric and skin losses, together with the small wavelengths, rule out the use of normal discrete components and transmission lines. Coaxial lines, if of low loss, may be employed at the low-frequency end of the region, but at frequencies above about 5 GHz wave-guides are usually employed. Where attenuation is unimportant, short lengths of coaxial line fabricated from copper tube and wire can be used. Careful attention should be paid to matching if stable, efficient performance is expected. Discontinuities, such as sharp bends, are undesirable.

Aerials for use at microwave frequencies may be made of high gain in small sizes, a 5 dB gain antenna is supplied with the CL8960.

Detection

In low-power industrial practice, microwave signal-frequency amplification is seldom employed. Signals may either be detected directly, or converted to some lower frequency by a diode mixer, or Gunn effect mixer-oscillator.

LIMITATIONS

The alarm has a filter which rejects all frequencies above 30 Hz. A person walking towards the unit at a reasonable rate generates frequencies in excess of 100 Hz. However parts of the body will be moving at different rates and there will be frequencies below 30 Hz as well. It may be possible to approach the unit from a distance at a high and uniform rate without setting off the alarm but the alarm will be triggered the moment one stops or changes pace.

Fluorescent lights, when operating, generate 50 Hz and 100 Hz noise. Whilst this is rejected by the filter the alarm may be triggered by the impulses generated when the lights are switched on, especially if switch-start types are used which flick on and off a few times when starting. This is not normally a problem as the lights will be left either on or off whenever the alarm is armed. ●

USING THE CL8960

1) The Gunn diode will be damaged if the supply voltage is reversed.

2) The mixer diode will be damaged by forward current in excess of 10 mA.

3) The module is despatched with a shorting strap between the mixer a.f. terminal and –E terminal.

The mixer has a low junction capacitance and may be damaged by transients of very short duration. It is recommended that soldering irons be isolated from the mains and that *the shorting strap should not be removed until all wiring is completed.*

4) A 10 nF capacitor should be connected to, and between, the +7 volt terminal and –E terminal to suppress parasitic oscillations in the supply circuit.

5) Power supplies should have a low source impedance and be capable of supplying up to 250 mA at approximately three volts during the initial voltage rise following switch on.

TABLE 1

Attenuation of 10 GHz microwaves by various materials. Note: true only for thicknesses greater than 1 wavelength (3 cm).

material	attenutation (one way)	notes
heavy rain	0,2 dB/km	not significant in short range radar
dense fog	0,1 dB/km	not significant in short range radar
dry wood	10 to 50 dB/m	very variable, greater when wet
Plexiglas Perspex	15 dB/m	methyl methacrylate type plastic
polyethylene/ polystyrene	<1 dB/m	dry surfaces
expanded polystyrene	<1 dB/m	dry and fresh
glass	up to 50 dB/m	extremely variable
pure water	approx. 5000 dB/m	

ELECTRONIC COMBINATION LOCK

There's only one chance with this unusual combination lock — any incorrect setting will sound an alarm!

THIS electronic combination lock is a simple device which may be used as a security device, or just for amusement. Very few parts are required and most of them will probably already be in the experimenter's junk box.

A total of 1000 combinations are provided by three, eleven-way switches, only one setting out of the possible 1000 will actuate the output relay (and hence any other device required to be operated). More combinations may be provided by simply wiring further switch banks in series with the existing three.

To prevent people from just rotating switches until the lock eventually opens, "lock" and "unlock" push buttons have been provided. Thus once a switch selection has been made the "unlock" button must be pressed to open the lock. Should *any* incorrect selection be made the alarm will sound. The lock push button must then be pressed to reset the alarm. There is therefore no way in which an intruder can test different combinations, without the alarm sounding, except in the 1 in 1000 chance of selecting the correct combination the first time.

CONSTRUCTION

Construction is very simple. We built our unit into a metal box, but if the unit is meant to prevent access to somewhere, or something, (such as the biscuit tin!) it could well be built directly into the lid or door etc.

Points to watch are the connections to the BC558 transistor, especially as there are two different base connections available, and that the alarm and relays have voltage ratings applicable to the selected supply voltage. The supply voltage may be anything convenient, up to a maximum of 30 volts, this being limited by the rating of the transistor specified. ●

PARTS LIST
ETI 233

R1	Resistor	10 k 20% ½W
Q1	transistor	BC178, BC558 or similar
D1	diode 1N914 or similar	
PB1	push button switch (normally closed)	
PB2	push botton switch (normally open)	
RLA, RLB	relay double pole change-over, voltage to suit battery supply used.	
SW1 2, 3	Switches single pole 11 position rotary.	
Alarm	- buzzer etc. to suit battery supply used.	

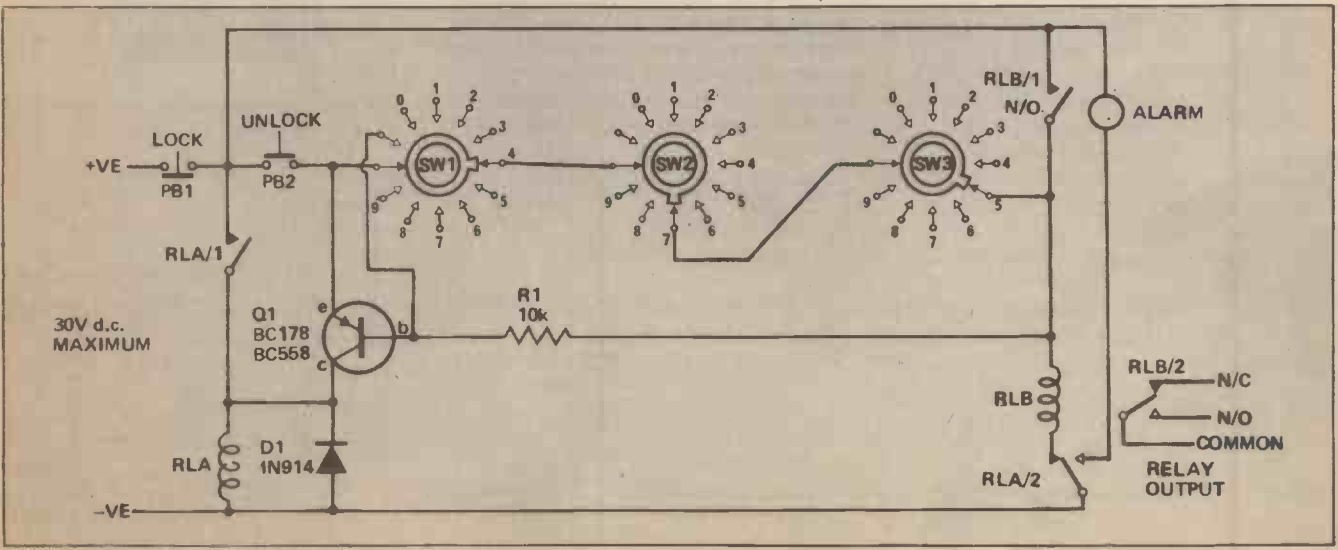
HOW IT WORKS

The three switches (SW1, 2 and 3) are prewired to some specific number. In our circuit diagram the switches are wired to unlock with 475 selected.

When the unlock push button is pressed, power is applied to Q1 and SW1. If the switches are set to the correct "UNLOCK" code, power is also applied to relay B causing it to close, RLB/1 contacts therefore close latching relay B on. The switches can now be altered without relay B opening.

If, however, when the "UNLOCK" pushbutton PB2, is pressed, the switches are not in the correct code position relay RLB is not actuated. Nevertheless, Q1 turns on due to base current flowing through the coil of RLB and R1, and RLA closes. Contacts RLA/1 therefore close, latching on RLA, and contacts RLA/2 change over disconnecting RLB and actuating the alarm. Only by pushing the "LOCK" button can the alarm be de-activated and a new combination tried. If desired the alarm could be connected across the coil of RLA rather than in the position shown.

The switches should normally be left in the number 11 (blank) position. If in this position the unlock button is pressed the alarm will not be actuated. This prevents accidentally raising the alarm.



light dimmer

ALTHOUGH commercially made light dimmers have fallen considerably in price recently, they still usually command about £4.00 (though we have seen them advertised a bit cheaper). In addition to giving control over the brightness of a bulb, modern circuits using a Triac actually save electricity and will eventually pay for themselves though we do not advocate them for this reason.

The circuit for a light dimmer is not complex, as will be seen from Fig. 1, nor are the components all that expensive. Including everything, we reckon the cost of this project at about £2.50. The circuit overcomes a drawback in many of the commercial models: the Triac is protected against mains transients. Many versions do not come on until the control is rotated over half way, yet current is still being drawn; in our circuit the light comes on almost at minimum setting.

An unusual facility is also incorporated in the design which some readers might wish to take advantage of. A light dimmer is perfect for use with a TV set as neither viewing in full light or complete darkness is very pleasant. The circuit is so arranged that the switch can also handle a load which is not controlled by the dimmer circuitry. Thus, the TV can be switched on using the unit, but only the light will be controlled. The same arrangement also makes it possible to control only one light, leaving others unaffected.

The unit will handle 500W as shown, but with some modifications can easily be adapted to control 1kW.

CONSTRUCTION

Use of a printed circuit board (the pattern as shown in Fig. 2) is recommended. Veroboard can be used but mains voltages are present and many people will consider that the track spacing is a bit close.

First mount the terminals A–D. These are taken from a small terminal connecting block. Each terminal is fitted to the component side of the board being held in place with a screw which can then be soldered to the copper track.

The choke L1 is made up from a piece of ferrite rod, ¼" diameter and 1¼" long, wound with 55 turns of 28 s.w.g. enamelled copper wire, wound tightly and secured at each end by a strip of adhesive tape. Tin the ends of the wire and attach the choke to the p.c.b.. Now mix up some quick setting epoxy resin (Devcon etc.) and smear this over the windings, making sure that some will anchor the choke to the board. If there is any epoxy left over, smear this over the soldered terminals as this will help with rigidity.

The other components can now be mounted, the Triac should be fitted as close to the board as possible. The switch contacts of the pot must fit through the p.c.b. and should be fitted so that the back of the switch

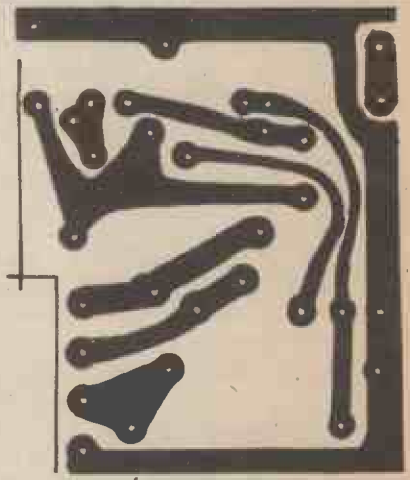


Fig. 2. The p.c.b. pattern.

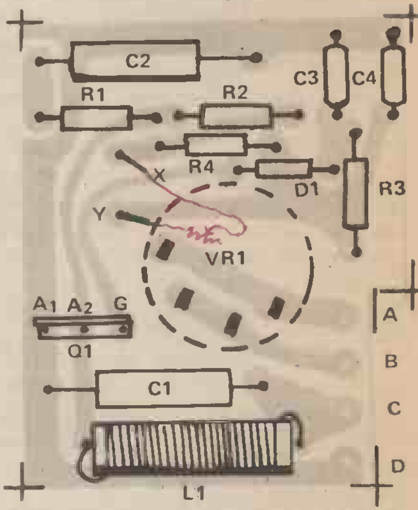
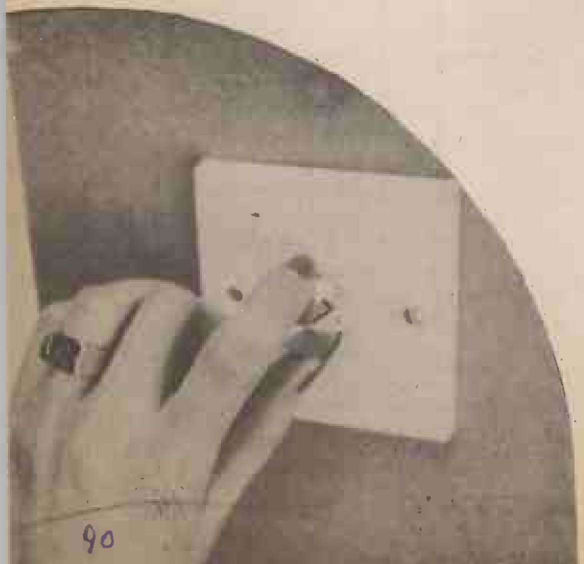


Fig. 3. Components layout, seen from the front of the p.c.b.



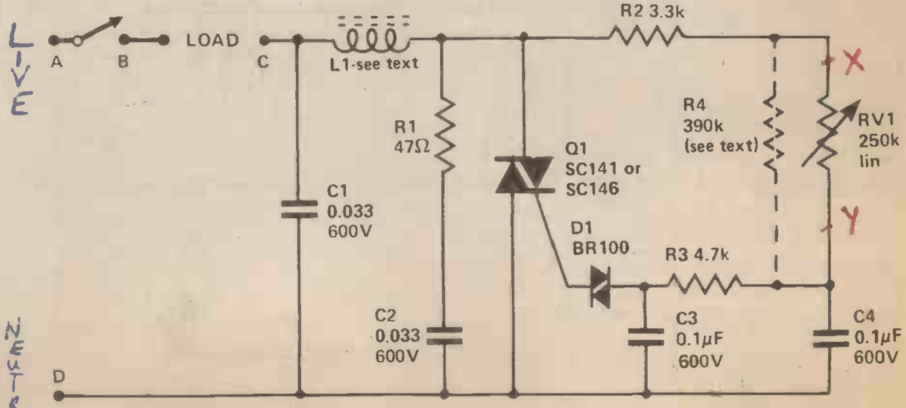


Fig. 1. The circuit of the dimmer.

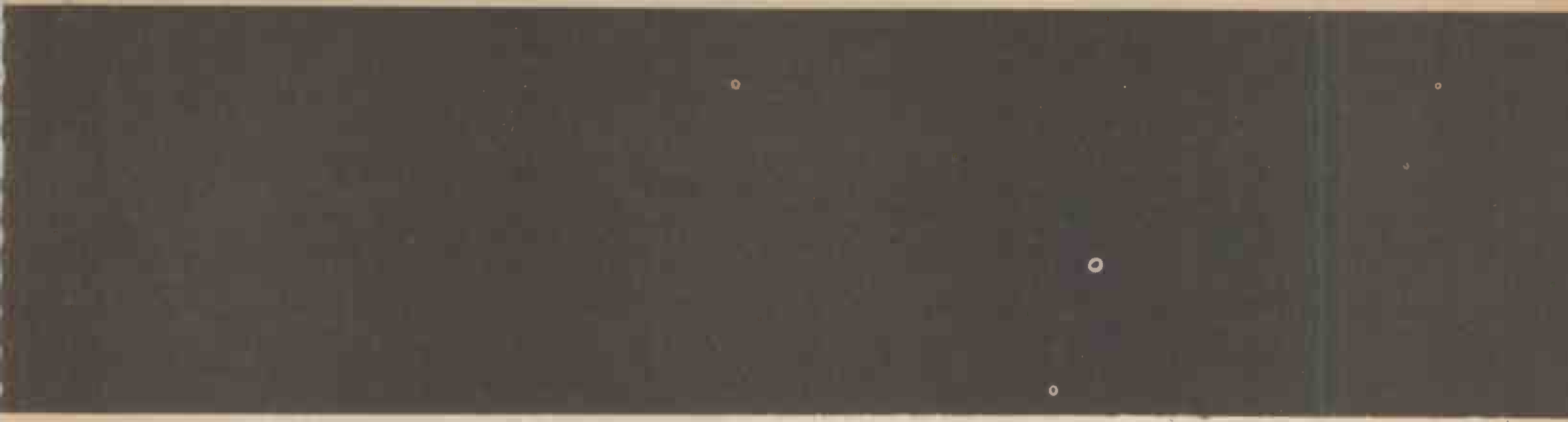


Fig. 4. This shows the mounting of the terminals A-D. The mounting screws are soldered to the copper track.

Fig. 5. The completed unit, without face-plate and knob.

is firmly up to the board. Note that a double pole switch is used and both poles are wired up in parallel. This is done as the rating of switch contacts in pots is usually about 2A, bringing it a bit close to our 500W rating: doubling up gives a better margin.

Blank switch plates are available, made by M. K. Products, and a 3/8" hole is necessary. As the plastic is rather brittle, it is best to drill a smaller hole and ream out the remainder. With the MK 3827 (used in the prototype) there is a moulded flange on the inside which requires a small slot to be filed to give clearance for the Triac.

For those wishing to use the unit at 1kW it is necessary, for safety reasons, to use a separate switch from that in the pot. A suitable heatsink will also be necessary on the Triac and the wire gauge on L1 should be slightly heavier: 24 or 26 s.w.g. The greatest drawback when using the higher power is that RFI can be annoying. When used with a lower load, the radio interference is very low and could not be detected 12" from the prototype, even with the radio's ferrite rod in line with the choke.

PARTS LIST

R1	resistor	47Ω	¼W or ½W	carbon film	
R2	"	3.3kΩ	"	"	
R3	"	4.7kΩ	"	"	
R4	"	390kΩ	"	"	see text
RV1	potentiometer	250k linear with double-pole switch			
C1,C2	capacitor	0.033μF, 600V			
C3,C4	"	0.1μF, 600V			
Q1	Triac	SC141 or SC146 or similar 400V, 6A Triac			
D1	Diac	BR100 etc.			
L1	choke	See Text			

PCB, terminal connectors (4 off), switch face-plate, control knob.

HOW IT WORKS

As with practically all modern dimmer circuits, this one makes use of a Triac for the power control.

A Triac can be regarded as an electronic switch that is turned on by a pulse at a predetermined time in each half cycle and turns off automatically at the end of the half cycle.

Control of the Triac is of the simple resistor/capacitor and diac system. By varying the resistance of potentiometer RV1, the time constant of RV1/C4 is so as to, change the phase.

The pulse at the junction RV1/C4 is passed to the Diac through limiting resistor R3. The Diac is connected to the gate of the Triac and as the Diac is in fact a bi-directional diode, both the positive and negative pulses are applied to the gate.

Capacitor C1 and choke L1 are for suppressing RF1 while R1 and C2 are used for transient suppression.

Resistor R4 is fitted so as to allow full control of light while using RV1. The ideal value for RV1 is 150kΩ but as this value is virtually impossible to obtain, it is paralleled by R4 to give effectively this value.

TEST AND OPERATION

Warning: The circuit board has 240V mains applied to and extreme caution should be used when installing the unit.

Before fitting the unit, it is worth testing on the bench, using a table lamp as a load. Connect this as follows. Terminal A: mains live, Terminals B and C: load, Terminal D: Mains neutral.

If all is well, the unit can be fitted in place of a modern switch fitted in a box. In very shallow boxes, there may not be room for the unit but extension mouldings are available from the same people who supply the switch plate itself.

If the facility for switching an uncontrolled load is not required (i.e. using it conventionally), a jumper wire should be fitted between Terminals B and C and the two wires which normally connect to the switch that the dimmer replaces can be connected to A and D. The unit will work whichever way around the wires are connected but to keep as little of the p.c.b. live as possible, the live should be connected to A. ●

INTERNATIONAL

INTERNATIONAL FM TUNER: SPECIFICATION

Sensitivity (75kHz, 26dB, 75Ω)	1.2μV
Signal plus noise to noise ratio (1mV, 75kHz, 400Hz)	67dB
Stereo channel separation (1mV, 75kHz, 1kHz)	40dB typical
Alternate channel selectivity (±400kHz)	55dB
AM suppression (FM–75kHz, AM–30%, 1mV)	60dB
Total harmonic distortion (1mV, 75kHz, 400Hz)	1%
AFC pulling range (>10μV, 75Ω)	±400kHz
Aerial input impedance	75 and 300Ω
Audio output impedance (both channels)	4.7kΩ
Audio output level (>2μV, 75kHz)	150mV RMS
Operating Voltage (ground neg.)	12V
Operating current	50mA

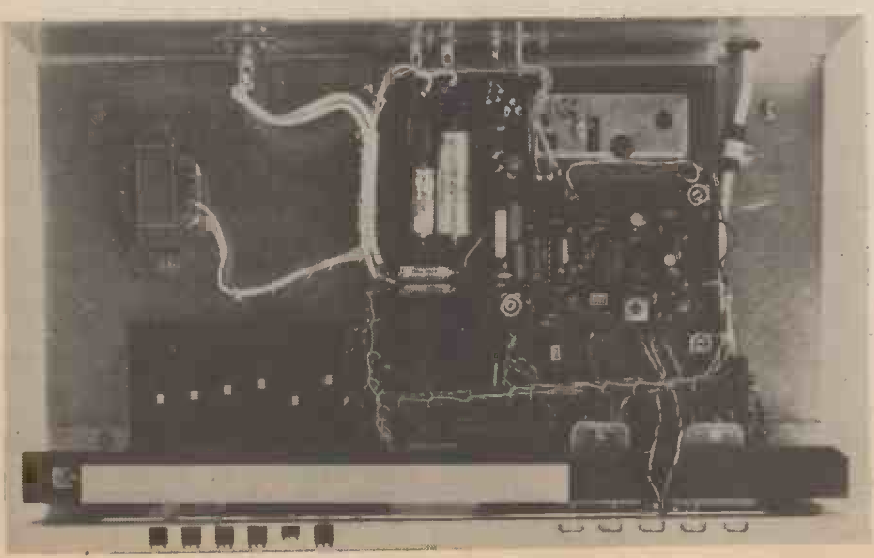
The International FM Tuner is a first class design with an excellent specification. It is designed as the 'brother' of the International 25

The design of an FM tuner was until quite recently, a major problem: numerous coils and i.f. cans were required and the component count, if one had a stereo decoder, was high.

The components now available to the constructor however, make the building of an FM tuner, even with a very high specification, hardly more complex than for a simple amplifier. Alignment was also a major problem and for decent quality, sophisticated equipment was necessary. Our design, the International FM Tuner has an excellent specification and is easy to build and can be lined up literally in seconds using only the meters which are an integral part of our design.

The design is greatly simplified by the use of a single p.c. board which carries all the components other than the transformer and the operator controls. These carry only d.c. (except of course the transformer) and so wires to the front panel are in no way critical. It would not be correct to say that layout is not critical — it is — but if the p.c. board layout is used, all this work is done for you already.

We have not attempted to build the tuner head, although the number of components included is not high, the construction is highly critical and special techniques are needed to align it.



The International FM has facilities way beyond those normally found in any but the most expensive designs. Stations can be tuned in using the cursor in the usual way but also included is a preset module enabling any six stations to be preselected. A disadvantage with multi-turn presets of the type used here is that it is often difficult to know whereabouts in the FM band you are tuning: our design includes a frequency meter which registers the approximate frequency of each push-button. Also included in the design are a tuning meter — to tell you when are right on tune and a signal strength meter to register the relative strengths of the stations heard. These meters are also used in the very simple alignment procedure.

A set of push buttons can select other facilities. There is of course AFC in the circuit and its capture ratio is so good that it has to be switched out for the reception of weak stations adjacent to strong local ones. Inter-station noise is annoying so a MUTE switch is included; once again this can be disabled for the reception of weak stations.

The 19kHz (and residual 38kHz) on stereo transmissions can cause a

FM TUNER

whistle if it beats with the bias oscillator of a tape recorder but more serious, if there is a reasonable level of it, it can overload some amplifiers. It will not be heard at these frequencies but the amplifier can be overloaded and cause distortion as a result. To overcome this a pilot tone filter is included on the output.

We felt that this circuit design was so good that to cut corners in the final appearance could not be justified so considerable thought was put to the final shape and general appearance. There is a fair bit of metal bashing we admit but we think most readers will be happy to spend a hour or two to make the final product acceptable in the living room. A specially long slider pot has been chosen to give good resolution.

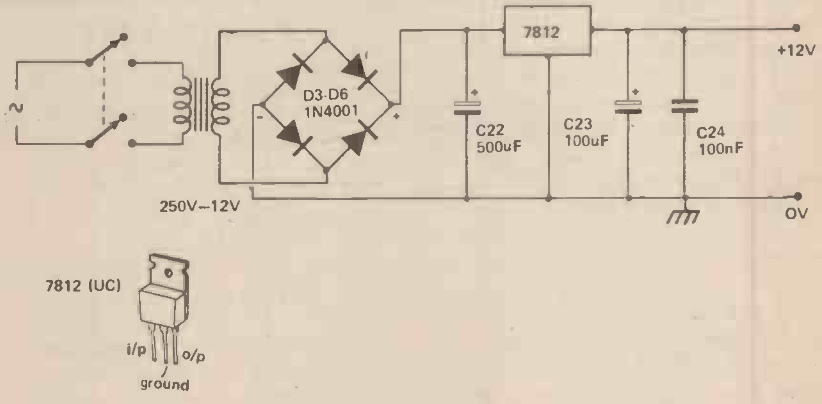


Fig. 1. The power supply circuit. Although not shown here the transformer should have two 12V windings, one as shown, the other for applying 12V a.c. to the panel and meter lights. The use of a voltage regulator is essential as varicap tuning is employed.

CONSTRUCTION

As we have already said, the layout of the components is critical and we therefore strongly recommend the p.c.b. design shown. This carries the power supply (except the transformer) and all the active components. The need for a properly designed layout will be appreciated when one considers that there is over 80dB of i.f. amplification in the main signal processing IC.

Room has been left on the p.c. board for the use of IC sockets and these are strongly recommended unless you always get things to work first time!

The components specified are all readily available from Ambit International who have cooperated closely with ETI in the circuit design.

A number of presets are used on the board: these should be the horizontal types to fit onto the board. Ceramic filters are used in the i.f. stage. These come with various colour codings but this does not matter as long as the colours of both are the same.

A voltage regulator (IC3) is used in the power supply. This is almost essential as the tuner relies on a stable and hum-free supply for the varicap diodes.

Note the lead-out connections of the BF224 — this is given on the circuit: as will be seen the lead-outs

HOW IT WORKS

The system is basically a single superhet VHF receiver. Signals in the range of 88-104MHz are tuned at the R.F. stage of the front end, by means of the varicap diodes. These varicaps are simply silicon diodes whose capacity changes when a reverse bias voltage is applied.

Following the R.F. stage, the mixer converts the R.F. signal to the intermediate frequency of 10.7MHz, by combining it with the signal from the local oscillator — which operates at the R.F. signal frequency plus 10.7MHz.

After amplication provided by QI the resultant signals are then fed through the ceramic filter to provide the necessary selectivity to prevent interference from nearby transmissions, and thence to the main IF amplifier and detector I.C. — the KB4402 (a cheaper but direct equivalent of the CA3089).

The KB4402 contains some ninety transistors that amplify the signal from an input level of 12 microvolts, to a suitable level for the quadrature detector to operate. The amplification is 'limiting', i.e. amplitude variations are removed, since it is only the frequency variations that convey the necessary intelligence. In fact, by the time the signal is ready for detecting, it is almost a square wave — so extensive capacitive decoupling is employed around the device to prevent unwanted R.F. feedback.

The quadrature detector compares with the IF signal with itself — by feeding a signal which has been shifted through a phase network known as the quadrature coil. The effect is similar to the mixer in an DSB generator, though in this instance the frequency variations are converted to the original amplitude variations, and thence fed via the muting circuit to the AF output pin. The muting circuit quietens the noise that appears when tuning between stations, by simply rectifying part of that noise and using it as the control for the audio gate.

A peak detector provides an output for the signal strength meter that is proportional to the signal level of the incoming signal. After the audio detector, the multiplex stereo decoder selects the 19kHz subcarrier, around which the basic stereo information of the L—R channel is encoded at the transmitter.

By matrixing the resultant signals, the decoder output returns the program to its original discrete form of left and right channels. The simplest analogy is to consider the decoder as switching at a rate of 38,000 times a second between left and right. A certain amount of the 19 and 38kHz signal remains in the audio and has to be removed to prevent distortion in subsequent audio amplification — and also to prevent mixing with tape recorder bias oscillators, and thereby producing an audible whistle. A 19kHz pilot presence detector provides a switch for the 'stereo-on' indicator.

Outside the main p.c.b., all the functions are strictly D.C. control voltages (other than audio). This permits flexibility in mounting, since no R.F. sensitive paths exist outside the main unit.

PARTS LIST

R1,7,9,16,21	resistor	10k
R2	"	2k2
R3,26	"	33k
R4,31	"	330 ohm
R5,8	"	390 ohm
R6	"	100 ohm
R10,29	"	3k3
R11	"	470 ohm
R12	"	68k
R13,24	"	100k
R14	"	2k2
R15	"	5k6
R17	"	1k2
R18	"	3k9
R19,27	"	1k5
R20	"	22k
R22	"	15k
R23	"	2k7
R25,28,30,33,34	"	4k7
R32	"	1k

All resistors ¼W, 5% types.

RV1	Slider pot.	50k linear-Rivlin
RV2-RV7		Preset, six position station selector module (Ambit)
RV8,RV11	Preset	10k skeleton type
RV9	"	100k skeleton type
RV10	"	25k skeleton type

C1,2,3,4,6,19	capacitor	22nF ceramic disc
C5,12	"	4.7μF,12V electrolytic
C7,8,17,18	"	10nF ceramic disc
C9,10	"	1μF,12V electrolytic
C11	"	47nF ceramic disc
C13	"	470pF ceramic or polyester
C14,15	"	220nF polyester
C16	"	470nF polyester
C20,21	"	10μF,12V electrolytic
C22	"	500μF,25V electrolytic
C23	"	100μF,16V electrolytic
C24	"	100nF ceramic disc
Q1	transistor	BF224 etc
Q2,4	"	BC108 etc
Q3	"	BC178 etc
ICI	integrated circuit	KB4402 (CA3089)
IC2	"	KB4400 (MC1310)
IC3	"	7812 (UC) voltage regulator
D1,2	diode	1N4148
D3-D6	"	1N4001 (50V, 1A)
LED		TIL209 etc
F1,2	ceramic filter	CFS-10.7 (matched pair)
F3	pilot tone filter	BLR-3107N
L1,2	inductor	22μH choke
Quadrature Coil		KACS-K586
Tuner Head		EC3302 Toko (Ambit)
M1	400μA	Frequency Meter scaled 88-104
M2	400μA	Signal Strength Meter scaled 0-10
M3	50-0-50μA	Tuning Meter, centre zero, scaled 3-0-3 3-0-3
Transformer		250V:12V,12V, 250mA each (one winding for panel and meter lights)
Push-button Assembly		One mains On-off, 4 single pole change-overs, all individually operated (Ambit)

Coax socket,
Balanced feeder terminals
Stereo phono sockets (or DIN socket)
PCB
Metalwork — details next month.

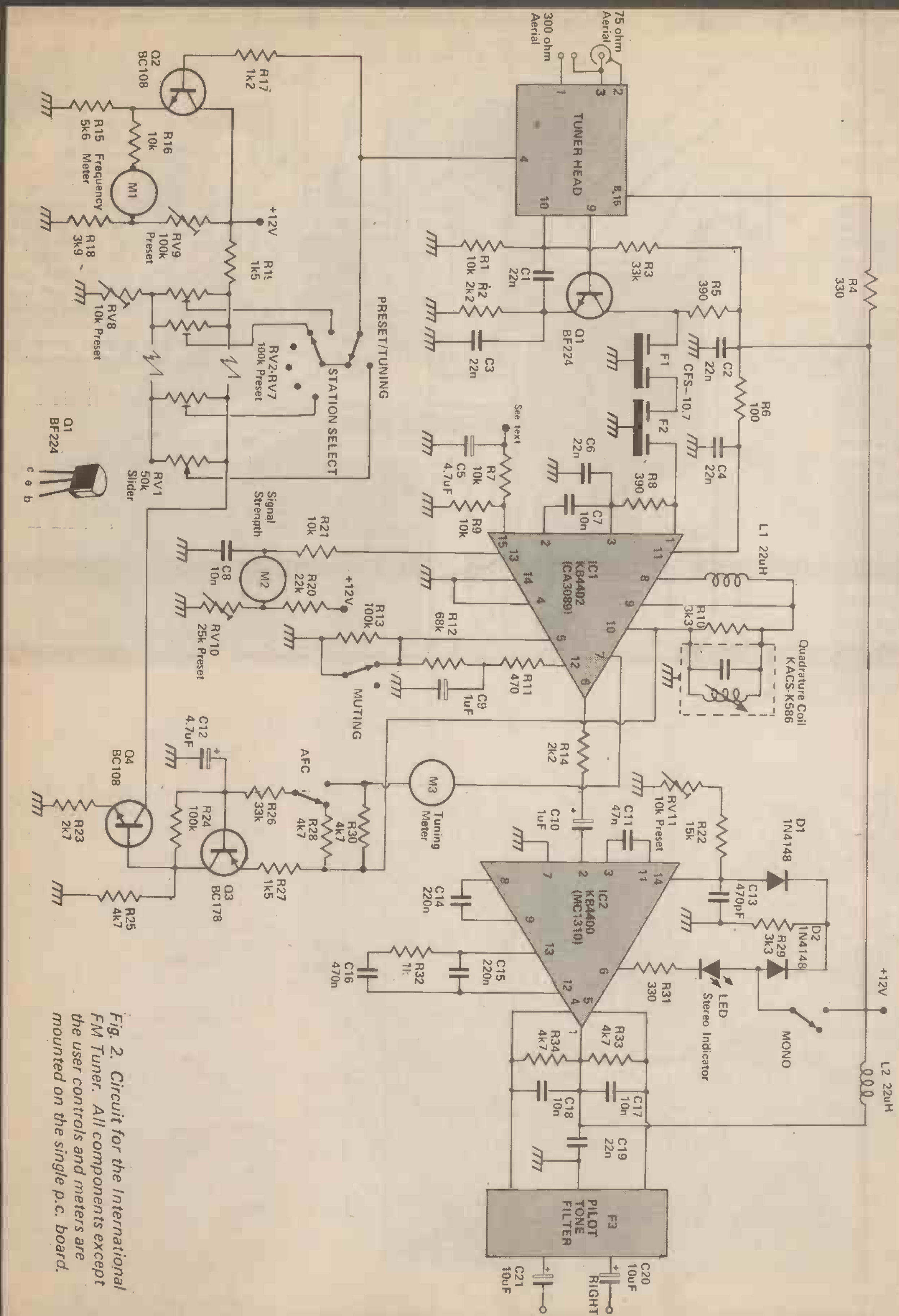


Fig. 2. Circuit for the International FM Tuner. All components except the user controls and meters are mounted on the single p.c. board.

INTERNATIONAL·FM TUNER

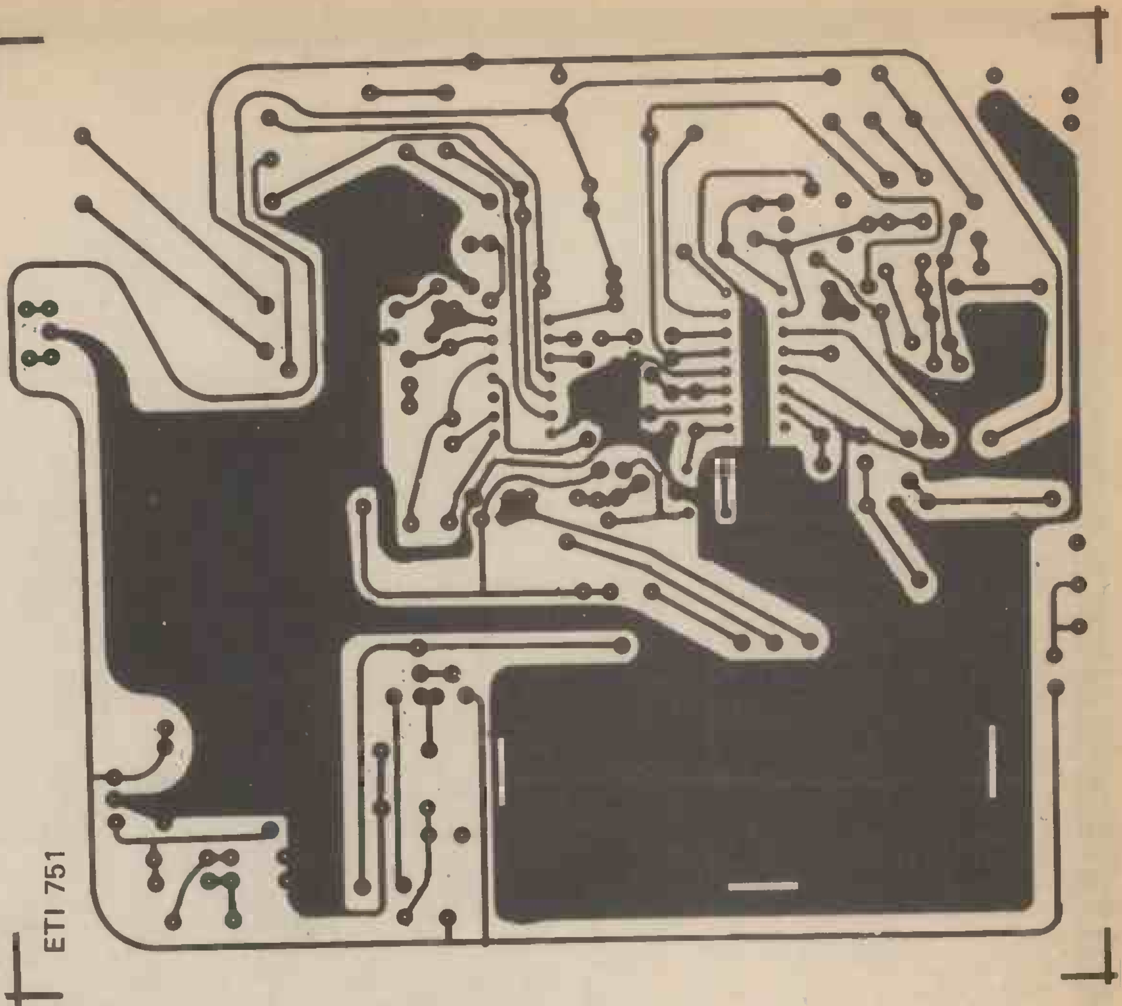


Fig. 3. PCB layout. Due to the high frequencies used this should not be changed.

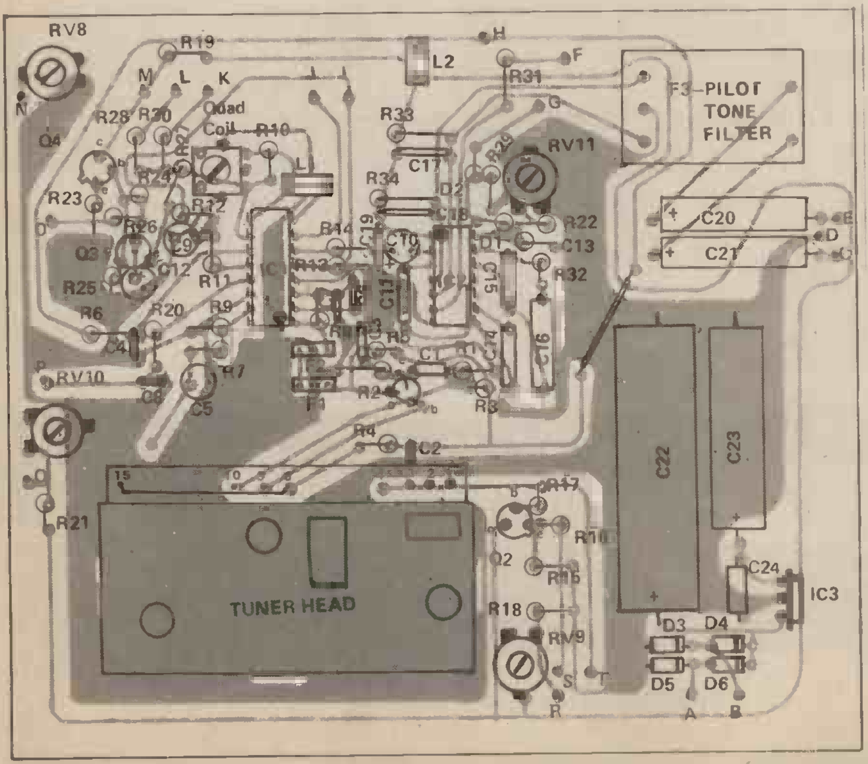


Fig. 4. The component layout on the p.c.b.

are far from standard. The other transistors have conventional lead-outs and should create no problems.

The Toko EC3302 Tuner Head has no provision for AGC but if an alternative is used, ICI has an output for AGC to tuners with such provision (pin 15). For use with the EC3302 R7 and C5 are unnecessary but R9 should be left in even if the EC3302 is used.

To keep the leads as short as possible, the tuner head is mounted on the p.c. board. This has its own board with 15 holes all in line, eight of which are used. Holes 8 and 15 should be connected together with a short wire. The p.c. board of the tuner head sits about 3mm above the main p.c.b. and four wires have to be run through both boards to carry the various connections. Three of the wires go directly to aerial connectors. If the p.c.b. pattern is followed exactly the holes in the two p.c.b.s will line up.

All take-off points on the boards are at the edges to neaten the wiring.

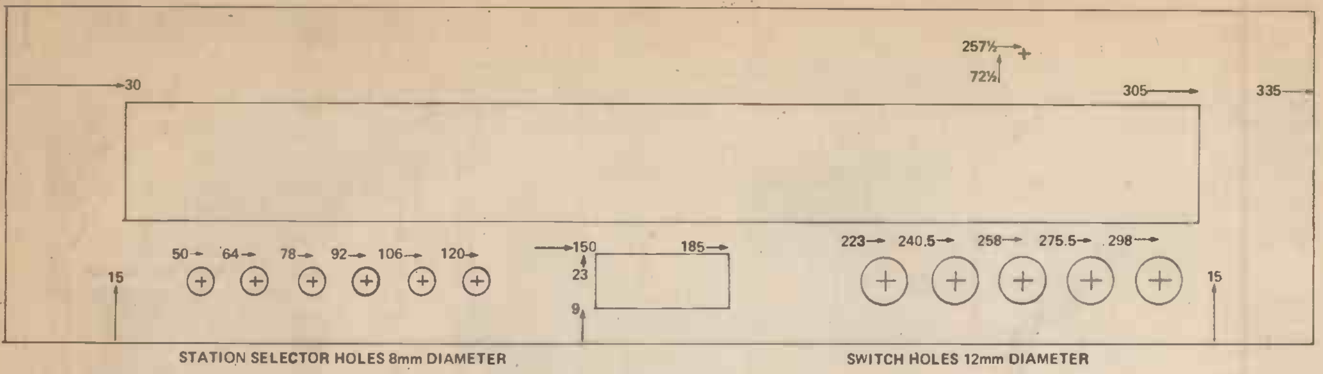


Fig. 5. The metalwork required on the front panel. Dimensions in millimeters.

THE METAL WORK

The chassis is the same size as the INTERNATIONAL-25: 335mm x 190 mm x 84mm. We decided to mount the controls and meters on a support bracket to leave the front panel looking neat. In fact the only components mounted directly onto the front panel are the frequency meter and the LED, both of which are push-fit. Figure 5 shows how we cut the front panel.

Because of difficulties in bending the aluminium and in fixing the components we made the support bracket in two sections. These are bolted together after the slider pot has been mounted into the top section (see photo 2). Figures 7 and 8 give details of the major cutting required in these sections. Because the meters are push-fit mounting types it is best to cut their holes a bit on the small side.

Figure 9 shows how to fix the cursor onto the slider pot. The cursor itself is made from 3mm perspex cut to 50 x 28mm. Any scratches can be cleaned off with metal polish. The knob should be removed from the slider pot and the slider cut back so that it protrudes 8mm from the slot. If the cursor and slider are carefully drilled they can be screwed and glued together (don't forget to scribe a line onto the back of the cursor).

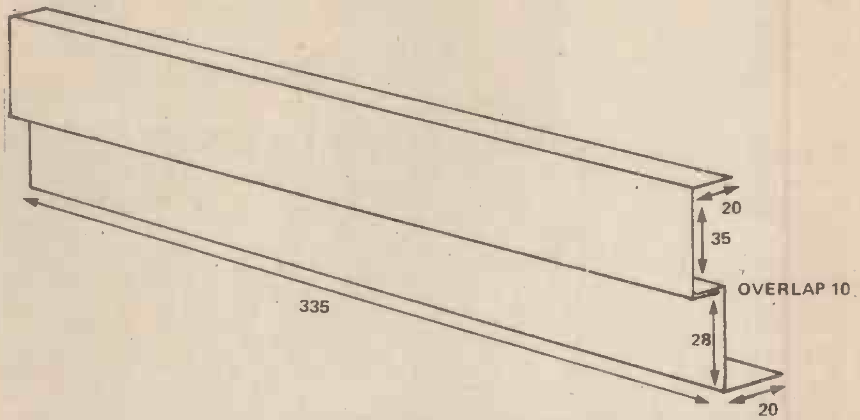


Fig. 6. This shows how the support bracket is constructed in two sections. The top section holds the slider pot and two meters. The bottom section mounts the switches and selectors and the frequency meter.

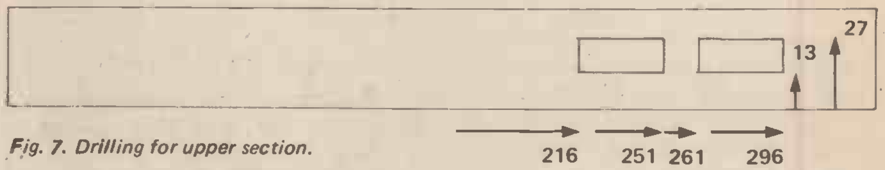


Fig. 7. Drilling for upper section.

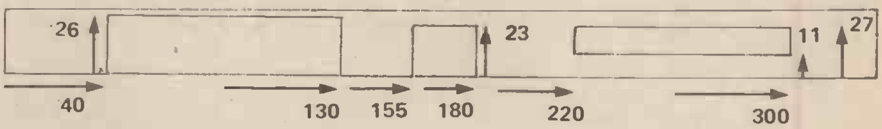


Fig. 8. Drilling for lower section.

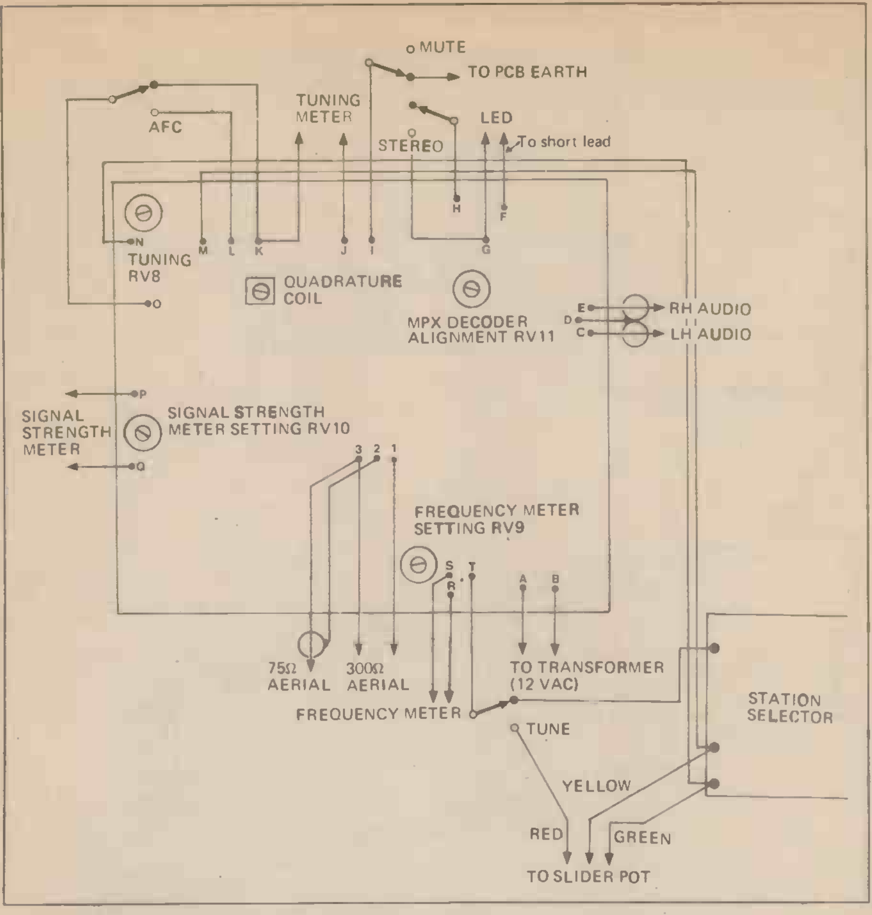


Fig. 10. Wiring up the board to rest of the tuner.

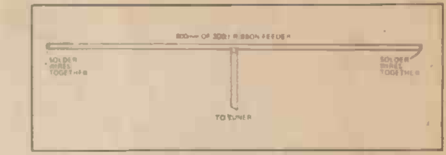
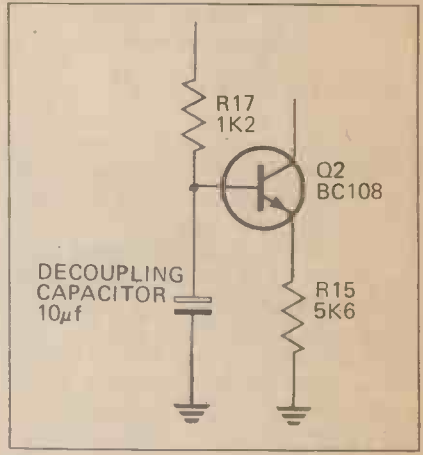


Fig. 11: How to make a folded dipole antenna for FM reception. 300Ω ribbon feeder is used for both dipole and feed.

Fig. 12. Hum in the tuning bias circuits can be cured by decoupling Q2 as shown.



Mounting the slider pot itself requires removing the black plastic end covers so that the case of the pot fits flush with the support bracket. It will be necessary to drill a couple of holes in the case so that the pot can be mounted from beneath. We prepared the frequency scale by sticking down some dark green plastic and gluing strips of white paper to this.

The pcb is mounted, as shown in photo 2, with the tuner head to the rear of the chassis. Figure 10 shows how the board is wired up to the rest of the tuner. The only wiring not shown in Fig. 10 is the mains wiring to the transformer via the on/off switch and the wiring to the meter lights.

A simple 300Ω antenna can be constructed as shown in Fig. 11 and then you are ready to try the tuner according to the test procedure. If you find that there is a gentle hum this can be cured by decoupling the base of Q_2 with a 10μF (10V) capacitor (see Fig. 12). There is sufficient room on the pcb to fit this component easily.

A kit of this project is available from Ambit International, 25 High Street, Brentwood Essex.

THE METALWORK

The three pieces of aluminium, cut to size and bent to our design, are available from H.L. Smith of 287 Edgware Road, London NW2.

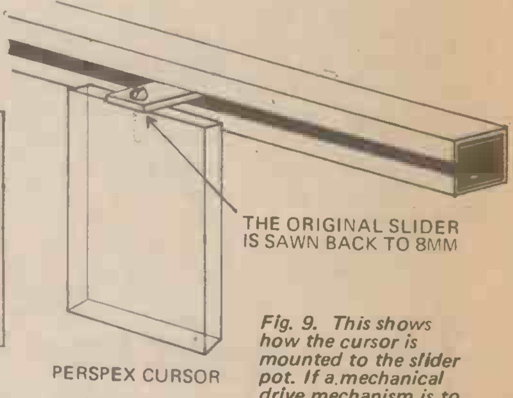


Fig. 9. This shows how the cursor is mounted to the slider pot. If a mechanical drive mechanism is to be used the drive cords can be attached to a tag under the screw.

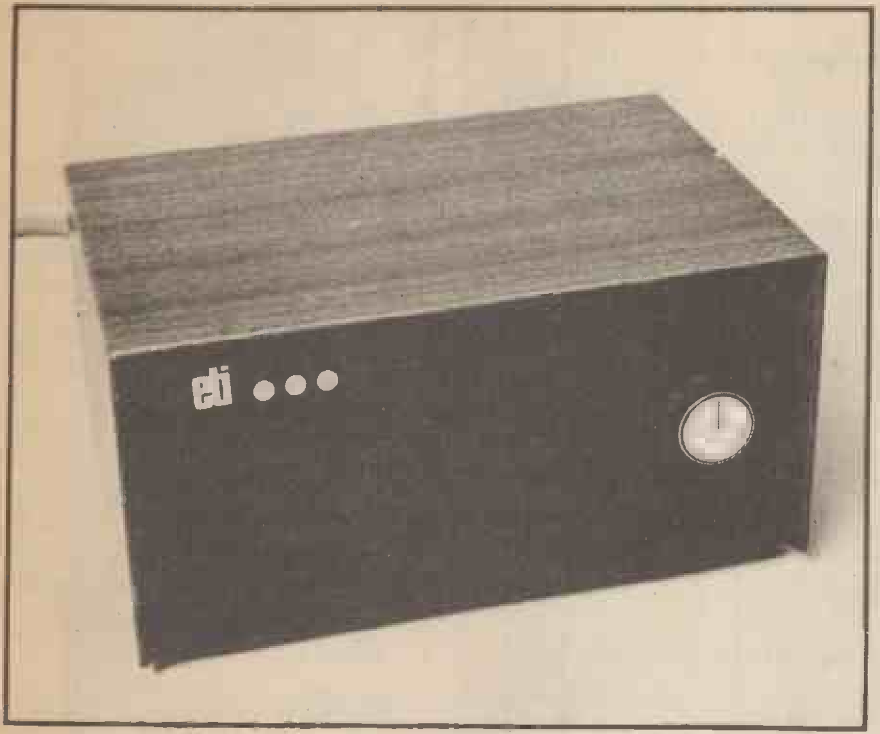
Photo 2: This shows the support bracket and pcb are mounted.

TEST AND ALIGNMENT OF THE INTERNATIONAL-FM TUNER

1. Make certain all connections are sound, and that solder does not overlap any of the PCB tracks.
2. Double check the orientation of all components such as ICs, diodes and the 7812, where it is easy to make a mistake.
3. Switch on check:
   Connect an audio amplifier with an input sensitivity of 100mV (approx.) to the output of the tuner.
   Switch off the mute and AFC, and switch to manual tune and stereo. Set the cursor to the high frequency end of the scale.
   - a) Switch on the mains, and check the PSU voltage to be 12V. Some hiss should be audible at the output.
   - b) Peak this noise by adjustment of the quadrature coil (an RS type trimmer tool should be used to avoid damaging the core).
   - c) Now check the meter functions: the centre zero should be roughly centred by the adjustment of the quadrature coil.
     The signal strength meter should be set at zero in a blank section of the band, by adjusting RV10.
     The frequency meter can only be calibrated accurately by selecting a station on the main scale, and then setting RV9 for the meter to coincide.
   - d) Tuning around for a station will result in the signal strength meter travelling from the end stop. To finely set the quadrature coil tune the signal strength meter for maximum and then adjust the core for centre zero on the tuning meter.
   - e) To align the MPX decoder, tune to a station which is known to be in stereo, and then rotate the preset RV11 until the LED beacon lights. This will also be accompanied by an increase in the noise in the background of the transmission. Rotate the pot across the entire range through which the lamp stays lit, and then set the control to the centre of this arc.
   - f) The IF output coil of the tuner head may also be peaked, using the signal strength meter for guidance. This is the purple coloured core near the output termination.
     The only coil to avoid in the tuner is that of the local oscillator. You will soon realize which this is, since a very minor adjustment will cause the station to disappear.
4. The most likely causes of trouble:
   First incorrect assembly and soldering
   -the LED may be the wrong way around for failure of the stereo.
   -incorrect switch wiring.
   -it is very unlikely that there is any component failure for manufacturer identified devices of established 'pedigree'.


ELECTRONICS TODAY
INTERNATIONAL 4600
SYNTHESISER
mes
maplin electronic supplies

COLOUR ORGAN



Produce all the colours of the rainbow in synchronism with your music!

THE SUBJECTIVE appreciation of music may be considerably enhanced by adding a coloured light display. If the three primary colours, red, green and blue, are projected onto a translucent screen, or some other diffuse material, and selectively modulated by the instantaneous amplitude and frequency content of the music you are listening to, the three colours mix to produce all the colours of the rainbow (as well as white) in synchronism with the content of the music.

A difficulty arises when you try to determine what frequency a 'blue' note should be, or for that matter red, green or any other colour. Bass instruments predominate the frequency range below 220 hertz. Vocals cover the midrange to about 1200 hertz. The higher fundamental notes of wind and string instruments complete the treble register to about 4000 hertz. Harmonics of course extend well beyond this.

It is generally agreed that red should represent low notes, green mid range, and blue the high notes. After much critical listening to tone oscillators and recorded music, in conjunction with light displays our panel of discriminating 'muso's' agreed that 'red' notes should extend to A — an octave below middle C. Green over the next three octaves and then followed by 'blue'. This is accomplished by dividing the frequency spectrum into three bands by means of filter networks. The amplitude content of each band is averaged and used to modulate the brilliance of the associated lamps.

For best effect, the direct light from the lamps should not be seen. It is not very stimulating, and in fact can be disturbing, to watch bulbs flashing on and off. However, the lights can quite readily be arranged to shine behind a translucent panel or be reflected off a wall. Alternately large diameter spheres made from crushed glass or plastic are available as standard lighting fixtures. We tried one that had been converted to accommodate three 100 watt coloured bulbs. Another simple effective arrangement we tried consisted of a cone which we made from a large sheet of translucent drafting film. This was positioned over our 250 watt floodlights mounted inside a five-gallon drum. Incandescent blue lamps are generally inefficient so we added an extra blue lamp in order to achieve colour balance. A lot of creative fun can be had trying different arrangements!

To keep this project as economical as possible we used only one control to vary the input sensitivity. Individual controls however can easily be added if desired. This involves substituting a log potentiometer with an appropriate series resistor in place of each of the resistors R23, R24 & R25.

CONSTRUCTION

We wound the line filter chokes, L1, L2 & L3, on three pieces of ferrite rod 30 mm long. These were cut from a 9 mm dia. aerial rod. To cut the rod, first file a V groove around the circumference of the rod at the point where it is to be cut. The groove need only be about 0.5 mm deep and can be cut with the sharp edge of a small triangular file.

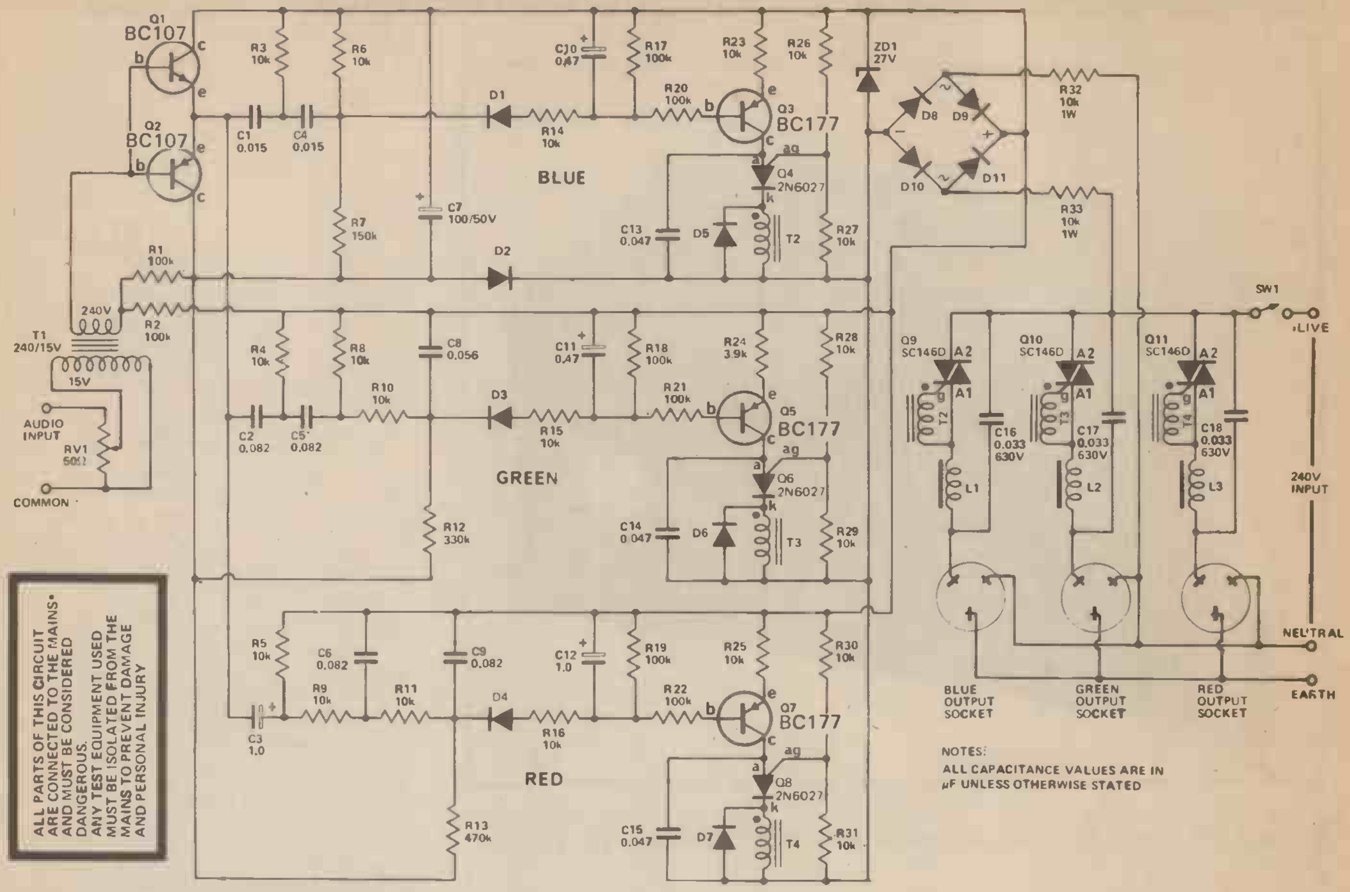
Grip the rod in a vice, at the notch, being careful not to screw up the vice too tightly, as the material is also very brittle and shatters easily. Now give the rod a gentle tap and the rod will part cleanly. Wind the chokes as detailed in Table 1.

The trigger transformers are wound on pot cores having split bobbins, again as detailed in Table 1.

The heat sink should be constructed from a piece of aluminium as shown in Fig. 4. Carefully follow the component overlay, when assembling the board checking that all diodes, transistors and electrolytic capacitors are inserted the right way around.

The line chokes are secured to the PC board by tinned copper wire looped

COLOUR ORGAN



ALL PARTS OF THIS CIRCUIT ARE CONNECTED TO THE MAINS AND MUST BE CONSIDERED DANGEROUS.
ANY TEST EQUIPMENT USED MUST BE ISOLATED FROM THE MAINS TO PREVENT DAMAGE AND PERSONAL INJURY

NOTES:
ALL CAPACITANCE VALUES ARE IN µF UNLESS OTHERWISE STATED

Fig. 1. Circuit diagram of the colour organ.

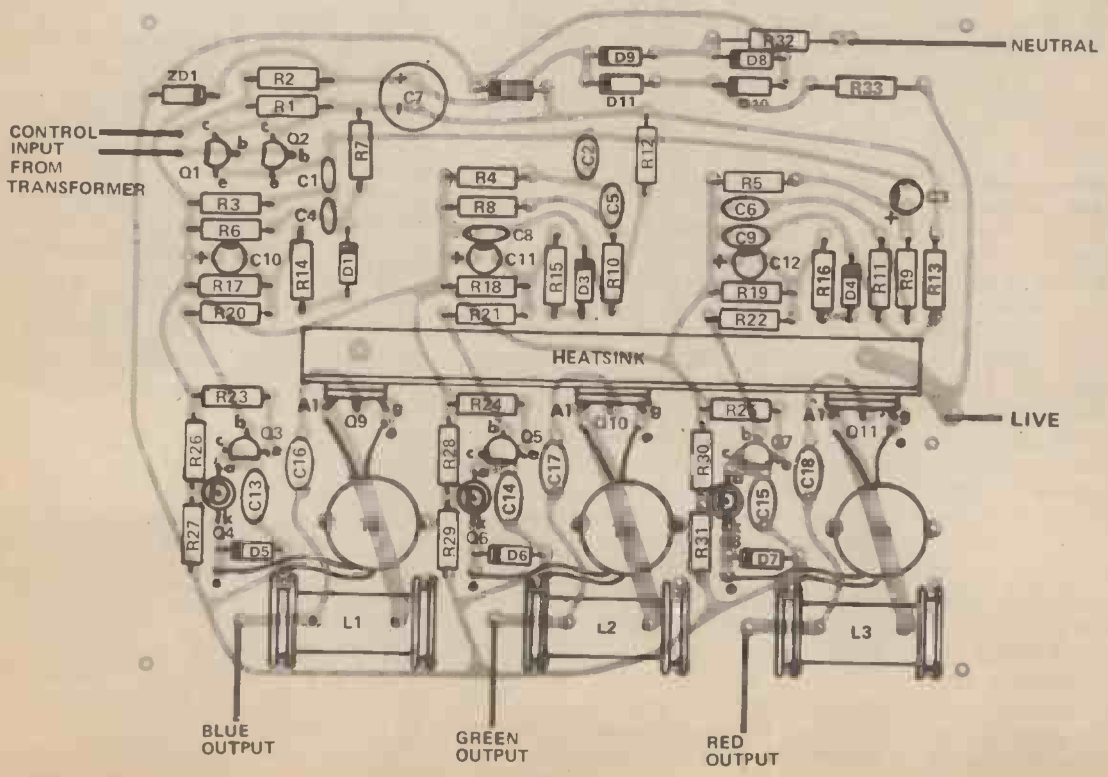
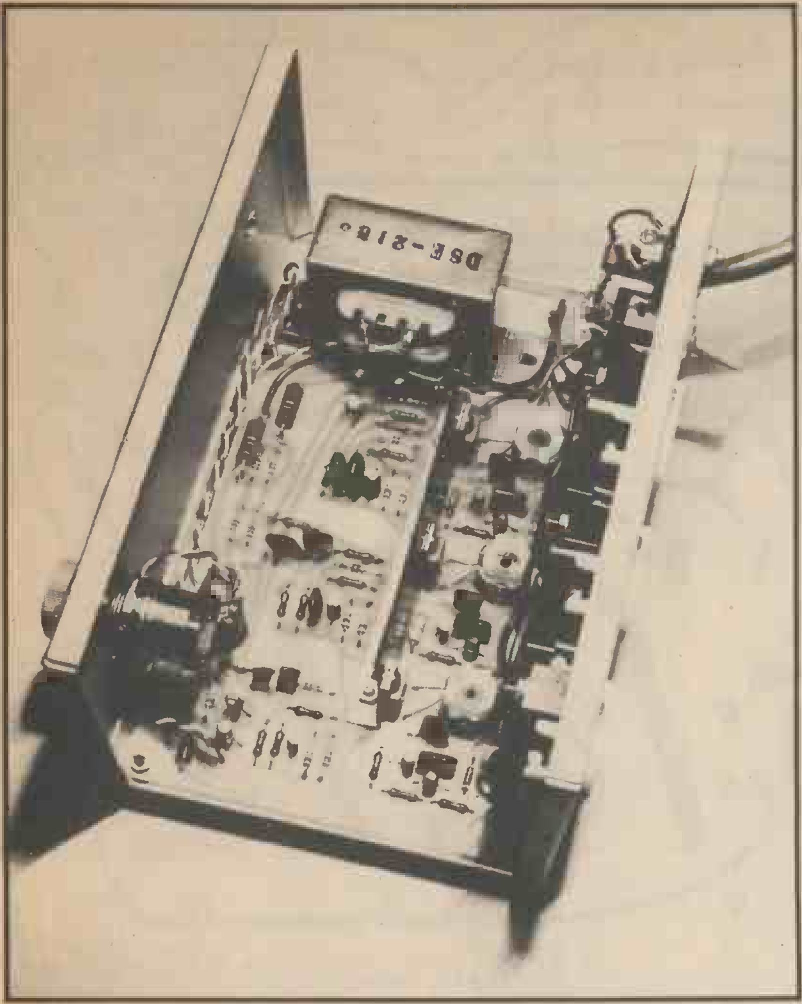


Fig. 2. Component overlay for the colour organ.



◀ *How the unit is constructed*

PARTS LIST

R24	Resistor	3.9k ½W 5%
R3,4,5,6	"	10k ½W 5%
R8,9,10,11	"	10k ½W 5%
R14,15,16, 23,25	"	10k ½W 5%
R26,27,28, 29,30,31	"	10k ½W 5%
R32,33	"	10k 1W 5%
R1.2.17.18	"	100k ½W 5%
R19,20,21,22	"	100k ½W 5%
R7	"	150k ½W 5%
R12	"	330k ½W 5%
R13	"	470k ½W 5%
RV1	Potentiometer	50 ohm 2W
C1,4	Capacitor	0.015µF polyester
C16,17,18	"	0.033µF 630 V
C13,14,15	"	0.047µF polyester
C8	"	0.056µF polyester
C2,5,6,9	"	0.082µF polyester
C10,11	"	0.47µF 35V electrolytic
C3,12	"	1.0µF 35V electrolytic
C7	"	100µF 50V electrolytic
Q1	Transistor	BC107 or similar.
Q2,3,5,7	"	BC177 or similar.
Q4,6,8	"	2N6027 or similar
Q9,10,11	Triac	SC146D or similar
D1-D7	Diode	1N914 or similar
D8-D11	Diode	1N4004 or similar
ZD1	Zener Diode	BZY88 C27 or similar (27V 400mW)
T1	Transformer	240V/15V
T2,3,4	Pulse Transformer	see table 2.
L1,2,3	Chokes	see table 1.
SW1	Switch	240V ac 10A
PC board		

Heatsink to fig. 4.
Three 3 pin outlets
Metal box to suit*
3 core flex and plug
7 rubber grommets
1 cable clamp
1 knob
terminal strip for mains connection.

*we used a box 210 x 100 x 140 mm

HOW IT WORKS

Audio is fed to the input from the loudspeaker terminals of the amplifier. RV1 controls the input sensitivity and transformer T1 steps up the input voltage as well as providing safety isolation from the 240 volt mains on the remainder of the circuit. Transistors Q1 and Q2 provide a low impedance drive for the three filters and present a constant load to the transformer thereby keeping the level independant of varying frequency.

The 'red' channel is driven via a two stage 12 dB/octave low pass filter. The principal frequency determining components are R9, R11 & C6, C9. Diode D4 rectifies the signal which is converted to an average dc level by R16, R19, R22, C12. This varies the bias on transistor Q7 which operates as a constant current source.

The instantaneous current is set by the applied bias, and by the value of Q7 emitter resistor R25. The resulting constant current charges C15 and when the voltage across C15 equals the reference voltage set at the anode gate terminal (ag) of the programmable unijunction transistor (P.U.T.) Q8, the P.U.T. fires discharging C15 through the primary winding of trigger transformer T4.

The resultant pulse, from the secondary of T4, fires triac Q11 thus switching power to the red lamp. The firing cycle of the P.U.T. is synchronised to the 50 Hz mains by the unfiltered supply derived from Zener diode ZD1. Diode D7 bypasses the reverse flyback pulse from the triac and ensures the pedestal voltage of C15 remains constant.

The operation of the green and blue channels is similar with the exception of the filters. Components C2, C5, C8, R4, R8 & R10 form a bandpass filter for the green channel, whilst C1, C4, R3 & R6 make a high pass filter for the blue channel. Chokes L1, L2 & L3 in combination with capacitors C16, C17 & C18 are incorporated in order to reduce radio frequency interference.

round the grommets and then soldered to the board. As the triacs used are rated at 10 amps, the main limitation on the maximum load is the associated domestic wiring which would limit the total load to 2400 watts. We have designed the heat sinks with this in mind. If it is required to drive heavier loads the area of the heat sink should be increased and possibly triacs rated to carry higher current substituted. Of course then ordinary domestic power outlets should not be used.

A 300 millivolt input is sufficient to drive the lamps to full brilliance. At one hundred hertz the input impedance is approximately 12.5 ohms, accordingly any amplifier capable of delivering a watt or more would suitably drive the unit.

Set the amplifier volume control to the normal listening level, then adjust the input sensitivity control such that the lamps only light up to maximum brilliance on musical peaks. If this control is not set correctly the input level will be too high with the result that the lamps will all light up together regardless of the frequency content of the programme. If everything is working at this stage, you can now watch the changing moods and drift into happy ecstasy!

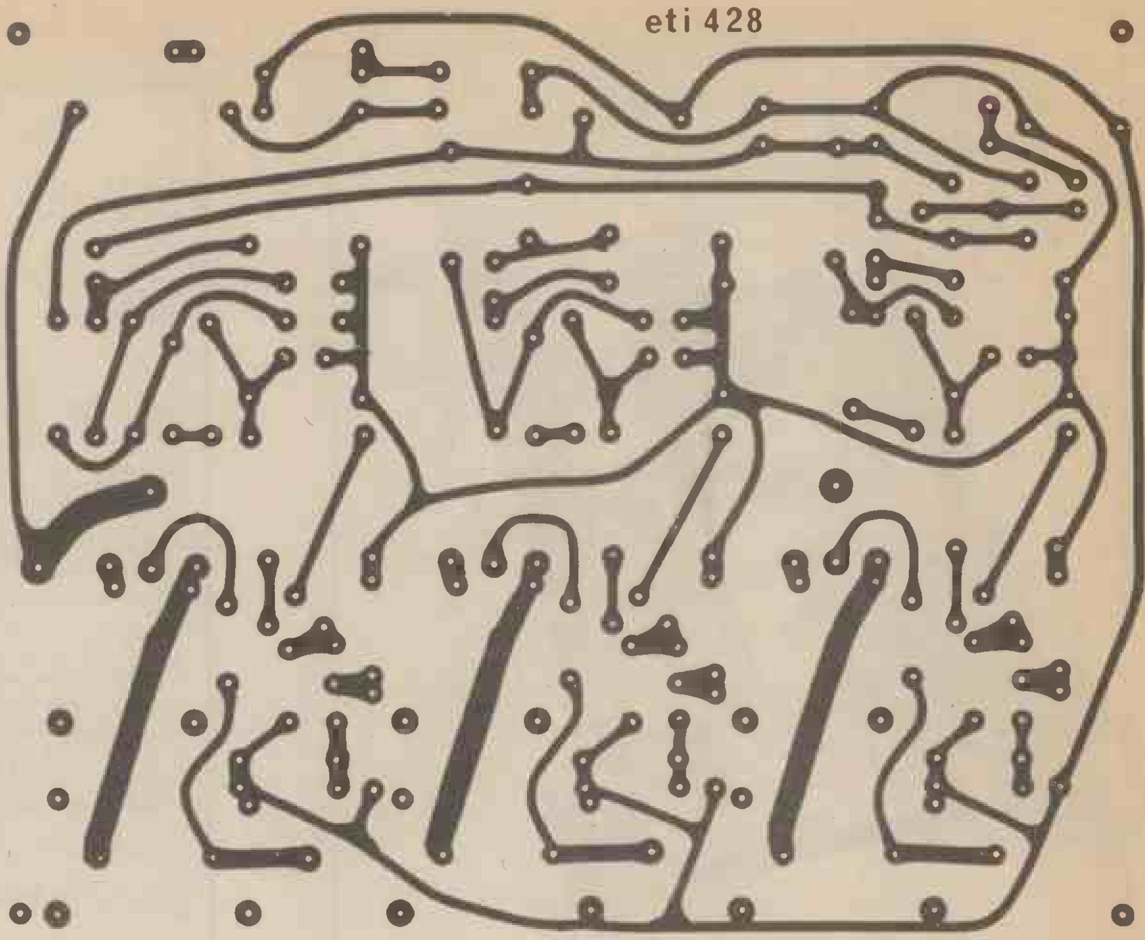


Fig. 3. Printed circuit board layout for the colour organ. Full size 127 mm x 158 mm.

TABLE 1 **CHOKE WINDING DATA**

L1, L2 & L3

Core	30mm length of 3/8" dia ferrite rod.*
Winding	40 turns 0.63mm (26swg) wound in two layers, each 20 turns, close wound using the centre 15mm only of the core.
Insulation	two layers of plastic insulation tape over complete winding.
Mounting	use rubber grommet (3/8" ID) over each end and join to PCB by looping turned copper wire around grommets and secured into holes provided.

* Made from an aerial rod — file a groove around it at the desired cutting point then snap off.

PULSE TRANSFORMER — WINDING DATA
TABLE 2

T2, T3, T4

Winding a double section bobbin
Primary — 30 turns 0.40mm (30swg) one section
Secondary — 30 turns 0.40mm (30swg) second section
Bring leads out at opposite ends of coil.

Winding a single section bobbin
Primary — two complete layers 0.40mm (30swg) close wound
Insulation — two layers of plastic insulation tape
Secondary — two complete layers 0.40mm (30swg) wire close wound
Bring leads out at opposite ends of coils.

For details on the core see box on the right.

GETTING HOLD OF THE COMPONENTS

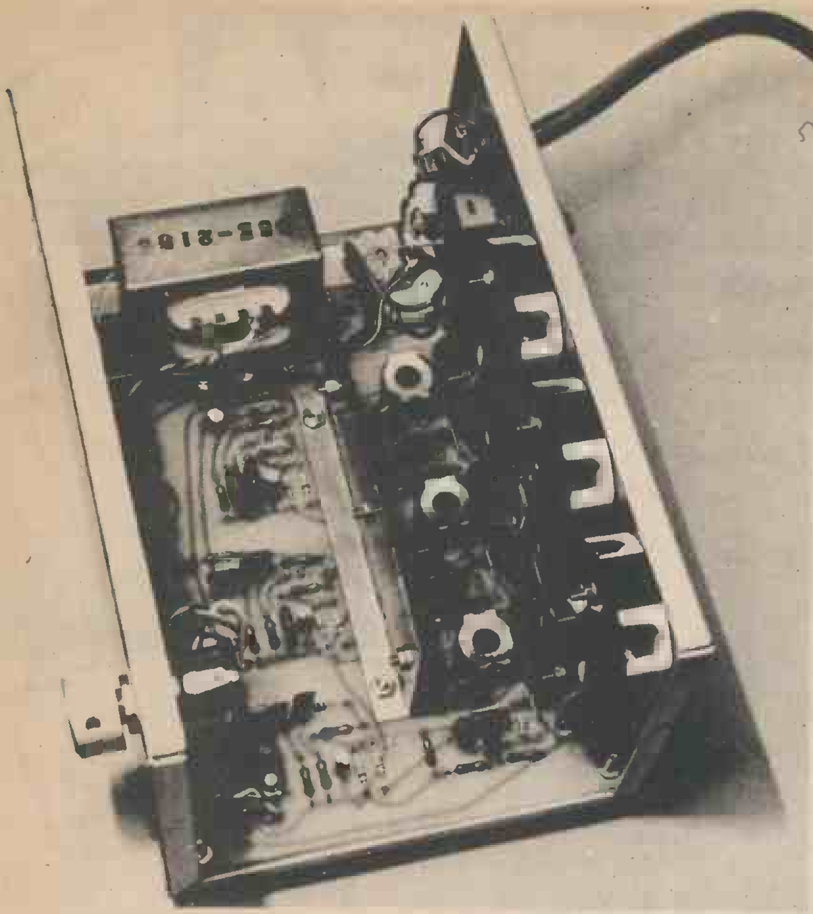
SEMICONDUCTORS
Marshall's will be able to supply all the semiconductors for this project (2xBC107, 3xBC177, 3x2N6027, 3xSC146D, 7x1N4004, 1xBZY88).

POWER OUTLETS
Any mains sockets will do, provided they can take the current. Marshall's have stocks of the Bulgin three-pin recessed power sockets in 2 sizes: the 1" version socket and plug and the heavy duty P437.

INPUT TRANSFORMER
This is used to step up the audio impedance and the current rating is not important. Any convenient 240V:15V transformer will do.

PULSE TRANSFORMER POT CORES
Problems may arise with these cores. The requirement is for a pot core with an AL value of 520 and a μe of something like 250. This can be achieved using the following Mullard components — core: LA1225; adjuster: LA1502; 2-section former: DT2281; ring: DT2356; tagboard: DT2359; clips (4 required): DT2357.

A. Marshall and Son, 42 Cricklewood Broadway, London NW2 3HD.



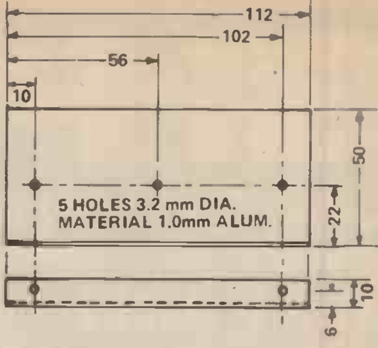


Fig. 4. Dimensions and drilling details for heat sink bracket.

WARNING. All components on the board and the heat sink, upon which the triacs are mounted, are at mains potential. Use extreme care as you would with any exposed wiring carrying 240V. Avoid working on the unit whilst it is connected to 240 volt mains, make sure any test equipment you are using is isolated from earth, and that you yourself are well insulated from the floor by a rubber mat etc.

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CP1	150	Capacitors, mixed bag of paper, silver mica, electrolytics, etc. Approx. quantity, counted by weight (post and packing)	60p
CP2	200	Resistors, mixed bag of different types, values, wattages, etc Approx. quantity, counted by weight	60p
CP3	40	Wirewound resistors, mixed types, values and wattages	60p'
CP4	12	Potentiometers, pre-sets, w/wound, carbon, etc. Mixed types and values	60p
CP5	5	Earphones, single low impedance for transistor radios, cassettes, etc. Less plugs, for suitable plugs see PAKs CP9 and CP10	60p
CP6	50	TO-5 mounting pads, fits between transistor and board, for that pro. finish	60p
CP8	500	Cable clips for G.P D. ⅛" dia. cable. Nylon with hardened steel pin (probably tungsten) per sealed box of 500	60p'
CP9	5	3.5mm plugs, miniature jack, to fit earphones in PAK CP5.	60p'
CP10	5	2.5mm sub miniature jack plugs, to fit earphones in PAK CP5	60p'
CP11	6	Screwdrivers, 1 x mains neon tester, 5 x grub screwdrivers.	60p'
CP12	10	Reed relay inserts, 1" long ⅛" dia. These will operate from an external magnet or coil. For magnets see PAK CP13.	60p'
CP13	10	Magnets of various sizes for operating reed switches on PAK CP12. Ideal for burglar alarms on doors and windows, etc.	60p'
CP14	40	Potentiometers, presets, wirewounds, carbons, dual gangs, with and without switches, etc. Mixed values and wattages.	£1.20
CP15	12	Standard crocodile clips, screw fixing, good quality	60p'
CP16	5	P.C. boards each containing a BF180 UHF amplifier transistor. A good basis for building a T.V. aerial pre-amp as various parts inc.	60p
CP17	25	Electrolytic Capacitors, various values and voltages, many useful types, from T.V. to transistor radio and HI-FI (post and packing 23p).	60p
CP18	1	Light activated SCR.50 volts 1 6 amps type L9F. Ready mounted on PC board with gate resistor and leads fitted. Full data and circuit diagrams for 14 projects, includes: slave photo flash unit, burglar alarm, etc.	
CP19	3	Micro switches 1 pole change over, standard model 1⅛" x ⅛".	60p'
CP20	10	Relays, assorted types, Ex-G.P.O and others, mixed voltages	£1.20'
CP21	200	Square inches of copper laminate P.C. board, in approx. 8 pieces	60p'
CP22	3	Fibreglass plain printed circuit boards, approx. 2½" x 14".	60p'
CP23	4	Switches miniature push to make, single pole	60p

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TP14	20	OC71 germanium PNP audio pre amp transistor, black glass type.
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TP16	20	OC200/1/2/3 transistors, PNP silicon TO-5, unmarked.
TP17	20	1 watt zener diodes, mixed voltages, 6.8 to 43 volts.
TP18	20	2N3707/8/9/10 transistors, NPN silicon plastic, unmarked.
TP19	100	Diodes, mixture of germanium, gold bonded, silicon, etc., a useful selection of many types, marked and unmarked.
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TP23	20	BFY50/1/2, 2N696/7, 2N1613, etc. NPN silicon TO-5 uncoded. COMPLEMENTARY TO PAK TP24.
TP24	20	BFY64,2N2904/5, etc., PNP silicon TO-5 uncoded COMPLEMENTARY to PAK TP23.
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● FIRST IN U.K. WITH PACKS FOR ELECTRONICS USERS

BICYCLE SPEEDOMETER

Be the first to have an electronic speedo on your bicycle!

BE THE FIRST to have an electronic speedometer on your, or your son's bicycle – calibrated in km/h too! The advantage of an electronic speedometer is that it doesn't take extra muscle power to drive it – as do those mechanical ones. The small amount of energy needed comes from a battery which is switched on only when a speed reading is required – this is obtained by pressing a bicycle horn button mounted on the handlebars.

This project was developed around a stripped down bicycle, hence the photographs show bare elements only.

The indicator part of the speedometer is a 1 mA meter mounted in the lid of a suitably sized tin can, see Fig. 1. This is attached to the handlebar pinch bolt by means of a bracket fashioned from aluminium as can be seen in the photo.

The electronics are in four connected sections: the indicating section (Fig 1); the switch, which is a push button mounted on the handlebar – a bicycle horn button is ideal; the photo transistor and resistor R2; and the lamp.

INDICATING SECTION

The components of the indicating section are mounted on a very simple printed circuit board, shown full size in Fig.4. This is attached by bent brass strips to the meter terminals. Veroboard or tagboard enthusiasts can use their favoured technique and save themselves the trouble of making a board if they wish.

The battery, comprising six 1.5V cells cells, is contained in a battery case also inside the tin box. Note that an extra wire has to be soldered to a connection of the battery case to provide the tap at the 6 volt point as shown.

LAMP AND PHOTOTRANSISTOR

These items are mounted on the insides of the front forks of the bicycle. If this location is not available,

Fig. 1. The meter section may be attached to the handlebars by a bracket held by the handlebar pinch bolt. (meter dial is seen here before re-calibration).

BICYCLE SPEEDOMETER

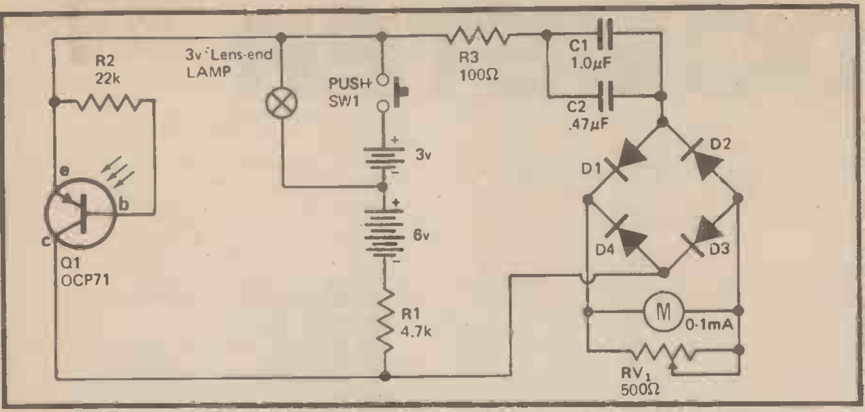


Fig.2. Circuit diagram of complete unit.

due to the existence of brakes for example, then the rear forks or seat stay may be used as an alternative position. Whatever position is used it is important that the mounting brackets are attached securely so that they will not allow the parts to tangle with the spokes.

The photo transistor is attached to a small strip of phenolic board by means of a shaped brass clip. The resistor R2 is mounted on the opposite side of the board with its leads passed through small holes and bent to form an anchor. When the speedo is working properly this resistor may be covered with epoxy resin. The active portion of the photo transistor is shrouded from unwanted light by a short length of black plastic tubing, cut from an empty ball pen, epoxied on to the board.

Directly opposite the transistor is a lens-end bulb (pen torch variety) in a lamp holder mounted on a suitable bracket. The bulb is shrouded with a piece of plastic conduit — mainly to keep dirt away. It is very important that the bulb selected should have its filament on the bulb axis — so that the bright spot formed by the bulb is in line with the bulb and can be directed on to the transistor. These two elements must be adjusted so that they are rigidly aligned.

CONNECTION

Light twin flex such as speaker lead is suitable for connecting the various elements together

BARRIERS

The barriers on the prototype were pieces of aluminium about 90mm x 25 mm, actually cut from the aluminium plates used on office offset printers. Simply bending the ends of the strips around the spokes and pinching them is sufficient to keep them in place.

Constructors who can't obtain similar aluminium could use old

HOW IT WORKS

The speedo is essentially a very simple tachometer which measures the frequency of pulses caused by interrupting a light beam shining on a photo transistor. Fig. 2 shows the circuit. The transistor and lamp are mounted on opposite sides of one of the bicycle wheels and the light from the lamp is interrupted by barriers between alternate pairs of spokes. Pulses of current flowing in the transistor circuit cause a pulsating voltage across the battery and load resistor R1. These pulses are fed to the 1 mA meter through a bridge rectifier circuit D1 – D4 in series with a capacitor (actually C1 and C2 in parallel). The rectified meter current is directly proportional to the size of the capacitor and pulse frequency. The variable resistor RV1 provides calibration adjustment.

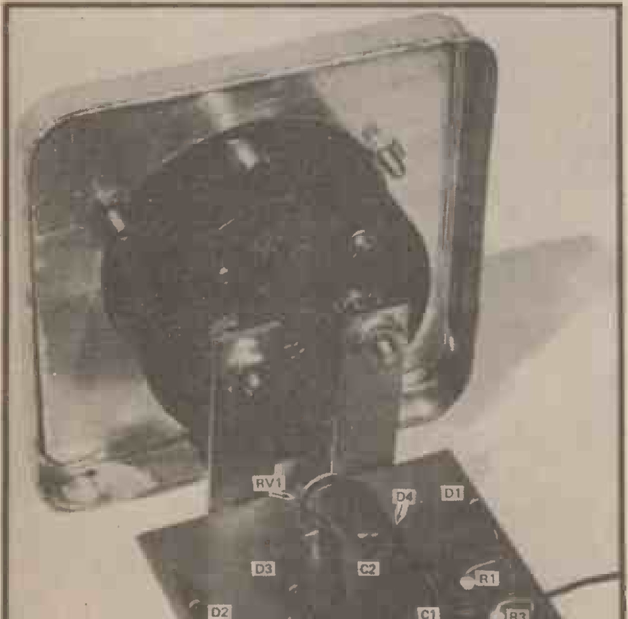
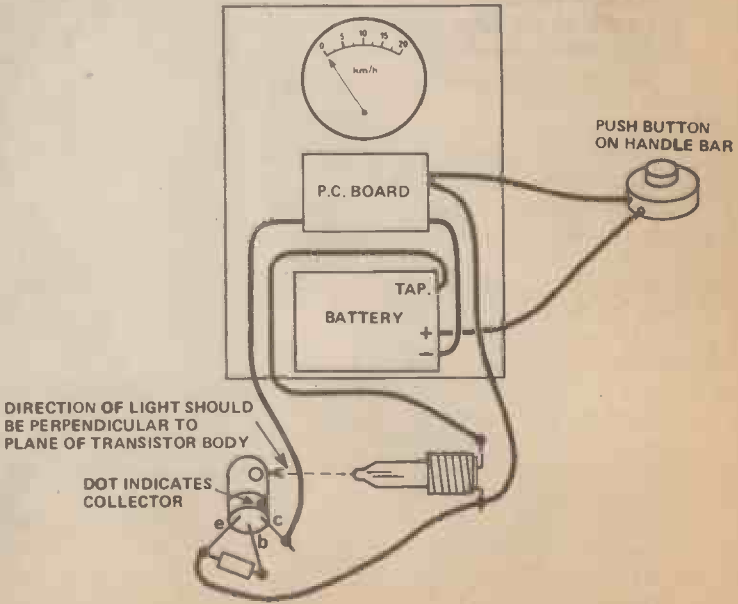


Fig.3. This schematic drawing shows how the various bits are interconnected.



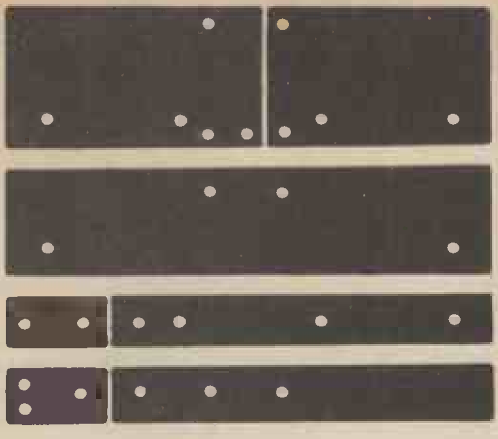


Fig.4. Printed circuit board (shown full size).

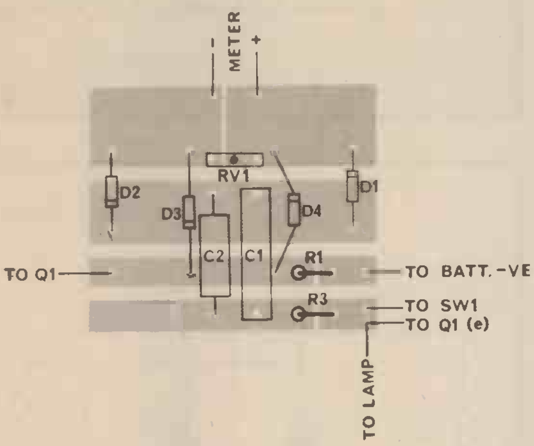


Fig. 5. How the components are mounted on the printed circuit board. The completed board may be fixed rigidly to the meter terminals by two copper straps.

aluminium or tin cans flattened out and perhaps painted.

CALIBRATION

A fairly accurate calibration may be made by attaching a piece of cardboard to the spokes so that it acts as a clicker as it passes the forks. Aim for a light click on one fork only so that the wheel is not slowed down too rapidly

Then, spinning the wheel, counting clicks over say 30 seconds and reading the meter at the same time, provides enough data to work out speeds and calibrate. (Something to do with your new calculator!)

The meter should be adjusted by the calibrating pot RV1 so that it reads full scale at some convenient speed such as 45 km/h. It may be hard to spin the wheel at this speed by hand, but the problem is overcome by driving it by a rope drive from a pulley fitted in the chuck of a drill. This works very well.

As the meter reads linearly, settings below full scale should be accurate enough using the divisions on the original meter scale.

Another possibility for calibration is for the bicycle to be paced by a car with a speedo of known accuracy, (remember that only a maximum full scale reading is required).

The meter scale should be fitted with fresh numbers — Letraset figures stuck on white Contact background are ideal.

PARTS LIST ETI 235

R1 Resistor 4.7k ¼ watt
R2 Resistor 22k ¼ watt
R3 Resistor 100 ¼ watt
Rv1 potentiometer 500 ohm
C1 capacitor 1.0 μF plastic
C2 Capacitor 0.47 μF plastic
D1-D4 diode OA200 or similar
 silicon diodes
Q1 photo transistor OCP71 or similar
S1 push button switch normally open
 — bike horn type
M 0-1mA meter
Lamp 3 volt lens end type as used in
 pen torches
Battery — 6 1.5V cells in case
Aluminium for barriers
Aluminium or light steel for brackets
Tin box

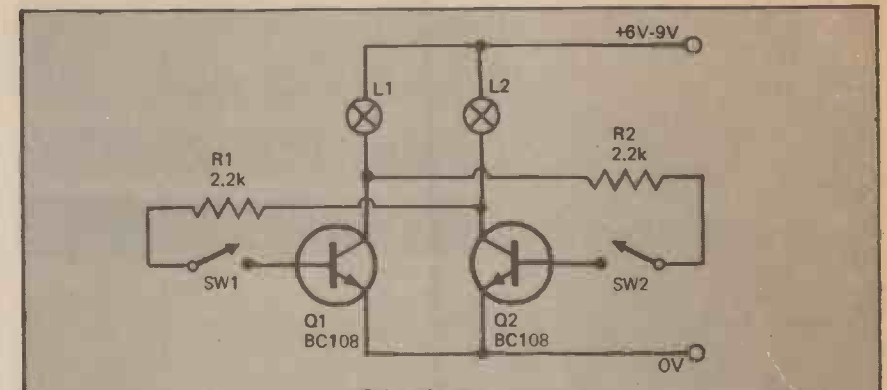
If there is any problem with getting a full scale reading the most likely causes are:— incorrect alignment of lamp and photo transistor, and a lamp which spreads out the light too much instead of concentrating it.

FINISHING TOUCHES

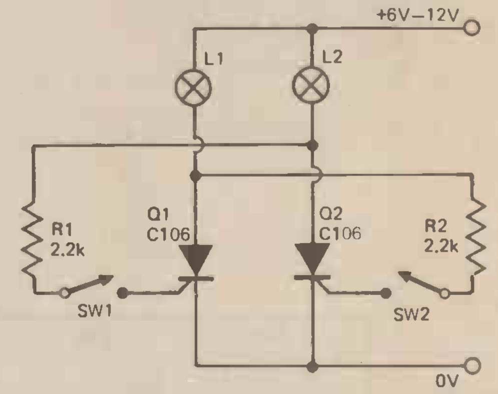
When all is in working order the battery case should be taped up and then 'nested' in plastic foam inside the tin box. The tin box should be sealed against weather with plastic tape, and the lamp should be lightly soldered to the lamp holder to prevent its being loosened by vibration. ●

Electronic Windicator

Circuit indicates which of two switches is first depressed.



Original entry



The circuit is self-latching if the transistors are replaced by SCR's.

The circuit was originally designed for use in a game in which two players on command each try to press their respective switch before the other.

The first to do so causes 'his' bulb to light, and providing he keeps his button depressed his opponent cannot cause his own bulb to light until the circuit is reset by momentarily breaking the power input or by the winner releasing his button.

With minor modifications, the circuit may be used in quiz games and/or the lights replaced by buzzers (in the latter case diodes should be wired across the buzzers to protect the transistors from voltage spikes generated by the back emf).

Operating principle is simple. Assume switches SW1 and SW2 are open, both transistors Q1 and Q2 have their bases 'floating' — neither is turned on. Neither bulb is alight.

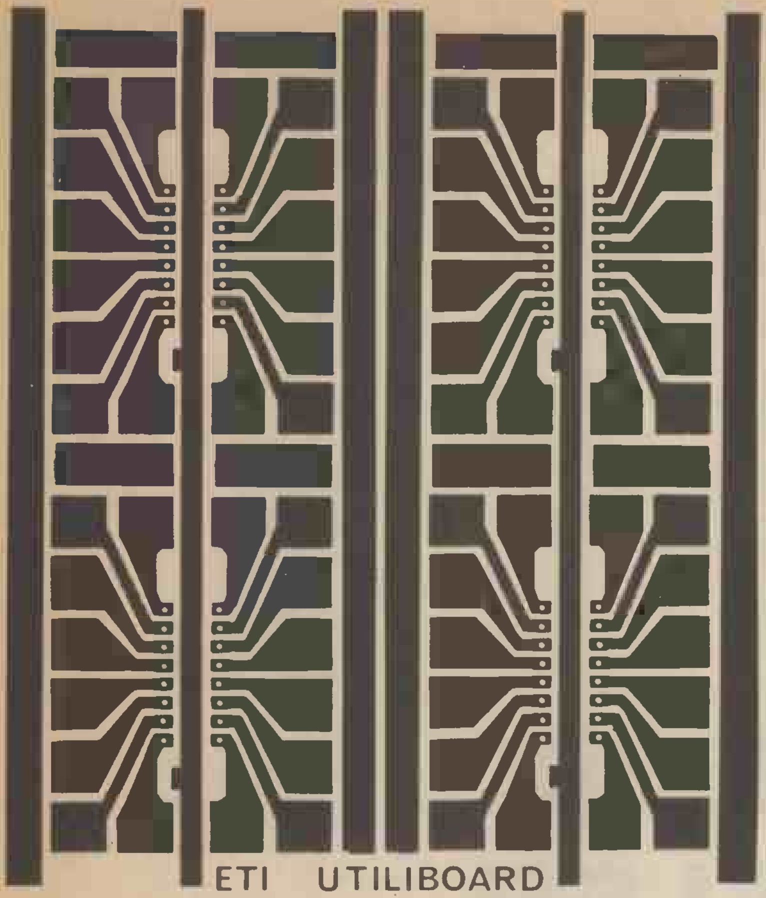
Now assume SW1 is closed. The voltage at the collector of Q2 (which is high) will flow via R1 to Q1's base. Transistor Q1 will now be switched on thus lighting L1. Although SW2 may now be depressed the voltage at Q1's collector is too low to bias on Q2. So L2 cannot be energized.

One disadvantage of the circuit is that it is not self-latching. The winner must keep his button depressed until his opponent has conceded defeat.

SELF-LATCHING

The modification shown here overcomes this disadvantage — at the cost of a slight increase in price.

Basically all that is required is to replace the two BC 108 transistors by two small SCR's. Almost any low current devices will do — C106's for instance. SCR's are self-latching devices so the first bulb to be illuminated will stay that way — even though the winner's button is released — until the main power is momentarily broken. ●



A versatile board for experimenters.

ETI UTILIBOARD

THE CONSTRUCTION of any project is always simplified by the use of a proper printed-circuit board. The neat and tidy appearance of a well made printed-circuit board, full of components, gives a professional look and is most satisfying. There are however some drawbacks. Each design requires a different board and you need a reasonable degree of knowhow and time to make your own boards.

Quite often it may be felt that the cost of a ready made printed circuit board, for a simple project, is unwarranted or it is just too much of a hassle to send away for one.

There are several alternatives, such as Veroboard and Matrix board, and many people are now using specially designed general purpose boards which are specifically made for versatility in the construction of general circuitry.

This latter approach has several advantages. The finished board looks neat and professional, fairly-complex circuits can be quickly assembled, and the large pads available allow experimental circuits to be debugged with ease. Such boards allow the builder to change the circuit of a particular project to suit his personal needs or, to use physically-larger components (eg junk-box parts) than those specified.

There are many of these boards available but many of them are quite expensive and some are lacking in versatility. Hence we decided to design our own board for use in simple projects.

USING THE UTILIBOARD

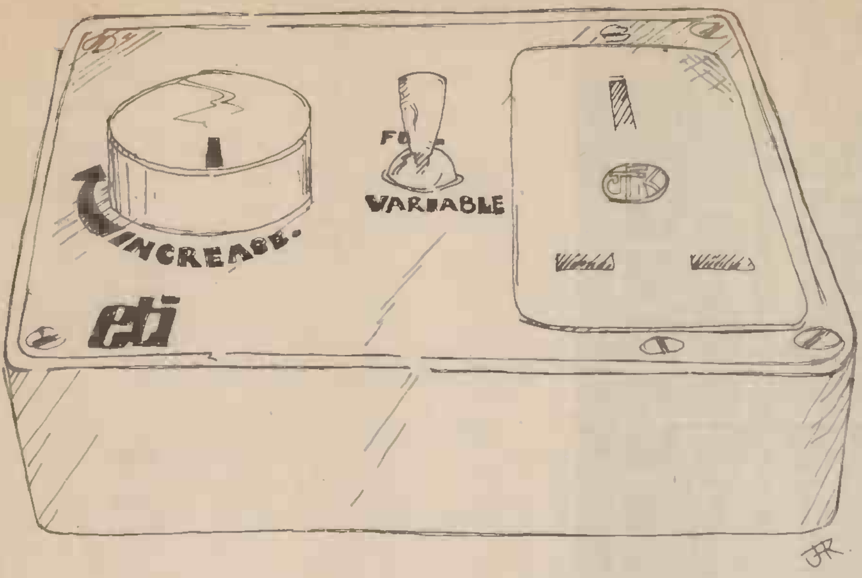
On conventional printed-circuit boards the components are always mounted on the non-copper side of the board and all our previous overlays have shown components in this way. However in experimental circuits it is more convenient to mount the components on the copper side. This allows components to be added, or shifted, without having to continually turn the board over.

Note that the board consists of four individual 16-pin dual-in-line IC pad-groups, each pin of which has associated with it a large pad to which several component leads can be soldered without the need for holes.

The broad lines through the centre of the pads, and on either side, are suitable for supply or earth connections. They are continuous so that the group of pads can be used together or the board may be sawn up into single or 2-way sections as required.

The broad line up the centre has indicator marks which point to pin I of an IC when it is mounted on the non-copper side of the board and the dot marker on the IC points to indicator-mark end of the board. Note that this central line is broad enough so that individual pads may be connected to it by solder bridging.

Of course any of eight, 14 or 16 pin DIL IC's can be mounted as required, or, discrete transistors may be inserted into appropriate holes. You will find this board extremely versatile and easy to use. ●



DRILL SPEED CONTROLLER

Variable speed control maintains constant (adjustable) speed regardless of load.

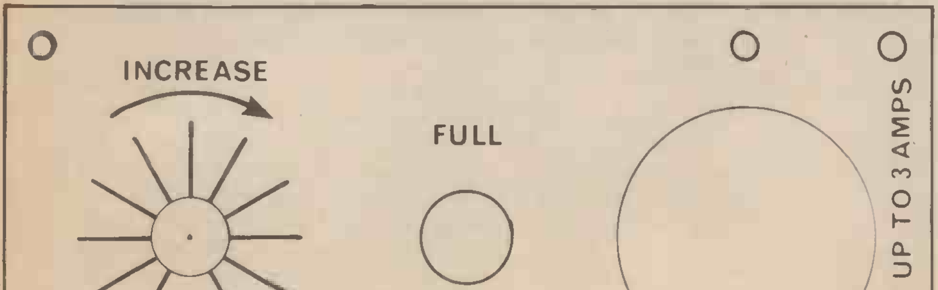
MOST HANDYMEN own a power drill.

There are tens of millions of them in use around the world — and they continue to be used for an ever greater variety of tasks.

Despite their popularity, many power drills have one major drawback and this is that their speed is often too high for many applications.

This is so even with dual-speed models where even the slow speed, typically 300-750 RPM, is too fast for such jobs as drilling masonry or using fly-cutters on sheet metal etc.

The speed controller described here allows infinite variation of speeds from zero to about 75% of full speed, and is provided with a switch to allow normal full-speed operation without disconnecting the drill from the controller. The controller has built in compensation to maintain substantially constant speed regardless of changes in load.



CONSTRUCTION

It must be emphasized that the controller is connected directly to the mains without the use of an isolating transformer. Care must therefore be taken with the construction to ensure that there is no likelihood of any dangerous conditions arising.

As there are relatively few components used, no supporting tag strip or PC board is necessary. From Fig. 2 it can be seen that only two "mid air" joints need to be made, and these should be carefully insulated to prevent any possibility of short circuits.

The SCR used is a stud mounting type and is mounted by using the solder lug, supplied with it, soldered onto the centre lug of the switch. For loads up to 3 amps no other heat-sinking is required. If a plastic-pack SCR is used a hole may be drilled through the switch lug and the SCR bolted directly to it. However in this case it is advisable to insert a piece of aluminium (about 25 mm x 15 mm) between the SCR and switch lug to act as a heatsink.

Remember that, since the unit operates at 240 Vac *all external parts must be earthed.* We used a plastic box with a metal lid. But we also used a cable clamp with a metal screw through the side of the plastic box. This screw *must* be earthed, along with the lid and the earth terminal of the output socket. The earth wire should be continuous That is, it should go from one earth point through to the next and not by separate links. Two earth wires may be soldered to one earth lug. But under no account should two wires be secured under a single screw.

The aluminium lid on the (type UB3) box used is not strong enough for this application, especially when the hole for the output socket is cut. A new lid should therefore be made from 18 gauge steel or 16 gauge aluminium.

To further improve safety it is suggested a small amount of glue, lacquer or even nail polish, be used to secure each screw inside the unit.

With some SCRs it may be found that the trigger current supplied by R1 and R2 is insufficient. If this is the case an additional 10 k resistor should be placed in parallel with each resistor.

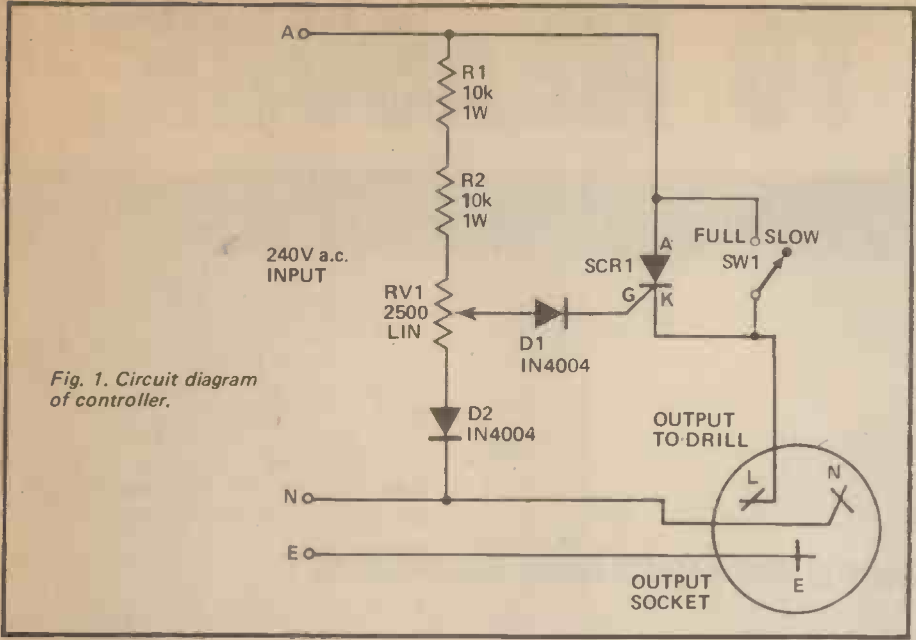


Fig. 1. Circuit diagram of controller.

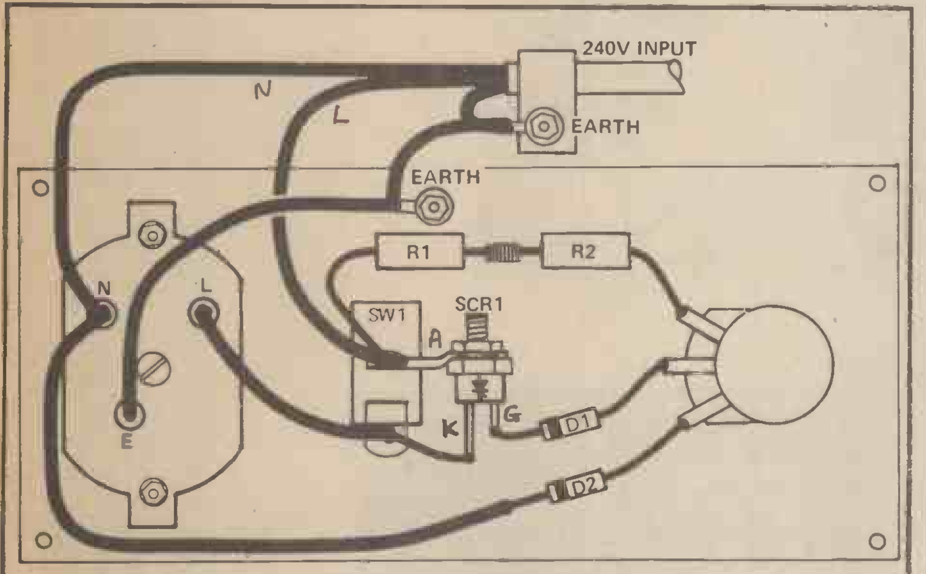


Fig. 2. Component layout

HOW IT WORKS
ETI 525

A universal motor, when running, produces a voltage which opposes the supply. This voltage, called the back EMF, is proportional to the speed of the motor. The SCR drill speed controller makes use of this effect to provide a certain amount of speed-versus-load compensation.

This controller uses an SCR (silicon controlled rectifier) to gate half-wave power to the drill motor. The SCR will conduct only when a/ anode (terminal A) is positive with respect to the cathode (terminal K), b/ when the gate (terminal G) is at least 0.6 volts positive with respect to the cathode, and. c/ when about 10 mA of current is flowing into the gate terminal. By controlling the level of the voltage waveform to the gate we effectively control the time at which the SCR turns on in each forward half cycle. By this means we effectively control the amount of power delivered to the drill.

Resistor R1, R2 and potentiometer RV1 form a voltage divider which provides a half wave voltage of adjustable amplitude to the gate of the SCR. If the motor is stationary the cathode of the SCR will be at zero volts and the SCR will turn on almost fully. As the drill speed increases, a voltage develops across the drill thus reducing the effective gate-cathode voltage. Thus as the motor speeds up, the power delivered decreases until the motor stabilizes at a speed determined by the setting of RV1.

Should a load be placed on the drill, the drill will tend to slow down, but as the voltage acorss the drill also drops, more power is delivered to the motor since the SCR firing-time is automatically advanced. Hence the speed, once set, is maintained relatively-constant regardless of load.

Diode D2 is used to halve the power dissipated in R1, R2 and RV1 by limiting the current through them to positive half-cycles only. Diode D1 protects the SCR gate against excessive reverse voltage.

In the full speed position the SCR is simply shorted out by SW1. Thus RV1 loses control and full mains supply is applied to the drill.

PARTS LIST

R1,2	Resistor	10K 1W 5%
RV1	Potentiometer	2.5 k lin rotary 2W W.W.
D1,2	Diodes	1N4004 or similar
SCR1	S.C.R.	2N4444 or similar (8A/10A, 400V)
SW1	Switch	

Box
3 core flex and plug.
cable clamp
3 pin power outlet

* Some SCRs used may have a higher than average trigger current and the unit may not operate. If so parallel the two 10 k resistor with additional 10 k resistor to increase the available trigger current.

USING THE CONTROLLER

Plug the controller into the mains and the drill into the controller. Select either full speed or variable as required. Note that there is no ON/OFF switch provided on the unit and the normal switch on the drill is used for this purpose. When full speed is selected the drill will run normally and the speed control on the controller will have no effect.

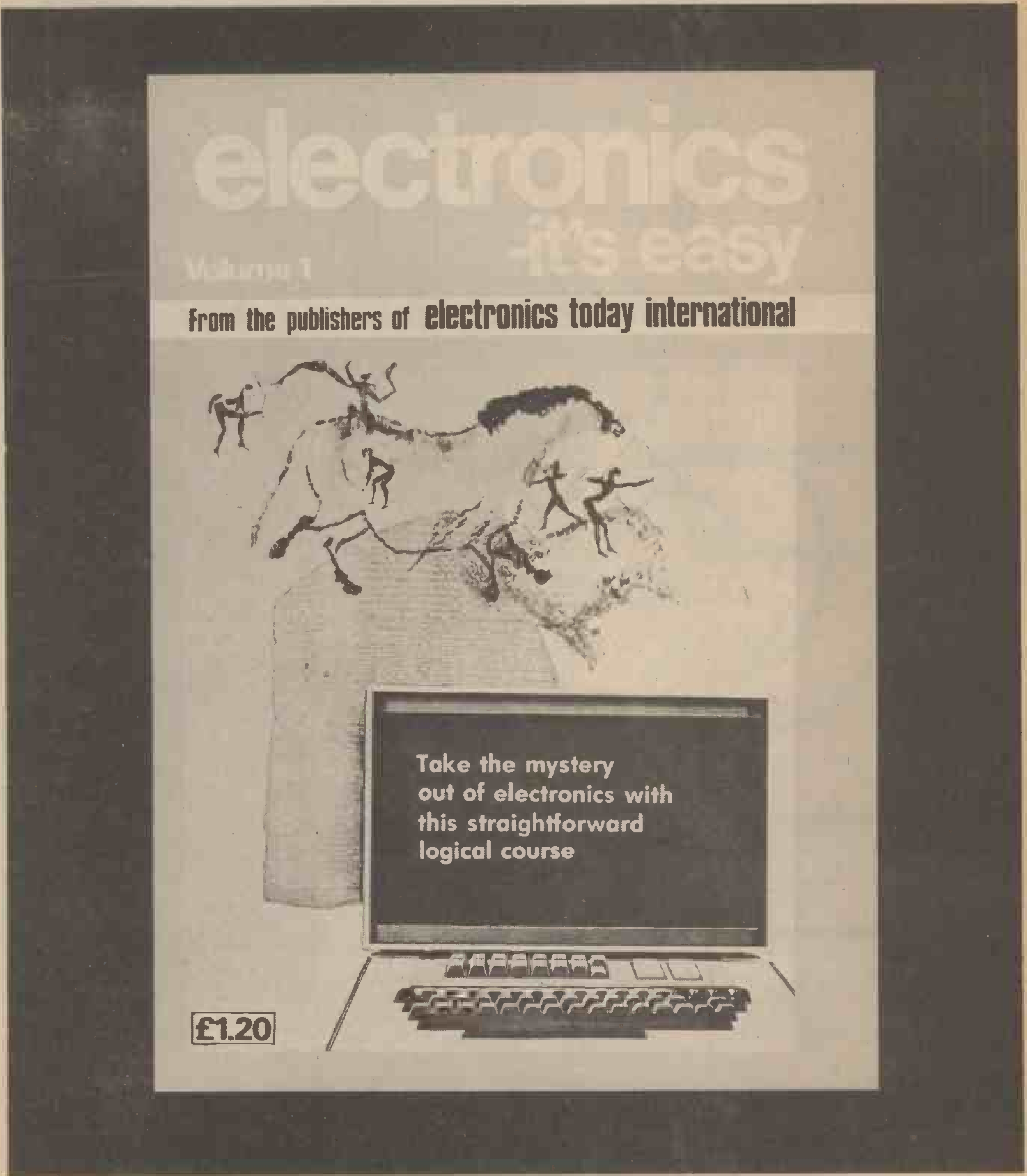
When variable speed is selected, the control will adjust the speed anywhere between zero and about 75% of full speed. There may be a dead zone at both low speed and high speed ends of the control. This is entirely normal and is due to different drill characteristics and component tolerances within the controller.

At very low speeds it may be found that drill runs jerkily under no load. However as load is applied the speed will smooth out.

When using the drill at less than full speed the cooling of the motor will be considerably reduced (as the cooling fan is on the armature shaft and also runs slower). Hence the drill will get hotter when used at low speeds, and extended periods of use in this mode should be avoided.

S4020L SCR (ISOLATED TAB)

MADE TO MEASURE



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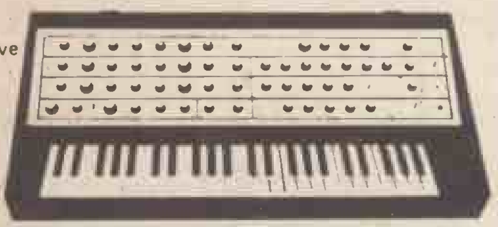

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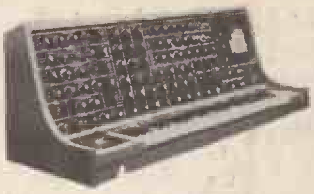

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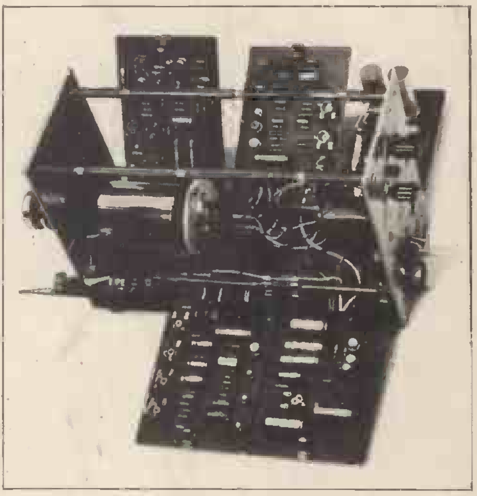

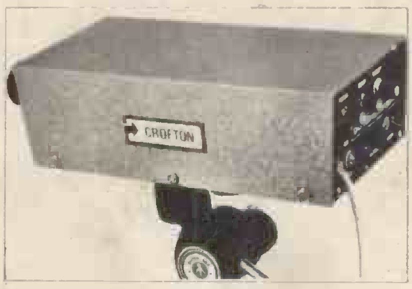

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