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TOP PROJECTS 1 + 2

SPECIAL REPRINT

OF

TOP PROJECTS No.1 and TOP PROJECTS No.2

TOP PROJECTS 1+2 SPECIAL REPRINT

PUBLISHED FEBRUARY 1977 FULL CONTENTS OVERLEAF

SINCE ETI was launched in the United Kingdom in April 1972, it has achieved not only a regular following but a rapidly growing one. Unlike many magazines covering a similar field, we do operate a back numbers service. These are not unsold copies for which to hope to find a market but extra numbers added to the print order and put to one side specifically for those who request an old article. We have reached the stage now where we have no copies of several issues.

In a reader questionnaire featured in the June 1974 issue, many people asked for reprints of previous articles: there was no specific question relating to this, every request was in the general comments section.

For these reasons we brought out Top Projects, followed by Top Projects 2. Both of these sold out, and so due to the continuing demand, we present this special combined reprint.

Generally articles appear as they did originally. Where an error, however insignificant, has been brought to our attention in the past, we have made changes. Where the components specified have proved hard to get we have substituted more widely available components.

COMPONENTS SUPPLY

A very high proportion of the letters we receive are from readers who want a source of supply — often for extremely common components. We feel that mailorder catalogues are as essential a tool to the amateur constructor as a soldering iron, yet it is amazing how many people have not got these. About £2.50 invested in catalogues can save you hours of trouble. We have yet to come across a mailorder catalogue, even expensive ones, which are not good value for money. Good catalogues are those from Henry's Radio, Home Radio, Electrovalue and Doram. There are also excellent more specialised catalogues from so many other companies that it would be unfair to single them out. Where components are really uncommon and are not listed in advertisements or catalogues, a supplier is given.

Readers are often worried because they are offered a component slightly different from that specified (4.7k pot. instead of 5k). It would be almost impossible to list every alternative: it would certainly be confusing.

Capacitors cause problems but they should not when one realises that only in tuning functions and a few others are the values in any way critical: most electrolytics have a tolerance of +100%, −50% for a start. Working voltage also causes problems. Never fit a component with a working voltage lower than that shown but you can always fit one with a higher working voltage.

Resistors are often fairly critical and, unless you are able to work out the function and can show that a value is unimportant, stick to those specified. In many circuits a variety of transistors can be used and experienced constructors will be able to make substitutions. However all the types specified in this issue are widely available.

Transformers can pose problems and manufacturers codings are not used widely. The mailorder catalogues list several types, failing this, two companies, Douglas and Barrie, advertise a large range in the electronics press.

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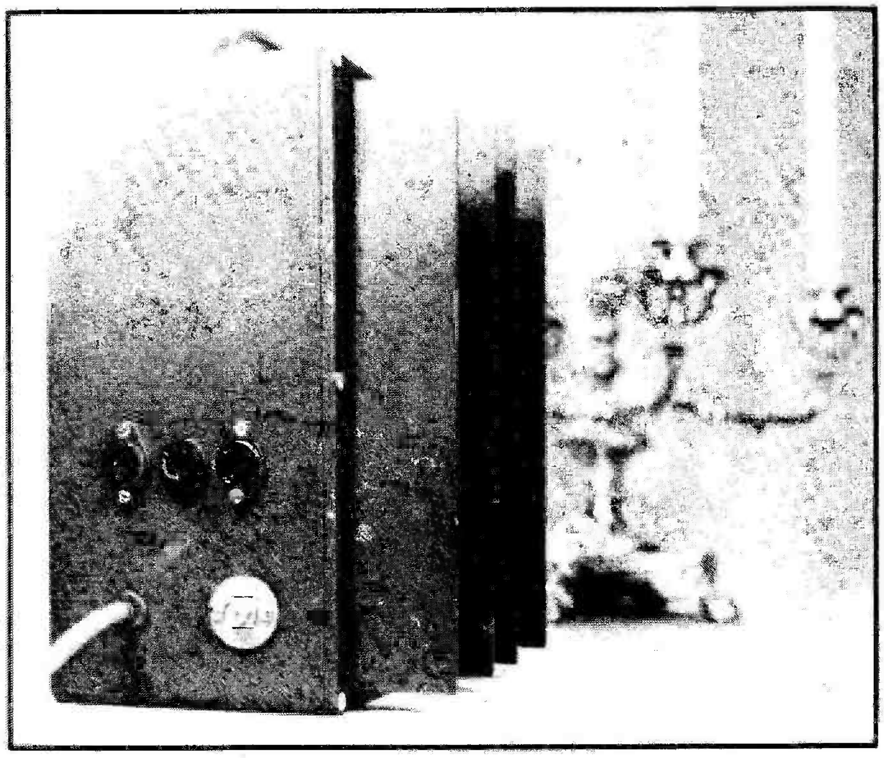


In the early days of radio one of the standard acceptance tests for shipborne radio apparatus was its ability to withstand a 13 stone radio operator climbing up the equipment rack wearing heavy boots.

Electronic equipment used by pop groups and for public address systems – whilst often built to substantially lower standards – often receives similarly rugged treatment.

For this type of use, the ability to operate reliably despite having spent the previous six hours rolling around in the boot of a car will be of far more importance than a stainless steel facia with a lot of coloured indicator lights and VU meters.

The amplifier described in this project has been specifically designed for just such applications.

It is intended primarily as a guitar amplifier and for public address systems. In the interests of ruggedness it has been put together entirely without frills. It has no tone or volume controls and must be used with a suitable preamplifier.

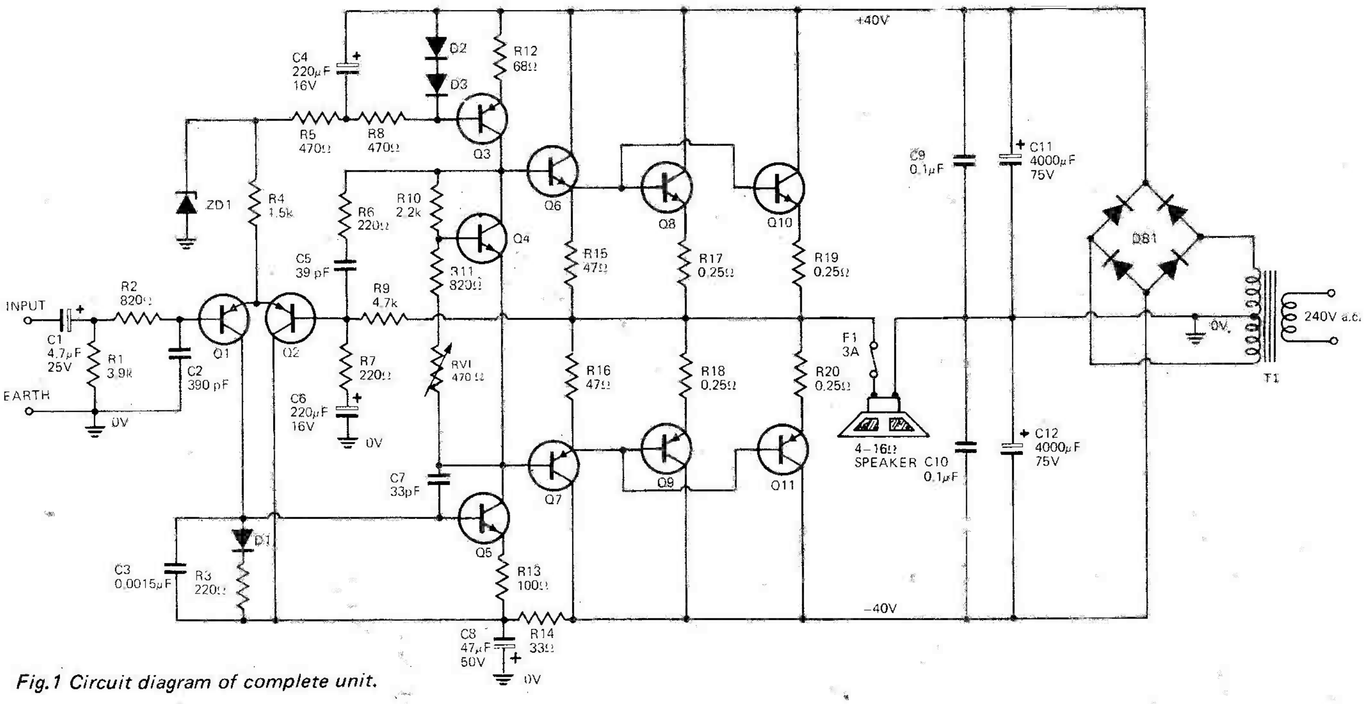


Fig.1 Circuit diagram of complete unit.

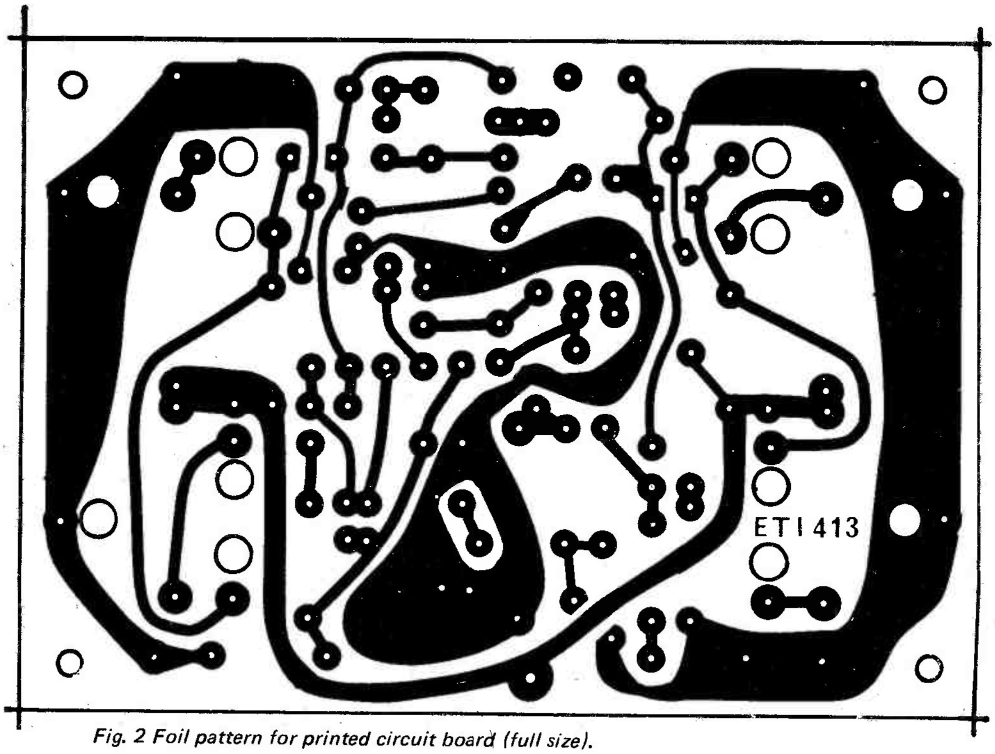


Fig. 2 Foil pattern for printed circuit board (full size).

HOW IT WORKS

The amplifier is of conventional design using a quasi-complementary symmetry, output stage and a differential input stage.

Output transistors are paralleled for greater output capacity – and transistors Q6 and Q7 connected in a Darlington configuration provide current gain.

Q3 is a current regulator supplying approximately 10 mA. This controlled current passes through Q4, thus setting the bias for the output stage, and Q5. The voltage at the collector of Q5 is set by its own base-emitter voltage. Since this transistor is working with an almost constant current in its collector it has a very high voltage gain. This gain is attenuated at high frequencies by C7.

Transistor Q5 is controlled by the differential pair Q1 and Q2. Due to the negative feedback via R7 & R9, the action of Q1 and Q2 is that of an error amplifier. Thus it tries to keep the voltage at its two inputs (the bases of Q1 and Q2) constant. Because of this action, the output voltage is held equal to the input voltage multiplied by (R9+R7)/R7. This gives the amplifier a voltage gain of approximately 22. This gain may be changed by varying the value of R7. An appropriate change must then also be made to C6 as R7/C6 determine the lower –3dB point. The value of R9 should not be altered.

The output bias current – which is necessary to prevent cross-over distortion – is set by RV1.

It is not only rugged mechanically, for it will handle over a hundred watts continuously with a sine-wave input.

Despite the design criteria of ruggedness, the performance specifications put the unit well into the hi-fi area. Frequency response – as the accompanying table shows – is virtually flat from 50 Hz to 20 kHz and total harmonic distortion is less than 0.5% from 0.1W to 80W.

Any number of speakers may be driven from this amplifier providing their combined impedance is equal to or exceeds four ohms.

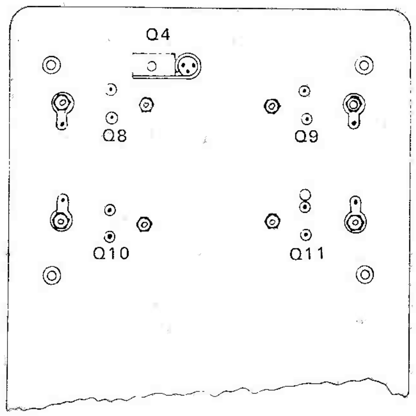
CONSTRUCTION

Construction is quite straightforward as most components are mounted on the printed circuit board.

Start by soldering the components on to the printed circuit board according to the layout shown in Fig. 3. Make sure that all capacitors, diodes and transistors are put in the right way round. Metal 'fan' type heatsinks are used on Q3 and Q5. Make sure that these are well away from any other component.

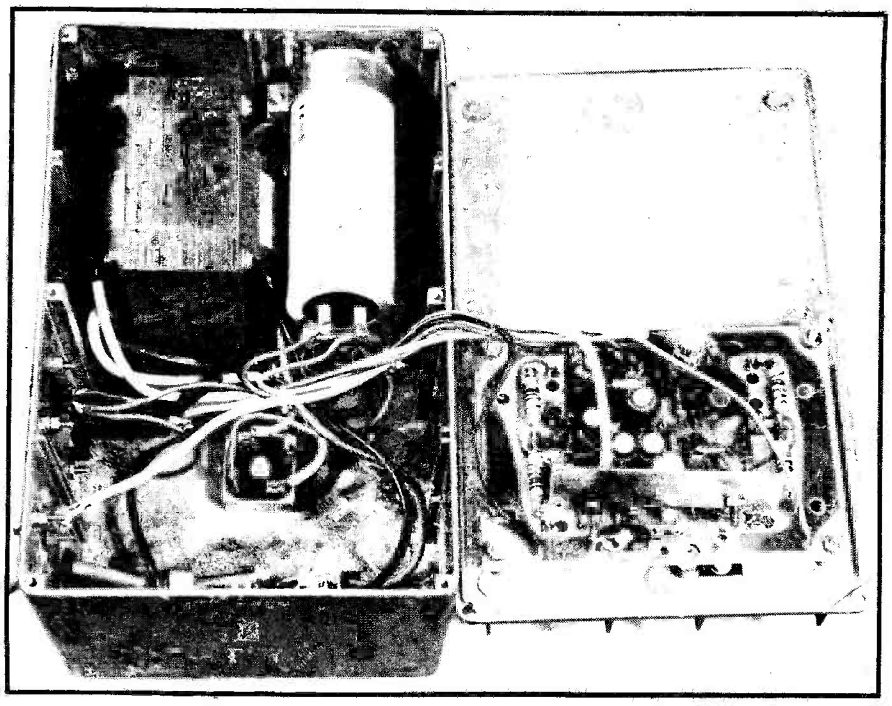
A heatsink is fitted between Q6 and Q7 (Fig. 4) and is insulated by mica washers. Note that the heatsink will be slightly skewed and the transistor slightly twisted so that the heatsink can be bolted on to the 'metal side' of the transistors. Remember that insulating washers must be used.

The printed circuit board will be mounted onto the lid of the die-cast metal box and short connecting leads will be used to connect the board to the output transistors which are mounted on the outside face of this lid.



Inside view of lid showing position of Q4, Q8, Q9, Q10 and Q11 (See also Fig. 6.)

PROJECT 413



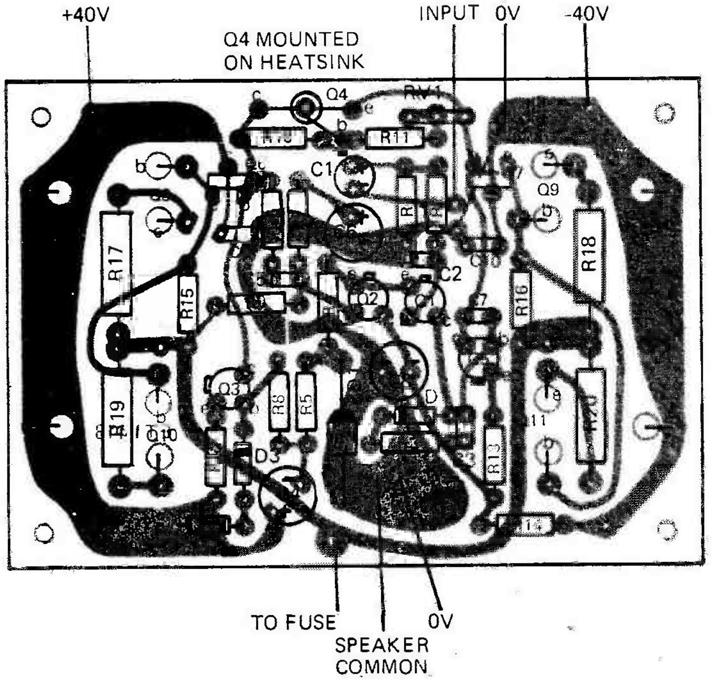


Fig. 3. How the components are mounted on the printed circuit board.

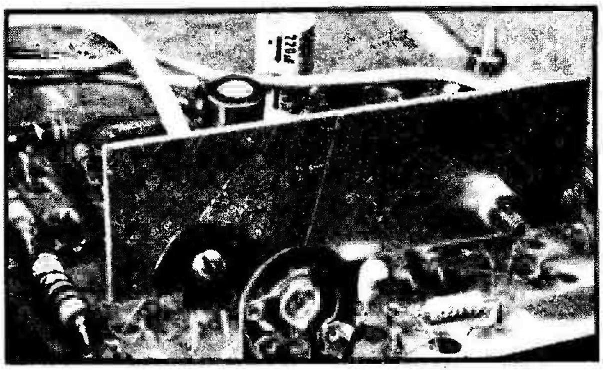


Fig. 4 A heat sink (detailed in Fig. 5) locates Q6 and Q7. In this illustration, Q7 can be seen just to left of the potentiometer.

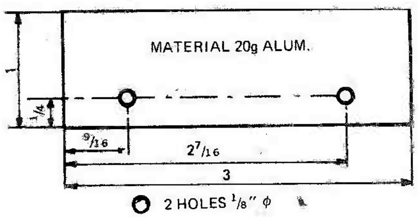
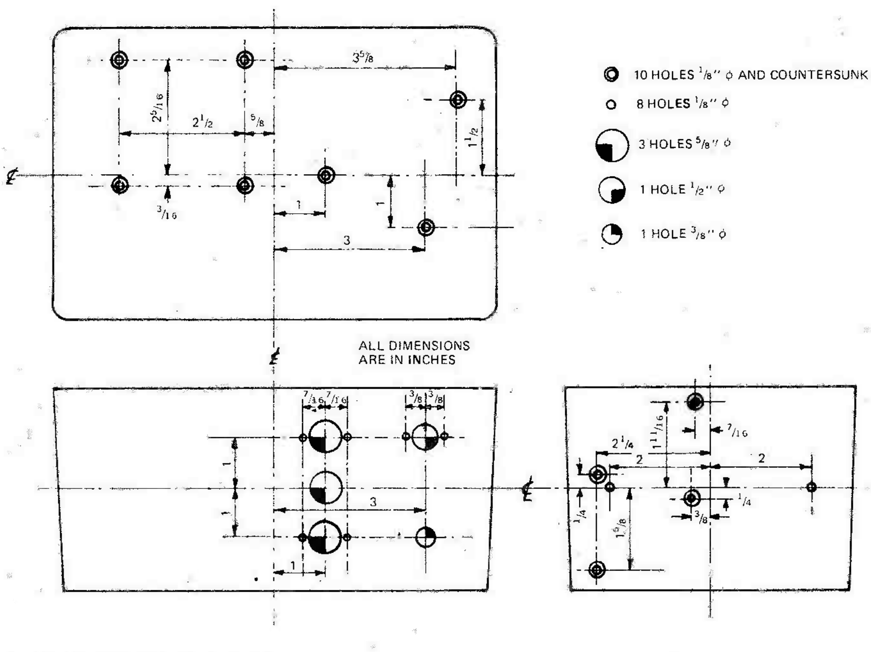


Fig. 5 Details of heat sink for Q6 and Q7.

Drilling details for the die-cast box.



Countersunk screws and spacers are used to ensure that the printed circuit board stands well clear of inner face of the lid. These should be installed at this stage — but do not yet attach the board itself.

The heatsink for Q4 should be attached to the lid using a countersunk screw and insulating washers. The heatsinks for the output transistors, and the output transistors, should now be installed. Make quite sure that the correct transistors are in the right places. Insulating washers must again be used.

Connect short leads to the emitter, base and collector of the output transistors (the connection to the collectors is made via the transistor mounting screw)'

Press transistor Q4 into its heatsink. Install metal connecting pins in the printed circuit board for terminating connections to the output transistors Q8, Q9, Q10, and Q11. Pins are also required for Q4. The pin positions are clearly marked on the printed circuit board overlay.

Now connect all leads from the power supply etc, to the printed circuit board and then fit the board over the leads from the output transistors and screw firmly into place.

Solder the leads from the various external connections to the appropriate pins on the board. Do not wrap the wire around the pins by more than half a turn as it will otherwise be very difficult to remove later (if necessary).

Install and connect all remaining components.

Ensure that the mains earth lead is securely attached to the case as must also be the transformer shield. The input shield should be earthed to the case at the input socket.

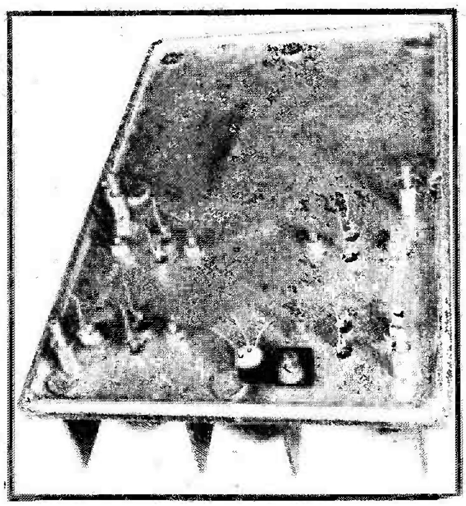


Fig. 6. Lid of the die-cast box showing heat sinks (and output transistor leads). Transistor Q4 and its associated heat sink is clearly visible.

100W GUITAR AMPLIFIER

Now carefully check out all connections — ensure that there are no loose ends of wire laying around inside the case.

The unit is now ready for testing.

TESTING PROCEDURE

A multimeter capable of measuring 100mA d.c. is required. Insert the meter in series with the +40V supply and rotate trimpot RV1 so that the wiper is nearest Q4 (i.e. maximum resistance). Switch the unit on and adjust RV1 until a reading of 65 mA is obtained. Allow the amplifier to warm up for about five minutes and then readjust the output current to 70–80 mA. (Note — the current will increase as the unit warms up). Switch the unit off and reconnect the positive power lead to the pc board.

Switch the multimeter to the volts range and check the voltage between the outputs and 0V. It should be within 200 mV of zero (either polarity).

If both measurements are correct the amplifier is ready for use. Switch off and disconnect the multimeter.

Connect a loudspeaker to the output and again switch on — no sound should be heard from the speaker.

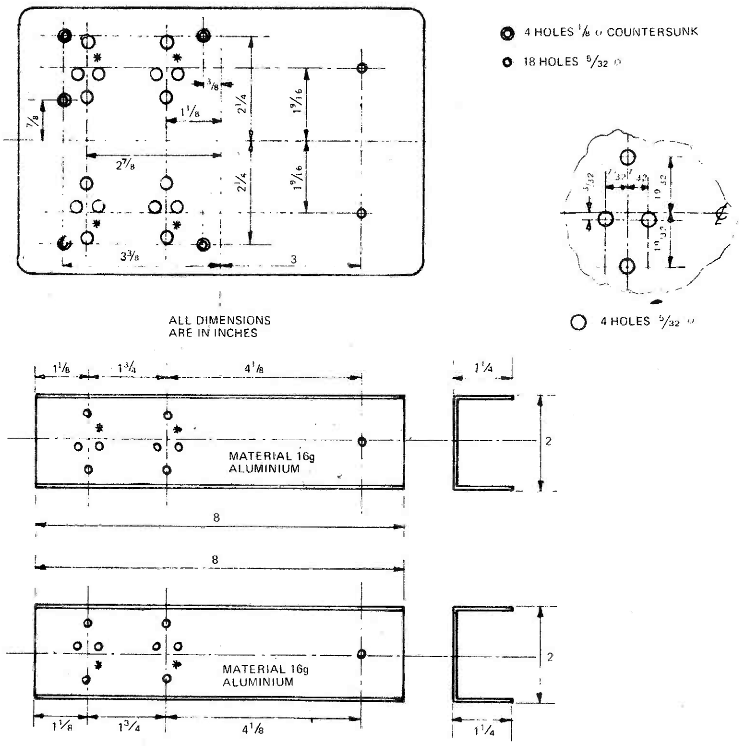
PREAMPLIFIER

The preamplifier used to drive this unit must be capable of producing approximately 1 volt into 3.9k. ●

SPECIFICATIONS

Output Power (into 4 ohms)	100 watts (continuous)
Frequency Response	50 Hz—20 kHz ±1 dB 20 Hz—150 kHz ±3 dB
Total Harmonic Distortion (0.1 watt — 80 watts)	20 Hz—20 kHz <0.5%
Damping Factor (4 ohm load)	80
Input Impedance	≏ 3.9 k

NB:
R17, 18, 19, 20 can be 0.27Ω.
TI can be 60V @1.5A



Drilling details of ITT box lid and associated heat sinks

PARTS LIST

R1	Resistor	3.9k ½W 5%
R2	"	820 ohm ½W 5%
R3	"	220 " ½W 5%
R4	"	1.5k ½W 5%
R5	"	470 ohm ½W 5%
R6	"	220 " ½W 5%
R7	"	220 " ½W 5%
R8	"	470 " ½W 5%
R9	"	4.7k ½W 5%
R10	"	2.2k ½W 5%
R11	"	820 ohm ½W 5%
R12	"	68 ohm ½W 5%
R13	"	100 " ½W 5%
R14	"	33 " ½W 5%
R15	"	47 " ½W 5%
R16	"	47 " ½W 5%
R17	"	0.25 " 2W 5%
R18	"	0.25 " 2W 5%
R19	"	0.25 " 2W 5%
R20	"	0.25 " 2W 5%
RV1	Preset Resistor	470 ohm Large type Trimpot
C1	Capacitor	4.7μF 25V TAG tantalum
C2	"	390pF ceramic
C3	"	0.0015 μF polyester
C4	"	220 μF 16V electrolytic (PC type)
C5	"	39pF ceramic
C6	"	220 μF 16V electrolytic (PC type)
C7	"	33 pF ceramic
C8	"	47 μF 50V electrolytic (PC type)
C9	"	0.1 μF polyester
C10	"	0.1 μF "
C11	"	4000μF 75V electrolytic
C12	"	4000μF 75V electrolytic
D1	Diode	IN 4005 or similar
D2	"	" "
D3	"	" "
ZD1	Zener diode	ZL15
DB1	Bridge Rectifier	4A 200 PIV
Q1	Transistor	BFX 30
Q2	"	BFX 30
Q3	"	BFX 30
Q4	"	BFY 50
Q5	"	BFY 50
Q6	"	BD 139
Q7	"	BD 140
Q8	"	AY 8149, 2N 3055
Q9	"	AY 9149, MJ 2955
Q10	"	AY 8149, 2N 3055
Q11	"	AY 9149, MJ 2955
T1	Transformer	56V CT@ 1.5A

PC Board ETI 413
3A Fuse
Fuse holder
Die cast box 5¾ x 8¾ x 4"
2 Heat Sinks
1 " "
1 phono socket
Output socket (2 pin din etc.)
4 spacers, ½" long for P.C. board.
1 three core flex and plug
2 Fan top heat sink for Q3 and Q5
Heat sink for Q4 (chassis mounting type, transistor vertical to chassis)
Screws etc.

MIXER PREAMPLIFIER

Simple yet effective unit is specifically intended for use with our 100 W guitar amplifier.

OUR 100 watt guitar amplifier, ETI 413, has proven to be extraordinarily successful. A very large number have been built, and are in use in conjunction with the 8 channel master mixer for which it was specifically designed.

There has also proven to be a large demand, as evidenced by letters to parts suppliers and to ourselves, for a simple preamplifier to be used with the guitar amplifier. This project describes such a preamplifier, which may be built as a separate unit, or within the 100 watt amplifier as desired.

The basic preamplifier may have up to four inputs, each with separate volume control, and the sensitivity and input impedance of each can be tailored to suit individual requirements. The inputs are mixed in a summing operational amplifier and the combined signal is then operated on by a common set of bass and treble controls.

A master volume control is provided so that the level of the combined signal may be varied. Although specifically designed for the 100 watt amplifier, this unit is very flexible and may be used as a separate general purpose mixer/preamplifier.

HOW IT WORKS

The input signals are attenuated as required by RV1-RV4 before being summed by amplifier IC1. The gain of IC1 is determined by the value of the resistor in series with each input. The value of this resistor must be at least five times the value of the input potentiometer otherwise input impedance will change with variations in the potentiometer setting.

For dynamic or electret microphones (250 or 600 ohm) a 1 k potentiometer and a 22 k series resistor will provide full output with an input of 2 millivolts. For guitar inputs a 47 k potentiometer and a 220 k series resistor will provide full output with 20 millivolts input and an input impedance of 47 k.

Amplifier IC1 is followed by conventional tone controls and a further amplifier IC2 in which RV7 alters the gain and hence is used as the master volume control. This stage is configured as a positive, or in phase, amplifier in which a gain of less than one cannot be obtained. However the gain variation of 37 db will be found adequate for most purposes.

Two different power supplies are described. The first is a separate mains supply (where the unit is to be built into a separate box) which is simply a 12.6 volt CT transformer rectified to provide ±9 volts for the ICs. The second is used where the unit is built into the 100 watt amplifier and derives its supply by resistively dividing down the power amplifier supplies.

PARTS LIST

R1	resistor)		
R2	"	)See text	
R3	"	)and Table I	
R4	"	)	
R5	"	470 k	½ Watt 5%
R6	"	2.7 k	" " "
R7	"	12 k	" " "
R8	"	1.8 k	" " "
R9	"	3.3 k	" " "
R10	"	470	" " "
R11 *	"	2.7 k	" " "
R12 *	"	1 k	" " "
R13 *	"	1 k	" " "
R14 *	"	2.7 k	" " "

* dc powered version only

RV1	potentiometer)	
RV2	"	) See text
RV3	"	) and Table I
RV4		)
RV5	"	250k log.

C1	capacitor)
C2	") See text
C3	") and Table I
C5	33 pF ceramic
C6	0.0022μF polyester
C7	0.022μF "
C8	0.022μF "
C9	0.22μF "
C10	33 pF ceramic
C11	1μF 25V tag tantalum
C12	47μF 16V electrolytic PC mount
C13	47μF 16V " " "
IC1	integrated circuit LM301A
IC2	" " LM301A

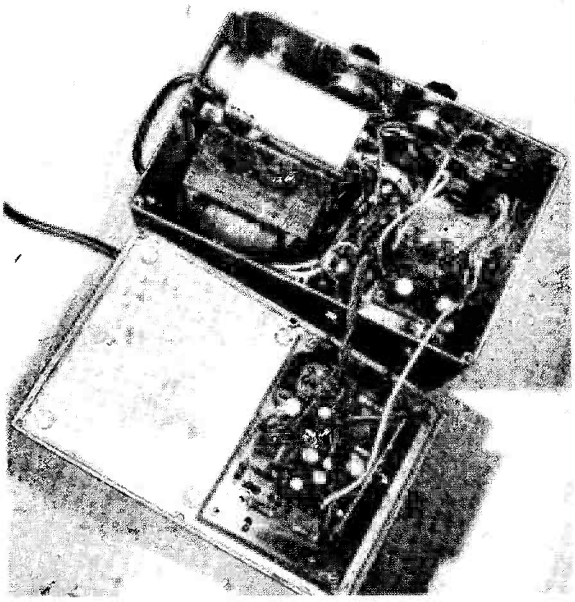
PC board ETI 419
* Transformer
* D1-D4 diode 1N4001 or similar

* 240 volt ac version only
Plugs, sockets, knobs to suit individual requirements.

MIXER/PREAMPLIFIER

TABLE I

APPLICATION	RV1	R1	C1	SENSITIVITY
Microphones (600 or 250 ohms)	1 k log	22 k	4.7µF	2 mV
Microphones or guitars (47 k)	47 k log	220 k	0.1µF	20 mV
Crystal microphones, line inputs, ceramic pickup etc	1 M log	2.2 M	0.1µF	200 mV



The preamplifier is mounted in the bottom of the existing power amplifier and the controls and input sockets on the right-hand side.

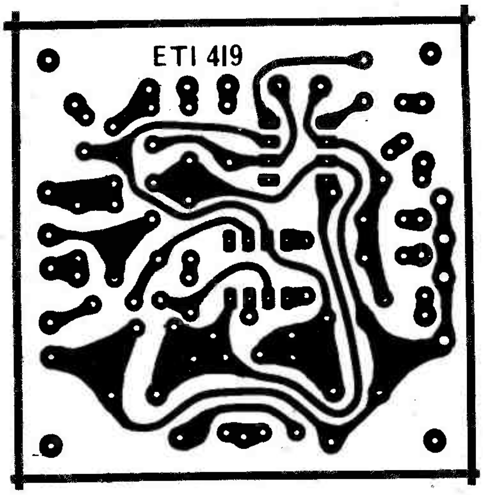
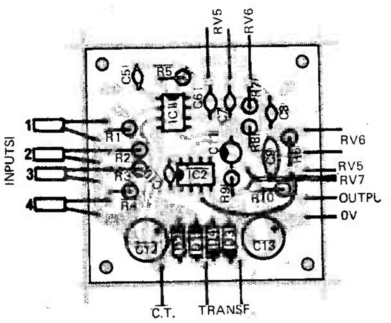
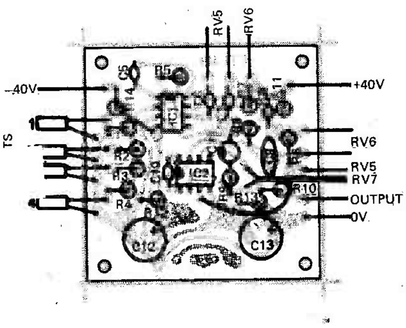


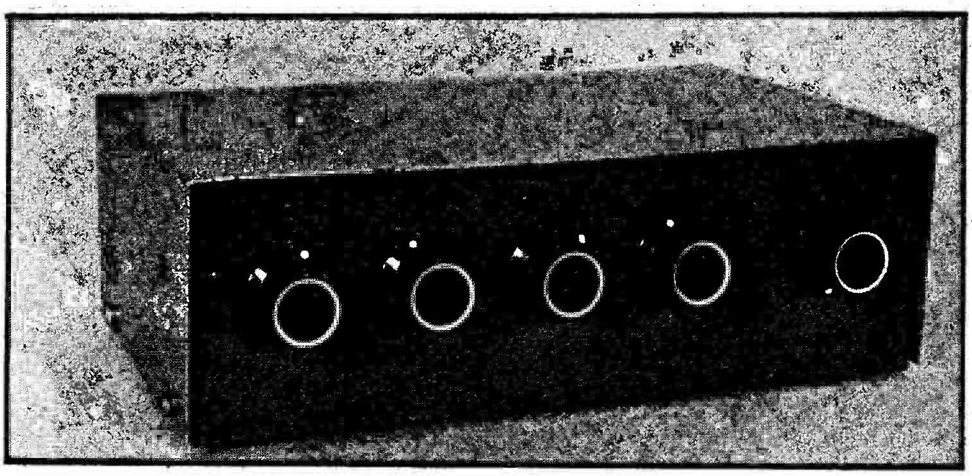
Fig. 4. PC board layout (both versions).

Fig. 5, Bottom left: Component overlay for ac powered preamplifier.

Fig. 6, Bottom right: Component overlay for preamplifier powered from 100 watt amplifier supply.







FET FOUR-INPUT MIXER

Mix any combination of four audio signals with this easily constructed unit.

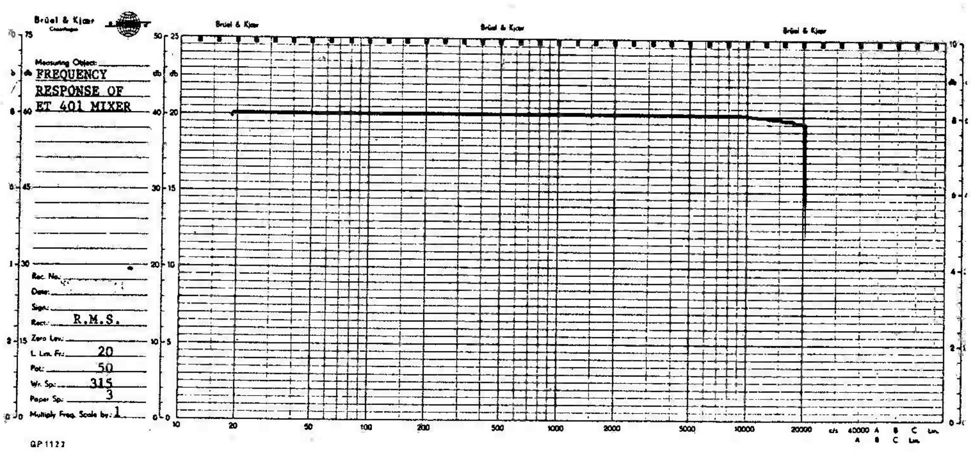
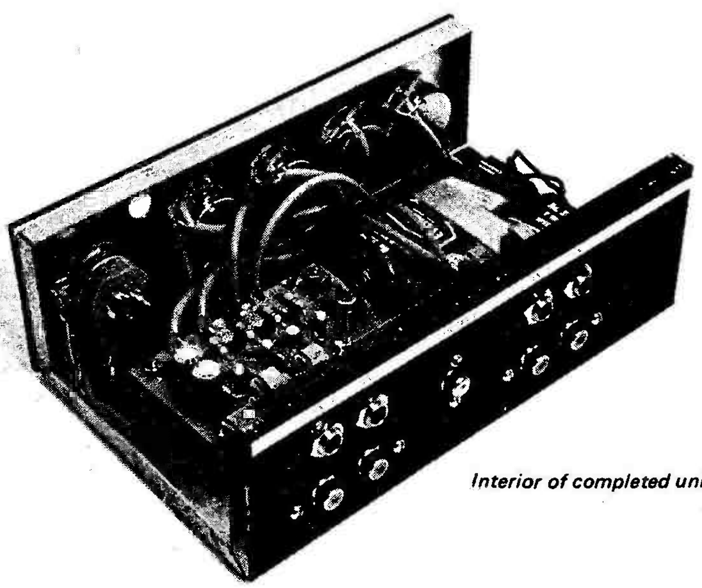


Fig. 1. Frequency response



Interior of completed unit.

THREE guitars and a microphone. One record player, two tape decks and an electronic organ. Or any combination you like of two, three or four separate audio signals can be smoothly blended together by using this simply constructed Input Mixer.

The unit can handle input levels from 10mV to 2V, input impedances from 4 ohms to 1 Megohm. It provides a maximum gain of 20dB, and has a frequency response that is absolutely flat from 20Hz to 10kHz and is still within 1dB at 20kHz. The response curve is shown in Fig 1.

Battery operation has ensured that internally generated noise is kept to a very low level, and the unit is suitable for all types of inputs except high performance microphones and cartridges with outputs below 10mV. Life expectancy of the batteries specified in the parts list is at least 100 hours of continuous use.

CONSTRUCTION

The circuit diagram of the complete unit is shown in Fig. 2, the circuit board pattern is shown in Fig. 3, and the component layout in Fig. 4.

Make sure that the electrolytics are connected the right way round, and do not use excessive heat when soldering

HOW IT WORKS

The mixer consists of four identical input stages and one summing amplifier.

Each input stage consists of a variable attenuator and a FET source follower. The attenuators are one megohm potentiometers, and since the input impedance of a FET is very high, the input impedance of the mixer is that of the attenuator — i.e. 1M.

Input signals are coupled to the mixer via standard jack plugs and sockets or RCA connectors. Both types of input connector were fitted to each input of the prototype unit — each pair being wired in parellel. Provision for both types has been made on the sheet metalwork drawings and included in the parts list. Either type may be omitted if required.

The output impedance of the FET stage is approximately 1k, and the internal gain of the FET is unity.

The summing amplifier is a LM 301A operational amplifier. This has an open loop gain of around 100,000 and a cut off frequency of approximately 10 MHz. Gain control is varied by the feedback potentiometer RV5.

Output impedance of the mixer is less than 100 ohms. It is desirable that the load impedance should exceed 2k. The mixer is however, short circuit proof, and the only effect of excess load is distortion. The output is dc coupled, and the offset voltage (dc component) is typically 2mV.

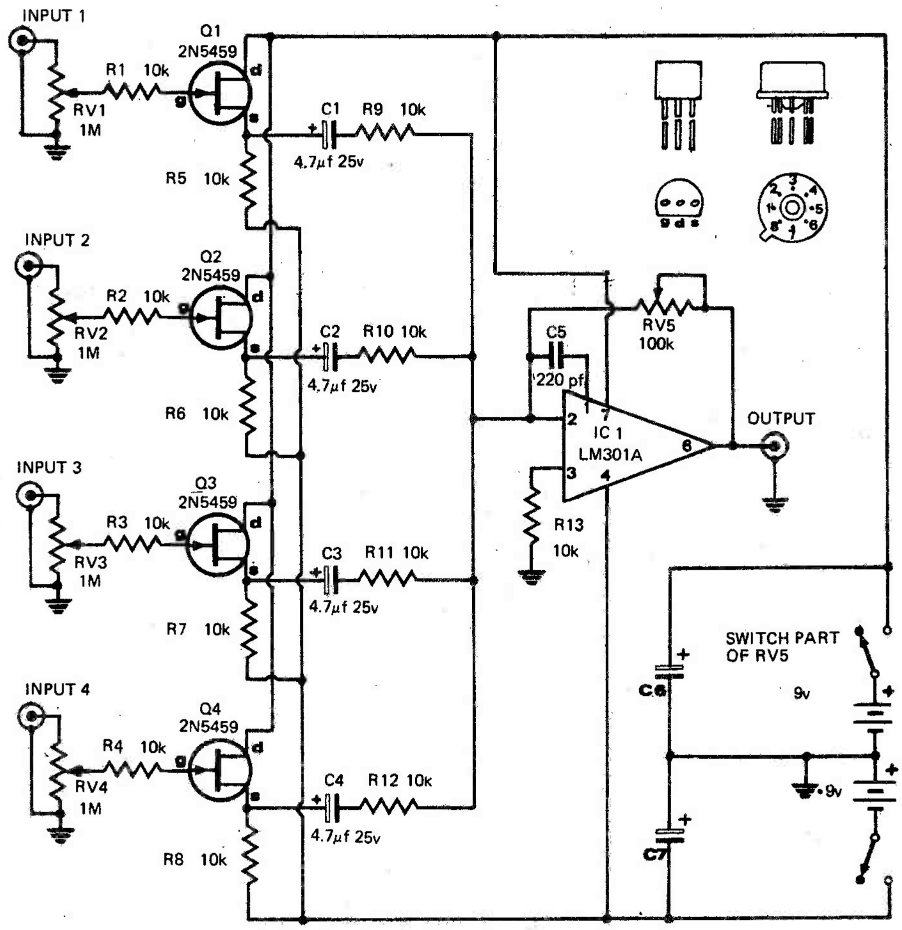
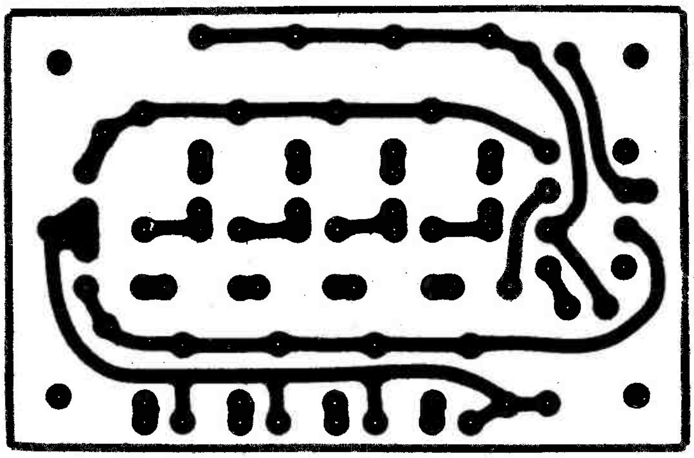


Fig. 2, Circuit diagram of complete unit



PARTS LIST

R1-R13	—	resistor 10k, ½W, 5%
RV1-RV4	—	potentiometer, 1 Megohm, log
RV5	—	potentiometer, 100k, log with double pole switch.
Q1-Q4	—	field effect transistors, 2N5459
C1-C4	—	Tag tantalum capacitors, 4.7µF.
C5	—	capacitor, 220pF
C6-C7	—	capacitor, pc board mounting, 100µF electrolytic.
IC1	—	integrated circuit LM 301A

Plus — 4 closed circuit jack sockets,
2 double type phono sockets.
1 single type phono socket.
1 printed circuit board
2 nine volt batteries,
1 metal case and cover.
4 spacers for pc board.
1 perspex front panel.
5 control knobs.
Coax cable, screws etc.

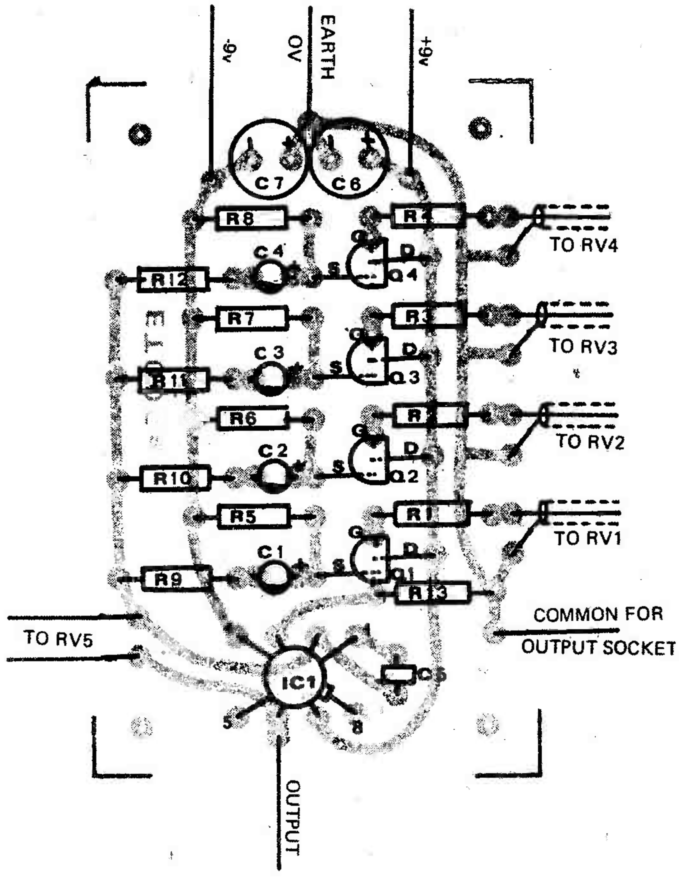


Fig. 4. How components are mounted on the printed circuit board — seen from components side.

FET FOUR-INPUT MIXER

the connections of the FETs and the I/C. Screened wire must be used for all leads from the input sockets to the potentiometers, and from the potentiometers to the printed circuit board.

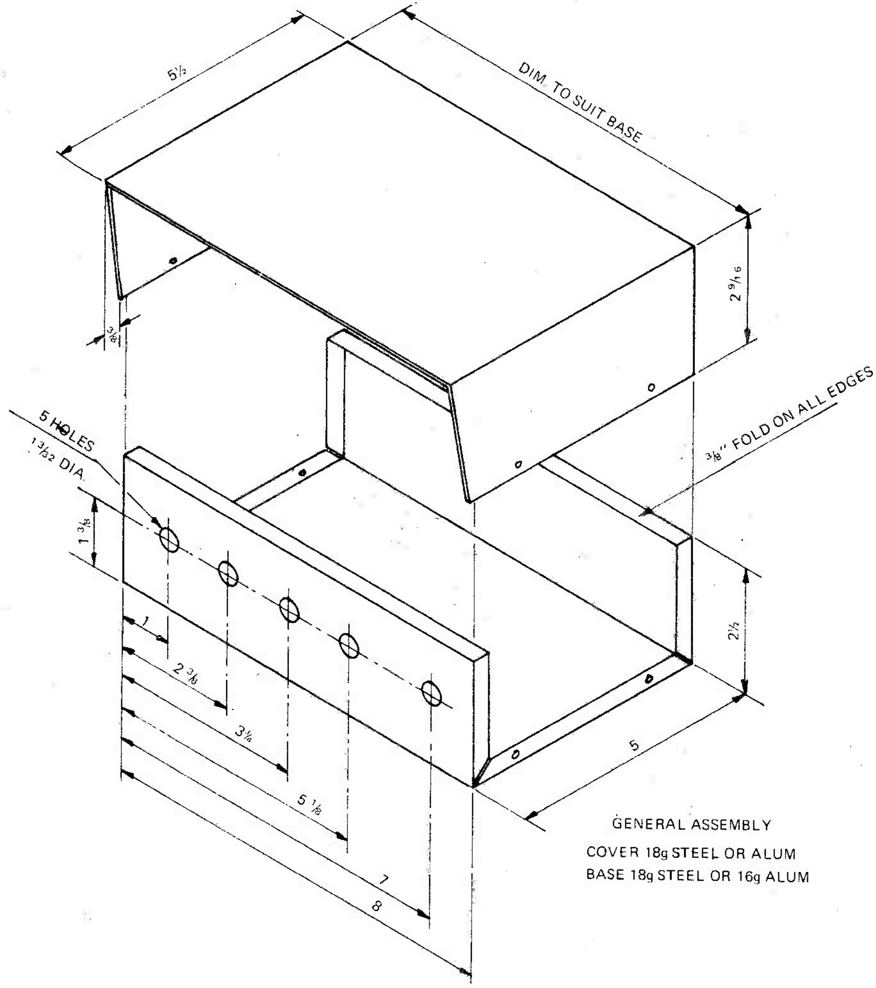
Sheet metal drawings for the chassis and cover are shown in Figs. 5 and 6.

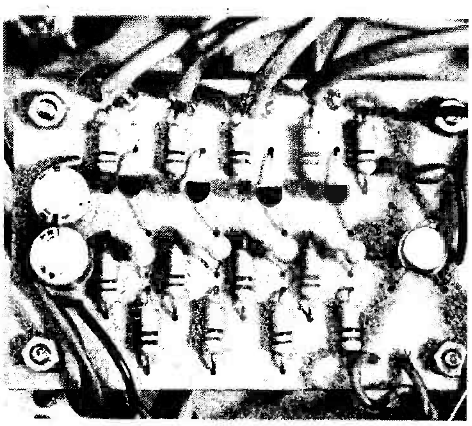
THE UNIT USE

The mixer may be connected, via screened cable, to any tape recorder or amplifier.

Connect the required audio inputs — again via screened lead — and set all four channel input controls to zero. Set the master gain control to just beyond halfway. Adjust the level of your amplifier (or if you are using a tape recorder, to the normal recording level) and bring up the level of each signal input as required. Leave the level of all unused inputs at zero.

Adjust the overall sound level by using the master gain control on the mixer. ●



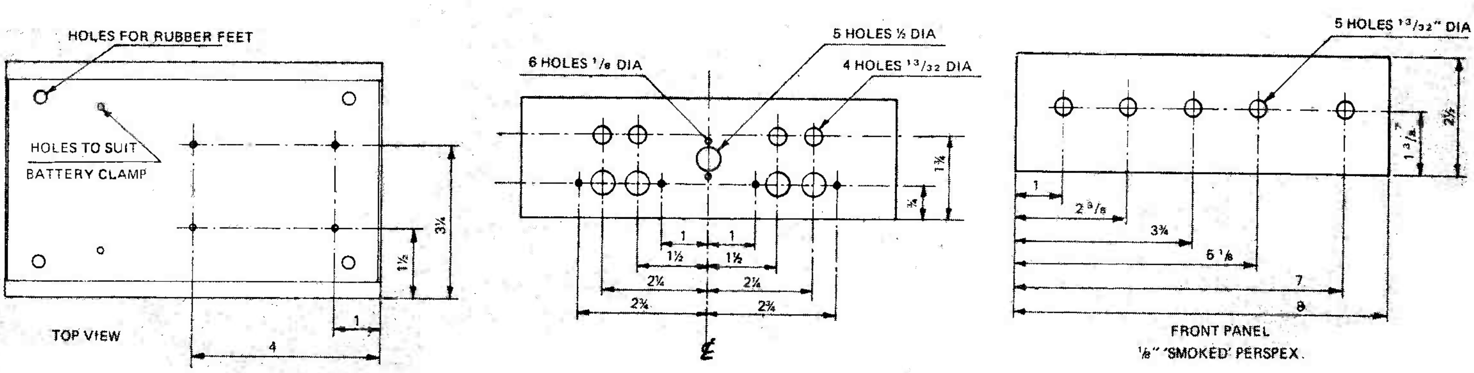


Compare this photograph of finished board with Fig. 4.

ET 401 MIXER

No. of inputs	–	4
Input impedance	–	1 Megohm
Input voltages	–	2mV -2V
Gain -max.	–	20 dB
Max. output V.	–	3V rms
Output impedance		<100 ohms
Output load	–	>2000 ohms
Freq. response	–	within 1dB (20Hz to 20kHz)
Power supply	–	18V at 15ma
Batteries	–	2 x 9V
Battery life	–	100 hours approx.

Fig. 6. Drilling details etc., of (below) base of chassis, (below centre) rear panel of chassis, (below right) perspex cover.



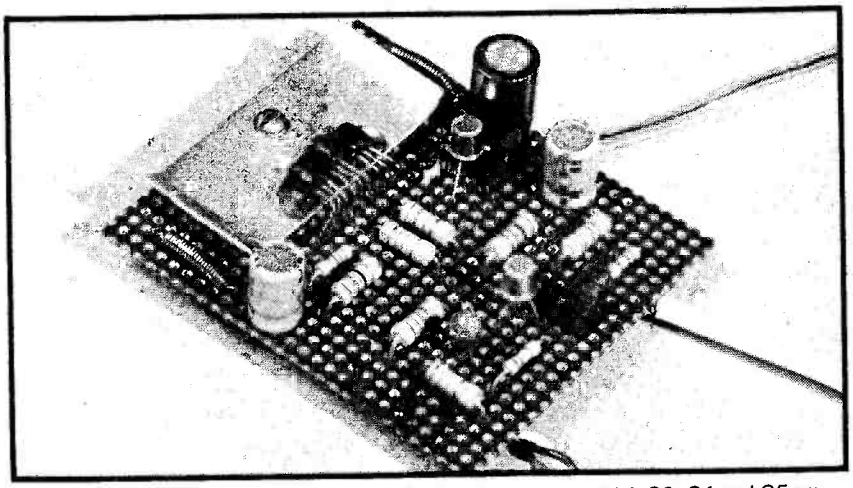
SIMPLE AMPLIFIER

A SMALL AMPLIFIER is an almost indispensable aid to the experimenter It may be used to amplify, and make audible, signals from oscillators operating in the audio range, to trace signals through another audio amplifier that is faulty, to amplify any other signal to a reasonable power level for metering or relay operation etc. etc.

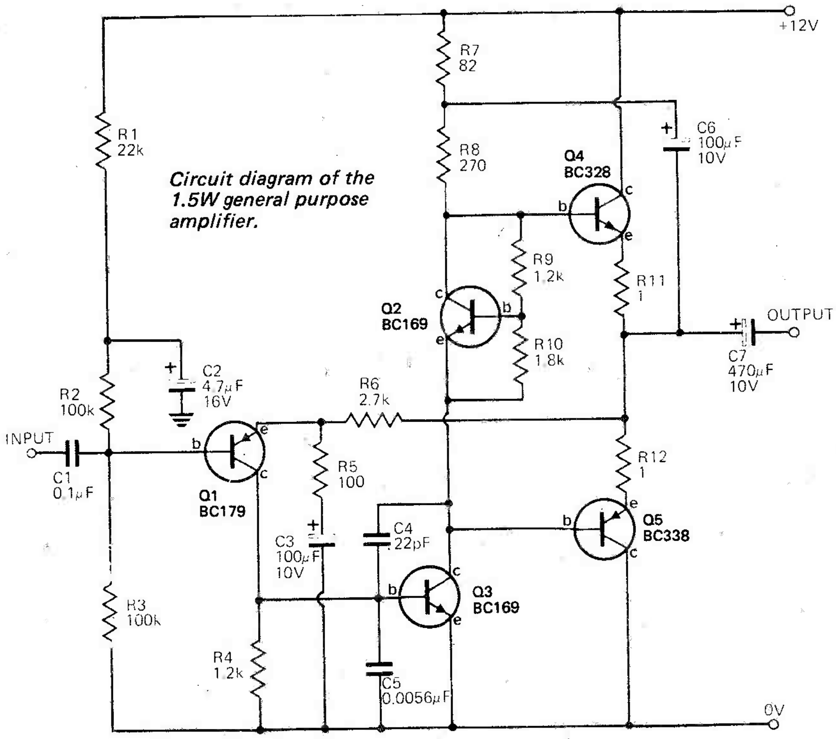
There are at present on the market many integrated circuit power amplifiers providing outputs of from 1 to 3 watts but most of them require very careful layout of the circuit in order to prevent instability (an unstable amplifier may oscillate and be damaged as a result). Additionally, a discrete transistor amplifier is far more educational in that voltages can be measured in order to gain a better understanding of its operation.

Hence the ETI 225 amplifier has been designed using discrete transistors which beside being much more stable than integrated designs, is ideally suited to the needs of the experimenter.

Transistors Q2, Q4 and Q5 are glued to a piece of aluminium which acts as a heatsink (use epoxy resin). These transistors must be the plastic types specified. Metal can types usually have the collector connected to the case and would be shorted by the heatsink. ●



The completed amplifier. Note the aluminium heatsink to which Q2, Q4 and Q5 are cemented. These transistors must be plastic TO92 types as per parts list.



Circuit diagram of the 1.5W general purpose amplifier.

PARTS LIST
AMPLIFIER ETI 225

R11,R12	Resistor	1Ω	½W	5%
R7	"	82Ω	"	"
R5	"	100Ω	"	"
R8	"	270Ω	"	"
R4,R9	"	1.2k	"	"
R10	"	1.8k	"	"
R1	"	22k	"	"
R2,3	"	100k	"	"
C4	Capacitor	22pF ceramic		
C5	"	0.0056μF polyester		
C1	"	0.1μF polyester		
C2	"	4.7μF 16V electrolytic		
C3,6	"	100μF 10V electrolytic		
C7	"	470μF 10V electrolytic		
Q1	Transistor	BC179 or similar		
Q2,3*	"	BC169 or similar		
Q4*	"	BC328 or similar		
Q5*	"	BC338 or similar		

* must be TO92 plastic types.

piece of matrix board

piece of aluminium approx. 1" x ½" for heat sink.

HOW IT WORKS ETI 225

This circuit is fairly typical of a large number of audio amplifiers.

The main voltage amplifier transistor Q3 drives the complementary pair (NPN plus PNP) Q4 and Q5 which are buffers providing high current gain but less than unity voltage gain.

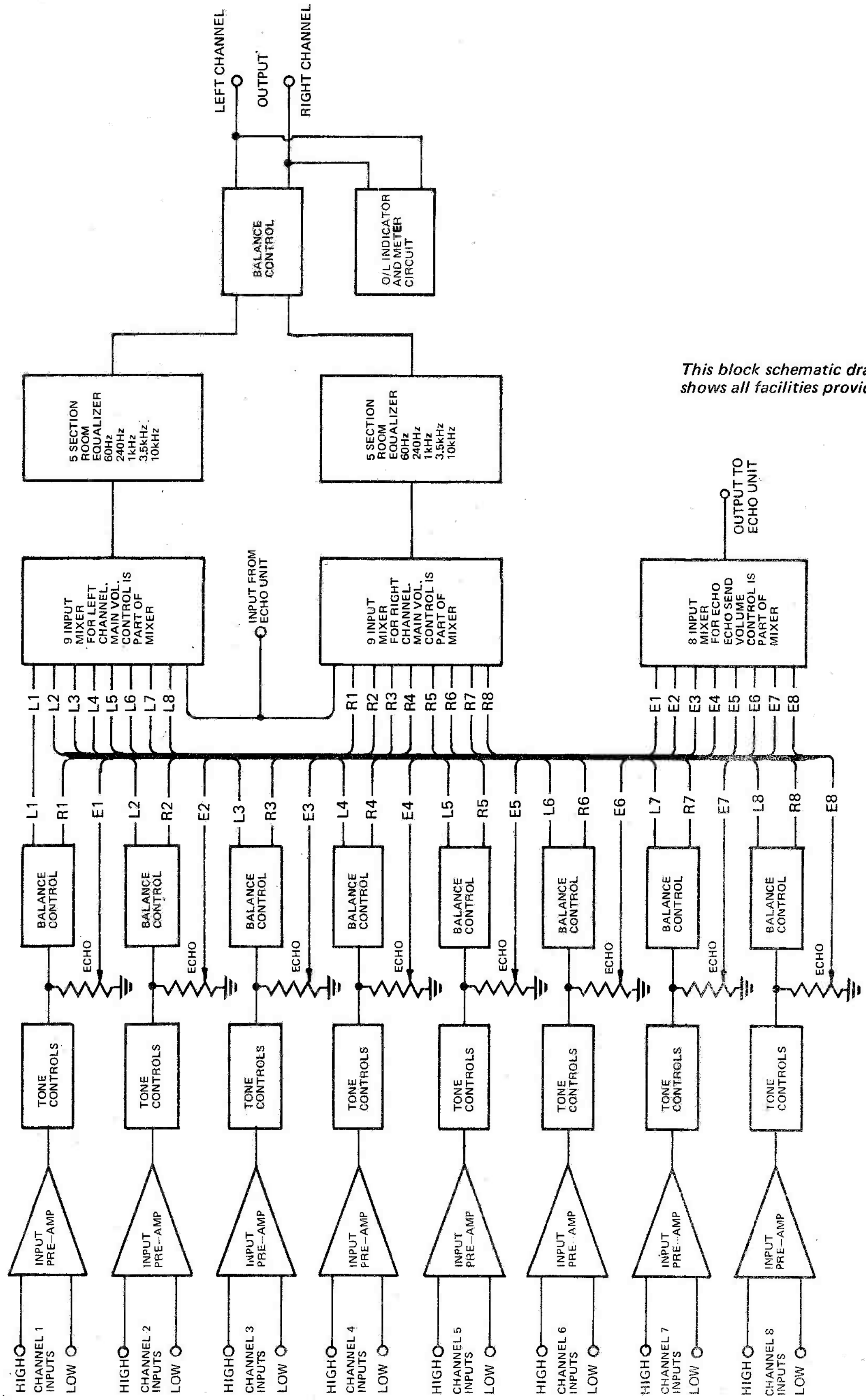
As the bases of Q4 and Q5 are effectively two base emitter junctions apart, Q3 is used to set the bias voltages for these transistors.

Transistor Q1 operates as an error amplifier which compares the input voltage and a divided down version of the output voltage. If there is any difference it provides a control voltage to Q3 in such a way that the error is corrected. The output voltage is divided down by the ratio of (R6 + R5)/R5 and hence the calculated gain will be 28 although the measured gain will be slightly less.

The dc bias point of the amplifier is also set by Q2 and this is unaffected by R5 and it is isolated by means of C3. To maintain an approximately constant current in Q3, capacitor C6 is used to keep the voltage across R8 (and hence the current through it) constant.

Capacitors C4 and C5 are used to provide frequency compensation.

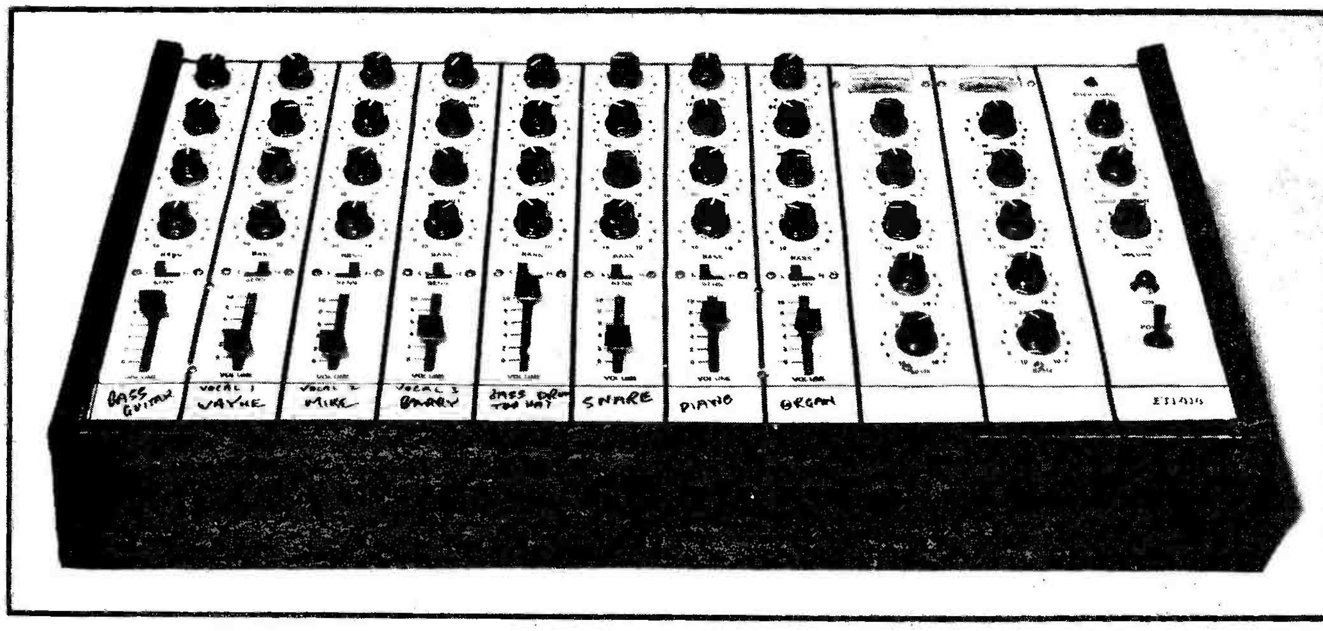
ETI MASTER-



This block schematic drawing shows all facilities provided.

MIXER

Versatile multi-input mixer/preamplifier has all the facilities required for professional PA use.



Features

* **Multiple inputs**
* **Low noise**
* **Stereo outputs**
* **Inbuilt equalizers**
* **Echo facilities**
* **Professional design**
* **Overload immunity**
* **Stage monitor facility**

Anyone who is associated with a pop group or band, will be familiar with the steps one must take to ensure optimum sound in varied localities and halls.

Outdoors, each amplifier and/or public address system must be adjusted separately to ensure sufficient sound and optimum overall mix.

Indoors, one must also cope with the acoustics of the particular building.

Many of the smaller groups merely adjust their sound on stage with one member at the back of the hall giving a subjective indication of the sound he is hearing. Larger groups often employ a person whose main function is to ensure that the final sound is exactly as it should be (as regards volume, mix, quality, etc).

The 8-channel mixer described in this article will allow the total sound to be adjusted at the one point — perhaps the rear of the hall, while at the same time, eliminating several expensive amplifiers, and still ensuring an optimum overall sound. (This is only part of the story as the reader will realize from the full description of the unit).

INPUTS

As the name of the unit indicates, there are eight separate input channels. Each of these input channels has two input sockets, one of 47k impedance, and the other adjustable by changing one resistor, (maximum 4.7k). In our case we have a 200 ohm resistor in circuit so we shall refer to the 200 ohm input from here on.

Each input channel has a slide control potentiometer for volume. This potentiometer is in series with a sensitivity network that is adjusted by a three position slide switch.

The remaining input channel controls are rotary potentiometers facilitating balance, bass, treble and echo-send volume. We shall discuss these controls in detail later in this article.

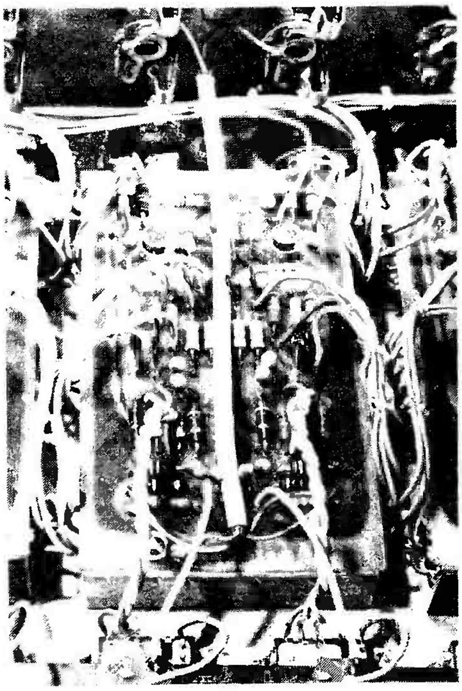
Each input, after passing through the preamplifier and tone control stages, is divided to provide identical signals. The relative level of these signals can be varied by the input channel balance control. The outputs from the balance controls drive the output mixers. This creates a stereo effect, allowing the performers to be audibly "positioned" on stage.

OUTPUTS

The unit has two output channels. The unit can of course be modified simply to provide one main output and an onstage monitor output. These receive signals from the input channel balance controls and external echo unit, or similar, if one is employed. Rotating any of the input channel balance or echo-send controls will affect the output for that particular input only.

There are also controls provided for overall volume, balance and echo volume. Finally five more rotary controls per output channel have been provided for frequency equalisation. These allow compensation for hall acoustics etc. These controls operate at 60Hz, 240Hz, 1000Hz, 3500Hz and and 10kHz and provide approximately 10dB boost or cut.

Two VU meters also feature on the front panel, together with an overload indicator light which becomes


Input pre-amps are built in modular form — two to each board.

illuminated should either output exceed one volt — which is the overload point of the 100 watt amplifier published in the February 1973 issue of ETI.

Having briefly covered the various controls and facilities provided, we shall now describe the operation and specifications of each section more extensively before we commence constructional details.

Each input channel is identical, so we only need concern ourselves with one.

The two input jacks for each channel are situated at the back of the unit, directly behind their respective control panels.

The 47k input is typical for electric guitar pickups, microphones and such, but if long leads are used, problems could arise due to hum pickup or other radiated interference. If this is the case, a matching stage or transformer may have to be inserted between the input source and the low impedance input socket.

Some microphones have an impedance of 50k, and in this case the same would apply if long leads are to be used. The optimum situation is a low impedance source (microphone etc) into the low impedance socket, but if there is a mismatch, a low impedance source and a high impedance input is preferable.

There may be situations where one wishes to feed two or three microphones to the same input channel. In this case a separate low cost mixer would be needed.

The situation above could occur for example with a drummer or with organs that have more than one output.

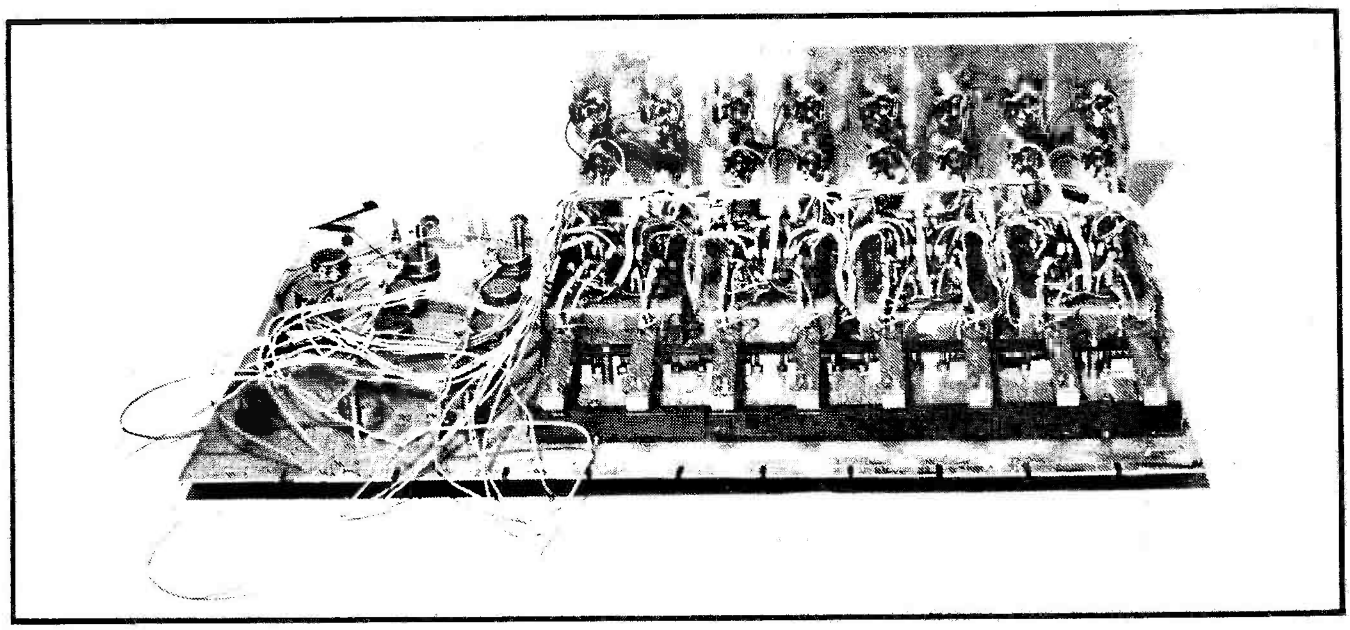
Each input employs an operational amplifier. The gain of this amplifier is varied by changing the negative feedback, as is customary with this type of device. Maximum gains of 20dB, 40dB and 55dB are available via the volume control and the switched sensitivity network.

The output from each input op-amp, feeds a second op-amp which acts as a tone control stage. The output from each tone control stage is then fed via a potentiometer to one of eight inputs of an echo send mixer I.C., and is also split by the input channel balance control network before being diverted to the output channel mixers.

The output from the echo-send mixer is brought out at the rear of the unit. This output is intended to drive a complete echo or reverberation unit etc. The output from the external unit is then fed back into the unit via another socket to a resistive splitter, which provides two identical signals for the output mixers. It is important to realize that all signals are "echoed" if their particular echo send controls are turned up, and that both output channels amplify the result equally, as indicated above. The overall echo gain control varies the feedback of the echo-send mixer.

SPECIFICATIONS

Inputs	eight (but may be expanded or reduced —in multiples of two — as desired)
Input Impedance	
(high)	47k
(low)	nominally 200 ohms, but may be any preset value under 4.7k
Sensitivity (high impedance Input)	10mV
(low impedance input)	1mV
Tone controls (on each input)	bass ±10dB at 100Hz treble ±10dB at 10kHz
Outputs	two, left and right
Output level	maximum 5 V rms
Output impedance	approx 4000 ohms
Output tone control	each channel has its own equalizer providing ±10dB boost or cut at following frequencies — 60Hz; 240Hz; 1kHz; 3.5kHz; 10kHz



This photograph was taken during construction of our prototype unit. The four input pre-amps may be seen on the right. Directly in front of the pre-amps are the slide potentiometers used for individual volume controls.

A nine-input mixer I.C. is employed at the input of each output channel. One of the nine inputs is in both cases used for echo input, while the others take the outputs from the eight input channels. The negative feedback of these op-amps is varied for overall volume control.

The outputs from the main mixers pass through the graphic equalisers and then to an overall balance control. The two VU meters and the overload indicator are connected at the output of the unit.

The metal panel of our unit is folded from one piece of 18 gauge steel. Eleven aluminium escutchions are used, although of only three different types.

PREAMPLIFIER IC

The device is a National type LM381 dual low noise preamplifier IC. We have used one IC per every two input channels — a total of four, if one requires all input channels.

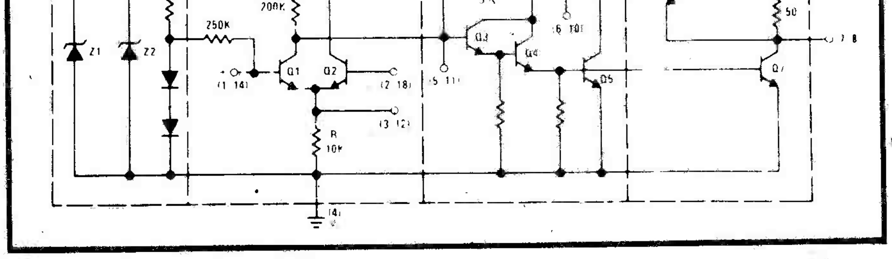
The total equivalent input noise is specified as maximum 1μV rms with a 600 ohm source impedance, over a frequency range from 10Hz to 10kHz

The open loop gain of each amplifier is typically 112dB, the supply range 9 to 40 volts, and power supply rejection better than 120dB.

Supply current is typically 10mA over the voltage range quoted above. Channel separation measured at 1kHz is typically 60dB. Total harmonic distortion measured at 1kHz with the gain set at 75dB is typically 0.1%.

The maximum recommended input voltage is 300mV, and the typical available peak-to-peak output voltage swing is Vcc minus two volts. This I.C. is short circuit protected.

Circuit of National type LM381 dual low-noise pre-amplifier IC used in the 8-channel mixer.



PREAMPLIFIER

There are four preamplifier boards each having two channels. Assemble the components to each board in accordance with the circuit diagram and component overlay provided. Take care not to damage the ICs with excessive heat (use a lightweight iron, and solder quickly) and pay particular attention to the orientation of the TAG tantalum capacitors.

Details of the connections between the preamplifier boards and their associated controls are given in Fig 1a. It is suggested that leads of adequate length are connected to the boards first. The boards may then be fixed in position and the leads routed to their respective controls.

After the preamplifier boards are assembled, we can assemble the main mixer — equalizer boards of which there are two. The winding data for the inductors associated with this section is given in Table 1.

The coils must be layer wound with care. Jumble winding will almost certainly prevent the full number of turns fitting on the bobbin.

The only remaining printed circuit board accommodates the power supply — echo mixer, overload and meter circuitry, The construction of this board will be covered next month, together with full details of the wood and metalwork required.

ETI MASTER MIXER

HOW IT WORKS MAIN MIXERS – EQUALIZERS

As indicated last month, there are nine inputs to each main mixer IC. This IC is connected in an inverting amplifier configuration, with the gain controlled by varying the negative feedback. This gives a control range from zero output to about 30dB gain.

The output from the main mixer is direct coupled to the input of the equalizer stage. This stage is a little unusual, since the equalizing networks are arranged to vary the negative feedback. If we consider one section with the others disconnected, at the resonant frequency of the series LCR combination the impedance of the entire network will be equal to 680 ohms. Either side of resonance the impedance of the network will increase (with a slope dependent on the Q of the network), due to uncancelled inductive reactance above resonance and uncancelled capacitive reactance below resonance. We can therefore represent the equalizer stage with equivalent circuits as reproduced below. These circuits consider only one network is in circuit, the input signal frequency is the resonant frequency of the network, and the resistance of the inductor is negligible.

With the slider of the potentiometer at the top end (Fig. 2a) we have 680 ohms to the zero volt line from pin 2 of IC2, and a 1k ohm between pin 3 and pin 2. The IC will act due to the feedback to keep the potential between pins 2 and 3 virtually zero, thus there is zero current through

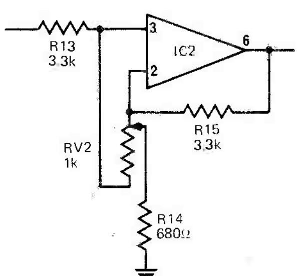


Fig. 2a – Equivalent circuit of the equalizer with potentiometer set for maximum boost at the resonant frequency of the network.

RV2. The voltage on pin 3 (IC2) is therefore equal to the output of the mixer since there is virtually no current through and no voltage drop across R13.

The output of IC2 in this case is approximately the input signal times (R15 + 680)/680 ohms, indicating a

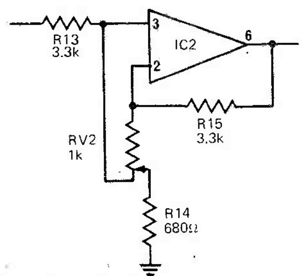


Fig. 2b – Equivalent circuit of the equalizer with the potentiometer set for maximum cut at the resonant frequency of the network.

gain of about 15dB. If the slider is at the other end of the potentiometer (Fig 2b) the signal appearing at pin 3 and thus also at pin 2 is about 0.2 of the output of the previous stage due to the voltage division of R13 and the 680Ω. There is still zero current through RV2 and also zero current through R15 since there is no path. The output voltage is therefore the same as that at pin 2, which happens to be about 0.2 times the output of the previous stage. The gain is therefore 0.2 or –13dB.

With all networks in circuit, the maximum boost and cut will be

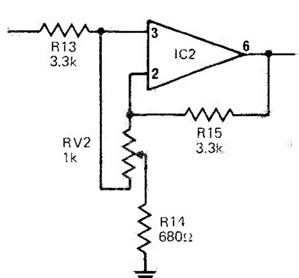
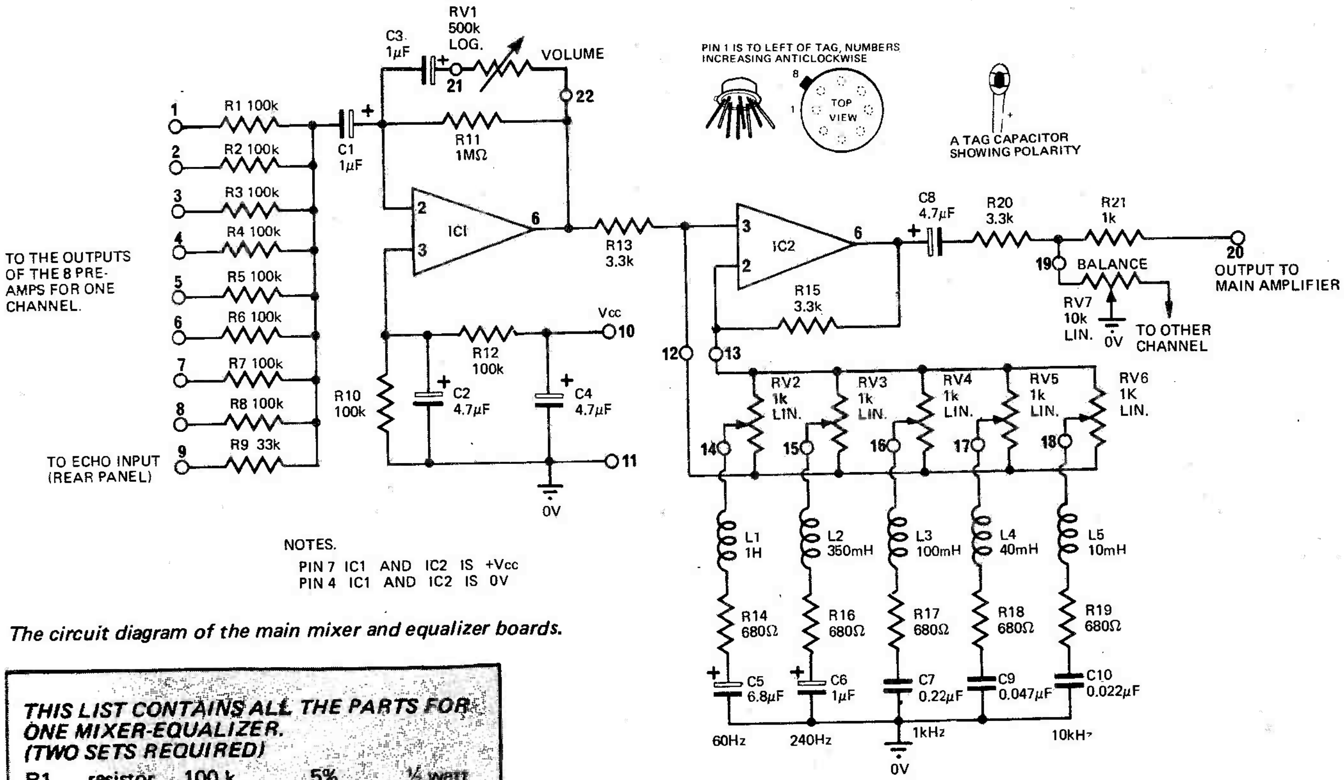


Fig 2c – Equivalent circuit of the equalizer with the potentiometer set for unity gain regardless of frequency.

reduced, but a range of ±10dB is still available. With the wiper of the potentiometers set midway – Fig 2c, the gain will be unity regardless of frequency, due to the symmetry of the entire network.

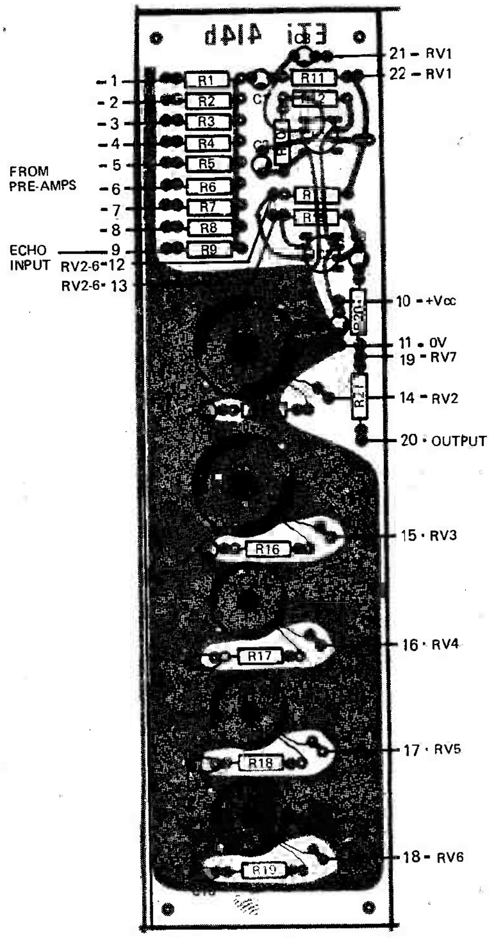


The circuit diagram of the main mixer and equalizer boards.

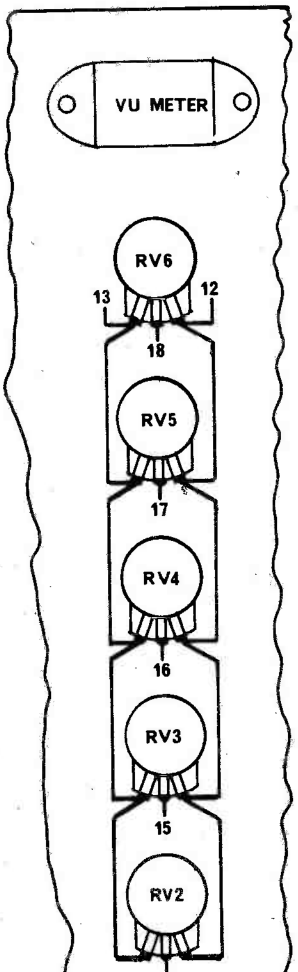
THIS LIST CONTAINS ALL THE PARTS FOR ONE MIXER-EQUALIZER. (TWO SETS REQUIRED)

R1	resistor	100 k	5%	½ watt
R2	"	100 k	"	"
R3	"	100 k	"	"
R4	"	100 k	"	"
R5	"	100 k	"	"
R6	"	100 k	"	"
R7	"	100 k	"	"
R8	"	100 k	"	"
R9	"	33 k	"	"
R10	"	100 k	"	"
R11	"	1 M	"	"
R12	"	100 k	"	"
R13	"	3.3 k	"	"
R14	"	680 ohm	"	"
R15	"	3.3 k	"	"
R16	"	680 ohm	"	"
R17	"	680 ohm	"	"
R18	"	680 ohm	"	"
R19	"	680 ohm	"	"
R20	"	3.3 k	"	"
R21	"	1 k	"	"
C1	capacitor	1μF	35V TAG tantalum	
C2	"	4.7μF	35V "	"
C3	"	1μF	35V "	"
C4	"	4.7μF	35V "	"
C5	"	6.8μF	25V "	"
C6	"	1μF	35V "	"
C7	"	0.22μF	polyester	
C8	"	4.7μF	35V TAG tantalum	
C9	"	0.047μF	polyester	
C1	"	0.022μF	polyester	
L1	audio choke	1H (see winding data table 1)		
L2	" "	350 mH	"	
L3	" "	100 mH	"	
L4	" "	40 mH	"	
L5	" "	10 mH	"	
IC1	integrated circuit	uA741, LM307 (metal can or mini dip only)		
IC2	" "	uA741, LM307 (metal can or mini dip only)		
*RV1	potentiometer	500 k ohm LOG dual		
RV2	"	1 k LIN		
RV3	"	1 k LIN		
RV4	"	1 k LIN		
RV5	"	1 k LIN		
RV6	"	1 k LIN		
*RV7	"	10 k LIN		

*ONE ONLY REQUIRED FOR COMPLETE UNIT
PC Board ETI 414B
6 knobs
4 1" spacers

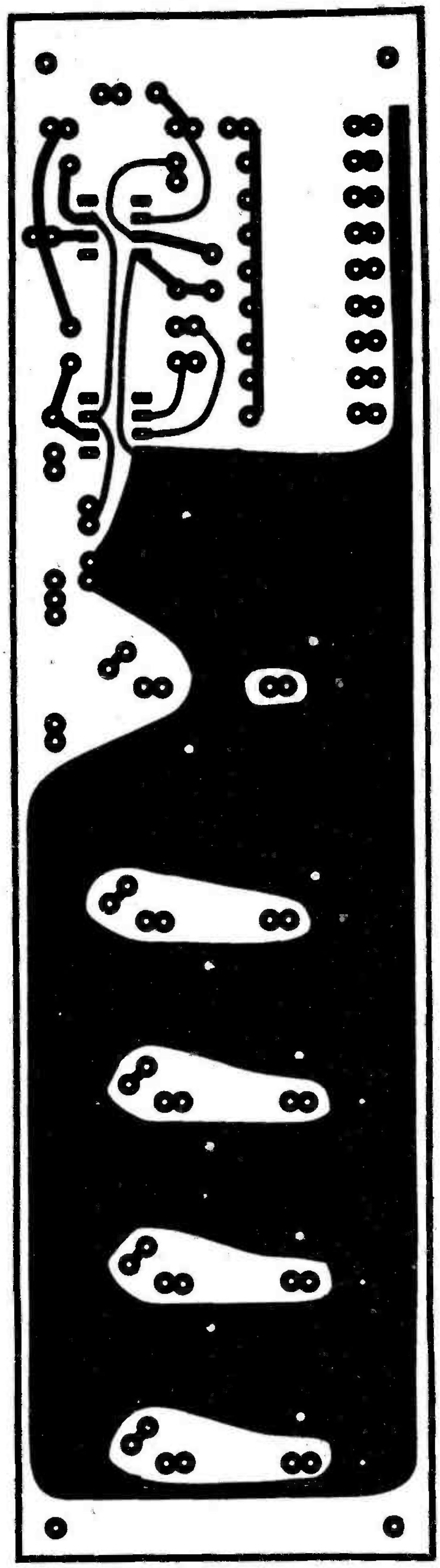


Component overlay for main mixer and equalizer.



This diagram shows the connections to the potentiometers associated with the equalizers. The numbers correspond one-to-one, to those on the main mixer – equalizer circuit and overlay diagrams.

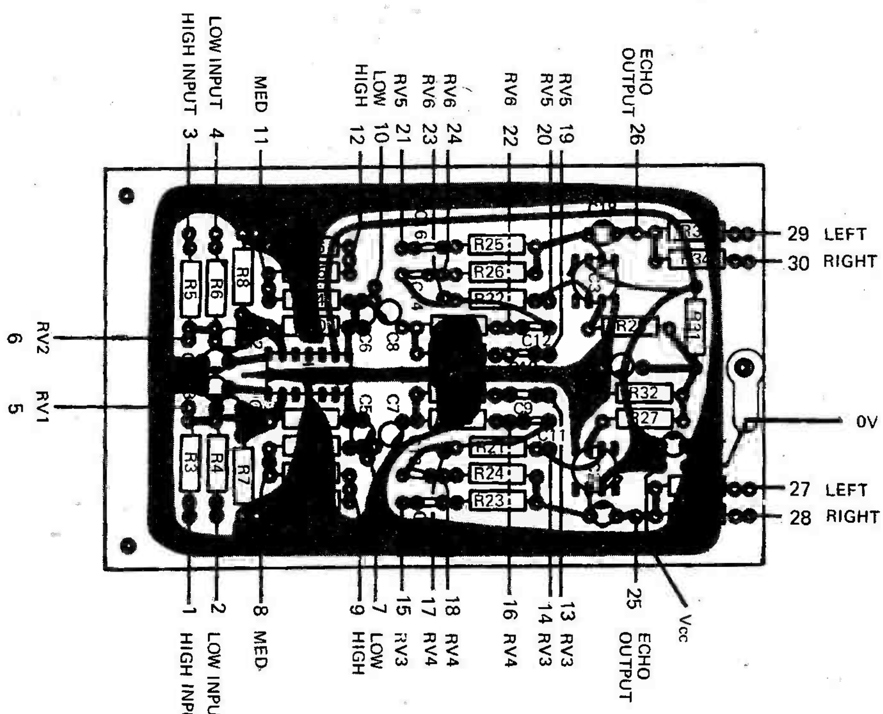
ETI MASTER MIXER



The main mixer and equaliser printed circuit board pattern – shown full size.

TABLE 1:– WINDING DETAILS EQUALIZER COILS

L1	1000 Turns 38 SWG enamelled copper wire. Core Siemens 26 x 16 mm. Type number B 65671 - L 0000 - R 030. Former Type B 65672 - A 0000 - M 001
L2	650 Turns 38 SWG. Core and Former as for L1
L3	300 Turns 38 SWG. Core Siemens 18 x 14 mm. Type number B 65561 - A 0000 - R 030. Former Type B 65562 - A 0000 - M 001
L4	205 Turns 38 SWG. Core and Former as for L3
L5	100 Turns 38 SWG. Core and Former as for L3



Preamplifier component overlay

HOW IT WORKS – PREAMPLIFIERS

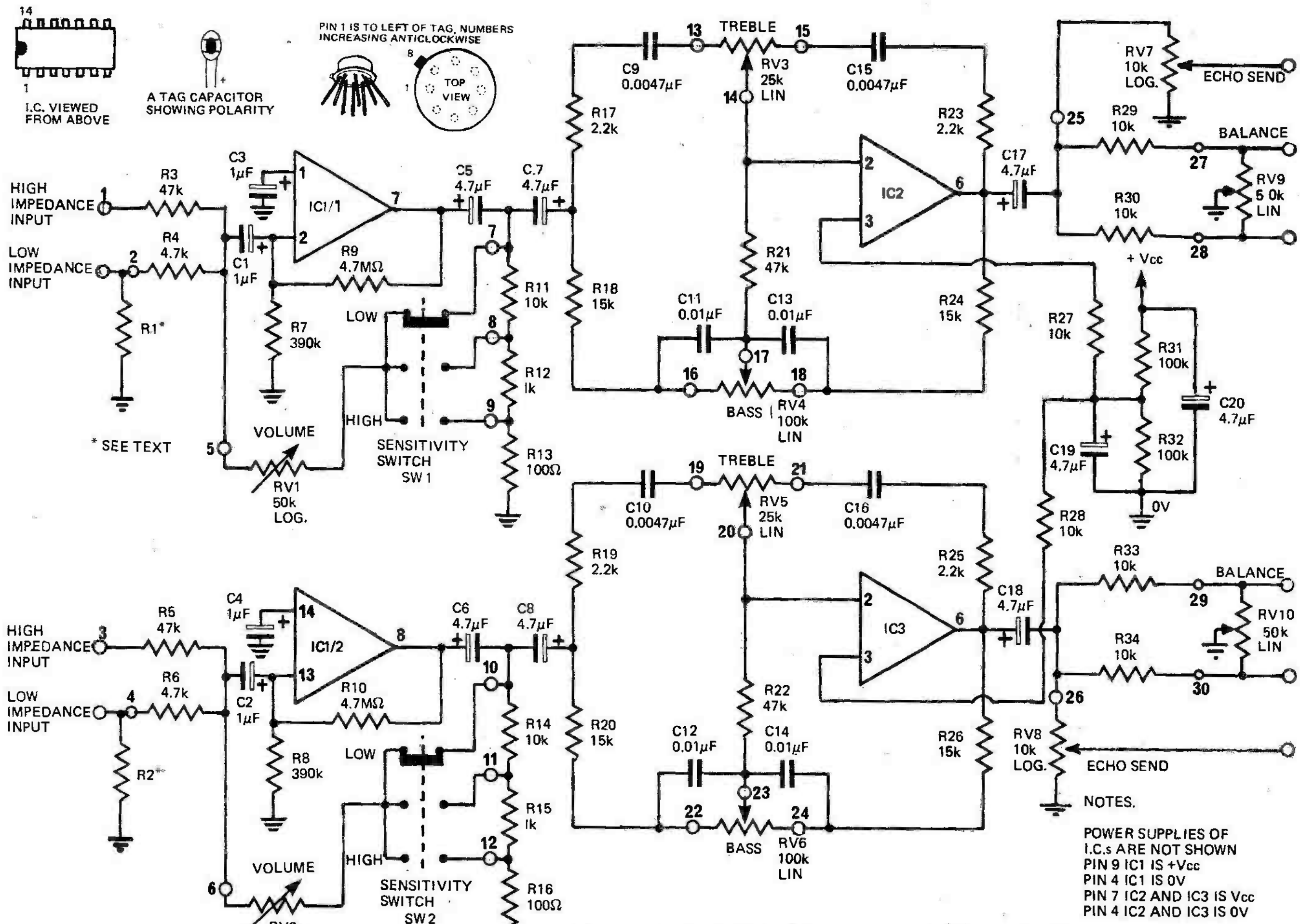
Considering channel 1 of the board only, IC1 is wired as an inverting amplifier. The gain of this amplifier is varied by RV1 – the volume control, and set at high, medium or low by SW1 – the sensitivity switch. These controls vary the gain of the amplifier by adjusting the negative feedback. More feedback, less gain, and vice-versa.

SW1 changes the range of RV1 for maximum gains of 20dB, 40dB and 55dB when the low impedance input is employed. With the sensitivity switch at low the minimum output of this stage is virtually zero, while a minimum gain of 6dB is realised when the sensitivity is set at either medium or high. Gains when the high impedance input is employed are all 20dB lower than those given above.

The input impedance to the IC is virtually zero, when used as an inverting amplifier. Therefore the input impedance to the preamplifier is determined by R3 for the high impedance input, and by R1 in parallel with R4 for the low impedance input. R9 and R7 set the bias of the IC. The tone control stage is a conventional feedback type.

Note that where different input impedances from those specified are required, the values of R1 (or R2) required may be calculated by the following formula

R = (4700 x Zin)/(4700 – Zin)
where Zin is the desired input impedance.



The circuit diagram of one of four identical preamplifier boards. I.C. 1/1 and I.C. 1/2 are in the same package.

THIS LIST CONTAINS ALL PARTS EXCEPT METAL WORK, FOR A COMPLETE PREAMPLIFIER AND TONE CONTROLS. FOR AN 8 CHANNEL MIXER FOUR SETS OF COMPONENTS ARE REQUIRED

PARTS LIST (PREAMP)

R1*	RESISTOR	200 ohm	5%	½W
R2*	"	200 ohm	"	"
R3	"	47k	"	"
R4	"	4.7k	"	"
R5	"	47k	"	"
R6	"	4.7k	"	"
R7	"	390k	"	"
R8	"	390k	"	"
R9	"	4.7M	"	"
R10	"	4.7M	"	"
R11	"	10k	"	"
R12	"	1k	"	"
R13	"	100ohm	"	"
R14	"	10k	"	"
R15	"	1k	"	"
R16	"	100ohm	"	"
R17	"	2.2k	"	"
R18	"	15k	"	"
R19	"	2.2k	"	"
R20	"	15k	"	"
R21	"	47k	"	"
R22	"	47k	"	"
R23	"	2.2k	"	"
R24	"	15k	"	"
R25	"	2.2k	"	"
R26	"	15k	"	"
R27	"	10k	"	"
R28	"	10k	"	"
R29	"	10k	"	"
R30	"	10k	"	"
R31	"	100k	"	"
R32	"	100k	"	"
R33	"	10k	"	"
R34	"	10k	"	"

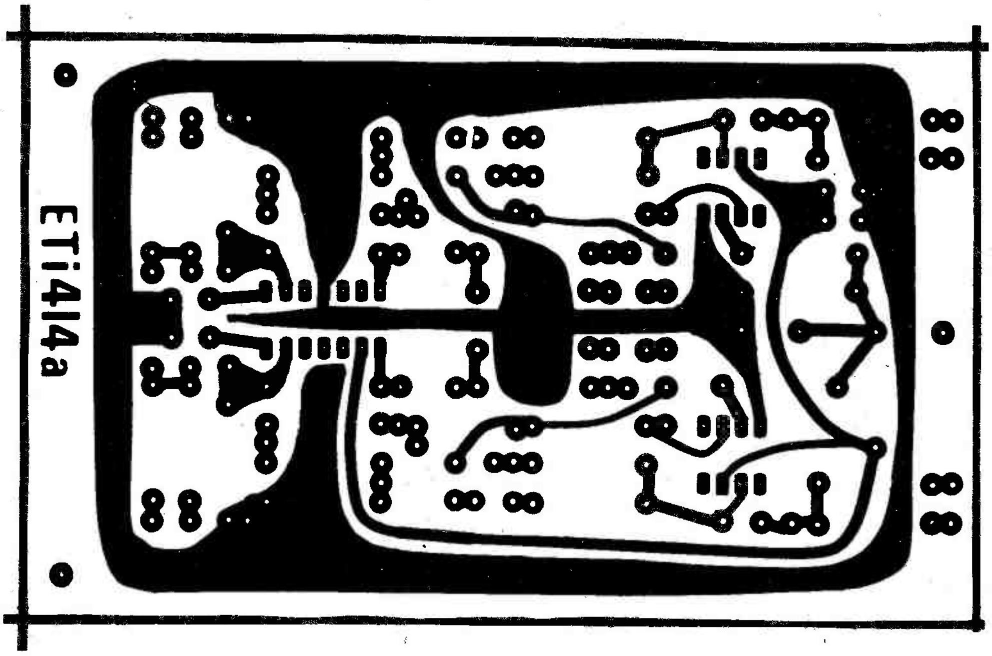
C1	CAPACITOR	1μF	35V	TAG	tant.
C2	"	1μF	35V	"	"
C3	"	1μF	35V	"	"
C4	"	1μF	35V	"	"
C5	"	4.7μF	35V	"	"
C6	"	4.7μF	35V	"	"
C7	"	4.7μF	35V	"	"
C8	"	4.7μF	35V	"	"
C9	"	0.0047μF	35V	polyester	
C10	"	0.0047μF		"	
C11	"	0.01μF		"	
C12	"	0.01μF		"	
C13	"	0.01μF		"	
C14	"	0.01μF		"	
C15	"	0.0047μF		"	
C16	"	0.0047μF		"	
C17	"	4.7μF	35V	TAG tantalum	
C18	"	4.7μF	35V	"	"
C19	"	4.7μF	35V	"	"
C20	"	4.7μF	35V	"	"

RV1	potentiometer	50 k LOG	slider pot
RV2	"	50 k LOG	" "
RV3	"	25 k LIN	
RV4	"	100 k LIN	
RV5	"	25 k LIN	
RV6	"	100 k LIN	
RV7	"	10 k LOG	
RV8	"	10 k LOG	
RV9	"	50 k LIN	
RV10	"	50 k LIN	

IC1 integrated circuit LM381
IC2 " " uA741, LM307 (metal can or mini dip only)
IC3 " " uA741, LM307 (metal can or mini dip only)
PC board
8 knobs for rotary potentiometers
2 knobs for slide potentiometers
2 3P-3T slide switches
3 1" spacers
4 6.5 mm phone sockets

* see text.

ETI MASTER MIXER



The printed circuit board pattern for the pre-amplifier sections — shown full size.

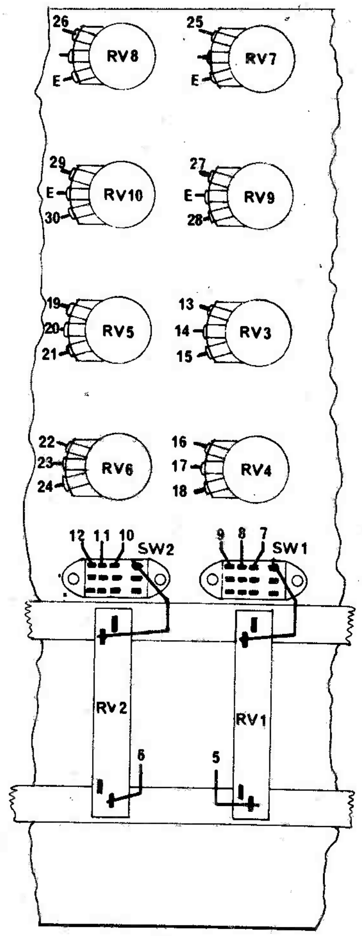


Fig. 1a This diagram shows connections to the potentiometers and sensitivity switches associated with the preamplifier boards. The numbers corresponds to those on the pre-amplifier circuit and overlay diagrams.

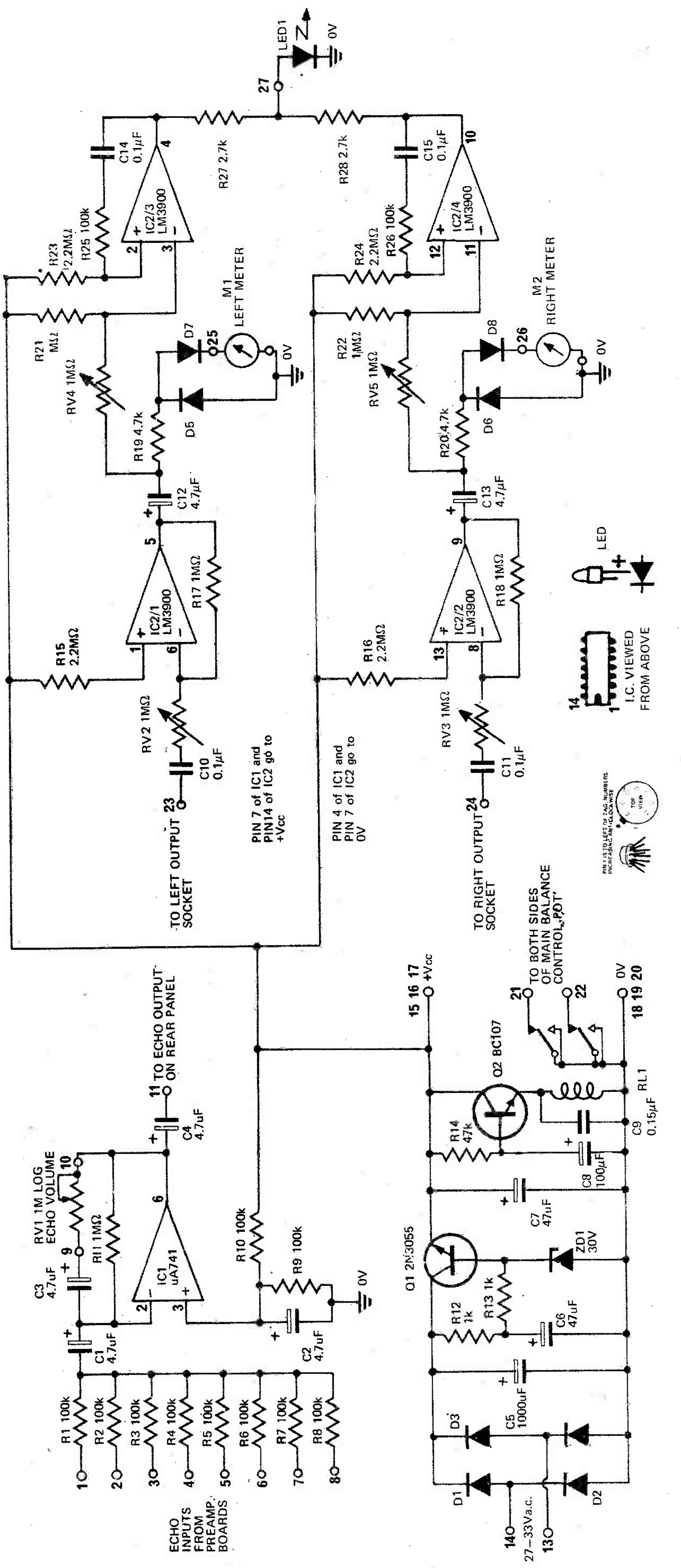


Fig. 1. Circuit diagram of power supply and metering board

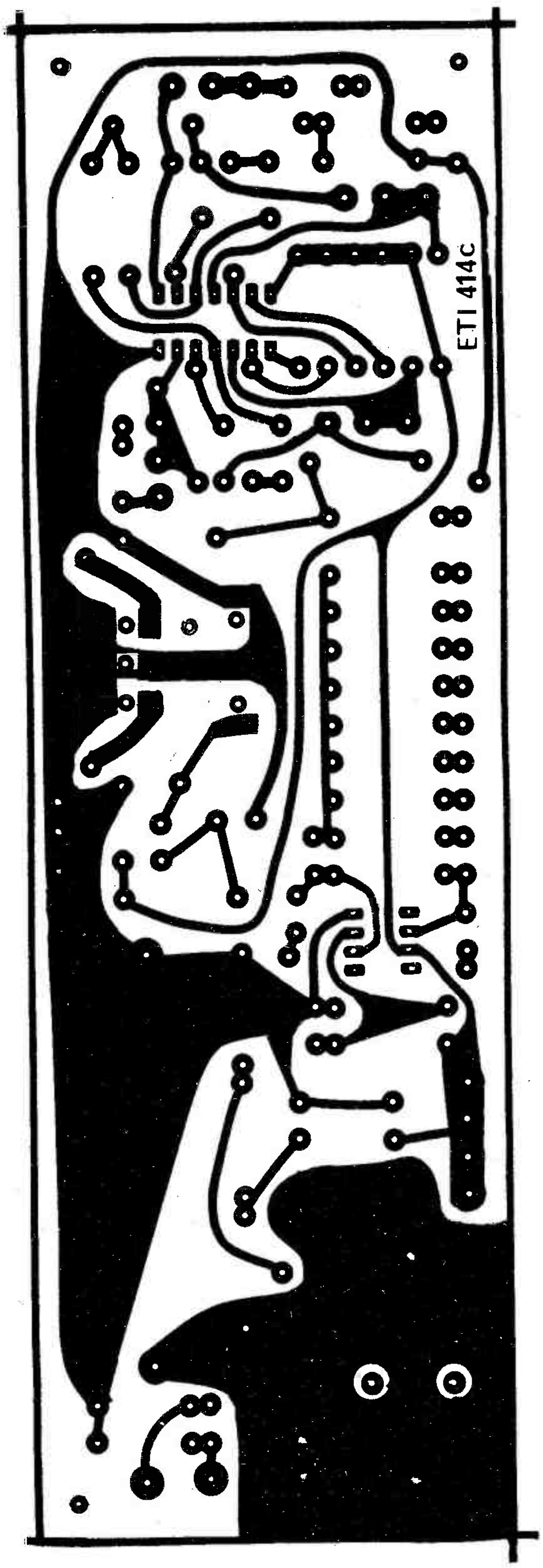
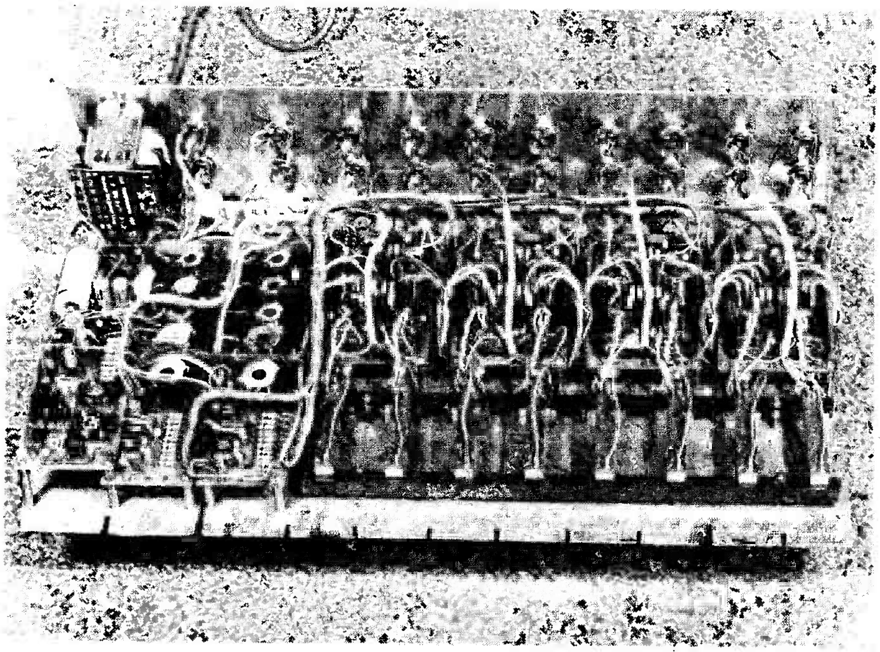


Fig. 2. Foil pattern for power supply board

ETI MASTER MIXER



POWER SUPPLY CONSTRUCTION

Begin by assembling components to the power supply board in accordance with the component overlay (Fig. 3).

Ensure that IC's and tantalum capacitors are fitted to the board with correct orientation (refer to insets on circuit diagram. Use care, when soldering, to avoid heat damage to components – especially IC's. Use a

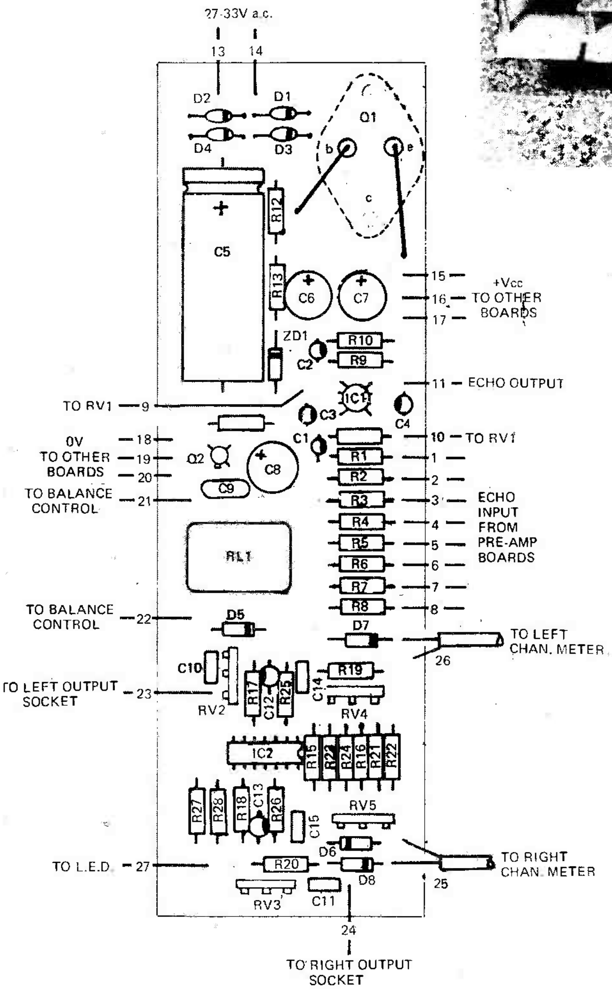
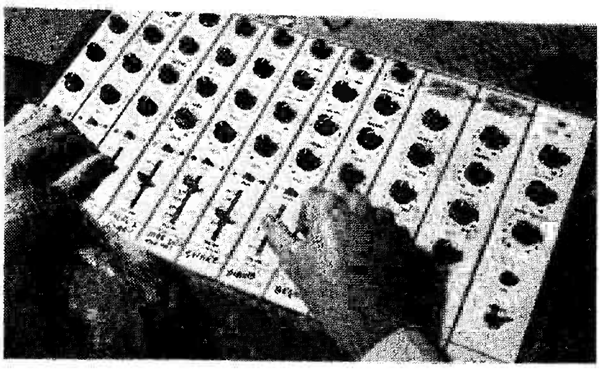


Fig. 3. C nponent overlay of power supply board.



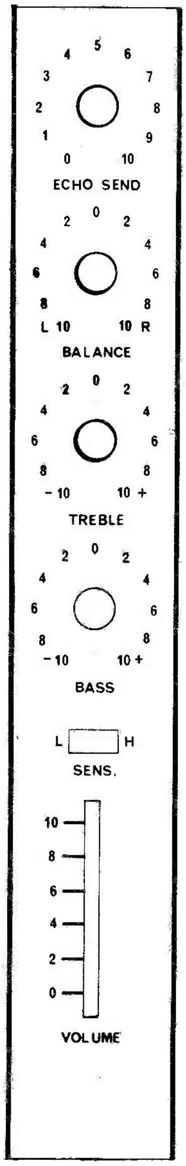


Fig. 4. Escutcheon for preamplifier (actual size 12" x 1¾").

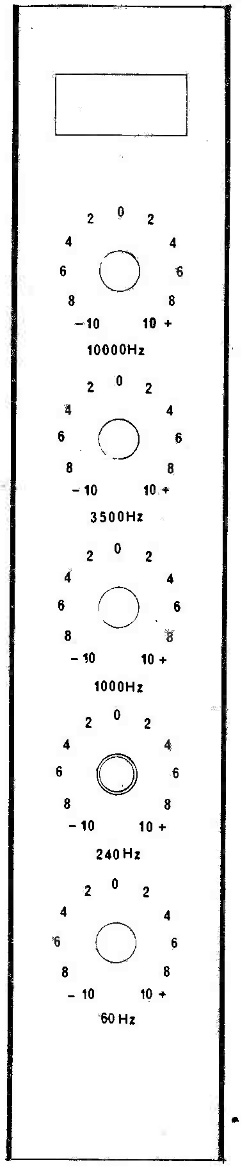


Fig. 5. Equalizer panel escutcheon (actual size 12" x 2¼")

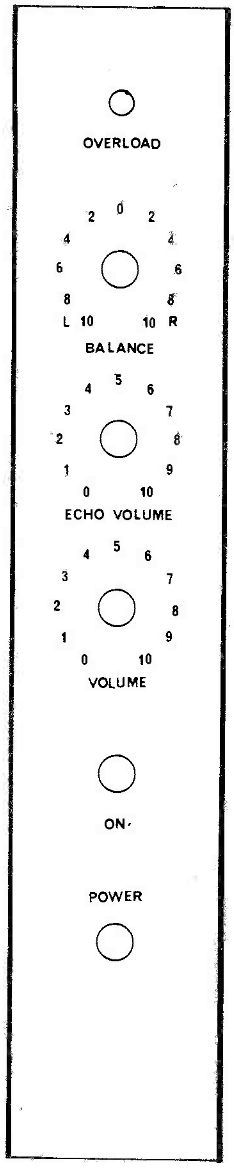


Fig. 6. Main control panel escutcheon. (actual size to be 12" x 2¼").

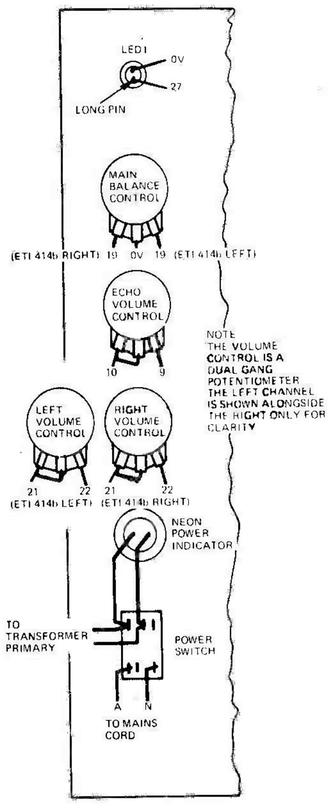


Fig. 7. Wiring to rear of main control panel.

light-weight, low-wattage soldering iron and work quickly.

Printed circuit boards purchased from suppliers may be varnished with resin or similar. Clean off the varnish where the 2N3055 regulator transistor is mounted, to allow electrical contact. Silicon grease should be used between the copper pattern and the transistor to aid heat transfer.

The pins of the relay are inserted into the holes provided in the board and bent to make contact with the copper tracks before soldering. We inserted pins to allow connection of the positive and negative supply leads which have to be routed to the various other boards.

There are three pins for positive leads and three for negative leads. Two leads connect to each positive pin (six leads total). The common leads from the four preamplifier boards and the two main mixer boards, are soldered to lugs secured between each respective board and one of its mounting pillars. Two of these leads are terminated at each negative pin on the power supply board.

By referring to the metalwork drawings and the photograph of the unit, boards and other components

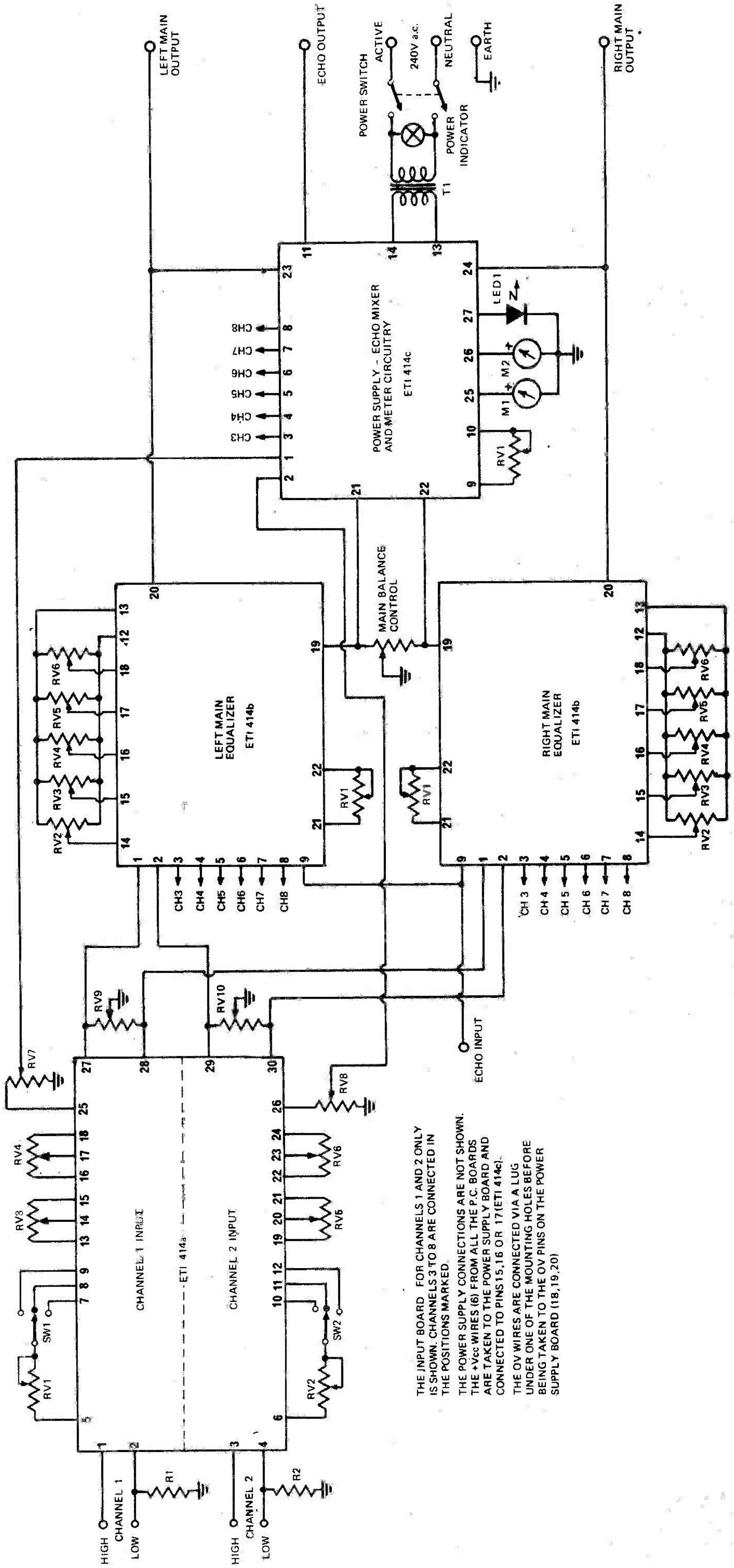


Fig. 8. Main interconnection diagram.

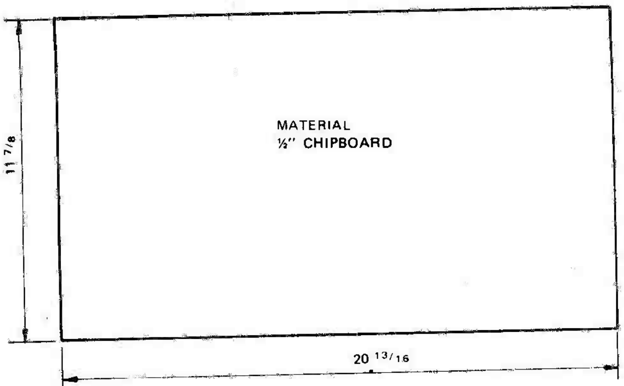


Fig. 9a. Cabinet baseboard.

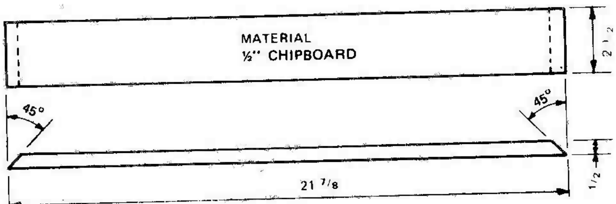


Fig. 9b. Cabinet front

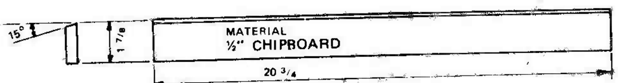


Fig. 9c. Front panel support

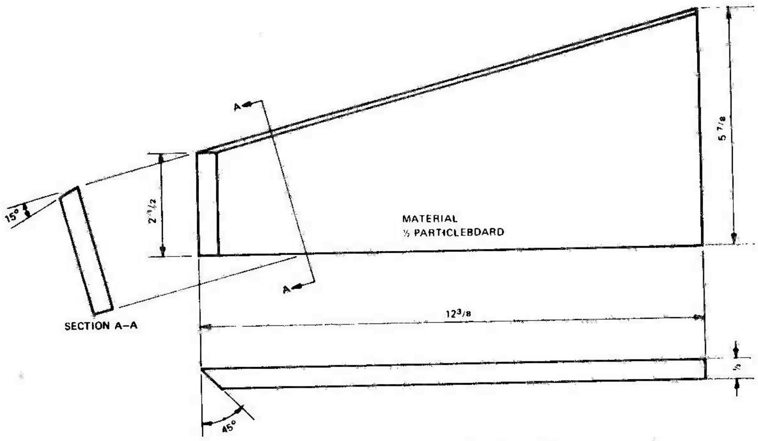


Fig. 9d. Cabinet sides – two required. Note that boards should be mirror image of each other, that is, chamfers should have opposite slope.

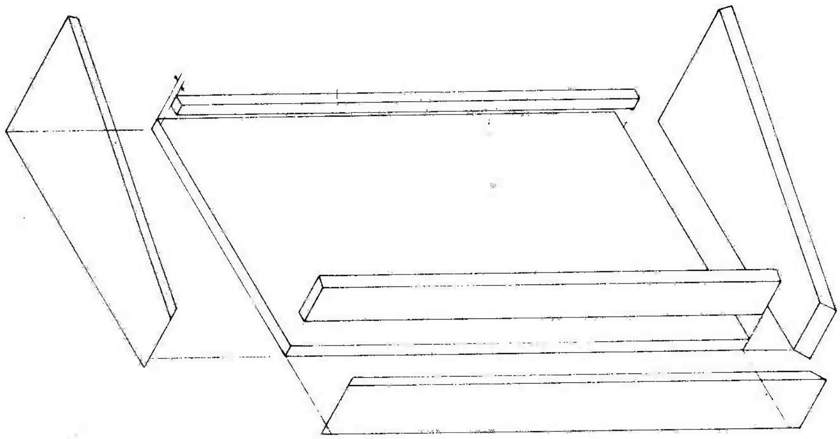


Fig. 10. Cabinet assembly details.

may be mounted to the panel in the following order.

1: Each preamplifier board is mounted on three 1" long threaded pillars. The main mixer – equaliser boards each employ four of these pillars which should be secured to the front panel with countersunk screws.
2: Mount the VU meters, with countersunk screws.
3: Mount the sensitivity switches.
4: The slide potentiometers are mounted on two rails, each of which is spaced from the chassis by four, ¾" long threaded pillars – eight in all. Ensure that pin 1 of each potentiometer is orientated towards the front of the panel.
5: Glue on the escutchions with contact cement and mount the rotary potentiometers, switches and indicator lights.

Note: Two of the escutchions will have to be drilled to allow the front panel to be secured (see the metalwork diagram).

6: Mount the input jacks on the rear of the panel.
7: Mount the transformer and the printed circuit boards.

This completes the front panel assembly and we can now make the interconnections.

WIRING THE UNIT

The interboard wiring should be carried out with reference to the underchassis photograph and to the interconnection diagram, Fig. 8.

All wiring should preferably be colour coded and should be routed down one side only of each board so that the board may be swung-up, sideways, if servicing is required at some later date.

Use one mil plastic tubing, or lacing twine, to tie the wiring into looms. This, as well as improving the appearance of the unit, also facilitates servicing.

Leads to the VU meters, output sockets, echo input and output sockets, and the main balance control must be in screened cable. These and, as far as possible, all other wiring should be kept well clear of the mains transformer to prevent hum pickup.

WOODWORK

Cut the five pieces shown in Fig. 9 from ½ inch chipboard, note that the two pieces cut as per Fig. 9d are mirror images of each other. Veneer the inside surfaces of the two sides (Fig.9d) and the front strip (Fig. 9b).

Assemble the box as per Fig. 10. Screws or nails should be used to hold the panels together while the glue sets. Take care to ensure that the sides are square to the base, otherwise the metal panel may not fit in place. In fact it is a good idea to use the panel as an assembly guide. The support piece (Fig. 9c) is assembled with the short side to the front. The rear panel support is merely a half inch square piece of timber, positioned 3/8 inches from the rear edge of the base (Fig. 10).

When the glue is set, the box can be sanded and all visible outside surfaces veneered, before final sanding and finishing operations are carried out. The inside of the box should be lined with cooking foil, and this earthed to the metal chassis. If the foil goes over the rear panel support, the metal panel will make contact with it and no other connection need be used.

TESTS AND ADJUSTMENTS

Before initially switching on, remove from the power supply board the +Vcc

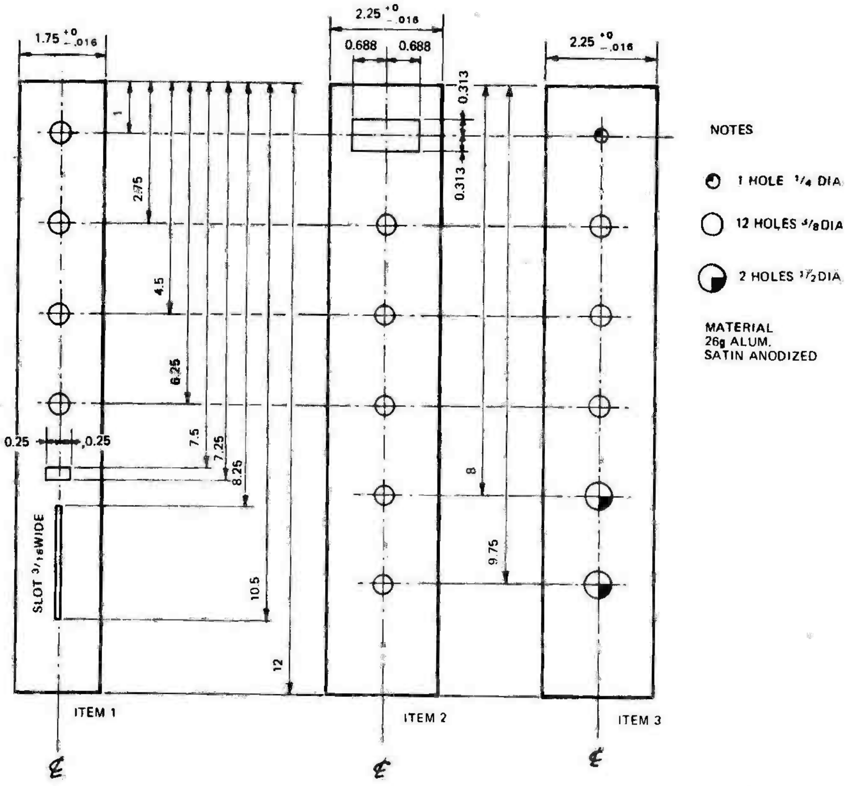


Fig. 12. Drilling details – Item 1: preamplifier panel. Item 2: equalizer panel. Item 3: main control panel.

PARTS LIST FOR POWER SUPPLY BOARD ETI 414

R1	Resistor	100k	½W	5%
R2	"	100k	"	"
R3	"	100k	"	"
R4	"	100k	"	"
R5	"	100k	"	"
R6	"	100k	"	"
R7	"	100k	"	"
R8	"	100k	"	"
R9	"	100k	"	"
R10	"	100k	"	"
R11	"	1M	"	"
R12	"	1k	"	"
R13	"	1k	"	"
R14	"	47k	"	"
R15	"	2.2M	"	"
R16	"	2.2M	"	"
R17	"	1M	"	"
R18	"	1M	"	"
R19	"	4.7k	"	"
R20	"	4.7k	"	"
R21	"	1M	"	"
R22	"	1M	"	"
R23	"	2.2M	"	"
R24	"	2.2M	"	"
R25	"	100k	"	"
R26	"	100k	"	"
R27	"	2.7k	"	"
R28	"	2.7k	"	"

RV1	Potentiometer	1 Meg Log	
RV2	"	1 Meg Trim type	
RV3	"	1 Meg "	"
RV4	"	1 Meg "	"
RV5	"	1 Meg "	"
C1	Capacitor	4.7µF	35V Tantalum
C2	"	4.7µF	35V Tantalum
C3	"	4.7µF	35V Tantalum
C4	"	4.7µF	35V Tantalum

C5	"	1000µF	50V Electrolytic Wire leads
C6	"	47µF	50V Electrolytic PCB mounting
C7	"	47µF	50V Electrolytic PCB mounting
C8	"	100µF	50V Electrolytic PCB mounting
C9	"	0.15µF	100V Polyester
C10	"	0.1µF	100V "
C11	"	0.1µF	100V "
C12	"	4.7µF	35V Tantalum
C13	"	4.7µF	35V Tantalum
C14	"	0.1µF	100V Polyester
C15	"	0.1µF	100V "
D1-D4	Diodes 1N4001, or similar		
D5-D8	" 1N914		
LED1	TIL209		
ZD1	Zener Diode BZY8830V		
IC1	µA741 (metal can or minidip)		
IC2	Integrated Circuit LM3900		
Q1	Transistor 2N3055		
Q2	" BC107		
PC board	ETI 414c		

Level indicator edge meters 400µA 410ohms, type PV31 or similar (two required).
Brass spacers, ½" by 1/8" clearance hole (three required).
Brass spacers, 1", tapped 1/8" (two required).
Phone jacks 6.5mm (two required).

Transformer 240V primary 27-33V secondary —200mA.
Power switch dpdt (or similar).
Neon indicator 240V (chassis mounting).
Three-core flex and plug, nuts, bolts, etc.
Relay 1250 ohm, miniature type, two change-over contacts.

wires leading to the preamplifier and mixer boards making sure they cannot touch other circuitry. Rotate the trim potentiometers to their mid position and switch on. Check the voltage between the Vcc and OV terminals. This should be between 27 and 32 volts. If not, there is a fault in the supply which should be located before proceeding further.

Using an oscillator, feed a signal into the output socket of the left channel. An indication should be visible on the left hand meter. Set the input level to that required to drive the power amplifier to full output (1V for the ETI 413 amp.), and adjust RV2 to give full scale deflection. Now adjust RV4 to the point where the LED just stops flashing. Now repeat the process for the right channel, adjusting RV3 for full scale deflection and RV5 for LED indication. This completes the metering circuit calibration.

Now connect the equalizer boards and one of the preamplifier boards. This preamplifier can be checked either with an oscillator or a microphone. Check that the gain increases when the sensitivity switch is moved to the right, also that the tone controls give maximum boost when moved clockwise. Make sure that the balance control operates correctly and the wires going to the mixers have not been crossed.

Add the other preamplifiers one at a time testing each as above. When all the above procedure is complete the unit is ready for operation.

USES AND MODIFICATIONS

Having built the ETI Master-Mixer you will wish to use it in the most effective way, and perhaps modify its performance to suit individual requirements. We cannot possibly cover all eventualities, but this article provides details of a typical installation and some commonly-needed alternative configurations.

BASIC PHILOSOPHY

The unit has been designed to provide master-mixing for the average sized group (which is usually similar to that shown in Fig.14). It provides a

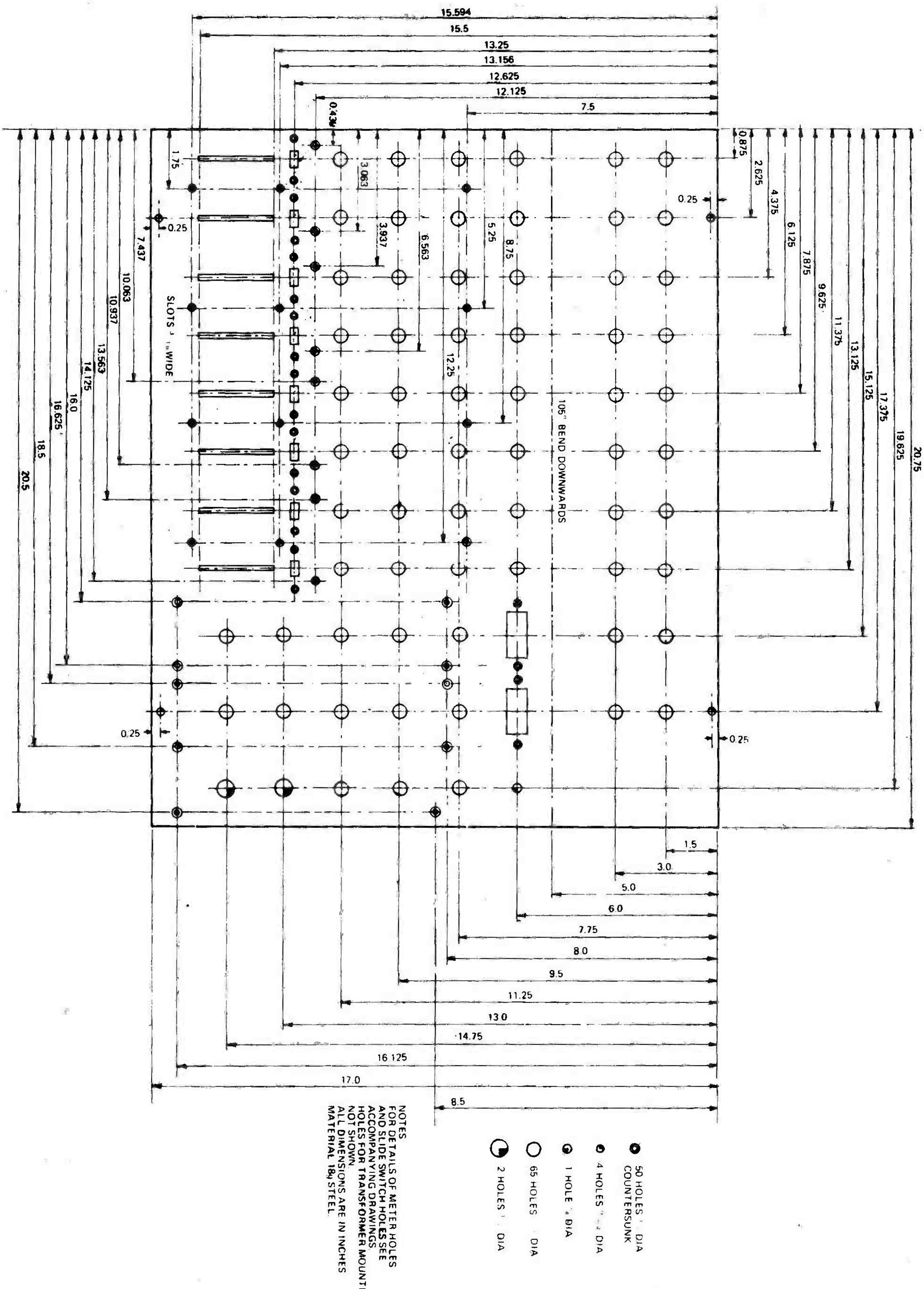


Fig. 11 Drilling details of front panel. The holes for the meters and slide switches should be cut to suit the type used.

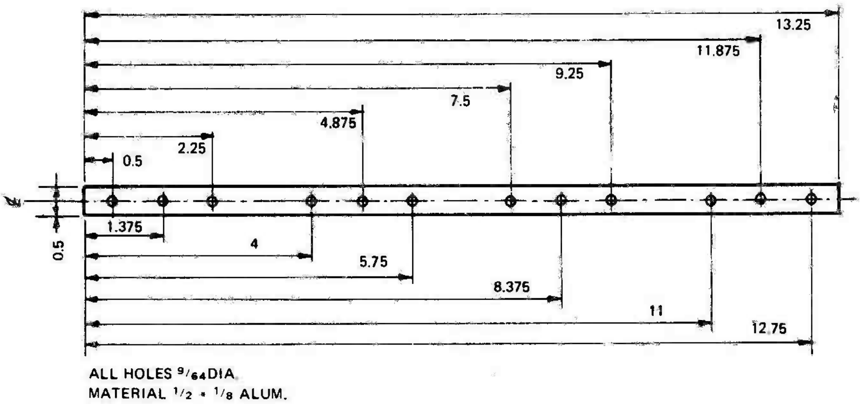


Fig. 13. Slide potentiometer support bars (two required)

HOW IT WORKS

MASTER MIXER POWER SUPPLY

The power supply is of conventional design. Any transformer which will supply 27 to 33 volts at 200mA will suffice. The regulator employs a 2N3055 as a series regulator, and by virtue of the 30V zener diode between the transistor base and the negative rail, maintains the output voltage at approximately 29.5 volts.

At switch-on Vcc rises immediately but the output of the unit is shorted out by relay RL1 for approximately four seconds while C8 charges exponentially via R14. Transistor Q2 is simply an emitter follower driving relay RL1. The voltage at its emitter is approximately 0.5 volts less than that on capacitor C7. After approximately four seconds the voltage across the relay rises sufficiently to activate it, removing the short from the output.

This prevents accidental damage to power amplifiers due to switching transients or other warm-up anomalies.

ECHO MIXER

The echo mixer is straight forward. As indicated earlier there are eight separate inputs. These receive signals from the input channel echo-send controls. The gain of the echo amplifier is controlled by RV1 which varies the negative feedback. The output goes to the echo output socket on the rear panel. From here it is intended to pass through an echo tape, reverberation unit, or similar type of device before returning to the unit and being split equally to provide an input to each main mixer stage.

METERING CIRCUITS

The metering and overload indicator circuits employ a quad-amplifier IC type LM3900 from National Semiconductor. This package accommodates four independent, internally compensated amplifiers which are designed to operate from a single power supply voltage and to provide a large output voltage swing. Each amplifier makes use of a "current mirror" to provide the non-inverting input.

Unlike a normal operational amplifier, the two inputs are current driven, not voltage. This means that when used as an amplifier the output tries to balance the current in the two inputs. Therefore an initial bias is required. This is provided by R15. For the amplifier to be balanced, an equal current must flow in R17. This sets the quiescent output voltage to approx. 15V.

The ac voltage gain is equal to R17/RV2 where RV2 is the preset value of RV2. The meter is driven by R19 and rectified by D5 and D7.

The second stage (IC2/3) is a comparator-monostable. Both inputs of this amplifier are biased from the supply rail although the current is higher into the negative input. Since this is outside the linear region the output is almost at 0V. When in use current is being added and subtracted to the current into the negative input.

If enough current is subtracted, such that it is less than the current into the positive input, the output of the IC will go high. Due to the positive feedback of R25 and C14 the IC will stay in the high state for approximately 0.1sec, even if the initiating signal has ceased. The overload light LED1 is on while either monostable (IC2/3 or IC2/4) is high.

If the output is continuously high the light will flash rapidly.

Two of these amplifiers are employed in each of the metering indicator circuits. A variable resistor in series with the input to the first amplifier allows zero VU to be adjusted for outputs in the range of 100mV to 3V.

If a single transient exceeds a preset level the indicator light will flash for approx 100 ms. This will allow the "transient" to be seen and thus act as a warning. On a continuous overload the light will flash rapidly. With the ETI413 amplifier this level should be approx 1V rms.

stereo output which may be used to drive the main amplifiers for an auditorium, or may be used for recording purposes. We have taped major performances using our own prototype master-mixer and have achieved very pleasing results indeed. Remember however that a system configuration suitable for recording is not necessarily suitable for auditorium use and vice versa.

Basically the unit should be located in the auditorium so that the operator may judge acoustic quality as the audience hears it – and to make appropriate adjustments as necessary.

Most groups nowadays use half acoustic and half electronic instruments. Instruments such as drums may not need 'miking' at all except in a very large auditorium or out-of-doors. Naturally when making recordings, all instruments have to be 'miked'. In such cases four microphones are usually needed adequately to cover the drums and these are best combined in a sub-mixer. Similarly, an electronic organ with Leslie is perhaps best handled by a sub-mixer. All other inputs will of course go direct to the master mixer.

One of the main problems within the group is that of monitoring. Each player of an electronic instrument needs to be able to hear himself and the drummer particularly needs to hear the bass guitar but there is so much noise on stage that this is usually not possible. As each player usually has his own amplifier/speaker for use in practice, these may be used on stage to provide the necessary monitor facilities. To split the instrument output for both monitor amplifier and master mixer a simple plug to twin socket adapter may be used. Another method is to use a separate monitor box, as shown in Fig.15, or monitor outputs may be fitted to the mixer unit itself as explained later.

It is of course posssible to 'mike' the output of monitor speakers but this usually results in loss of fidelity. On the other hand such a procedure, together with deliberate overloading, is often used to provide special effects by distorting the output.

SETTING UP THE MIXER

Before connecting any inputs, set each input channel sensitivity switch to low, volume controls to zero, tone controls to centre position.

Switch on, connect the instruments one at a time and perform the following adjustments. Adjust both master-volume and channel volume to position 7 and then switch channel sensitivity for maximum desired level at these settings.

Then adjust the tone controls for the nicest sound for each instrument – without destroying its natural sound. Bear in mind that to increase the response in mid-range it is necessary to turn down bass and treble and turn up the volume.

If echo is to be used, connect the 'Echo Send' input and output to an echo unit, or alternatively, to a suitable reverberation unit. The echo effect may be increased or decreased by using the echo-send control.

Audibly position each member of the group left or right, by adjusting his channel balance control. Note that a balance control at centre will make the instrument appear audibly centred as well. These controls may need some readjustment when the full group is playing. The master balance control is then adjusted to achieve overall uniformity.

The equalizers may now be used to obtain a level overall frequency response by subjective listening and appropriate adjustments. Note that a five-section equalizer **cannot** correct major defects in auditorium acoustics, but can compensate for minor problems and for poor quality speakers.

As said before, the unit may be used for recording on stereo tape or disc and this is done by taking direct line outputs from the mixer to the recording equipment. Again, as said before, all instruments need to be 'miked'. Remember that the quality of the acoustics, particularly when recording, is affected very much by the choice of microphone. Most dynamic microphones drop off at the high end and we suggest that, providing sufficient funds are available, a good Electret microphone be used. It is essential that microphones should be as directional as possible to avoid problems with acoustic-feedback.

MODIFYING THE SYSTEM

Innumerable individual variations may be required – a few of those most commonly requested are dealt with here.

Some of these modifications can be performed without changing the basic wood and metal-work, others cannot. Because of the variety of combinations that may be used, details of wood and metal-work must be left to the individual constructor.

These modifications are therefore of necessity presented in a general way and should only be undertaken after careful consideration of exactly what is needed, and only if what needs to be done is fully understood. We regret that we cannot assist in individual design requirements, however do tell us about your requirements and problems, and, if sufficient people ask for the same thing, we may be able to publish details of a modification at some later date.

Before dealing with specific modifications we will expand on the general theory previously given so that limitations may be more readily understood.

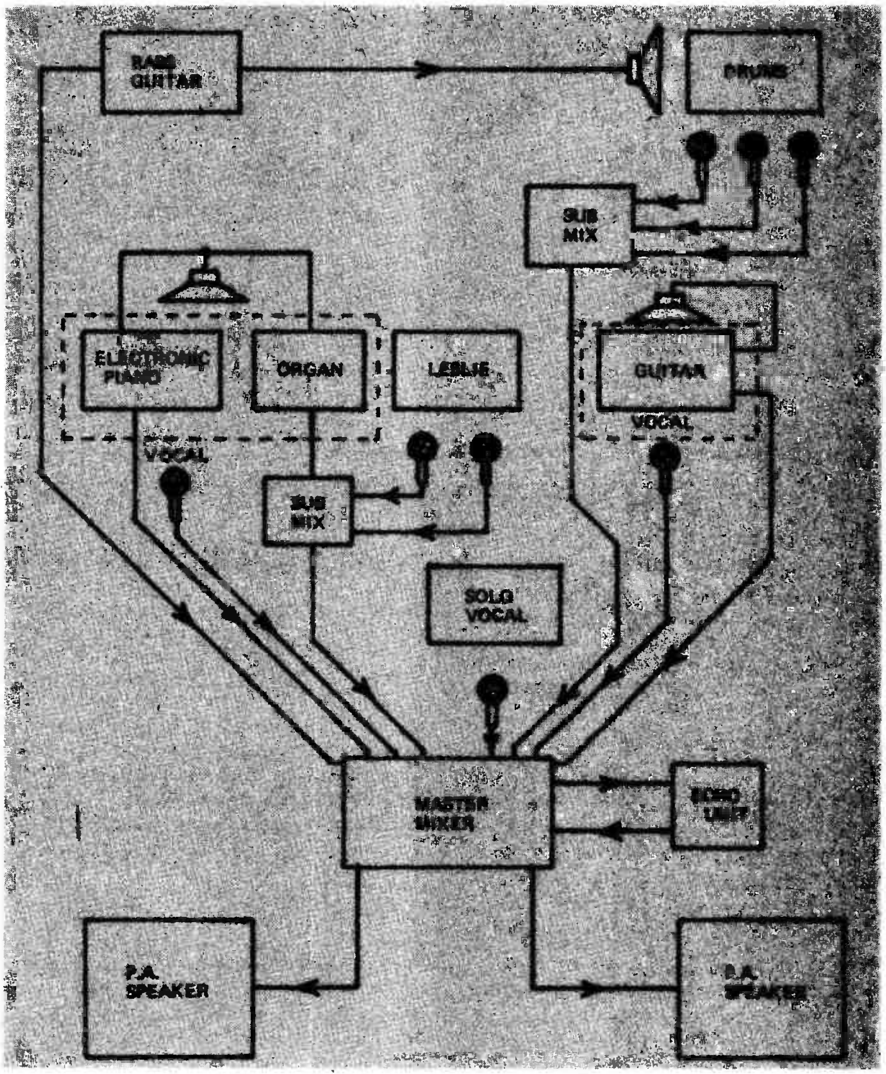


Fig.14. Arrangement for average-sized group.

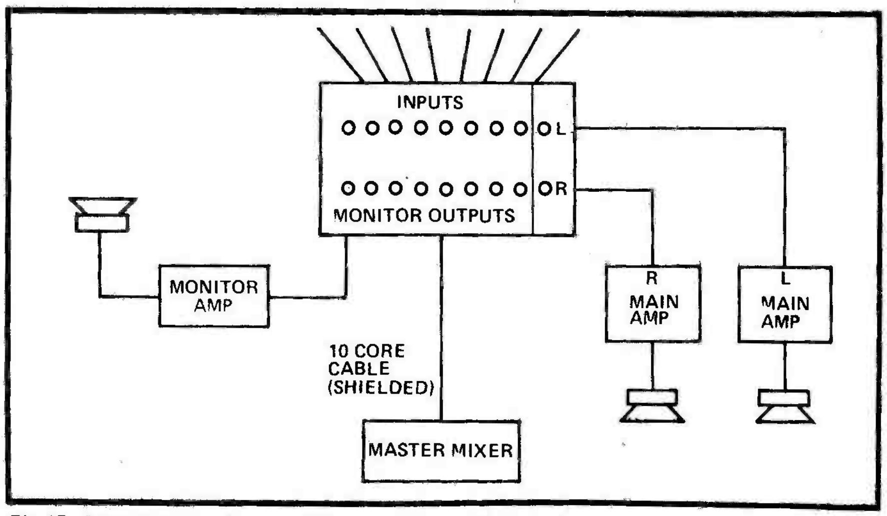


Fig.15. A separate monitor amplifier may be used if desired.

PREAMPLIFIERS

We see that input amp IC1 has three selectable gains the maximum gain being 500. This means that a one millivolt signal will become 500 millivolts at the output. A higher gain may be obtained by reducing the value of R4/R6 but to maintain input impedance R1/R2 will have to be increased.

MASTER MIXER

The tone control stage is a standard feedback-type providing a maximum boost of 15 dB which corresponds to a voltage gain of approximately 6. The maximum output voltage of IC2 is 6 volts RMS and the maximum output of the preamplifier must therefore not exceed 1V RMS if clipping under maximum boost conditions is to be avoided. In addition an overload margin of 20 dB should be allowed, and this implies a maximum nominal output of only 100 mV from the preamplifier.

MIXER AND EQUALIZERS

The mixer is simply a summing amplifier, the output voltage being the vector sum of the input voltages multiplied by the resistance of RV2 divided by 100,000. The maximum gain, one channel only driven, is 3 1/3 and although the individual gain remains constant the power level is greater with all channels driven. Overall gain is controlled by RV1, the master volume control.

Each section of the equalizer is a series LCR filter whose sharpness is determined by the circuit Q and with the coils given, the reactance at resonance is approximately 700 ohms. If more than five sections are required the filter must be made sharper and hence the reactance of the capacitor and inductor must be increased. Note however that phase shift problems limit the number of sections to seven in this type of circuit.

POWER SUPPLY

The current consumption is approximately 10 mA per channel and the power supply has adequate reserve for up to 20 channels, however if more than 10 channels are used a heatsink of about four square inches should be added to Q1.

If meter and overload indicators are required for each channel then a printed circuit board with this section only wired up should be made for each channel. If each channel is required to have a separate LED overload indicator, separate R27 and R28 and use each resistor to drive an LED.

CHANGING THE NUMBER OF CHANNELS

If less channels are required it is simply a matter of deleting the appropriate number of preamplifier/tone control boards and fitting blank panels to the cabinet in their place.

If more channels are required, the existing metalwork and woodwork will have to be extended to accommodate the extra preamplifiers.

One 100k resistor must be added to the main mixer summing network for each additional channel. These may be mounted by glueing them to the existing resistors with epoxy cement and making flying lead connections. Alternatively a small sub-board may be constructed for them.

In an exactly similar manner the echo mixer may be modified to accommodate the required extra channels. Extra input sockets must also be provided and the appropriate interwiring carried out.

SUB-MIXERS

As discussed earlier, sub-mixers may be required to implement a complete system. A simple sub-mixer may be constructed using the circuit shown in Fig.16. This circuit is quite simple, is based on the echo mixer, and may be built on veroboard. Alternatively the echo-mixer PC board could possibly be adapted fairly readily.

As the instruments associated with each sub-mixer are usually grouped left-and-right, splitting may be performed after the sub-mixer as shown in Fig.16. If balance is required before mixing it will be necessary to use two sub-mixers controlled by a ganged potentiometer, and to use balance circuitry similar to that in the circuit on page 43.

The outputs of the sub-mixers are taken to the normal inputs of the main mixer.

MONITOR OUTPUTS

The need for monitoring has been explained previously, and if only one monitor channel is required, and echo is not required, the echo channel may be used to provide a monitor output. However two or more monitor outputs are often required and they may need to each have an equalizer for the elimination of microphone feedback. This may be achieved by wiring additional potentiometers in parallel with the echo potentiometers as monitor level controls. The output from these potentiometers may then be fed directly or via additional equalizer/main-mixer boards to the monitor amplifiers. A balance control is not required on monitor, hence R21 and RV7 (page 43) may be omitted and the output taken from terminal 19. Again, if equalization is not required, a mixer similar to that of Fig.16 may be used.

CUEING OUTPUTS

When recording it is sometimes necessary to suppress the main output of the mixer while still monitoring the final mixed sound.

This may be done quite simply by taking an output from the junction of R20 and C8 (page 43) of the final mixer to a cue-monitor outlet, and using a good-quality key switch to short terminal 19 to ground.

This allows monitoring of equalizer output whilst inhibiting output to the main amplifier.

That completes our project. We trust that this versatile unit helps you become a good mixer! ●

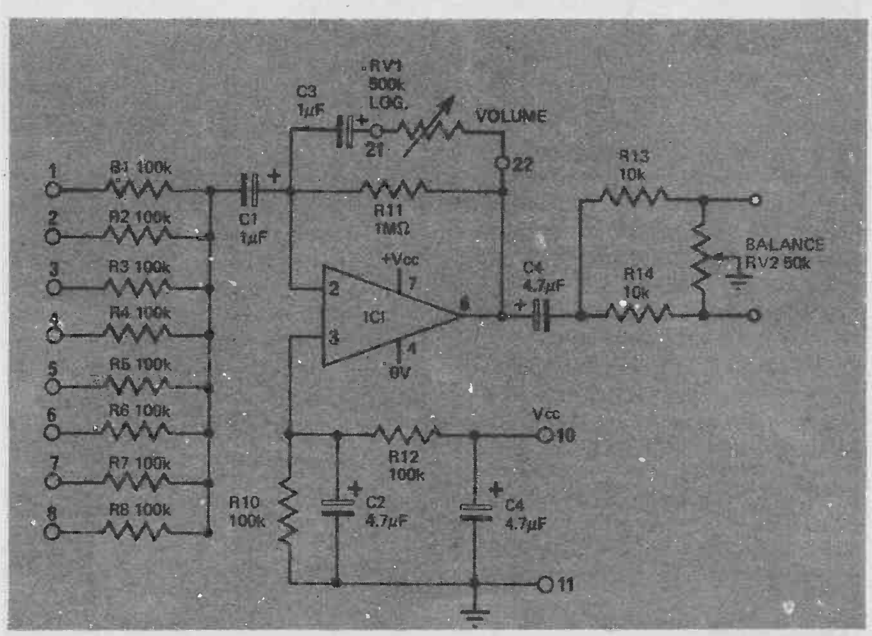
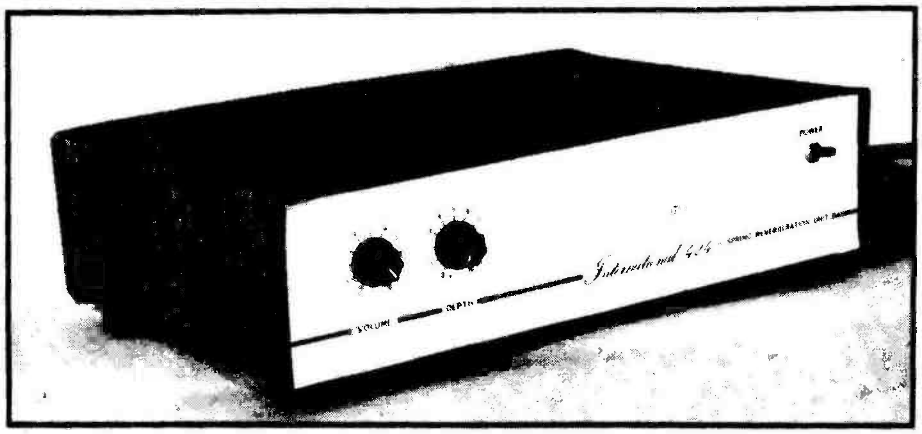


Fig.16. Simple sub-mixer.

SPRING REVERBERATION UNIT



Built-in mixing facilities and stereo operation are provided in this versatile unit.

THE SOUND of many musical instruments may be "enhanced" by the addition of reverberation. Particular examples of instruments, to which reverberation is commonly applied, are the electronic organ and the guitar.

Reverberation is defined as the persistance of sound within an enclosure after the original sound has ceased. It may also be defined as a series of multiple echoes, decreasing in intensity, so closely spaced in time as to merge into a single continuous sound eventually dying away to nothing.

Reverberation, added with discretion, gives life and brilliance to the music from individual instruments which otherwise appear dull and flat. It is less commonly known that, when reproducing recorded material, the addition of reverberation can considerably enhance the liveliness of the material and its apparent spatial depth.

SPECIFICATION

INPUT VOLTAGE	
Maximum	1 volt
Range	100 mV – 1 volt
FREQUENCY RESPONSE	
Direct	–3 dB at 20 Hz, 50 kHz
Delayed	50 Hz – 4 kHz
IMPEDANCE	
Input	approx. 47 k
Output	< 5 k
CROSS TALK	
With 10 k source impedance	– 40 dB
GAIN	
Maximum	unity
SIGNAL TO NOISE RATIO	
Direct	> –60 dB ref 1V
Reverberation	> –60 dB ref 1V

Artificial reverberation can be achieved in several ways. One system employs echo chambers to achieve the delay. A second system employs magnetic tape-loop techniques, whilst a third, the one used in this project, uses an amplifier that drives springs to provide the delay. It is also possible to achieve delay by fully electronic means but, for normal instrumental or home use, the circuitry is prohibitively complex and expensive.

The unit described is based on a sensitive reverberation spring assembly and is suitable for incorporation into existing amplifier instrumental setups, or for adding reverberation to the reproduction from stereo Hi-Fi systems.

This unit has the required mixing facilities built-in, the proportion of echo to original signal being adjustable by a control called DEPTH. In addition, we decided to make the unit capable of adding reverberation to stereo systems. This involves very few extra components since both channels are mixed into the reverb spring and the combined echo then separately mixed with the original left and right channels. This extra expense is only that of an extra transistor stage and is well justified, even if the unit is mainly intended for monophonic work.

As the unit is completely functional within itself, and fitted into a strong but attractive metal cabinet it will be equally suitable for use by professionals or high-fidelity audio enthusiasts.

CONSTRUCTION

We housed our unit in a simple pan-shaped chassis with metal cover.

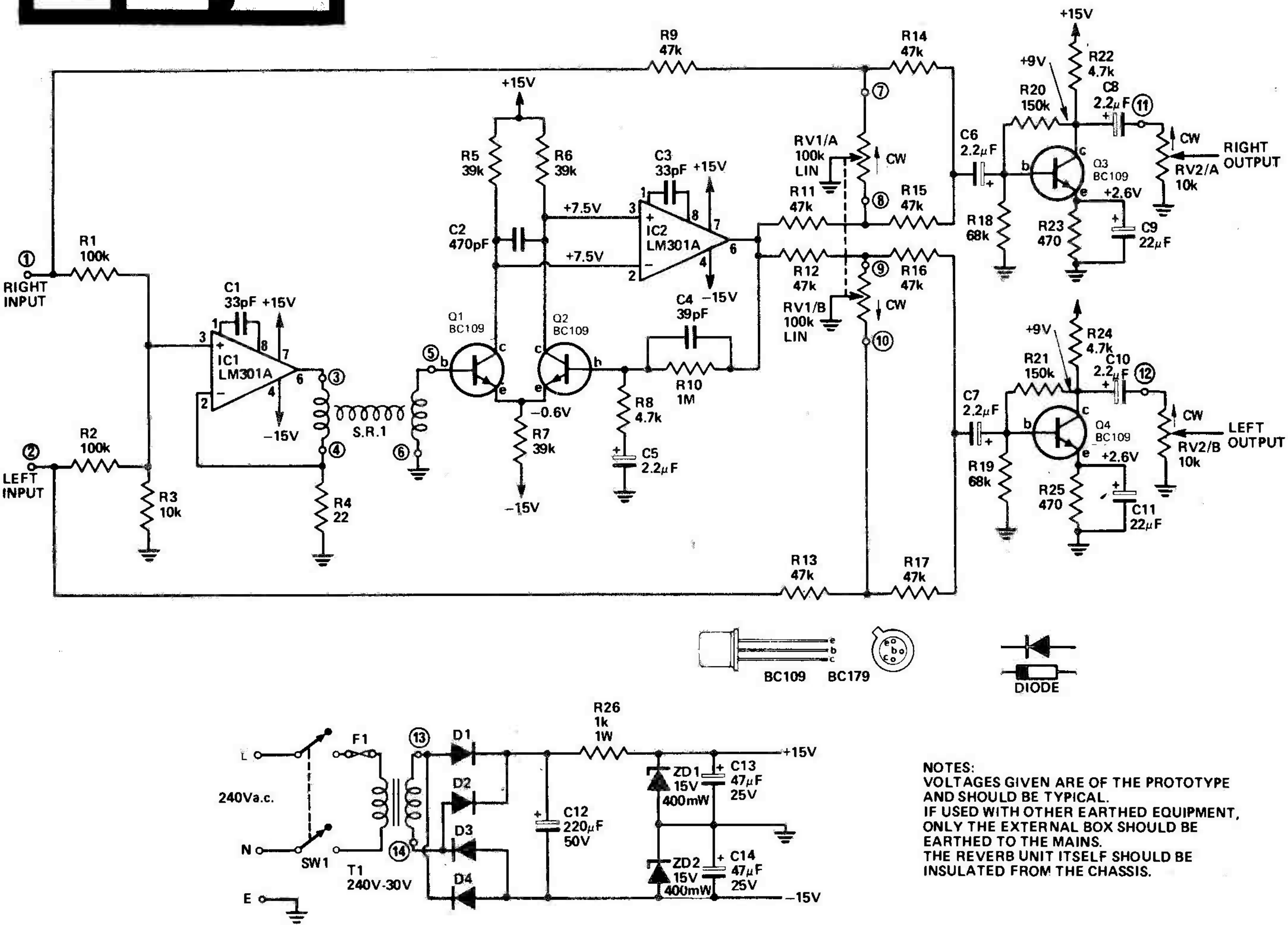


Fig. 1. Circuit diagram of the spring reverberation unit.

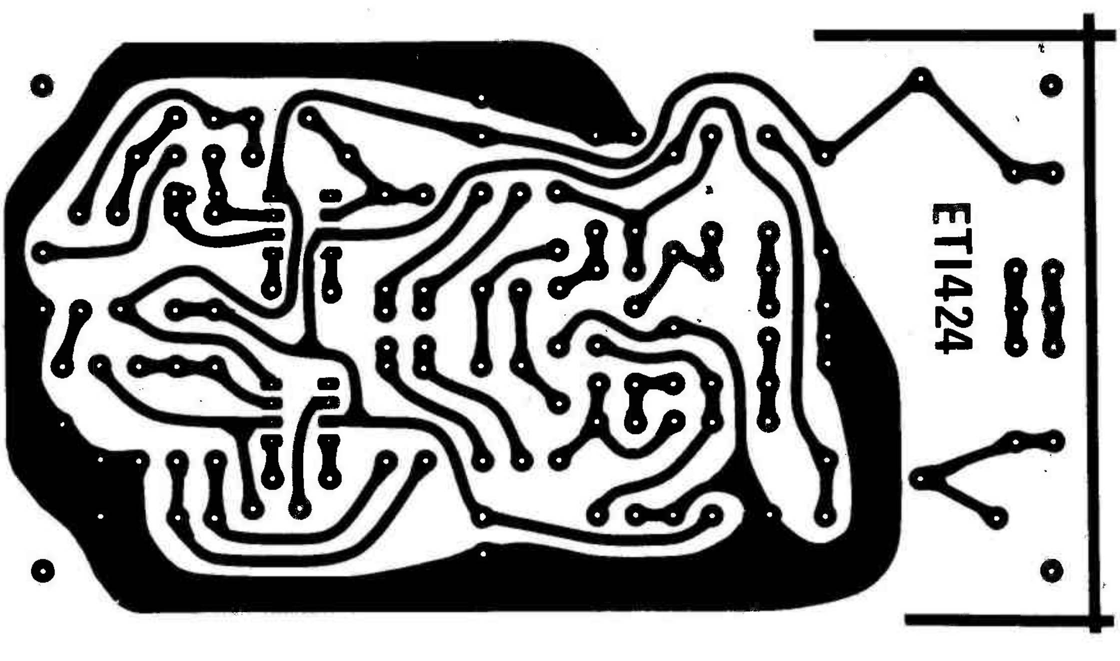


Fig. 2. Full size printed circuit board layout.

SPRING REVERBERATION UNIT

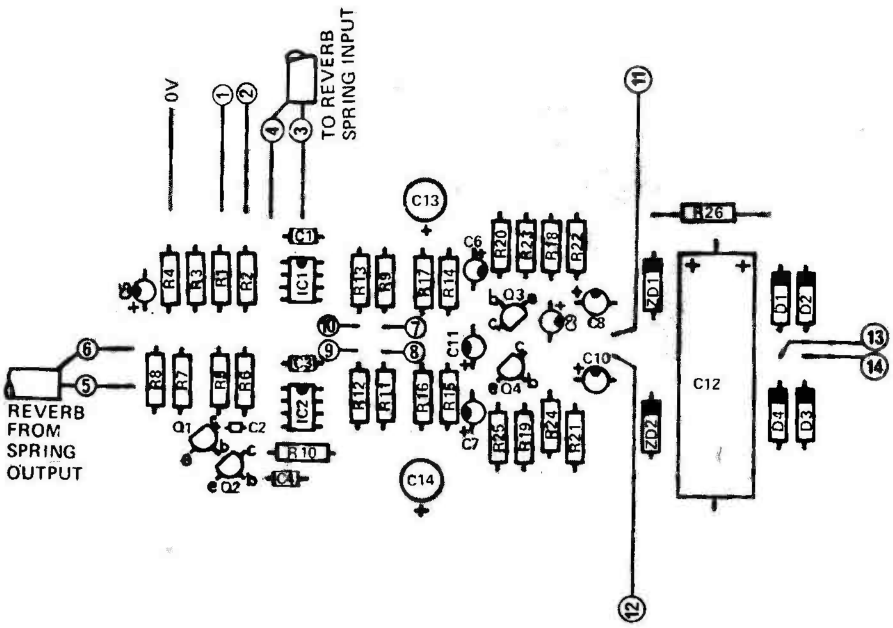


Fig. 3. Component overlay.

This enables the unit to be used as a flexible system component, but, if desired, the electronics may easily be incorporated within an existing system-box if room permits.

The majority of the components are mounted upon one single printed-circuit board, although matrix or veroboard can quite easily be used if preferred.

Whichever constructional method is used, it is essential to check polarized components, for correct orientation, before soldering.

HOW IT WORKS

The reverberation spring is an electro-mechanical device for delaying and producing echo on audio signals – it operates in the following manner. A relay-like transducer vibrates one end of a spring in response to an input audio signal. The spring continues to vibrate after the excitation has been removed and thereby produces a decaying 'echo' as well as delaying the propagation of the signal to the transducer at the other end.

The mechanical system naturally has many resonances and the frequency response therefore cannot be flat over a small frequency range, but is substantially flat over the broad frequency range of 50 Hz to 4 kHz.

Integrated circuit IC1 is connected so as to provide current drive to the input transducer of the spring. The transducer is inductive and hence, the voltage across it will increase with frequency. However, since the current remains constant, the power in the transducer also remains constant. The stereo input is summed into R3 by resistors R1 and R2 (with a loss of 20 dB) to provide a composite signal at pin 3 of IC1. As the amplifier always tries to keep pin 2 at the same potential as pin 3, the voltage across R4, and the current through it, is therefore proportional to the input voltage. As very little current flows into pin 2 of the IC, all this current flows through the transducer.

The output signal from the transducer at the other end of the spring is very small (about –50dB referred to the input and is therefore amplified back to a reasonable level by Q1, Q2 and IC2. Transistors Q1 and Q2 are low noise types and are arranged as a differential pair to add gain before the inherently noisy IC. The gain is set by (R10+R8)/R8 to about 46 dB. The low frequency cutoff is set by C5 and R8, and the high frequency cutoff by R10 and C4. Note that these last figures refer only to the receiving transducer amplifier and not to the whole system.

The direct inputs, left and right, are now both mixed with the common reverberation signal in mixers Q3 (right) and Q4 (left). The proportion of direct and reverberation signals is adjustable by means of depth control RV1. The gain of the output stage is set by R20, R21 and the bias by R18, 19, the overall gain of the complete system being approximately unity.

If single channel operation only is required, simply delete the second mixer transistor and its associated components. If reverberation only, without the mixing facility, is required the output may be taken direct from pin 6 of IC2.

In the event that a volume control is not required resistors may be fitted to the board (holes provided on board) to set the volume to any desired level. These resistors may have any value between 10 k and 1M.

ETI 424 PARTS LIST

R4	Resistor	22	½W	5%
R23,25	"	470	"	"
R26	"	1 k	1W	"
R8,22,24	"	4.7 k	½W	"
R3,	"	10 k	"	"
R5,6,7	"	39 k	"	"
R9,11,12,13	"	47 k	"	"
R14,15,16,17	"	47 k	"	"
R18,19	"	68 k	"	"
R1,2,	"	100 k	"	"
R20,21	"	150 k	"	"
R10	"	1 M	"	"

RV1	Potentiometer	100k dual lin rotary
RV2	"	10 k dual log rotary

C1,3	capacitor	33pF ceramic
C4	"	39pF ceramic
C2	"	470pF ceramic
C5,6,7,8,10	"	2.2μF 10V electrolytic
C9,11	"	22μF 10V electrolytic
C12	"	220μF 50V electrolytic
C13,14	"	47μF 25V electrolytic

Note: all electolytics except C12 are pc mounting.

D1-D4 diodes 1N4001 or equivalent
ZD1-ZD202 Zener diodes BZX 79 C15 or any 15V 400mW type

Q1-Q4 transistor BC109 or equivalent
IC1,2 operational amplifier LM301A
PC board ETI 424
SW1 switch 2 pole on-off 240V rated
F1 fuse and fuse holder 500 ma chassis mounting
Spring reverb unit

T1 transformer 250V/30V 500mA

3 core flex and plug
2-way phono sockets – 2 off
12mm long spacers 4 off
chassis to Fig. 7
metal cover to Fig. 8
front panel to Fig. 6
rubber grommet for power cord and insulating reverb unit.
Insulated phono socket for reverb.

The unit should be wired, as shown in Fig. 1, taking care to keep all 240 volt ac wiring well clear of the electronics and especially clear of the receive end of the reverberation spring. The metal case itself should be earthed even though the electronics itself is not earthed.

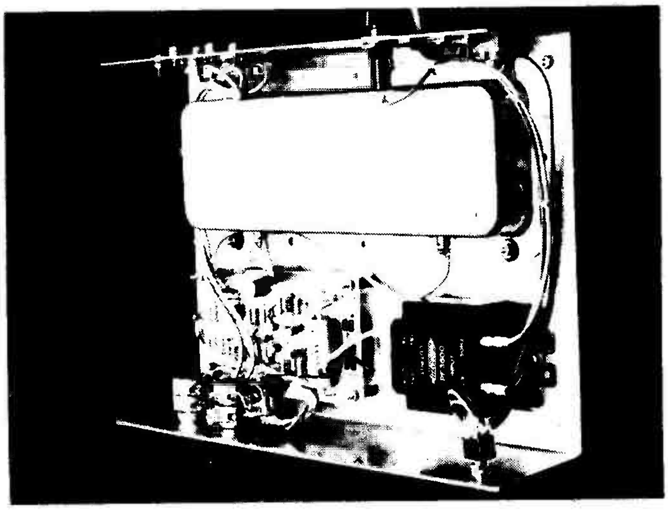


Fig. 4. Method of mounting the hardware and printed circuit board into the chassis is illustrated in this internal view.

SETTING UP

As the reverberation spring is a mechanical device, vibration will produce unwanted outputs. Hence it is an inherently noisy device and should be used at a point in the system where the signal level is high.

Two typical points at which the unit may be inserted in the system are:–

1. Between the preamplifier and the main amplifier.
2. After the disc preamplifier, or high level input and the preamplifier.

If inserted between pre and main-amplifiers, i.e. after the volume control, turn the reverb volume control to maximum and adjust the preamplifier volume control such that the main amplifier is just below clipping level. The reverb volume control can then be used to set the level required.

If the reverberation unit is inserted before the system volume control, the volume control on the reverberation unit should be set to maximum (or deleted altogether if desired) and the preamplifier volume control used to set the required level. ●

SPRING LINE: a sensitive spring line unit is needed – the LM301A cannot drive the common 16Ω type. An input impedance of 150Ω or more is required. Elvins Electronic Musical Instruments of 40 Dalston Lane, Hackney, London E8, have an 150Ω unit, the E150, selling at £10.68 inclusive of VAT, P & P.

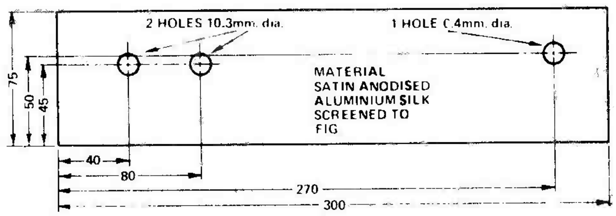
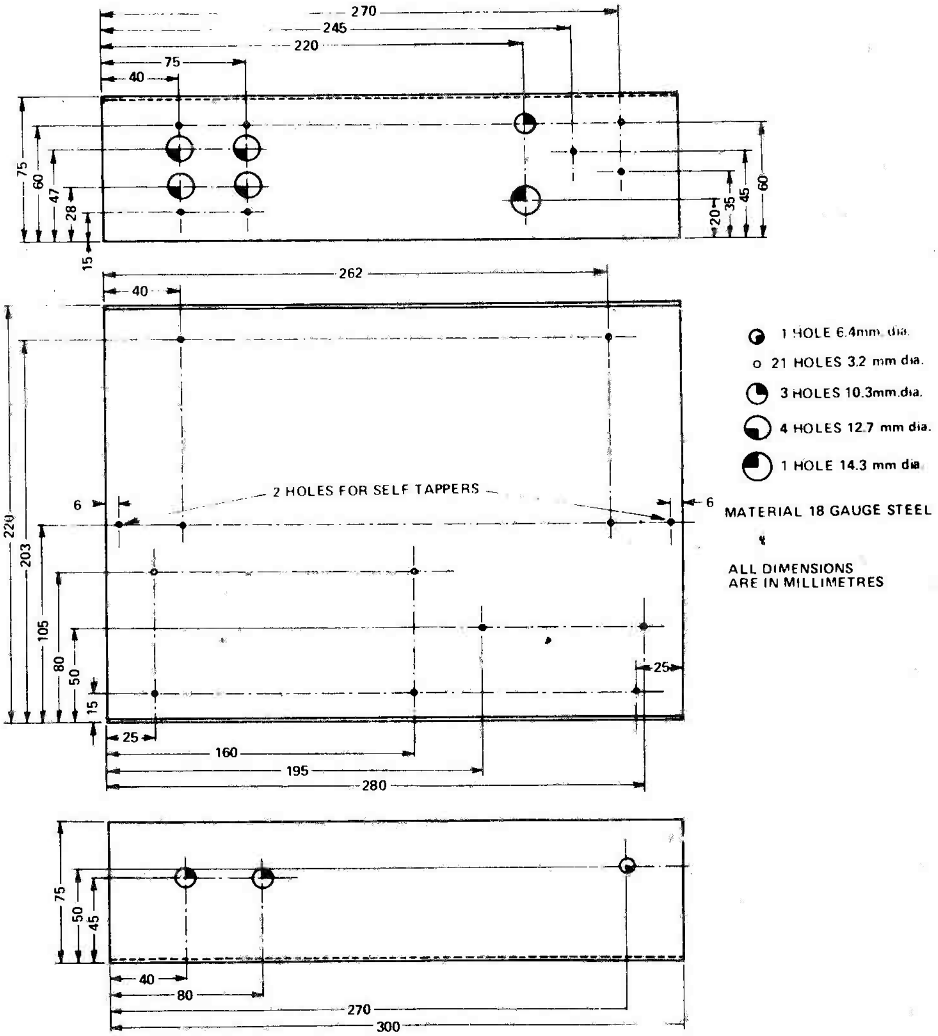


Fig. 5 Front panel drilling details.



Dimensions and drilling details of the chassis.

TOP PROJECTS No.3

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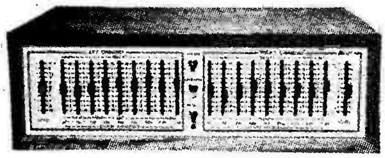
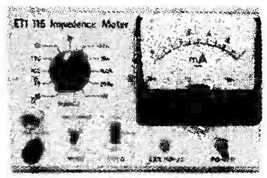
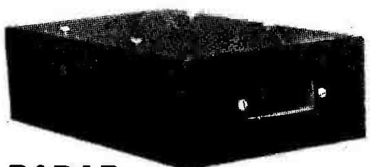


GRAPHIC EQUALISER



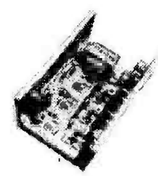
IMPEDANCE METER

BIKE SPEEDO

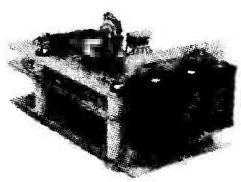


RADAR
INTRUDER ALARM

INTERNATIONAL 25



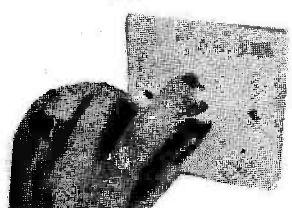
COLOUR ORGAN



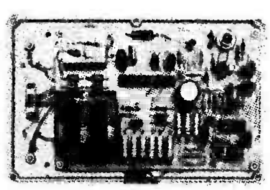
DIGITAL VOLTMETER

STEREO FM TUNER

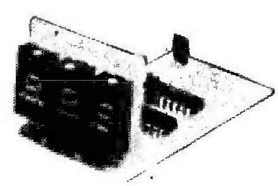
LINE AMPLIFIER



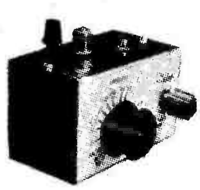
LIGHT DIMMER



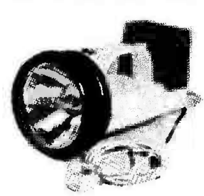
ELECTRONIC IGNITION



DIGITAL DISPLAY



AF METER



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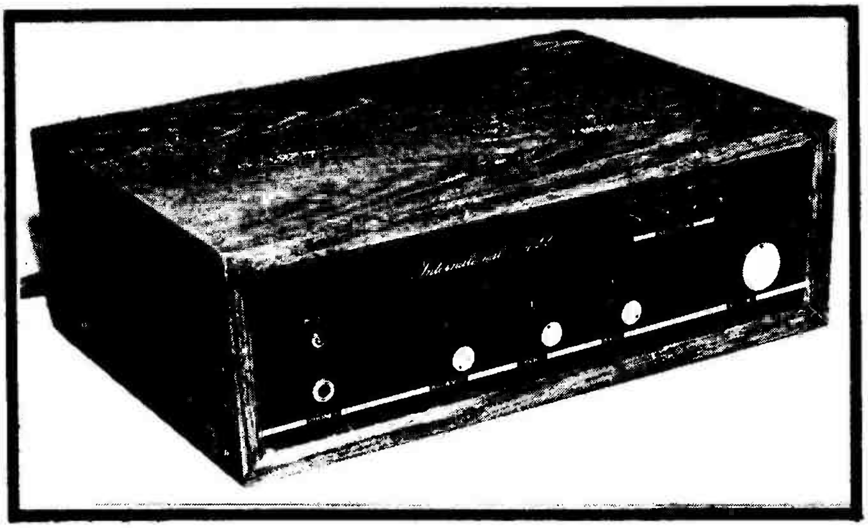
INTERNATIONAL 422 STEREO AMPLIFIER



SINCE publication of our 100 watt guitar amplifier, several thousand have been built and a surprisingly large quantity of these have been for home stereo use. People have used two of these together with a separate preamplifier for stereo, and would you believe it we know of a few people using four in a quadraphonic system!

This is not as way out as it sounds for many present-day speakers sacrifice efficiency to gain quality. Many high quality speakers need at least 50 watts ('rms') to drive them satisfactorily.

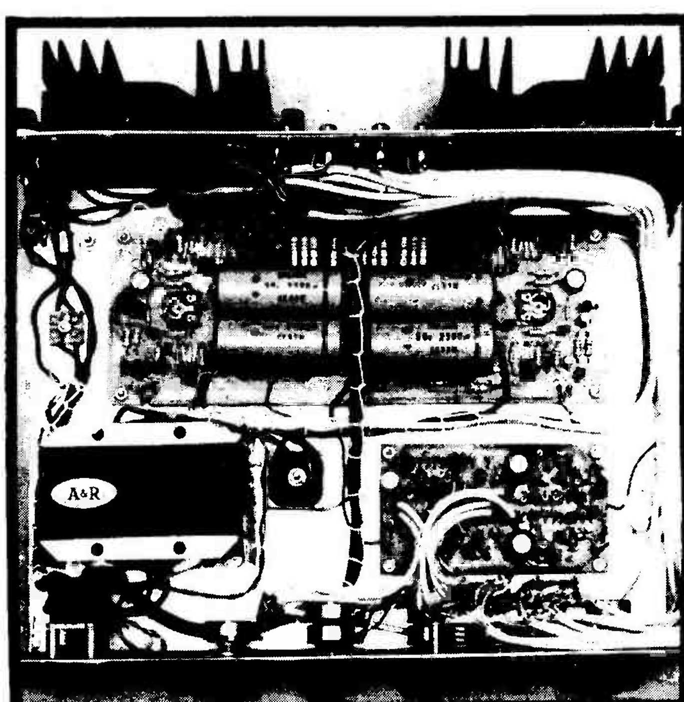
There is an obvious *need* for a high powered amplifier, and in response to many pleas, we have designed an inexpensive amplifier that will deliver a genuine 50 watts rms per channel, both channels driven, into 8 ohms.

Since most modern speakers are 8 ohms impedance, we have not designed the amplifier for 4 ohm operation. Such an amplifier would require a much larger transformer and would be considerably more expensive, so we have decided to

MEASURED PERFORMANCE OF PROTOTYPE UNIT

POWER OUTPUT			
Both channels driven $8\Omega + 8\Omega$ loads	50W rms		
FREQUENCY RESPONSE			
20Hz-20kHz	±0.5dB		
CHANNEL SEPARATION			
At rated output and 1kHz	45dB		
HUM AND NOISE			
With respect to rated output			
Tape, Tuner and Aux, inputs	−78dB		
Disc input (re 10mV)	−67dB		
INPUT SENSITIVITIES (for rated output)			
Tape, Tuner and Aux. inputs	210mV into 47k		
Disc at 1kHz	2.1mV into 47k		
Main amplifier	500mV into 10k		
TOTAL HARMONIC DISTORTION			
	100Hz	1kHz	6.3kHz
1W output	0.14%	0.11%	0.12%
5W output	0.17%	0.13%	0.15%
10W output	0.16%	0.11%	0.13%
50W output	0.27%	0.38%	0.60%
TONE CONTROLS			
Bass	±13dB at 50Hz		
Treble	±13dB at 10kHz		
DAMPING FACTOR	>70		

Internal view of the completed amplifier.



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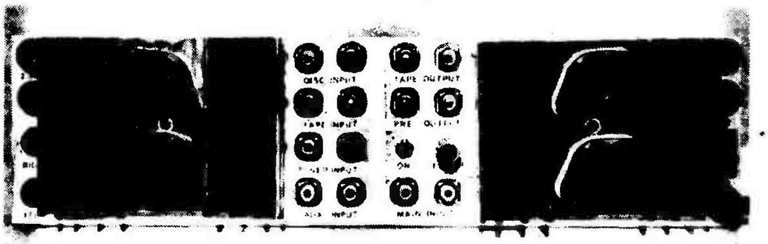


View of the rear panel of the amplifier.

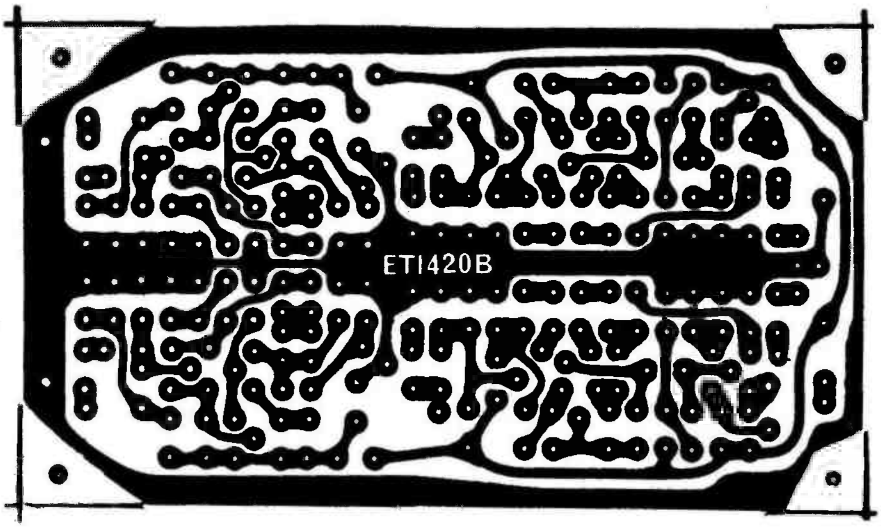
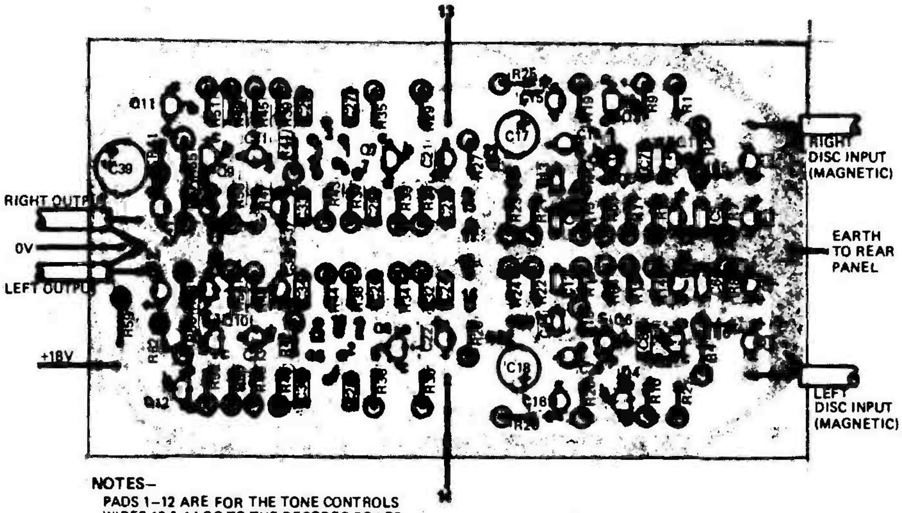


Fig.2. Printed circuit board pattern for the preamplifier.



NOTES–
PADS 1–12 ARE FOR THE TONE CONTROLS
WIRES 13 & 14 GO TO THE DECODER BOARD
PADS 19 & 20 ARE THE MAG. AMP. OUTPUT
PADS 21 & 22 ARE THE SHIELD OF 19 & 20
PADS 15 & 16 ARE ARE THE PREAMP. INPUTS
PADS 17 & 18 ARE THE SHIELD OF 15 & 16

Fig.3. Component overlay for the preamplifier.

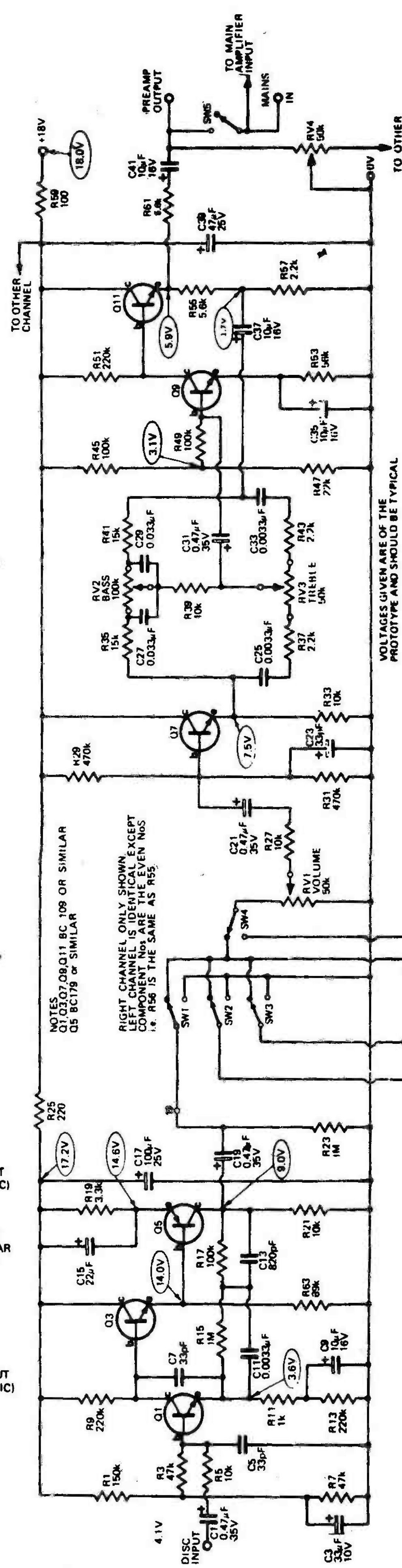


Fig.1. Circuit diagram of the preamplifier (one channel only shown).

satisfy the many, rather than the few.

As well as being designed to provide high power at low cost, the amplifier has been kept simple from the constructional point of view. It uses the preamplifier from our ETI420 four-channel amplifier with only a few minor changes. Tape-in, tape-out and main amp in/preamp-out facilities have been provided. Tape monitoring may be achieved by pressing, simultaneously, the tape button as well as that for the desired input.

A new main amplifier board is used. This carries the components for both main amplifiers (apart from those mounted on the heatsinks) and the power supply components. All components are mounted on a simple pan-type chassis which slides into the same wooden case as was used for the four channel amplifier.

CONSTRUCTION

The construction has been kept as simple as possible so that a person with only average electronics experience should have no problems in building the amplifier.

The printed circuit boards carry the majority of the components apart from hardware items such as switches, potentiometers and the transformer etc.

The boards should be assembled with reference to their component overlays making sure that all components are in the correct position and that they are orientated correctly.

It is preferable that pins be used to connect all external wiring to the main amplifier board, as this will considerably facilitate wiring up the board at a later stage.

The components should be assembled onto the heatsinks with the aid of Fig. 7 and Fig. 8. Note that a mica washer should be used on both sides of the heatsink for each of the 2N3055's so that the BD139-140 transistors may also be insulated from the heatsink.

The 2N2219 transistor, Q13, should be glued into the heatsink in the position shown in Fig. 7 and the wires which connect to the flying leads of the transistors should also be secured to the heatsink with glue. The new quick-dry epoxies are ideal for this application.

The chassis hardware should be assembled in the following order:—

1. Fit all the phono sockets (tape in, tape out etc), the two-pin DIN sockets for the speaker outlets and the power outlet socket.

2. Fit the rear panel escutcheon using the fuse holders, the main-preamplifier connect toggle switch, the earth terminal and the 3-core flex and grommet, to secure it to the rear panel.

3. The heatsinks can now be fitted by passing the wiring through the rear panel holes (which should be fitted with grommets) and securing them using 12 mm long ¼" screws. The screws will screw directly into the

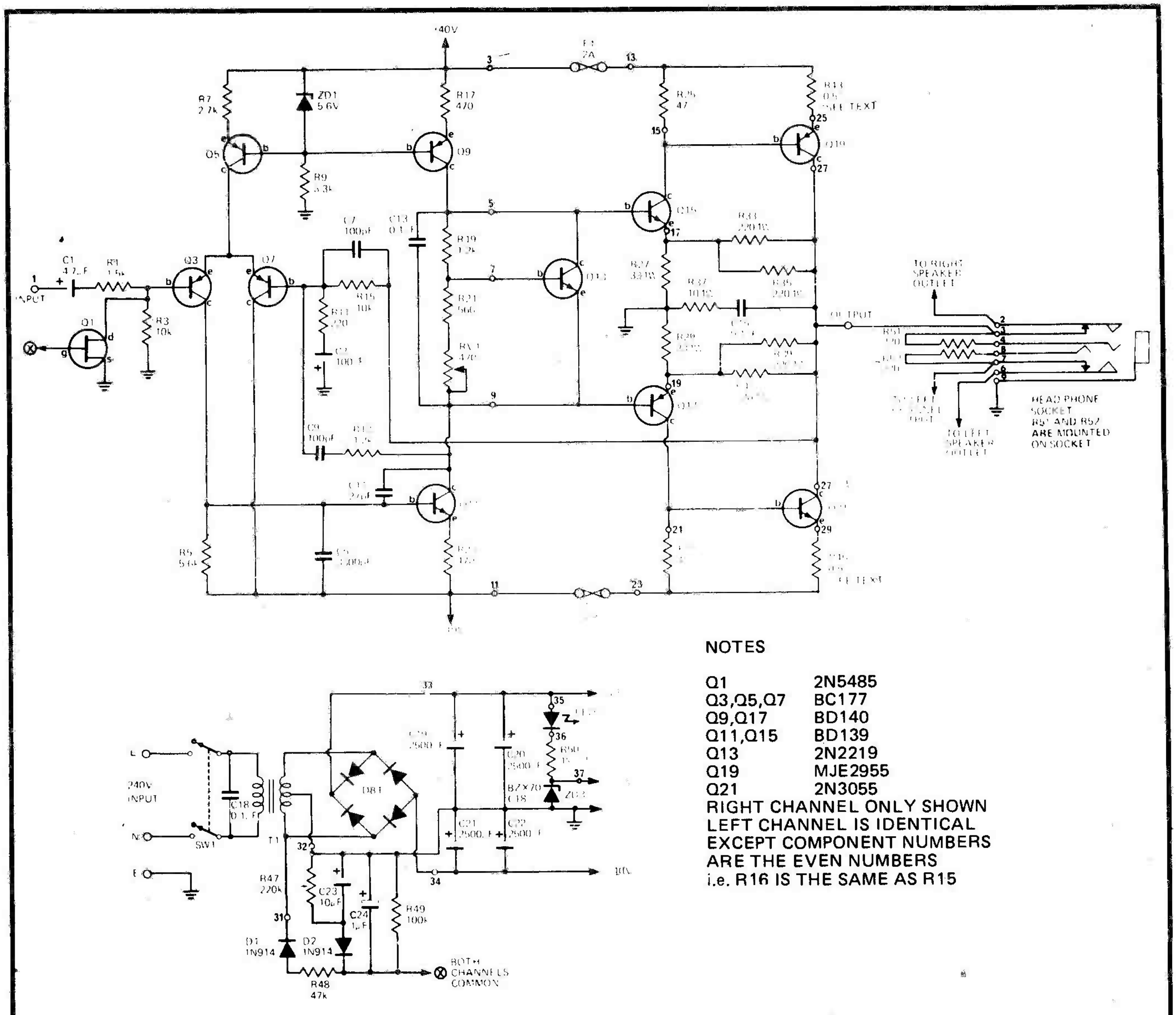


Fig. 4. Circuit diagram of the main amplifier (one channel only) and the power supply.

INTERNATIONAL 422 STEREO AMPLIFIER

heatsink-fin spacing which is designed for such a mounting technique.

4. Fit a cable clamp to the 3-core power flex and terminate the cable into a two way terminal block and a separate earth screw.

5. The power switch and the selector switch should now be mounted using 12.7 mm spacers.

6. The front panel can now be mounted. It is secured by the potentiometers, LED and the phone socket.

7. Mount the preamplifier board after connecting coax. or hookup wire where applicable. The board should be supported on 6 mm spacers.

8. Mount the power amplifier board, also on 6 mm spacers, the power transformer and the bridge rectifier.

9. The interconnection wiring should now be carried out with the aid of the schematic wiring diagrams. Note that the earth lugs of the phono sockets for right channel PRE-OUT and MAIN-IN should be linked, and so should those for the left channel. There is no link between left and right and all other sockets have independent earths.

10. All exposed 240 volt wiring should be taped up to provide safety against personal contact. The capacitor C18 should be mounted on the power outlet socket and similarly taped up.

SETTING UP

The only setting up required is the adjustment of bias current in the output stage. For this a milliammeter having a 100 mA range is required.

Rotate trim potentiometer wipers such that they are closest to the front. This adjusts bias current to its lowest value.

Remove both fuses from the right hand channel and the top fuse of the left hand channel. Connect the milliammeter across the left channel fuseholder from which the fuse has been removed.

If a variac is available wind the ac line supply up slowly whilst monitoring the bias current. If a variac is not available the amplifier will have to be switched on, if there is any gross fault the remaining fuse will blow but no other damage should result.

The bias current should be adjusted to about 25 mA. If it is adjustable, but too high, increase the value of R21 to 820 ohms. If it is adjustable but too low, decrease the value of R21 to 330 ohms.

If it is not adjustable *at all* check for errors in the layout or wiring. In a normal amplifier the range of bias

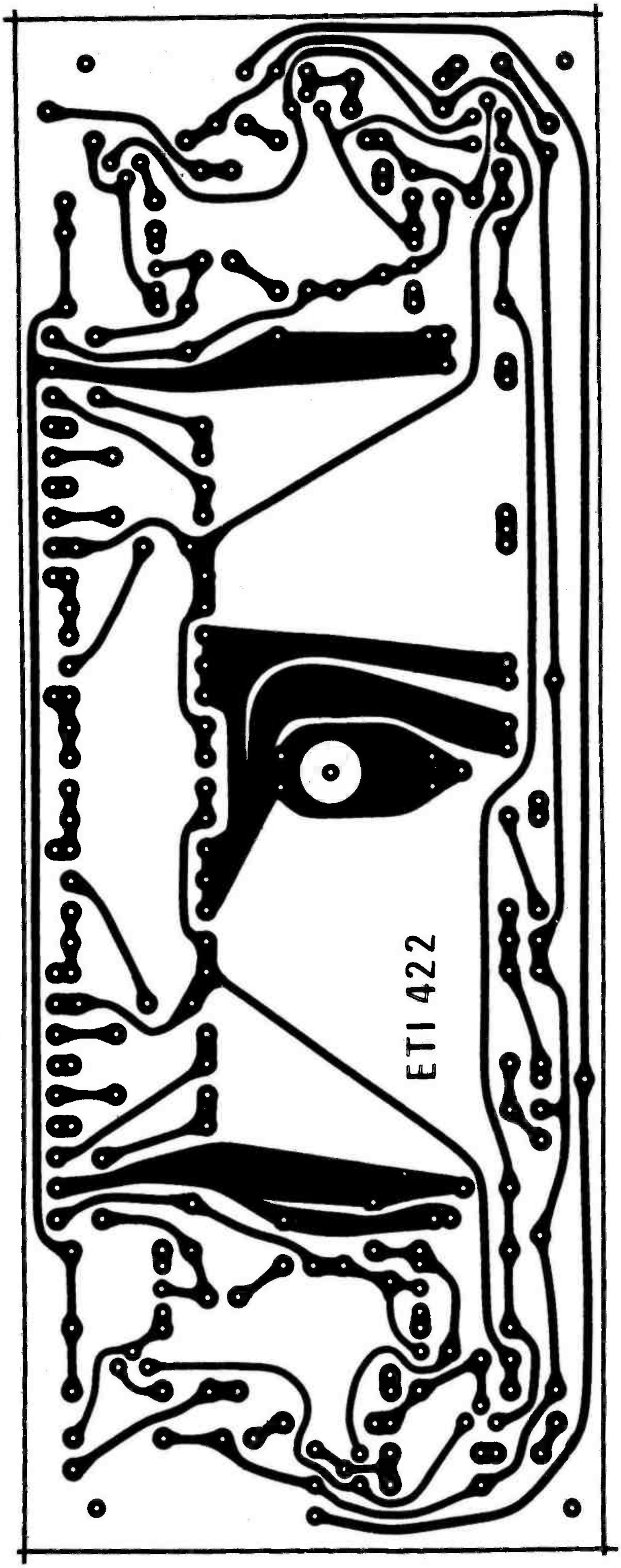


Fig. 5. Printed circuit board pattern for the main amplifier and power supply (full size).

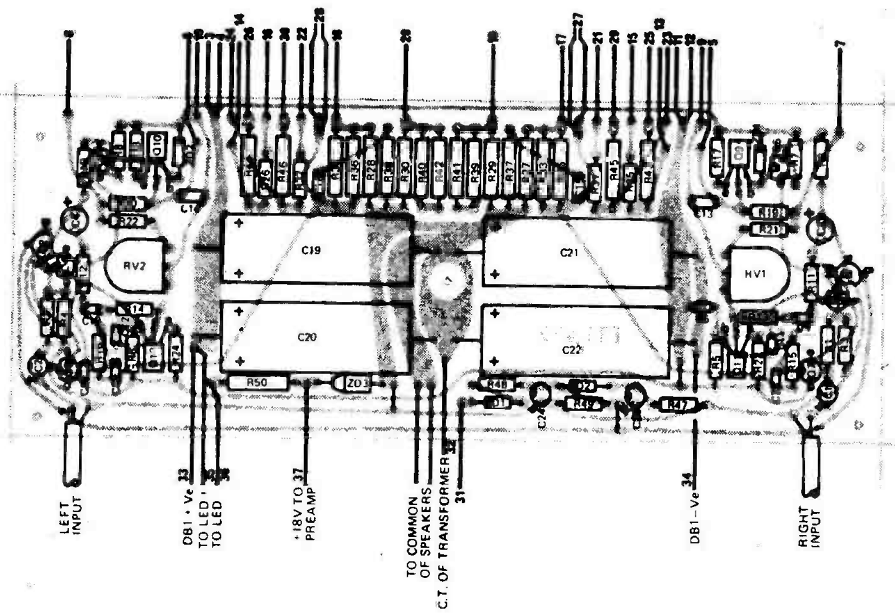


Fig. 6. Component overlay for the main amplifiers and power supply.

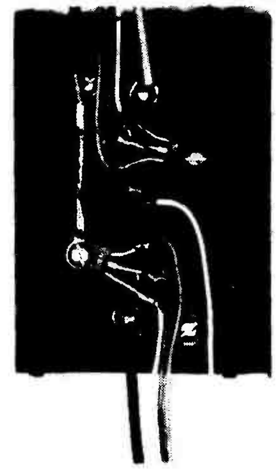


Fig. 7. Details of heatsink assembly. Note particularly the orientation of Q13.

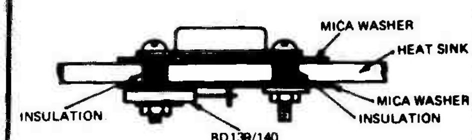


Fig. 8 Method of assembly of power and BD139-140 transistors to the heatsink.

adjustment offered by the trim potentiometer should be entirely adequate.

Switch off and replace the missing left channel fuse together with the lower right channel fuse. Using the milliammeter across the top right-channel fuse holder, adjust the right channel bias current to 20 to 25 mA as for the left channel.

The amplifier, because of its wide frequency response, will reproduce pops and clicks, etc, introduced into the mains by equipment (such as refrigerators) switching on and off. Some protection against this is given by C18 (across the primary of the power transformer). If this is insufficient, 0.0047 microforad capacitors may be fitted between the live end of C18 and earth, and also between the neutral end of C18 and earth. If used, these components must have a rating of at least 600V. ●

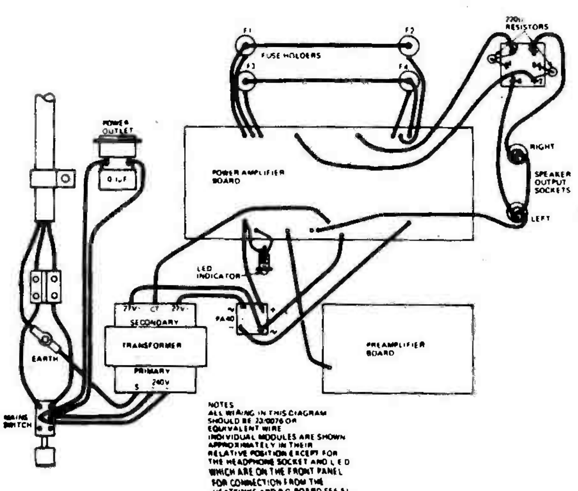


Fig. 9. Power wiring diagram of the complete amplifier.

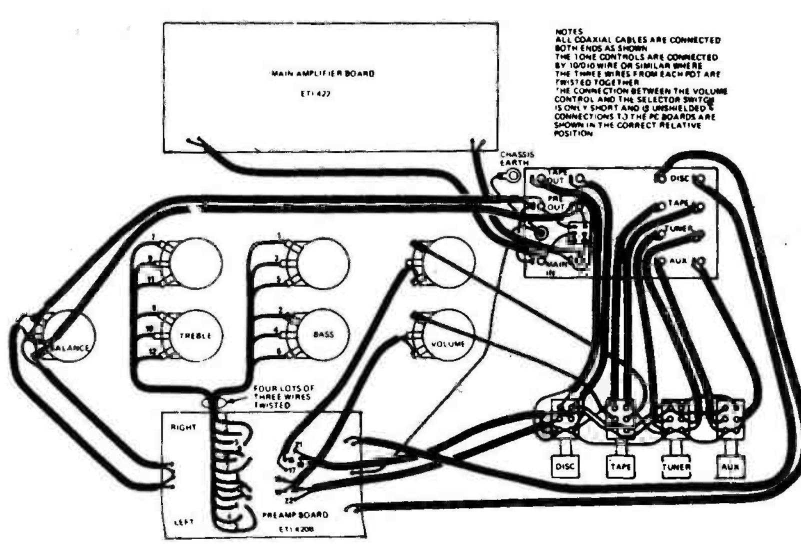


Fig. 10. Signal wiring diagram of the complete amplifier.

INTERNATIONAL 422 STEREO AMPLIFIER

HOW IT WORKS – PREAMPLIFIER

The output level of a magnetic cartridge may be as low as 1 mV and this must be amplified and equalised before being applied to the tone controls.

Transistors Q1, 3 and 5 form this equalizing amplifier. The gain is controlled by R11, and the frequency response by R15, R17, C11 and C13. This complex network provides the correct RIAA equalization, the desired signal source and appropriate network being selected by SW1, 2 and 3 and 4. The signal is then passed to Q7 which buffers the output of the volume control and drives the tone control network.

Transistor Q9 and Q11 form a high gain amplifier in which the gain is determined by the relative positions of the bass and treble controls. The gain at 1 kHz is approximately 2.

MAIN AMPLIFIER

The input signal is fed via C1 and R1 to the base of Q3 which, with Q7, forms a differential pair. Transistor Q5 is a constant current source where the current is [5.6V (ZD1) – 0.6 (Q5)]/2700 (R7) – that is about 2 mA. This current is shared by Q3 and Q7. Transistor Q9 is also a constant current source supplying about 10 mA which, if no input signal exists, flows through Q13 and Q11. The differential pair controls Q11 and thus the voltage at its collector.

The resistors R19 and R21, together with potentiometer RV1, control the voltage across Q13 and maintain it at about 1.9 volts. But as Q13 is mounted on the heatsink, this voltage will vary with heatsink temperature. Assuming that the voltage at points 5 and 9 is equally spaced about zero volts (ie ± 0.95 volts), the current will be set at about 12 mA through Q15 and Q17. The voltage drop across the 47 ohm resistors (R25 and R31) will be enough to bias the output transistors, Q19 and Q20, on slightly to give about 10 mA quiescent current. This quiescent current is adjustable by means of potentiometer RV1.

Local feedback is applied to the output stage by the network R33, R35, R39 and R41, giving the output stage a voltage gain of about four. The overall feedback resistor, R15, gives the required gain control.

Protection to the amplifier, against shorted output leads, is provided by fuses in the positive and negative supply rails to both amplifiers.

Temperature stability is obtained by mounting Q13 on the heatsink. Q13 will thus automatically adjust the bias voltage. Frequency stability is ensured by C9/R13, C5, C11 and C7.

Although the power amplifier itself does not produce a thump in the loudspeaker, when switched on, the preamplifier does. This is because the preamplifier uses a single power rail and has to stabilize. To reduce this thump to an acceptable level, Q1 is used to short the input for about 2 seconds on switch-on and immediately after switch-off.

The power supply is a conventional full-wave bridge with centre tap, providing + 40 volts and – 40 volts. Diode D1 is used to rectify a second negative supply which is used to control the FETs. Due to the resistance in series with the diode, the charge of C24 is slow. In addition, during the charge period, C23 is also being charged increasing the delay. On switch off, however, C23 cannot assist the voltage on C24 and the off-timing is much shorter than the on-timing.

The power supply for the preamplifier is derived by an 18 volt zener which is fed from the +40 volt rail via an LED power-on indicator and R50.

PARTS LIST — Preamplifier

R59 Resistor 100 ¼ or ½W 5%
R25,26 " 220 " " "
R11,12 " 1k " " "
R37,38,43 " 2.2k" " "
R44,57,58 " 2.2k" " "

R19,20 " 3.3k ¼ or ½W 5%
R55,56,61,62 " 5.6k " " "
R5,6,21,22 " 10k " " "
R27,28,33,34 " 10k " " "
R39,40 " 10k " " "

R35,36,41,42 " 15k " " "
R47,48 " 22k " " "
R63,64 " 39k " " "
R3,4,7,8 " 47k " " "
R53,54 " 56k " " "

R17,18,45 " 100k " " "
R46,49,50 " 100k " " "
R1,2 " 150k " " "
R9,10,13 " 220k " " "
R14,51,52 " 220k " " "

R29,30,31,32 " 470k " " "
R15,16,23,24 " 1M " " "

RV1 Potentiometer 50k log dual r'tary
RV2 " 100k lin dual r'tary
RV3 " 50k lin dual r'tary
RV4 " 50k lin rotary

C5,6,7 Capacitor 33pF ceramic
C8,23,24 " 33pF ceramic
C13,14 " 820pF ceramic
C11,12,25 " 0.0033µF polyester
C26,33,34 " 0.0033µF polyester

C27,28,29,30 " 0.033µF polyester
C1,2,19,20 " 0.47µF 35V tag tantalum
C21,22,31,32 " 0.47µF 35V tag tantalum
C9,10,35,36 " 10µF 16V electrolytic *
C37,38,41,42 " 10µF tag tantalum

C15,16 Capacitor 22µF 16V elect'ytic*
C3,4 " 33µF 10V "
C39 " 47µF 25V "
C17,18 " 100µF 25V "

* PC mounting or tag tantalum

Q1,2,3,4,7 Transistor BC109, BC549*
Q8,9,10,11,12 " " "
C5,6 " BC179,BC559
* can be BC108,548 except for Q1,Q2

SW1-4 Switch assembly

PC board ETI 420 B

PARTS LIST — Main Amplifiers and Power Supply

R43,44,45,46 Resistor 0.5ohm
R37,38 " 10 " 1W 5%
R27,28,29,30 " 33 " 1W 5%
R25,26,31,32 " 47 " ½W "
R11,12,51,52 " 220 " ½W "

R33,34,35,36 " 220 " 1W "
R39,40,41,42 " 220 " 1W "
R17,18,23,24 " 470 " ½W "
R21,22 " 560 " ½W "
R50 " 1k " 1W "
R13,14,19,20 " 1.2k " ½W "

R1,2 Resistor 1.5k ½W 5%
R7,8 " 2.7k " "
R9,10 " 3.3k " "
R5,6 " 5.6k " "
R3,4,15,16 " 10k " "
R48 " 47k " "
R49 " 100k " "
R47 " 220k " "

RV1,2 Potentiometer 470 ohm Trim type

C11,12 Capacitor 27pF ceramic
C7,8,9,10 " 100pF "
C5,6 " 0.0033µF polyester
C13,14,15,16 " 0.1µF "
C18 " 0.1µF 250V ac

C24 Capacitor 1µF 35V electrolytic *
C1,2 " 4.7µF 10V "
C23 " 10µF 25V "
C3,4 " 100µF 10V "
C19,20,21,22 Capacitor 2500µF 50V electrolytic
* should be PC mounting type

Q1,2 Transistor 2N5485
Q3,4,5,6,7,8 " BC177
Q9,10,17,18 " BD 140
Q11,12,15,16 " BD 139
Q13,14 " 2N2219
Q19,20 " MJ2955
Q21,22 " 2N3055

D1,2 diode IN 914,
ZD1,ZD2 zener diode (5.6V,400mW)
ZD3 zener diode (18V,1.5W)

DB1 diode bridge 100V, 2A

T1 Transformer 56V CT 1.5A (60V alternative)

PC Board ETI 422
F1-F4 miniature 2 AMP Fuse and holders
SW1 Mains on/off
4 covers for TO3 transistors
4 insulation kits for TO3 transistors
4 extra mica washers for TO3

PARTS LIST — General

Chassis
Front panel
Rear panel
Wooden box
12.7 mm spacers 4 req.
6.4 mm spacers 9 req.
3 small knobs
1 large knob
1 stereo phone jack
1 LED indicator
2 heatsinks
Miniature DPDT toggle switch
Earth binding post
3 core flex and cable clamp
3 rubber grummets
6 ¼" Whit ½" long screws
17 1/8" Whit 3/8" long c/s screws
4 1/8" whit 3/8" long c/s screws
17 1/8" whit 3/4" long r/h screws
coax cable
23/0076 cable
10/0076 cable

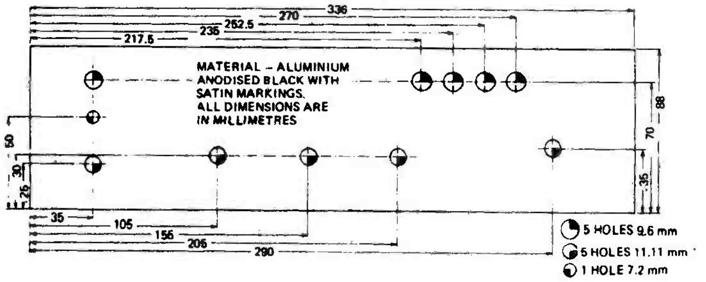


Fig. 13. Drilling details of the front panel escutcheon.

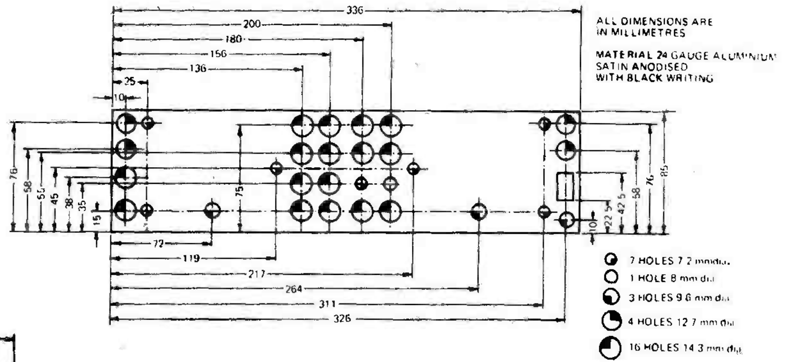


Fig. 14. Drilling details for rear-panel escutcheon.

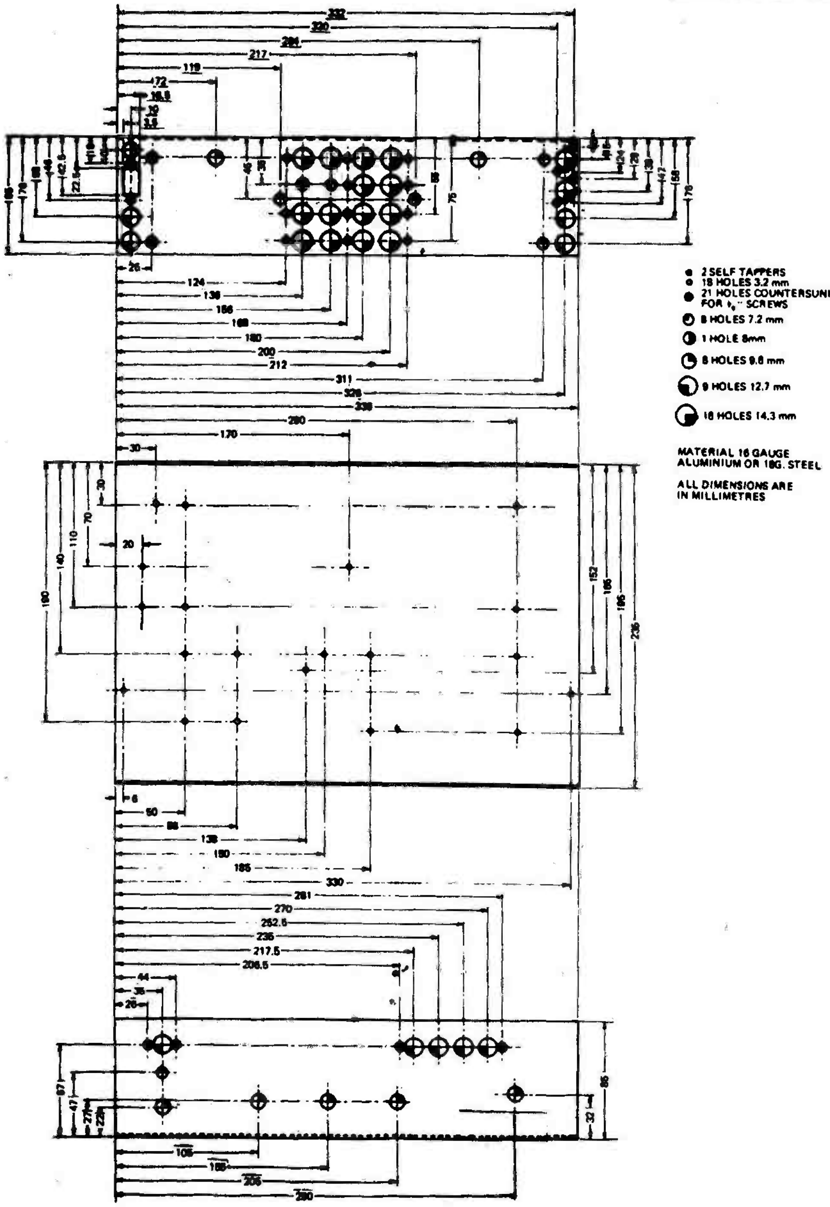


Fig. 15. Drilling details and dimensions of the chassis.

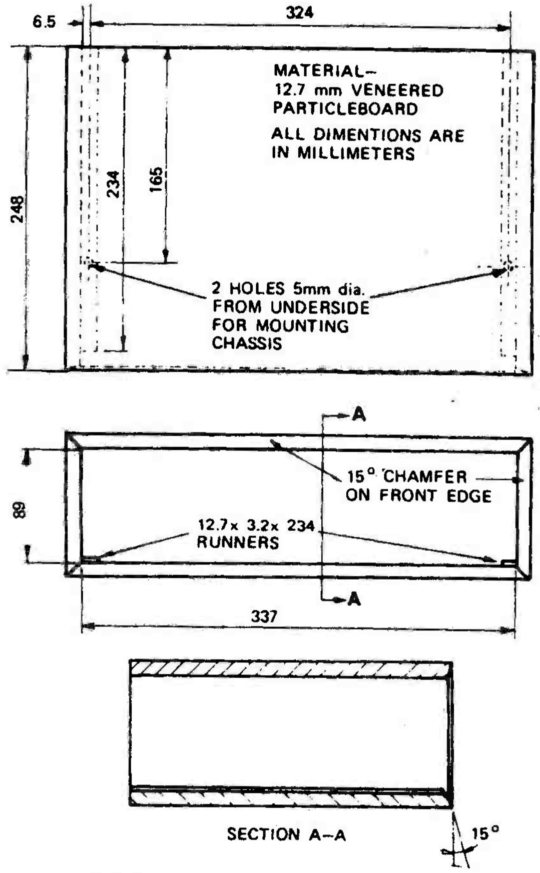


Fig. 16. Constructional details of the cabinet.

ETI TOP PROJECTS: No. 4

THE FOURTH IN A SERIES OF SPECIAL ISSUES CONTAINING REPRINTS OF POPULAR ETI CONSTRUCTIONAL PROJECTS

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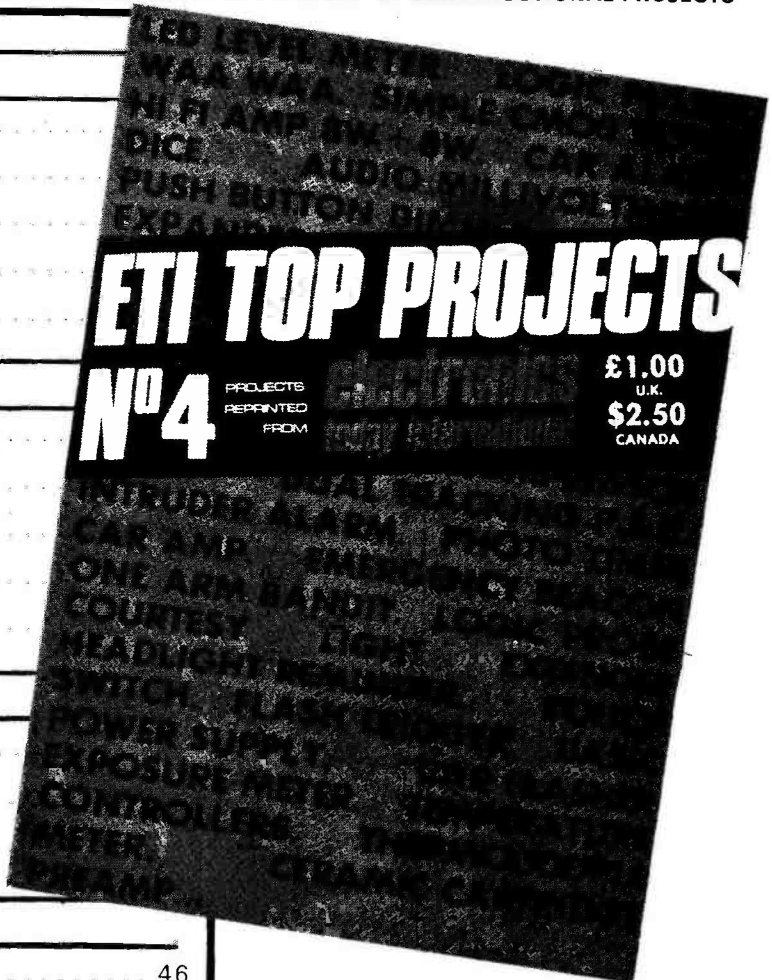

We show the actual contents section here — there's really something for everybody! All articles appear as they did originally but have been updated for new components etc. where necessary.
The book is bound in a special thick cover to protect it from the use you are bound to give it.

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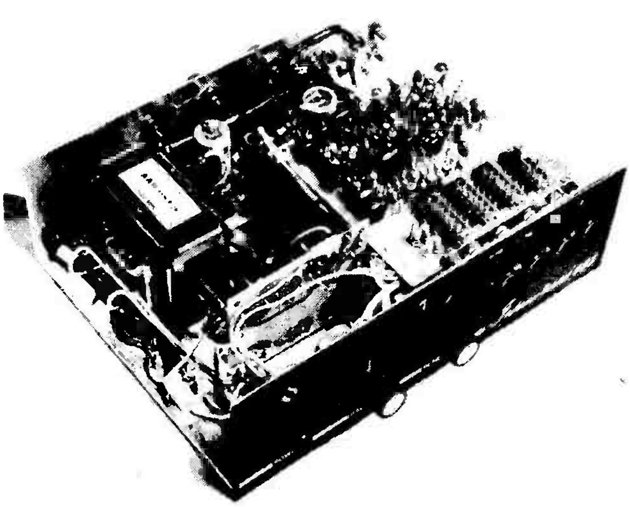
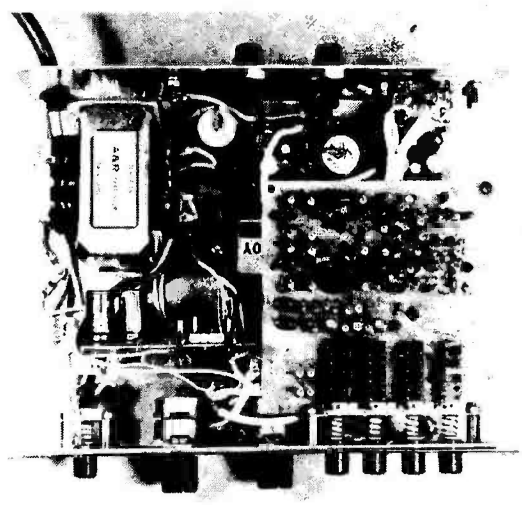
ALL PAYMENTS MUST BE IN STERLING

etiproject

PLUS TWO add-on decoder amplifier

Adapt your stereo hi-fi to full four-channel SQ operation





eti project

SPECIFICATION

Output Power (at 1% distortion)			
Both channels driven	12.5 watts per channel		
Distortion	100 Hz	1 kHz	10 kHz
At 0.1 watt output	0.15%	0.43%	0.20%
At 1 watt output	0.14%	0.11%	0.10%
At 10 watt output	0.14%	0.1%	[illegible]
Maximum Input Voltage	2 V		
Gain			
Input to front output	Unity		
Damping Factor			
100 Hz	5		
1 kHz	30		
10 kHz	30		
SQ Decoder Phase Shift			
30 Hz to 20 kHz	90° ± 10°		

MANY OF US have watched the evolution of four-channel systems with interest, but, being already possessors of a stereo system, have rejected four-channel as being too expensive to implement.

But here is a cheap and relatively simple way to convert your stereo into a full SQ, four-channel system. Apart from this unit the only extra equipment needed are two rear speakers, which need not be as high in quality as your existing front speakers.

The add-on unit is connected to your existing stereo amplifier via the pre-amplifier 'out' and main amplifier 'in' sockets. This facility — together with a 'connect/disconnect' switch is provided on most good quality amplifiers. If it is not, your existing amplifier must be modified by disconnecting the internal wiring and bringing all four points out to the rear panel via shielded cable.

Although this is a quick simple modification, it should only be attempted by those who have a good understanding of amplifier operation — if you don't know how to do it — do obtain advice.

The add-on unit's mode of operation may be readily understood by referring to Fig. 1. It will be seen that the SQ matrixed signals are amplified by the existing preamplifier tone control stages, and then passed to the add-on unit. Here they are decoded into left front, right front, left back and right back channels. The left and right back channels are amplified and passed direct to the rear speakers. The left and right front signals are passed back to the existing main amplifiers and speakers, and there you have it — inexpensive four-channel sound.

The SQ Decoder board is identical to that described for the 4-channel amplifier in ETI April 1974 or the discrete decoder described in ETI June 1974.

Photocopies are available from ETI for 50p each including postage.

The power amplifier module uses the Sanken SI-1010G modules and is similar to that used in the International 420 four-channel amplifier (April 1974).

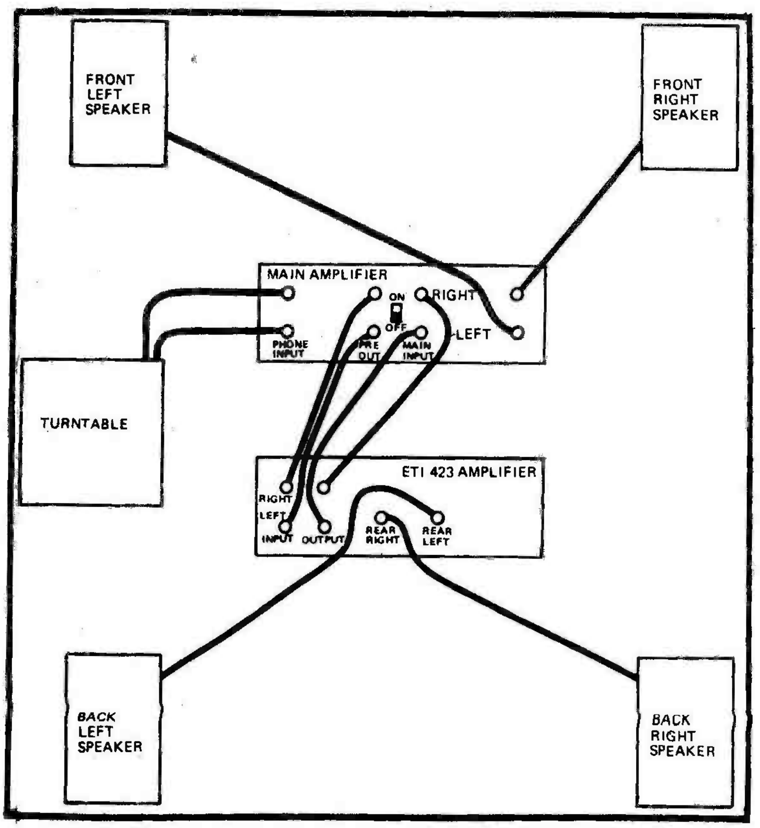


Fig. 1. This schematic drawing shows how the add-on unit is connected into the existing stereo system.

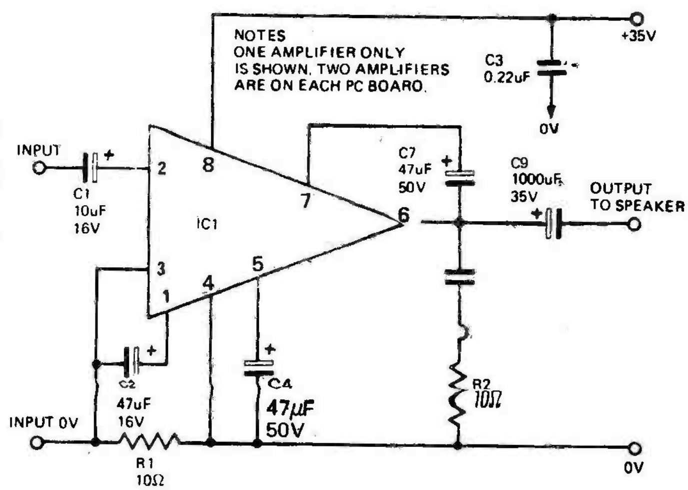


Fig. 2. Circuit diagram of one power amplifier module (two per assembly).

PLUS TWO add~on decoder amplifier

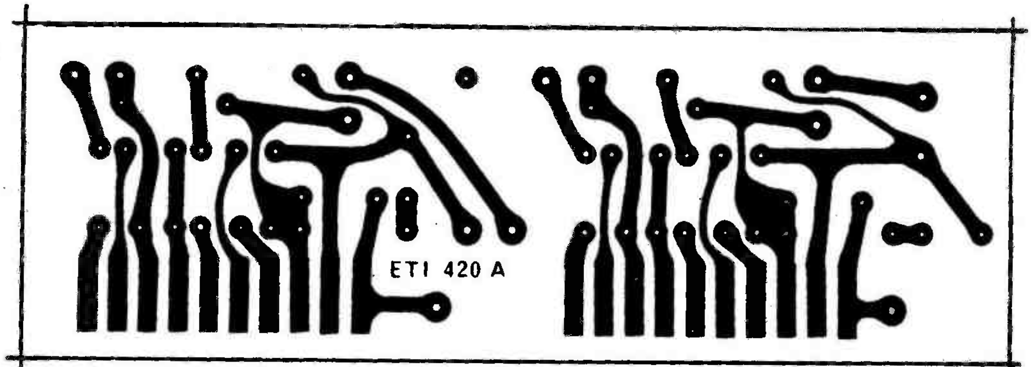


Fig. 3. Printed circuit board for the twin power amplifier assembly. N.B. The pcb layout was designed for the SI–1010Y module. This is no longer available but the SI-1010G module which we recommend as a substitute has different pin connections. We recommend cross-wiring according to the diagram below.

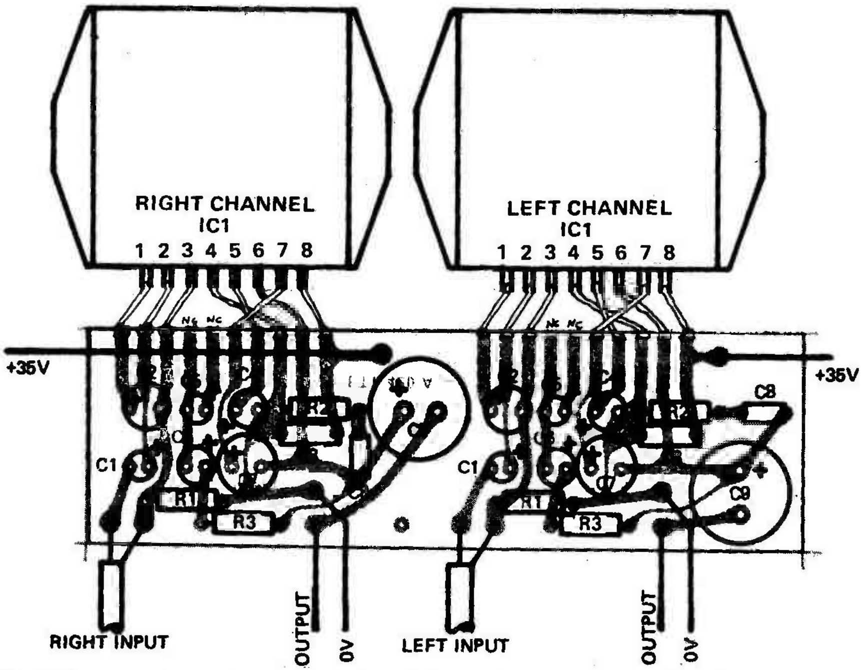
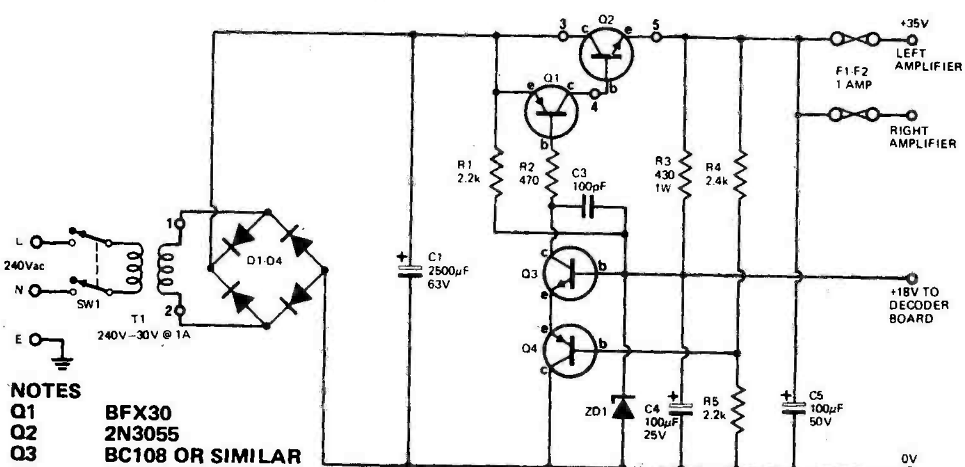


Fig. 4. Component overlay for the twin power amplifier assembly. N.B. The SI-1010G does not use C5, C6 or R_3 (which were necessary with the original SI-1010Y).



NOTES

Q1	BFX30
Q2	2N3055
Q3	BC108 OR SIMILAR
Q4	BC178 OR SIMILAR
ZD1	ZENER 18V 1.5W

Fig. 5. Circuit diagram of power supply.

PARTS LIST

POWER SUPPLY

R1 Resistor 2.2k ¼W 5%
R2 " 470 " "
R3 " 430 1W "
R4 " 2.4k ½W "
R5 " 2.2k " "

C1 Capacitor 2500µF 63V electrolytic
C3 " 100pF ceramic
C4 " 100µF 25V electrolytic PC mounting
C5 " 100µF 50V electrolytic PC mounting

Q1 Transistor BFX30 or similar
Q2 " 2N3055 or similar
Q3 " BC108 or similar
Q4 " BC178 or similar

D1-D4 Diode 1N4002 or similar
ZD1 Zener Diode BZX70C18 18V, 400mW
T1 Transformer 240V/30V @ 1A
SW1 Switch
PC Board ETI 423
F1-F4 Amp Fuse and panel mounting holders
Cover for 2N3055 transistor
Insulation kit for 2N3055

CHASSIS AND MISCELLANEOUS

Complete decoder board as published on page 28.
1 spacer ¼" long (plain).
4 spacers ½" long (plain).
2 knobs
2 2-way phono sockets
2 two pin DIN sockets
Mains cord, grommet and clamp
2 way terminal block
Metal chassis to Fig. 13
2 small right angle brackets to hold power supply board
Wood box to Fig. 12
23/0076 wire
Screened cable
Front panel to Fig. 14

AMPLIFIER

R1,2 Resistor 10Ω ¼W 5%

C1 Capacitor 10µF 16V electrolytic*
C2 " 47µF 16V electrolytic*
C3 " 0.22µF polyester
C4 " 47µF 50V electrolytic*
C7 " 47µF 50V electrolytic*
C8 " 0.1µF polyester
C9 " 1000µF 35V electrolytic*

* all electrolytics should be PC mounting type

IC1 Amplifier Module, Sanken S1-1010G. Available from Photain Controls Ltd., Unit 18, Hanger No. 3, The Aerodrome, Ford, Arundel, West Sussex.

PC Board ETI 420A

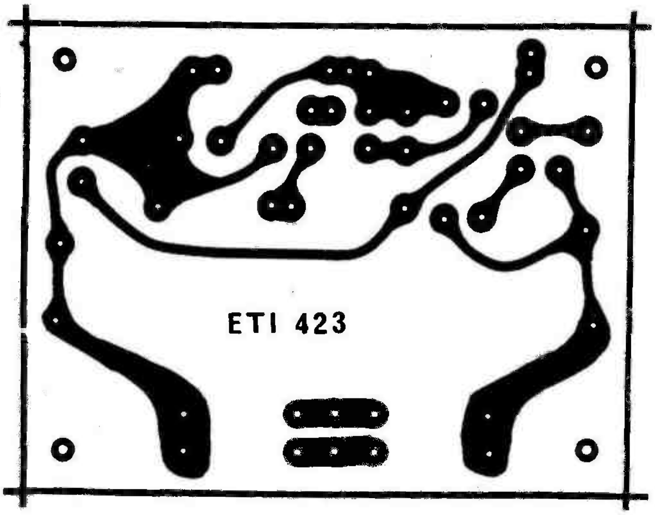


Fig. 6. Printed circuit board for the power supply.

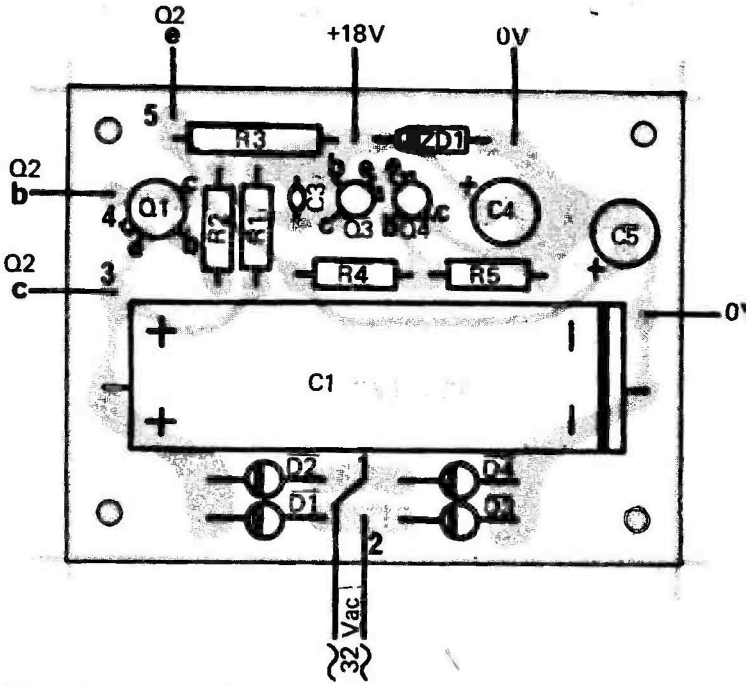


Fig. 7. Component overlay for power supply.

CONSTRUCTION

Components should be assembled onto the printed circuit boards with reference to the appropriate component overlays. Take particular care with the orientation of polarized components such as transistors, capacitors and diodes etc.

The interconnection wiring diagrams, Fig. 8 and Fig. 9, give details of the power and signal wiring respectively. The mounting positions of the printed circuits boards, transformer and potentiometers etc may readily be seen from the metalwork drawing and from the internal photograph of the unit.

The rear-channel amplifier may be omitted if a decoder unit *alone* is required. For this, the coaxial cables, that otherwise go to the power amplifier inputs, should now be connected to two additional phono sockets on the amplifier rear panel.

Power requirements for the decoder board are negligible (0.36 watt compared with 30 watts for the complete unit). Thus a much smaller transformer and simpler power supply circuit may be used. A transformer having a secondary of 12.6 volts at 150 mA, a bridge rectifier, D1-D4, and a single smoothing capacitor, C1, is all that is required. The complete regulator section of the power supply may be omitted.

Although the existing printed circuit board could be used, by simply leaving off the unwanted components, it would be simpler and cheaper to use a tag strip to mount the components for this simpler supply. ●

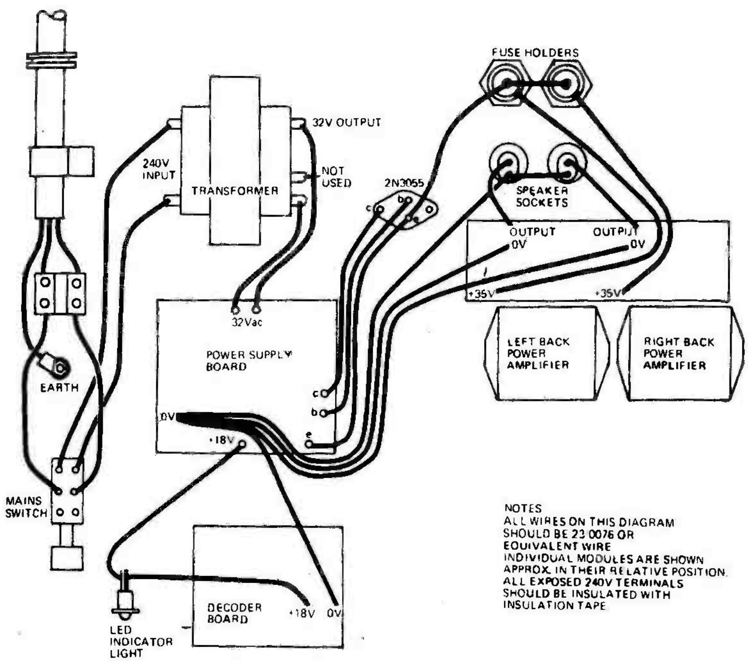


Fig. 8. Interconnections – power wiring.

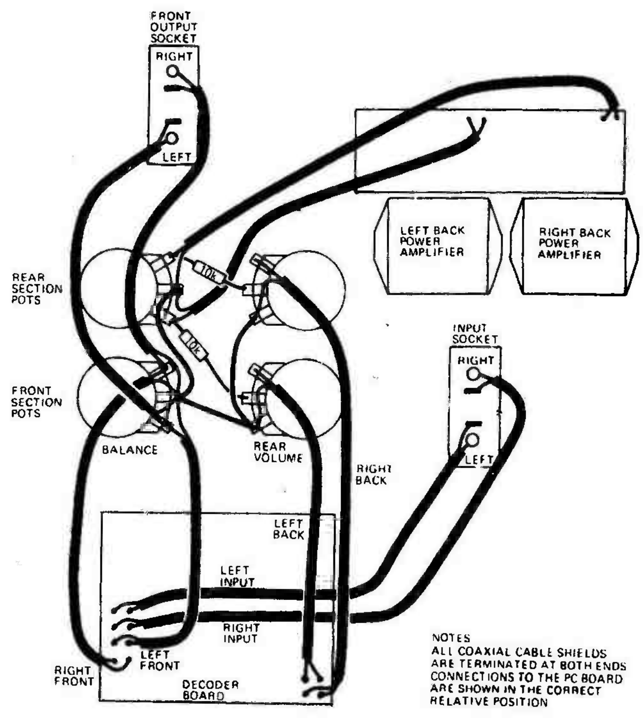


Fig. 9. Interconnections – signal wiring.

PLUS TWO add-on decoder amplifier

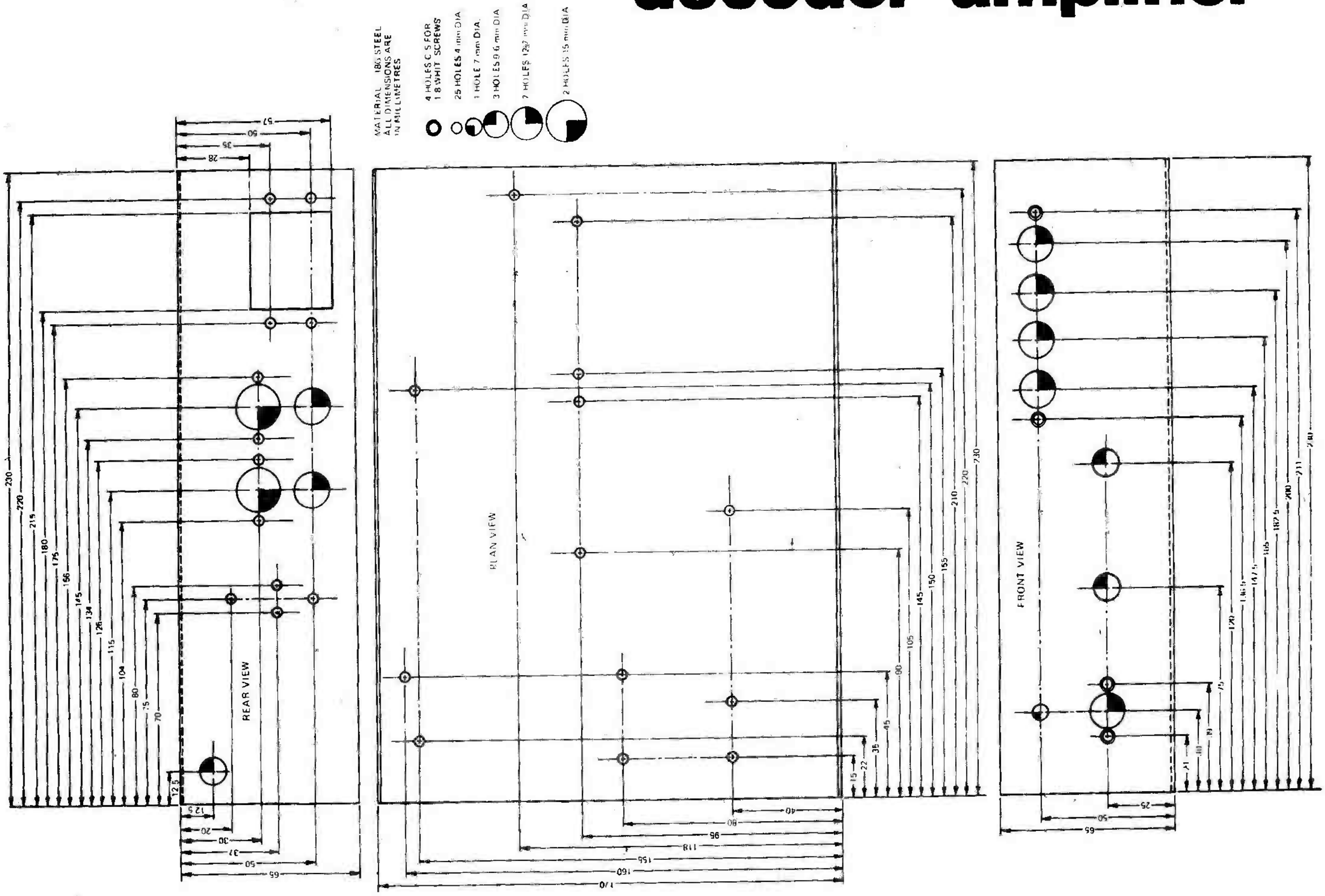


Fig. 12. Details of wooden cabinet

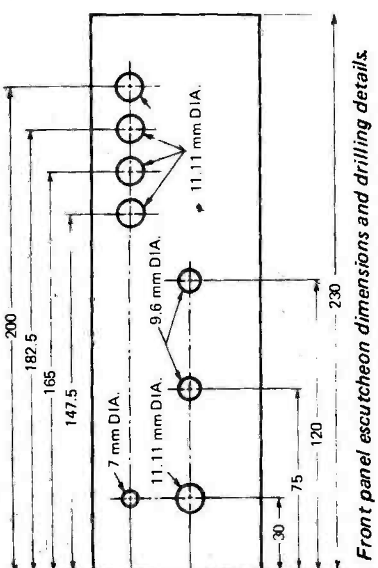
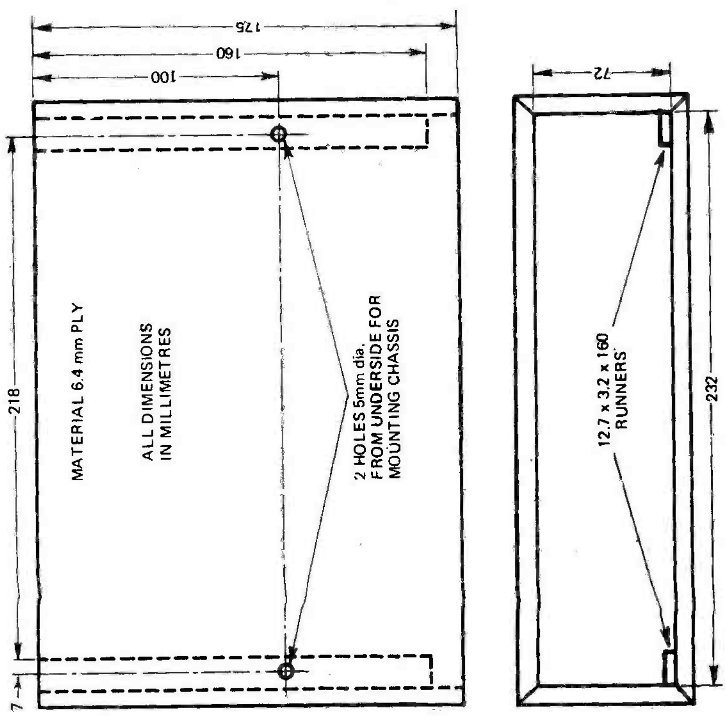
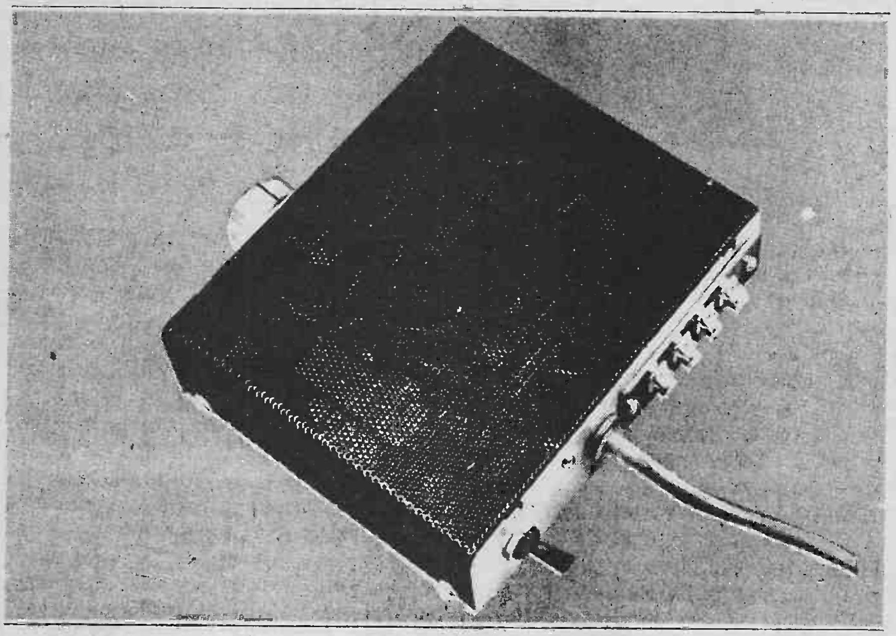


Fig. 14. Front panel escutcheon dimensions and drilling details.



SUPER-



When stereo reproduction was a novelty, many recordings were made with grossly exaggerated stereo 'image'. So much so that on some orchestral recordings the second violins appeared to be playing somewhere to the left of the gentlemen's toilet.

Now, some record companies have swung the other way, and music lovers complain that a number of recordings — especially of symphonic music — have *insufficient* spread, and the apparent stage is restricted to a small area either side of the centre line of the speaker enclosures.

To some extent this can be remedied by increasing the spacing between speakers — but only if room dimensions permit.

This is a problem that has attracted the attention of Mullard Ltd, and they have developed a 'sound-source width control' that enables the stereo 'image' to be adjusted so that at one extreme both stereo channels are spatially combined so that the sound apparently emanates from a point half way between the two speakers, whilst at the other extreme, the effective

ETI PROJECT 410

SELECT THE WIDTH OF YOUR STEREO'S EFFECTIVE IMAGE — FROM A POINT SOURCE TO A SPREAD MUCH GREATER THAN NORMAL.

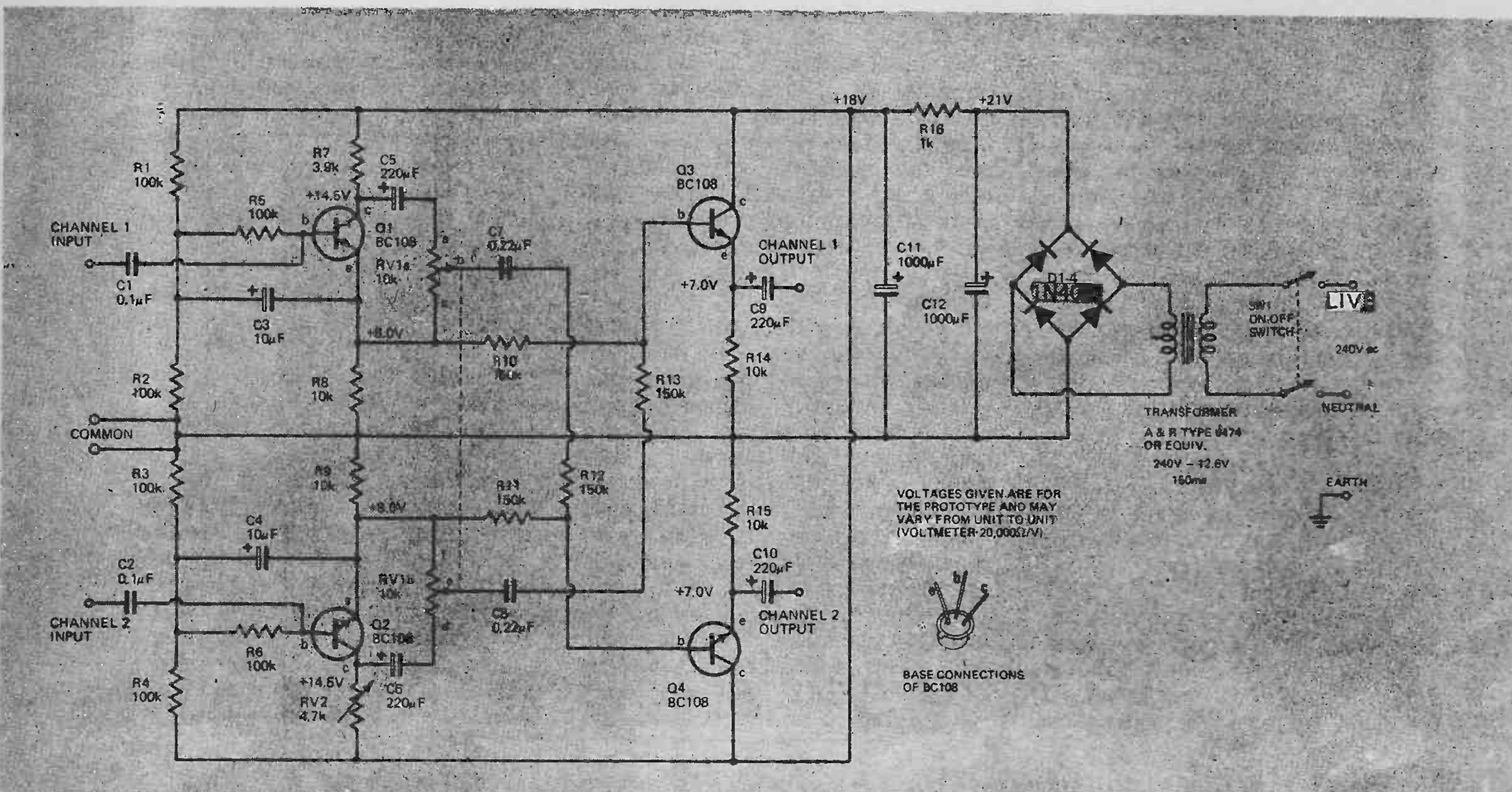


Fig. 1. Circuit diagram of complete unit.

STEREO

stereo image is increased quite considerably.

The circuit operates by adding part of the signal in one channel to the signal in the second channel. This is done with both signals in phase (to produce mono effects), or with the signals out of phase (to produce stereo-width enhancement).

Care has been taken to ensure that the unit does not introduce hum or distortion.

When we first assembled the unit we found that the range of adjustment provided by the width control was not really sufficient to cater for all programme material and the circuit described here has been modified to provide continuous adjustment, from mono, through the normal stereo image, to an apparent stereo spread approximately 40% greater than normal.

INTER-UNIT CONNECTIONS

This unit is designed to accept high level signals – exceeding 100 mV, and is intended for connection between a pre-amplifier and main amplifier.

It is not suitable for handling signals directly from a low level (less than 100 mV) magnetic pick-up. This is because internal noise generated by the unit will degrade the low level signals.

Crystal or ceramic pick-ups, have sufficient output successfully to drive the unit and it may of course also be used between a pre-amplifier and tape recorder, tape recorder (reel-to-reel or cassette) and amplifier, or between two tape recorders.

Many modern amplifiers are of course built with the pre-amplifier and main amplifier combined. With these it is generally possible to connect the unit's input to the 'tape-out' connections and the unit's output to the 'tape-input' sockets on the stereo amplifier. (This approach is also used by the Bose company – their active equaliser is interconnected in the same way).

TESTING

At this stage connect input 1 and output 2 only, input 2 and output 1

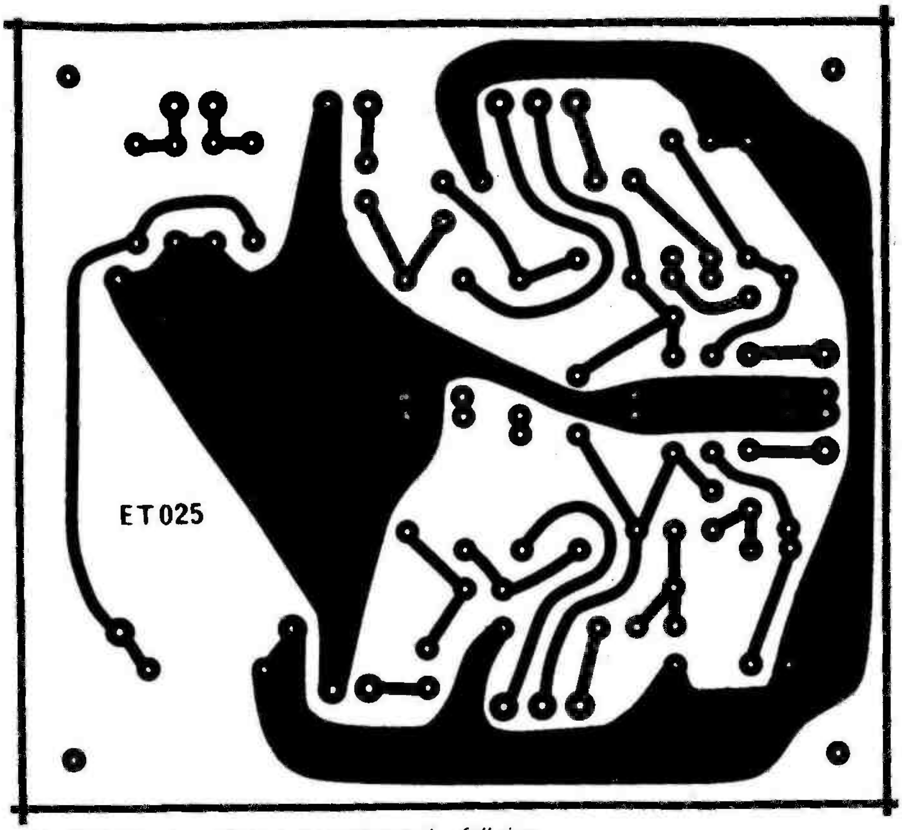


Fig. 2. Foil pattern of printed circuit board – full size.

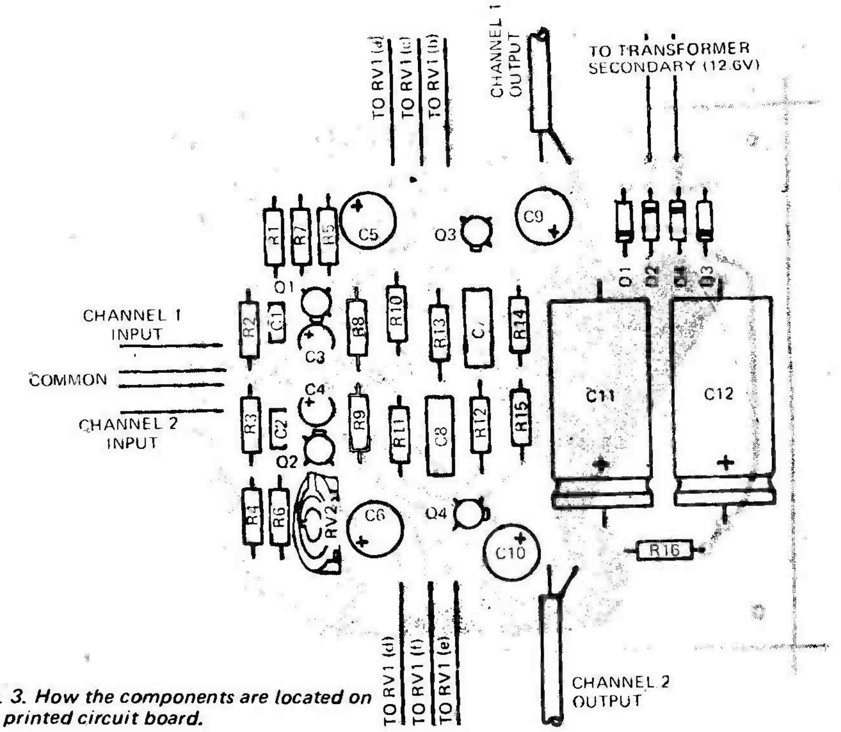
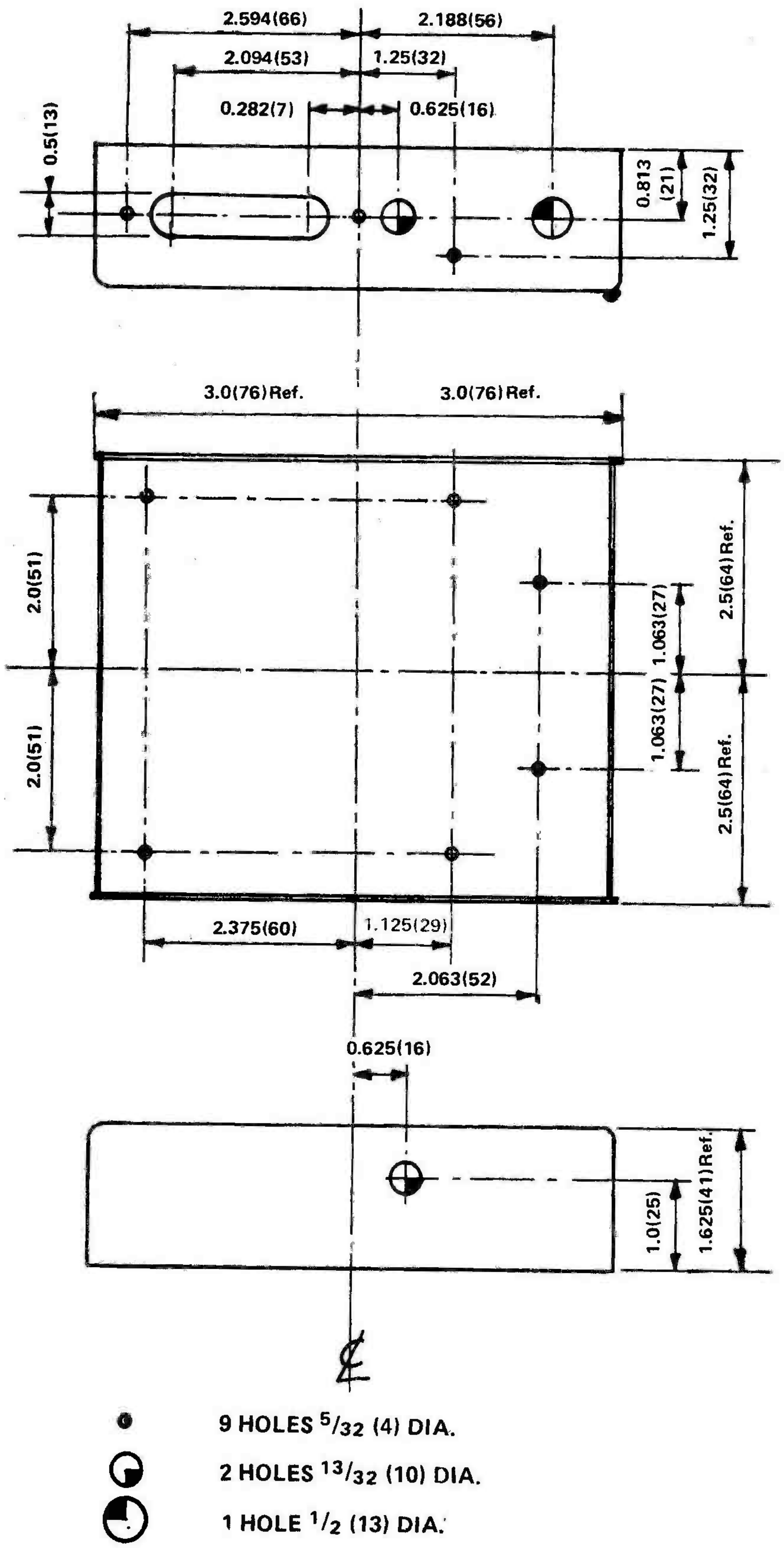


Fig. 3. How the components are located on the printed circuit board.



DIMENSIONS IN BRACKETS
ARE IN MILLIMETRES

Fig. 4. Constructional and drilling details of metal case.

PARTS LIST ET410

R1 — resistor 100k ½ W 5%
R2 — " 100k " "
R3 — " 100k " "
R4 — " 100k " "
R5 — " 100k " "
R6 — " 100k " "
R7 — " 3.9k " "
R8 — " 10k " "
R9 — " 10k " "
R10 — " 150k " "
R11 — " 150k " "
R12 — " 150k " "
R13 — " 150k " "
R14 — " 10k " "
R15 — " 10k " "
R16 — " 1k " "
RV1 — 2 gang 10k Lin. Pot

RV2 — Trimpot 4.7k (Large Type)
C1 capacitor 0.1 uF 100V
C2 " 0.1 uF 100V
C3 " 10 uF 25V electrolytic
C4 " 10 uF 25V "
C5 " 220 uF 16V "
C6 " 220 uF 16V "
C7 " 0.22 uF 100V
C8 " 0.22 uF 100V
C9 " 220 uF 16V electrolytic
C10 " 220 uF 16V "
C11 " 1000 uF 25V "
C12 " 1000 uF 25V "

Q1 Transistor BC108 or equivalent
Q2 " BC108 "
Q3 " BC108 "
Q4 " BC108 "
D1-D4 Diode 1N4001 or equivalent
Transformer 240/12.6V 150mA

PC board ET025.
Metal box

4 way coaxial sockets.
Double pole 240V switch MSP 625 or similar.
Rubber grommets.
3 core flex and plug.
Cable clamp (for mains cord).
Knob for pot.
Nuts and bolts.
4 spacers ¼" long for PC board.
Coaxial cable wire etc.

must be left disconnected.

Switch on all units, and play a stereo recording through the system. Adjust RV1 (front panel control) for minimum output in speaker channel 2. Leave RV1 in this position for the time being. Mark this position on the case — it represents the normal stereo setting.

Now connect input 2 and output 1, and disconnect input 1 and output 2. Again play the record through the system but this time adjust RV1 to give minimum output in speaker channel 1.

Reconnect input 1 and output 2. The unit is now ready for use.

It should be noted that the volume level will drop as RV1 is turned towards the 'super-stereo' position, this should be corrected by adjusting the volume control.

CONSTRUCTION

The circuit diagram of the complete device is shown in Fig. 1.

The simplest way to build the unit is to assemble the components on the printed circuit board — the foil pattern of which is shown full-size in Fig. 2.

Figure 3 shows how the components are assembled on the printed circuit board. Ensure that transistors, diodes and electrolytic capacitors are correctly orientated. Trimming potentiometer RV2 should be bent over slightly to allow ease of adjustment.

The assembled printed circuit board, together with the mains transformer and potentiometer RV1, should then be fitted into the metal case.

For our prototype unit, we used the chassis shown in Fig.4. This drawing shows sufficient details for those who wish to construct their own case.

Leads carrying audio signals must be screened if they are longer than an inch or so. However if the unit is assembled as shown in Fig. 5, only the output leads require screening. Co-axial cable or standard screened lead is suitable for this purpose.

When wiring up the power supply note that the transformer centre tap is not used.

It is of course perfectly feasible to build the circuit and controls within an existing stereo amplifier — in which case the power supply would not be required. (The unit draws only a few milliamps and within the range of 12 to 18 volts, voltage is not overly critical). ●

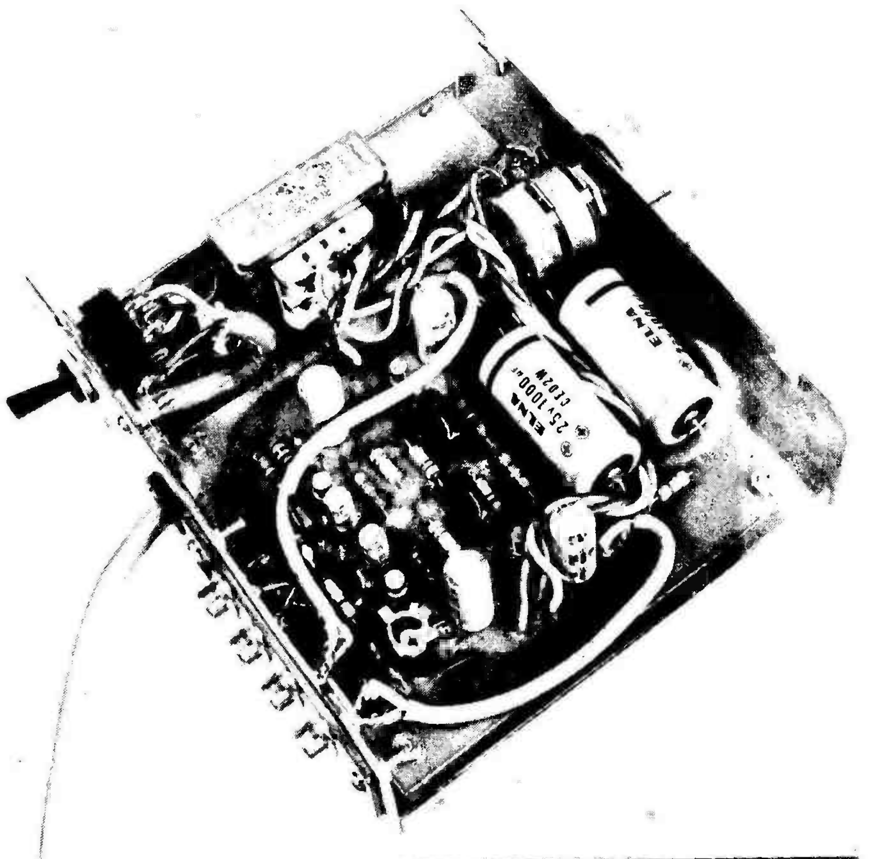
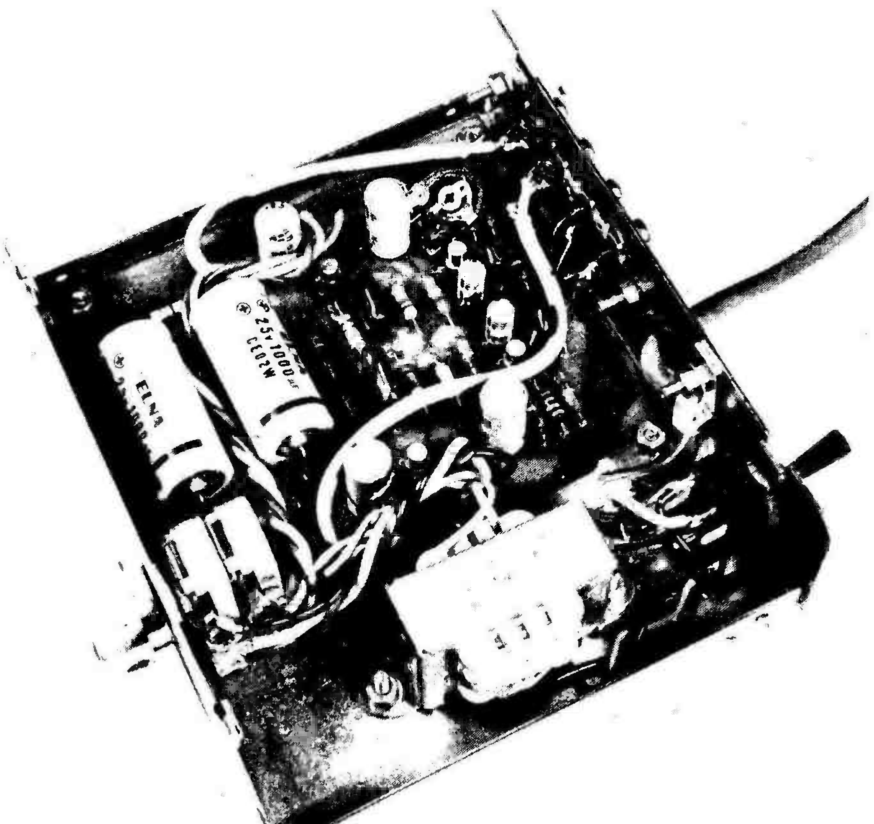


Fig. 5. Note how very short leads are used to connect the output sockets to the printed circuit board. Screened leads have been used only for the longer input connections.



HOW IT WORKS

Basically the circuit consists of two practically identical channels. This text describes the operation of channel 1.

The circuit consists of a buffer stage that provides both a unity gain 'in-phase' output, and an attenuated (39%) 'out-of-phase' output. Potentiometer RV1 enables the output of the buffer stage to be varied between either the 'in-phase' or 'out-of-phase' condition. This output is fed to mixer transistor Q3.

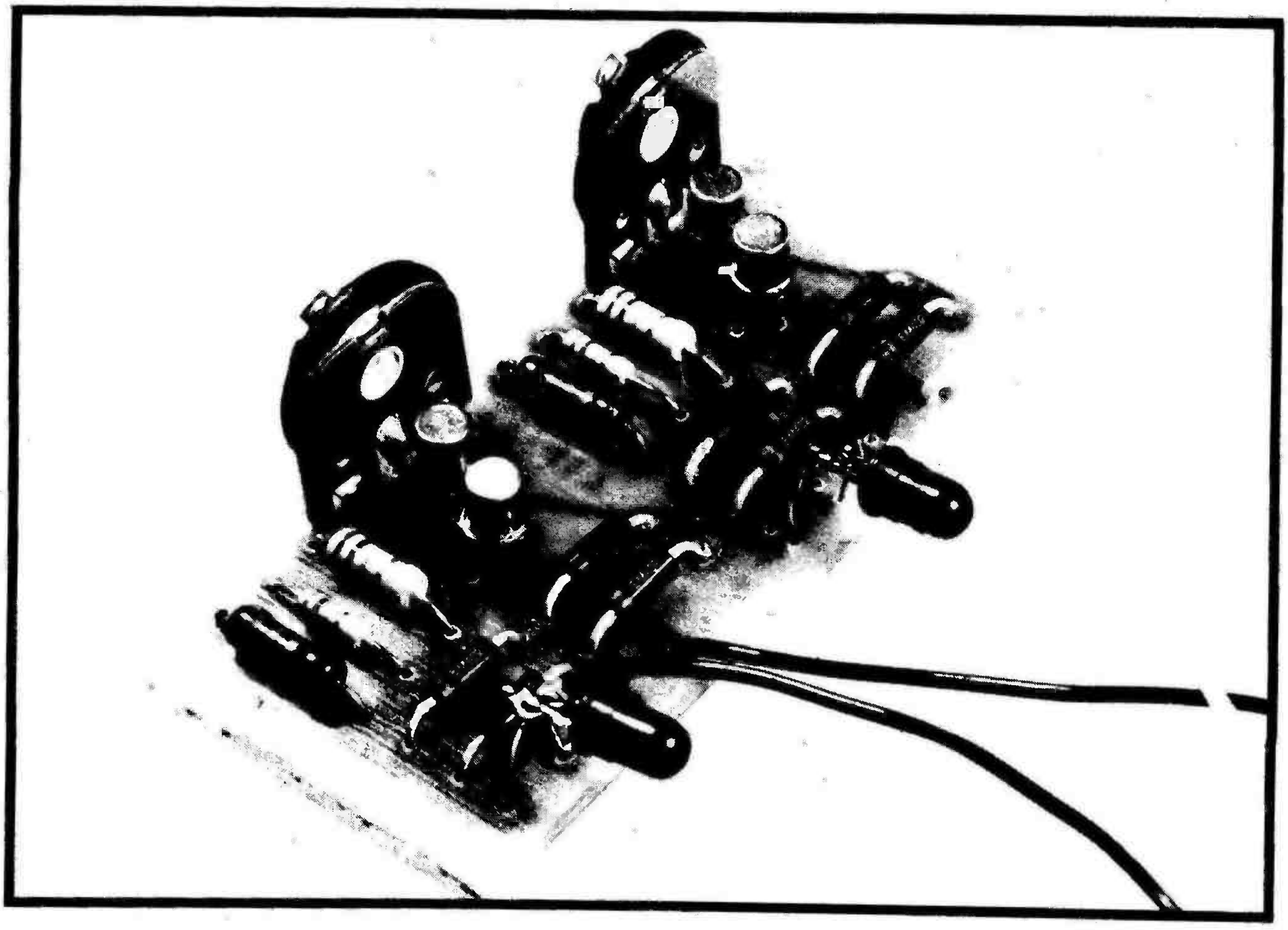
The output of Q3 consists of the channel 1 input plus a proportion of channel 2. The amount of channel 2 signal that is mixed with channel 1 depends upon the setting of RV1 and can vary from the full 'in-phase' channel 2 signal (mono) through zero input from channel 2 (normal stereo), through to 39% 'out-of-phase' (super-stereo).

The operation of channel 2 is similar to that described above.

The mixing process either amplifies signals common to both channels — or attenuates the common signal (super stereo).

Buffer transistor Q1 is biased by R1, R2 and R5. Capacitor C3 provides some positive feedback to increase the input impedance (bootstrapping). Q1 has unity gain at the emitter (in-phase), and an inverted signal of 39% of the input voltage at its collector. RV1 provides the variable output. The bias for mixer Q3 is derived from the output of Q1 via R10.

The power supply consists of a 12.6V transformer, a bridge rectifier, and filter capacitor C12. Further filtering is provided by R16 and C11. Due to the large amount of filtering capacitance — and the low current drawn by the unit — the unit will continue to operate for about 45 seconds after it is switched off.



eti project

THE OVER-LED

Is your power amplifier clipping? This simple monitor lets you know.

MANY people are aware of distortion when they turn up the volume control on their hi-fi equipment – but are usually unaware of the cause.

Nine times out of ten this distortion is caused by 'clipping'. That is, the amplifier does not have enough reserve power to handle the peak music transients at the required volume.

During such peaks, the amplifier is driven into an overload condition and as a result the music peaks are 'clipped'. This results in harsh sounding reproduction.

This simple device, which may be built into your existing amplifier, or separately located, flashes a warning light if the power level at which clipping occurs is exceeded.

Two completely independent circuits are provided so that each channel of a stereo system may be monitored separately.

TABLE 1

	SPEAKER IMPEDANCE					
RMS watts per channel	4Ω		8Ω		16Ω	
	R1	R3	R1	R3	R1	R3
5	68	5.6k	82	8.2k	120	12k
10	82	8.2k	120	10k	180	18k
15	100	10k	150	15k	220	22k
20	120	12k	180	18k	240	24k
25	150	15k	220	22k	270	27k
35	180	18k	240	24k	330	33k
50	220	22k	270	27k	390	39k
75	240	24k	330	33k	470	47k
100	270	27k	390	39k	560	56k

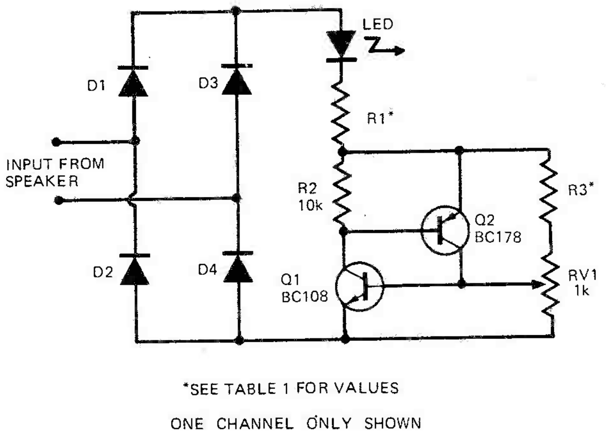


Fig. 1. Circuit diagram of overload detector. One channel only shown.

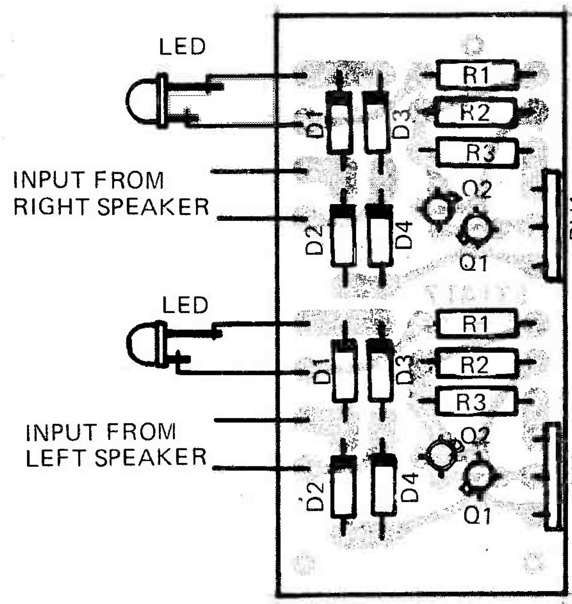


Fig. 2. Component overlay.

HOW IT WORKS

The output of each power-amplifier channel is monitored at the speaker terminals. The output is bridge rectified by D1-D4 so that both positive and negative transients may be detected.

Transistors Q1 and Q2 (together) are equivalent to a sensitive gate SCR (silicon controlled rectifier). If the voltage at the base of Q2 is more than about 0.6 volts above its emitter, Q1 and Q2 will each turn hard on and latch on, until the current through them drops to zero. When transistors, Q1 and Q2 are on, the current flowing through them also flows through the LED causing it to illuminate. Resistor R1 limits the peak current through the LED to about 100 mA. The range of calibration potentiometer RV1 is set by resistor R3. The values of R1 and R3 are provided in Table 1 for various amplifier power ratings and speaker impedances. These values are not critical. If your amplifier has a power rating other than that specified, the nearest values will do.

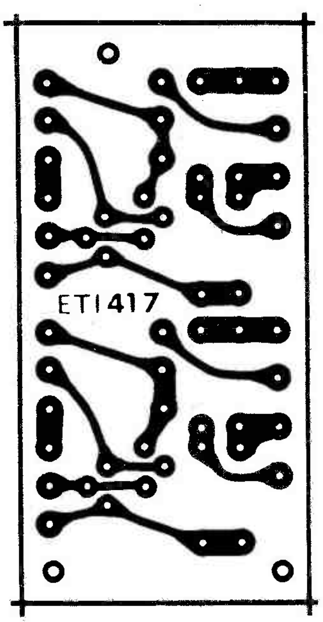
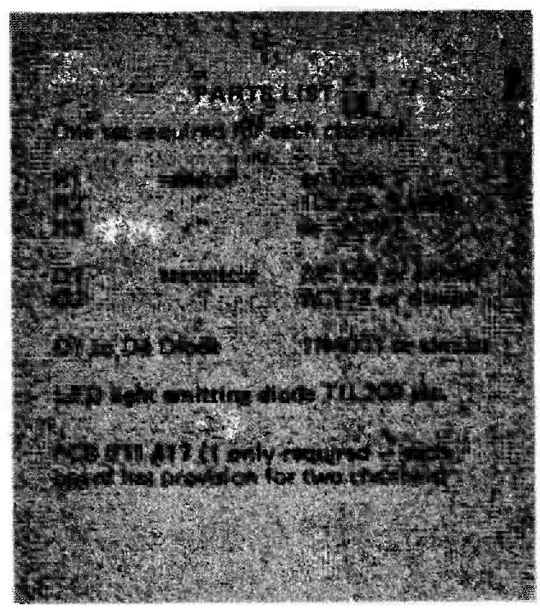


Fig. 3. Printed circuit board (full size).



CONSTRUCTION

Mount all components on to the printed circuit board in accordance with the component overlay. Make sure that all diodes are correctly orientated, in particular the LED's. The LED's will not be damaged by reverse polarity but will not operate in that mode.

Whether the unit is mounted inside the amplifier or external to it in a small box will be a matter for the individual constructor. The printed circuit board may be mounted in any suitable position within the amplifier and leads extended to front-panel mounted LEDs if required.

Polarity of the leads to the amplifier output terminals is immaterial but make sure that the leads of separate channels are not mixed. This is best avoided by twisting each pair of leads to each channel.

CALIBRATION

There are several ways of calibrating the unit.

By far the best way is to connect an audio oscillator to the input of the amplifier (both channels driven at the same time), then, with the amplifier volume control at a low setting, adjust the oscillator to provide a 1 kHz sine-wave.

Set both trim potentiometers (RV1) so that their wipers are nearest R3.

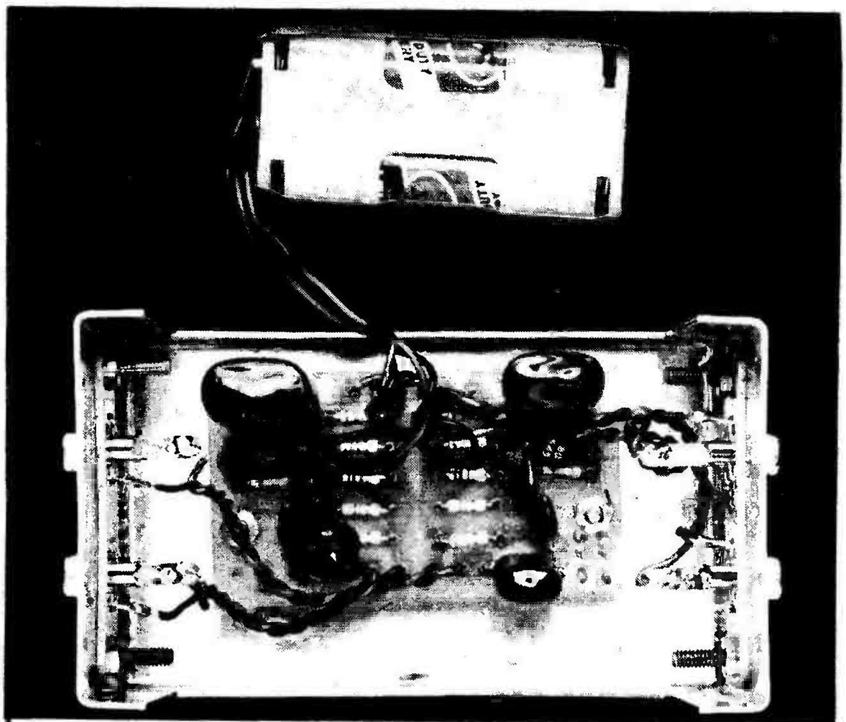
Now increase the amplifier volume until clipping occurs. This is very easily identified as a sudden harshness of tone. Do not leave the volume control at this setting for more than a second or two, as apart from the pounding you are giving to your ears, some amplifiers will not tolerate a sine-wave input at clipping level for extended periods without damage.

Once the clipping point has been established, turn the volume down again, and then quickly turn up to the clipping point momentarily, meanwhile adjusting the trimming potentiometers RV1 until a point is reached where the light emitting diodes just come on.

Repeat the procedure a few times — finally arriving at a setting at which the LED's come on just before the clipping point.

If you do not have access to an oscillator, the device can be set by playing a test record that contains a sine-wave tone — or failing this — by playing a record of a solo instrument such as a flute. A recording of the human voice is also very effective. In such cases the same calibration procedure described above should be followed. ●

STEREO RUMBLE FILTER



This internal view shows how the rumble filter is assembled.

Active filter design improves clarity of bass reproduction.

IN BYGONE DAYS rumble filters were very popular because even the best of turntables, used then, generated considerable vibration due to bearing and motor deficiences. These vibrations, mechanically transmitted to the pickup cartridge, resulted in an audible output. Hence high-pass filters were often incorporated in amplifiers to reduce this objectionable rumbling sound to an acceptable level, and as bass response seldom extended below 50 Hz, a simple RC filter with 6 dB per octave roll-off below 50 Hz was considered adequate.

Modern turntables have far smoother bearing and drive arrangements than their early counterparts – and for this reason many amplifier manufacturers no longer include a rumble filter facility.

Those that do are rarely satisfactory. Their slope is generally inadequate and the main effect of switching them in is to roll off the low-frequency response to the detriment of programme content.

At first sight it would seem better to exclude the rumble filter altogether and just make sure that our turntables do not generate any appreciable rumble.

Surprisingly perhaps, a rumble filter is still very much required and if designed correctly can make an appreciable improvement to reproduction – even when used with turntables that generate no rumble at all!

The reason why will be clearly apparent if you take the front grille

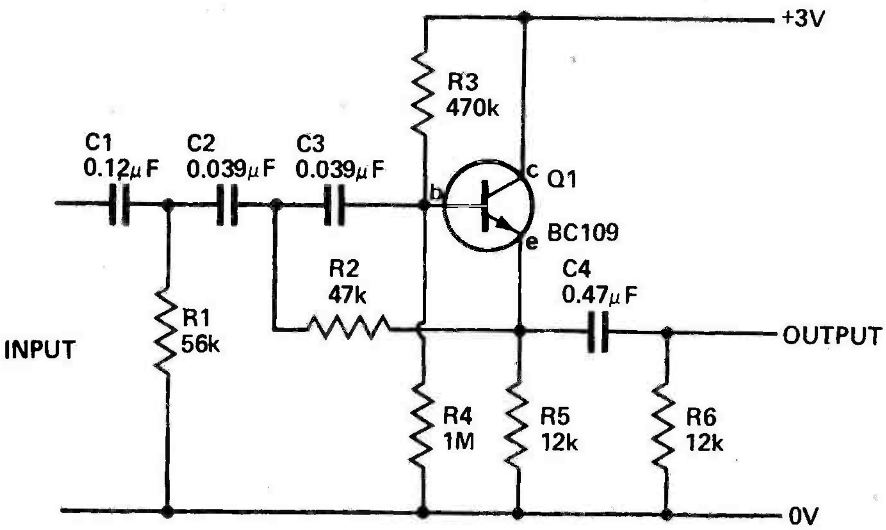


Fig. 1. Circuit diagram of the rumble filter. Two required for stereo.

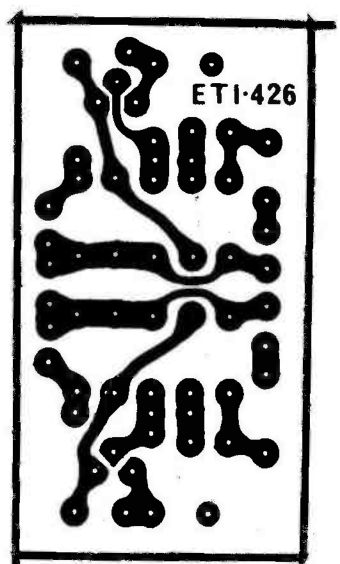


Fig. 2. Printed circuit board layout for the rumble filter 40mm x 70mm.

off one of your speakers and — with the phono-cartridge tracing a section of record that has no recorded content (or very low level content) — turn the volume control up fairly high. You will almost certainly find that the cone of the bass driver is making wild excursions to and fro, probably at frequencies between 5 Hz and 15 Hz.

So it's sub-audible — why then does it matter?

Well it really does — and we'll explain just why later in this article — but first let us consider just where this 5 Hz — 15 Hz content comes from.

Firstly, modern turntables and arms have mechanical resonances lying within the 5-15 Hz region. Secondly, stereo cartridges are sensitive in the vertical as well as horizontal planes and will respond to uneveness in record or turntable surfaces. They will also respond to a defect in the record surface known as pressing rumble.

In addition the noise finds its way onto the record during the actual recording process. This recorded noise is due to LF noise and rumble sometimes being induced in the recording lathe by seismic disturbances, and by vibration in drive gears and cutting head carriage rails.

Lastly vibration of a low frequency nature, due to people walking past the turntable or vehicles passing by outside, may well excite the turntable and arm resonances even though the turntable is reasonably well sprung.

WHY SUB-AUDIBLE NOISE MATTERS

This very low-frequency noise is responsible for a remarkable amount of intermodulation distortion which generally makes the bass sound muddy. In extreme cases it may cause the reproduction to sound as if speaker cone break-up is occurring. The reasons for this are as follows.

Preamplifier stages usually have two or three transistors around which large negative feedback is applied for equalization and/or tone control. At sub-audio frequencies these feedback networks are not generally effective. Thus the LF signals may well receive considerably more amplification in the preamplifier than would normally be expected. Secondly although the magnitude of the LF signal may not itself be sufficient to overload the preamplifier, the combined LF and music signals may well cause the preamplifier to clip. Even if clipping does not occur the LF signal will cause intermodulation distortion despite the fact that the LF signal is inaudible!

Most modern power amplifiers are quite capable of amplifying this noise signal, presenting it to the loudspeaker at a surprisingly high power level. The speaker itself has very little acoustic loading at these low frequencies and the cone will thus move considerably and may even be driven beyond its linear excursion region. Even if not actually overdriven, the presence of such large cone excursions will produce a high level of intermodulation distortion.

Whilst elimination of factors causing the noise is by far the best procedure, a lot of these factors are completely beyond the control of the average hi-fi owner. Hence a rumble filter would, seem to be the obvious answer. But, we do not want to sacrifice any low frequency response and we want signals in the offending 5-15 Hz region to be attenuated as far as possible — two apparently conflicting requirements. In addition, as LF noise cannot be allowed to enter the equalization stages of the preamplifier,

PARTS LIST

R1	Resistor	56k	¼W	5%
R2	"	47k	"	"
R3	"	470k	"	"
R4	"	1M	"	"
R5,6	"	12k	"	"
C1	Capacitor	0.12µF	polyester	
C2,3	"	0.39µF	"	
C4	"	0.47µF	"	
Q1	Transistor	BC109 or similar		

* for stereo 2 off each of the above parts are needed.

PC Board
2 dual phono sockets
2 dual battery holders or one 4 way holder.
4 1.5V batteries.
2 8mm long spacers
1 small aluminium box.

HOW IT WORKS

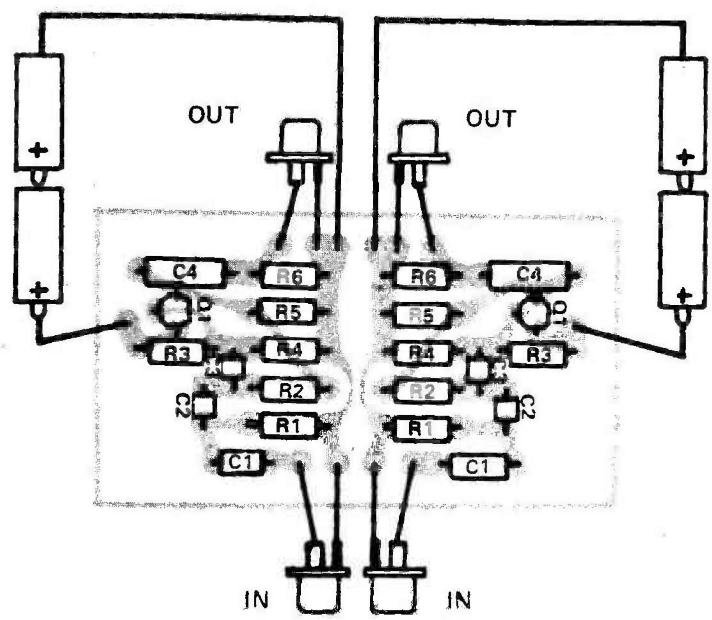
The filter consists of three separate sections:

1. A passive RC filter consisting of R1 and C1.
2. An active filter comprising C2, 3, R2, 3, 4 & 5 and Q1.
3. A passive filter comprising C4 and R6.

The active filter (from input of C2 to output to C4) is a standard design with the exception that values have been selected to give a peak in the response at the cut-off frequency. The maximum lift is about 2 dB and this characteristic, combined with those of the two RC filters, gives a sharp knee to the roll-off. The composite filter has a lift of 0.2 dB before turning over sharply.

Thus low frequency response is maintained substantially flat down to 50 Hz and is only 2 dB down at 40 Hz. Thereafter the response drops very rapidly and is in excess of 30 dB down below 15 Hz where most LF noise occurs.

Current drain of the two filters is only 100 µA and the batteries will last their normal shelf life of about 12 months, thus no power switch is required. Batteries should be replaced annually.



STEREO RUMBLE FILTER

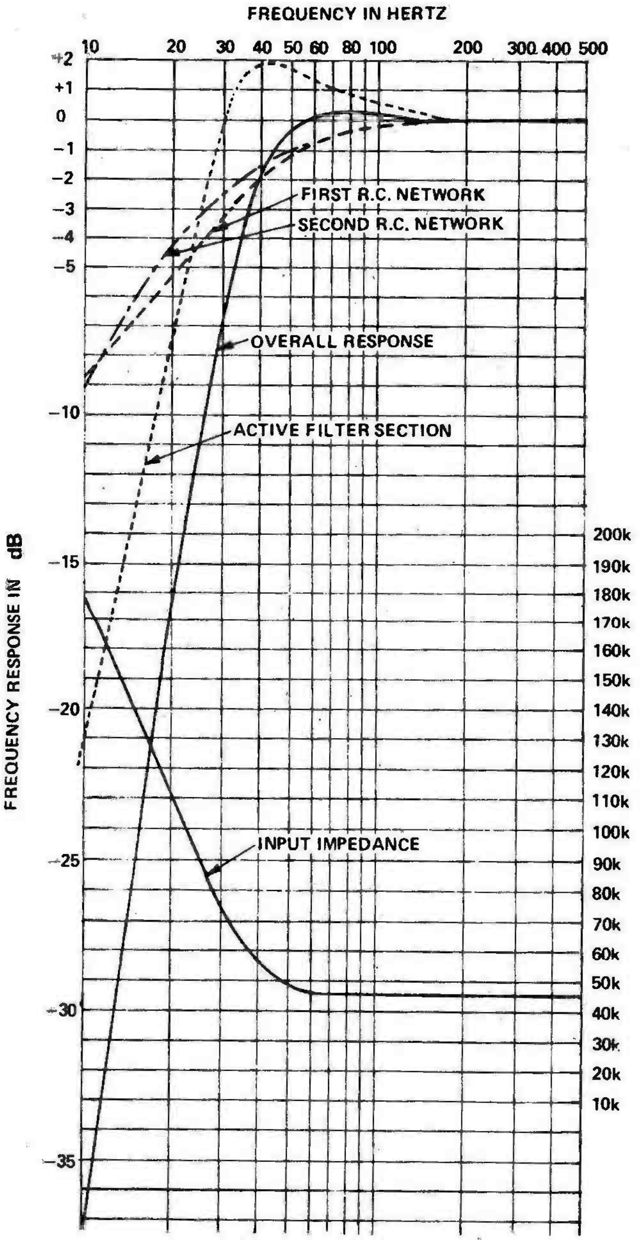
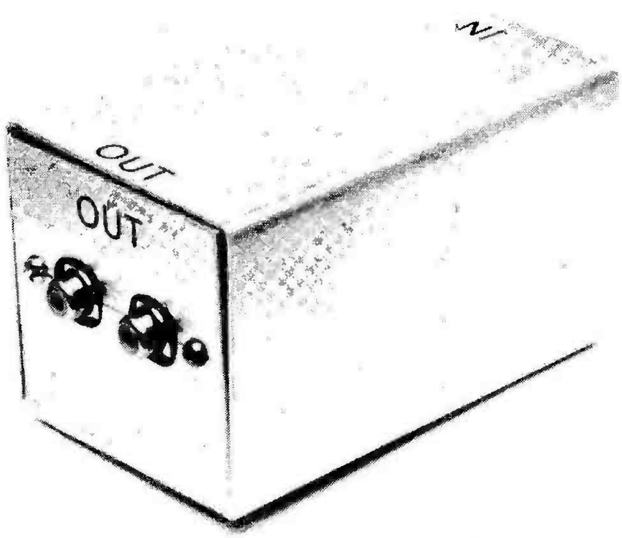


Fig. 4. Characteristics of the rumble filter.



SPECIFICATION	
Input impedance (rises below 50 Hz)	47k
Output Impedance	< 5k
Input voltage (maximum)	250mV
Cut-off Frequency (−3dB)	36 Hz
Cut-off Slope (maximum)	24dB octave
Attenuation at 10 Hz	37 dB
Gain at 1 KHz	0.2 dB

the filter must be situated before the preamplifier. This also poses problems as the signals at this point are very low-level, and there is a danger of introducing hum which would be merely replacing one fault by another.

THE SOLUTION

To maintain response down to at least 50 Hz, whilst obtaining 30 dB or more attenuation to LF noise, we must use a filter which has a sharp knee and an ultimate attenuation slope of 24 dB per octave. The most satisfactory (and cheapest) method of doing this is to use an active high-pass filter — and this is the approach we have used. To obviate the possibility of hum-pickup, the unit uses a battery power supply, one each for left and right channel filters. The use of separate batteries prevents earth loops and ensures that channel separation is maintained. As current drain is very low the batteries may be expected to last their shelf life (12 months or so) and for that reason an on/off switch has not been included.

The unit fits between the turntable and the amplifier, cuts any frequency below 35 Hz and has a total attenuation of 37 dB at 10 Hz increasing at 24 dB/octave below that.

CONSTRUCTION

We built our unit onto a small printed circuit board, but layout is not critical and other alternative methods, such as matrix or Veroboard, may be used successfully.

The signal levels involved are extremely small (about 100 μV at 50 Hz) and for this reason a metal box is a must if hum pickup is to be minimized. And, as said before, two separate battery supplies should be used in order to avoid earth loops. We used a conventional four-way battery holder to hold the two sets of batteries. These holders normally connect all four batteries in series. However it is a simple matter to snip the connection between the two sets of two cells.

The phono sockets for both input and output should be insulated from the metal case. When connecting the unit we found minimum hum was introduced by earthing the turntable to the metal box and then, by taking a separate earth from the metal box to the amplifier. However experimentation in the positioning of earths may well show that some other configuration is best for your particular setup. ●

SIMPLE LOUDHAILER

eti PROJECT

This cheap and simple loudhailer can be built in a few hours

HERE's a simple device to save your voice at sports meetings, large picnics or any other occasion that requires you to raise your voice above the surrounding noise.

It needs a minimum of components, all of which are easily obtainable; it is cheap and can be built in a very short space of time.

THE CIRCUIT

The circuit is shown in Fig. 1. A single transistor (Q1) is arranged as an amplifier with resistor R2 providing the necessary bias. The resistance of the carbon microphone will vary as sound is impressed upon the diaphragm, thus varying the voltage across R1.

Resistor R1 is ac coupled to the base of the transistor Q1. This transistor amplifies the signal and drives the speaker.

CONSTRUCTION

All the minor components are easily mounted on a single tagstrip (as shown in Fig. 2). This tagstrip may be bolted to one wall of the loudhailer enclosure and wiring taken to the microphone, speaker, pushbutton and battery.

Any suitably enclosed box of the right dimensions, may be used to house all the components including the battery and the speaker.

Generally, the larger the speaker the better, but remember this is a loudhailer not a public address system!

The back of the carbon must be enclosed to prevent feedback from the loudspeaker – if this is not done the system will oscillate.

The unit is surprisingly effective – and quality is excellent – despite the bias caused by some dc energization of the loudspeaker voice coil. ●

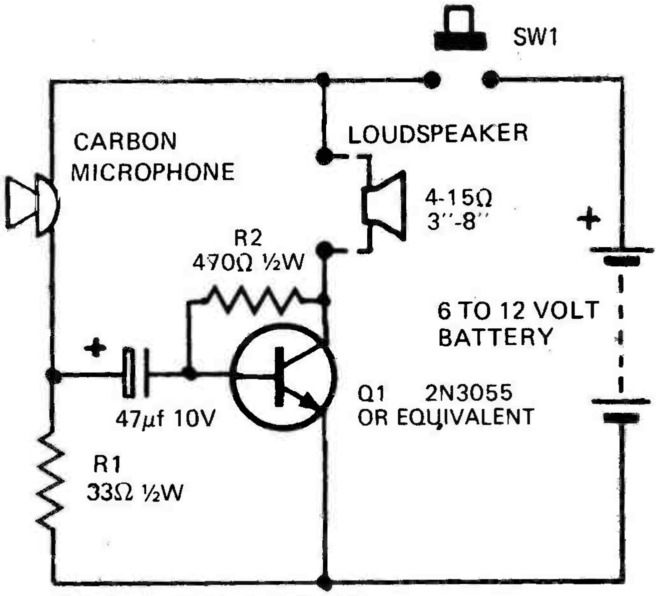


FIG. 1 CIRCUIT DIAGRAM

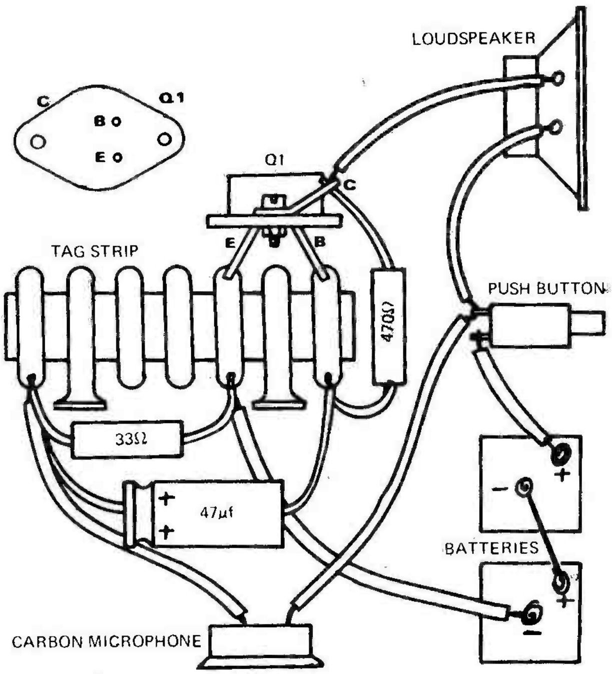
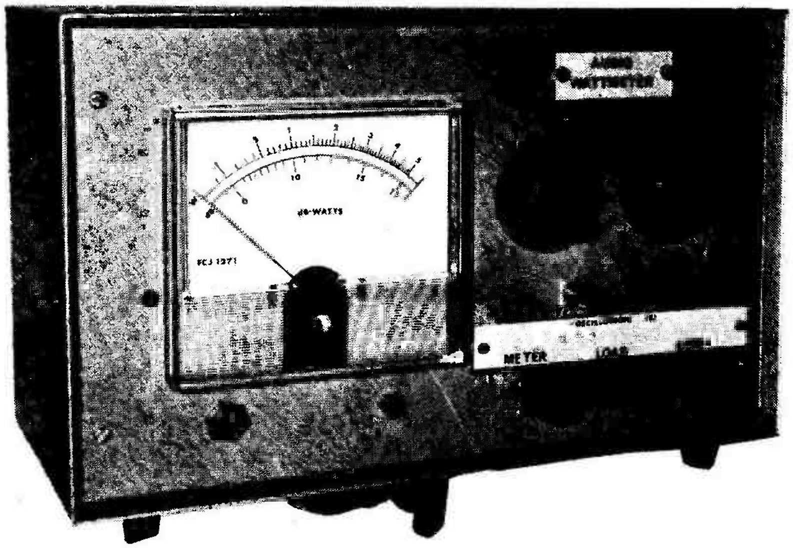


FIG. 2
COMPONENT CONNECTIONS

AUDIO WATTMETER

etiproject



MEASURE AUDIO POWER DIRECTLY WITH THIS INGENIOUS AUDIO PROJECT

THE MOST COMMON method used for checking audio power levels is first to measure the r.m.s. voltage (V) across a given load resistance (R) connected to the amplifier output and from V^2/R obtain the r.m.s. power in watts. Test gear requirements are an audio signal voltmeter that will operate over a frequency range of at least 10 to 100,000 Hz (+1dB), a load resistance of accurately known value and an oscilloscope for monitoring the signal output. The latter is essential for (a) checking that the signal output is not distorted by overloading at the amplifier input stages and (b) for verifying the onset of clipping when measuring maximum r.m.s. output power. If power level differences are to be expressed in decibels, when plotting power bandwidth for example, then the ratios must be connected by 10 log10 P2/P1 (or by a decibel coversion table or chart).

The advantage of a direct reading audio wattmeter is that instant power readings in watts (r.m.s.) and level differences in decibels can be obtained at any frequency within the normal audio range. This facility is particularly useful for example, when carrying out total harmonic distortion checks at different power levels and frequencies. An instrument of this nature could be particularly advantageous in a busy service department dealing mainly with amplifiers of various kinds and to those who like the writer, are frequently engaged in testing hi-fi amplifiers and the like for performance to manufacturer's specifications.

The audio wattmeter described here was designed and constructed expressly for checking the r.m.s. power output of amplifiers operating into standard loudspeaker loads of 4, 8 and 15 ohms. Three power ranges are provided, 0 to 0.5W, 0 to 5W and 0 to 50W with minimum levels on each range of 0.01 0.1 and 1W respectively. The lowest level that the meter is capable of indicating with reasonable accuracy is 0.01W (10 milliwatts). Absolute maximum on the 0 - 50W range is 56 watts for the meter f.s.d. The audio frequency range of the meter is 10 to 200,000Hz ± 1dB. The 4, 8 and 15 ohm load resistors are incorporated within the meter but note that the meter will not indicate true wattage readings with loads of values other than 4, 8 or 15 ohms.

THE CIRCUIT

The meter circuit is shown in Fig. 1 and consists simply of the dummy load resistors R1, R2 and R3, the attenuation and correction networks RV1 to RV6 and the two stage audio voltmeter Q1-Q2. The input impedance to the meter circuit is never less than 1[illegible]k ohms, the value of R4, and imposes no load on the dummy load resistors R1, R2 and R3. From R4 signals are fed via RV1, RV2 or RV3 which provide signal level correction according to the dummy load in use. For instance 20W into 8 ohms will produce a lower r.m.s. voltage than 20W into 15 ohms, so correction must be provided in order that one wattage scale only can be used on the meter itself.

The pre-sets RV4, RV5 and RV6 set the wattage ranges to either 0 to 0.5, 0 to 5 or 0 to 50W, the signals across these being taken to the meter amplifier Q1-Q2. The meter operates from a bridge rectifier D1 to D4 with negative feedback applied via RV7 to ensure a uniform frequency response, from 10 to 200,000Hz, and also to set the initial sensitivity of the meter amplifier. The meter circuit is powered from a 24V stabilised supply, the circuit of which is shown in Fig. 2.

CONSTRUCTION

The prototype, as shown in the photos was housed in a mild steel case with louvres in the base and rear (Home Radio type BX5 12¼ x 7½ x 5½ins). If any other, ready made or home made, case is used it must have holes or louvres in the base and rear to allow air circulation around the dummy load

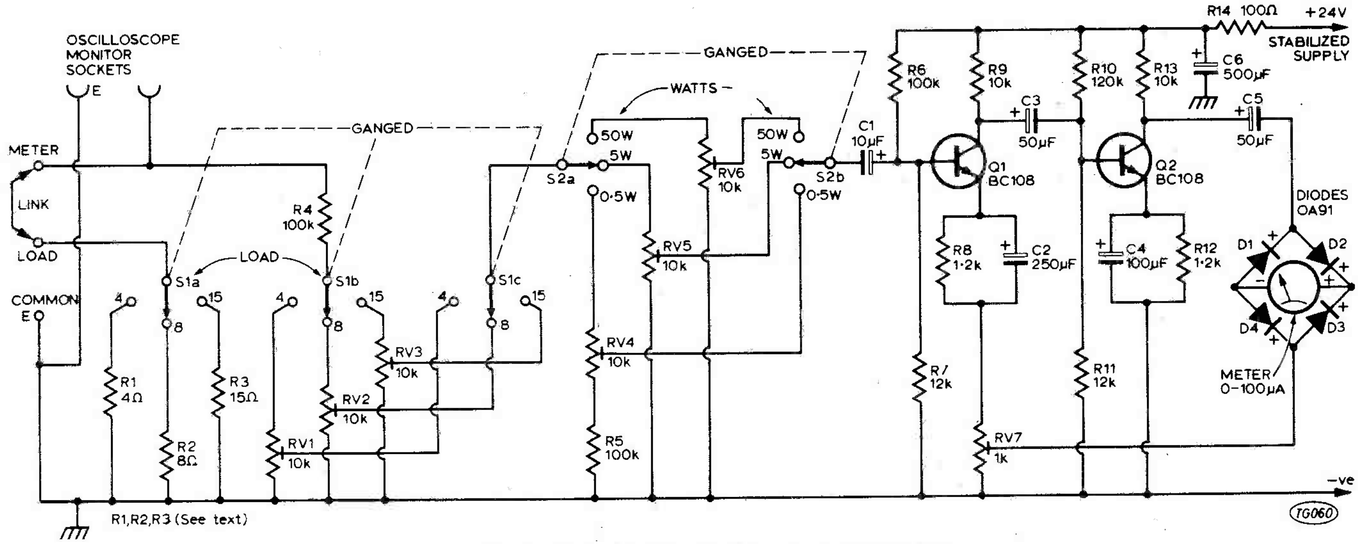


Fig. 1. Complete circuit of the Audio Wattmeter.

resistors. Details for the panel layout are given in Fig. 3a and for the chassis in Fig. 4. The chassis is attached to the front panel as in Fig. 3b.

There are four circuit boards, one for the power supply, one for the meter amplifier, one for the meter rectifier and one for the pre-sets RV1 to RV6. Details for these are given in Figs. 5, 6 7 and 8. The two larger boards, meter amplifier and power supply, are mounted on the chassis on stand-off pillars in the positions shown in Fig. 9. The pre-sets board is mounted upright on a piece of aluminium angle and the meter rectifier board is secured under the meter terminals (see also Fig.5).

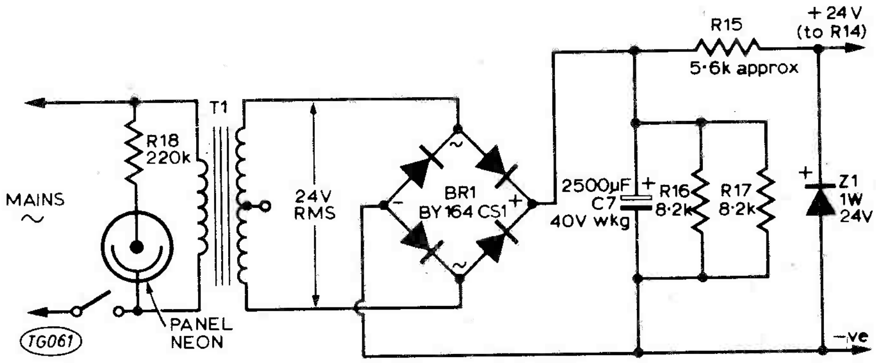


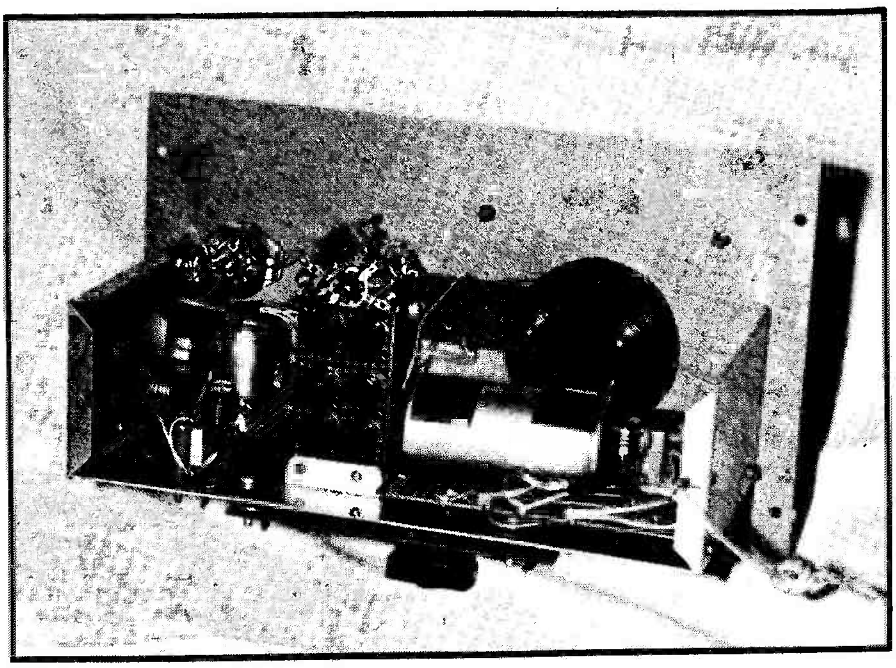
Fig. 2. Power supply circuit.

THE DUMMY LOADS

These must be accurate to within about one tenth of an ohm, if the meter itself is to give accurate readings. The load resistors are made from spiral electric fire elements rated for 1,000 watts and which can be purchased readily from electrical goods retailers. The frame for the resistors is made from paxolin (not less than 1/16th in. thick) as shown in Fig. 10a. The 4 ohm load is made from three lengths of spiral element connected in parallel as in Fig. 10b.

Each length is approximately 11 ohms but the best way of being sure to obtain the right amount in each piece and then arrive at the final 4 ohms, is to cut three pieces each of say 12 ohms. Join them in parallel on the frame as in Fig. 10c and trim each piece by a turn or two of the spiral at a time until exactly 4 ohms is obtained. The preliminary cutting can be done with the ohms range on an ordinary multimeter but the final adjustment must be done by measuring voltage and current with accurate meters.

A supply voltage can be obtained from a transformer capable of delivering say 6V at 1A or by tapping a car battery. The test set up is as shown in


Rear view of the prototype. Various sub-assemblies can be seen though the load resistors are hidden underneath.

PARTS LIST

R1	Resistor	made from 1000W electric		
R2	''	fire spiral element (2 required)		
R3	''	See text		
R4	''	100k	5%	¼W
R5	''	100k	''	''
R6	''	100k	''	''
R7	''	12k	''	''
R8	''	1.2k	''	''
R9	''	10k	''	''
R10	''	120k	''	''
R11	''	12k	''	''
R12	''	1.2k	''	''
R13	''	10k	''	''
R14	''	100ohms	''	''
R15	''	5.6k	''	''
R16	''	8.2k	''	''
R17	''	8.2k	''	''
R18	''	220k	''	''
C1	Capacitor	10uF	25V min. electrolytic	
C2	''	250uF	''	
C3	''	50uF	''	
C4	''	100uF	''	
C5	''	50uF	''	
C6	''	500uF	''	
C7	''	2,500uF	40V min. electrolytic	
RV1	Miniature Pre-sets		10k	
RV2	''		''	
RV3	''		''	
RV4	''		''	
RV5	''		''	
RV6	''		''	
RV7	''		1k	
D1	Diode		OA91	
D2	''		''	
D3	''		''	
D4	''		''	
Z1	Zener Diode		24V, 1W	
Q1	Transistor		BC 108	
Q2	''		BC 108	
S1	Switches		3 pole 3 way	
S2	''		2 pole 3 way	
BR1	Rectifier		BY164	
T1	Transformer	Primary 230V; Secondary 12V + 12V, 50mA (Eagle MT12)		

Meter 0 - 100uA f.s.d.; Anders KM118

Case 12¼ x 7½ x 5½ ins. (BX5, Home Radio)

On/off Swtich; mains panel neon; 2 pointer knobs; 3 insulated panel terminals; 2 insulated sockets; four 0.15 in. matrix circuit boards (1 x 3¾ in., 3 x 1½ in., 5 x 3¼ in., 4 x 3 in.); Aluminium sheet (16 s.w.g.), 16¼ x 4¾ in. for chassis, 2 x ½ in. for link; Aluminium angle, 3/8 x 3/8 in. (2 pieces, 3 in. long and one 1½ in.); Paxolin sheet 5 x 3 3/4 x 1/16 in; 4 stand-off pillars.

Needed in setting up

For load resistors: 6V, 1A supply; meters for 1A and 6V; 20 ohm, 1A variable resistor (see text)

For Calibration: Signal Generator; Audio millivoltmeter.

Fig. 11 and requires a heavy duty variable resistor in addition to the voltage supply and meters. The 4 ohm load resistor (R1) can be adjusted for true value with a current of say 0.5A at 2V. Do not use higher voltage and hence higher current, as the resistor will heat and give a false value. Even at 0.5A some heat will be produced but not enough to effect the readings. If a heavy duty variable resistor is not available a temporary one can be made from about 6 inches of spiral element (as used for the loads) and a couple of crocodile clips. The 8 ohm load (R2) is adjusted the same way but this time with 0.25A (250mA) at 2V and the 15 ohm load (R3) with say 0.2A (200mA) at 3V.

Considerable care must be taken over this operation as the accuracy of the meter depends on it. The resistors are arranged on the frame as in Fig. 10c and the frame is finally mounted spaced off by about half inch on the underside of the chassis as shown in Fig. 12. Note that leads from the load resistors con-

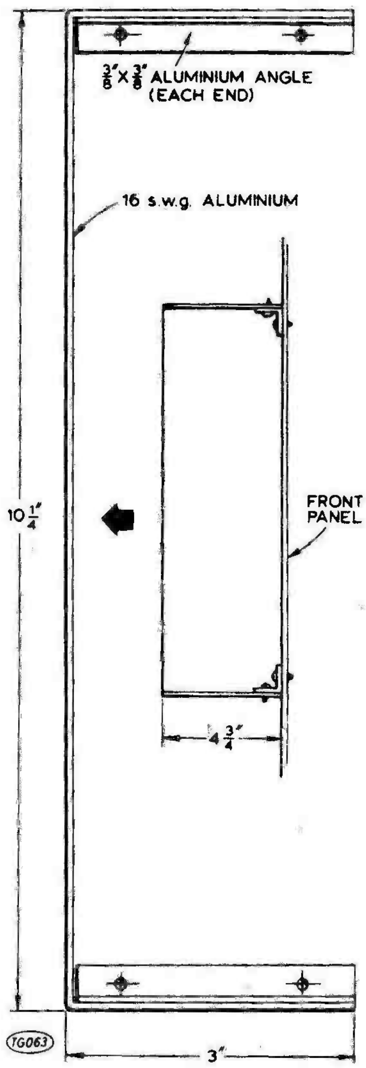
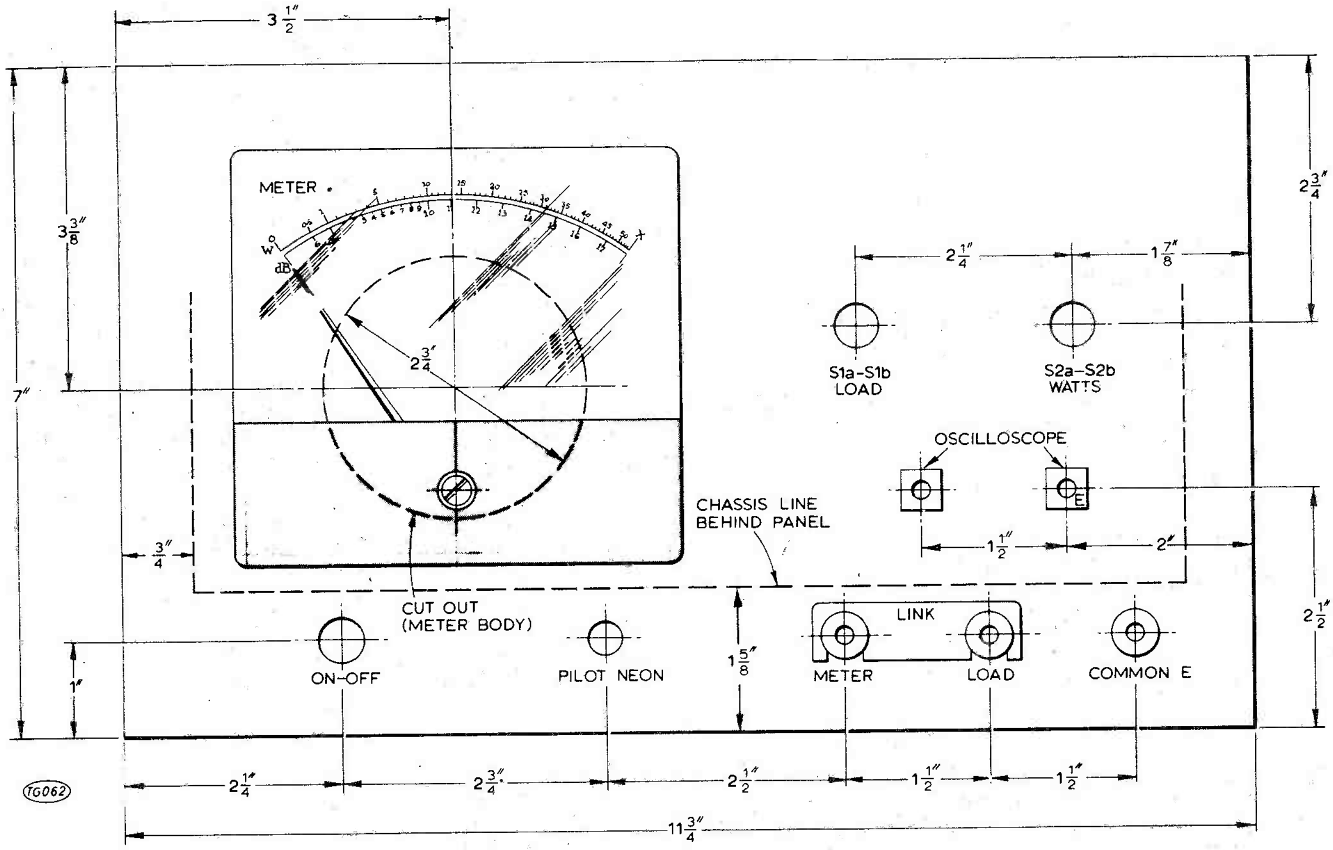


Fig. 4a) Details of the chassis.
b) How the chassis is bolted to the front panel.



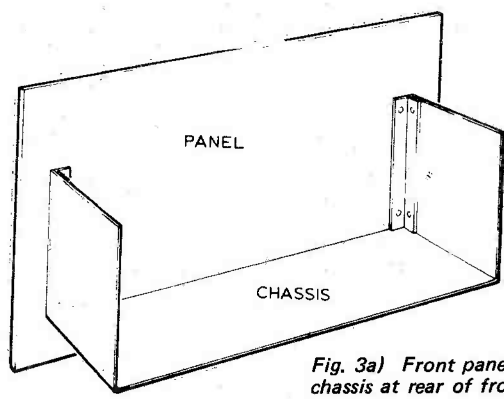


Fig. 3a) Front panel layout and drilling details. b) Position of chassis at rear of front panel.

necting to the load input terminal and to S1A should be heavy flex or 18 s.w.g. covered wire.

THE METER

The meter used for the prototype shown in the photos was an Anders type KM118 0-100uA f.s.d. The meter scale can easily be removed for re-calibration in watts and decibels to the scale given in Fig. 12. The figures on the meter scale will come off with an ordinary India rubber leaving a plain white surface. The new scale, which is suitable only for the meter specified, can be drawn on with Indian ink and the figures transferred from Letraset. Again accuracy is important and great care must be taken to avoid damage to the meter movement and the pointer.

CALIBRATION

The new meter scale must be drawn on and the meter itself connected in cir-

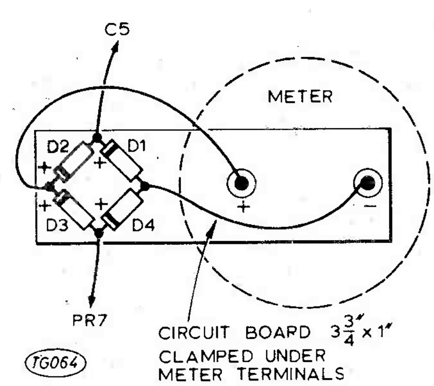
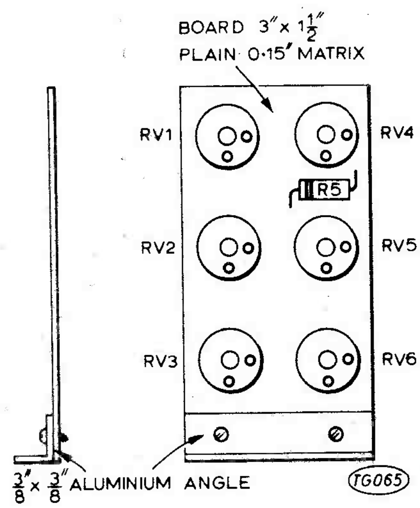


Fig. 5 (above). D1-D4 are fitted to a board which mounts on the meter terminals.

Fig. 6 (right). Circuit board for the presets.



AUDIO WATTMETER

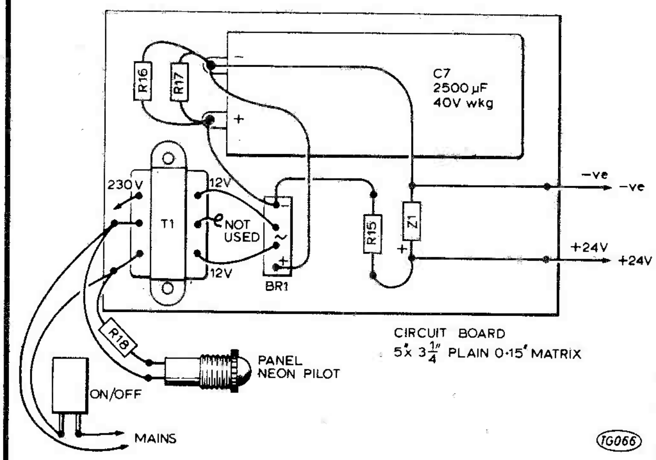


Fig. 7. Layout of the power supply board.

cuit. A signal generator (sine-wave) capable of 10V r.m.s. output and an audio millivolt meter are required for the adjustment of the attenuator presets RV1 to RV6 and the feedback control RV7.

The signal generator is used at 1,000 Hz and is connected to the input of the meter amplifier at C1 and with the lead between C1 and S2b common disconnected. The audio millivolt meter is

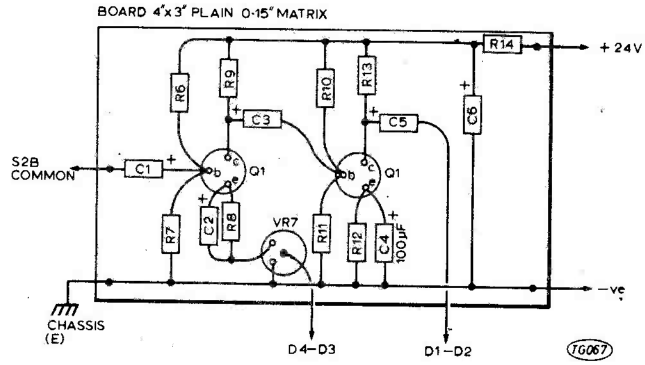


Fig. 8. Layout and wiring of the meter amplifier.

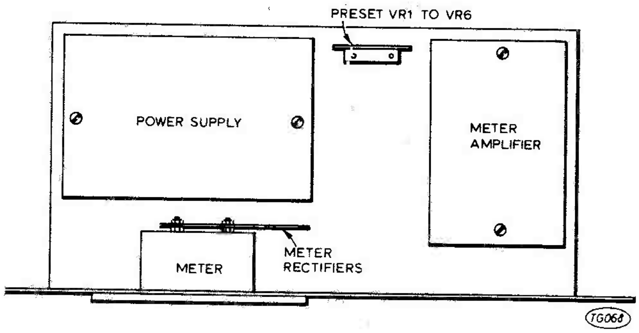


Fig. 9. Layout of circuit boards on the chassis.

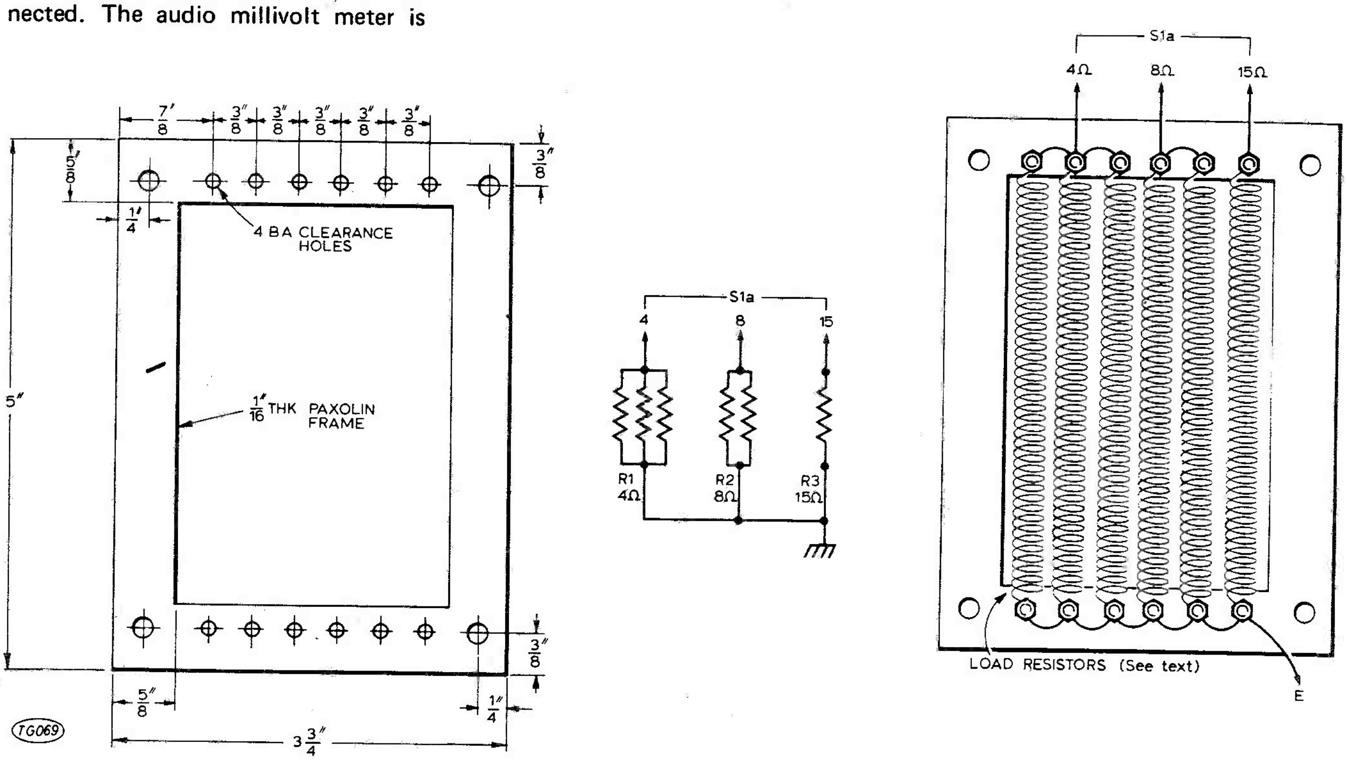


Fig. 10a). Frame for the dummy loads R1, R2, R3. b). The circuit of the dummy loads. c). Assembly of dummy load resistors on the frame.

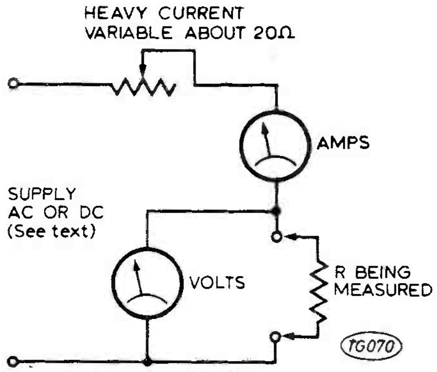


Fig. 11. Measuring set up for determining values of the dummy load resistors.

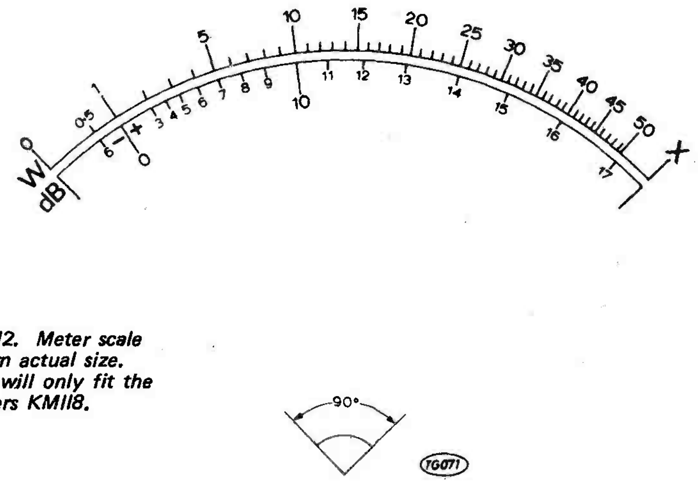


Fig. 12. Meter scale shown actual size. This will only fit the Anders KM118.

connected across the output from the generator, i.e. between C1 and earth. Set the generator to provide exactly 50 millivolts output and adjust RV7 to obtain full scale reading on the power level meter, that is to point X, Fig.12. At this stage the meter amplifier can be checked for frequency response by keeping the generator output constant at 50mV and running through the frequency range from about 10 or 20Hz to at least 10,000Hz.

Now reconnect C1 to S2b common and disconnect the common of S2a from S1c. Couple the audio generator, with the audio millivolt meter in parallel, to the common of S2a. Set S2a to the 50W range and adjust RV6 to obtain meter f.s.d. (to point X) from a 600mV signal from the generator (all these tests are at 1000Hz). Now set S2a to the 5W range and adjust RV5 to obtain meter f.s.d. (to point X) from 180mV signal from the generator. Finally, set S2a to the 0.5W range and adjust RV4 to obtain meter f.s.d. (to point X) from 68mV input. Again accuracy is important.

Reconnect the common of S2a with S1c. Couple the audio generator with the audio millivolt meter in parallel between the main input terminal marked 'METER' and the common E terminal. The "link" to the loads must be disconnected. Set S2 to the 5W range and S1 to 15 ohms. Adjust RV3 to obtain a meter reading of 5W with a signal input (at 1,000Hz) of 8.66V. Check with S2 on the 50 watt range to obtain meter reading of 5W.

Reset S2 to the 5W range and S1 to 8 ohms. Adjust RV2 to obtain meter reading of 5W with a signal input of 6.32V. Check with S2 on the 50W range to obtain reading of 5W.

Reset S2 to the 5W range and S1 to 4 ohms. Adjust RV1 obtain meter reading of 5W with 4.47V input signal. Check with S2 on the 50W range to obtain a meter reading of 5W.

TABLES FOR CHECKING CALIBRATION

Range 1, 0 to 0.5W $V = \sqrt{P_O \times R}$

Power level watts	4 ohms (volts)	8 ohms (volts)	15 ohms (volts)
0.5	1.414	2.00	2.739
0.4	1.265	1.789	2.449
0.3	1.095	1.599	2.121
0.2	0.894	1.265	1.732
0.1	0.632	0.894	1.224
0.05	0.447	0.632	0.866
0.01 (0dB)	0.200	0.282	0.383

Range 2, 0 to 5W $V = \sqrt{P_O \times R}$

Power level watts	4 ohms (volts)	8 ohms (volts)	15 ohms (volts)
5	4.472	6.325	8.660
4	4.00	5.657	7.746
3	3.464	4.899	6.708
2	2.828	4.00	5.477
1	2.00	2.828	3.873
0.5	1.414	2.00	2.739
0.1 (0dB)	0.632	0.894	1.224

Range 3, 0 to 50W $V = \sqrt{P_O \times R}$

Power level watts	4 ohms (volts)	8 ohms (volts)	15 ohms (volts)
50	14.142	20	27.386
40	12.649	17.889	24.495
30	10.954	15.492	21.213
20	8.944	12.649	17.321
10	6.325	8.944	12.247
5	4.472	6.325	8.660
1 (0dB)	2.00	2.828	3.837

AUDIO WATTMETER

Some further checks can be made as follows:—
Set S2 to 0.5W range and S1 to 15 ohms. With the audio generator at 2.73V output the power level meter should read 0.5W. Now set S1 to 8 ohms and the audio generator to 2.0V in which case the power level meter should again read 0.5W.

Providing all the pre-sets have been adjusted as already described the calibration for different power levels and for the three load ranges of 4, 8 and 15 ohms can be checked simply by coupling known audio signals into the meter circuit via the 'METER' terminal on the front panel and common E. The load link must be disconnected. The tables provide a number of spot checks for various power levels and for each of the three load values.

It will be seen that the tables have been worked out from $V=\sqrt{P_0 \times R}$ to three decimal places. In practice, meter readings to this accuracy are almost impossible but if readings to one decimal place only can be achieved, then providing everything else has been adjusted to the same degree, the audio wattmeter will be accurate enough for all practical purposes. The interior of the finished prototype is shown in the photograph.

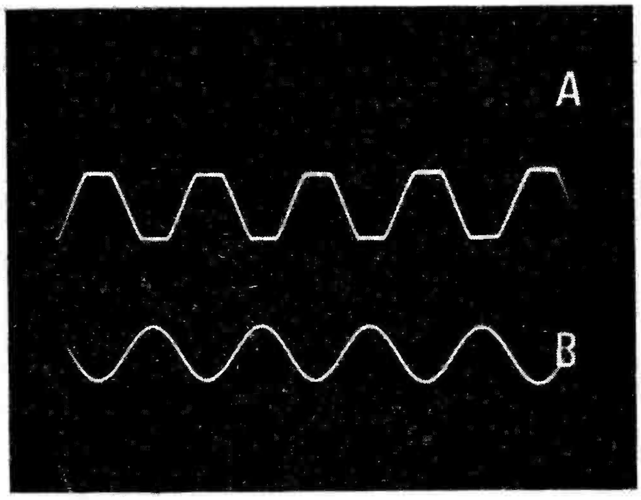
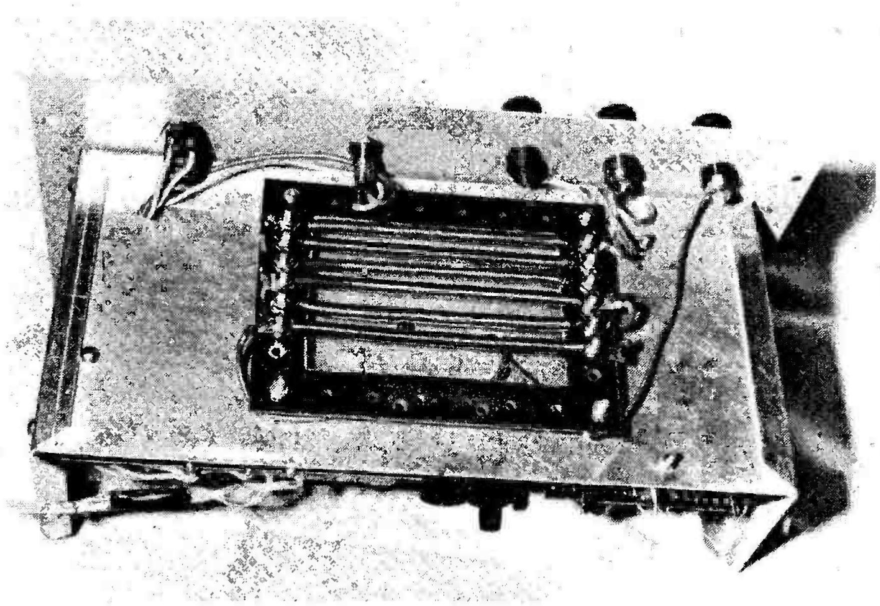


Fig. 13. A) Clipped output B) Sine wave at maximum power, just before clipping.


The dummy load resistors mounted under the chassis.

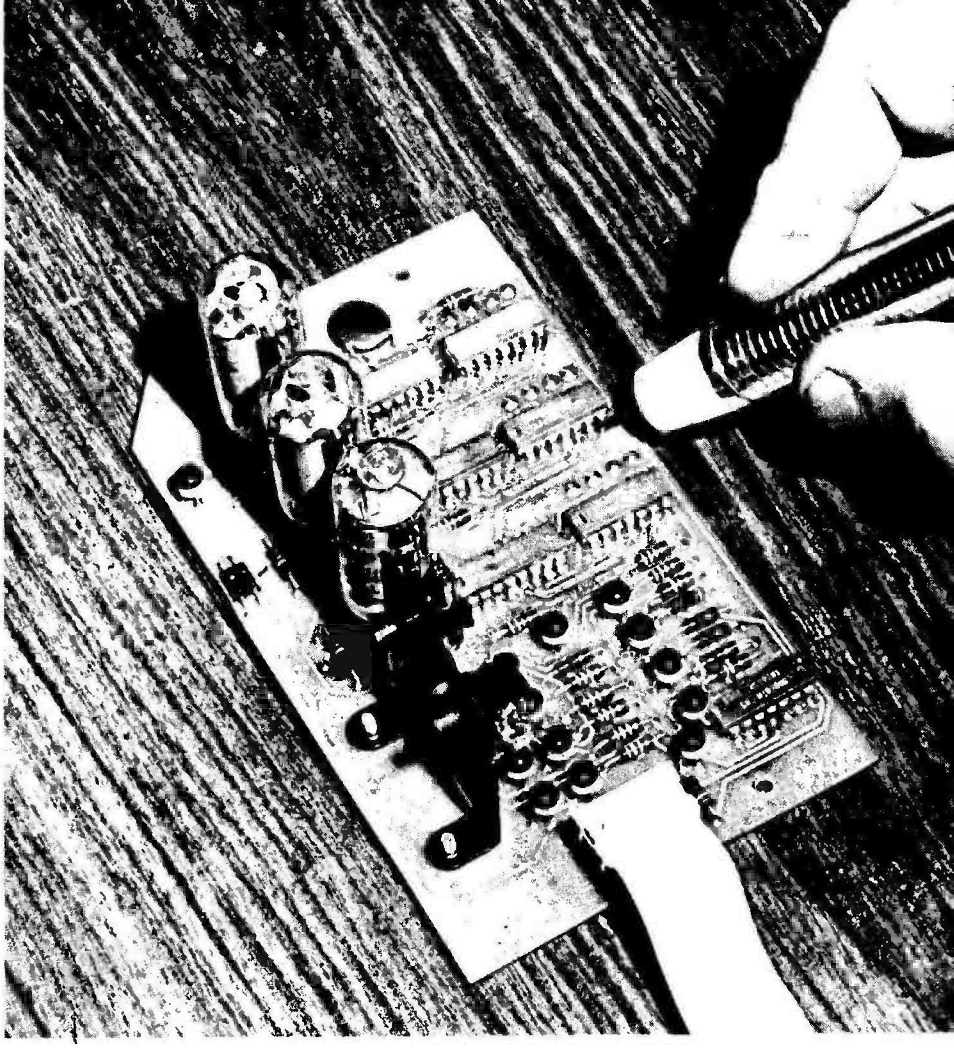
IN OPERATION

The prototype was finally checked against laboratory standard instruments and found to have a high degree of accuracy. The loads of 4, 8 and 15 ohms were chosen because these are more or less standard. The load ranges and even the power ranges could be extended with additional attenuators and correction networks. In operation the load resistors will run warm at high power levels but these should not be sustained for longer than is necessary to take a reading. The loads have no inductive effects and the material used for them was chosen because it is readily available and fairly cheap. High wattage load resistors of precise values are difficult to obtain and the one or two firms who do manufacture them were not prepared to supply other than *bona-fide* trade users. In any case they were very expensive.

When a meter of this nature is used it is essential to know when the maximum output of an amplifier has been reached, i.e. at the point just before clipping occurs. It is for this reason that an oscilloscope monitoring point has been included to check the waveform across the load. Maximum power output must always be checked with an oscilloscope monitor and the usual procedure is to set the amplifier gain control at maximum and then bring up the input signal (sine wave) to the point at which clipping occurs as on the upper trace in Fig. 13a. The input signal is then reduced until clipping just ceases and the amplifier output signal resolves into a sine-wave as in the lower trace Fig. 13b. Even at lower power levels, i.e. well below maximum power output, a check should always be made on the amplifier output waveform as clipping can occur at amplifier input stages if the input signal is too high. *Do not connect the power meter to an amplifier unless the load link is connected between the 'METER' terminal and the "LOAD" terminal.* This link may be a piece of wire or a thin plate with slots to fit under the terminals as shown in Fig. 3b. Finally please note that the decibel scale is for power dB related to 10 $\mathrm{Log}_{10}P2/P1$. ●

LOGIC PROBE

This probe provides visual indication of the logic state at any point in a circuit using digital ICs. Capable of detecting pulses as short as 50 nanoseconds, it is an invaluable tool for trouble-shooting and prototype development.



DIGITAL integrated circuits are being increasingly used by both professionals and amateurs, and a number of projects using digital ICs have been published in ETI.

The first of these projects is a logic probe designed to meet the needs of both professional engineers and amateur experimenters. It is not a toy.

The probe will work with all commonly used logic systems, including:

RTL (resistor-transistor logic).
DTL (diode-transistor logic).
TTL (transistor-transistor logic).

The logic probe may also be used with equipment using discrete components (such as pulse amplifiers and relay drivers).

The probe will indicate any of five conditions:

(1) Steady positive voltage.
(2) Steady ground potential.
(3) Single fast positive pulse.
(4) Single fast negative pulse.
(5) A pulse train with a frequency not exceeding 10 MHz.

As the probe must detect pulses as short as 50 nanoseconds, a monostable multivibrator is used as a pulse extender to provide indication times of 100 milliseconds. Separate monostables are used for positive and negative going pulses.

The necessary monostable and inverting functions required to meet conditions (1), (2), (3) and (4) are provided by interconnecting the gates of the quad two-input nand gate G1, 2, 3, 4.

CIRCUIT OPERATION

(a) Input Buffer

The input buffer consists of diodes D1, D2 and D3, resistors R1, R2 and R3, and transistor Q1.

With an open circuit on the probe, current flows through R1, D3 and R2, thus providing approximately 4 Volts bias on the base of Q1 which is switched into conduction. This results in a high level at point B (logical 1 at the 7400 gate input 2.

If, on the other hand, the probe is connected to a positive voltage greater than 2 Volts, diodes D1 and D2 block the flow of current to D3 and the subsequent operation is the same as for an open circuit on the probe.

If the probe is connected to ground potential, current flows through R1 whilst the forward voltage drops of D1 and D2 bias point A at approximately 1.2 Volts. This voltage is further divided by D3 and R2, and results in a negligible voltage on the base of Q1 which is consequently switched off. Point B is thus at ground potential and R3 'sinks' the current from the input gate of IC1, resulting in a logical 0 at the input.

When used to detect pulses, the operation is the same as that described above: a positive going pulse produces logical 1, whilst a negative going pulse provides logical 0. The limit of operation is approx. 20 MHz.

(b) Monostable/Inverter

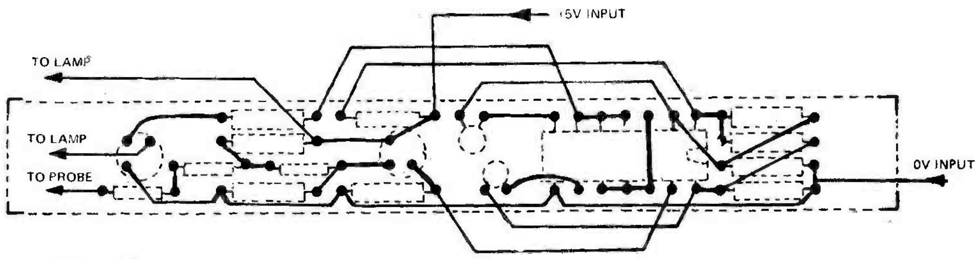
This stage is built around IC1, which is a quad two-input nand gate. As shown in Fig. 1, two gates are interconnected to form a monostable multivibrator. The remaining two gates are likewise interconnected, and the output of the first pair of gates becomes the input of the second pair.

(c) Steady Positive Voltage

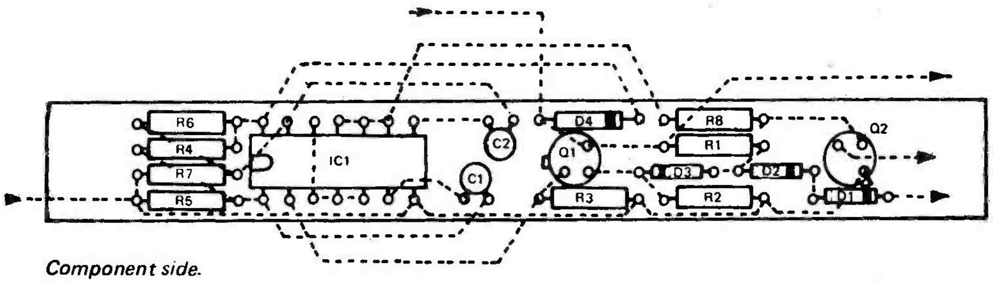
When the probe becomes positive, point B becomes 1. This is inverted to 0 at point C and again inverted to 1 at point D. This logical 1 is applied to the base of transistor Q2 which is switched into conduction, illuminating the indicator lamp.

(d) Positive Pulse

The logical 1 appearing at the output of gate G3 is applied to the input of gate G4, and these two gates now act as a monostable multivibrator because



Wiring side.



Component side.

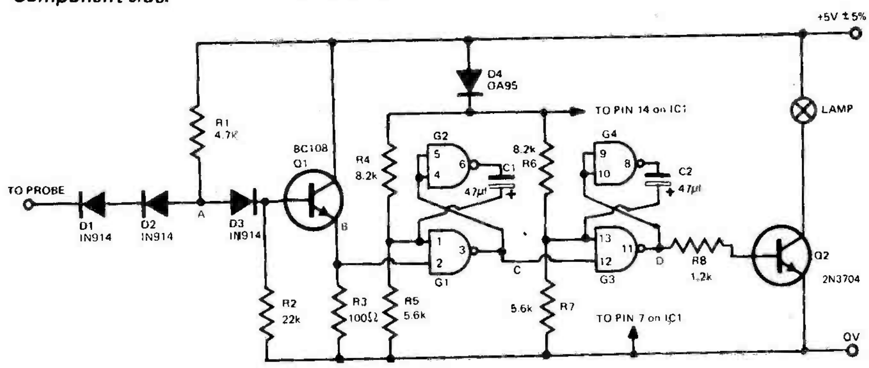


Fig. 1. Circuit diagram of complete unit.

the output G4 becomes 0 and capacitor C2 starts charging through R6/R7 potential divider.

During this charging period the second input of G1 is held at 0 and, even if output C changes to 1, the output of G3 will be 1. Thus a fast positive pulse at the probe input will be sensed and extended to illuminate the indicator lamp for 100 milliseconds.

(e) Steady Ground

A grounded probe produces 0 at point B. The 0 is inverted by G1, resulting in 1 at point C and, hence, 1 at the inputs of G2. The output of G2 is 0 and C1 is discharged. The output at point C is also fed through G3, which inverts it to produce 0 at point D, extinguishing the indicator lamp.

(f) Negative Pulse

When the probe is at positive potential and senses a negative going pulse, the operation is as follows:

Before the negative going pulse arrives, point B is at logical 1; this is inverted to 0 at point C and again inverted to logical 1 at point D, thus causing the indicator lamp to be illuminated. As soon as a negative pulse arrives, B goes to logical 0, resulting in 1 at C; this is again inverted by G3 and the output appears as logical 0 at point D, thus causing the lamp to be extinguished. At the same time the logical 1 is applied to the inputs of G2. G1 and G2 now form a monostable multivibrator ensuring that the lamp remains off for 100 milliseconds.

(g) Pulse Train

A pulse train will cause the monostable vibrators to cycle continuously, thus causing the indicator lamp to glow at reduced brightness.

Lamp Driver

The lamp driver stage consists of R8, Q2, and the indicator lamp. When a logical 1 appears at point D current flows through R8, causing Q2 to conduct and thus energizing the indicator lamp. A logical 0 appearing at point D will cause the transistor Q2 to be biased off and the lamp will be extinguished.

SPECIFICATIONS

Supply voltage	5 Volts dc ± 5%
Input voltage (high input)	> 2.4 Volts
Input voltage (low input)	< 0.8 Volts
Indication — steady positive	lamp on
Indication — steady ground	lamp off
Indication — fast positive pulse	lamp flashes on
Indication — fast negative pulse	lamp flashes off
Indication — pulse train	lamp glows less brightly
Minimum detectable pulse width	50 nanoseconds
Extended indication of lamp	100 milliseconds

CONSTRUCTIONAL DETAILS

A pen torch case makes an ideal housing for the probe. We used an Eveready unit that has a translucent lamp surround.

A small nail glued into the translucent end serves as the probe (remember to solder a wire to the end of the nail before glueing it into position). With the probe in place, the translucent tip will glow due to the light diffusing from the indicator lamp mounted directly behind it.

Pen torches vary in their methods of construction, but in most cases the switch mechanism will have to be removed. If the Eveready torch case is used, the switch is removed by drilling out the retaining rivet located behind the small label on the end of the unit.

For our prototype we mounted the components on a piece of phenolic resin board (0.1" hole centres).

A printed circuit board may be used, but point-to-point wiring is considerably easier. If the conventional components specified in the parts list are used, the finished product will fit easily into the torch case.

It is advisable to wrap some insulating material around the component board before inserting it into the torch body.

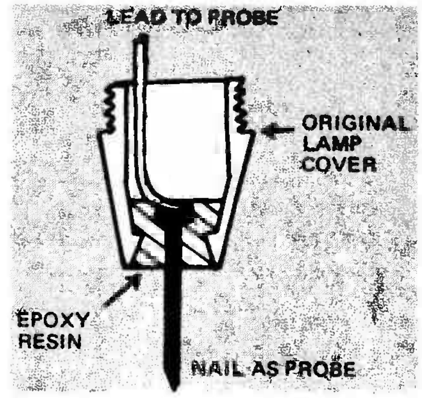
TESTING

Check the wiring carefully and connect the probe to a 5 Volt dc supply. The lamp should glow immediately. If it does not, recheck the wiring and measure the voltage at points B, C and D after referring to the circuit description.

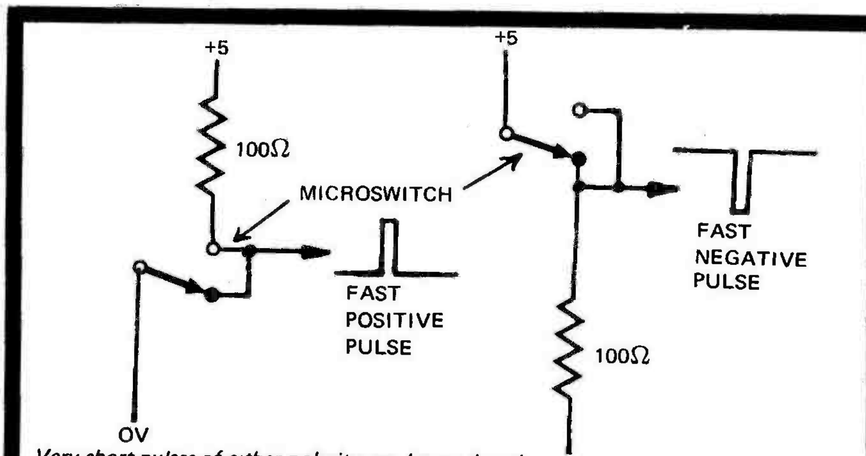
Next touch the probe onto a point that is at ground potential. The lamp should extinguish. If it does not, check the voltages at points B, C and D as above.

A source of fast pulses is required to check that the monostable stages are working. If a pulse generator is not available, the probe can be tested by connecting it to the common connection of a microswitch. When the microswitch is operated, the contacts momentarily open circuit and produce a very short pulse across the probe.

If all tests prove satisfactory, the probe is ready for use. ●



Probe tip, solder a lead to the nail before glueing into position.

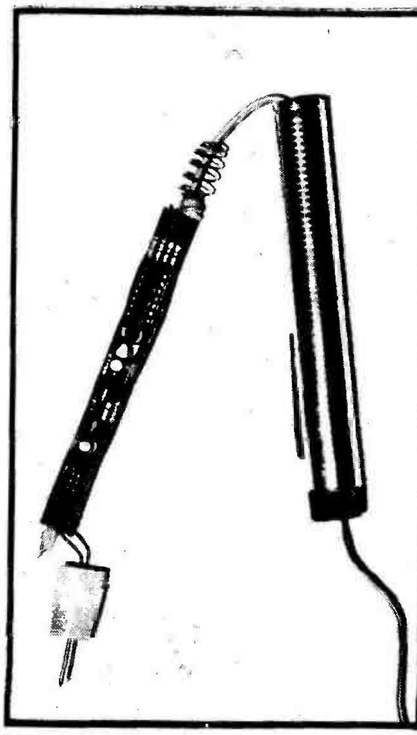


Very short pulses of either polarity can be produced by connecting the probe to a microswitch. (see text).

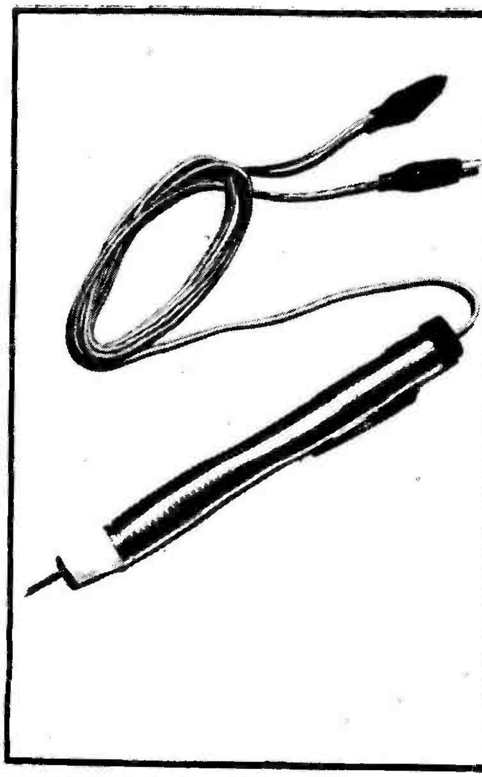
PARTS LIST

R1	–	resistor 4.7k ¼ watt 5%
R2	–	" 22k " " "
R3	–	" 100Ω " " "
R4, R6	–	" 8.2k " " "
R5, R7	–	" 5.6k " " "
R8	–	" 1.2k " " "
D1,2,3	–	diodes type 1N 914 (or equivalent)
D4	–	diode OA 95
C1, C2	–	tantalum tag capacitor 47μF, 6.3 volt
Q1	–	transistor, BC108
Q2	–	" 2N3704
IC1	–	integrated circuit 7400*
Lamp	–	6V 100MA

Matrix Board
Pen torch (see text)
*Note – the prefix for the 7400 series IC depends on the manufacturer

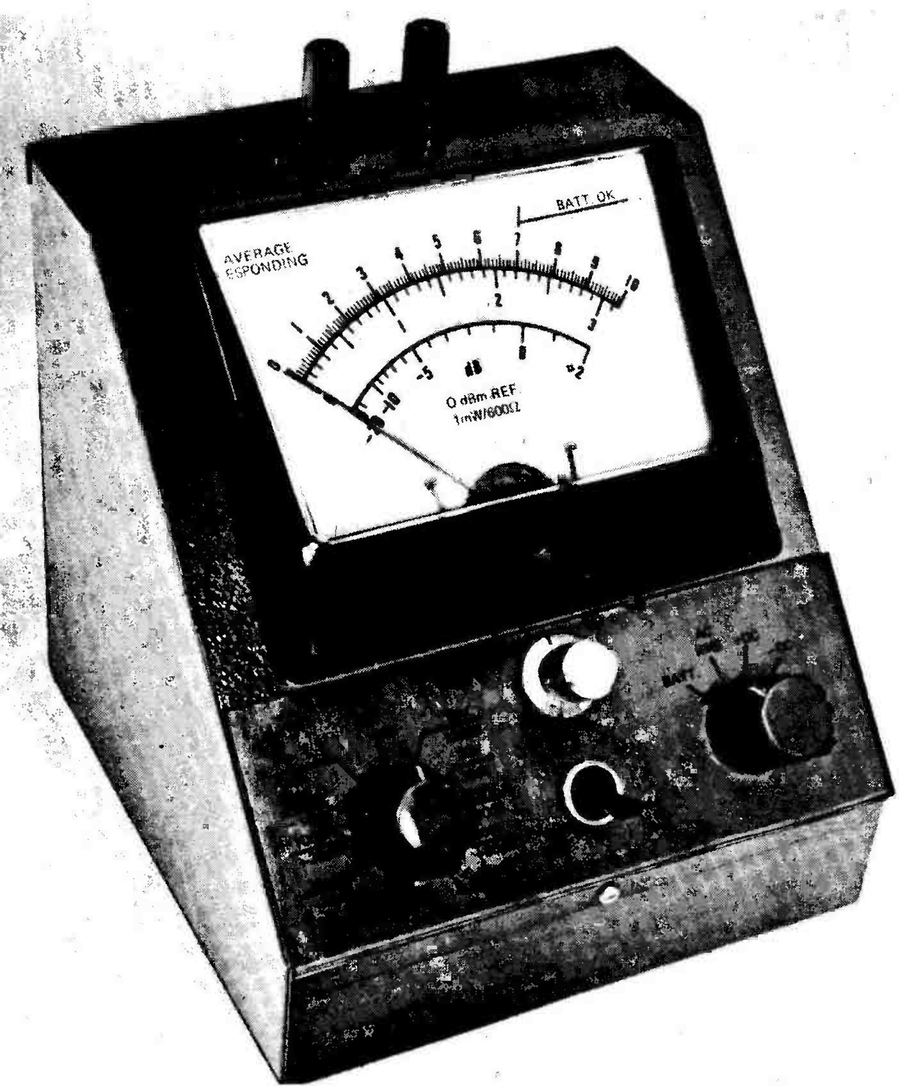


How prototype unit was constructed; the circuit board should be insulated from the metal case.



Completed probe housed in a torch case.

WIDE-RANGE VOLTMETER



SURPRISINGLY good multimeters can now be purchased for less than £12 and these instruments will perform many of the functions of an ac/dc voltmeter.

But none of these instruments is capable of measuring low level ac or dc signals, and few have input impedances in excess of 50,000 or 100,000 ohms/volt.

The meter described in this project is necessarily more complex than a basic multimeter. The smallest measuring range is 10 mV full-scale deflection (both ac and dc) and levels as low as 0.5 mV can be measured. The input impedance of 10 Megohms on all ranges ensures that measuring errors due to meter loading are kept to a minimum.

Unlike most ac measuring instruments, the ac scale of the Electronics Today meter is linear. The same scale is used for both ac and dc measurements, thus avoiding errors due to reading the 'wrong' scale.

The meter is protected against application of excess voltage – 1000 volts can be applied to the input terminals on all ranges without damage.

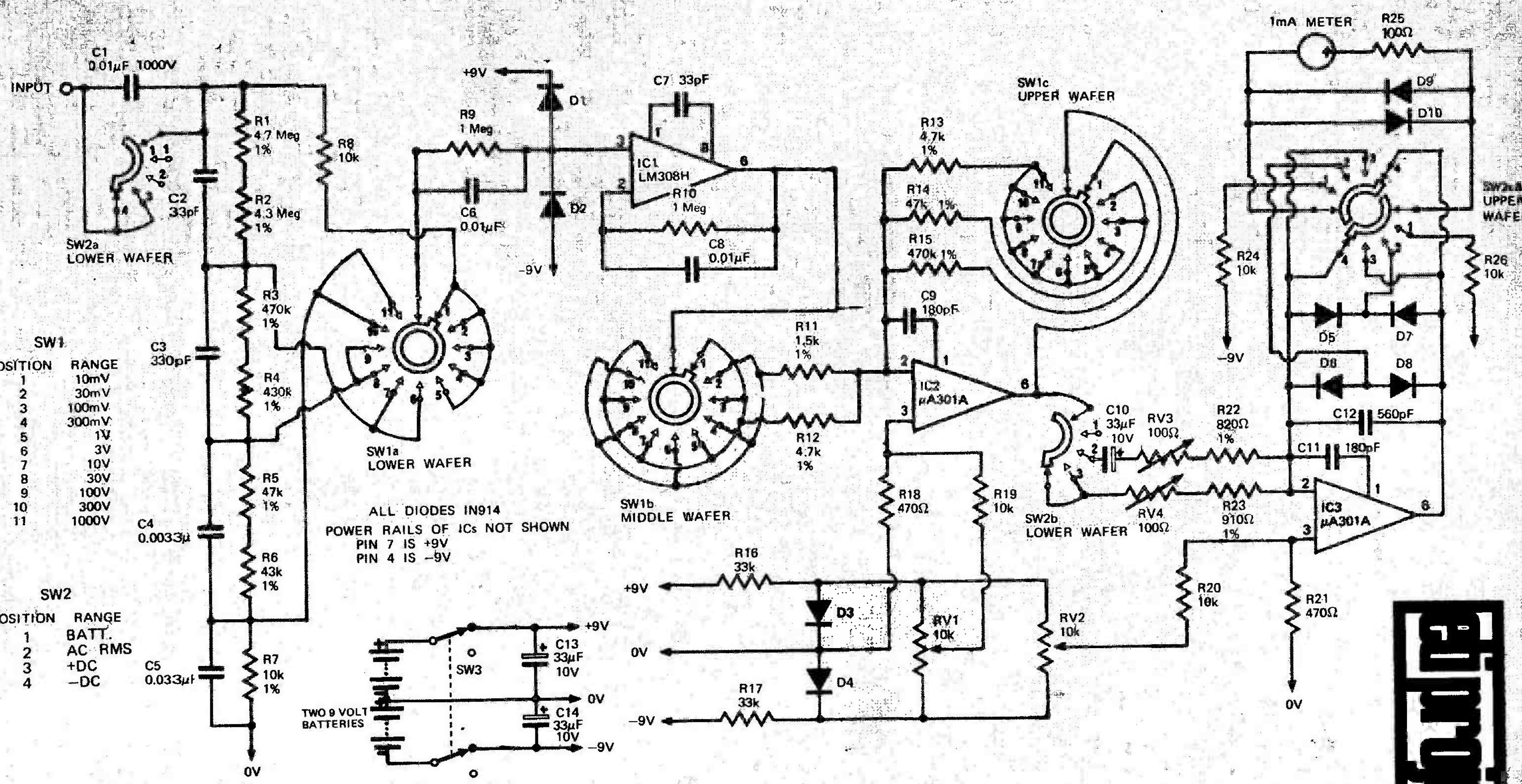
The instrument uses three integrated circuits, together with 12 diodes plus capacitors and resistors, to provide voltage measuring ranges from 10mV to 1000 volts full scale deflection. If only the millivolt ranges are required, the cost of the meter can be reduced substantially by eliminating the input divider (R1 – R9), (C2 – C5), the

This solid-state ac/dc voltmeter has 22 ranges – from 10 mV fsd to 1000V fsd.

NOTE:
IC1 may be advantageously replaced by the less common LH0042C. This has a lower input current resulting in lower zero errors on the low ranges.
No changes are required to the circuit and pin connections remain the same.

SPECIFICATION

	DC	AC	dB
Ranges –	0- 10mV	0- 10mV	- 40
	0- 30mV	0- 30mV	- 30
	o- 100mV	0- 100mV	-20
	0- 300mV	0- 300mV	- 10
	0- 1V	0- 1V	0
	0- 3V	0- 3V	+ 10
	0- 10V	0- 10V	+ 20
	0- 30V	0- 30V	+ 30
	0- 100V	0- 100V	+ 40
	0-1000V	0-1000V	+ 60
	0- 300V	0- 300V	+ 50
Input impedance	10M (all ranges)	10M paralleled by 33 pF. (all ranges)	
Accuracy	±3%	±3% 10Hz – 20kHz.	
Reverse polarity	meter switch.		
Protection.	Over voltage protected up to 1000V on all ranges.		



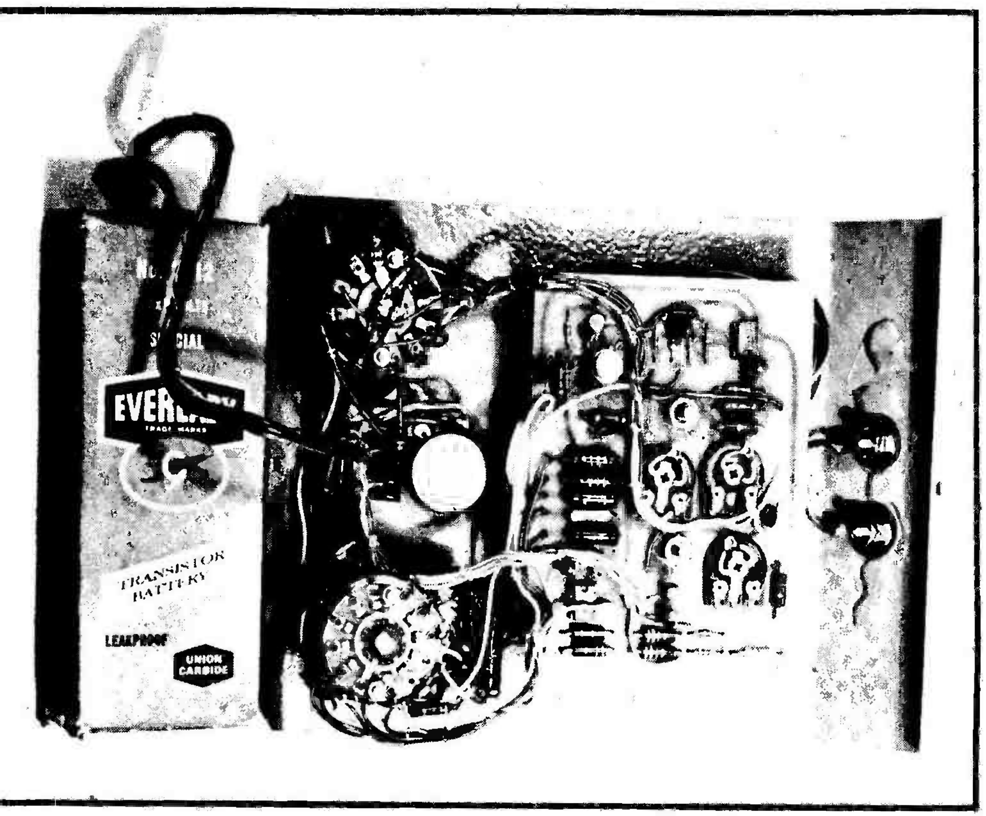
SW1

POSITION	RANGE
1	10mV
2	30mV
3	100mV
4	300mV
5	1V
6	3V
7	10V
8	30V
9	100V
10	300V
11	1000V

SW2

POSITION	RANGE
1	BATT.
2	AC RMS
3	+DC
4	−DC

WIDE-RANGE VOLTMETER



wafer of SW1a, and by changing SW1 to a 2 pole, 5 position switch.

Power is supplied by two nine-volt batteries (Eveready type 2512), and since the current drain of the meter is about 4 mA, the battery will have a life of approximately 500 hours. A battery check position is provided.

CONSTRUCTION

Although it is possible to construct this unit using tag strip or matrix board construction we strongly recommend using a printed circuit board. The foil pattern of the board is reproduced full size in Fig. 1.

Figure 2 shows how components are assembled on the board. Ensure that all components are orientated correctly as shown. Note that the 'tag' on the metal can type ICs indicate pin 8 and that the pins are numbered anticlockwise when viewed from above. For 8 pin plastic cased ICs — the 'notch' is between pins 1 and 8. Wiring connections to and from components mounted external to the board are shown in Fig. 3, all as seen from the rear of the components.

Mount the meter, switches, potentiometer RV1 and terminals on the front panel. The switch interconnections — shown in Fig. 3 — should now completed, and the switch

HOW IT WORKS

The circuit may be studied in four separate sections.

1. INPUT DIVIDER

This is a string of resistors in series, having a total resistance of 10 Megohms. Four switch-selected tappings, provide division ratios of 1, 10, 100 and 1000.

Switch SW1a selects the division ratio required — SW2a shorts out the input series capacitor when the instrument is used in the dc modes.

All resistors in the division network should be 1% tolerance: the capacitors should be 5% tolerance (or at least selected within 5% tolerance).

2. INPUT BUFFER

This consists of an operational amplifier, IC1, connected as a unity gain voltage follower, i.e. the output voltage is the same as the input voltage but at a lower impedance. The input current to this amplifier (LM308) is extremely low, typically 1.5 nanoamps. To compensate for this current, 1 Megohm resistors are used in both inputs to the amplifier. Capacitors are paralleled across these resistors to eliminate noise. Capacitor C7 provides frequency compensation for the IC.

Diodes D1 and D2 protect the input of this IC against over-voltage.

3. AMPLIFIER

This stage is again an op amp (IC2 — LM301A or uA301A). The gain of this amplifier may be changed by switching resistors in the input circuit (by SW1b) and resistors in the feedback loop (by SW1c). Using the values specified, the selected gains are 1, $\sqrt{10}$, 10, $10\sqrt{10}$, and 100.

A zero control (RV1) is provided on this stage to compensate for the initial offset of the IC, and to correct for any drift when measuring very low dc levels.

Diodes D3 and D4 stabilize the voltage across RV1. Capacitor C9 frequency compensates the IC.

4. METER CIRCUIT

A third operational amplifier is used in this stage. This is to enable the output of IC2 to be rectified and to compensate voltage drops across the rectifying diodes. This enables the meter scale to be linear on all ac ranges.

Contacts on SW2 enable the meter to be connected across the IC in either polarity, in all dc modes.

In the ac mode a capacitor is switched in series with the input to IC3 to eliminate any dc level that may be present on the output of IC2.

Two separate potentiometers (RV3 and RV4) are provided on the input to IC3. These enable the ac and dc meter scales to be calibrated independantly. A 100 ohm resistor is in series with the meter resulting in a total 'meter resistance' of about 200 ohms, and at 1 mA (which is full scale deflection) the voltage across the meter plus resistance will be 200mV on dc, and 340mV peak on the ac range.

The diodes D9 and D10 connected across the meter network conduct once the voltage across the meter exceeds approx 500 mV. This limits the maximum meter current to approximately 2.5 mA on any overload condition.

In the 'battery check' position the meter is connected across the battery with 20 KΩ in series. An associated marking is provided on the meter scale.

mounted components — shown in Fig. 3 — wired in place.

The completed printed circuit board is located by the terminals at the back of the meter. The board should be drilled to suit the meter, and the terminal area tinned, before final assembly.

The board can now be located in position and the remaining wiring completed. All external wires should be held together in a loom where practicable.

Before switching on recheck all wiring and component values. The unit is now ready for calibration.

CALIBRATION

Zero setting — short circuit the input terminals.

Select the + dc and 10 mV range. Adjust the zero set potentiometer on the front panel to give 'zero' on the meter. Select the 1000V range and set the meter to zero by using preset potentiometer RV2. Recheck zero on the 10 mV range and adjust RV1 if required.

Voltage calibration — the dc range is calibrated by connecting the input to a known dc voltage and adjusting RV4 to give the correct meter reading. The ac range is adjusted by connecting the input to a known ac voltage and adjusting RV3 to give the correct meter reading.

Check that all ranges work correctly, if any are faulty recheck the wiring of the switches and the components on the printed circuit board.

Once set, the calibration and zero setting of the instrument will remain constant for measurements across impedances not exceeding 1 Megohm.

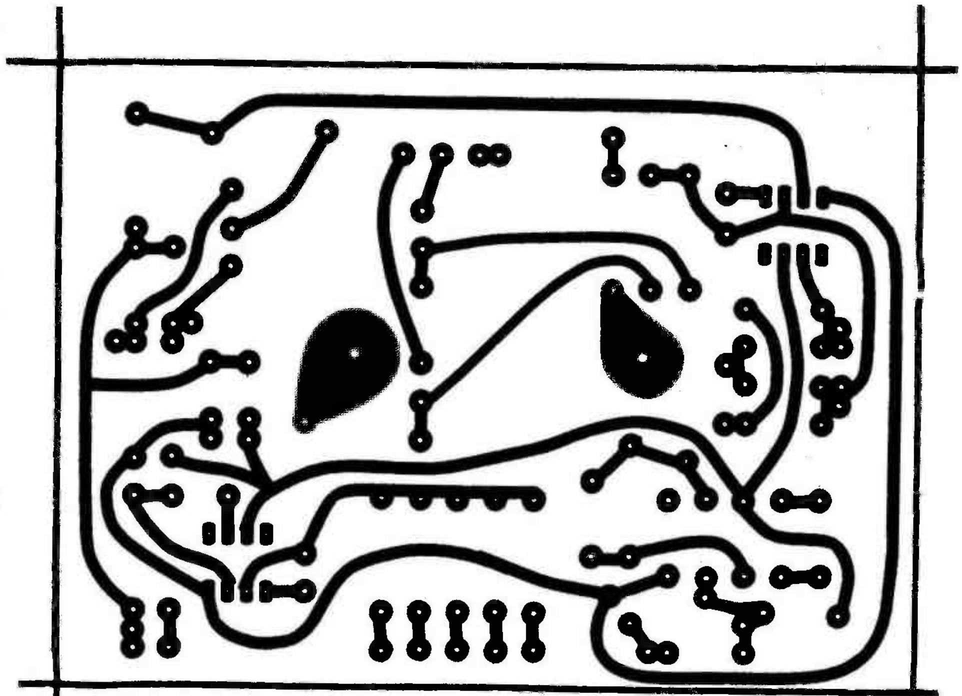
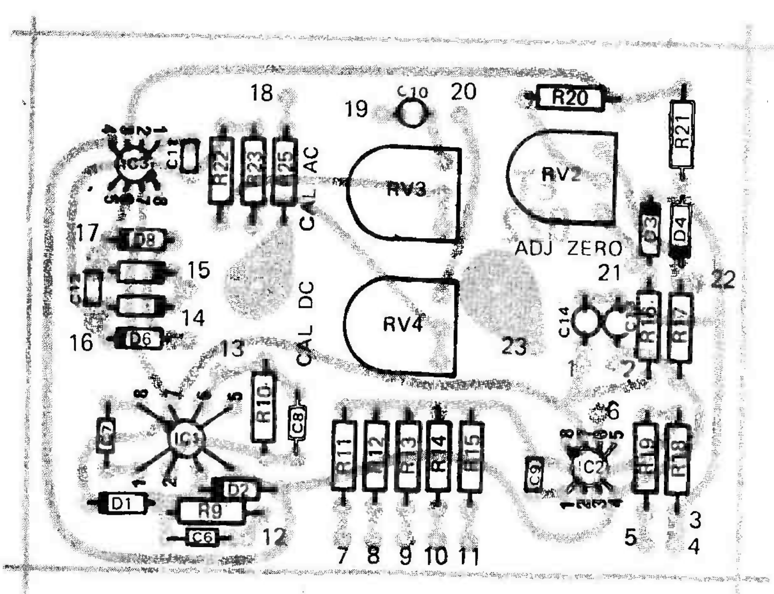


Fig. 1. Here is the foil pattern of the printed circuit board — reproduced full size.

Fig. 2. How the components are assembled on the printed circuit board.



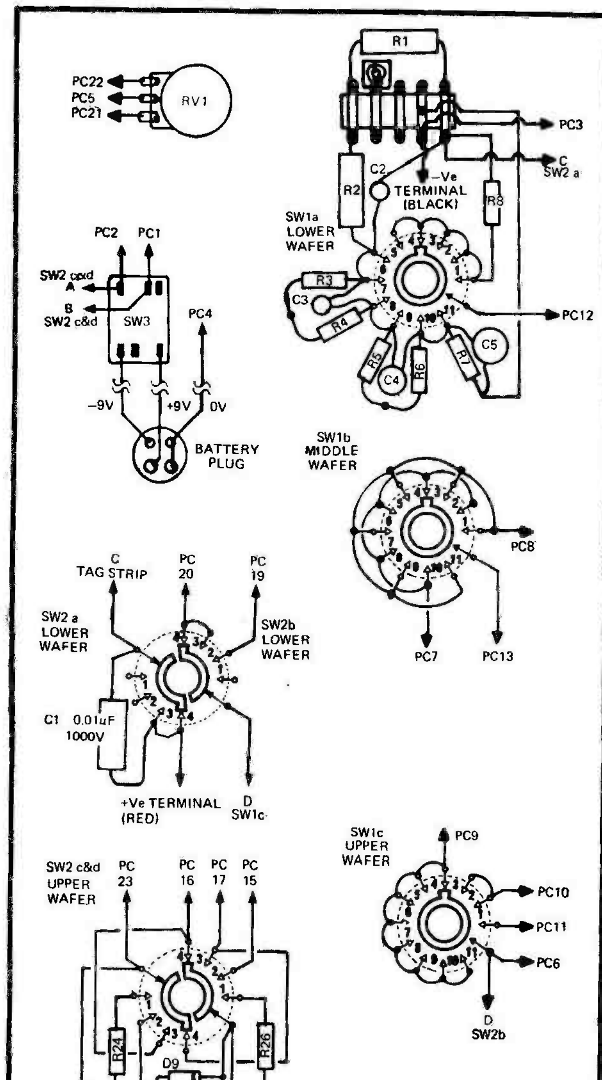


Fig. 3. Components and interconnections associated with the front panel.

WIDE-RANGE VOLTMETER

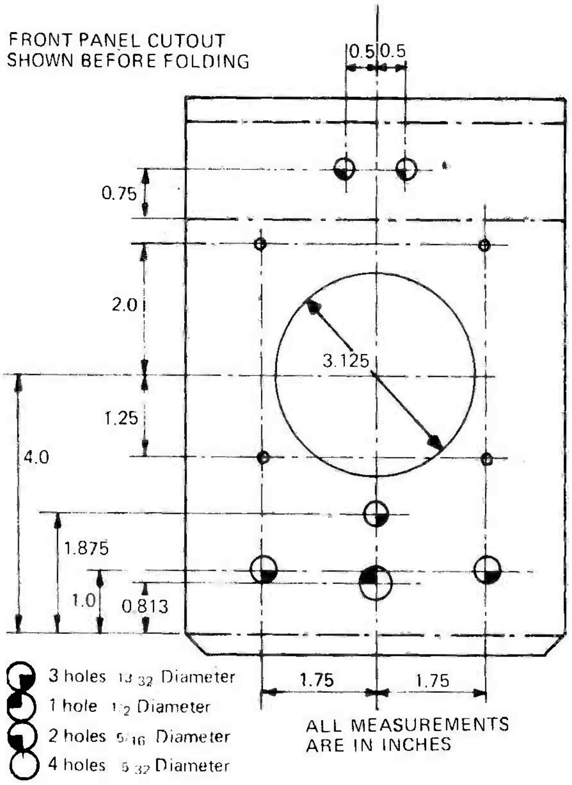
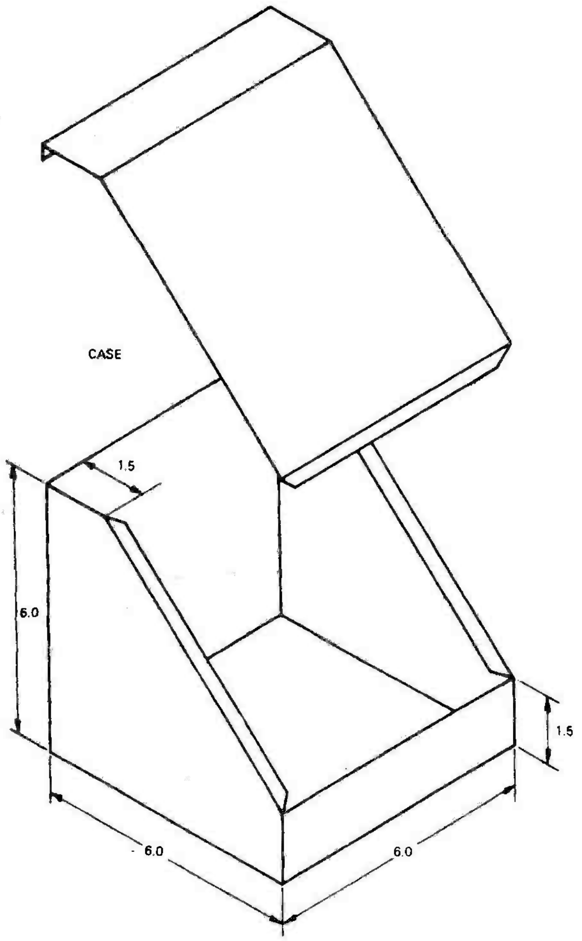


Fig. 4. Constructional details of the meter case.



PARTS LIST

R1	–	Resistor	4.7 Megohm,	½ Watt,	1%
R2	–	"	4.3 "	" "	"
R3	–	"	470k	" "	"
R4	–	"	430k	" "	"
R5	–	"	47k	" "	"
R6	–	"	43k	" "	"
R7	–	"	10k	" "	"
R8	–	"	10k	" "	5%
R9	–	"	1 Megohm	" "	"
R10	–	"	1 Megohm	" "	"
R11	–	"	1.5k		1%
R12	–	"	4.7k	" "	"
R13	–	"	4.7k	" "	"
R14	–	"	47k	" "	"
R15	–	"	470k	" "	"
R16	–	"	33k	" "	5%
R17	–	"	33k	" "	"
R18	–	"	470 ohms	" "	"
R19	–	"	10k	" "	"
R20	–	"	10k	" "	"
R21	–	"	470 ohms	" "	"
R22	–	" "	820 ohms	" "	1%
R23	–	"	910 ohms	" "	"
R24	–	"	10k	" "	5%
R25	–	"	100 ohms	" "	"
R26	–	"	10k	" "	"
C1	–	capacitor	0.01 uF, 1000V		
C2	–	"	33pF, 1000V, 5%		
C3	–	"	330pF, 100V, 5%		
C4	–	"	3300pF, 100V, 5%		
C5	–	"	0.033uF, 100V, 5%		
C6	–	"	0.01uF, 100V		
C7	–	"	33pF, 25V		
C8	–	"	0.01uF, 100V		
C9	–	"	180pF, 25V		
C10	–	"	33uF, 10V, TAG electrolytic		
C11	–	"	180pF, 25V		
C12	–	"	560pF, 25V		
C13	–	"	33uF, 10V, TAG electrolytic		
C14	–	"	33uF, 10V, TAG electrolytic		
RV1	–	potentiometer, 10k linear			
RV2	–	trimming potentiometer 10k, (large type)			
RV3	–	" " .. " 100 ohms, (Large type)			
RV4	–	" " " " " " " "			
IC1	–	integrated circuit National Semiconductor LM308			
IC2	–	" " " " " LM301A (or Fairchild uA301A)			
IC3	–	As above			

(note – ICs must be metal can type, or 8 pin plastic type)

D1-D10	–	diodes 1N914
SW1	–	rotary switch, 3 pole, 11 position
SW2	–	" " 4 pole, 4 position
SW3	–	toggle switch, 2 pole on-off.
Meter	–	1 mA movement, scaled 0-10 (Or 0-1) and 0-3.16, plus a dB scale. or similar.

Metal case

Plug for batteries.
Metal clamp for battery
Terminals – 2, one black, one red
Knobs – 3
Anodized front panel (optional)

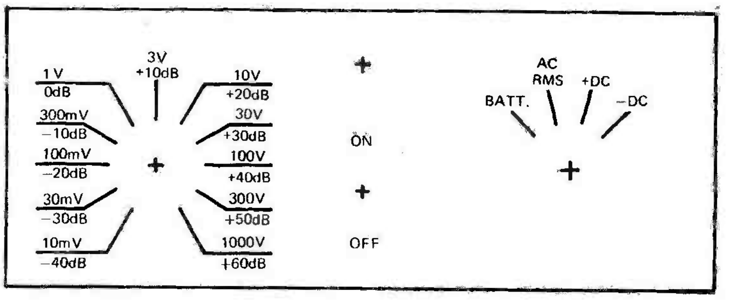
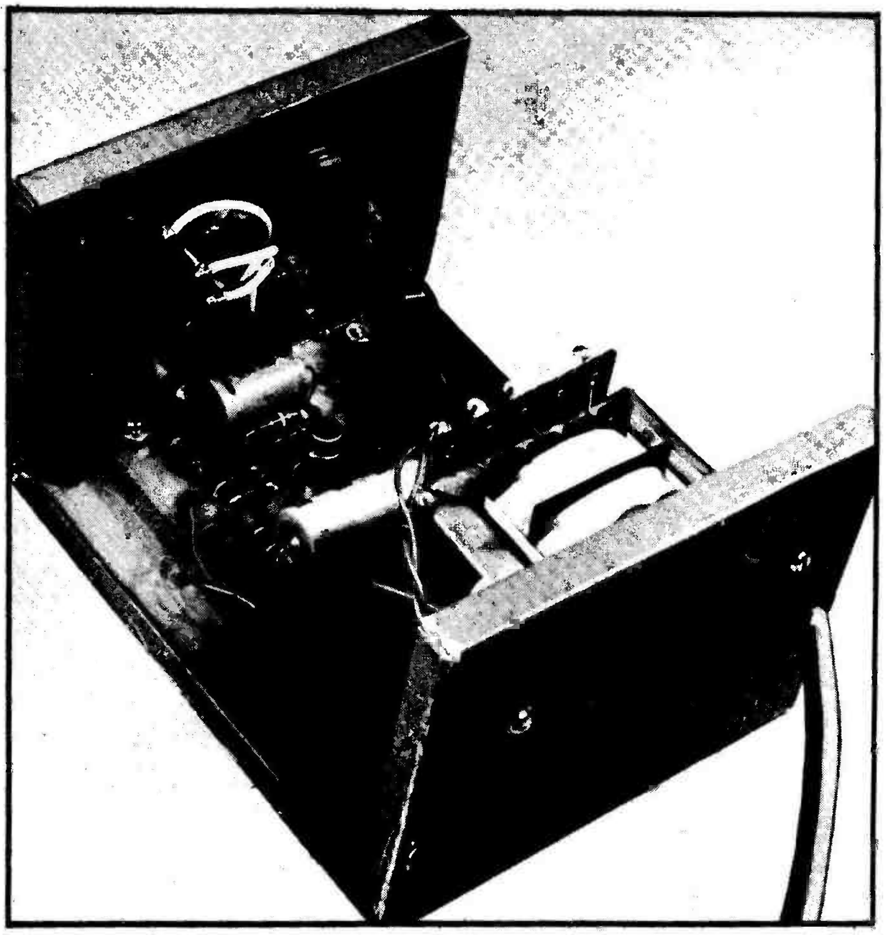


Fig. 5. Details of lettering on front panel.

IC POWER



THIS PROJECT builds into a versatile power supply capable of delivering 1 amp up to 10 volts and ½ amp up to 15 volts.

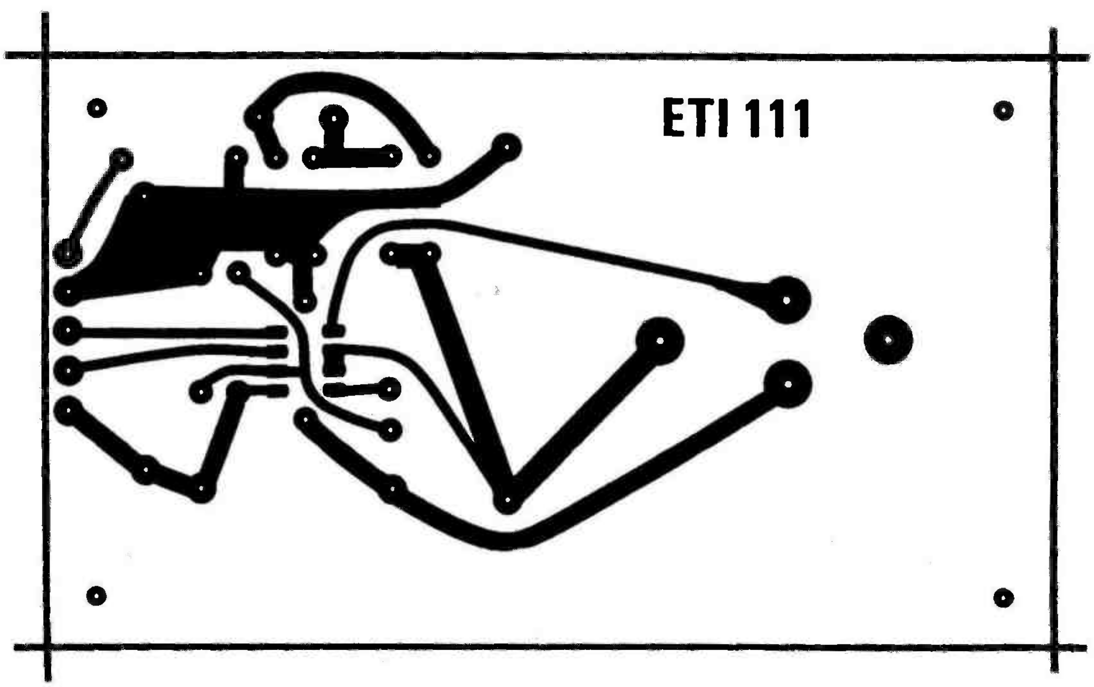
The unit may readily be adapted to operate over other voltage and current ranges.

If required, refinements such as output voltage and current metering, variable current limiting etc. may be added to the basic circuit.

VOLTAGE REGULATOR IC

The control circuit of this supply is formed by the integrated circuit precision voltage regulator – shown as IC1 in Fig. 1. This IC is now produced by a number of companies including SGS, Fairchild and Motorola (respective type numbers are included in the parts list for this project).

The integrated circuit is a monolithic voltage regulator constructed on a single silicon chip using the planar expitaxial process. The device consists of a temperature compensated



Foil pattern for logic power supply (actual size).

SUPPLY

Simple, adjustable power source has innumerable applications.

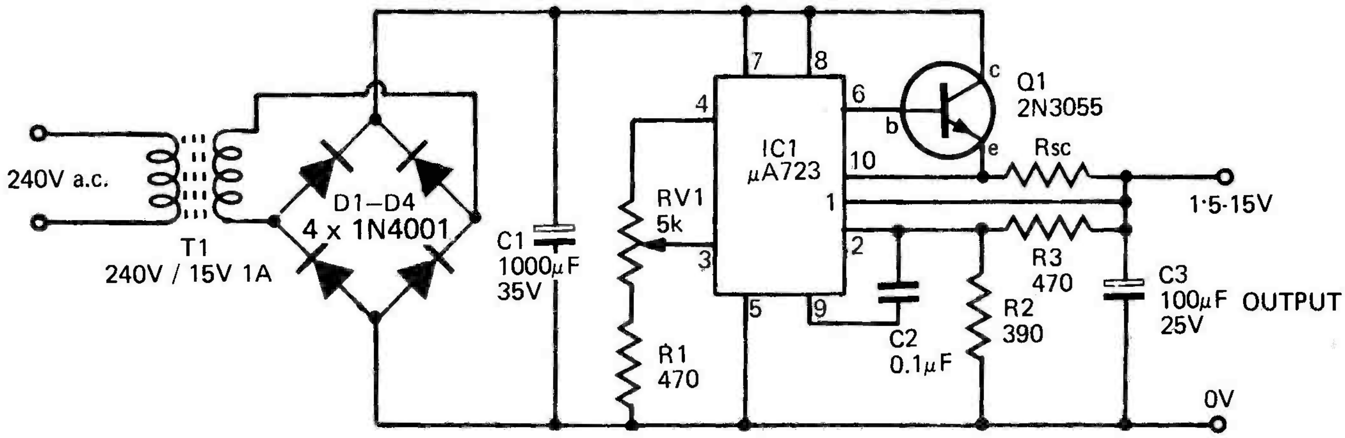


Fig. 1. Circuit diagram of regulated supply.

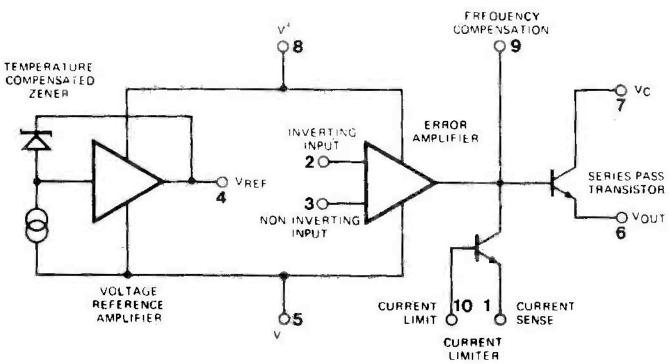
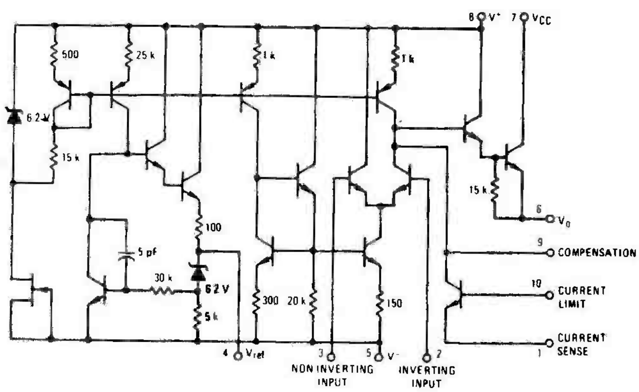


Fig. 2. Simplified schematic of uA723.



Circuit schematic of IC uA723.

reference amplifier, error amplifier, power series-pass transistor and current limiting circuit. Additional external npn and pnp pass elements may be used when output currents exceeding 150mA (from the IC) are required. Provision is made for adjustable current limiting and remote shut-down. In addition to this the IC features low standby current drain, low temperature drift and high ripple rejection.

CONSTRUCTION

Our prototype unit was built on an epoxy glass board, however the constructional method is not critical and the unit may alternatively be built on matrix board, tag strips etc.

The power transistor is mounted on a 2" strip of extruded heatsink which in turn is located on the printed circuit board by the same screws that locate the transistor. One of these screws is

HOW IT WORKS

Figure 2 shows a simplified equivalent circuit of IC1. The voltage reference amplifier produces (typically) 7.15V at pin 4, this voltage has a maximum temperature coefficient of 0.015%/°C.

The V_{ref} voltage is taken to potentiometer RV1 which enables it to be varied between 0.7V and 7.15V. The error amplifier (within the IC) drives a power transistor (also within the chip), and this in turn drives the external series pass transistor Q1.

The output of Q1 is divided by R2 and R3 (÷2.2) and this voltage provides the feedback signal for the error amplifier. Hence the output voltage will be approximately 2.2 times the voltage on RV1.

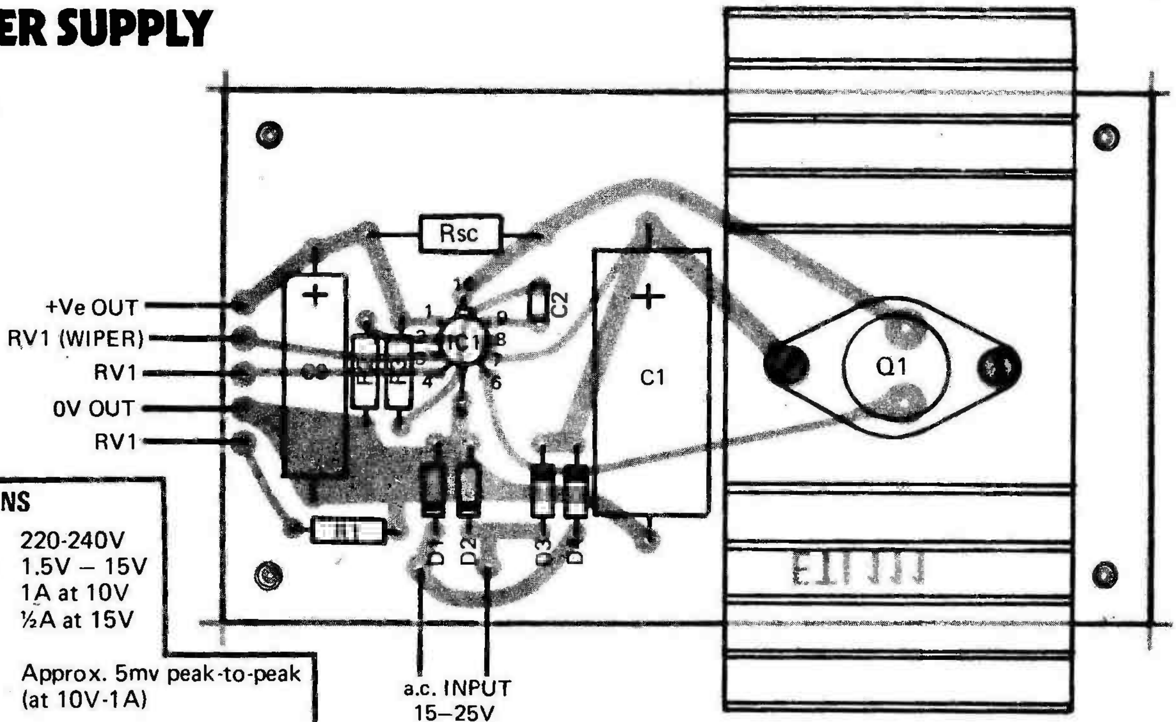
Current limiting is determined by the voltage drop across RSC. If this exceeds 0.6V, the current limit transistor within the IC becomes forward biased and bypasses any further increase in drive current from the output stage.

The max. output voltage and current of this unit is a function of the transformer, filter capacitor, and the heatsinking of Q1. The prototype unit used a 15V centre tapped 1A transformer and this provided 1A up to 10V and ½A at 15V. The drop in output current is due to rectified dc voltage decreasing on load. If a higher voltage transformer is used – or one with a higher current rating, thus providing better regulation – then higher output currents may be expected.

The maximum output voltage may be altered by changing the ratio of R2 and R3. Note that the maximum no-load voltage across C1 should not exceed 35V.

IC POWER SUPPLY

Fig. 3. Layout of components on circuit board.



SPECIFICATIONS

Input Voltage	220-240V
Output Voltage	1.5V – 15V
Output current	1A at 10V ½A at 15V
Ripple	Approx. 5mv peak-to-peak (at 10V-1A)
Regulation	0-100mA = 4mV (10 Volt) 0-1.0A = 20mV (10 Volt)

also used for the electrical connection for the collector of the transistor.

The IC may be soldered directly into the circuit – ensure that the device is correctly orientated – and avoid excess heat. Recommended maximum lead temperature during soldering is 300°C.

A load sensing resistor (Rsc) is used to provide overload protection. In our prototype we used a short length of resistance wire cut to length to limit the current to the desired value. An interesting alternative is to substitute a 20 ohms 5 Watt wire-wound potentiometer for Rsc. This enables the current limiting facility to be steplessly varied. With this feature the user can start experimenting with a very low current limit and then increase the current when the circuit is operating correctly.

The basic circuit described in this article can be modified to provide other ranges of voltage and current. The main design limitations are that the voltage across the IC must not exceed 40V and that the output current from the IC must not exceed 150mA, or 800mW of power.

Transistor Q1 (2N 3055) is capable of dissipating up to 115 watts but if power levels of this magnitude are envisaged then a second transistor should be added, in a Darlington pair configuration, to transistor Q1. This will reduce the loading on IC1. A larger heat sink will also be required.

INCREASED RIPPLE REJECTION

The integrated circuit chosen for this project has a typical ripple rejection of 74 dB. This is more than adequate for most applications. However by additional filtering at the non-inverting input (pin 3), the ripple can be even further reduced. A typical performance, using a 4.7µF capacitor across the non-inverting input and V_{ref} is approximately 86 dB. ●

RSC – TYPICAL VALUES

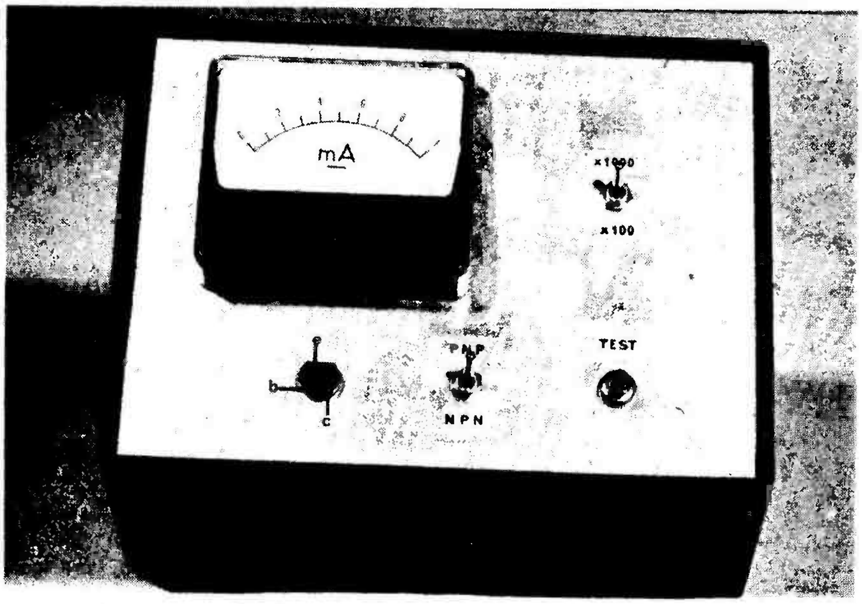
Value of Rsc	Current Limiting
10 ohms	65mA
1 ohm	650mA
0.5 ohms	1.4A
0.2 ohms	3.2A

PARTS LISTS ETI 111

R1	resistor 470 ohm ½W 5%
R2	resistor 390 ohm ½W 5%
R3	resistor 470 ohm ½W 5%
Rsc	see text
RV1	potentiometer 5k linear
D1-D4	diodes 1N4001 or similar
Q1	transistor 2N3055
IC1	integrated circuit µA723 (or SGS L123, or MC1723CG) (metal can type)
C1	capacitor 1000µF 35V electrolytic
C2	capacitor 0.1µF 100V
C3	capacitor 100µF 25V electrolytic
T1	transformer 240V primary 15-20V sec @ 1A

PC board ETI 111
on-off switch, terminals, knob, 3 core flex and plug
metal box approximately 4½x3½x6 etc.

TRANSISTOR TESTER



The transistor tester mounted in a metal case.

ETI PROJECT

Measure and test your transistors with this easily built device.

EXPERIMENTERS will frequently use the same transistors in a whole sequence of experimental circuits, for recovering and re-using such components saves considerable outlay.

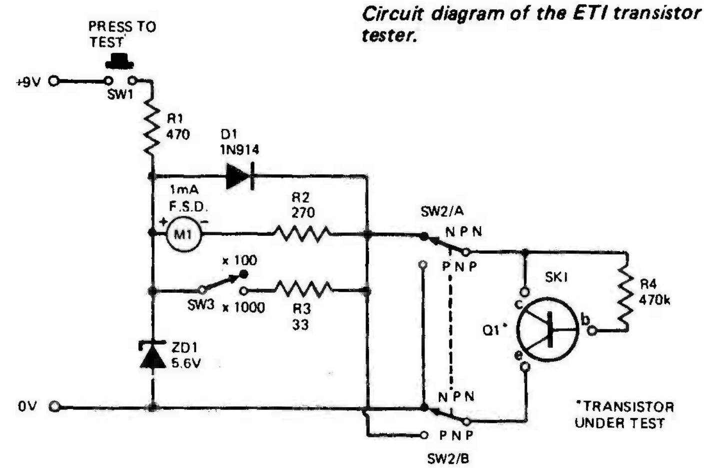
But semiconductors are easily damaged — by incorrect operating conditions — or by excessive application of heat when soldering.

Only too often a malfunctioning experimental circuit will be checked and rechecked before one realises that a transistor is dead.

A transistor tester will save hours of such frustrating and unproductive effort.

Transistors can often be bought cheaply in bulk — usually in unmarked and untested lots — or recovered from old computer boards. Here again a transistor tester will prove invaluable in eliminating the faulty bits.

The simple transistor tester described in this project not only sorts out the good from the bad but indicates also the approximate gain (β) of the transistor. This is a most useful feature for those circuits where transistors need to be matched. Two ranges of gain (beta) are provided, 0-100, and 0-1000. The tester may also be used to check transistor polarity. ●



Circuit diagram of the ETI transistor tester.

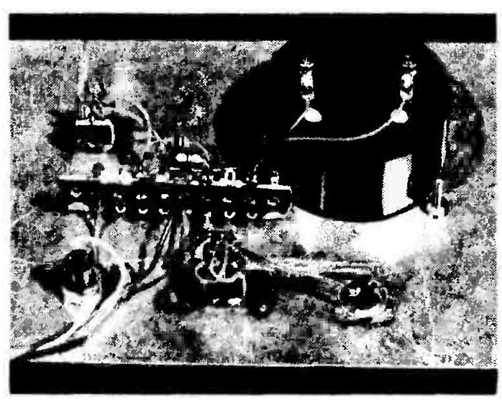
PARTS LIST — Transistor Tester

R3 Resistor 33Ω ½ watt 5%
R2 Resistor 270Ω ½ watt 5%
R1 Resistor 470Ω ½ watt 5%
R4 Resistor 470k ½ watt 5%
D1 Diode IN914
ZD1 Zener diode BZY88C5V6
SW1 Push button push-to-make
SW2 Switch toggle DPST
SW3 Switch toggle SPST
9V battery
M1 Meter 1mA movement
SK1 Socket T05 transistor type
Metal case or minibox

HOW IT WORKS

Operation of the tester is very simple. The meter, M1, monitors the collector current of the transistor under test whilst R4 supplies a current of about 10 μA into the base of the test transistor. Thus, on the 100β range, the maximum collector current will be 1 mA and, on the 1000β range, 10 mA. Switch SW3 therefore changes the meter sensitivity according to the beta range selected.

The meter is protected by means of D1 against damage due to test transistors being shorted. The zener diode ZD1 stabilizes the battery voltage to 5.6V.



The construction method may readily be seen from this photograph of the back of the front panel.

FET DC VOLTMETER

This cheap and easily constructed dc voltmeter has 10 Megohm input resistance.

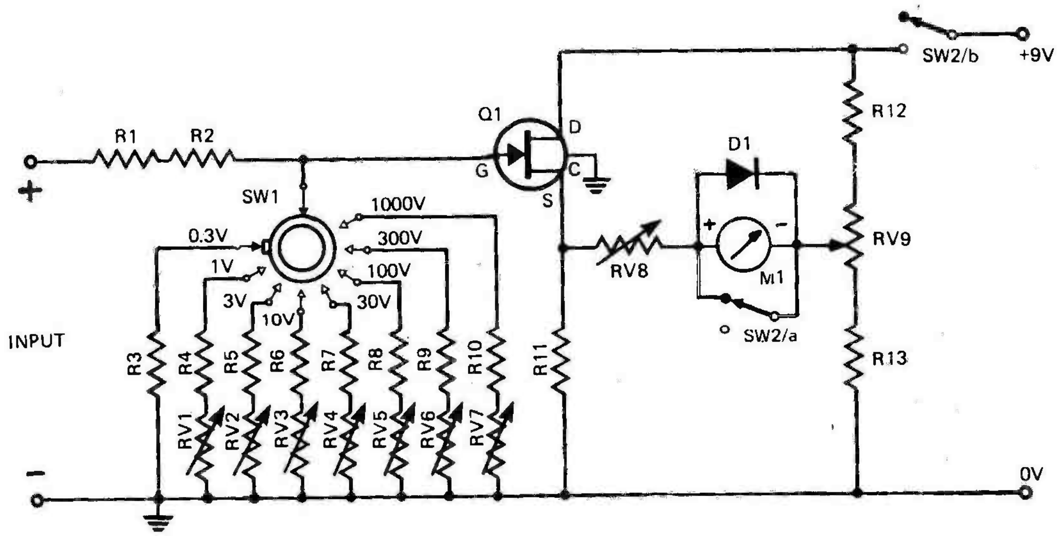


Fig. 1. Circuit of complete instrument.

PARTS LIST

R1, R2	–	5 Meg 5% ½W	
R3	–	18M	
R4	–	2.2M	
R5	–	560k	
R6	–	180k	
R7	–	56k	
R8	–	18k	
R9	–	5.6k	
R10	–	1.8k	
R11	–	4.7k	
R12	–	680 ohm	
R13	–	120 ohm	
RV1	–	470k	trim pot
RV2	–	220k	"
RV3	–	47k	"
RV4	–	22k	"
RV5	–	4.7k	"
RV6	–	2.2k	"
RV7	–	470 ohm	"
RV8	–	4.7 ohm	"
RV9	–	250 ohm	ww pot
Q1	–	BFW 61 BFW 10 BFW 11	
D1	–	OA91	
SW1	–	Single pole eight position rotary switch	
SW2	–	DPDT Toggle Switch	
M1	–	50 uA meter 0-10 and 0-3.16 scales.	

For accurate voltage measurements in high impedance circuits it is essential that the measuring instrument has an input impedance that is very much higher than the circuit being measured. If the meter drains current away from the point being measured then an inaccurate reading will be obtained.

The valve voltmeter (VTVM), with its inherently high input impedance has for many years been used for such measurements.

But until the advent of the field effect transistor (FET), solid state technology was not commonly used in these instruments, for the bi-polar transistor has the disadvantage of having an inherently low input impedance.

The field effect transistor, on the other hand, has a *high* input impedance and because of this, forms an excellent basis for a high input impedance voltmeter.

Here then are constructional details of a simple yet accurate FET dc voltmeter having an input impedance greater than 10 megohms on all ranges.

The attainable accuracy is very much determined by the quality of the 50 uA meter (M1). We have not specified any particular make or type, for this will be determined by the accuracy required. Generally however the meter chosen should be at least four inches in diameter and should have a guaranteed 1% to 2% accuracy at full scale deflection.

Three types of FET may be used in this circuit – BFW10, BFW11, and BFW61. Of these the BFW61 is the cheapest and this is the one that we have used in this project.

High stability resistors must be used throughout. These should be of 5% tolerance (or better). Metal film resistors – such as those produced by Philips are ideal. Corning Electrosils are also an excellent choice.

CONSTRUCTION

The physical design of the instrument is determined primarily by the size and shape of the 50 uA meter. Within reason the larger this is the better.

A good quality switch must be used for SW1 – preferably of ceramic construction. A single-pole twelve-way switch was used in the prototype (four of the available positions were not used for switching).

The electronic components may be located on tag strips or on matrix board. A matrix board layout is shown in Fig. 2.

As FET's are a bit touchy about input voltage it is wise to keep their terminal leads shorted together by a thin strand of wire whilst soldering them into the circuit.

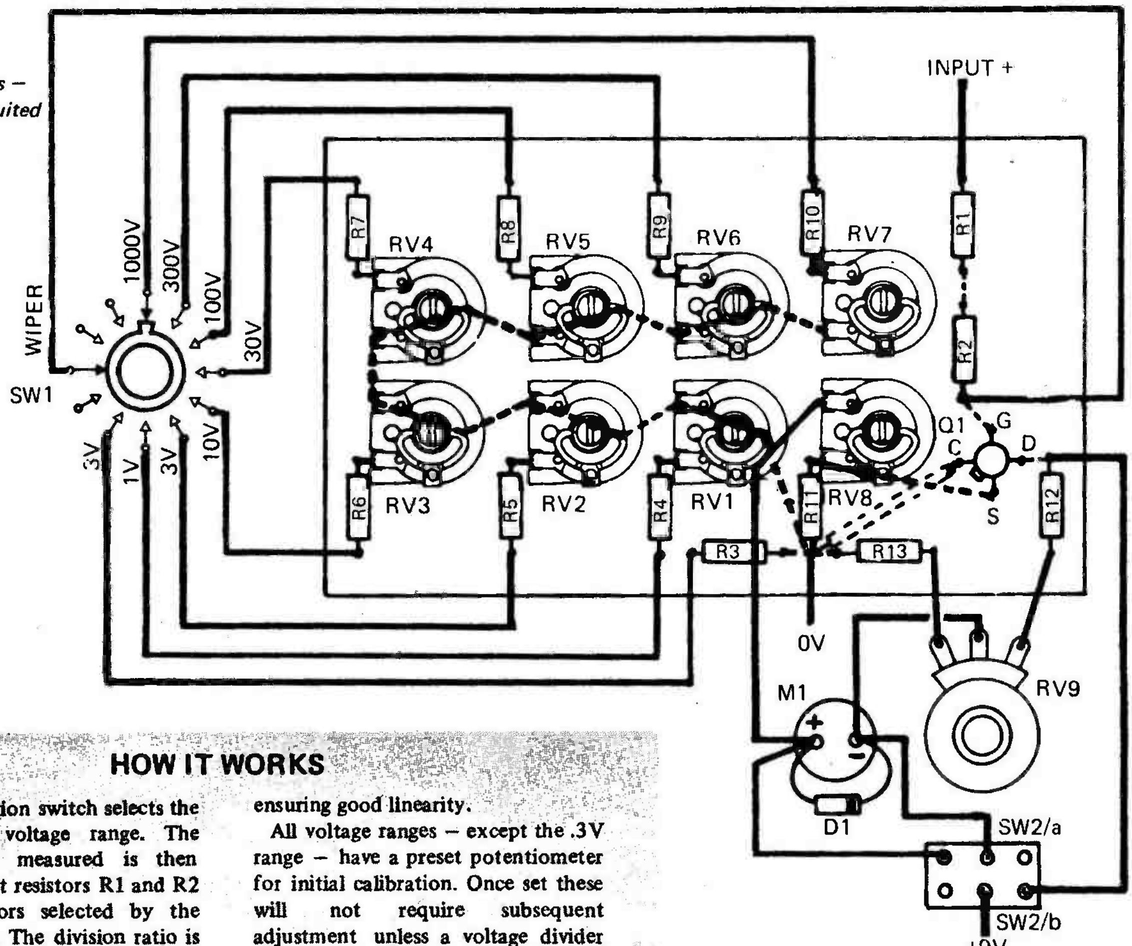
The battery 'on/off' switch should be double-pole double throw. When it is in the 'off' position the second set of switch contacts place a short circuit across the meter movement thus protecting it against mechanical damage whilst the instrument is not in use.

This switch together with range switch SW1 and 'zero-adjust' potentiometer RV9 must be mounted on the front panel of the instrument case.

CALIBRATION

1. Connect the meter to a nine volt battery. Make sure that the polarity is correct. Switch the instrument to 'on'.
2. Switch SW1 to the .3V range. Short circuit the input terminals and adjust the 'zero-set' potentiometer (RV9) for zero meter deflection. Then remove the short circuit.
3. Apply an accurately known 300mV to the meter input terminals and adjust RV8 to obtain full scale deflection on the meter.
4. Repeat steps 2 and 3 until the meter reads correctly both at zero and full scale deflection. Once this has been achieved do not readjust RV8. during any subsequent operation.
5. Switch the meter to the 1V range, apply an accurately known 1V and adjust RV1 to obtain full scale deflection.
6. Now switch to the other ranges in turn and, in a similar fashion to operation 5, apply the appropriate input voltage and adjust the appropriate potentiometers for each range (RV2, RV3, RV4, RV5, RV6, and RV7) to obtain full scale deflection on each range. This completes calibration. ●

Fig 2 Interconnections – layout shown here is suited to matrix board construction



DOTTED LINES REPRESENT INTERCONNECTIONS ON THE UNDERSIDE OF THE BOARD

HOW IT WORKS

An eight position switch selects the desired input voltage range. The voltage to be measured is then divided by input resistors R1 and R2 and the resistors selected by the setting of SW1. The division ratio is such that approximately 200mV is applied to the gate of the FET with 100% input.

The naturally high input resistance of the FET together with negative feedback from R11 ensures that, even on the lowest range, there is never less than 18 Megohms in parallel with the lower end of the input voltage divider. This will have a negligable effect on meter accuracy.

Another advantage of using negative feedback is that this limits the working range of the FET thus ensuring good linearity.

All voltage ranges – except the .3V range – have a preset potentiometer for initial calibration. Once set these will not require subsequent adjustment unless a voltage divider resistor or the FET is replaced.

Potentiometer RV8 establishes full scale deflection on the 0-3V range. It is also used to correct for any spread in the transfer conductance (gain) of the FET.

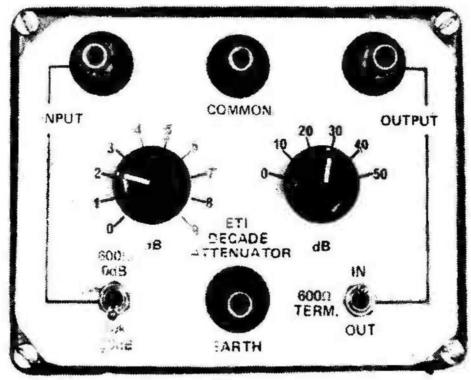
The 250 ohm wire wound potentiometer RV9 is mounted on the front panel of the instrument and is used as a 'zero adjustment'. In effect it cancels out the voltage appearing at the source terminal or the FET when there is zero voltage at the input.

AUDIO ATTENUATOR

This useful audio attenuator project for the experimenter provides 0-59dB attenuation in one dB steps.

SPECIFICATION	
Max attenuation	59dB
Resolution	1dB
Accuracy	±0.3dB
Frequency range	dc to 100kHz
Input impedance	600 Ω nominal
	10k switched (+30dB attenuation)
Output impedance	600 Ω nominal
Max input voltage	15 volt

Internal switched termination resistor for use with high impedance loads.



PROJECT 112

ACCURATE attenuators are required in a multitude of design, service, testing and measuring situations. These units are designed with varying degrees of accuracy and as many steps of attenuation as the designer feels necessary. They may be balanced or unbalanced and have whatever input and output or impedances the designer requires.

There are three common types of attenuator configuration, Pi, T or L. The latter is mainly employed where the output impedance is not required to be constant.

THE CIRCUIT

We have chosen Pi type sections for our unit. We could have connected the various sections in tandem to form a ladder attenuator, but this would have made more complex rotary switches necessary. Instead, we chose to employ a separate section for each step of attenuation, making only simple rotary switches necessary.

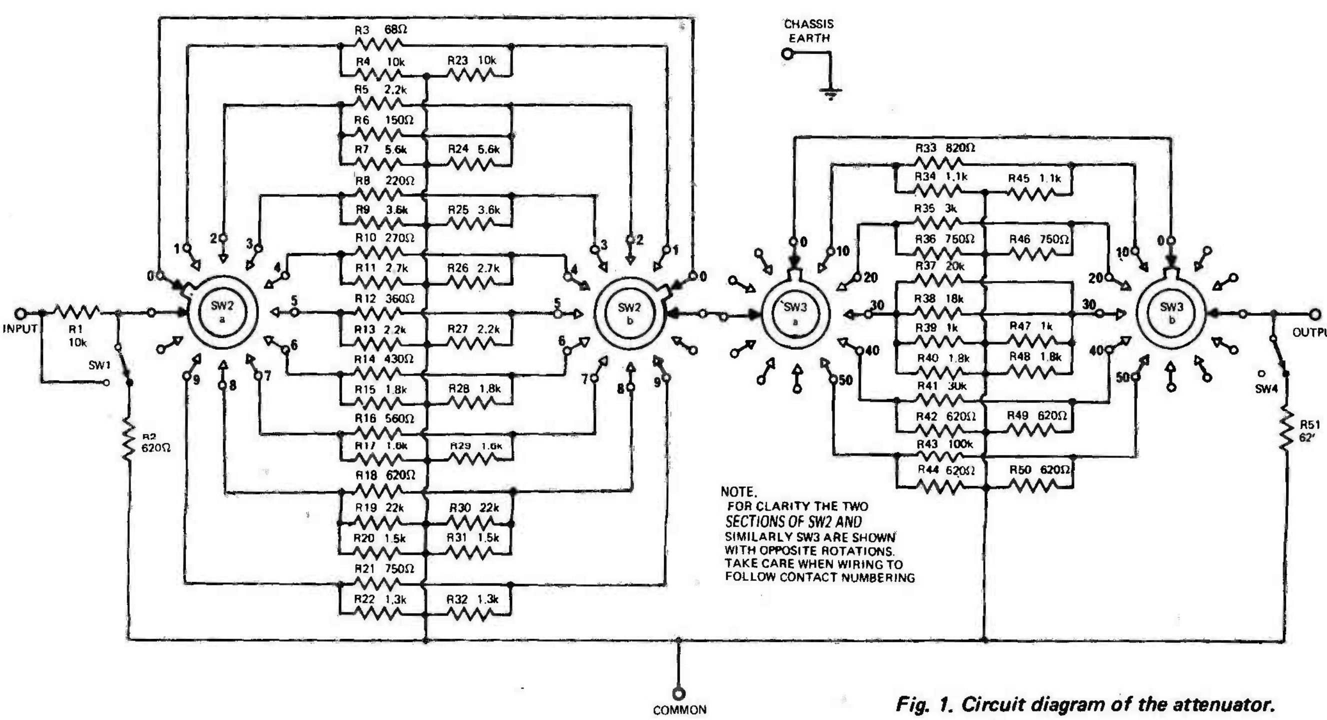


Fig. 1. Circuit diagram of the attenuator.

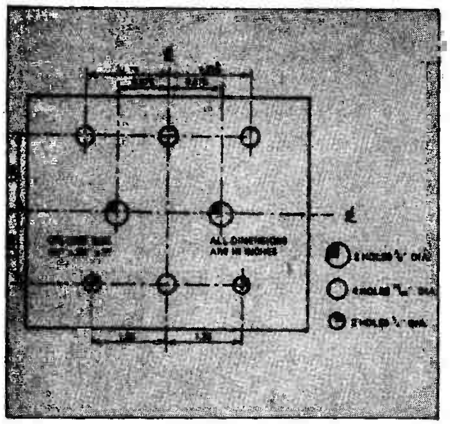


Fig. 2. Drilling details for the die cast box.

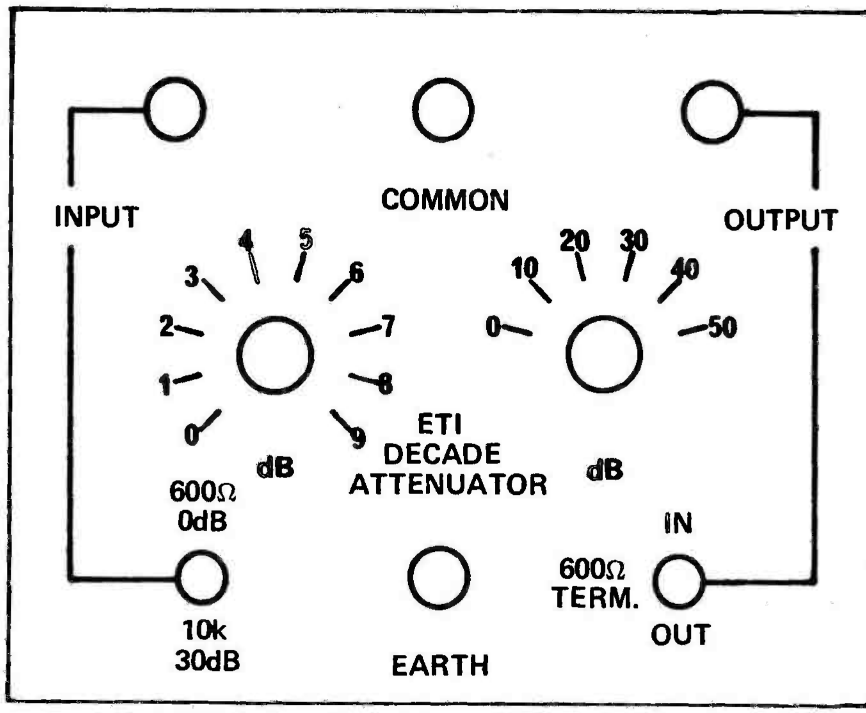
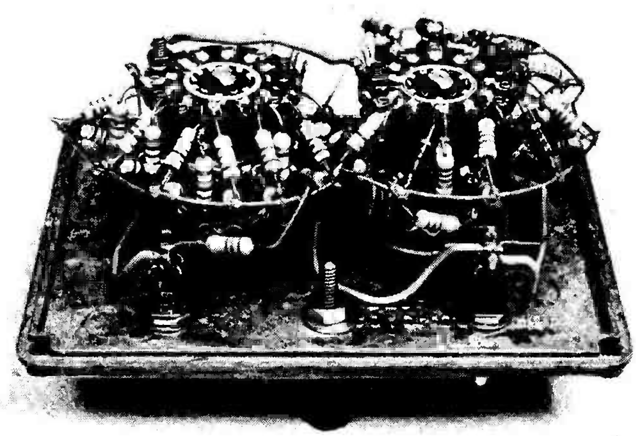


Fig. 3. Lettering and front panel artwork – full size.

PARTS LIST ETI 112

R1	Resistor	10k	2% ½W
R2	"	620Ω	" "
R3	"	68Ω	" "
R4	"	10k	" "
R5	"	2.2k	" "
R6	"	150Ω	" "
R7	"	5.6k	" "
R8	"	220Ω	" "
R9	"	3.6k	" "
R10	"	270Ω	" "
R11	"	2.7k	" "
R12	"	360Ω	" "
R13	"	2.2k	" "
R14	"	430Ω	" "
R15	"	1.8k	" "
R16	"	560Ω	" "
R17	"	1.6k	" "
R18	"	620Ω	" "
R19	"	22k	" "
R20	"	1.5k	" "
R21	"	750Ω	" "
R22	"	1.3k	" "
R23	"	10k	" "
R24	"	5.6k	" "
R25	"	3.6k	" "
R26	"	2.7k	" "
R27	"	2.2k	" "
R28	"	1.8k	" "
R29	"	1.6k	" "
R30	"	22k	" "
R31	"	1.5k	" "
R32	"	1.3k	" "
R33	"	820Ω	" "
R34	"	1.1k	" "
R35	"	3k	" "
R36	"	750Ω	" "
R37	"	20k	" "
R38	"	18k	" "
R39	"	1k	" "
R40	"	1.8k	" "
R41	"	36k	" "
R42	"	620Ω	" "
R43	"	100k	" "
R44	"	820Ω	" "
R45	"	1.1k	" "
R46	"	750Ω	" "
R47	"	1k	" "
R48	"	1.8k	" "
R49	"	820Ω	" "
R50	"	820Ω	" "
R51	"	820Ω	" "

SW1 Single pole change over miniature toggle switch
[illegible] 1 pole 11 position rotary switch
[illegible]
[illegible]
[illegible]



As the photograph shows, the resistors are wired directly onto the wafers

The input and output resistances of the unit remain relatively constant at 600 ohms over the full attenuation range. The input impedance can be changed to 10k by SW1 but an additional 30dB of attenuation is added. The output can also be terminated internally by SW4 when using a high impedance load such as a meter.

The maximum attenuation when the input and output resistances are set at 600 ohms is 59dB. There are ten 1dB steps from 0dB to 9dB, via a 10 position rotary switch, and a further six 10dB steps from 0dB to 50dB via a six position rotary switch, giving a total of 60 steps from 0dB to 59dB. This range of attenuation is adequate for most purposes. Although further sections could be added, noise becomes a limiting factor in a simple attenuator such as this.

CONSTRUCTION

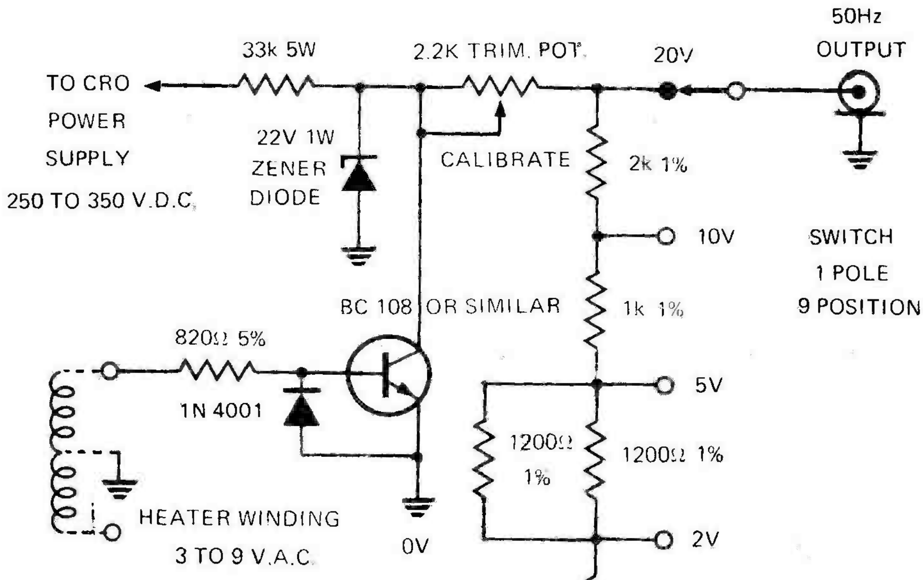
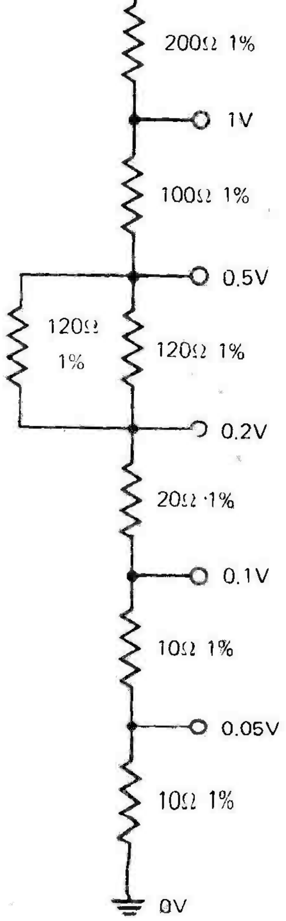
It is advisable to employ separate wafers for each switch pole. If the type of switch that has two poles on one wafer is employed, there may be problems at the high frequency end due to stray capacitance. This would be evident as spikes on the leading edges of high frequency square waves.

The common rail for each switch is a length of 18 gauge tinned copper wire formed into a ring to allow termination of the shunt resistors (R4, R23, R7 and so on). The series resistors are connected directly between the relevant switch contacts. Layout of the unit may be seen by the accompanying photographs. ●

OSCILLOSCOPE CALIBRATOR

eti PROJECT

This simply-constructed voltage calibrator can be built into practically any existing oscilloscope.

THIS simple calibrator enables 50 Hz square waves of exact amplitude to be displayed on an oscilloscope.

The calibrator can be added to existing oscilloscopes, or built as an external accessory. It eliminates measuring errors due to gain controls, or probe dividers, as a calibration signal is obtainable by inserting the probe tip directly into the calibration output socket and checking the displayed calibration signal against the calibration control switch setting.

The oscilloscope time-base accuracy can also be checked with this calibrator — the 50 Hz square-wave signal is derived from the mains thus providing a stable 20 millisecond period.

The calibration voltage is derived from a 22 volt zener diode; this voltage is chopped at 50 Hz by the BC 108 transistor, trimmed to exactly 20 volts by the calibration potentiometer and applied across a chain of precision resistors.

The consumption of the unit is negligible and is energized by the power supplies of the oscilloscope to which the unit is fitted.

It is obviously impossible to give installation instructions for each individual make and type of oscilloscope — however all that is required is to locate an HT rail carrying between 250 and 350 volts for the main divider supply, and the filament transformer for the chopper supply. The diode connected between the BC 108's base and emitter protects against excess voltage at this point.

The divider earth point and the emitter of the BC 108 chopper transistor should be taken to the same point. All wiring should be shielded or located away from existing oscilloscope wiring to avoid cross talk.

The 50 Hz calibrator output should be taken to a binding post mounted on the front panel of the scope. The rotary calibrator switch should also be mounted on the front panel. If a miniature switch is used for this function no problem should be found finding a suitable location — the existing panel lamp mounting can often be utilized for the purpose.

The calibration potentiometer is best mounted internally. Once set it rarely needs further adjustment.

Initial calibration is performed by disconnecting the collector of the BC108 transistor and then using an accurate dc voltmeter to set the top of the divider chain at exactly 20 volts. ●

Circuit of complete oscilloscope calibrator — note that some resistor values in the divider chain are obtained by parallel resistors of higher value.

LINEAR IC TESTER

The completed linear IC tester

Test all commonly available operational amplifiers for three vital parameters.

LINEAR integrated circuits are available today at prices little higher than those of discrete transistors. As they offer far better performance parameters, and greater versatility than transistors they are being used in new designs in ever increasing numbers.

Most linear ICs are now built into a standard 8-pin, dual-in-line plastic pack, have the same pin connections and very similar characteristics. Hence as the only real difference is in the associated frequency compensation network, a universal, linear – IC tester is quite a feasible proposition.

The tester, described here provides a quick check of vital operating parameters. Checks are provided for offset voltage (max ±10mV), offset current (max ± 1000 nA) and of operation in an actual circuit configuation.

It is a most valuable instrument; saving an experimenter time that would otherwise be spent tracing down faulty ICs.

CONSTRUCTION

We chose to mount our circuitry on a small piece of matrix board, rather than a printed circuit board, as there are relatively few components used.

Make sure that IC1 is orientated correctly (note pins 1, 5 and 8 are not used). The wires from the compensation switch (SW2) should be as short as possible in order to minimise the chance of unstable operation.

The test socket should be glued into place (taking care not to get glue down the pins) and, after the wires to the socket are soldered on, these should also be held to the panel with glue or a metal clamp.

The wires to the socket must be supported in some way, as detailed above, to prevent the rather fragile pins breaking off.

HOW TO USE

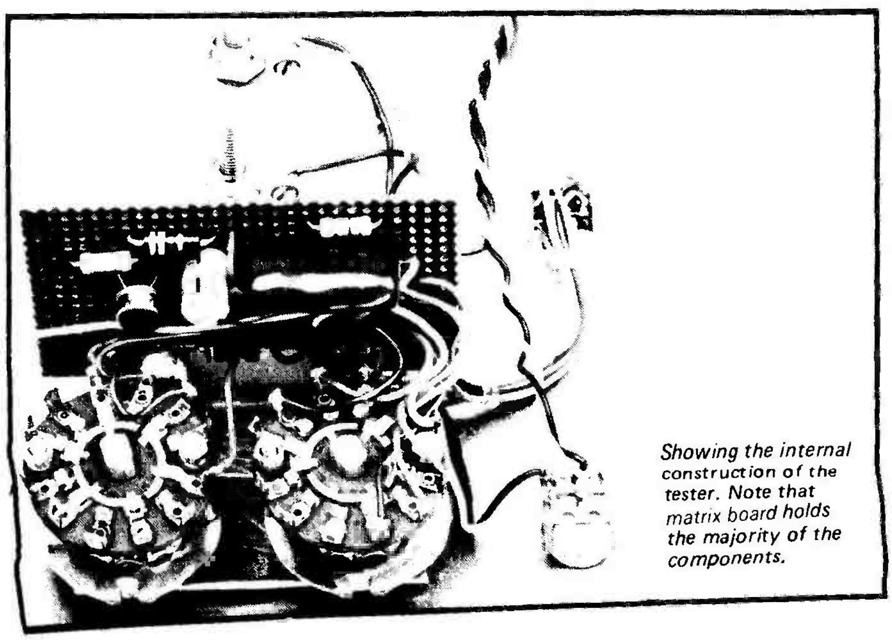
The parameters of commonly-available ICs are detailed in Table 1. An IC on test should not exceed these figures. Those that do exceed these values may not operate correctly in some circuits and should be discarded.

To test an IC, plug it into the test socket making sure that it is orientated correctly. Select the appropriate equalization as detailed in column 4 of Table 1 and switch the unit on. Select 'OSCILLATOR' mode and observe that the meter should sweep up and down the scale at about 1 Hz.

Now switch to 'OFFSET VOLTAGE' mode and read the meter which is calibrated at 10 mV full scale deflection.

Next switch to 'OFFSET CURRENT'. In this mode the meter is calibrated at 1000 nA (1 microamp) full scale deflection.

Discard any IC that does not oscillate or has excessive offset current or voltage.



Showing the internal construction of the tester. Note that matrix board holds the majority of the components.

TABLE 1

TYPE	MAX OFFSET CURRENT	MAX OFFSET VOLTAGE	COMPENSATION
301	50 nA	±7.5 mV	C
307	50 nA	±7.5 mV	A
308	1 nA	±7.5 mV	C
709	500 nA	±7.5 mV	B
741	200 nA	±6 mV	A
748	200 nA	±6 mV	C
777	20 nA	±5 mV	C
1456	30 nA	±12 mV	A

PARTS LIST ETI 115

R1,2	Resistor	100	5% ½W
R3,5	"	2.2M	" "
R4	"	1 M	" "
R6	"	22 k	" "
R7	"	1.5 k	" "
R8	"	3.9 k	" "
R9	"	33 k	" "
R10	"	150 k	" "
C1	Capacitor	1μF polyester	
C2	"	0.0047μF polyester	
C3	"	33pF	ceramic
C4	"	220pF	"
C5,6	"	10μF 16V electrolytic	

IC1 integrated circuit μA741

M1 meter 0.5 mA — 0 — 0.5 mA (available in the 38 series of Henelec from Henry's Radio)

SW1 Switch 2 pole, 3 position rotary

SW2 " 2 pole, 3 position rotary

SW3 " 2 pole on-off toggle.

Metal box approx. 150 x 180 x 90mm.

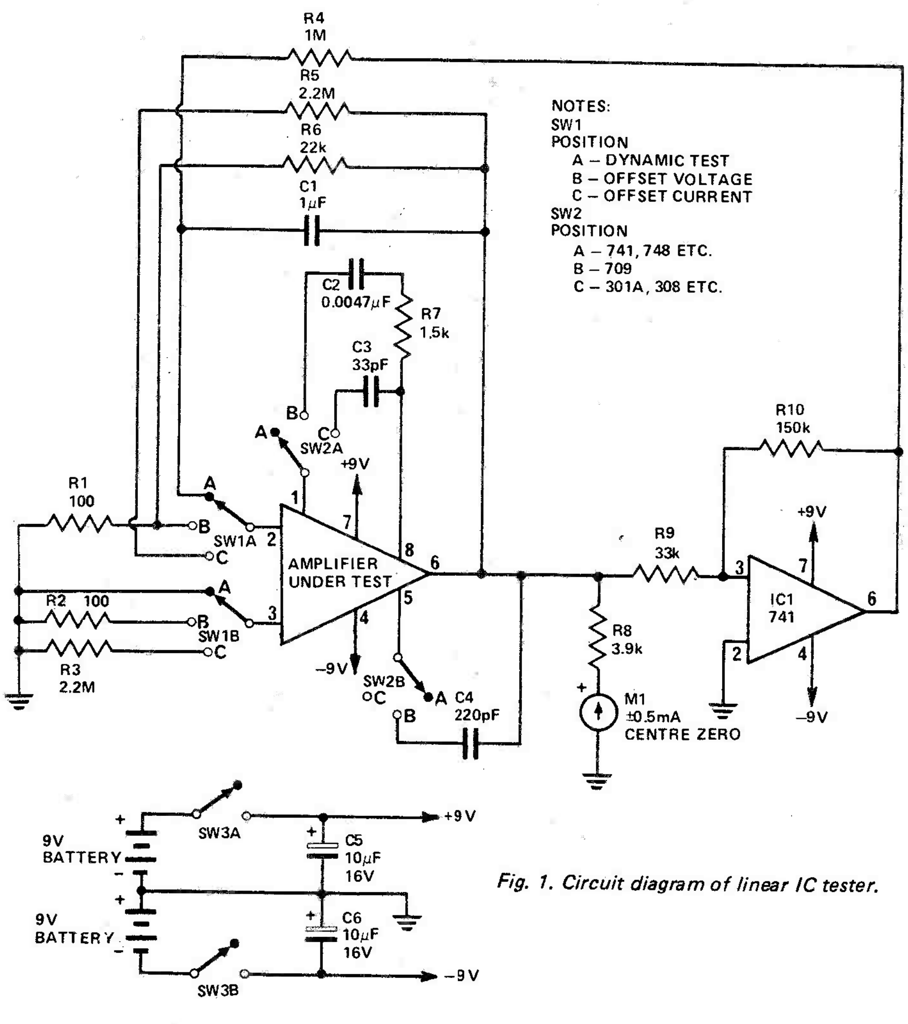


Fig. 1. Circuit diagram of linear IC tester.

HOW IT WORKS – ETI 115

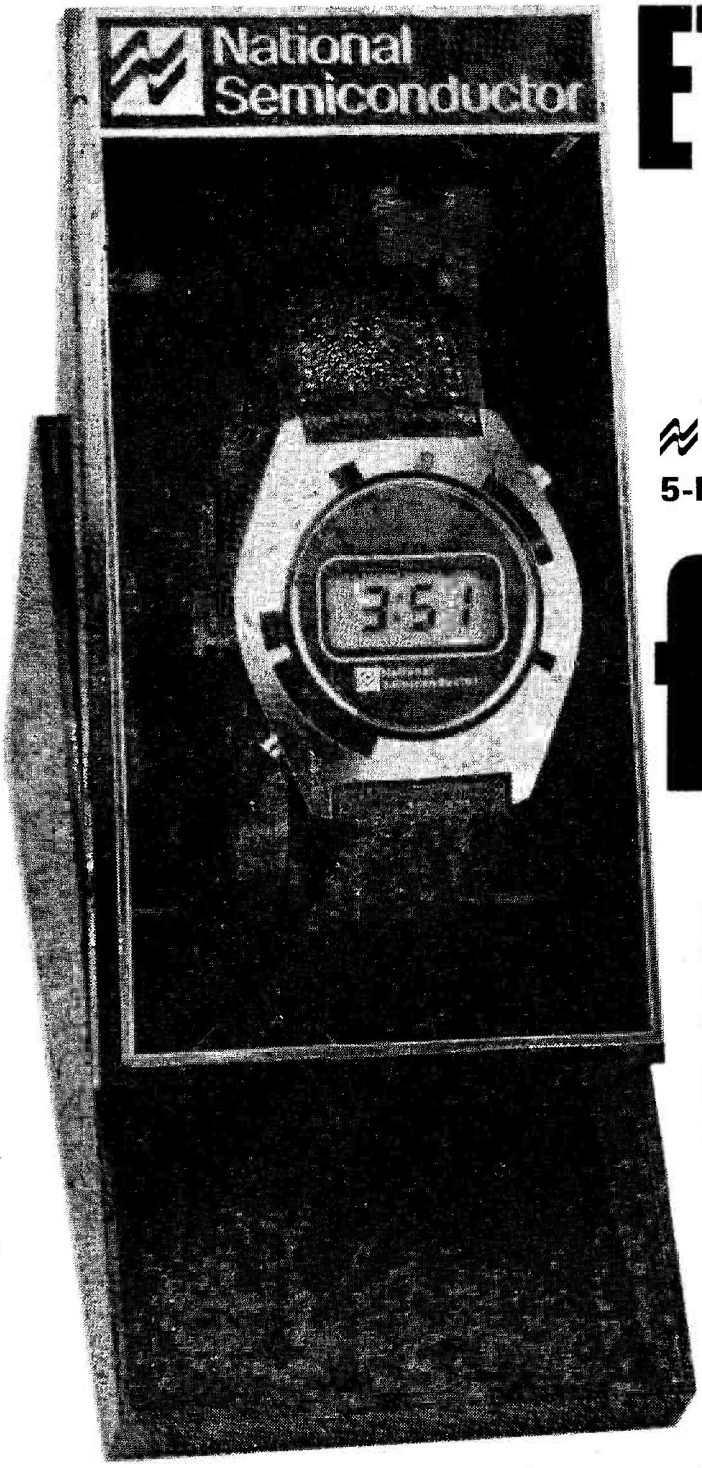
Centre-zero meter M1, via resistor R8, indicates the output voltage from the IC under test. The frequency compensation components for the particular IC under test are selected by SW2, and the test mode is selected by SW1.

In position "C", of SW1, a 2.2 megohm resistor is connected from the output (pin 6) of the IC under test to the inverting input (pin 2), and a 2.2 megohm resistor from the non-inverting input (pin 3) to ground. Current is drawn by both pin 2 and pin 3 of the IC and, if these currents are equal, the output voltage will be zero. Any difference in input currents will therefore be indicated as an output voltage on meter M1.

In position B the resistor from pin 6 to pin 2 is reduced to 22k and a 100 ohm resistor, R1, is connected from pin 2 to ground. This results in the IC having a voltage gain of 220. Resistor R2 is also made 100 Ω so that offset current does not affect the operation in this mode. Hence the IC will now amplify any offset voltage between pin 2 and pin3 (that is, it is operating in the linear mode) by 220 and the meter deflection will be proportional to the offset voltage.

If either offset voltage or offset current are excessive the meter will read off scale and the IC should be discarded.

In mode A the IC is connected as a triangular wave oscillator having an operating frequency of 1Hz. Integrated circuit IC1 is connected as a Schmitt trigger where the output of the Schmitt goes high if its input drops below -1.5 volts, and will go low if the input exceeds 1.5 volts. The output of IC1 is taken, via a 1 megohm resistor, to the input of the IC under test and the output of the Test IC becomes the input of the Schmitt trigger. An integrating capacitor, C1, is connected across the IC under test. The effect of this is to cause the output of the test IC to rise at 7 volts per second until +1.5 volts is reached. At this point the Schmitt operates and the output of the test IC now commences to fall at the same rate. When -1.5 volts is reached the direction reverses again and the cycle repeats. Thus we have an oscillator with a frequency low enough to be followed by the output meter as an indication of correct operation.



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STANDARD IGNITION

The simple ignition circuit which is still used in virtually all mass-produced cars is shown in Fig.1. Incredibly it was designed 60 years ago by Charles Kettering as an improvement on early magneto ignition. The way it works and the reasons why it is no longer adequate for today's highly developed petrol engine are as follows.

The contact breaker (or 'points') in Fig. 1 is driven by a cam to break the current in the ignition coil primary every time a spark is required to ignite the petrol vapour in a cylinder. Consider when the contact breaker has just closed. The battery is then connected across the primary, via the ignition switch and, since the primary has inductance, the current increases at a slow exponential rate as shown in Fig. 2. With typical primary inductance and resistance values of 10 millihenries and 3 ohms the circuit's time constant (the time for the current to reach 63% of its final value) is about 3.3 millisecond, though there is considerable variation between coils. If the engine is not running (so the cam is not turning) the primary current will settle at its maximum value of 4A or more which is set only by the battery voltage and the primary resistance. This high current tends to overheat the coil and run down the battery if a car's ignition switch is left on with the engine stationary.

Primary current causes magnetic flux in the coil, representing stored energy of value $\frac{1}{2}LI^2$ joules. When a spark is required, the contact breaker opens and the primary current is broken. As the previously created flux collapses it induces voltages in the coil windings, proportional to their numbers of turns. The peak voltage induced in the primary is about 300V but, since the secondary has about a hundred times as many turns, the secondary voltage is about 30,000V. This is sufficient to ionise the air gaps in the distributor (between the rotor arm tip and whichever terminal connected to a spark plug is nearest) and at the selected spark plug, so a spark occurs. Actually the spark plug is not firing in air but in a gas compressed to 200 lbs per square inch or more which requires a higher voltage to ionise it.

The weak link in the Kettering circuit is the contact breaker. This is a simple mechanical device which must be driven relatively slowly compared with rise of voltage in the primary; this is dictated by practical factors such as the return spring strength, the weight of the moving contact and the allowable force on the distributor cam. The unavoidable result is that the primary voltage transient rises faster than the breakdown potential of the newly opening air gap in the contact breaker and therefore arcing occurs in the early stages of contact breaking. Besides wasting some of the energy stored in the coil, this arcing detaches metal from one contact face and deposits it on the other and after only a few miles driving the first signs of pitting become visible — see the photograph. Pitting creates sharp edges on the contact faces which worsen arcing; the available spark voltage is reduced since arcing limits the voltage achieved in the primary. Also pitted contacts have significant resistance when closed so that optimum current (energy) is no longer built up in the primary. Eventually the loss of engine performance becomes so serious that the contacts have to be replaced.

THE 'CONDENSER'

This is a small capacitor which is connected across the contact breaker to reduce pitting and improve the spark slightly. When the contacts open, this capacitor is in effect connected across the coil primary and slows down the voltage transient so the contacts have a better chance of breaking the primary current cleanly. It is only a partial improvement, sufficient to make the Kettering circuit barely useable, and the capacitor must not be too large or the spark voltage will suffer.

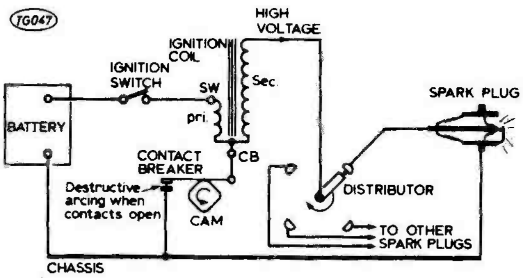


Fig. 1 (Above) The standard (Kettering) ignition circuit as fitted to virtually all mass produced cars for 60 years.

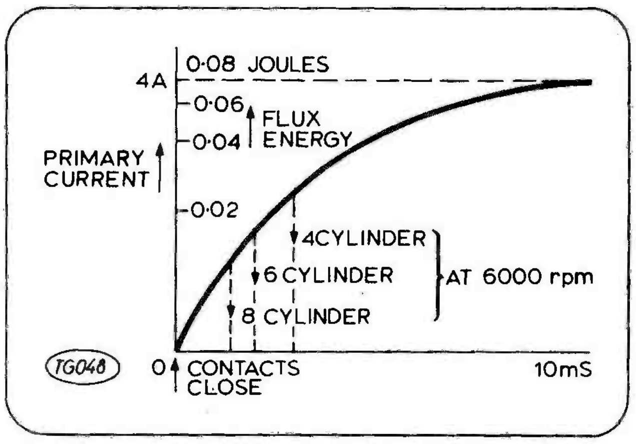


Fig. 2 (Right) After the contact breaker closes, current in the coil primary builds up at an exponential rate. Dotted lines show the times when the contact breaker opens for different sizes of engine at high speed. This graph assumes the contact breaker is in good condition and is driven with 50/50 mark/space ratio.

DESIGN LIMITATIONS

Two situations stretch conventional ignition to its limit. These are:

a) Starting on a wintry morning when the starter motor loading reduces the battery voltage and hence the primary flux so only a feeble spark is available to ignite a cold mixture, and

b) High speed running when the time between sparks does not allow adequate flux to build up.

Most drivers are well aware of shortcoming a) but it is not well known that most cars with conventional ignition suffer from misfiring at high speeds, though there is a definite loss in m.p.g. and smoothness. The reason for spark deterioration at high speeds

Electronic Transistorised Ignition

is shown by the dotted lines in Fig.2; ignition is only satisfactory if there is 0.04 joules or more flux energy in the coil at the time the contacts open. Only half the time between sparks is utilised for energy buildup since the contact breaker has an open/shut time ratio of about 50/50. Also, the contact breaker may suffer from bounce after closure so that as much as half a millisecond is wasted before primary current can start to rise.

The only way the Kettering circuit can be made to cope better with a) and b) is by redesigning the coil with lower primary inductance and resistance so more primary current can build up in shorter time – this is the aim of so-called 'sports' coils. Unfortunately this carries the penalty of even shorter contact breaker life. A cunning answer is the 'cold start' coil fitted by some manufacturers. This is actually a coil which would draw excessive current if continuously fed 12V so is normally run with a current-limiting ballast resistor in the primary circuit. However for starting only, the primary is supplied directly from the starter switch or solenoid (see Fig.3) to obtain a hotter spark.

'TRANSISTOR ASSISTED' IGNITION

This is an early type of transistor ignition which was popular in the U.S.A. in the 1960's. The idea is to use a high voltage switching transistor to handle the coil primary current instead of the contact breaker. This eliminates contact pitting since the contact breaker need only switch the tiny bias current which controls the transistor. A typical circuit is shown in Fig. 4. Zener diode(s) or choke(s) must be included to protect the transistor(s). The circuit could be said to simulate a contact breaker that never wears out although the other basic weaknesses of the Kettering circuit remain, plus it has the special disadvantage that some battery voltage is 'lost' across the transistor junctions when saturated ('on'). Performance is improved by replacing the standard ignition coil by one with 400:1 step-up ratio designed for transistor operation.

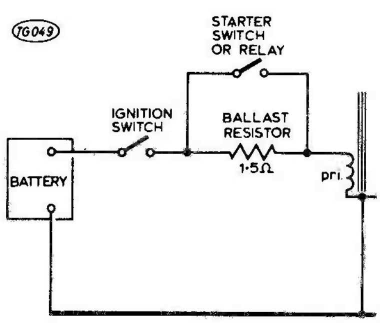


Fig. 3. 'Cold-start' circuit such as used by Ford and Vauxhall. The ballast resistor may be a button type mounted on the coil, or be incorporated in the ignition cable.

CAPACITOR-DISCHARGE IGNITION

This is the principle used by the ETI Electronic Transistor Ignition and it is a complete departure from Kettering's circuit. In spite of this it can be fitted to your car without changing the standard coil or any other ignition components!

The basic arrangement is shown in Fig.5. The battery voltage is no longer applied directly to the coil primary but is instead converted to a higher voltage by an 'inverter'. The inverter charges up C1 one end of which is in effect connected to chassis via the coil primary. A peak voltage of about 400V is obtained. When the contact breaker opens, the trigger circuit 'fires' the S.C.R. (silicon controlled rectifier or thyristor) which suddenly behaves as a short circuit. This connects the 400V on C1 to the coil primary, the SW terminal being driven 400V negative with respect to the CB terminal. The 400V is stepped up in the secondary to give a spark pulse of up to 40,000V. The coil primary and C1 form a parallel tuned circuit so that the primary current increases sinusoidally to a maximum, decreases to zero and then swings negative – see waveforms. The inverter circuit provides a route (D1, D2) for this backswing current to partially recharge C1 ready for the next spark, improving the efficiency of the circuit. The backswing also ensures that the S.C.R. turns off so the inverter can recharge C1.

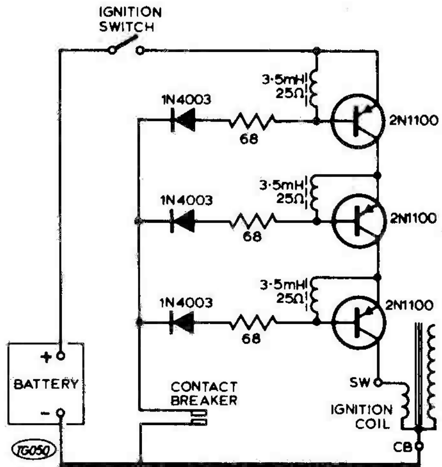


Fig. 4. A 'transistor assisted' ignition circuit built by the author some years ago for a negative-chassis car. Today a single high voltage transistor could replace the three 2N1100's used in cascade. The circuit effectively eliminated contact breaker pitting.

The most important difference between C-D and Kettering ignition is that in the former the coil is no longer used to store energy for the spark. Instead the spark energy is stored in a capacitor C1. The coil is merely used as a pulse transformer to transfer energy from C1 to the spark plug when the S.C.R. completes the primary circuit. Your existing coil, be it standard, cold-start or sports type is suitable since it is only necessary for the secondary/primary turns ratio to be about 50 or 100:1.

Capacitor-discharge ignition has important advantages. Contact breaker arcing is eliminated since the trigger circuit passes only a small non-inductive current through the contacts. A hot spark is provided under both the 'difficult' conditions a) and b) described earlier for conventional ignition since the inverter can be designed to give adequate output even with reduced battery voltage when starting, and is capable of recharging

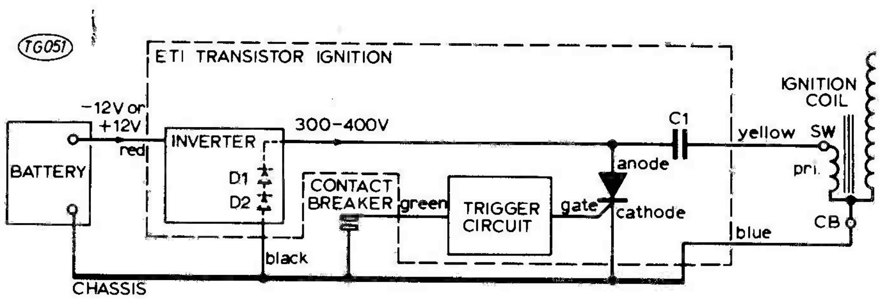


Fig. 5. Block diagram of ETI transistor ignition. Suggested cable colours for connection to the vehicle are shown.

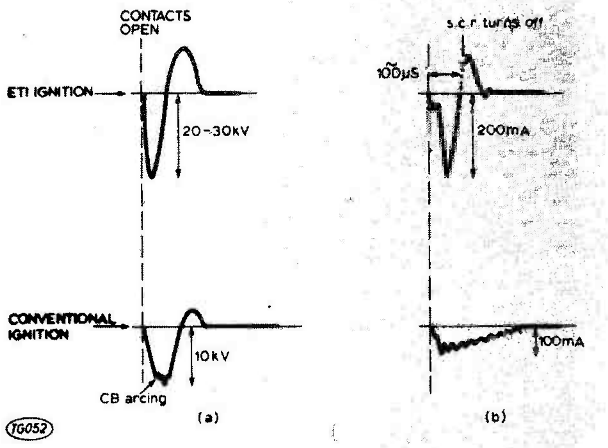


Fig. 6. Comparison of capacitor discharge and conventional ignition. In a) are shown the coil secondary voltages. The spark plugs were disconnected to discover the peak voltage available and the coil was damped to prevent ringing. The actual spark currents are shown in b) — note the fast bi-directional spark obtained with C-D ignition.

C1 in a much shorter time than the interval between sparks, even for an 8 cylinder engine going flat out! Under more likely conditions, charging will probably be almost complete before the contacts close in readiness for the next spark; 'charging' (flux buildup) in the Kettering circuit can not even begin until the contacts close.

The turn-on action of the S.C.R. is much faster than the arcing-degraded opening time of the contact breaker in the conventional system, as a result the rise time of the spark pulse is faster. If a spark plug is fouled with engine deposits it may have enough leakage resistance to dissipate the energy of the slower pulse before it can ever rise to the firing voltage. Tests with badly fouled plugs have proved C-D ignition's ability to produce good sparks where conventional ignition fails. Probably helpful is the 'forward and back' nature of the C-D spark current — see waveforms.

Other advantages of C-D ignition are that it is unaffected by contact breaker bounce, there is no overheating if the ignition is left on with the engine stationary, and the current demand is less. The superior spark continually ensures good combustion with resulting improvements in m.p.g., performance and pollution which are not claimed to be dramatic, but are noticeable and do not deteriorate. Cold starting is very much improved and the incidental savings on battery and starter lives (and temper!) are obvious.

INVERTER

An inverter with the minimum number of components, and hence the maximum reliability, was sought for this design. A single transistor inverter is possible but would give poor output and be rather inefficient. Therefore the simplest possible two-transistor inverter circuit was adopted — see Fig. 7. Here Q1 and Q2 are connected as a multivibrator with the 30-turn primary windings of T1 as collector loads and base drive provided by the 220 ohm resistors. There are no isolated feedback windings so the transformer cost is kept low. The circuit works as follows:

At switch-on whichever of Q1 and Q2 has higher gain conducts first. suppose Q1 conducts first. Its collector is pulled down to negative rail potential so that Q2 receives no base drive and remains off. Since the centre tap of the primary is connected to 12V positive, transformer action sends Q2 collector nearly 24V positive which ensures continuing base drive for Q1, keeping it on. The collector current of Q1 increases at a rate set by the inductance of the upper half of the primary winding. Eventually Q1 collector current exceeds the product:

Q1 base current x Q1 current gain and Q1 collector voltage rises as the transistor comes out of saturation. This immediately starts to turn on Q1 which removes Q1 base drive. Thus Q1 and Q2 rapidly drive each other off and on respectively and the cycle begins again but with Q2 conducting and current flowing in the opposite direction in the lower half of the primary. The cycle continually repeats and squarewaves are produced at the collectors — see Fig. 7. These are stepped up by the transformer and bridge-rectified to produce the inverter output of 300 to 400V d.c.

Low value base resistors are used to place the point at which the primary current reverses near the saturation limit of the transformer. The operating frequency and the inverter performance depend on the characteristics of the transformer and a suitable component has been specially designed for this project. The operating frequency is in the audio range and a clear whistle can be heard from the transformer core, showing the inverter is working. The only other components in the primary side of the inverter are the base-emitter protection diodes. These are mainly intended to protect the transistors against inadvertent reversed battery connections. In this case a heavy current will flow through the diodes, (the base-emitter junctions being protected from zener breakdown) the base-collector junctions and the primary, and hopefully the fuse incorporated in the unit will blow before components are damaged.

A large electrolytic reservoir capacitor is fitted in the supply to the inverter. This ensures good performance and also positively avoids the problems sometimes experienced with other ignition designs of false triggering of the S.C.R. caused by the inverter producing voltage spikes across the supply lead resistance.

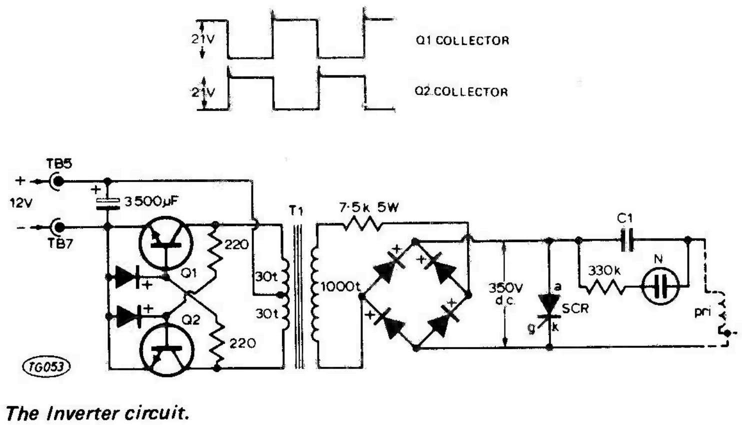


Fig. 7. The Inverter circuit.

Electronic Transistorised Ignition

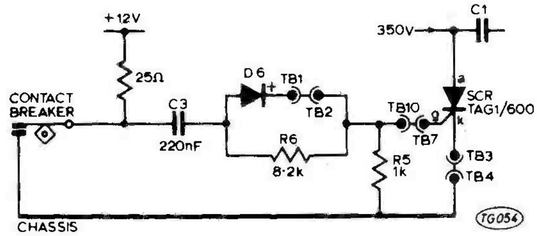


Fig. 8. Trigger circuit for negative chassis vehicles.

A surprising feature of the inverter circuit is that it continues to function weakly if one of the transistors is removed or goes open circuit. This might suffice to get you home at 30 m.p.h.!

In most previously published designs the inverter is allowed to 'see' a short circuit (via the bridge rectifier), for example at switch-on when C1 is not charged, and every time the S.C.R. fires. Although this does no damage it causes the inverter to run briefly in a high-frequency low-efficiency mode since the only inductance loading the transistors is the leakage inductance of the transformer. An alternative is to design the inverter to stop oscillating when shorted but this presents starting delay problems. For this design it was thought preferable to keep the inverter running continuously in the proper audio-frequency high-efficiency mode. A simple way of achieving this is by having a resistor in series with the secondary winding. The inverter now continues to run audibly even if the bridge output is shorted. If a milliammeter is used to do this a short-circuit current of 30 - 40mA can be measured indicating the circuit has excellent 'pick up' after each spark. Note that T1 and the secondary resistor normally run warm but get quite hot if the bridge output is shorted continuously. No difficulty has been found in relying on the backswing from the ignition coil to turn off the S.C.R. specified in this circuit, in spite of the high charge current.

OVERSHOOTS

The inverter provides adequate output voltage to start the engine at reduced battery voltage of 8V or less yet will not exceed 400V with a fresh battery, so no attempt has been made to use the inverter waveform overshoots for output regulation. As can be seen on the waveforms in Fig. 7 the overshoots are small, partly because the primary of T1 is bifilar wound for low leakage inductance and partly because most of the overshoot power is taken by the neon indicator.

NEON LAMP

A neon lamp with series resistor is connected across C1 so that illumination indicates that the inverter is working, C1 (a highly stressed component) is not short circuit and that the ignition coil primary connections are intact. To avoid taking excessive power from the circuit, the neon is not driven very brightly but should be clearly visible in the shade of the engine compartment.

S.C.R. TRIGGERING

The S.C.R. must be triggered by means of a positive pulse at its gate relative to its cathode every time a spark is required, i.e. every time the contact breaker opens. Different means of triggering are used for negative- and positive-chassis vehicles as shown in Fig. 8 and Fig. 9. Viewing Fig. 8, 0.5A is passed through the contact breaker when closed by the 25 ohm resistor. The purpose of this current is to keep the contacts clean by burning off any minute deposits; contact breakers switching smaller currents can be very troublesome due to a fine film of oil and dirt building up on the contact faces. Since the contact breaker has approximately 50/50 open-shut period, the mean current drain of this arrangement is negligible at 250mA.

When the contact breaker opens, the 25 ohm resistor pulls one side of C3 from OV to 12V, D6 conducts and a positive pulse, differentiated by C3 and R5, is fed to the S.C.R. gate causing it to fire and discharge the 350V on C1. It is not possible for another trigger pulse to be produced until C1 discharges. D6 blocks the discharge current which cannot flow until the contact breaker closes and must then flow through the comparatively high value resistor R6 and R5. Thus a new trigger pulse cannot be produced until the contact breaker has been closed long enough to discharge C3. This arrangement effectively makes the system immune to false triggering caused by contact breaker bounce. The component values are chosen to suit the trigger characteristics of the S.C.R. specified and may not suit other types.

The trigger circuit for positive chassis in Fig. 9 works similarly with the difference that the trigger is a *negative* pulse which is passed by D5 to the S.C.R. *cathode.* Since the gate is connected to chassis this gives the correct trigger conditions. When the S.C.R. fires the discharge current flows through D7.

FULL CIRCUIT

The full circuit is shown in Fig. 10 and has the features of easy switch-over from transistor to conventional ignition by means of toggle switches S1, S2, and convertibility for positive or negative chassis by mounting a link strip in alternate positions on a miniature terminal block. The main elements of the circuit have been described; the connections to the terminal block are rather complex but can be understood by reference to Figs. 8 and 9. When S1 and S2 are both switched to conventional the transistor circuit is isolated (though

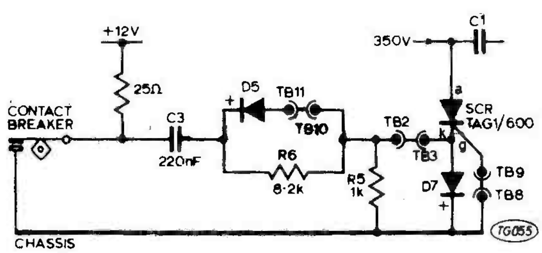


Fig. 9. Trigger circuit for positive chassis vehicles.

the inverter still receives power) and the normal connections for Kettering ignition are remade i.e: coil primary connected to ignition switch and contact breaker. This switchover facility can be used while the engine is running for comparison purposes.

COMPONENTS AND CONSTRUCTION

For obvious reasons the unit must be dependable while driving. To this end all the components specified are of high quality and in many cases of higher than necessary ratings. Construction must be equally sound. Component substitutions are not recommended e.g. slide switches should *not* be used in place of the toggle switches because of the inductive circuit switched, nor is it a good idea to remote these switches to the dashboard.

The components are mounted on the lid of a standard Norman AB10 aluminium box for easy access. The layout is shown in Fig. 11 and in the photograph. Drilling details are given for the box in Fig. 13 together with

PARTS LIST

R1	Resistor	220ohm 5W wirewound
R2	"	220ohm "
R3	"	7·5k "
R4	"	25-39ohm 10W "
R5	"	1k ½W 5%
R6	"	8·2k " "
R7	"	330k " "
C1	Capacitor	0·47uF or 0·5uF 440V a.c. tubular (MFD type TSAC)
C2	"	3500uF 25V electrolytic
C3	"	220nF (0·22uF)
D1-D4	Diodes	1N4006 or 1N4007
D5-D9	"	1N4001 (or -2, -3 etc.)
SCR	Thyristor	TAG 1/600
Q1-Q2	Transistor	NPN silicon plastic power type with min Vce of 50V and min gain at 500mA of 40.
T1		Inverter Transformer (Bi-Pre-Pak)
S1,S2	Switches	Heavy duty DPDT toggle switches
FS		5A 1¼in fuse with holder
TB		11 way miniature terminal block with screws and solder tags (Carr)

Miscellaneous
Norman AB10 chassis with lid; Heatsink; Neon bulb; 2 x 10 way tag strips; Transistor mounting hardware; Grommets; Coloured wire; Nuts and bolts etc.

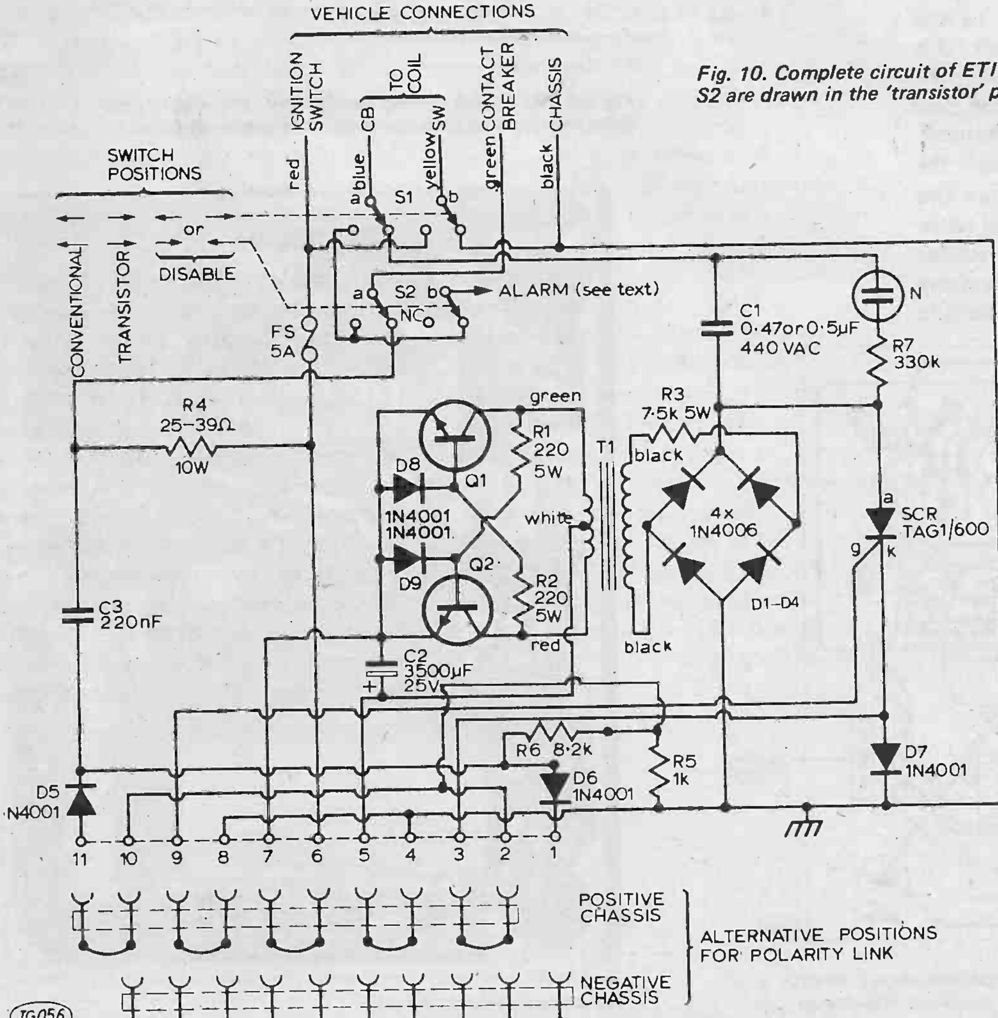
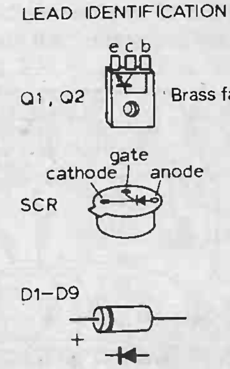


Fig. 10. Complete circuit of ETI Transistor Ignition. S1 and S2 are drawn in the 'transistor' position.

LEAD IDENTIFICATION



DESIGN NOTE

A few readers have experienced trouble with starting. This can be cured by increasing the value of C1 to 1μF.

All electronic ignition systems, including this one, can upset electronic tachometers. Unfortunately these work using several methods and it is not possible to modify some systems. We regret we are unable to offer advice on this point.

Electronic Transistorised Ignition

an aluminium heatsink for the transistors and inverter transformer but the kit is supplied with a predrilled chassis and will not in this case be necessary.

It is convenient to mount as many components as possible on the tagstrips before mounting the tagstrips in the box. Pass the tagstrip mounting bolts through both the lid and the heatsink. Then mount the plastic power transistors using the mica washers and insulating bushes supplied to isolate the metal part of the transistor (collector) from the box — see Fig. 12. The transistor mounting bolts are live to the collectors.

Mount the toggle switches, transformer, fuseholder and terminal block. The wiring can now be completed. Take special care to make robust connections to the transistor leads, using sleeving to prevent shorts. Wrap component wires round tags before soldering to give strength to the joint. Be careful with connections to the small tags on the terminal block, this is mounted with pin 1 on the right when viewing the unit from the outside with the heatsink uppermost. Check these tags cannot foul the edges of their rectangular cutout. Use insulating sleeving on all exposed wires. The neon is held in a black rubber grommet to improve visibility and give physical protection. All connections to

An excellent example of pitting on a contact breaker. Due to the very much lower current switched for an electronic ignition system such problems are eliminated.

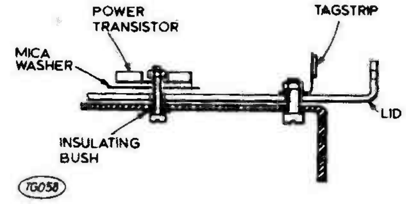


Fig. 12. Method of mounting power transistors. The shaded part is the heatsink.

Please note that this project is only suitable for 12V cars and we are unable to provide modifications details for 6V models.

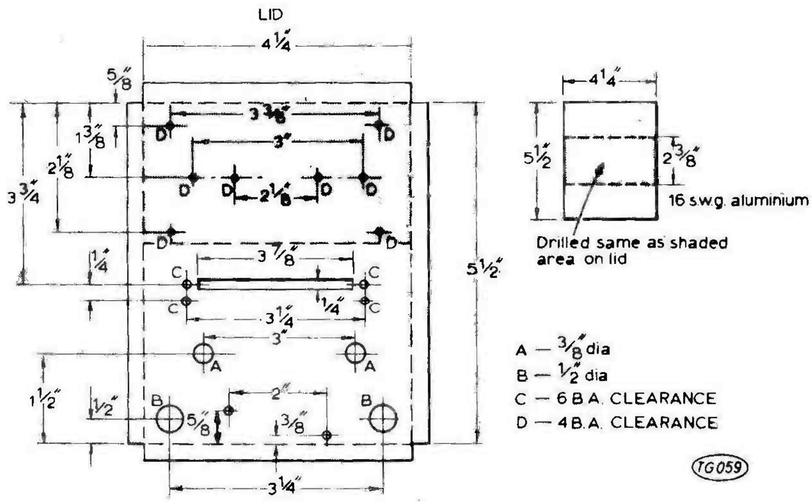


Fig. 13. The chassis drilling details. The three-eighth inch holes may have to be larger with some toggle switches.

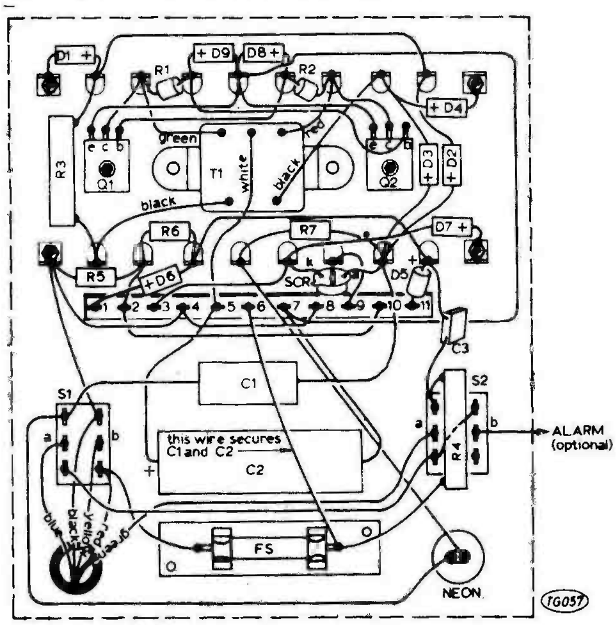
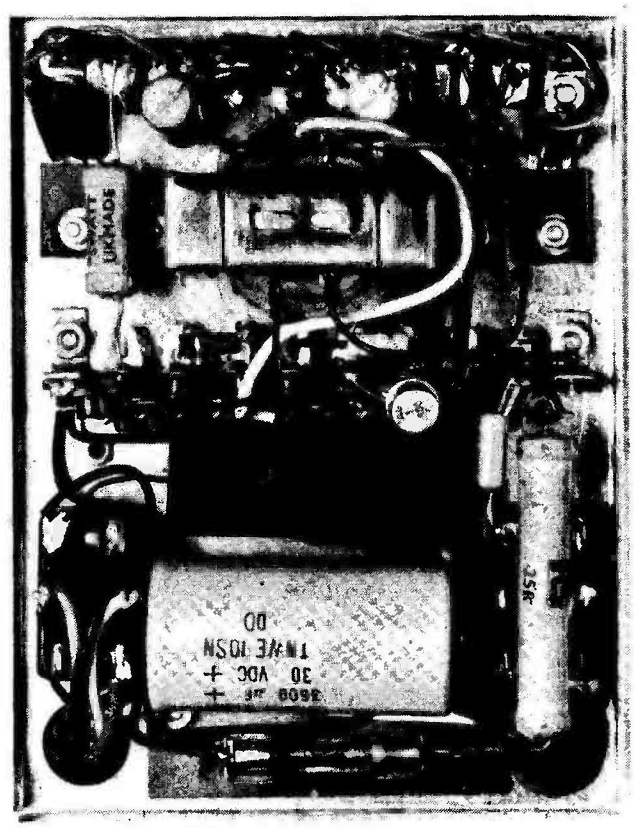


Fig. 11. ETI Transistor Ignition Component layout. (Prototype has Q1, Q2 in slightly different positions, also has an unused position 12 on the tag block).



An internal view of the unit.

the vehicle are by means of heavy gauge colour-coded cables which pass out of the unit through a grommet. Note that C1 and C2 are held secure by the wire from the fuseholder to TB6 being passed over them. R4 is mounted flat against the bottom of S2. Check that there are no shorts to the box when the two halves are screwed together. Solder the five links on the link strip and screw it to the terminal block in the correct position:

LEFT (heatsink uppermost) for positive chassis;
RIGHT for negative chassis.

INSTALLATION AND USE

With the ignition switched off, disconnect the existing leads to your car's ignition coil. Mount the unit by means of two screws passed through the base of the box in a convenient part of the engine compartment, less than 30in from the ignition coil and in a position well away from the hot exhaust manifold and reasonably well ventilated. DO NOT mount unit on engine. A good position is on a flat surface such as the main bulkhead since this helps heatsinking. Recheck the polarity setting, then connect the colour coded leads as follows:

RED: To ignition switch. Normally the lead just disconnected from the ignition coil SW terminal can be used but there must be no ballast resistor in series with the supply to the unit. Beware of ballast resistors incorporated in the SW lead.

BLACK: To chassis. This lead can be anchored under a nearby bolt to ensure a low resistance connection. It may seem anomalous that on positive chassis vehicles, red goes to battery negative and black goes to positive!

GREEN: To the contact breaker in the distributor. It can be connected to the free end of the lead previously disconnected from the CB terminal of the ignition coil.

BLUE and **YELLOW:** To the CB and SW terminals of the ignition coil. Remove any suppressor capacitor on the coil.

Check that all connections are secure (especially those to the coil) and taped to prevent shorts. Dress all wiring neatly and clear of hot or moving engine parts.

Put both toggle switches towards the heatsink and switch on the ignition. The neon should light and a whistle come from the unit showing the inverter is working. Start the car and observe the neon while revving up; it should not dim greatly. Treat your car to a new contact breaker, a plug gap check and a garage tune-up since these will not have to be repeated for a long time. If the garage is suspicious of transistor ignition, switch back to conventional. Resistive (suppressor) plug leads in poor condition should be replaced as they deteriorate faster with transistor ignition.

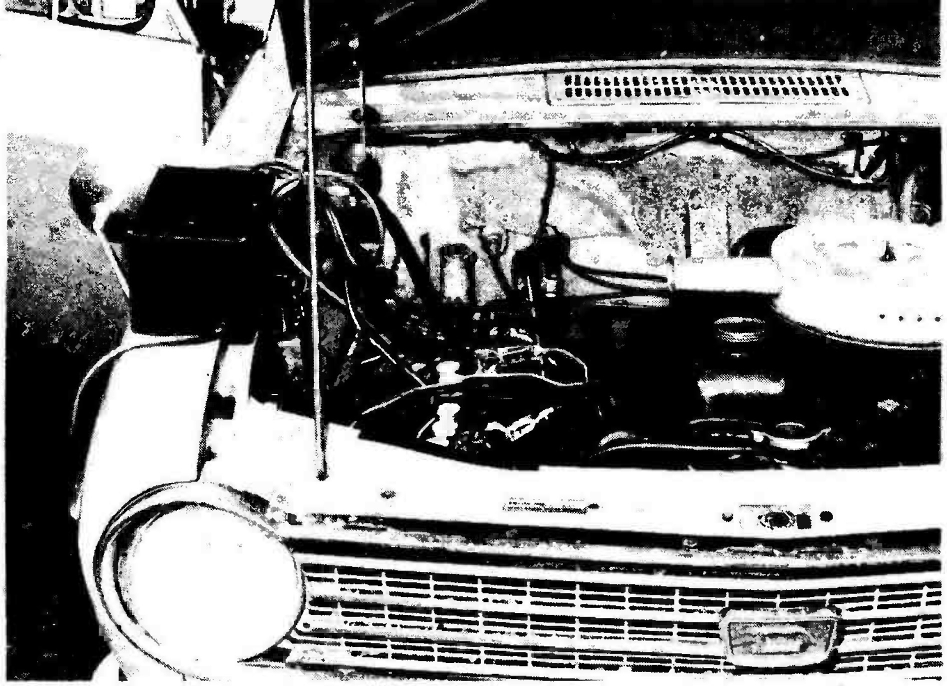
BURGLAR FOILING

If the toggle switches are put in alternate positions (one up, one down) neither transistor nor conventional ignition circuits are complete and the engine will not start. This feature can be used to immobilise the car when parked. Most car thieves will give up at this but a stronger deterrent can be arranged for more persistent thieves. A wire can be taken from the unused pole (b) of S2 (see circuit and layout) to the coil of the horn relay (if fitted) or to an extra hidden relay which when energised operates the horn or other alarm. Then if the ignition is disabled by putting S1 down and S2 up, any unauthorised use of the ignition switch will energise the relay and sound the alarm. Since the alarm supply at S2b comes via the ignition coil primary it may not be able to operate the horn directly although this may be possible with some horns if they are sufficiently sensitive. Horns that are switched in their chassis returns cannot be used without a relay.

SPARK POLARITY

At speed the tip of a spark plug runs at high temperature and some cathode emission, as in a radio valve, occurs. This means that the breakdown voltage is slightly lower for a negative spark pulse (with respect to chassis) than a positive one. The effect is usually ignored and is fairly academic with transistor ignition where adequate spark voltage is always available. However some claims are made that reversing the leads from the unit to the ignition coil (blue and yellow) improves performance and there is no harm in experimenting.

To increase the spark energy another 0.47uF or 0.5uF capacitor can be added across C1 but the unit is then suitable only for fairly low-revving engines with 4 cylinders or less.



NOTE

This battery charger described in this article has been designed specifically for charging 12 volt lead acid batteries.

Six volt batteries may be charged but there will be no automatic voltage cutoff. Six volt batteries should therefore not be permanently connected to the charger.

eti project

International 309 battery charger

This battery charger is fully protected against ALL fault conditions.

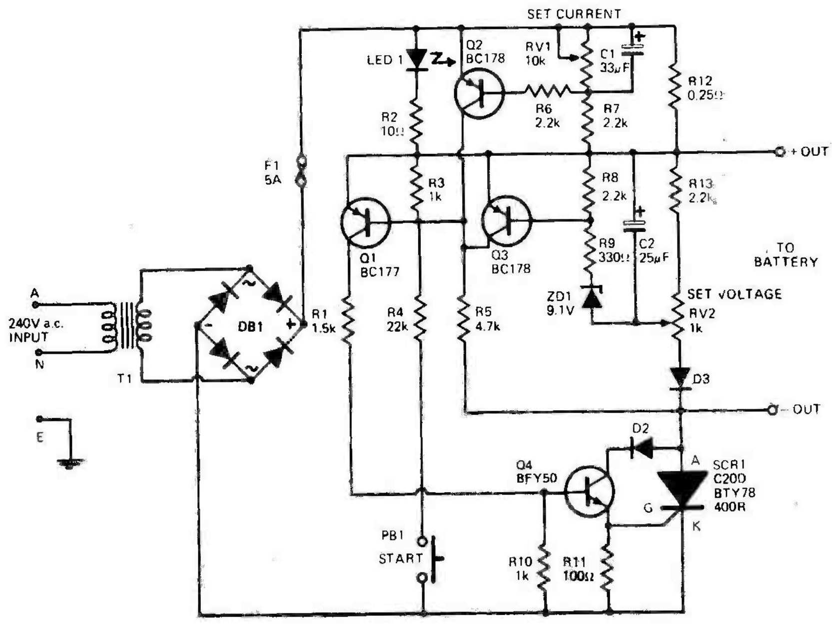


Fig. 1. Circuit diagram of battery charger.

AT first sight there would seem few circuits simpler to design than a battery charger.

But this is not so — to the extent that during our preliminary research we could not find a single unit that offered the protection against misuse that a charger really does need.

To be fully protected a charger must be able to:—

1. Operate into a short circuit.
2. Not be damaged by, or attempt to charge, a reverse connected battery.
3. Operate into a totally flat battery.
4. Be regulated for both current and voltage.
5. Be capable of floating a fully charged battery for extended periods.

In the International 309 charger all these conditions have been met.

Both current and voltage regulation are provided — initially the unit will charge at its maximum current limit of four amps — then, as the battery voltage rises, the charger changes automatically to a voltage limiting mode (maximum 14 volts).

In the voltage regulator mode of operation the current will be in the form of pulses with a relatively long time between them and the LED will noticeably flicker if the current falls to

SPECIFICATION

Charging Current	
Within battery voltage range 1V to 14V	4 amps.
Cutoff Voltage	14 volts
Starting	
Automatic self start range	4-14 volts
Push button start	0-4 volts

Protection

Constant current charging of 4A for all battery voltages from 1V to 13.5V.
Protected against reversed battery.
Protected against reversed battery with start button pressed.

Charge Indication

Illumination of LED indicates charging.
Flicking of LED indicates charge current has fallen to less than 1 amp.

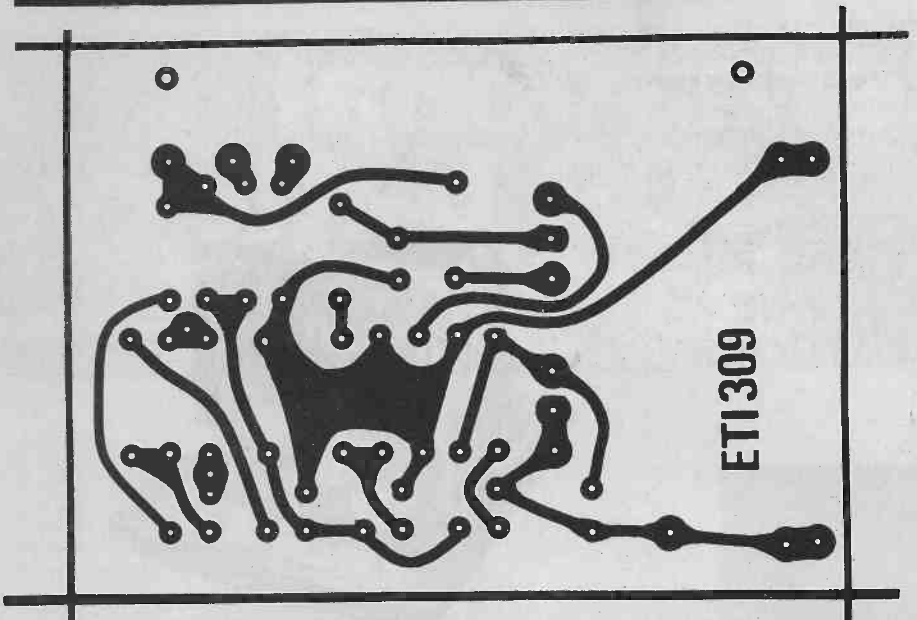
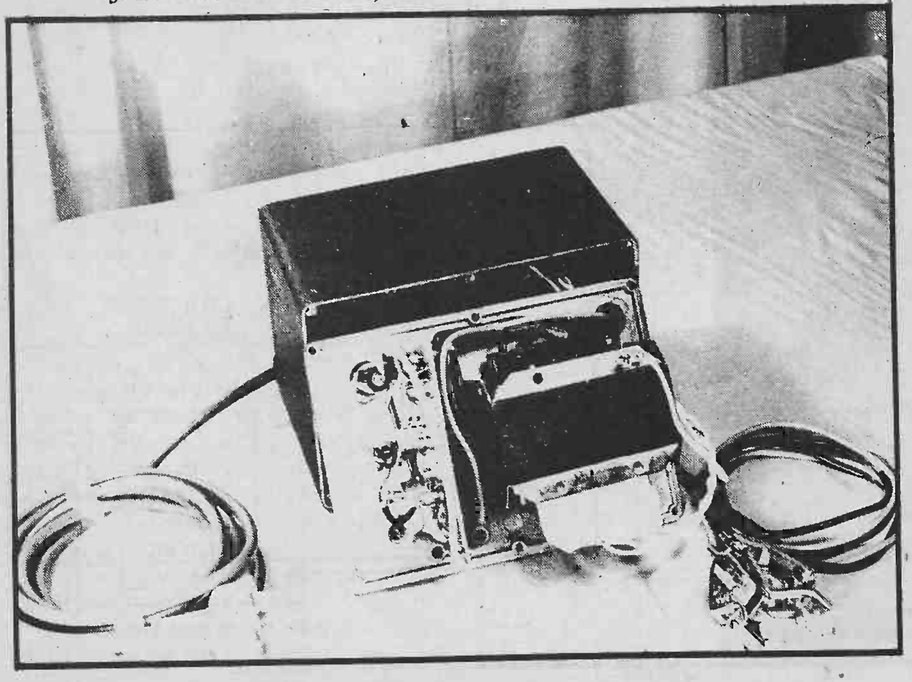


Fig. 2. Printed circuit board layout.



HOW IT WORKS

The battery charger is basically a switching regulator limiting the output voltage to 14 volts and the output current to four amps. Thus there are two modes of regulation, current and voltage, the changeover between these two modes being quite sharp. An increase of 0.1 volt above 14 volts causes the output current to drop from four amps to zero.

The 17 volt secondary of transformer T1 is bridge rectified by diode bridge DB1 to provide pulsating dc to the regulator. The main control element is SCR1 the gating sensitivity of which is increased by transistor Q4. A current of 2.0 mA through R1 is sufficient to turn Q4 and SCR1 on.

When a battery is connected with correct polarity across the output terminals, current will flow through R5 and the base emitter junction of Q1 turning Q1 on. This produces current in R1 sufficient to turn on Q4 and hence SCR1. The current flowing through SCR1 is sensed by R12, and if this current exceeds four amps average, Q2 turns on and is held on for a short time by virtue of the charge on C1. Hence the turn on of SCR1 on the next half-cycle is delayed thus reducing the average current. This control action ensures that the current stabilizes at four amps.

When the battery reaches 14 volts, transistor Q3 will turn on, the turn-on point being set by RV2. This again prevents SCR1 from turning on until later by by-passing, the base current of Q1. Thus the current falls until the voltage across the battery stabilizes at 14 volts.

International 309 battery charger

one amp or less. On batteries of 30 amp hour rating or less which are in good condition this flickering of the LED indicates the fully charged condition. On older batteries, or those of greater than 30 AH capacity, the float current may never drop below one amp and no flickering will be seen.

In applications where it is required, batteries may be 'floated' continuously across the charger without damage to charger or battery.

The unit is normally self-starting (into batteries that are already charged to four volts or over). For totally flat batteries – or those charged to less than four volts – a starting button is provided to initiate the charging cycle; after an initial couple of seconds the battery voltage will have risen sufficiently to maintain operation.

The charger will not start if a battery is connected to it with reversed polarity – even if the start button is pressed. Nor will the charger be damaged if the output leads are accidentally shorted together – however if the start button is pressed whilst the leads are shorted, the protection fuse will blow.

This last condition is most unlikely to occur and it is solely to protect against this eventuality that the fuse has been incorporated. A blown fuse should therefore be a rare occurrence.

PARTS LIST

R1	Resistor	1.5k	5%	½ watt
R2	"	10 ohm	"	"
R3	"	1k	"	"
R4	"	22k	"	"
R5	"	4.7k	"	"
R6	"	2.2k	"	"
R7	"	2.2k	"	"
R8	"	2.2k	"	"
R9	"	330 ohm	"	"
R10	"	1k	"	"
R11	"	100 ohm	"	"
R12	"	0.25 ohm 5% 15W (or 2 0.47 ohm 10W in parallel)		
R13	"	2.2k	"	½ watt
RV1	Large trimpot	10k		
RV2	Large trimpot	1k		
C1	Capacitor	30µF	6.3 volt electrolytic	
C2	"	25µF	25 volt electrolytic	
Q1	Transistor	BC177	or similar	
Q2	"	BC178	"	
Q3	"	BC178	"	
Q4	"	BFY50	"	
SCR1	Thyristor, 7A, 400V (TAG8–400, etc)			
D2,D3	Diode 1N4001 or similar			
DB1	Diode bridge 50V, 5A			
ZD1	Zener 9.1V, 400mW			
LED 1	Light emitting diode TIL209 or similar			
T1	Transformer 17 volt at 4A or similar			
PCB	ETI 309			

Die-cast box [illegible], metal bracket, 3 core flex, two grommets, mains terminal block, fuse holder, 5A fuse, single pole push button (push to make).

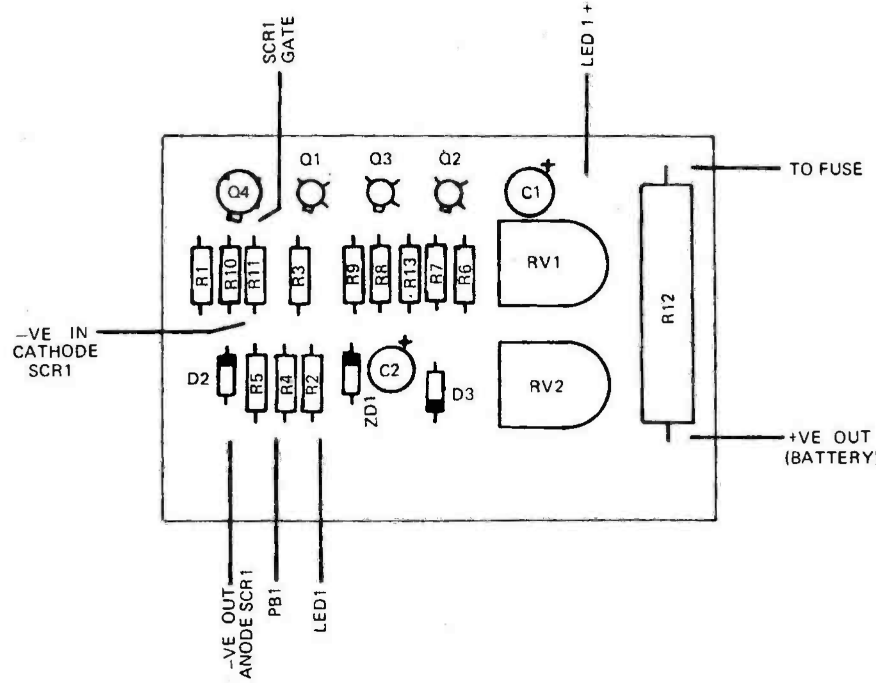
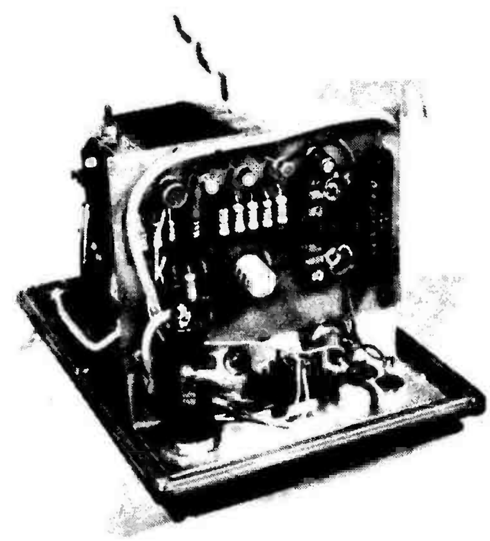


Fig. 3. Component overlay.



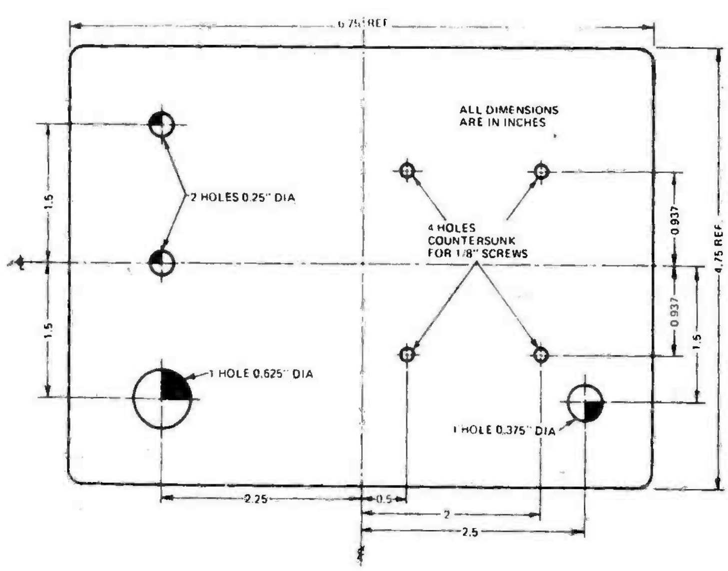


Fig. 4. Drilling details for lid of die-cast box.

CONSTRUCTION

We built our unit into a diecast box 4¾" x 6¾" x 4", all the components being mounted on the lid, drilling details for which are provided in Fig. 4.

Most of the components are mounted on a fibre-glass printed circuit board.

Assemble all components to the printed circuit board in accordance with the component overlay, making sure that all diodes and electrolytic capacitors are correctly orientated.

The transformer should be mounted onto the lid using countersunk screws making sure that the 240 volt input leads are away from the lid. The printed circuit board mounting bracket is secured to the front panel, such that it passes through the bracket, but is screwed directly to the front panel. The hole through the bracket provides clearance for the light emitting diode.

The diode bridge is mounted on the transformer side of the bracket and the SCR on the opposite side. The SCR must be insulated from its heat sink by mica or similar insulating washers. These should preferably be smeared with silicon grease to aid heat transference. The printed circuit board is then mounted to the bracket and connected as shown on the overlay and circuit diagrams.

For all four amp wiring use reasonably heavy gauge wire.

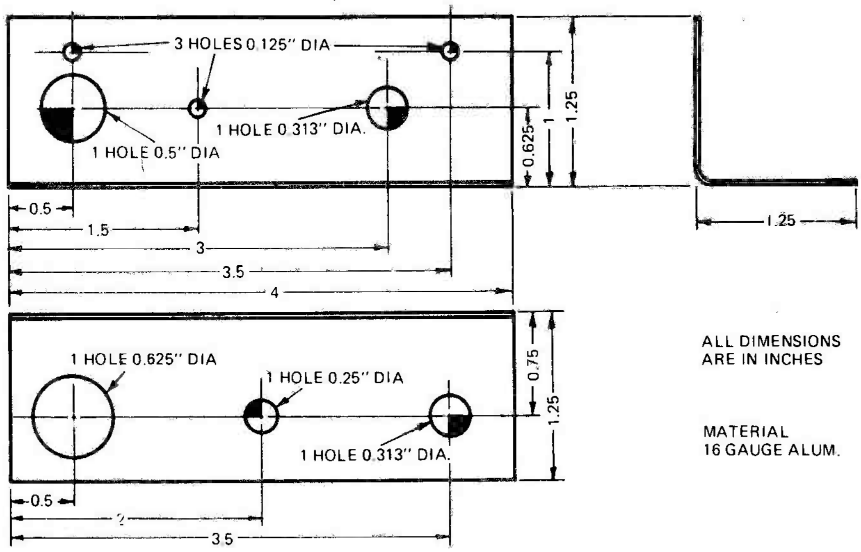


Fig. 5. Mounting bracket for printed circuit board.

ADJUSTMENT

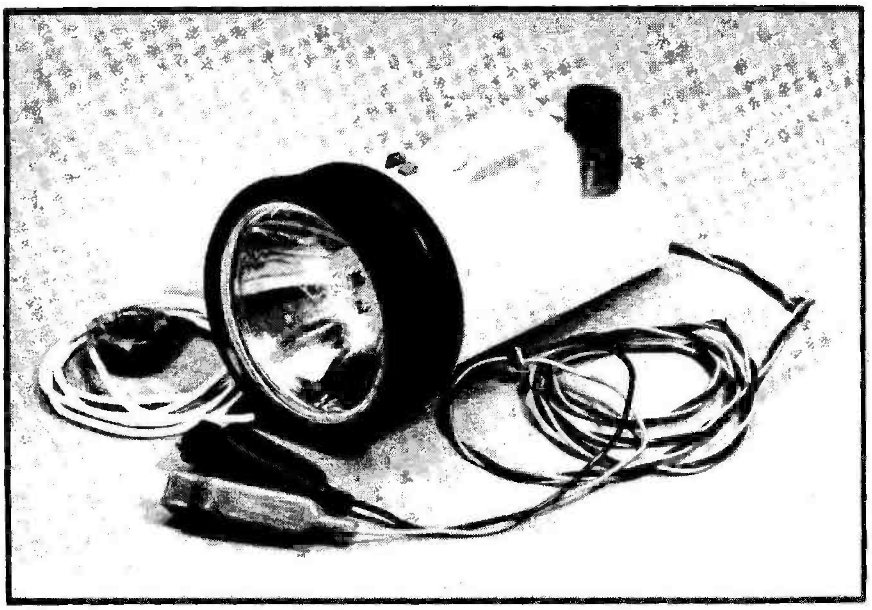
Current – Using an ammeter (10 amp range) in series with a flat battery, adjust RV1 for a four amp charge current. A four or five amp meter range may be used providing the meter does not have internal diode protection.

Alternately the voltage across R12 may be adjusted (using RV1) to one volt whilst charging a flat battery. Use a 2.5 volt or higher meter range.

Voltage – When the battery is fully charged the current will fall. When it has fallen to 2 amps, adjust RV2 for 14 volts across the battery. ●

eti project

IGNITION TIMING LIGHT



◀ *The ignition timing light complete with battery leads and spark-lead transducer.*

Obtain maximum performance and economy from your car.

A CAR'S performance and fuel consumption is affected quite drastically by the condition of the ignition system and upon correct ignition timing.

Before the advent of high performance engines and high octane fuel, ignition timing could be optimized by adjusting it until 'pinking' could just be heard under heavy load at low speed in top gear.

But these days have long since gone. In fact if an engine, running on high octane fuel, can be heard 'pinking' then it is grossly over-advanced and bearing damage will be caused.

Despite this there are still garage mechanics who blithely set ignition timing 'by ear'.

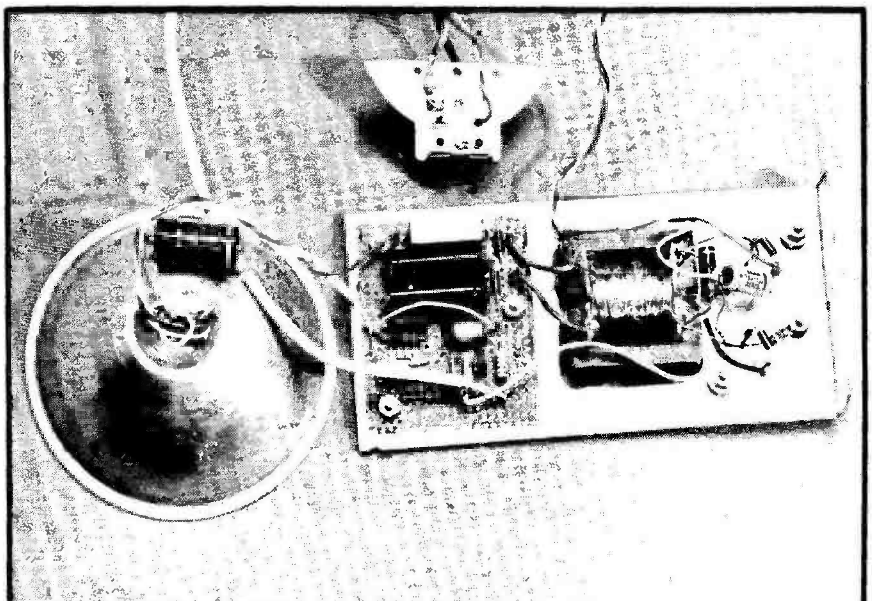
There is only one way to set ignition timing accurately. That is with a timing light specifically designed for that purpose.

Timing lights in common use range from a simple neon to the complex units used by auto electricians.

Neon timing lights are barely acceptable. Their light output is necessarily limited – to the extent that most have to be used in darkness. And, due to their low light output, they become a safety hazard as one attempts to hold them close to the timing mark – and to the rapidly turning fan blades.

Timing lights incorporating a Xenon flash tube are a much better proposition. As with neon lights, they are triggered by the firing of the first sparking plug in the engine firing order, but, as their flash energy is supplied directly from the vehicle battery they have a much greater light output.

The simple unit described in this project operates in this way.

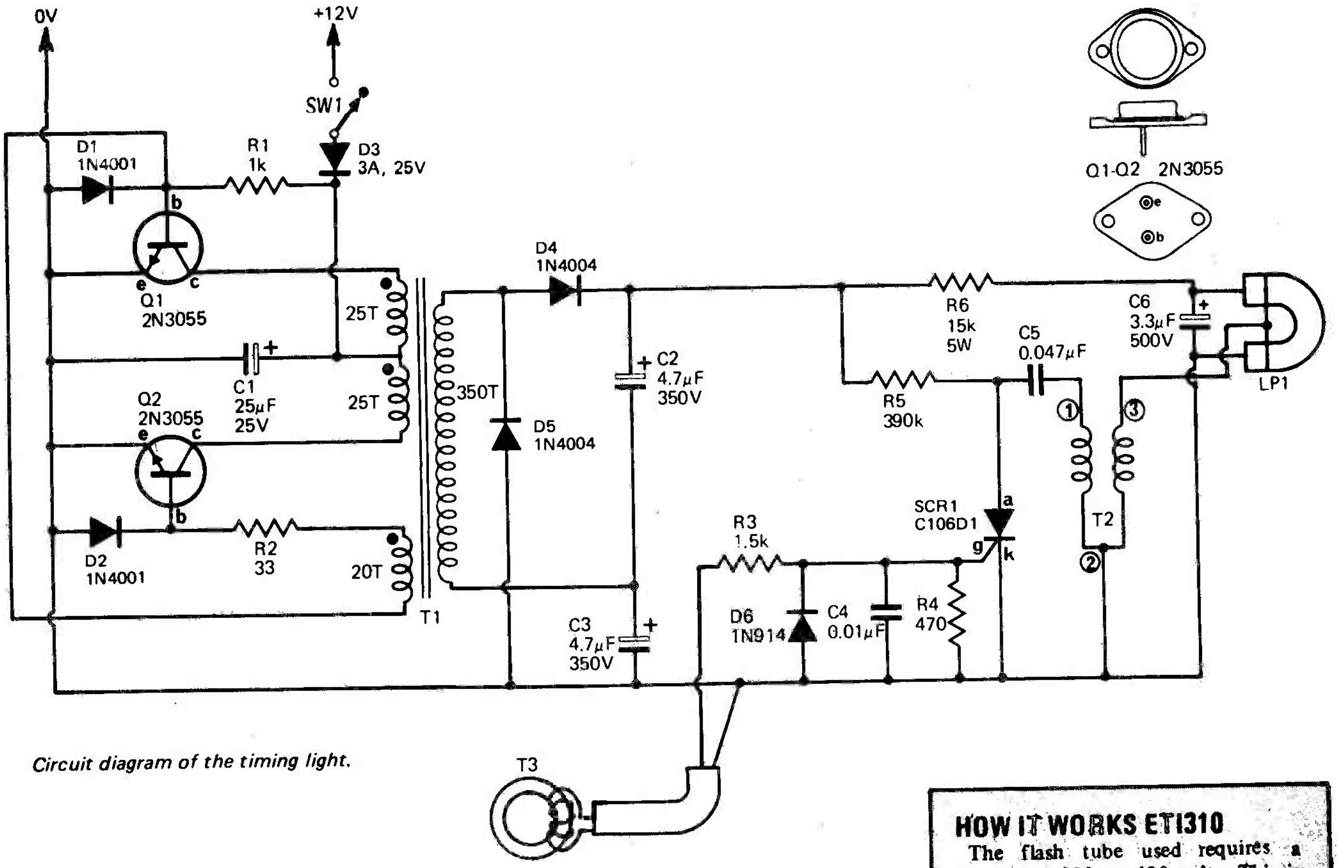


The completed electronics of the timing light. Note that diode D3 is mounted on the rear of the switch assembly and C6 on the rear of the reflector.

CONSTRUCTION

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

We purchased a cheap torch which



Circuit diagram of the timing light.

TABLE 1. Transformer Winding Details

WINDING	TURNS	GAUGE	NOTES
Primary 1	25	24 s.w.g.	Bifilar wound
Primary 2	25	24 s.w.g.	
Feedback	18	30 s.w.g.	
	0.01" insulation between primary and secondary windings.		
Secondary	350	30 s.w.g.	

TABLE 2. Pick-up Winding Details
Wound on Ferrite Ring, 1" inside diameter (Mullard FX1588 or similar). 20 turns of the inner of screened audio cable. Details in text and photo.

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**

HOW IT WORKS ETI310

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.

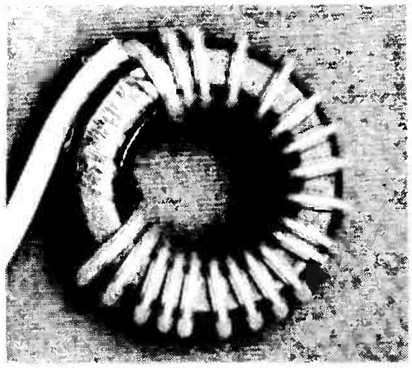
Transformer T1, together with transistors Q1 and Q2 form a self oscillatory inverter. The frequency of operation, 2 kHz on 12 volt supply in our case, is primarily determined by the core material, the number of primary turns and the supply voltage. Protection against reversed supply leads is afforded by diode D3.

Output from the secondary of T1 is voltage doubled by D4, 5 and C2, 3 to provide about 350 volts dc which charges C5 via R5.

The pickup coil T3, which is fitted over number one spark-plug lead, generates a pulse when the spark plug fires and draws current through the lead. This pulse is used to trigger SCR1 into conduction thus discharging C5 into the pulse transformer. The secondary of the pulse transformer provides a high voltage pulse, to the trigger electrode of the flash tube, causing the gas to ionize. The tube becomes a low resistance and C6 discharges through the tube providing the flash energy. Whilst the flash tube is in a virtual "short circuit" condition, current from the inverter is limited by resistor R6.

When capacitor C6 is fully discharged, the tube reverts to a high impedance allowing C6 to be recharged via R6. The current in R5 is not sufficient to hold SCR1 on and it too ceases to conduct. The maximum flash rate is in excess of 50 per second corresponding to 6000 RPM on a four cycle engine.

IGNITION TIMING LIGHT



How the pick-up is made.

takes four HP-2 batteries.

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

As there are only a few components, tag strips or veroboard could easily be used — rather than matrix board.

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

Details of the transformer are given in Table 1. As there are relatively few turns, this transformer may quite readily be wound by the home constructor. Ensure that the polarities of the primary (25T + 25T) and feedback (18) windings are as shown in the circuit diagram - this is important! See the box on page 63 if you wish to purchase a ready wound transformer.

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 2, between the primary and secondary windings in the transformer, and to keep the windings separate on the matrix board.

PARTS LIST
Ignition Timing Light ETI 310

R1	Resistor	1k	½ watt 5%
R2	"	33	5 watt 5%
R3	"	1.5k	½ watt 5%
R4	"	470	½ watt 5%
R5	"	390k	½ watt 5%
R6	"	15k	5 watt 5%
C1	Capacitor	25μF	25 volt electrolytic
C2,3	"	4.7μF	350 volt electrolytic
C4	"	0.01μF	polyester
C5	"	0.047μF	400 volt polyester
C6	"	3.3μF	500 volt electrolytic
Q1,Q2	Transistor	2N3055 with mounting kit.	
D1,2	Diode	1N4001 or similar	
D3	"	3A, 25V silicon	
D4,5	"	1N4004 or similar	
D6	"	1N914 or similar	
SCR1	SCR	C106D1 or similar	
T1	Transformer (see table 1)		
T2	Pulse transformer		
T3	Pickup coil (see table 2)		
LP1	Flash tube ZFT-8Z		

Reflector box, aluminium heat sink etc. see text.

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 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, C6, should be mounted on the rear of the flash-tube/reflector assembly as shown in the photograph. Note also that we mounted diode D3 on the rear of the torch switch assembly.

The transducer 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. Finally tape up the whole assembly as shown in the photograph.

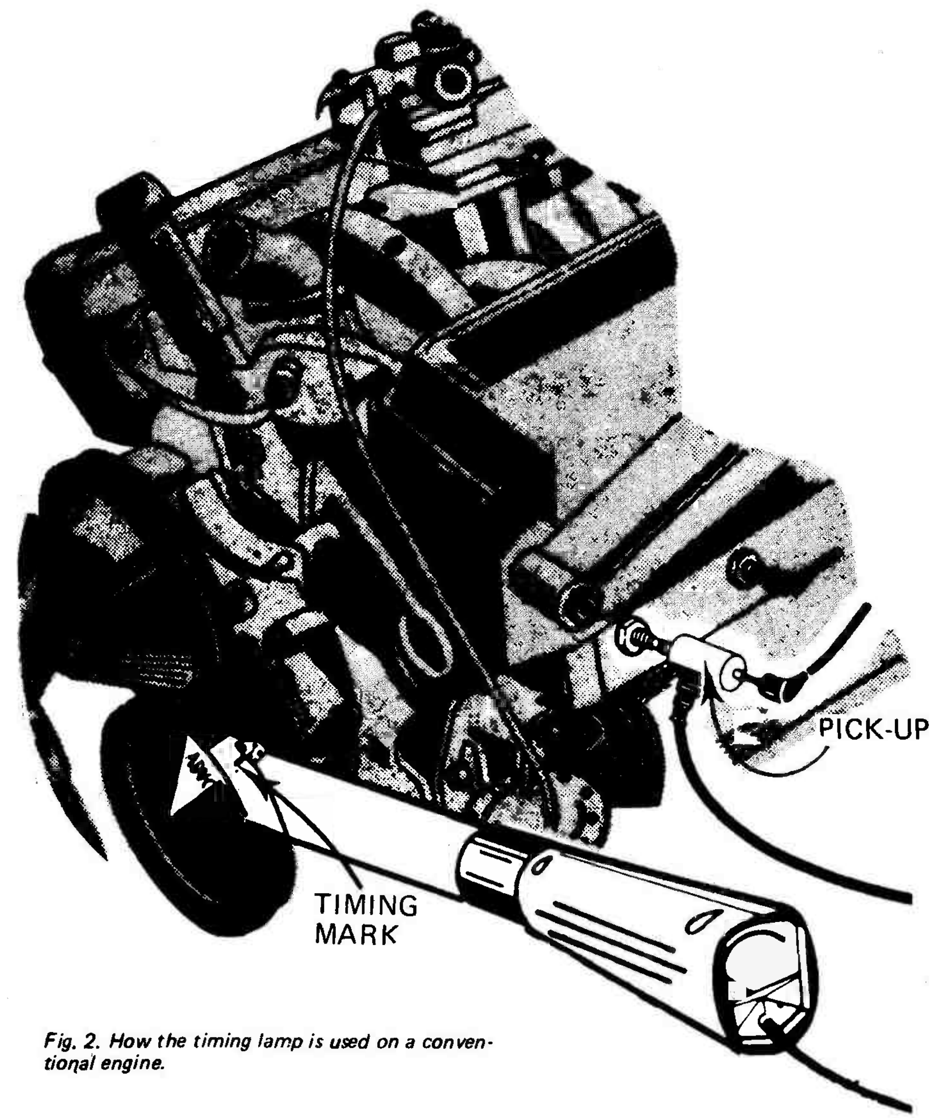


Fig. 2. How the timing lamp is used on a conventional engine.

USING THE TIMING LIGHT

To time an engine, first establish the position and *significance* of the ignition timing mark. This information will be found in the manufacturer's handbook.

The timing mark — usually displayed as an engraved '0' or straight line — is generally located on the crankshaft pulley or occasionally on the engine flywheel.

On nearly all modern cars the timing mark is engraved the appropriate number of crankshaft degrees before TDC. Certain others have a complete scale starting at TDC and extending to 40 degrees before TDC.

A few vehicles have the mark at TDC.

Some form of pointer will be found attached to the engine block — or flywheel housing — to act as a datum point for the timing mark.

Except where the timing mark indicates TDC only, ignition timing is a simple affair.

Firstly clean off any dirt or grease that might obscure the timing mark, then connect the timing light power leads to the vehicle battery and place the pick-up transducer over number one spark plug lead. Now start the engine.

The light should flash — note that the pick-up produces more stable flashes with one side facing the engine block than the other. Establish which is the best way and mark the pick-up accordingly.

Remove the rubber pipe to the vacuum advance mechanism (if fitted) and set engine tick-over to the speed recommended in the vehicle handbook. (if you don't have a rev counter set idling speed to lowest possible).

Now shine the timing light onto the timing mark. With the distributor clamp loosened slightly, slowly rotate the distributor a few degrees in either direction.

The timing mark will now appear to move relative to the datum pointer. Set the distributor so that the mark aligns exactly with the pointer and retighten the clamp once the correct setting has been obtained.

A very similar method is used for vehicles where the timing mark is a calibrated scale. In this case the manufacturer's recommended setting should be used.

Where the mark indicates TDC only it is necessary firstly to place a chalk mark at the appropriate number of degrees before TDC and to use this as the timing mark.

A quick check that the automatic advance and retard is working can be made by speeding up the engine. If all is well the timing mark should appear to move away from the datum pointer as engine speed increases.

If the timing mark appears to oscillate to and fro by more than a degree or so this is an indication that the timing is actually changing in this fashion. This is a fault generally caused by a worn distributor spindle, and/or sloppy drive to the distributor offtake.

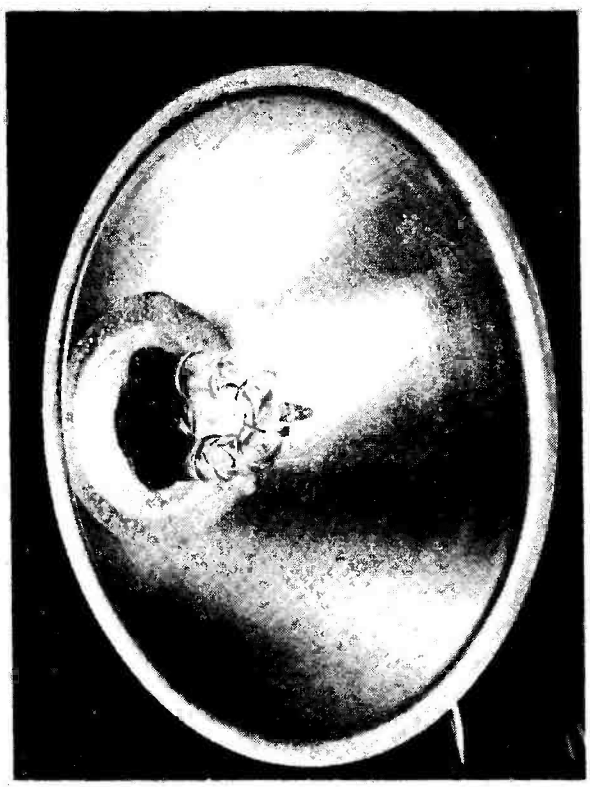
Remember to re-connect the vacuum line when timing is completed. ●

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.

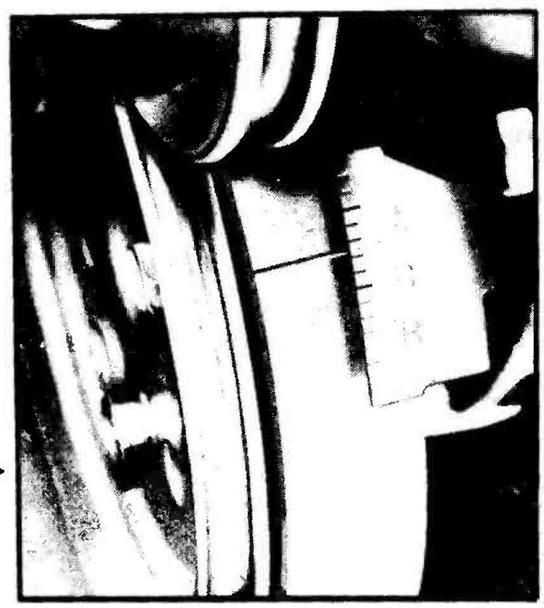
This is common to all strobe light timers and failure to remember this can result in serious personal injury, or a wrecked timing light.

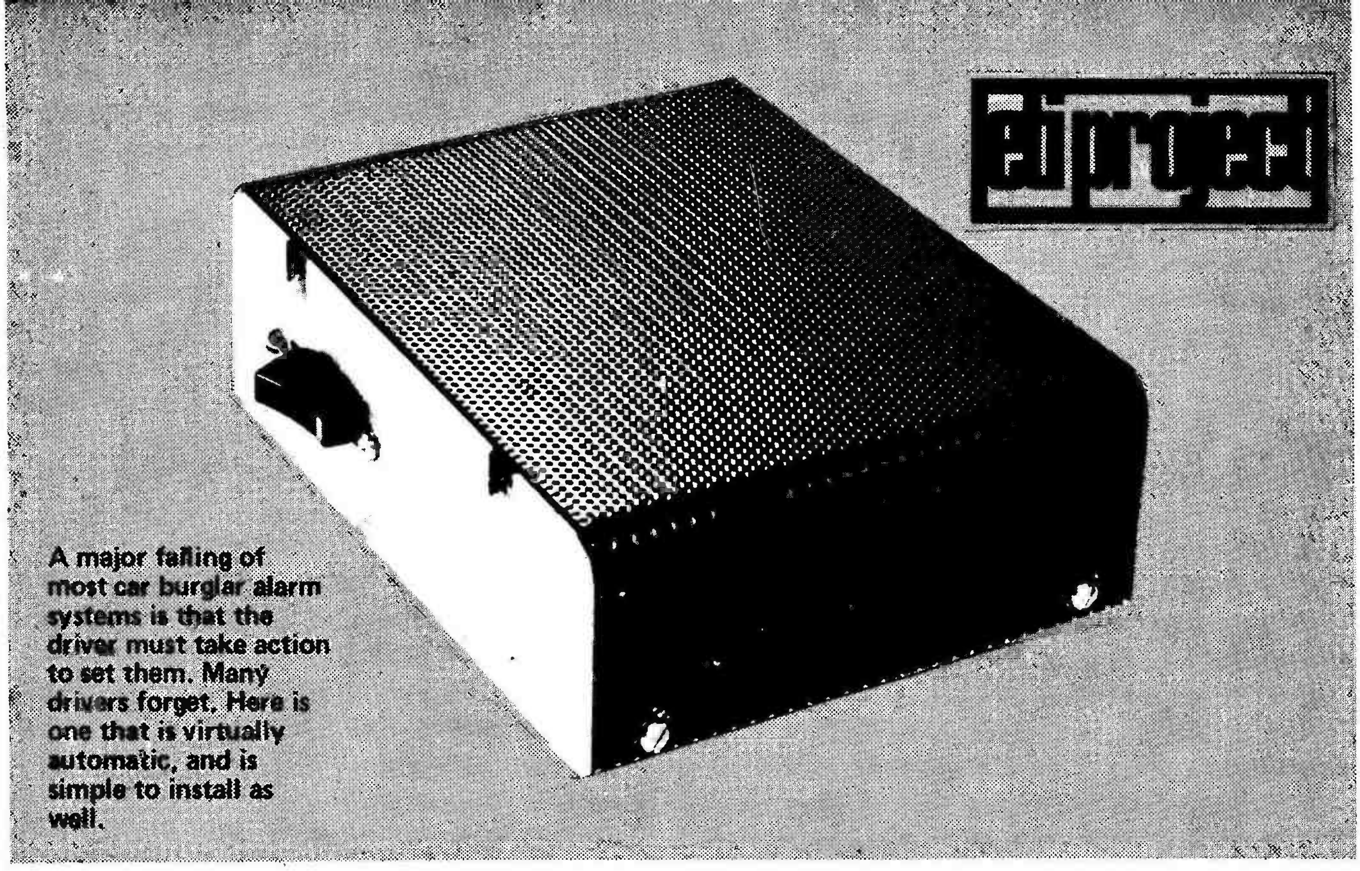
ALWAYS — keep well clear of the fan.



◀ *Method of mounting the flash tube in a torch reflector with epoxy resin glue.*

A typical method of marking top dead centre on the crankshaft pulley. ▶





A major failing of most car burglar alarm systems is that the driver must take action to set them. Many drivers forget. Here is one that is virtually automatic, and is simple to install as well.

AUTOMATIC CAR-THEFT ALARM

also protects trucks, boats & caravans

AN ORGANIZATION that we know received a car burglar alarm for evaluation. One day someone forgot to switch it on, and the car was stolen complete with the alarm.

Question. — Was this a good alarm system?

In our opinion emphatically NO — for just as some people steal cars — others forget to switch on alarm systems.

And so the ETI car-theft alarm system is automatically set. This is achieved by incorporating a circuit that 'arms' the alarm system some 30 seconds after the ignition is switched off.

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, this will activate the interior light, and the increase in electrical load will trigger the alarm.

This operating principle simplifies installation, for practically all vehicles have courtesy lights with actuating switches installed in at least two doors — and it is fairly easy to install further switches in the rear door pillars 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 incorporate them into the circuit.

Remember that these lights must be switchable at all times — not just when the ignition is on.

The alarm will also be actuated by anyone pressing the brake pedal — or if a light is fitted — by opening the lid of the glove box.

DELAY CIRCUIT

The delay circuit built into the unit enables the driver to leave the vehicle without triggering the alarm.

As the alarm is triggered by an *increase* in electrical load, any doors or other protected areas may be closed at any time before or after the end of the time delay period, providing the doors are initially *opened* before the preset time. The subsequent *decrease* in load as the lights are extinguished will not trigger the alarm.

In the initial design stage we considered incorporating a second time delay to obviate the need for any external re-entry switches.

But as this would allow a thief quickly to break into a parked car and steal goods from the interior before the alarm was energized, we decided to use an instantaneous alarm and an external re-entry switch.

AUTOMATIC CAR-THEFT ALARM

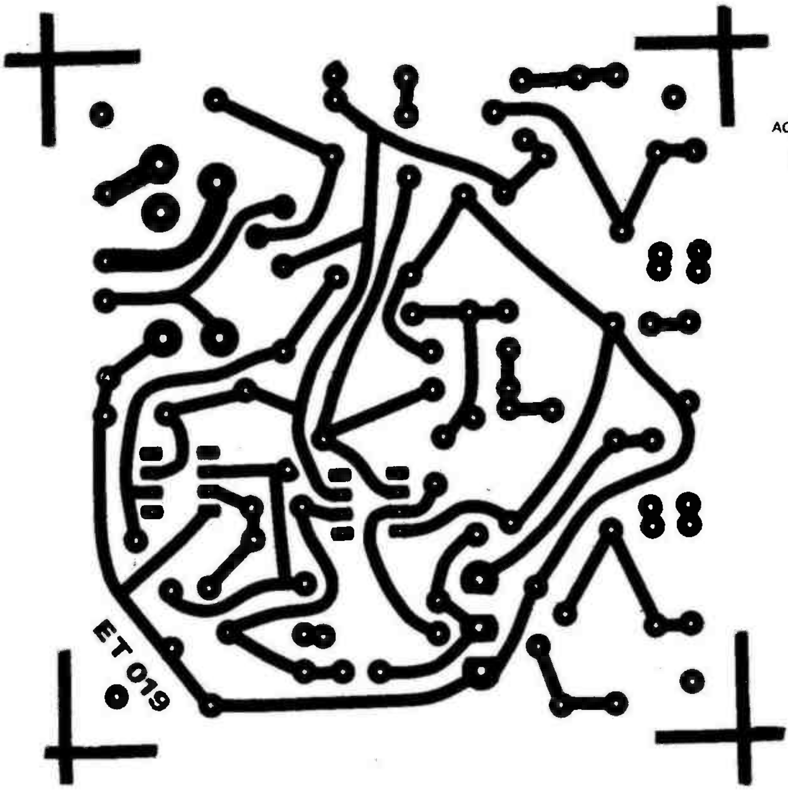


Fig. 1. Foil pattern of printed circuit board, reproduced full size.

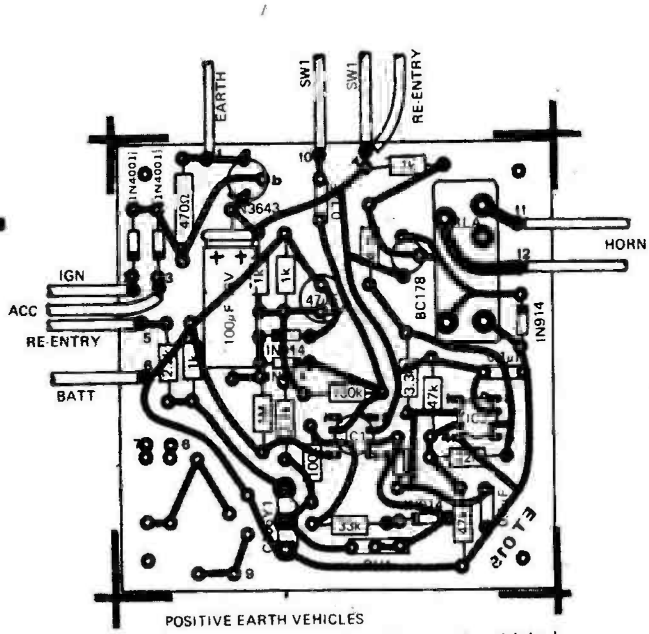


Fig. 2. Component layout (positive earth vehicles).

In the Metropolitan (London City) area alone, nearly 10,000 cars a year are reported as stolen and unrecovered, and 30,000 cars 'taken unauthorised' (Scotland Yard's term for cars stolen but recovered within a month). Theft of motor vehicles and/or their contents is one of today's most prevalent crimes.

What can one do to protect one's own vehicle and its contents? The Police advise the following precautions:

Close all windows, lock all the doors and take your key with you when you leave the car.

Never leave valuables such as clothes, cameras, or radios on seats or anywhere visible within the vehicle.

Avoid loading valuables into your car in public, for a thief may be watching.

Do not leave any papers of identification, such as Driver's Licence, Registration papers or private correspondence within the car. At least don't keep them in the glove box.

Avoid parking in isolated places. If you have no garage, try to park under a street lamp, or in a lighted area.

Record the serial numbers of your engine, car body and car radio somewhere other than in your car. This data will considerably assist the Police in identifying your vehicle. If you leave it in the car, you are providing the thief with the support of the claim that the car is his.

Promptly report anyone loitering near or trying the door handles of parked cars.

Leave only the ignition key with the attendant when leaving car in a garage where the car is parked for you.

Install a steering lock and/or alarm system. (Legal regulations in UK have required compulsory fitting of steering locks in cars manufactured since April 1971).

In the alarm system shown here, once the alarm has been de-activated by the external key, it remains de-activated until the ignition key is switched on. It is then automatically cancelled.

Bear in mind that the re-entry switch merely inhibits the alarm circuit. The unit is actually switched off as the ignition is switched on.

It is quite feasible to interconnect the re-entry key with the main door locking mechanism. Police statistics show that it is very rare indeed for a car to be illegally entered by using a door key. We have equipped one of our staff cars in this fashion and the system has proved both reliable and practically impossible to misuse — for the alarm is 'armed' by switching off the ignition, and reset by using the door key to enter the car in the normal way.

Alternatively a re-entry switch may be located on a body panel, or other convenient place.

A separate switch is built into the alarm unit to de-activate the system whilst the vehicle is being serviced.

The circuit is arranged so that once the alarm has been triggered it cannot be de-energized by either the re-entry or de-activating switches. It can only

HOW IT WORKS

The alarm circuit is best considered as a number of separate interconnected units. These are:–

1. Power supply.
2. Detector.
3. Initial time delay.
4. Inhibiting network.
5. One cycle oscillator.
6. Output stage.
7. Maximum alarm-time unit (optional).

POWER SUPPLY

For vehicles with positive earth systems, the power supply is formed by Q1a, D1a, D2a, R1a and C1. (Components with suffix 'b' are used in the negative earth version.)

With the ignition key in the acc., on, or start positions, power is supplied to resistor R1a via D1a or D2a. If power is supplied to this resistor, Q1a is turned off and no power is supplied to the alarm circuit. When the ignition key is turned to the off position no power is supplied to R1a and so R1a turns on Q1a and power is applied to the alarm circuit.

The reason for taking power signals from both the ignition coil and acc. positions is that in many vehicles all secondary electrical loads are disconnected in the start position. This would otherwise cause the alarm to operate whilst starting the car.

DETECTOR CIRCUIT

This is primarily an operational amplifier (IC1) with differential inputs. The inverting input (–ve) is Pin 2, and the non-inverting input (+ve) is Pin 3. If the input to Pin 2 is more than four millivolts higher than Pin 3, the output (Pin 6), will be within two volts of the *negative* supply rail. If Pin 2 is four millivolts, or more, lower than Pin 3, the output at Pin 6 will be within two volts of the *positive* supply rail.

A common centre tap, derived from R3 and R4, is used for both inputs. The voltage at the non-inverting input (Pin 3) is modified by feedback from the output, (Pin 6).

When the alarm is in the non-triggered state the output of IC1 is in the low state and the voltage at Pin 3 is between 5mV and 1V lower than the voltage at Pin 2 depending on the setting of RV1.

If a negative pulse occurs on the supply rail, this pulse is coupled into Pin 2 by C4. Providing this pulse is greater than the bias on Pin 3, the output of IC1 will go high and will be held in this state by the action of the feedback loop.

If the de-activating switch SW1 is in the off position, the negative pulse on the supply rail cannot be coupled into Pin 2. This will prevent the alarm from being triggered, but will not stop the alarm once it *is* triggered.

INITIAL TIME DELAY

When power is initially applied to the circuit, C2 charges via D4, R8 and R2. The charging current through R8 causes Pin 2 of IC1 to go higher than normal for the first 30 seconds, and during this time a negative pulse on the supply rail will not trigger the alarm. After 30 seconds or so, C4 is completely charged by R2 and has no further effect on the circuit.

INHIBITING NETWORK

To enter the car without triggering the alarm it is necessary to make a momentary contact between the two 're-entry' terminals. When this contact is made, SCR1 latches on and pulls the voltage on Pin 3 of IC1 out of the range of the triggering pulse. This circuit is inoperative if the alarm has already been triggered.

ONE CYCLE OSCILLATOR

This circuit causes the horn to pulse at one second intervals.

It is based on a second operational amplifier of a similar type to that used in the detecting circuit.

Increasing the value of R13 will decrease the pulsing frequency – and vice versa. If the output of IC1 is in the low state, the oscillator is inhibited and the output of IC2 is held high.

OUTPUT STAGE

The output stage is simply a relay driven by transistor Q2 which in turn is driven by IC2. Diode D7 prevents reverse spikes from the relay damaging the transistor.

MAXIMUM ALARM TIME UNIT

This is an optional unit and has not been included on the main printed circuit board. Details are shown in Fig. 6. The unit resets the alarm circuit after a preset time.

The unit is connected across the alarm horn which is energized when voltage is applied to the circuit. Capacitor C7 is charged via R18. Transistors Q3 and Q4 are emitter followers and carry the relay current. When voltage is high enough the relay closes and momentarily applies power to the accessories. This resets the alarm. The alarm will be retriggered if the vehicle's electrical system is again disturbed. The circuit values shown will provide a time period of approx 1.5 minutes, but this may vary with different relay coil resistances and capacitor tolerances. Increasing R18 or C7 will increase the time period and vice versa.

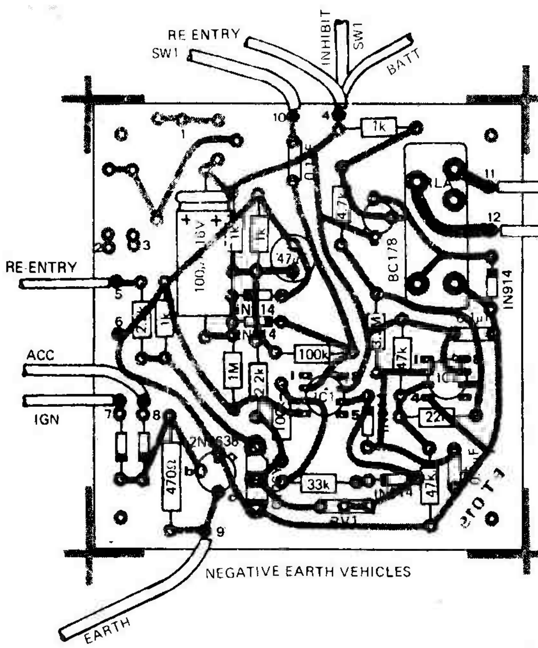
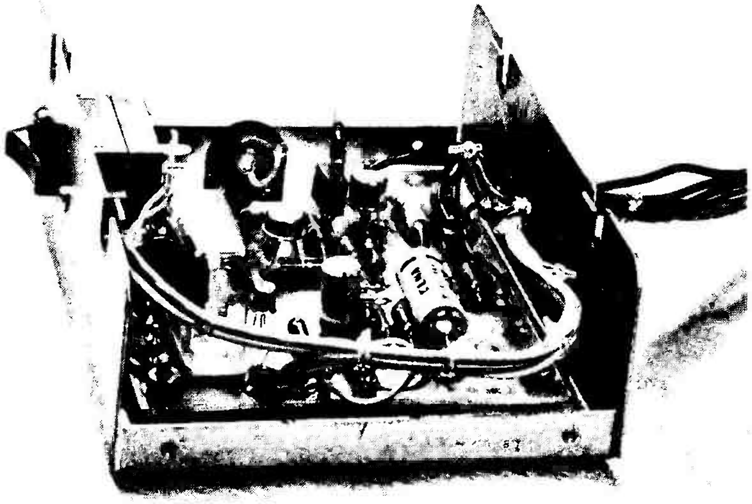


Fig. 3. Component layout (negative earth vehicles).



be reset by switching on the ignition.

The unit has been designed for vehicles with 12V electrical systems and by including or excluding a number of components (marked clearly on the circuit diagram), it can be used with either positive or negative earth electrical systems.

It is not possible to use this alarm circuit with six volt electrical systems.

CONSTRUCTION

By far the simplest way to assemble this unit is to mount all the components on the printed circuit board (the foil pattern of which is reproduced full-size in Fig. 1). The same board is used for both positive and negative earth systems.

Figures 2 and 3 show how the components are located on the board. Note that Fig. 2 shows the component layout for positive earth vehicles, and Fig. 3 is for negative earth vehicles.

The circuit diagram of the complete unit, shown in Fig. 4, illustrates the difference between the positive and negative earth systems.

When assembling the board observe carefully the polarity of the electrolytic capacitors and the pin connections of the operational amplifiers and transistors. Check all soldering for dry joints, or for drops of solder that may be shorting across any tracks. Also check that all components are rigidly mounted and that no leads are touching. Re-check all connections to the operational amplifiers. Set

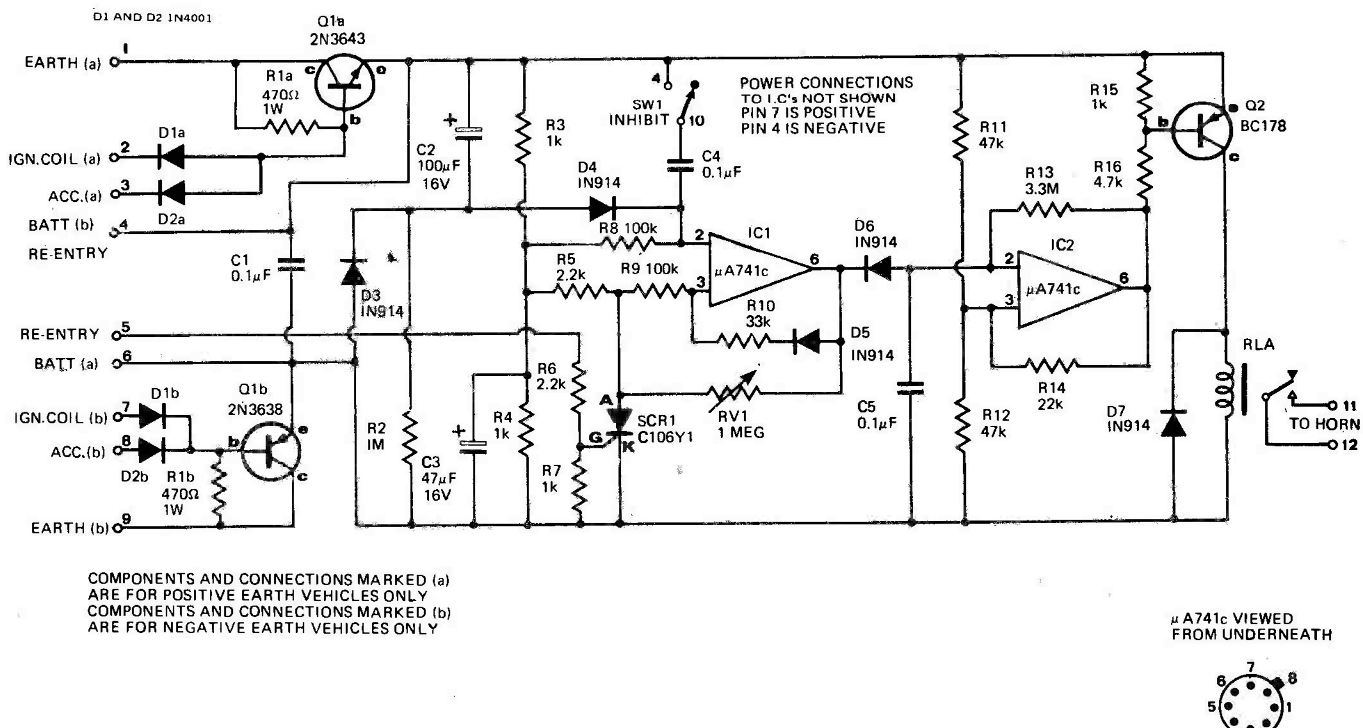
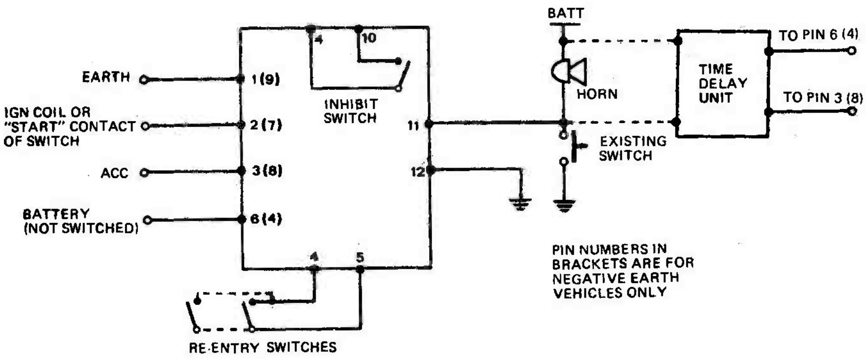


Fig. 4. Circuit diagram of complete alarm unit.

AUTOMATIC CAR-THEFT ALARM

Fig. 5. This drawing shows how the alarm unit is connected into the vehicle's electrical system.



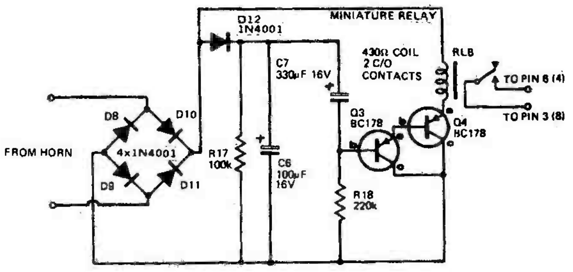


Fig. 6. This (optional) unit switches off and resets the alarm system after a preset time.

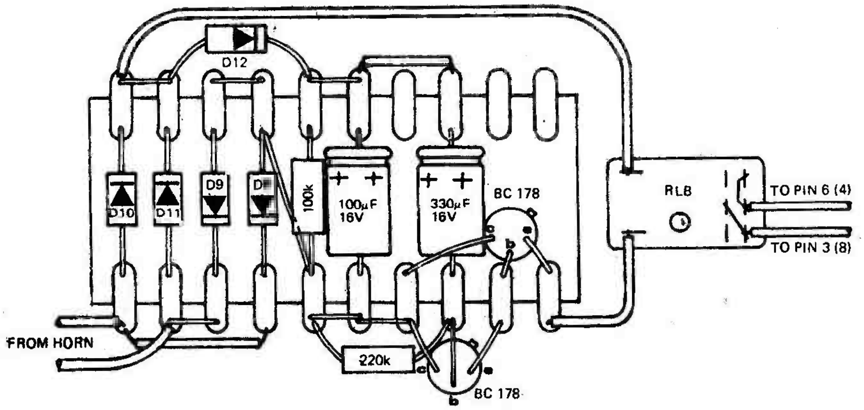


Fig. 7. Constructional details of circuit shown in Fig. 6.

PARTS LIST ET305

R1	—	resistor 470 ohm, 1 Watt, 5%
R2	—	" 1M, ½ Watt, 5%
R3	—	" 1k, " "
R4	—	" 1k, " "
R5	—	" 2.2k, " "
R6	—	" 2.2k, " "
R7	—	" 1k, " "
R8	—	" 100k, " "
R9	—	" 100k, " "
R10	—	" 33k, " "
R11	—	" 47k, " "
R12	—	" 47k, " "
R13	—	" 3.3M " "
R14	—	" 22k, " "
R15	—	" 1k, " "
R16	—	" 4.7k, " "
RV1	—	potentiometer 1M trimpot (large type)
C1	—	capacitor 0.1uF, 100V
C2	—	" 100 uF, 16V. electrolytic
C3	—	" 47 uF, 16V. "
C4	—	" 0.1 uF, 100 V. "
C5	—	" 0.1 uF, 100 V. "
IC1	—	integrated circuit uA 741C (metal can type only)
IC2	—	integrated circuit uA 741C (metal can type only)
SCR1	—	SCR type C106Y1 or similar
Q1a	—	transistor BC328
Q1b	—	" BC338 (note — Q1a for +ve earth vehicles, Q1b for -ve earth vehicles)
Q2	—	transistor BC178
D1	—	diode 1N4001
D2	—	" "
D3-D8	—	" 1N914
RLA	—	relay 12V coil, 1 c/o 6A.

PC board — ET019
PC board pins —

SW1 — single pole single throw switch
Metal case.

potentiometer RV1 to maximum resistance.

INSTALLATION

The completed unit should be installed out of sight, but in a fairly accessible place to enable the unit to be disabled when the vehicle is in for servicing.

Ensure that the alarm unit has been built to the correct polarity for the vehicle and that the electrical system is 12 Volt.

Solder leads onto the pins provided on the alarm unit and long enough to reach the points indicated on the installation drawing (Fig. 5).

Mount the alarm unit in the chosen location and run the wiring to the positions indicated on Fig. 5.

As explained earlier, the external re-entry switch, can with a little ingenuity, be built into the existing door locking mechanism. But make sure that the switch is operated only by the key and not when the door is opened from the inside.

If an external key switch is used it should either have a momentary contact mechanism (or if a normal type of switch is used it may be momentarily turned on, then off again).

(If the vehicle has any fibreglass or alloy panels a reed switch may be used for the external reset function. Just mount the reed behind a convenient panel and actuate it externally by a small bar magnet).

As the unit is operated by a momentary drop in battery voltage, caused by lamps being energized, it is essential that all bulbs be maintained in working order. One advantage of this system is that any fault in the triggering mechanism is immediately obvious.

The function of the potentiometer RV1 is to provide a sensitivity control. During the early development of this unit we were plagued by false alarms at intervals of a few hours. This was finally traced to the electric clock which had a mechanism that was electrically rewound at regular intervals! If this occurs then just back off RV1 meanwhile ensuring that the unit functions correctly when triggered in the normal way.

The vehicle's existing horn may also be used as the alarm horn – however it is well worth while installing a separate horn specifically for the alarm function. If this is done it should be mounted in an inaccessable position and the associated wiring carefully concealed.

Whilst not included in the basic alarm unit we have also shown a circuit (Fig. 6.) that will switch off the horn alarm at the end of a 90 second period. The unit then resets automatically and will be re-activated if any further attempt is made to re-enter the vehicle. ●

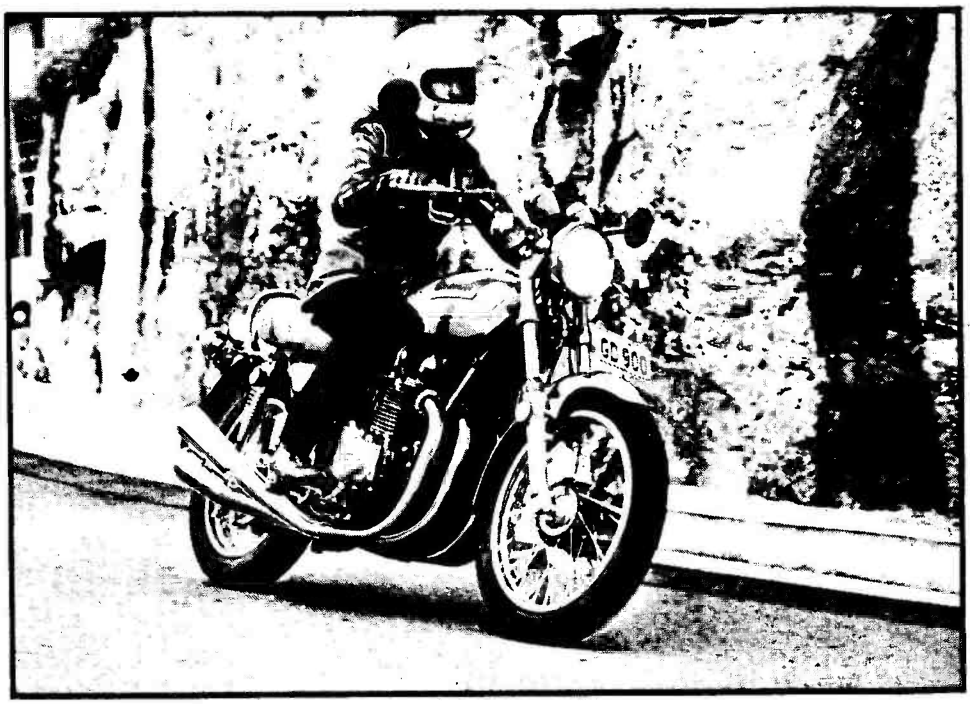
TURN INDICATOR CANCELLER

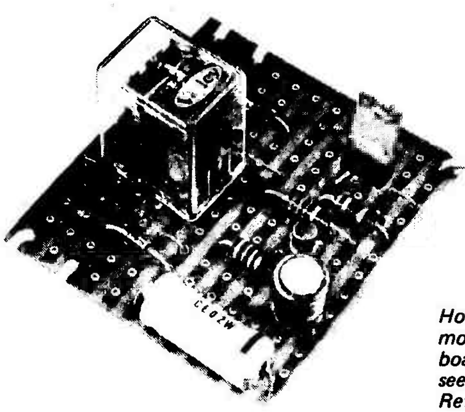
Simple electronic unit cancels turn indicators after 30 seconds.

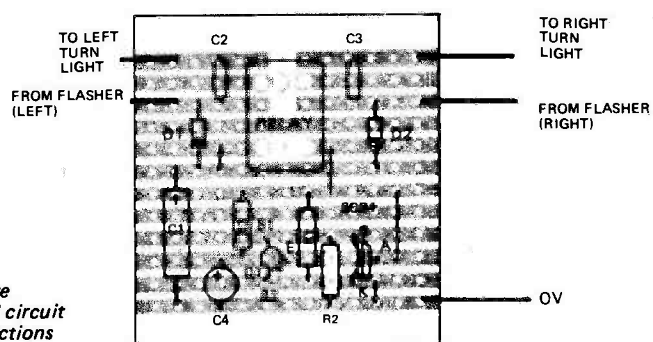
For some time now, in some countries, it has been compulsory for drivers of vehicles fitted with turn indicators to signal right or left turns, to cancel the turn indicator after a turn has been executed.

In the UK, the regulations do not (as yet) require legally obligatory cancellation of turn indications. All modern cars are fitted with automatically cancelling indicators. However, there are still, on our roads, many older vehicles which require manual operation to signal a turn as well as to cancel the indication. Besides, motor cycles, scooters and some mopeds fitted with turn indicators, also do not have automatic cancelling facility.

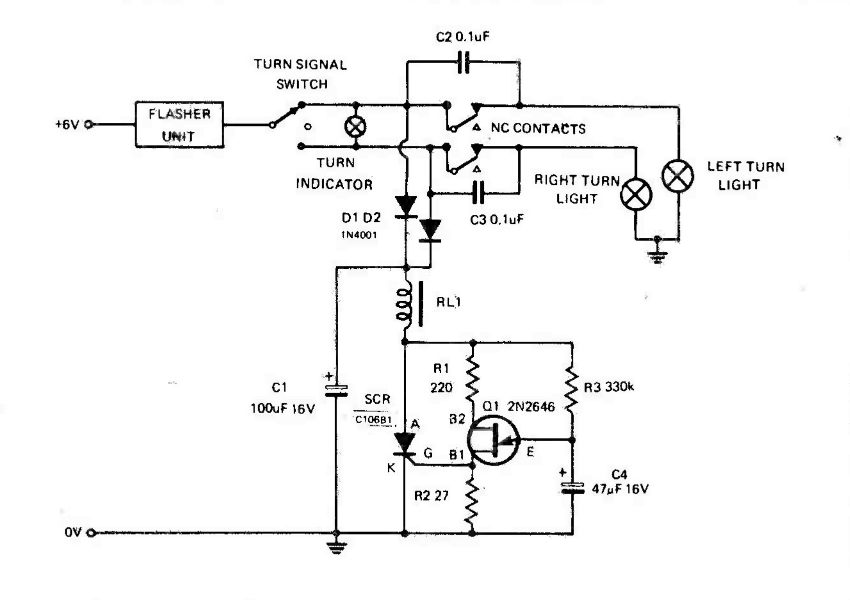
Driving or riding such vehicles, fail-



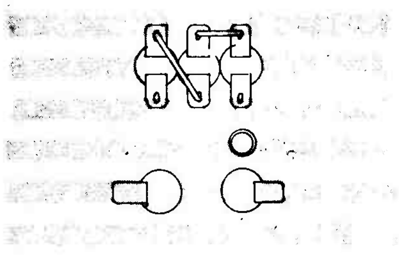




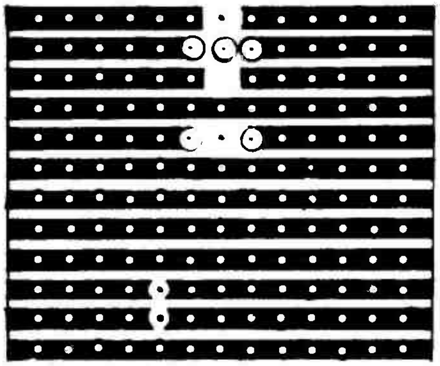
How the components are mounted on the printed circuit board. (For relay connections see accompanying drawing). Refer also to photograph left.



Circuit diagram of complete unit.



Relay connections. Holes should be drilled through the veroboard large enough to accomodate the twin tags. The tags are then bent over and soldered as shown.



Use a sharp drill to break the tracks on the veroboard as shown. Several holes must be enlarged to enable the relay tags to pass through.

ure to remember to cancel the indicator causes traffic nuisance and hold-ups and, in extreme cases, may even render you legally culpable (in the eyes of some magistrates) for any ensuing accident.

ETI presents this project specifically for users of such vehicles. The unit described is an economical means of ensuring that turn indicators are switched off automatically 30 seconds after a turn signal has been initiated. However, being essentially a 'delay-off' circuit operating on 6 or 12 volt pulses, it may also find other uses such as immobilisation of electrical circuits after an alarm has been initiated etc.

CONSTRUCTION

There are only 12 components all told, therefore there should be no problems with construction providing the wiring diagram and overlay are studied carefully.

Most motor cycles have six volt power, either from a battery, or mag-dynamo and in this case a relay with 52 ohm coil should be used. Where a 12 volt system is used, the relay should have a 185 ohm coil.

Locating the unit will be a matter of choice, and will depend on the particular machine — for this reason we have not provided case details. The unit should be mounted as close to the turn signal switch as possible so that long leads are not necessary.

To wire the unit into the turn indicator circuit, locate the two wires coming from the flasher, cut both and connect them as shown on our overlay diagram. There is no need to identify left and right, so long as each wire is cut and then terminated with both sections on one side of the matrix board as shown. ●

HOW IT WORKS

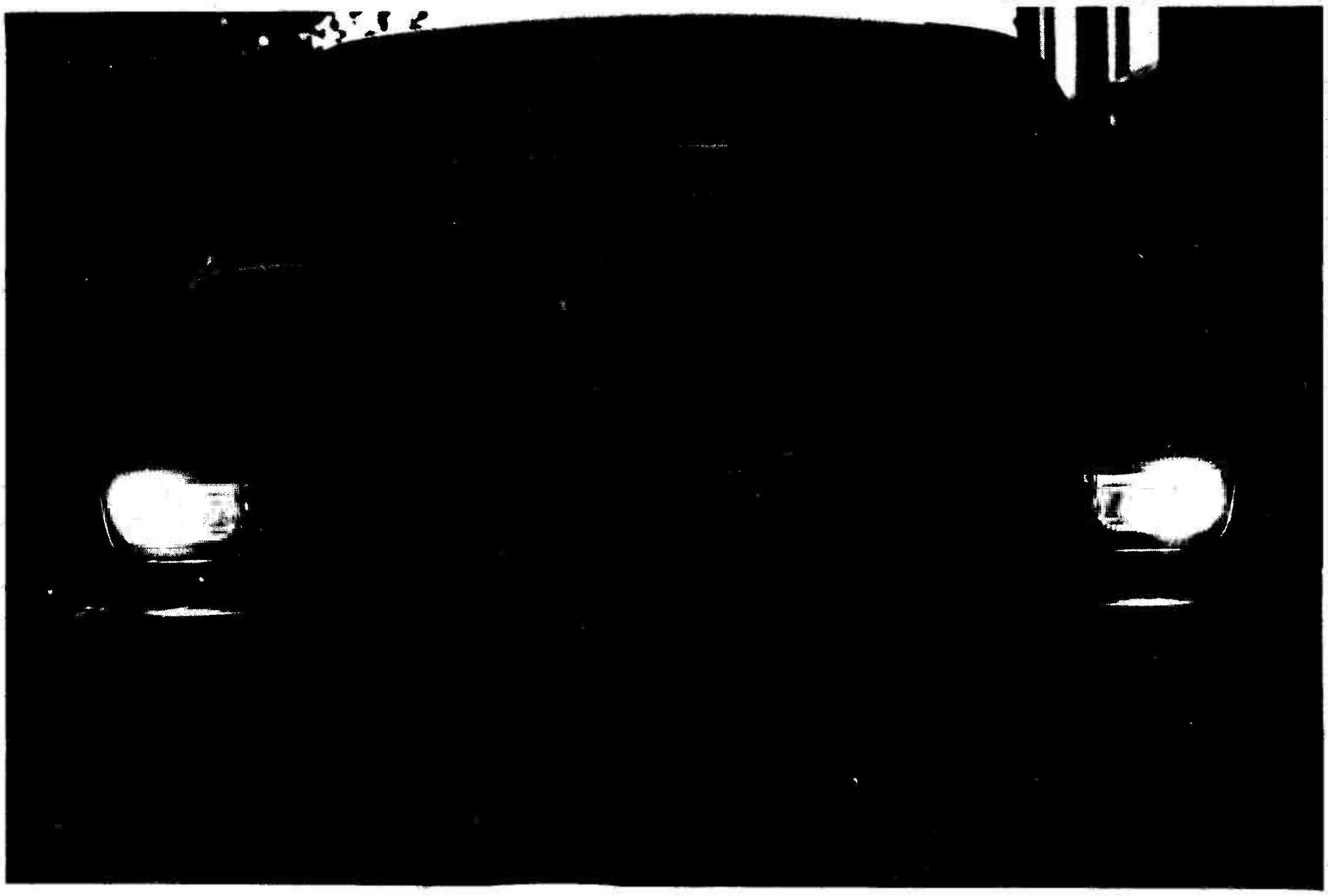
When either blinker is switched on, pulses from the flasher unit charge C1 and C4 via either D1 or D2, and in the case of C4, also via the relay winding and R3. When the charge on C4 is sufficient to trigger UJT Q1, a pulse occurs across R2. This in turn gates the SCR on allowing C1 to discharge via the relay and the SCR. The C1 discharge current through the relay winding actuates the relay and the normally closed contacts are opened, breaking the current path to the light concerned.

This removes the major load on the flasher unit, which then stays on. Providing the indicator switch is left on, the SCR will continue conducting via the relay winding, thus the contacts remain open. Since the timing circuit is directly across the SCR, it is reset immediately the SCR turns on which ensures that the next timing period will be the same as the first. Switching the indicator switch to the off position, removes power from the relay and it then drops out.

The blinker on-time is determined by the C4/R3 time constant — in this case about 30 seconds. Increasing the value of either component lengthens the 'on' time, and vice versa. The capacitors across the relay contacts are included to protect the contacts from arcing.

PARTS LIST

SCR	—	silicon controlled rectifier C106B1
Q1	—	unijunction transistor 2N2646
D1, D2	—	silicon diode 1N4001
R1	—	resistor 220 ohm, ½ watt, 10%
R2	—	resistor, 27 ohm, ½ watt, 10%
R3	—	resistor, 330k, ½ watt, 10%
C1	—	electrolytic capacitor, 100uF, 16V
C2, C3	—	polyester capacitor, 0.1uF, 100V
C4	—	electrolytic capacitor, 47uF, 16V, upright
Relay	—	miniature relay. For 6V vehicles (52 ohm coil), 12V vehicles 185 ohm coil — see text
Veroboard	—	2¾ inches wide, 3 inches long, 0.2 inch spacing
Sundries	—	hookup wire, solder etc.



BRAKE LIGHT WARNING

eti PROJECT

Faulty brake warning lights are dangerous — to others as well as to yourself. This simple fail-safe unit tells whether they are working, at all times.

A vehicle with inoperative brake lights is a menace on today's roads.

But what is far worse is a vehicle with only one brake light working, for this may be mistaken for a turning indicator.

ETI's brake alarm unit is designed to detect both conditions. It indicates, via a dashboard mounted lamp, that both brake lights are working each time the brake pedal is depressed. If either or both brake lights fail, then the indicator lamp fails to light.

As the great majority of cars use 12 volt electrical systems, the unit has been designed specifically for this system. It will not work satisfactorily with six volt systems.

The unit shown in this article is for vehicles with negative earth systems. The unit can be constructed for positive earth systems merely by substituting transistors shown under 'positive earth' in the parts list. Make sure that you specify the correct type for your vehicle when ordering the components (or kit set) from your parts supplier.

The unit is shown here in two forms, in its simpler form (Fig. 1) the indicator light operates at the same intensity day or night. A simple modification to the basic unit, (Fig. 2) automatically reduces the intensity of the indicator light when the headlights are switched on.

Many vehicles are fitted with a handbrake warning light, and this can be adapted as a dual purpose indicator. Alternatively a separate indicator light may be used.

CONSTRUCTION

Our original prototype was constructed on a printed circuit board the foil pattern of which is reproduced (full size) in Fig. 3. Alternatively, the components may be assembled on veroboard, matrix board, or tag strips. The layout is not at all critical.

The component layout for printed circuit board construction is shown in Fig. 4. The same board and basic component layout is used for both versions of the unit. In the simpler version the extra components are omitted and resistor R8 replaced by a shorting link. At this stage do not install R3 (220 ohms).

The completed board should be mounted in a small case — we used an aluminium case 3" x 2" x 1½". Ensure that no internal wiring touches either R1 or R2, as these become hot when the brakes are used for a long period.

INSTALLATION

Locate the box in a convenient place under the dashboard or in the engine compartment.

Now refer to Fig. 5.

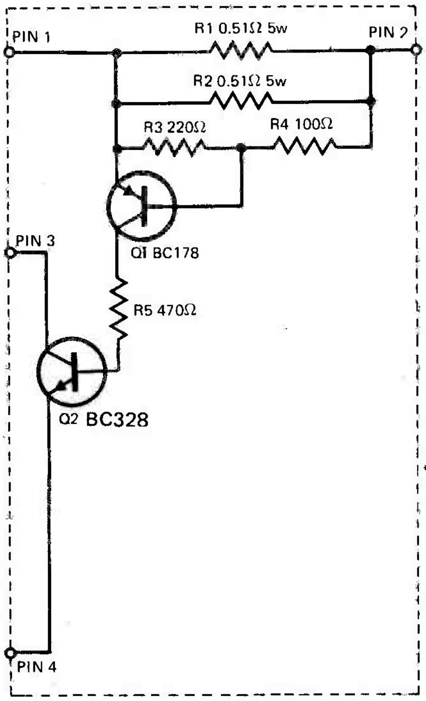


Fig. 1. Circuit diagram of the basic unit.

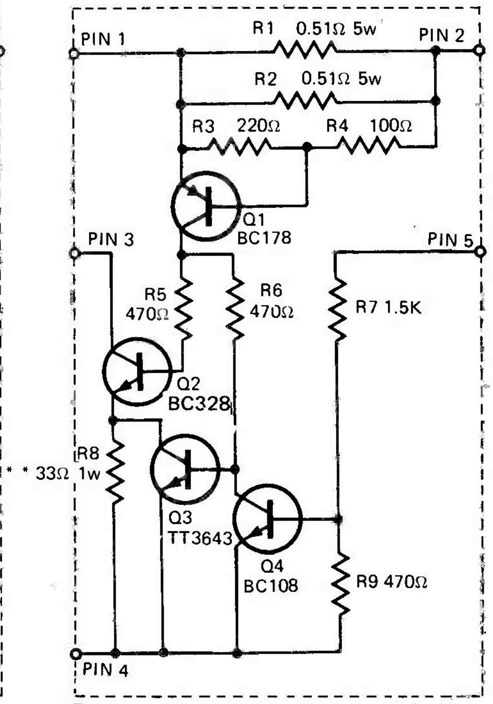


Fig. 2. In this form the intensity of the indicator light is automatically reduced when the headlights are switched on.

The existing wire from the brake lights is removed from the brake switch and wired to Pin 2 of the warning unit. A new wire is then taken from the brake switch to Pin 1 of the warning unit. Pin 4 is connected to any convenient earth. In the automatically dimmed version of the unit, Pin 5 is wired to the switched side of the side or tail-light circuit.

The brake warning indicator light should be rated at 12 volt, approximately 150 mA. One side of the light should be connected to the vehicle's 12 volt supply, preferably via the ignition switch, and the other side of the light is wired to Pin 3 of the warning unit.

If a handbrake warning light is fitted to the vehicle (and if the actuating switch is of the type that earths one side of the light when operated) then this handbrake light may also be used for the brake warning function. All

Fig. 3. Foil pattern for the printed circuit board (full size).

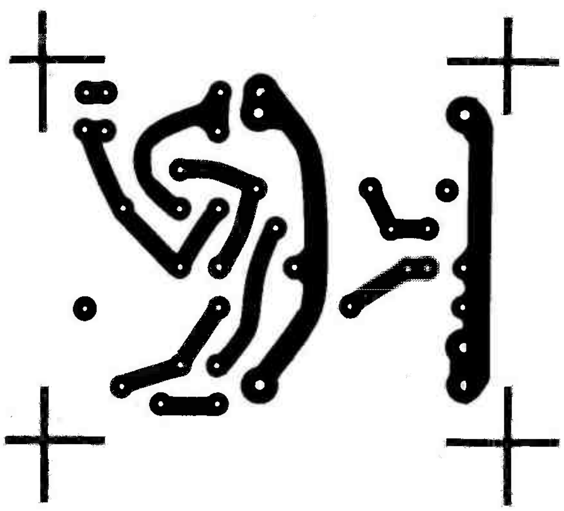
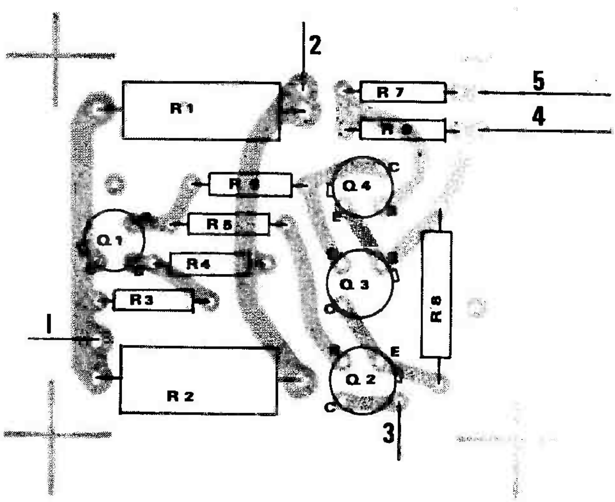
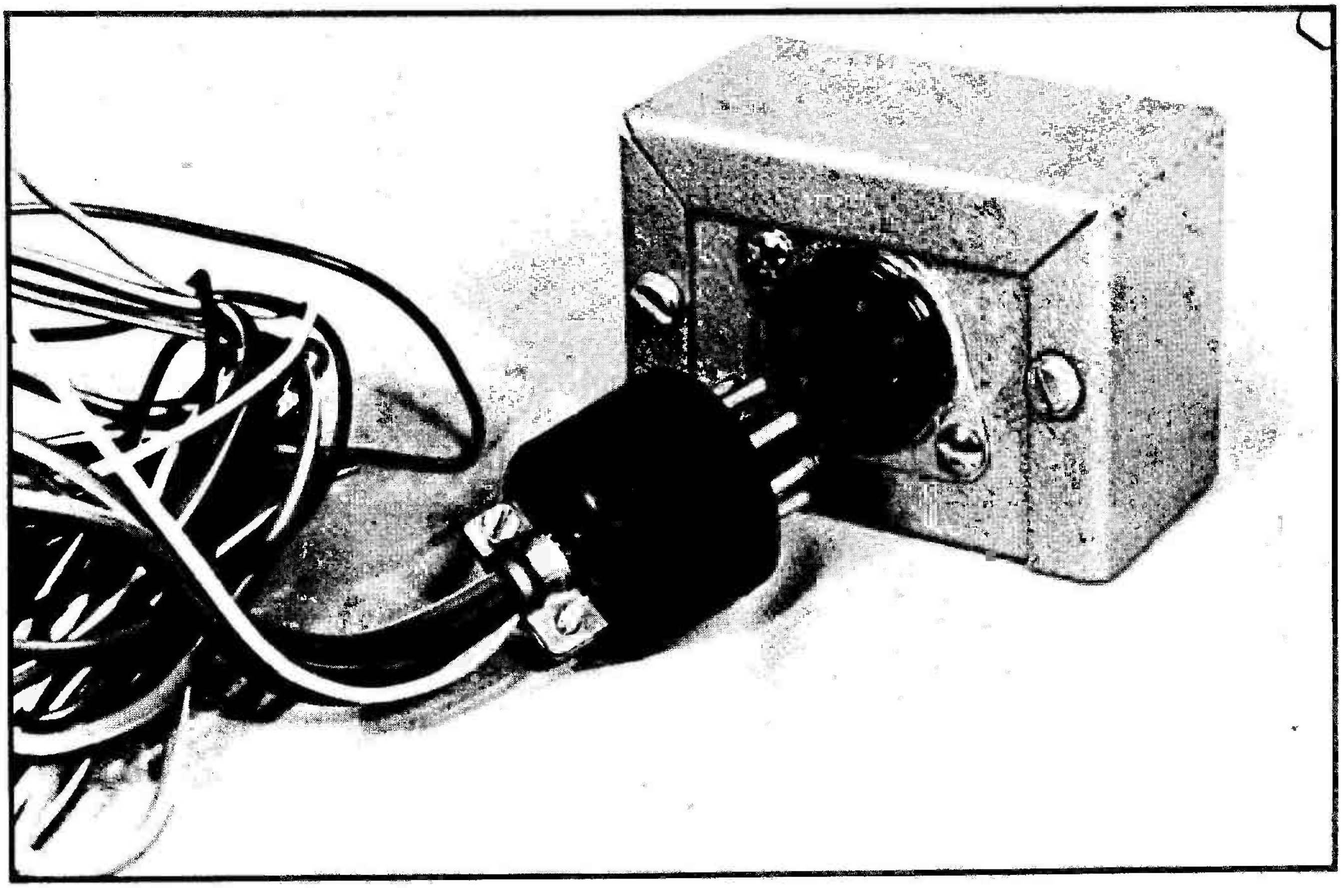


Fig. 4. How the components are assembled on the printed circuit board — in the basic version some components are omitted, and a shorting link wired across the position shown for R8.



BRAKE LIGHT WARNING



The completed unit — we used an octal plug and socket to connect the unit to our testing vehicle, but for general use it is better to connect the unit directly to the vehicle's wiring system.

that is required is to connect Pin 3 to the junction of the handbrake warning light and the actuating switch. (Fig. 5 refers).

TESTING

Having installed the brake warning unit, chock the wheels of the vehicle, release the handbrake, switch on the ignition and depress the brake pedal. The brake indicator light should be illuminated each time the brake pedal is depressed.

Now remove one of the rear light bulbs and depress the brake pedal again. This time the light should not come on. Check that it does not come on when the engine is running (i.e. when the battery voltage is higher). Replace the rear light bulb.

Finally — if the modified circuit is used — switch on the sidelights, and again press the brake pedal. This time the light should be illuminated, but with decreased brilliance. The degree of light reduction is determined by the value of R8 — this is normally 33 ohms but may be varied as required.

FAULT FINDING

Indicator does not come on at all.

If the indicator does not light up

PARTS LIST

Negative earth vehicles.

Q1	—	transistor	BC 178
Q2	—	"	BC 328
Q3	—	"	" "
Q4	—	"	BC 108

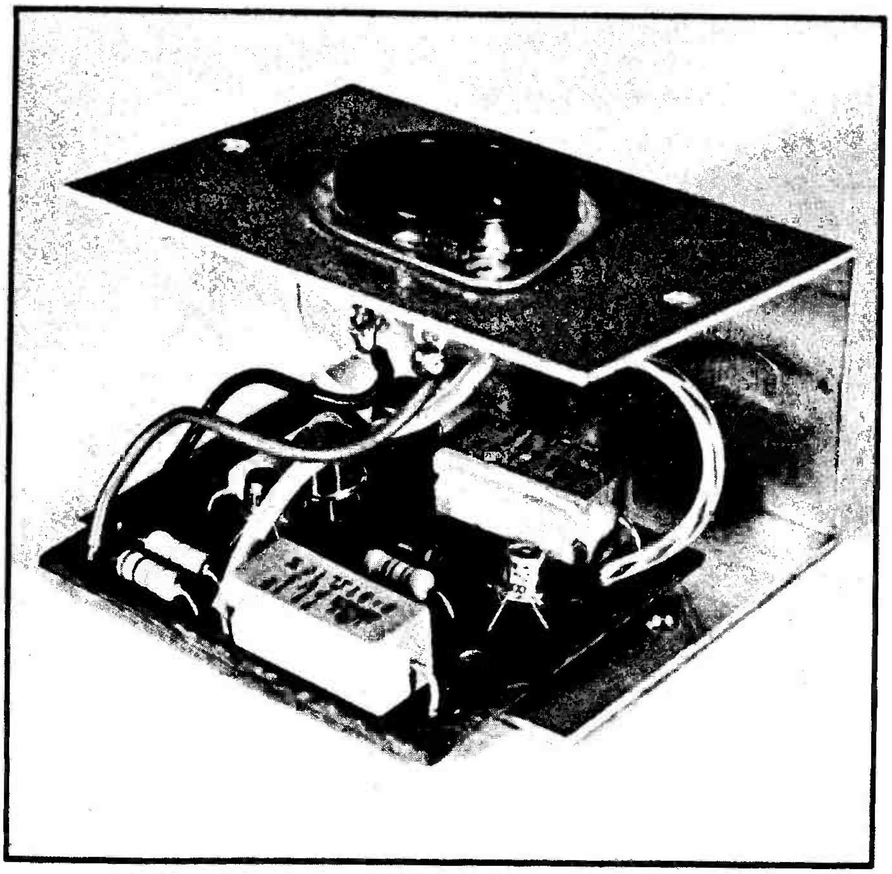
Positive earth vehicles

Q1	—	transistor	BC 108
Q2	—	"	BC 338
Q3	—	"	BC 338
Q4	—	"	BC 178

All vehicles

R1	—	resistor	0.51 ohms,	5 watt.
R2	—	"	" "	" "
R3	—	"	220 ohms,	½ watt, 5% (see text)
R4	—	"	100 "	" " "
R5	—	"	470 "	" " "
R6	—	"	" "	" " "
R7	—	"	1.5k "	" " "
R8	—	"	33 "	1 Watt "
R9	—	"	470 "	½ " "

PC board — ET 007, 1 metal case, wire, screws, grommets etc.



Here the assembled printed circuit board is ready to be located within the case.

HOW IT WORKS

Resistors R1 and R2 are in series with the brake lights. The voltage drop across them is proportional to the current through them, and if this voltage is high enough Q1 will be, turned on via R4. When both brake lights are working the current is approximately 3½ to 4 Amps thus producing about one volt drop across the resistors.

This exceeds the base emitter voltage of Q1 and so Q1 and Q2 conduct, extending an earth to the indicator lamp which is thus energized.

In the modified circuit shown in Fig. 2 the earth to the indicator lamp is extended via 33 ohm resistor R8, thus giving a lower intensity than otherwise. However transistor Q3 is in parallel with this resistor, and, unless the sidelights are switched on, Q3 is biased on by R6. Thus in effect, Q3 shorts out R8 ensuring normal lamp brightness.

But if the sidelights are switched on, Q4 will be biased on via R7, and will clamp the base of Q3 to zero potential. Q3 will be switched off. Hence the full 33 ohms will appear in series with the indicator light, thus atuomatically reducing its brightness whenever the sidelights are on.

when the brake pedal is depressed, make sure that the ignition switch is on and that both brake lights really are working. Then make a thorough check of wiring both inside and outside the brake warning unit.

Indicator not extinguished when one rear light removed.

Firstly disconnect the lead to the rear brake lights from Pin 2 of the warning unit. If the indicator still does not extinguish, then the fault is within the unit; check internal wiring and transistor Q1.

If, one the other hand, the indicator goes out with the brake lights disconnected, check the number of lights connected in the brake circuit. Normally there is only one each side, each rated at approximately 2 Amps. The unit is normally set up for this load.

If there are more than two brake light bulbs , then for each additional globe a further 0.51 ohm resistor must be paralleled across R1 or R2. In other words the total number of 0.51 ohm resistors, must equal the total number of brake light bulbs

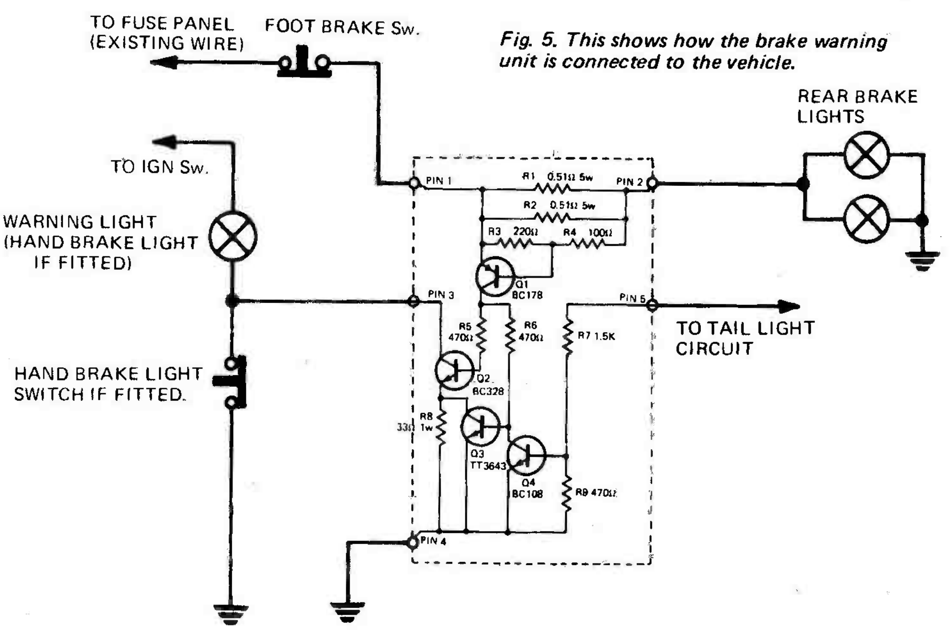


Fig. 5. This shows how the brake warning unit is connected to the vehicle.

Some vehicles use brake light bulbs of a rating other than the usual 18 or 24 Watts. If this is the case, solder resistor R3 (220 ohm) into place as shown in the circuit diagram.

If a trailer is to be used, a separate brake light circuit should be wired to the trailer socket bypassing the warning unit. If trailer brake light warning is specifically required, a second brake warning unit should be installed in the towing vehicle. ●

The Revealer

PROJECT 213

BEAT THE CROOKED CAR-DEALER AT HIS OWN GAME, WITH THIS SIMPLE METAL DETECTOR

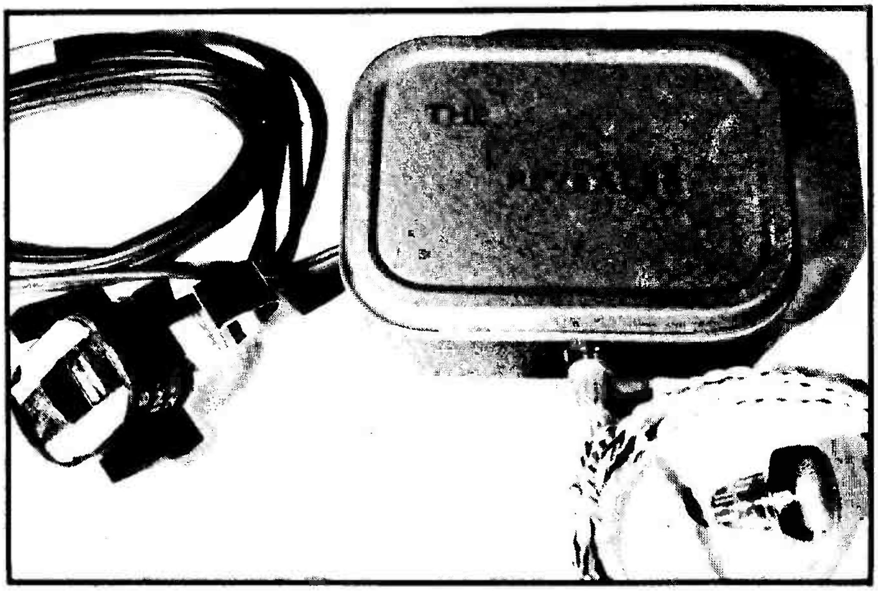


Fig 1. The completed unit together with earpiece and search coil.

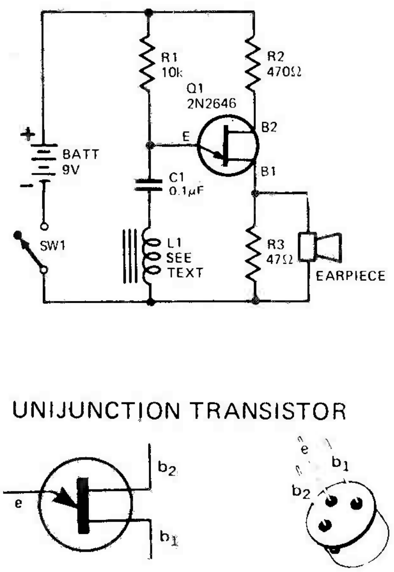


Fig. 2. Circuit diagram illustrates the simplicity of the unit.

'HONEST JOE', down at the used car lot, knows *all* the tricks, and uses as many as need be, to make his vehicles appear better than they really are.

Patching up rust holes, and filling up the dents from collisions – with putty, fibreglass, epoxy and paint, are just a few of the tricks for disguising the poor condition of bodywork. As bodywork is very costly to repair properly its condition is of vital importance to a used-car buyer.

Here's a little gadget – THE REVEALER, which will help to even up the game, by detecting what goes on below that beautiful but oh-so-thin coat of paint.

WHAT IT DOES

The revealer is an electronic test device to determine whether or not there is steel below the paint work. It comprises three elements – a search coil, the electronics, which are in a tin box, and an earpiece. The circuit generates a tone in the earpiece. When the search coil is placed over, and close to, steel, the tone changes significantly.

A would-be buyer of a used car can carry the tin box in his pocket, the earpiece in his ear, and the search coil discreetly in his hand. Tests can be made on door panels and mudguards and other places where rusting or filling is likely to exist. The best way to check a door panel, for example, is to hold the search coil at the top of the panel, where rust is unlikely, and then quickly transfer it to the bottom – where rust is more likely. If the note starts off – 'eeeeeee' and finishes up – 'mmmmmmmm', – look out! the bottom of the door panel has been filled with something that's not steel.

Of course a test can be made by simply moving the search coil over suspect areas, and listening for any change in pitch and tone.

Thus by listening to the frequency of the oscillator one can tell whether there's steel – or something else – under the coat of paint on a car.

While moving the search coil over the body work, the note should remain steady. If it fluctuates – take heed, all is not well.

THE SEARCH COIL

The search coil used in the prototype is a 1.5 henry choke of 85 ohms resistance and 10 mA rating, which happened to be on hand. The iron core is made of E and I laminations, with all the Es facing one way. After removing the choke from its mounting

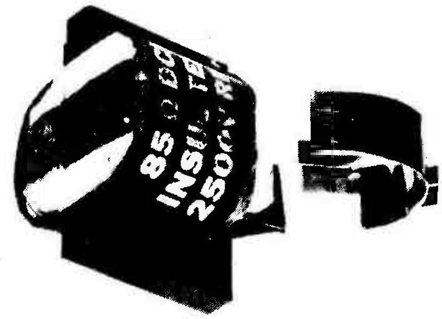


Fig. 3. The search coil may be constructed from an iron-cored coil having an inductance of 1.5 Henry and dc resistance of 85 ohms.

frame, the Is are discarded, thus leaving the choke with open-ended Es only.

The sensitivity of the search coil is increased by discarding about half of the E laminations, so that when the open ends of the remaining laminations are brought near any steel, then this steel makes a significant change in the inductance of the coil, and hence in the frequency of the oscillator.

On the prototype the remaining laminations were wedged securely with a wooden wedge, which also held a suitable small steel handle. See Fig. 3.

Constructors who do not have a similar choke on hand should experiment with similar chokes, or small transformers. An old transformer with one winding open-circuited would do, as long as the coil in use is continuous. Practically any small **transformer will work; just try** whatever is to hand. Naturally the smaller the search coil the better able it is to locate small flaws beneath paint.

HOW IT WORKS

The tone is generated by a unijunction transistor relaxation oscillator. This oscillator is quite conventional except – that, in addition to the usual capacitor between the emitter and negative rail, there is an inductor in series with the capacitor. (Fig. 2.).

The value of this inductance determines the frequency and tone of the note generated.

The inductor is actually the search coil, and its inductance is varied by the proximity of steel to the open ends of its iron core.

When the inductor search coil is close to steel the frequency of the note decreases, when there's no steel there it remains high.

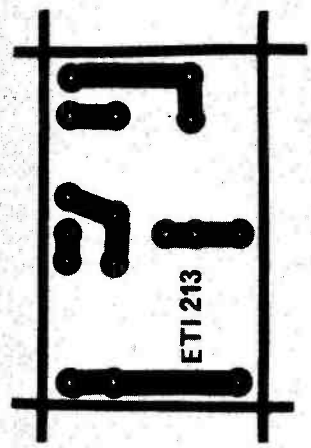
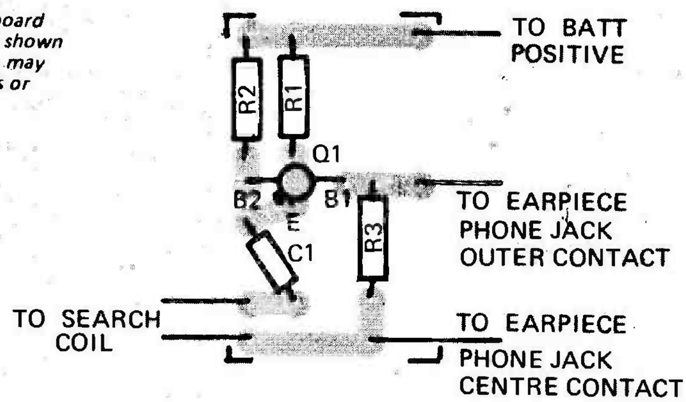


Fig. 5. A printed circuit board may be used (foil pattern shown here full size), or the unit may be assembled on tag strips or Veroboard.

Fig. 6. Component overlay



CONSTRUCTION

Construction is not in any way critical. In the original model the components were mounted on a printed circuit board measuring 1 7/8" x 1", and assembled with the batt y in a small tin box which once h d throat tablets

The jack used for the earpieces was of the type used in some transistor radios, with three terminals, and fitted with a normally-closed switch. Before use, this was adapted, by bending the fixed contact of the switch, so that the switch became normally-open, and was closed by the insertion of the earpiece plug. Figure 4 shows the jack after adaptation. The battery negative lead goes straight to one of the terminals of the jack.

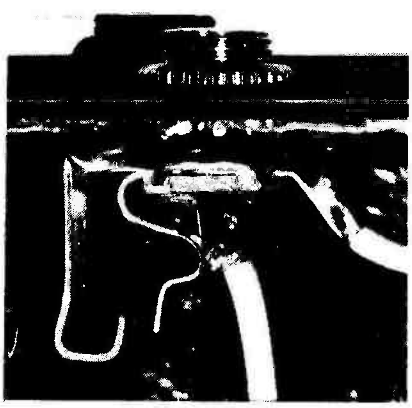


Fig. 4. The jack must be bent as shown so that the switch makes contact when the earpiece is inserted.

This switch is used as the battery on-off switch, SW1 in Fig. 2, so that the device is switched on simply by inserting the earpiece plug.

If constructors use a choke different from that in the original then they should experiment with the value of the capacitor C1 to adjust the frequency of the oscillator to a satisfactory value. The layout of the copper side of the printed circuit board is shown in Fig. 5. Fig. 6 shows the component positions on top of the pc board.

Constructors who are not equipped to make a little pc board could easily mount the components on a tag strip or on Veroboard.

Well there it is – a one evening low cost project, but it could save its **maker a small fortune on his next car deal.** ●

eti project METER BEATER

Internal view of the completed timer showing how it is assembled into a small tin.

FOR THE PRICE of just one parking fine you can build the Meter Beater — and never get caught again!

The Meter Beater is simply a portable audible alarm which can be set for common parking meter periods — ½ hour, 1 hour and 2 hours. Several minutes before the expiry of the period it sounds a warning — giving you time to get back to your car. It is set by sliding one of the three switches visible in Fig. 1.

CONSTRUCTION

The prototype was constructed on a 47 x 55 mm piece of 0.1 inch pitch Veroboard. This may conveniently be mounted in a small tin such as that shown in the photograph. The Veroboard tracers should be cut in the pattern as shown in Fig. 2. Note that in the component overlay (Fig. 3) the components are drawn as seen from the opposite (component) side of the board.

Take particular care to orientate ICs transistors and electrolytic capacitors as shown in the component overlay. Use a lightweight soldering iron and solder quickly and cleanly. Take particular care with the CMOS IC, IC2.

As tantalum capacitors have tolerances of +50% to −25% it may be necessary to select values for R1 and R2 to obtain the time required for the ½ hour alarm. Once this is set the other times are right.

OUTPUT TRANSDUCER

The output transducer used in the prototype was a hearing-aid earpiece of about 400 ohms. However these are quite expensive. Alternatively a cheap lapel crystal microphone, mounted on the outside of the tin box, makes a good 'speaker' or a crystal radio earpiece may be used. If a magnetic earpiece is available it may be also used provided that it is fed through a small electrolytic capacitor — say 4.7μF. All of these will work quite well but the best of all, if available, is the hearing-aid earpiece. Whichever device is chosen it is not worn in the ear, but mounted on the lid of the tin box, by means of a small aluminium strap. The complete alarm may then be slipped into a pocket where it is easily heard.

The inside of the tin box and the lid should be insulated with plastic sheeting before fitting the 'works'.

ADJUSTMENTS

The only adjustment provided is the

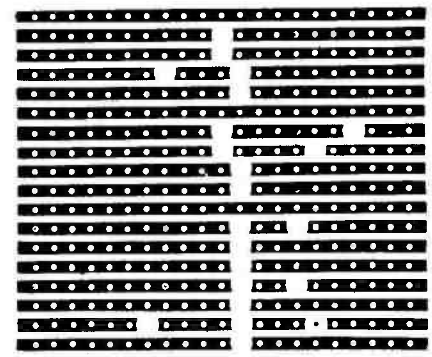


Fig. 2. Veroboard pattern. The tracks should be cut as shown. Full size 47 x 55 mm.

preset pot RV1. This sets the duration of the "½ hour" alarm as close to half an hour as desired. However, as pointed out earlier, if the tantalum capacitor is well off the marked value, then a change may be needed to R1 and R2 to obtain the correct adjustment range for RV1.

The switching transistor Q8 should be turned hard on, to obtain the maximum voltage across IC3. This may be checked by measurin the voltage across the transistor whe it is on — i.e. the alarm is sounding. It should be less than 1 volt. If it exceeds 1 volt then the value of the base resistors R4, 5 and 6 should be reduced to ensure saturation.

USE

To use the Meter Beater simply switch it on after putting your money in a parking meter, using the switch appropriate for the time for which you've paid. Put the Meter Beater in a shirt pocket and in due time it will sound off a warning that you must be heading back to your car.

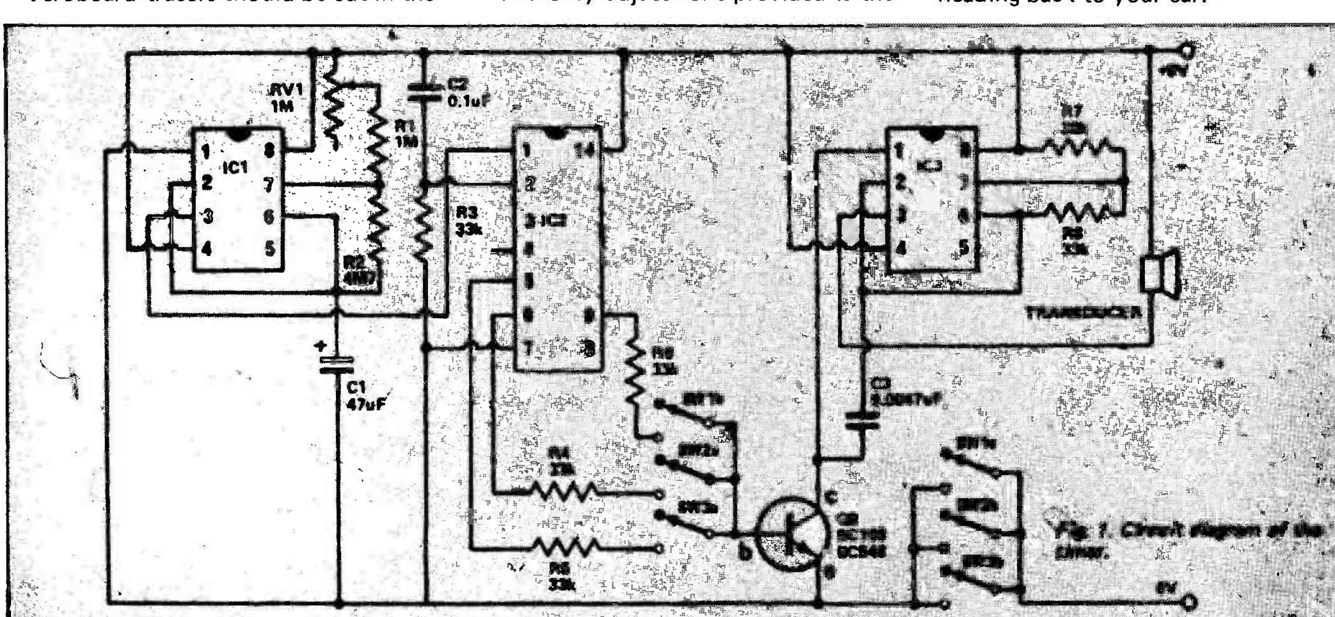


Fig. 1. Circuit diagram of the timer.

OTHER USES

As will have been noted, only three of the outputs of IC2 have been used. The other outputs can be used for shorter or longer times if desired — up to nearly eight hours. Thus the unit is essentially a long period timer and may be adapted for such purposes as timing hire periods of, say, billiard tables; process timing; a medicine reminder alarm, and any similar long period applications.

Battery consumption is about 4mA about 100 hours, at two hours per day.

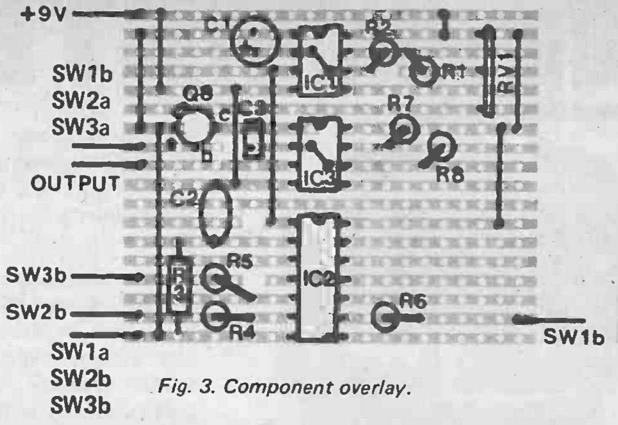


Fig. 3. Component overlay.

HOW IT WORKS

The Meter Beater comprises three elements — a 555 timer connected as a very slow-running astable multivibrator; a seven stage ripple counter; and a 555 timer connected as an audio frequency astable multivibrator feeding an output transducer.

Potentiometer RV1, R1, R2 and C1 are the timing elements associated with the first 555 timer IC1. At switch on, the output of IC1, terminal 3, goes high. About 5½ minutes later it goes low, and two minutes later it goes high again. This is shown in the timing diagram. The first high period is longer than subsequent ones because during the first period the capacitor C1 has to be charged from zero up to 2/3 of battery voltage, whereas in later periods the capacitor is charging only from 1/3 to 2/3 of battery voltage. Hence each full cycle lasts about 6½ minutes.

The output pulses from IC1 are connected to the input of the seven stage ripple counter IC2. For those not familiar with this device — it comprises seven, bistable multivibrators (flip-flops) connected in series. One output terminal of each flip-flop (FF) is brought out to a pin and they are named Q1 to Q7 in the pin assignment diagram Fig.5. Assuming all outputs are first set low, i.e. logic 0, then when the first negative going edge of the input pulse reaches the input of FF1, its output Q1 changes and goes high. When the next negative going edge reaches the input of FF1, its output changes again, i.e. goes low. See graph of output of Q1 on Fig.4. The negative going edges of the input pulse train are numbered 1 to 16. It can be seen that, at edge 2, the output of FF1 is negative going, and this, being connected to FF2 which is also negative edge sensitive, sends the output Q2 of FF2 high. It can be seen that the output of FF1 goes high at half the frequency of the input, and similarly, the outputs of the other FFs are at half the frequency of the preceding FF.

It can be seen that Q3 goes high after four negative going edges, Q4 goes high after eight negative going edges and Q5 goes high after 16 negative going edges.

It will be noted that only outputs Q3, Q4 and Q5 have been used in this project. Q1, Q2 and Q3 could have been used if IC1 had been made to oscillate much more slowly — but this would have involved higher timing resistors and capacitors — with associated problems of leakage current approaching charging current, and the consequent inaccuracy.

Now, reverting to the circuit diagram — it will be seen that each of the three switches is a double pole type and each performs two functions. One pole of each switch i.e. S1a, S2a and S3a connects the battery to the circuit, but S1b connects output Q3 to IC2 to Q8 (called Q8 to avoid confusion with the outputs of IC2) an NPN transistor used as a switch. S2b connects output Q4 to Q8, and S3b connects output Q5 to Q8. Thus when S1 (the ½ hour switch) is closed, the battery is connected and output Q3 is connected to Q8. After about 25 minutes the output Q3 goes high and turns on Q8. This energises the second 555 timer IC3, for which R7, R8 and C3 are the timing elements. These timing elements set the 555 in the astable mode at audio frequency. The output is connected to the transducer which provides an audible alarm. Similarly when S2 (the one hour switch) is closed, the alarm sounds after about 50 minutes, and when S3 (the hour switch) is closed the alarm sounds after about 1 hour 45 minutes. The amount by which the alarm is ahead of the exact meter period is greater with longer periods, and this allows for the fact that one probably goes further from one's car when it is parked for two hours.

For the device to work it is obvious that all outputs of IC2 must be set low at switch on. The IC has a reset terminal, Pin 2, which must be set high so that all outputs are reset to low, and must be set low to enable counting to proceed. R3 and C2 provide these functions. At switch on, Pin 2 is 'flicked' high by the pulse through C2, but as C2 charges (which takes very little time) Pin 2 is brought down to negative rail voltage, allowing counting to proceed.

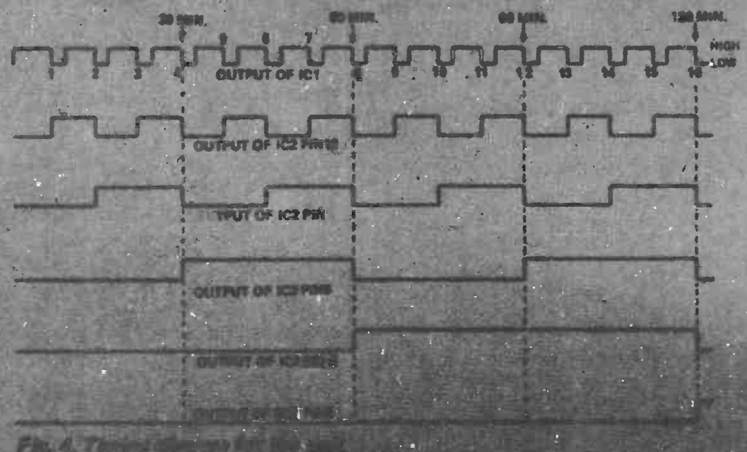


Fig. 4. Timing diagram for the unit.

PARTS LIST ETI 229

R3,4,5	Resistor	33k ¼watt 5%
R6,7,8	"	33k ¼watt 5%
R1	"	1M ¼watt 5%
R2	"	4M7 ¼watt 5%
RV1	Potentiometer	preset 1 megohm
C3	Capacitor	0.0047µF polyester
C2	"	0.1µF polyester
C1	"	47µF 6.4 volt tantalum
IC1,3	Integrated Circuits NE555	
IC2	Integrated Circuits CD4024AE, MC14024 or similar	
Q8	Transistor silicon NPN type BC108 or similar	
S1,2,3	Switch DPST slide	

Transducer — see text, metal box, spacers, nuts and bolts.

PHOTOGRAPHIC TIMER

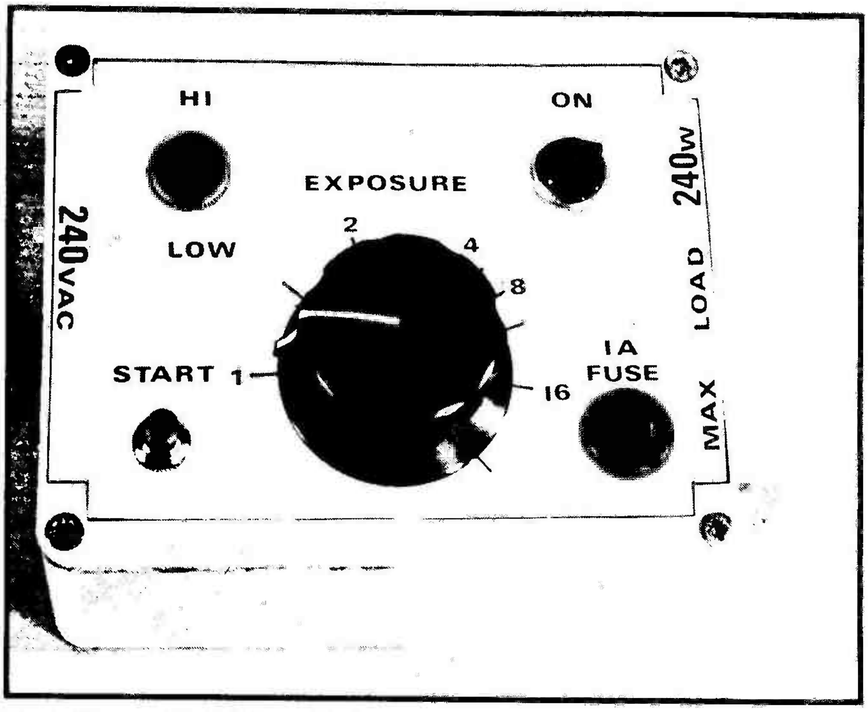


Fig. 1. The completed photographic timer.

This unit provides reliable and accurate timing of photographic processes.

ACCURATE, dependable timing of photographic printing processes is essential to avoid costly wastage of paper.

ELECTRONICS TODAY INTERNATIONAL's process timer provides just this. This unit ensures precise and repeatable timing from less than one second to over 300 seconds.

The wide timing range of the instrument allows it to be used as an enlargement exposure or development timer. This dual application makes the unit superior to all but the most expensive commercial timers that are usually only suitable for one or the other of the above tasks.

CONSTRUCTION

By far the easiest method of construction is by the use of a printed circuit board, and this is the method we used in our prototype. However, layout is not critical and any other construction methods, such as veroboard, may be used if desired.

It must be firmly kept in mind that the unit is connected directly to the mains power and the circuitry is "above earth". Therefore, good workmanship is essential with particular attention being given to such points as clearances and insulation.

Our unit was constructed in a diecast aluminium box which although a little expensive, is convenient and results in a very professional appearance.

Full drilling details for this box are given in Fig. 4. If a different box is used it may be necessary to vary the layout somewhat.

Assemble the components to the board in accordance with the component overlay Fig. 5. Make sure that all components are mounted the right way round as shown in the overlay.

Leads should now be soldered to the

HOW IT WORKS

The 240V ac mains is rectified by D1-D4. Resistor R1 drops this voltage down to about 20V and capacitor C1 provides smoothing.

The main control device SCR1 (C106D1) and the load connected in series with its anode are connected across the rectified mains. The SCR being a two state device – is either non-conducting, or conducting. If the SCR is turned on by a pulse or a dc potential on its gate it will remain on as long as there is a dc potential at the gate or current is flowing in the anode circuit. The anode current will drop to zero every half cycle as the mains voltage passes through zero (resistive load). With this circuit a dc potential is applied to the gate for a preset time interval. The SCR will be on for this time plus the time remaining in the half cycle during which the control signal is removed.

Transistors Q2 and Q3 form a flip flop having two stable states. These are – Q2 on and Q3 off, or Q2 off and Q3 on. If Q3 is on, the voltage at its emitter will be high and the SCR will also be on. Pressing PB1 applies a "turn on" pulse to the base of Q3. The consequent drop at Q3 collector is passed to the base of Q2 turning Q2 off.

When Q2 turns off, capacitors C2-C6 begin to charge via RV1 and R7. These capacitors are across the emitter of the unijunction transistor Q1. The emitter appears as an open circuit until the capacitors reach about 60% of the supply voltage. When this point is reached the emitter-B1 junction of the unijunction becomes a very low resistance and the capacitors are discharged through R4. The resulting pulse across R4 is coupled to the base of Q2 by R2 turning Q2 on and Q3 off thus ending the timing cycle.

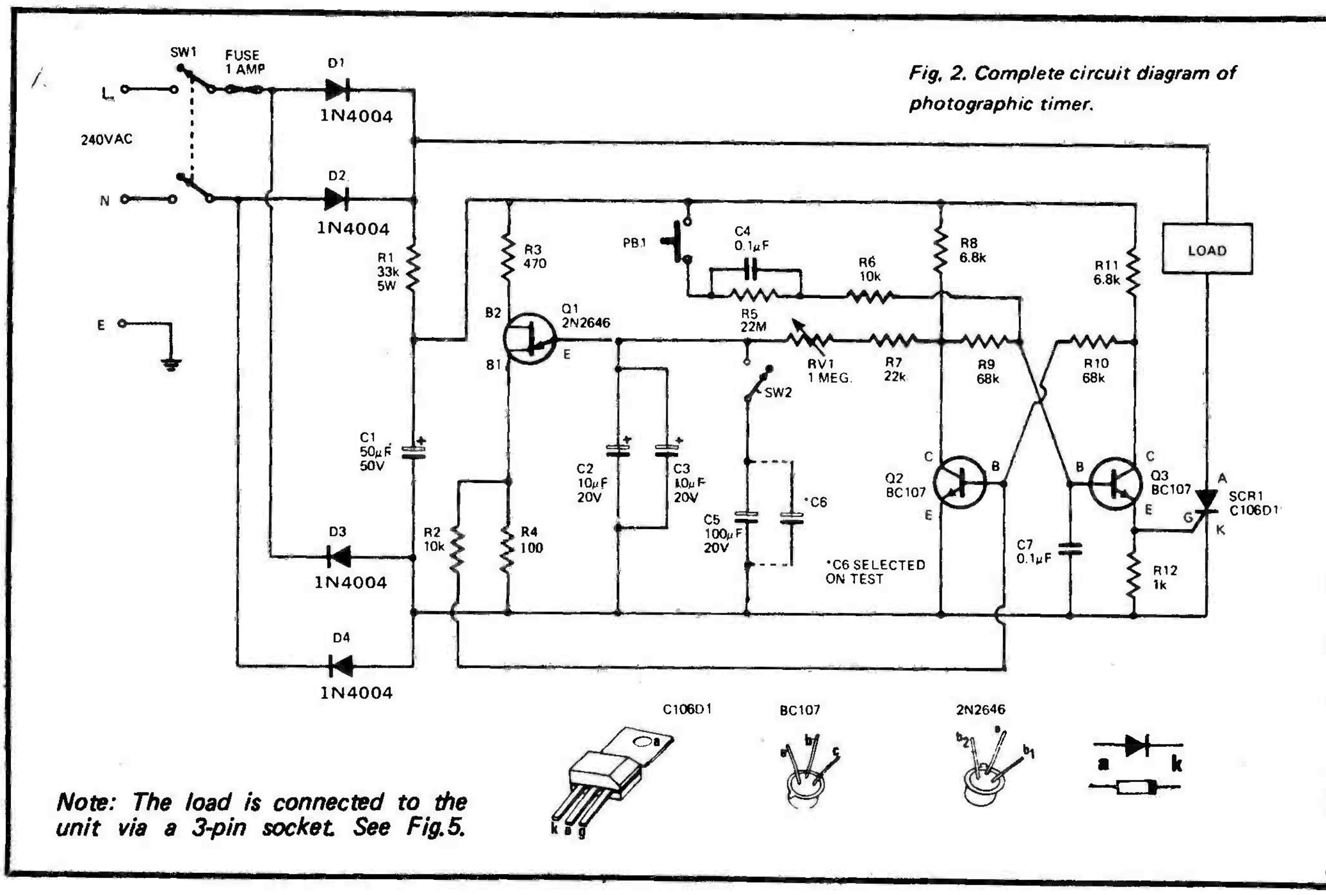


Fig. 2. Complete circuit diagram of photographic timer.

Note: The load is connected to the unit via a 3-pin socket. See Fig.5.

board for later connection to the switches and other components mounted directly on the box. Assemble the completed board into the bottom of the box using half inch spacers, making absolutely certain that all wiring and components are clear of the case.

Mount all external components on the box and wire them in accordance with Fig. 5. Note that where wires pass through the metal case a rubber grommet must be used. Instal the mains cable and secure it with a proper clamp. The practice of tying a knot in the cable is highly dangerous, illegal, and should not be used. The earth lead of the cable should be firmly bolted to the case. Check the unit thoroughly to ensure that all wiring has been properly performed before switching on.

TEST AND CALIBRATION

Remember that this unit operates at mains potential. Before attempting to make any internal changes or adjustments, switch off and remove the power plug from the mains outlet.

Connect a lamp load not exceeding 240 watts. Plug the unit into the mains outlet and switch on. A short flash from the lamp may occur at initial power switch-on and is quite normal.

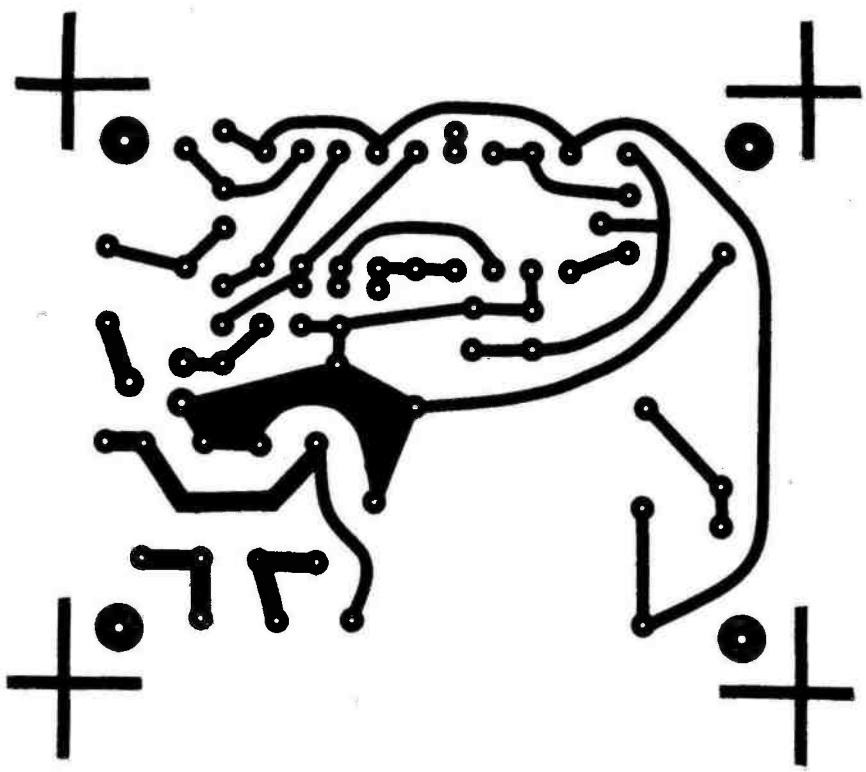


Fig. 3. Foil pattern for printed circuit board.

PHOTOGRAPHIC TIMER

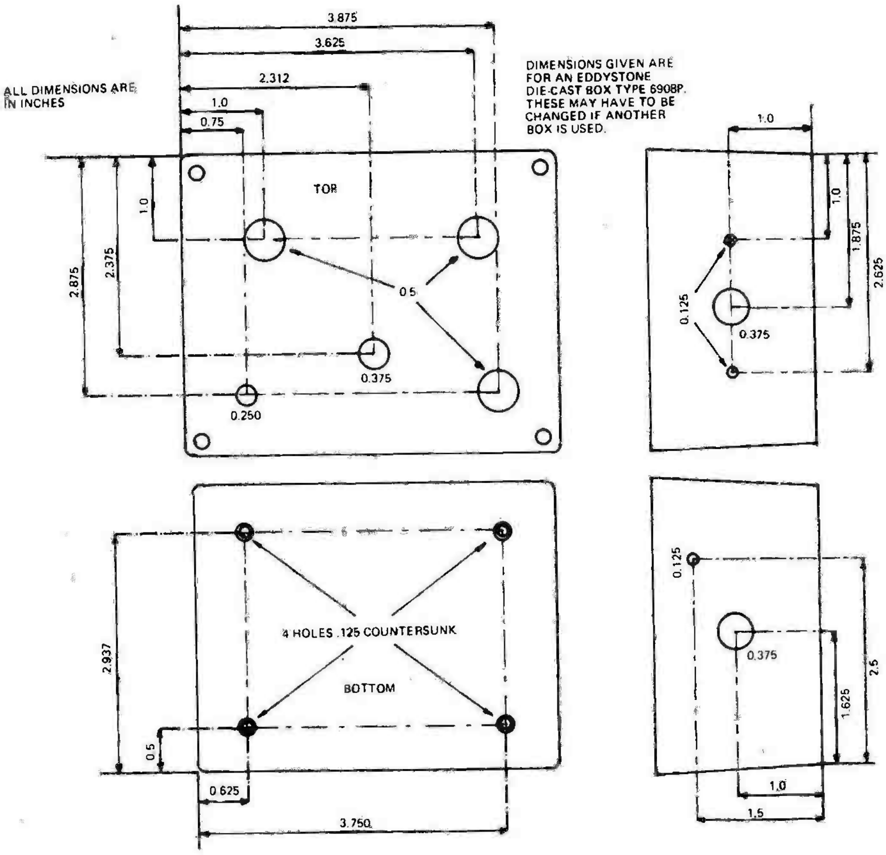


Fig. 4. Drilling details for cast aluminium box.

PARTS LIST		
All resistors ½ watt 10% unless specified otherwise.		
R1	resistor	33 kohm 5W 10%
R2	resistor	10 kohm
R3	resistor	470 ohm
R4	resistor	100 ohm
R5	resistor	22 Mohm
R6	resistor	10 kohm
R7	resistor	22 kohm
R8	resistor	6.8 kohm
R9	resistor	6.8 kohm
R10	resistor	6.8 kohm
R11	resistor	6.8 kohm
R12	resistor	1 kohm
C1	capacitor	50μF 50V electrolytic
C2	capacitor	see text
C3	capacitor	see text
C4	capacitor	see text
C5	capacitor	see text
C6	capacitor	0.1μF 100V
C7	capacitor	0.1μF 100V
Q1	transistor	2N2646
Q2	transistor	BC107
Q3	transistor	BC107
SCR1	SCR	C106D1/2N4444
D1-D4	diodes	1N4004
PC board		
SW1	switch, on-off, 2 pole 240V 1 amp	
SW2	switch, on-off, 1 pole	
PB1	push button single contact push to make	
Metal box Eddystone type 6908P or similar.		
Wire	3 core flex	
Plug	3 pin, 2 or 5 Amp	
Socket	3 pin	

Select the low range, minimum time and press the start button. The light should come on for less than one second. Now turn to maximum time and press the start button again. The timer should now stay on for about 30 seconds. Perform the same procedure again on the high range, the time range should now be about ten times that obtained on the low range.

The calibration of the timer may vary widely from unit to unit due to component tolerances and timing capacitor leakage. Tantalum capacitors have been recommended for this unit because of their relatively low leakage. These capacitors are expensive and may be replaced by ordinary electrolytics with some deterioration in performance. Different scales would then be required for each of the two ranges due to the higher leakage of these capacitors.

Calibration is performed by selecting the value of C2 or C3 to obtain the desired time range on "low" and C5 or C6 for the desired time range on "high".

On the scale as shown in Fig. 7, the calibration is from one to sixteen, the graduations being at half stop intervals. Capacitor values should be trimmed to make the time range

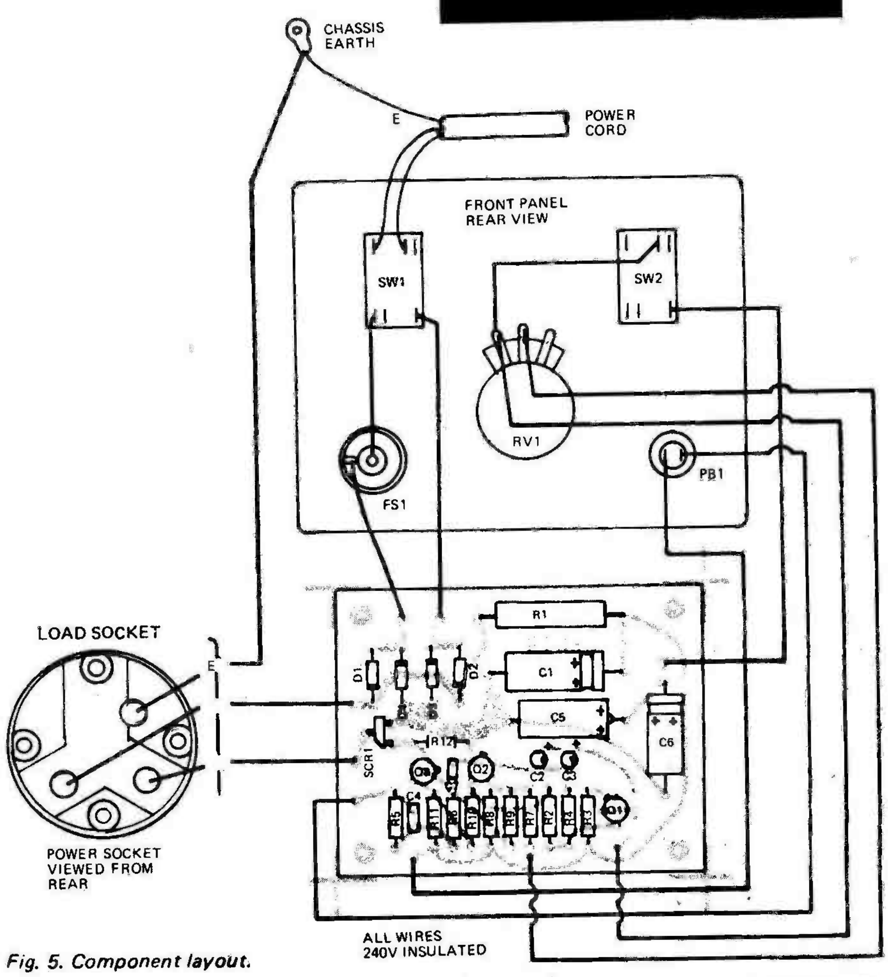


Fig. 5. Component layout.

PHOTOGRAPHIC TIMER

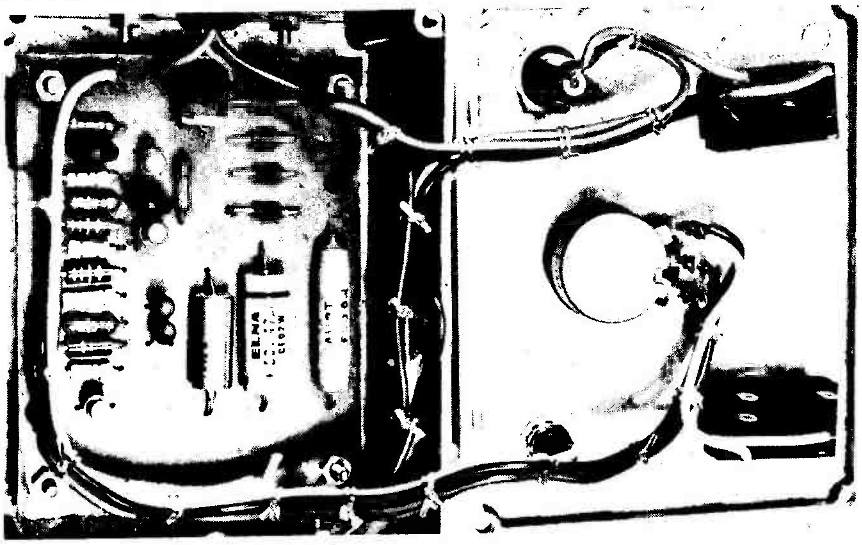


Fig. 6. Internal layout of the timer.

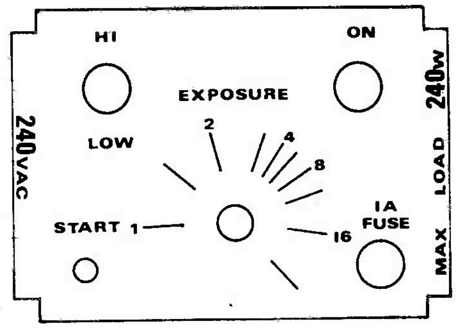


Fig. 7. front panel marking reproduced half size.

SPECIFICATION		
Power	maximum load	1 amp (240W).
Time	(low range)	1 sec — 30 sec.
	(high range)	10 sec — 300 sec.

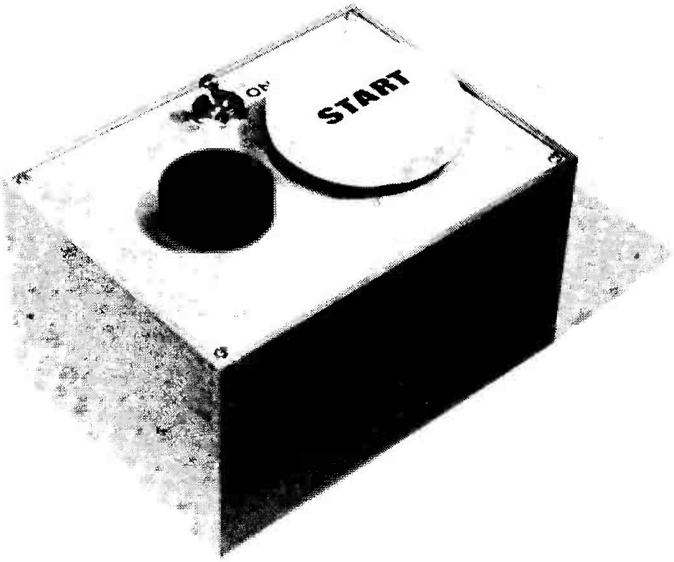
Time ranges simply selectable by change of capacitance values.

correspond to the scale markings. This is done by increasing capacitance to extend the time interval, or reducing capacitance to shorten the time interval.

The same procedure should be used if different time scales are required, the same scale graduations but different time figures are used. However it should be borne in mind that capacitor leakage may well prevent the practical realisation of time intervals much longer than 300 seconds. ●

eti project

THE PRINTIMER



Improve your photo print quality with this simple design.

ONE OF the major causes of poor quality in enlarging black and white photographs is lack of consistency in print-development time.

Many photographers think that they can get away with making enlargements without exposure test strips by pulling the print out of the developer when it looks about right.

The PRINTIMER should teach them better 'manners' and help them produce better prints.

The unit described in this article gives an alarm a fixed time after pushing the start button. Once the timer is set at the development time you believe is right for you, whether that is 1½ minutes, three minutes, or anywhere between, consistent development times will be obtained giving consistency of results. Poor prints are then the result of wrong exposure, not a combination of wrong exposure *and* wrong development.

WHAT IT DOES

As can be seen from Fig. 1, the timer has an on/off switch and a start button as its only visible controls. It can be turned on, and left on, for the whole of a darkroom session as the current drawn is very low. Once an exposed photo paper has been truly dunked in the developer, the start button is touched, and (say) two minutes later, an audible alarm beeps for a few seconds to indicate the expiry of the chosen development time. The device is ready for immediate re-use. It saves all the problem of watching a clock while development is taking place. The start button, which has been made super large, costs nothing and can't be missed in the darkroom. It can be operated with an arm or wrist by those darkroom workers who like having their fingers wet all the time.

Other uses for this device are as an egg timer, or even as a timer for quiz shows where a contestant must answer in a particular time. It could also be used as an STD telephone-call timer to remind you of the passage of time. Although it is basically a preset timer

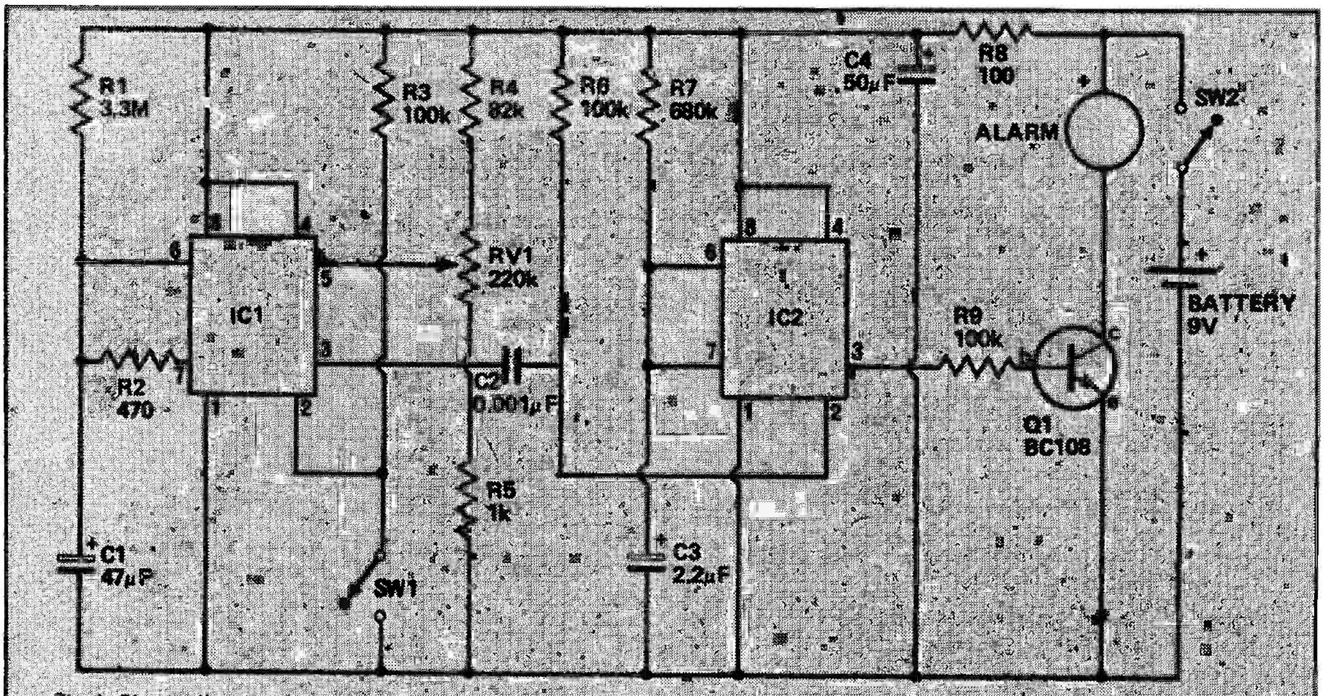


Fig. 1. Circuit diagram of the print timer.

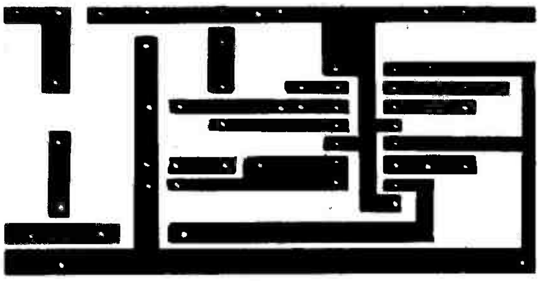


Fig. 2. Printed circuit board (full size).

HOW IT WORKS

The timer uses two NE555V IC timers as shown in the circuit diagram Fig. 1.

Integrated circuit IC1 is the main timer – its time of operation being determined by the values of R1, C1 and the preset pot RV1. When the start button, S1 is pressed, terminal 2 of IC1 is connected momentarily to the negative rail. This sends the output of IC1 (terminal 3) high.

At the preset time, terminal 3 goes low, and so applies a negative going pulse to terminal 2 of IC2 which is the second NE555V timer. Terminal 3 of IC2 goes high, turning on the BC108 transistor Q1, thus allowing current to flow through the alarm. After the alarm has sounded for a couple of seconds or so, as determined by the values of the timing components of IC2 (R7 and C3), terminal 3 of IC2 goes low again, and the alarm is turned off.

The fact that terminal 3 of IC1 is low (in the quiescent state of the device) does not cause IC2 to restart as a negative going pulse is required to do that.

Resistor R8 and capacitor C4 stabilise the supply to the ICs so that they are not affected by pulses produced when the alarm switches off and on.

PARTS LIST

R1	Resistor	3.3 megohms	¼W
R2	"	470 ohms	"
R3,R6,R9	"	100k	"
R4	Resistor	82k	"
R5	"	1k	"
R7	"	680k	"
R8	"	100 ohms	"
RV1	Preset potentiometer 220k		

C1 Capacitor electrolytic 47µF 6.3 volt tantalum
C2 Capacitor .001µF ceramic
C3 Capacitor electrolytic 2.2µF 25 volt
C4 " " 50µF 25 volt

IC1 IC2 Integrated circuit timers NE 555V

Q1 Transistor BC 108

Alarm module, e.g. "Audible Warning Device" from Doram.

S1 Push button switch — see text.

S2 Toggle switch on/off

Battery 9 volt

Case, p.c. board, aluminium for bracket etc.

NOTE: R9 may be too high a value for some circuits. This may either be reduced or even omitted to obtain correct operation.

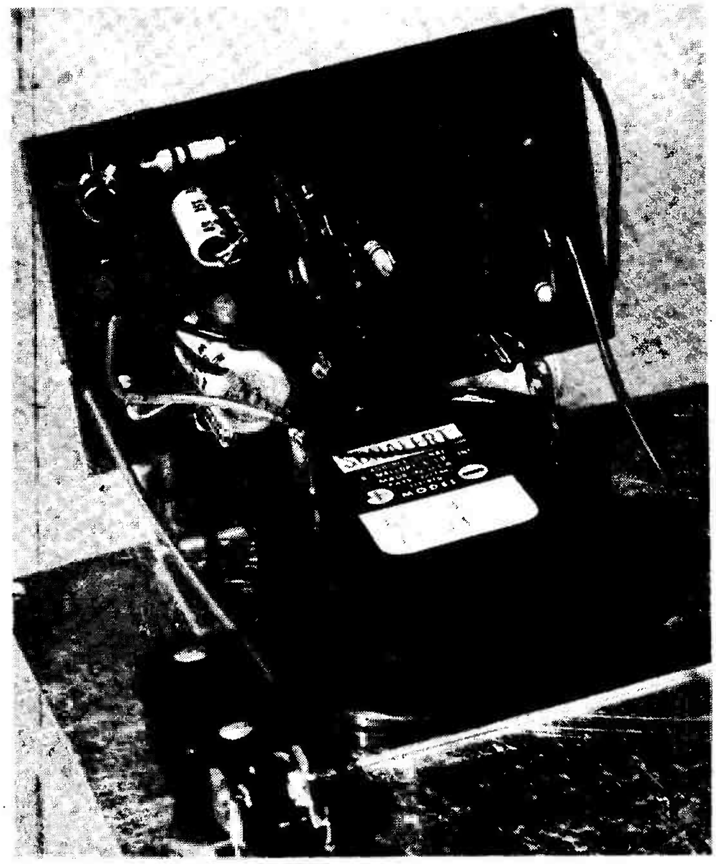


Fig. 3. The printed circuit board is mounted on an aluminium bracket which, in turn, is secured to the front panel by means of the Sonalert.

it could be made readily adjustable, as described later.

CONSTRUCTION

The timer was built into a plastic case measuring 140 x 100 x 75 mm with the works mounted on a printed circuit board 70 x 47 mm. The printed circuit board is mounted on an aluminium bracket, which in turn is secured to the front by the Sonalert as shown in Fig. 3. The arrangement shown leaves enough room in the case for a 9 volt Eveready battery, type No 276-P, which will last a very long time.

There is nothing critical about the layout, and those who prefer Veroboard or matrix board construction can easily work out their own layouts.

The copper side of the printed circuit board used in the prototype is shown full size in Fig. 2, and the layout of components on it is shown Fig. 4.

Both ICs are mounted in one 16 pin DIP socket with their notches nearer the positive rail. Note that pin 5 of IC2 is not used and so the bottom right hand corner pin of the IC socket may simply be run through a hole in the board or cut off.

Polarity of electrolytic capacitors C1 C3 and C4 must be observed, as must the polarity of the Sonalert.

The large 60 mm diameter push button marked START is a gift from your friendly jam manufacturer – it's the screw cap off one of his jars. The 'spring' of the push button (developed after much experimenting) is a disc of plastic foam about 3 mm thicker than the depth of the cap, and about

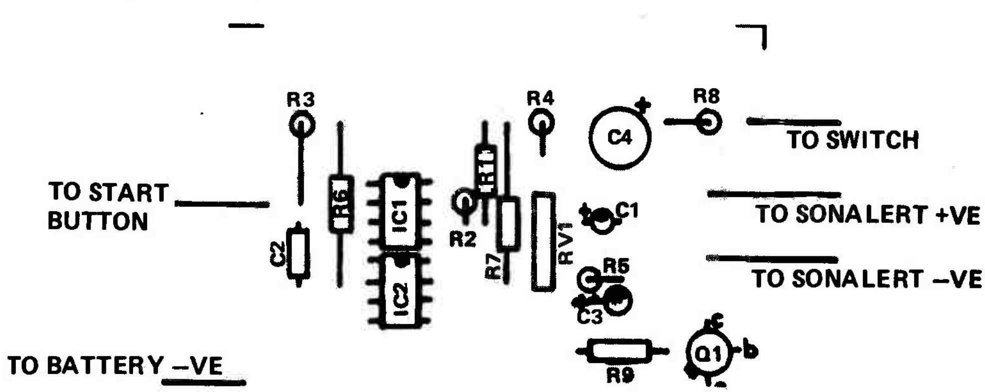
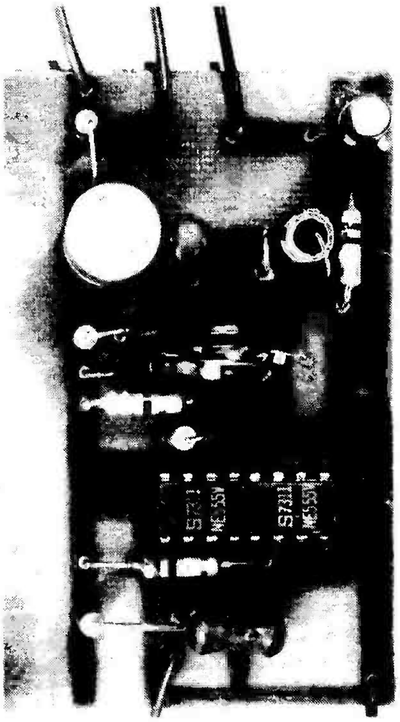


Fig. 4. Component overlay.

THE PRINTIMER


The completed print timer.

20 mm less in diameter.

First solder a flexible lead to the inside of the screw cap — out near the rim. Then paint the cap white if it carries some brand name.

Next carefully remove the paint from the lower edge of the rim of the cap by rubbing it on a piece of emery cloth. The edge of the cap must be clean all round because this is the surface which makes contact with the aluminium panel, and it must 'make' wherever the button is touched. Glue the plastic foam 'spring' centrally, to the inside of the cap. When it is set the push button is ready for mounting on the panel. Its position should be determined and then a hole drilled obliquely through the panel at some point below the cap, but clear of the foam-plastic spring. Thread the lead (soldered to the cap) through the hole, and position the cap so that the lead does not cause any restraint to pressing the cap.

When all is in position the bottom side of the plastic foam may be glued to the front panel. You now have a first class push button, far bigger than any you could buy.

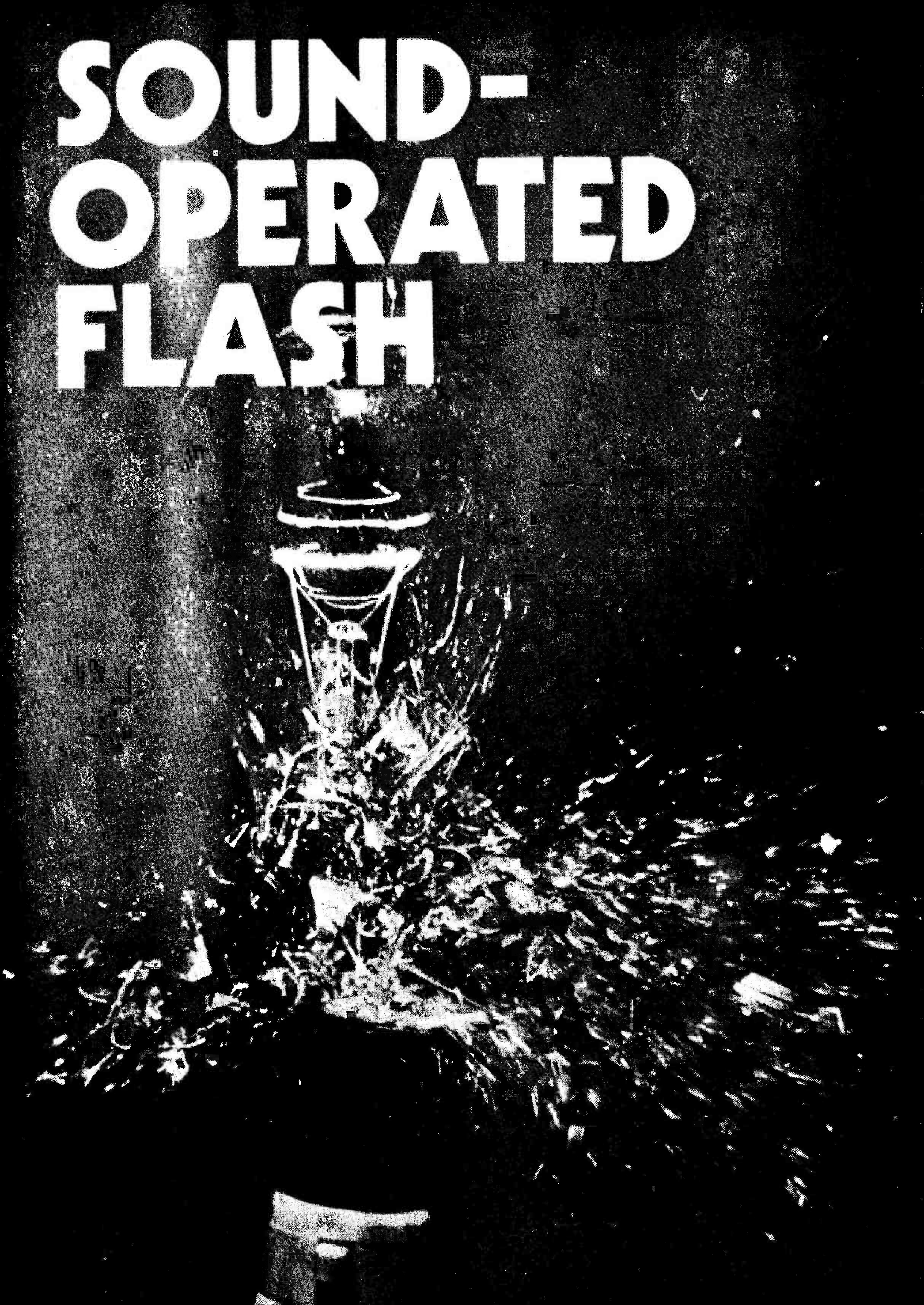
Note that the battery negative lead is connected to the panel by means of a suitable tag on the printed-circuit board mounting bolt. From there the negative lead goes to the printed-circuit board itself.

The battery should be anchored inside the box by a suitably shaped aluminium bracket.

ADJUSTMENT

With the component values shown the timer range is from about ½ to 3½ minutes. Component tolerances could affect these figures, but timing is not sensitive to battery voltage variations. The actual time delay before the Sonalert sounds is set by the preset pot RV1. This should be adjusted to the time of development you intend to use.

Those who want to have an adjustable timer, for other purposes, could bring out leads from the printed-circuit board and substitute a panel mounted potentiometer for the preset pot RV1. ●


SOUND-
OPERATED
FLASH

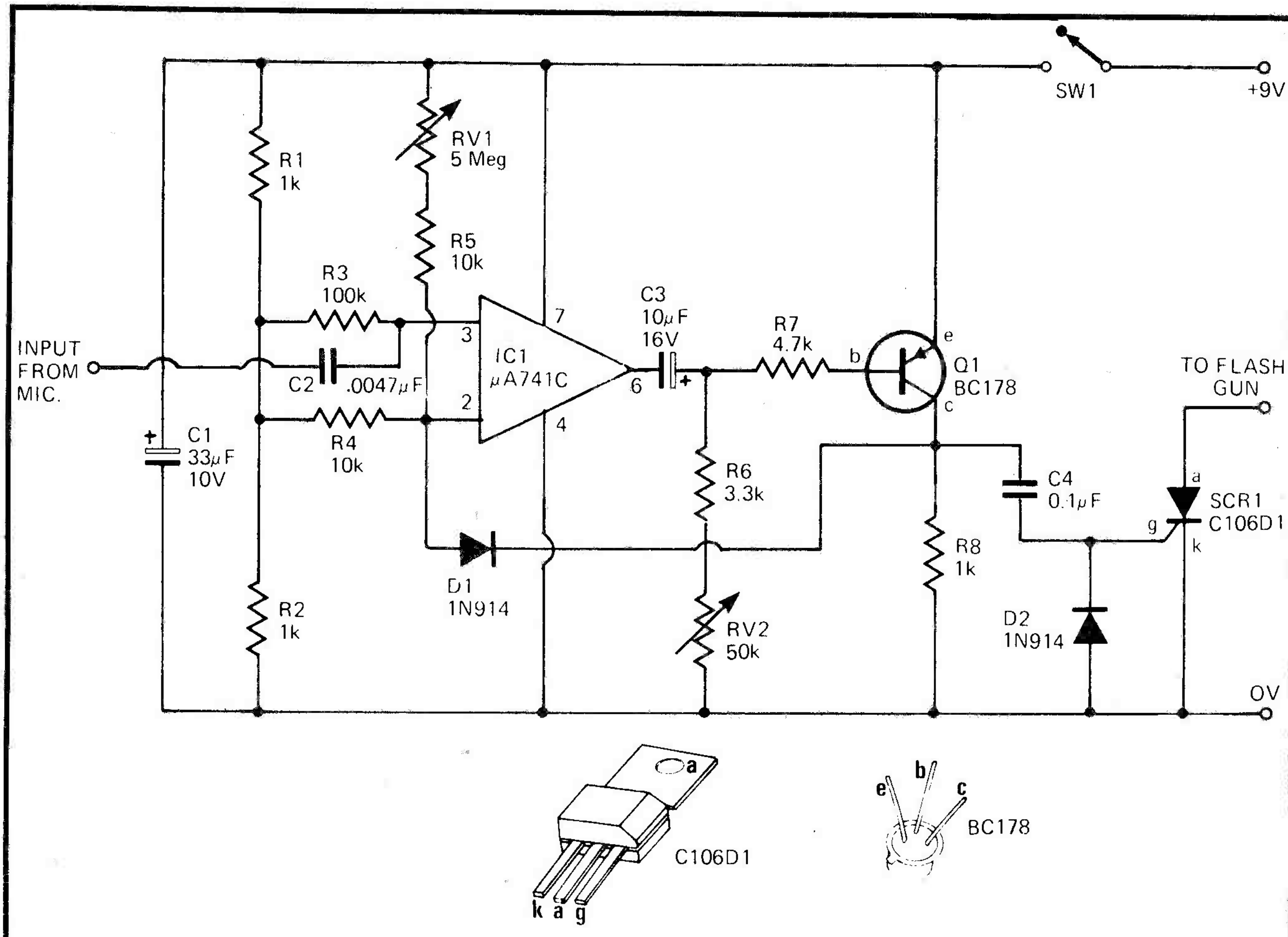


Fig. 1. Circuit diagram of complete unit.

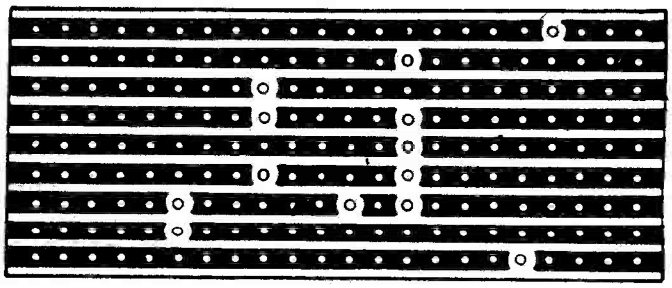


Fig. 2. This is the foil pattern of the Veroboard. The breaks shown in the copper tracks should be made using a sharp-pointed drill.

THE dramatic picture opposite and the sequence reproduced overleaf were taken using the sound operated flash described in this article.

The unit triggers any standard electronic flash gun a predetermined (and adjustable) time after any specific sound. The sound level at which the unit will trigger is adjustable by potentiometer RV1.

The unit is intended to photograph practically any fast (sound causing) transient phenomena — a surprisingly large number of uses can be found in specialized photography, science, and industry. The ability to delay the flash from five milliseconds to 200 milliseconds after the onset of the event increases the unit's versatility very considerably.

CONSTRUCTION

The unit is very simple to make — and for this reason we decided to build it onto Veroboard rather than go to the expense of a special printed circuit board.

Figure 2 shows the foil pattern of the Veroboard, Fig. 3 shows the component layout.

Cut the Veroboard to size and use a sharp pointed drill to break the copper tracks as shown. Locate and solder the components onto the board, paying particular attention to the polarity of capacitors and diodes, and to the pin connections of the integrated circuit.

The unit is physically quite small and may be housed within any suitable box or plastic container.

Assembly should be completed to the level shown in Fig. 4 and the unit fully tested before final assembly into the box.

OPERATION

The unit is designed for use with electronic flash guns using the capacitive discharge firing system.

To use, simply connect a high output

SOUND-OPERATED FLASH

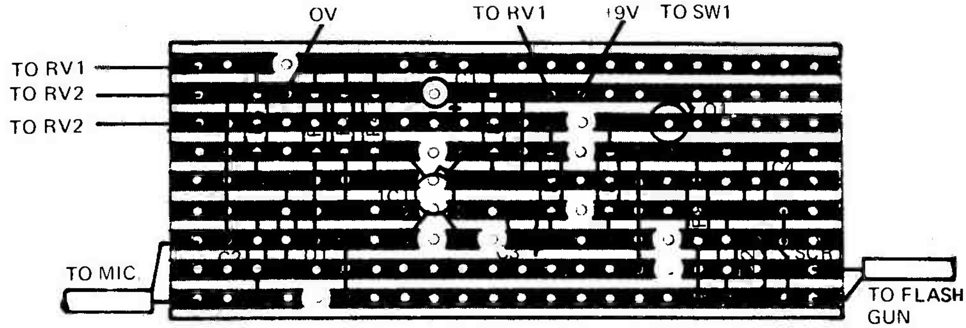


Fig. 3. How the components are located on the Veroboard.

PARTS LIST ETI514

R1 – resistor 1k ohm ½ Watt 10%
R2 – " 1k " " "
R3 – " 100k " " "
R4 – " 10k " " "
R5 – " 10k " " "
R6 – " 3.3k " " "
R7 – " 4.7k " " "
R8 – " 1k " " "
RV1 potentiometer 5M log
RV2 " 50k "
C1 Capacitor 33 uF 10V electrolytic
C2 " 0.0047 uF 100V
C3 " 10 uF 16V
C4 " 0.1 uF 100V
Q1 Transistor BC178 or similar
D1, D2 diode 1N914 or similar
1C1 Integrated circuit uA 741C
(metal can type only)
SCR1 C106D1
SW1 Switch single pole single throw
9V battery
Plug for flash and or an extension cord
Microphone jack
Microphone – High output crystal
Veroboard (0.15").

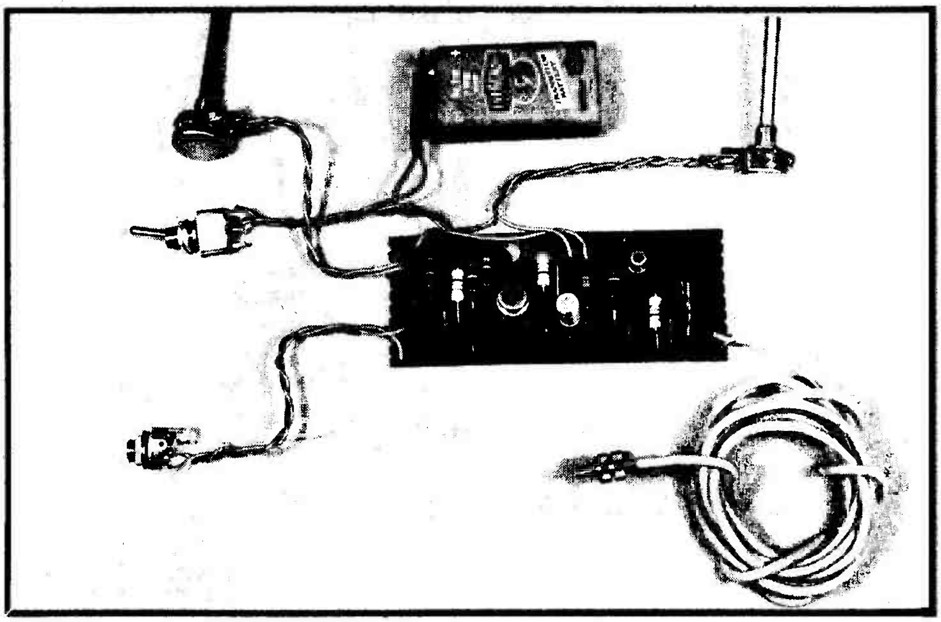
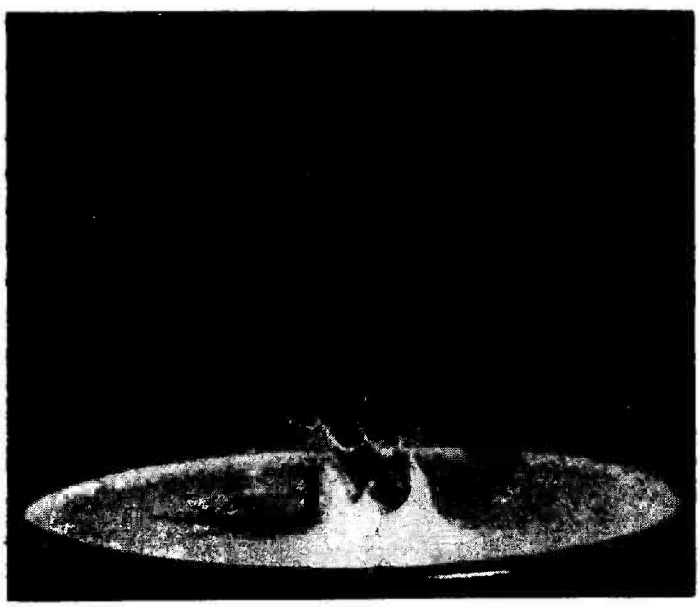
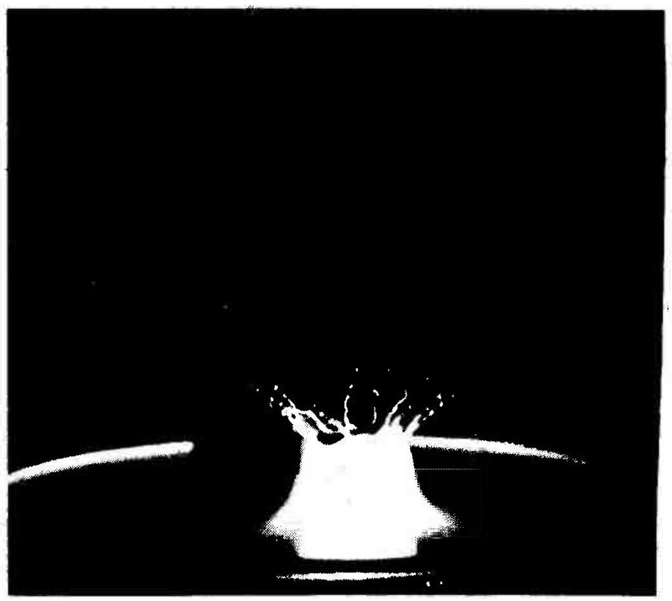


Fig. 4.

These pictures show how the variable time delay facility can be used to capture the effect of a ball bouncing in a container of fluid. The pictures were taken with the sound operated flash unit set at time delays between 50 milliseconds and 200 milliseconds.





crystal microphone (these are cheap and readily obtainable) into the mic. input socket on the unit, and plug the unit's flash lead into the flash gun.

Switch on SW1 and adjust RV1 so that the flash is not triggered by ambient noise, but will be triggered by the event to be recorded — i.e., a gun firing, hands clapping, glass breaking, etc.

In most circumstances the stop-action photography must be done in a dark room with the camera shutter open, or if only black and white film is used — using a red photographic safe-light. Assume for example, that we wish to photograph a bottle at the instant of being broken by a stone from a catapult. The equipment, catapult and bottle are set up initially in the light and tested to confirm correct function and sequence.

A test run is then performed, using an arbitrary setting of the delay, in the now darkened room. This is done by opening the shutter, firing the catapult and then closing the shutter before turning on the lights. (Although shooting a bottle in the dark may seem very difficult — with a little practise it is surprisingly easy — our front cover picture was taken just this way. It is of course potentially dangerous and it is essential to wear eye protection.)

Subsequent development of the film will show whether the chosen delay was correct. If too short, the bottle will be photographed before actually breaking up — if too late the action will have progressed further than required. Further pictures should then be taken varying the time delay to 'bracket' the actual delay that is now estimated as correct. With a little experience the user will be able to estimate the required delay within close limits.

As the flash duration is typically of the order of one or two thousandths of a second, quite high-speed activity can be frozen — as our own pictures show. ●

HOW IT WORKS

Basically the microphone triggers the IC monostable circuit which subsequently triggers an SCR, and hence the flash, after a time delay. This delay is adjustable – by varying a monostable on-time – from 5 milliseconds to 200 milliseconds.

Integrated circuit IC is an μA741C. This is a dc differential amplifier with a high gain – typically 25,000. The output swing of the IC with a 9 volt dc supply is of the order of 6 volts, and this is obtained with an input swing of only 240 microvolts. This makes the IC ideally suited for use as a comparator and is the mode of operation utilised in our circuit.

Due to the very high gain and the relatively large input signals normally encountered, the IC is almost always either fully cut off or fully saturated. The linear region is very narrow and is not utilized in this circuit.

The two inputs of the IC (pins 2 and 3) would be at the same potential were it not for the bias current supplied through RV1. This raises the voltage at pin 2 of the IC by 10mV or more above pin 3 depending on the setting of RV1. The IC will therefore normally be fully saturated and the output voltage will be low.

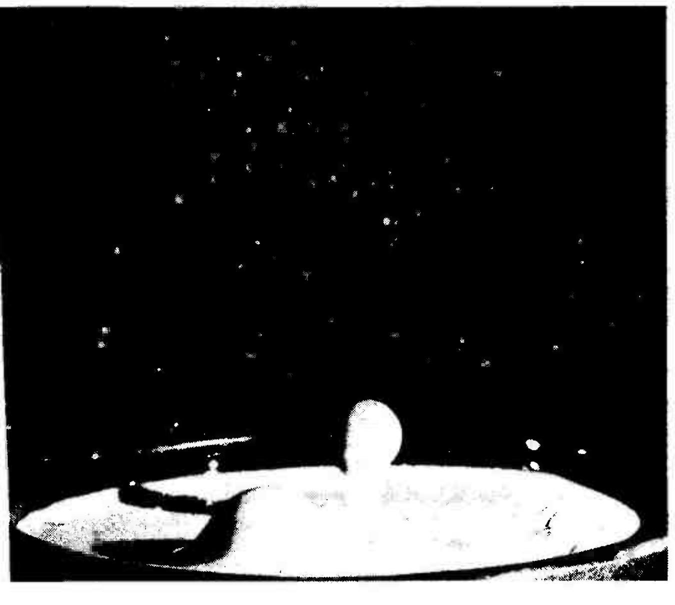
Transistor Q1 is normally held on by the current through RV2, and its collector is high, reverse biasing diode D1.

When an audio signal from the microphone produces at pin 3 a level exceeding that set on pin 2 by RV1, the IC will rapidly change state and its output will go high.

The front edge of this transition turns off Q1 via C3. The collector of Q1 will fall, D1 becomes forward biased and pulls down pin 2 to about one volt – the IC output is maintained in its high state

After a time – determined by the time constant of C3 and RV2 – Q1 turns on again allowing the IC to revert to its normal low output.

The output signal from Q1 is differentiated by C4 and the negative pulses (which occur first) are clipped off by diode D2. The positive pulse which occurs at the end of the delay period, triggers the SCR and fires the flash.



TAPE/SLIDE SYNCHRONIZER

This unit automatically changes slides on an automatic projector. It does this at predetermined times, synchronizing with the commentary prerecorded on a two-channel, cassette or reel-to-reel tape recorder.

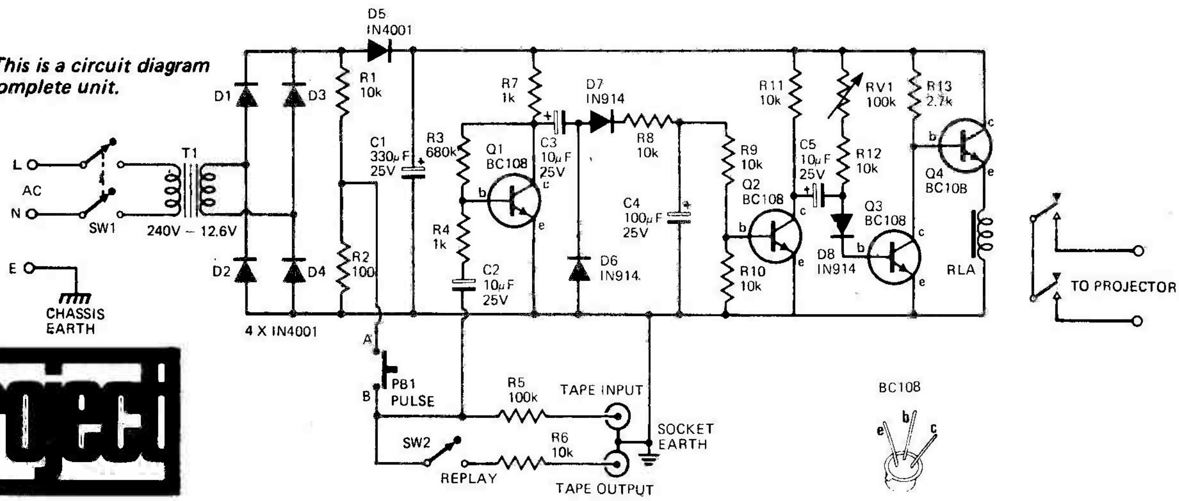
Practically all tape recorders sold today have two-channels, and when used to record commentaries for slide shows, only one of the two available channels is normally used. The automatic slide changer described in this article utilises the second, normally unused channel.

The projector's slide mechanism is actuated by short tone bursts recorded onto this second channel at the points where slide changes are required. The tone that is used for this purpose is derived from the full-wave rectified (but unsmoothed) mains frequency.

To record the tape initially, the slides are loaded into the magazine of the projector in the order in which they will be shown. The commentary is then recorded onto Channel 1 in the normal way, and the pulse button on the front of the control unit depressed whenever a slide change is required. This changes the slide and simultaneously records a control tone onto Channel 2.

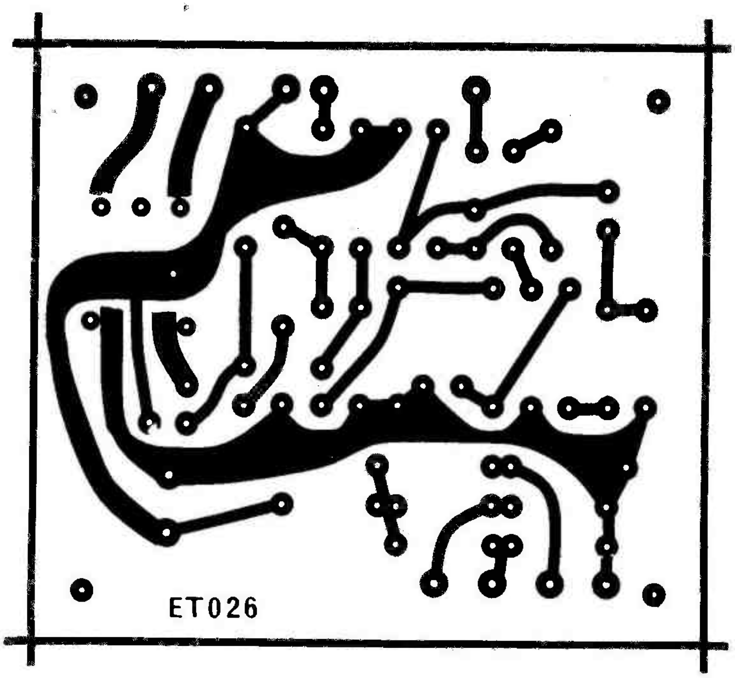
Once the tape has been prepared, the control unit can be used automatically to switch the slide projector at the

Fig. 1. This is a circuit diagram of the complete unit.



eti project

Fig. 2. Foil pattern of printed circuit board — full size.



predetermined times in synchronization with the tape recording.

CONSTRUCTION

The circuit diagram of the complete unit is shown in Fig. 1.

The unit may be assembled on matrix board, tag strips, or, preferably, on the printed circuit board, the foil pattern of which is shown in Fig. 2.

Figure 3 shows how the components are assembled on the printed circuit board. Note that resistors R5 and R6 are mounted on the front panel of the unit — as shown in Fig. 4.

Having completed assembly, check the orientation of diodes, transistors and electrolytic capacitors.

Figure 5 shows how the completed printed circuit board and remaining components are located within the case. Ensure that all wiring carrying mains voltage is adequately insulated and the metal case is well earthed.

CHECKING THE UNIT

Figure 6 shows how the various units should be interconnected — both for checking and for subsequent recording of the tape. The relay output lead of the control unit is connected to the slide projector's external control socket; the second (normally unused) input socket of the tape recorder is connected to the input socket of the control unit, and a microphone is then

HOW IT WORKS

The sync. pulse is derived from the mains. It is simply the 100 Hz rectified but unsmoothed output from the secondary of tranformer T1.

This 100 Hz signal is suitably attenuated by R1 and R2 to achieve a level suitable for recording onto the tape.

Diode D5 isolates the filter capacitor from the pulse generating network.

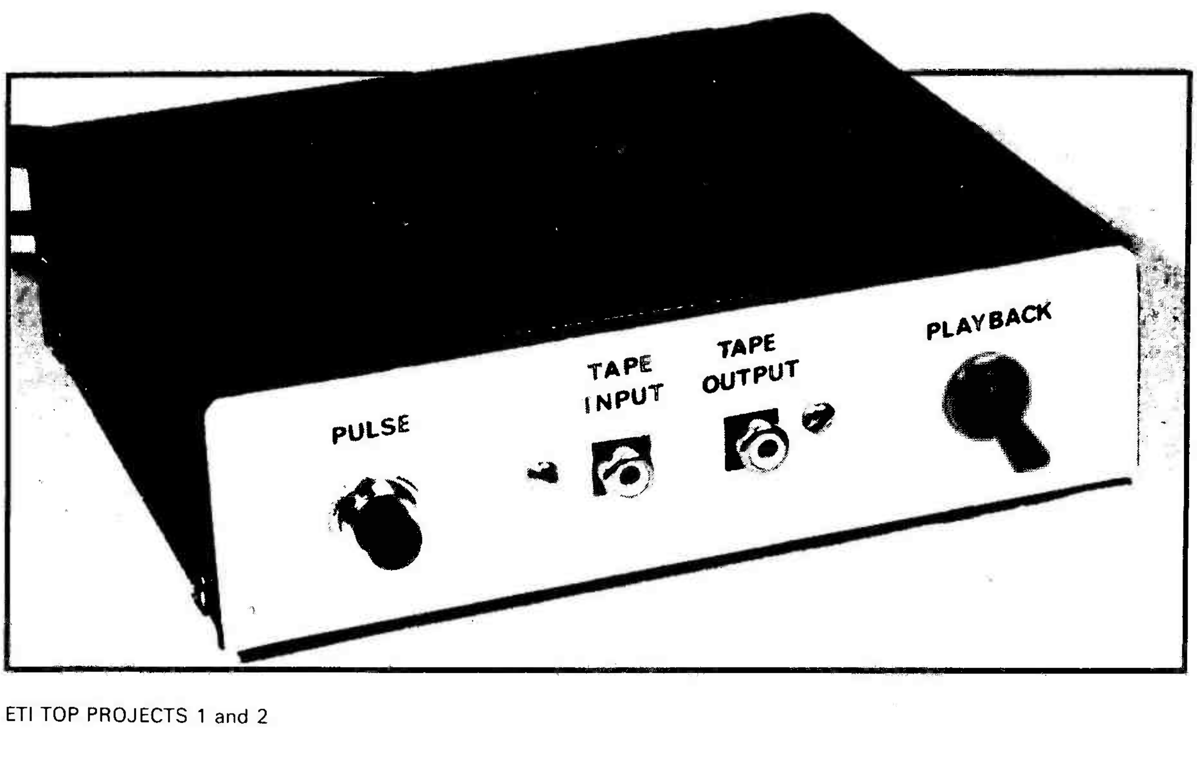
When push button switch PB1 is pressed, the signal from R1, R2 is fed to the tape recorder and also, via C2 and R4, to the remainder of the control unit.

The 100Hz signal is amplified by Q1 and then rectified and smoothed by D6, D7, C3 and C4. Capacitor C4 takes a few cycles to charge, and when it does Q2 turns on.

The action of Q2 turning on, causes C5 momentarily to remove the bias from Q3. The length of time for which the bias is removed is determined by the setting of RV1.

Transistor Q4 is an emitter follower and applies power to the output relay during the time that Q3 is turned off, and so RV1 in effect controls the length of time that the relay contacts remain closed. The contacts of this relay then actuate the slide change mechanism of the projector.

During the replay period, the control pulses from the tape recorder are fed into the control unit via R5, C2 and R4 and then actuate the unit in the same manner as described above.



TAPE/SLIDE SYNCHRONIZER

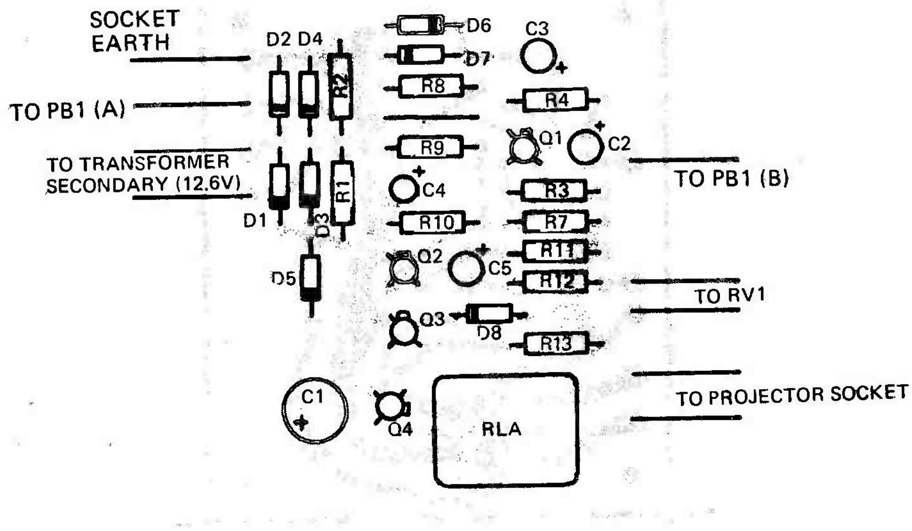


Fig. 3. How the components are assembled on the printed circuit board.

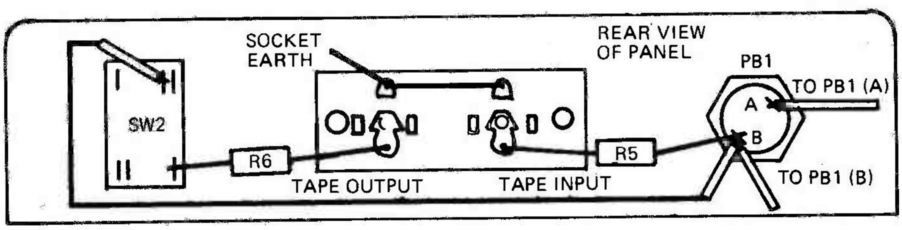


Fig. 4. This drawing shows components and wiring on the front panel of the unit.

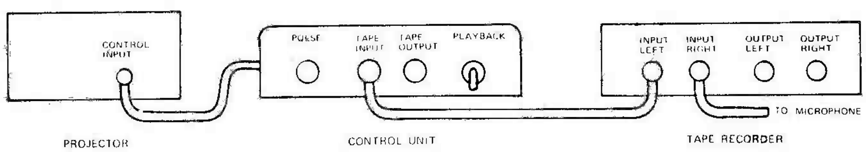


Fig. 6. Interconnections — checking and recording.

connected to the tape recorder (Input Channel 1) in the normal way. The output of the tape recorder is left disconnected at this stage.

Load the slides into the magazine of the projector in the order in which they will be shown.

Switch on all three units. Slides can now be changed by pressing the 'pulse' button on the front of the control unit. It will be necessary to press this button for about one second. The time period is not critical providing it is long enough for the slide to change.

Internal circuitry — controlled by RV1 — ensures that only one slide is changed at a time, this feature is lacking on many proprietary units. If more than one slide is changed — or a slide does not change at all — adjust potentiometer RV1 until satisfactory operation is obtained.

OPERATION

Once the unit has been checked out for satisfactory operation it is ready to use.

A minimum period of about five seconds must be allowed between slide changes to enable the control unit to reset.

Move the first slide in the required sequence into position, start the tape recorder, and record the required commentary, changing the slide whenever required by actuating the button on the control unit. Stop the tape recorder when the last slide has been shown.

Figure 7 shows how the units are interconnected for replay. As can be seen the relay output lead of the control unit is still connected to the external control socket of the slide projector, but the output from Channel 2 of the tape recorder (from preamplifier or speaker output sockets) is now connected to the tape output socket of the control unit. The input to the tape recorder Channel 2 is left disconnected.

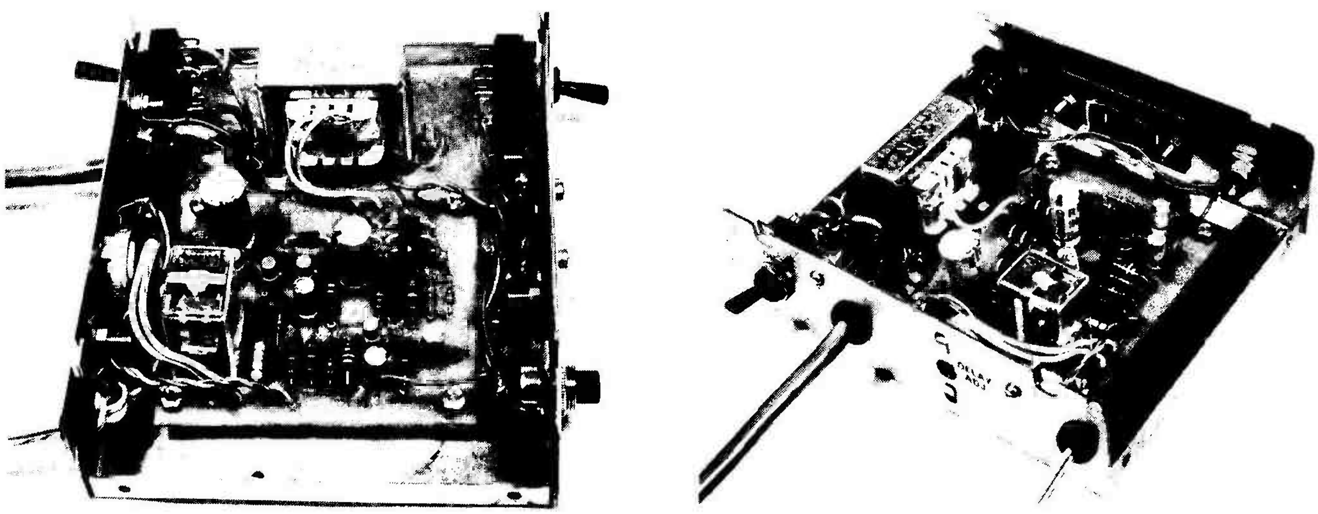


Fig. 5. The printed circuit board and remaining components assembled within the case.

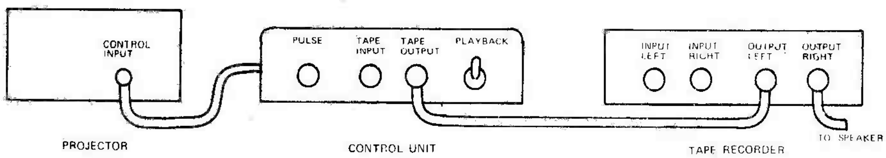


Fig. 7. Interconnections – replay.

PARTS LIST ET 513

R1	— resistor	10k	½ Watt		5%
R2	— resistor	100ohm	½ Watt		5%
R3	— resistor	680k	½ Watt		5%
R4	— resistor	1k	½ Watt		5%
R5	— resistor	100k	½ Watt		5%
R6	— resistor	10k	½ Watt		5%
R7	— resistor	1k	½ Watt		5%
R8-R12	— resistor	10k	½ Watt		5%
R13	— resistor	2.7k	½ Watt		5%
C1	— capacitor	330µF	25V	electrolytic	
C2	— capacitor	10µF	25V	electrolytic	
C3	— capacitor	10µF	25V	electrolytic	
C4	— capacitor	100µF	25V	electrolytic	
C5	— capacitor	10µF	25V	electrolytic	
Q1-Q4	— transistors	BC108			
D1-D5	— silicon diodes	IN4001	or equivalent		
D6-D8	— silicon diodes	IN914	or equivalent		
RLA	— miniature relay 430 ohm coil (or equivalent)				
T1	— mains transformer — 12.6V, 150 mA				
PC board	— ET 026				
SW1	— double pole on/off switch				
SW2	— single pole on/off switch				
PB1	— push button switch — press to make RCA sockets, metal case, three-core flex, cable clamp, plug to suit projector, hook-up wire etc.				

Flick the replay switch SW2 to the off position and move the first slide into position. Now start the tape recorder and switch the replay switch into the on position as soon as the commentary starts. The slides will now be changed automatically at the prerecorded times.

The 'pulse' button on the control unit may still be used to override the control unit at any time.

The replay switch must be in the off position when stopping, starting or rewinding the tape as any signal from the tape recorder will initiate a slide change. ●

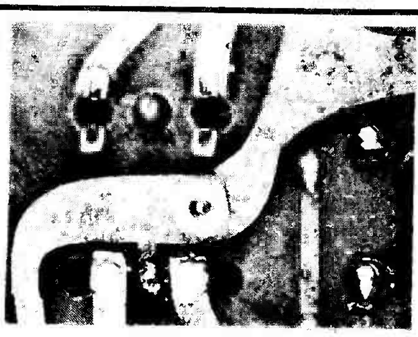
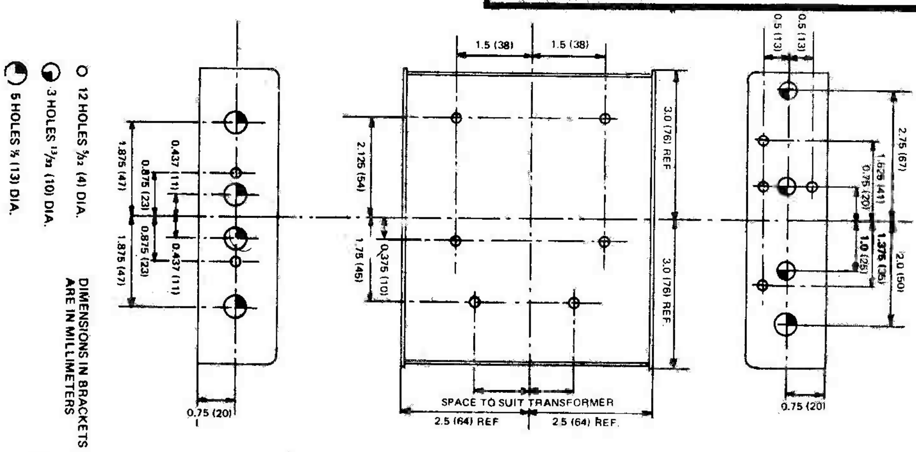
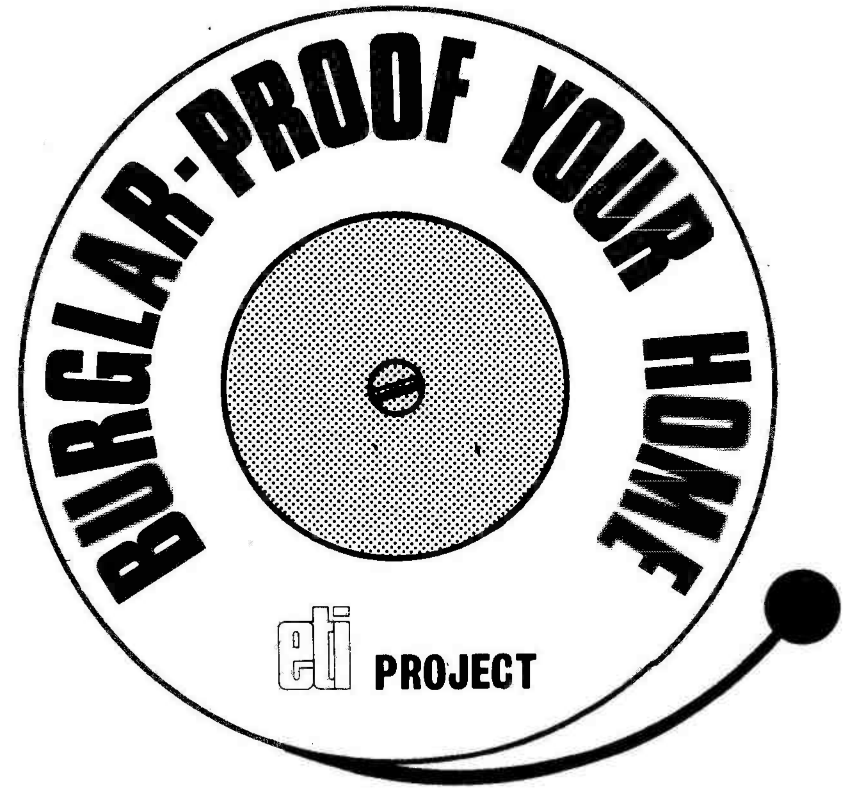


Fig. 8. The relay is soldered directly onto the printed circuit board. The two centre pins of the change-over contacts are commoned – as shown here.



Metalwork details.



THE UNLAWFUL ENTRY of domestic premises is usually considered to be largely fortuitous, advantage being taken of the complete lack of any kind of security device. In these circumstances entry is possible while the family is asleep, or even occupied in another room. These circumstances are very different from those where a definite plan is made to enter a building known to have valuables, and thus relatively simple intruder alarm systems can assist the householder.

If some typical alarm circuits are considered in detail, it will be seen how an installation can be built up.

PRESSURE OPERATED BELL

The circuit in Fig. 1 is of the simplest type. The transformer T1 provides a low voltage for the bell, which rings when switch contacts SW1 close. The contact may be placed under a mat or elsewhere, or may be a pressure mat of the type described later. This circuit is appropriate for a shop where a person entering operates SW1, but could be used with a mat in a corridor or passage, or possibly on the stairs.

As current is only drawn briefly, operation could be from a dry battery.

TRANSFORMER

All the circuits operate at low voltage and, where current is drawn continuously, and to avoid battery replacements, operation is from a transformer. The primary should be for the 200/250V mains. The secondary delivers a much reduced voltage; with a typical bell transformer, a tapped secondary allows 3V, 5V or 8V to be selected.

The transformer should be of the approved "double insulated" type; or the core and one secondary tapping may be earthed. These precautions are to prevent any possibility of the full mains voltage arising in the low voltage secondary circuit if a fault should develop.

Transformers of other than miniature types will have integral holders with fuses, which avoid overheating if a fault should arise in the secondary wiring.

LOCK-ON CIRCUIT

Alarm circuits are generally required to lock on, so that the bell continues to sound even after the connection to SW1 has been broken. This can be arranged by including a relay as in Fig. 2.

When SW1 is closed, current flows through the operating winding of the relay RL1. This causes relay contacts X-X to close. The circuit is now completed through these contacts, so that if SW1 is opened, the relay continues to be energised. Contacts Y-Y close at the same time, completing the circuit to the bell.

With this circuit, even a momentary closing of SW1 will switch the circuit on and it will remain so until the manual switch SW2 situated near the relay, is opened. This circuit, with contacts Y-Y replacing SW1 in Fig. 1, can thus make quite an effective alarm.

RELAY SUPPLY

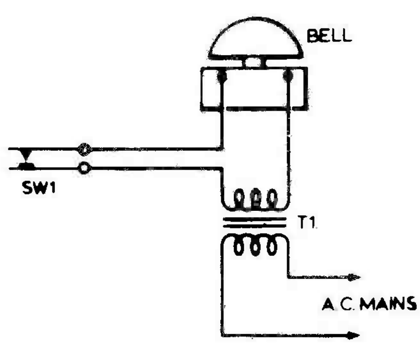
Relays to operate from a.c. derived from a transformer, can be obtained. However, if inexpensive surplus and similar relays which operate satisfactorily from d.c. are to be used, a rectified and smoothed supply is necessary. This may employ a bell type transformer, 2A or similar silicon rectifier D1 and capacitor C1, as in Fig. 3. If C1 is 1000μF 25V this will be adequate for most purposes.

CLOSED CIRCUIT SYSTEM

This is often employed. Warning is provided when a circuit is interrupted. This interruption can be by means of door or window switches, and also arises if the lead to the switches is cut.

Figure 4 shows the method of working. SW1 is a test switch near the relay. SW2, SW3 and SW4 are door or window switches. Any number of switches can be used, the circuit passing through each in turn. SW5 is used only to set the circuit and is then normally open.

When SW5 is closed, current flows through the relay coil RL1, and contacts X-X are closed, while contacts Y-Y are opened. When SW5 is opened, the circuit is retained through X-X. If any switch SW1 to SW4 is opened, even momentarily, the relay releases, opening X-X. Closure of the affected switch will thus not re-energise the relay, X-X remaining open. In this position, Y-Y are closed, ringing the alarm.



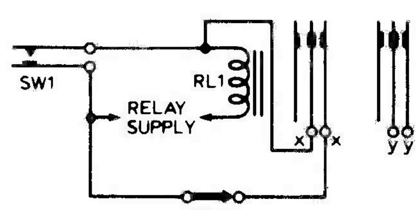


Fig. 1. (left) Ultra-simple pressure operated alarm.
Fig. 2. (above) How to wire the relay for a lock-on facility.

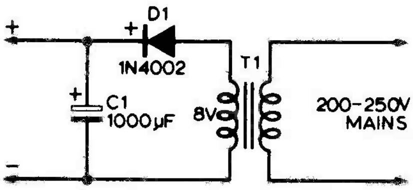
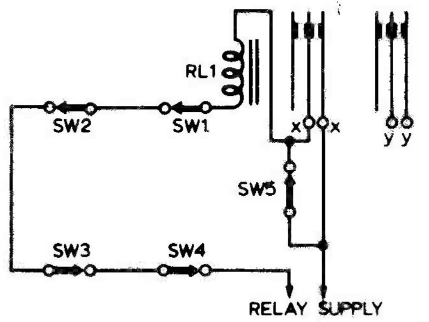


Fig. 3. (above) DC power supply.

Fig. 4. (right) Closed circuit system.



Small push-switches inset in the door frame at the hinged side may be used, and will be held open only so long as the door is closed. Similar switches may be obtained or improvised for windows.

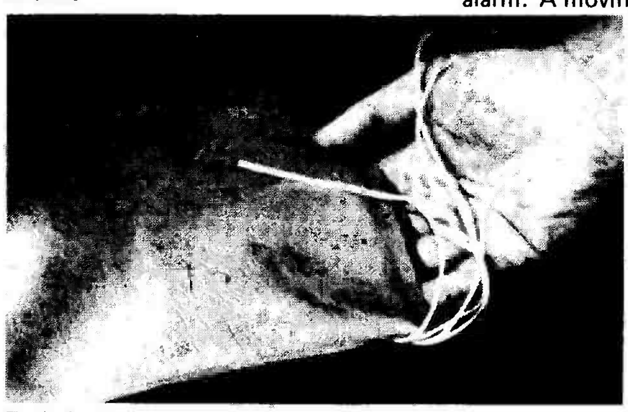
PRESSURE MATS

These can be obtained in various sizes, and are very thin, to place under a doormat or elsewhere. Their construction results in the circuit being completed when pressure is applied almost anywhere over the mat area.

In addition, the mats may have a closed circuit lead, so that if a wire is cut, a warning is operated by the means shown in Fig. 4.

Figure 5 shows a combined pressure mat and closed circuit system. RL1 operates as in Fig. 4, the mat closed circuit lead being included. Opening this, or any switch SW1 to SW4, results in relay contacts Y-Y of RL1 closing, ringing the bell.

RL2 operates on the mat contacts SW5, with contacts X-X holding the circuit on so that ringing can only be stopped by opening SW6. Other mats may of course be included in the circuit.



Typical pressure mat.

ASSEMBLY

Any of these circuits can be assembled in a single case, which houses the relay, transformer and other components. Any wanted re-setting switch or test switch is included on the front of the case.

Such circuits have the advantage of being straightforward and reliable and they can readily be extended by placing any number of door or other switches in circuit.

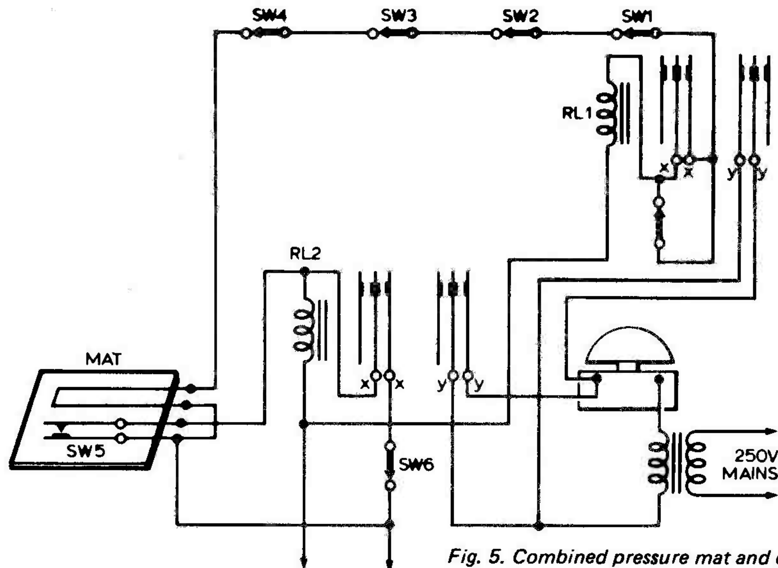


Fig. 5. Combined pressure mat and closed circuit system.

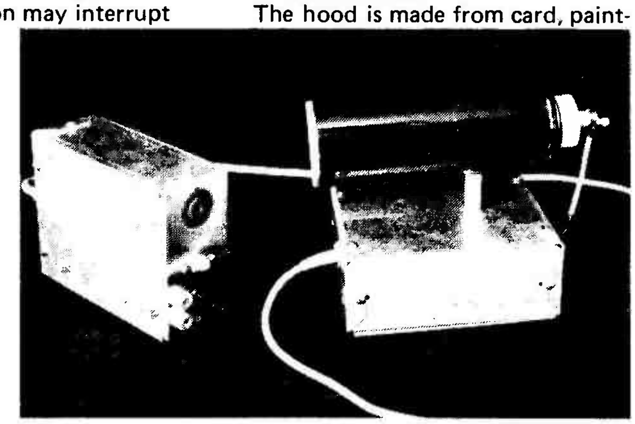
PHOTO-ELECTRIC ALARM

With photo-electric devices, the interruption of a light beam triggers the alarm. A moving person may interrupt the beam, but the projector and receiver units may alternatively be situated so that opening a door does this. In some cases the beam can be deflected by a mirror, so that the same equipment guards two or more doorways, or a door and window.

The construction of a light beam projector for the receiver described is shown in Fig. 6. Here, the base is a 4 x 5 x 2in universal chassis box, with an extra 4 x 5in plate for the top. The transformer may be one with a 6.3V 500mA secondary, for a 6.3V 0.5A bulb, or 12V (or 12.6V) secondary for a 12V 6W bulb.

A canister with the bottom cut away can be used for the lamp housing. Fit a holder for the bulb as in Fig. 6. The lens need only be a simple condenser type, double convex or plano-convex (magnifying) with a focal length of 2 or 3in. A sleeve is made from strong card, and rings glued in hold the lens. If needed for a lens which is slightly undersize, the sleeve can be several layers of card. When the apparatus is first set up, slide the lens assembly in or out, as required to give a sharp spot from the bulb, projected on some surface at the necessary distance.

The hood is made from card, painted matt black and is intended to reduce the stray light. The front disc of the hood has a small hole, centrally placed. Lamps, lens, and this aperture should be lined up to avoid unnecessary loss of illumination at the distant point. Brackets hinged together allow the lamphouse to be tilted as necessary.



Light beam transmitter and receiver.

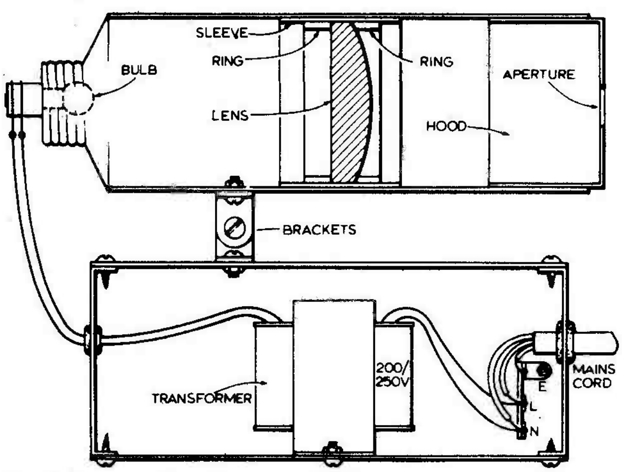
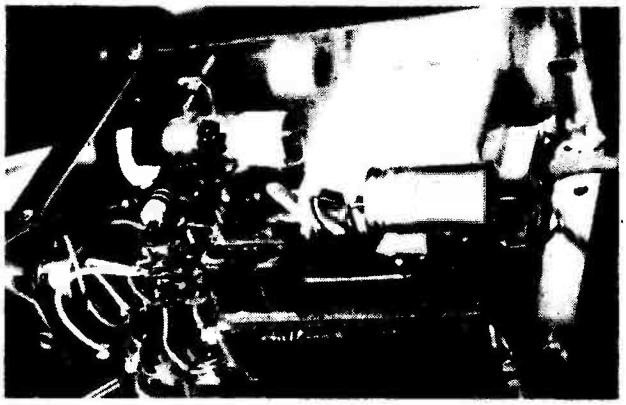


Fig. 6. Construction of beam projector.



Inside view of the light beam receiver.

BEAM PROJECTOR COMPONENTS

200/250V 12V or 12.6V 0.5A transformer.
12V 6W MES bulb and holder.
Lens approx 1¼in. to 1¾in. in dia., 2in. to 3in. focus.
Materials for lamphouse etc.
5 x 4 x 2in. universal chassis box with extra 4 x 5in. flat plate (Home Radio, Mitcham).
Tag strip, grommets, mains cord etc.

BEAM RECEIVER COMPONENTS

R1 470k ¼W
R2 1k ¼W
R3 100 ohm ½W
RV1 small 100k linear pot.
Knob.
LDR: ORP60
Q1 BC108
Q2 BFY51
100 ohm 2-pole 2-way or similar relay.
SW1 Slide switch.
D1 Rectifier rated 8V r.m.s. 0.5A or larger.
T1 200/250V 3/5/8V bell transformer.
C1 1000μF 25V or similar.
Case: 5 x 4 x 2in. universal chassis box and extra 4 x 5in. flat plate (Home Radio, Mitcham).
Tag strips, sockets, etc.

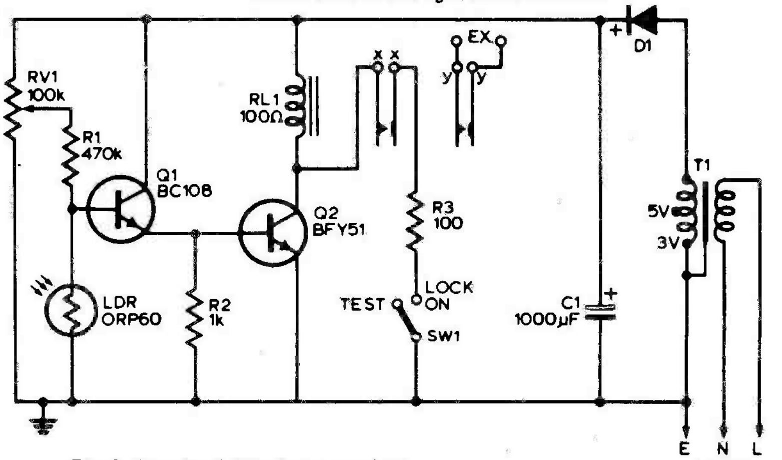


Fig. 7. Circuit of light beam receiver.

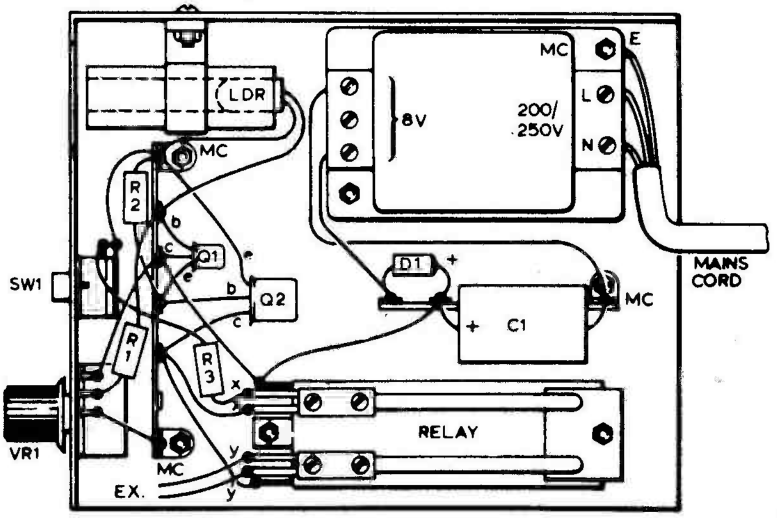


Fig. 8. Wiring of the light beam receiver.

RECEIVER

The circuit in Fig. 7 was found to operate readily at up to 20ft from the projector. Light normally falls upon the light dependent resistor LDR. When this illumination is interrupted, the LDR resistance increases. Q1 base moves positive, conducting, so that Q1 emitter and Q2 base also move positive, and Q2 collector current rises, energising the relay. Contacts X-X close, locking on the circuit, release only being possible by opening SW1. Contacts Y-Y close so that leads to the extension circuit EX ring the warning bell. T1 provides current, and RV1 is a means of adjusting the sensitivity.

Figure 8 shows the assembly of this unit, again in a 5 x 4 x 2in universal chassis box, with extra 5 x 4 plate. Wiring is most easily carried out before fitting the remaining sides as shown.

The LDR is an end type, and is fitted in a card tube to screen it from stray illumination. This is arranged by rolling glued card round the LDR. The tube is blacked inside, and is fixed by a bracket so that its angle can be changed. The tube is behind an aperture in the case. The leads are extended with thin flex.

Other items can be assembled as in Fig. 8, noting that the case of Q2 must not touch the metal box. The working voltage across C1 will be about 10V to 11V.

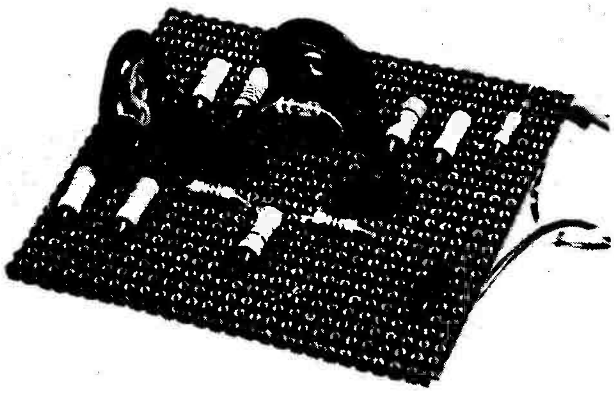
With the LDR fitted in a small blackened tube as described, it is very directive, and reasonable illumination for other directions will not have much effect. Initially, direct the LDR towards some moderate source of light, and adjust VR1 so that the relay operates when a hand is placed across the aperture.

The two units should preferably be screwed to the wall, or set up so that they will not be disturbed. Focus and locate the projector beam on the LDR tube opening, and adjust this tube in line with the beam. SW1 is placed in the open position while testing the working of the units, but is then closed to give the lock on described.

The beam is less likely to be seen when the projector is in an inconspicuous position and all its light passes into the receiver case. The LDR will operate with infra-red or dark red light, but this considerably reduces the sensitivity. For such illumination, a red or infra-red photographic filter can be included in the projector lamphouse. ●

TEMPERATURE METER

Solid-state meter displays temperatures — even from distant points



The completed temperature meter. Note that the sensing diode is shown mounted on the board. This would normally be located remotely with a pair of leads running back to the board.

AN ELECTRONIC temperature meter is an extremely useful instrument, and, is far more versatile than the mercury, or alcohol-in-glass types. For example, the temperature sensing element does not have to be located with the meter and thus, a remote sensor could be used to monitor swimming pool temperature on a meter readout located within the house. Additionally, several sensors may be used, e.g. monitoring temperatures of pool water, outside air and air inside the house. This is simply achieved by running separate sensor leads back to the meter and using a switch to select the appropriate sensor.

Many devices are capable of being used as temperature sensors. Examples of these are the thermistor, the thermocouple and the semiconductor diode junction.

The voltage across a forward biased diode junction, whether it is part of a transistor (e.g. base emitter) or a discrete diode, has a negative temperature coefficient. This means that with an increase in temperature the voltage across the diode drops. This effect is normally detrimental to stable operation of other circuitry but may be used, as in this circuit, to measure temperature.

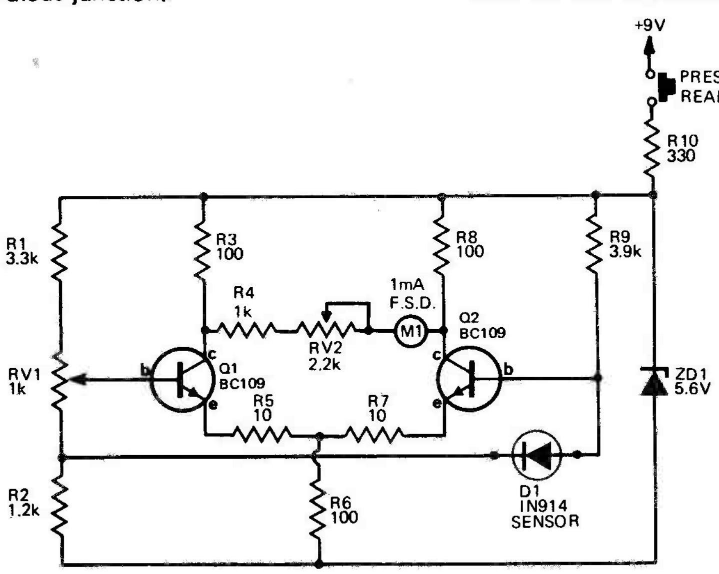
CALIBRATION

The meter is calibrated by adjusting the meter at two known temperatures. The temperatures of melting ice and boiling water should be used as reference points.

With the diode sensor and the thermometer immersed in melting ice, adjust RV1 to read 0°. Then insert the sensor into boiling water and adjust RV2 for 100°. A kettle is ideal for the boiling water adjustment or some vessel that restricts the steam to some extent. Do not use an electric jug **having an exposed heater element.**

A known ambient temperature can be used as the low reference if desired by first adjusting RV1 such that the meter reads 0° with the sensor at ambient temperature. Then with the sensor in hot or boiling water adjust RV2 such that the meter reads the *difference* between the two temperatures. With the sensor back at ambient (allow time to cool) readjust RV1 to read the actual ambient temperature.

Recheck the meter at both set points for which ever method of calibration is used. ●



SPECIFICATION

Temperature Range	0-100°C
Sensor	silicon diode
Scaling	reasonably linear over 0-100°C

HOW IT WORKS

The negative temperature coefficient of a diode is of the order of 2 mV/°C, and in our circuit, this voltage is measured by a differential amplifier Q1 and Q2.

The diode has an offset voltage of 0.55 mV which is compensated for by RV1. A differential amplifier is used so that variations in transistors due to temperature do not affect the calibration.

As there is no instrument warm-up time, it is suggested that a push-to-read button be used to switch on power in order to extend battery life. Battery drain is about 10 mA when the meter is operational hence, if *continuous* readout is required, a small power supply should be used.

PARTS LIST

R5,7	Resistor	10 ohms	5% 1/4W
R3,6,8	"	100 ohms	" "
R10	"	330 ohms	" "
R4	"	1k	" "
R2	"	1.2 k	" "
R1	"	3.3 k	" "
R9	"	3.9 k	" "
RV1	Potentiometer 1k trim Potentiometer		
RV2	"	2.2 k	
Q1,2	Transistor BC109 or similar		
D1	Diode 1N914		
ZD1	Zener diode BZY88C5V6		
M1	1mA meter scaled [illegible] 0-100		
PB1	push-to-read pushbutton		
Small piece of matrix board			
9V	battery		

USING THE LM380

Two projects using the LM380/SL60745 audio I.C.

TIME WAS when the main considerations in any circuit design were to assemble the electronic components in the right order. IC's have changed all that: now we have a vast variety of 'standard' circuits already encapsulated. Even now most linear IC's require a number of external components, to set the gain, decouple, provide bias currents etc. The LM380, which has been around for some time is an IC which requires virtually no external components. For most purposes it can be regarded as having four connections, +, −, in and out. Although encapsulated in a 14-pin package, there are only six different connections (see Fig. 1). The connections in addition to the four already mentioned are a second input pin giving a choice of inverting or non-inverting input relative to the output and an optional hum-decoupling pin.

The LM380 is available from a number of suppliers but carry a different coding as they have a slightly higher voltage rating than the regular LM380 (the coding is SL60745).

The supply voltage for the LM380 can lie between 9V and 22V. However the low limit is a bit misleading as one assumes that a common 9V battery will do. Certainly it will, but distortion will appear under 8V giving you little use from a 9V battery. For full output about 200mV at the input is necessary, though this varies with the supply voltage.

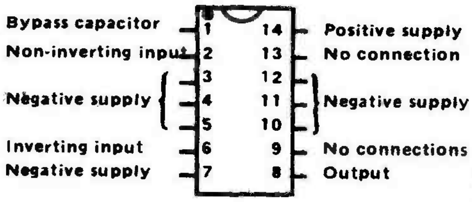


Fig. 1. Connections to the LM380.

The maximum output at 22V is about 4W. No heatsink is necessary, nor is a tab provided for this.

Two circuits are described in some detail but of course the LM 380 has almost unlimited uses.

INTERCOM

Intercom circuits have appeared in all the constructional magazines at one time or another but most of them that we have seen are thoroughly impractical.

Our circuit has a number of useful points. 1. Only two wires connect the Master Unit to the Slave. 2. Either station can signal the other with a tone burst to draw attention. 3. Batteries are only needed at the Master Unit. 4. The quiescent current on standby is insignificant.

The circuit is shown in Fig. 2 but has the disadvantage that it appears considerably more complex than in fact is it due to the wiring of SW1. Operation is fairly unusual and is explained in the separate box.

The Master Unit contains all the main components including the battery and amplifier. The Slave unit comprises a small loudspeaker, electrolytic capacitor and switch and these can be housed in a much smaller case.

Relatively few components are used and although we have used a PCB and show the pattern (Fig. 3), some readers may feel that a small

PARTS LIST

C1	Capacitor	100μF 25V electrolytic
C2	"	3000pF polystyrene, ceramic, etc.
C3	"	100μF 25V electrolytic
C4	"	100μF " "
IC1		LM380/SL60745 Audio I.C.
T1	Transformer	Transistor output transformer (Approx. 10 or 20:1 ratio).
LS1	Speaker	8Ω small type
LS2	Speaker	8Ω small type
SW1	Rotary Switch	4-pole, 3-way.
SW2,3	Switch	Push-to-make.

P.C. Board or Drilled S.R.B.P.
Plastic Boxes, one large one small.
Twin wire to connect units
2xPP3 or equivalent 9V batteries.
Battery terminals.

COMPONENT COMMENTS

The LM380 is available from many of the semiconductor mail-order companies. Transformers suitable for T1 are widely available, perhaps the best known is the Eagle LT700 but other types are listed in catalogues.

The electrolytic capacitors should have a minimum working voltage of 25V but this can be higher. The unit will work using even 10μF components for C1 and C4 but output will be marginally down. Values higher than 100μF will improve output but only marginally and the cost will be higher.

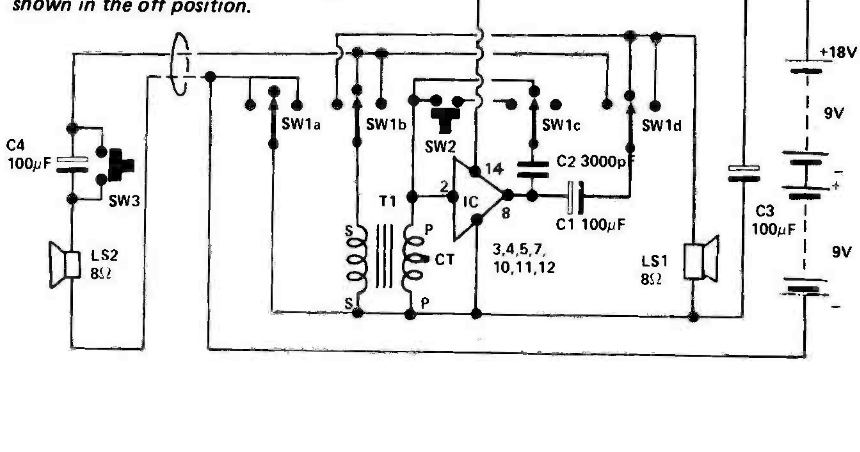
C2 can be any form of capacitor and the value can be between 2000pF and 0.01μF; in the main text we suggest that this may advantageously be experimented with.

Suitable cases are the M2 and M3 from Doram but others will do quite as well.

The speakers listed are 8 ohm types but we tried the circuit using the high impedance speakers (35 ohm—80 ohm) and operation was perfectly satisfactory.

We have in the past used very small push button switches made in Japan: we cannot recommend these as even when soldering quickly to the terminals, the plastic body melts.

Fig. 2. Complete circuit of the intercom. All sections of SW1 are ganged and are shown in the off position.



piece of drilled s.r.b.p. board is all that is necessary.

T1, the LM380 and three capacitors are mounted on the board which should be near the main switch SW1. The PCB or component board should be mounted at right angles to the front panel of the case. The construction, component layout and switch wiring are shown in Fig. 4. The two PP3 type batteries should be clamped firmly in the body of the case.

The Slave unit is much simpler and a component layout can be seen clearly in the photograph.

Some readers may query using two small batteries for an IC which can draw up to 200mA at the supply voltage of 18V used here. This is quite satisfactory for an intercom circuit. Firstly current is only drawn when the unit is actually being used. Secondly the input will not normally be high enough to give full output. When the IC is used to signal one of the units the current drain is very high but this will normally be only for a second or two at the most. Even if the unit is left switched on, unless there is a lot of noise near the input, current drain is a modest 15mA or so.

OPERATION

MASTER TO CALL SLAVE. Switch SW1 to Talk and press SIGNAL button, SW2. If there is doubt about anybody being there, switch SW1 to LISTEN for acknowledgement, otherwise talk.

HOW IT WORKS

The loudspeakers at the Master and Slave double as microphones but as a microphone are unsuitable for connecting to the input to the LM380 and therefore a transformer is used to step up impedance and signal level, this is T1.

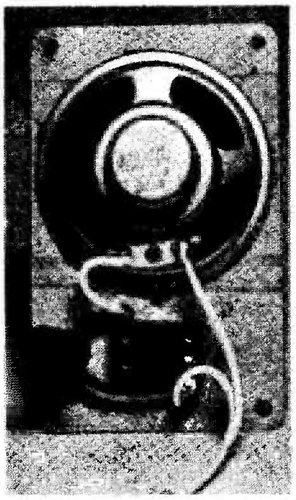
SW1 is the main controlling switch and it can be seen in the off position shown in the circuit that the battery does not connect to the main circuit. Other parts of the switch place C2 between the input and the output of the I.C. making it oscillate; LS1 is connected to the output and the slave loudspeaker LS2 connected to the input via C4.

When the slave presses SW3, battery negative is applied to the main circuit negative line via LS2 and one winding of T1. The circuit oscillates and a tone comes up on LS1.

On receiving the signal the master unit switches to listen, disconnecting C2 and picking up the battery negative.

For the Master to call the Slave, SW1 is switched to Talk and SW2, a push-to-make switch, can be pressed, the tone will then be connected to LS2.

SW1b and SW1d switch the speakers as required.



Inside views: Above is the slave, on the right is the master. Note the mounting of the components board and the method of holding the two batteries.

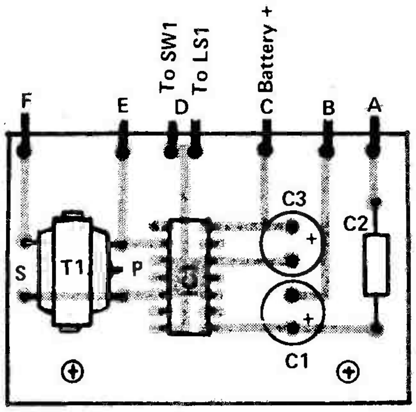


Fig. 4a. The components layout on the p.c.b. The letters A–F refer to the switch connections.

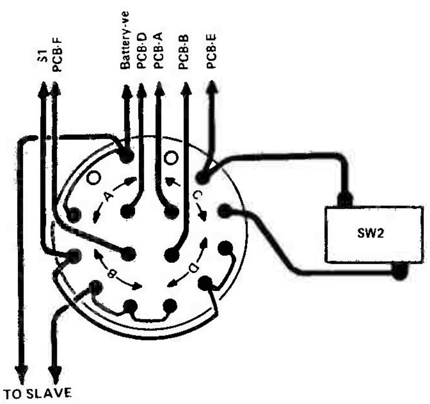


Fig. 4b. The wiring of the switches in the master unit.

SLAVE TO CALL MASTER. Press SIGNAL button SW3, wait a couple of seconds and talk.

MASTER ACTION ON RECEIVING TONE. Switch to TALK if acknowledgement is the normal practice or LISTEN if not.

The need for acknowledgement will depend on individual circumstances.

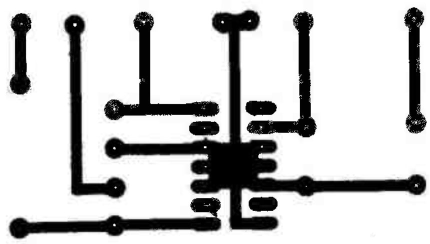


Fig. 3. The p.c.b. pattern shown full size.

GENERAL NOTES

All components should be widely available: alternatives and suppliers are mentioned in the special box.

Fixing speakers to flat surfaces is often a problem. We used an ordinary impact adhesive — this is quite adequate.

Continued overleaf.

Note that T1 is used in reverse: the windings normally regarded as the primary (and marked as such on the circuit) become the secondary. Most transformers of this type have a centre tap on the primary – this should be ignored.

The signal tone may be considerably different from one station to the other: this will be due to the use of C1 and C4 in series when Master calls Slave, the effect of the wire etc. C2 is not a critical value and may be experimented with to obtain a satisfactory tone in both units.

The only current drain on standby should be the leakage of C4: it is worthwhile checking to ensure that C4 is a healthy component by measuring current drain: it should certainly be no higher than 20μA. If it is, change C4.

BABY ALARM

The circuit and switching allow the unit to operate as a baby alarm, but two modifications are suggested for this. Firstly a baby alarm will have to be on for several hours at a stretch and battery operation is therefore uneconomical. A mains power supply should therefore be substituted (a suitable one is used with our record player).

Secondly, whilst a volume control is unnecessary with an intercom, this does not apply with a baby alarm. Therefore a simple volume control can be fitted. This should be a 1MΩ log pot wired with one end connected to input pin 2, the slider and other end wired to pin 6. This should be fitted with a d.p. switch which can be connected to the power supply mains.

RECORD–PLAYER AMPLIFIER

Having an output of about 3W, the LM380 makes for an excellent record player amplifier for use with ceramic or crystal pickups. The quality will be nothing to write home about but compares favourably with commercial amplifiers at the low end of the price scale.

To match the high impedance of the pickup, a high value volume control is needed – 500kΩ is shown in the circuit. The tone control is a simple passive top cut but this gives adequate control for the type of amplifier we have in mind. The circuit is shown in Fig. 5.

The power supply is perfectly conventional; a 15V transformer feeding into a bridge rectifier. The low value of the smoothing capacitor C4 is not an oversight. If a low value capacitor (10μF) is connected between pin 1 on the I.C. and the negative line, there is exceilent hum rejection permitting the use of a low value for C4 (and a resulting cost saving).

A higher value capacitor is used for C3 than in the intercom to improve the low frequency response.

PARTS LIST

RV1	Potentiometer	500kΩ log. pot with double pole mains switch.
RV2	"	10kΩ linear pot.
C1	Capacitor	0.05μF ceramic, polyester etc.
C2	"	10μF, 25V electrolytic
C3	"	500μF, 25V "
C4	"	500μF, 25V "
IC1		LM380/SL60745 integrated circuit.
D1-D4	Diode	1N4001 (50V, 1A) silicon rectifier.
T1	Transformer	240V/15V at 500mA.

Drilled s.r.b.p. board.
Small metal chassis as illustrated.

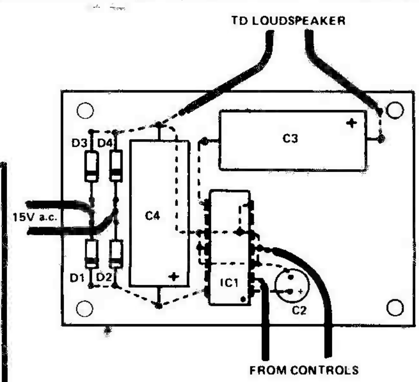


Fig. 6. Top view of the components layout. Underneath connections are shown dotted.

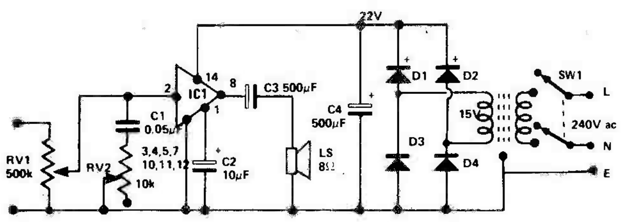
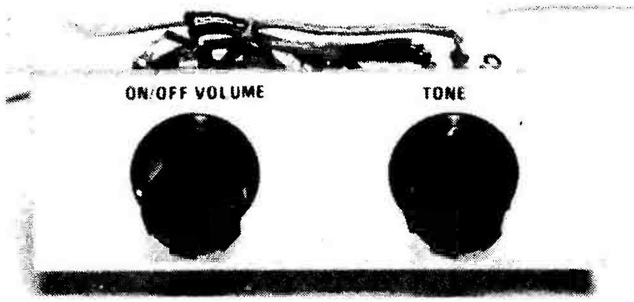


Fig. 5. Circuit of the record-player amplifier.



COMPONENTS COMMENTS

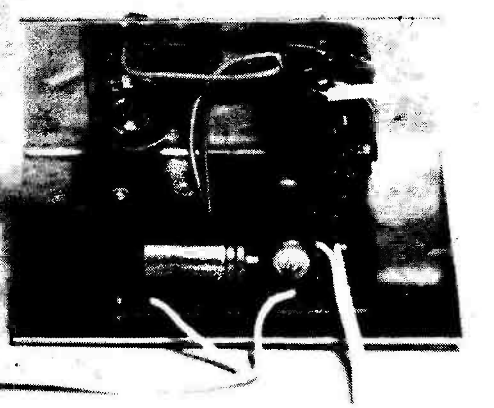
RV1 can lie anywhere in the range 250kΩ to 2MΩ with no effect on performance. RV2 should by the value shown to give proper control over the tone but a 25kΩ could be used. C1 can be any type of capacitor and should lie in range 0.03-0.1μF: different values will effect the tone.

All electrolytics can have working voltages higher than the 25V shown.

A bridge rectifier capable of handling at least 0.5A can be used in place of D1-D4 but these are much dearer than using the four individual diodes.

The transformer can have a secondary in the range 12-15V. If lower than 12V the output will be reduced; if higher than 15V the voltage rating of the components will be exceeded after the a.c. is rectified. Current rating should be at least 200mA but the 500mA value specified is more common and will give sufficient reserve power. Most of the mail order catalogues list transformers of this type.

For safety reasons a double-pole mains switch should be used and the negative line of the circuit connected to the record player deck and earth.



Rear view of the amplifier. For clarity the on/off switch wires are not shown. C1 is mounted on the tags of RV1 and RV2.

CONSTRUCTION

There are so few components that a P.C. board is hardly necessary – we built our unit on drilled s.r.b.p. board (the layout is shown in Fig. 6). The component board can be mounted on a simple chassis as shown with the front bent up to hold the two controls as seen in the photograph. However layout is not critical and readers may well wish to build the unit into the record players plinth.

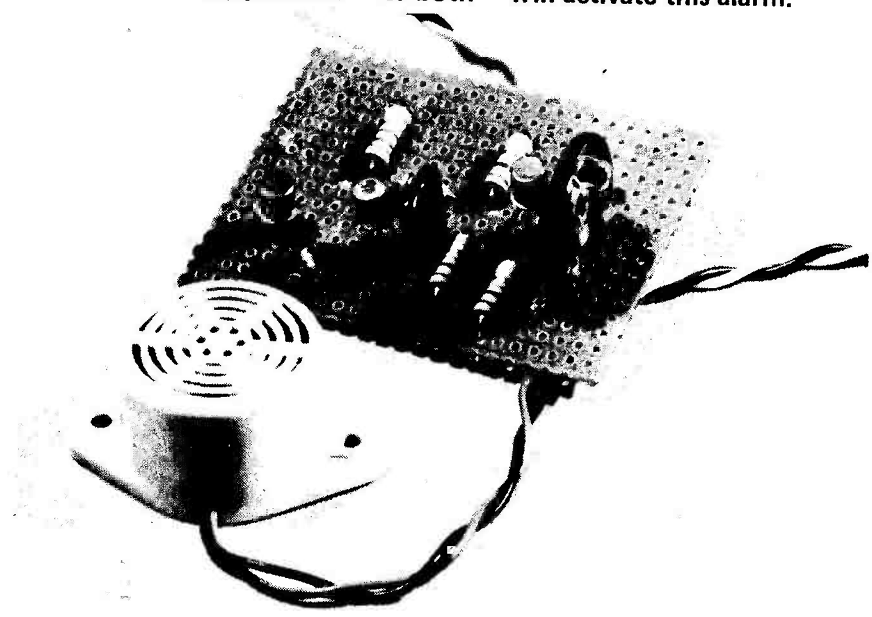
It is worthwhile using a reasonable sized speaker; these are more efficient and give better quality than small ones.

It is important that screened wire is used for the connection between the pickup and RV1. ●

eti project

TEMPERATURE ALARM

Under or over temperature — or both — will activate this alarm.



The completed temperature alarm.

THIS circuit is designed to provide an alarm (either audible or by relay contact closure) whenever a temperature, as monitored by a thermistor, drops below, or rises above, a preset level. The thermistor sensor is a negative temperature coefficient device (NTC), that is, as temperature rises the thermistor resistance falls.

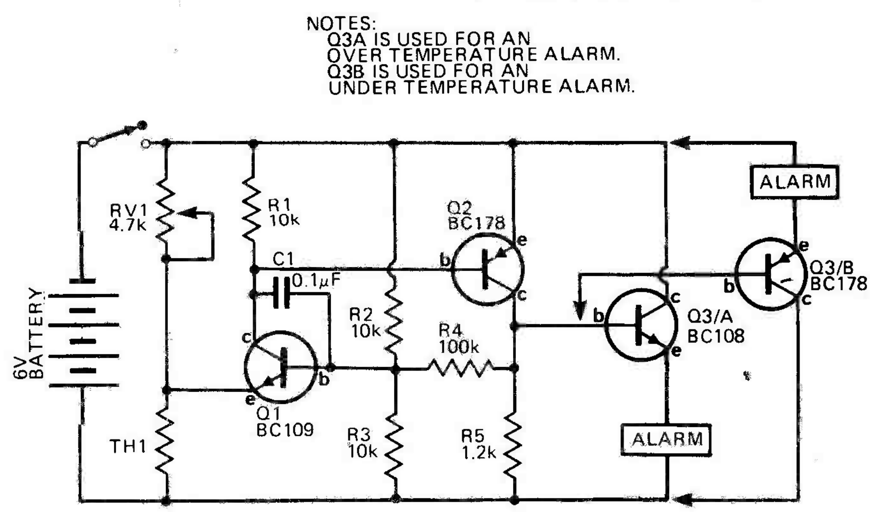
Using thermistors, the range of temperatures over which the unit will operate is from −20 to +150°C. However any one single type of thermistor is only useful over a 30°C range and it is therefore necessary to select a thermistor for the desired operating point by referring to Table 1.

Select the desired temperature from column 1. The corresponding nominal value of thermistor will be found in column 2. The thermistor will have a value of resistance between 1 and 4 k at the operating temperature.

The hysteresis, or deadband, between the on and off switching points is only a few degrees centigrade and the circuit may therefore be used to switch a heater, etc, for temperature control in non-critical applications. If desired, the deadband may be widened by reducing the value of resistor R4.

TABLE 1

Operating Temperature °C	Suggested Thermistor (resistance, in ohms, at 25°C).
−20	180
0	560
+25	2200
+40	3900
+70	10 k
+100	27 k



Circuit diagram of the temperature alarm.

HOW IT WORKS

The emitter of Q1 is connected to the junction of RV1 and TH1 (thermistor) which form a voltage divider. As TH1 varies with temperature the voltage at the emitter of Q1 will also vary with temperature.

Transistors Q1 and Q2 together form what is known as a Schmitt trigger. The Schmitt trigger is in fact an amplifier with positive feedback. If the temperature is below the point set by RV1, transistors Q1 and Q2 will be off, that is, not-conducting. The voltage at the base of Q1 will be set by R2, 3, 4 and 5. Since Q2 is off it does not affect the parallel arrangement of R4 plus R4 with R3. Thus with a 6 volt supply there will be 2.86 volts at the base. If the emitter voltage of Q1 falls below 2.86 − 0.6 volts, i.e. 2.26 volts, Q1 will turn on. This causes Q2 to turn on thus effectively putting R4 in parallel with R2. This causes Q1 to latch on, hence, its emitter voltage now has to exceed 3.14 − 0.6 volt before the transistor will turn off.

Reducing the value of R4 will make the difference between these two voltages greater thus increasing the deadband.

The relay or alarm is driven by Q3 which buffers the output of Q2. The circuit may be used for over-temperature, under temperature or both types of alarm simply by using the appropriate Q3 circuitry.

PARTS LIST Temperature Alarm

R1,2,3,	resistor	1.2k	½W	5%
R4	"	10k	"	"
R5	"	100k	"	"

RV1 potentiometer 4.7k linear

TH1 Thermister see Table 1

Q1	Transistor	BC108 or similar
Q2	"	BC178 or similar
Q3	"	See circuit diagram

Audible warning device (12V version available from Doram, P.O. Box TR8, Wellington Road Industrial Estate, Wellington Bridge, Leeds LS12 2UF) or 6V relay.

SW1 SPST toggle switch
6V battery
Pieces of matrix board.

PEAK UP YOUR S.W. SIGNALS WITH OUR AERIAL MATCHER

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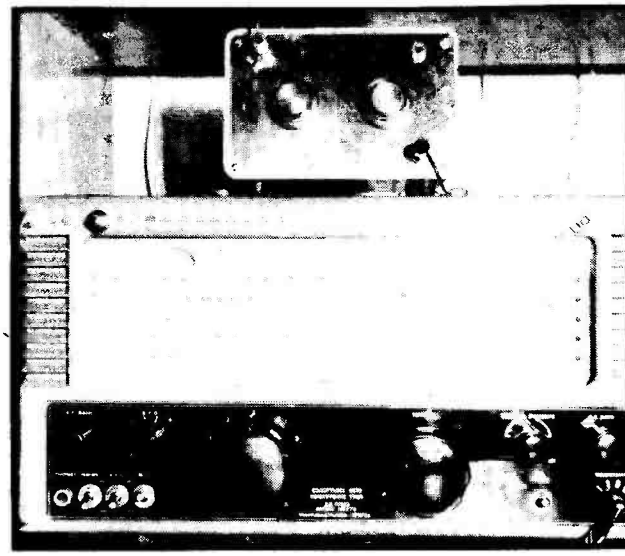


FOR GENERAL RECEPTION purposes over the 1.7 MHz to 30 MHz range, an end-connected wire antenna is popular. This may be anything from a few feet of insulated wire indoors, to a long, high outdoor aerial. Such aerials can, and do, provide good long-distance reception, but the matter of matching the aerial impedance to the receiver is often totally disregarded. There is a maximum transfer of energy from the aerial to the receiver only when the end impedance of the aerial approximately matches the input impedance of the receiver aerial circuit.

Many specialised short wave receivers have an aerial input impedance of about 75 ohms. With other receivers, the input impedance may be unknown, and in any case it is likely to alter with changes in operating frequency.

The end impedance of the aerial, in its turn, depends on the length of the aerial system in terms of wavelength. If the aerial is a half wavelength long, or a multiple of half wavelengths, its end impedance is high — it may easily exceed 1000 ohms. On the other hand, if the aerial is a quarter wavelength long, or an *odd* multiple of quarter waves, its end impedance is low. In fact it will probably be under 50 ohms at some frequencies.

The length of a half-wave, in feet, is found with sufficient accuracy from **length** = 468/MHz. As much specialised short wave listening takes place on the Amateur Bands, and these are spaced nicely through the spectrum* it is convenient to use them as examples.

Adopting a centre-frequency for the 20 metre band of about 14.2 MHz, the length is 468/14.2, or near enough to 33 ft for this to be used. Suppose 33 ft of wire forms the aerial and down-lead, the near end being taken to the receiver. The end impedance is high at the frequency which corresponds to a half-wave — about 14.2 MHz in the 20 m band. At twice this frequency, or about 28.4 MHz in the 10 m band, 33 ft is *two* half-waves so the end impedance is also high. But at half the frequency, or about 7.1 MHz, the aerial is one-quarter of a wavelength long, and its end impedance is low. In fact, if the aerial impedance were measured through the range 30 MHz to 1.7 MHz, it would be found to make excursions from one extreme to the other, reaching a low figure as the frequency falls and the wire grows short in terms of a half wavelength.

Similar effects arise with any length of aerial. To compensate for them, an aerial matching device such as that described here may be placed between the aerial and receiver.

(* 160 metre band, or 1.8 – 2.0 MHz; 80 m or 3.5 – 3.8 MHz; 40 m or 7.0 – 7.1 MHz; 20m or 14.0 – 14.35 MHz; 15 m or 21.0 – 21.45 MHz; and 10 m or 28.0 – 29.7 MHz.)

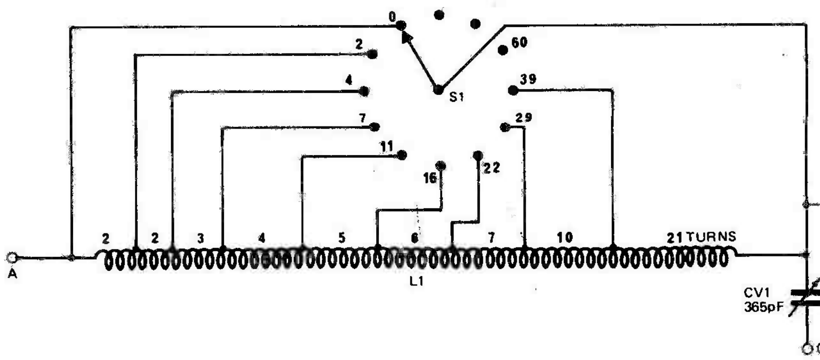


Fig. 1. The circuit of the aerial matcher.

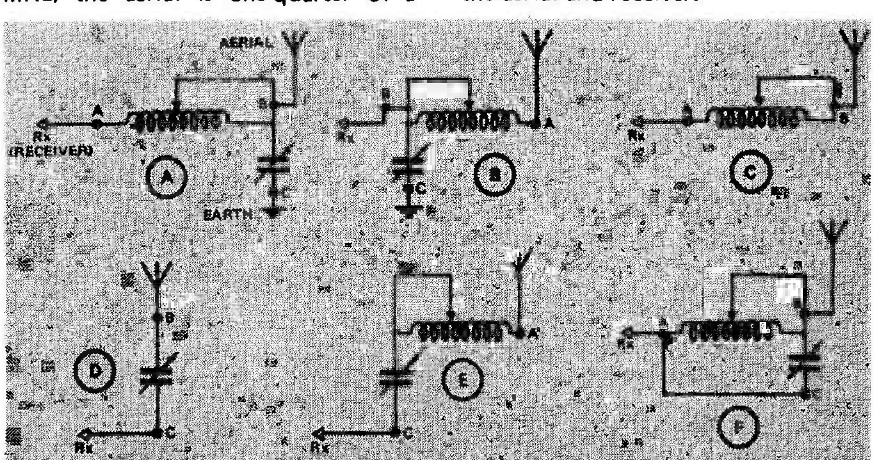


Fig. 2. The various permutations that can be obtained from the circuit in Fig. 1.

MATCHER CIRCUIT

This is shown in Fig. 1 and employs the tapped inductance L1 and variable capacitor CV1. The switch S1 has 10 positions. At '0' all of L1 is shorted out. At '2' two turns are in circuit. At '4' two plus two turns, or four turns, are in use. This continues for the remaining switch positions, so that 0, 2, 4, 7, 11, 16, 22, 29, 39 and 60 turns may be selected.

To cover the widest possible range of conditions, the matcher can be employed in any of the ways shown in Fig. 2. So many circuits may make it seem that operation is complicated. However this is not so, as it is only necessary to use any one which allows the switch and capacitor to be adjusted for best results. As a guide, the following will be helpful:

A. CV1 is at the aerial side. This method is likely generally to be useful. Rotate the switch S1 from '0', meanwhile swinging CV1 from minimum to maximum to peak up signals. Use S1 and CV1 settings which prove best.

B. Aerial and receiver plugs are reversed. Try this if A proves unsatisfactory. Adjust as for A.

C. A simplified inductive loading, broad-banded.

D. Series capacitor only. Not likely to be needed often, but useful with some receivers.

E. CV1 and L1 in series. This will allow many unknown aerial impedances to be matched.

F. Parallel tuning by joining sockets A and C. This can prove useful with very short aerials on low frequencies, allowing the whole system to be tuned to resonance.

If the receiver has a tuning indicator, watch this while making adjustments. If there is no indicator, but an automatic volume control switch, put the AVC off so that changes in volume are more easily heard. If the AVC cannot be switched off and there is no tuning indicator, adjust the matcher with a weak signal. The benefit it can give is not necessary with strong signals, which will in any case operate the AVC system and mask the change in signal strength at the receiver aerial terminal.

INDUCTOR

This uses 24 swg enamelled wire, wound on a paxolin tube 1½ in in diameter and 3½ in long. Anchor the wire about ¼in from one end, Fig. 3, and wind on two turns. Scrape the wire, twist a small loop, and wind a further two turns. Make a further loop, and wind three turns. Continue in this way until the coil is finished as in Fig. 3. A small space is left between each section. Anchor the end as when starting.

A little adhesive, such as Bostik 1, may be applied at the ends and tappings, to prevent turns moving, but the whole winding must not be treated in this way.

ASSEMBLY

The panel is approximately 6 in x 4 in and is drilled or punched for three insulated sockets, S1, CV1. The latter requires a ½ in hole, and is fixed by three 4BA countersunk screws. These *must* be short to avoid damaging the capacitor.

The coil is placed directly behind the switch, and leads are cut from 20 swg tinned copper or similar wire, and soldered from the tappings to the switch tags as shown. No other support for the coil is necessary.

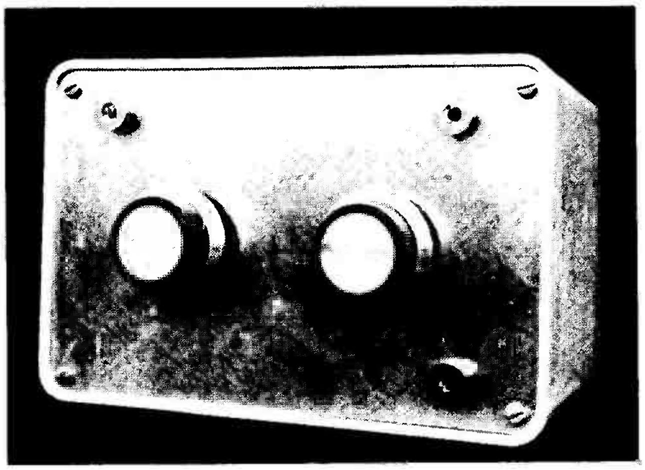
Audio gain potentiometer knobs numbered from 0-10 were fitted to S1 and CV1. '0' corresponds to '0' in Fig. 1, and the numbers 1 to 9 for the other positions, two positions of the 12-way switch being unused. As CV1 rotates only 180 degrees, numbers beyond 7 here can be blocked out.

USE OF MATCHER

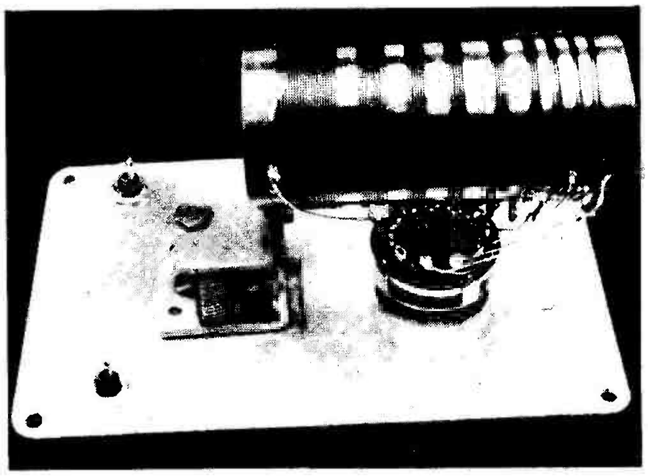
Leads are equipped with plugs to place in the panel sockets. The case listed is completely insulated. It will be seen that when circuits such as D, E and F are used, the variable capacitor frame, and thus the metal panel, are not earthed. This appears to be of little importance, and there was felt to be no point in substituting an insulated panel, or insulating CV1 from the metal panel. With A and B, the panel is earthed.

Tuning adjustments are relatively flat with a longish aerial, but peak more sharply with a short aerial. Any circuit in Fig. 2 which gives best results can be used.

The matcher is not intended for use with universal AC/DC mains receivers where the chassis and other circuits are connected directly to the mains. ●



The completed unit.



An internal view of the completed unit.

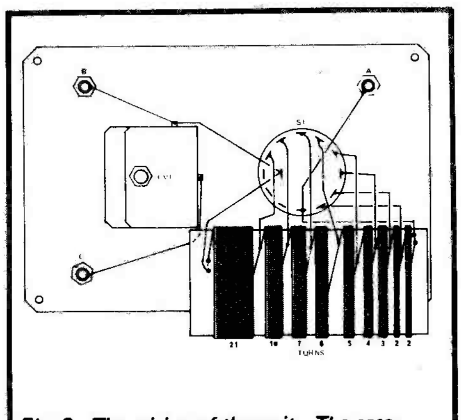


Fig. 3. The wiring of the unit. The case used for the prototype is the 'Elf', available from West Hyde Developments Ltd, Ryefield Crescent, Northwood, Middlesex.

UHF TV PREAMP

ETI project

A PREAMPLIFIER can raise a low television signal input to a level where a useable picture is obtained. Most modern sets are extremely sensitive and the minimum useable signal is quite close to the background noise. However, in many cases, extra gain from a preamplifier can help to make results more acceptable. The first necessity is a good aerial with as short a run of UHF cable as possible. Ideally, the preamplifier should be at, or close to, the aerial. This, however, is generally a professional installation job. Nevertheless some benefit is usually obtained even when the amplifier is close to the set. This article contains constructional details for a self-contained preamplifier that can be mounted on the back of the television set. The cost of components including VAT is probably about £2, but prices vary between suppliers.

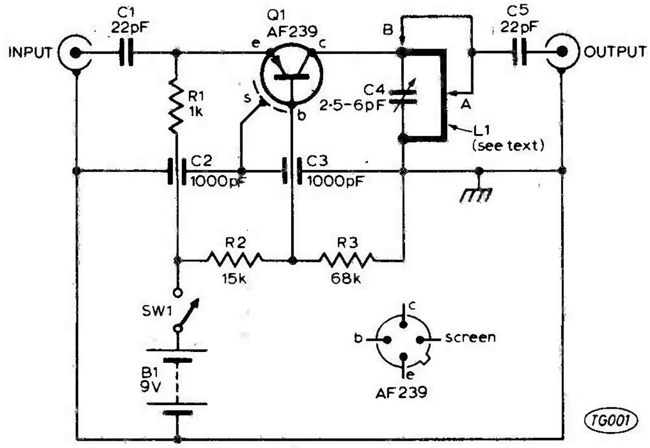


Fig. 1. The circuit diagram of the UHF preamplifier

CIRCUIT

Although modern silicon NPN transistors can have very high cut-off frequencies in the lower gigahertz range, allowing low-noise broadband common emitter amplification, they are expensive and often difficult to obtain. For these reasons the germanium PNP AF239 is preferred. The price is usually under 50p. It operates well up to the top of the UHF bands when connected in common base. The emitter receives the input via a ceramic capacitor C1. The output is taken via a similar circuit in the collector lead. The base is at chassis potential to R.F. via a feed-through capacitor C3. The resistor network, R1, R2, R3, provides the bias for the transistor. The battery supply is decoupled by a second feed-through capacitor, C2.

All the components except C1 and C5 are mounted on a small tinplate sub-chassis which can be soldered. This is then bolted into an aluminium box. The chassis is connected to the negative side of the battery. At UHF stray capacitance and inductance from the leads can upset the operation of the circuit, hence all connections are made as short as possible. Careful separation of output and input to avoid instability is also needed. The sub-chassis divides the space in the box into three parts; the largest contains the on/off switch and battery. The two smaller screened sections contain the majority of the circuit except R2 and R3. The input region is made very small to minimise stray inductance. The size of the box was chosen to enable a PP6 battery to be used with a long life on the very small current drain of the preamplifier. This results in the output enclosure being larger than would otherwise be necessary.

The collector, while at D.C. chassis potential, is maintained above this to R.F. by the coil, L1. The circuit is tuned by a small trimmer, C4. This is Doram type 982-075, nominally 2-6pF. Most other trimmers have too high a minimum capacitance to allow tuning of the top of band 5. If trouble is experienced here, then 986-162 slightly lower in value, can be used instead for channels 5-68 only. The maximum will not tune the lower channels. The length of collector lead soldered to the coil produces the correct inductance for the UHF bands. The trimmer is soldered from earth to the junction of collector and coil.

The output is taken from a tapping on the coil via C5. The impedance of the output will vary according to the position of the tapping. It will always be a mismatch to the 75 ohm output. This mismatch is deliberate in order to broaden the bandwidth and make the amplifier cover more channels without altering the setting of C4.

Two alternative tappings are shown in the circuit diagram. Tapping **A** is approximately half way along the coil. High gain results but only over one or two adjacent channels for any setting of C4. This is acceptable where the preamplifier is required for only one particular channel such as a neighbouring ITV station. For more general use a tapping at **B** where the trimmer, coil and collector lead join is better. In the prototype this broadened the bandwidth sufficiently to give above unity

PARTS LIST

R1	Resistor	1k	5%	¼W
R2	"	15k	"	"
R3	"	68k	"	"
C1	Capacitor	22pF	ceramic	
C2	"	1000pF	ceramic feed-through	
C3	"	1000pF	ceramic feed-through	
C4	"	2.5-6 pF	trimmer (see text)	
C5	"	22pF	ceramic	

Q1 AF239

L1 See Fig. 4. Made from 1 3/16ins of inner conductor of coaxial cable.

SW1 Single pole on/off switch.

2 coaxial sockets, battery connector, aluminium box (Norman AB8) 22swg tinplate sub-chassis, 3¾in x 2 5/8in, low-loss coax (for lead to set).

gain over about 15 channels. If instability should result on any channel, then a resistor from about 2.2k ohms down to about 100 ohms connected across the output socket should effect a cure. The value should be as high as possible compatible with a cure.

No direct measurements of gain were made, but connected at B, the preamplifier gave a very visible signal increase on all the channels available in the author's district, 24-63. If the higher channels do not show a similar gain, a change to trimmer 986-162 should solve the problem.

CONSTRUCTION

An aluminium box type AB8 from the widely available "Norman" range, (Norman Rose Ltd), was chosen to permit the use of a PP6 battery. Input and output coaxial sockets are located in convenient positions near the top of the box to allow as much room as possible for the components. The output socket is positioned so that a hole can be drilled alongside it in the case wall to allow a screwdriver to trim C4 while the amplifier is operating. The box measures 4 in x 4 in x 1½ in. A tin-plate sub-chassis holds all the components, 22s.w.g. is convenient, but any solderable sheet that can be cut and bent to shape is acceptable. Although the position of the holes is not critical, the dimensions in Fig. 2 are those found suitable in the construction of the prototype. The transistor is mounted in a 5/16 in hole in the chassis with its emitter and base leads in the input compartmént and the collector in the output section. The screen is folded back at 180° to its original position and is carefully soldered to the chassis using a heat sink, such as a pair of pliers. The size of the holes for the feed-through capacitors must be determined for the components used as they vary from type to type. (One of these decouples the power rail and the other grounds the base to R.F.). After the holes have been drilled, the

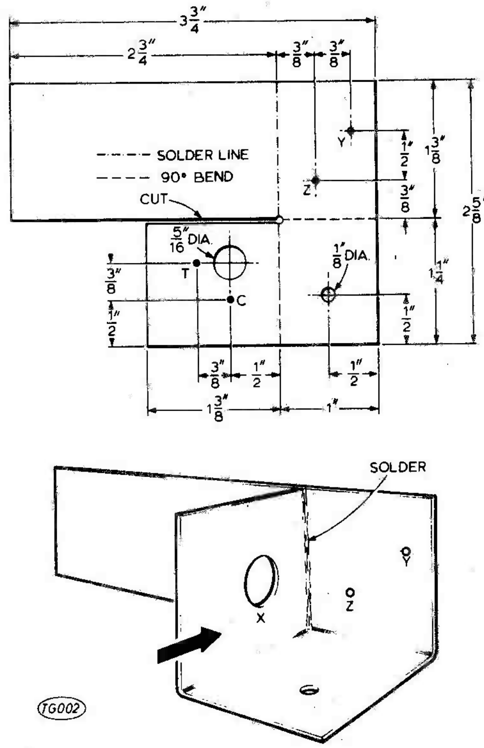


Fig. 2. Construction of the sub-chassis. Any solderable sheet can be used (even a tin can!)

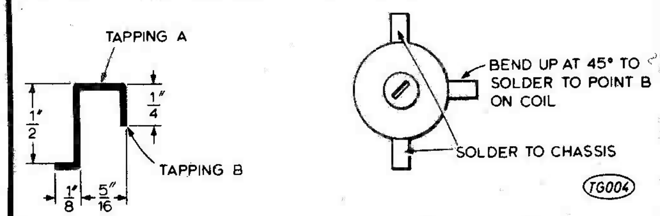
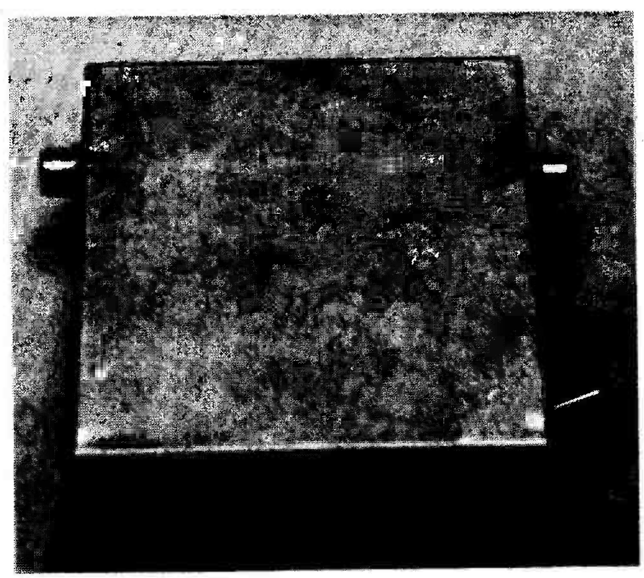


Fig. 4. The construction of the coil, made from a 1 3/16in length of the inner conductor of coaxial cable. On the right is shown the preparation of the trimmer, C4, which is soldered above the transistor



The finished preamplifier

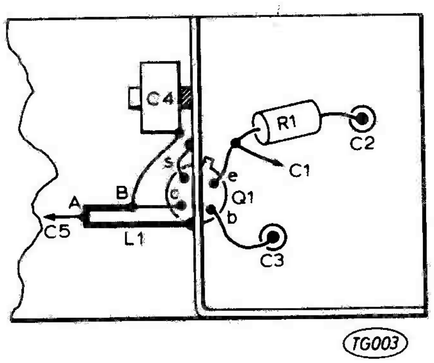


Fig. 3. Layout around the transistor, which is mounted in the 5/16in hole in the sub-chassis, with the emitter and base leads in the input compartment, and collector and screen to the output compartment

UHF TV PREAMP

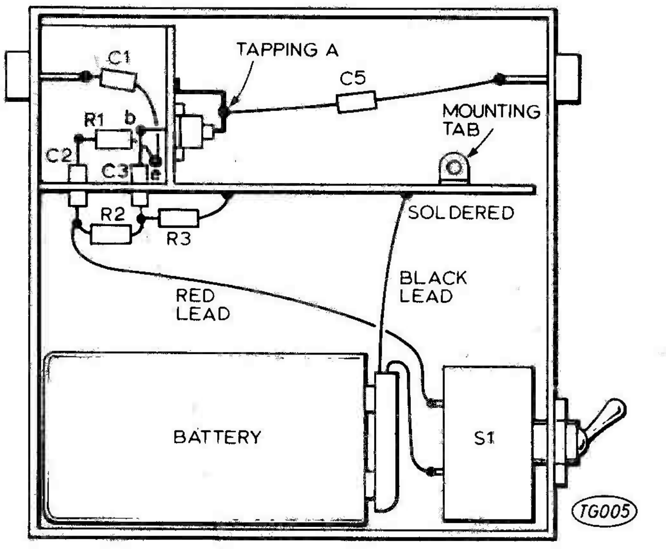
chassis is cut and bent as shown in Fig. 2. The bent-up wall of the input section is soldered to the long wall to give mechanical stability. The chassis is bolted to the case by two 6BA screws, One goes through both the box bottom and the tin plate at any convenient position in the input area. The other locates a small tab of tin-plate which is then soldered to the unsupported back wall of the chassis to give further strength. All these holes should be drilled and a trial assembly made before removing the sub-assembly to mount the components.

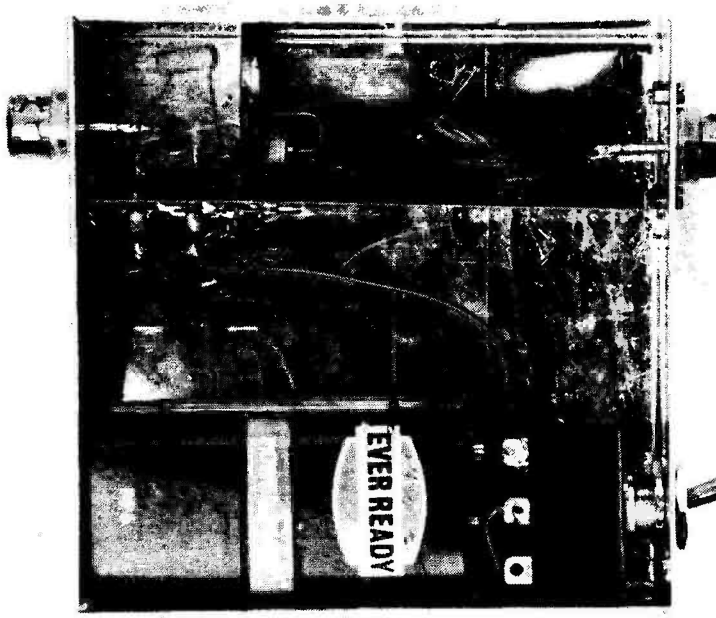
ASSEMBLY OF COMPONENTS

Fit the two coaxial sockets to the case and also mount the on/off switch. In the prototype this was a dtdt type used as a single pole on/off switch so that the battery with its clip just pushed snugly in place without any other support. However, any convenient switch may be used and double-sided tape used to hold the battery down.

Returning to the sub-chassis, first solder the two lead throughs, C2 and C3, and the two resistors R2 and R3 which go on the outside. R2 joins C2 to C3 and R3 is soldered from C3 to ground as close to the post as possible. Next mount the transistor. Always use a heat sink on the lead to avoid the risk of damage due to overheating. Fig. 3 shows how the leads are bent. As shown the base is soldered directly to the inner tag of C3. R1 is taken as directly as possible from the end of the emitter lead to the post of C2. The collector lead is bent so that it is vertical to the mounting wall. The coil made as shown in Fig. 4, is soldered down so that its ¼ in length is in the same line as the collector. The collector lead is cut so that the two form a butt joint, point **B**. The trimmer C4 has its central lead bent up at 45^{o} to the other two feet. It is soldered to the chassis by these feet so that the bent up tag exactly joins the butt joint of coil and collector. C1 and C5 are not attached until the sub-chassis has been mounted in the main box. C1 has very short leads cut to suit the locations of the socket and the joint of R1 and the emitter. One end of C5 is soldered to the output socket and the other to either position A or B on the coil. The values of C1 and C5 are not critical, they only need to be low impedance to R.F. The first prototype used 1000pF ceramic, but the version in the photograph employs 20pF tubular ceramics with no visible difference in performance.

Fig. 5. Complete layout, with C5 connected to tap A (for high gain on a narrow bandwidth)





The photograph shows the inside of the finished preamplifier. Here C5 is connected to tap B (for reasonable gain on a wide band-width).

When propagation conditions are right it is possible to pick up more than one extra TV station. This picture shows a transmission from Holland on UHF picked up in Southern England, using a good aerial in conjunction with an aerial preamplifier almost identical to the one described here

Output to the set is taken by way of a low loss coaxial lead. The length is not critical but it should be at least 1 ft. long.

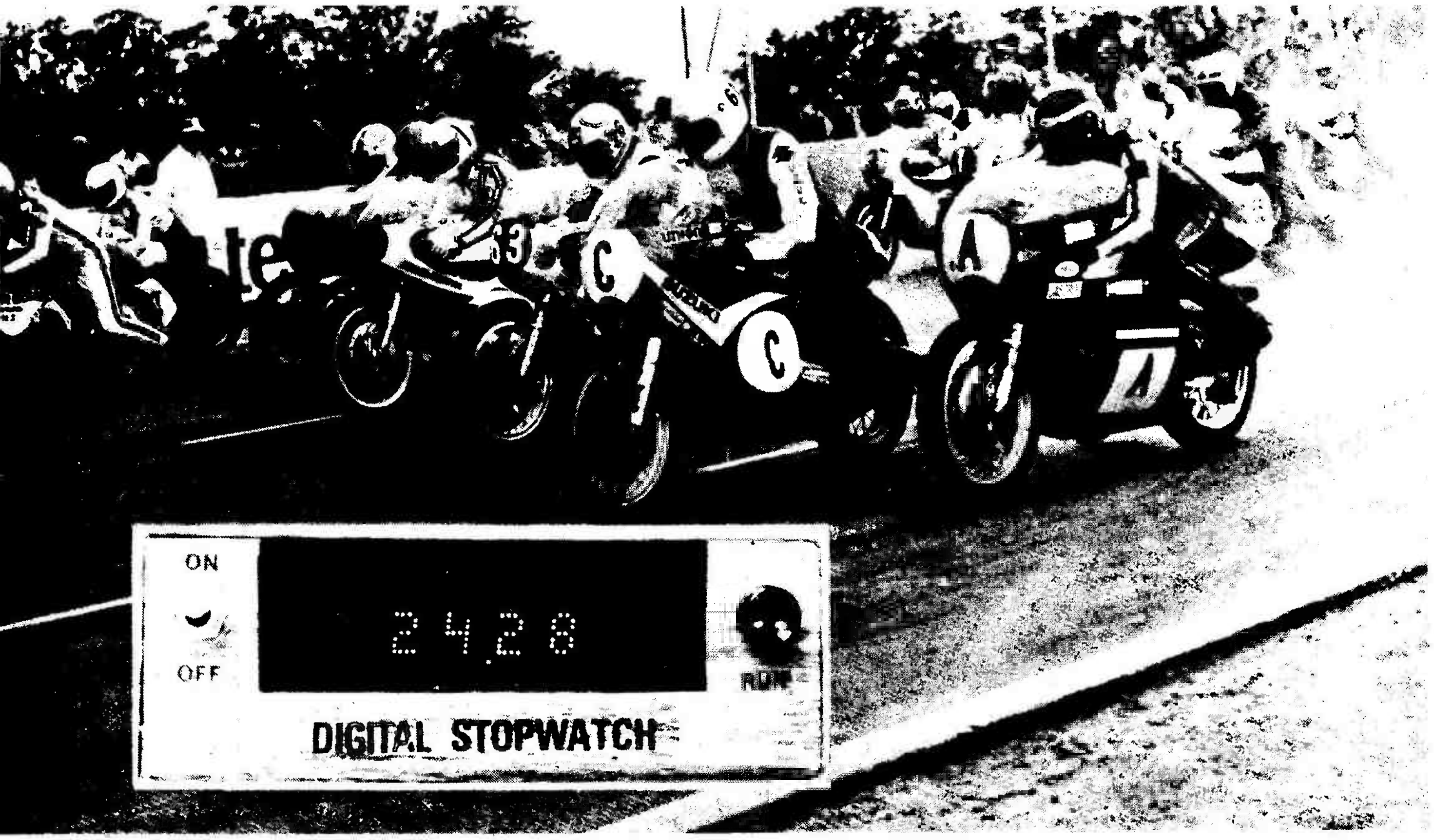
Figure 5 shows a general view of the preamplifier with the lid removed.

RESULTS

The prototype gave a very visible gain on all the channels available at the author's location. Using tapping **A**, for any given setting of C4, above unity gain was only obtained on one or two adjacent channels. Using tapping **B** a reasonable gain appears probably over all the channels of a given transmitter with the possible exception of some of those requiring an exceptionally broad bandwidth.

AVAILABILITY OF COMPONENTS

The Norman range of aluminium boxes is widely available from component stockists. The AF239 transistor is also widely available. ●



DIGITAL STOP WATCH

Measure elapsed time electronically with this digital system.

ALTHOUGH entirely adequate in many situations, conventional stopwatches have a number of limitations which preclude their use — or at least their accuracy of timing — in many applications.

This is particularly true of sporting applications, where the start line may be in a different geographical location from the stop line, and where timing accuracy to within hundredths of a second may be required.

Another serious drawback of many conventional stopwatches is that the display consists of multiple hands and/or dials, the readings of which must be added together to give elapsed time. At best this arrangement is clumsy — at worst it may be misread.

Apart from the form of display, another serious limitation of conventional watches is that human reflex time may cause errors in the measured time by a (variable) amount. Delays of 0.1 to 0.5 seconds are typical. Clearly this last limitation makes readings to anything better than 1/10th second virtually impossible — even though some watches are capable of this degree of resolution.

For these reasons, international sporting bodies are turning to digital timers that are started and stopped by electronic means, such as light beams (horse and motor racing), or touch plates (swimming).

Whilst extremely effective and reliable, commercially built systems of this sort are generally very costly and well beyond the means of the average car, motorcycle or athletic club.

The ETI Digital Stop Watch has been designed specifically to fill this low-cost need, whilst still providing the required accuracy and flexibility of operation. With suitable inputs, the standard instrument will provide a resolution of one hundredth of a second. Accuracy is one two hundredth of a second (±½ digit).

A unique overflow arrangement allows the four digit display to read times up to 3999.9 seconds in tenths of a second, or 399.9 seconds in hundredths of a second.

It is also possible to modify the unit to read to one millionth of a second for short time interval measurements (such as are occasionally required in science and industry). The necessary changes for this are detailed in Table II.

Three different modes of operation are provided to cater for practically any application. These are:—

MODE 1

STOPWATCH — In this mode a single push-button (either internal or external) provides the functions, Press to start, Press to stop, Press to reset — just as with a conventional watch.

MODE 2

REMOTE START/STOP — In this mode three push-buttons may be used at separate locations to Start, Stop, and Reset the timer. This mode would be very useful for timing events such as 50-metre swimming, motor car standing start quarter miles etc.

MODE 3

LAP TIMER. — Here a single push-button is used to provide separate lap times. The counter

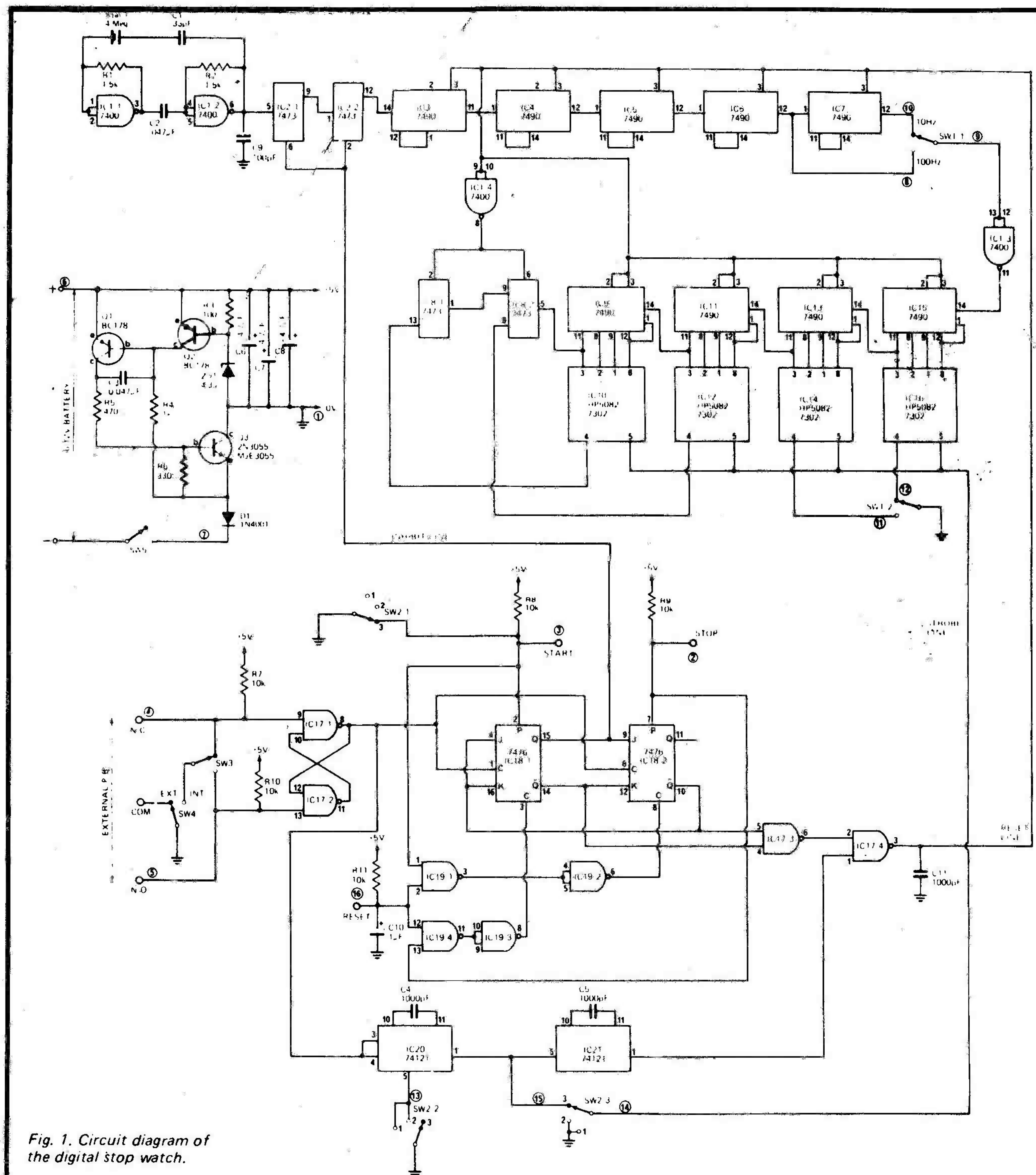


Fig. 1. Circuit diagram of the digital stop watch.

SPECIFICATION

RESOLUTION (selectable by slide switch)	**0.1 or 0.01 sec**	**CONTROL**	**internal or external push buttons, or external electronics at TTL levels**
(if modified)	**1.0μ sec**	**POWER REQUIREMENTS** (External battery)	**6-16 volts** **700 milliamps**
DISPLAY (overflow indication to 39999)	**4 digits**	**OPERATING MODES**	
		Mode 1	**normal stop watch**
		Mode 2	**remote stop/start**
ACCURACY (crystal controlled timebase)	**±1/2 digit**	**Mode 3**	**lap timer**

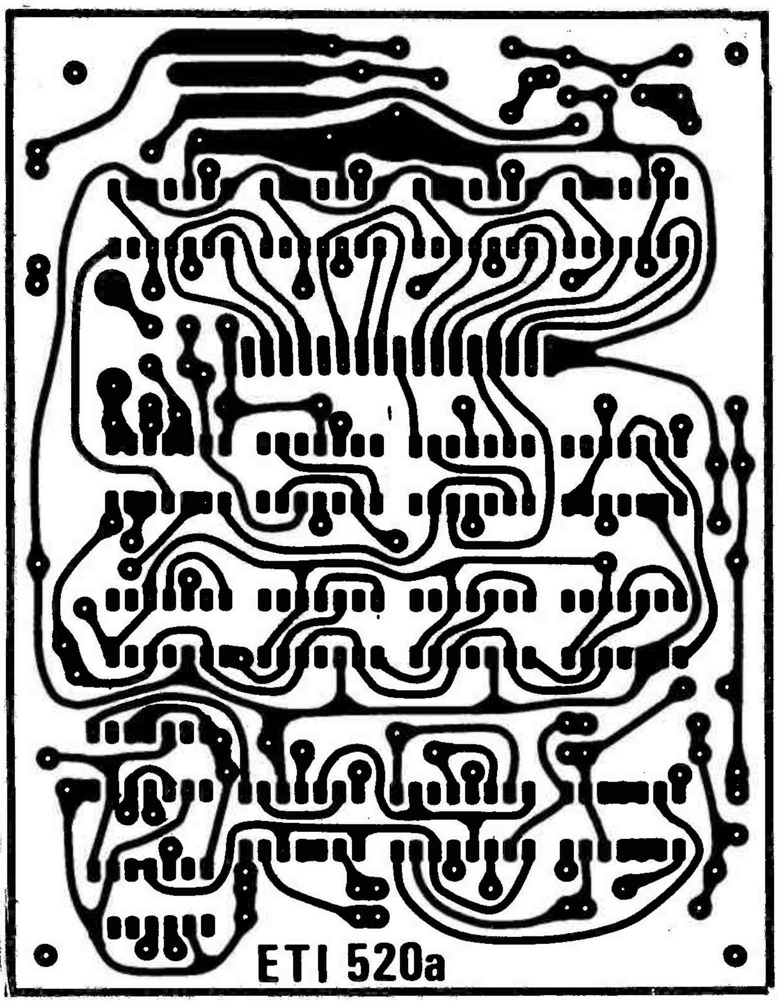


Fig. 2. Main PC board layout for the stopwatch.

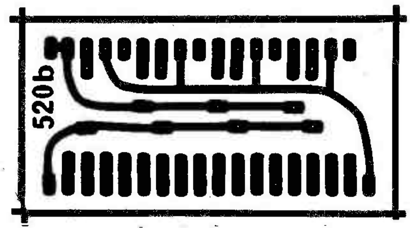


Fig. 3. The display chips are mounted on this small sub PC board.

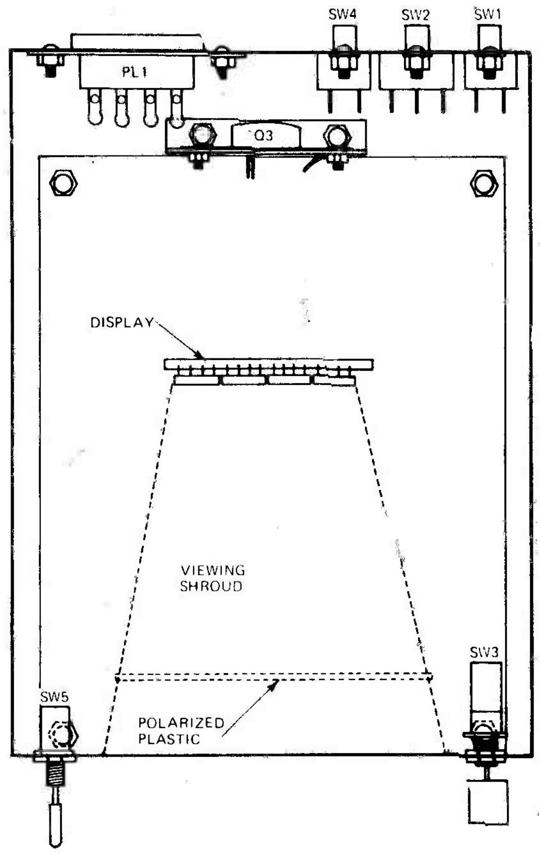


Fig. 5. Positioning of major components on the chassis.

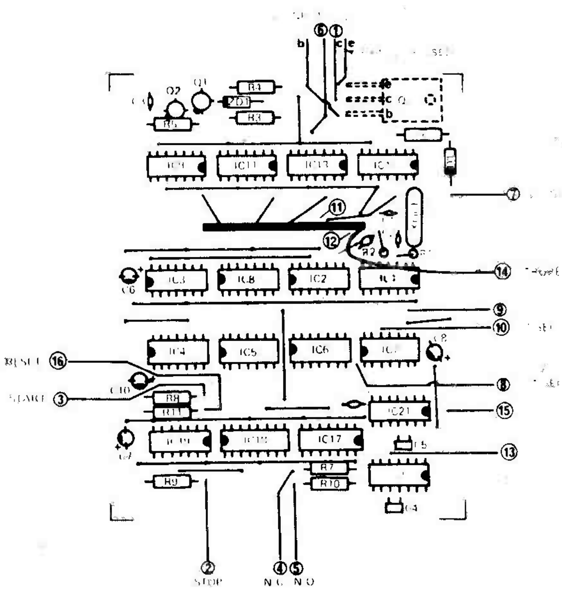


Fig. 4. Component overlay for main board.

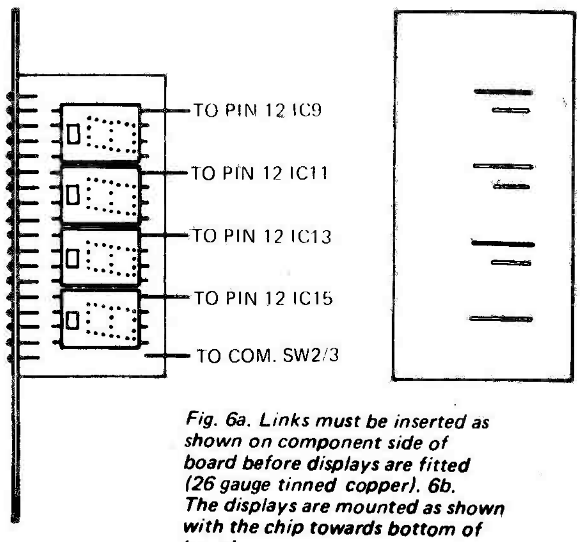


Fig. 6a. Links must be inserted as shown on component side of board before displays are fitted (26 gauge tinned copper). 6b. The displays are mounted as shown with the chip towards bottom of board.

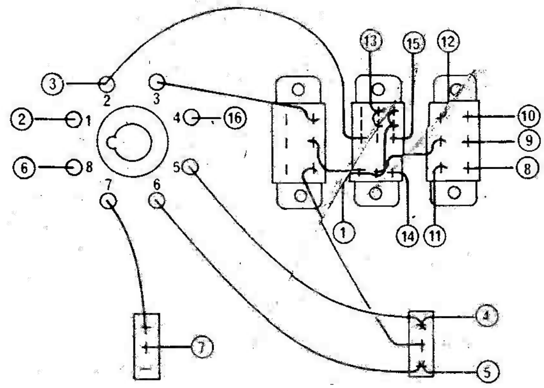


Fig. 7. Wiring to switches and power/control socket.

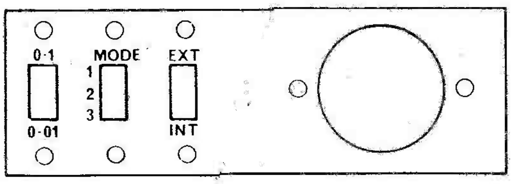
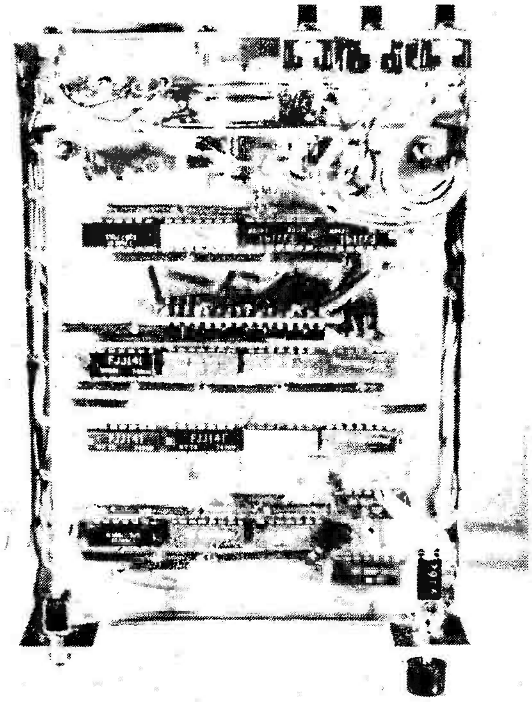


Fig. 8. Rear panel layout.



Internal view of the stop watch.

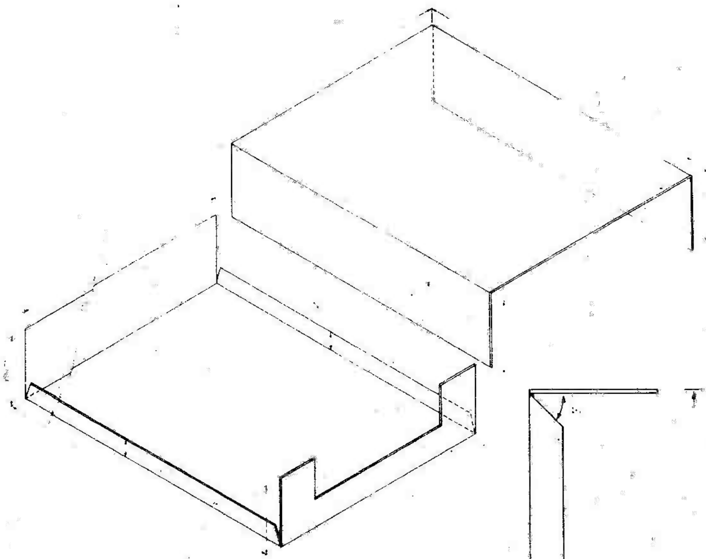
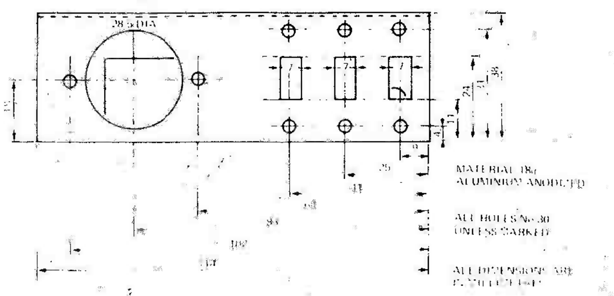
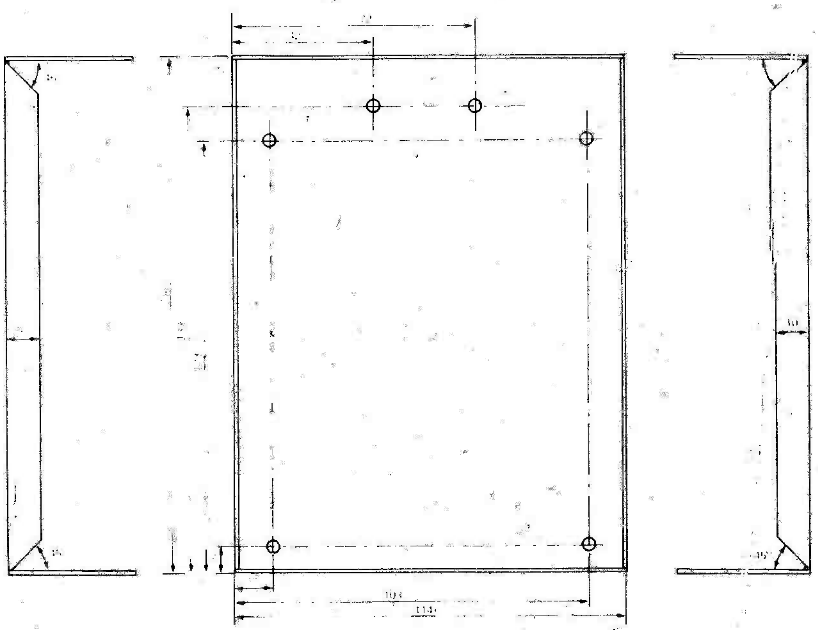


Fig. 9. Case dimensions.





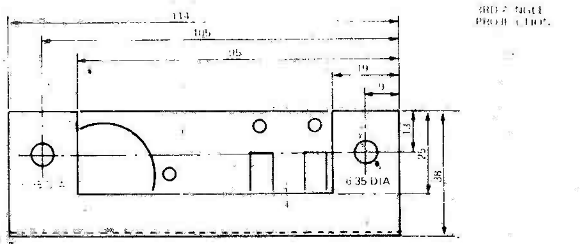


Fig. 10
Drilling details of chassis.

displays the time elapsed between successive presses of the button, hence there is no timing error due to time lost whilst taking readings.

The whole unit operates from a single five volt supply, hence an inbuilt regulator is provided enabling the unit to be run from any six to 16 volt battery – or any other source capable of providing 700 mA without the need for switching. A series diode is included in the power circuit to prevent damage in the event of inadvertent reversed battery polarity.

CONSTRUCTION

This is not really intended as a suitable project for absolute beginners, nevertheless if the recommended printed circuit board is used, construction should not present any major difficulty.

Firstly mount all integrated circuits onto the main board paying particular attention to orientating the spot or notch on the IC as shown in the component overlay.

Fit resistors capacitors, transistors and the crystal, again paying attention to polarities and orientation — where applicable.

If an MJE3055 flat-pack transistor is used for Q3 it may be mounted as shown in Figures 4 and 3. Make sure that the transistor is insulated from the chassis.

If the 2N3055 is used, it must be mounted on a separate aluminium bracket as per Fig. 14. It too must be insulated from the bracket by a mica washer and insulation bushes. Connection to the collector of the 2N3055 is made by fitting a solder tag under one of mounting bolts. The three connections to the 2N3055 are made by flying leads to the board as per the overlay Fig. 4.

Next fit tinned copper links and then the display ICs to the small display board as per Fig. 6. When the display chip is viewed at a particular angle, the approximately 3mm square IC chip can be seen through the red plastic front lens. This should be positioned towards the bottom of the display board to obtain correct orientation.

The display board is attached to the main board by tinned copper wire links (26 SWG). The easiest method of linking is to begin with a separation of about 12mm between the boards and sew the two boards together with a length of tinned copper wire. Then pull the display board down onto the main board making sure the display board is vertical. Solder the wires in place and snip off the excess wire.

Now mount the switches, power socket, PC board assembly and 2N3055 and bracket (if used) to the chassis and interconnect as per Figures 4, 5, and 7. The displays are mounted well back in the body of the timer to allow good visibility in daylight.

A viewing duct should be constructed from light cardboard (manilla folder) as per Fig. 11. The inner surface should be painted matt black and a piece of polarized plastic (as per Fig 12) inserted in the duct where indicated by the slot markings.

USING THE TIMER

The timer draws around 700 mA and therefore, should be operated from a car battery (or similar) supplying a minimum of 6 volts and a maximum of 16 volts.

Although the timer operates extremely well as a hand operated stop watch, the major advantages of the unit are only realized in lap timing (which does not require further explanation) and in the remote start/stop mode. In this latter mode the full accuracy of the unit is realized by using light-beam (or other electronics) start/stop control.

PARTS LIST

R1, R2 resistor 1.5 k ½W 5%
R3, resistor 100 ohm ½W 5%
R4, resistor 1 k ½W 5%
R5 resistor 470 ohm ½W 5%
R6 resistor 330 ohm ½W 5%
R7-R11 resistor 10 k ½W 5%
C1 capacitor 33 pF ceramic
C2, C3 capacitor 0.047pF polyester
C4, C5, C11 capacitor 0.001uf polyester
C6, C7, C8 capacitor 4.7μF 10V electrolytic
C9 capacitor 100pF ceramic
C10 capacitor 1μF 10V electrolytic.
Q1, Q2 transistor BC178 or similar
Q3 transistor 2N3055 or MJE3055
D1 diode 1N4001
ZD1 zener diode BZY88C4V3
IC1, IC17, IC19 integrated circuit 7400
IC2, IC8 integrated circuit 7473
IC3, 4, 5, 6, 7 integrated circuit 7490
IC9, 11, 13, 15 integrated circuit 7490
IC10, 12, 14, 16 integrated circuit HP5082-7302
IC18 integrated circuit 7476
IC20, 21 integrated circuit 74121.
(Note that the prefix of 74 series ICs depends on manufacturer.)
XTAL 1 crystal 4MHz 30pF capacitance
PC boards ETI 520A and ETI 520B.
SW1 switch DP DT slide
SW 2 switch 3P3T slide
SW3 switch SPDT push button
SW4 switch SPDT slide
SW5 switch SPDT toggle
Metal box to Fig. 10. Heatsink to Fig. 14 (If required) 8 pin octal valve base, piece of polarized plastic (preferably circular polarization) as per Fig 12.
4 ¼" long spacers for PC board (3 only if MJE 3055 is used).

HOW IT WORKS

Basic timing is generated by a 4 MHz crystal, in conjunction with IC1/1 and IC1/2 which are digital gates operated in a linear mode. The output of IC1/2 is divided by four in IC2/1 and IC2 to provide 1 MHz. This is further divided to 10 Hz by IC3 – IC7. The 10 Hz or the 100 Hz output from IC6 is selected by SW1/1 as the basic 0.1 second or 0.01 second timing.

The selected clock frequency is inverted by IC1/3 and counted by ICs 15, 13, 11 and 9. Inverter IC1/3 is used to give the clock an initial ½ digit lead in order that the accuracy should be ±½ digit rather than the usual +0 –1 digit in conventional digital instruments.

The display ICs provide a visual indication of the counter's contents. These ICs contain a store as well as decoders and drivers for the display. A four bit binary code is used where digits 10 to 15 are not used, and a control line or strobe is used to gate counter data into the store. If this line is low (less than 0.8 V) the information at the four inputs will be decoded and displayed. If the line is high (greater than 2.4 V), the store will still register the last input, and the counter state may change without affecting the display.

Only four display chips are used but by using the two most-left-hand decimal points as overload indicators, the full range is extended to 39 999 rather than 9999. There is no indication of overflow beyond 39 999 but the timer will continue to recycle and multiples of 40 000 can be added to obtain the correct time.

Three control lines are used for the counters. These are: –

1. The Reset Line: This line is used to stop the counters, reset and hold the counter to zero whenever it is in the high state (greater than 2.4 V).

2. Inhibit Line: This line stops the clock divider whenever it is in the low state (less than 0.8 V). Thus it stops the counting and freezes the display without resetting it.

3. Strobe Line: This line controls the store as previously described. In modes 1 and 2 SW2/3 applies a permanent zero to the line hence the store is only used in mode 3.

In modes 1 and 2 the state of the reset and inhibit lines is determined by IC18. The output states of IC18 for reset, start and stop conditions are given in Table 1. In mode 1 these states are set up by directly setting the preset (pins 3 and 8) and clear (pins 2 and 7) inputs whereas in mode 2 the IC's are toggled from one state to the other.

Either an external push-button or the internal one, SW3, may be used to toggle IC18 through its three states. Switch contact bounce is eliminated by RS flip-flop IC17.

In mode 3, IC18 is locked into "start" by SW2/1. IC20 and IC21 are monostables that provide, when triggered, a single, one-microsecond-wide, pulse which goes from 'high' to 'low' and back to 'high'. As the two monostables are in series, IC21 provides its pulse at the end of that from IC20. The first pulse controls the display stores, and the second pulse resets the counters to zero. Thus when the button is pressed, IC20 provides a strobe pulse that transfers the contents of the counter to the store. The store then closes and the second pulse from IC21 resets the counters to zero; the contents of the store, however, are retained and displayed until the next time the button is pressed. In modes 1 and 2 IC20 is inhibited by an earth on pin 5 from SW2/2.

The power supply is a series pass regulator type and will accept input voltages within the range six to 16 volts whilst providing the correct output of five volts. Correct operation will be maintained on batteries down to about five volts but display brilliance drops off. Diode D1 is used to prevent damage from reversed input polarities.

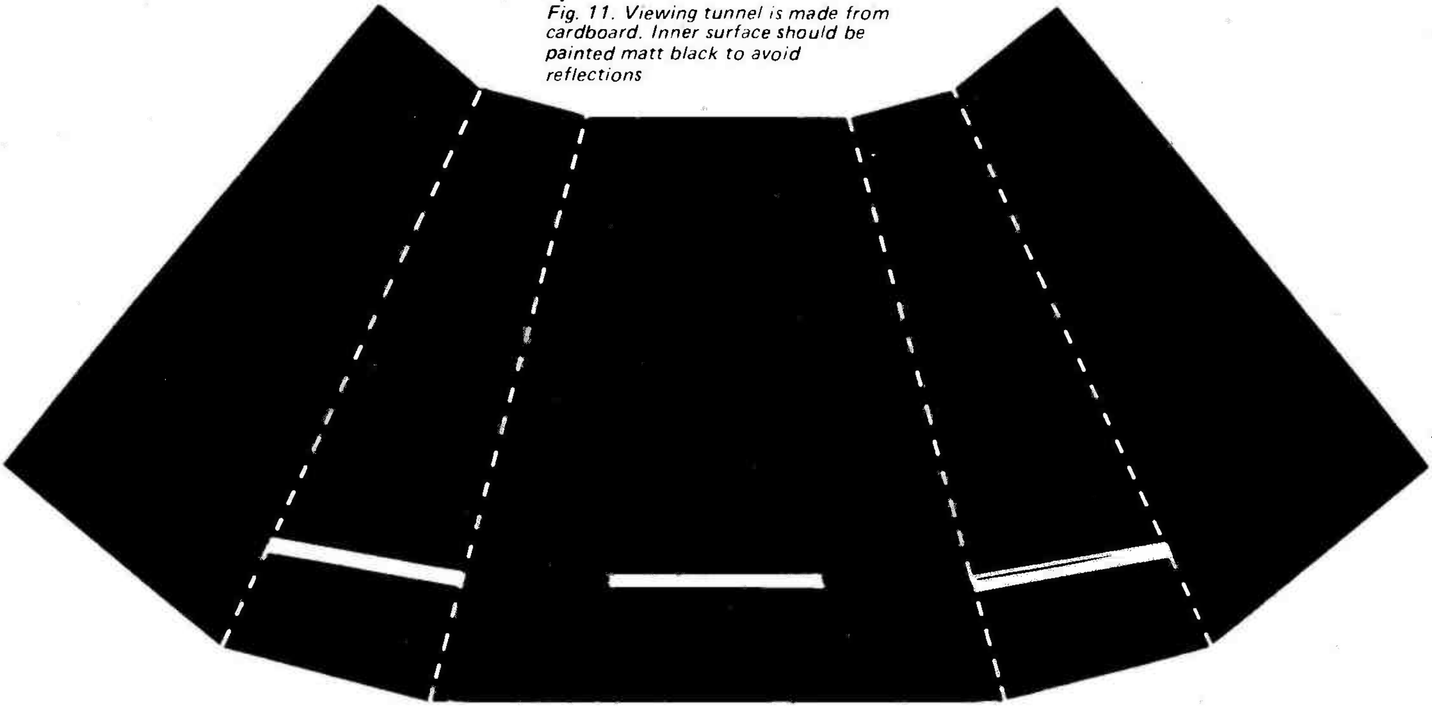


Fig. 11. Viewing tunnel is made from cardboard. Inner surface should be painted matt black to avoid reflections

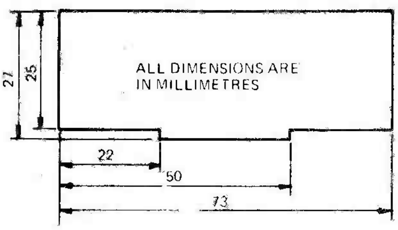


Fig. 12. Dimensions of polarized plastic window (fitted in slots of viewing tunnel).

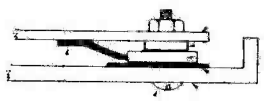


Fig. 13. Mounting details of MJE 3055.

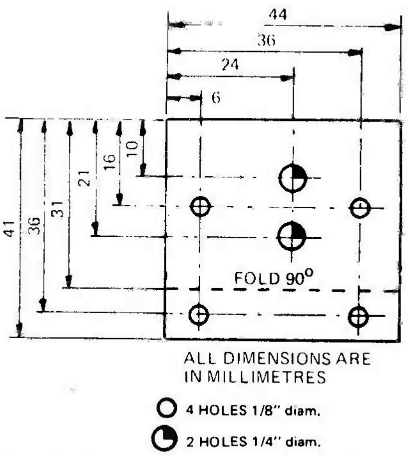


Fig. 14. Heat sink (if required) for 2N 3055

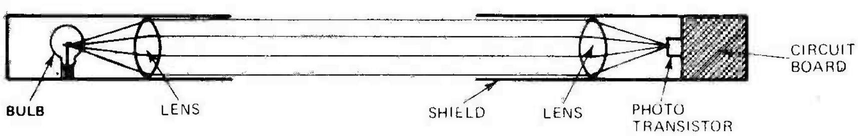


Fig. 15. Arrangement of light beam transmitter and receiver.

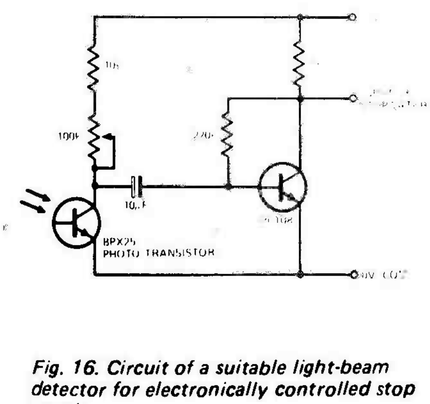


Fig. 16. Circuit of a suitable light-beam detector for electronically controlled stop watch.

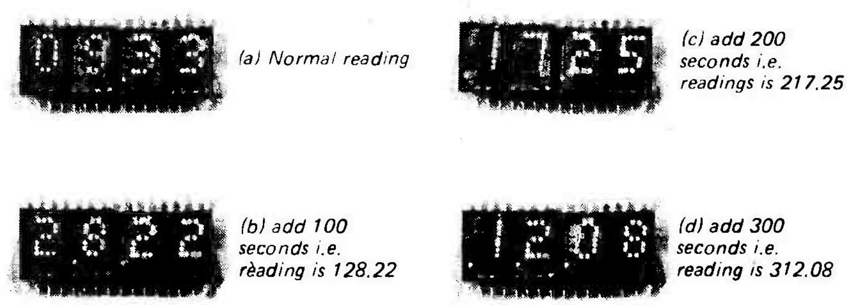


Fig. 17. Method of extending timing range.

TABLE I

STATES OF IC18

	PIN 10	PIN 11	PIN 14	PIN 15
RESET	1	0	1	0
START	1	0	0	1
STOP	0	1	1	0

note that 1 means $>$2.8 V, 0 means $<$0.8 V

TABLE II CONNECTIONS FOR DIFFERENT RESOLUTIONS

RESOLUTION (SECS)	MAXIMUM & INDICATED TIME	CONNECT TIME BASE OUTPUT (SW 1/1) TO	CONNECT DECIMAL POINT TO
* 0.1	3999.9 secs	PIN 12 of IC7	PIN 4 of IC16
* 0.01	399.99 secs	PIN 12 of IC6	PIN 4 of IC14
0.001	39999 msecs	PIN 12 of IC5	NO CONNECTION
0.0001	3999.9 msecs	PIN 12 of IC 4	PIN 4 of IC16
0.00001	399.99 msecs	PIN 12 of IC 3	PIN 4 of IC14
0.000001	39999 μsecs	PIN 12 of IC2	NO CONNECTION

* Standard on stop watch as published. All ranges may be included by using a rotary switch in place of SW1.

Note: An additional error of ±½ digit occurs on 1 μsec range. In laptime mode 3, IC20 and IC21 contribute a 2μ sec delay. Mechanical switches are not suitable for very short resolutions, electronic means must be used.

TABLE III

1ST POINT	2ND POINT	READING	
OFF	OFF	as indicated	(a)
OFF	ON	add 100 seconds	(b)
ON	OFF	add 200 seconds	(c)
ON	ON	add 300 seconds	(d)

The four-digit display is capable of reading to 99.99 seconds (0.01 sec resolution) after which it recycles to zero and commences a new cycle. The maximum reading however is extended to 399.99 by using the two leftmost decimal points to count display cycles.

The count cycle is given in Table III and Fig. 17 where the decimal points are numbered from left to right.

When on 0.1 second resolution the maximum displayed time is 999.9 seconds and thus 1000, 2000 or 3000 seconds must be added as appropriate.

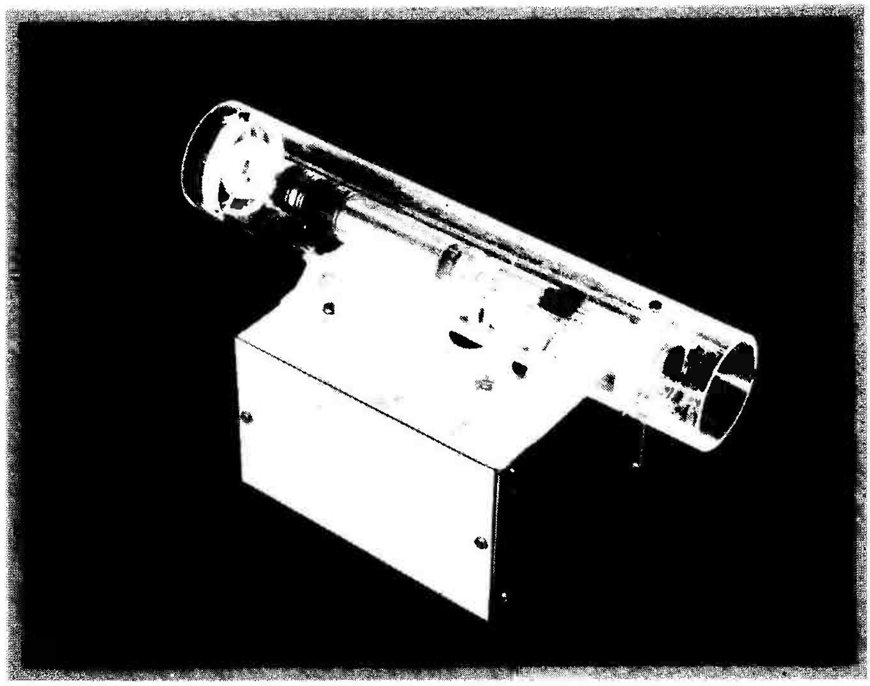
The viewing tunnel in position.

A typical light beam set-up is illustrated in Fig. 15, and a suitable transistor detector/amplifier in Fig. 16. A certain amount of mechanical work is required, as the light output of the globe must be focused into a parallel beam by a lens. A lens in the receiver must also be used to focus the light onto the "active spot" of the photo-transistor. A light shield should extend in front of the receiver lens to prevent operation of the detector due to sunlight etc.

After the transmitter and receiver are mechanically aligned the 100 k potentiometer should be adjusted to provide about 1.5 volts across the photo-transistor. When the beam is broken the voltage across the photo-transistor should rise to four volts or more. Almost any available NPN photo-transistor may be used. ●

LOW POWER LA

Helium-neon laser can be used for communications, and innumerable applications in every area of science



The ETI laser – note the 9.5 mm thick perspex rings mounted within the tube to take the support screws. These rings and the tube mounting base were made from small off-cut of the material which can be obtained from any acrylic supply house.

IN the past ten years, lasers have enabled scientists to know more about physics than the combined efforts of all previous scientific endeavour.

From demonstrations of basic principles, to, 'sawing' up unwanted buildings, providing sight lines for surveyors, to shooting down enemy missiles, applications for lasers are virtually unlimited.

Until recently, lasers have been totally out of the realm of all but the wealthiest amateur experimenter.

But now, simple helium-neon laser tubes are available at reasonable cost. It is absolutely practicable for the amateur to build a working laser for about £300.

The helium-neon laser is simply a 'cold-cathode' type of gas tube with mirrors mounted internally to 'generate' the lasing action, (a full description of the operating principles of this, and other, lasers was published in ETI August 1973 issue).

To energize the laser, a suitable high voltage power supply must be used. This supply is in fact the major part of this constructional project.

The characteristics required are shown graphically in Fig. 1(a).

Over the range OA, very little current is drawn and no light is given off – this is known as the 'dark discharge' or 'Townsend' discharge region. At point 'A' (about 6kV for the suggested tube) a breakdown occurs and the dark discharge changes to the characteristic orange-coloured, neon-glow discharge i.e. the tube is 'fired'. Region A to B is the region in which this glow discharge continues. However at C, a further breakdown occurs and the glow discharge becomes an arc discharge.

The glow discharge and arc discharge regions are characterised by successively lower voltages and higher currents, i.e. there is a 'negative resistance' characteristic.

The laser tube must be operated at an optimum point that is determined by tube parameters such as gas pressure, discharge length and optical volume in the arc discharge region. For the tube the specified operating point is 900V at 5mA. The laser power supply must hence perform the dual role of:–

1. Supplying at least 6 kV at low current to fire the tube, and
2. Supplying 900V at 5mA to 'maintain' the tube.

A suitable circuit, that does just this, is a modified form of the Cockcroft

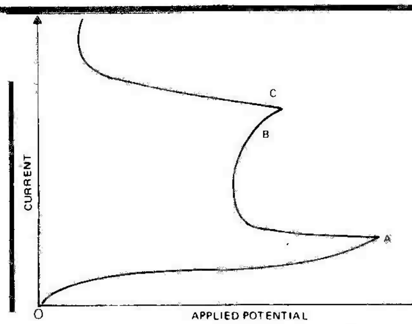


Fig. 1(a). Characteristic V1 curve for a low pressure gas discharge tube.

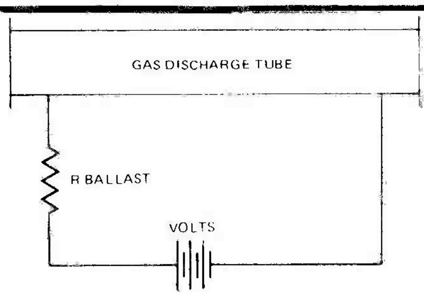


Fig. 1(b). A ballast resistor is required to counteract the 'negative resistance' characteristic of the tube.

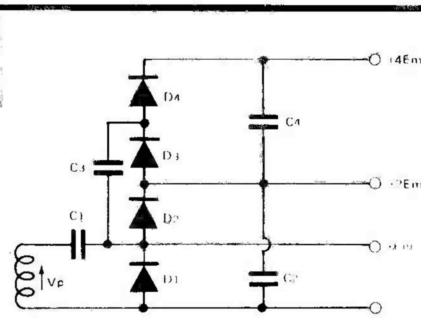


Fig. 2. The basic Cockcroft-Walton voltage quadrupler circuit.

SER

A major article accompanied this feature when it first appeared describing accessories and experiments that can be made using this laser. Back numbers are not available but a set of photostats are available from Electronics Today International, 25-27 Oxford Street, London WIR 1RF for 55p including postage.

ETI PROJECT

LASER TUBE DATA

Model	LGR7621 (Siemens)
Beam divergence (milli-radians)	3.0
Beam diameter (for one tenth intensity)	1.3mm
Trigger volts	6kV
Operating volts	900V
Tube length	220mm
Tube diameter	29mm
Ballast resistor	100k
Maximum current	5.5mA
Light output power	1mW at 6328A (Mode TEMmnq)

PARTS LIST

R1,2,3,4,	Resistor	22 k	1 Watt	5%
R5,6	"	27 k	1 Watt	5%
R7	"	12 k	1 Watt	5%
R8	"	6.8 k	1 Watt	5%
R9	"	3.3 k	1 Watt	5%
R10,11,12,13	"	1 M	½ Watt	5%
R14	"	33 k	"	"
R15	"	2.2 k	"	"
VDR1	Voltage Dependent Resistor	220V,1mA,800mW (Home Radio,240 London Road,Mitcham,Surrey CR4 3HD)		
C1	Capacitor	50pF	6.5kV min	disc ceramic
C2	"	0.01μF	3kV	" "
C3	"	1000pF	4kV	" "
C4,5,6,7	"	8μF	500V	electrolytic
C8	"	10μF	25V	"
D1-D16	Diode	1N4007		
Q1	Transistor	MJE340		
Laser Tube		LGR7621	see box	
T1	Transformer	240V to 1325V, 13mA see box		
SW1	Switch	Double pole on-off		

See text and photograph for mechanical components such as box and tube.

The Laser tube LGR 7261 is made by Siemens and can be ordered from: A. Marshall (London) Ltd., 40-42 Cricklewood Broadway, London NW2 3ET. Price is £230 plus VAT. Transformer type MT141 available from: Douglas Electronic Industries Ltd., Thames Street, Louth, Lincs. Price is £6.50 inclusive of VAT and postage.

Walton, voltage-multiplier circuit. The basic configuration of this is shown in Fig. 2.

The 'modification' is simply the choice of capacitor values. C_1 is chosen to be quite large (by a factor of 100) with respect to C_2, C_3, and C_4; and C_2, C_3, and C_4 are chosen such that under light loading, as is present before the tube actually 'fires', (i.e. in the 'dark discharge' region,) the circuit does in fact operate as a voltage multiplier but, under the heavier loading of the glow discharge, these capacitors cannot hold the necessary charge for the circuit to continue operating as a voltage multiplier. Since C_1 is larger than these capacitors, and *can* maintain sufficient charge, the circuit now acts as a simple half wave rectifier with D_1 and C_1.

To overcome the negative resistance characteristic of the laser, a ballast resistor is inserted in series with the anode (or cathode) lead to the tube. There is usually an optimum value specified for this resistor, but it is not critical and can be varied to obtain correct tube operating voltage.

ETI have made arrangements with

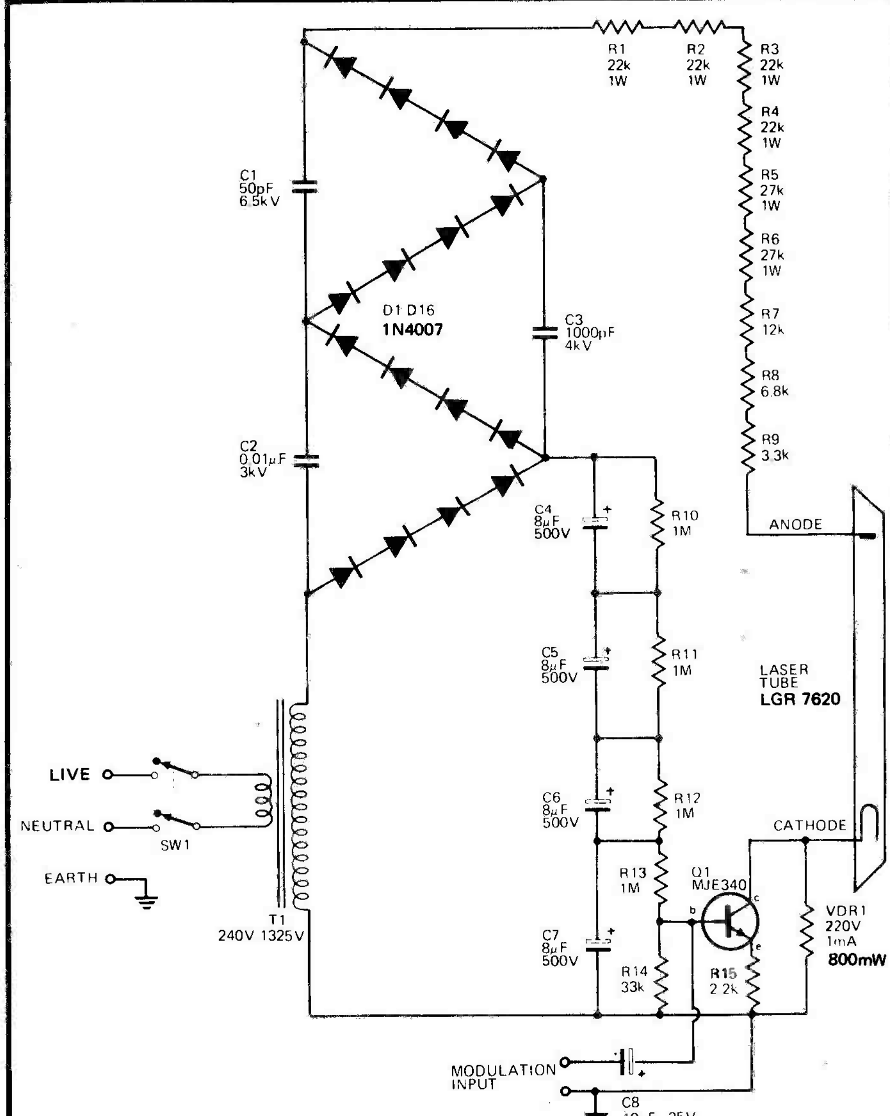


Fig. 3. Circuit diagram of the laser power supply.

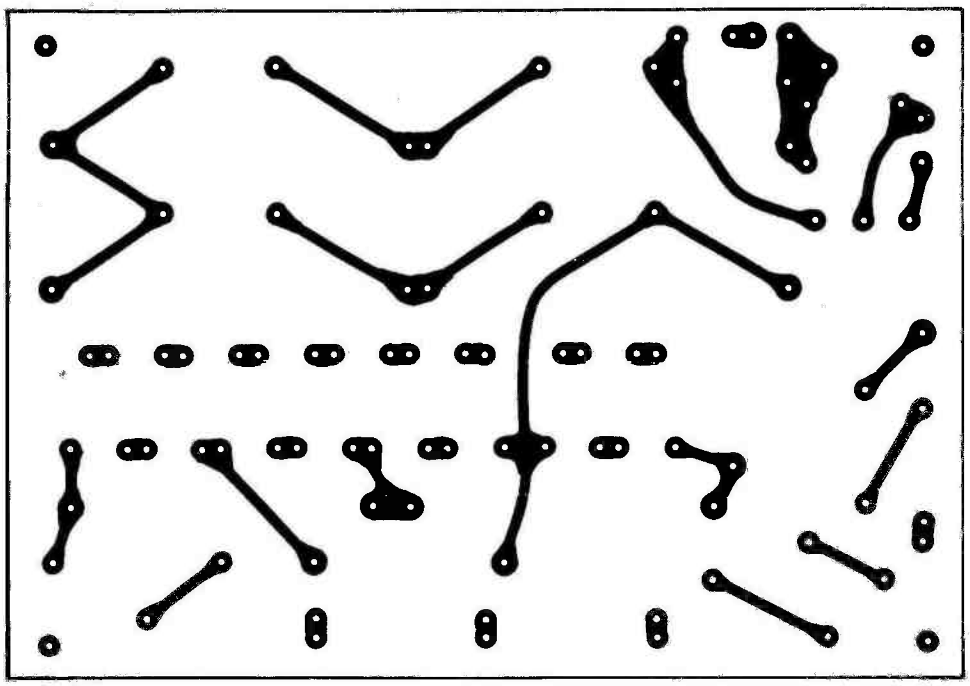


Fig. 4. Printed circuit board layout for the laser power supply.

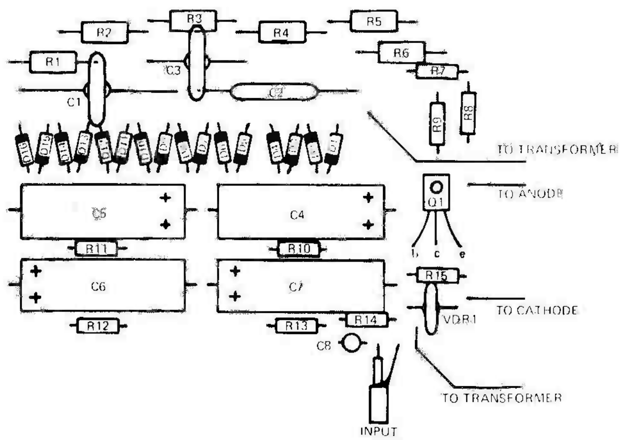


Fig. 5. Component overlay.

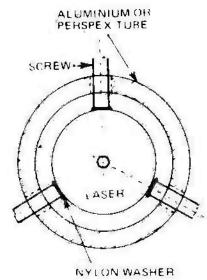


Fig. 6. Proposed method of mounting the laser tube. If perspex tubing is used a reinforcing piece may be required (see photo of laser).

Douglas for the supply of suitable transformer for T1. This has a secondary of 1325V at 13mA.

This, after half-wave rectification, becomes 1870 volts peak and when multiplied provides 7.5 kV which is sufficient to cause the tube to strike (more than 5 kV).

This simple power supply circuit would operate the tube satisfactorily but it can be considerably Improved to provide better output stability and reduced ripple and quantum noise on the output. This is achieved by maintaining constant tube current by means of a constant current regulator incorporated in the cathode lead. (Transistor Q1).

Varying the current through the laser tube will vary the coherent light output proportionally, and hence, a signal applied to the base of the regulator transistor will cause the laser output to be modulated. The modulation source should not exceed one volt peak (to avoid clipping). The voltage dependent resistor, VDR1, is incorporated to prevent the laser being cut off by over modulation which would result in Q1 being destroyed.

CONSTRUCTION

Mount the components to the PC board in accordance with the component overlay. The board, after the interconnecting wiring is attached, is mounted on 12 mm spacers in one end of the box. The transformer, switch, input jack and mains input cable are fitted to the other end.

The tube itself may be mounted in a variety of ways, as long as there is not a heat source, or heat sink, near the body of the tube. Uneven temperature gradients along or across the tube may cause buckling and consequent minor mirror misalignment.

A good simple method of mounting the tube is to use a three point mounting for the tube at both ends of a piece of aluminium or perspex tubing. The tubing will need to be about 50 mm inside diameter and about 305 mm (12 inches) long. Distance between the mounting points will depend on the type of tube used.

The perspex has the advantages of insulation and transparency so that the tube may be seen (for school demonstrations etc). However the orange glow from the gas discharge may be a nuisance in some experiments. We cemented our perspex mounting tube to a 3/8 perspex base, and drilled holes through the combined base and tube to accommodate the anode and cathode leads.

The lead from the ballast resistance to the pin connection of the tube should be as short as possible. Connection to the pins must be made with small clips. DO NOT FORCE the clips onto the pins, but use a gentle twisting movement. DO NOT attempt to solder to the pins. The pin-to-glass seals are extremely fragile.

Remember also that the voltage on the tube is high — **THIS IS LETHAL** if due care with insulation and layout is not taken.

ADJUSTMENT

When the laser is switched on it will be necessary to adjust the ballast resistance such that 100 volts is obtained across the collector to emitter of Q1. This will also ensure that the tube operates in the correct current range.

THE LASER TUBE

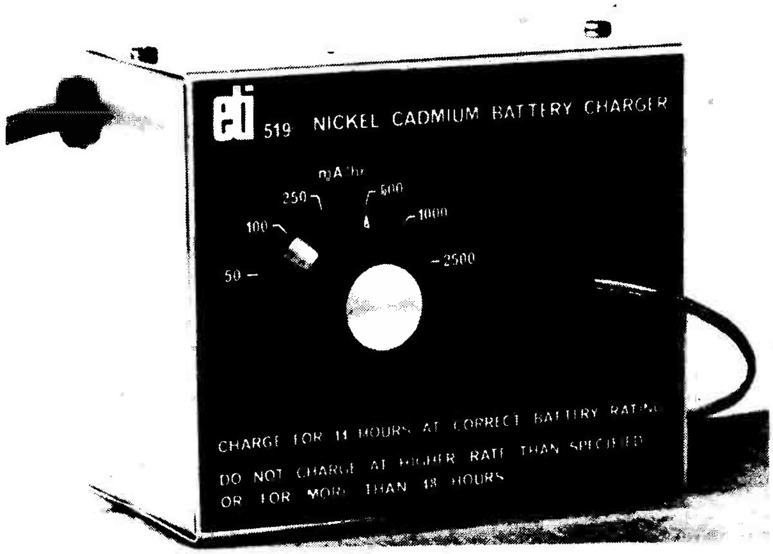
The LGR762 has a multimode output that is several spatial modes propogate in the cavity resulting in a multi-spot output.

The LGR762 has prealigned mirrors and so no adjustment is necessary. A data sheet will be sent out with each tube which gives details of connections.

NICKEL-CADMIUM BATTERY CHARGER

Universal unit will charge practically any nickel-cadmium battery currently in use.

eti project



THERE is an increasing proliferation of portable equipment, such as flash guns and calculators, which could, or already do, use rechargeable batteries of the nickel-cadmium type.

If the equipment was originally fitted with rechargeable batteries, a charger may well have been provided. But when replacing ordinary dry cells with rechargeable types a charger will be required. Unfortunately, nickel-cadmium battery packs come in a variety of voltages and ampere-hour ratings and a charger supplied for one piece of equipment (eg, an electronic flash) will seldom, if ever, be suitable for other equipment such as an electronic calculator.

The ETI 519 battery charger will charge almost any nickel-cadmium battery in use today. The charging rate is switch-selectable for batteries from 50 mA/h to 2500 mA/h capacity.

Any battery voltage up to 20 volts is *automatically* accommodated. No voltage selection is required.

Charging time is approximately 14 hours for a flat battery and proportionally less for one that is partially discharged.

Overcharging at the correct ampere/hour rate will not damage a nickel-cadmium battery. Thus an overnight charge for a partially discharged battery may be safely given. In fact, provided the correct ampere/hour charging rate has been selected no damage will occur if left on charge for 48 hours.

CONSTRUCTION

The circuit is a very simple one. Practically any method of construction may be used provided care is taken with the insulation of 240 Vac wiring.

In our prototype unit we assembled all components on tag strips, with the exception of the range resistors which were mounted directly on the range switch itself.

If only a single range is required, a

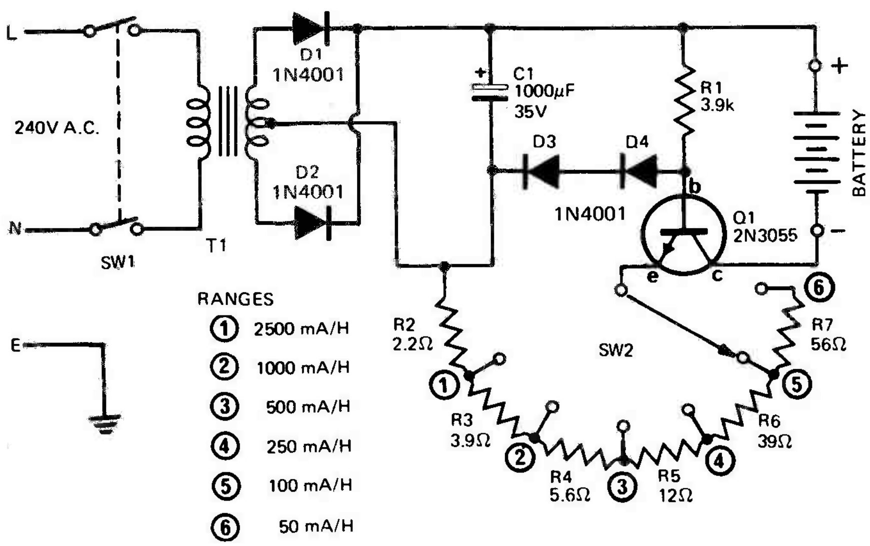


Fig. 1. Circuit diagram of the Nickel-Cadmium Battery Charger.

TABLE 1

BATTERY VOLTAGE	TRANSFORMER**	R1
1.25—3.75	12.6 V CT	1.8k
5—10	24 V CT	2.2k
11.25—20	40 C CT	3.9k
21—30*	60 V CT	5.6k

* Capacitor C1 voltage rating should be 50V.

** Current rating of the transformer, in mA, should be greater than the maximum mA/h battery rating divided by 10. A single winding transformer of half voltage may be used if a bridge rectifier is employed.

single resistor may be used. Its value in ohms should be 6000 divided by the mA/h rating of the battery. The nearest 5% nominal value to that calculated as above will be adequate.

By virtue of the nature of the constant current supply any battery, or bank of batteries up to 20 volts may be charged. If the 20 volt capability is not required a different transformer may be used as detailed in Table 1.

The transistor dissipates a fair amount of heat and hence should be mounted on a piece of aluminium to act as a heatsink. This piece of aluminium should be insulated from the case, or if not, the transistor should be mounted on the aluminium via a mica washer and insulating bushes. ●

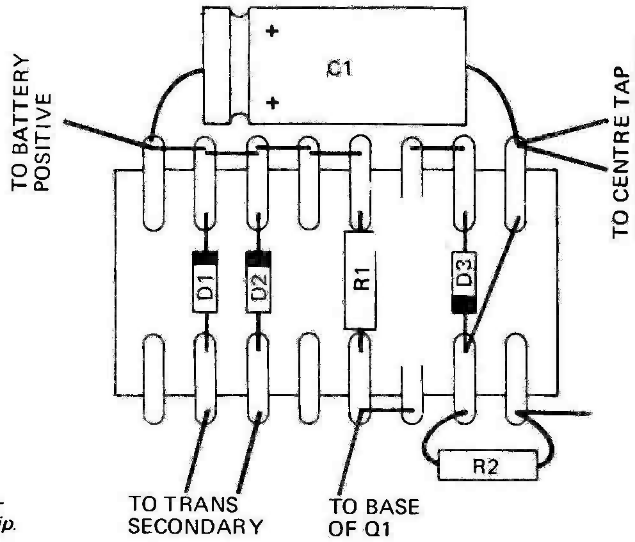
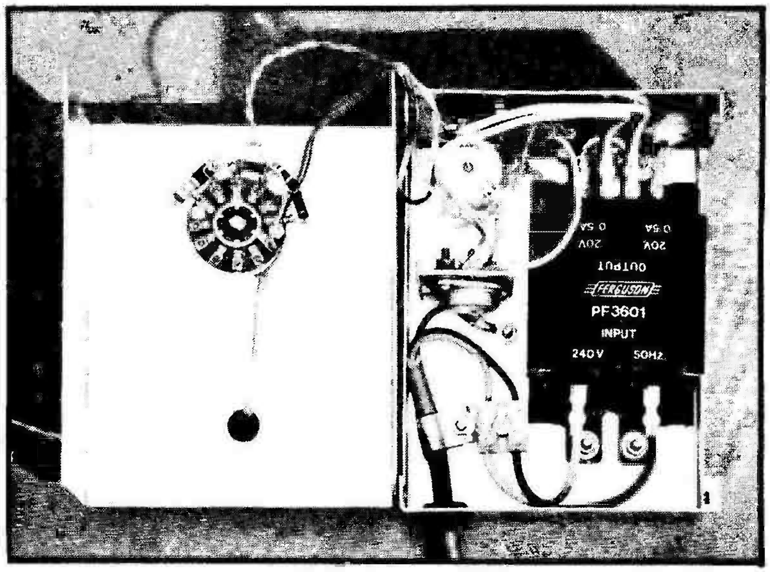


Fig. 2. Layout of components on the tag-strip.



HOW IT WORKS

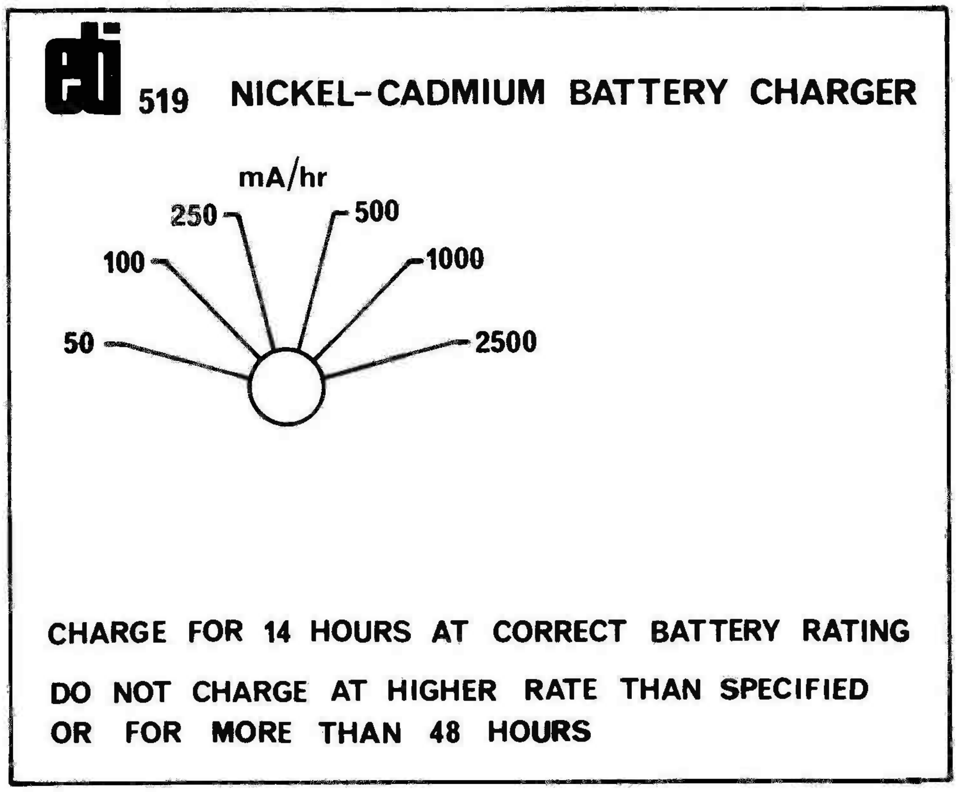
Current regulators operate in opposite fashion to voltage regulators. In a current regulator, the current remains constant regardless of changes in load impedance – the output voltage varies to maintain constant load current.

In this circuit, the 240 Vac mains is reduced by T1 to 40 Vac. This is then rectified by D1, D2 and filtered by C1 to provide approximately 28 Vdc.

This dc supply is then regulated by Q1 and its associated components to produce a current level selected by SW2.

Transistor Q1 is biased by D3 and D4 such that there is about 1.2 V between the base of Q1 and the negative side of C1. As there is 0.6 V between base and emitter of Q1, there will be 0.6 V developed across the resistor network R2-R7. Therefore the emitter current of Q1 must be 0.6 V divided by the resistor value selected by SW2.

The emitter current generated as above will produce an approximately equal collector current which charges the battery and remains constant provided there is at least one volt between the collector and emitter of Q1.



PARTS LIST
ETI 519

R1	Resistor	3.9k	½W	5%
R2	"	2.2Ω	"	"
R3	"	3.9Ω	"	"
R4	"	5.6Ω	"	"
R5	"	12Ω	"	"
R6	"	39Ω	"	"
R7	"	56Ω	"	"

D1-D4 Diodes 1N4001 or similar
C1 Capacitor 1000μF 35V electrolytic
Q1 Transistor 2N3055
T1 Transformer 240V/20-0-20VA 500mA
SW1 Two-pole on-off switch
SW2 Six-position single-pole rotary switch
Metal box, bracket for 2N3055, 3-core flex and plug.

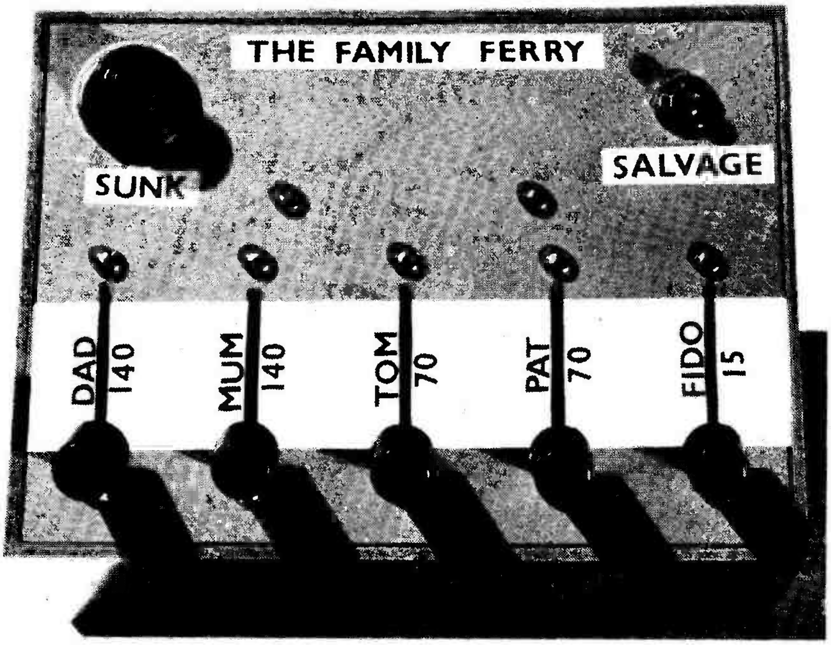
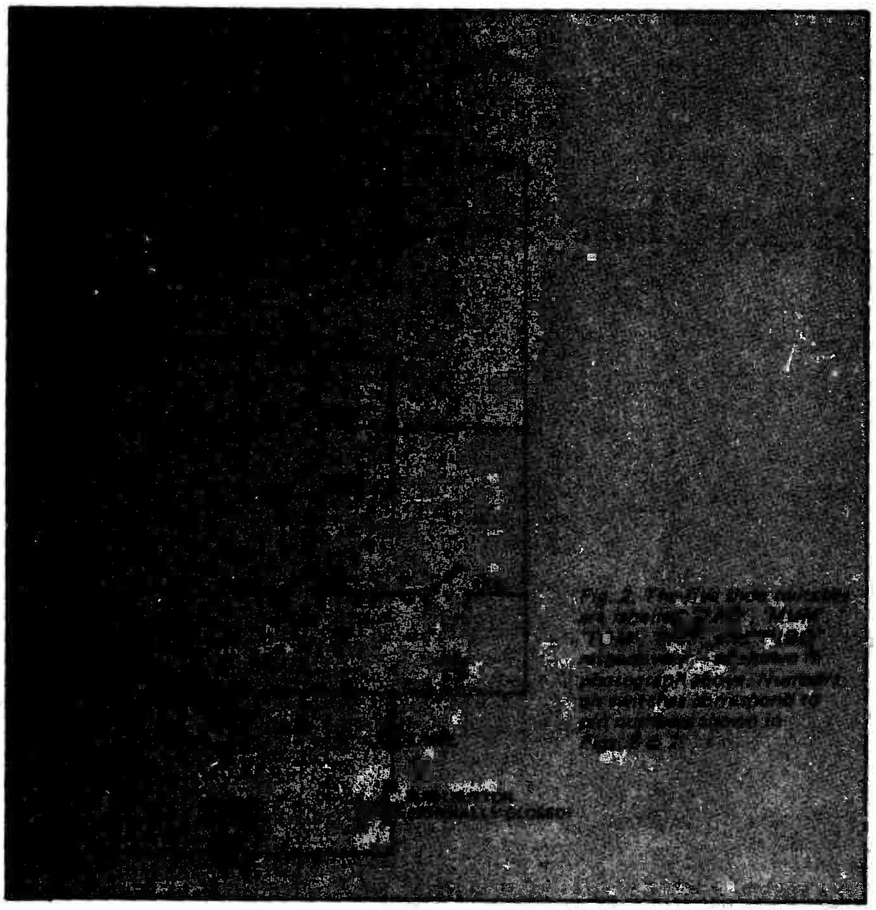


Fig. 1.

THE FAMILY FERRY

An old problem updated – electronically



THE ORIGIN of this problem is not known. The writer heard it a while back, and thought it would be fun in electronic form. So here's the story:

> A family comprised Dad, who weighed in at 140 lbs, Mum, who also tipped the scales at 140 lbs; son Tom – 70 lbs, and daughter a nimble 70 lbs, plus Fido a well fed dog of 15 lbs. They all came to a river which they wanted to cross. In the boat which was tied up there, was a notice which read 'CAUTION! MAXIMUM LOAD 150 lb.' Now this river was infested with crocodiles, so no one was keen on swimming. Problem: how did all the family get across the river?

The circuit is arranged so that the alarm operates while switches are being moved from side to side – if the total load they represent exceeds 150 lbs.

Each member, including the dog, is represented by a three-position lever switch.

Only the contacts in the middle position are used, as they are closed while the levers are passing through the 'dangerous' position, i.e., while people are in the boat. Fig. 1 illustrates the arrangement. The alarm is a red pilot lamp marked SUNK.

The circuit is shown in Fig. 2. The lever switches used are 3-pole three position, although the links between poles are not shown in the circuit. All the levers are shown in one side position, and they close circuits only momentarily as they pass through their centre positions. This brief contact applies a voltage to the gate of the silicon controlled rectifier SCR, which turns it on and leaves it on, thus leaving the SUNK light turned on. The moving contacts on the switches are so wide that if the switches are moved reasonably together there is no chance of failing to make a circuit when one should be made.

To reset the game after the boat has been sunk, a SALVAGE push button is provided. This is a normally closed push button, which, on being pushed, simply opens the circuit momentarily

PARTS LIST – ETI 230

R1	Resistor	1k	½W	5%
R2	"	3.3k	"	"

Switches 5 by 3 pole 3 position rotary
1 by normally closed push button.
SCR1 Silicon controlled rectifier C106 or similar
4.5 volt battery, 4.5 volt pilot lamp.

and so turns off the SCR — unless the switches have been left in a 'sunk' arrangement.

A study of the circuit will show that the lamp is turned on if any circuit is made between the right and left hand side lines. The switches between these lines are such that, in all dangerous situations, a circuit IS made. No main switch is provided as the leakage through the SCR is negligible.

CONSTRUCTION

This project was assembled on an aluminium panel in a plastic box. The underside view of the panel is shown in Fig. 3. The SCR and two resistors involved are mounted on a tag strip, as shown in Fig. 4 and the wiring diagram.

Switches should be assembled first, and wired one by one as they are mounted — there is too little space to get at all the terminals once they are all mounted.

The switch wiring is shown in Fig. 4, where each dot represents one of the 12 terminals on each switch. The terminals on the switches are not actually numbered, but the numbers given to them in the right hand column of Fig. 6 relate to the positions indicated by numbers in the switch diagram in Fig. 5.

After mounting and wiring the switches the tag strip should be wired and mounted. An aluminium clip was made to hold the flat 4.5 volt battery, and this was anchored by the tag strip mounting screws. The pilot lamp and push button should be mounted and wired last.

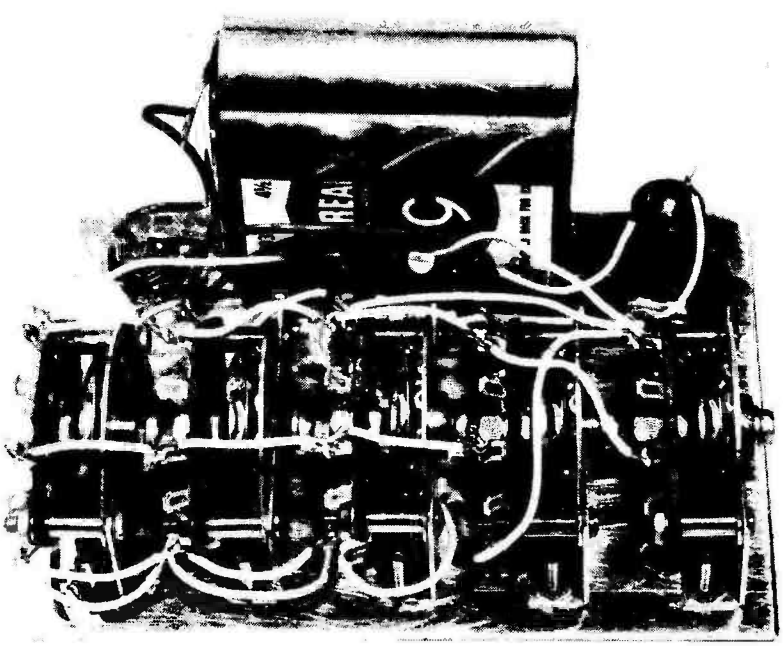


Fig. 3. Underside view of the front panel showing how switches are mounted.

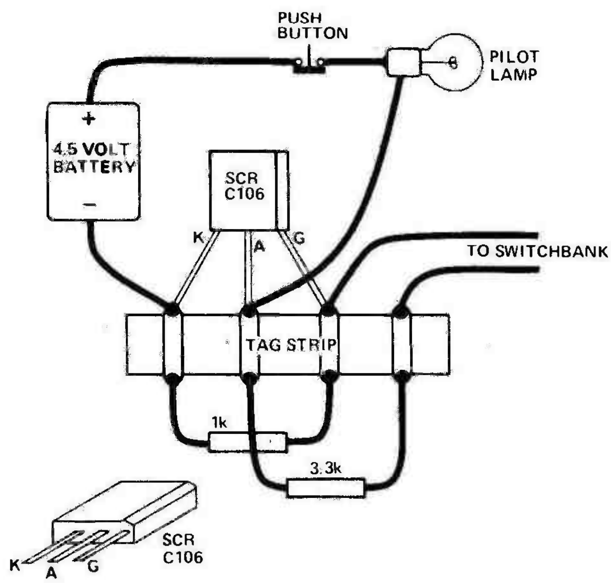


Fig. 4. Schematic of the connections to the tag strip.

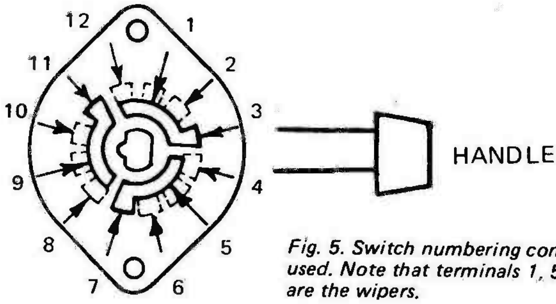


Fig. 5. Switch numbering convention used. Note that terminals 1, 5 and 9 are the wipers.

CHECKING

Each of the 'dangerous' conditions should be set up to see that the SUNK lamp comes on as it should. If there is any difficulty with the SCR turning on, the value of R2 may be reduced. The value shown suits the SCR specified, but other SCRs with less sensitive gates may need more current to trigger them, and so the resistor may be reduced to suit.

Incidentally, if you can get this family across the river safely in less than eleven crossings, let's know how you do it! ●

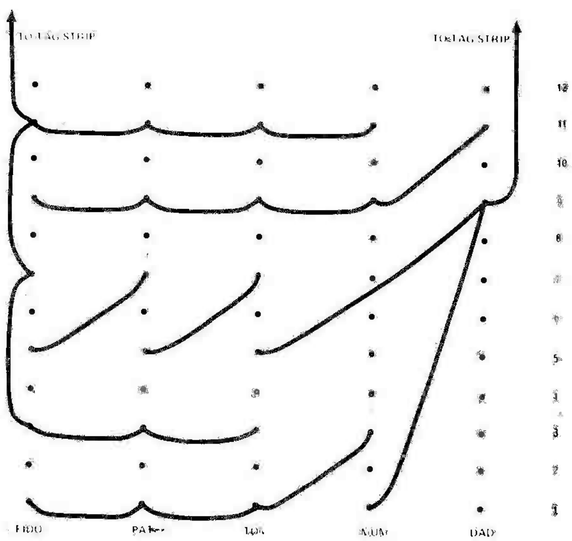


Fig. 6. Method of wiring the switches. Pin numbers at side are the same as those shown in Fig. 5.

EARTH RESISTIVITY METER

From gold to archaeological remains — this simply constructed instrument will assist your prospecting.

AS the article on page 121 explains an earth resistivity meter can be used to identify the composition of various earth strata — and the depth at which each strata occurs — and by detecting changes in earth composition, to point to the existence of buried objects.

An earth resistivity meter may be used to locate archaeological objects — to assist in finding conditions favourable for alluvial gold or gestones, or even for such prosaic duties as determing where to locate a septic tank!

These instruments are not expensive compared with most electronic instrumentation. Nevertheless at £250 or so they are way above the budget of most amateur archaeologists or rock-hounds.

But for such people all is not lost — it is possible to construct a simple dc operated resistivity meter for a mere fraction of the price of commercial units.

For this to be possible we have to accept a few operating limitations — primarily of operating depth — for whereas a commercial unit may be used to depths of several hundred feet our unit is limited to fifty feet or so. But unless you are hoping to locate oil bearing deposits in your garden the limitation on operating depth should not be a problem.

The basic instrument is extremely simple — four equally spaced electrodes are placed in line in the earth. An accurately known current is caused to flow from one outer electrode to the other — and a measurement is taken of the voltage between the two inner electrodes.

Having measured both voltage and current, a simple formula (explained on page 121) is used to establish depth and composition of the strata.

Professional earth resistivity meters use alternating current across the earth electrodes in order to eliminate the effects of the small galvanic voltages caused by the earth.

This effect cannot be totally eliminated with dc instruments but it can be minimized by switching the battery across the electrodes in alternate polarities — a centre position of the switch (SW2) meanwhile short-circuits the two centre electrodes between readings to discharge the galvanic potential.

Figure 1 shows the circuit diagram of the instrument.

We have not provided any mechanical assembly drawings, for this will depend almost entirely upon the meters used. A pair of cheap multimeters are ideal — but if these are not available then a voltmeter and a milliameter with switchable ranges should be used. The milliameter should be capable of measuring from microamps to a maximum of 100 milliamps or so, the voltmeter should cover a range from approximately 100 microvolts to three volts or so and should have a sensitivity of about 20,000 ohms per volt.

Switch SW2 is a three-pole four-way wafer switch. All switching contacts are located on one wafer. Each of the four segments shown in the circuit diagram (ie. SW1 SW2 etc) consists of a wiping contact and three fixed contacts — the connections will be readily apparent when the circuit diagram is compared with the switch.

The ground probes should ideally be made of copper coated steel or brass — however electrodes made from ½" to 1" steel tubing or rod will work quite well as long as they are kept clean. It is of course essential that they make the best possible contact with the surrounding earth. Electrode cable connections must be securely made using proper terminals — remember that you are looking for fairly minor changes in earth resistance.

Operating voltage is not critical — a six or twelve volt dry cell is adequate for most applications. ●

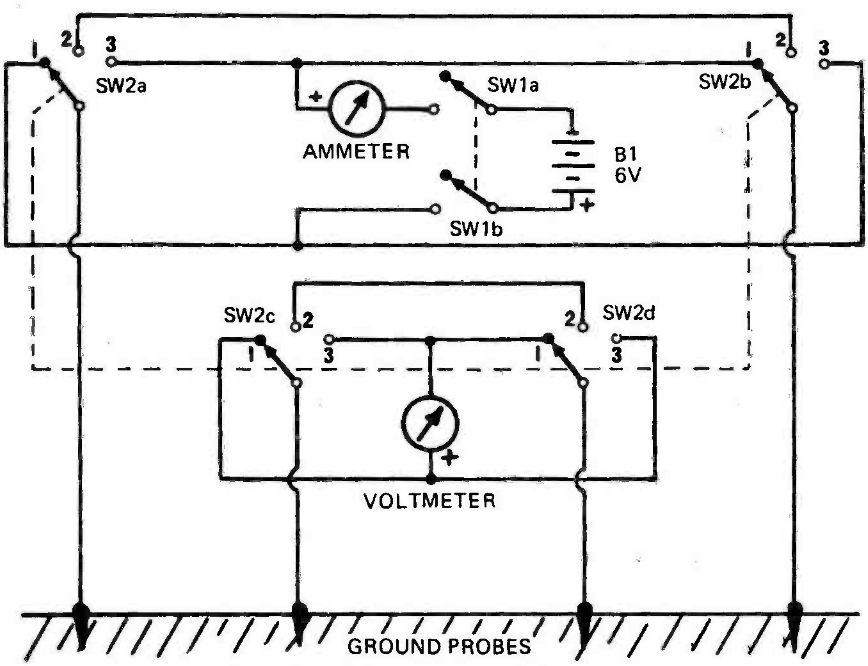


Fig. 1. Circuit diagram of resistivity meter.

Using a resistivity meter

MEASURING EARTH RESISTIVITY

THERE are several methods of measuring soil resistivities, mostly variations of the original method devised by Wenner. This consists of driving four metal spikes (commonly called electrodes), into the ground, at equal intervals along a straight line as shown in Fig. 1.

A current is passed through the outer electrodes C_1 and C_2 and the resulting voltage drop across the earth resistance is measured across the inner pair p_1 and p_2.

If the ground has a uniform resistivity p then

$$p = 2\pi a \, {}^{V}/_{I} = 2\pi a R$$

where 'R' is the apparent resistance measured between the inner potential electrodes.

Generally the current will flow in an arc between the electrodes and hence the depth penetrated will increase as the electrode separation is increased. The effective depth at which R is measured is usually taken as 0.6 times the separation 'a'.

For the greatest accuracy in determining the ratio V/I it is desirable that the current flow I be maximized and hence in dry surface conditions it is common to moisten the soil about the electrodes to reduce the contact resistance. The depth to which the electrodes are inserted must not exceed 1/20th of their separation. This is important if standard curves are to be used for the interpretation of the experimental data.

Having inserted the four electrodes an average value for both V and I must be determined for both polarities of the battery. Reversing the polarity removes the possibility that the earth may have its own potential due to galvanic reactions underground. From these measurements the resistivity p can be calculated.

RESISTIVITY DEPTH SOUNDING

Consider for example the problem of measuring the depth beneath the ground of the water table or perhaps the thickness of soil overlying the bedrock. This type of situation is by far the most common — where a layer of resistivity p_1 and thickness 'd' is overlying a layer of different resistivity p_2.

We can determine the depth 'd' with the aid of 'standard curves'. The procedure is to measure the resistivity of the ground each time the electrode separation 'a' is increased about a central point. To use the standard curves provided it is necessary to plot the measured resistivity (p) on the vertical axis, against the electrode separation distance on log/log graph paper.

The standard curves provided (Fig. 2), are also constructed on log/log graph paper i.e. graph paper that is ruled in both directions at logarithmic intervals. Each major division on the paper corresponds to a power of 10 and is therefore called a decade. We suggest that for plotting your data you purchase semi-transparent paper that has three decades on either axis and a decade separation of 2½ inches. The 2½ inch decade separation is most important as paper having other decade separations will not allow your plotted results to be overlayed on the standard curves. This paper should be readily available from major stationary suppliers.

Figure 3 shows a typical plot of field data overlayed onto the standard curve.

To do this, place your plotted curve over the standard curve and slide it horizontally until you find the standard curve that best matches your plotted curve.

When the best matching curve has been found, note where the vertical axis of the standard curve intersects the 'ab' curve of your plotted data. This line extended vertically downwards to intersect the 'electrode separation' axis of your plotted data will show the depth of the first layer — in our example this is 4.25 metres.

We know from our plotted data that the resistivity p_2 is about 1000 ohms/metre and the standard curve that is a best match shows a p_2/p_1 ratio of one tenth, that is p_2 equals 0.1 p_1.

Thus p_2 is approximately 100 ohms/metre. Relating these figures to Table II we see that the most likely strata formation is two layers of sandstone of different densities — or a top layer of sandstone and a lower layer of limestone.

From the section bc it is possible to calculate the resistivity and depth of the second layer but this requires the use of a second set of auxiliary standard curves. These are very complex and beyond the scope of this article. Similarly section cd provides data on the third layer and so on. There are a number of standard texts on such measurement and the interested experimenter should refer to these for further information.

RESISTIVITY TRENCHING

Another common application of the resistivity meter is in searching for buried objects such as large water mains, buried stream beds or underground sewerage tunnels. The method used is simply to decide approximately at what depth the object is likely to be found, and divide the distance by 0.6 to give a suitable electrode separation. Maintaining this same separation, the array of all 4 electrodes should be progressively moved in a line over the ground being explored. Readings of resistivity should be made at each point and the value plotted against distance moved. (See Fig. 6 page 29) The distance between each reading point should be no greater than half the dimension of

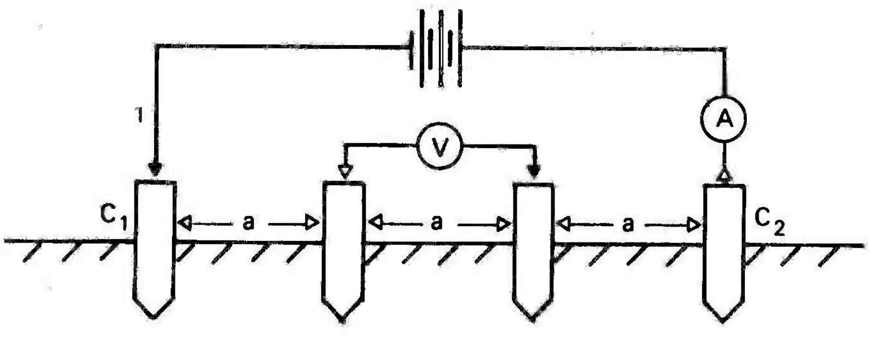


Fig. 1. The electrodes are driven into the ground at equal intervals and in a straight line.

TABLE I

Materials	Resistivity (ohms/metre)
Clay	1-120
Water (fresh)	50
Sandstone	35-4000
Limestone	120-400
Granite	$5000\text{-}10^6$
Sand (dry)	$>10^6$
Marble	$>10^{12}$
Alluvium	Variable
Air	Infinite

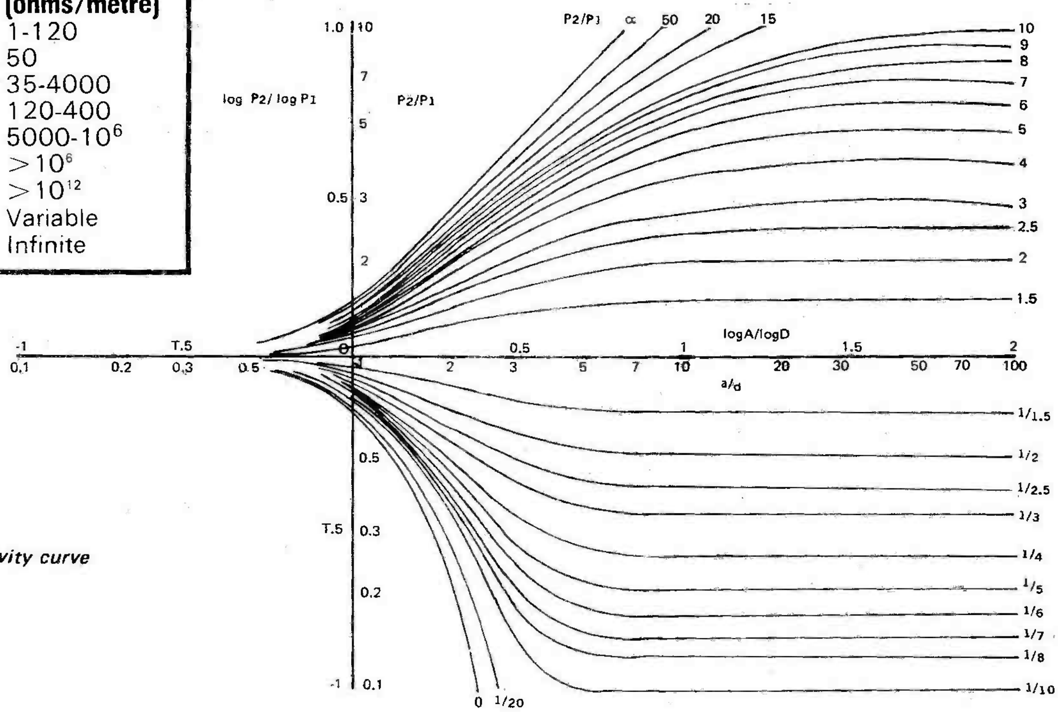


Fig. 2. Standard resistivity curve

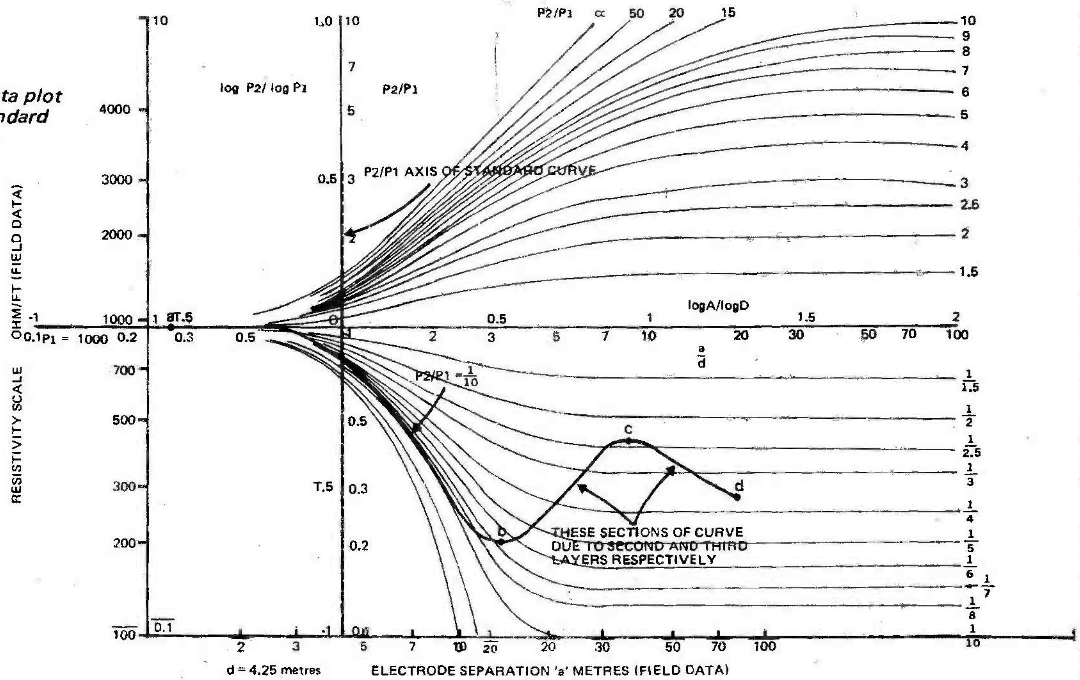


Fig. 3. Typical field data plot superimposed over standard curve shown in Fig. 2.

Earth electrodes should not be inserted into the ground to a depth greater than 1/20th of the probe separation. Because of this, poor electrode/ground contact may result at close spacings. This problem can be reduced by using porous pots filled with copper sulphate solution. Electrodes specifically intended for such work are available from geophysical supply houses.

the object to be located; in fact the closer the readings are taken, the greater will be the resolution.

If it is desired to follow the depth of bedrock beneath the surface, it is best to first carry out a vertical depth sounding to locate the bedrock. Then divide this depth by 0.6 to give the most suitable electrode separation. The depth sound will also tell you whether the bedrock has a higher or lower resistivity (from the ratio p_2/p_1). If p_2 is greater than p_1 then an increase in your measured resistivity will tell you that the basement is getting shallower and vice versa. Alternatively, if p_2 is less than p_1 an increase in resistivity will indicate that the basement is becoming deeper. This method is most suitable for looking for alluvial gold or heavy gemstones which tend to be concentrated in the hollows of the bedrock along alluvial creekbeds. ●

HI-POWER

eti project

Build this high-power strobe for parties, light shows and discotheques.

This high-power strobe light is ideal for use at parties, light shows and discotheques.

It provides a short intense pulse of light adjustable in frequency between one flash per second and twenty flashes per second.

The circuit is unusual in that several strobe lights may be driven from the one basic triggering unit.

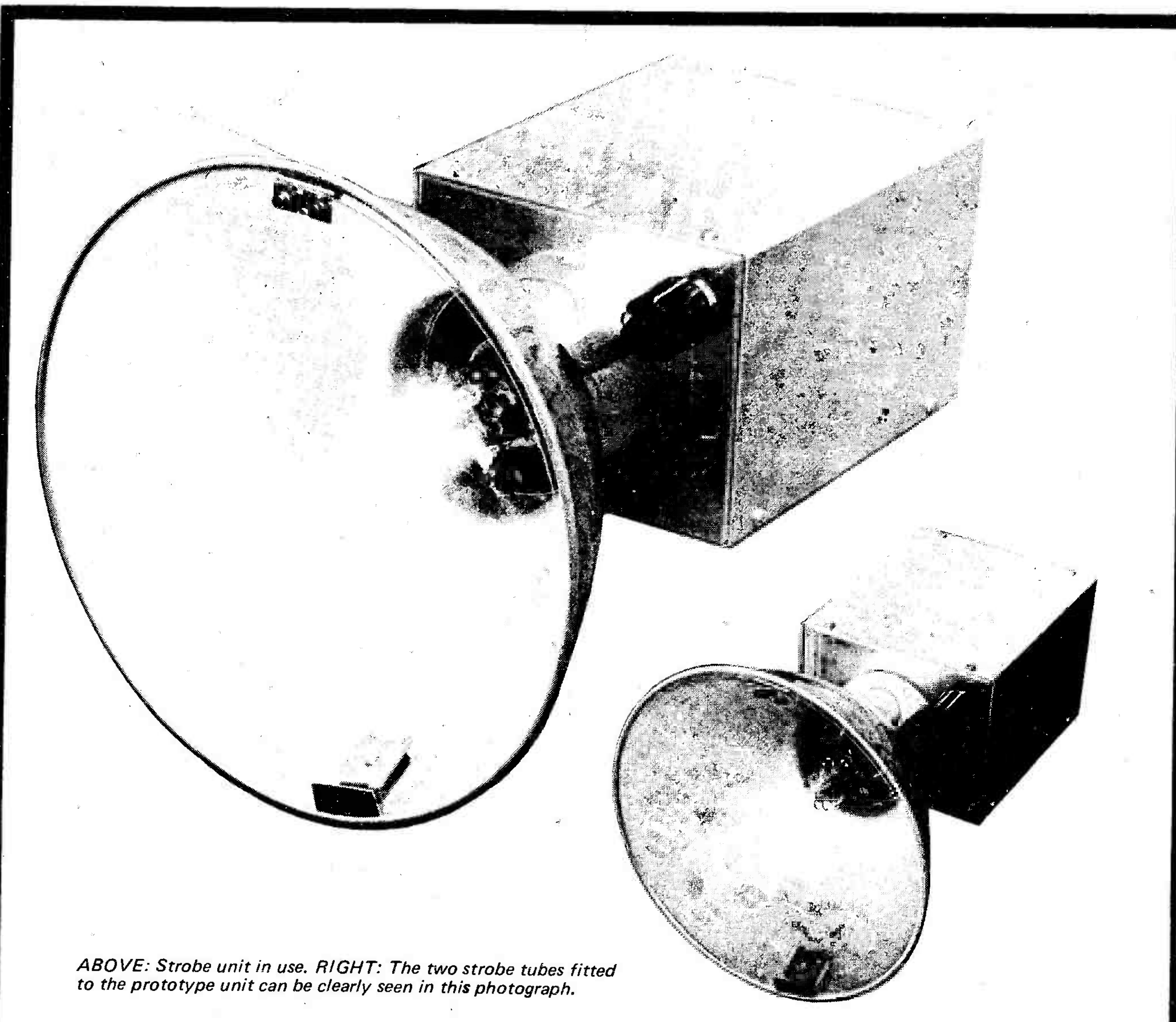
CIRCUIT DESCRIPTION

The circuit of the complete strobe unit is shown in Fig.1.

Diodes D1 to D4 produce positive voltages, at the points marked 'A' and 'B', on alternate half-cycles.

The voltage appearing at point 'A' charges the capacitors C2 and C3, these two capacitors supply the energy for the strobe tube.

Strobe operating frequency is determined by the timing circuit of SCR1, RV1, R2, C1 and LP1/2. Timing capacitor C1 is charged via RV1 and R2 by the positive voltage appearing at point 'B' on alternate half-cycles. When the charge on C1



ABOVE: Strobe unit in use. RIGHT: The two strobe tubes fitted to the prototype unit can be clearly seen in this photograph.

STROBE

exceeds the break-over voltage of the neons LP1 and LP2, these conduct triggering SCR1.

When SCR1 conducts, the timing capacitor C1 discharges through the primary winding of the pulse transformer (T1) and SCR1.

This causes a high voltage spike to be generated in the secondary winding of the pulse transformer, and it is this spike that triggers the strobe tube into conduction.

Capacitors C2 and C3 discharge practically instantaneously through the strobe tube resulting in a brilliant flash of light. Peak current may exceed 60 amps during this short period.

Since both the timing circuit and the storage capacitors are charged by an unsmoothed half-wave supply, neither can conduct for longer than one half-cycle of supply voltage.

The amount of light produced by the strobe tube during each flash is a function of the capacity of C2 and C3. Increasing the size of these capacitors will increase the amount of light but only at the expense of tube operating life. The capacitors specified will provide several hundred hours operation at a light level adequate for most purposes.

A far more satisfactory way to increasing light output is to fire two or more strobe tubes from the main triggering circuit. This is done by connecting the second and further tubes, additional 220 ohms resistors, and 6.5uf storage capacitors, as indicated by the dotted lines in Fig.1.

No modifications are required to the main timing circuit.

If desired the additional strobe tubes may be mounted within the existing single reflector.

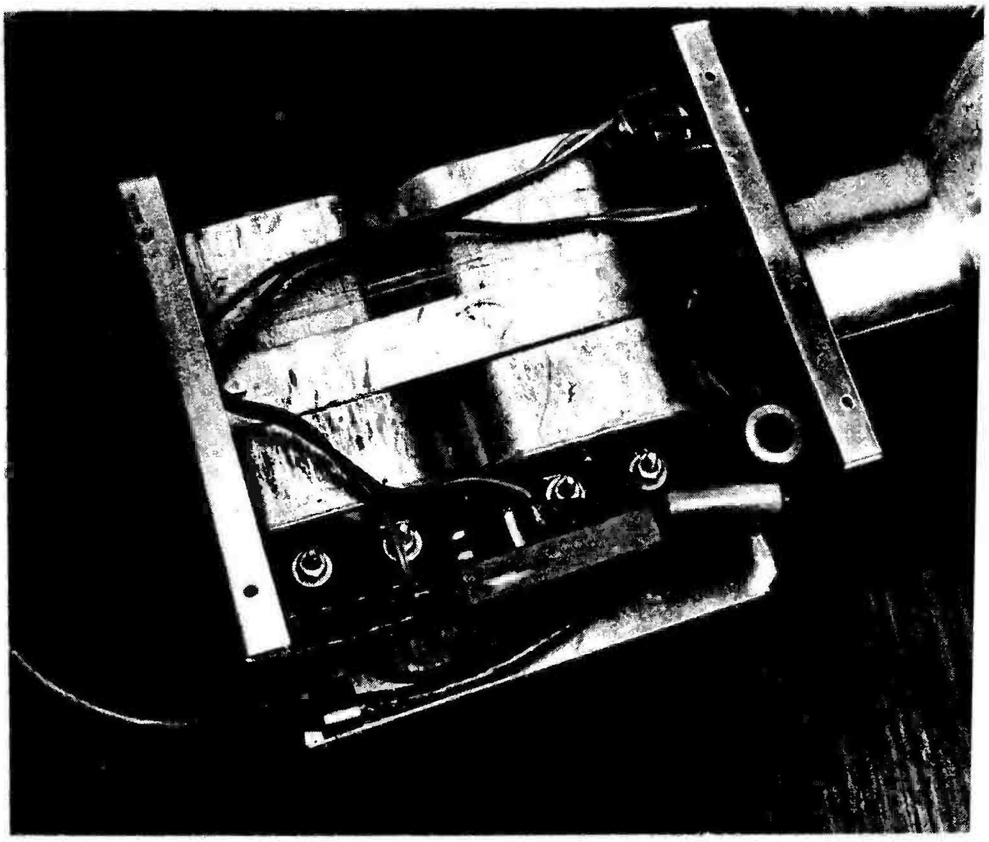


Fig. 5. Construction of the unit -- this particular unit has been constructed to drive two flash-tubes. The additional capacitors and 220 ohm, 10 watt resistor referred to in the text can be clearly seen. The pulse transformer is on the extreme light of the matrix board which in turn is bolted securely to the energy storage capacitors.

CONSTRUCTION

Our prototype unit was constructed from an aluminium case 5¾" x 4½" x 3½" onto which was mounted a 7" diameter photographic type reflector.

The reflector should be fitted with a perspex cover to protect the tube. A suggested method of locating this cover is shown in Fig.2.

The strobe tube or tubes should be soldered into an octal plug. A corresponding octal socket is housed in the base of the reflector (as shown in Fig.2.) This enables the tube/s to be easily removed for replacement.

Since this unit is connected directly to the 240 volt mains, great care must be taken to earth all external metal parts. Unless you are thoroughly conversant with electrical wiring, have the finished unit checked by an electrician.

Component layout is simple and non-critical. Apart from the capacitors and strobe tubes, all components may be mounted on a matrix board or on tag strips.

The storage capacitors are 6.5uf, 250 volt working, paper insulated units of the type used for power factor correction with fluorescent lights. These have been selected for this purpose because they have high discharge current ratings and are readily obtainable from electrical wholesalers. This type of capacitor is larger than the electrolytic variety.

If space is critical, electrolytics of the same capacity, but having a 450 volt dc voltage rating, may be used in their place. They will however require replacement at frequent intervals.

If the recommended type of capacitor is used, the matrix board carrying the remaining components can be bolted to these capacitors' terminals, and the capacitors securely located within the metal case.

LOCATE COMPONENTS SECURELY

All components must be fixed rigidly in position so that there is no possibility of their contacting the metal case. If there is the slightest doubt, insulate the component with tape, and line the interior of the metal case with an insulating board.

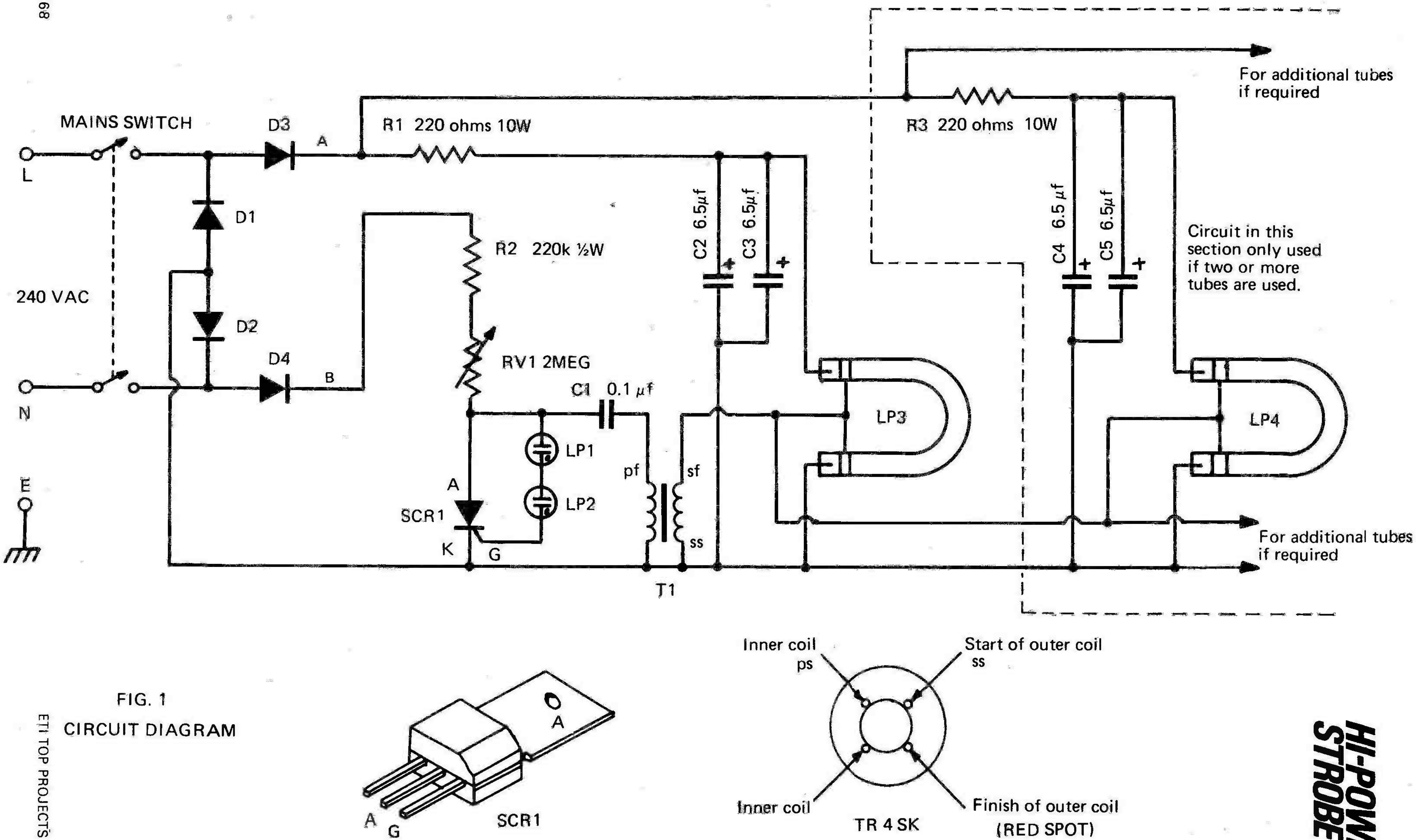


FIG. 1
CIRCUIT DIAGRAM

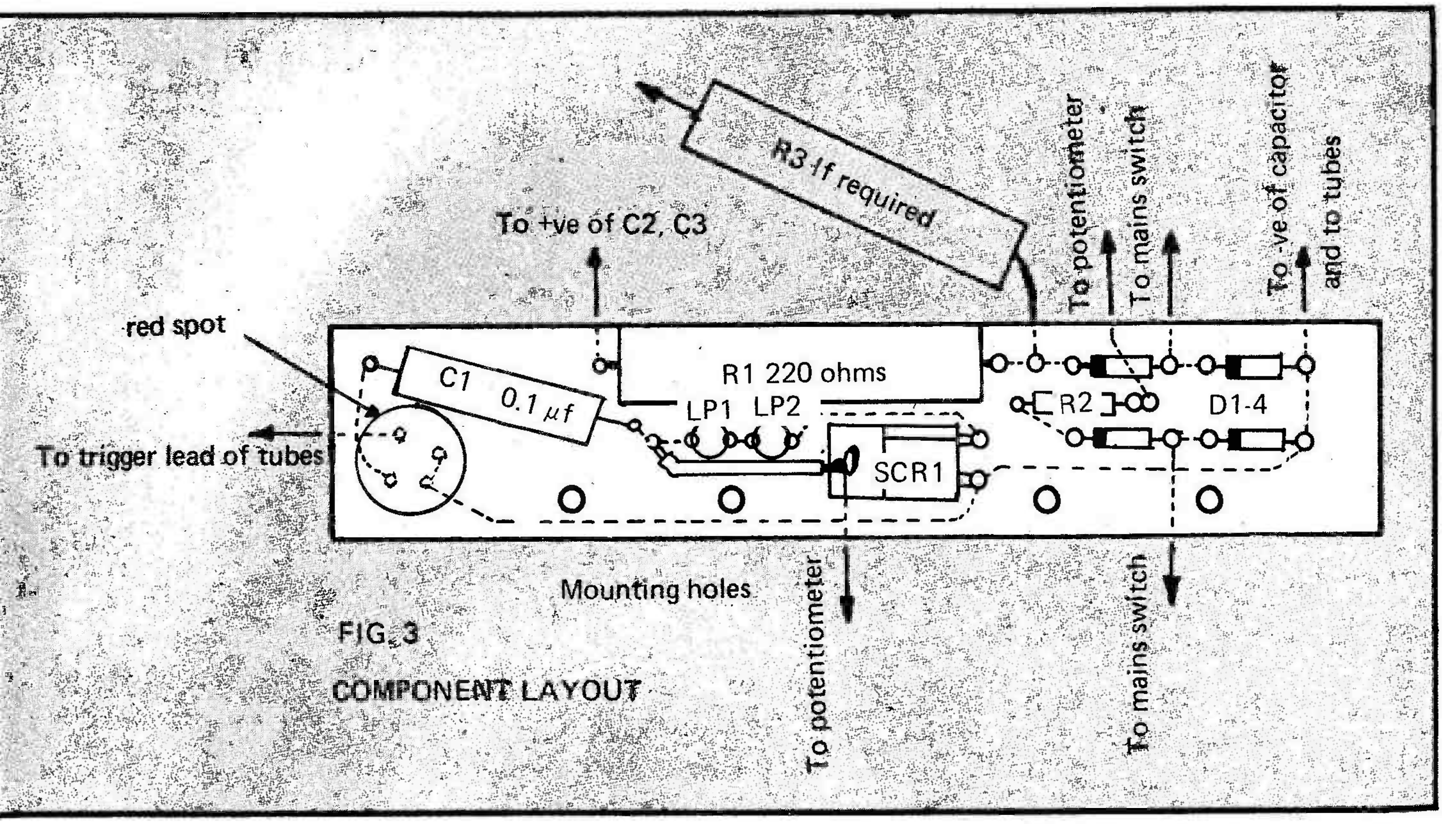


FIG. 3
COMPONENT LAYOUT

Fig. 4. Two strobe tubes are mounted in one octal holder. A triggering lead has been wrapped around one tube to show technique.

Connect components using 23/0076 240 volt insulated wire. A two-pole mains switch must be used, this may consist of a separately mounted unit, or it can be combined with the main speed-setting potentiometer (a combined switch-potentiometer is specified in the parts list).

The mains cable must be protected by a grommet at the point where it enters the case, it must also be securely attached to the case by a suitable clamp.

Many types of strobe tubes have been found to operate satisfactorily with this project. The tube used in our prototype is the Philips type 126048.

A length of tinned copper wire must be wrapped around some types of tube to act as a triggering lead (Fig. 4).

This lead is inbuilt in the Philips strobe-tube, but we have found that an additional winding may be required (in this application) to eliminate erratic triggering. ●

WARNING

Repetitive pulses of light — especially those occurring at frequencies around nine flashes a second — may cause epileptics to have convulsive seizures.

Those prone to grand mal, petit mal, or psychomotor attacks should avoid areas where strobe lights are used.

In the event of such an attack whilst a strobe is being used, the strobe light must be turned off immediately.

PARTS LIST

D1,D2,D3,D4.	—	silicon diode 1N4004 (or equivalent)
R1	— —	resistor 220 ohm, 10 Watt, 10%
R2	— —	resistor 220k, ½ Watt, 10%
R3 *	— —	resistor 220 Ohm, 10 Watt, 10%
RV1	— —	potentiometer, 2 Megohm, linear scale, with double pole switch.
C1	— —	capacitor, 0.1uf, 400V.
C2, C3 **	—	capacitor 6.5uf, 250 volt ac.
C4, C5 *	—	as above
LP1, LP2	—	neon indicator tube
LP3	—	strobe tube.
LP4 *	— —	strobe tube — as above
T1	— —	pulse transformer —
SCR1	— —	silicon controlled rectifier, C106D, BT100A 500R or equivalent.
Octal plug	—	McMurdo type L8USP1
Octal socket	—	McMurdo type RT8
Sundries	—	reflector, metal box, spacers, perspex cover, hinge, magnetic catch, hook-up wire, three-core flex, nuts, bolts, washers, etc.

** Components marked with one asterisk — only required if two or more strobe tubes are to be used.*
*** If unobtainable from your parts supplier, these capacitors can usually be obtained from main electrical dealers handling fluorescent lighting equipment.*

ETI COIN

TREASURE HUNTING is one of the country's fastest growing hobbies and a large number of commercial metal locators are now available. What makes this hobby so popular is that it works! It is not only possible to find lost objects - it is almost impossible not to find something.

Why do we call it the Coin Collector? Although you can find almost any reasonably sized metal object, coins are the most interesting items you are likely to find. The face value may be low but older coins are often worth considerably more than this. The size of search head is ideal for objects the size of coins although it will pick up larger and smaller items.

The presence of metal is indicated by a change in frequency of an audio note and a light headset or earphone can be used.

The electronic circuitry is contained in the same cover as the 5¼" diameter search coil, and operation can be adjusted over a band around 100kHz, which falls within the legal frequencies for such equipment. There are two external controls - the on/off switch S1, and the knob for adjusting the heterodyne frequency. The enclosed construction and use of a shielded search coil gives good protection from troublesome external effects such as changes in frequency from rain showers or stray capacitive effects influencing the coil.

DETECTOR CIRCUIT

Figure 1 shows the circuit and L1 is the shielded search coil. Such a shield is known as a Faraday screen and is not usually provided on metal locators of the cheaper type. It is arranged in such a way that inductive coupling changes

COLLECTOR

the coil frequency, while the coil is screened against capacitive effects from wet sand or soil, etc. Trimmer TC1 allows for some adjustment to the coil frequency.

Q2 is the reference oscillator. L2 is a 470kHz i.f. transformer, loaded by the capacitor C6 so that oscillation can be adjusted over a narrow band around 100kHz. Cx is the capacitor normally fitted in the IFT and is ignored. The manual control VC1 allows a small change in frequency, so that operation can be immediately adjusted, as necessary, at any time.

L2 must be screened and the usual can provided is connected to the negative line. The component listed is for mixer and IF coupling in transistor receivers. It is quite probably that other 465kHz or 470kHz single-tuned transistor receiver IFT's will give similar results here. However, pin connections will have to be changed to suit, and the value of C6 may also have to be modified.

Two diodes, D1 and D2, are used for mixing and demodulation, and this method avoids the pulling of one oscillator by the other. Q3 and Q4 are audio amplifiers and boost the weak audio tone resulting from the difference in frequency of oscillators Q1 and Q2. The audio output is sufficient for normal listening in conditions of wind or other reasonable level of external noise.

PARTS LIST

R1	Resistor	390k	5%	¼W
R2	"	2.7k	"	"
R3	"	390k	"	"
R4	"	1M	"	"
R5	"	3.3k	"	"
R6	"	1M	"	"
C1	Capacitor	0.047μF	Mylar etc	
C2	"	2700pF	5%, Polystyrene or Silver Mica	
C3	"	22pF	Polystyrene or ceramic	
C4	"	0.047μF	Mylar etc	
C5	"	330pF	Polystyrene	
C6	"	5000pF	5%, Polystyrene or Silver Mica	
C7	"	470pF	Polystyrene	
C8	"	22pF	Polystyrene or ceramic	
C9	"	2200pF	Polystyrene	
C10	"	0.047μF	Mylar etc	
C11	"	50μF	10V min. Electrolytic	
TC1	"	500pF	Compression Trimmer (R.S. Components)	
VC1	"	200–300pF	solid dielectric variable capacitor	
Q1	BC107			
Q2	BC107			
Q3	BC108			
Q4	BC108			
D1	OA81 or OA91			
D2	OA81 or OA91			
L1	Search coil, 26s.w.g. — see text.			
L2	I.F. transformer — see text. Denco Type IFT 13 used in prototype			

Plain Veroboard, 0.15in matrix about 4.9 x 2.8in; Veropins; Battery connectors; control knob; on-off slide switch; 3.5mm jack socket; 6in disc of 1/16in paxolin; Plastic case, flower pot stand; Aluminium cooking foil; Drawer handle; Aluminium tubing, ¾in outside diameter; Plastic plumbing tube, ¾in diameter; Bicycle hand grip; Medium impedance headphones or earpiece.

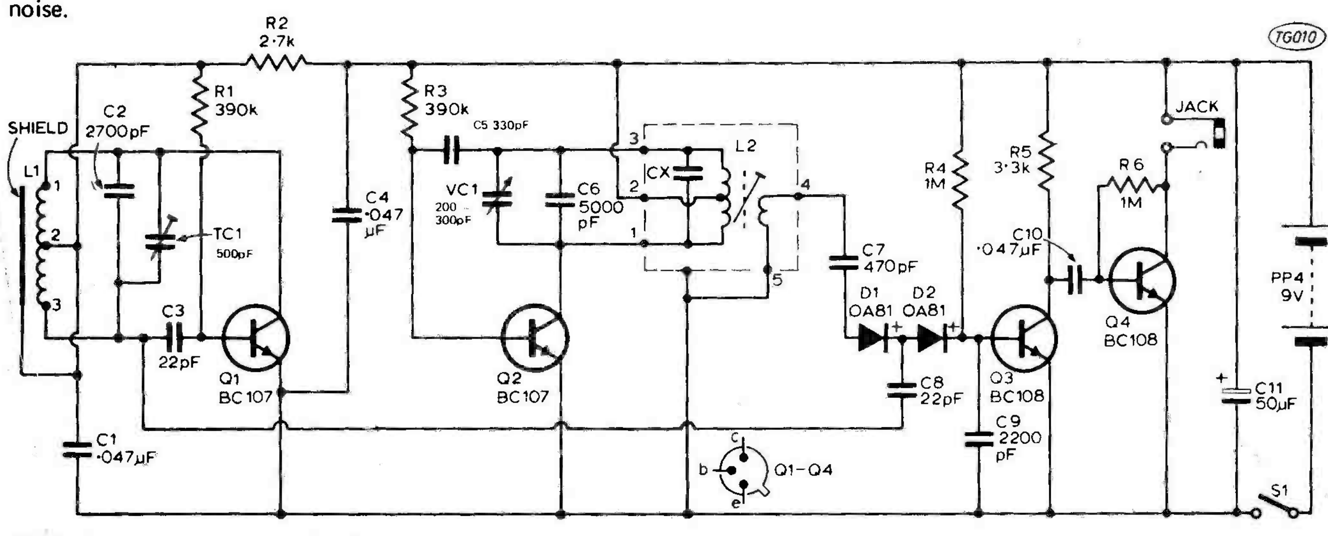


Fig. 1 The complete circuit of the ETI Coin Collector. L1 is the screened search coil and L2 the modified i.f. transformer acting as the reference oscillator.

COIN COLLECTOR

THE CASE

This will be found in many shops and popular stores which include gardening items, and is brown plastic 6¼in. in diameter and 1¾in. deep ("flowerpot saucer or bowl"). The inside diameter of the open top is 6in. and a disc of 1/16in. paxolin is cut to fit this. Perspex or similar material can also be used. A 4½in or similar drawer handle, also plastic, is bolted to the bowl which is used inverted.

Details of the long handle are shown in Fig. 2. This is a 3ft. length (longer or shorter depending on your height) of plastic piping with an inside diameter of ¾in. This is available from most plumbing shops at low cost. Both polypropylene and PVC piping is available and, while both can be used, the latter is best as it is rather more rigid.

A bicycle handlebar grip will fit nicely onto the outside top of this.

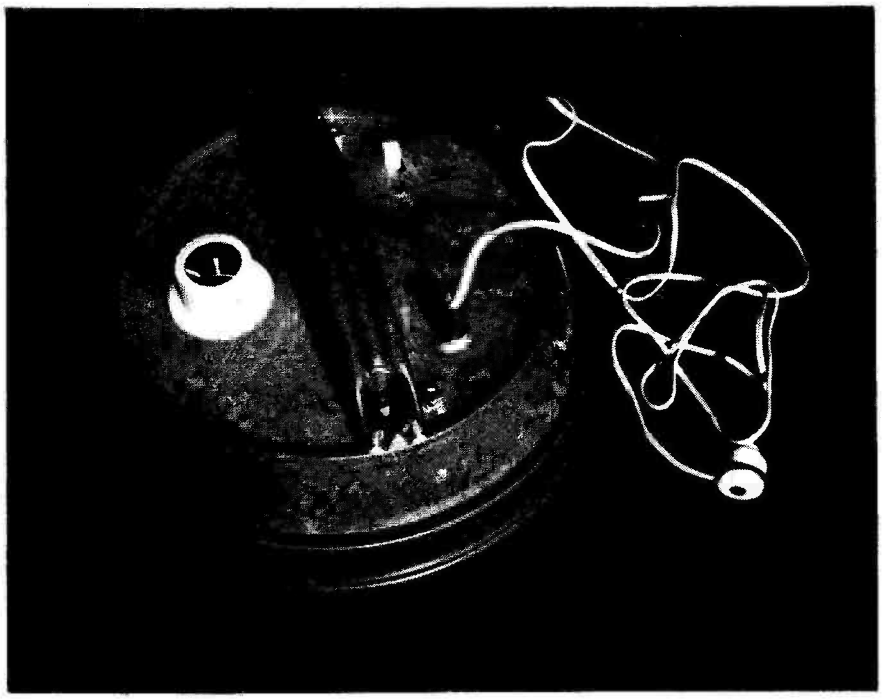
The bottom of the handle is connected to the main casing by means of a bracket made from a length of ¾in. outside diameter aluminium tubing. One end of this is squeezed flat in a vice and the flat part is bent at about 45°. Two holes should be drilled in this and on the case and secured by 4BA nuts and bolts.

An extension lead is necessary for the headphones or earphone. This can be done by adding wire to the existing lead but a neater job is achieved by having a separate wire running inside the tube. A hole should be drilled about 5in. from the bottom of the handle (this is to prevent it being fouled by the bracket) and the extension feeds through this; a 3.5mm jack plug should be fitted to this.

The 3.5mm jack socket at the top is more difficult to fit as it should be about 4in. from the top. A ¼in. hole should be drilled to take this. The wire should be soldered to the socket *outside* the tube and a knitting needle jammed gently into the switching section. This can then be fed down the tube and the thread passed through the ¼in. hole. It is not easy, but it can be done.

Note that the aluminium bracket has an effect on the search coil and if the Coin Collector is converted to the hand held version (or vice versa) realignment is necessary.

The locator is built as a working unit on the 6in. paxolin disc. The cover or casing, with handle, is afterwards attached with two 6BA bolts. The on-off switch and headphone jack are on short flexible flying leads and they can be permanently mounted on the cover.



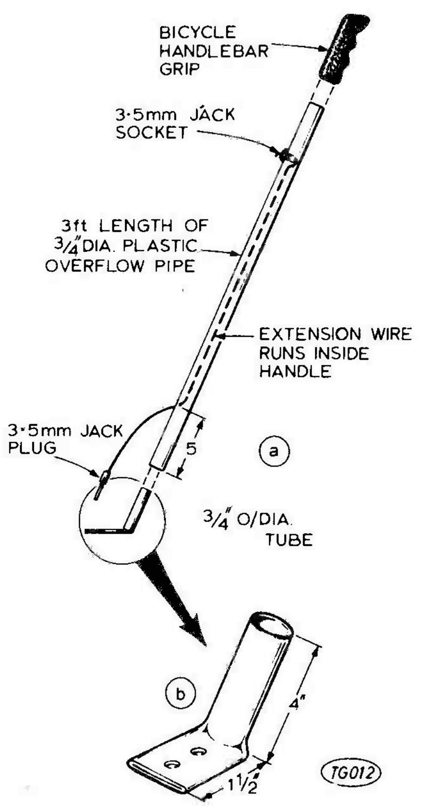


Fig. 2 Details of the long handle and bracket

The length of the handle should be cut to suit the user's height

To change the battery it is necessary to remove the control knob and two 6BA nuts, but the battery has a long working life in this circuit and should only have to be renewed occasionally.

CIRCUIT BOARD

This is cut as in Fig. 3, and the placement of components can then be exactly as shown. The polarity of D1, D2 and C11 must be as marked.

First locate the circuit board correctly on the 6in. paxolin disc and drill the three holes "A" completely through both. Run 1¼in. countersunk 6BA bolts up through the paxolin, locking them with nuts. Put an extra nut on each bolt, so that the circuit board will be raised about 1in. from the paxolin (to clear the components in Fig 3).

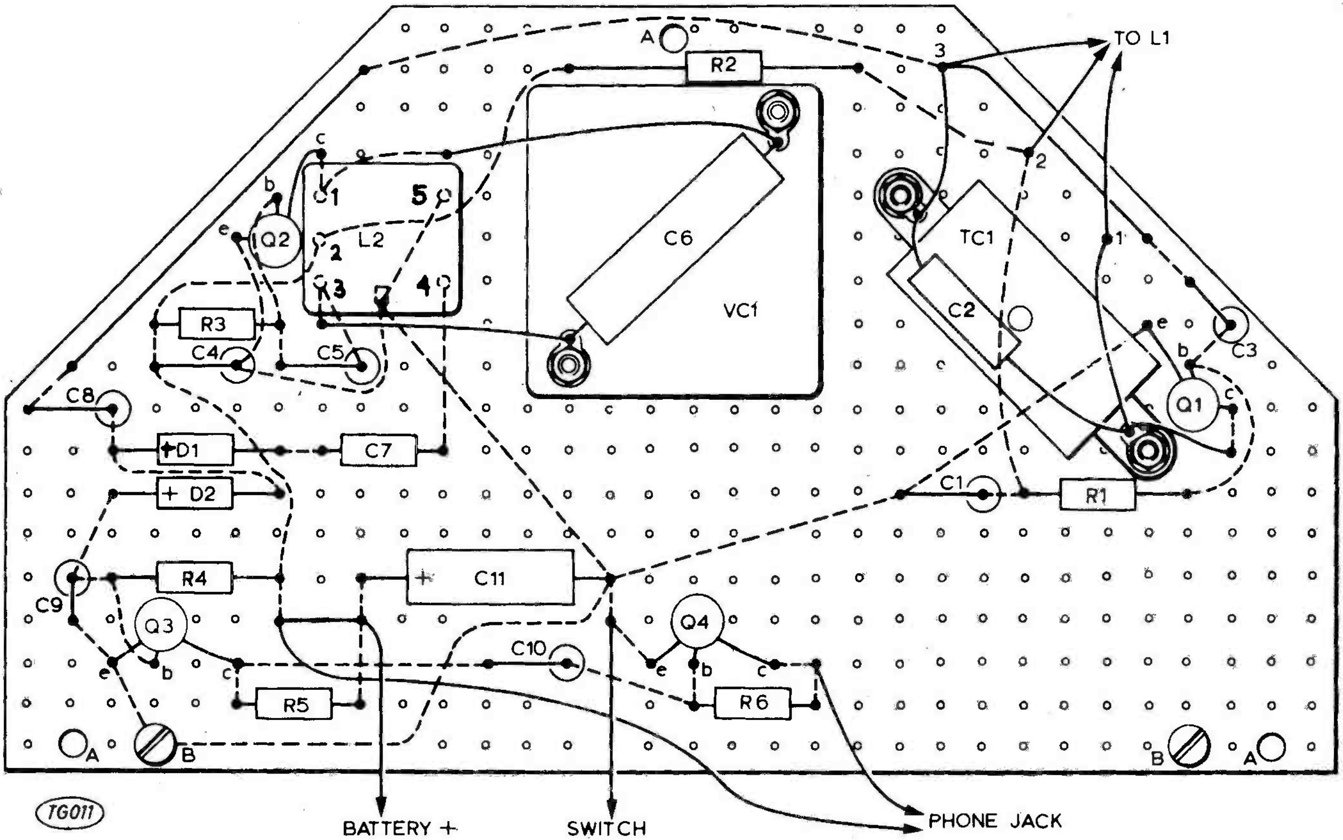


Fig. 3 The component layout – a piece of drilled s.r.b.p. board 4.9 x 2.8 ins with two corners trimmed as shown. The dotted lines represent wiring on the reverse side.

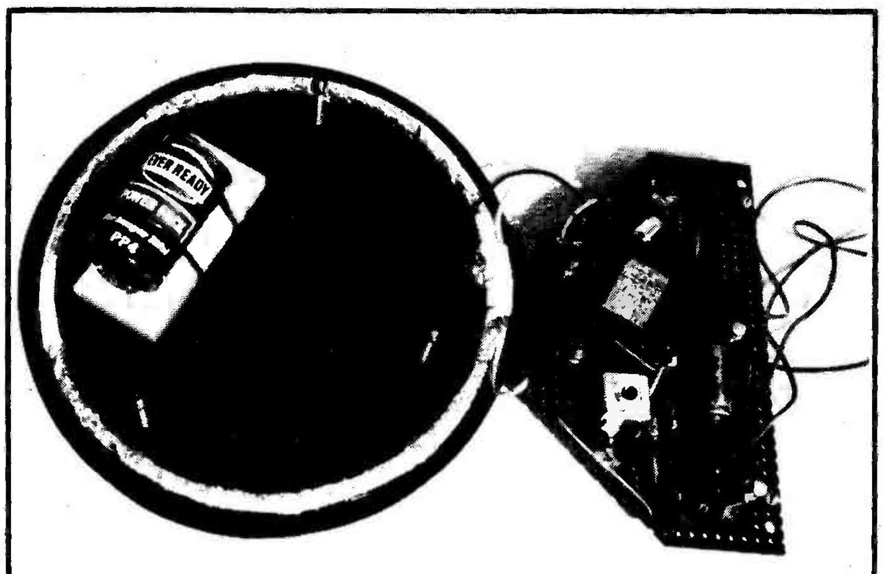
When wiring is completed, the board is fixed in this position by three further nuts.

Drill two holes for the ½in. bolts "B" which secure the cover. Each of these bolts has two nuts, plus a further nut each to hold the cover when it is on.

VC1 is located as shown, with a clearance hole in the cover to match. TC1 is mounted with bolts and spacers or extra nuts, with a hole so that its adjusting screw can be reached from the upper side of the board. A hole allows the core of L2 to be adjusted from this side also.

Wiring need not run *exactly* as shown in Fig. 3, provided connections are correct. Where the ends of resistors and capacitors are not long enough, use 26swg or similar wire for connecting purposes, with insulated sleeving where necessary to avoid short circuits.

Three Veropins, numbered 1, 2 and 3 are inserted for the leads from L1. A thin flexible lead from positive at C11 is fitted with a positive battery clip. A lead from negative of C11 runs to the on-off switch. A lead with a negative battery clip is soldered to the second switch stage. Flexible leads from Q4 collector and the positive line are taken to the output jack. Both the switch and jack are left free, and only fixed to the cover when construction is otherwise completed.



The prototype circuit board wired to the search coil

SEARCH COIL

This consists of 50 turns, centre-tapped of 26swg enamelled wire, with a mean diameter of 5¼in. An object about 5 1/8in. in diameter is most suitable as a temporary former for winding. A tapering object (such as a plant-pot) may be used by measuring it and marking the winding position.

Wind 25 turns in a compact pile, and secure with adhesive tape to prevent the turns becoming loose. Form a short loop for the centre-tap, and wind a further 25 turns in the same direction. The coil is then removed and bound in several places as in the photograph to hold the turns together.

Solder a lead to the centre-tap 2, and place insulated sleeving on ends 1 and 3.

Another photograph shows the 6in. paxolin disc with three 6BA bolts and the coil before the shielding is done.

Cut a ring of aluminium foil 7in. in diameter and 1in. wide and place the coil on this. Completely cut away a narrow piece from the foil, opposite the centre tap of the coil.

COIN COLLECTOR

The foil is folded over the winding, from inside and outside, to enclose it. Regular folding of the inner edge outwards will be eased by snipping about 3/8in. into the foil at ½in. intervals from the inside. Leave a foil projection near the centre tap, Secure a thin flexible lead to this with a short 8BA bolt and washers and solder this connection to the same lead as is used for the centre tap.

Bind the coil with thread or with adhesive tape. Tape the flying leads, and also the gap in the foil, taking care that the ends of the foil do not touch each other here.

The coil is smeared liberally with adhesive, and is placed onto the paxolin disc. After checking its position, place a few small weights on it to hold it until the adhesive sets. The leads should come near the Veropins to which they will be connected.

BATTERY HOLDER

This is made of a small piece of wood, about 2½ x 1 x 3/8in. A channel is cut for a PP4 or similar battery. Two saw-cuts are made across the wood on its other side. Elastic bands are placed in the cuts round the wood, which is cemented in place. When the cement is dry the battery can then be secured by the bands.

FINISHING ASSEMBLY

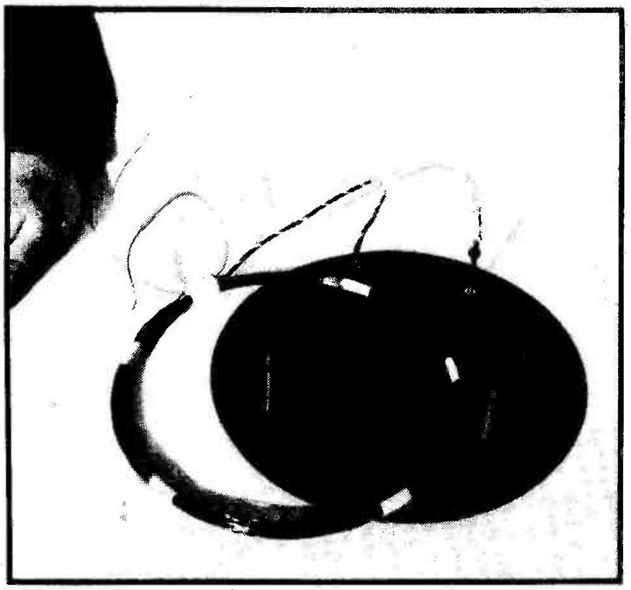
Place the circuit board in position and fix it with the three nuts. Cut the leads from L1 to suit the pins 1, 2 and 3. These are long enough to allow the board to be turned over.

Other photographs show the finished construction before the cover is fitted.

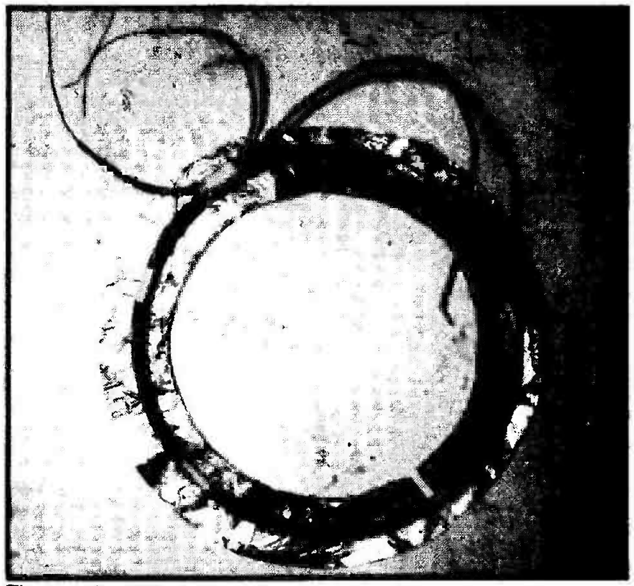
ALIGNMENT

Temporarily fit a knob to VC1 and set this capacitor about half closed. Screw TC1 about half down. With the phones plugged in and the detector switched on, rotate the core of L2 until a loud audio tone is heard. Set the core for about the "zero beat" position.

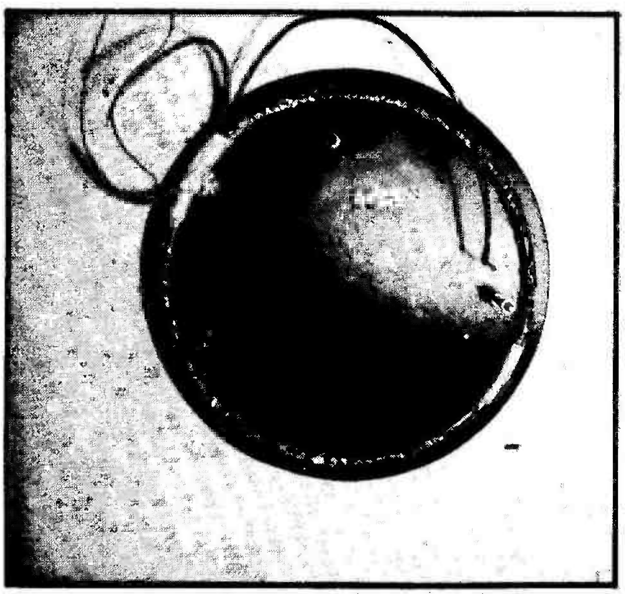
In these conditions, turning the core either way will cause a tone, which rises in pitch the farther the core is turned. A similar effect arises with VC1: the control knob has a central or zero beat position and turning it either way from this will cause an audio tone



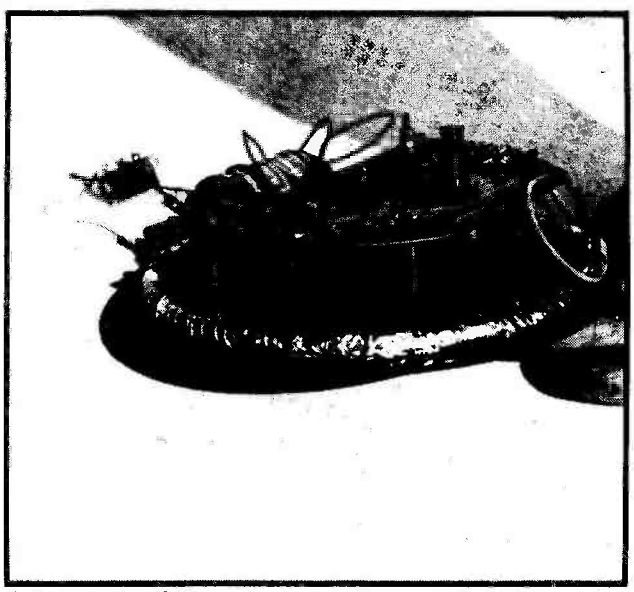
L1 before being screened.



The coil should be laid on the aluminium foil as shown. Note the gap opposite the wire ends.



When screened the coil should be glued to the paxolin disc.



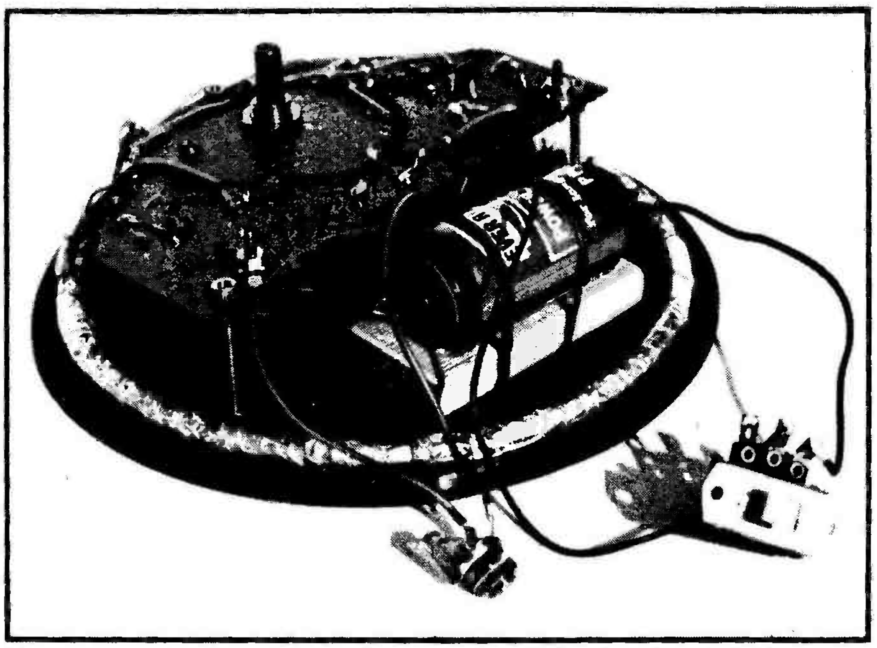
A general view of the prototype out of the case showing the circuit board in position. The extending nuts to the cover can also be seen which rises in frequency with further rotation of the control knob.

At this time the frequency can be set to whatever may be required, within the range of TC1 and L2. The second harmonic of the oscillators can be picked up by a radio receiver having long wave coverage, and placed near the detector. A frequency a little removed from 100kHz can be chosen, so that possible interference to nearby reception of the 200kHz LW broadcasts does not arise.

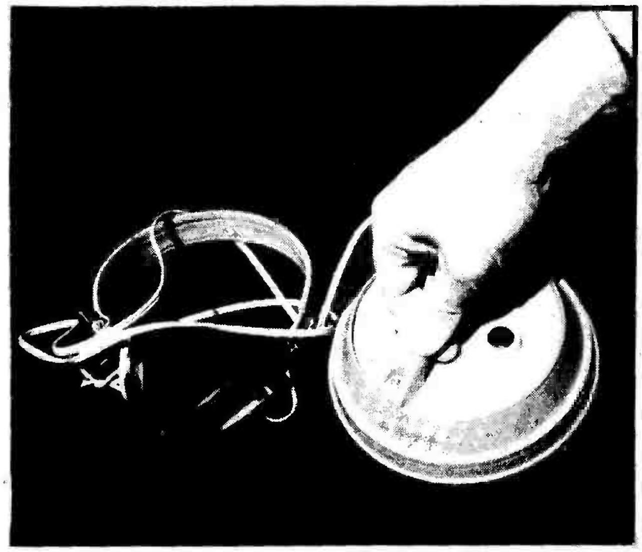
The switch and output jack can then be fitted permanently to the cover, which is secured by nuts on the projecting bolts.

LOCATOR USE

Unseen metal is located by a change in the audio tone heard. Initially rotate VC1 so that a steady audio tone is heard. The approach of metal into the vicinity of the search coil will then cause a change in pitch. Most metals vary the tone one way, but certain metals will cause the shift in frequency to be in the other direction. The way in which a particular metal causes a change in frequency can be adjusted by setting VC1 for the wanted effect.



The main assembly without the case. The wires to the switch and earphone socket should be left reasonably long



The completed prototype. Either headphones or an individual earpiece can be used.

The hand held version is ideal for a close investigation of a small area.

Nearby, or large pieces of metal will cause a very pronounced shift in frequency. For maximum range, a very low frequency audio beat is most suitable, with VC1 adjusted so that this falls in frequency when the coil approaches metal. The limit of detection range is reached when it is no longer possible to observe any change in frequency at all.

It is always difficult to give a binding "maximum range" specification for an instrument of this kind, as this depends so much on individual circumstances of use, such as the size and shape of the metal objects, kind of soil, and even the skill of the user. The actual range achieved is of course the same as that of other heterodyne locators with a search coil of similar size — this could be a matter of a very few inches for the detection of a small item such as a coin, but up to a foot or more for a large metal object.

HEADSET

Best of all will be a light pair of phones with muffs, such as those listed. These help exclude external noise, and can be carried in a pocket. Headphones of similar type will usually be of about 500 to 2,000 ohms.

A single earpiece is most suitable when there is little outside noise, and the usual medium impedance type can be used.

Great fun can be had with the Coin Collector but it will take you a little while to get used to it and achieve optimum performance.

Resist the temptation of scanning a large area of ground quickly - you will only be wasting your time. If you concentrate on a small area - say 100 square feet - If the area has been frequented by people over the years, even your back garden, the chances are pretty good of finding something - even if it is of no value.

We cannot promise you anything of course and your chances of striking it rich are remote but just bear in mind that there are people who *make a good living* using a metal locator - think about it!

A licence is required to use a metal locator; this costs 75p for five years. Application forms (it is called a Pipe Finder Licence) are available from the Ministry of Posts and Telecommunications, Waterloo Bridge House, Waterloo Road, London, S.E.1.

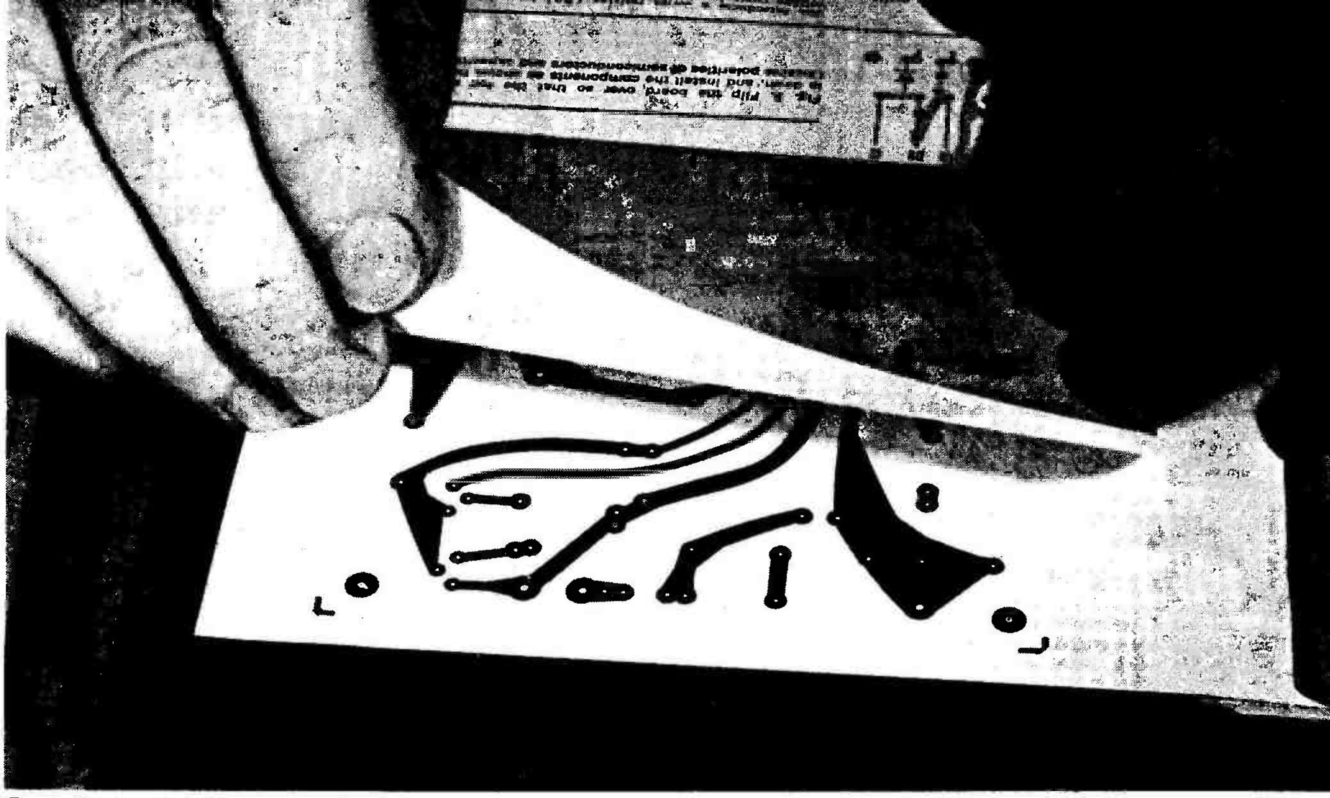
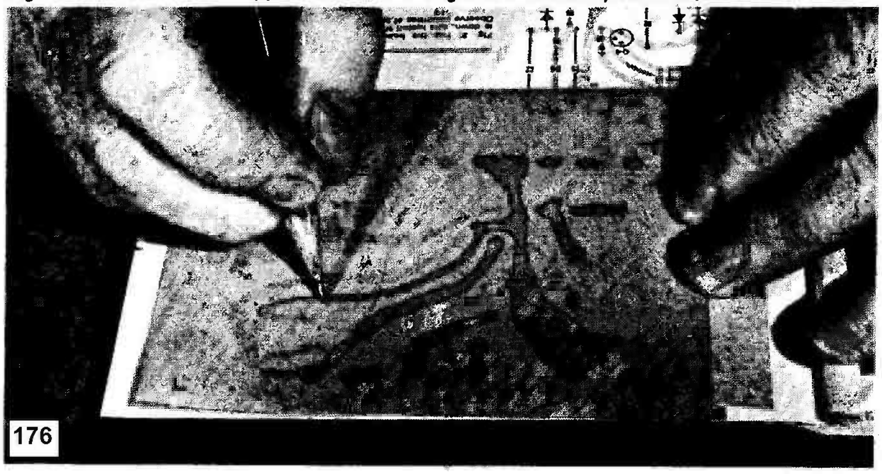


Fig. 1. Place the Letrafilm over the diagram.

Easier way to make your own P.C. boards

Now you can do away with all the fuss and bother of conventional printed circuit preparation, says A. J. Lowe

Fig. 2. Trace around the copper areas on the diagram. Mark hole positions and corners also.



At last! Here's a quick, clean method of preparing printed circuit boards for etching – and it's for the home constructor.

Photographic methods are fine if you want to produce a large number of identical boards, but far too slow, expensive and involved for the 'one-off' man who simply wants to make one board – usually from a diagram in a magazine.

The standard method, for the experimenter, involves the use of tracing paper, carbon paper, and a resist paint. Sure, it works – but those who have used it know how hard it is to get narrow clean-edged lines with paint. Sometimes the paint is thin and porous and lets the etchant through, and sometimes it runs across narrow gaps, leaving short circuits to be cleaned up later. Sometimes the paint is thick and hard to manage. Besides, it takes ages for the paint to dry.

This new method requires no tracing paper, no carbon paper, no paint, no brushes, no solvents – and you can have a printed circuit board ready in an hour or so.

It depends on the use of a cut-out colour film used in the graphic arts field, called LETRAFILM. Made by the manufacturers of the widely-used Letraset stick-on letters, it is obtainable from artists' shops and drawing office supply houses.

Letrafilm is a thin sheet of film available in a range of 50 colours, tacky on one side and 'toothed' on the other. The tacky side is backed with a translucent paper support. The toothed side can be written or drawn on with ease. The film is quite impervious to etchants and so makes

Fig. 3. Separate the Letrafilm from its backing support.

Fig. 4. Place the film down on the copper side of the p.c. board.

Fig. 5. Press the film down gently.

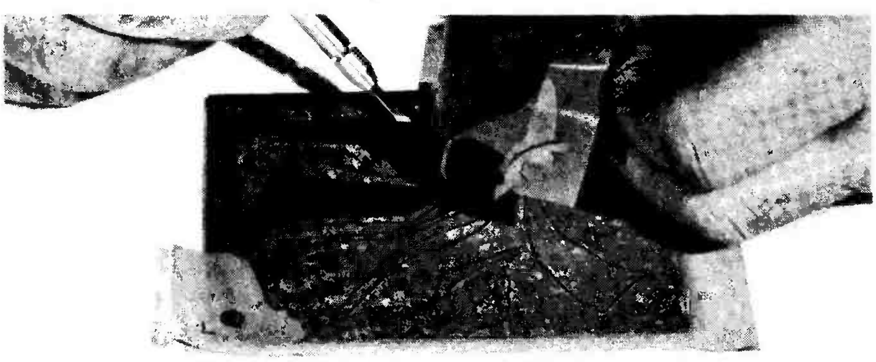


Fig. 6. Cut around the copper areas with a sharp craft knife.

Fig. 7. Remove the unwanted film, leaving film over the areas where copper is to remain.

an ideal resist. It is available in sheets 10" x 15" and is quite inexpensive. Only a few pence worth will cover the typical printed circuit board. A light colour, such as pale yellow, is ideal for this application.

Here's how to use it:

1) Cut a piece of Letrafilm, complete with its backing, about 3/8" or so larger all round than the printed circuit board.

2) Place a sheet of aluminium, or phenolic board, or even printed circuit board, below the diagram of the printed circuit. This gives a hard support for the next few operations.

3) Lay the Letrafilm over the diagram (see Fig. 1) and hold it down at one side with sticky tape. It will be found that the diagram can be seen quite clearly through the Letrafilm.

4) Trace around the copper (i.e. black) areas in the diagram with a pencil. (Fig. 2), making sure that the corners of the board are marked as well. The position of holes for the component leads should be marked with a pencil dot. This is another advantage of this method over the paint method, in which hole positions have to be gauged later.

Many diagrams prepared professionally, using stick-down circles and lines, have lots of fine curves and indentations where none is really required. There's no need to follow unnecessary detail and it may be eliminated as tracing proceeds.

5) Remove the Letrafilm from the diagram and carefully separate the film from its backing sheet (Fig. 3).

6) Lay the film, tacky side down, on to the thoroughly cleaned copper surface of the printed circuit board, using the corner marks as a guide (Fig. 4).

7) Press the Letrafilm gently down on to the printed circuit board. (Fig. 5). Do not press too hard, as this will make later removal of the unwanted film portions unnecessarily difficult. Small air bubbles need not be squeezed out.

8) Cut around the pencilled outlines of the copper areas with a sharp craft knife (Fig. 6). This process is much easier than painting, and quicker – and clean sharp lines are automatic.

Do not, at this stage, do anything about the dots marking component lead hole positions.

9) When cutting is complete, carefully peel away the *unwanted* film

from the board — that is, the film which does not cover areas where copper is required. This is done by gently lifting the film at one corner and easing it back. It will break as you progress, but that's no disadvantage (Fig. 7). Watch that none of the 'islands' lifts, due to bad cutting along the pencil lines. If one does lift, press it back and cut around it once again.

10) When all the unwanted film has been lifted, lay a sheet of paper over the board and press down firmly all over it. This bonds the film to the wanted copper so that it acts as an effective resist (Fig. 8). Make sure that no air bubbles are near the edge of an island. In the middle they don't matter.

11) Etch the board. This can be done in your usual etching bath. For those who have never made a printed circuit board before, an effective etching solution is 4oz. of ferric chloride dissolved in 10oz. of hot water. This will etch a typical board in 20 to 30 minutes. Protect your eyes and hands — the solution is corrosive.

12) When etching is complete, remove the board from the etching bath and wash it clear of etching solution under running water. Dry the board by dabbing it with a rag.

13) With a scriber, mark the positions of the holes for component leads by pressing through the film into the copper (Fig. 9). The pencil dots already made (see introduction 4 above) give the positions.

14) Remove the remaining Letrafilm. This can be peeled and rubbed off (Fig. 10).

15) Clean away any residual adhesive from the film by cleaning the board with an abrasive domestic cleaning powder and, if needed, some steel wool. The board is now clean and ready marked for drilling (Fig. 11).

16) To prevent the copper oxidising, it should be sprayed with a special printed circuit board lacquer. Alternatively — and much more cheaply — it can be brushed with a rosin solution (one lump of rosin dissolved in a little methylated spirit). This makes a first-class flux and maintains the shiny look of the board.

Well, there it is — a simple, clean, efficient and quick method of doing-it-yourself and, at the same time, saving money. ●

Fig. 8. Press down hard, to bond the remaining film to the board.

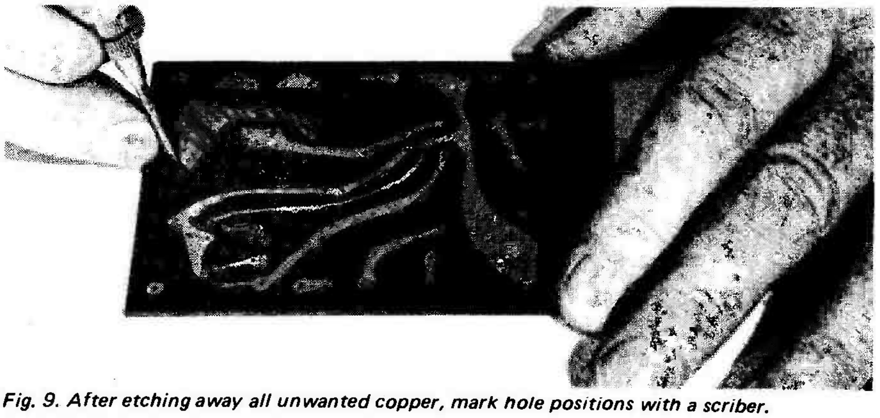


Fig. 9. After etching away all unwanted copper, mark hole positions with a scriber.

Fig. 10. Remove remaining film from the board.

Fig. 11. The board, cleaned and ready for drilling.