much too high for correct biassing and a different technique is called for.

With the arrangement illustrated in Fig. 6, the effective resistance is:—

$$R_{eff} = \frac{R2 + R3}{R2} \cdot R1$$

provided $R2 << R1, 3$ and $X_{C3} << R2$

If the value of X_{C3} approaches R2 the effective resistance drops and, if the value of R2 and C3 are properly chosen, a 12 dB/octave cut-off at the low end can be obtained which effectively removes the rising low-end response due to the recording characteristic.

Other advantages of the charge amplifier are firstly that it is easy to obtain gain (unlike the source — follower FET approach) and secondly that cable capacitance does not affect the performance in any way. One disadvantage is that the cables are slightly microphonic and movement of the leads can cause an output — this however is not an insurmountable problem.

The overall response of the Decca Deram Cartridge into a charge amplifier is given in Fig. 3, and as can be seen the response at the low end is greatly improved. As said before the drop around 2 kHz could readily be compensated for but this was not considered necessary.

If a pickup having a different capacitance were to be used the only change would be in the gain of the amplifier — the frequency response (of the amplifier) remains the same. If the gain is too high then simply changing the feedback capacitor to a higher value will restore it. However, if the low frequency cut-off is to be maintained both R4 and C3 must also be altered. Table 1 illustrates the values required.

CONCLUSION

Cost for cost the ceramic cartridge is better value for money than the magnetic type. The use of a properly designed preamplifier can produce a substantially flat response.

However whilst an almost perfect frequency response can be obtained by properly processing the output from a cartridge like the Decca Deram it can *never* sound like the Shure V15 MK 3! Other factors such as transient response and channel separation are generally not as good as those of a magnetic cartridge. Whether the inbuilt mechanical resonance is actually responsible for the poor transient response is probably known only to the cartridge manufacturers — one feels that if it were done electronically it may well be better.

This has not been presented as a normal project but rather as a basis for experimentation. The circuit described has been built up and does give the response expected. Try it. The results may be surprising. ●

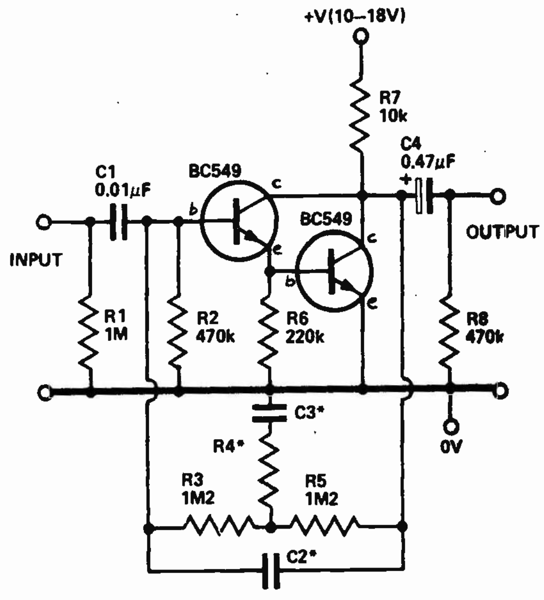

Fig. 8. Circuit of practical charge amplifier for ceramic cartridges which gave the overall response as in Fig. 4. For values of C2, 3 and R4 see table 1.

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This publication is the fourth containing reprints of earlier ETI projects. How can we be cheeky enough to continue to do this?

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ETI has been among the top five fastest growing magazines in Britain for two successive periods. Not in the electronics field, not in the hobbies field but among ALL magazines (several hundreds of them). Whilst other electronics magazines have taken huge falls in sales, ETI has increased 150%. Some of the articles in Top Projects No. 4 were published when our sales were only 40% of the current level.

We don't expect you to take our word for it that ETI is the freshest, most-up-to-date electronics magazine. Just flick through the pages of an issue; if we don't come up to standard, put us back on the shelf. But be warned; 10,000 people did that in the last year and have stayed with us.

NOTES FOR OVERSEAS READERS

Most of the components used will present few problems — resistors, capacitors, switches, etc. However, as semiconductor codes vary, some general specifications are listed for your convenience:

BC108 general purpose and audio NPN
BC109 low noise audio NPN
BC178 PNP complement to BC109
BC184 medium power NPN
BC212 complement to BC184 PNP
OA91 germanium signal diode

Transformers are specified with 240 volt inputs — obviously they can be replaced with 110 volt ones if the output is the same! However circuits connected directly to line need special consideration, in general output devices need changing for ones with double the stated current rating. Other components may need altering to suit — above all extreme care is to be taken.

None of the circuits rely on 50Hz or 60Hz for correct operation.

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

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Sweet Sixteen

eti project 457

A simple stereo amplifier which gives about 6W r.m.s. per channel (well over 8W peak) with facilities for three inputs. Simplicity in construction and low cost have been major considerations in establishing the design.

THERE IS A TEMPTATION for projects in electronics magazines to concentrate on the high-power, highly sophisticated designs. Sweet Sixteen has been designed with other criteria in mind: it should have a reasonable output, should be reliable and easy to build. At this stage we have a confession — output is not quite 8W r.m.s. per channel but is nearer 6W r.m.s. At quite a late stage in development the output stage was altered completely for reasons we shall go into. Output is still well over 8W *music power* and that's our excuse for retaining the name.

Readers will find their own uses for this project but it is ideal for a teenager's record player —thus the double meaning of our name.

Design considerations

With the very large range of audio IC amplifiers around we saw no point is using discrete components. Originally we opted for a dual output stage IC and two prototypes were built using this. The particular device was supposed to be short-circuit proof and to include internal thermal limiting. Despite this we ruined two devices — since they were dual types this ruined the whole device. We are certain that the IC is basically O.K. but the troubles were such that we opted for LM380's operating in a bridge configuration — this has cost advantages in that the LM380 is very reasonably priced and output capacitors are not necessary in a bridge configuration.

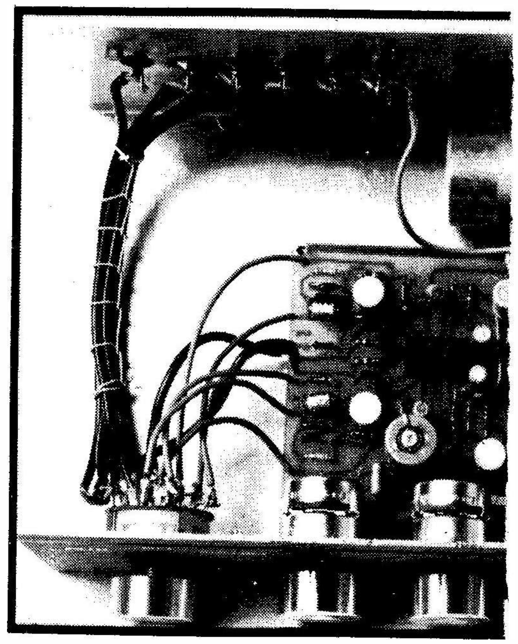
For the preamp we chose the RCA CA3052 with four identical op-amps on one chip; this is specifically designed for use in stereo preamps.

Three inputs are allowed for: magnetic pickup plus another two for use with higher level signals. The p.c.b. has space for a resistor which can be selected for the input level required (this is shown, but not labelled on the circuit).

The tone control, even though it is passive, is extremely effective giving boost of 11.5 dB at 100Hz and 10KHz relative to 1KHz and a cut of 10dB.

The chassis is super simple — a piece of thick aluminium with two bends in it. This will fit easily into a wooden case later or can be covered by a second piece of aluminium to form a cover.

Once you have opted for construction on a PCB, you can take the approach that we took on our International 25 (October 1975) and put *everything* onto the board. This was the original plan as inter-wiring takes far longer than mounting components onto a board. However a selector switch is essential and push-button types



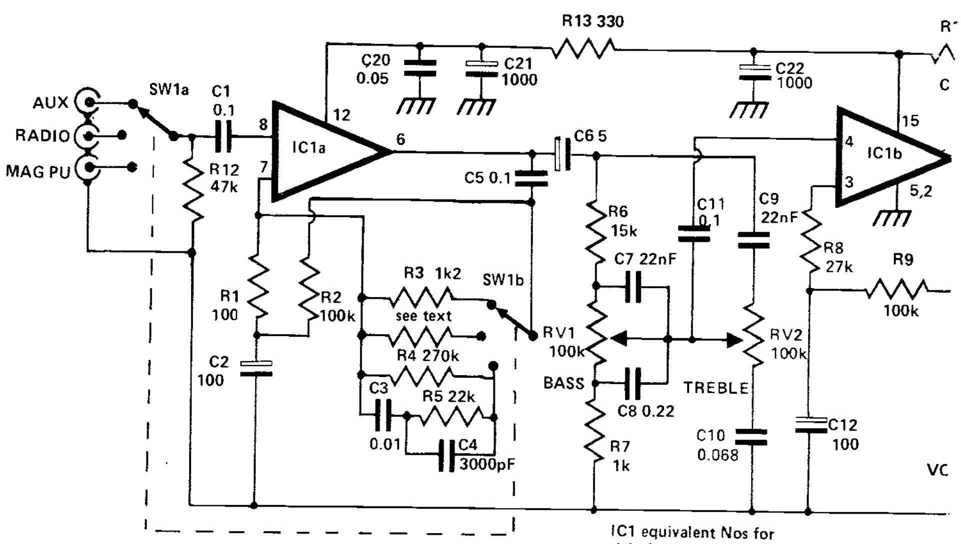


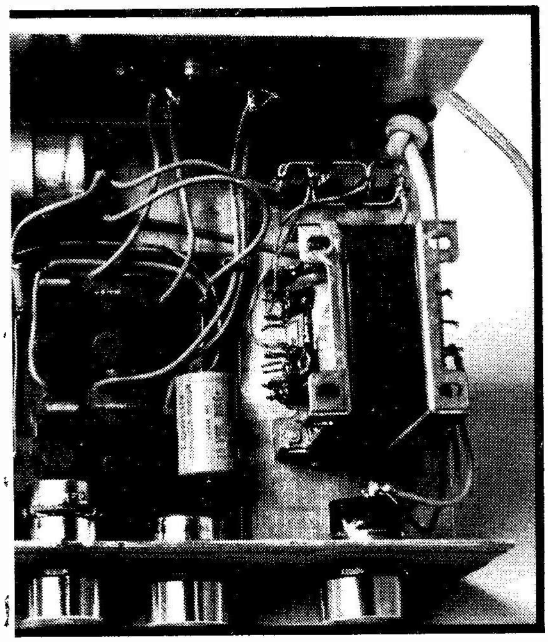
Fig. 1. Circuit of one channel of the amplifier. IC1 is quad op-amp, CA3052, and the lead-outs for the other channel are different as shown. R13, R14, C20, C21 and C22 are common to both channels.

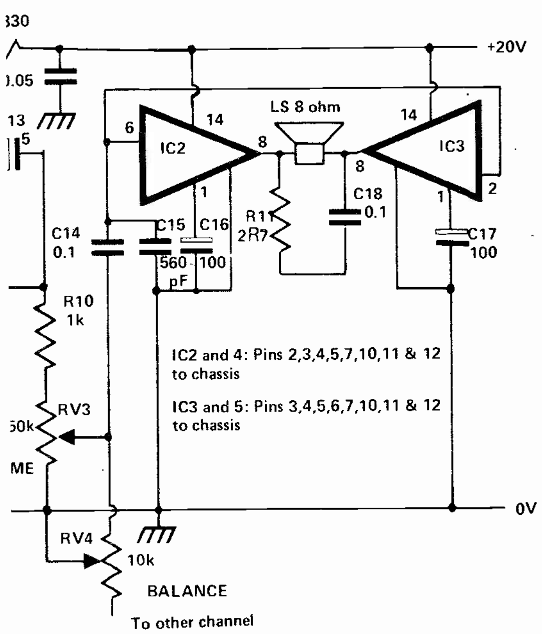
IC1 equivalent Nos for right hand channel:
1 – 16
3 – 14
4 – 13
6 – 11
7 – 10
8 – 9

Pins 12,15,5 & 2 are shared

are expensive and not widely available in any standard design. Secondly PCB mounting pots are not available from many component suppliers. Rather than making a fetish of putting everything on the board, we opted for a more conventional approach.

The positive supply to the three main sections (preamplifier and both output stages) is deliberately supplied via 'above-board' pins — this greatly simplifies testing and isolating problems. The four sections of the preamp IC are independent except for the power supply so a fault in one channel will not normally affect the other.





Construction

First you'll need to obtain your PCB. Advertisers in this issue including Ramar and Croften do all ETI circuit boards but you can do your own. The technique we now use at ETI for quick prototypes may be of interest: for I.C. pads and component terminations we use the press-down transfers (Alfac, Mecanorma etc) but use a resist pen for the tracks.

Once the PCB is etched and drilled the components can be mounted — there's nothing out of the ordinary here except perhaps for the connection of the pots. The beauty about all components on a single PCB is that testing and checking are very easy — so it is with Sweet Sixteen. The components associated with the tone control are soldered first to the pots and then these 'flying leads' to the board. This is shown (for one channel only) in Fig. 5 and can be seen in the photograph.

Once the board is completed the power supply can be built — this is done directly on to the chassis. The wiring is shown in Fig. 6. The bridge rectifier diodes are mounted on a small tagstrip behind the transformer.

Heatsinks have to be fitted to the output IC's. These should be cut from thin tin-plate (tin-cans are ideal) to the size shown in Fig. 8. The centre three pins on both sides of LM380's are at chassis potential

HOW IT WORKS

The input is selected by SW1a and is amplified by IC1a. Part of the signal is fed back to pin 7 via the equalisation network selected by SW1b — a very normal arrangement, R4, R5, C3 and C4 give correct equalisation for a magnetic pickup. R3 reduces the gain of the stage to allow signals of 100mV to be handled.

The outputs of IC1a connects to the tone control network — this is passive but gives adequate gain and boost to be regarded as very effective. The loss of signal is substantial and it is necessary to recover this in IC1b. The output connects to the volume control via R10. The value of R10 should be selected so, that clipping—and possible instability — does not occur in the output stage. C14 is not theoretically required due to the input stage of IC2 but blocks any stray d.c. C15 holds back any very high frequencies which may break into the circuit if screening is inadequate. IC2 and IC3 are connected in a bridge configuration doubling the output. LM380's will give a minimum of 5W and up to 7W r.m.s. in this configuration. C16 and C17 are rarely shown for an LM380 but their inclusion reduced the hum level. R11 and C18 are a Zobel network across the speaker.

Substantial decoupling is necessary to IC1 and as large electrolytics are poor at getting rid of high frequencies C20 is included; C19 is fitted close to the positive connection of the output stage for the same reason.

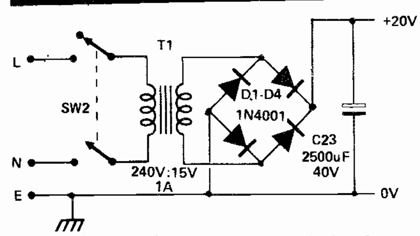


Fig. 2. Circuit of the power supply for Sweet Sixteen.

Resistors

R1	—	100 k	¼W	5%
R2	—	100 k	"	"
R3	—	1 k2	"	"
R4	—	270 k	"	"
R5	—	22 k	"	"
R6	—	15 k	"	"
R7	—	1 k	"	"
R8	—	27 k	"	"
R9	—	100 k	"	"
R10	—	1 k	See text	
R11	—	2 R7	¼W	
R12	—	47 k	"	

(Two off each R1-R12 required)

R13	—	330	¼W	5%
R14	—	330	"	"

Potentiometers

RV1 — 100 k linear dual
RV2 — 100 k linear dual
RV3 — 50 k log dual
RV4 — 10 k linear dual

Capacitors

C1	—	0.1 µF ceramic disc
C2	—	100 µF 25V
C3	—	0.01 ceramic disc
C4	—	3nF polystyrene etc
C5	—	0.1 µF ceramic disc
C6	—	5 µF 25V
C7	—	22 nF ceramic disc
C8	—	0.22 ceramic disc
C9	—	22 nF ceramic disc
C10	—	68 nF ceramic disc
C11	—	0.1 µF ceramic disc
C12	—	100 µF 25V
C13	—	5 µF 25V
C14	—	0.1 µF ceramic disc
C15	—	560 pF polystyrene
C16	—	100 µF 25V
C17	—	100 µF 25V
C18	—	0.1 µF ceramic disc
C19	—	50 nF ceramic disc

(Two off each C1-C19 required)

C20	—	50 nF ceramic disc
C21	—	1000 µF 16V
C22	—	1000 µF 25V
C23	—	2500 µF 40V

Semiconductors

IC1 — CA3052
IC2-5 — LM380 (14-pin package)
D1-D4 — 1N4001

Miscellaneous

SW1 — 4 pole, 3 way rotary switch
PCB — ETI 457
T1 — 240V:15V 1A Douglas (has several taps up to 30V)

Six way bank of phono sockets (or two 3-way)
Two DIN speaker sockets
Tagstrip for Diodes
Screened cable (for inputs to selector switch)
Rotary on-off switch
Chassis as Fig. 7.
Eight heatsinks as Fig. 8.
Six knobs

SWEET SIXTEEN

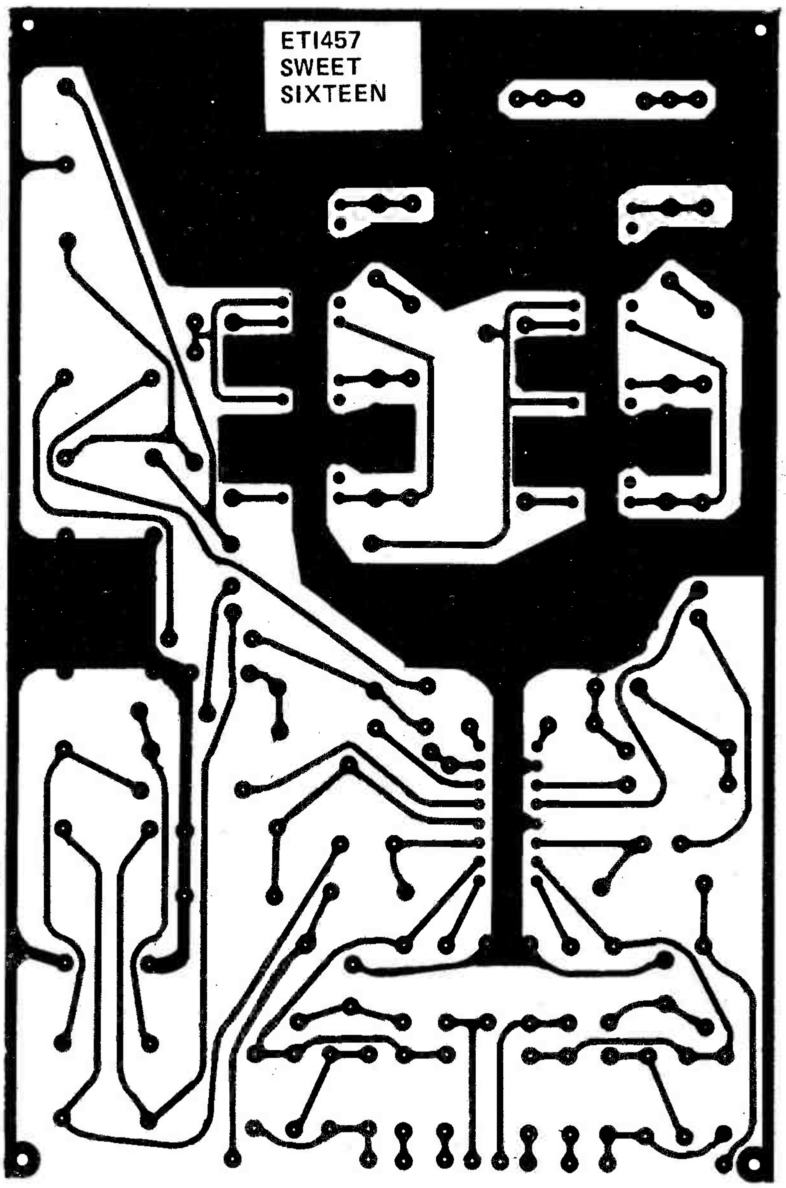
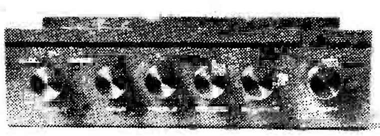


Fig. 3. The P.C.B. design shown full size (6in x 4in).



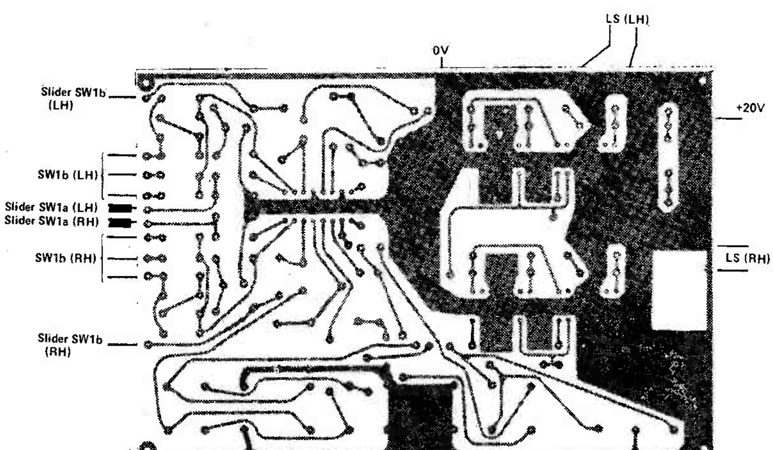
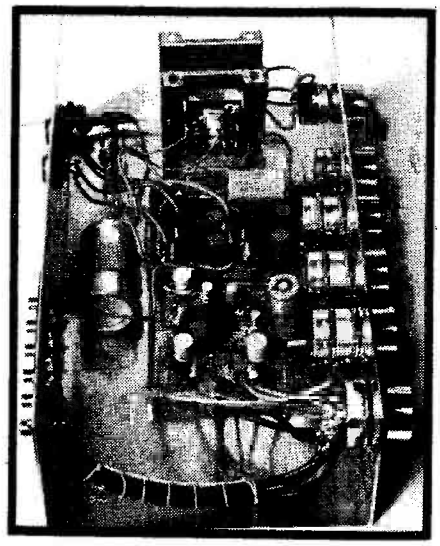


Fig. 4. The component overlay and connections to and from the circuit board.



and are designed to carry away the heat. There is no need to fit the heatsinks until after all the testing is completed as the LM380's are thermally protected and the underside of the PCB is a pretty fair heatsink itself — the maximum area of copper has been left for just this purpose.

We have not shown a drawing of the switch wiring as this will depend on the construction of the rotary switch but is very straightforward. If the high-level inputs are to have the same sensitivity one wire can be omitted to the equalisation network by connecting the wires from R3 to the adjacent tag on the switch.

Testing

Obviously the power supply must be tested first — few problems should occur here. If this is O.K., the 0V can be wired to the pin shown and +20V applied to one of the pins feeding the output stages. The usual 'damp finger' tests to the

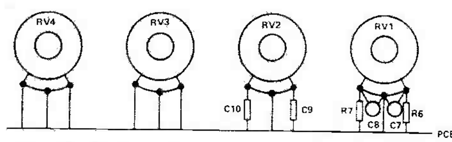


Fig. 5. The tone control components are mounted from the pot tags to the board. The length of lead should be about 14mm when mounted onto the P.C.B. (only the components for one channel are shown).

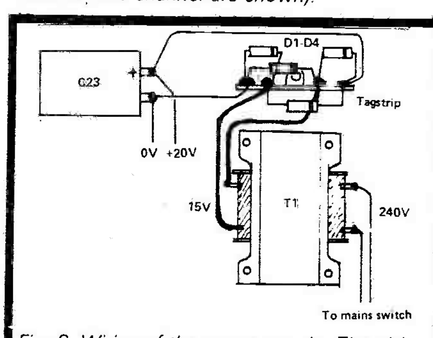


Fig. 6. Wiring of the power supply. The siting of this can be seen from the photographs.

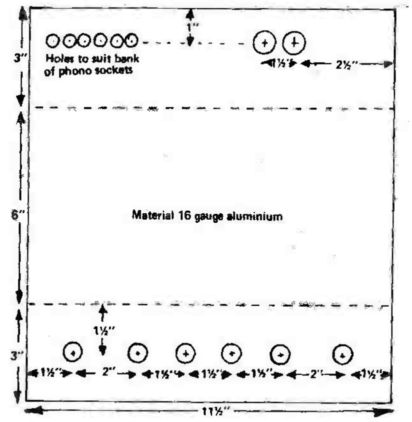


Fig. 7. Metalwork details. The front panel holes are standard ⅜in as are the holes for the bank of phono sockets. ⅝in holes are needed for the DIN speaker sockets.

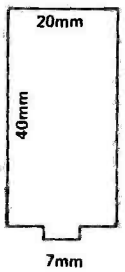


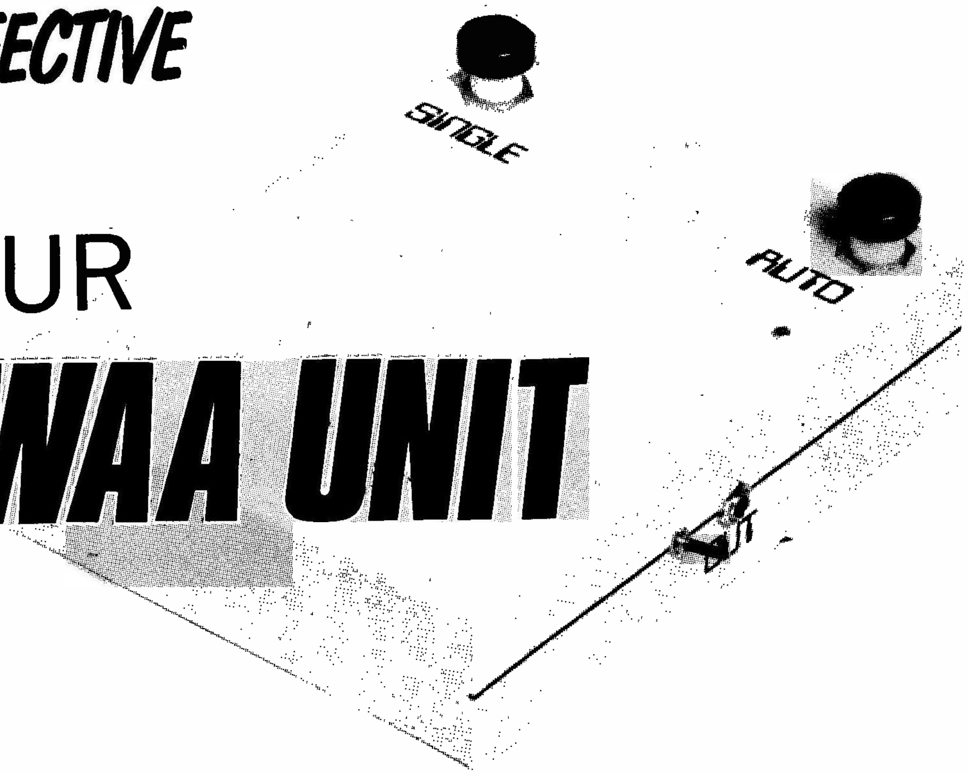
Fig. 8. Heatsinks can be cut from tin-plate to the size shown. Eight are required. The small lug at the bottom should be soldered to the centre three pins on the LM380's on both sides.

input capacitor should establish if there is any output. If it is found that the cone of the speaker is pushed out, or pulled in, *substantially* this will be due to constant d.c. as a result of imbalance of the two I.C's. In theory a 1Mohm preset should be connected with the track ends to the two pins 1 and with the slider to chassis — this will overcome the problem. We tried 16 LM380's and found that it was unnecessary to add this; in any case the d.c. varies back and forth depending on the output level (presumably due to slight non-linearity in the IC's) but was so small as to be of no importance.

It is possible that instability will occur if the output is driven hard into clipping (this is not uncommon in commercial amps either). If this occurs R13 should be increased until clipping cannot occur with normal level inputs — it may go quite high.

Once everything works the heatsinks can be soldered to the pins of the LM380's. (The heatsinks are not shown in the photograph as they would have hidden much of the circuit board.)

PLAY *EFFECTIVE* GUITAR WITH OUR **WAA WAA UNIT**



PERHAPS THE MOST used of all the various guitar effects is that of the 'Waa-Waa' unit. The sound of this circuit has been screaming from speaker stacks for many a decibel-ridden year now, and no doubt will continue to do so for a while yet.

Our unit described here will, we hope, contribute to this longevity!

Basically the chracteristic sound of a Waa-Waa unit is produced by sweeping a band-pass filter across the audio spectrum of a guitar. A frequency range of approx 70Hz–6kHz. This can be done in various ways, but is usually tailored to be operated by a foot pedal. However, these pieces of hardware are both expensive and hard to obtain other than full of electronics.

BACK PEDALLING

Since our design was to be for the home constructor, we decided against the use of a pedal, and instead we have substituted two foot switches. These are much cheaper and should be easy to get hold of.

By avoiding the pedal, we created a problems for ourselves, in that we could no longer operate the filter with a variable resistor. Instead it is made to sweep across the range by the switching into circuit of three capacitors, which alters the resonant frequency of the filter.

ON THE LEVELS

The input impedance of the unit is about 2k and the first stage gain such that the device operates best with an input of around 10–20mV. Signals much higher will cause the stage to distort the incoming signal. If you wish to cause distortion of course, then go ahead (did someone mutter 'Fuzz to you too'?) If not then a volume control of at least 2k is a good idea if the input exceeds 50mV. Output impedance is low and will match any amplifier.

USE AND ABUSE

Using the unit should pose no real problems, and there is no setting up to be done. Operating the single switch will result in a 'waa' on the next note played through the circuit. It is best not to hold the switch closed, but to release it quickly. After a short while it becomes easy (relatively!) to add

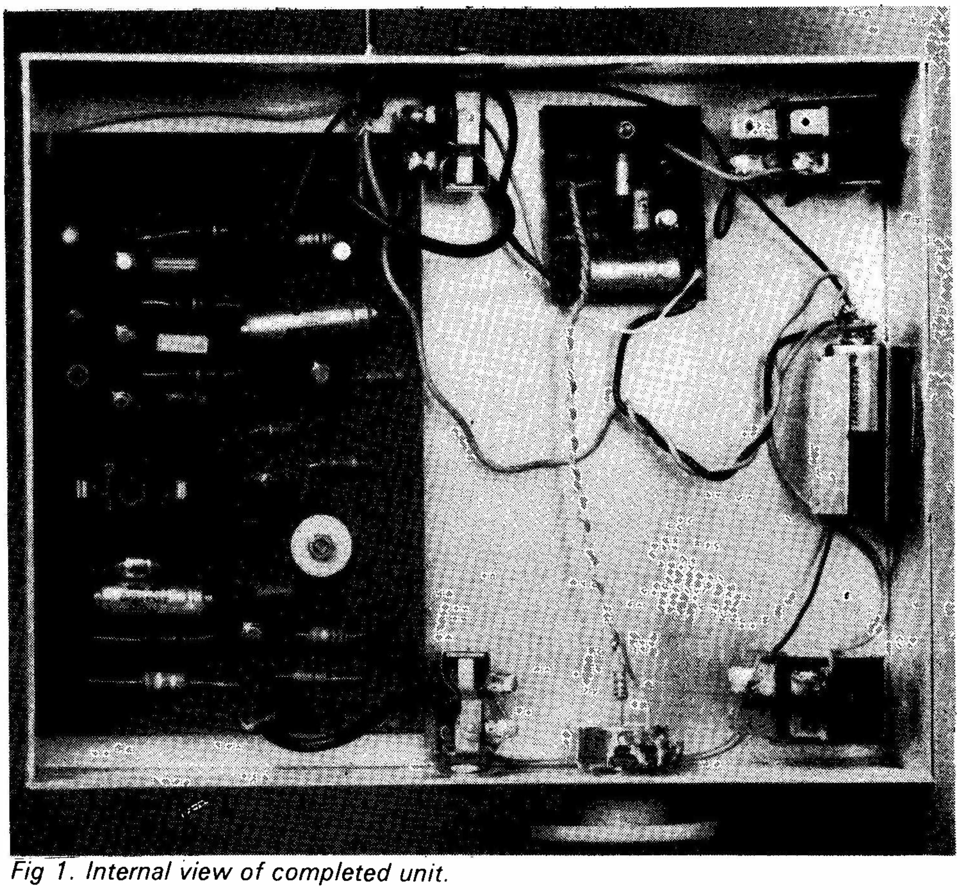


Fig 1. Internal view of completed unit.

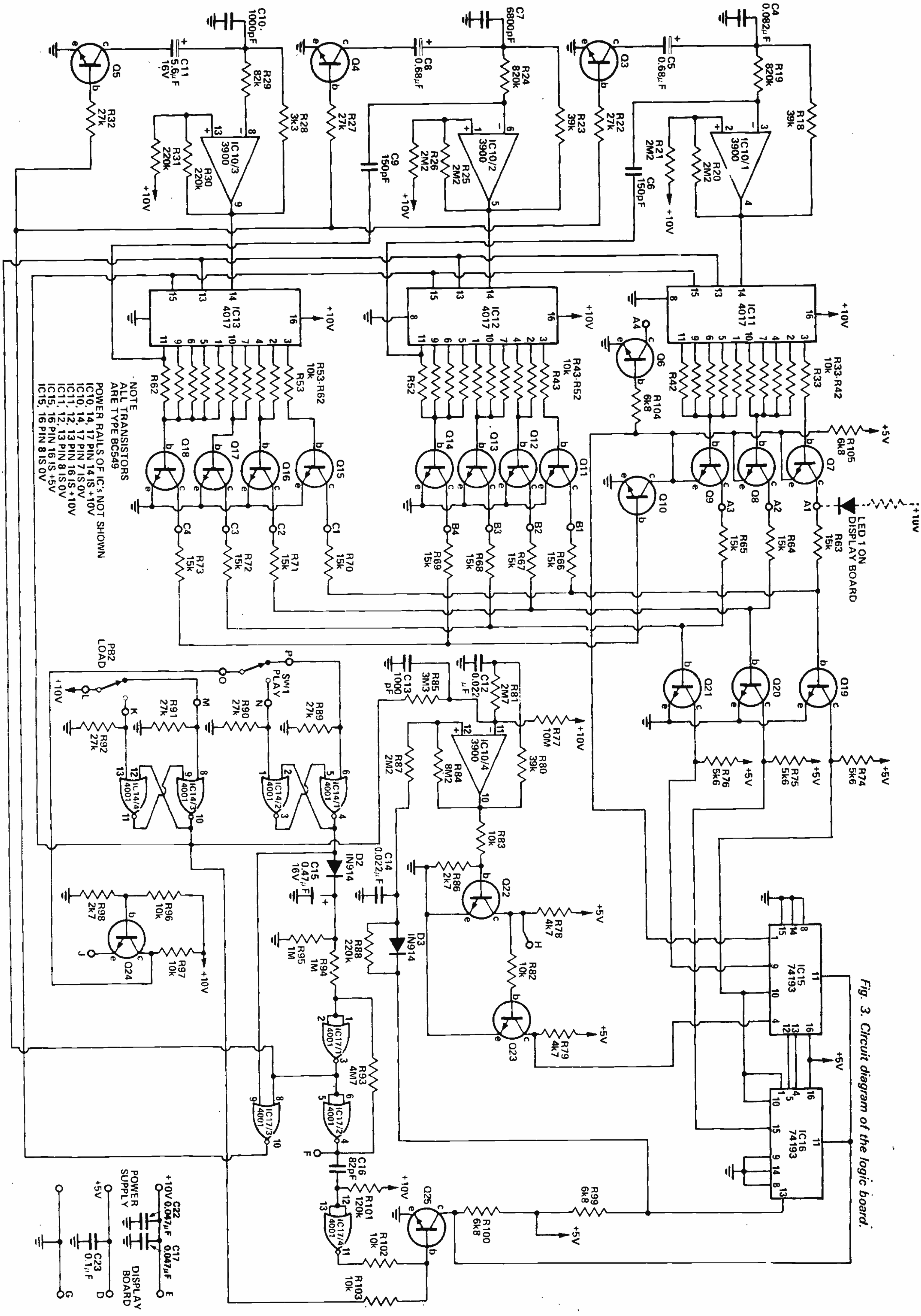


Fig. 3. Circuit diagram of the logic board.

PRIZE	1st ROLLER	2nd ROLLER	3rd ROLLER	WINS 1000 Plays	ODDS	VALUE OF PRIZE	TOTAL VALUE IN 1000 Plays
Jackpot	1	1	1	1	1000/1	100	100
2nd	2	2	4	16	62.5/1	16	256
3rd	2	3	5	30	33/1	8	240
4th	5	4	10*	200	5/1	2	400
TOTAL				247	4/1		996

* 4th prize is not decoded on the 3rd roller. However if 4th prize is on both the 1st and second roller it is automatically lit up on the 3rd. This is similar to [10|10|—] on a normal machine.

This table shows the number of times each symbol is on each 'roller' – and a breakdown of the odds of each 'prize'.

PARTS LIST – ETI 529

R106 Resistor 33 ohm 1W 5%
R6-R7 " 820 ohm ¼W 5%
R86,98 " 2k7 " "
R28 " 3k3 " "
R5 " 3k9 " "

R78,79 " 4k7 " "
R74,75,76 " 5k6 " "
R99, 100, " 6k8 " "
R104,105 " 6k8 " "
R1,3,4 " 10k " "
R33-R62 " 10k " "

R82,83,96 " 10k " "
R97,102,103 " 10k " "
R63-R73 " 15k " "
R22,27,32 " 27k " "

R89,90,91,92 " 27k " "
R2,18 " 39k " "
R23,80 " 39k " "
R29 " 82k " "
R101 " 120k " "

R30,31,88 " 220k " "
R19,24 " 820k " "
R94,95 " 1 M " "
R20,21,25 " 2M2 " "
R26,87 " 2M2 " "

R81 " 2M7 " "
R85 " 3M3 " "
R93 " 4M7 " "
R84 " 8M2 " "
R77 " 10M " "

C16 Capacitor 82pF Ceramic
C6,9 " 150pF "
C10,13 " 0.001µF Polyester
C15 " 0.47µF 16V electro-

C7 " 0.0068µF "
C12,14 " 0.022µF "

C2,3,17, 22 " 0.047µF Ceramic
C4 " 0.082µF Polyester
C18,21, 23 " 0.1µF Ceramic

C5,8 " 0.68µF 16V "
C11 " 5.6µF 16V "
C1 " 100µF 6V "
C20 " 220µF 16V "
C19 " 2200µF 25V "

Q1-Q25 Transistor BC109, BC549 or similar

IC1,2,3 Integrated Circuit FND 500 (DISPLAY)
IC4,5,6 " " 9368
IC7,8,9 " " 74192
IC10 " " 3900
IC11,12,13 (CMOS) " " 4017
IC15,16 " " 74193
IC14,17 (CMOS) " " 4001
IC18 " " 7805

D1,2,3 Diode IN914 or similar
D4,5 " EM401 or similar

LED1 – LED12 TIL 209 or similar

PB1 Push Button normally open
PB2 Push Button 1 pole change over

SW1 Switch see text.
SW2 " 2 pole 240V toggle

T1 Transformer 240V/9V-0-9V @ 1A

PC Boards ETI 529A, 529B
Metal Box SF 6, (150 x 150 x 150 mm sloping front)
8 way tag strip
3 core flex and plug
front panel escutcheon
handle
nut & bolts
12mm threaded insulated spacers

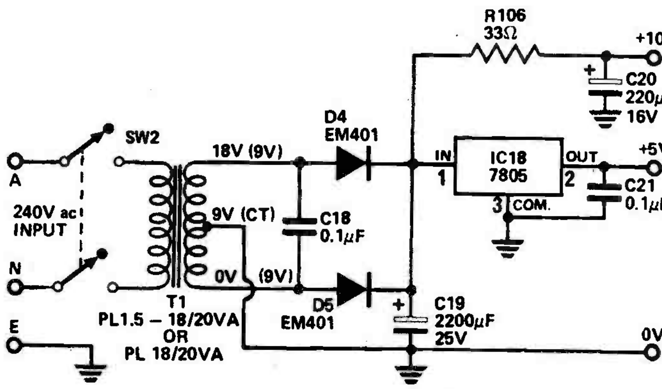
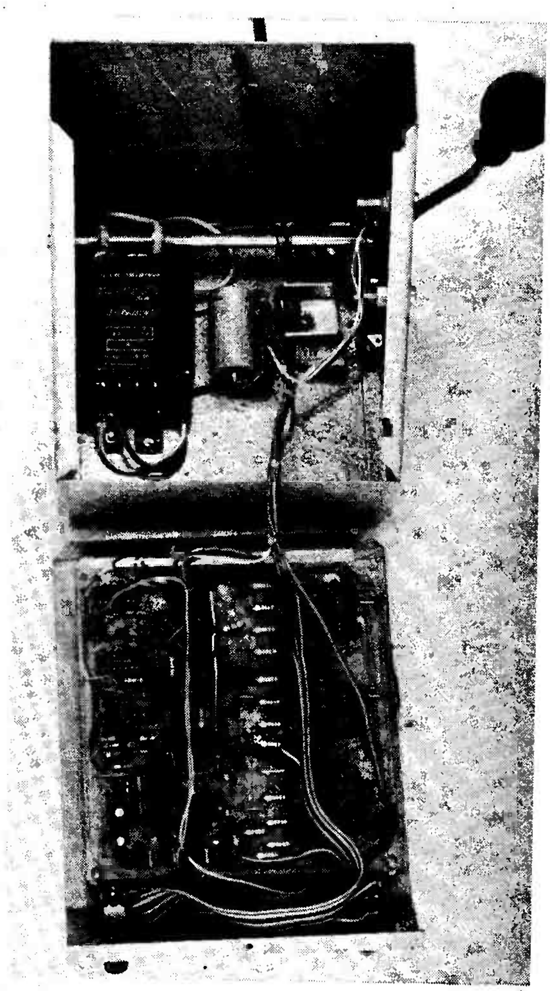


Fig. 4. Circuit diagram of the power supply.

must be pressed. This resets the rollers to zero which represents a jackpot, loads this into the payout counter and is then clocked into the bank.

Obviously this machine would not last long in a club with a payout of 99.6%. If required the payout can be changed either by changing the value of the prize or changing the weighting of the rollers. Reducing the jackpot to 64 (which is easy) reduces the payout to 96%.



Internal view of poker machine showing location of major components. Note rubber band arm-return spring.

CONSTRUCTION

Because of circuit complexity it is recommended that printed-circuit boards be used as their use will greatly simplify construction.

When assembling components to the printed circuit boards take particular care to correctly orientate integrated circuits, electrolytic capacitors, diodes and transistors. Construction should commence by installing links to the logic board in accordance with overlay diagram Fig. 10. Make sure that the supply-rail decoupling capacitors C2, 3, 16, 17, 22 and 23 are ceramic types for best possible bypassing.

On the display board Q1, Q2 and C1 should be laid flat on the PC board so that there is sufficient clearance when the board is mounted to the front panel. The leads of the LEDs were bent to form the shape of a circle (don't bend close to the body of the LED or the lead will fracture) thus giving a spring action against the rear of the panel.

When assembling the main logic board, use care with integrated circuits IC11, 12, 13, 14 and 17. These are CMOS devices and are easily damaged by static discharges. Avoid handling the pins, insert them after all other components are mounted and insert them as quickly and cleanly as possible. Lastly with these ICs, and indeed all semiconductors avoid overheating the device when soldering. Apply the iron only long enough to obtain a good joint.

Interconnect the two boards as shown in Fig. 6. Keep the leads as short as possible especially power supply leads E, D and G as interference picked up on these leads could affect the operation of the machine. Also at this time attach leads to the outputs of the boards which are long enough to reach the switches and power supply.

Both boards may now be mounted on the rear of the sloping front panel. Making sure that the LEDs are aligned with the holes, mount the display panel (component side towards rear of panel) by means of 19 mm countersunk screws. Space the board from the front panel about 8 mm by means of a pair of nuts or plain spacers. Hold the board in position by screwing 12 mm spacers onto the protruding screws. Now attach the logic board by screwing to the 12 mm spacers (component side away from front panel).

The power supply is built into the bottom of the box and wired up as in Fig. 11. An eight-way tag strip being used to support all the components. Make sure that the polarities of the diodes and electrolytic capacitors are correct. The five volt regulator, IC 18, is bolted to the bottom of the box after first scratching away the paint so that good thermal conduction is obtained – a little silicon grease between tab and box will help. When mounting the tag strip make sure that both earth lugs have good electrical contact with the box.

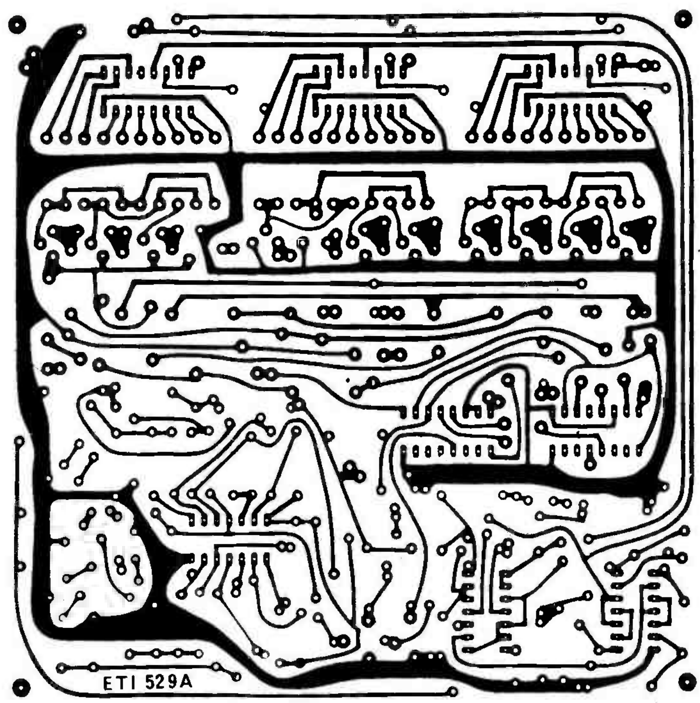


Fig. 7. Main logic board (full size 140 mm x 135 mm)

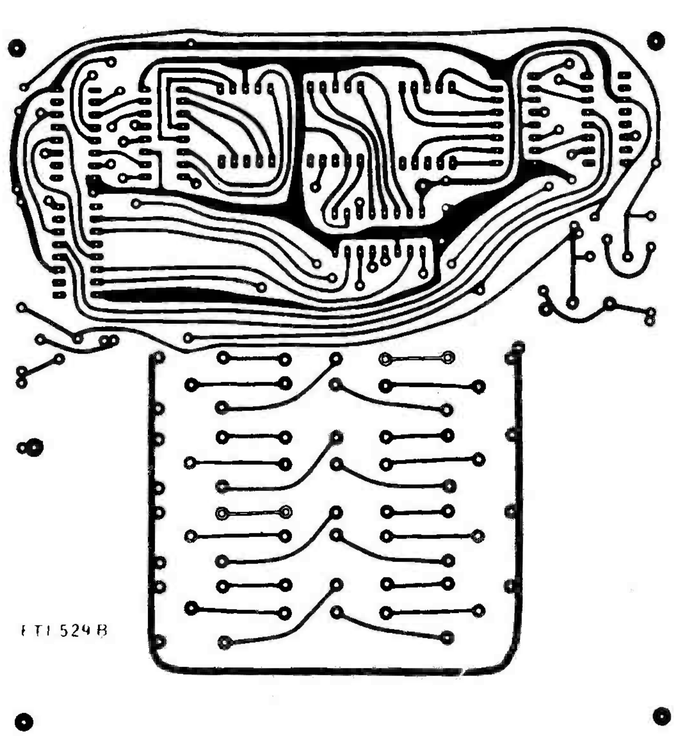


Fig. 8. Display board (full size 140 mm x 135 mm)

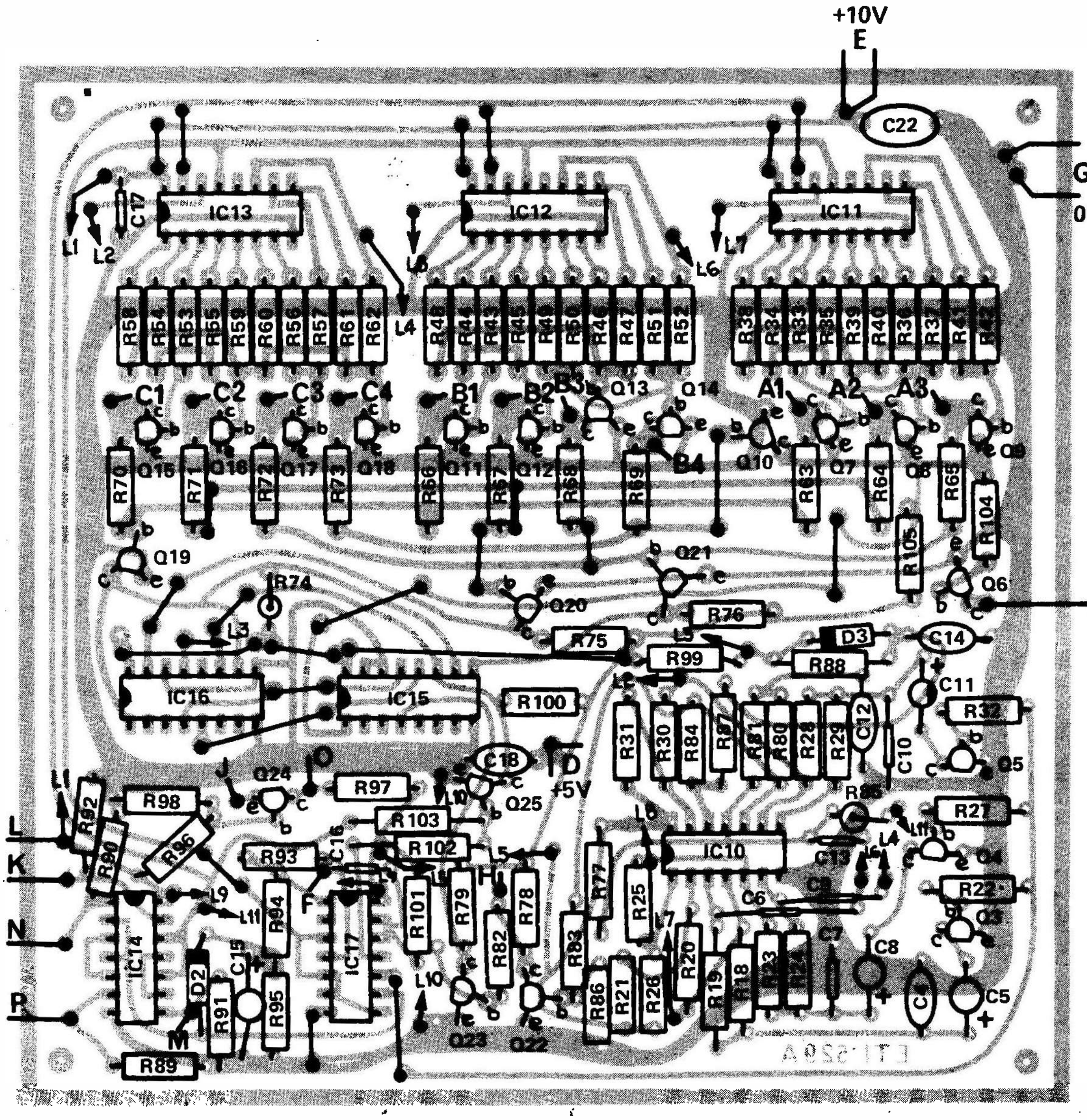


Fig. 5. Component overlay for the logic board.

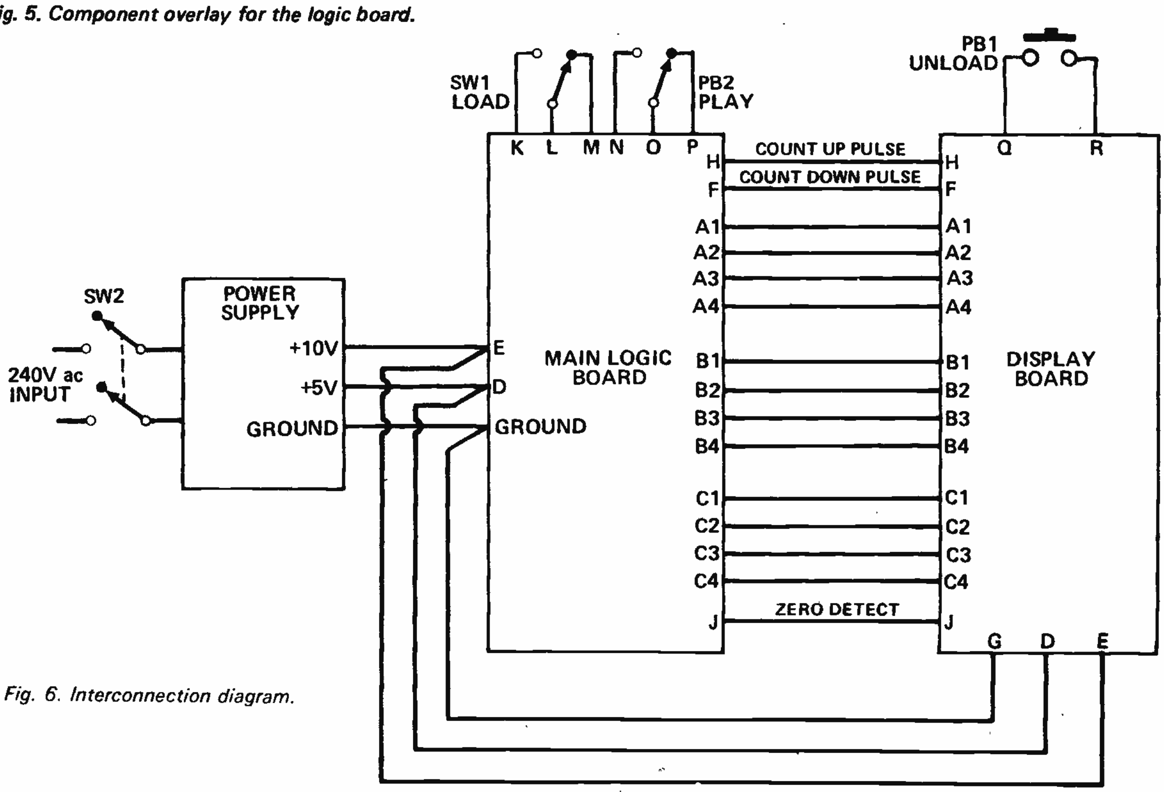


Fig. 6. Interconnection diagram.

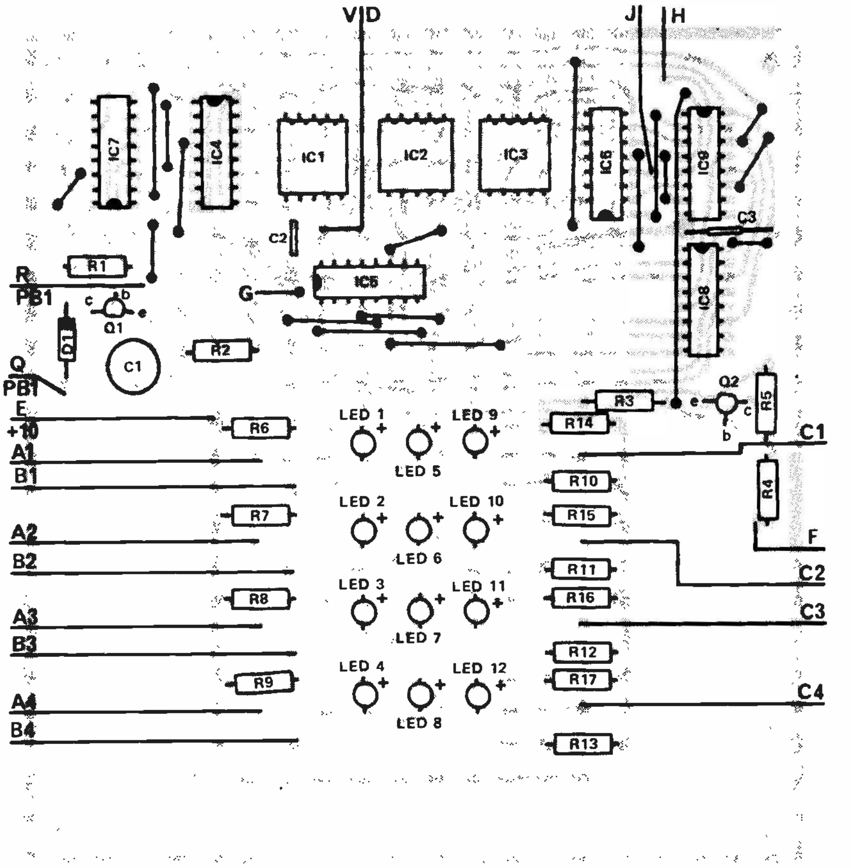
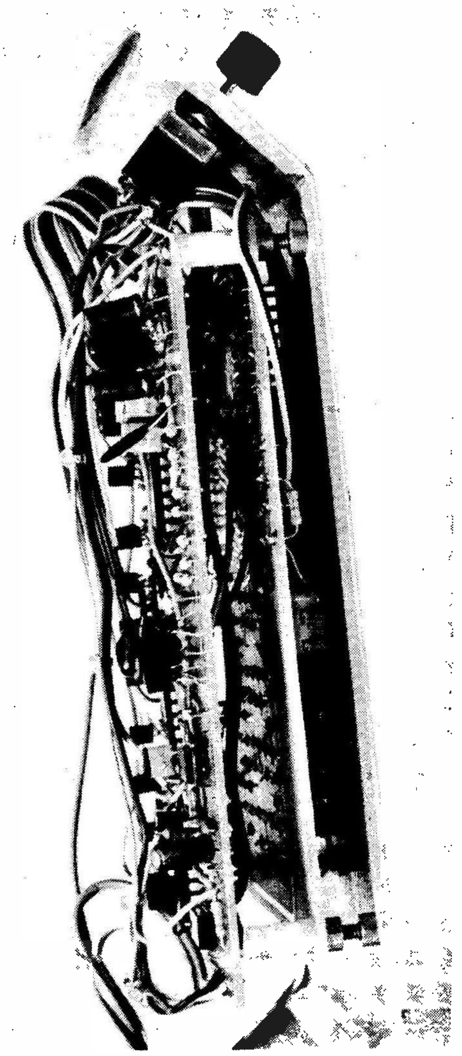


Fig. 9. Component overlay for display board.



This picture shows how the two boards are mounted to the rear of the front panel

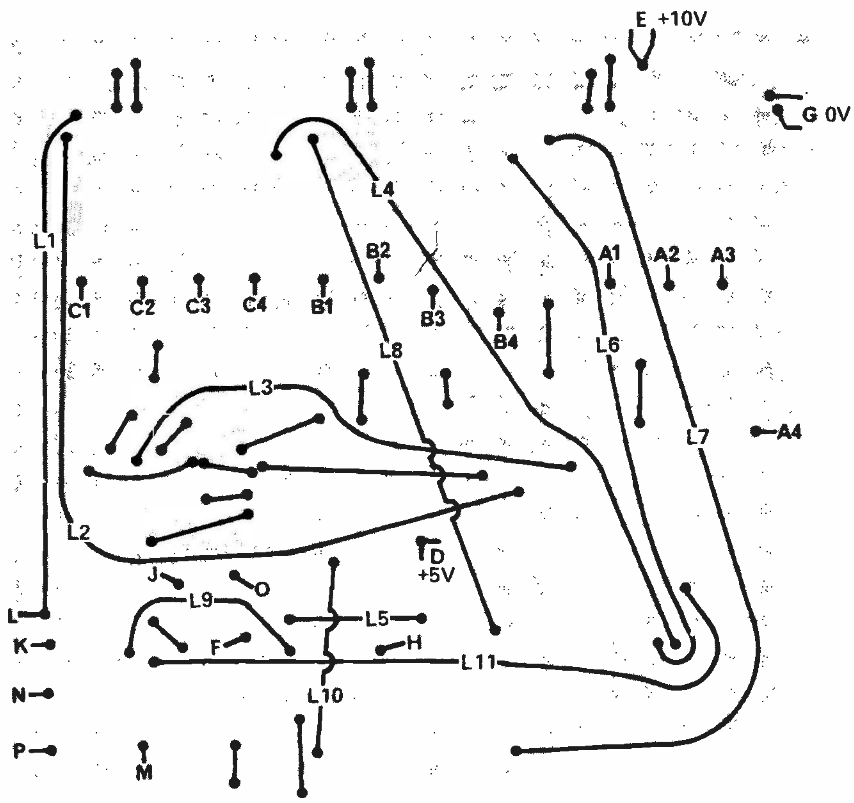


Fig. 10. Linking diagram for the logic board.

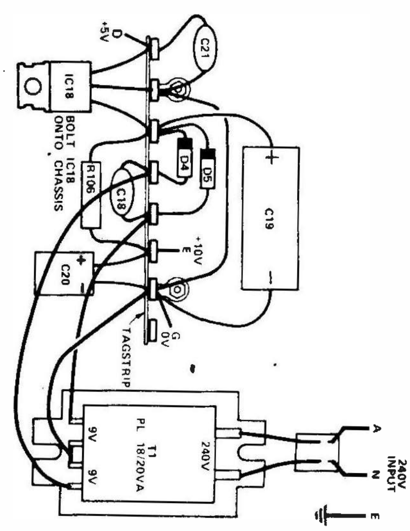


Fig. 11. Wiring of the power supply.

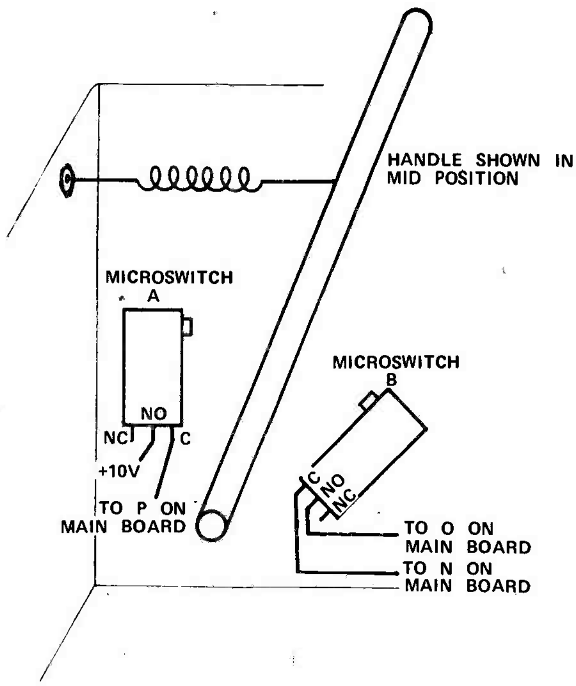


Fig. 12. Alternate arrangement of two micro-switches on the play handle.

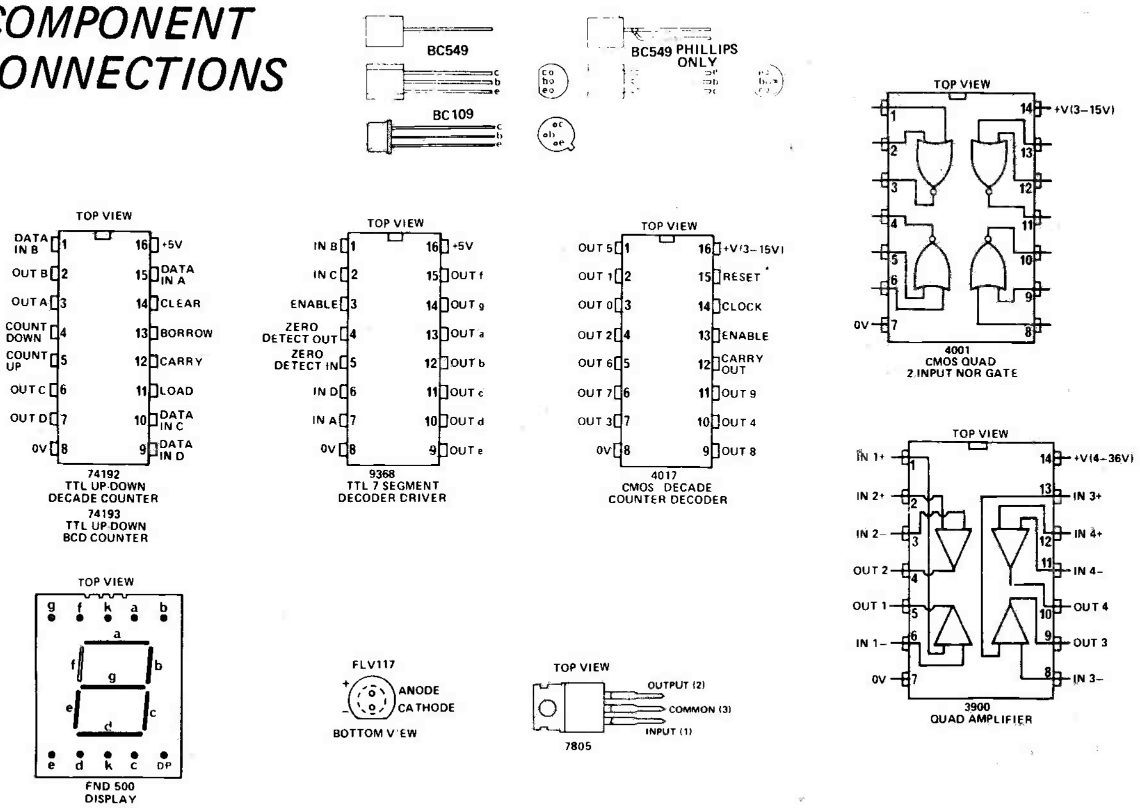
The play handle may be fashioned from a piece of 6 mm metal rod, formed into an 'L' and fitted with a wooden handle (a file handle is just right). The handle should be passed through holes drilled in either side of the box and held in position by split pins or small collars and grub screws.

A microswitch may then be mounted such that it is actuated by the grub screw (or end of the split pin) when the arm is pulled forward. A pin and spring should be fitted such that the handle returns to the upright position when released. The travel of the handle should be restricted by means of two bolts through the side of the case. Rubber grommets may be mounted under the head of the bolt to cushion the end stop.

The 'load' and 'unload' switches may then be mounted on the top of the front panel and the unit interconnected.

Note that, if desired, extra realism may be added by using two microswitches to replace SW2 (the play switch). The first microswitch is operated with the arm fully vertical and the second one with the arm fully forward as before. This means that the arm must be fully depressed and then fully returned for each play. Connection of the microswitches is illustrated in Fig. 12

COMPONENT CONNECTIONS



HOW IT WORKS ETI 529

The roller counters IC11, 12 and 13 are CMOS decade counters and decoders. These counters provide a high output on only one of the ten output lines for each and, when enabled, this high will shift through the outputs at a rate determined by an oscillator (IC 10A, B and C respectively) associated with each counter. The oscillators run continuously but the counters are only enabled when pins 13 are taken low.

The outputs of the roller counters are taken via resistors R33 through R62 to the 'odds decoders' Q7, 8, 9, and 11 through 18. These transistors are wired as resistor/transistor NOR gates. Thus, for example, the collector of Q14 will be low when ever any of IC12 pins 5, 6, 9 or 11 are high. When the collector of Q14 is low the roller indicator LED, connected to B4, will be illuminated.

Note that the emitters of Q7, 8 and 9 are grounded via Q10. Therefore if Q10 is off Q7, 8 and 9 are disabled. Transistor Q10 is off only when Q14 and Q18 are both on, in which case Q6 is also turned on illuminating LED A4.

The four pay conditions are decoded by Q19, 20, 21 and Q10 which are all wired as NOR gates. For example, when a jackpot occurs, pins 3 on IC11, 12 and 13 all will be high causing Q7, 11 and 15 to conduct. Hence Q19 base will be at ground potential and its collector at +5 volts. This high will be transferred to the payout counters IC15 and 16. These ICs are up/down binary counters which can be preset to any desired count by applying a four line code to pins 1, 9, 10 and 15. Pin 15, 1, 10 and 9 have weights of 1, 2, 4 and 8 respectively on IC15 and, as IC15 drives IC16, will have weights of 16, 32, 64 and 128 on IC16.

Returning now to our jackpot conditions, the high from Q19 will appear at pin 10 of IC15 (weight 4) and pins 1 and 10 of IC16 (weight 32 and 64 respectively). Hence the counter will be loaded with 64 + 32 + 4 = 100. When the counters are not at zero the 'borrow' output pin 13 will be high. This high is delayed by R88 and C14 and passed to oscillator 4 (IC 10d) gating it on. A train of positive going pulses is generated which is inverted by Q22 and passed, via terminal H, to pin 5 of IC9 thus incrementing the display counter. At the same time IC15 and 16 are also decremented by the same pulse train via Q23. When IC15 and 16 reach zero the borrow output goes low stopping oscillator 4. Diode D3 discharges C14 rapidly ensuring no delay in switch off.

The switch-on delay allows time for the counters to be loaded before the oscillator starts – hence ensuring an accurate count. By this means the count loaded into IC15 and 16 is loaded into the display counters and simply adds to any count already displayed.

If no prize is decoded by Q10, 19, 20 and 21 zero will be loaded into the pay out counter and oscillator four will not be started.

THE PLAY SEQUENCE

The play switch SW1, and the load button, PB1, are both shown in the non-operated position. Both switches are connected to RS flip-flops (IC14) which eliminate any contact bounce.

When the handle is pulled SW1 sets the output of IC14-1 'high' charging C16 to 10 volts. This causes the output of IC17-1 to go 'low' and this low enables roller-counters IC11, 12 and 13. The same low gives a high at the output of IC17-2.

When the handle is released the IC14 latch resets and, as C15 discharges only slowly through R95, both inputs to IC17-3 will be low. Transistors Q3, 4 and 5 will therefore turn on switching capacitors C5, 8 and 11 in parallel with C4, 7 and 10 respectively. The oscillators 1, 2 and 3 therefore slow from 20 kHz, 2 kHz and 200 cycles respectively and continue at a much slower speed. This slow speed operation is maintained to give the appearance of wheels spinning to the roller indication LEDs and has little bearing on the final roller display. This being mainly determined by the period of high speed oscillation that is gated to the roller counters.

After a delay of several seconds C16 discharges to the threshold point of the Schmitt trigger formed by IC17-1 and IC17-2 causing IC17-1 output to go high thus disabling the roller counters IC11, 12 and 13. At the same time the output of IC17-2 goes low triggering the monostable formed by C16, R101 and IC17-4. The output of IC17-4 is a narrow positive pulse which turns on Q25 momentarily, loading IC15 and 16 with whatever is at the input terminals.

The output of IC17-2 also is connected to the down-count of the bank counters via the level translator and inverter Q2. Thus at the time the rollers stop one is also subtracted from the display. If a prize has been won this will immediately be added to the display and the one deduction will not be seen but still occurs.

Should the display counters all be at zero, after this pulse, the display decoders IC4, 5 and 6 will detect the all zero condition (by the leading edge zero suppression feature of IC6) and ground the emitter of Q24. Transistor Q24 will therefore conduct and ground the +10 volt supply to SW1 inhibiting any further play.

To restart playing, the load switch PB1 must be pressed. This resets counters IC11, 12 and 13 to the zero position and, since the zero position is also the jackpot position, Q19 will detect a jackpot. Pressing PB1 also generates a load pulse via R103 which causes 100 to be loaded into the payout counter. Whilst PB1 is pressed oscillator 4 is inhibited via R85. When PB1 is released oscillator 4 starts (because the payout counters are no longer at zero) and 100 counts are added to the display counters.

The three counters of the display section IC7, 8 and 9 are cascaded decade counters providing a maximum count of 999. The output of these counters is decoded to seven segment format by IC4, 5 and 6 to drive the displays (IC1, 2 and 3). On switch-on C1 charges slowly delaying the turn-on of Q1. Until Q1 turns on, IC7, 8 and 9 are held, reset to zero, the delay allowing the payout counters time to settle. To clear the machine pressing the unload button cuts of Q1 thus generating a positive going pulse which clears IC7, 8 and 9.

The power supply is a simple full wave rectifier and capacitor filter the output of which is regulated by IC18 to +5 volts. This IC has thermal cutout and overload protection. Resistor R1 provides an unregulated supply of 10 volts which is smoothed by C20.

The play switch SW1 was described previously as a single pole push button, or microswitch, activated by pulling the handle. A more realistic handle action may be obtained by using two microswitches to replace SW1. The first microswitch is actuated when the handle is at the rest position and the second when the handle is at the end of its forward travel. These switches should be interconnected as shown in Fig. 9, and such connection means that the handle must be pulled all the way forward, and then, all the way back to operate the machine.

THE OSCILLATORS

Oscillators 1, 2, 3 and 4 are based on the LM3900 IC which contains four, identical Norton operational amplifiers. These amplifiers operate a little differently from conventional devices.

Unlike the conventional op-amp both inputs of the Norton amplifier are about 0.6 volts above ground (one base-emitter junction) and the output is dependant upon the ratio of the currents into the two inputs. That is the output will remain centred if both currents are varied from say 10μ A to 1 mA providing there is never any differential current between them. However if the current into the negative input is higher than that into the positive, the output will go low and vice versa. The amount of difference in the currents depends on the open-loop gain of the amplifier. We, at the moment, are only concerned with their operation as an oscillator.

Referring to the main circuit diagram and to IC10-1 we can assume that its output is low and C4 is discharged. (Ignore for the moment Q3 and C5). Under these circumstances a current of 4.5 μA flows into the positive input (10V/R21) and none into the negative input. This causes the output to go to +10 volts. As a result the current into the positive input rises to 9μA and C4 begins to charge via R18. As C4 charges R19 passes current into the negative input and when the voltage across C4 reaches about 7.5 volts the current in R19 will equal the current into the positive input thus forcing the output hard low (since the current through R20 is now lost).

The voltage across C4 will now drop and when it reaches about 3.5 volts it falls below the positive input and the output goes high again. This process continues producing square wave oscillation.

There are two ways to stop the oscillator. One is to remove the bias current into the positive input and the other is to swamp this bias current by adding a higher bias current into the negative input. Both these methods are used on oscillator 4.

electronics today international

Sounds pompous, doesn't it: International? But ETI is a truly international magazine.

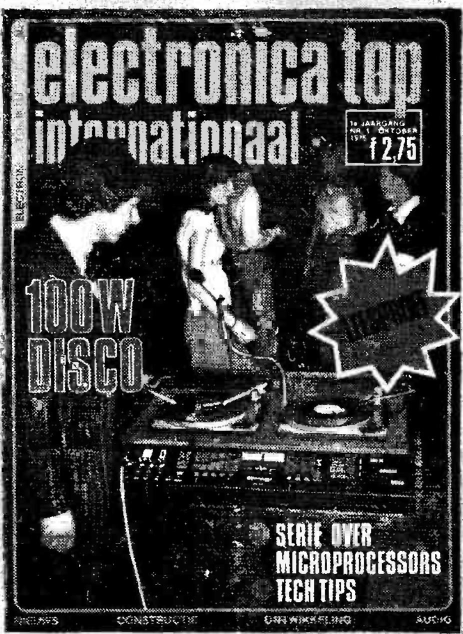
In addition to Britain, there's Australia and France. During the week that this publication goes to press, the first issue of ETI Holland rolls off the press. In the same week, ETI staff will be in Canada, planning for the launch of ETI-Canada at the end of 1976 or January 1977.

How does this help the reader? Firstly it gives access to resources way beyond any other technical magazine in the world. The issues each have access to the research and articles of the others. Each magazine is edited locally for its own market and, of course, many features are of little interest to readers in other lands, but much of electronics is truly international.

Australia, Holland and Britain have their own laboratories and workshops to initiate projects and conduct proper tests on projects and equipment.

ETI is international and is a unique international experiment: more important, it's an international experiment that works.

INTERNATIONAL?



All these should be very familiar to you. If they're not, you *must* be missing out on a lot. Not that we're boasting — but we are the fastest growing electronics magazine in the country. This means some people have trouble getting hold of ETI. These poor unfortunates may have missed one of the superb issues shown here. Don't join the ranks of the despairing — take yourself out a subscription and ensure regular doses of ETI.

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ALL PAYMENTS MUST BE IN STERLING

the effect to any required note or chord. Depressing the auto switch couples the filter to the oscillator, and thus produces a 'Waa-Waa' sound independent of the input, at a rate set by VR1, for as long as the switch is held down.

With no controls operated, the section of the filter which remains in circuit means that a 'treble boost' occurs on the signal. If you don't want this effect, then a third switch wired to take the signal away from the waa-waa is needed, and should not be difficult to add.

BUILDING UP

Construction of the unit is made easier by using the PCBs, but layout is not that important, and something like veroboard would serve the purpose. We split up the circuit onto two boards to facilitate the fitting of the small multivibrator auto control into the guitar itself. This system has the advantage that the rate control for the auto-waa is then easy to alter while playing. The lead between the two parts of the circuit need not be screened, as it carries no audio signal just the supply to the oscillator, and the square wave switching signal to the filter.

The sound of the effect in use is set by the capacitors in the filter section, and these can be experimented with to change the nature of the resulting sound.

HOW IT WORKS

L and C4 form a band-pass filter with resonant frequency equal to

$$f = \frac{1}{2\Pi\sqrt{L.C4}}$$

With the values shown here this value is about 6kHz. The R-C networks R5–C6 R6–C8 R7–C10 act as time delays to switch on Q2,3,4 respectively in sequence following the depression of SW2.

This switches C5, C7, C9 across the filter in turn, pulling the resonance point across the audio band. The time constants are such that the order of switch on is Q2, Q3 and Q4.

This resonance changes from 6kHz–2k7Hz–950Hz–to 400Hz when Q4 switches on. Upon releasing the switch the electrolytics discharge through the 100k resistors to earth, switching off the transistors.

Automatic switching is provided by the multivibrator, the frequency of which is set by VR1. When the 'auto' switch, S1, is depressed a slow square wave of about 8V is applied to the charging resistors. Thus the transistors are pulsed on and off. C13 is to decouple the supply to the oscillator to prevent problems with variations as the oscillator switches state.

PARTS LIST

R1,8	–	47k
R2,9	–	39k
R3	–	2k2
R4	–	470R
R,5,6,7	–	100k
R10	–	820R
R11	–	680R
R12,14,15	–	1k
R13	–	82k
	–	
C1	–	30µF
C2	–	0.1µF
C3,12,13,14	–	100µF
C4	–	3900pF
C5	–	.015µF
C6,15	–	1.0µF
C7	–	.15µF
C8	–	2.5µF
C9	–	1.0µF
C10	–	4.7µF
C11	–	.01µF
C16	–	5µF
Q1,5	–	BC109C
Q2,3,4,6,7	–	BC109 or similar

L – 180mH – available from Maplin Electronics as 'L5' for the ETI Graphic Equaliser Can be wound as 424t of 38swg on Mullard LA 4543 core and DT2534 bobbin.

SW1, SW2 – Single pole changeover foot switches

Aluminium case to suit. On/off switch, 9V battery. ¼" jack sockets (2 off).

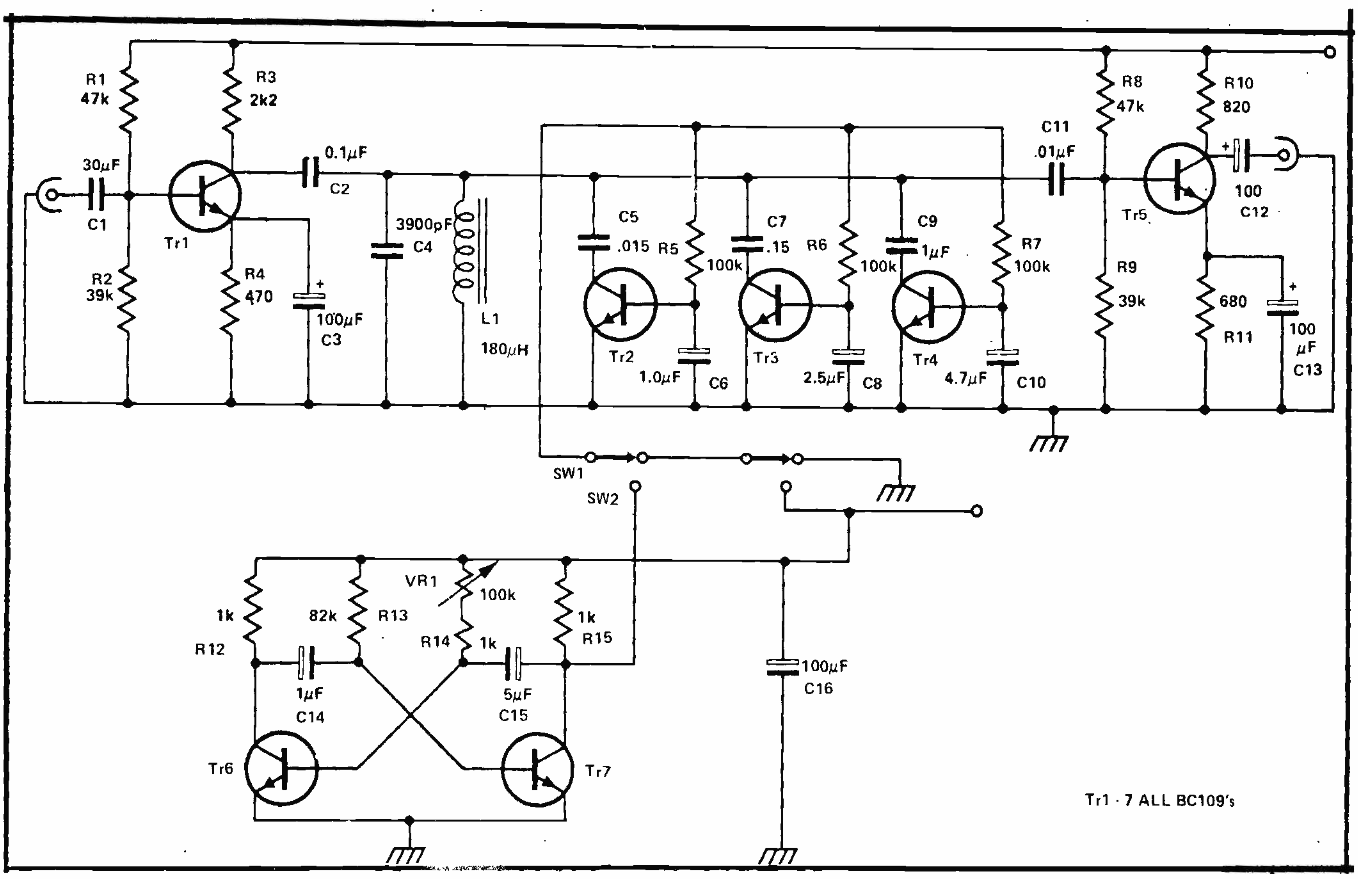

Fig 2. Circuit Diagram.

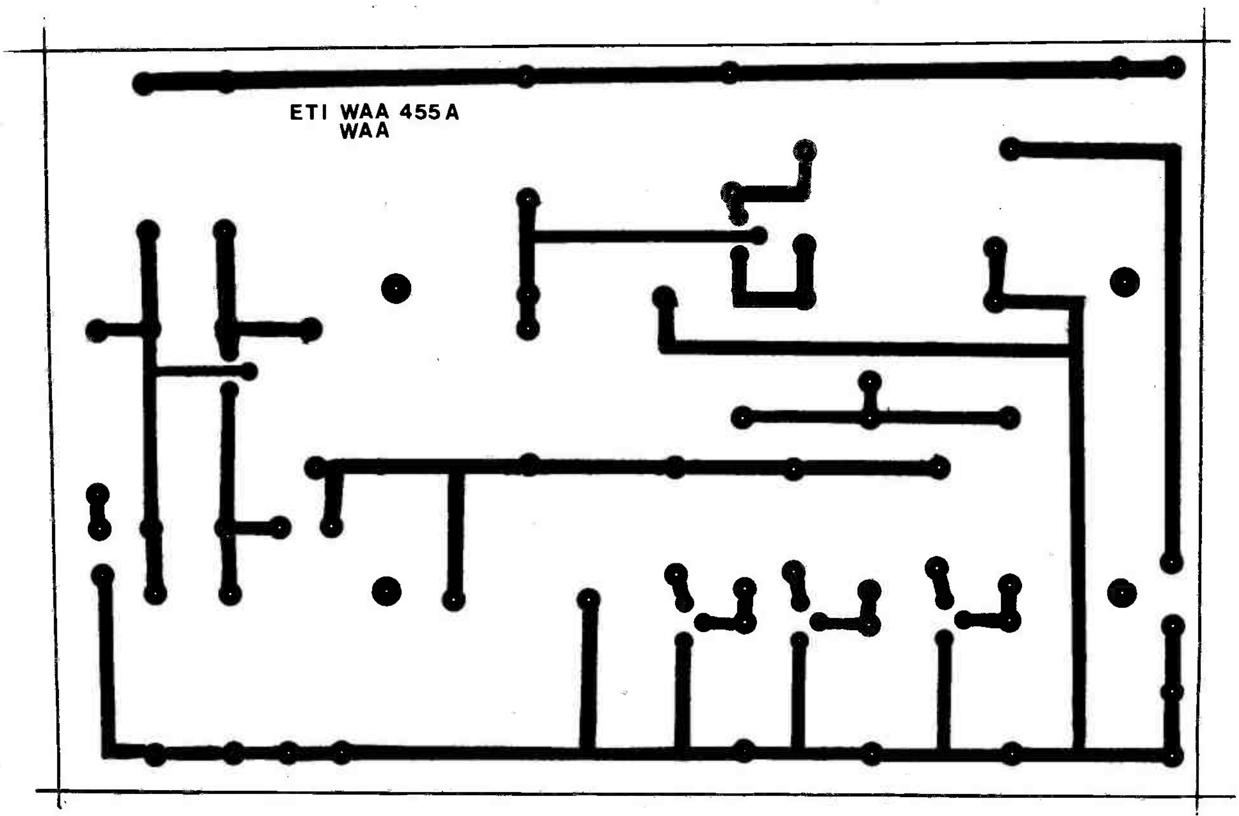

Fig. 2. P.C.B. Layout for main board (Full size)

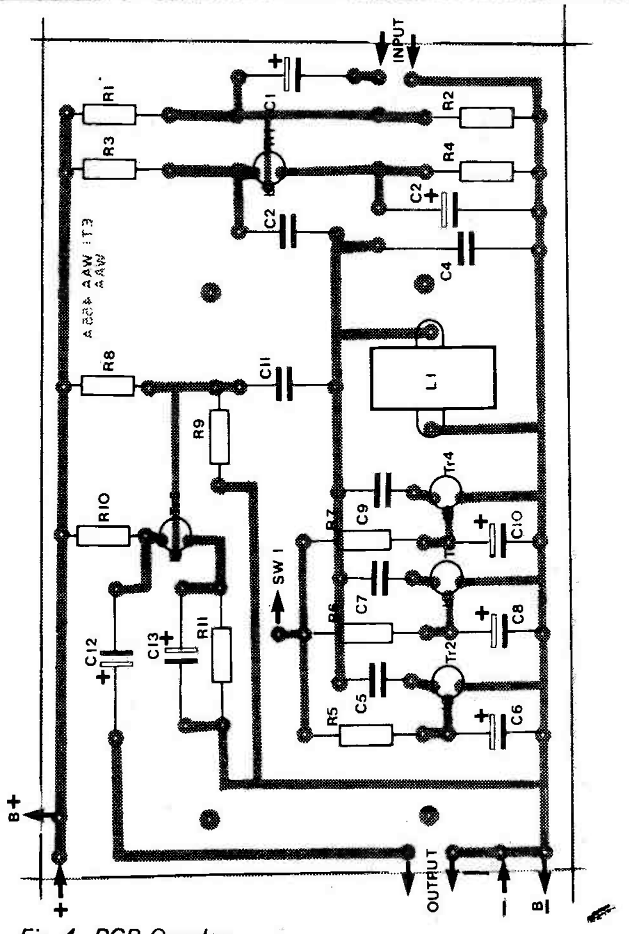

Fig 4. PCB Overlay.

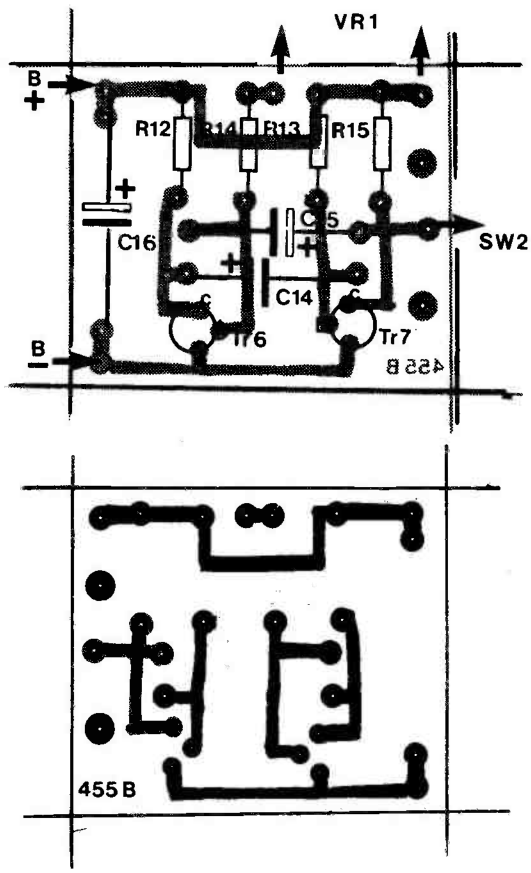

Fig 3. Oscillator Board and overlay (Full size).

CERAMIC CARTRIDGE PREAMPLIFIER

Use of charge amplifier improves performance of ceramic cartridges.

MOST amplifiers of commercial design, including our own ETI designs, omit facilities for ceramic cartridges and allow only for the use of magnetic cartridges. This is because magnetic cartridges are capable of much better performance than ceramic although top line magnetics are much more expensive.

Magnetic cartridges are expensive to build whereas ceramic cartridges are relatively cheap to build so there is a crossover point, and many top line ceramic cartridges are much better value-for-money than are magnetic cartridges in the same price range. Hence many people with limited funds have asked for details of a preamplifier input stage specifically tailored for use with ceramic cartridges.

The two types of cartridge, ceramic and magnetic are entirely different in terms of electrical qualities. The ceramic cartridge has a much higher output, the working load impedances of the two are entirely different and the magnetic type requires equalization whereas the ceramic type does not (or does it?). The magnetic provides an output which is proportional to stylus velocity whilst the ceramic provides an output proportional to acceleration. This means that where a record is recorded with constant acceleration characteristic the output from a ceramic cartridge would be flat with frequency whereas the output from a magnetic cartridge would be a response rising with frequency at 6 dB/octave. Converseley if a constant velocity record characteristic were used the ceramic output would fall with frequency at 6 dB/octave.

Today all records are recorded to the RIAA standard of equalization. This attenuates bass and boosts treble to provide a characteristic very close to constant acceleration. This procedure gives best compromise between the conflicting requirements signal-to-noise ratio and of pickup trackability. To replay an RIAA equalized record with a magnetic cartridge we must use a preamplifier having the reverse characteristic, i.e, bass must be boosted and treble must be cut in order to obtain a flat frequency response. This process is used on all preamplifiers for magnetic cartridges and is loosely just known as equalization.

However a *perfect* ceramic cartridge, when replaying RIAA equalized material would give an unequalized response as shown in Fig. 1. In order the make ceramic cartridges easier to use manufacturers build in a broad mechanical resonance at the high frequency end to boost the response. At the low end, the rise in response below 50 Hz is cured by selecting a terminating impedance which causes a roll off at about 130 Hz. The response of such a cartridge would be as shown in Fig. 2. If the bass end were not corrected rumble of the turntable would be accentuated and this is clearly not desirable.

Thus clearly, the impedance into which a ceramic cartridge works is of great importance and with this in mind we investigated different methods of matching the cartridge to the amplifier with a view to obtaining the utmost from ceramic cartridges.

DESIGN APPROACH

The ceramic pickup may be simulated by a voltage source and a series capacitor.

The value of the capacitor and the magnitude of the voltage source vary

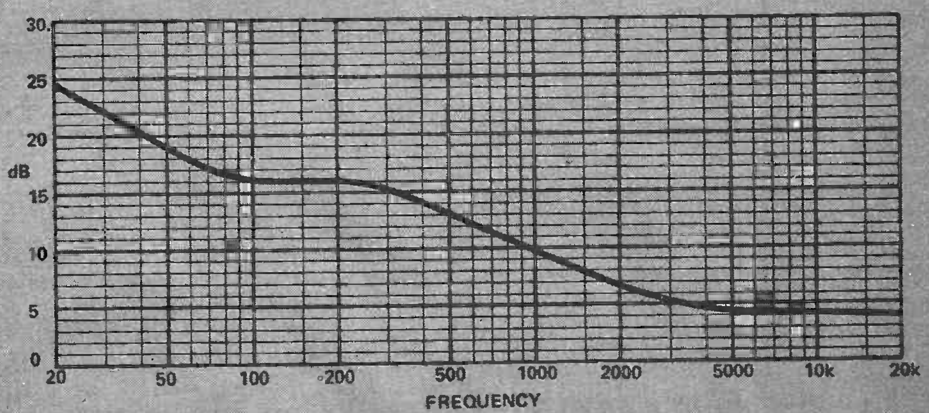

Fig. 1. Typical response of a ceramic pickup without mechanical equalization.

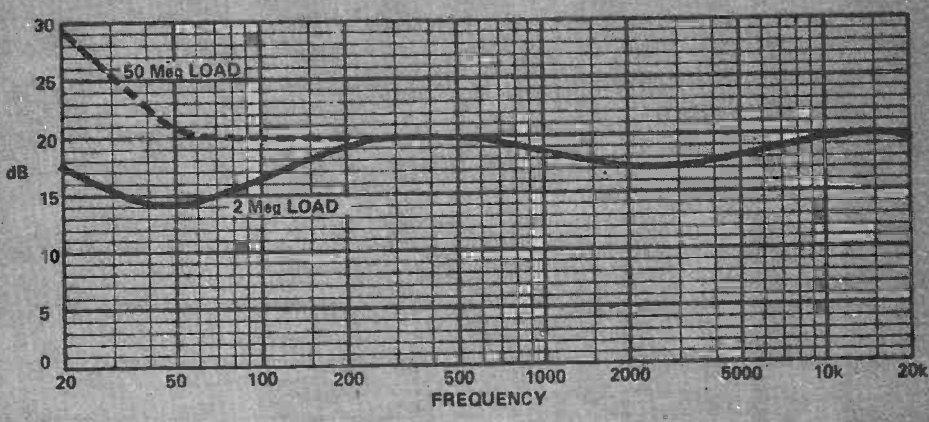

Fig. 2. Response of Decca Deram showing effect of terminating impedance at low end and of mechanical equalization at top end.

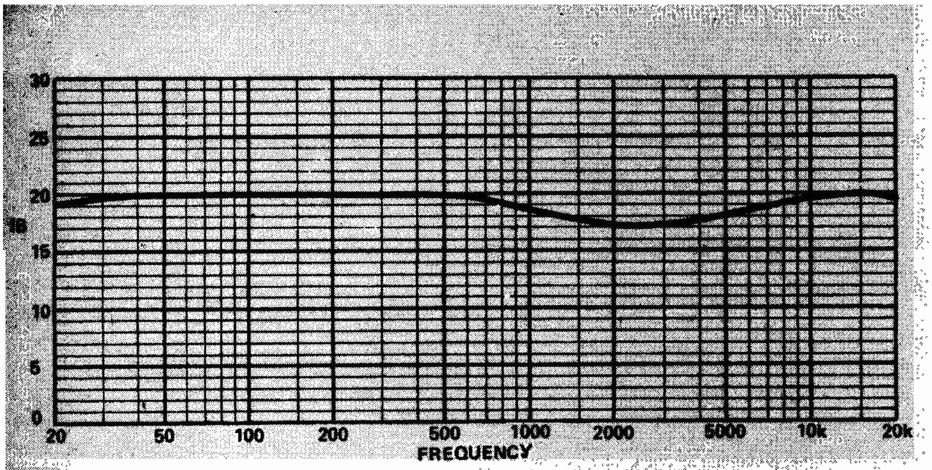

Fig. 3. Overall response of a Decca Deram into a charge amplifier.

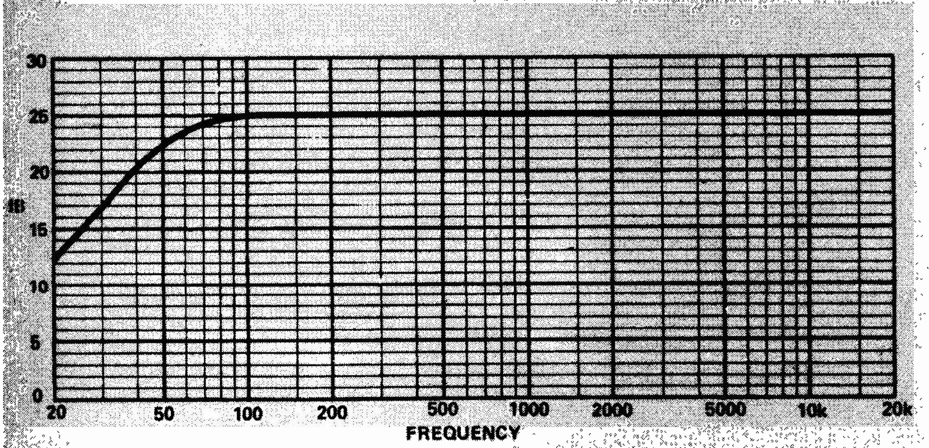

Fig. 4. Response of charge amplifier. Roll off at low end is designed to compensate for rising response of cartridge in this area.

from manufacturer to manufacturer but lie in the range 200-900 pF and 100 to 1000 mV at 1 kHz and 5cms/second.

One of the most popular and readily available cartridges is the Decca Deram and we performed all our tests with this cartridge. The unit has an output of about 150 mV and a capacitance of 600 pF. The recommended load impedance is 2 megohms and this gives the response as shown in Fig. 2. The bass response can be improved but only at the expense of greatly increasing the rumble. The dip at 2 kHz can readily be compensated for but we have not experimented in this area.

Another system commonly used is to load the unit with a low impedance (e.g. 75 k ohm) which causes a loss of bass below 3 kHz, and then boost the bass again electronically. This overcomes the need for a very high impedance. Such a technique combined with a rumble filter to cut the rising response below 50 Hz can give good results. However due to the large differences between various makes a different network needs to be designed to suit the bass roll-off characteristic of each cartridge type.

A third system which we propose, and to our knowledge this is the first time such a system has been described, is to use a "charge" amplifier.

CHARGE AMPLIFIER

With the charge amplifier the input impedance is zero — how then does it work? A conventional inverting amplifier is shown in Fig. 5. and, as anyone familiar with amplifiers will know, the output voltage will be:—

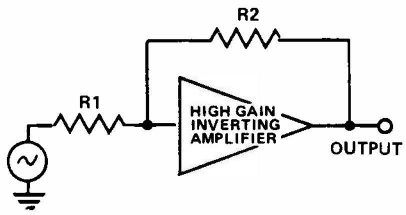

Fig. 5. Conventional inverting amplifier stage.

$$V_{out} = \frac{R2}{R1} \cdot Vin$$

What is not always realized by beginners is that R1 and R2 need not be resistive — they may be capacitors, inductors or combination of impedances. It is only the impedance that is important. Since the output of the ceramic pickup is a capacitor we may connect it directly to the input of an inverting amplifier and use a capacitor as the feedback element. The gain of the stage now becomes the ratio of the two capacitor impedances. Although the impedance of the capacitor drops with increasing frequency the ratio remains constant. Therefore, with a 'perfect' amplifier, the *frequency response is flat at* all frequencies.

In real circuits we generally need a bias resistor across the feedback capacitor. This causes a roll-off at the low end similar to that obtained when using a FET amplifier.

If a response down to 10 Hz is required a resistance of 50 megohm minimum is required. However this is

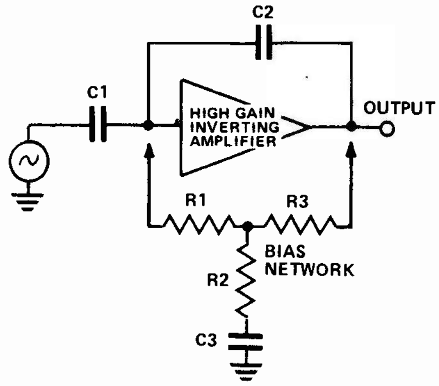

Fig. 6. Basic charge amplifier with bias and filter network. Gain control elements are capacitors. Bias network R1, 2, 3 and C3 are required for dc stability and to roll of bass response.

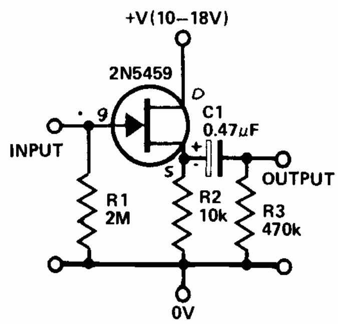

Fig. 7. Circuit of FET follower used to obtain the responses shown in Fig. 2.

TABLE 1			
GAIN (600 pF cartridge)	C2	C3	R4
unity	560 pF	0.0082μF	390 k
6 dB	330 pF	0.015μF	180 k
12 dB	150 pF	0.039μF	47 k

ETI TOP PROJECTS: No. 2

CONTENTS

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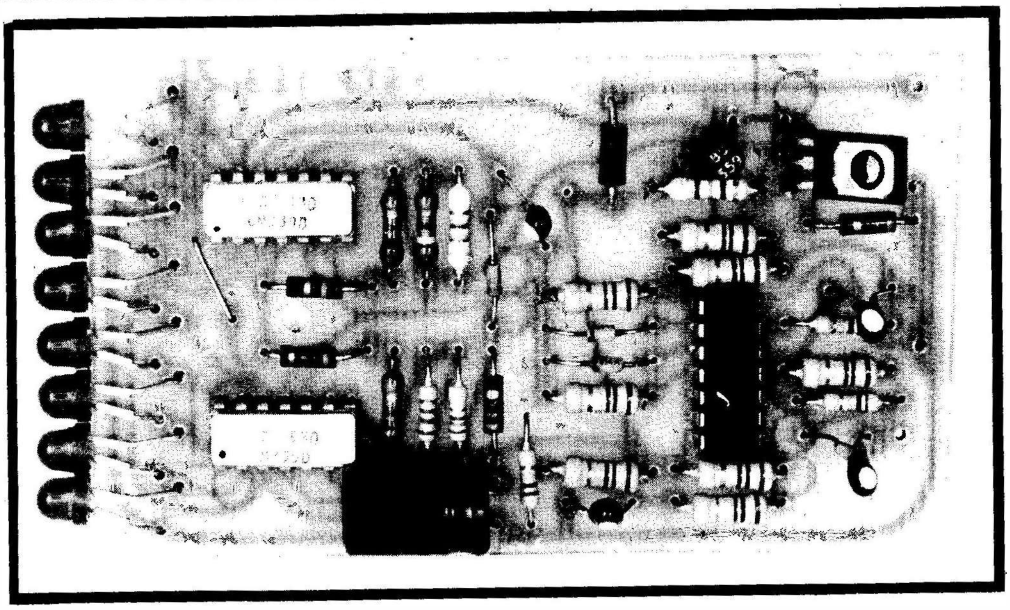
AUDIO LEVEL METER



Peak and average audio levels are indicated by a bar of light.

HIGH-POWER amplifiers usually incorporate meters to indicate the output-power levels in each channel. These meters are often called VU meters but in most cases they resemble proper VU meters only in the way they are scaled.

A professional VU meter is the industry standard for measuring the levels of complex music waveforms. It has a scale marked from −20 to +3 VU (on a steady state signal VU correspond to dB) where '0' VU corresponds to a level of one milliwatt into 600 ohms. The meter has a carefully controlled time constant such that if a reference tone level is applied the pointer of the meter will take 0.3 seconds to reach 99% of the reference level, and will then overshoot by not more than 1.5% and not less than 1.0%.

The professional VU meter is thus an instrument that has been designed to give a reasonable compromise between indicating the fast peaks and the average levels of a complex music waveform.

In contrast the meters fitted to some amplifiers have scales calibrated in VU but usually relying on the inertia of the meter movement to provide meter averaging. Apart from this the 0 VU point corresponds to the rated power output of the amplifier – not to 1 mW into 600 ohms (equivalent to 75 mW in 8 ohms). Strictly speaking therefore such meters should be called level or power meters, not VU meters.

Even the best of such meters are not fast enough to indicate accurately the peak levels which occur in music and hence are useless for detecting the onset of amplifier clipping. This is vital as at clipping amplifier distortion rises rapidly.

The circuit described in this project is best described as a 'level meter'. It uses an array of LED diodes set to illuminate at successively higher increments in music level. With this type of display an estimate can quite easily be made of channel balance, and all transients, no matter how fast, are detected and indicated.

SPECIFICATION

Supply voltage	20 to 32 volts dc 15 to 20 volts ac
Supply current	16 mA dc approx,
Input sensitivity (VU meter)	500 k/v
Indication	8 LEDs 3 dB apart
Attack time	1 ms
Release time	0.5 sec.

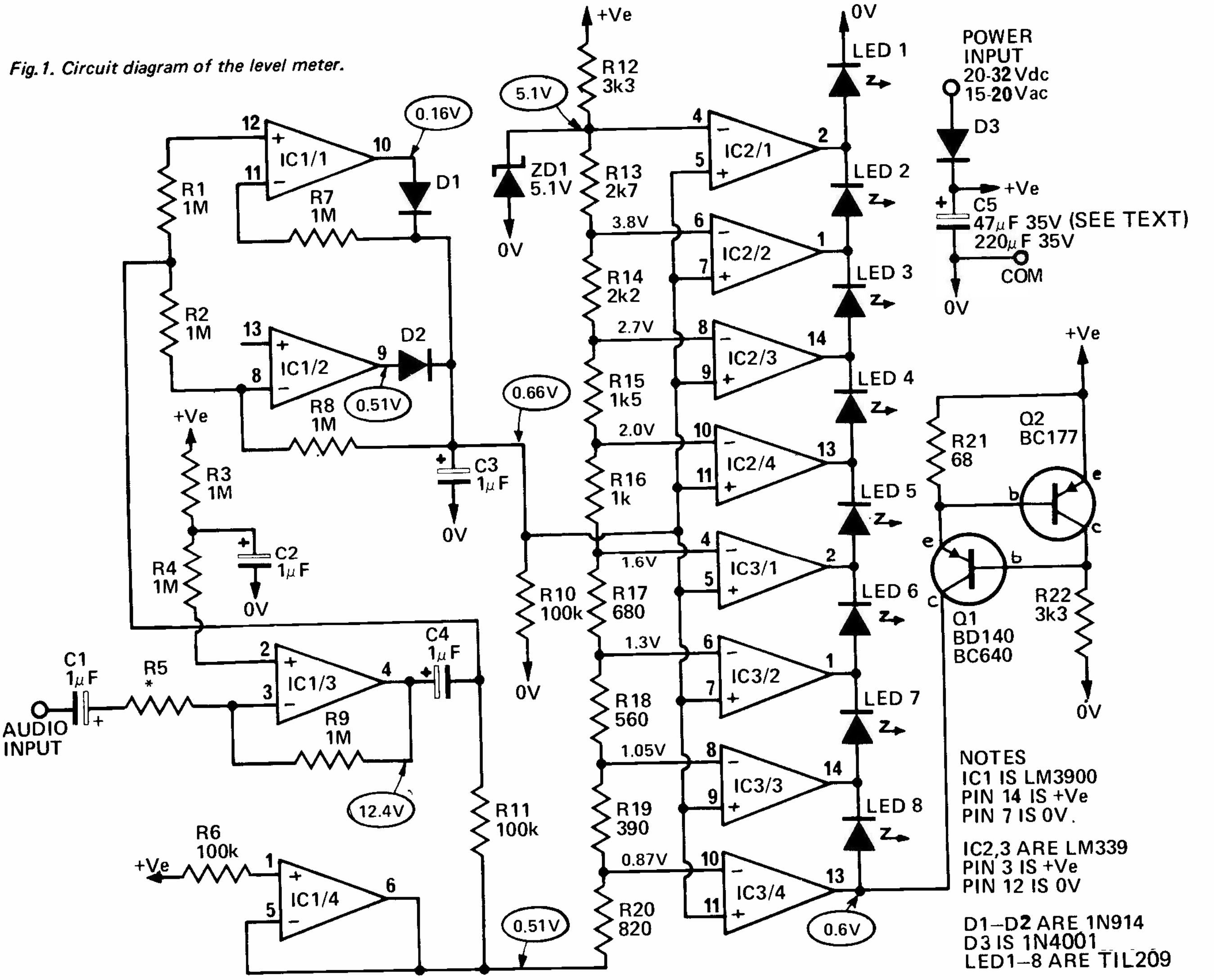
DESIGN FEATURES

The ETI 438 Level Meter can be arranged to indicate levels either in 'VU meter' format or in output power format. In the 'VU-meter' format the eight diodes light at 3 dB intervals from −18 to +3 VU where 0 VU corresponds to the nominal voltage required. Alternately as a power meter (remember that an amplifier cannot be driven beyond the clipping point) the top LED indicates maximum power and each lower LED indicates half the power of the one above it. The LEDs of the meter could thus be labelled, for example (for a 100 watt amplifier) 100, 50, 25, 12.5 watts etc.

The fast attack time of the meter

AUDIO LEVEL METER

Fig. 1. Circuit diagram of the level meter.



VOLTAGES GIVEN ARE OF THE PROTOTYPE BUT SHOULD BE TYPICAL MEASURED WITH 25Vdc SUPPLY AND NO INPUT SIGNAL

HOW IT WORKS – ETI 438

Although the circuitry of the level meter looks complicated the complete instrument only uses three ICs. These are an LM3900 which is a quad amplifier and two LM339s which are quad voltage comparators.

The input signal is amplified and buffered by IC1/3 to provide about 2.5 volts out at 0 VU input. The value of R5 is selected to give the sensitivity required for amplifiers of different power outputs. The gain of this amplifier is equal to the ratio of R9/R5.

A positive peak detector, IC1/1, and an inverting negative peak detector, IC1/2, give an output which represents the absolute peak level. Capacitor C3 and resistor R10 provide the peak hold and decay time. IC1/4 provides compensation for the 0.6 volt offsets of the LM3900 inputs.

The eight comparators are connected to a resistor divider chain the top of which is fed from a 5.1 volt supply which is stabilized by a zener. The resistor values are calculated to provide reference voltage steps at 3 dB intervals. The output of the detector is applied to all the non-inverting inputs of the comparators.

The LEDs are all connected in series and supplied with a constant current of 10 mA by the source consisting of Q1 and Q2. The outputs of the comparators are via open collector transistors which are "ON" if the input is lower than the reference voltage at the particular comparator input. With no input signal at all the comparators are all on thus shorting out all the LEDs so that none is on. As the input voltage rises the comparators turn off in sequence allowing the 10 mA to flow through the LEDs. Thus as the voltage increases a bar of light of increasing height is formed by the LEDs.

The current drawn from the power supply is about 16 mA and is independent of the number of LEDs which are on. Supply voltage is not critical and may be anywhere between 20 and 32 volts. Providing the supply is between these limits the unit will also be insensitive to supply ripple. When working from a dc supply a 47 microfarad filter capacitor is required but if an ac supply is used then the capacitor should be increased to 220 microfarad to minimize ripple. A single diode is used to both rectify the ac input and to prevent damage due to accidental reversed polarity if a dc supply is used.

PARTS LIST – ETI 438

R21	Resistor	68 ohm	½W	5%
R19	"	390 ohm	½W	5%
R18	"	560 ohm	½W	5%
R17	"	680 ohm	½W	5%
R20	"	820 ohm	½W	5%
R16	"	1k	½W	5%
R15	"	1k5	½W	5%
R14	"	2k2	½W	5%
R13	"	2k7	½W	5%
R12,22	"	3k3	½W	5%
R6,10,11	Resistor	100k	½W	5%
R1,2,7,8	"	1M	½W	5%
R3,4,9	"	See Table 1	½W	5%
R5	"	See Table 1	½W	5%
C1,2,3,4	Capacitor	1 μF	35V	
*C5A	"	47 μF	35V	
*C5B	"	220μF	35V	

* use 47 μF for dc operation 220 μF for ac operation

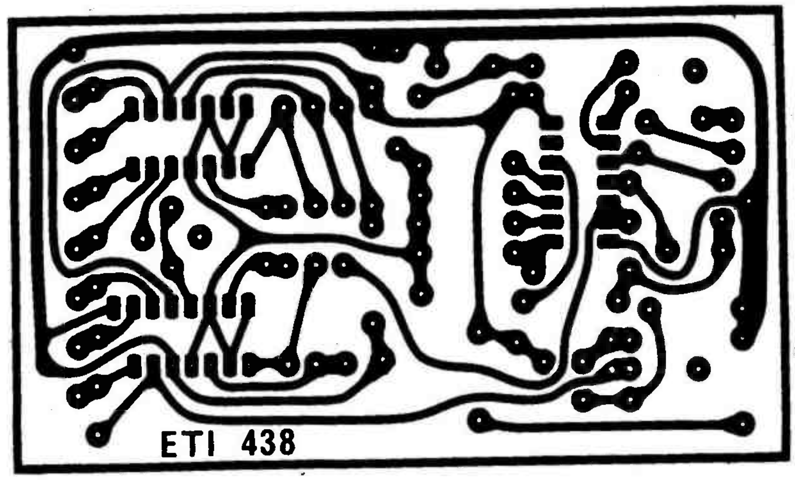
IC1 Integrated Circuit LM 3900
IC2,3 Integrated Circuit LM 339

D1,2 Diode IN914, BA318 or similar
D3 " 1N4001 or similar
ZD1 Zener diode 5.1 V 400 mW

Q1 Transistor BD 140,
Q2 " BC177,

LED 1-8 L.E.D. TIL209 or similar

PC board ETI 438



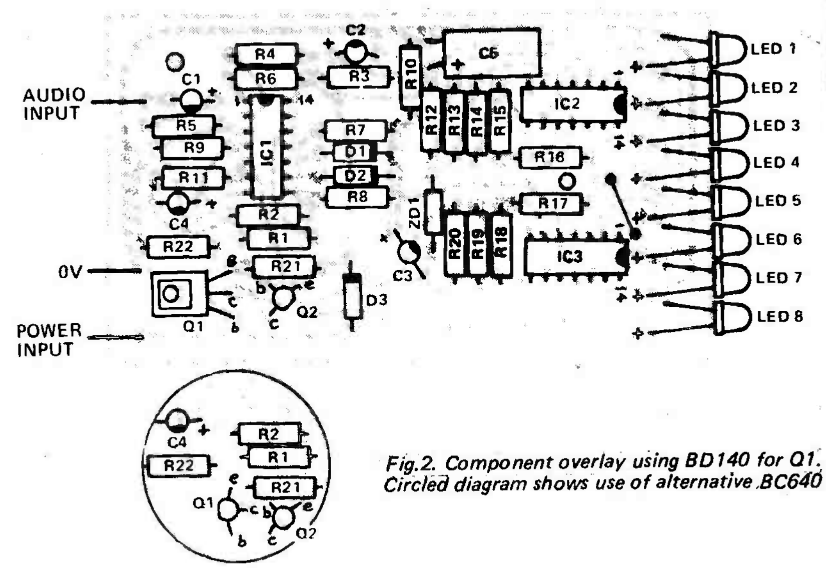


Fig.2. Component overlay using BD140 for Q1. Circled diagram shows use of alternative BC640

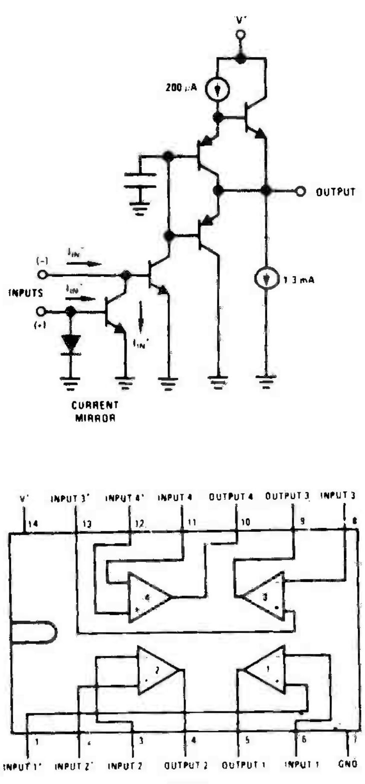


Fig.4. Internal circuitry and pin connections of the LM3900 IC.

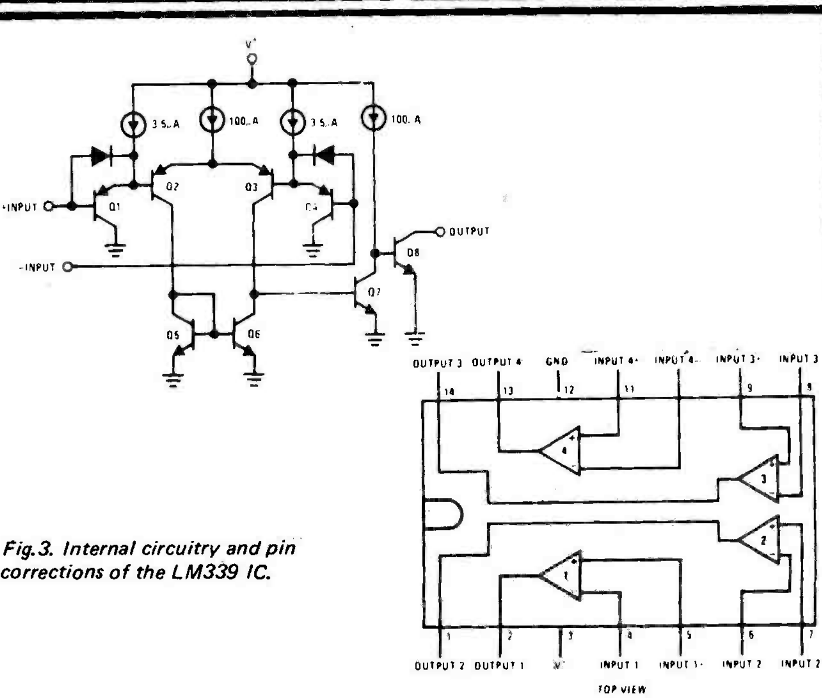


Fig.3. Internal circuitry and pin corrections of the LM339 IC.

(less than one millisecond) ensures that even very short transients are detected, whilst the relatively slow release time (0.5 seconds) provides a reasonably-accurate, average — level indication.

In most previous designs for such meters, discrete transistors were used to build level detectors. Temperature effects and variations in gain led to inaccuracies and to calibration difficulties. These problems have largely been overcome in the ETI 438 meter by using the LM339 IC which contains four accurate level detectors in one package. Additionally the LM339 also has an open-collector output stage which enables a constant current supply for the LEDs to be used. Thus the current and LED brightness are the same no matter how many LEDs are alight.

If required the interval between LEDs may be altered by changing the values of R13 to R20. Thus for example, a 6 dB interval could be used. Additionally the display could be extended to 12 or even 16 diodes by adding comparators and LEDs and by substituting another divider chain for R20 (values would have to be calculated for the levels required). The positive inputs of the comparators would also be fed from C3 and R10.

A separate current source would be required as there is insufficient supply voltage available to light 16 LEDs in series. If the bottom LED in such a system indicates a level more than 30 dB down it may also be necessary to use a trimpot as the bottom resistor of the second divider chain to adjust for offsets etc.

The LM3900 is a quad differential amplifier which uses a current balancing technique at the input rather than the voltage balancing that is used with conventional operational amplifiers. Both the inputs "look" like the base-emitter junctions of normal transistors and both are at 0.6 volts with respect to ground. The currents into the two inputs must be equal if the output of the amplifier is to be in the linear region. In the case of IC1/3 the current into the positive input is set at about 12 microamps by R3 and R4. Current into the negative input is provided from the output by R9. If the current into the negative input is too low the output voltage will rise thus increasing the current into the negative input until balance is achieved. This self balancing ensures correct static biasing.

Gain is obtained by feeding a signal into R5 which adds or subtracts current into the negative input. For the amplifier to remain balanced there must be a corresponding shift in output voltage. The voltage gain is the ratio of R9 to R5.

TABLE 1B — POWER METER

FSD = 0 dB

R3, 4 and 9 are 100 k

POWER OUTPUT IN WATTS	VALUE OF R5 4 Ohms	8 Ohms	16 Ohms
5	150 k	200 k	270 k
10	200 k	270 k	390 k
15	240 k	330 k	470 k
20	270 k	390 k	560 k
25	330 k	430 k	620 k
30	360 k	470 k	680 k
40	390 k	560 k	820 k
50	430 k	620 k	910 k
75	560 k	750 k	1.1 M
100	620 k	910 k	1.2 M
150	750 k	1.1 M	1.5 M
200	910 k	1.2 M	1.8 M
250	1 M	1.5 M	2 M

$R5 = 32\sqrt{PR}$ Where P = power in watts
R = speaker impedance in Ohms.

SPECIFICATION LM3900

Maximum supply voltage	32 V
Supply current	6 mA typical
Voltage gain	2800 V/V typical
Input current range	1 μA – 1 mA
Current balance	0.9 – 1.1 at 200 μA
Bias current	30 nA typical
Output current capability	18 mA source typical. 1.3 mA sink typical

The LM339 is a quad voltage comparator where the output of each is an NPN transistor which has an unterminated collector and its emitter connected to ground.

SPECIFICATION LM339

Maximum supply voltage	36 V
Supply current	0.8 mA typical
Voltage gain	200 000 V/V typical
Offsett voltage	2 mV typical
Bias current	25 nA typical
Response time	1.3 μS typical
Output sink current	16 mA typical
Input common-mode voltage range	0 to (V^+ – 2 volts)

TABLE 1A — VU METER

FSD = +3 dB

R3, 4 and 9 are 1 megohm

SENSITIVITY	VALUE OF R5*
50 mV	22 k
100 mV	47 k
250 mV	120 k
500 mV	220 k
1 V	470 k

**Sensitivity equals R5 x 500 000 ohms.*

CONSTRUCTION

The meter will most likely be mounted in an existing amplifier or piece of equipment and for this reason the board construction only is given.

Layout of components is non-critical but, as with any multiple IC device, construction is greatly simplified by using the printed-circuit board specified. The usual precautions with polarities of components, such as capacitors, diodes, ICs and transistors should be observed. Some care must be taken when mounting the LEDs in order to obtain even spacing and good alignment. The long lead of the LED should be inserted in the hole furthest from the edge of the board. Put a slight curvature in the leads so that the LEDs can be aligned against the edge of the board (see photo). Take care not to bend the leads too often or too close to the body of the LED as the leads break very easily.

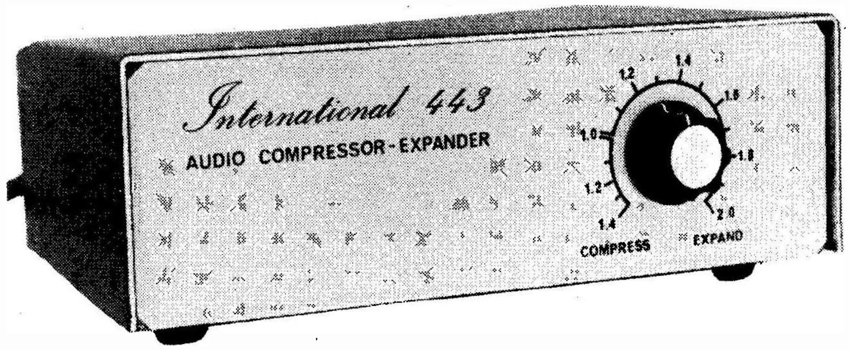
CALIBRATION

Resistor R5 is selected from Table 1 and this will ensure a result within 10 percent of that required. Greater accuracy may be obtained by using a variable potentiometer in series with R5. To adjust this potentiometer inject a signal (around 1 kHz) equal to 0 VU (VU meter) or maximum power ($E = \sqrt{RP}$, e.g. 4 ohms and 100 watts, E = 20 volts) and adjust such that the second top LED (VU meter) or the top LED (power meter) just lights. ●

AUDIO EXPANDER-COMPRESSOR

eti project 443

Increase dynamic range of tape recordings or reduce record surface noise with this versatile unit.



MANY OF US have tapes in either the reel to reel format or on cassettes which leave a lot to be desired in terms of signal to noise ratio. It is not that we necessarily made a bad job of the recording in the first place, but rather the limitations of our equipment and tape were generally just a little bit too much compared with what is available today. And because the signal to noise ratio is so poor, many of these tapes (and quite a few records as well) tend to lie on the shelf because of their audible inadequacies. Apart from this it is by no means unknown for commercially pre-recorded tapes and records to be below an acceptable standard.

Many people arbitrarily think that this problem is what the Dolby system is intended to resolve. But this is not so. The Dolby system helps *maintain* the original signal to noise ratio when recording from one medium to another but it has very little to offer when faced by *existing* inadequacies.

DYNAMIC RANGE

Another problem that plagues many of us is the poor dynamic range of our tape recorders or of the pre-recorded material that we buy. For example, the majority of cassette recorders are hard pressed to offer even a 55 dB dynamic range. Many of them offer little more than 40 dB. As if this were not bad enough, few records have a dynamic range exceeding 50-55 dB and even this is soon degraded to 40-45 dB after a dozen or so playings in a dusty environment.

THE SOLUTION

Audio volume expansion is the simplest and most effective way of increasing the apparent signal to noise ratio of a worn or noisy recording. There is also no more effective way of preserving the full dynamic range of a sound than by recording with volume compression, and replaying with equal volume expansion. However, for these applications, the compression and expansion must be done in a precise and reproducible manner; which is by no means as simple as it first appears.

The Compressor-Expander described here is relatively inexpensive to build, yet its performance is quite adequate for all practical purposes. It is sufficiently versatile to interface with most existing audio equipment, at nominal signal levels from about 25 millivolts to 1 volt.

CONSTRUCTION

Due to the relative complexity of the circuit a double-sided printed-circuit board has been used to simplify the construction, and we strongly recommend that this board be used. A single-sided board would be much larger and would require a great number of wire links.

Begin construction by assembling the components to the board in accordance with the component overlay Fig. 2. Take particular care with the orientation of components as marked on the overlay. When soldering component leads to the top of the printed-circuit board use a soldering iron which has a small tip and use a small gauge of solder (1 mm recommended). Take care not to bridge solder between the IC pads. It is easy to miss soldering connections on the component side of the board and these should be double checked.

Take care to insert the electrolytics with the polarity as marked on the overlay and even more care with the orientation of the diodes. A reversed diode can result in the destruction of one or more of the dual transistors.

The resistors in the signal side of the circuit and those in the current-sink circuit should be 2% or better. Alternatively they may be selected from 5% values. In selecting values an ordinary multimeter (operated at about the centre of the range) suffices. The resistors in question are all values between R37 and R65.

For best results the two 12 volt zeners should also be matched but in practice any slight discrepancy may be compensated by using the normal stereo-balance control.

A value of 1 microfarad for C5 allows compression or expansion to follow the signal amplitude so rapidly that the ear is unlikely to detect the attack or release, which is virtually complete in about 20 milliseconds. However, with this value, low frequency signal components (50 Hz or lower) will not be averaged out in obtaining the gain control voltage, and severe intermodulation and 3rd harmonic distortion will result. At the other extreme, a value of 4.7 microfarads for C5 will prevent this distortion right down to the lower audible limit, but the attack and release time

AUDIO EXPANDER-COMPRESSOR

(about 100 milliseconds) is so long that the effects can be audible, although not necessarily unpleasant. A value of C5 equal to 4.7 microfarads will be found quite acceptable by most people.

Potentiometer RV2 is used to match the signal levels of the compressor-expander with those of the associated equipment. Potentiometer RV2 should be a wirewound type; and for the front-panel calibration to apply, it should have an effective electrical rotation of 280°, and the midpoint of rotation should be set opposite the 1.0 index line.

Capacitor C5 should be chosen in accordance with the particular compromise that suits the user of the unit. Alternatively a switch may be used to select different values.

The box used in our prototype measured 200 × 125 × 63 mm and, although a little cramped did adequately hold the unit. The next larger box available was thought to be too big. The printed-circuit board is mounted at the rear of the box to allow room for the front panel potentiometer to be mounted. The board is mounted on 6 mm spacers and the transformer is then mounted directly onto the rear panel together with the phono input and output sockets.

POWER SUPPLY

The output of the transformer is rectified by a full-wave bridge to provide ±22 volts, as set by the Zener diodes. The voltages obtained from the MC1468L regulator are the ±15V required for correct operation of the compressor-ex-

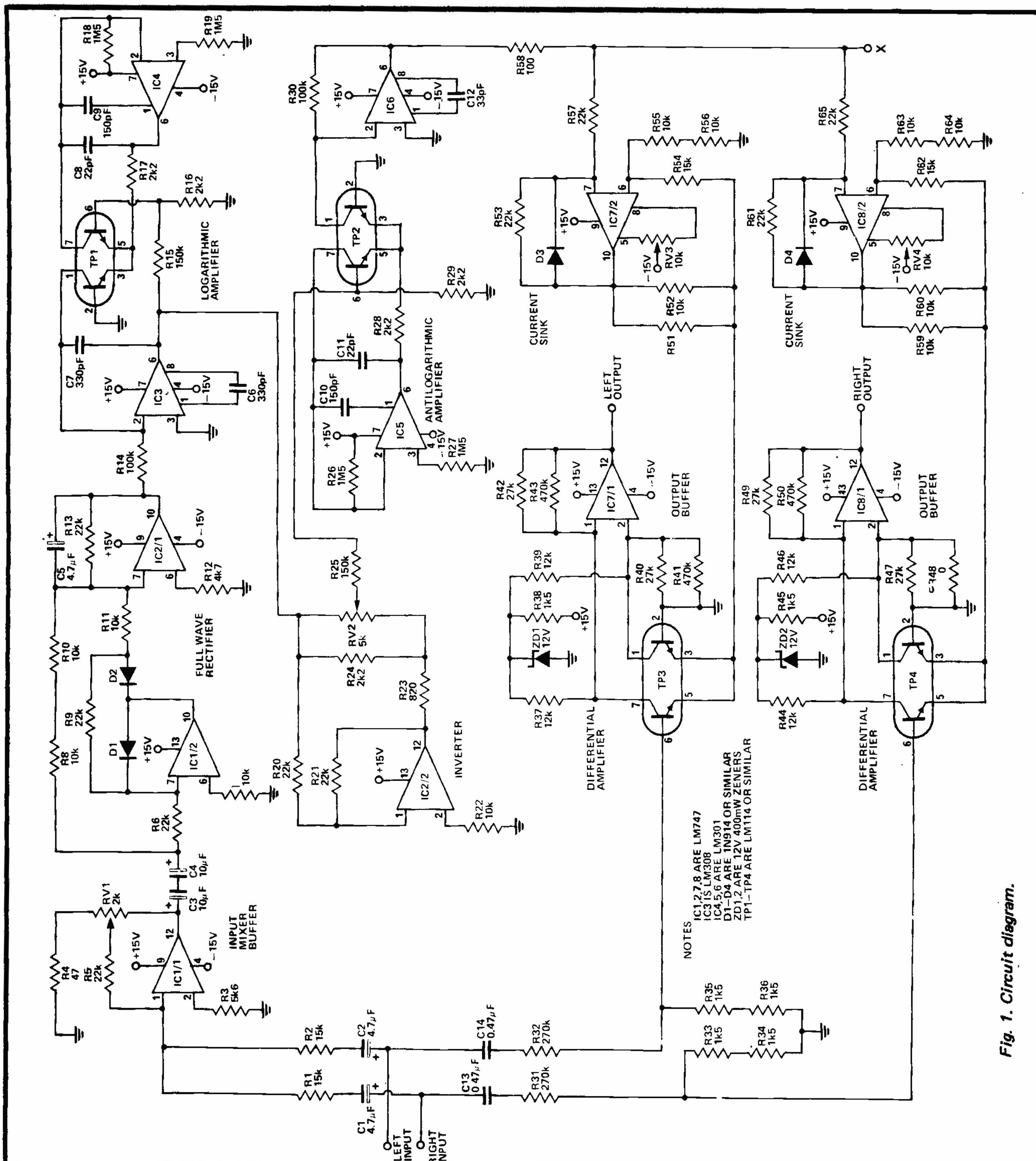


Fig. 1. Circuit diagram.

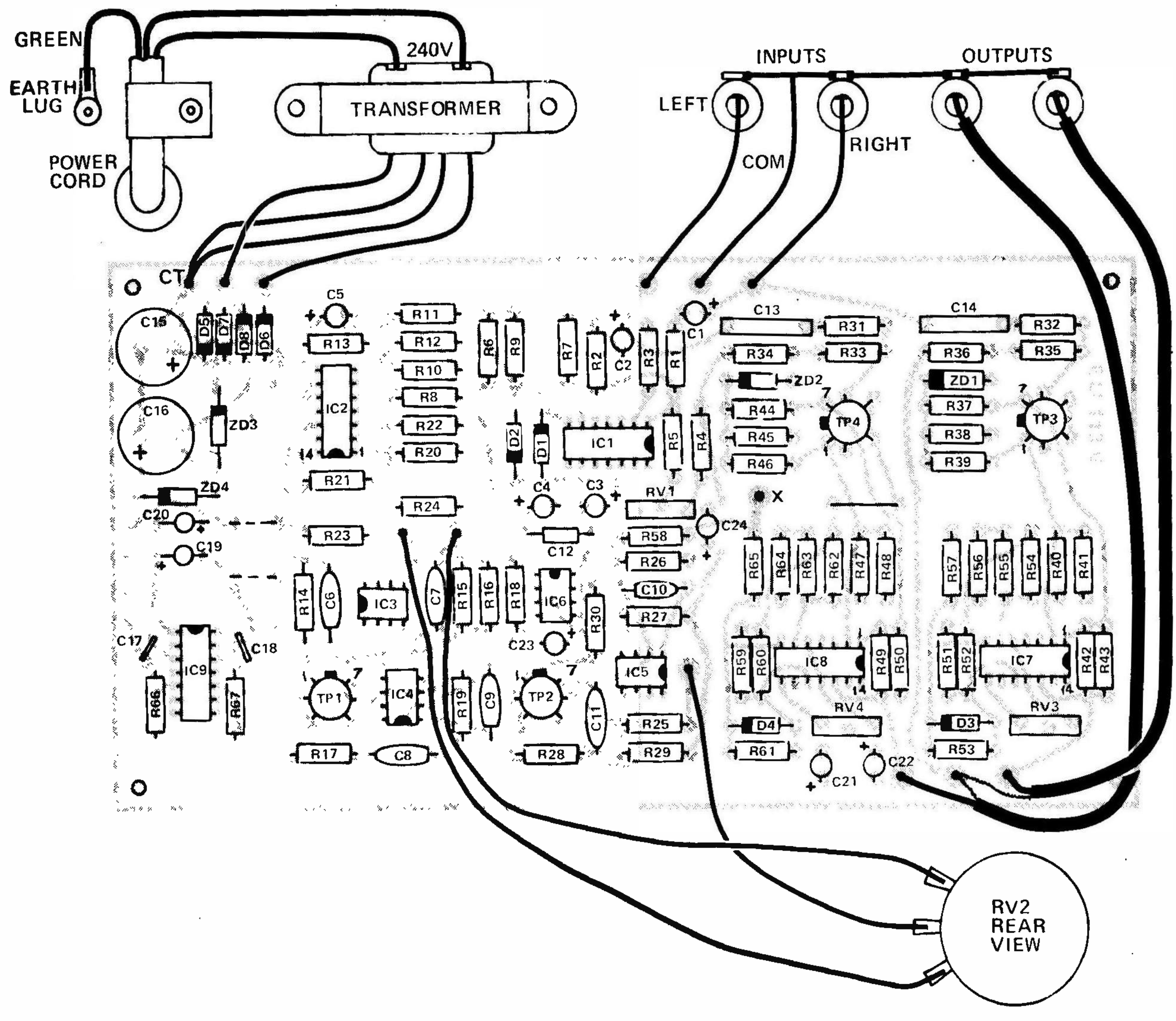


Fig. 2. Component overlay (not full size)

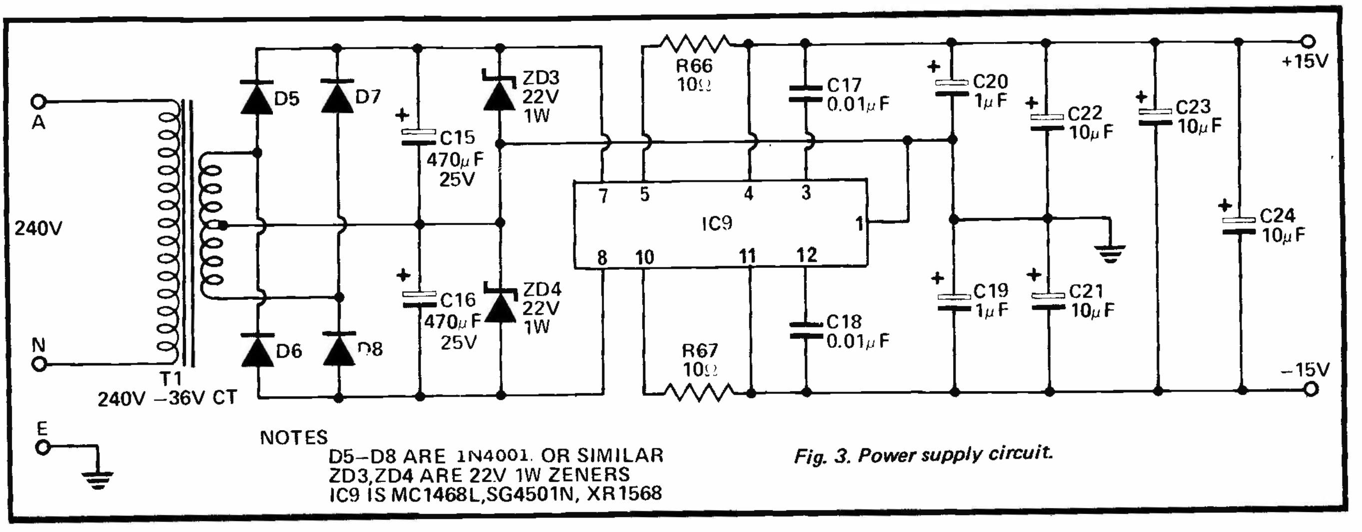


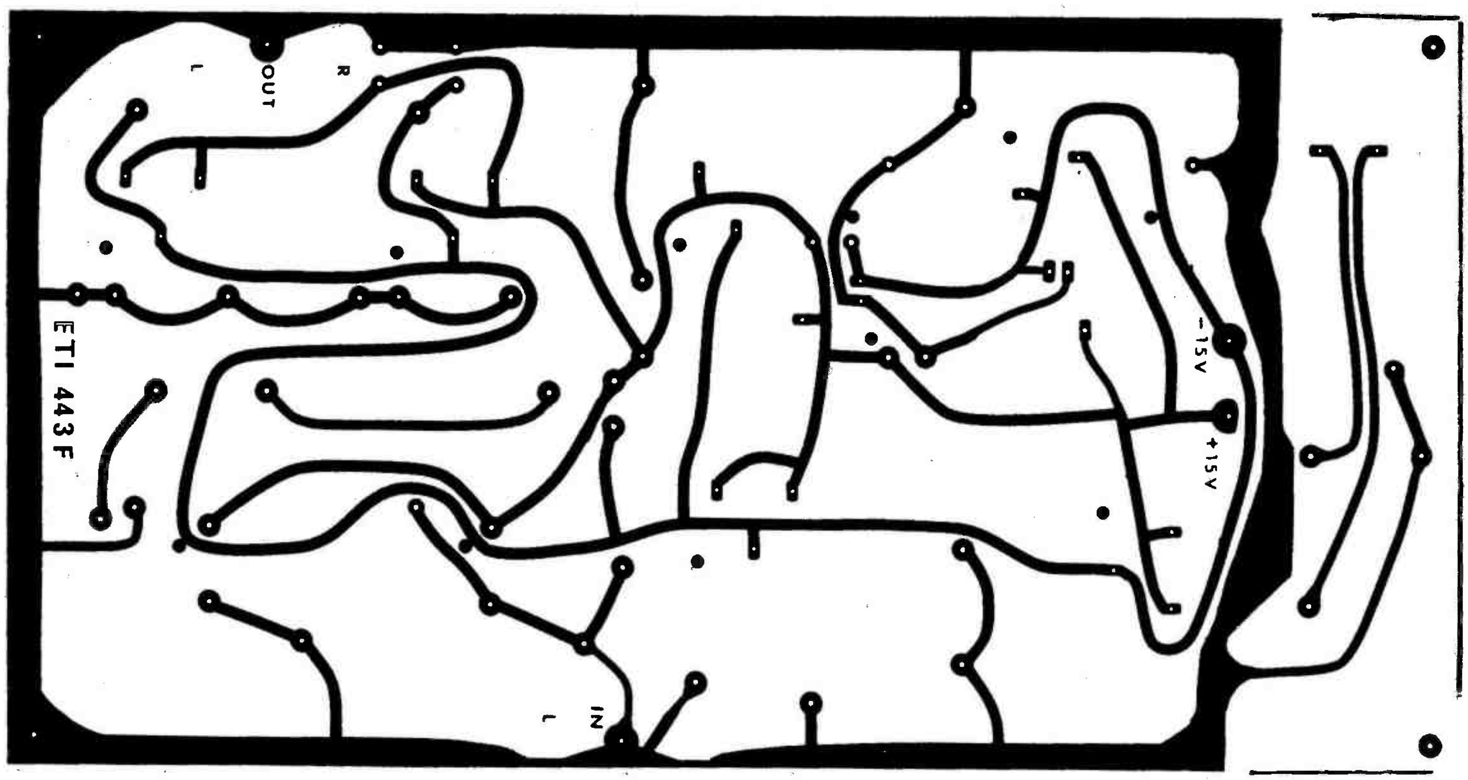
Fig. 3. Power supply circuit.

pander.

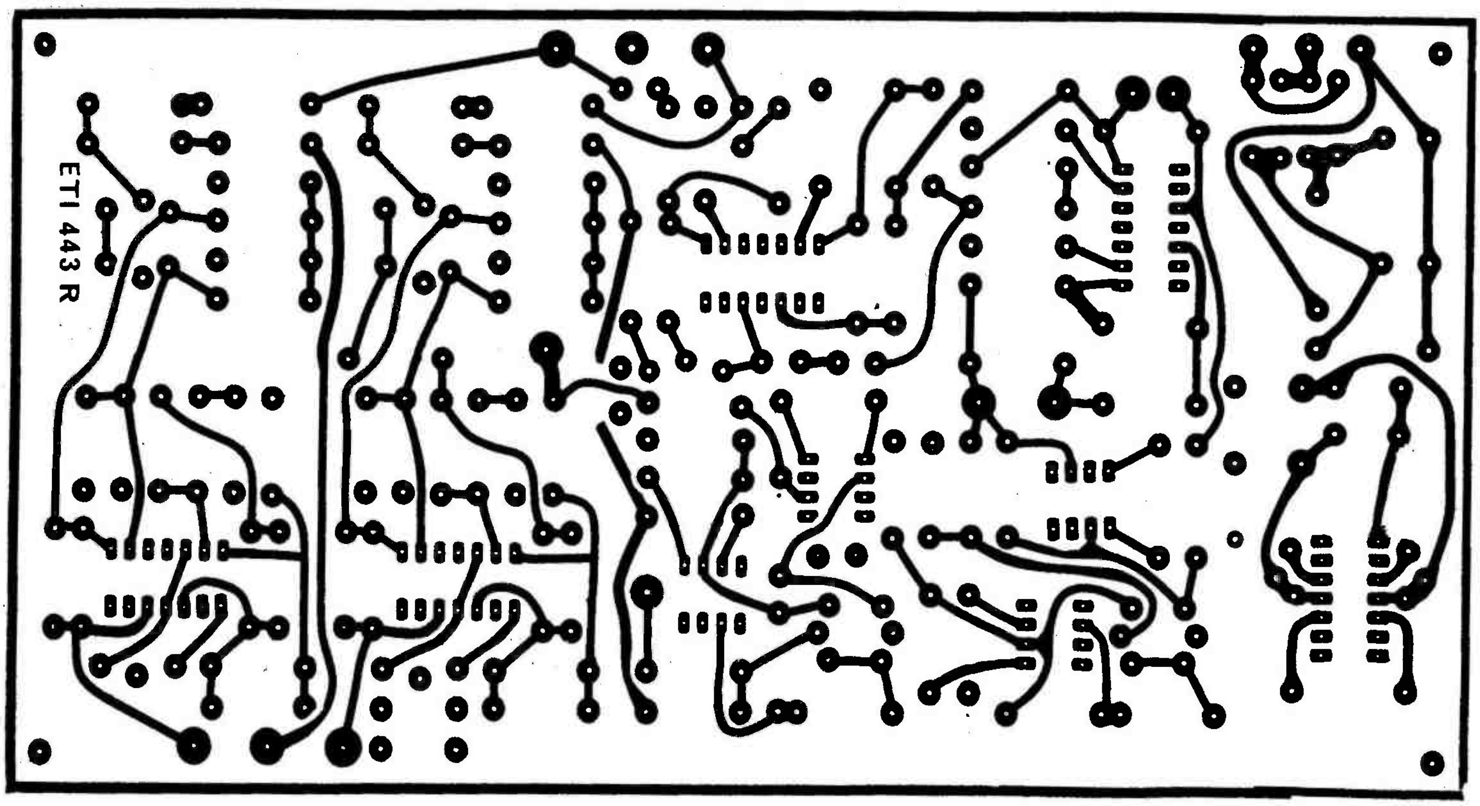
SETTING UP

With the power supply connected (check for correct polarity), apply a strong (about 1 volt) audio signal to both stereo inputs, while the point marked 'X' is shorted to ground. Monitor the left channel output with a high sensitivity meter (or amplifier) and adjust RV3 to the point where the output JUST disappears. Repeat with the right channel and RV4. This procedure balances out the input offset voltage of the current sinks, and ensures that the audio gain will be controlled correctly at the low end. Remove the input signal and the short circuit.

RV1 is set by the following



Double-sided PCB pattern (full size).



procedure:

(1) Connect the compressor-expander to its associated equipment, and supply an input of moderate level (e.g. music of average loudness). RV1 should be fully clockwise when viewed from the input edge of the board.

(2) Turn the compress-expand control to full compression, and adjust RV1 to bring the output up to its original level (loudness).

(3) Turn the compress-expand control towards the expansion end, and note any obvious change in output level.

(4) If a decrease in level occurs, turn RV1 slightly anticlockwise; if an increase occurs, turn RV1 slightly clockwise.

(5) Repeat steps (3) and (4) until the level remains reasonably constant over the whole range of compression and expansion. Note that this adjustment is subjective, and it does not need to be done with any great accuracy.

If RV1 cannot be adjusted as described, it means that the signal level is outside the optimum range of the compressor-expander. Somewhat higher signal levels can be accommodated by increasing the value of R1 and R2, whilst for lower signal levels, R4 should be decreased. If correct adjustment of

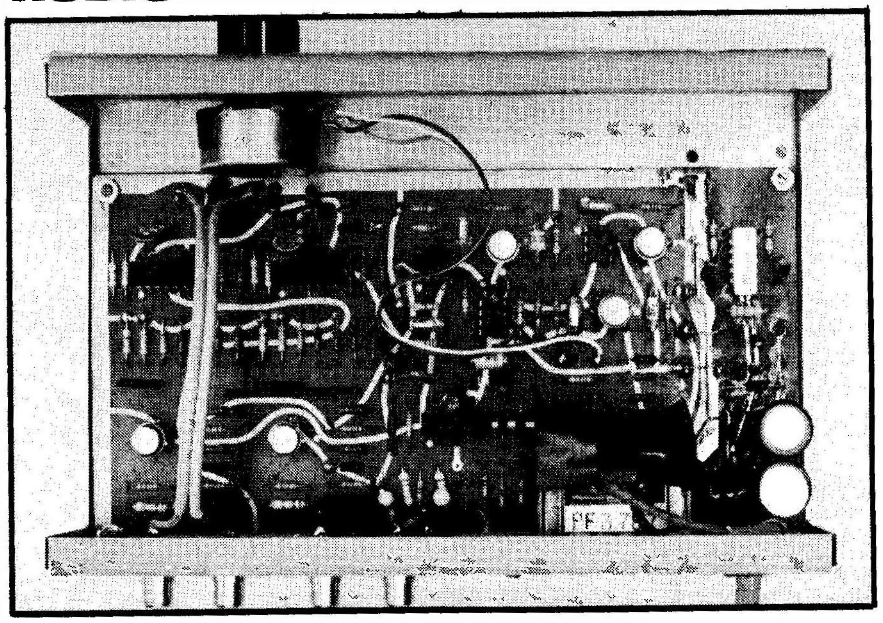
AUDIO EXPANDER-COMPRESSOR

RV1 is obtained well towards the anticlockwise end, then an improved signal-to-noise ratio results if R34 and R36 are increased to 18K, and the stereo outputs are each attenuated by a 470 ohm/3.9K divider. However, this modification is not essential.

With no input signal applied adjust RV2 such that the voltage at its wiper is zero volts. Now fit the knob such that the pointer lines up with the 1.0 calibration. Now check that the potentiometer travel approximately matches the scale. If not reverse the two outside leads to it.

HOW TO USE

The use of a compressor-expander need not be confined to those situations where such a device is really needed. Practically all tapes and many records become more listenable with a small amount of expansion.. On the other hand, background music is far less obtrusive if the volume is compressed to some extend. The key to listening pleasure lies in the handling of the compress-expand control. Don't move it far from the 1.0 position unless there is some definite reason.



Interior of the unit.

One final word of warning — this device is quite capable of outputting a signal of 10 volts. It would be wise to ensure that your amplifier is capable of accepting this voltage without damage.

HOW IT WORKS

The heart of an audio compressor-expander is invariably a voltage controlled amplifier; that is, an amplifier whose gain is set by means of an applied voltage. This voltage itself must be derived from the amplitude of the audio input signal, averaged over some preset period, and modified to give the required compression or expansion characteristics. In the circuit of Fig. 1, each portion of the circuit is identified according to its function. These portions, in turn, are grouped into three main sections; an AC to DC converter, a power function generator, and a stereo analogue multiplier.

The two channels of stereo input are mixed in buffer amplifier IC1/1, and the gain of this stage is set so that an output of about 1 volt is given by a signal which corresponds to moderate loudness. Amplifers IC1/2, and IC2/1 are used to obtain precision full-wave rectification of the mixed input, and the resulting positive DC voltage is stored in capacitor C5. The choice of value for C5 is important, and it will be discussed in detail later on.

Amplifiers IC3 and IC4 together with the transistor pair TP/1 constitute a logarithmic amplifier. With the components shown, the behaviour of this amplifier is described by the equation:

$$E_{out} = -4.15 \log E_{in}$$

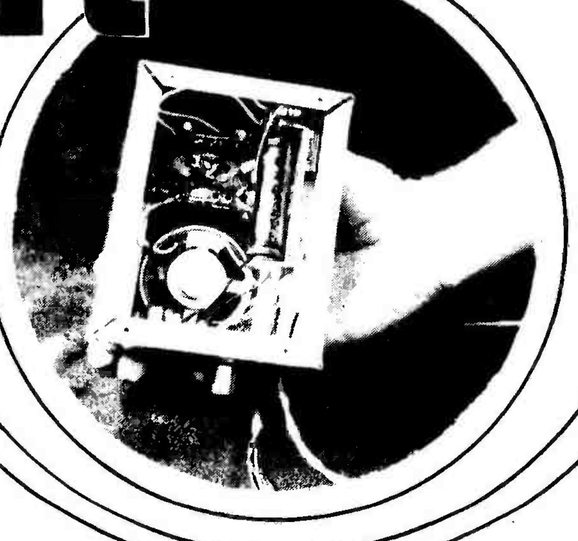
The inverse of E_{out} is obtained from amplifier IC2/2 and by connecting the compression-expansion control potentiometer as shown between the input and output of this stage, any voltage between E_{out} and $-0.3E_{out}$ can be obtained. IC5, IC6 and TP_2 are combined as an antilogarithmic or exponential amplifier which is the exact inverse of the logarithmic amplifer, so that the effect of all these operations on the input signal is to give to a positive DC output voltage, equal in magnitude to the input voltage raised to the power k, where k can have any value from —0.3 to 1.

In the analog multiplier sections, this voltage (E_{in}) is converted to current by amplifiers IC7/2 and IC8/2 thus setting the effective gain of the differential amplifiers TP_3 and TP_4. These are directly coupled into the output buffers IC7 and IC8/1 so that the stereo signals reaching the outputs have been amplified by a factor which depends on the average amplitude of the signals, and the compression-expansion control setting. The actual voltage gain can vary from 0.0004 to 14, which represents a power gain range of 97dB.

PARTS LIST — ETI443

R1, R2	15k
R3	5k6
R4	47R
R5, R6, R9, R13, R20, R21	22k
R7, R8, R10, R11, R22	10k
R12	4k7
R14, R30	100k
R15, R25	150k
R16, R17, R24, R28, R29	2k2
R18, R19, R26, R27	IM5
R23	820R
R31, R32	270k
R33, R34, R35, R36	1k5
R66, R67	10R
All ½W, 5%	
R37, R39, R44, R46	12k
R38, R45	1k5
R40, R42, R47, R49	27k
R41, R43, R48, R50	470k
R51, R52, R55, R56, R59, R60, R63, R64	10k
R53, R57, R61, R65	22k
R54, R62	15k
R58	1k
All ½W, 2% (may be selected from 5% resistors)	
RV1	2k trimmer
RV2	5k wirewound pot
RV3, RV4	10k trimmer
C1, C2, C5	4.7µF 25V tantalum
C3, C4	10µF 25V tantalum
C6, C7	330pF
C8, C11	22pF
C9, C10	150pF
C12	33pF
C13, C14	0.47µF polyester
C15, C16	470µF 25V electrolytic
C17, C18	0.01µF polyester
C19, C20	1µF 25V tantalum
C21, C22, C23, C24	10µF 35V tantalum
TP1, TP2, TP3, TP4	LM114 Dual transistor or equivalent
IC1, IC2, IC7, IC8	LM747
IC3	LM308
IC4, IC5, IC6	LM301
IC9	MC1468L or equivalent
D1, D2, D3, D4	1N914
D5, D6, D7, D8	1N4001
ZD1, ZD2	12V, 400mW
ZD3, ZD4	22V, 1W
T1	240V/36V CT transformer
PCB ETI 443	
4 Phono sockets	4 6mm spacers
chassis and cover 200x63x125mm approx	
nuts, bolts and assorted hardware	

anti-theft auto alarm



THIS UNIT OPERATES from the vehicle supply, and is a real deterrent to the unauthorised opening or taking away of the car to which it is fitted. This, in itself, can scare away an intruder as it is clear that some electronic means of protection is present. When this tone is heard, the owner has a few seconds in which to operate a master switch, the location of which is known only to himself. A pre-set control allows this "delay" to be adjusted. If the master switch is not operated, after this delay interval the vehicle horn is switched on -- and closing the door, with the would-be thief either in the car or outside, will not stop the horn.

The whole circuit is quite straightforward and for convenience can be divided into three sections. The *whole* circuit is shown in Fig. 1.

1. CAR WIRING

This is shown in thick lines in Fig. 1. The 12V accumulator supplies the interior light, which has its integral switch S1. The two door switches, S2 and S3, are in parallel, and operate automatically when a door is opened. None of this wiring has to be disturbed in any way.

2. TONE OSCILLATOR

Apart from its deterrent effect, this warns the legitimate user that the circuit is in operation. He can thus remember to operate the master switch S4 if he wishes to keep the door open, or to use the interior light during darkness. The tone also reminds him that the circuit is in use, when getting out of the car.

Q1 and Q2 form the tone oscillator, operating a small speaker contained in the case. When S2 or S3 are closed by a door being open, 12V appear across the interior light, and leads A (negative) and B (positive) make this available for the oscillator.

3. HORN SOUNDER

Q3 and Q4 operate in this part of the circuit. When the 12V supply is present across A and B, C2 commences to charge through R2 and RV1. When Q3 conducts, the base of Q4 is moved positive, causing Q4 to conduct, and drawing on the relay. Relay contacts RC1 close. The relay is then energised from circuit B (positive) through R5 and circuit C (chassis and negative) so that the relay remains locked on even if the door is closed, opening S2 or S3. The second set of contacts RC2 completes the circuit to the horn.

If the door is closed before the relay locks on, the charging of C2 ceases, and the horn is not operated. This is necessary in order that the owner can get out of the car without starting the sequence.

When S4 is opened, this prevents the warning circuit working. The delay is adjustable, as mentioned, but RV1 can be set to give about 5 seconds or so. S4 is placed in an inconspicuous position, under the parcel shelf, or elsewhere, and it is unlikely that anyone could find this switch and operate it in the short time available.

The rectifier in the negative lead A is required because if the horn sounded when the owner entered the car, and the door were closed opening S2 or S3, and S4 were also opened, a path for positive supply would then exist through the interior light itself, holding on the relay. (Eg., with S1, S2 or S3 closed, circuit point A is negative. But with S1, S2 or S3 open, point A is positive via the lamp filament.)

TAG BOARD

The components are assembled on a tag board about 2 x 1½in. as in Fig. 2. Emitter E, Base B and Collector C wires of the transistors are identified from the underside views in Fig. 2.

Solder on two short flexible leads from C Q3 and C Q4, to take to the relay coil tags. Also provide leads from E Q1 and R2, to take to RV1. Further short leads are necessary for the speaker, and rectifier negative.

CASE

A 5 x 4 x 2in. metal box is suitable. A 1¾in. or 2in. hole is cut or punched for the speaker. This hole is covered on the inside with fabric or perforated metal to protect the speaker.

Mount the tagboard with long bolts and spacers or extra nuts so that it is clear of the metal. RV1 is fitted to one end of the case.

The small tag strip holding the rectifier and forming a junction point for S4 and B leads is bolted to the side of the case.

Components for Auto Alarm.

	Resistor			
R1	"	680k	5%	¼W
R2	"	27k	"	"
R3	"	10k	"	"
R4	"	100 ohm	"	½W
R5	"	82 ohm	"	"
RV1		100k linear carbon pot.		
	Capacitor			
C1	"	1000pF tubular.		
C2	"	100µF 15V electrolytic.		
Q1		AC128		
Q2		BC108		
Q3		BC107		
Q4		BC107		
D1		IN4001		

Relay, 100 ohm surplus type; S4 Toggle on/off switch; 75 ohm or similar 2in. to 2½in. speaker; Box 5 x 4 x 2in.

Tag board, tag strip, coloured flex; etc; Small knob.

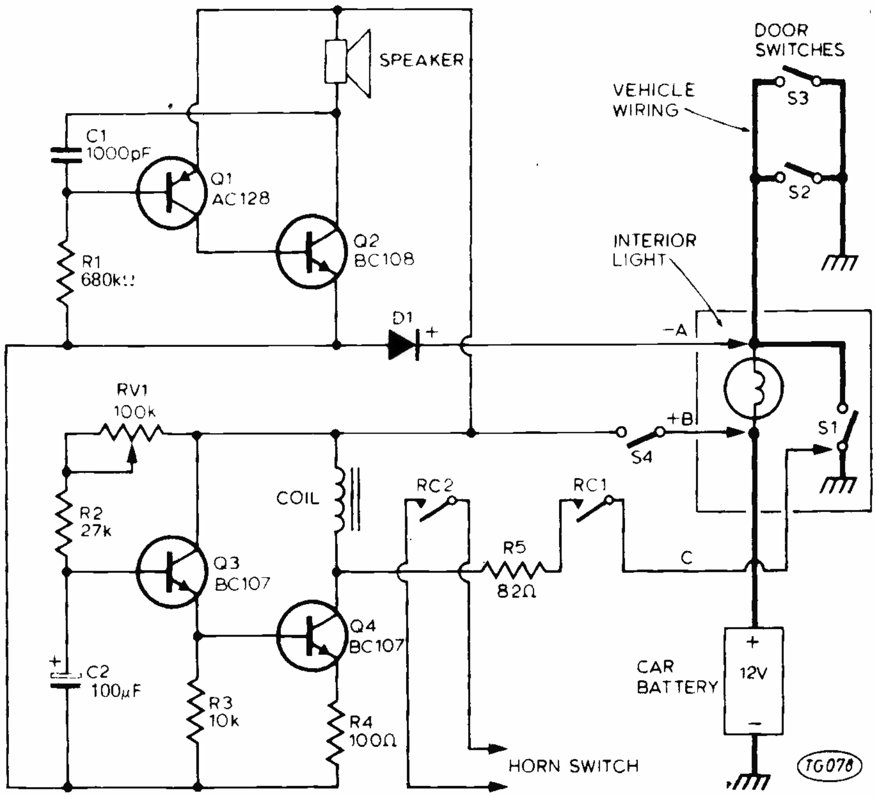


Fig. 1. Complete circuit of the Auto Alarm

EXTERNAL LEADS

These are most readily arranged by using three separate cords -- a twin for the horn switch circuit, a twin for the master switch S4, and a 3-core for the circuits A, B and C. The latter is best made from thin single bell wire, or thin 7/0076 coloured flex, as this will result in a thin cord which can be inconspicuously run up to the interior light. Black is best for A (negative), with red for B (positive) and green or some other colour for chassis connection C. Chassis connection C could be taken to some other part of the vehicle chassis, but as it is available at S1, it is felt that the 3-core cord is more convenient.

RELAY

This is bolted to the end of the case. Numerous other contacts will be found on some relays, especially surplus types. Only two sets of "On" contacts are needed. These close when the relay is energised. It should pull on at a current of about 30–40mA or so.

VEHICLE CONNECTIONS

Figure 3 shows actual connections for the 850 Mini Saloon and this should prove of aid with other vehicles.

This switch is returned to the vehicle chassis by one of the fixing screws, so this forms a connecting point for lead C.

When S1 (or the door switches) is operated, this completes the circuit to A. The remaining contact of the lamp

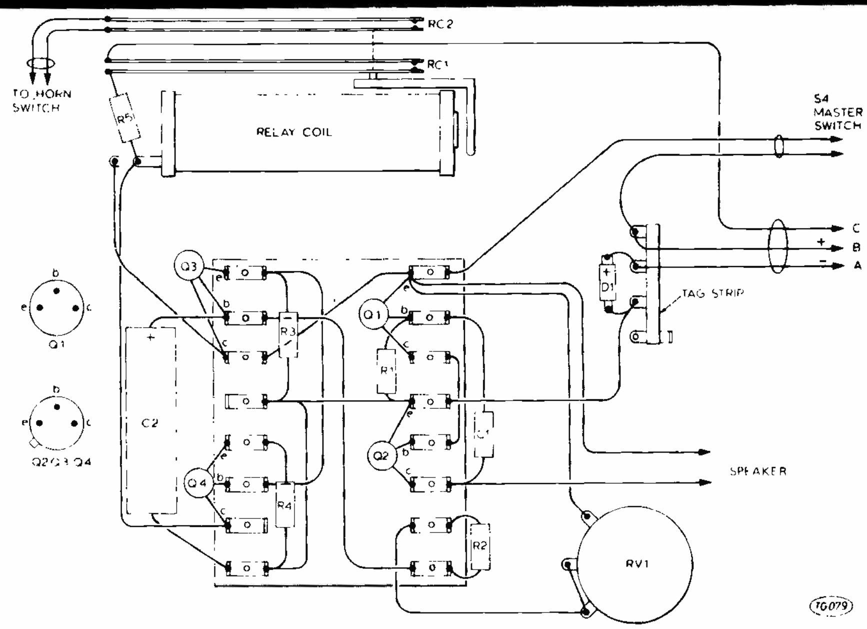


Fig. 2. (Above) The component wiring.

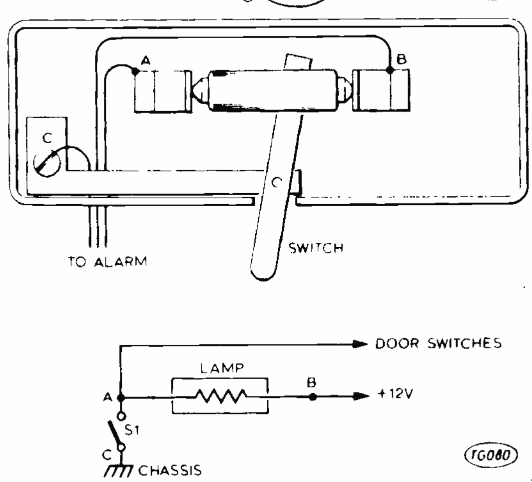
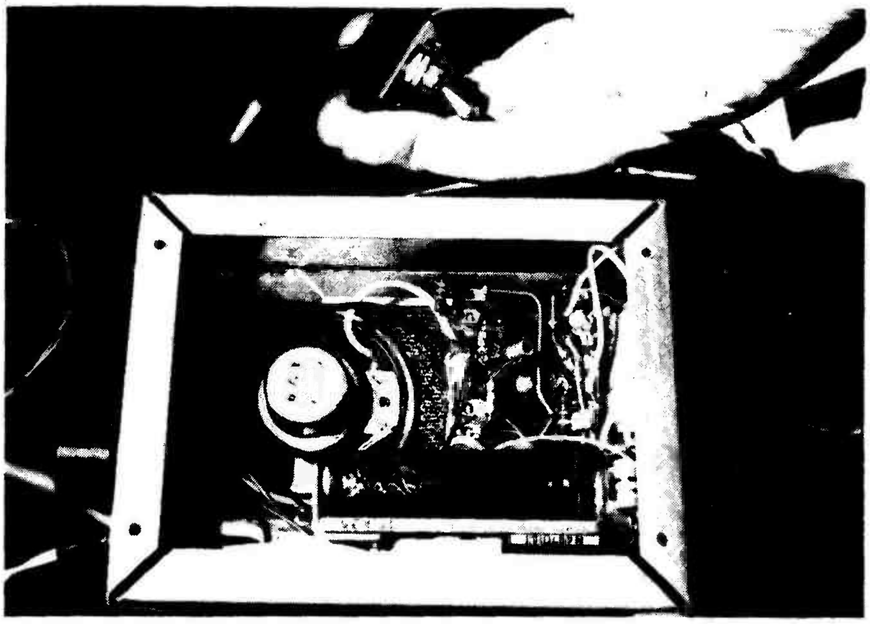
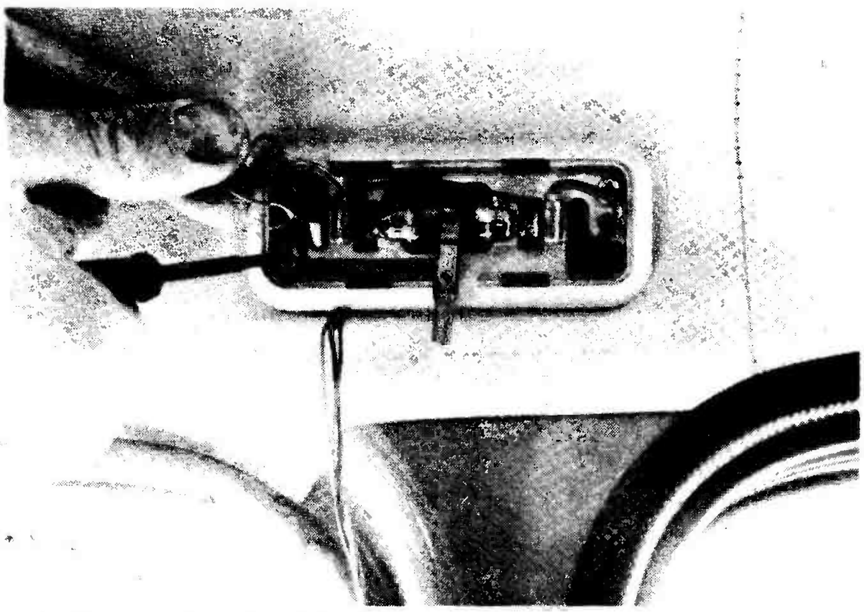


Fig. 3. (Right) Guide to the interior light connections.



The completed unit with the disabling switch.



Making the connections to the interior light on a Mini.

holder is wired to accumulator positive (via a fuse) so this forms connecting point B. The thin 3-core cord can be secured and hidden with adhesive tape.

There is, of course, no reason why these connecting points should not be sought at the door switch, junction box, or elsewhere, by anyone who is prepared to delve more deeply into the vehicle circuits.

It should also be noted that the circuit, as shown, is intended for a vehicle with negative chassis line.

The alarm unit is constructed so that the metal case is floating and not electrically connected to either circuit. This case can be fitted at any point individually chosen and not easily seen. Remember to place it in the "off" position when leaving the car to be serviced.

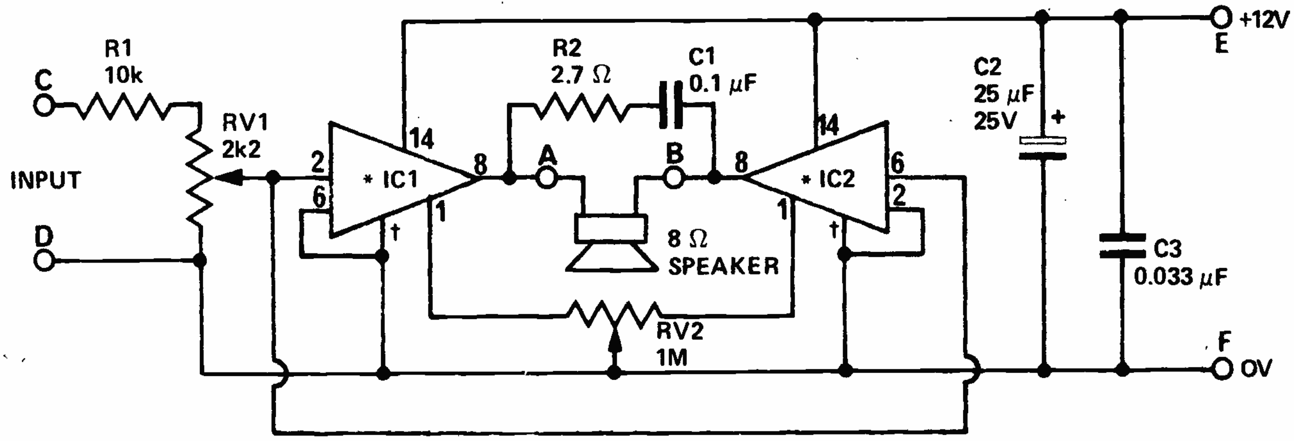
The individual twin cord running from contacts RC2 are isolated from other circuits. Present-day vehicles generally have a multi-purpose dip/direction-indicator/horn switch, and this forms a very awkward connecting point. However, the horn switch section is usually between one horn terminal and chassis. It is thus easy to run these leads to chassis and horn, at the horn. The correct horn terminal can be found, without following the circuits, with a meter or 12V lamp. Connect the meter or lamp from chassis to one horn terminal. If *no* voltage is shown when the horn is sounded, this is the correct terminal.

With a separate horn switch, merely connect these leads to its terminals.

AUTO-AMP

Boost portable radio output in your car.

PROJECT 314



*IC1, IC2 LM380
† PIN 3, 4,5,7,10,11,12

Fig. 1. Circuit diagram of the booster amplifier.

MOST portable radios and cassette players have a power output which seldom exceeds 100 milliwatts. Whilst this is entirely adequate for normal listening, many people find that it is entirely inadequate when such equipment is used in a car. There the extremely high noise level effectively drowns out such radios and one is left with the choice of buying a proper (and quite expensive) car radio, or, of forgetting about the whole deal.

However this problem can be overcome by using a small booster-amplifier to provide the additional power required. Such an amplifier should be powered from the 12 volt car supply and should accept an input from the earphone, or external speaker socket of the radio or cassette player.

The ETI booster amplifier has been designed to suit such applications and uses the inexpensive LM380 ICs. Two ICs are connected in a bridge arrangement which provides an output of around five watts RMS (12 volt supply and 8 ohm speaker). The amplifier may be used to drive an eight-ohm speaker permanently mounted in a suitable position in the car.

CONSTRUCTION

The components should all be mounted on a small printed circuit board (or Veroboard etc) as shown in the component overlay diagram. If Veroboard construction is used it is preferable to mount the ICs, in line, such that a common heatsink may be attached to both ICs on each side. Each heatsink should be at least 25x50mm and be constructed from copper or tin plate.

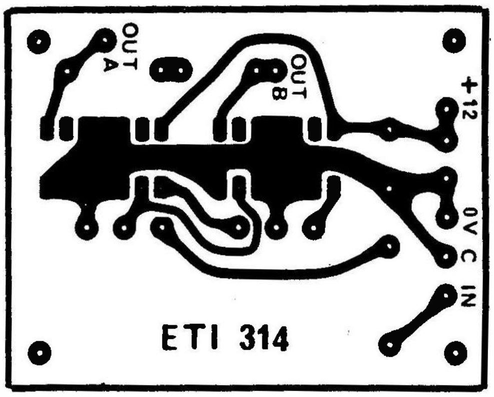


Fig. 2. Printed circuit board.
Full size 50 x 65 mm.

Two preset potentiometers are provided for setting up the amplifier. The preset-volume potentiometer, RV1 should be adjusted to suit the output voltage available from the radio or cassette. Sensitivity of the booster is such that 5 watts output will be obtained (with RV1 at maximum sensitivity) with an input of 50 mV. This should be entirely adequate as most radios will provide in excess of 200 millivolts.

The balance potentiometer should be set for minimum dc through the speaker as detailed in the 'How It Works' section.

The compactness and simplicity of the amplifier enable it to be mounted in any convenient position, eg, even on the rear of the speaker itself! However, care should be taken to position it such that mechanical damage is unlikely to occur, and that adequate ventilation of the heatsink is obtained.

PARTS LIST ETI 314

* R1	Resistor	10k ½W 5%
R2	"	2.7 ohm ½W 5%
* RV1	Potentiometer	2k2 Trim
RV2	"	1M Trim
C1	Capacitor	0.1μF polyester
C2	"	25μF 25V electro
C3	"	0.033μF polyester

IC1, IC2 Integrated Circuit LM380
PC Board ETI 314

* The value of these components may vary for different input requirements.

HOW IT WORKS – ETI 314

The LM380 is an integrated audio amplifier which has a fixed gain of 50 dB and can be connected in either inverting or non-inverting mode (ie output 'out of phase' or 'in phase' with the input respectively).

Two of these ICs have been used in a bridge arrangement which allows a higher power output to be obtained with the low supply voltage (12 volts) available from the car. To do this we drive both amplifiers with the same signal, but connect one for inverting, and the other for non-inverting mode. The speaker is now connected between them and thus receives twice the output voltage that would be available from a single IC.

The input required for full power output is about 50 millivolts. Hence we have provided an input attenuator to increase the input requirement to about one volt which will enable preset adjustment to suit most radios or cassettes.

We used a trim potentiometer on the board to adjust sensitivity such that full volume is obtained with the volume control of the source about half way up. If desired, a separate potentiometer may be used in place of the preset as a volume control.

Output voltage of the ICs is about half of the supply. However since the speaker is direct coupled, any slight difference in amplifier outputs will result in a dc current flow through the speaker. Potentiometer RV2 should be adjusted, with the aid of a multimeter, for zero volts across the speaker (or minimum current from the supply). Alternatively, if a multimeter is not available, make and break one speaker connection and adjust RV2 for minimum 'clicking' sound from the speaker.

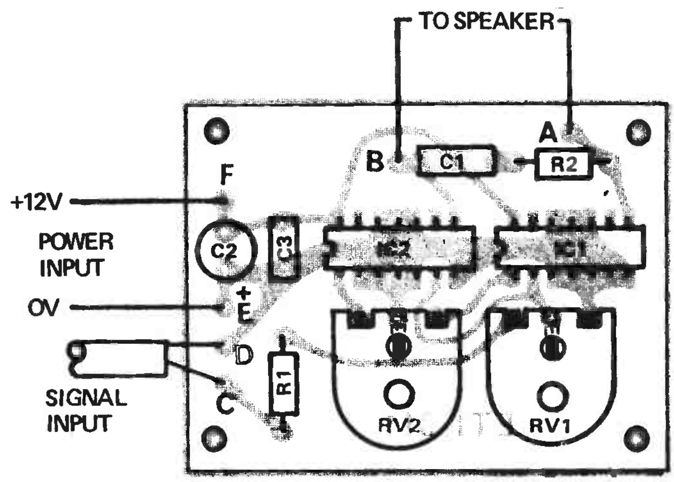


Fig. 3. Component overlay.

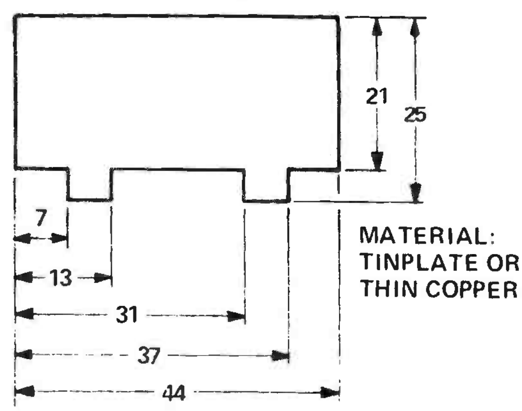
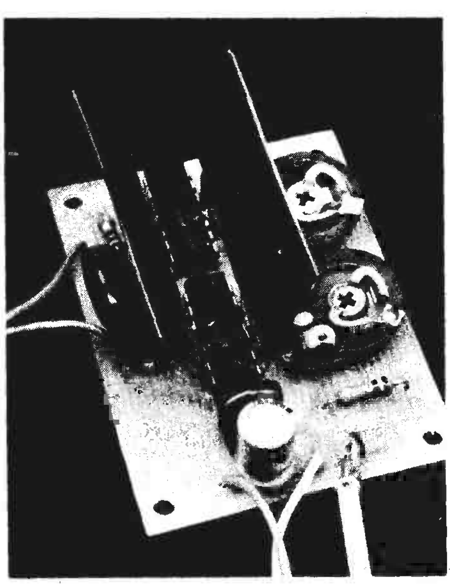


Fig. 4. Heatsink (two required) to be attached to either side of both IC's as shown in main picture.



SPECIFICATION

POWER OUTPUT		
12.6 volt supply 8 ohm load		[illegible]
DISTORTION		
12.6 volt, 8 ohm, 1 kHz		
at 5 watts		[illegible]
at 3 watts		[illegible]
SUPPLY VOLTAGE		
Nominal		12 volts
MAX SUPPLY VOLTS	Speaker load	
LM380	8	15 volts
	16	22 volts
SPEAKER IMPEDANCE		> 7 ohms
FREQUENCY RESPONSE		
10 Hz – 100 kHz		$\pm^{0}_{3}$ dB
SENSITIVITY		
Maximum (no input attenuator) into 75 k ohm		50 mV

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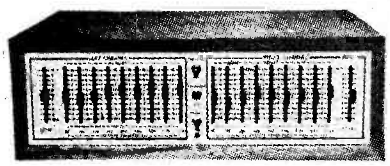
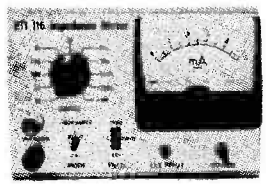
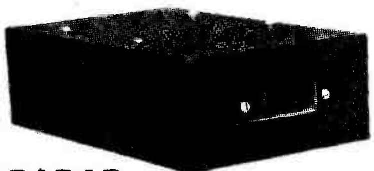


GRAPHIC EQUALISER



IMPEDANCE METER

BIKE SPEEDO



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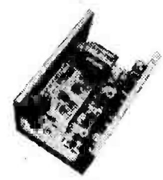
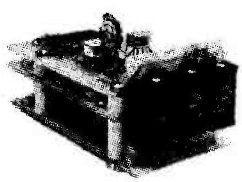
INTERNATIONAL 25



COLOUR ORGAN



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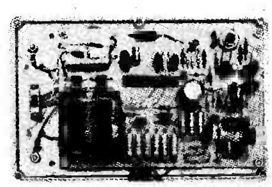
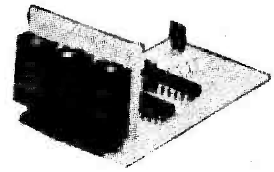
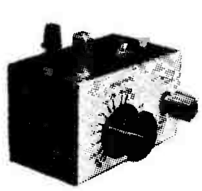


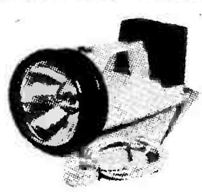
ELECTRONIC IGNITION



DIGITAL DISPLAY



AF METER



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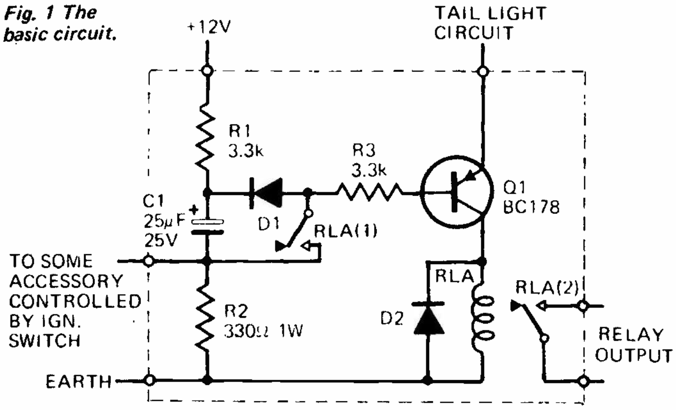
ALL PAYMENTS MUST BE IN STERLING

HEADLIGHT REMINDER

Electronic 'reminder' safeguards against flat batteries.

Fig. 1 The basic circuit.



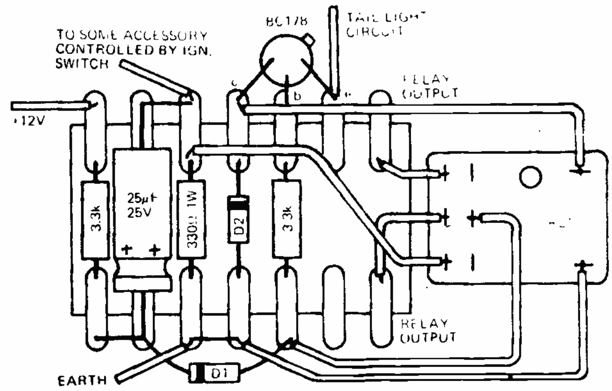


Fig. 2. How the components are connected.

HOW IT WORKS

Normally capacitor C1 is discharged via R1 and the closed switch contacts of an accessory wired via the ignition switch. If the ignition is now switched off, C1 will charge rapidly via R2 thus producing a negative going pulse at the base of transistor Q1.

If the vehicle's headlights (or side and tail lights) were switched on at this time, this pulse will turn on Q1, and close RLA.

The relay contacts RLA(1) and RLA(2) now close and contacts RLA(1) connect the base of Q1 to ground via R2 and R3 thus causing the relay to 'latch on'.

If either front door of the vehicle is opened with the relay in the latched condition an earth will be extended to the audible alarm device via the now closed contacts of RLA(2) and the closed door light switch.

The audible warning will cease immediately the door is reclosed. Q1 will of course be cut off and the relay reset when the lights are turned off (thus removing the positive voltage from the emitter of Q1).

If at any time it is required to disable the alarm circuit all that is necessary is – having first switched off the ignition – to switch the lights off and then on again. The circuit will revert to the status quo next time the ignition is switched on.

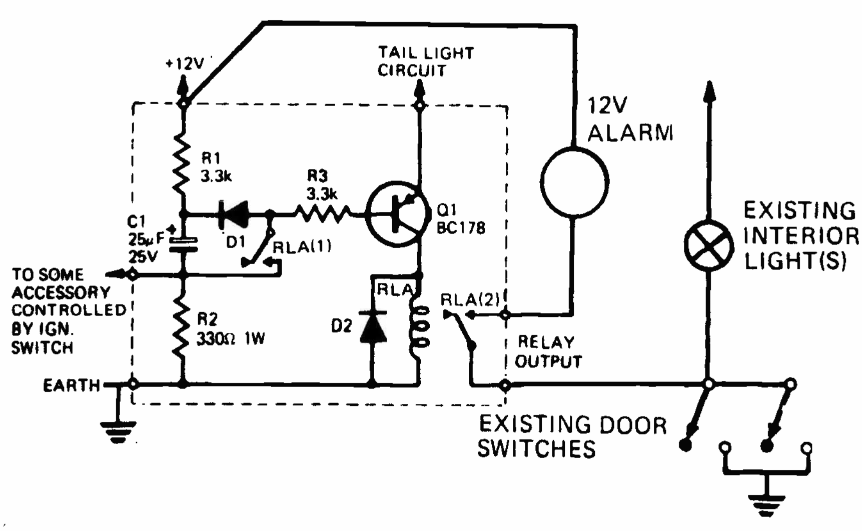


Fig. 3. How the warning circuit is wired into the vehicle's electrical system.

A CAR'S headlights cost very little to run whilst in use. Until you forget to turn them off.

Then you are up for recharging the battery, tow starting, apologising to the managing director who has just waited two hours to discuss your future with the company, placating uptight parents whose daughter you've returned just after they realised it was now daylight, or whatever combination of circumstances are least favourable to your immediate situation.

To avoid such predicaments is relatively simple and a number of circuits have been published that provide an audible warning if the ignition is switched off whilst the headlights or sidelights are still burning.

These circuits are simple and effective but invariably fail to cater for those occasions when one requires lights to be on whilst the ignition is switched off.

Here then is a slightly more complex circuit that provides a 'headlight on – ignition off' warning as the driver opens a door to leave the vehicle. The

PARTS LIST — ETI-307

R1	—	3.3k	5%	½W
R2	—	330 ohms	5%	1W
R3	—	3.3k	5%	½W
D1	—	1N4001 — 1N4005		
D2	—	"	"	
D3	—	"	"	
Q1	—	BC178		
C1	—	25 uf 25V electrolytic cap.		
	—	miniature relay 100-300 ohm coil two change-over contacts		
	—	alarm, bell etc. tagstrip etc.		

GETTING THE COMPONENTS

TRANSISTOR No-one should have trouble on the BC108 — anywhere selling transistors will have them. If you have a negative earth then the PNP equivalent is the BC178. Other suitable PNPs are the BC478 or the BCY72.

ALARM This should operate on 12V and you can use a simple buzzer or Audible Warning Device which gives a piercing 2600Hz modulated tone when connected to a car battery.

RELAY Given the range 100Ω to 300Ω you should be able to find a suitable 12V relay in a mail-order catalogue (the contacts need be only two, normally open, types).

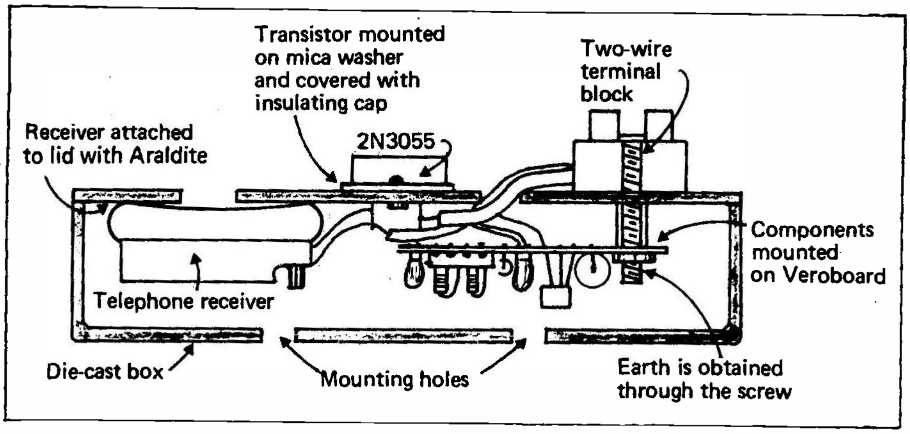
alarm ceases as soon as the driver closes the door.

The basic circuit is shown in Fig.1. The components may readily be mounted on matrix board or tag strips, and wired as shown in Fig.2.

As shown in Fig.1, the circuit is suitable for vehicles with a negative earth electrical system. To convert the circuit for use with positive earth vehicles replace the BC 178 by a BC 108 (the connections are the same) and reverse the diodes and the 25 μF capacitor.

Figure 3 shows how the basic circuit is wired into the car's electrical system. The alarm unit may be a buzzer, bell or even a flashing light. The existing door-operated interior light is used to extend an earth to the relay thus obviating the necessity to install any additional switches.

The lead marked 'tail light circuit' should be connected to the live side of the tail light wiring. (If a headlight only warning is required, this lead should be connected to the live side of one of the headlights). Further leads connect the unit to earth, the 12V vehicle supply and to the live side of any accessory that is wired through the ignition switch. ●



Suggested method of construction.

Solid-state flasher for cars

This inherently reliable flash unit is not affected by voltage or load changes.

FLASHING TURN INDICATOR lamps on cars are invariably controlled by a thermal relay unit. Many of these units are fragile and unreliable. A further disadvantage is that the flashing rate is affected by the load current. Thus, connecting up a trailer or caravan may vary the flash rate beyond the legal limit.

The unit described has the inherent reliability of solid state components and is not affected by load current. Its flashing rate is independent of supply voltage, and should cost little more than a commercial thermal relay unit.

The flash rate and duty cycle can be varied (providing they remain within the legal limit – which is between 60 and 120 flashes per minute). It can be used in either a 6 V or 12 V system.

Details are shown for both +ve and -ve earth systems. A switch can be added to give an "all lamp flashing" mode as a warning signal at the scene of an accident.

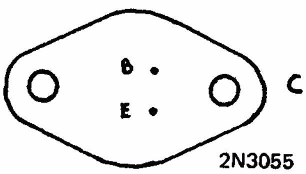
CIRCUIT DESCRIPTION

The solid state flasher unit consists of two sections, the adjustable timing circuit and the high current switching circuit.

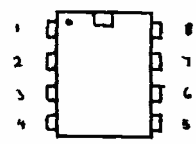
The heart of the timing circuit is Signetics' versatile integrated timer – NE555. It is used here in an "astable" or "free running" mode. Its frequency and pulse duty factor are determined by three external components R_A, R_B, and C.

A flash rate and duty cycle of ½ sec on – ½ sec off is achieved using the values shown in the parts lists and Fig. 1, however for those who might wish to vary this the necessary calculations are shown elsewhere in this article.

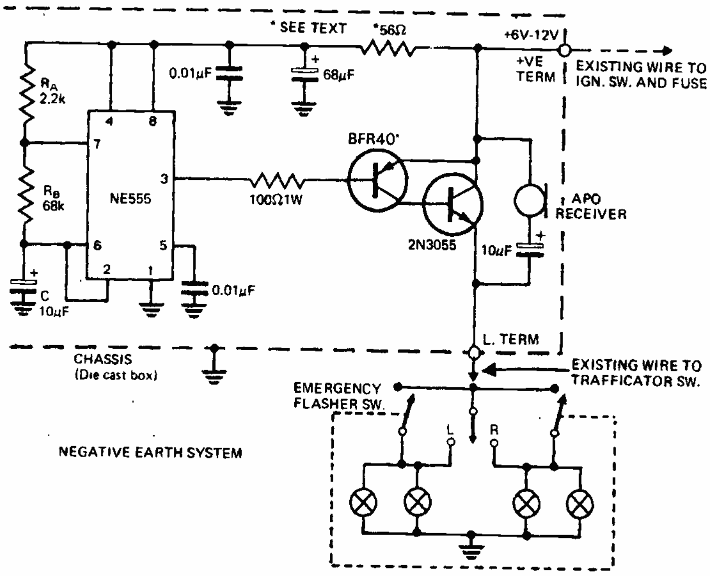
The NE555 is decoupled from the supply rail by a 56Ω resistor and a 0.01μF capacitor in parallel with a 68μF tantalum. For 6 V auto systems, the 56Ω resistor is not really essential as the chip will operate from a Vcc of between 4 V and 16 V and still produce the same accurate timing. Decoupling capacitors are required across the supply to eliminate voltage spikes on the supply rail. The 68μF capacitor smooths out most of these spikes but it is just not quick enough (it has too much inductance) to ground the very sharp, short spikes that may damage the NE555, hence the 0.01μF capacitor which must be

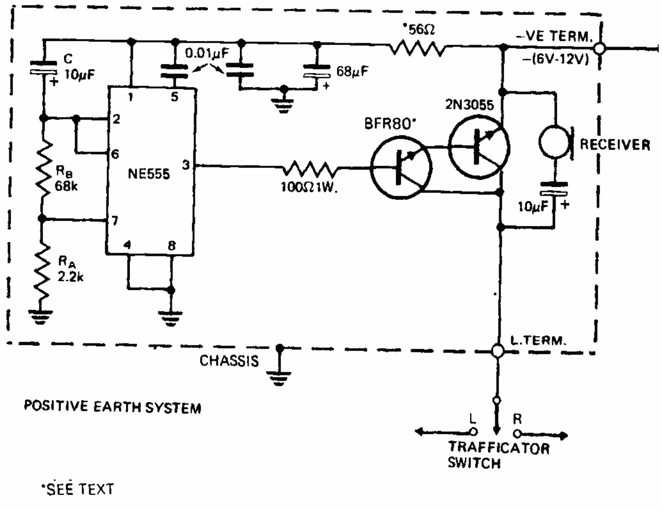


BOTTOM VIEW



NE555
TOP VIEW





placed as close to the chip as possible.

The output (pin 3) controls a direct coupled Darlington transistor output stage that switches the current through the lamps, the 100Ω resistor limits the current from the chip. The circuit is energized continuously when the ignition is switched on but the power consumed is negligible. Only when the trafficator control switch is moved right or left, does heavy current flow through the 2N3055. The driver of the 2N3055 is not a critical type but seeing that this unit was designed to switch 10 amps comfortably a medium power transistor with a collector current of 1 amp was chosen.

The law requires that an audible indication be given to indicate that the trafficators are operating. This is achieved by connecting a telephone receiver earpiece across the 2N3055, thus producing the audible clicks.

Most cars have two pilot lamps on the dashboard to indicate right or left hand indicator operation. If, however, there is only one pilot lamp, it can be connected between the two sides of the trafficator lever, providing that the lamp can be completely insulated from the dash. Thus when one set of lamps is energised, the pilot lamp operates in series with the un-energised lamps, which, being of high wattage and with cold filaments, do not light.

It is also a good idea to provide an "emergency flash" mode to warn other drivers of a road accident, etc. A double-pole switch capable of handling the current (shown on the -ve earth circuit) will provide this. The extra load will not affect the flash rate or ratio, but one should check the fuse/s used in conjunction with the flasher unit to see if it will handle twice the normal current.

VARYING THE FLASH RATE AND DUTY CYCLE

The charge time (the high or + ve output) is given by:—

$$t_1 = 0.685\,(R_A + R_B)\,C$$

and the discharge time (the low or — ve output) by:—

$$t_2 = 0.685\,(R_B)\,C$$

Thus the total period is given by:—

$$T = t_1 + t_2 = 0.685\,(R_A + 2R_B)\,C$$

The frequency of oscillation is then:—

$$f = \frac{1}{T} = \frac{1.46}{(R_A + 2R_B)C}$$

The duty cycle is given by:—

$$D = \frac{R_B}{R_A + 2R_B}$$

CONSTRUCTION DETAILS

The most convenient method of building this flasher unit is to mount the components on to the lid of a die-cast box. The main part of the box should be bolted firmly to the car chassis, thus providing the necessary earth. The receiver can be attached to the lid, using epoxy resin. The 2N3055 can be mounted on the outside of the lid, thus providing the transistor with a ready-made heatsink. This transistor must be completely insulated from the metal lid and a transistor cover must be used. The remaining components can easily be mounted on a small piece of Veroboard which in turn can be secured to the lid via the screw used for the terminal block. ●

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eti PROJECT

COURTESY LIGHT EXTENDER

Car interior light stays on briefly after the door is closed

ALL MODERN CARS are fitted with door-switch operated courtesy lights. Useful devices, but not *quite* as useful as they might be because they are so arranged that the light is extinguished as soon as you close the door — just when you need light to find the ignition switch, do up your seat belt etc. How much better if the internal light stayed on for a few seconds *after* the door is closed.

This little project does just that. It provides a four-second delay (approx) after which the interior light slowly dims — being finally extinguished after 10 or 12 seconds.

The unit is very simple to construct and once tested and properly insulated it may be wired across one of the car door switches. In operation, after a short delay the lights will gradually dim until they are completely extinguished. There is no battery drain in the off-state as the unit only operates during the delay period after the door is closed.

HOW IT WORKS

Most car door switches are simply single-pole switches, with one side earthed. When the door is opened the switch earths the other line thus completing the light circuit.

In a car where the negative terminal of the battery is connected to the chassis the negative wire of the unit (emitter of Q2) is connected to chassis and the positive wire (case of 2N3055) is connected to the wire going to the switch. In a car having a positive earth system this connection sequence is reversed.

When the switch closes (door open) C1 is discharged via D1 to zero volts and when the switch opens C1 charges up via R1 and R2. Transistors Q1 and Q2 are connected as an emitter follower (Q2 just buffers Q1) therefore the voltage across Q2 increases slowly as C1 charges. Hence Q2 acts like a low resistance in parallel with the switch — keeping the lights on.

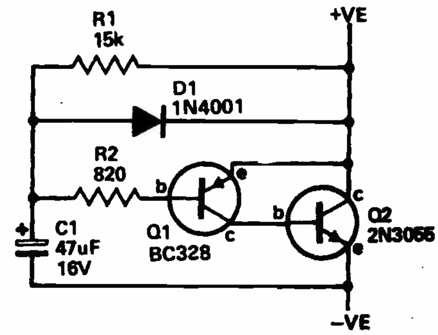
The value of C1 is chosen such that a useful light level is obtained for about four seconds, thereafter the light decreases until in about 10 seconds it is out completely With different transistor gains and with variation in current drain due to a particular type of car the timing may vary, but may be simply adjusted by selecting C1.

CONSTRUCTION

In our prototype, as shown in the photograph, all the components are assembled directly onto the 2N3055 transistor. This only requires two "mid-air" joints to be made.

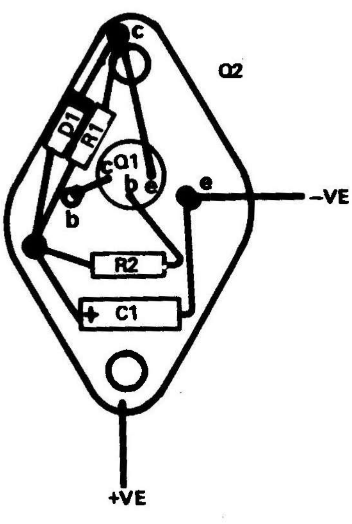
After checking that the unit works correctly the assembly may be placed in a small plastic pill box which is then filled with epoxy. Alternatively merely wrapping the unit in insulation tape will be sufficient.

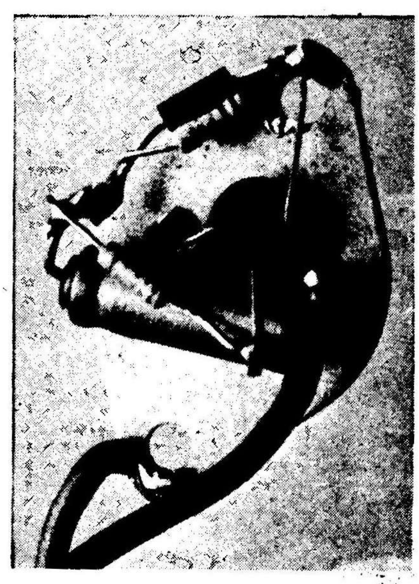
Due to the fact that the 2N3055 only conducts for a few seconds every so often, a heatsink is not required for cars fitted with a single lamp courtesy light. If your car has *more* than the usual amount of interior lighting operate the unit a number of times in fairly quick succession. Then, if the 2N3055 gets too hot to touch, use a small piece of aluminium as a heatsink. This need should however be rare. ●



PARTS LIST

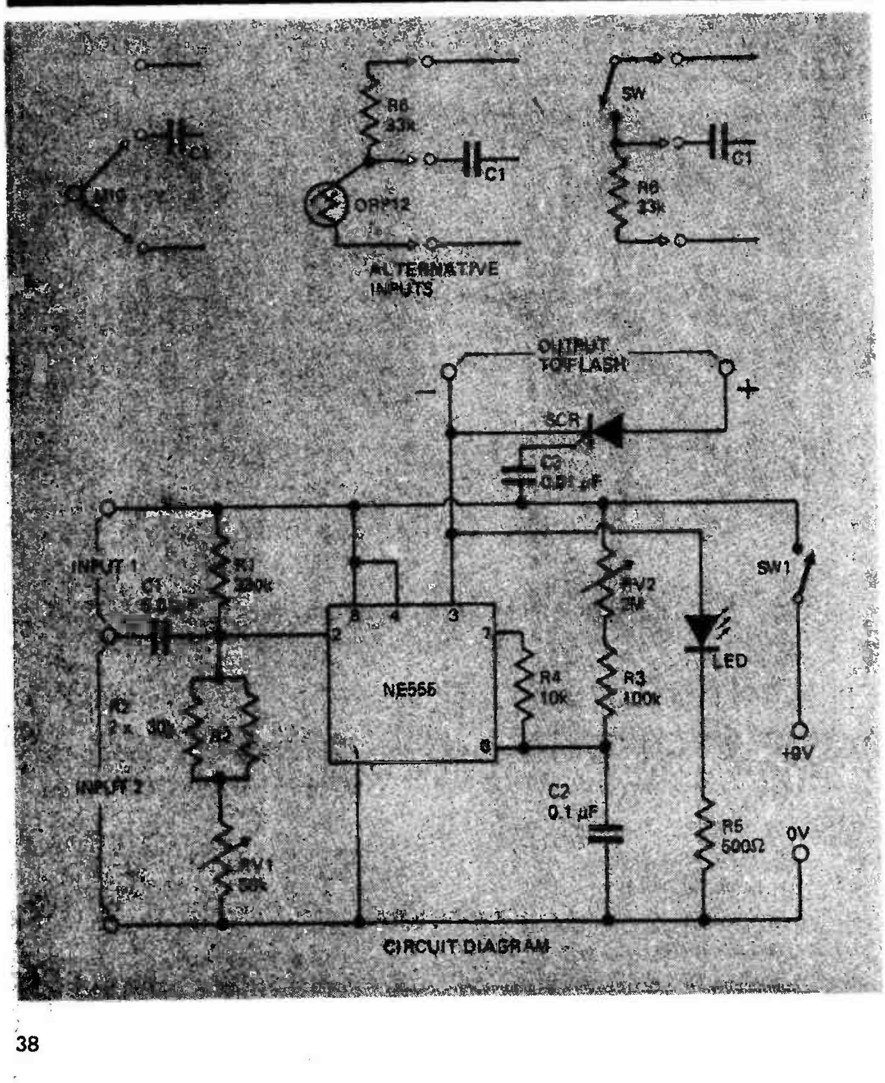
R1	resistor	15 k ½ watt 5%
R2	"	820 ½ watt 5%
C1	capacitor	47µF 16 volt electrolytic
D1	diode	1N4001 or similar
Q1	transistor	BC328 or similar
Q2	"	2N3055





ELECTRONIC FLASH TRIGGER

Trigger your photo-flash from light, impulse, or sound with this ingeniously simple unit.



CIRCUIT DIAGRAM

MANY sound-operated flash trigger circuits have been published, some of which can be adapted to accept other means of triggering.

The one described here will trigger from virtually any energy source. All that is required is a sound, light flash or other effect that can provide a sudden voltage change.

The unit also incorporates a variable time delay between the trigger input and the flash triggering.

It has been based on the NE 555 timer IC – this has a very sensitive input, the ability to provide the required variable time delay and an output of sufficient energy to trigger an SCR.

CONSTRUCTION

The prototype unit was constructed on Veroboard, taking care not to apply too much heat to either the components or the board.

The most critical part of the circuit is around pin 2 of the IC. The triggering current needed is only 0.5 microamps and with pin 1 being the negative supply line and pin 3 the output, leakage currents across a dirty board can easily cause continuous triggering. To prevent this the strip to which pin 2 is attached should be as short as possible. It is also a good idea to clean off any excess flux with methylated spirits on completion of soldering.

Input is via two miniature phone plugs mounted on an insulating strip. The outside connection goes to the positive and negative lines respectively with the centre connection of both plugs going to the input.

The only problem likely to be experienced is continuous triggering. This is caused by a dirty board. The slightest trace of dampness around pin 2 on the board may cause this trouble.

USING THE UNIT

Sound trigger. The unit may be triggered by a crystal microphone insert or by a loudspeaker used as a microphone. The input can be to input 1 or 2. When the sensitivity is turned up to maximum, (RV1 at minimum) the unit may trigger continuously. To avoid this, simply turn the control back until the LED goes out, but flashes when the required sound is made. The photo of the tennis ball hitting a stool was made in this way with the time delay at minimum (about 4 milliseconds).

Light trigger. The resistance change of a cadmium sulphide cell may be used to trigger the unit when the light level falling on the cell varies. If the intensity of light increases, the resistance drops rapidly, while if the intensity falls, the resistance increases – but much more slowly. Triggering is thus best done by increasing the light level. Connect the CdS cell to input 2 via a 33 k resistor across input 1. A sudden increase in the light level will then fire the flash. If the time is set at a minimum this can be used as a slave flash unit as it only responds to sudden changes.

The photos of the fluid drop falling into the beaker of water were taken by having the drops interrupt a light beam falling onto a cadmium sulphide cell. The cell is in the tube in the top left of the large photo. The drops were indian ink to be certain they would block out the light beam. The time delay was about 250 milliseconds.

Switch triggering. With a switch connected to input 1 and a resistor to input 2 (33 k), the unit will fire when the switch is opened. If the position of the switch and resistor are interchanged the unit will fire as the switch is closed.

For simplicity in use the inputs have been devised using miniature phone sockets with a resistor connected to a plug – so by simply changing the plugs the input can be changed. ●

HOW IT WORKS

A negative pulse at the input is fed via capacitor C1 to the input pin (2) of the IC. Pin 2 is held slightly above its triggering voltage of 1/3 V_{CC} by the voltage divider comprising R1, R2, and RV1. The negative pulse triggers the IC and the output (pin 3) goes high for a time period controlled by RV2, R3 and C2. When the output goes low again at the end of the time interval capacitor C3 charges through the gate cathode circuit of the SCR switching it on and firing the flash.

Capacitor C1 isolates the input from the voltage divider so that the unit isn't sensitive to the dc level at the input. RV1 acts as a sensitivity control by allowing the voltage to be adjusted to a suitable level so that the input signal will trigger the IC. Resistor R4 limits the discharge current from C2 at the end of the timing cycle so protecting the IC. The LED and its protective resistor R5 act as an indicator to show that the unit has triggered, so simplifying the setting up process and minimising the number of times the flash has to be fired. This means that the flashgun needn't be fired until a photo is to be taken.

PARTS LIST

SEMICONDUCTORS
IC NE 555.
SCR C106 D1 or similar with a 400 volt rating
LED Miniature red.

RESISTORS (10%0
R1 330 k
R2 165 k (2x330 k in parallel)
R3 100 k
R4 10 k
R5 560 ohm
R6 33 k (optional depending on input)

CAPACITORS
C1 0.01 µF
C2 0.1 µF
C3 0.01µF

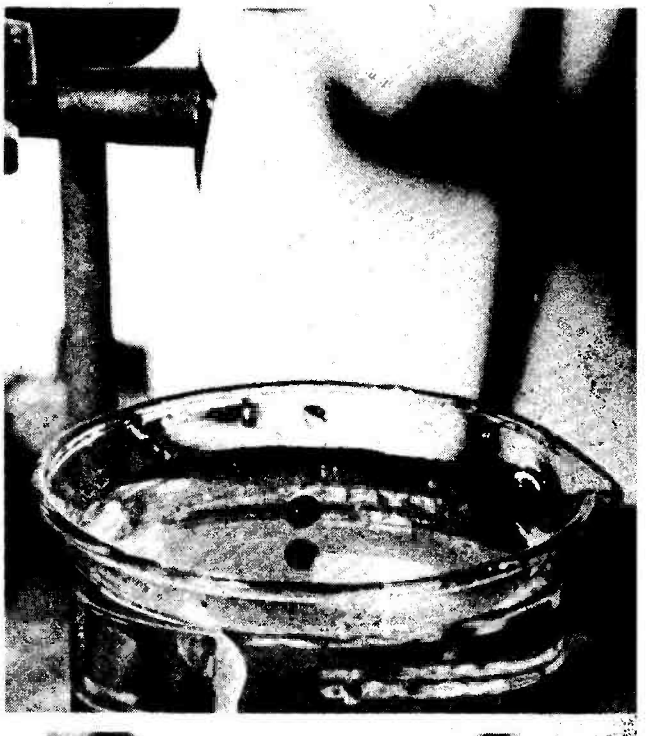
SWITCH
Any SPST switch suitable

POTENTIOMETER
RV2 2 Meg linear
RV1 50 k linear

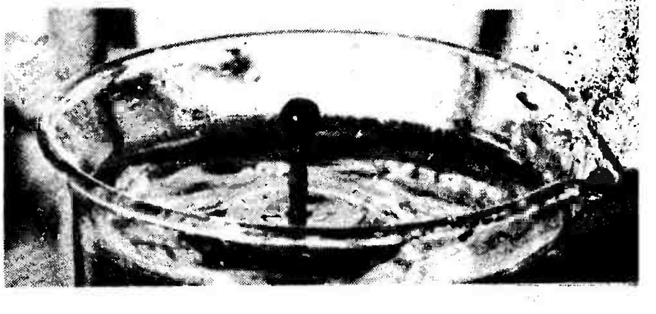
INPUT DEVICE
CdS cell (ORP 12)
Crystal mike insert etc.

OUTPUT DEVICE
Electronic flashgun, preferably computer type as these give a much shorter flash duration at close range.

OTHER PARTS
Metal case (58 x 58 x 100 mm)
Veroboard (40 x 80 mm)
Input sockets minute phone.
Output to suit flash unit being used
Knobs 2 for pots.
Battery Connector.



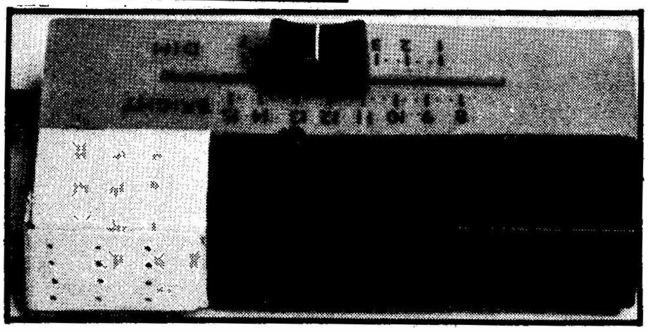
Drops of Indian ink are 'caught' here splashing into a beaker.



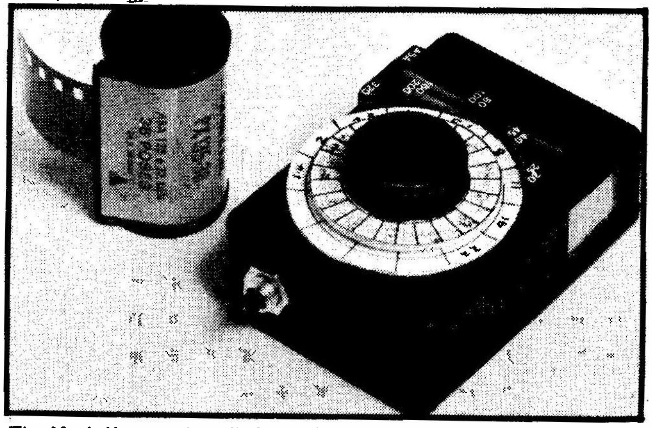
EXPOSURE METER

eti project

By Dave Adams



The prototype unit. The case is a Kodak 20-exposures transparency case.



The Mark II meter is built into a Vero box.

IT IS COMMON for amateur photographers to find three or four useless prints in the wallet picked up from the chemists, and usually there are a couple of shots lost because the exposure was so way-out that there is no image on the negs. For a few quid, however, you can build this simple instrument and ensure that all your shots are correctly exposed.

The exposure meter uses an LDR (Light Dependent Resistor) to measure the amount of light falling on a translucent window. The position of the potentiometer control when the meter is set is directly related to this quantity. Setting up simply involves adjustment of the knob until the two LEDs glow with equal brightness.

The prototype is built in a 20-exposures transparency case and uses a slider control. The control is calibrated in units which are 1 stop (representing a doubling in quantity of light) apart; we call these LV (Light Value) units. Having found the LV number, the camera setting can be found using the circular calculator on the underside of the meter.

After building the first prototype we found that we needed to build a second one (there were two of us at ETI who wanted the meter, so to save arguments we built another). The mark II shows some of the possible alternative methods of construction – we used a small Vero box and a conventional pot. Now the rotation of the control automatically sets the calculator without the need for LV numbers, The circuit was the same in each case.

As it stands the meter is ideal for measuring light levels normally found indoors – but it cannot cope with highly illuminated sets or outdoor work. To give an additional range to the meter we use an optical attenuator, a mechanical filter placed in front of the LDR window. Now the instrument can cope with all the lighting conditions met by the amateur photographer.

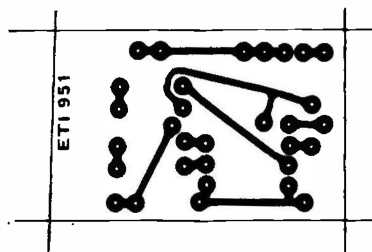


Fig. 2. The pcb design.

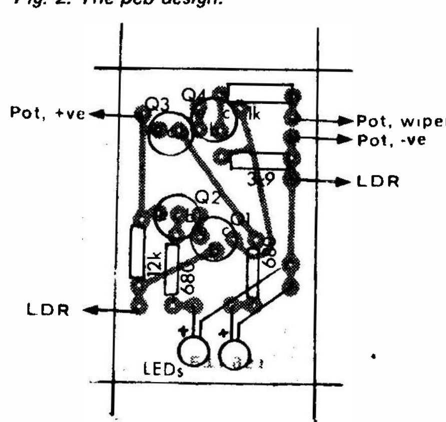


Fig. 3. The component overlay.

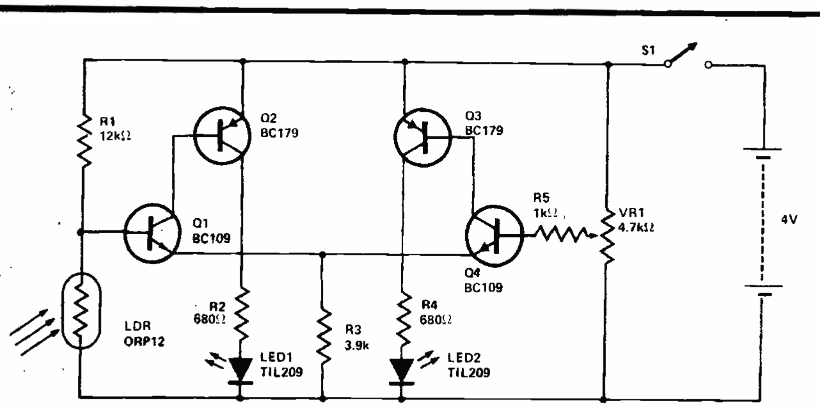


Fig. 1. The circuit diagram of the Exposure Meter.

PARTS LIST

R1	Resistor	12k	1/8W	10%
R2	"	680Ω	"	"
R3	"	3k9	"	"
R4	"	680Ω	"	"
R5	"	1k	"	"
VR1	Potentiometer	4k7 lin	"	"
Q1,Q4	Transistors	BC108		
Q2,Q3	"	BC178		
LEDs		TIL209		
LDR		ORP12		
S1		Miniature slide switch or push-on switch		
Batteries		3x1.35V Mercury Cells		
PCB		ETI 951		
Box		Either Kodak (or similar) 20-exposures transparency case or Vero 75-1413-E.		

Also: 18swg aluminium for the filter; 3.1mm perspex (at least 50 x 35mm), red perspex 30 x 15mm; matt black paint, plastic card, impact adhesive, etc.

The reward! This is the kind of picture you can take with this meter.

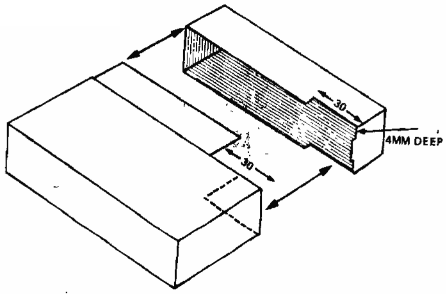


Fig. 4. The work required to modify the transparency case.

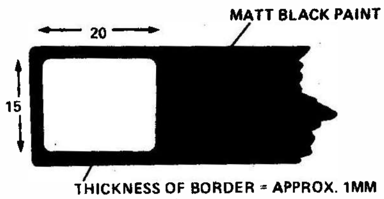


Fig. 5. The LDR Window. This is rubbed inside with wirewool and then the surrounding area is painted matt black.

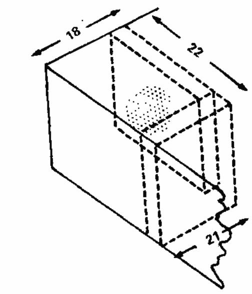


Fig. 6. How the LDR Holder is made using two pieces of perspex inside the lid.

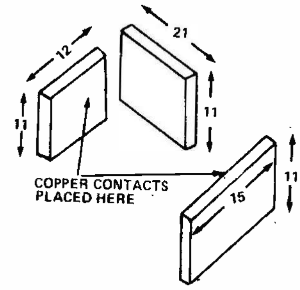


Fig. 7. Construction of the battery holder. The inside of the end faces of the holder should be lined with copper contacts.

mounted. Fig. 8 gives details of calibration for the pot. The pcb is mounted by one bolt through the centre — this bolt also acts as the centre of the calculator. The prototype calibrations, Fig. 9, will work if the meter is constructed exactly like the prototype. Check the meter against a known accurate instrument, then if adjustment is required this only needs to be done by moving the scale of LV numbers a little (the time and aperture scales ought to be ok).

The prototype was held together by

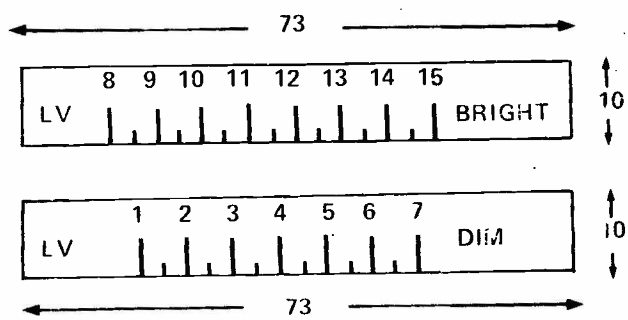


Fig. 8. The scales for calibrating the slider pot.

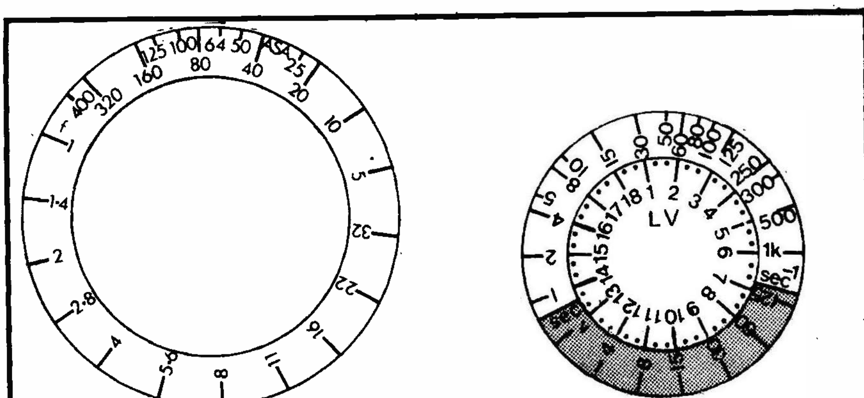


Fig. 9. The calculator.

The top of the transparency box is painted black inside. Then the Battery Holder (left) and LDR Holder (right) are built into opposite ends.

CONSTRUCTION

The pcb holds all the electronics except the pot, the batteries, the switch and the LDR. The transistors must be mounted as low as possible on the board so that it can be fitted under the pot. The positioning of the LEDs can be finalised only when the board is mounted in its case.

We will give details of construction in the slide case. Fig. 4 shows how slots are cut to enable the mechanical filter to be fitted. The LDR window is marked out, according to Fig. 5, and made into a diffuser by rubbing with wirewool. Then the transparent top is painted (except for the window) with a couple of coats of matt black paint.

Fig. 6. shows the construction of the LDR holder. The dimensions here are important — they decide how much of the light falling into the window will be measured by the LDR. The holder must be a light-tight box — use matt-black paint and glue to achieve this.

The battery holder is located at the other end of the box top, and is made from perspex; see Fig. 7. A useful source of copper contacts is raw printed circuit board — glue pads at each end of the holder and solder leads to these.

The photographs show how the slider pot and on-off switch are

EXPOSURE METER

a 6BA bolt (Fig. 10), but less crude methods can be used if you can think of them.

The mechanical filter is constructed from 18swg aluminium. The necessary information is given in Fig. 11. Twelve holes are drilled, in three columns of four. Vertical separation is 4mm, horizontal 9mm. The size of the holes is 1.16mm diameter. Check that all the holes are over the window (the format of the matrix is not critical, but should be symmetrical).

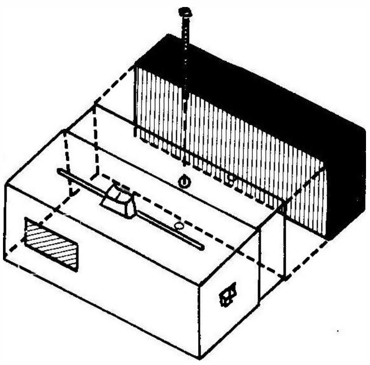
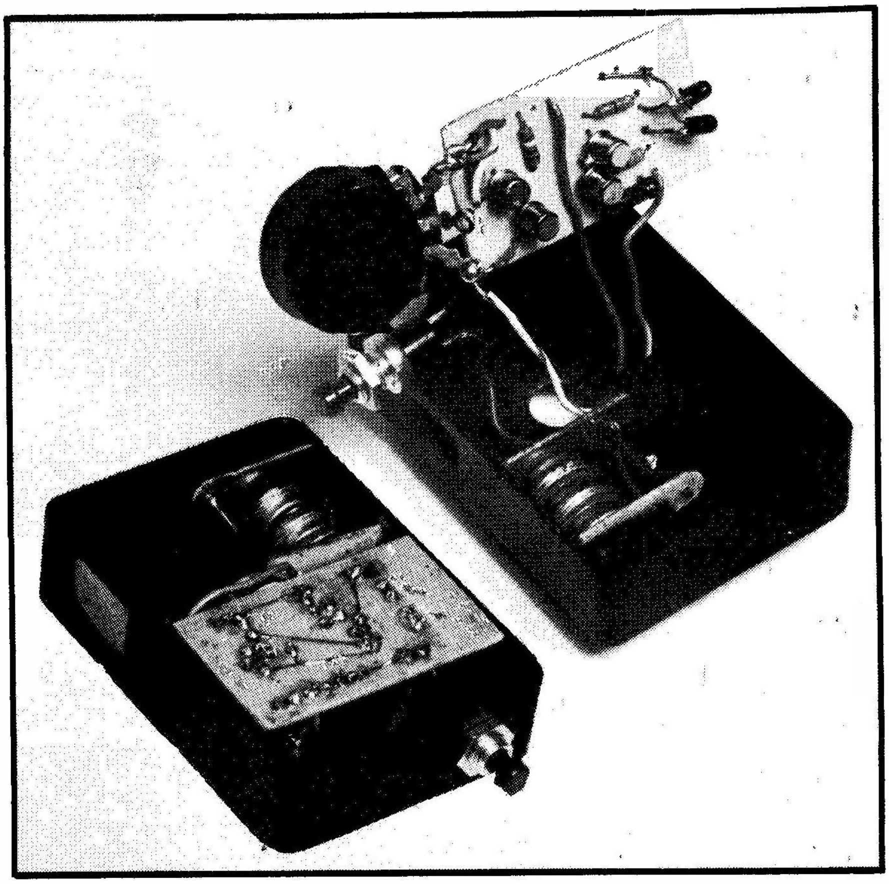


Fig. 10. How the meter is held together — a 6BA bolt.



Inside the Mark II. The pcb is mounted on the back of the pot.

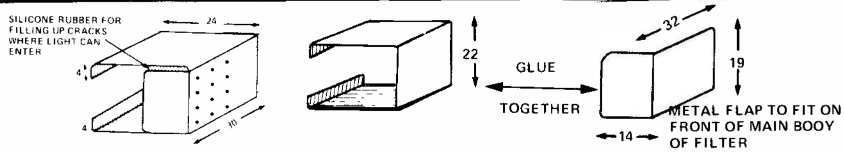


Fig. 11. The mechanical filter for the Mark I meter is constructed from 18swg aluminium. For the Mark II the front is the same but the supports need re-designing to fit the case.

Construction in the Vero box can be seen from the photographs. The LDR holder and battery holder are the same as before. We used a push-on miniature switch — this will keep the drain on the mercury cells down to a minimum. The pcb is mounted on the back of the pot. It is held by the connecting wires. The body of the pot is covered in pvc tape to prevent shorting.

The calculator was made from two discs cut from plastic board. Perhaps the best way to calibrate the MkII is to use an accurate meter (borrow one). We found that we needed to divide the circle into 13 segments. The useful range of the pot's rotation has nine stops (nine of these segments). The aperture settings found on your camera can be marked on the outer disc (in the sequence 1, 1.4, 2, 2.8, 4, 5.6, 8, 11, 16, 22, etc).

Beneath the outer disc we glued a pointer (a plastic arrowhead) which runs in a slot cut into the thick perspex block beside the calculator. This holds the outer disc firm while the inner is rotated and allows the outer disc to be turned for setting film speed.

In the middle of the perspex block we marked a speed of 80 ASA. (the full sequence was 20, 40, 80, 120, 320; with extra markings for 25, 50, 100, and 200 ASA). With the pointer at 80 ASA we found that with the control set mid-range an aperture of f5.6 would require an exposure of 1 second. So we calibrated the inner scale 1/15, 1/8, 1/4, 1/2, 1, 2, 4, 8, 16; to give times for all apertures marked on our meter. To extend the range for other film speeds we marked two more stops each way.

The mechanical filter is of the same basic design as before but needs remodelling to fit around this box. The inner scale of the calculator is in fact cut into 26 sequents so that the second range (with the mechanical filter) could be incorporated. On this range we got an exposure of 1/250 sec at f5.6, ASA 100, with the pot mid-range.

All that remains now is to find some black leather, a 5" zip, and some obliging lady to make you a case! ●

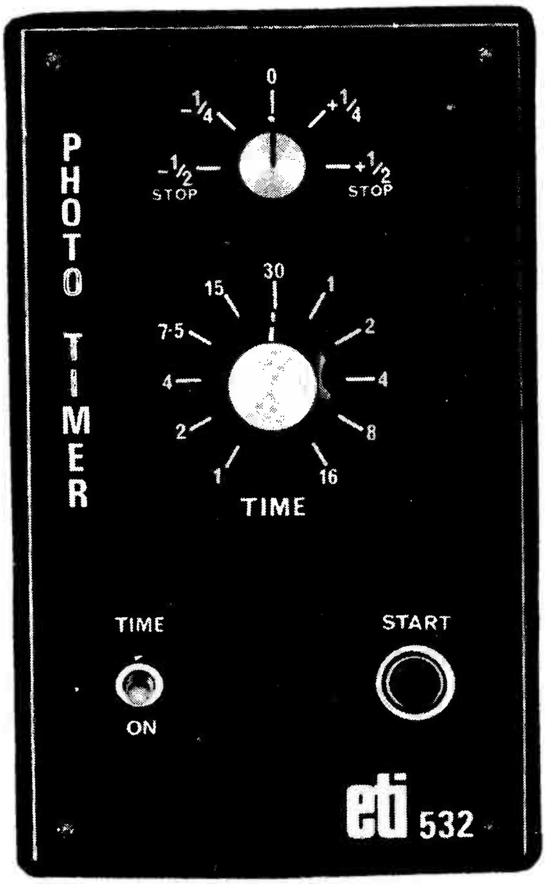
HOW IT WORKS

The resistance of the LDR varies from 300Ω to 10MΩ, from bright sunlight to darkness. When the meter is set up the ratio of LDR resistance to R1 is the same as the ratio of resistances on the pot, so the position of the wiper contact varies with the light being measured.

In equilibrium Q1 and Q4 are both turned off (Q2 and Q3 sense this condition and the LEDs light up). Setting up equilibrium is made critical by the common emitter resistor, R3. When one transistor is conducting the potential on the emitter rises and helps turn off the other transistor.

Versatile and accurate unit displays progress through time interval.

PHOTO TIMER



WHEN making multiple photographic prints the repeatability of exposure timing is considerably improved by using an accurate timer.

Mechanical timers, give excellent results but must be set for every exposure. Conventional electronic timers, do not need resetting but give no indication of the time remaining in the selected interval – as do mechanical timers.

Indication of progress within the selected time interval is very helpful, particularly if parts of a print need burning in. Such indication also helps co-ordinate other activities which may be carried out during the exposure period.

The electronic timer described here divides the total selected time into eight equal periods and indicates the elapse of each portion of the interval via light emitting diodes.

Eight LEDs are arranged in a vertical row. When the timing interval is initiated all LEDs light up. As time elapses the lights go out progessively, until all are out and the timing is complete. An internal relay is held on until the last of the LEDs is extinguished. This relay controls the mains output to the enlarger, or other device, via a standard three-pin power outlet.

The timing interval can be varied from one second to sixteen minutes in eleven switched ranges. Starting from the lowest, each range covers twice the time interval of the receding one. Thus the exposure may be increased or decreased, by one stop simply by switching up one range or down one range respectively. A variable potentiometer allows the range-selected time to be adjusted by half a stop either side.

As a further aid to timing another LED is provided which flashes once per second, regardless of selected range. This once-per-second pulse may be fed to a small loudspeaker, if desired, to provide an audible one-per-second tick.

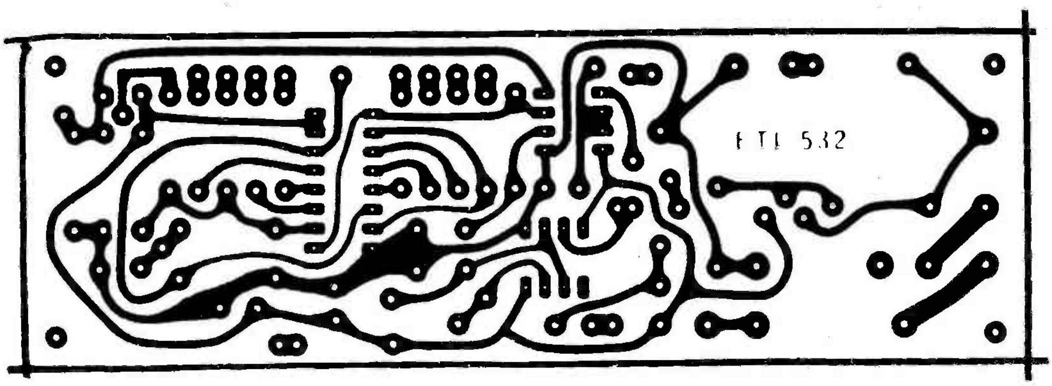


Fig. 4. Printed circuit layout. Full size 133 x 44 mm.

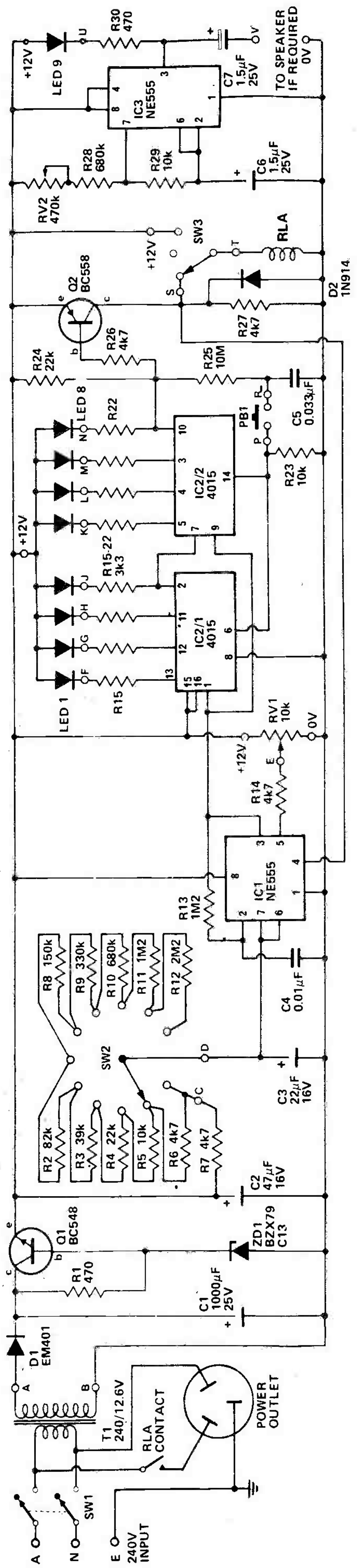


Fig. 1. Circuit diagram of the timer.

HOW IT WORKS

The basic timing is performed by an NE555 timer, IC1. The timing is varied by selecting a charging resistor via the range switch SW2. The range may then be varied around the SW2-selected period by providing a variable threshold voltage, (normally two-thirds supply) to pin 5 from RV1. Resistor R13 and capacitor C4 are used to ensure that C3 is completely discharged at the end of each charge cycle thus ensuring accurate timing.

Integrated circuit IC2 is a dual, four-bit shift register connected as an eight-bit shift register. For those unfamiliar with shift registers a brief explanation follows. There are eight outputs (labelled 1-8) a clock input, a data input, and a reset. When the unit is clocked the information at the data input is transferred into the '1' output. The information which was at the '1' output transfers to the '2' output, and so on, so that the information, at outputs 1-8, shifts along sequentially one place on each clock pulse – hence the name shift register.

The clock input to the shift register is the output from the 555 timer and the data input is connected directly to the +12 volt rail. Hence after eight clock pulses all outputs will be high. An LED is connected between each shift register output and +12 volts such that they are only illuminated when the associated shift-register output is low.

If push button PB1 is pressed all outputs of the shift register are set to zero and all LEDs will light. These then go out one at a time as the 'high' at the data input is clocked through the shift register.

The relay is driven by transistor Q2 which, in turn, is driven from the last LED. The relay can be switched out by SW3 and the LED display may then be used without the relay. Alternatively the relay may be switched on or off, without using the timer, again by SW2. When the shift register is reset the relay closes and when the last light goes out the relay opens.

The output of Q2 also controls the reset line of IC1 thus ensuring accurate timing in the first cycle.

The third IC is also a 555 timer which provides an output of one 10 millisecond pulse per second. This pulse drives LED 9 and a speaker if required.

A 12.6 volt transformer, rectifier D1, and filter capacitor C1 feeds a regulator consisting of Q1 and ZD1 to provide an output of 12 volt dc.

If required an external push button, or foot switch, may be paralleled across the local one to enable the start. Another may be used between the relay (point T) and +12 volts to allow the relay to be closed remotely.

PARTS LIST

R1,30	Resistor	470	¼ or ½W	5%
R15,16, 17,18	"	3 k3	"	"
R19,20 21,22	"	3 k3	"	"
R,6,7, 14	"	4 k7	"	"
R26,27	"	4 k7	"	"
R5,23, 29	"	10 k	"	"
R4,24	"	22 k	"	"
R3	"	39 k	"	"
R2	"	82 k	"	"
R8	"	150 k	"	"
R9	"	330 k	"	"
R10,28	"	680 k	"	"
R11,13	"	1 M2	"	"
R12	"	2 M2	"	"
R25	"	10 M	"	"
RV1	Potentiometer	10 k lin rotary		
RV2	"	470 k trim		
C4	Capacitor	0.01 µF	Polyester	
C5	"	0.033µF	"	
C6,7	"	1.5µF 25V electrolytic		
C3	"	22µF 16V TAG		
C2	"	47µF 16V electrolytic		
C1	"	1000 µF 25V		
Q1	Transistor	BC548 or similar		
Q2	"	BC558 "		
D1	Diode	EM401 or similar		
D2	"	1N914 "		
ZD1	Zener Diode	BZX79 C13		
LED 1-9	Light Emitting Diode			
IC1,3	Integrated Circuit	NE555		
IC2	"	" 4015,14015		
SW1	Switch	DPDT switch 240V toggle		
SW2	"	11 position 1 pole rotary		
Sw3	"	SPDT, with centre off, toggle		

RLA Relay 12V coil, 240 Vac 6 amp contacts type E3201
T1 Transformer 240V/12.6V DSE 2851 or, A&R PT 6474 or similar

PB1 Push Button Press to make.

Plastic Box UB1 or similar
240V outlet Clipsal 415 or similar
3 core flex & plug.

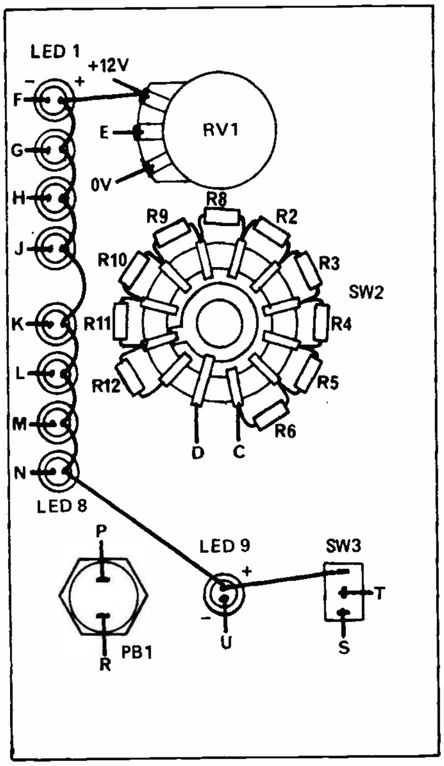


Fig. 3. Front panel wiring details.

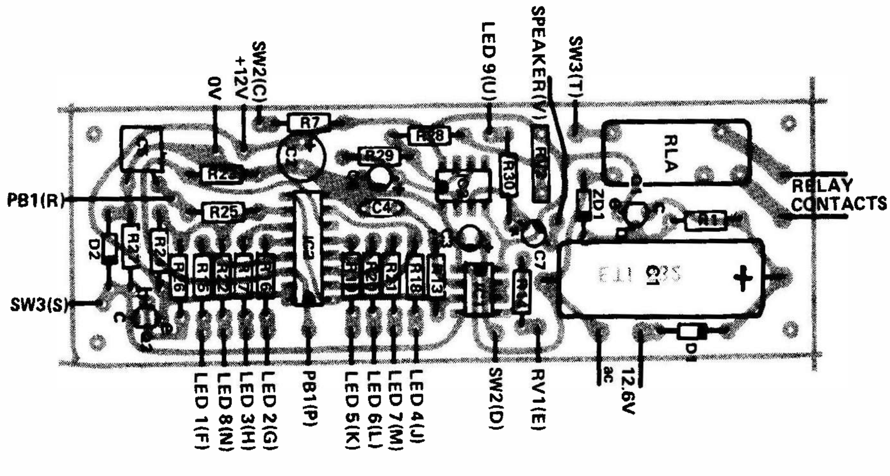


Fig. 2. Component overlay.

CONSTRUCTION

Our prototype was built into a small plastic box, 160 x 95 x 50 mm. The front panel shown in Fig. 6 is designed to suit that box. All the electronics apart from switches and LEDs are mounted on a single printed circuit board. It is recommended that this board be used as construction would otherwise be much more difficult.

Assemble components to the printed circuit board with the aid of component overlay Fig. 2. Make sure that the polarities of transistors, diodes and capacitors are correct and that integrated circuits are correctly orientated. Note also that IC2 is a CMOS device and should therefore be the last component to be fitted. The pins of this device should not be handled unneccessarily and an earthed soldering iron should be used. Solder the supply pins (16 and 8) first.

Capacitor C5 and transistor Q2 should be mounted such that they are flat on the printed circuit board otherwise they may touch the power-outlet socket.

The components, mounted on the lid of the box, should be wired as illustrated in Fig. 3. Note that resistors 2 to 12 (with exception of R7) are mounted on SW2.

Before drilling any holes in the box for the transformer etc, make sure that all components are clear when the lid is in place as there is not a great deal of room in the box. The photograph of the box shows where components should be located.

All 240 volt ac wiring should be 23/0076 wire rated for 240 volts ac, and any bare terminals should be well covered with insulation tape to prevent accidental shorts or personal contact.

The range of timing available – one second to 16 minutes makes this timer suitable for a variety of applications other than photographic printing – it is an extremely versatile and useful device.

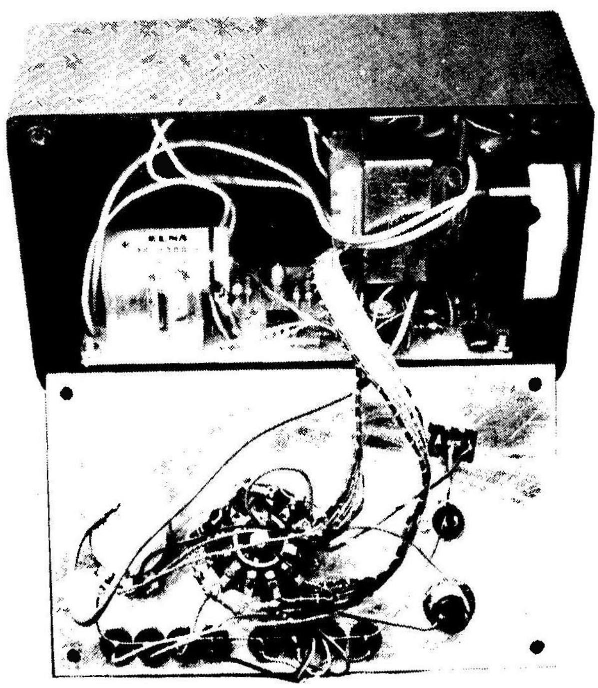
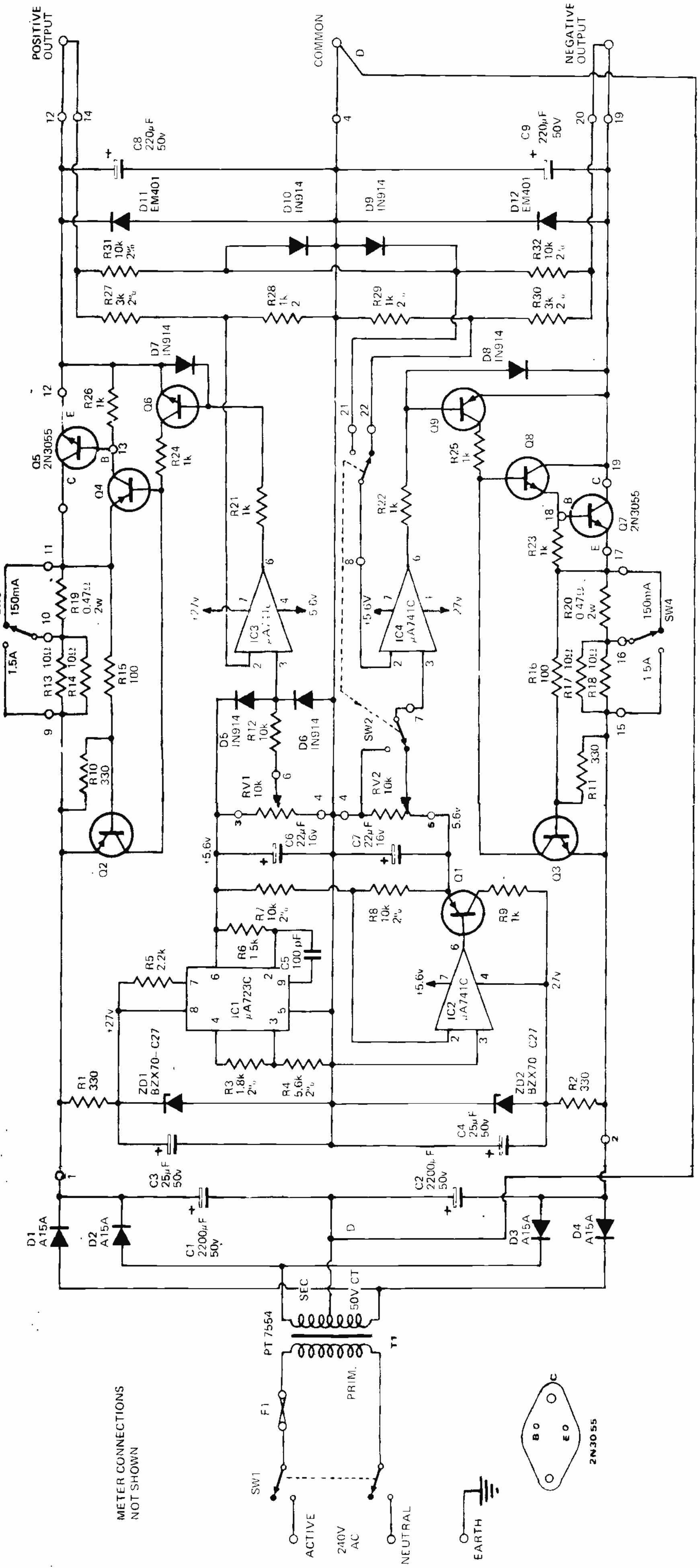
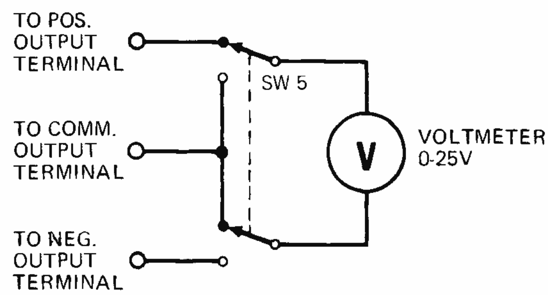


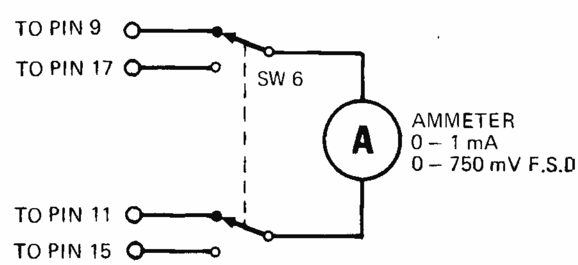
Fig. 5. This internal view shows how the components are mounted within the box. If the size of box specified is used watch component clearances – there is not much room.

DUAL

Specifically intended for powering experimental integrated circuit projects, this power unit features independent positive and negative supplies – but with automatic tracking when required.







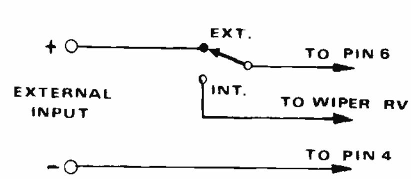
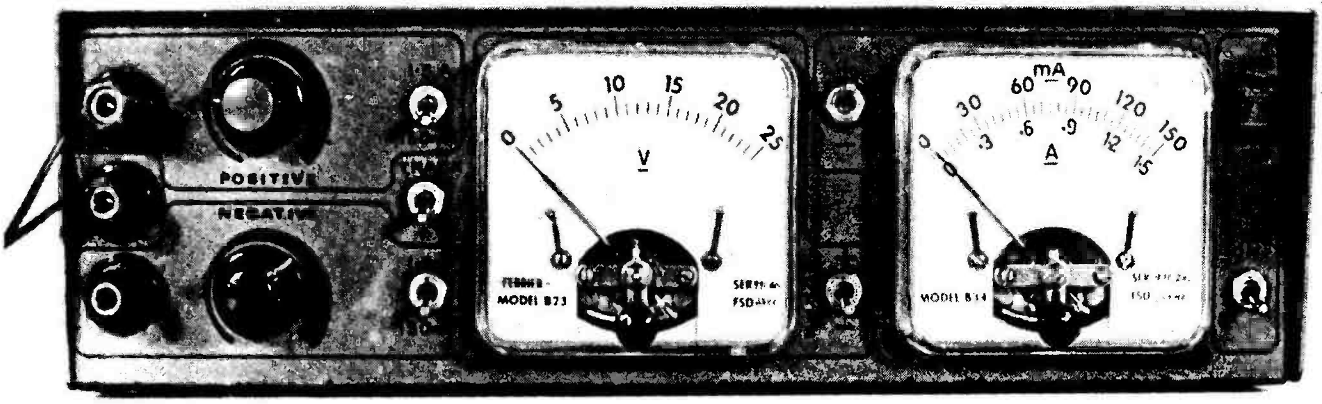


Fig. 1. Circuit diagram of complete unit.

POWER SUPPLY



There is one minor drawback to integrated circuits and this is that many of them require both positive and negative power supplies. These supplies must also have a better level of line and load regulation than was previously necessary.

The power supply described in this project has been designed specifically for this purpose. It is intended for both the serious enthusiast and the professional development engineer.

As may be seen from the specifications, its performance is equivalent to many commercially built units at many times the price.

The unit has two outputs, one positive, and one negative — each separately adjustable from zero to 20 Volts, or settable in such a way that the negative supply automatically tracks the positive supply.

CURRENT LIMITING

Both the unit, and your experimental circuits, are protected against damage by current limiting networks incorporated within the power supply.

A panel mounted switch is used to select the maximum desired current at either 190 mA or 1.80 Amps. If this level is reached, the output voltage will drop and current will be held at the selected limit.

For the professional user of this unit,

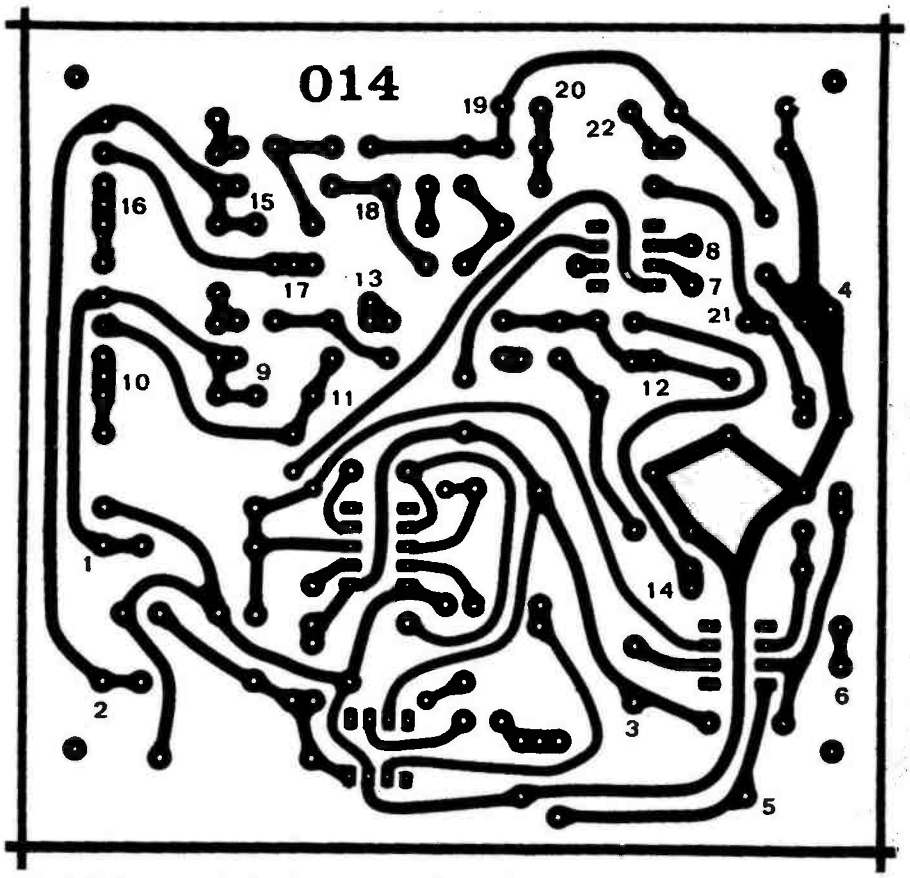


Fig. 3. Foil pattern of printed circuit board (full size).

DUAL POWER SUPPLY

provision has been made for the positive regulator to be externally programmed. The necessary wiring changes are shown in Fig. 2.

Due largely to the use of externally mounted heatsinks, and the use of integrated circuits in the control and voltage reference circuits, the complete power supply unit is quite small and compact. Yet despite this, the internal layout is spacious and all major components are readily accessible.

CONSTRUCTION

Construction is reasonably straightforward if work progresses in the correct manner. The unit may be assembled on matrix board, but we strongly recommend that the correct printed circuit board be used. The foil pattern of the p.c. board is shown in Fig. 3.

Assuming that the printed circuit board is used, commence construction by inserting the pc board pins into the positions numbered on the board. These pins should be inserted with the flange (if flanged) on the component side of the board. All external wiring to and from the printed circuit board will be attached to these pins on the foil pattern side of the board.

When installing the integrated circuits ensure that they are orientated correctly before soldering. (Note that Fig. 4 shows all components, including integrated circuits, as seen from the component side of the board.)

Small heatsinks are fitted over transistors Q4 and Q8. Ensure that these do not contact any other component by mounting them about 1/8" above other nearby components.

When all components have been mounted on the board, recheck for correct orientation and polarity.

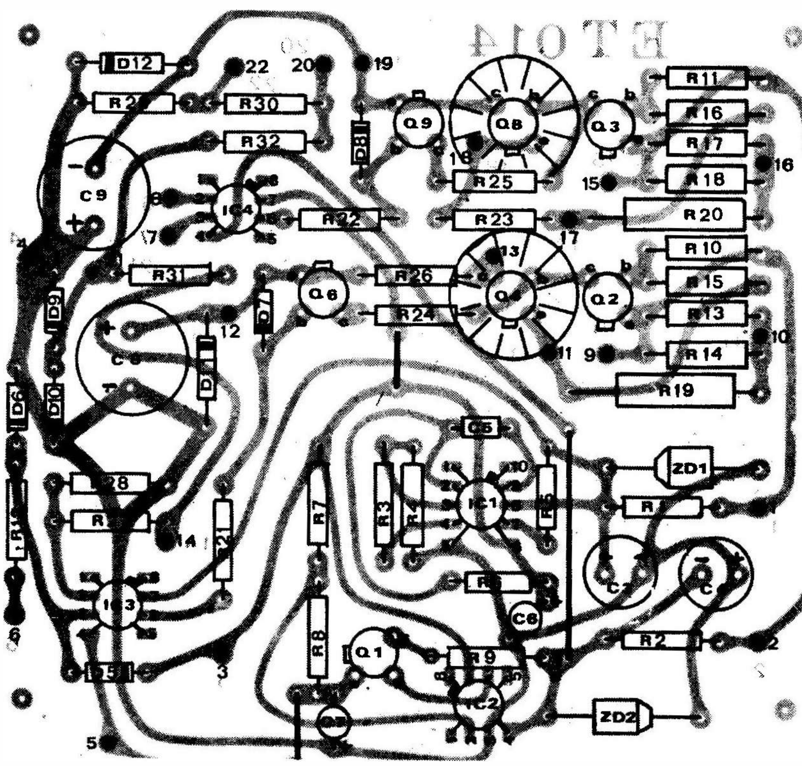


Fig. 4. How the components are mounted on the printed circuit board. Compare this with Fig. 3.

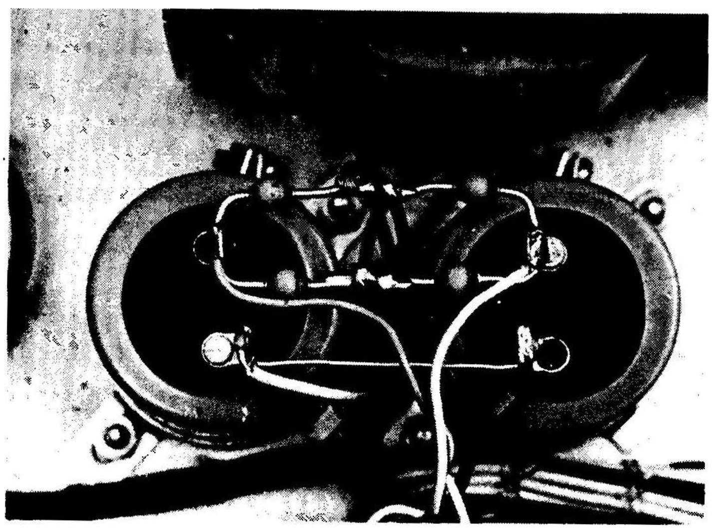
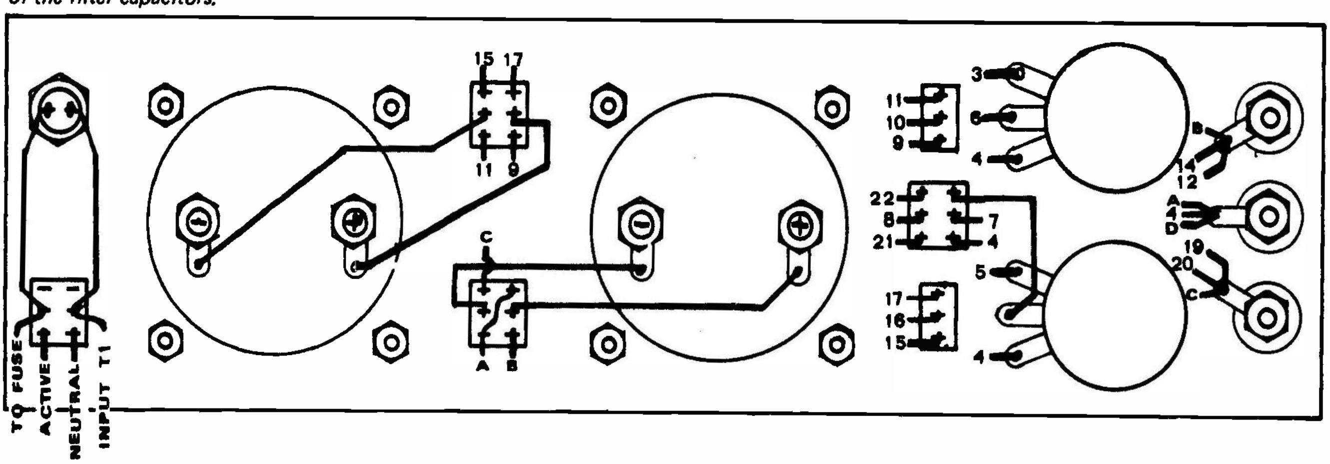


Fig. 5. Diodes D1 – D4 are mounted on top of the filter capacitors.

Fig. 6. This drawing shows front panel wiring details. Wires A, B and C are interconnecting wires on the front panel. Wire D goes to the common of the filter capacitors.



DUAL POWER SUPPLY

PARTS LIST ET105

R1	—	resistor 330 ohm
R2	—	" "
R3	—	" 1.8k, 2%
R4	—	" 5.6k, 2%
R5	—	" 2.2k
R6	—	" 1.5k
R7	—	" 10k, 2%
R8	—	" 10k, 2%
R9	—	" 1k
R10	—	" 330 ohms
R11	—	" 330 ohms
R12	—	" 10k
R13	—	" 10 ohms
R14	—	" 10 ohms
R15	—	" 100 ohms
R16	—	" 100 "
R17	—	" 10 "
R18	—	" 10 "
R19	—	" 0.47 ohms, 2 Watt,
R20	—	" 0.47 " "
R21	—	" 1k
R22	—	" 1k
R23	—	" 1k
R24	—	" 1k
R25	—	" 1k
R26	—	" 1k
R27	—	" 3k, 2%
R28	—	" 1k, 2%
R29	—	" 1k, 2%
R30	—	" 3k, 2%
R31	—	" 10k, 2%
R32	—	" 10k, 2%
		(all resistors are ½ Watt 5% unless otherwise stated. The 2% resistors are Pye type TR5 or equivalent)
C1	—	capacitor, 2200 μF, 50 Volt,
C2	—	" " " " "
C3	—	" 25 μF, 50 Volt,
C4	—	" " " " "
C5	—	" 100 pF.
C6	—	" 22 μF, 16 Volt, tag tantalum type
C7	—	" " " " " " "
C8	—	" 220 μF, 50 Volt,
C9	—	" " " " "
D1 — D4	—	diodes type A15A or equivalent.
D5 — D10	—	" " " 1N914 " "
D11 — D12	—	" " " EM401 " "
ZD1	—	zener diode type BZX70 C27
ZD2	—	" " " "
Q1	—	transistor type BC178 or equivalent
Q2	—	" " " "
Q3	—	" " BC108 "
Q4	—	" " MJ430 "
Q5	—	" " 2N3055 "
Q6	—	" " 2N3053 "
Q7	—	" " 2N3055 "
Q8	—	" " 2N3053 "
Q9	—	" " BCY54 "
IC1	—	integrated circuit type μA 723C
IC2	—	" " " μA 741C
IC3	—	" " " μA 741C
IC4	—	" " " μA 741C
		(all the above ICs are metal can type).
SW1	—	miniature switch, double-pole changeover, 240 Volt, Plessey C & K type 7201 or similar.
SW2	—	" " " " " " "
SW3	—	" " single pole changeover, C & K 7101
SW4	—	" " " " " " "
SW5	—	" " double pole changeover, C & K 7201
SW6	—	" " " " " " "
T1	—	transformer, , 50 Volt, centre tapped, 1.5 Amp.
RV1	—	potentiometer, linear, 10k, Plessey type E or equivalent.
RV2	—	" " " " " " "
Sundries	—	

TO5 Heatsinks, 2 off, McMurdo TXBF 032 025 CB Power transistor heatsinks, 2 off, Mullard 35 DB 3C drilled to suit. Two transistor covers, McMurdo 9151 09 01. Two anodised insulating washers, McMurdo type 2210 01 01. One set of metalwork. One front panel. 240 Volt neon panel light. Three terminals. Two potentiometer knobs. One fuse holder for size 00 fuse. One 1 Amp size 00 fuse. One 3 core flex and plug. One cable clamp. One printed circuit board ET 014. Twenty two pc pins
Three grommets. Four rubber feet. Four ¾" spacers.
14/0076 connecting wire (insulated) various screws, washers, nuts etc.

Voltmeter	—	25 Volts fsd, 2½" square,
Ammeter	—	750 mV fsd, 1mA, scaled 1.5 Amps and 150 mA. (when ordering, specify that meters should be scaled for steel panels).

Now mount the transformer and the filter capacitors onto the chassis. Locate diodes D1 – D4 on top of the filter capacitors as shown in Fig. 5.

The heatsinks must now be drilled to take the two 2N3055 output transistors. Carefully remove any burrs from around the holes and then mount the transistors preferably using insulating washers. If available, use a smear of silicon grease between transistors and the heatsinks – this will further improve heat transference. Finally, check insulation between the transistor and the heat sink, and then fit the transistor covers.

On our prototype unit we

HOW IT WORKS

The mains input voltage is reduced and isolated by transformer T1. The 25-0-25 Volt output from the transformer is then rectified and filtered by diodes D1-D4, and capacitors C1 and C2 to provide an unregulated ± 40 Volt dc supply.

Series regulators are used in the main control system. The two regulators – one for each supply – are almost identical in operation, therefore only the positive regulator will be described in detail.

The series pass transistor Q5, is mounted on an external heat sink. Transistors Q4 and Q6 provide current amplification for Q5 giving the combination a total current gain exceeding 50,000. The voltage gain is approximately unity.

The main reference supply is generated by IC1 which is a precision voltage regulator. The reference level required is obtained by potentiometer RV1 which is connected across the 5.6 Volt regulated output from IC1.

Power for the IC voltage reference is supplied by R1, ZD1 and C3. This maintains a constant voltage across the IC, eliminating variations due to changes in mains voltage. The 27 Volt supply from this circuit is also used to supply power to IC3.

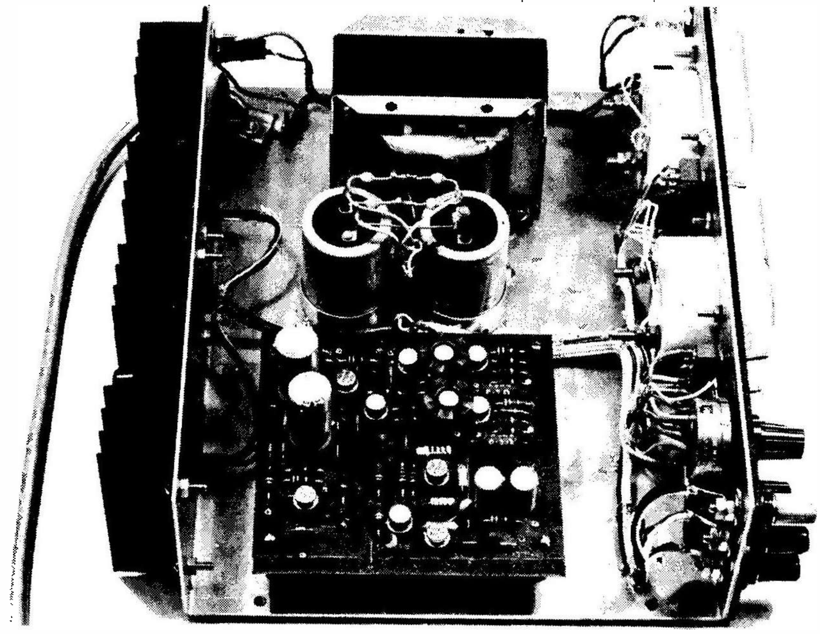
The reference for the negative supply is obtained from operational amplifier IC2 which is connected so as to track the positive reference supply. The 5.6 volt output from this circuit is just as accurate as the output from the main regulator. Power for this operational amplifier is supplied from a 27 volt zener which is also used to supply IC4.

The power supplies for IC1 are + 27 Volt and 0 Volts; for IC2 and IC4, the supplies are + 5.6 Volts and - 27 Volts; for IC3, +27 Volts and - 5.6 Volts.

Resistors R27 and R28 divide the output voltage by four. This voltage constructed our front panel by sandwiching a line drawing between the chassis and a piece of smoked perspex. This provides a very professional looking appearance. An even better finish can be obtained by using an anodised aluminium panel, and these may be available from parts suppliers.

Having determined the method of finishing the front panel, assemble all the relevent components onto the panel.

Wires should now be attached to the pins on the underside of the printed circuit board. Insulated 14/0076 wire



is compared against the voltage set by RV1 by operational amplifier IC3. The output of IC3 controls the series regulator configuration, and hence the output voltage. The action of IC3 is to keep the two voltages at its input at the same level. Thus, the output voltage will be four times the input voltage, and virtually independent of load current.

When load current approaches the level set by the limit switch, transistor Q2 becomes forward biased sufficiently to cause it to conduct. This bypasses current from the base of Q4 and causes IC3 to lose control of the output. If the load continues to increase, the output voltage will fall and the current will remain effectively constant.

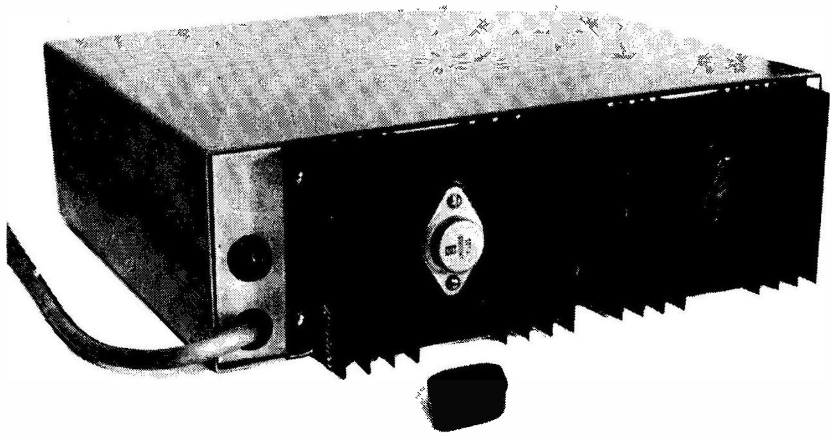
The negative regulated supply works in the same manner when the power supply is used in the normal mode.

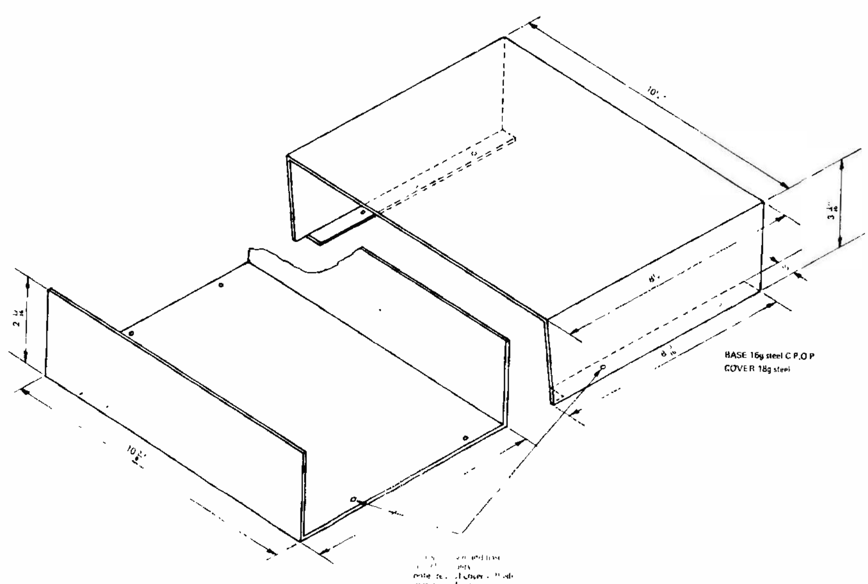
A tracking mode of operation is also included, and in this mode the negative supply tracks the positive supply. If, for example, the positive regulator is set at + 14.5 Volts, then the negative supply will automatically be set at - 14.5 Volts.

In the tracking mode of operation, the reference voltage is zero volts and the voltage used as the output voltage reference is the centre voltage of the two supplies. And since the IC tries to maintain both inputs at the same level (in this case zero volts) then the two output voltages must be of the same value.

Diodes D7 through D12 are used to protect the integrated circuits and output transistors against various forms of misuse, including shorting the positive and negative outputs together.

Provision has been made in the design for externally programming the positive regulator. If this facility is required, alter the wiring as shown in Fig. 2 (Resistor R12, and diodes D5 and D6 protect the IC when this mode of operation is employed).





DUAL POWER SUPPLY

should be used for this purpose. Two wires should be attached to pins 9, 12, 17 and 19, three wires attached to pins 11 and 17, and four wires attached to pin 4. All wires should be either colour coded or marked so that they may be clearly identified.

The printed circuit board should now be mounted onto the chassis and the wires loomed to their respective destinations. Note that one each of wires 11, 12, 17 and 19, together with wires 13 and 18 go to the back of the unit and to the heat sinks. Wires 1 and 2 go to the filter capacitors and a wire D comes from the common of the filter capacitors up to the loom and to the common terminal on the front panel.

The front panel can now be wired as shown in Fig. 6.

The wires to the heat sink mounted transistors are taken through the grommets provided, and the already assembled heat sinks mounted into position.

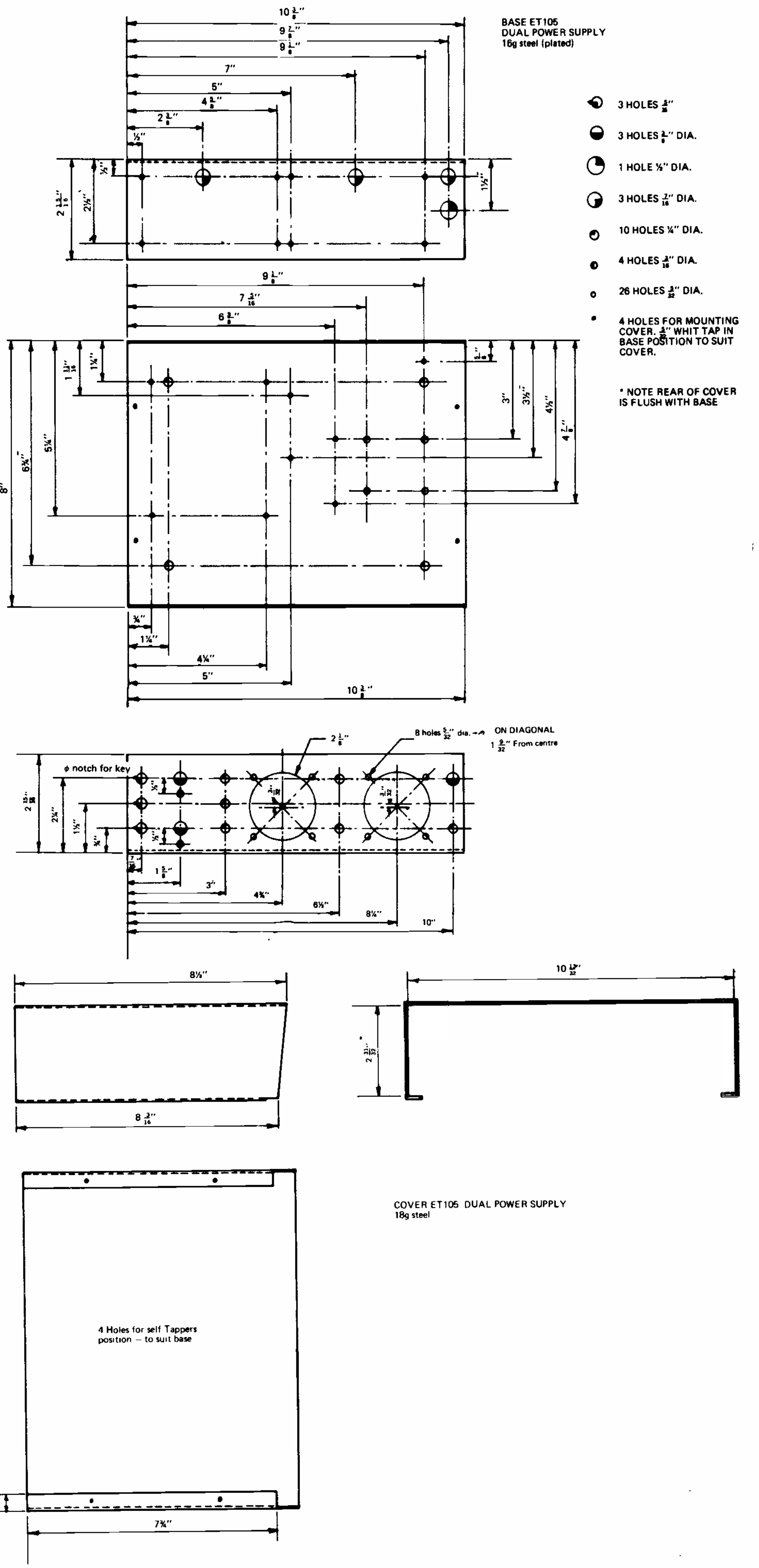
Complete all remaining wiring taking care that all leads carrying 240 Volts are adequately insulated. The mains lead must enter the case through an insulating grommet and the lead must be securely anchored to the case. It is not sufficient merely to tie a knot in the mains cord — this is a dangerous practice.

The supply should now be ready for use, but before connecting to the mains, recheck all point-to-point wiring and all soldered connections.

One point that may not be commonly realised is that meters are calibrated specifically for one panel material. A meter calibrated for mounting on a steel panel may be as much as 30% out if it is mounted on an aluminium panel — and vice-versa. We recommend that a steel chassis is used for this project — but if you decide to use aluminium notify the meter supplier accordingly. ●

SPECIFICATION – POWER SUPPLY – ET 105

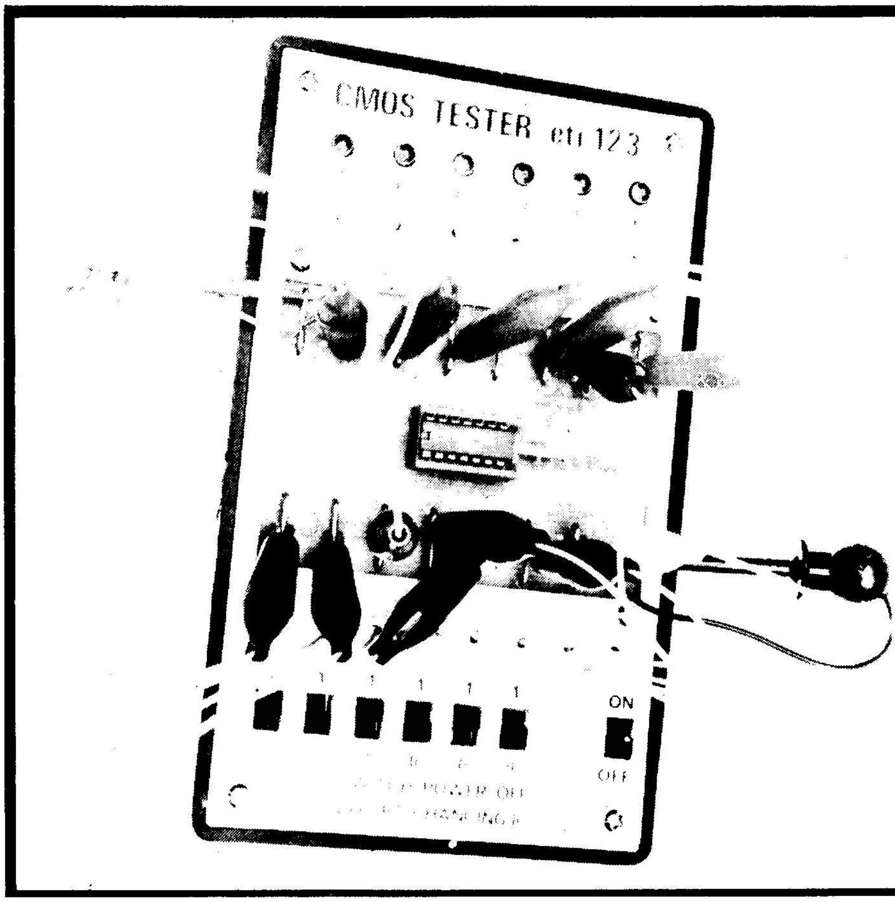
Output Voltage	0 — 20 Volts positive 0 — 20 Volts negative
Output Cu[illegible]	0 — 1.5 Amps
Current L[illegible]	190 mA and [illegible] Amps
Meter R[illegible]	
(current)	150 mA anc [illegible] Amps
(voltage)	25 Volts
Line Regu[illegible]	better than [illegible] mV for 15 Volt input voltage change
Load Regulation	less than 10 mV drop from no-load to full-load
Ripple	less than 2 mV peak to peak
Output Impedance	7 mΩ @ dc — 1.5 kHz 14 mΩ @ — 3 kHz 56 mΩ @ — 15 kHz 200 mΩ @ — 100 kHz



...SEE PAGE 16

SIMPLE CMOS TESTER

An inexpensive unit for the hobbyist.



eti project 123

NOW THAT the use of CMOS logic is becoming widespread there is an obvious need for a simple CMOS tester suitable for the hobbyist.

A simple CMOS tester, although being inexpensive, must be capable of performing the majority of tests required for CMOS logic without causing any damage to the ICs under test or being damaged itself. It must also use only those components which are readily available to the average home constructor. The ETI 123 Tester fulfills all these requirements.

The tester circuitry draws very little current except for that drawn by the LEDs. Even the LEDs only draw current whilst a device is actually under test. For this reason we thought that the expense of a mains power supply was unwarranted and chose to use batteries instead. For those who would rather operate the unit from a mains derived supply, one capable of supplying anywhere between 5 and 12 volts at up to 40 milliamps will be suitable. Another major expense, that of providing a large number of programming switches to set up the test conditions, has been alleviated by using flying leads fitted with alligator clips to connect to the IC under test.

Several steps have been taken to prevent damage to the IC by the tester and conversely, damage to the tester by the IC. Firstly each pin of the test socket is fitted with a static discharge resistor to earth. A current limiting resistor, R 37, is in series with the supply so that the tester is protected against damage due to possible excessive current into an internal short in the test IC. This limiting resistor also ensures that current through the input-protection diodes on the IC does not exceed the specified limit of 10 mA.

Only readily available components are used in the tester and, in fact the ICs used are available from at least four different manufacturers.

To test simple gate functions, eg NAND gates, NOR gates, we need at least four switches and a logic level detector but for the more complex functions, eg multipliers, we need at least six switches and six level detectors. A clock – pulse generator is required for the testing of flip flop and other clocked devices. This pulse generator must be free of the contact bounce that is typically encountered with mechanical switches. For this reason we used a pair of CMOS NAND gates wired as an astable multivibrator to generate a continuous train of pulses. This may be used to increment counters and to shift data in shift registers. As it is a CMOS circuit it is perfectly suited to driving other CMOS devices.

CONSTRUCTION

We recommend that the printed-circuit boards as specified be used as construction is thereby greatly simplified. The printed-circuit boards should be assembled as detailed in the component overlay diagrams. Switches SW1 to SW7 should be mounted by first glueing two strips of printed-circuit board to the front panel (copper side out). The switches may then be soldered to the copper side of the board. This procedure avoids the necessity of having 14 screw heads visible on the front panel.

The test socket is mounted on the non-copper side of board 123b. This board also carries links Lk1 to Lk16 which connect directly to the pins of the test socket. These links are also mounted on the non-copper side of the board and should be of reasonably heavy gauge tinned-copper wire, and should be installed such that sufficient room is under the link to enable test leads to be attached to them by means of aligator clips or Easy-Hooks Resistors R1 to R16 are mounted on the *copper* side of this board so that they are not visible when the board is bolted to the front panel. The top two screws, nearest to the LEDs, should be 18 to 25 mm long so that board 123a may also be mounted on them later.

On board 123a, mount and solder in position on the component side of the

SIMPLE CMOS TESTER

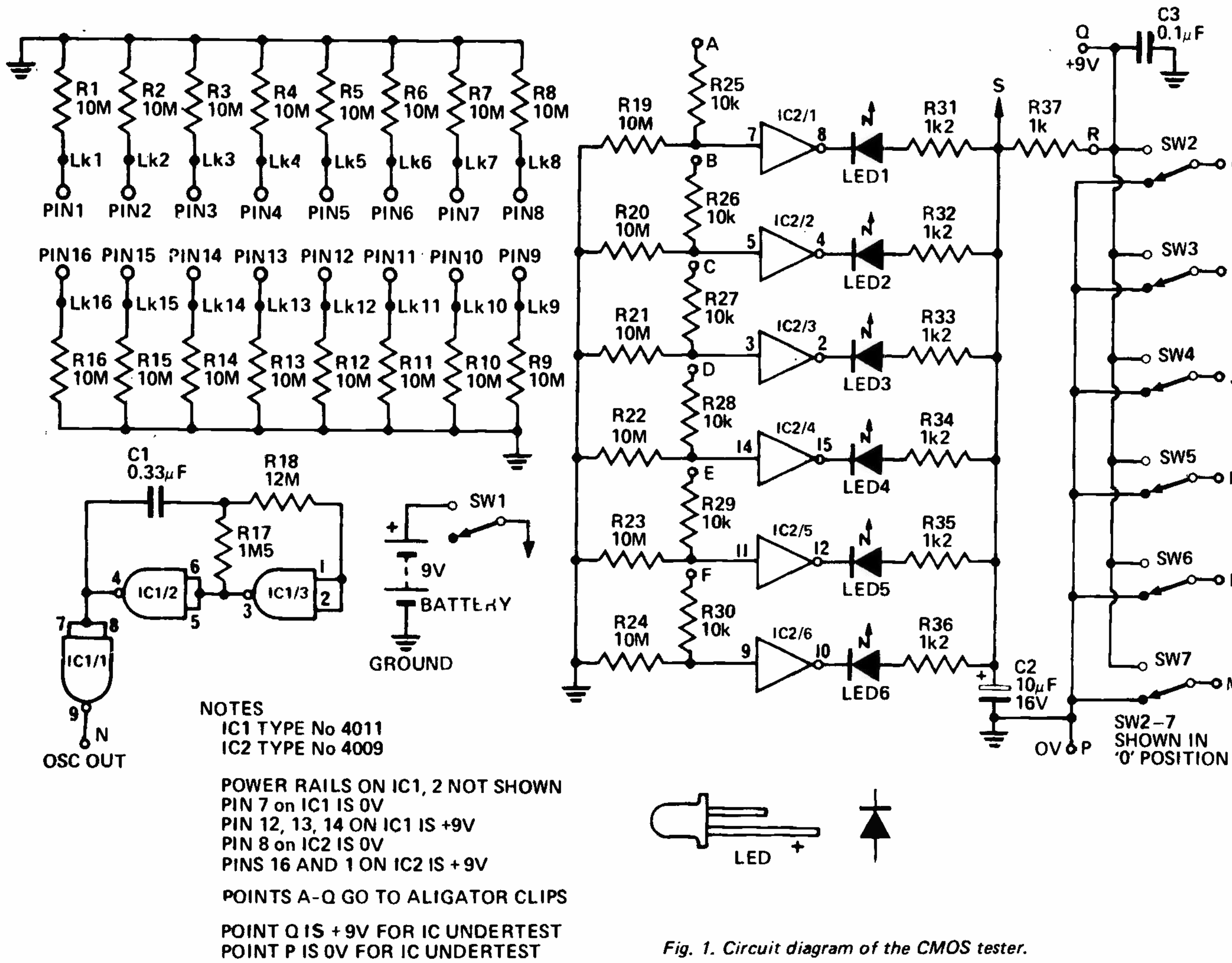


Fig. 1. Circuit diagram of the CMOS tester.

HOW IT WORKS – ETI 123

The ETI 123 CMOS tester can be described in three separate sections. Firstly there is the test socket for the device under test. The test socket is mounted on a printed circuit board which also holds a 10 megohm static-discharge resistor to protect each pin of the IC. Each IC pin is also connected to a surface mounted link by which connections can be made to the IC.

The next major section of the tester contains detectors which monitor the voltage at each pin of the IC. Each detector consists of a CMOS inverter which drives an LED indicator. When the voltage at the input of the inverter is greater than half the supply voltage the LED will be alight. Conversely the LED will be off when the voltage at the input to the inverter is below half supply voltage. Resistors R19 to R30 protect IC2 against static charges and from the condition where a detector has no input. Resistors R31 to R36 set the operating currents for the LEDS.

The final section contains switches SW2 to SW7 and a clock oscillator. The output of the switches can be either 0 volts or +9 volts that is, a logic '0' or a logic '1'. These outputs are made available at test leads which may be connected to the IC under test as required. To protect the tester against internal shorts on the IC under test, and incorrect connections, R37 has been inserted in series with the supply rail to limit the current that may be drawn to a level which cannot cause any damage.

IC 1/2 and IC 2/3 are wired as an astable multivibrator where the frequency of oscillation is determined by the time constant of C1 and R17, whilst R18 is used to protect the input of IC 1/3 from any voltage excursions past the supply rails. IC 1/1 is used as an inverting buffer and the output of the circuit is made available at the front panel by means of a lead and alligator clip.

PARTS LIST — ETI 123

R37	Resistor	1k	¼ Watt	5%
R31-36	"	1.2k	"	"
R25-30	"	10k	"	"
R17	"	1.5M	"	"
R1-16	"	10M	"	"
R19-24	"	10M	"	"
R18	"	12M	"	"
C3	Capacitor	0.1μF polyester		
C1	"	0.33μF "		
C2	"	10μF 16 electrolytic		
IC1	Integrated Circuit	4011 (CMOS)		
IC2	" "	4009 (CMOS)		
LED 1-6	Light Emitting Diodes			

SW1-7 Miniature slider switch 2 pole 2 position.
IC Socket 16 pin DIL (preferably with IC removing slide)
Case 160 x 90 x 50 mm plastic box with aluminium front panel
Alligator clips (15)
Battery 9V (6 penlight cells).

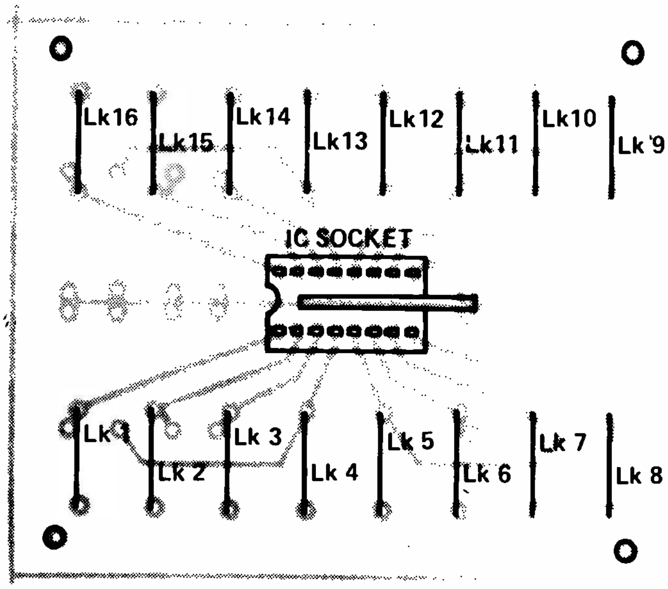


Fig. 2. Component overlay for the test-socket board ETI-123b, non-copper side.

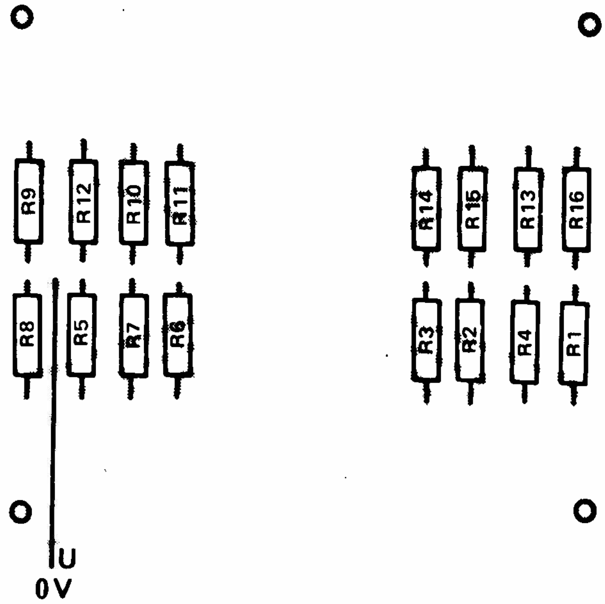


Fig. 3. Component overlay for the copper side of board ETI-123b.

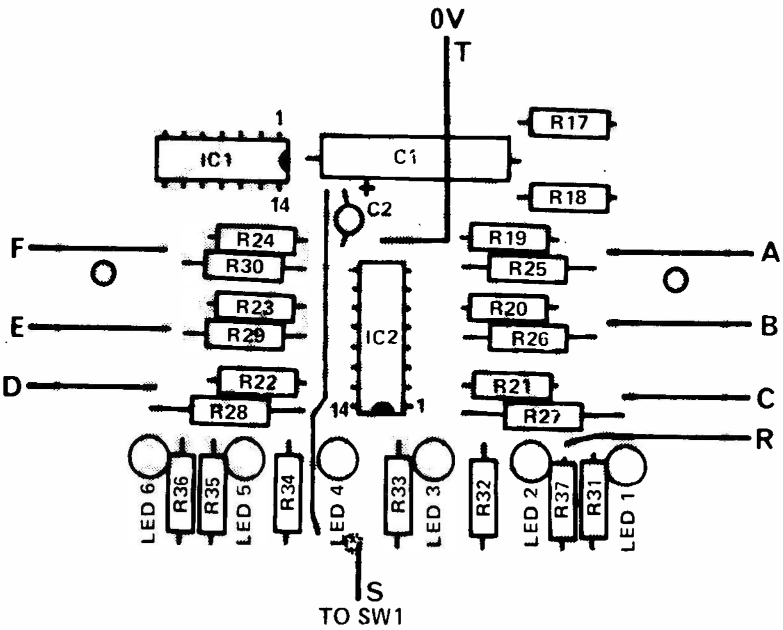


Fig. 4. Component overlay for board ETI-123a. Note that C1 may need to be mounted on reverse side, and that the LEDs should be mounted as detailed in the text.

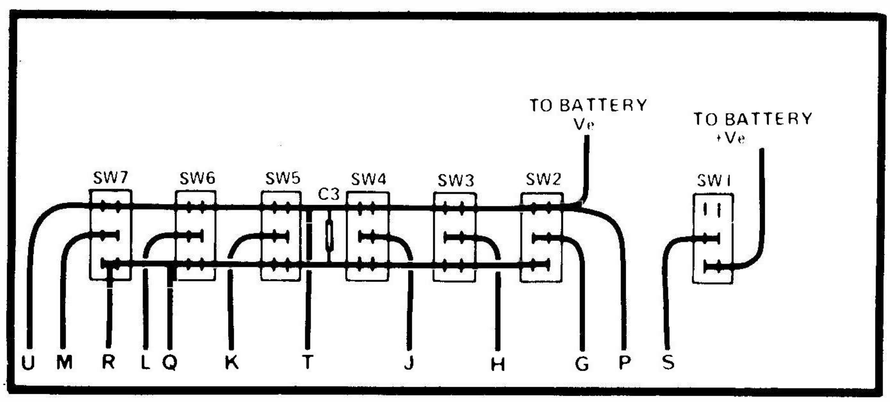


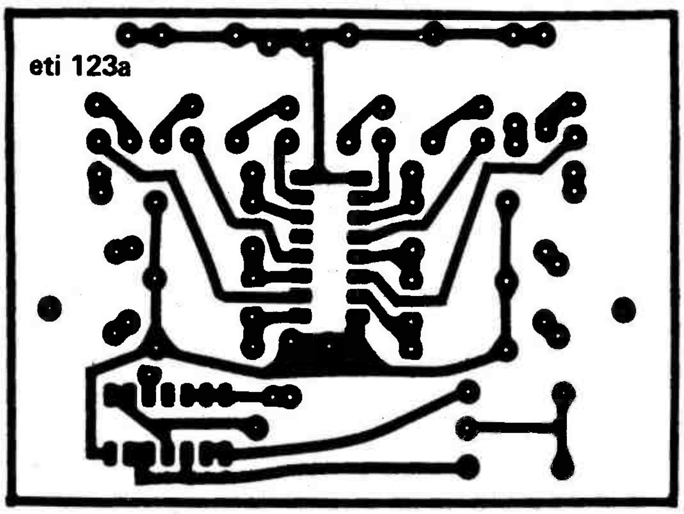
Fig. 5. Switch interconnection diagram. Note that C3 is mounted across one of the switches.

board, all components with the exception of the LEDs and capacitor C1. As C1 needs to be a polyester type it may be physically too big to be mounted on the component side without fouling the front panel and should therefore be mounted on the copper side. The LEDs should be inserted in their positions but not yet soldered. Temporarily mount the board in position such that the LEDs protrude through their correct holes in the front panel. Keeping the front panel face down, solder the LEDs into the board. Remove the board and solder 150 mm lengths of hookup wire to the points marked A to F on the overlay and pass these leads through the corresponding holes in the front panel. Do the same for the leads G, H. J. K L M P and Q from switches SW2 to SW7 using a different coloured wire to that used previously. These wires should also be passed through the appropriate holes in the front panel.

Finally solder alligator clips or Easy Hooks to the ends of all these leads and connect supply and earth leads to the 123b board. Check both boards for wiring errors or errors in component insertion before bolting board 123a in position. The battery may then be connected and the unit is ready for use.

Note tnat the top corners of the 123a board may have to have the corners trimmed off at 45 degrees so that the board will fit in the box

SIMPLE CMOS TESTER



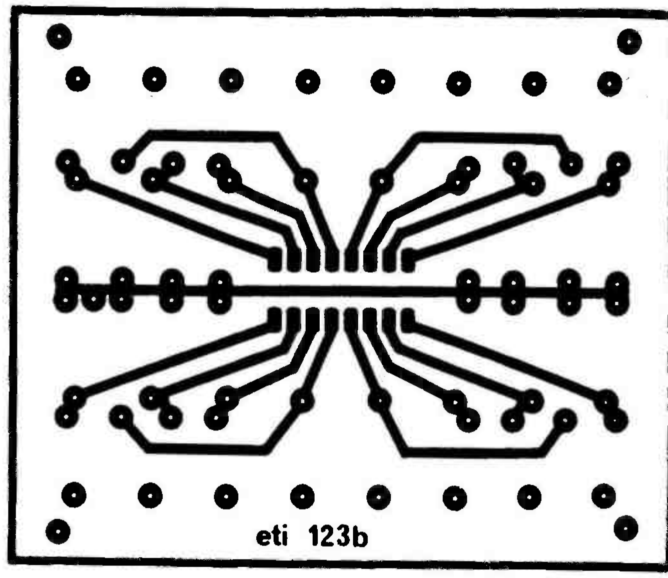


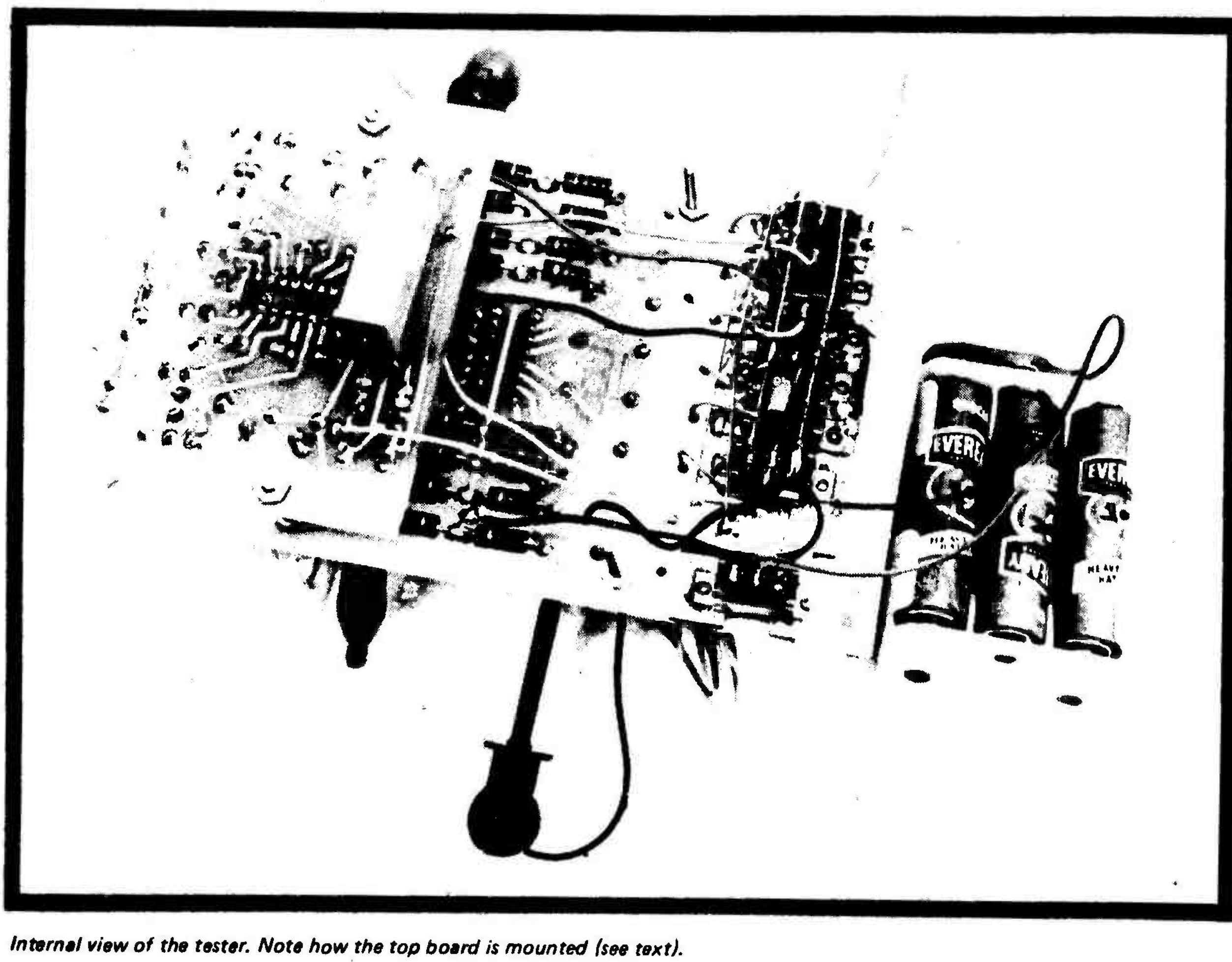
Fig. 6. Printed-circuit board layout – ETI 123a. Full size 88 x 63 mm. *Fig. 7. Printed-circuit board layout – ETI 123b. Full size 88 x 71 mm.*

without fouling the mounting pillars for the front panel.

OPERATION

Before testing or inserting any IC make sure that the power is switched off. Set up the operating conditions for the IC to be tested either by consulting the manufacturers data or by duplicating the conditions under which the IC will be used in the circuit.

Next insert the IC to be tested into the test socket and connect the power supply leads to the links for appropriate pins of the IC. Double check these connections to make absolutely sure that these connections are correct. Reversed power connections will destroy the IC. Switch on the tester and use the input switches to systematically apply all the possible input conditions to the IC whilst noting that the output conditions of the IC are as they are supposed to be. ●

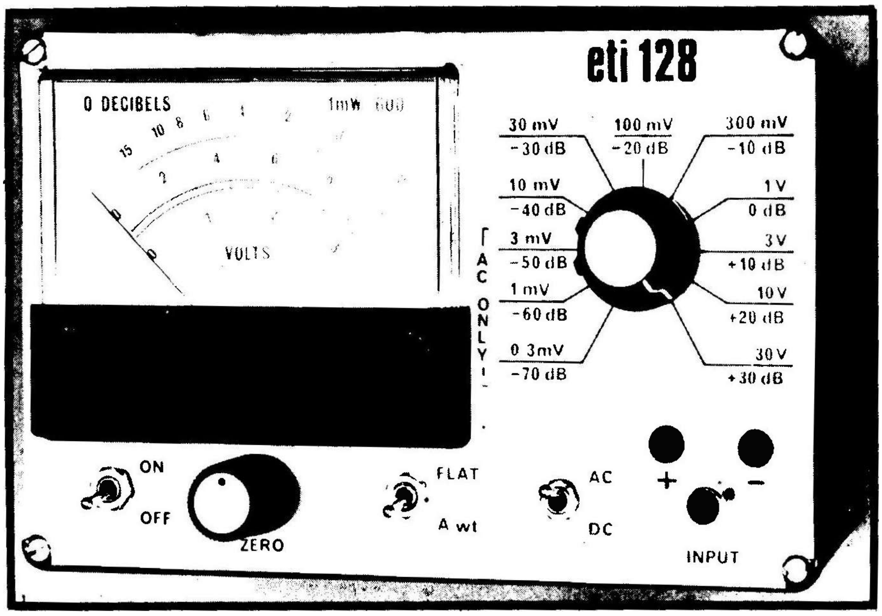


Internal view of the tester. Note how the top board is mounted (see text).

AUDIO MILLIVOLTMETER

Sensitive instrument for 'A' weighted audio noise and signal measurements.

eti project 128



AN ACCURATE and sensitive ac voltmeter is needed for many audio equipment measurements.

Whilst for example, maximum power output is readily measurable with a conventional multimeter, more complex instrumentation is required for measuring noise output (a measurement required when checking signal/noise ratio).

Even signal levels as high as 100 mV, typical output of most pre-amplifiers, are not readily measured with accuracy on a conventional multimeter.

The ETI 128 Millivoltmeter is specifically designed for such measurements whilst also being useful as a general purpose ac/dc voltmeter. The lowest range, of 300 microvolts FSD, allows measurements to 80 dB below one volt, whilst other ranges allow measurements up to 30 volts ac or dc. These ranges cover most of the measurement requirements of audio work.

When measuring noise levels account must be taken of the non-linear characteristics of the ear. For this reason a network has been incorporated which tailors the meter response-versus-frequency to match the subjective response of the ear. Such a network is known as an 'A weighting network' and its use provides a measurement which is realistically related to what is heard. When measurements are made using this network the results must be quoted as being 'A weighted'. Typically this is done by quoting dBA rather than just plain dB.

CONSTRUCTION

The meter is a highly sensitive instrument and for this reason the constructional method given should be followed closely if noise and hum pickup are to be minimized.

A diecast box is used to house the meter as this provides excellent shielding against external signals.

The meter used in the prototype measured 100 x 82mm but needed to be rescaled. Any similar meter may be used as long as it has 100 microamp sensitivity.

The ac/dc and Flat/'A' weight switches are four-pole types although only the outer two poles are used. The centre two poles are earthed in order to reduce the capacitance between the two outer poles. Such precautions are necessary to prevent any possibility of instability on the most sensitive ranges. The metal bracket which supports the printed-circuit board also acts as a shield between the meter circuitry and the input stages.

Commence construction by assembling components to the printed-circuit board, making absolutely sure that all are mounted in the correct position and with the correct polarity. This should be carefully done – once the meter is fully assembled, it is very difficult to change components.

Assemble the front panel, fitting all switches with the exception of SW3, LEDs, potentiometer, input socket, meter, and the shield. The shield passes between the centre two contacts of the 'A'-weighted switch.

Solder a tinned copper lead to each of the 12 contacts on the rear wafer of switch SW3 (about 25 mm long). Feed these wires through the holes provided in the printed-circuit board (1b to 11b and Wb) making sure that the wiper contact on the switch goes to Wb and that the other wires are inserted in sequence. Do not solder as yet.

Assemble the printed-circuit board onto the shield and the rotary switch to the front panel. We used a 3 mm

SPECIFICATION

RANGES	
dc (FSD)	10, 30, 100, 300 mV, 1, 3, 30 V. auto-polarity, LED indication.
ac (FSD)	0.3, 1, 3, 10, 30, 100, 300 mV, 1, 3, 10, 30 V 0 dB = 1 mW into 600 ohms (0.775 V) weighting curves, ac only, flat, 'A' weight
ACCURACY	± 3% nominal
MINIMUM READING	
Open circuit	–76 dB
Terminated 47 k	–85 dB
POWER SUPPLY	
Voltage	+6 and –6 volt (batteries)
Current	approximately 12.5 mA
Battery life	approx 100 hours (8 x 1015 cells)

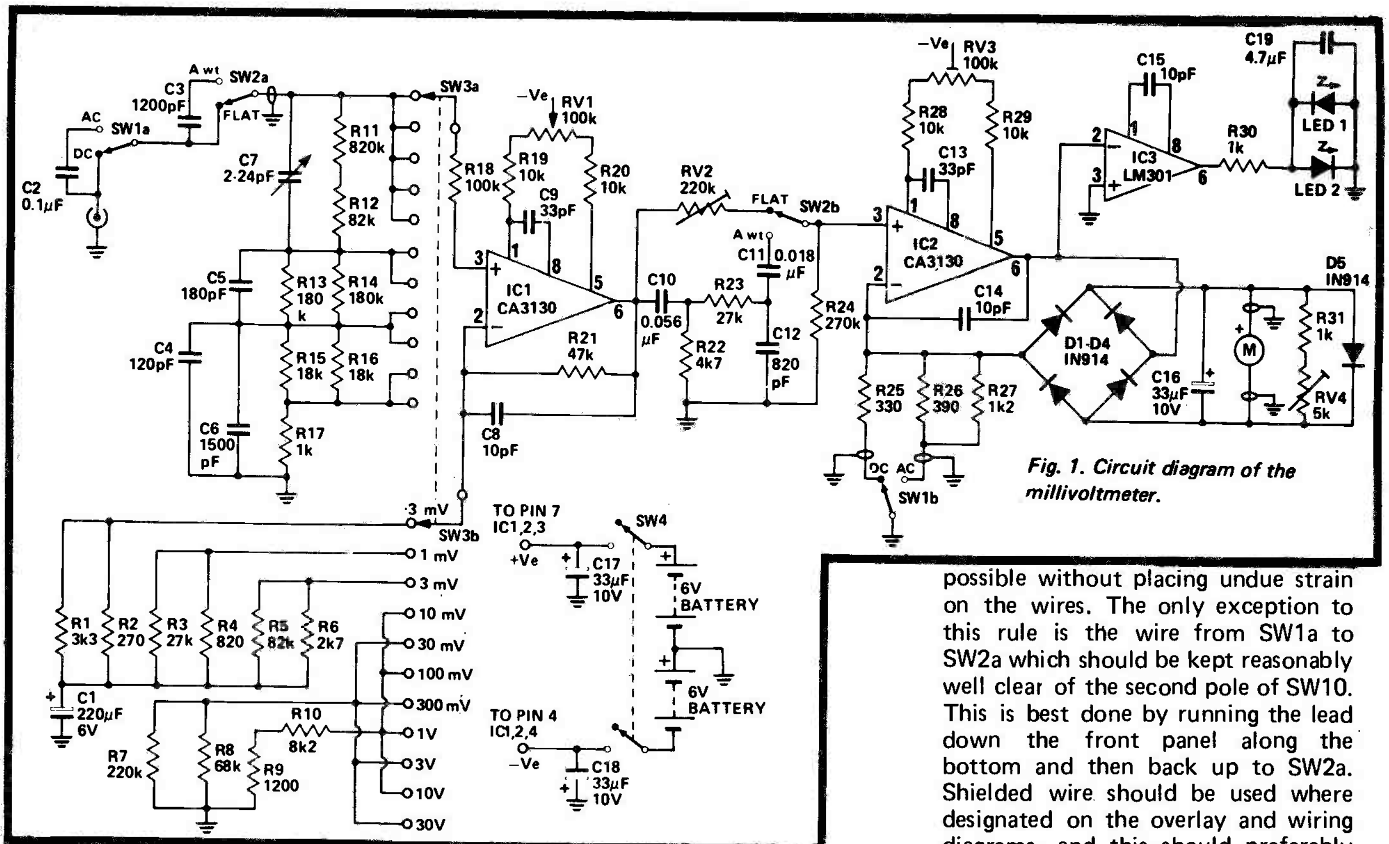


Fig. 1. Circuit diagram of the millivoltmeter.

stack of washers to space the switch back from the front panel so the control knob would sit down closer to the front panel. Remove any slack in the tinned-copper wires, connecting the switch to the printed-circuit board and then solder them to the board. Now remove the printed-circuit board and switch assembly from the front panel. The switch will now be rigidly held onto the board, and the front wafer can now be wired to the board via further tinned-copper links. Make sure that none of these wires is touching.

Add leads to the printed-circuit in the locations shown on the overlay and reassemble the board and switch assembly to the front panel. The components on the front may now be connected to the board by these leads which should be kept as short as possible without placing undue strain on the wires. The only exception to this rule is the wire from SW1a to SW2a which should be kept reasonably well clear of the second pole of SW10. This is best done by running the lead down the front panel along the bottom and then back up to SW2a. Shielded wire should be used where designated on the overlay and wiring diagrams, and this should preferably be of the low capacitance variety.

The LEDs are connected in parallel but opposite polarity the actual polarities may be determined later if necessary during the calibration procedure.

CALIBRATION

Before commencing calibration, check that the meter performs as it should on all ranges by applying known voltages and checking that a

HOW IT WORKS – ETI 128

The millivoltmeter may be separated into several sections in order to simplify the explanation of its mode of operation. These are:–

(a) Input attenuator.
(b) Input amplifier.
(c) 'A'-weight network.
(d) Meter drive circuitry.
(e) Polarity detector.

The input attenuator consists of resistors R11 to 17 and capacitors C4 to 7, and gives division ratios of 1, 10, 100 and 1000. The capacitors are required to ensure that the division remains accurate at high frequencies.

The input amplifier is a CA3130 operational amplifier where the gain is selected by SW3b. Gains of 190, 60, 19, 6 and 1.9 are available which together with the input divider ratios provide the 11 ranges required. The high gain ranges of 190, 60 and 19 are ac coupled, as the temperature stability of the CA3130 will not allow voltages of less than 10 mV dc to be used. The output of this amplifier is 60 mV when the meter is indicating full scale on any range. A potentiometer, RV1, is provided to adjust the offset voltage on the CA3130 and thus acts as a zero-set control. Since the offset voltage is affected by temperature this control is available externally.

When measuring noise in audio systems a weighting network is often used to give a measurement which is related to the non-linear response of the ear. The most commonly used weighting is known as 'A' weight and this facility is built into the meter. The 'A' weight curve is produced by a network that has a three-pole, high-pass filter and a single-pole, low-pass filter. The main section of this filter is formed by C10, C11, C12 and R22, 23, and R24 (two poles). The third pole is due to C3 and the one megohm combined resistance of R11 to R17. This later section prevents saturation of the input amplifier at low frequencies. Since this filter introduces some loss at 1 kHz, RV2 is incorporated to provide the same loss in the 'flat' mode.

The second IC acts as a meter amplifier. The input signal is rectified by the diode bridge D1 to D4 whilst the amplifier effectively compensates for the diode drops. A preset for offset adjustment, RV3, is provided for this IC. Calibration is performed by adjustment of the shunting resistance, R31 and RV4, across the meter. Due to the full-wave action of the rectifier the meter when on the dc ranges reads uni-directionally regardless of dc polarity. The output of IC2 will however will either be at over one volt positive or one volt negative (voltage drops across the diodes) depending on whether the input voltage is positive or negative. This is compared by IC3 against zero volts and, depending on polarity, either LED 1 or LED 2 will be illuminated. With an ac input both LEDs will be on. These LEDs are therefore the polarity indicators. Capacitor C19 removes any high frequency components which could be coupled into the input, as the LEDs are located next to the input socket.

Due to the difference between the average and the RMS values of a sine-wave a slight change in gain is necessary in the ac mode and, this change is made by SW1b.

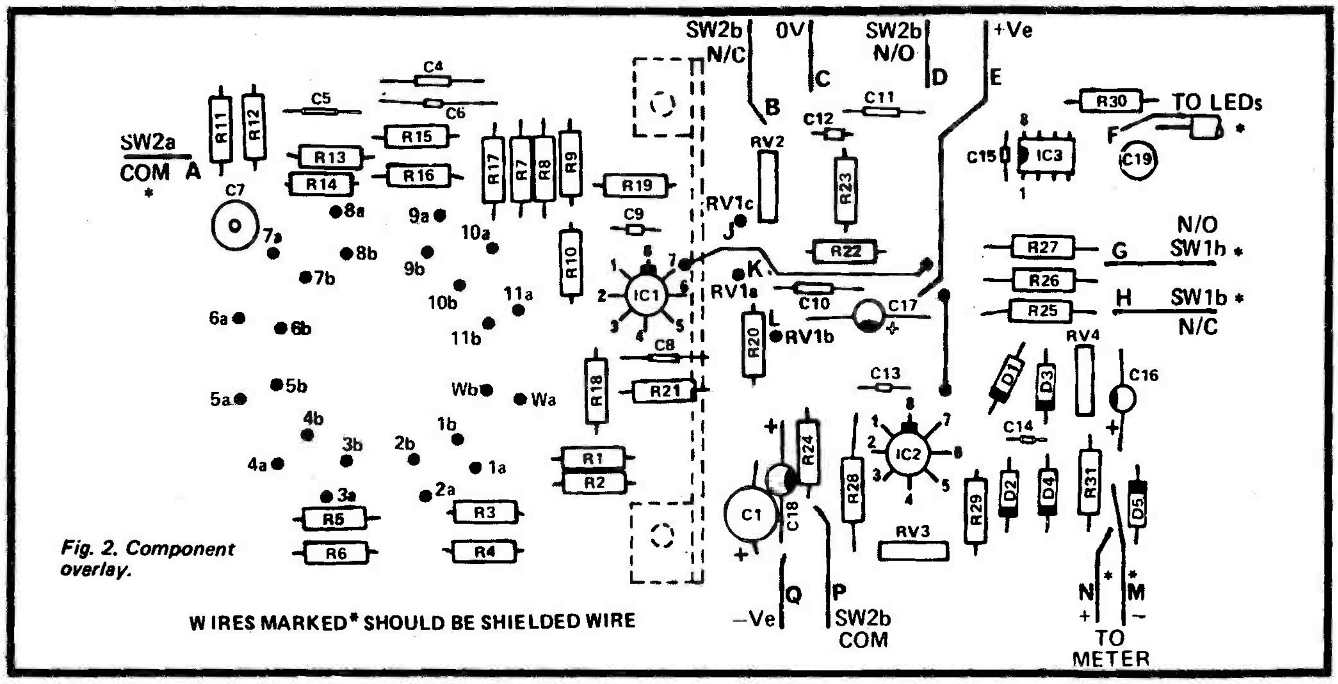


Fig. 2. Component overlay.

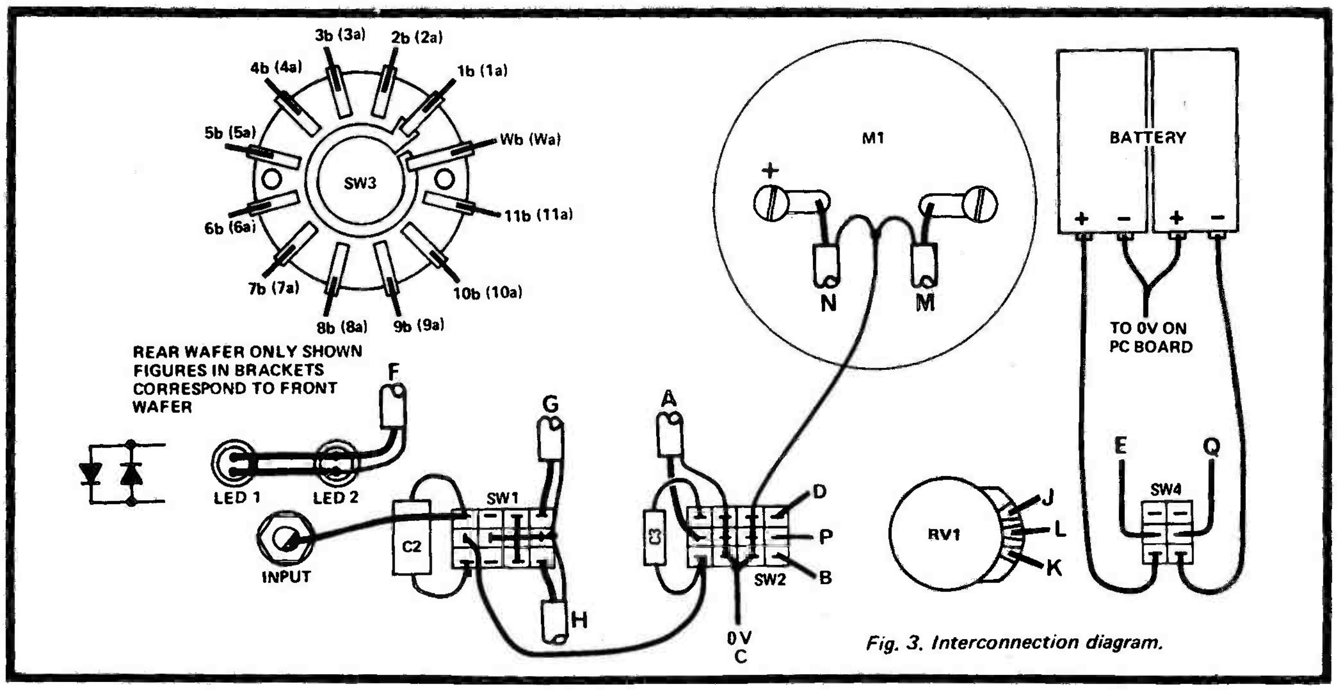


Fig. 3. Interconnection diagram.

PARTS LIST — ETI 128

R2	Resistor	270 ohm	2%	¼W
R25	"	330 ohm	2%	¼W
R26	"	390 ohm	2%	¼W
R4	"	820 ohm	2%	¼W
R17	"	1k	2%	¼W
R6	"	2k7	2%	¼W
R10	"	8k2	2%	¼W
R15,16	"	18k	2%	¼W
R21	"	47k	2%	¼W
R8	"	68k	2%	¼W
R13,R14	"	180k	2%	¼W
R11	"	820k	2%	¼W
R30,31	Resistor	1k	5%	¼W
R9,27	"	1k2	5%	¼W
R1	"	3k3	5%	¼W
R22	"	4k7	5%	¼W
R19,20	"	10k	5%	¼W
R25,29	"	10k	5%	¼W
R3,23	"	27k	5%	¼W
R5,12	"	82k	5%	¼W
R18	"	100k	5%	¼W
R7	"	220k	5%	¼W
R24	"	270k	5%	¼W
RV1	Potentiometer	100k lin rotary		
RV2	"	220k pres		
RV3	"	100k "		
RV4	"	5k "		
C7	Capacitor	2-24 pF beehive trimmer 2222 808 00006		

C8,14,15	"	10 pF	Ceramic
C9,13	"	33 pF	Ceramic
C4	"	120 pF	Ceramic
C5	"	180 pF	Ceramic
C12	"	820 pF	Ceramic
C3	"	1200 pF	polyester
C6	"	1500 pF	polyester
C11	"	0.018µF	polyester
C10	"	0.056µF	polyester
C2	"	0.1µF	polyester
C19	"	4.7µF	non polarised, electrolytic
C16,17,18	"	33µF	10V electrolytic
C1	"	220µF	6V electrolytic
IC1,2	Integrated Circuit		CA3130
IC3	"	"	LM301
D1-D5	Diode	IN914, BA318 or similar	
LED 1,2	TIL209 or similar with panel mounting		
SW1,2	Toggle switch 4 pole 2 positions		
SW3	Rotary switch 2 pole 11 positions		
SW4	Toggle switch 2 pole 2 positions		
M1	Meter	100µA FSD * see text	
PC Board ETI 128			
Die cast Box			
Two knobs			
One phono socket			
Eight 1½V batteries			
Shield to Fig. 7			

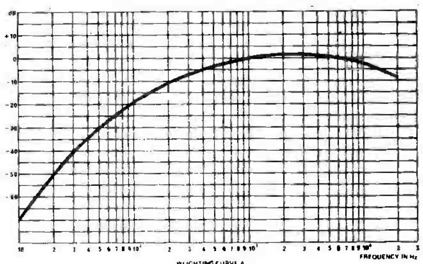


Fig. 4. Curve of 'A' weight response.

deflection of roughly corresponding magnitude is obtained. Also check that the 'A'-weighted switch appears to work as it should.

1. Short the input, select the 3 mV range and switch on.

2. Allow about 5 minutes for the instrument to stabilize thermally and

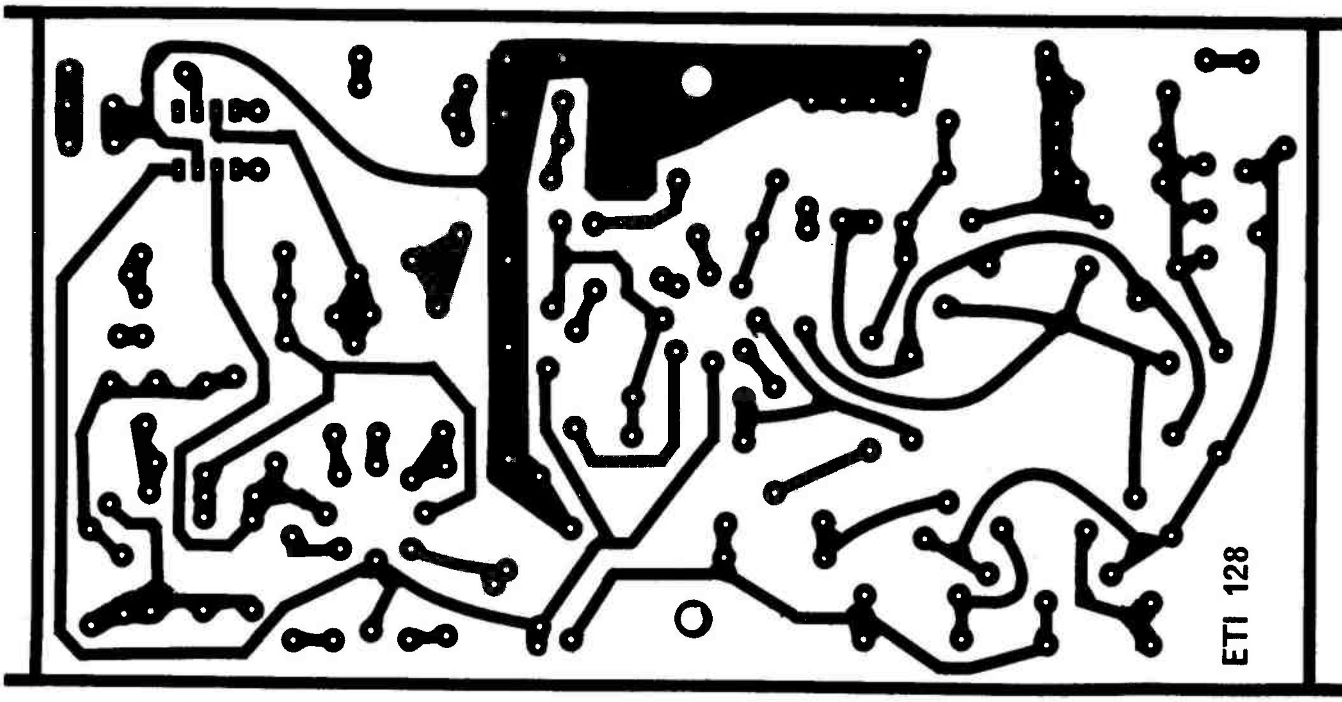
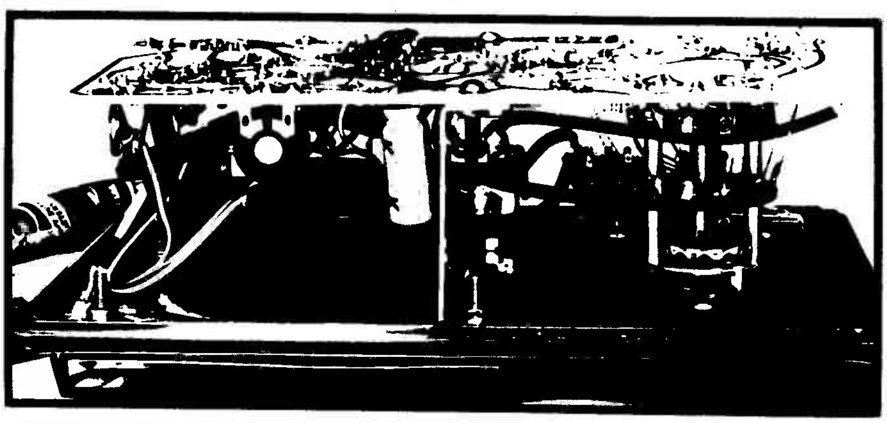


Fig. 5. Printed circuit layout. Full size 170 x 87 mm.



This internal view of the meter shows on the right, how the range switch is wired to the printed-circuit board. Note also the shield.

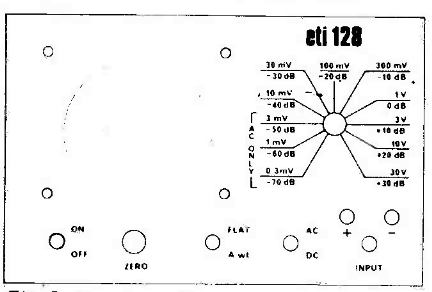


Fig. 6. Front panel artwork.

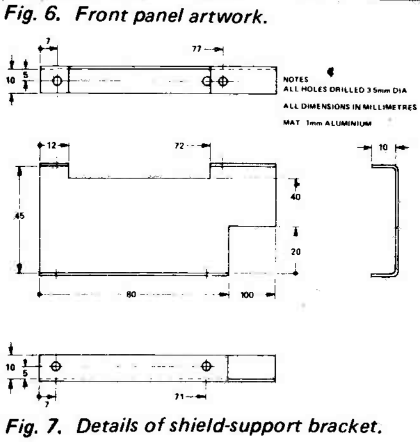


Fig. 7. Details of shield-support bracket.

Note how the shield passes between the earthed, centre contacts of the 'A' weight switch.

then adjust RV3 to zero the meter.

3. Select the 10 mV range, dc, and 'flat', and adjust the front panel control RV1 to zero the meter.

4. Remove the short from the input, select the 300 mV range and apply an input having a frequency of less than 500 Hz and a level which gives a convenient indication, eg 0 dB. Change the frequency to somewhere between 10 kHz and 50 kHz making sure that the input level is the same in both cases, and adjust capacitor C7 so that the meter reads the same in both cases.

5. Apply an ac input signal and switch between ac and dc. The reading on ac should be about 10% higher than on dc. If it is 10% lower the leads to switch SW1b should be reversed.

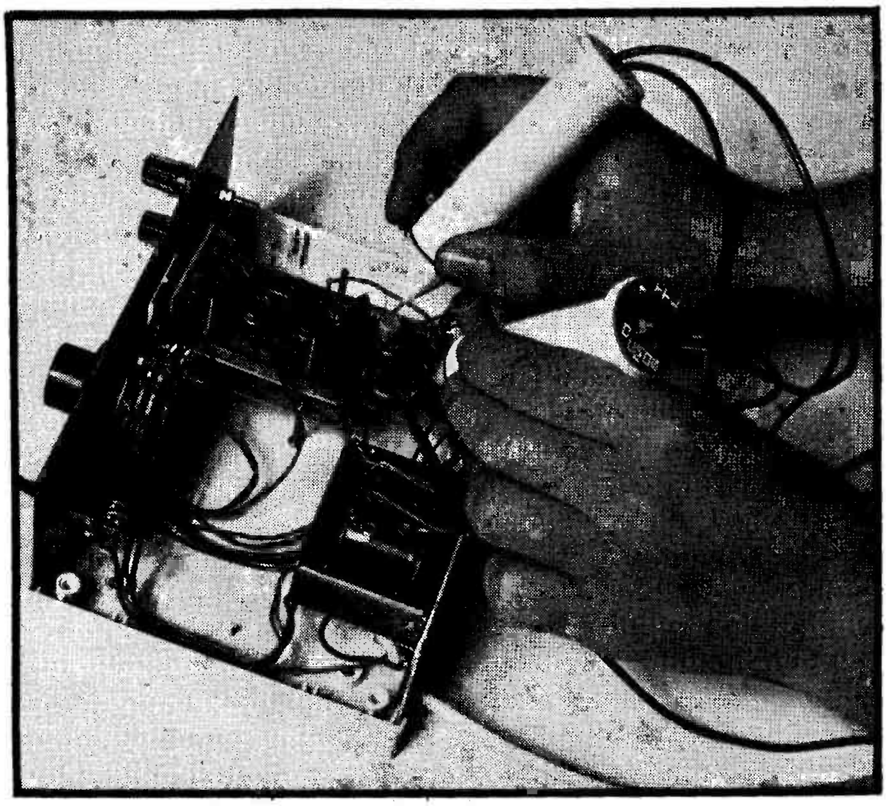
6. In the ac mode select 'A'-weight and apply a 1 kHz signal of sufficient level to obtain a 0 dB indication on the 1 volt range. Vary the frequency over the whole audio range and check that the response as shown in Fig. 4 is obtained.

7. Go back to 1 kHz and check that zero dB is indicated in the 'A'-weight mode. Now select 'flat' and adjust RV2 to obtain the same reading.

8. Apply an accurately known voltage with the instrument set to the flat and ac modes and adjust HV4 to give the correct reading.

9. Apply a dc input of known polarity and check that the correct LED illuminates. If not, reverse the leads to the LEDs.

This completes the calibration and the instrument should now give accurate readings on all ranges and at all frequencies within the specified range. ●



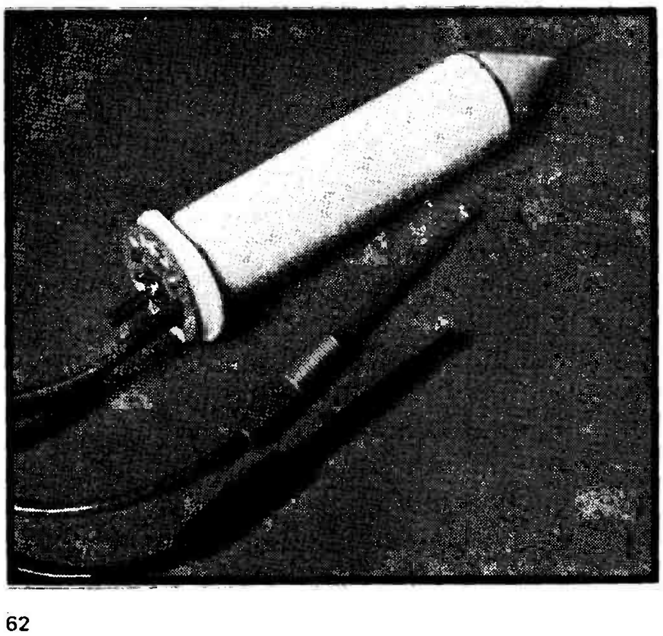
LOGIC PROBE

A basic tool for digital servicing.

THE SERVICING of digital equipment is greatly simplified by the use of a logic pulser and logic probe, for these two instruments enable one to follow circuit operation stage by stage.

THE PROBE

The probe must be capable of detecting pulses as short as 50 nanoseconds (for TTL operation) and make them visible. It was found that readily available linear ICs were not suitable as they are too slow and required dual supply voltages. Neither could CMOS be used as it also is too slow, for testing TTL gates, and its threshold voltages are not consistent. Further, TTL could not be used as it cannot withstand the voltages used with CMOS logic. This virtually means that the only devices that are suitable are discrete transistors.



The logic probe we built in a solder tube.

HOW IT WORKS

The probe consists of two independent voltage level detectors which, via pulse stretching monostables, drive light-emitting diodes to give a visual indication of the logic state being monitored. Transistors Q1 and Q4 form the low level or '0' detector, transistors Q5 and Q6 the high level or '1' detector whilst the remaining components form the pulse stretching monostables and visual indicators.

The high level detector works as follows. If the input level is below about 2.5 volts (1.3 volts above the level set on R17 by transistor Q5) transistor Q6 will be cut-off. When the input level rises above 2.5 volts, transistor Q6 will turn on, as will Q7, causing LED 2 to light – indicating a '1'. The transition at the collector of Q7 will, at the same time, be passed to Q8 turning it off. The current which was flowing through Q8 will now flow via R22 in to the base of Q7 holding it on even though Q6 may by now have stopped conducting. After fifty milliseconds the charge on C2 will leak away via R19, 20 allowing Q8 to conduct. When Q8 conducts it robs the current from the base of Q7 turning it and the LED off. However should the voltage at the tip of the probe still be present Q6 will still be turned on holding on in turn Q7 and the LED.

Resistors R11, 12, 13 and 14 set the operating conditions of Q5 such that the threshold voltage is optimized for either TTL or CMOS. As CMOS logic works on supply voltages ranging from five to fifteen volts, transistor Q5 has been arranged to track the supply so that the correct threshold is maintained at all times.

The low level detector works in exactly the same fashion except that it is inverted in order to detect pulses which approach within 0.45 volts of the negative line (TTL only). Each PNP transistor and each NPN transistor have been replaced with their complements. In this case Q4 sets the thresholds and the circuit operates exactly as stated for the high detector. Note that the diodes have also been reversed.

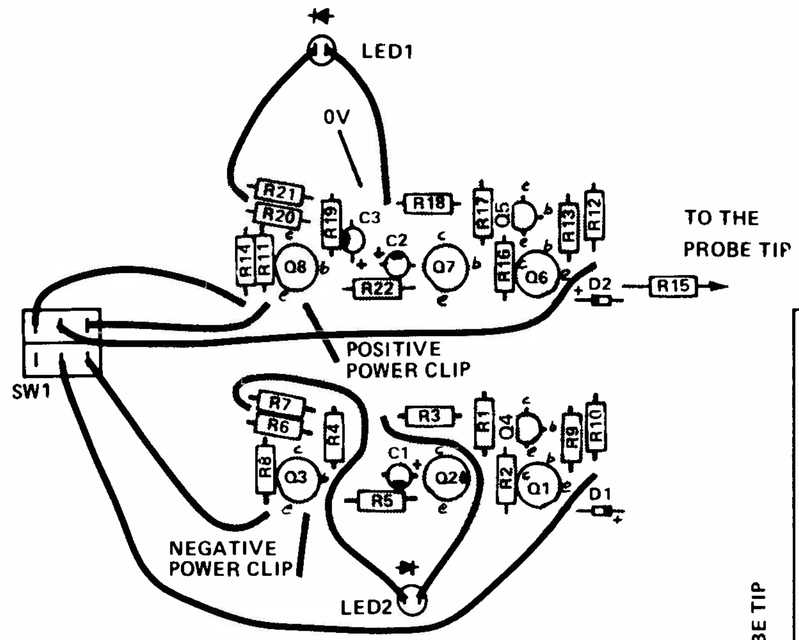


Fig. 3. Component overlays for the two comparators showing interconnection wiring.

PARTS LIST – ETI 120

R3,18	Resistor	680	¼ W	5%
R4,15,19	"	1 k	"	"
R10,13	"	1 k8	"	"
R1,9,12,17	"	2 k7	"	"
R5,14,22	"	3 k3	"	"
R2,16	"	8 k2	"	"
R7,21	"	10 k	"	"
R8,11	"	27 k	"	"
R6,20	"	100 k	"	"
C1,2	Capacitor	0.47 µF	25 V tantalum	
C3	"	10.0 µF	25 V "	
D1,2	Diode	IN914 or similar		
Q1,7,8	Transistor	BC177		
Q2,3,6	"	BC107		
Q4	"	BC179		
Q5	"	BC109		
SW1	Switch	Two pole, two position miniature toggle		

PC boards 2 off ETI 120
Probe case (see text)
LED 1, 2 Light emitting diodes TIL209 or similar
2 Alligator clips or Ezy-hooks

CHARACTERISTICS

PULSER – ETI 121

- Will source, or sink, up to 500 mA.
- Operates on supply voltages from 5 to 15.
- Suitable for both TTL and CMOS.
- Power supply drain less than 15 mA under worst case conditions.
- Press for '1' release for '0'. High impedance at other times (>1 M).
- Will drive capacitive loads up to 1000 pF.
- Protected against accidental reversal of supply leads.
- Duration of pulse 500 nanoseconds.

PROBE – ETI 120

- Pulses as narrow as 50 nanoseconds will be detected.
- Stretches narrow pulses to 50 milliseconds for ease of detection.
- Operates on supply of 5 to 15 volts.
- Suitable for TTL or CMOS.
- True '1' and '0' level detectors. Neither LED is alight if the circuit is faulty or the probe is not making contact.
- Current drawn from the circuit is less than 20 microamps.
- Current drawn from power supply (one LED alight) 12 mA on 5 volts, 35 mA on 15 volts.

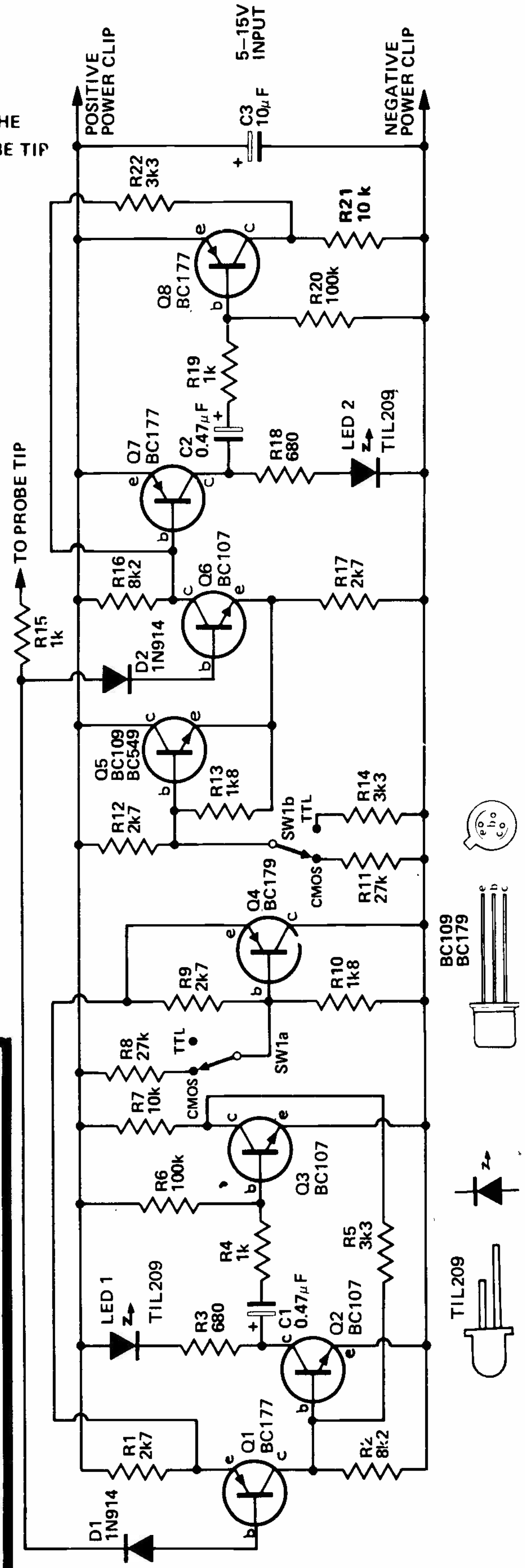


Fig. 1. Circuit diagram of the logic probe

LOGIC PROBE

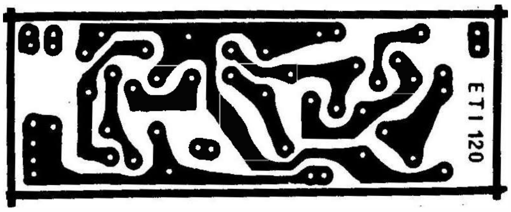


Fig. 2. Printed circuit board for the logic probe (2 required). Full size 23 x 66 mm.

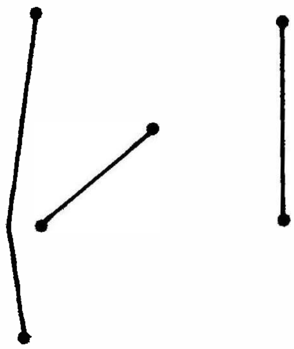


Fig. 4. Linking required between the two boards.

As both high and low logic states must be detected, a discrete transistor voltage-comparator circuit was designed to detect each state separately. These comparators must not load the circuit under test as CMOS is sensitive to current and capacitive loading. In our prototype the current drawn was a maximum of 19.7 microamps for a high, and 10 microamps for a low.

In both comparators the transistors associated with the pulse detector are turned on by an input level that exceeds the comparator threshold.

As transistor turn-on time is much faster than turn-off time, using the transistors in this way ensures the highest possible speed of operation for the particular types of transistors used. Additionally, the delay in turning off assists by lengthening the pulse, thus ensuring more reliable triggering of the monostable on very short pulses.

The input transistors Q1 and Q6 are protected against breakdown, due to excessive base-emitter voltage, by diodes D1 and D2. The diodes are also required to ensure that Q1 and Q6 remain conducting even when the probe tip is taken to the supply voltage.

Transistors Q3 and Q8 are also protected against reverse base-emitter voltages by R4 and R19 respectively.

In operation the probe will light LED 1 if a low level is detected, LED 2 for a high, neither LED if the point being monitored is at ground potential or a poor contact is made with the tip, and both LEDs will light if there is a pulse train present.

A single pulse input will be lengthened, by the monostables, to 50 milliseconds with the pulse polarity being indicated by the LED which is illuminated. Thus even single pulses as short as 50 nanoseconds may readily be detected.

CONSTRUCTION

We assembled our probe in a case made from a solder tube. This is commonly available from component shops for about 35p (containing Ersin Multicore Solder). Any probe case or tubing with a diameter of 23mm and a length at least 90mm (excluding nozzle) will do. The solder tube has a detachable plastic end-cap which supports SW1 and the LEDs. SW1 is used to hold a small name-plate in position as shown in Fig. 6. Two LEDs are mounted into the end plate, together with SW1, and after soldering leads to the LEDs they should be passed through the holes in the plate, and the plastic end-piece, and secured in position with a drop of epoxy cement. Another hole is drilled in the stopper through which is passed the two supply-voltage leads.

A removeable nozzle has to be made and for this we used a polyester resin filler (Isopon or any of the car body repair fillers is ideal). First saw of the original nozzle and line the inside of the tube with grease or cow gum. This stops the filler making a permanent joint. Then mix some filler and spread it for about 25mm down the inside of the tube. Roughly mould the nozzle shape around the polythene tubing which comes with the solder and bed this firmly in the end of the tube. After a couple of minutes the nozzle can be whittled into shape. After hardening remove the nozzle and clean up the inside face (saw off the rough moulding). Remove the polythene tubing and in the hole R15 and the probe tip can be fixed with more filler. Use a darning needle or one of the needles made for sewing up knitting as the tip. Do not leave more than 15mm protruding or the needle is likely to break. Finally the nozzle can be filed and sanded to give a neat appearance.

The electronics are built on two printed circuit boards. The two boards are identical and care should be taken to use the correct overlay for each board as different transistors are used and some components are reversed on the two boards. Note particularly diodes D1 and D2 and capacitors C1 and C2. Also note how the two boards are linked together and that the supply rails are reversed. No difficulty should be experienced if the printed-circuit boards and the component overlay as specified are used.

Connect the leads from the stopper assembly to the boards. Position the boards together, copper side to copper side, with a piece of insulating material between them. Make sure that the board assembly will fit into the tube without bending the sides. Cut a piece of cardboard or plastic 75 x 85mm, roll it into a tube and fit in the probe body. Now fit the board assembly into the tube – it may be necessary to dress the sides of the boards with a file to obtain a neat fit.

The tip may now be connected and both ends screwed into position. Finally, alligator or, better still, Ezy-hooks clips should be fitted to the supply leads. ●

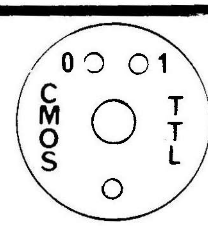


Fig. 5. Artwork for the nameplate on the probe.

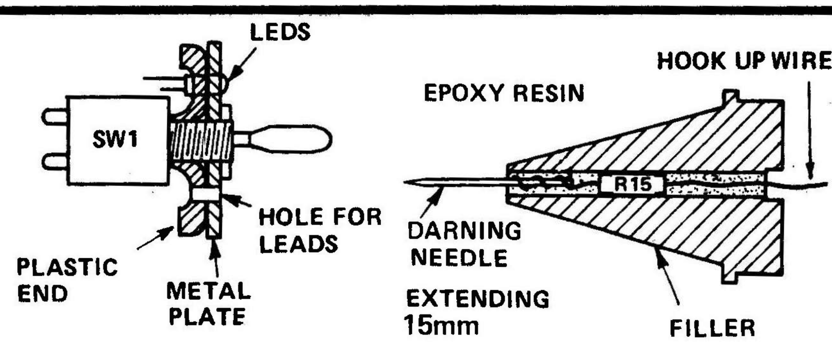


Fig. 6. How the probe ends are constructed.

etiproject 121

LOGIC PULSER

Companion instrument to the logic probe.

ALTHOUGH the logic probe used alone is a very valuable piece of digital test equipment, it is limited by the fact that it can only observe the logic states that occur naturally within the piece of digital equipment under test.

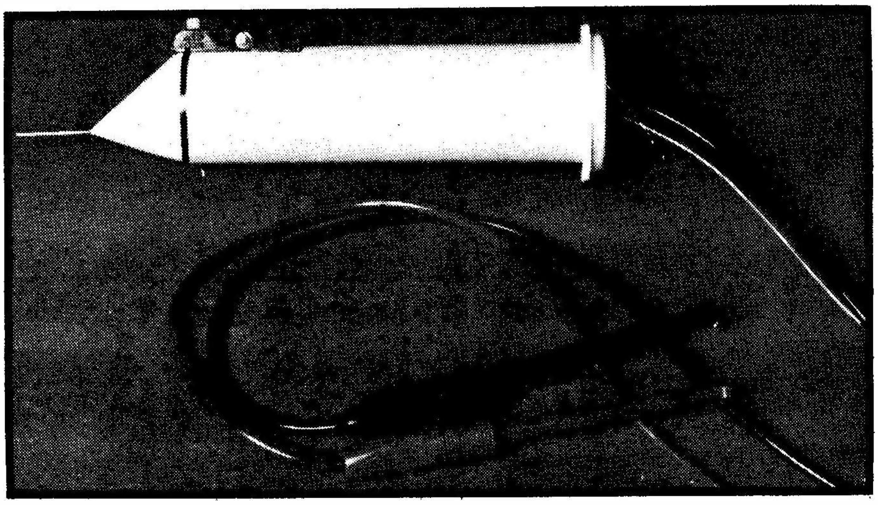
The logic pulser is a further valuable tool that is used in conjunction with the logic probe. It's function is to override the naturally occurring state at the particular circuit node under test. That is, if the circuit node is normally at the '1' state, the pulser will drive that node to a '0' for a very short period when the microswitch is pressed. If the circuit node is normally at a '0', the probe will drive it to a '1' for a very short period when the microswitch is released. Thus it puts a short pulse into the circuit node regardless of it's normal state when SW1 is pressed and released.

A fairly powerful pulse is required to override the normal logic state of a circuit node and care must be taken to ensure that the devices either driving, or being driven from that node are not damaged. This is achieved by making the pulse of very short duration. In our probe the pulse width is 500 nanoseconds. Thus although the pulse is of high current the energy released is insufficient to damage normal logic devices.

The probe must be suitable for driving either TTL or CMOS that is, it must operate from a supply ranging from 5 to 15 volts, it must be capable of operating into loads having a capacitance as high as 1000 picofarads and must supply a current pulse of around half an amp. All these conditions are fulfilled in the ETI 121 Pulser and the prototype has been tested by causing it to generate several hundred thousand half amp pulses without any problems. The probe is quite capable of pulling two (in parallel) high-power TTL 'zeros' to a '1' level and this is the most severe condition it has to meet.

At the same time as providing high level pulses, the pulser should not draw too much supply current as some CMOS supplies may not have much additional capability. Under worst-case conditions the ETI Pulser drew a maximum of 10 mA.

The probe is capable of overriding a normal logic state but is not capable of overriding a point that is connected to ground or to a supply rail. Thus by pulsing a node and at the same time looking at that point with the logic probe it is possible to tell if that point



A basic tool for digital servicing.

is shorted to either rail.

The logic pulser combined with the logic probe is thus capable of performing stimulus – and – response testing of both TTL and CMOS logic and of determining the exact nature of a fault at a particular circuit node.

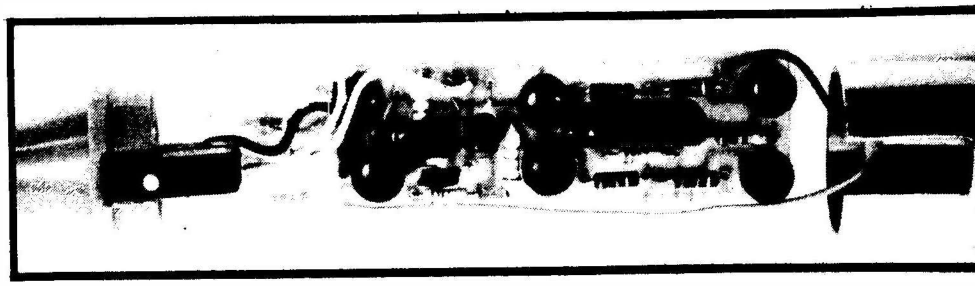
CONSTRUCTION

Construction is greatly simplified if the printed circuit board of Fig. 2, is used. This should have the components assembled to it in accordance with the component overlay. Note particularly the polarity of C1, and the connections of the microswitch such that the normally-closed terminal of the switch is connected to the base of transistor Q1. Also make sure that a red lead is connected to the positive rail of the board, and a black lead to the negative rail, to facilitate later connection.

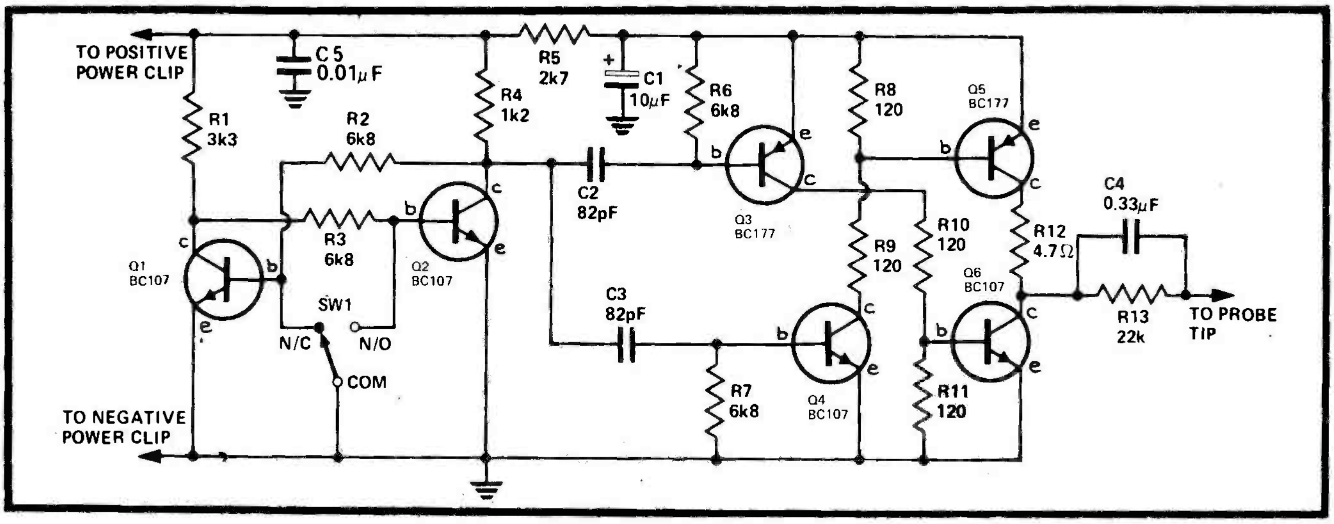
We used the same probe case for the pulser as for the logic probe. The probe tip again uses a darning needle and the microswitch SW1 is mounted into the plastic filler tip as follows. First check switch to determine what the contact arrangement is. Attach colour coded wires to the switch, to aid later identification. If you use a solder tube as a case you have to saw off the nozzle and cut a slot for the microswitch. Keep the switch as far forward as possible to give more room for the pcb. Line the tube end with grease so that the filler will not stick. Wire or tape the switch into position and fill the end of the tube with filler. Make sure there is a hole, for fixing the probe tip by inserting the polythene tubing which comes with the solder. Roughly mould a nozzle. After a couple of minutes this can be carved with a knife. Then remove the polythene tubing and insert the needle. Fix this into the correct position using more filler. When the filler is hard the nozzle can be removed for filing and sanding into shape.

Connect the probe tip and microswitch leads to the board and, after insulating the inside of the case with cardboard or plastic as previously described, insert the board into the case. Pass the supply leads through the plastic end piece and then fit both end pieces and secure them in position. Finally attach Ezy-hooks or crocodile clips to the supply leads.

Keep the supply leads as short as is reasonably possible as excessively long leads will degrade the performance of the pulser.



Internal construction of the pulser.



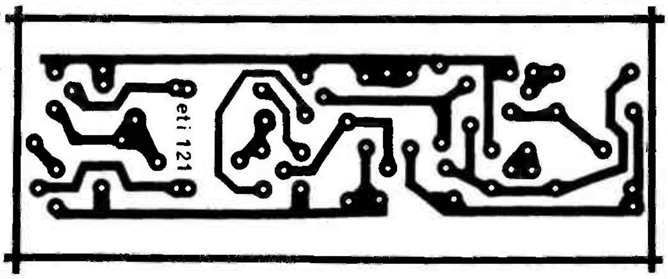


Fig. 2. Printed circuit board for the pulser. Full size 23 x 65mm, or 23 x 85mm.
If this board is made to 23 x 85mm (same scale as shown here) it will not fit into a solder tube case. In this case the board should be reduced to 65mm in length (as shown below). To save confusion when ordering the board ask for ETI121–85 or ETI121–65.

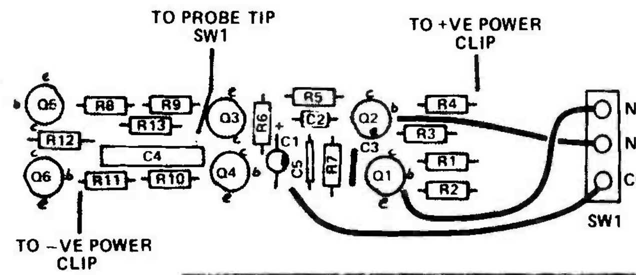


Fig. 3. Component overlay for the pulser.

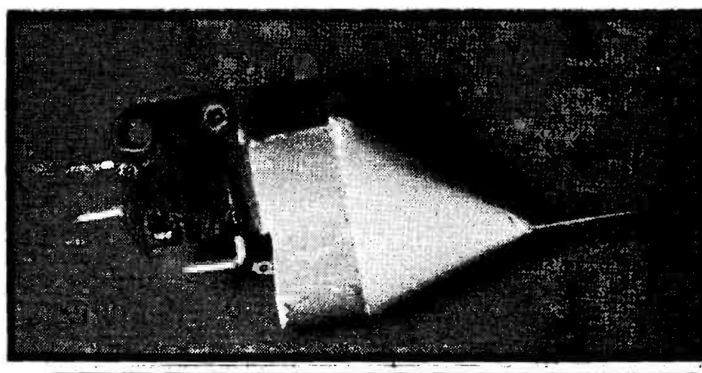


Fig 4. The tip of the logic pulser, made from a darning needle, a microswitch, and a small quantity of car body filler.

HOW IT WORKS

The pulser is activated whenever microswitch SW1 is pressed. This switch controls the state of a flip-flop formed by transistors Q1 and Q2. The flip-flop is necessary to prevent contact bounce of the microswitch from having effect.

The output transistors of the probe, Q5 and Q6, which in turn are controlled by Q3 and Q4 are both normally off. However when the microswitch is pressed Q2 turns off and the rising voltage on its collector is coupled, via C3, to the base of Q4 turning it on. This in turn, turns on Q5 pulling the output to the positive rail. This generates a '1' pulse if the point under test was at a '0' level. Resistor R12 provides a current limit of around 500 milliamps. Due to the small value of C3 the pulse output is only about 500 nanoseconds long, short enough so that there is insufficient energy to damage the device under test.

When the switch is released Q2 turns on and the negative-going edge is coupled to Q3 by C2 turning it on. This turns on Q6 causing the output to be pulled to the negative rail. This gives a '0' pulse which, like the '1' pulse, is only 500 nanoseconds long.

The output from the probe is taken via the paralleled combination of R13 and C4 where C4 carries the current and R13 discharges C4 between pulses. This network protects the probe against the condition where the probe is inadvertantly connected to a voltage which is above or below the logic supply rails.

Resistor R5 isolates the high current pulse from the power supply, capacitor C1 providing the actual current needed.

SPECIFICATION
See page 63.

PARTS LIST

R12	Resistor	4.7 ohm	¼W	5%
R,8,9,10,11	"	120 ohm	¼W	5%
R4	"	1k2	¼W	5%
R5	"	2k7	¼W	5%
R1	"	3k3	¼W	5%
R2,3,6,7	"	6k8	¼W	5%
R13	"	22 k	¼W	5%
C2,3	Capacitor	82 pF	ceramic	
C5	"	0.01 µF	polyester	
C4	"	0.33 µF	polyester	
C1	"	10 µF	25 V tantalum	
Q1,2,4,6	Transistor	BC107 or similar		
Q3,5	"	BC177 or similar		

1 micro switch
2 crocodile clips, Ezy-hooks
PC board ETI 121
probe case (see text).
polyester filler (from a car accessories shop).

ETI PROJECT BASIC POWER SUPPLY

Simple regulated supply provides 4.5-12 volts at 400 mA maximum.

The power supply shown unmounted. Note the aluminium heat sink for the power transistor.

THIS little power supply provides a range of switch selectable output regulated voltages from 4.5 to 12 volts, selectable by a switch. The supply will provide up to 400 mA and the output can withstand a short circuit without damage. It is therefore ideal for the experimenter or for use with high drain appliances.

PARTS LIST
POWER SUPPLY ETI 221

R6	Resistor	1.5 ohms ½W 5% (2 x 1.5 ohms in parallel for organ)
R7	"	220 ohms ½W 5%
R3	"	820 " " "
R1, 8	"	1k " "
R4, 5	"	1.5k
R2	"	2.7k
Q1	Transistor	BC337 or similar
Q2	"	2N3055 "
Q3	"	BC327 "
D1-D4	Diode	1N4001 or similar
ZD1	Zenerdiode	BZY88C13 " (13V, 400mW)
T1	Transformer	240V/15V at 1A
SW1	DPST	240V switch
SW2	4 position single pole switch	
	heatsink for Q2	
C1	Capacitor	220μF 25V electrolytic
C2	"	100μF 16V "

Piece of matrix board.

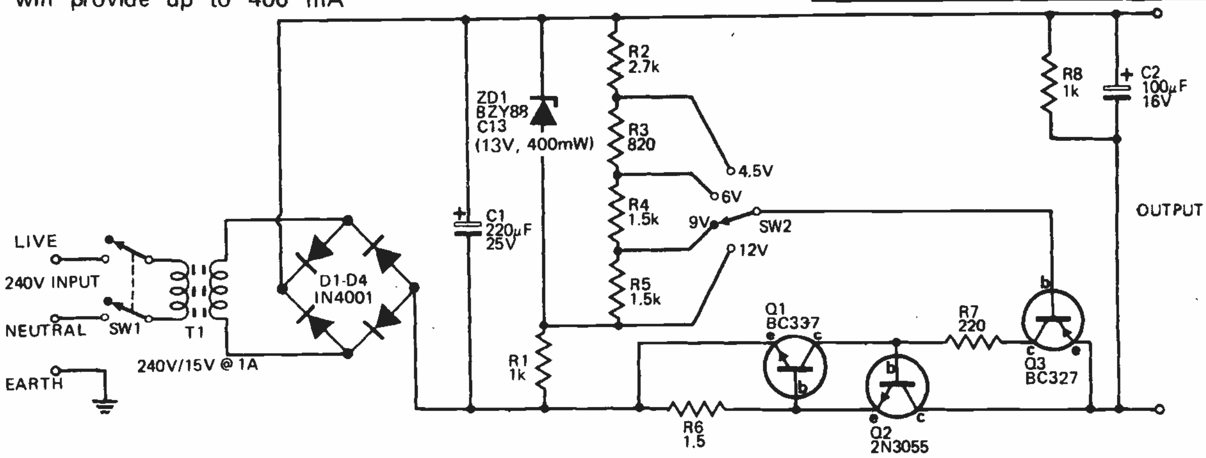


Fig. 1. Circuit diagram of the regulated power supply.

SPECIFICATION

Nominal output voltage 12V, 9V, 6V and 4.5V
Output current 0 – 400mA
Current limit approx. 500mA

HOW IT WORKS

The 240 V mains voltage is reduced to 15 volts by transformer T1, and this secondary voltage is then full-wave rectified by rectifier bridge D1-D4.

The output of the bridge rectifier is filtered by C1 to provide approximately 20 volts dc.

The series combination, of Zener diode ZD1 fed by resistor R1, provides a stabilized voltage of around 13 volts which is applied across the voltage divider R2, R3, R4 and R5. Thus a series of reference voltages are generated for the regulator, where the positive rail is fixed and the negative rail is the one that is varied.

Transistor Q3 is an emitter follower where the output (emitter) is about 0.6 V higher (more positive) than the base. The base voltage is selected by SW2 from one of the tappings on the reference-voltage divider. Since Q3 cannot handle the required output current, it drives Q2, a power transistor, which *can* handle the required load.

When the load exceeds 400 mA (approximately), the voltage drop across R6 forward biases Q1 which turns on and diverts current away from the base of Q2. Thus the regulator loses control and the output voltage falls, limiting the current to 400 mA. As the power dissipated in Q2 under short-circuit conditions is around 10 watts, Q2 must be fitted to a heatsink. Additionally, resistor R7 limits the current supplied by Q3 to a safe value (for Q3) under short circuit conditions.

If a fully variable supply is required, a 10 k potentiometer should be used in place of the voltage divider. The wiper of the potentiometer is then fed directly to the base of Q3.

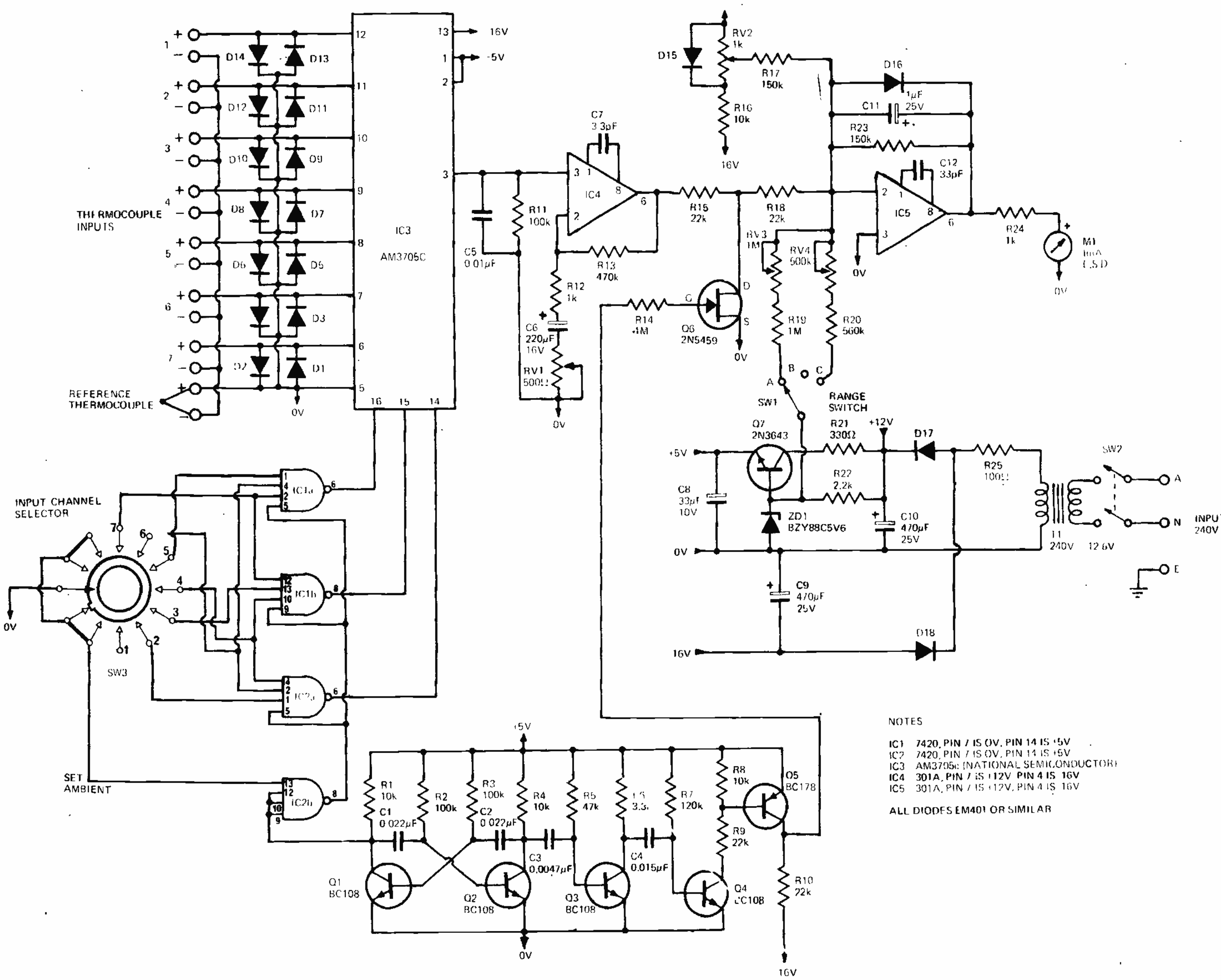


Fig. 1. Circuit diagram of the thermocouple meter.

INTERNATIONAL THERMOCOUPLE METER

The International 113 thermocouple meter enables 0 to 200°C temperature measurements to be made from up to seven separate

ETI PROJECT 113

THE need to make temperature measurements, often from a number of different points virtually simultaneously, is a common requirement of experimenters – both amateur and professional.

But measuring the temperature of small objects is much more difficult than it at first appears.

A temperature measurement determines the degree of heat possessed by a body at a particular instant – if that body is small it is essential that the transducer used to make the measurement does not remove a significant amount of heat energy in the process of taking the measurement. Whilst thermistors and diodes may be used as heat sensing transducers, thermocouples are generally more satisfactory where accurate repeatable measurements need to be made of small devices.

The ETI thermocouple meter has

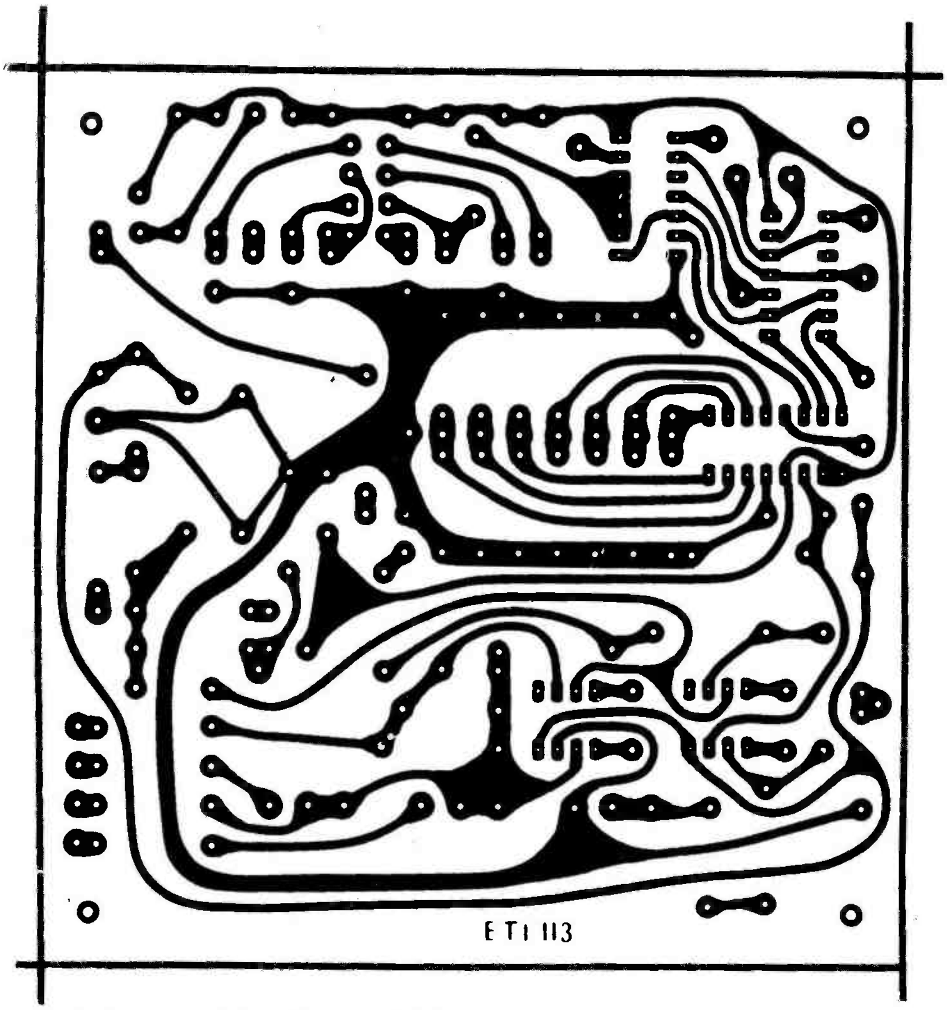


Fig. 2. Printed circuit board layout — full size.

INTERNATIONAL THERMOCOUPLE METER

been designed to suit the requirements of the average experimenter, nevertheless its specification is sufficiently good to enable it to be used satisfactorily for the majority of industrial and scientific applications.

Facilities are included for seven thermocouple inputs, thus enabling temperatures to be monitored at up to seven different points without the need to reposition thermocouple sensors.

Three, overlapping, temperature ranges are provided, so that any varying temperature in the range of 0° to 200° Celsius may be monitored without end-of-scale problems. The 200 degree range of the meter is more than adequate for the range of temperatures normally encountered in most applications.

CONSTRUCTION

Our unit was constructed using a 152 x 152 x 152 mm box with a sloping front panel. Any suitable box may be used as the layout is not critical.

Drawings of front panel and terminal strip art work are provided for those who wish to use the same box.

The meter is a standard 1 mA movement rescaled as shown in Fig. 5.

Do bear in mind that meters are delicate instruments, and great care must be taken whilst dismantling and re-assembly. If you are doubtful of your ability to tackle this operation it is better, either to find someone who can, or to purchase a 0 to 100 scaled meter and to add, mentally, 50 or 100 to the reading, depending on the range in use. If this latter course is adopted the range switch should be marked accordingly.

SPECIFICATION

Number of inputs	7
Ranges	0-100°C 50-150°C 100-200°C
Sensing element	iron/constantan thermocouple wire
Linearity	(see Figure 7)
Accuracy at full scale reading	±3°C ±linearity
Calibration points	ambient temperature 100°C
Ambient compensation	Manual

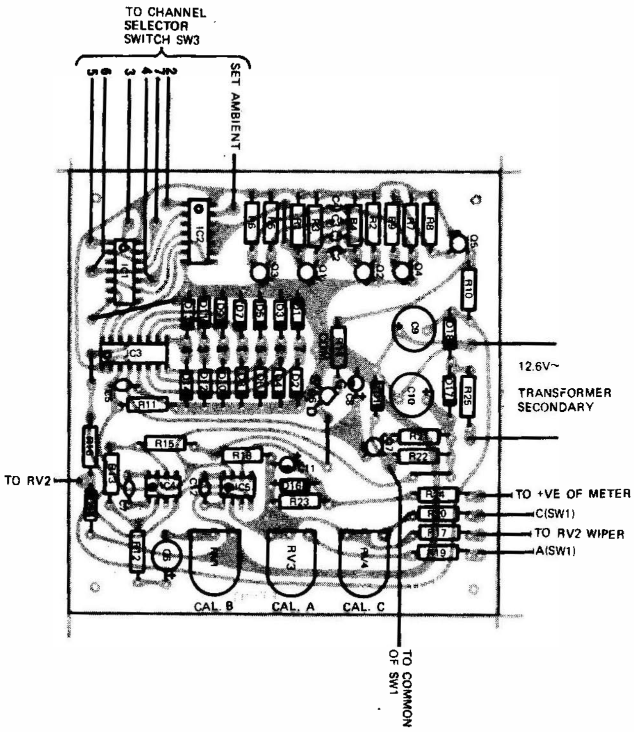
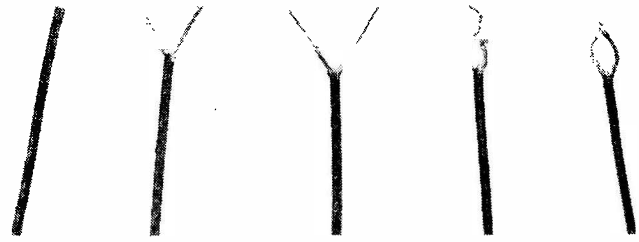


Fig. 3. Component overlay.



Preparation of a thermocouple.
(a) Unprepared wire
(b) Braid bared back
(c) Individual wires stripped
(d) Wires twisted
(e) Wires soldered and cut back.

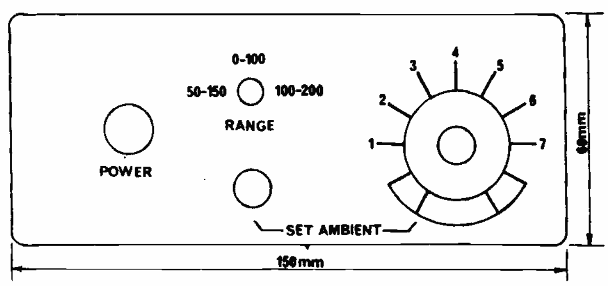


Fig. 4. Front panel artwork (half scale).

Figure 2 shows, full size, the foil pattern for a suitable printed circuit board. Whilst this unit can be built using veroboard or other forms of construction, we strongly advise that our printed circuit board be used.

Assemble all components to the board except IC3 (AM3705C). Make sure that the components, particularly ICs, diodes and capacitors are correctly orientated *before* soldering.

The AM3705C is a MOS device and is easily damaged by static electricity discharges or leakage currents from certain types of soldering irons. Because of this, do not insert this IC until all other components have been soldered in place.

Then, before soldering it in, check that the soldering iron is correctly earthed. Check this with a meter if possible. Finally, once you pick up the IC, do not let go of it until it has been correctly inserted in place. Then solder it in quickly and cleanly.

Instal the assembled printed circuit board, meter, switches and connector block into the case and complete interconnections in accordance with the component overlay and circuit diagram.

Note that all the negative thermocouple terminals are linked together on the terminal block, and that the reference thermocouple is mounted external to the unit (interior of box may be 5° hotter than ambient). All unused thermocouple inputs should be shorted.

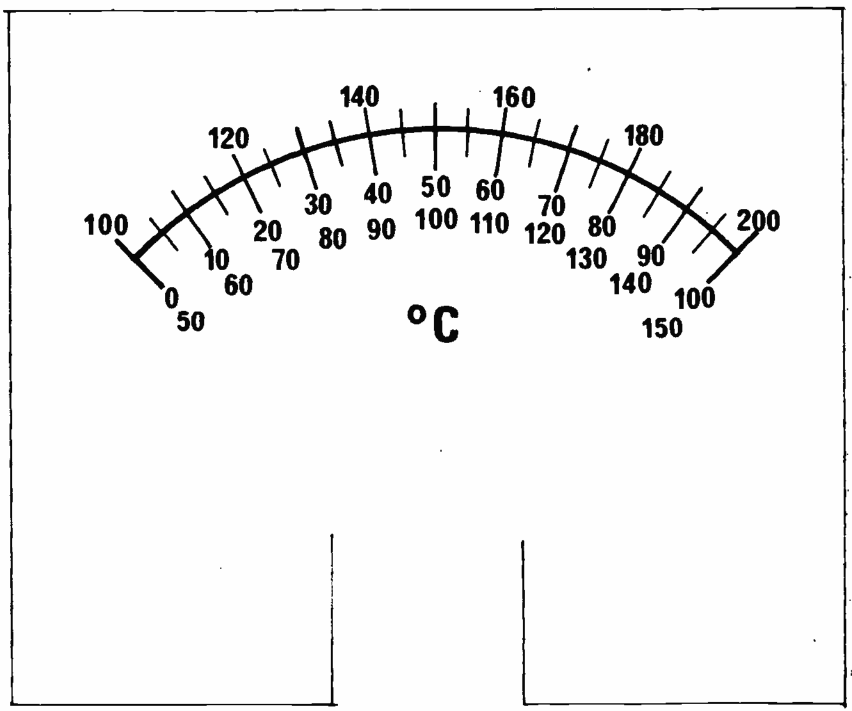


Fig. 5. Meter scale artwork.

INITIAL CALIBRATION

Following assembly, the instrument must be calibrated.

Firstly it is necessary to establish a reference standard for ambient temperature correction. This is best done by mounting an accurate mercury-in-glass thermometer, together with one thermocouple, in a small jar of oil. This jar should then be located somewhere where temperature is reasonably constant.

Leave the temperature of the reference standard to stabilize for a few hours and then connect the reference thermocouple to the reference thermocouple input of the meter.

Now connect thermocouples to all inputs – or short out those inputs that are not used – switch the front panel selector switch to any of the four 'Set Ambient' positions and adjust the 'Set Ambient' control so that the meter reads the same temperature as that shown on the reference thermometer.

Next select a thermocouple by means of the selector switch. Place this thermocouple in boiling water. Adjust RV1 for 100°C indication on the 0-100 range, RV2 for 100°C on the 50-150 range, and RV4 for 100°C on the 100-200 range.

This completes the initial calibration procedure.

CALIBRATION BEFORE USE

Before use, the reference thermocouple should be switched into circuit (any of the four 'Set Ambient' switch positions) and the meter adjusted to the temperature shown on the reference thermometer. This indication should be checked from time to time throughout the day if ambient temperature varies to any marked extent.

For some applications it is possible to set the 'Ambient Temperature' adjustment to read zero. If this is done, the instruments will indicate temperature rise above ambient. In other applications it is possible to use the reference thermocouple to establish a 'base' temperature, then the measuring thermocouples will register temperature rises above the reference level.

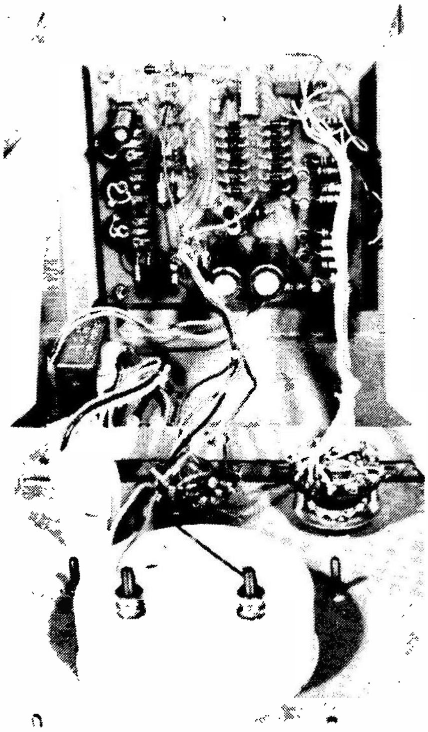
A thermocouple consists of two lengths of (dissimilar) metal wire. If these wires are joined together at one end, a voltage will be developed across them. This voltage will be proportional to the temperature at the point where the wires are joined.

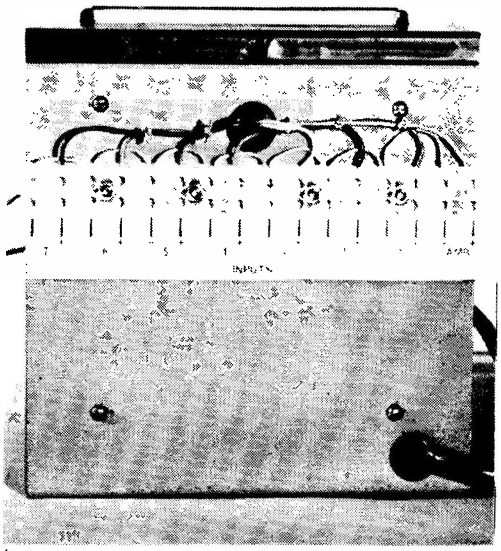
The magnitude of this voltage depends on the types of wires used. It is not in any way related to their diameters.

Many types of thermocouple wire exist, but of these only four types are in common use. These, together with their characteristics, are listed in Table 1.

WARNING

The individual thermocouples are not isolated from each other. If two points, having different potentials are to be measured, the thermocouples MUST be insulated to avoid shorting the two points.





Rear of the meter – showing the thermocouple connector block.

◀ *Interior of the meter showing positioning of PC board and transformer.*

The easiest to obtain are iron/constantan, and copper/constantan. Of these, we have chosen the former because of its superior linearity.

Because most thermocouples are non-linear (i.e. do not have a directly proportional relationship between voltage and temperature) they are usually compensated over the temperature range used. However with iron/constantan the non-linearity is less than 1°C from 0 to 140°C and less than 3°C up to 200°C. If greater accuracy than this is required, the correction graph (Fig. 7) should be used. It is possible to build correction circuitry into the instrument, but this is very complex and costly.

Thermocouple wire, and iron/constantan pairs, are not easy to come by. However British Driver Harris & Co. Ltd, Bird Hall Lane, Cheadle Heath, Stockport, Cheshire will supply small quantities to readers. Their constantan wire is known as *Special Advance* and matched Iron/Special Advance pairs can be supplied.

The junction should only be as long as is necessary to make a strong joint and the wires should not be allowed to touch before the actual junction.

The thermocouple should be taped or glued (using epoxy resin) onto the point where temperature is to be measured.

Temperature measurements of 'live' electrical devices requires especial care if the points at which temperature are to be measured are at different potentials. For such applications, the thermocouple *must* be insulated from

TABLE I
CHARACTERISTICS OF BASE METAL THERMOCOUPLES

THERMOCOUPLE TYPE	TEMPERATURE RANGE (DEGREES CELSIUS) MINIMUM	MAXIMUM 20 gauge	MAXIMUM 24 gauge	MAXIMUM 30 gauge	Microvolts per degree C	Error at 200°C
TYPE J (Iron-Constantan)	−18	480	370	370	53	+2.6°
TYPE T (Copper-Constantan)	−180	260	204	204	43	+14°
TYPE E (Chromel-Constantan)	−180	538	427	427	63	+10°
TYPE K (Chromel-Alumel)	−18	982	870	870	41	−3°

Note: Soldered thermocouples may not be used above 200°C.

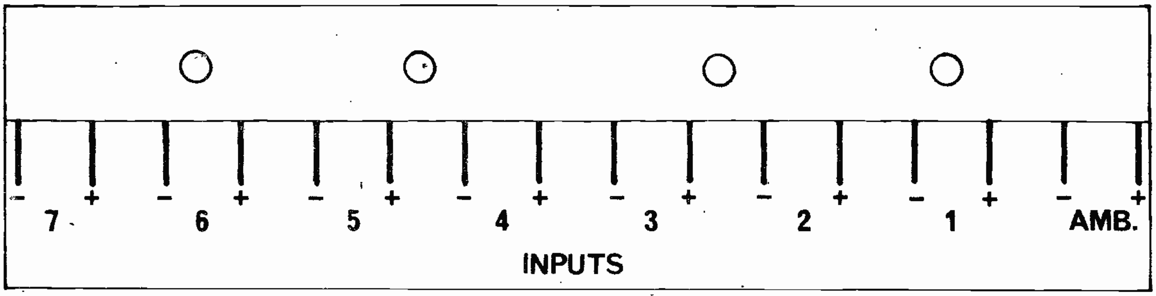


Fig. 6. Artwork for rear-panel connector.

the device.

Thermocouple wire is available in various diameters, however for most purposes 30s.w.g. is a good bet.

Ideally, the complete run from thermocouple junction right back to the meter input should be completed in thermocouple wire. In practice it is satisfactory to use copper wire between the thermocouple and the meter but it is absolutely essential that the two places where the copper wire is joined to the thermocouple wire be at the same temperature.

This is because each junction between the copper wire and the thermocouple wire forms in effect another thermocouple, however if the temperatures of these junctions are identical the voltages that they generate will be of equal magnitude but opposite polarity, and hence will cancel out. ●

TABLE II

COLOUR CODE FOR THERMOCOUPLE WIRE

TYPE	OVERALL COLOUR	POSITIVE COLOUR	NEGATIVE COLOUR
J	Brown	White	Red
T	Brown	Blue	Red
E	Brown	Purple	Red
K	Brown	Yellow	Red

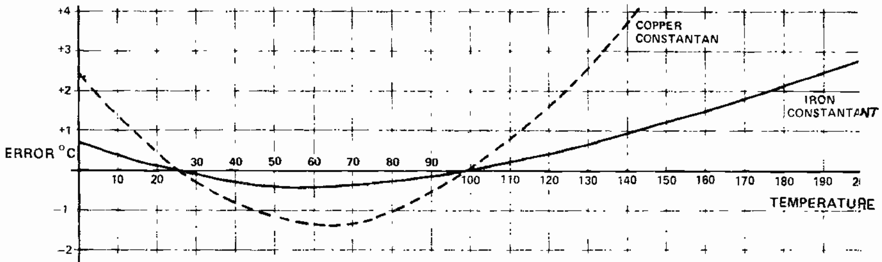


Fig. 7. Comparison of errors for copper/con and iron/con thermocouples calibrated at ambient and 100°C.

PARTS LIST

R1 resistor 10k 5% ½w
R2 resistor 100k 5% ½w
R3 resistor 100k 5% ½w
R4 resistor 10k 5% ½w
R5 resistor 47k 5% ½w
R6 resistor 3.3k 5% ½w
R7 resistor 120k 5% ½w
R8 resistor 10k 5% ½w
R9 resistor 22k 5% ½w
R10 resistor 22k 5% ½w
R11 resistor 100k 5% ½w
R12 resistor 1k 5% ½w
R13 resistor 470k 5% ½w
R14 resistor 1M 5% ½w
R15 resistor 22k 5% ½w
R16 resistor 10k 5% ½w
R17 resistor 150k 5% ½w
R18 resistor 22k 5% ½w
R19 resistor 1M 5% ½w
R20 resistor 560k 5% ½w
R21 resistor 330k 5% ½w
R22 resistor 2.2 k 5% ½w
R23 resistor 150k 5% ½w
R24 resistor 1k 5% ½w
R25 resistor 100k 5% ½w
RV1 potentiometer 500Ω trimpot
RV2 potentiometer 1k linear pot.
RV3 potentiometer 1M trimpot
RV4 potentiometer 500k trimpot
C1 capacitor 0.022uF polyester
C2 capacitor 0.022uF polyester
C3 capacitor 0.0047uF polyester
C4 capacitor 0.015uF polyester
C5 capacitor 0.01uF polyester
C6 capacitor 220uF 16V electrolytic pc mounting
C7 capacitor 3.3pF ceramic
C8 capacitor 33uF 10V electrolytic pc mounting
C9 capacitor 470uF 25V electrolytic pc mounting
C10 capacitor 470uF 25V electrolytic pc mounting
C11 capacitor 1uF 25V electrolytic pc mounting
C12 capacitor 33pF ceramic.
D1-D18 diode 1N4001 or similar
ZD1 Zener diode BZY88C5V6
Q1-Q4 transistor BC 108 or similar
Q5 transistor BC 178 or similar
Q6 transistor 2N5459 or similar
Q7 transistor 2N3643 or similar
IC1 integrated circuit 7420
IC2 integrated circuit 7420
IC3 integrated circuit AM3705C (National Semiconductors)
IC4 integrated circuit LM 301A (National Semiconductors)
IC5 integrated circuit LM 301A (National Semiconductors)
SW1 toggle switch single probe double throw with off.
SW2 power switch
SW3 rotary switch 1 pole 11 position.
T1 transformer 240V-12.6V 150mA.
M1 meter 1mA FSD scaled 0-100 or scaled to Fig.7
Printed circuit board ETI 113.

HOW IT WORKS

The output voltage from a thermocouple is of the order of millivolts. Typical sensitivities are around 40 to 60 microvolts per degree celsius.

This small dc signal must be increased in level, in order to drive a meter. This is done by chopping between the signal level and zero and amplifying the resultant square wave. The amplified ac signal is then rectified for the meter.

An 8-channel MOS analog multiplexer (IC3) is used both to select the input and to provide the chopping action. Each input is protected by back-to-back diodes, and all the negative sides of thermocouples are joined to the negative side of the reference couple the positive side of which goes to zero volts. Thus the voltage generated is proportional to the difference in temperature between the selected and the reference couples (54µvolt/dc).

Transistors Q1 and Q2 form a 300 Hz multivibrator, the output of Q1 being fed via IC2 to an input on each of the IC2a, IC1a and IC1b. When a channel is selected by SW3, eg. channel 5, zero volt is applied to pin 1 of IC1. The gates of IC1 and IC2 are NAND gates and if any input to a NAND gate is zero its output will be high. Hence the output of IC1a will be high and the outputs of IC1b and IC2a will be low. This code when applied to pins 14, 15 and 16 of IC3 will cause it to select the input on pin 8, that is thermocouple 5.

However as the output of Q1 goes high, the output of IC2b goes low and IC2a, IC1a and IC1b outputs will all go high regardless of other inputs. The all-high state causes IC3 to select pin 5 which is zero volts, thus the signal from the selected thermocouple is chopped between signal level and zero.

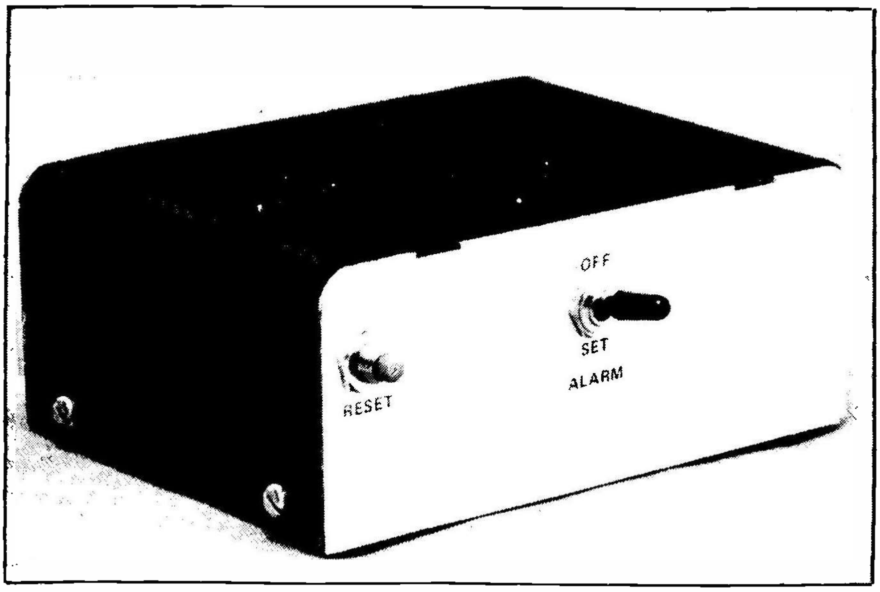
This signal is amplified by approximately 300 by IC4, the output voltage of which will be centred about zero due to ac coupling. For a 75°C rise (4 mV from thermocouple) this voltage will be typically ± 0.6 volts.

Transistor Q6 chops the output of IC4 so that slightly more than one half of the signal is eliminated. Thus the signal now effectively has a dc component. The first and last 150 microseconds of the half cycle are discarded to allow IC4 to settle and eliminates switching errors. The effective sampling time is therefore about 42%.

The amplified signal is then summed in IC5 with an 'ambient set current from RV2 and an offset current from either RV3 or RV4 on the two higher ranges. The output from IC5 is then used to drive the meter.

INTRUDER ALARM

A simple burglar alarm with superior performance.



This increase in crime rate is common to the entire western world, and seems to be related to affluence rather than to poverty as was previously thought by many.

Hence, these days, the chances of your home being burgled are high indeed, and getting higher. Each householder should therefore give serious consideration to protecting his home by an effective alarm system.

A burgler alarm for the home should preferably be battery operated (as it is quite easy to switch off the power from outside most houses), should be reliable over long periods and should not be subject to false alarms.

In the ETI Alarm the CMOS IC has sufficiently low power drain (less than 1 mA) to make battery operation feasible. And by virtue of the high noise immunity of CMOS (half supply voltage) the unit is not susceptible to false alarms due to lightning flashes etc. Add to this the inherent reliability of integrated circuits and you have the basis of a very simple, but very effective, system.

Three modes of operation are built in to the unit which functions as follows:

ALARM MODE

Microswitches or reed relays fitted to each window and door are arranged to have closed contacts when the door, etc, is shut. All contacts are wired in a series loop such that if any door or window is opened, the loop will be broken activating the alarm. The series loop should be wired between the 'external loop' and 'common' terminals shown in Fig. 4.

SILENT ENTRY

This mode of operation allows the owner, when leaving the premises, 30 seconds to open and close the front door before the alarm mode is activated. Additionally it allows the owner 30 seconds to disable the alarm after entering through the front door. Thus the front door microswitch is not included in the normal alarm loop but to its own 'silent entry' loop. The silent entry switch should be wired between 'silent entry' and 'common' – see Fig. 4.

EMERGENCY

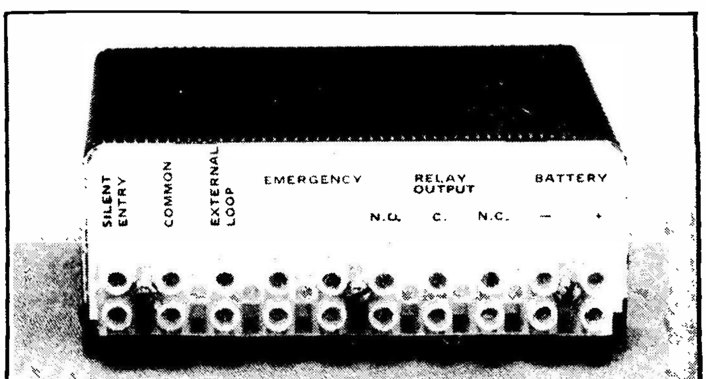
In this mode, any contact closure from a switch or sensor (eg fire, smoke or gas detector) will immediately sound the alarm. Wire switch/s across 'emergency' terminals (Fig. 4).

CONSTRUCTION

Assemble all components to the printed circuit diagram in accordance with the component overlay diagram, Fig. 3. *Do not* fit the CMOS IC until all other components are in place. Make sure that the diodes, the transistor and the tantalum capacitors are all orientated correctly before

SPECIFICATIONS

Power requirements	12 volts
Current consumption	1 mA
Silent entry delay	30 seconds approx.
Alarm circuits	Normally closed
Emergency circuits	Normally open
Alarm output	Relay change over contacts



INTRUDER ALARM

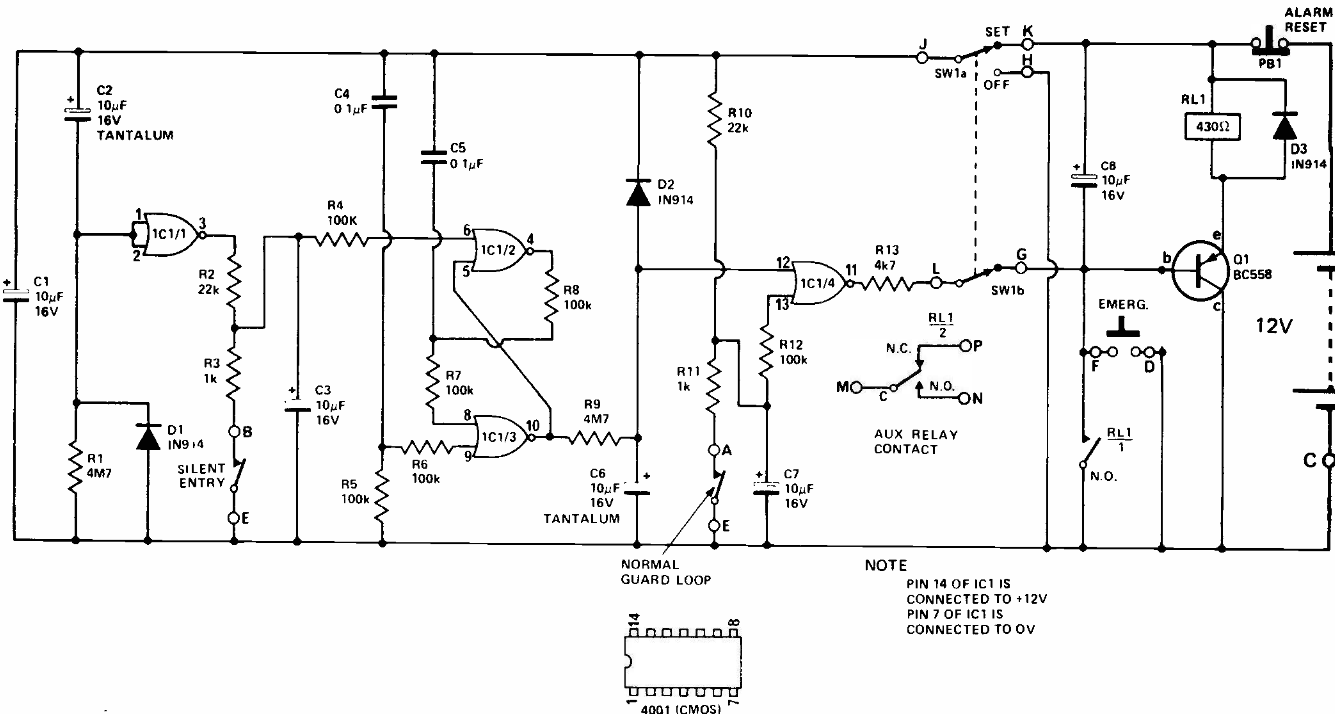


Fig. 1. Circuit diagram of the ETI Burglar alarm.

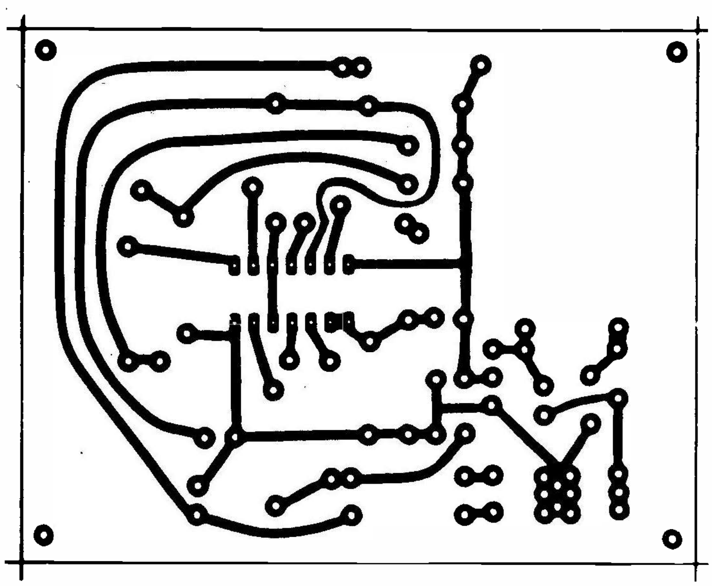
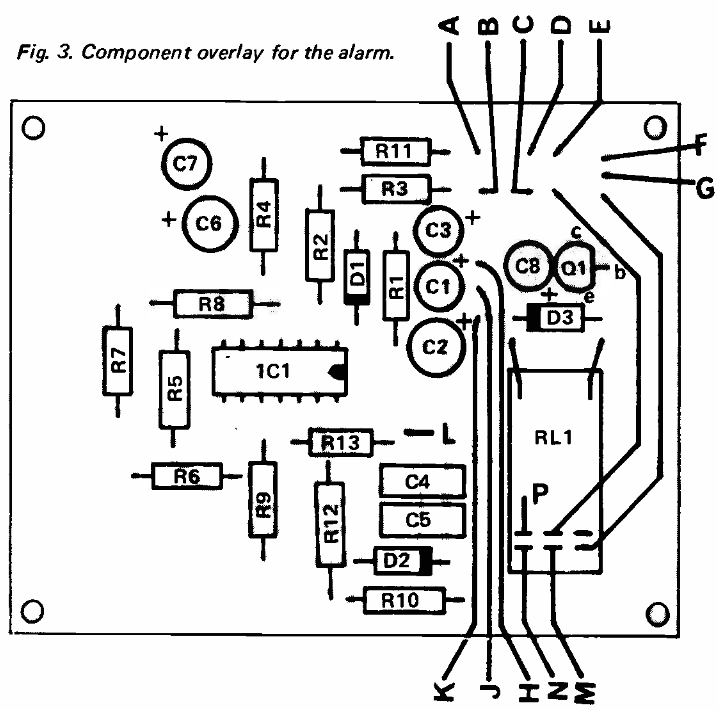


Fig. 2. Printed circuit board lay-out for the alarm. Full size 90 x 70 mm.

Fig. 3. Component overlay for the alarm.



soldering. The relay should be cemented in position on the board with a little contact cement or 5-minute epoxy.

CMOS integrated circuits are supplied with their pins inserted into black conductive foam. The ICs should be left in this foam, which protects them from damage due to static electricity, until you are ready to insert them into the printed circuit board. On no account should the devices be stored in ordinary polythene foam (the static electricity generated by withdrawing the device may well destroy it).

To insert the device into the printed circuit board, first check the orientation of the device, avoid touching the IC pins and insert as quickly, and with as little fiddling, as possible. Then using a lightweight soldering iron (with a clean tip) solder pins 7 and 14 first. These pins are the supply rails and their connection allows the internal-protection diodes to safeguard the gates against electrostatic damage. The remaining pins may then be soldered.

The completed printed circuit board should then be assembled into the box, together with the switches and terminal block, and the complete unit wired with reference to the component overlay and the wiring diagram Fig. 4.

The completed alarm unit should be located in a reasonably well concealed position close to the 'silent entry' door.

The alarm bell is best located in a high, well concealed and not readily accessible position. As very high voltages are generated across the bell 'make and break' contacts it is preferable to use a separate bell battery of suitable voltage rather than to connect it across the main system battery.

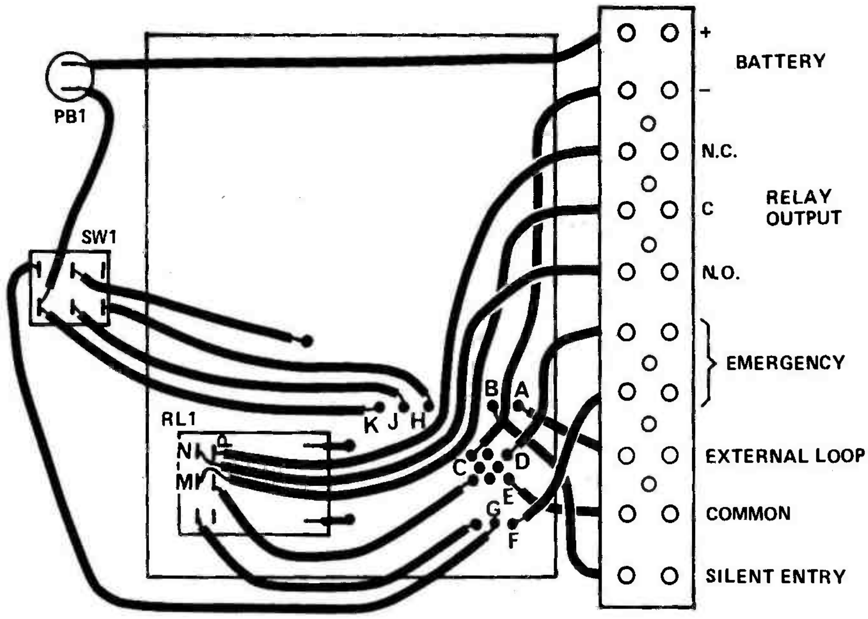


Fig. 4. Wiring diagram showing connections from printed circuit board to switches and connector strip.

HOW IT WORKS

The alarm has three different modes of operation as described in the text.

When power is first applied, i.e. normal alarm mode enabled, capacitor C2 initially has no charge. This momentarily lifts the inputs of IC1/1 to +12 volts. The capacitor then charges slowly via R1 and the voltage presented to IC1/1 falls exponentially to zero. The output of IC1/1 will be zero if the input is over 7 volts, and at +12 volts if the input is less than 5 volts. There is a small linear region, around 6 volts, in which the output changes from zero to +12 volts. With the values given to C2 and R1 a delay of 30 seconds is provided which may be altered, if required, by changing C2. During this delay opening or closing the silent entry door will not affect the level presented to pin 6 of IC1/2.

An RS flip-flop is formed by IC1/2 and IC1/3 in which the control inputs (pins 6 and 9) are normally low (zero volts). On first switch-on pin 9 is pulled up momentarily to +12 volts by C4 before returning to zero. This presents a "1" to the input of IC1/3 and therefore its output will be low (see Table 1). Since pin 7 is at zero, and pin 5 is also at zero, (connected to pin 10) the output of IC1/2 will be high. Since this is coupled to the input of IC1/3 the flip-flop will be locked into the state where IC1/3 output is low.

The only way the flip-flop can be reversed is for the input to pin 6 to go high. However during the first 30 seconds, as explained above, the output of IC1/1 is low. Hence, opening or closing the silent entry door during this time will not set the flip-flop and activate. the alarm.

After this 30 second period, opening the silent entry door will present a "1" to pin 6 which will cause the flip-flop to change state. Closing the silent entry door will now have no effect and the flip-flop will remain set.

The high output of IC1/3 will allow C6 to charge slowly to +12 volts via R9. When this voltage reaches 6 volts (about 30 seconds) it will cause the output of IC1/4 to go low (assuming the normal alarm loop is closed). The low output of IC1/4, via emitter follower Q1, pulls in relay RL1 activating the alarm. When the relay closes contacts RL1/1 cause it to latch on, and only removing power by pressing PB1 will reset it.

If at any time the normal guard loop is broken, when the alarm is activated, a "1" is presented to pin 13 of the IC1/4 causing the output to go low and the relay to close.

When the emergency switch is closed the base of Q1 is taken to zero and the relay closes and latches. This action will take place regardless of whether the alarm is enabled or not.

Diodes D1 and D2 discharge capacitors C2 and C6 respectively via SW1 when it is in the "off" position, thus ensuring that the 30 second delay is always obtained. Resistors R6, 7 and 12 protect the CMOS IC against voltages in excess of the supply rails. Capacitors C3, 5, 7 and 8 add further protection against false triggering due to lightning etc.

INPUT		OUTPUT
A	B	
0	0	1
1	0	0
0	1	0
1	1	0

TRUTH TABLE FOR
2 INPUT NOR GATE
4001 (CMOS)

NOTES
INPUT
1 means >55% supply voltage
0 means <45% supply voltage

INTRUDER ALARM

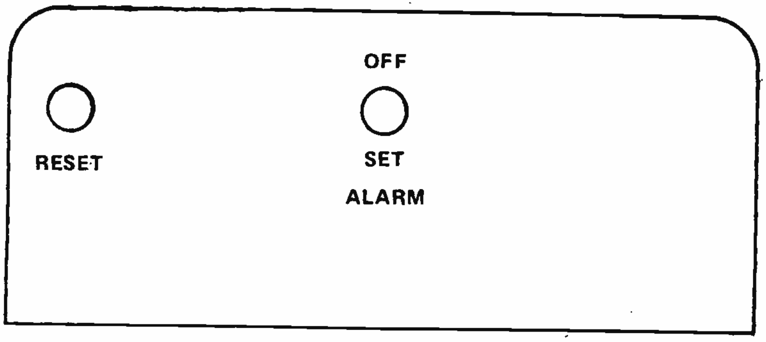
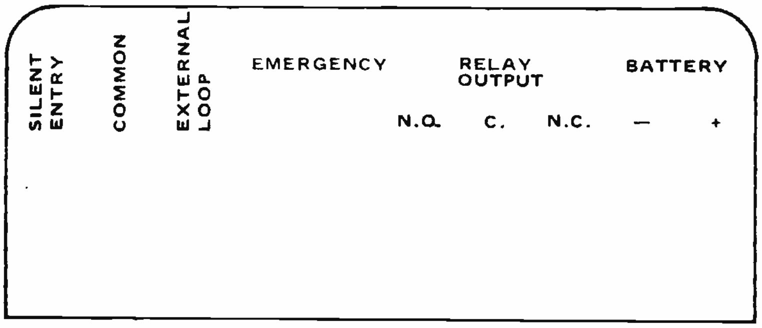
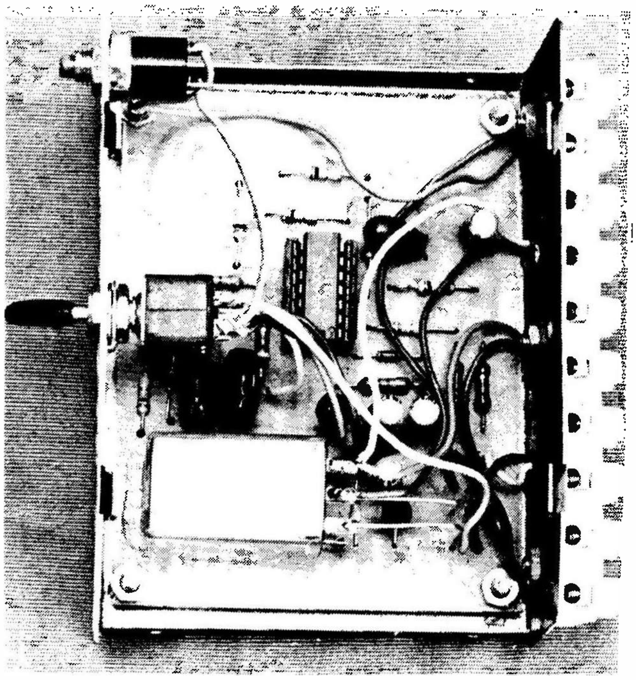


Fig. 5. Front panel artwork.

Fig. 6. Rear panel artwork.





ETI INTRUDER ALARM PARTS LIST

R1, R9	Resistor	4M7 ohm ¼W 5%
R2, R10	"	22k ohm ¼W 5%
R3, R11	"	1k ohm ¼W 5%
R4, R5, R6, R7, R8, R12	"	100k ohm ¼W 5%
R13	"	4k7 ohm ¼W 5%
C1,C3,C7,C8	Capacitor	10μF 16v electrolytic
C2,C6	"	10μF 16v tag tantalum
C4,C5	"	0.1μFpolyester.
D1,D2,D3	Diode	IN914
Q1	Transistor	BC 558, BC 178 or equivalent
IC1	Integrated Circuit	SCL4001A, MC14001, etc.
SW1	Switch	DPDT subminiature
PB1	Switch	Push button switch NC.
RL1	Relay	Miniature relay, 150Ω to 1k coil, two c/o contacts.

PCB, box, 10way terminal block, two 6V lantern cells, hookup wire, etc.

SOME METHODS OF KEEPING THINGS BLOOMING IN YOUR PLOTS WITHOUT REALLY TRYING!

GARDEN WATERING

THIS ARTICLE is really intended for use by wives, to get their electronically-oriented men out of the workshop and into the garden!

The project provides an arrangement for checking comparative moisture levels in soil, and an arrangement responsive to a predetermined level of moisture. Further development allows for automatic watering or sounding of an alarm. A particularly attractive application takes the form of automatic watering of valuable indoor plants.

The circuits are almost ridiculously simple, and yet provide considerable interest in their preparation, construction and use.

OPERATING PRINCIPLE

Soil conductivity varies with moisture content, so that an absolute or a comparative measurement of conductivity can be translated into a corresponding measurement of moisture content. Elaborate instrumentation has been used for years in places like agricultural research stations to provide very accurate determination of soil moisture content and to control plant environments. However, intelligent use of a very simple arrangement providing only comparative indications can be very useful.

One arrangement to be described generates a tone, the frequency of which is dependent on soil conductivity, that is, on moisture content. Another arrangement triggers an external function when the soil conductivity falls below a predetermined level. The reader can gain useful experience to facilitate use of these arrangements by researching his own soil conditions.

SOIL CONDUCTIVITY

If an ohmmeter is connected to two wires pushed a few centimetres into the ground, a resistance reading will be obtained. This resistance varies with the dampness of the soil. However, this is an over-simplification, as will be found if the ohmmeter connections are reversed almost inevitably a different reading will be obtained.

The situation becomes even more interesting if a high impedance voltmeter on a low range is connected to the wires, as a reading will usually be obtained. This potential may arise in various ways or in a combination of ways. Stray currents will usually be found, particularly near dwellings, arising from earth returns of power reticulation systems, galvanic action at buried waterpipes, and so on. Furthermore, because the soil almost certainly will not have a neutral pH balance, but will be either acidic or alkaline, two electrodes will themselves produce a battery action.

In addition to all this, soil characteristics vary a great deal. In the author's case, resistance (reciprocal of conductivity) readings which formed part of a preliminary exercise to get the "feel" of things varied

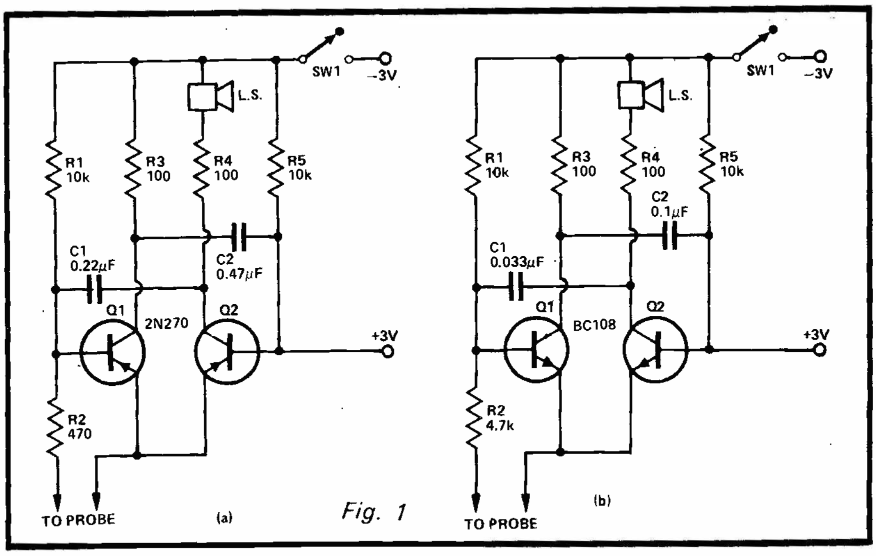


Fig. 1

GARDEN WATERING

considerably in apparently similar soils measured at the same time. For example, comparatively thin wires, about 18 gauge tinned copper, showed readings varying between 15 k and 200 k for what appeared to be a reasonable range of dampness in good, "imported" garden soil. The use of thin wires was found less reliable and consistent than the use of flat electrodes or substantial rods.

Flat electrodes with effective surface areas of, say, 3-4 square centimetres in similar conditions produced a range of 10 k to 25 k. In an open yard with a heavy clay sub-soil and little dirt on top, two 8 gauge rods about 25 mm apart gave readings of 800-2000 ohms the day after a good rainstorm, and up to 15 k (on average) after a few dry days.

Indoor plants are a special case as they have only a finite amount of water available, that is, the soil being restricted to a pot, cannot call up sub-surface moisture as happens in the open garden. Potting soils can dry out to produce quite high resistance values, say several hundred thousand ohms even when substantial electrodes are used. Of course this represents a condition in which a plant will already have permanently wilted.

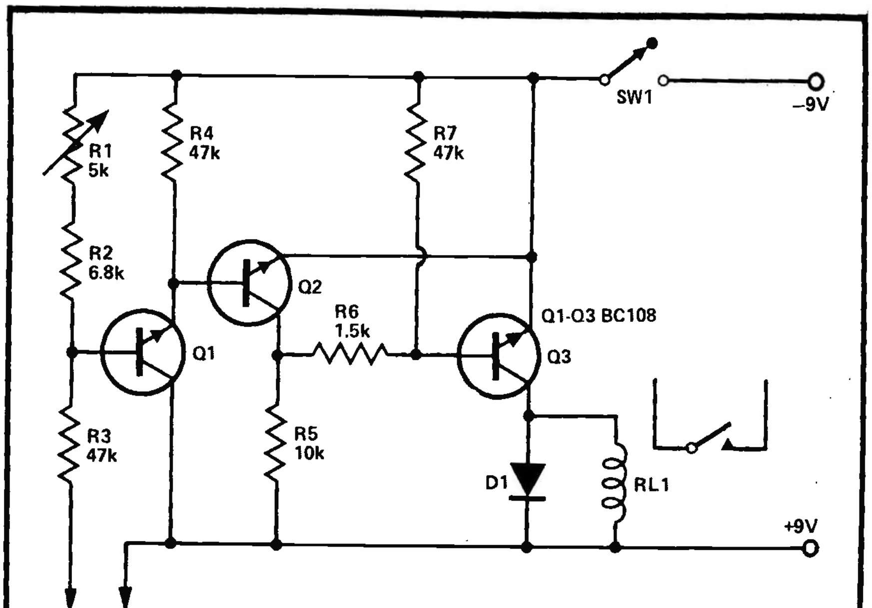


Fig: 2 .

THE MOISTURE MOOD

In rather light-hearted vein the first arrangement to be described has been given a fancy name to make up for the fact that it really needs no description at all! One example using junk-box parts and two re-cycled 2N270 Ge pnp transistors is seen from Fig.1a to be a simple multivibrator, with the addition of a small speaker. Alternatively a low impedance ear plug could be used in lieu of the speaker.

With the probes in air, the circuit delivers a continuous low-pitched tone, which then increases in pitch as the probe is inserted in the soil. The higher the pitch the higher the moisture content. In cases of very high soil conductivity the note may rise above the level of hearing; in this case increase the 0.22 mfd capacitor until the highest audible pitch is obtained with a saturated area of soil.

THE WATER TRIGGER

The second device is shown in Fig.2. Its function is primarily the continuous monitoring of soil moisture content responding to a fall below a predetermined level to initiate an action. This circuit comprises a simple trigger, which operates the relay RL for values of soil conductivity below a level preset by the 5 k variable resistor. The soil

THE PROBE

The probe can take a variety of forms, being basically two spaced electrodes inserted into the soil. However, the most successful form comprises at least two flat electrodes, rather than wires, although wires become more acceptable over 12 gauge and merging into rods. In either case a reasonably substantial exposed surface area of, say, 3-4 square centimetres produces acceptable operation in most soils.

For permanent insertion and for use with soft, friable soils, flat electrodes will probably be found most attractive, whilst for portable use with heavier soils, rod electrodes are probably best. Whilst the details are optional and dependent on the constructor's workshop resources,

The electrodes should be made of material which will not corrode. Monel metal or stainless steel are suitable. Short term experiments with tin plate are fine, but something better is needed for long-term use.


The circuits will also cater for house plants

conductivity is sensed by a probe connected to the terminals shown. The circuit is very simple and reliable, and will operate anywhere between 6 and 12 volts or more, provided the supply voltage provides sufficient energisation for the relay. If a very low current relay is used, an appropriate limiting resistor can be inserted in the common emitter leads of Q2, Q3.

The only point really requiring attention in this circuit is the base circuit of Q1, here comprising the probe terminals, two fixed resistors (47 k and 6,8 k) and a 5 k variable resistor. There are two possible approaches. One can insert a large value of variable resistor (say 250 k – 500 k) in place of the 6.8 k fixed and 5 k variable shown. This produces a circuit which will accept a wide range of values across the probe terminals, but will in general result in the adjustment of the variable resistor being far too wide, and all cramped at one end. The alternative is to decide the probable range of values across the probe terminals, based on tests of the kind described earlier, and then select values to suit. To see how this is done, the author's case will be worked through.

The triggering point of the circuit is with about 1.25 volts at Q1 base, but do not try to measure it with a low impedance voltmeter. This voltage corresponds to a supply voltage division at Q1 base of 1.25:7.75, so that the voltage between Q1 base and the positive supply rail is 6.2 (7.5 ÷ 1.25) times the voltage between Q1 base and the negative rail. Therefore the resistances in the two parts of the circuit need to have the same relationship. This ignores Q1 base current, which has fallen to a negligible value near the triggering point.

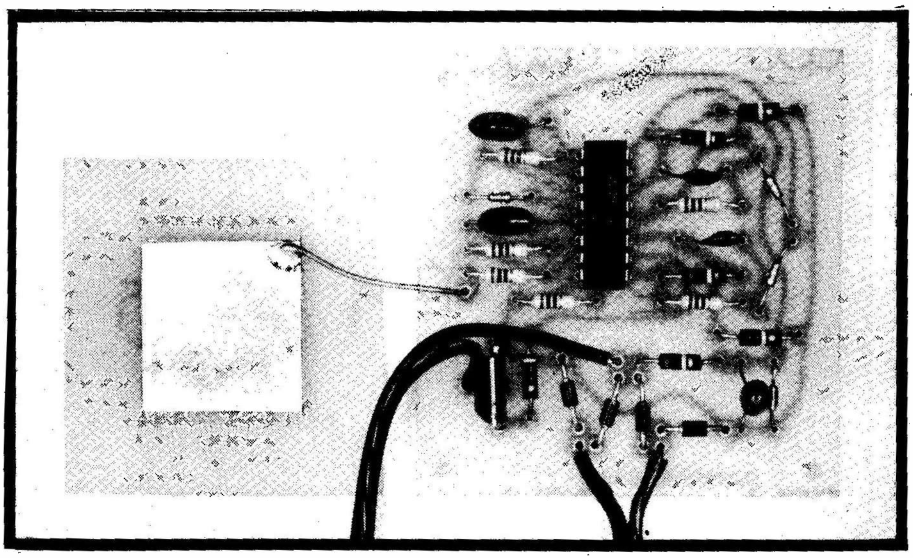
Initially a range of 500-25 000 ohms across the probe terminals was chosen as being correct for the application intended, based on tests plus a margin. For the 500 ohm case, therefore, 47 k + 50 = 6.2x, where x is the resistance Q1 base to supply negative. This produces x = 7661 ohms. Similarly for the 25 k case, 47 k + 25 k = 6.2x, so that x = 11613 ohms. This shows a variation in x of 11613 – 7661 = 3952 ohms. However, this is an awkward value, the nearest reasonable value being 5 k. Then 11613 – 5 k = 6613, the obvious choice for the fixed resistor being 6.8 k. Checking back then with these values, for 5 k + 6.8 k = 11.8 k, so that + 47 k = 73.16 k (11.8 x 6.2), so that the probe resistance is 73.16 k – 47 k = 26.16 k. For 6.8 k alone and the 5 k variable all out of circuit, the probe + 47 k = 42.16 k (6.8 x 6.2), giving a negative value for the probe resistance (42.16 – 47 = 4.84). Thus the chosen values provide for a probe variation of zero to 26.16 k ohms, slightly wider than required. Similar simple calculations will provide values suitable for any other range of probe values.

WATER TRIGGER APPLICATIONS

One of the circuits of Fig.1, less the probe connections, can be connected into the circuit of Fig.3 in place of the relay and protective diode. A resistor of about 1 k would also be needed in the common emitter lead of Q2, Q3 and Fig.2. This combination draws about 8-10 mA in the alarm condition.

However the most important application of the trigger circuit is as an automatic waterer. Consider the case of an indoor planter box. The probe will indicate water content in the soil and trigger the circuit at a preset point. The relay is used to operate a low-voltage water pump, such as an aquarium pump, to pump water from an available supply into the plant container. If the water is well distributed over the surface, for example using a meandering tube with many small holes, the soil moisture content will be increased fairly evenly until the probe decides the minimum level has been left behind. At this stage the circuit resets and awaits further transpiration and evaporation. ●

eti project 539



New 240V design offers toggle action and complete safety.

TOUCH SWITCH

TOUCH switches are fascinating devices and have been in use for many years in lift controls. The circuit used in lifts usually consists of a high-frequency oscillator which has a touch plate connected to the tuned circuit. When the plate is touched the additional capacitance introduced either detunes the oscillator thus changing the frequency, or couples the oscillation into the detector and switching circuitry. This approach, whilst effective, is very expensive and thus touch switches of this type are not widely used.

Most of the touch switches published in electronics magazines to date have required the sensing element actually to be touched — usually via a series resistor of about one megohm or higher. Such circuits rely on body resistance to activate the switch, and are therefore not safe for use in controlling devices operated on 240 Vac.

In the touch switch described in this project, it was specified that the action of the switch should be touch-on touch-off, and that no actual contact with the circuit be made (for safety reasons). These constraints led us to use a capacitive circuit. The touch plate is in effect a capacitor. When this plate is touched, the input of the first stage is capacitively referenced to earth, however as the supply rails to the control circuit are floating at rectified 240 Vac the 50 Hz waveform effectively appears at the input of the control circuit and initiates the switch action. The actual contact plate is a piece of single-sided printed-circuit board arranged so that the *non-copper side* is touched — the copper on the other side is connected to the control circuit. Thus a full 1.6 mm of insulation is always between the user and the circuitry at mains potential.

CONSTRUCTION

A touch switch may be constructed (and used) in many different ways. It may be mounted within the base of a lamp; fitted onto a conventional switch-plate to control overhead lights; or mounted in a piece of electronic equipment. It is however unlikely that the switch would be used as a separate unit and for that reason housing details have not been provided.

As stated above the touch plate is constructed from a piece of printed-circuit board as detailed in the drawing. The touch-plate need not be exactly as shown but can be any convenient shape or size. However make sure that the copper surface of the plate cannot touch any of the external metal surfaces and that it cannot be touched by the fingers. If the unit is to built into a lamp that has a plastic base a piece of aluminium foil may be glued to the *inner* surface of the base to act as the pickup plate.

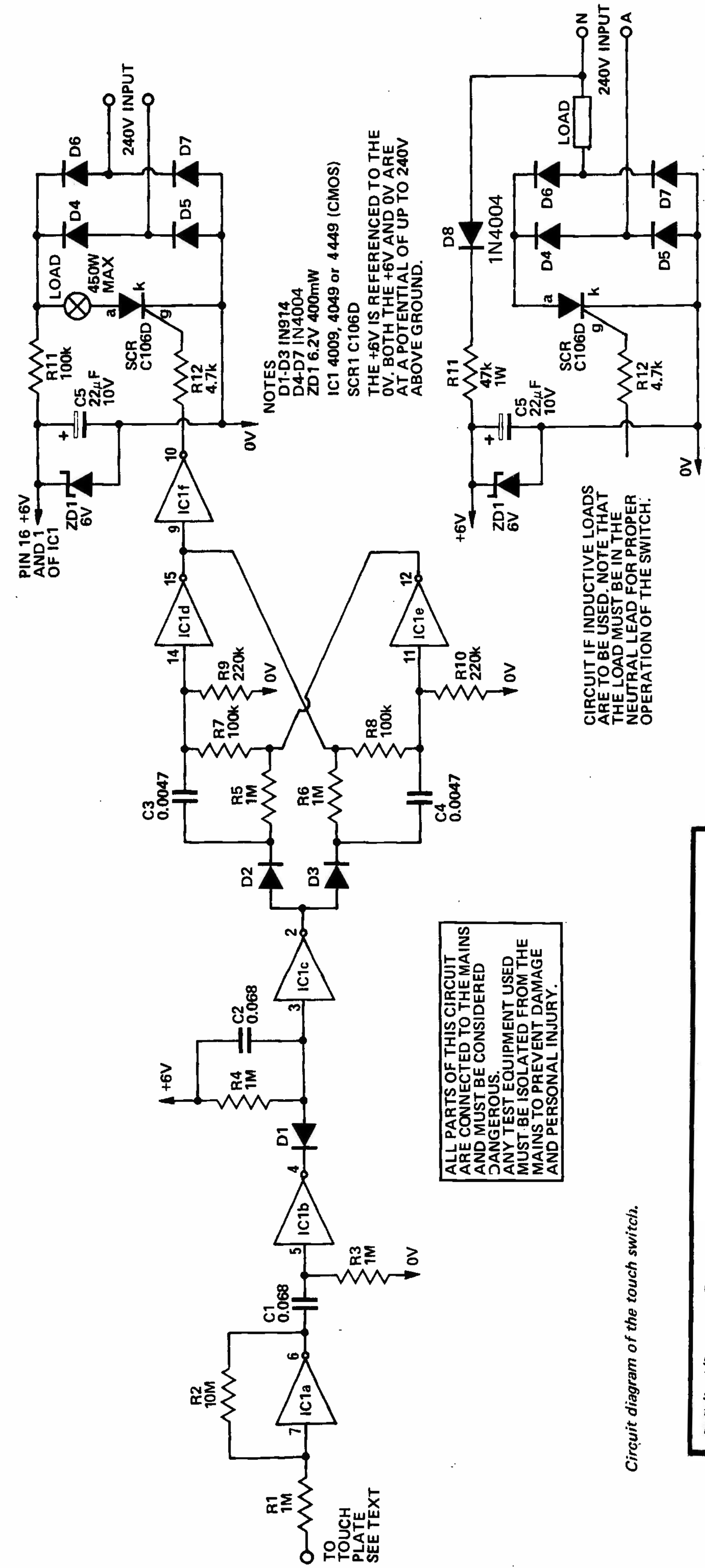
If the plate is too large or the lead connecting it to the circuit too long, stray capacitance to ground may be sufficient to prevent the switch operating. If the lead is more than about 50 mm long shielded cable should be used (shield connected to '0' volts not to ground). If a large plate is used the gain of the first stage should be reduced by changing the value of R2. (Try 3.3 M first and if this is not effective try 1 M).

The circuit given in the main circuit diagram supplies the load with pulsating dc and is therefore suitable to drive resistive loads (such as light bulbs) only. If an inducive load must be supplied the slightly more complex alternative circuit (shown in the insert) must be used. In this circuit the load must be inserted in the neutral lead if the switch is to operate correctly. Thus it is essential to ensure that the active and neutral are connected correctly. To make the changes required for inductive loads it is necessary to instal a link between D4/D6 and the anode of the SCR. The resistor R11 is removed from the board and D8 and the new R11 are glued to the board with epoxy cement.

SPECIFICATION

Mode of Operation	touch-on, touch-off
Triggering Mode	capacitance
Power	450 VA resistive
	450 VA inductive*

*alternative circuit for load.



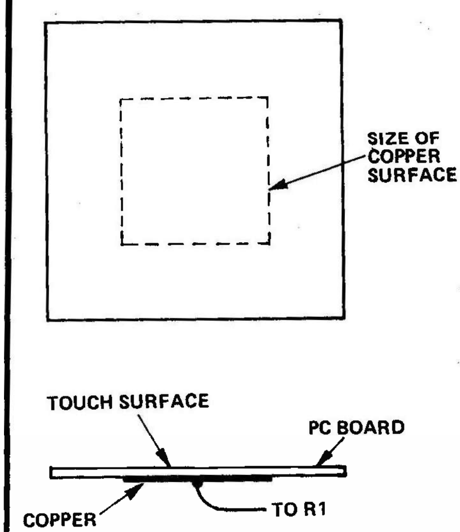
Circuit diagram of the touch switch.

PARTS LIST – ETI 539

R1,3,4,5,6	Resistor	1M	5% ½W
R2	"	10M	" "
R7,8,11	"	100k	" "
R9,10	"	220k	" "
R12	"	4.7k	" "
C1,2	Capacitor	0.068μF Polyester	
C3,4	"	0.0047μF Polyester	
C5	"	22μF 10V electro	
D1-D3	Diode	1N914 or similar	
D4-D7	"	EM404 or similar	
ZD1	Zener Diode	6.2V 400mW	
SCR	C106D		
PCB	ETI 539		

Case to suit

For inductive loads change R11 to 47k 1W add D8 — 1N4004



We constructed our touch plate from a 50 mm square piece of printed-circuit board. The board was etched to leave a 25 mm square section of copper in the centre. See text if different sized plate or long connecting lead is to be used.

HOW IT WORKS

POWER SUPPLY

The 240 Vac is rectified by diodes D4 to D7. The output of the diode bridge is then reduced, smoothed and regulated to 6 volts dc by R11, ZD1 and C5. The load is connected after the rectifier and has power switched to it via the silicon-controlled rectifier, SCR. Note particularly that the load is supplied with pulsating dc and therefore the type of load used with this circuit must be resistive, for example, an incandescent lamp. For inductive loads such as transformers etc, the load circuit must be modified as shown in the small diagram.

DETECTOR

The detector is formed by one section of a CMOS hex inverter, IC1a, in which the gain is set by the ratio of R2/R1. The touch plate is connected to the input of the detector and touching it effectively adds a capacitor to ground. However the '0' volt line (due to the diodes D4 to D7) when referenced to ground is effectively 50 Hz 240 volt rectified. The touch plate capacitance introduced therefore couples this waveform into the input of the detector and over-drives the amplifier so that the output is a 50 Hz squarewave. If the plate is not touched the capacitance is very much lower and hence the output of the amplifier is very much lower in level. The sensitivity may be altered by changing the value of R2 (lower value gives less sensitivity).

LEVEL SHIFTER

The output of IC1a is centred about 3 volts, and C1, R3 and IC1b are used to provide level shift such that the output of IC1b is normally high at +6 volts until the plate is touched. When the plate is touched the output of IC1b oscillates between +6V and 0 V at a 50 Hz rate. The hex-inverter IC has diodes internally which connect each input to ground. Thus these diodes prevent the inputs from being driven below −0.6 volts.

PULSE STRETCHER

The 50 Hz output from IC1b is not in a convenient form and must be converted into a signal which is only high and stays high whilst the plate is touched. This is performed by a pulse stretcher and inverter consisting of IC1c together with R4 and C2. The output of IC1c is normally low and goes high and stays high whilst ever the plate is touched.

FLIP FLOP

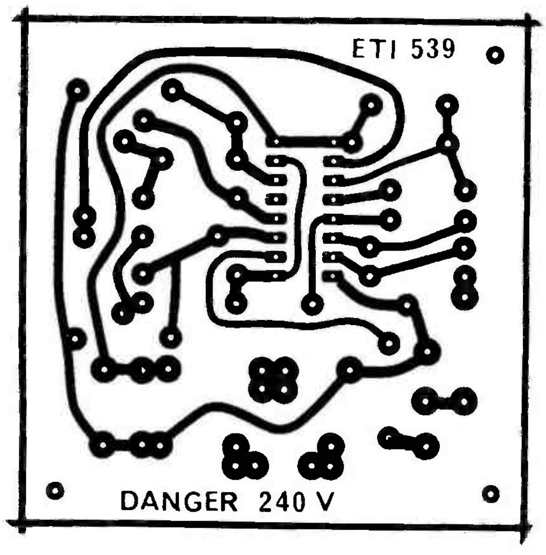
To meet our mode of operation requirement the circuit needs to be held on after the finger is removed from the plate and only switched off when the plate is touched a second time. Thus a toggle action is required and this is obtained by incorporating a flip flop formed by IC1d and IC1e. Cross coupling of gates normally provides an RS flip flop which may take up any state if both inputs are taken high together. For this reason the capacitors, resistors and diodes at the inputs to the flip flop are used to provide steering logic to ensure that correct toggle action is obtained.

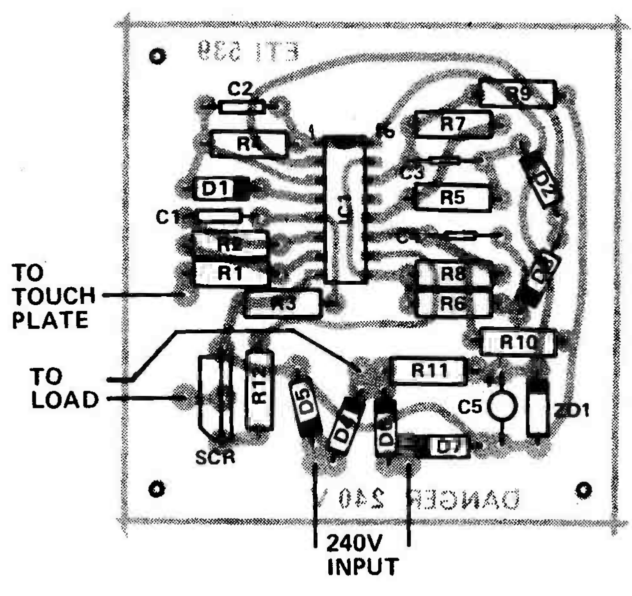
BUFFER

To prevent loading the flip flop, and because a spare section of the hex inverter is available, a buffer amplifier is inserted between the flip flop and the SCR. The SCR used is a C106D which is a sensitive gate type. This particular SCR will operate reliably with the 1 mA gate current provided. The SCR specified will be used – don't try substitutes.

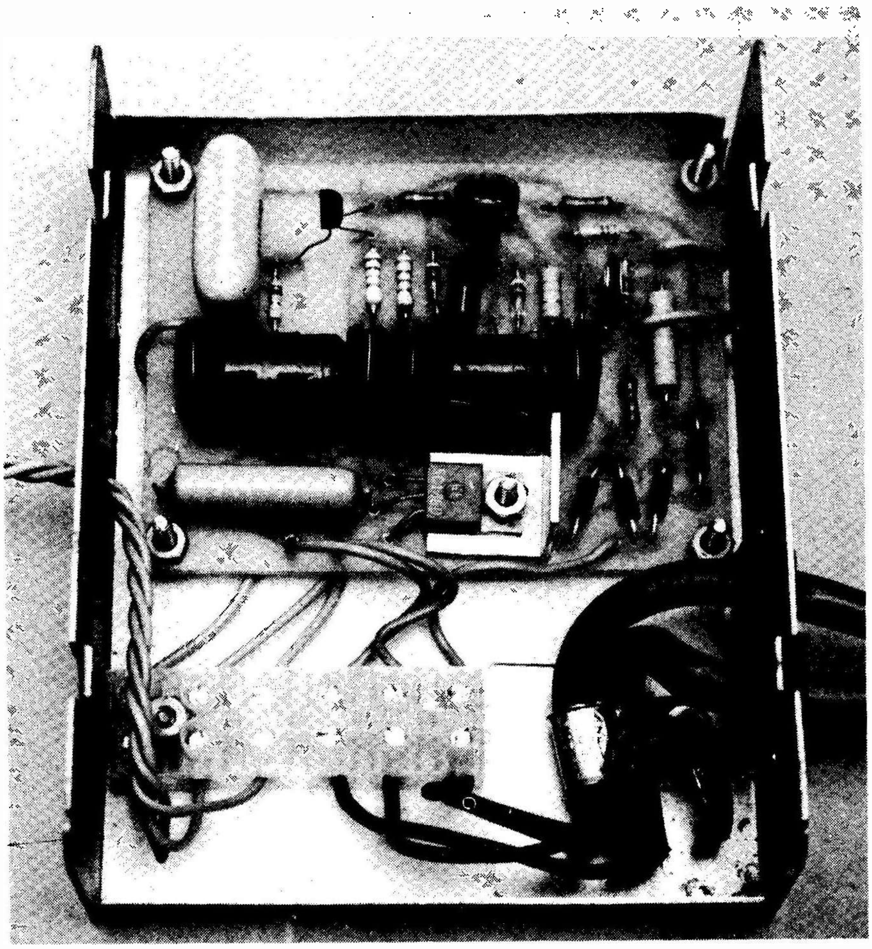
TOUCH SWITCH

Printed-circuit board layout for the touch switch. Full size 68 mm by 68 mm.





How the components are positioned on the board.



eti PROJECT

PUSH BUTTON DIMMER

Simple circuit allows light control from a number of locations.

MANY CIRCUITS for light dimmers have been published over the years (including some by us) which are of very simple construction, and which use a rotary potentiometer. Whilst such circuits are adequate in most respects — especially in terms of cost, there are some strong reasons for a more sophisticated dimming system.

The first objection to simple dimmers is that they usually have an unsightly knob by which light level is adjusted. A second objection is that the light level can only be adjusted from the position where the dimmer is mounted.

The dimmer described in this project can be operated from one or more remote positions — e.g. doors on opposite sides of a room, top and bottom of a long flight of stairs, bedside tables — or even from a control point beside your armchair.

The unit has an on/off switch and two (or more) sets of push buttons, one of which causes the light level to increase, smoothly from minimum to maximum in about three secs, and one which does the reverse. The adjustment may be stopped at any particular level, and that level will be maintained without change for periods up to 24 hours.

The dimmer will handle incandescent or fluorescent lamps up to 500 VA with the specified heat sink but, with a larger heat sink, may be used up to 1000 VA.

CONSTRUCTION

Wind the choke and transformer in accordance with the details provided in Tables 1 and 2. Be particularly careful to provide adequate insulation between the primary and secondary of the pulse transformers.

If a printed circuit board is used, construction will be considerably simplified. Mount all components on the board with the aid of the component overlay taking particular care with the orientation of diodes and transistors before soldering in position.

A small piece of aluminium (30 mm x 15 mm) bent at 90° in the centre of the long side, is used under the triac as a heatsink. The pulse transformer and the choke are mounted by means of rubber grommets and secured by tinned copper wire around the grommets and soldered into the holes provided.

After all components are soldered into place, and all external wires attached, the underside of the board should be washed with methylated spirits to remove any flux residue which could cause leakage.

The PC board should be mounted on spacers into an earthed metal box. A piece of insulation material, about 1 mm thick, should be positioned under the board to prevent any long component leads from touching the chassis.

A six-way terminal block should be used to connect all external wiring.

SETTING UP

All setting up, adjustments should be made using plastic, or well insulated tools. This circuit is live at mains potential and therefore dangerous to handle. BE EXTREMELY CAREFUL.

Potentiometer RV2 should be adjusted to obtain the desired minimum light level setting, (with the down button held). Adjust potentiometer RV1 for maximum light level (with the up button held) to just past the point where maximum light level is obtained.

If the lamp load is fluorescent more care must be taken with these adjustments. Additionally the setting up must be redone if the fluorescent loading is changed.

When adjusting the maximum light point on a fluorescent load, slowly increase the light level until the lights just start to flicker. Then turn RV1 back until there is just a noticeable drop in light level. This increased setting difficulty is due to the inductive nature of fluorescent loads.

If the required minimum light level cannot be obtained within the range of RV2, increasing R6 will provide lower light level range, and decreasing R6 will provide a higher level range.

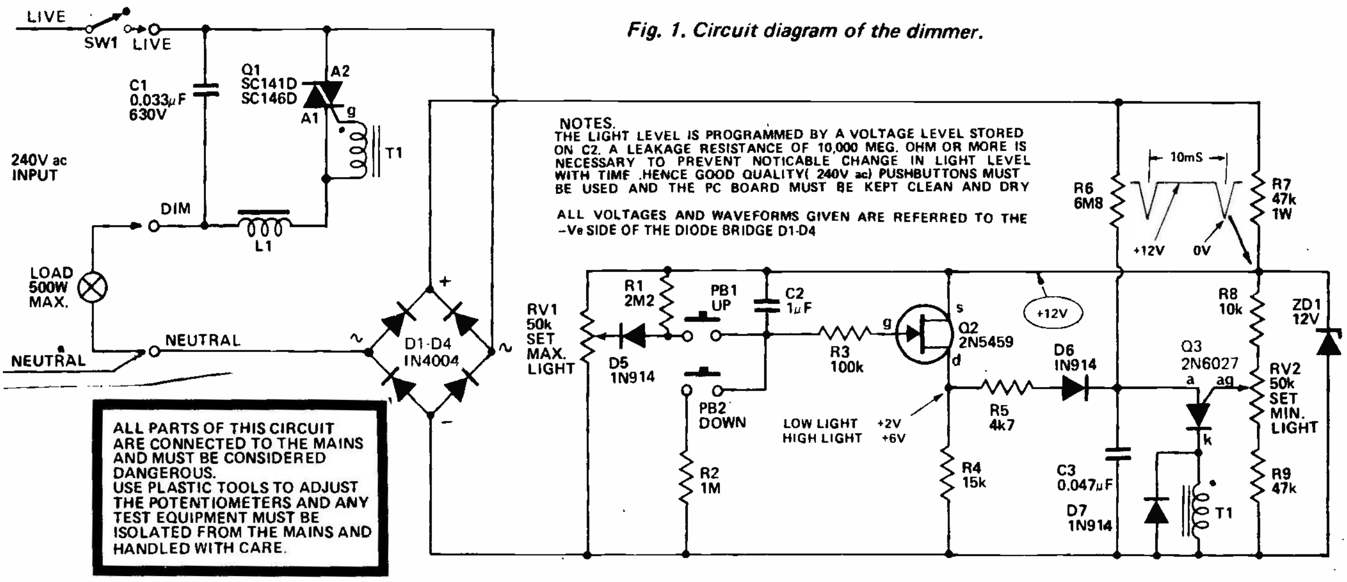
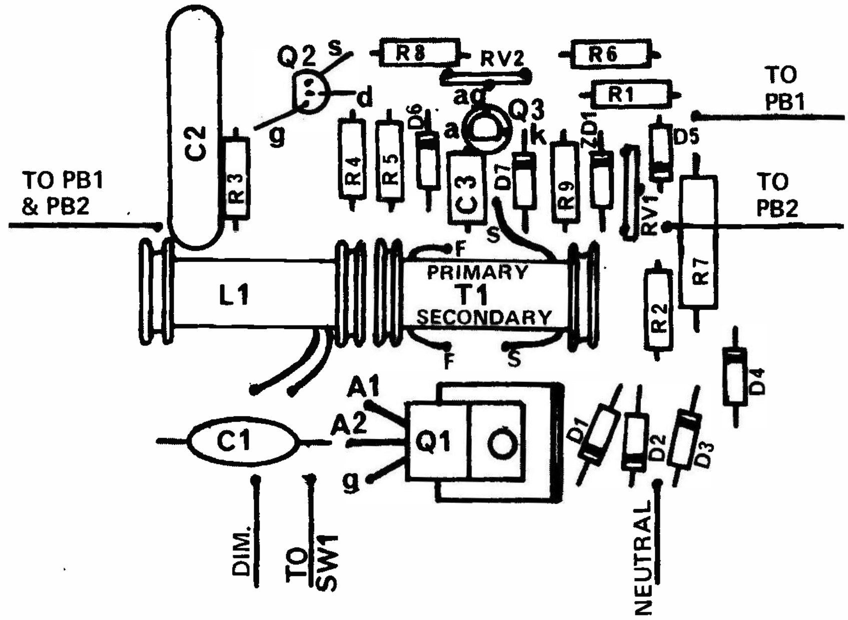
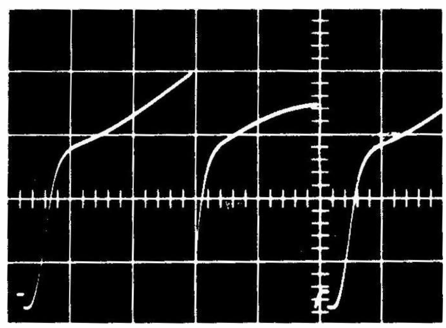


Fig. 1. Circuit diagram of the dimmer.



◀ *Fig. 2. Component overlay.*



Ramp and pedestal charging (dimmer set to provide about half light output).

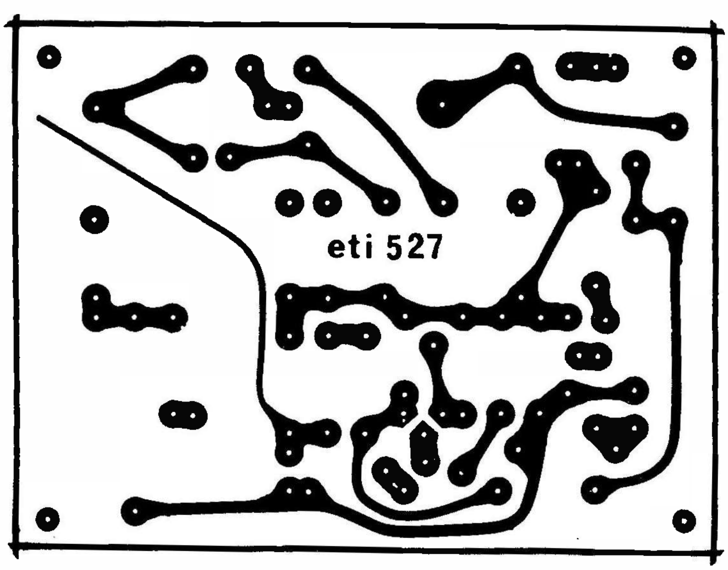


Fig. 3. Printed circuit board layout for the dimmer. Full size.

PARTS LIST

R5	Resistor	4 k7	½ W	5%
R8	"	10 k	"	"
R4	"	15 k	"	"
R9	"	47 k	"	"
R7	"	47 k	1 W	"
R3	"	100 k	½ W	"
R2	"	1 M	"	"
R1	"	2 M2	"	"
R6	"	6 M 8	"	"

RV1,2 Potentiometer 50 k trim type VSU or similar

C1	Capacitor	0.033 μF 630V polyester
C2	"	1 μF 200 V polyester
C3	"	0.047 μF polyester

D1-D4 Diode IN4004 or sim.
D5,6,7 Diode IN914 or similar
ZD1 Zener Diode BZX70C 12 or sim.

Q1	Triac	SC141D, SC146D,
Q2	FET	2N5458, 2N5459 or sim.
Q3	PUT	2N6027 or similar

L1 Choke see Table 1.
T1 Pulse transformer see Table 2.

PC board ETI 527.

6-way terminal block (240 V type)
Metal box
2 pushbutton switches, front plate, power switch

PUSH BUTTON DIMMER

HOW IT WORKS

As with most modern dimmers, we have used a phase-controlled triac for power control.

The triac, which may be regarded as a switch, is turned on by a pulse at a pre-determined point in each half cycle, and automatically turns off at the end of each half cycle.

Most conventional dimmers use a simple RC and diac system to generate the trigger pulse, but this dimmer is in effect voltage controlled. The 240 volt ac mains is rectified by D1-D4. This full-wave rectified waveform is clipped at 12 volts by R7 and ZD1. As no filtering is used, this voltage will fall to zero over the last half millisecond of each half cycle.

To provide the correct timing, and the energy required to fire the triac, a programmable unijunction transistor (P.U.T.) Q3 is used together with capacitor C3. A PUT also acts like a switch in the following manner. If the anode (a) voltage is higher than the anode-gate voltage (ag), the anode to cathode (k) path becomes effectively a short circuit.

The voltage on the anode-gate, is set by RV2 and, will be between 5 and 10 volts. Capacitor C3 is charged, via R6, and when the voltage across it exceeds that on terminal ag, the P.U.T. fires discharging C3 through the primary of pulse transformer T1. This induces a pulse in the secondary of T1 which gates on the triac.

As the voltage supply to R6 is unsmoothed the rise of voltage on capacitor C3 will follow what is called a cosine modified ramp. This gives a more linear change in light level versus control voltage.

Once C3 is discharged the P.U.T. may either stay on or turn off depending on the individual device. If it turns off it may well fire again if C3 charges quickly enough, but the operation of the dimmer is unaffected by either situation.

If C3 does not charge to the ag voltage before the end of the half cycle, the ag voltage will fall at the end of the cycle and the PUT will fire. This is an essential part of the operation as it ensures synchronization of the timing to the mains. It is for this very reason that the 12 volt supply is not filtered.

To control the charge rate of C3 (and hence the timing of the turn on of the triac within each half cycle) an auxiliary timing network of R5 and D6 is used. As the value of R5 is much less than that of R6, C3 would charge much quicker via this path. If we set the input to R5 at, say, 5 volts, the capacitor C3 would charge to about 4.5 volts quickly and then at the slower rate set by R6. This is called a ramp and pedestal type of charging.

As a result of the initial start given by R5, the PUT would fire earlier, and the triac will turn on earlier, delivering more power to the load. Hence by controlling the voltage at the input of R5 we may control the output power.

Capacitor C2 is used as a memory device. It can be discharged by R1 via PB1 (up) or charged by R2 via PB2 (down). The capacitor C2 is connected from the positive side of the 12 volt supply and hence when the capacitor is discharged the voltage actually goes up with respect to the zero volt line.

Diode D5 is used to prevent the voltage rising above that set by RV1. The capacitor C2 is connected to the input of Q2 by R3. Transistor Q2 is a field effect transistor FET which has a very high input impedance. Hence the input current is virtually zero and the source tracks the gate voltage but at several volts level. (The exact voltage difference depends on the individual FET).

Therefore if the gate voltage is changed, ie, the voltage on C2, the voltage applied to R5 will also vary. By pressing either PB1 or PB2 the capacitor voltage and hence the triac firing point and the power delivered to the load may be varied.

Upon releasing the push buttons the capacitor will 'hold' this voltage – EVEN WHEN THE POWER IS SWITCHED OFF – for extended periods of time. The memory time is dependent on a number of factors as listed below.

1. A capacitor with a leakage resistance in excess of 100,000 megohm is required. Use a good quality capacitor, preferably rated at 200 volts. If necessary try different brands.
2. The pushbutton switch should be rated for 240 Vac operation. These types have greater separation and hence insulation between the contacts. By physically disconnecting the pushbutton it is easy to determine whether this is a cause of low memory times.
3. Leakage across the PC board could be a problem. It will be noticed that there is a track running from the source of Q2 which appears to go nowhere. This is a guard line to prevent leakage from high voltage components. If you are using different construction method make the junctions of R3 and Q2 and of R3 and C2 by mid air joints or by good quality ceramic standoffs.
4. The FET itself does have a finite input resistance. We tried many FETs without finding any that would not work. Nevertheless do not overlook this possibility.

The dimmer can be controlled from any number of stations simply by paralleling sets of pushbuttons. No damage will result from pressing both up and down buttons at the same time. However adding many stations increases the likelihood of leakage and consequent loss of memory time. The dimmer should be mounted in a dry dust-free position – as should the pushbutton. Do *not* try to use the dimmer or push buttons in a bathroom or kitchen as moisture will render the memory virtually useless.

TABLE I
CHOKE WINDING DATA

CORE
30mm long piece of (3/8" dia.) ferrite aerial rod. (see main text).

WINDING
40 turns 0.63mm dia (26 swg) wound as two layers, each 20 turns, close wound using the centre 15 mm of the core only.

INSULATION
Use two layers plastic insulation tape over complete winding.

MOUNTING
Use a rubber grommet (3/8" I.D.) over each end and join to pc board using tinned copper wire in the holes provided.

TABLE II
PULSE TRANSFORMER WINDING DATA

T1
CORE
30mm long piece of (3/8" dia.) ferrite aerial rod.

PRIMARY
30 turns 0.4mm dia (30 swg) close wound on the centre 15 mm of the core.

INSULATION
Use two layers plastic insulation tape over primary winding.

SECONDARY
30 turns 0.4mm dia (30 swg) close wound on the centre 15 mm of the core. Bring wire out on the opposite side of the core to the primary.

INSULATION
Use two layers of plastic insulation tape over complete winding.

MOUNTING
Use a rubber grommet (3/8" dia.) over each end and join to pc board using tinned copper wire in the holes provided.

Anne E. Crump looks at the development of dice and suggests a technological innovation—

ELECTRONIC DICE

THE CUBICAL DIE is the oldest game known to man. The dice our ancestors rolled more than two thousand years ago had pretty well the same configuration of dots as the ones we use today. Even before he gambled with them, primitive man considered them to be magical devices, and by their fall he divined the future.

It wasn't very long, of course, before he cottoned on to the possibility of making special dice with which he could cheat! We have found crooked dice along with the treasures of the tombs of the ancient Egyptians, which leads to at least two intriguing possibilities. Did they intend going on into the next world armed with slightly more than a fair sporting chance, or did they take their dice along for old times sake, having used them to acquire all that treasure in the first place? On either count, that's really no way to get to heaven!

But times have changed. Modern man produces hand-made "perfect" dice for his casinos. Sawn from extruded plastic rods and produced to a tolerance of 1/5,000in, these perfect dice have spots drilled approximately 17/1,000in into each face and filled with a paint of the exact same weight as the plastic which has been removed. Buffed and polished so that no recesses remain, they are then ready for the gambling tables of the world.

Now, after 2,000 years, electronic technology has caught up with the oldest game in the world, and electronic dice have been proven to be even more random than their predecessors. The dice described in this article has been designed with minimisation of cost in mind.

The complete circuit uses 74 series integrated circuits only, plus a few discrete components, and is divided into three main areas, i.e. the pulse generator, the pulse counter, and the final decoding electronics.

THE PULSE COUNTER

The Pulse Counter is a simple arrangement utilising two 2-input NAND gates with the output of the second gate connected to the inputs of the first — a straight forward and convenient way of producing a low-cost oscillator. The frequency of oscillation is determined by the capacitor and resistance values selected, the actual frequency being relatively unimportant so long as it is as high as possible in order to avoid any possibility of the user being able to predetermine his "throw." A figure of 120kHz is suitable. The oscillator output is connected directly to a 7492 counter, which is used in the "divide by six" mode, and in this way a full scan of counts one to six occurs 20,000 times each second.

THE DECODER

The BCD output of the 7492 is connected to an arrangement of gates which decode the BCD information into suitable drive signals for the LEDs. The decoding arrangements and the diode drive combination have been derived in such a way that the final illuminated display appears in the same dot configuration as a conventional die. The Boolean equations for the gating system are shown on the circuit diagram.

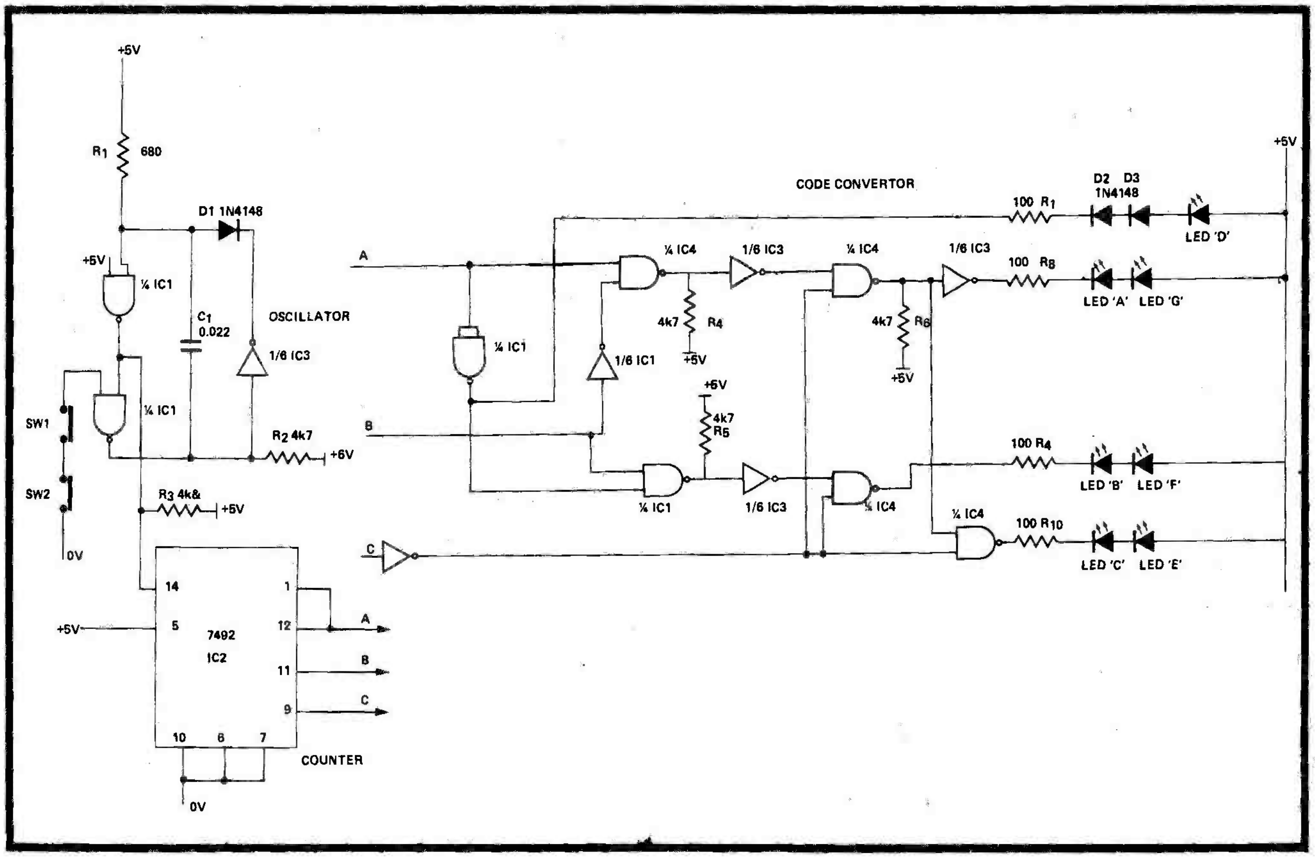
THE PULSE GENERATOR

In order to obtain the maximum degree of randomness, it is essential that the dwell time should be equal on each of the six counts. The main factors affecting these requirements are the stability of the oscillator and also the spread of output reactances around the counter. If, for example, the frequency of the oscillator shifts during the one to six count cycle, the length of time spent on some of the counts will be greater, and the "throw" will therefore be biased in favour of those numbers. In practice, however, the simple oscillator shown gives adequate stability over the significant period of six pulses, long-term drift being of little importance. A further important point to be borne in mind is the parasitic reactances around the counter area, which could also be instrumental in biasing the "throw," and a good layout of the final unit is therefore essential. A ready-made printed circuit board, complete with assembly and testing instructions, is currently available, and its use is recommended.

The actual degree of randomness of the die is easily obtained by pressing the operating button a number of times, and recording the amount of times each number appears. In order to get a reasonable accurate picture, it is necessary to record at least 3,000 "throws," from which an average should be worked out. The results obtained are excellent, and in tests have shown the random distribution figures of the electronic dice to be in most instances superior to that of the conventional dice. In any group of 10 or 20 "throws" there will always tend to be a predominance of one or two numbers which does tend to be discouraging when first encountered. It is therefore essential to remember that this also happens when using ordinary dice!

CONSTRUCTION

There are a number of ways in which an electronic die can be activated. The method chosen for the particular unit described here is for the unit to display the last throw until play resumes and the operating switch is pressed again. The last "throw" remains clearly visible for all to see, this avoiding any danger of arguments which might arise if the "throw" was only displayed while the operator's finger remained on the button. Two microswitches



LED MATRIX

E A
B D F
G C

Physical placement to simulate dot format on ordinary dice.

Fig. 2.

	1	2	3	4	5	6
A:	H	L	H	L	H	L
B:	L	L	L	L	H	H
C:	L	H	H	L	L	L

Fig. 3. Logic states at A,B & C for each number.

are shown on this circuit. One is sufficient, but it is useful to have a number of switches in series so that people at different parts of the table can operate the unit by pushing a local button.

Power for the circuit is provided by four 1½ volt transistor radio cells, and the randomness of the counter is unimpaired so long as the brightness of the LEDs is reasonable. As soon as the LEDs begin to dim, the batteries should be changed immediately, as deterioration in the random quality of the circuitry may occur. It is important that the battery supply should not be allowed to fall below 4.5V or to exceed 7V. The voltage adversly affects the random operation and the higher voltage is the maximum safe ceiling at which TTL can be run. With LEDs and solid-state electronics used throughout, the reliability of the dice is excellent, and the switches should be first to wear out.

The finished product is very much to the design of the individual himself. Double or even treble dice, operating from a single switch or two or three individual buttons, can be made. A buzzer could be added, to be triggered each time a single, double or treble six is "thrown." This is easily done by adding the necessary gating to the outputs of the A, B and C outputs of the 7492 so that the buzzer is activated each time the appropriate combination appears. Some form of sound, even if only the click of the microswitch, is essential in order to prove to other players that the button has actually been pressed, and a further improvement could be a brief audible tone emanating from the dice when activated.

It is important to note that in addition to their obvious leisure uses, electronic dice have other varied applications, particularly where statistical calculations are involved, an excellent example being their use for quality assurance in factories. Here, by their use, a truly random selection of the production run of a factory can be obtained for testing purposes. Perhaps if the Romans had had electronic dice, human nature being as it is, the selection of Christians going to the lions would have been a trifle more random? And Nero would still have fiddled while Rome burned — but chances are he'd have been fiddling with an electronic die! ●

PARTS LIST

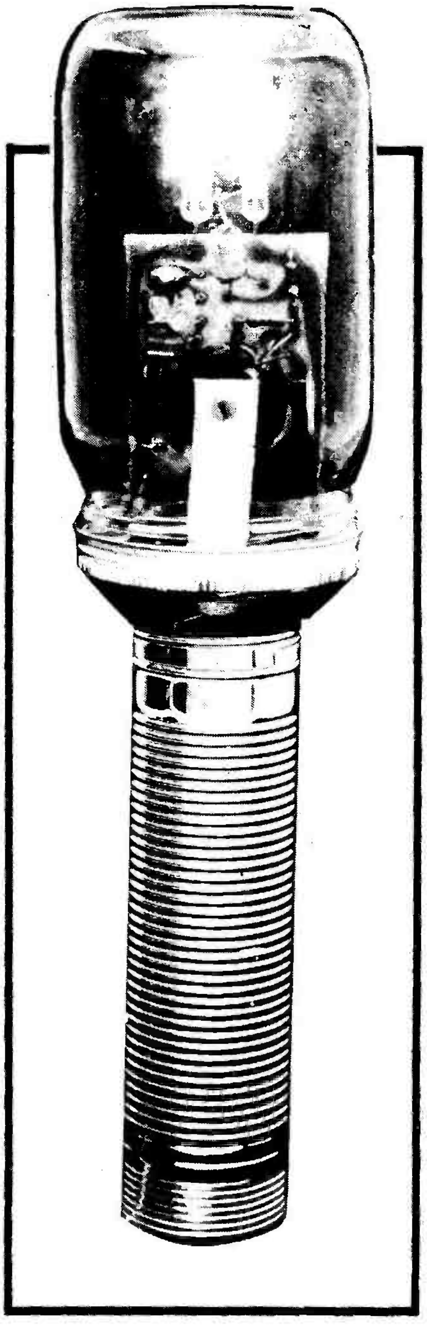
R1	Resistor	680Ω
R2–R6	"	4k7*
R7–R10	"	100Ω
C1	Capacitor	0.022μF
D1,D2,D3	Diodes	1N4148
LED 'A'–LED 'G'		TIL409
IC1, IC4	7400 or 7403*	
IC2	7492	
IC3	7404	
SW1, SW2	microswitches	

* NB: R2–R6 are not used with the 7400 gates — only with open – collector gates, such as 7403.

High Power Beacon

Truly portable battery-operated unit generates immensely bright flashes about fifty times a minute for up to 20 hours.

ETI project 240



A COMPLETELY PORTABLE emergency flash unit has many applications — particularly as a rescue aid when boating or hiking in isolated areas.

For such purposes it is essential that the unit be self-contained, compact and light in weight. It must above all produce a brilliant powerful flash that will attract attention over long distances, yet be capable of operating for at least eight hours from a couple of torch batteries.

The two requirements of high power and battery economy preclude the use of incandescent globes. However a xenon flash tube is capable of producing about fifty 0.6 joule flashes per minute for 20 hours or so if energised — via suitable circuitry — from a pair of alkaline "D" cells.

CONSTRUCTION

This may take any number of suitable forms. One approach is shown in the drawings and photos in this feature. No doubt readers will be able to construct individual housings to suit their own requirements.

Our unit was based on a metal-cased torch powered by two "D" cells. We discarded the torch globe and reflector but retained the switch mechanism. Regardless of the form of housing, construction should be based on the printed circuit board shown. All components should be mounted on the board as shown in the overlay drawing taking care that the diode, SCR, power transistor and pulse transformer are the correct way round.

The trigger lead of the pulse transformer is connected to a spiral of copper wire wound around the body of the flash tube to ensure reliable triggering. The inverter transformer is mounted to the board with a 4 BA or similar screw. This also secures the special bracket that contacts the positive terminal of the battery. This bracket is made from a piece of 18 gauge aluminium as shown in the side view diagram. The brass strip in the torch housing which normally makes contact with the reflector is soldered to the large pad provided for this purpose. This connection, as well as forming the negative battery connection, also holds the board down into the torch body.

We discarded the torch glass and the threaded flange which retains the glass, trimmed back the torch housing a little with tin snips, and then soldered the lid of a jam jar to the torch housing. The jar lid had previously had a hole cut through it to allow the electronics to protrude through into the jar. The jar should be kept over the unit whenever it is being operated as some parts of the circuit are at 400 volts or so and a nasty shock could be received.

The capacitor used for C1 is not rated at 300 V but has been found to be entirely suitable for such intermittent pulse operation. A capacitor rated at the full voltage would not only be much bigger and much more expensive, but would not add anything in the way of reliability.

PARTS LIST – ETI 240

Resistors				
R1,2*	–	220	½W	5%
R3,4	–	2M2	"	"
R5	–	10 k	"	"
Capacitors				
C1	–	10 μF	250 V polyester	
C2	–	0.1 μF	200 V	
Transistor				
Q1	–	TIP 3055		
Diode				
D1	1N4008			
SCR1	C106D			

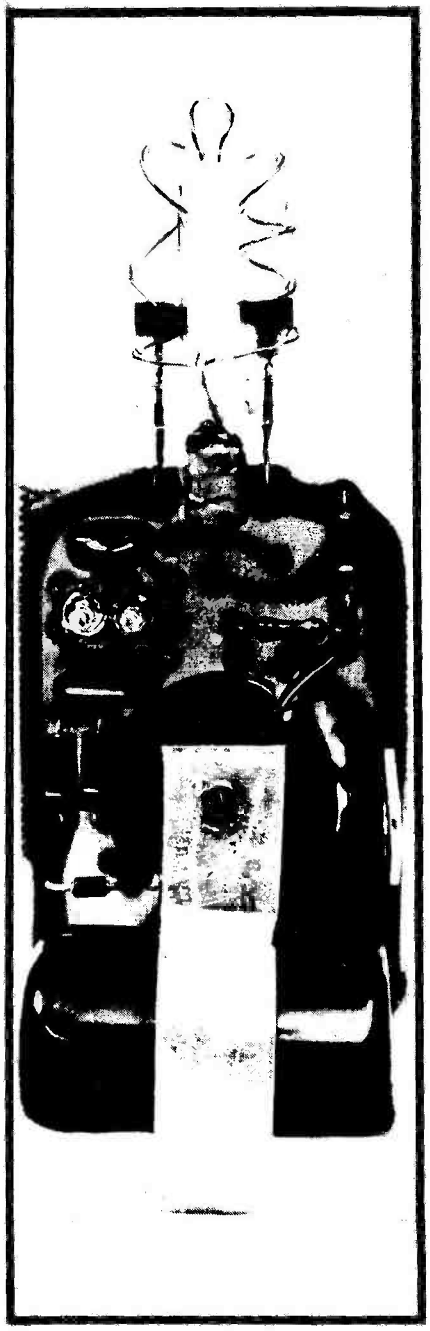
Transformer
T1 See Table 1
T2 See Table 1

LP1, LP2, Neon Lamps NE2 (75 v)
LP3 Flash Tube (see Table 1)

PC Board ETI 240

Torch, Battery etc.

* For 6v operation change R1 to 470 ohm.



HOW IT WORKS – ETI 240

The flash tube requires about 300 to 350 volts to supply the flash energy, and about 4000 volts to trigger it into conduction. The 300 volts is generated from a three-volt battery supply via a blocking oscillator. The oscillator works as follows.

On switch-on the transistor Q1 is biased on by R1 and R2 and a small voltage is generated across the primary of transformer T1. Due to the action of the transformer a voltage is induced in the feedback winding of the transformer which turns on Q1 hard. The current in the primary therefore increases sharply until the transformer core-material saturates. At this time normal transformer action stops, the feedback voltage disappears and the transistor turns off. The polarity of the voltage on the primary reverses and the energy stored in the core must be dissipated. In effect the energy is dumped into capacitor C1 via the diode D1 causing C1 to change to the 300 volts or so required. If the capacitor was not present the voltage on the collector of the transistor would be high (60 volts or more) and the secondary voltage would be well over 1000 volts. Therefore it is essential that the oscillator never be run without the load connected. It is also essential that the polarity of the windings be correct as marked on the circuit diagram (PS for primary start etc).

When the energy in the core has been dumped into C1 the transistor turns on again and the cycle is repeated. The repetition rate depends on the voltage across C1 but is typically within the range 8 to 15 kHz.

When the voltage across C1 reaches 300 to 350 volts the voltage across the scr is about 150 volts and at this point the two neon lamps conduct thus triggering the 'SCR. The SCR now discharges C2 via the primary of the pulse transformer thus generating a pulse of about 4000 volts amplitude on the secondary. The pulse is applied to the trigger electrode of the xenon tube causing it to strike. The flash tube then discharges capacitor C1 in about 10 microseconds giving a very intense and high-speed flash of light. The peak current in the flash tube is about 350 amps.

The SCR turns off automatically due to ringing of the pulse transformer and the low amount of current available through R3.

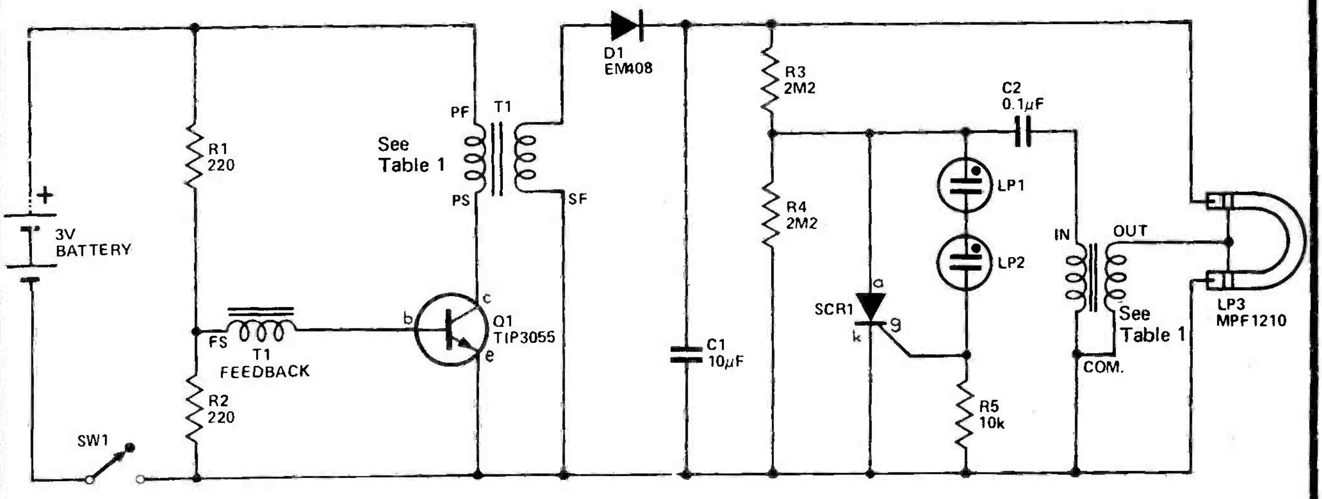


Fig. 1. Circuit diagram of the portable emergency flash.

High Power Beacon

TABLE 1

Winding details transformer T1.

CORE	FX2240 (2 halves) plus single section bobbin to suit
SECONDARY (wound first)	see below
PRIMARY	4 turns 0.5 mm wire (or two 0.315 mm in parallel)
FEEDBACK	4 turns 0.315 mm wire

Mark the start of all windings clearly as polarity is important
Add a layer of Sellotape over the secondary for insulation.
Note that for six volt operation primary should be wound with eight turns of 0.315 mm.

With Philips 126048 or MPF1210 the TR-4KN trigger transformer should be used, but with the Tandy 272 1145 the secondary of T1 should be reduced to 110 turns and the matching trigger transformer 272 1146 used.

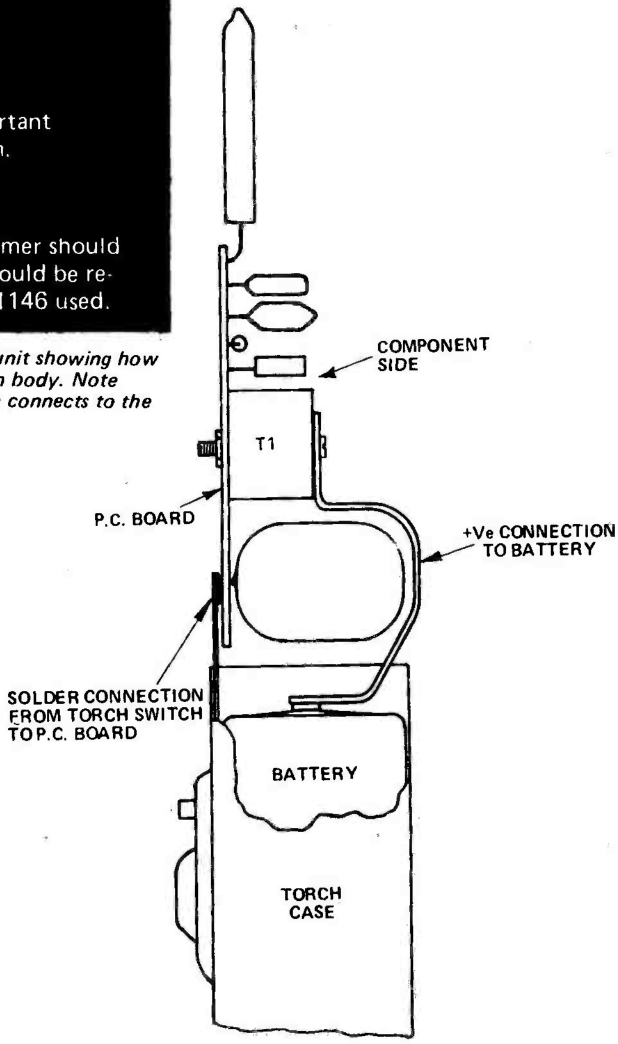


Fig. 3. Side view of the flash unit showing how board is secured into the torch body. Note particularly the bracket which connects to the battery positive terminal.

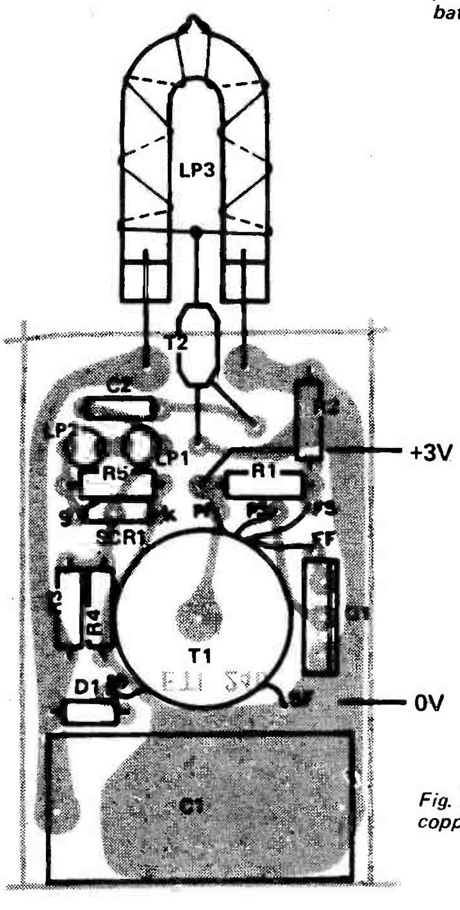


Fig. 2. Component overlay. Note copper wire spiral around flash tube.

SPECIFICATION ETI 240

INPUT	
Voltage	3 volts (nominal)
Current	400 to 450 mA at 3 volts
Power	1.25 watts
OUTPUT POWER	0.6 joules/flash
FLASH RATE	1.2 seconds per flash typical
EXPECTED BATTERY LIFE (2 D size cells)	
Alkaline	20 hours
Normal	8 hours
Nickel cadmium	10 hours

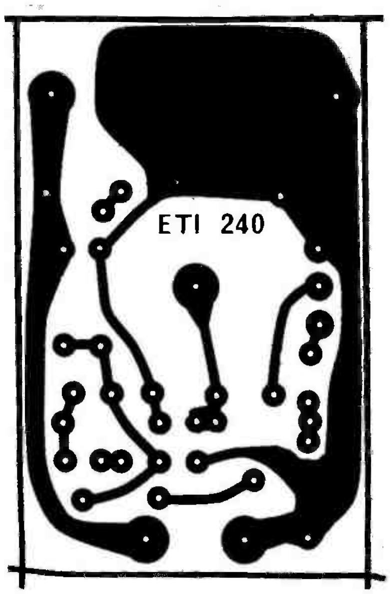
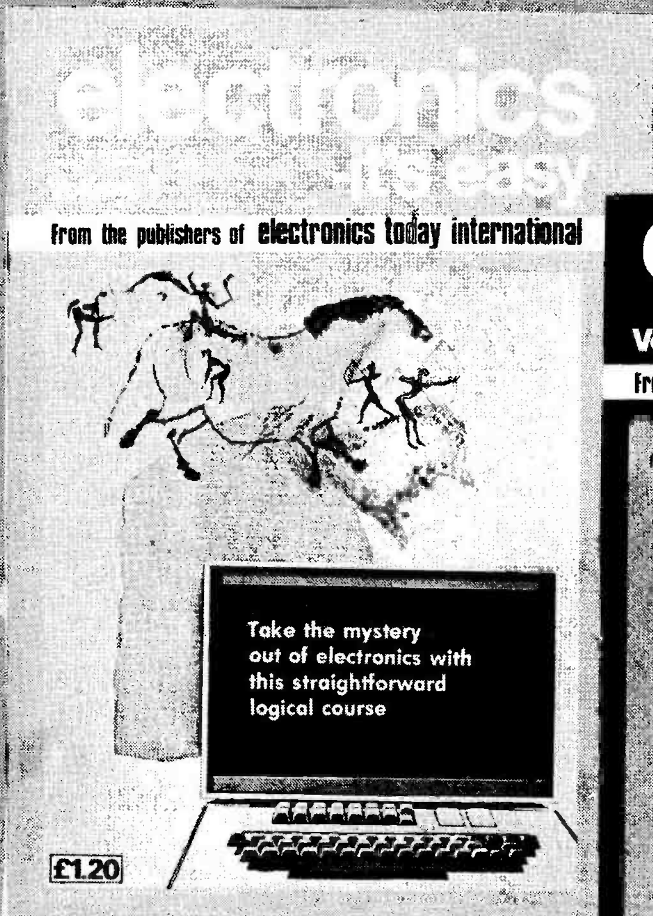
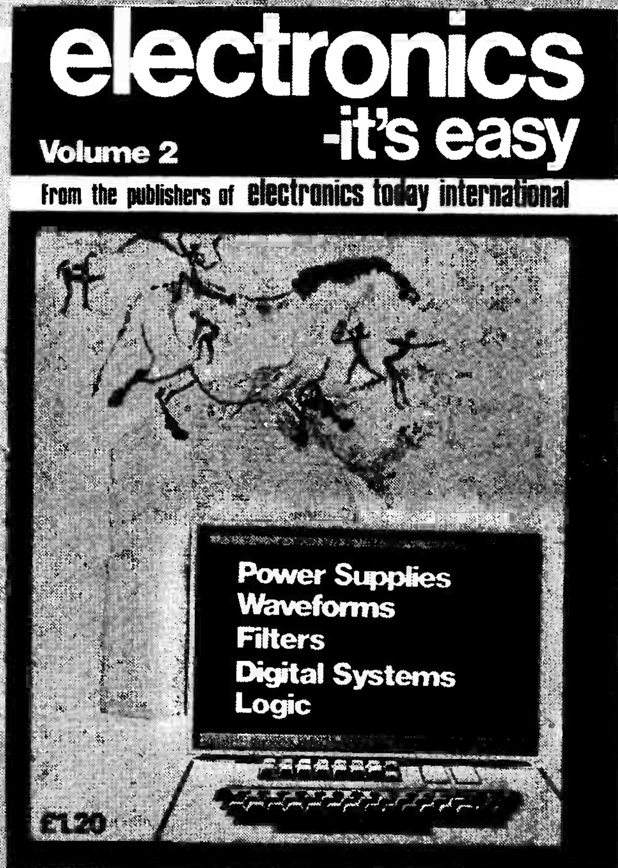


Fig. 4. Printed-circuit layout for the flash. Full size 73 x 47 mm.

BY POPULAR DEMAND





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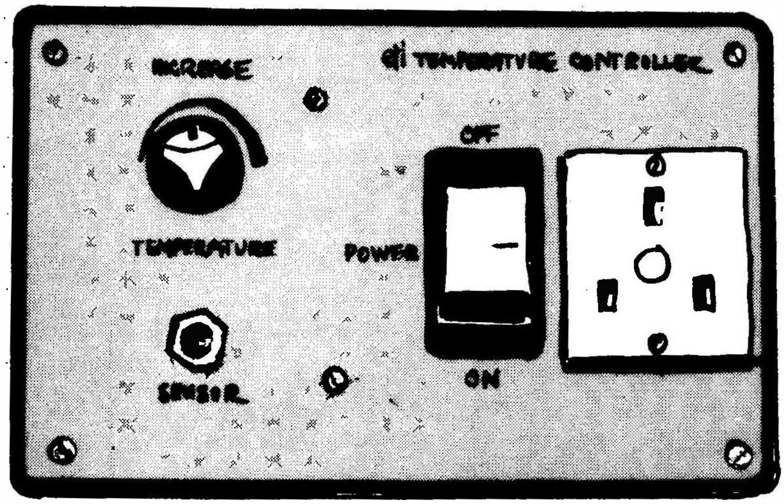
TEMPERATURE CONTROLLERS



Three temperature controls — phase control, zero crossing (on/off), zero crossing proportional.

MANY scientific experiments depend upon the maintenance of a stable temperature — often, as with pathological specimens, over long periods of time.

Even the cheapest of useable laboratory ovens and water baths must therefore incorporate a controller capable of maintaining temperatures constant to better than 1°C — in fact many will better this by a factor of at least two.

Other applications of temperature controllers include processing of colour film on an industrial scale where large quantities of water must be held to close temperature limits, maintaining air temperature constant in chicken hatching or even just controlling a room heater in the home.

The accuracy required and the heating power necessary will depend very much on the application, and thus there is no such thing as a universal temperature controller. In this article we describe three different temperature controllers which will cover the majority of applications. They are all designed primarily for use with a thermistor as the sensor and all may be constructed on the one basic printed circuit board. They have been specifically designed to operate with an isolated thermistor thus simplifying installation and minimizing risk of shock.

CONTROL METHODS

Temperature controllers may be of two basic types, simple ON/OFF control and proportional control. In the simple ON/OFF controller the heater is ON when the temperature is below the set point, and OFF when the temperature is above the set point.

Unlike the ON/OFF system where full power is applied until the set temperature is reached, proportional control continuously varies the power applied to the heating element (over a small range known as the proportional band see Fig. 1) by an amount depending upon the deviation of the actual temperature from the required temperature.

Solid state controllers — apart from having either ON/OFF or proportional control — may be categorized as using either phase control, or zero-voltage switching techniques.

PHASE CONTROL

Phase control is a technique used to control the average power input to a load by varying the time during which current is allowed to flow in each half cycle of mains supply. This is possible by using a triac (or back to back SCRs) between the load and the mains supply. A triac may be triggered into conduction by a pulse on its gate at any time during the half cycle, and then remains conducting for the remainder of the half cycle. Thus by controlling the time at which the trigger pulse occurs, with respect to the commencement of the half cycle, we may set the power input to the load at any desired level. This is illustrated in Fig. 2.

This type of control, although inherently suitable for proportional control applications, generates large amounts of radio interference, primarily at low and medium frequencies (up to 3 MHz). It seriously affects long and medium wave radio transmissions and may also interfere with audio equipment.

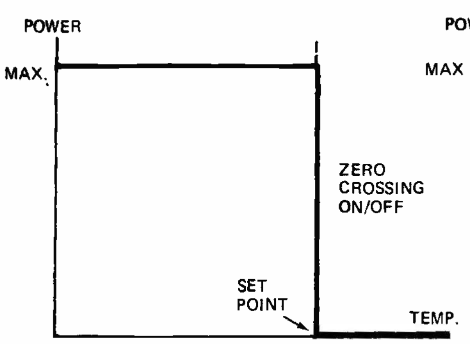
Whilst the extent of RFI may be reduced by filtering, the size of chokes required for large loads — such as heating systems — becomes excessive.

Phase control also introduces another problem — that of bad power factor. This is difficult to compensate for as the power factor changes with control setting. Some supply authorities object to this quite strongly, and others ban phase control completely.

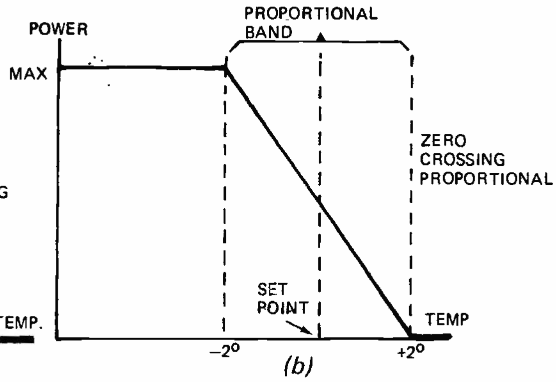
The use of phase control should therefore be restricted to light-load applications requiring only a few hundred watts, even though potentially it is the best control system of all.

ZERO VOLTAGE SWITCHING

Zero voltage switching overcomes most of the problems inherent in phase control systems. The technique differs from phase control in that the supply is switched to the load *only* as the ac waveform passes through zero, eliminating RFI.



(a)



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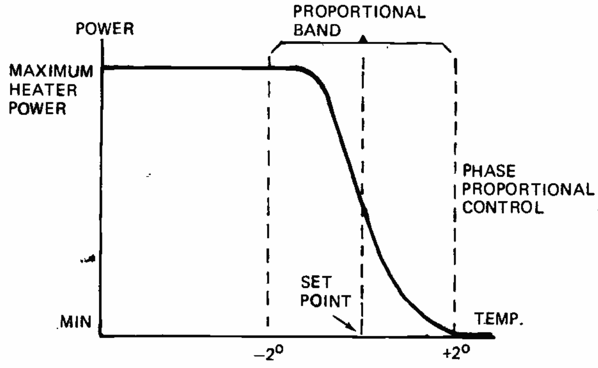


(c)

Fig. 1a. In straight on/off control the heater is ON when the load is below the set point temperature and OFF when it is above.
1b. In zero-crossing proportional control the heater power is varied linearly over a small temperature range known as the proportional band.
1c. In phase-proportional control the same proportional band is used but the control curve follows a cosine law. (Power proportional to phase angle of firing point).

In straight ON/OFF zero crossing control the power is switched "ON" when the temperature is below the desired set point and "OFF" when the temperature reaches the set point. Whilst very accurate control is possible with this method, the size of heater must be carefully selected to suit the thermal inertia of the system. Too large a heater will produce large overshoots hence this system should be used only where the load has large thermal inertia, or where the heater is selected to provide only 25% or so more heat (at full output) than is dissipated by the system through losses. In such a system the heater will switch on and off at a fairly rapid rate allowing bursts of complete half cycles to flow. The ON/OFF switching always occurs at the zero crossing point.

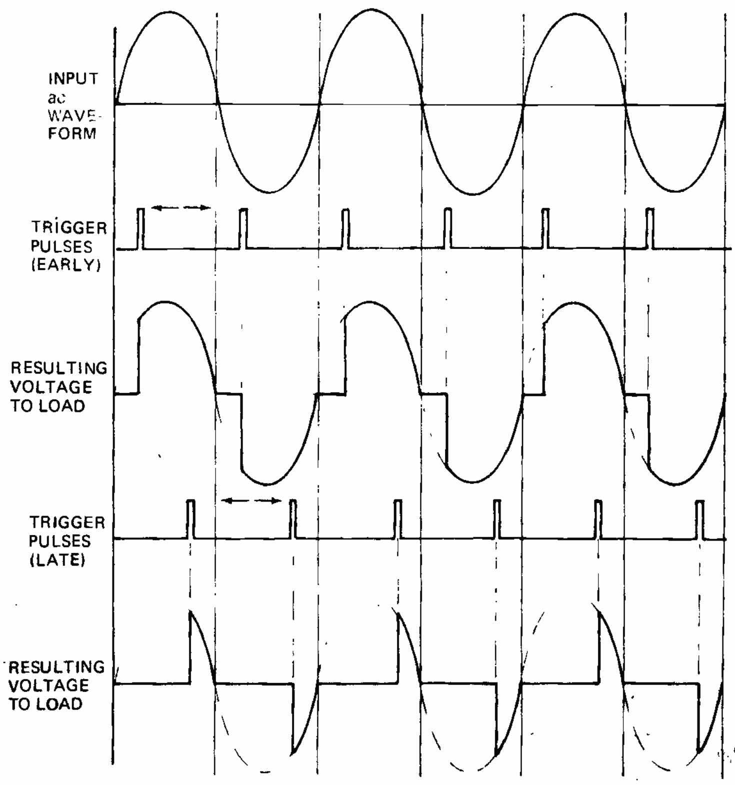


Fig. 2. In phase control the time relationship of the trigger pulse is varied to control the amount of power delivered in each half cycle.

In zero-crossing proportional control the control system varies the amount of power delivered within a set time period, eg 1 or 10 seconds, by sweeping the control voltage over a small range. Using this method the average power delivered by the heater is smoothly varied within the proportional band.

Again the zero-crossing mode ensures that little RFI is generated. The method relaxes the requirement for selection of the heater to a considerable extent but accuracy is not necessarily as good as with straight ON-OFF control.

CONSTRUCTION

Construction of the controllers will vary considerably depending on the application. We built a phase control unit into a box as shown in the photograph. However it may be more practical, where a particular device (oven etc) is to be controlled, to build the electronics into the controlled system.

Most, if not all, of the ICs manufactured for phase or zero-crossing control have the thermistor at mains potential and the thermistor must therefore be insulated in some manner for most applications, this is often quite difficult to do – especially for home constructors, consequently the ETI controller circuits have been designed such that the thermistor is completely isolated from the mains. It is only necessary to protect it with a sheath etc, when used for monitoring such things as liquids.

The triac itself should be mounted on a heatsink. In our prototype we mounted the triac on the front panel. Remember however that the triac must be carefully insulated electrically from the heatsink, and the heatsink triac assembly should be mounted in a cool place.

Pulse transformer T2 may be constructed as per the winding details in Table 4. It is essential that adequate insulation be provided over the ferrite rod (some ferrites are conductive) and between the primary and secondary windings.

Choke L1 is only required in the phase-control circuit and this too must be carefully insulated.

Where a box is used to house the assembly care must be taken to earth all exposed metal surfaces including screws. The mains earth should be secured under a single screw provided for this specific purpose. In our case the mains earth was made direct to the front panel.

Finally take care with the polarization of components on the printed circuit board. Also ensure that reference is made to the *correct* overlay for the type of controller used.

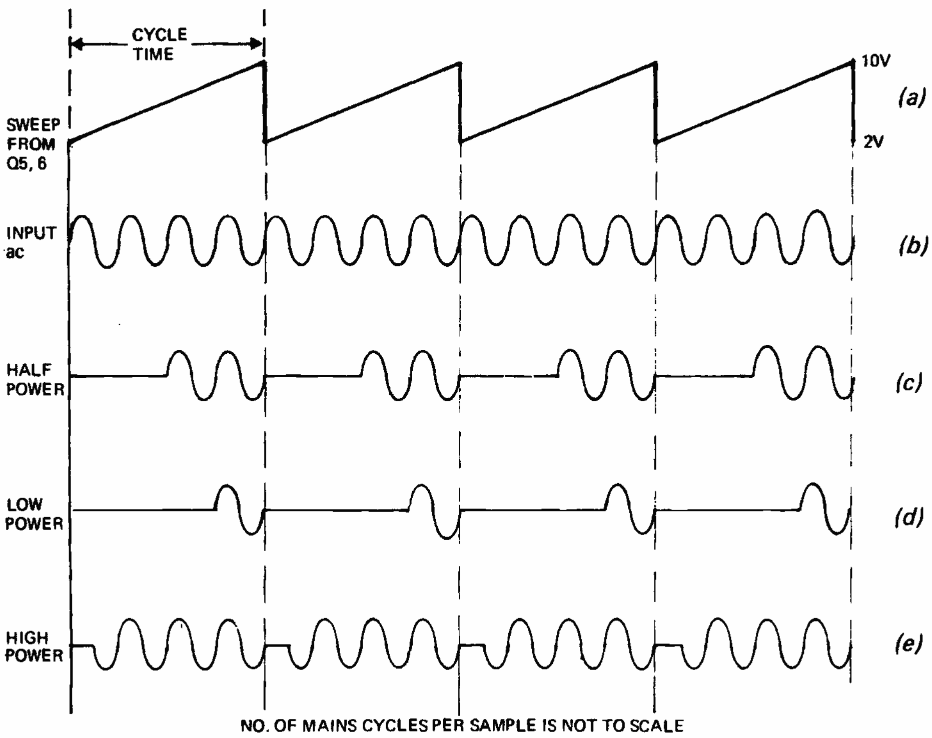


Fig. 3. The sweep voltage (a) is used to obtain a fixed cycle time. When the load has reached a temperature within the proportional band, the controller will vary the number of complete, half cycles within the time period in order to maintain the correct temperature, Note that in a typical system the cycle time may contain 50-500 cycles of mains, not four as shown.

TEMPERATURE CONTROLLERS

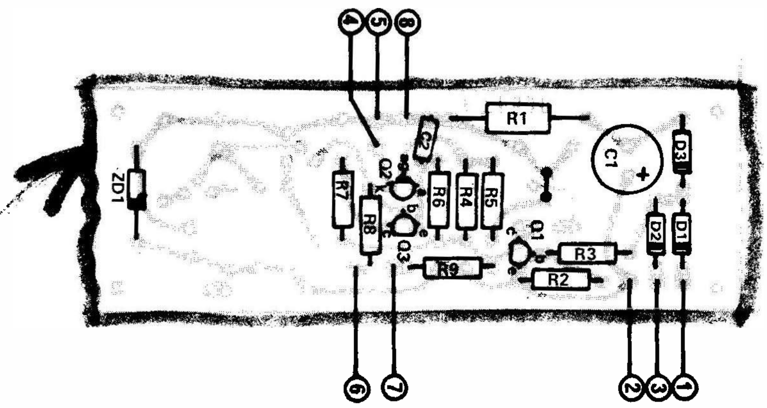
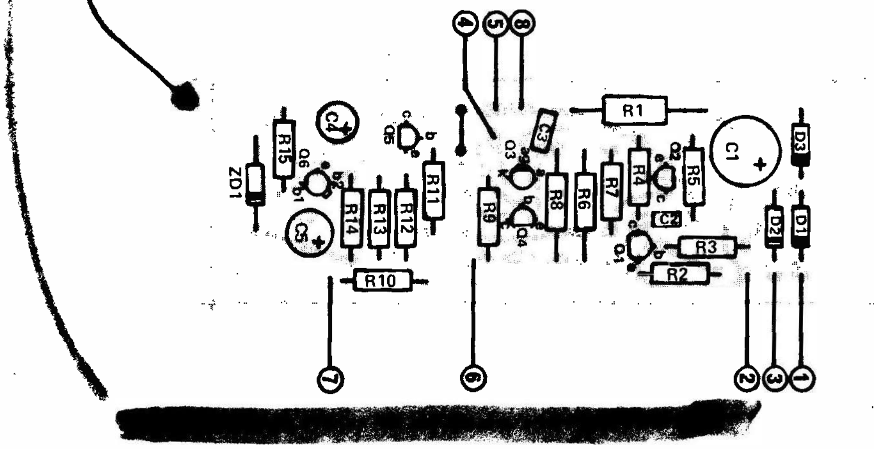


Fig. 5. Component overlay for the zero-crossing controllers. Note that for ON/OFF control some components are not fitted (refer Fig. 4).



HOW IT WORKS

THERE are three different methods of control.

(a) Zero crossing control.

(b) Zero crossing proportional control.

(c) Phase control.

All three methods use the same power supply and synchronization method, that is the circuitry to the left of Q1. Up to this point only, component numbers are identical for all circuits.

Transformer T1, together with diodes D1 and D2 provide a full-wave rectified 100 Hz that is negative going with respect to terminal 2 of the transformer. This charges C1 via isolating diode D3 to about 21 volts peak (typically 20 volts when loaded). From this supply resistor R1 together with zener diode ZD1 generate a stabilized 15 volts supply for the triggering circuit.

The negative going 100 Hz waveform at the junction of D2 and D3 is applied to divider network R3 and R2. Thus Q1 will be turned on whilst ever its base is 0.6 volts negative with respect to its emitter. Hence at the collector of Q1 a narrow negative going pulse will be generated every 10 milliseconds that is centred around the zero-crossing point of the mains waveform.

ZERO CROSSING CONTROL

The synchronization pulse from Q1 is passed via C1 to the base of Q2. The positive going edge of the pulse turns Q2 on producing a negative going pulse at the collector of Q2. Thus at the junction of R6 and R7 there will be a pulse which drops from 15 to 7.5 volts just after each zero crossing. This pulse is passed to the gate of the programmable unijunction transistor Q3 (PUT). The PUT has the characteristic that it will fire only when the anode is more positive than the gate. Thus the anode must be higher than 7.5 volts if the PUT is to fire. Capacitor C3 is charged via R8 but transistor Q4 does not allow C3 to charge beyond the voltage at the base of Q4 plus 0.6 volts. If C3 does not reach 7.5 volts, therefore, the PUT cannot fire and the heater will be off.

Thermistor TH1 is chosen such that, at the working temperature, its resistance is equal to the combined value of R10 plus RV1 (set at mid point). If the temperature falls the resistance of TH1 will rise and the voltage at Q4 base will rise, and, if the temperature increases the resistance of TH1 drops and the voltage at Q4 base drops. That is the thermistor has a negative temperature coefficient.

Thus the voltage to which C3 is allowed to charge (as clamped by Q4) is dependant on temperature. When the temperature falls below the set more and this voltage at the anode of the PUT will allow the pulse at the gate of the PUT to fire it discharging C3 through the pulse transformer T2 thus in turn firing the triac. The triac continues to fire on each half cycle until the temperature rises above the set point.

Thus the heater will be on when the temperature is below the set point and off when the temperature is above the set point. Additionally switching occurs very close to the zero crossing point of the mains ensuring that little RFI is generated.

ZERO CROSSING PROPORTIONAL CONTROL

In the zero-crossing proportional mode unijunction transistor Q6 produces a sawtooth waveform with a period depending on the value of C4. With 100μF this period will be approximately 10 seconds and with 10μF approximately 1 second. This waveform is buffered by Q5 and then passed via R11 to the base of Q4. The effect of this voltage is to sweep the voltage to which C3 is clamped over a time period selected by C4 and over an amplitude (proportional band) determined by R11. Thus the temperature of TH1 will determine at what point in each sweep the triac turns on. Hence the triac turns on for a number of half cycles in each sweep, that is, for a *time* in each sweep inversely proportional to the temperature sensed by TH1. Switching still occurs at the zero-crossing point and RFI is therefore minimal.

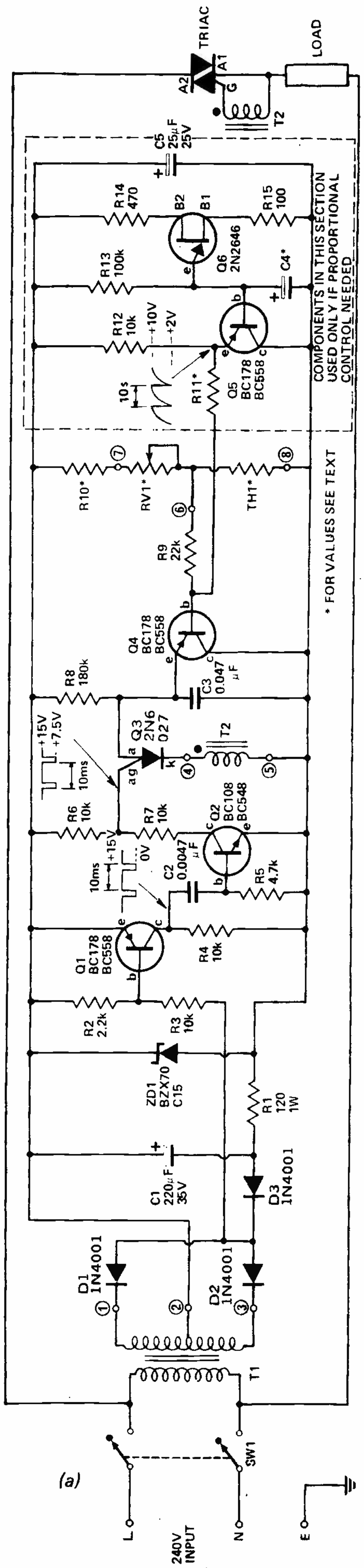
PHASE CONTROL

In the phase control circuit Q1 will turn off for a short period centred around the zero crossing point of the input ac waveform. Thus the voltage at the junction of R4 and R5 will fall to zero at the crossing point and then rise to 7.5 volts for the remainder of the half cycle. Additionally the pulse at the collector of Q1 is fed to the entire timing circuit (including the thermistor) and synchronises firing to the mains.

Capacitor C2 will charge rapidly via Q3 and R7 until the voltage at Q3 emitter reaches 0.6 volts less than that at its base. Capacitor C2 will continue to charge thereafter at a slower rate determined now by R6 (1 to 10 megohm) until such time as the voltage at the anode of the PUT exceeds that on the gate. When this occurs the PUT will fire discharging C2 through the pulse transformer and gating the triac on as before.

Thus the triac will be switched on for a period within each half cycle and this period will be inversely proportional to the temperature sensed by TH1.

This last mode of operation generates radio interference and capacitors C3, C4 and C5 and choke L1 are 'incorporated in the circuit to minimize this'.



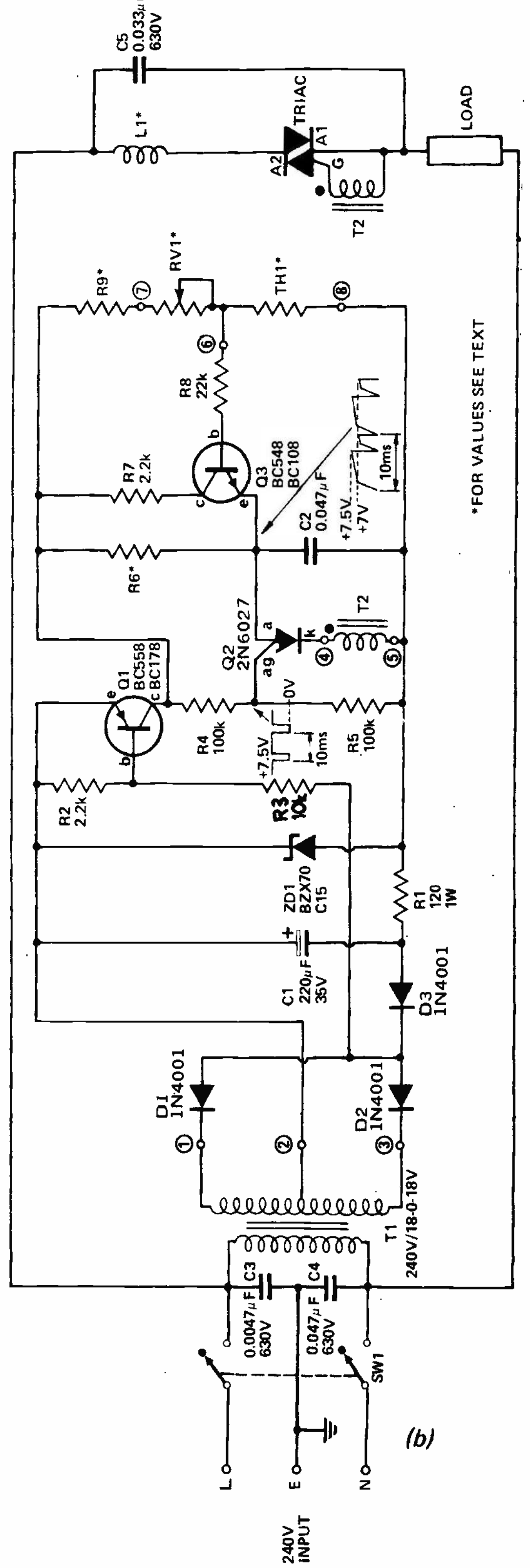


Fig. 4a. Circuit diagram of the zero crossing controllers. Those components within the dotted box are fitted if proportional control is wanted.
4b. Circuit diagram of the phase-proportional controller.

TEMPERATURE CONTROLLER

THE RESISTANCE of a thermistor at any temperature may be calculated from the formula

$$R = Ae^{\beta/T} \quad \ldots\ldots\ldots\ldots 1$$

where A = a constant
e = base of Napierian logs (2.718)
β = slope factor
T = temperature deg K.

and from the above resistance versus temperature change.

$$\Delta R = A\,(e^{\beta/T_1} - e^{\beta/T_2}) \ldots\ldots\ldots 2$$

The values of R6 (phase control circuit) and R11 (zero crossing proportional) must be selected to obtain the desired proportional band. These values will depend upon the characteristics of the thermistor used and may be calculated as follows.

Firstly the thermistor should be selected to have a value between 4.7 k and 100 k at the desired working temperature. This value may be found by use of the graphs, if available, or calculated using equation 1 and the data provided for the particular thermistor.

Resistor R9 (or R10) should be chosen to equal 0.9 of the resistance of the thermistor at the maximum working temperature and R9 + RV1 should equal 1.1 times the resistance of the thermistor at the minimum working temperature.

Having selected a thermistor it is then necessary to determine the resistance change over the desired proportional band.

For example assume we select the 330 k 0.6 watt standard rod type to operate at a working temperature of 70°C and a proportional band of ±2°C.

Then from equation 2.

$$\Delta R_{TH} = 0.25\,(2.718^{\frac{4200}{341}} - 2.718^{\frac{4200}{345}})$$

$$= 7432$$

From equation 1

$$R_{TH} = 0.25\,(2.718^{\frac{4200}{343}})$$

$$= 51979 \text{ ohms}$$

Now we must determine the voltage change at point 6 as follows.

$$\Delta V = \frac{\Delta R_{TH}}{R_{TH}} \times 7.5$$

$$= \frac{7432}{51979} \times 7.5$$

$$= 1.07 \text{ volts}$$

For the phase control circuit we may now calculate R6 from:–

$$R6 = \frac{1.5 \times 10^6}{\Delta V}$$

$$= \frac{1.5 \times 10^6}{1.07}$$

$$= 1.4\text{ M say } 1.5\text{ Meg}$$

For the zero crossing circuit we may calculate R11 from:–

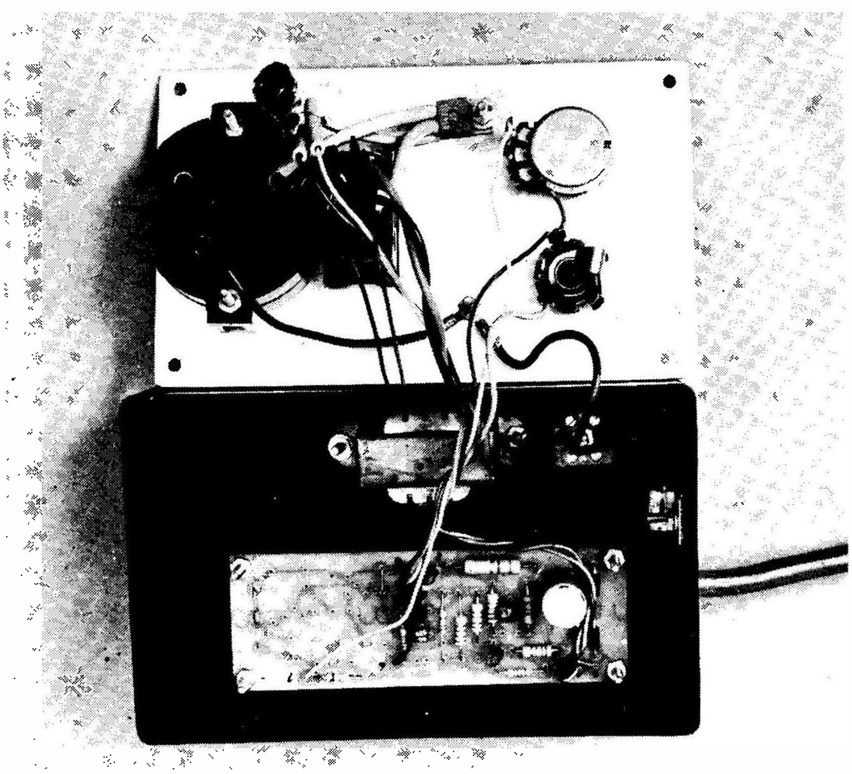
$$R11 = \frac{8 \times (\frac{R_{TH}}{2} + 22\text{ k})}{\Delta V}$$

where R_{TH} and ΔV are as determined above.

$$\text{Thus } R11 = \frac{8\,(25989 + 22{,}000)}{1.07}$$

$$= 358{,}800 \text{ ohms}$$

say 330 k



Internal construction of a typical controller. Note that board is assembled as phase-control version, triac is insulated by mica washer and mounting bush from front panel. Note also pulse transformer is epoxied to front panel at top left.

The thermistor used in the above example has the following spec:

A = 0.25

B = 4200

To convert °C to °K add 273°.

WINDING DETAILS TABLE 4
Pulse Transformer

Former 25mm of 8.0mm or 9.6mm diameter ferrite rod.

Primary 30 turns, single layer close wound of 0.25mm enamelled copper.

Secondary 30 turns, single layer close wound of 0.25mm enamelled copper.

Insulation between primary and secondary and over core – 4 layers of cellulose tape.

Bring out leads for primary and secondary at opposite ends of transformer.

Choke L1

Former 50mm of 8.0mm or 9.6mm diameter ferrite rod.

60 turns single layer close wound of 0.63mm enamelled copper.

Insulate former and over winding with plastic insulation tape.

PARTS LIST – ETI 530 A

Zero Crossing (ON/OFF)

R1	Resistor	120	1 watt	5%
R2	"	2.2k	½ watt	5%
R3,4,6,7	"	10k	½ watt	5%
R5	"	4.7k	½ watt	5%
R8	"	180k	½ watt	5%
R9	"	22k	½ watt	5%

C1 Capacitor 220 µF 35 volt electrolytic
C2 Capacitor 0.0047µF polyester
C3 Capacitor 0.047 µF polyester

D1,2,3 Diode 1N4001 or similar

ZD1 Zener Diode BZX70C15 or similar.

Q1,4 Transistor BC178, BC558 or similar
Q2 " BC108, BC548 or similar
Q3 " 2N6027 (PUT)
TRIAC SC146D or similar

T1 Transformer 240/18-0-18 volt

T2 Pulse transformer see text.

SW1 Switch DPST 240 volt ac 10 amp.

R10,RV1, TH1 are selected as detailed in text. Suitable box, heat sink for triacs, outlet socket, nuts, bolts, power cord and plug. Printed circuit board and 4 off 8mm spacers.

PARTS LIST – ETI 530 B

Zero Crossing (proportional)

All parts for ETI 530 A plus the following.

R11 selected as per text.

R12	Resistor	10 k	½ watt	5%
R13	"	100 k	½ watt	5%
R14	"	470	½ watt	5%
R15	"	100	½ watt	5%

C4 Capacitor selected as per text.
C5 " 25 µF 25 volt electrolytic

Q5 Transistor BC178, BC558 or similar
Q6 Transistor 2N2646 (unijunction)

PARTS LIST ETI 530 C

Phase Control

R1	Resistor	120	1 watt	5%
R2,7	"	2.2k	½ watt	5%
R3	"	10k	½ watt	5%
R4,5	"	100k	½ watt	5%
R8	"	22k	½ watt	5%

C1 Capacitor 220µF 35 volt electrolytic
C2 " 0.047µF polyester
C3,4 " 0.0047µF 630 volt polyester
C5 " 0.033µF 630 volt polyester

D1,2,3 Diode 1N4001 or similar
ZD1 Zener Diode BZX70C15 or similar

Q1 Transistor BC178, BC558 or similar
Q3 " BC108, BC548
Q2 " 2N6027 (PUT)
TRIAC SC146D or similar
T1 Transformer 240/18-0-18 volt

T2 Pulse Transformer see text.

L1 Choke (see text)
SW1 Switch DPST 240 volt 2 amp

R6, R9, TH1 and RV1 selected as detailed in text. Suitable box, heat sink for triac outlet socket, nuts, bolts, power cord and plug. Printed circuit board and 4 off 8mm spacers.

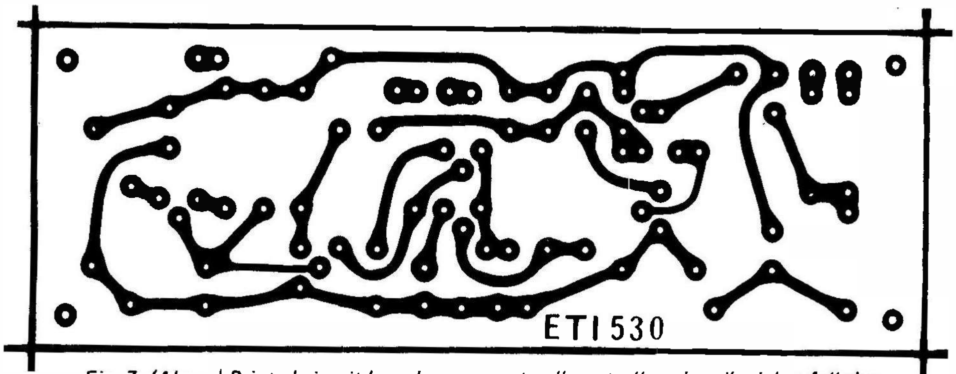


Fig. 7. (Above) Printed circuit board, common to all controllers described, has full size dimensions of 120 x 41mm.

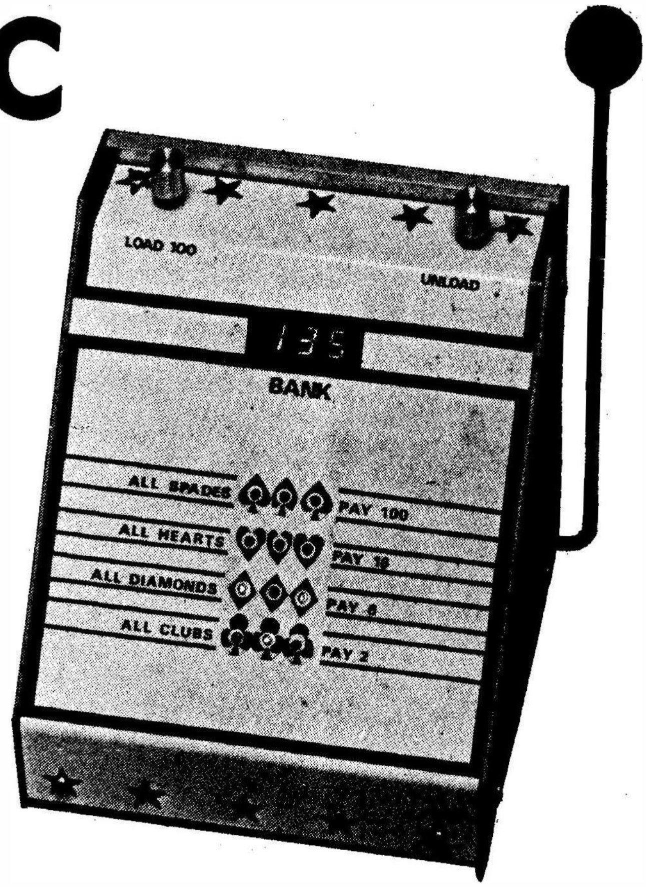
GETTING A SUITABLE THERMISTOR

There are three main types — rod, disc and bead thermistors. The bead types are low power devices best suited for control circuits. However the disc and rod types are cheaper and easier to obtain. Brimistors are broad tolerance rod thermistors usually used in temperature compensation circuits.

Essentially one needs a thermistor with a negative temperature coefficient and a resistance between 4.7k and 100k at the working temperature. When buying the component be sure to get a data sheet. Some suppliers give the constant 'A' but this can be calculated from the resistance value at a specified temperature.

ELECTRONIC ONE-ARM BANDIT

eti project



Play for hours — without it costing you a penny!

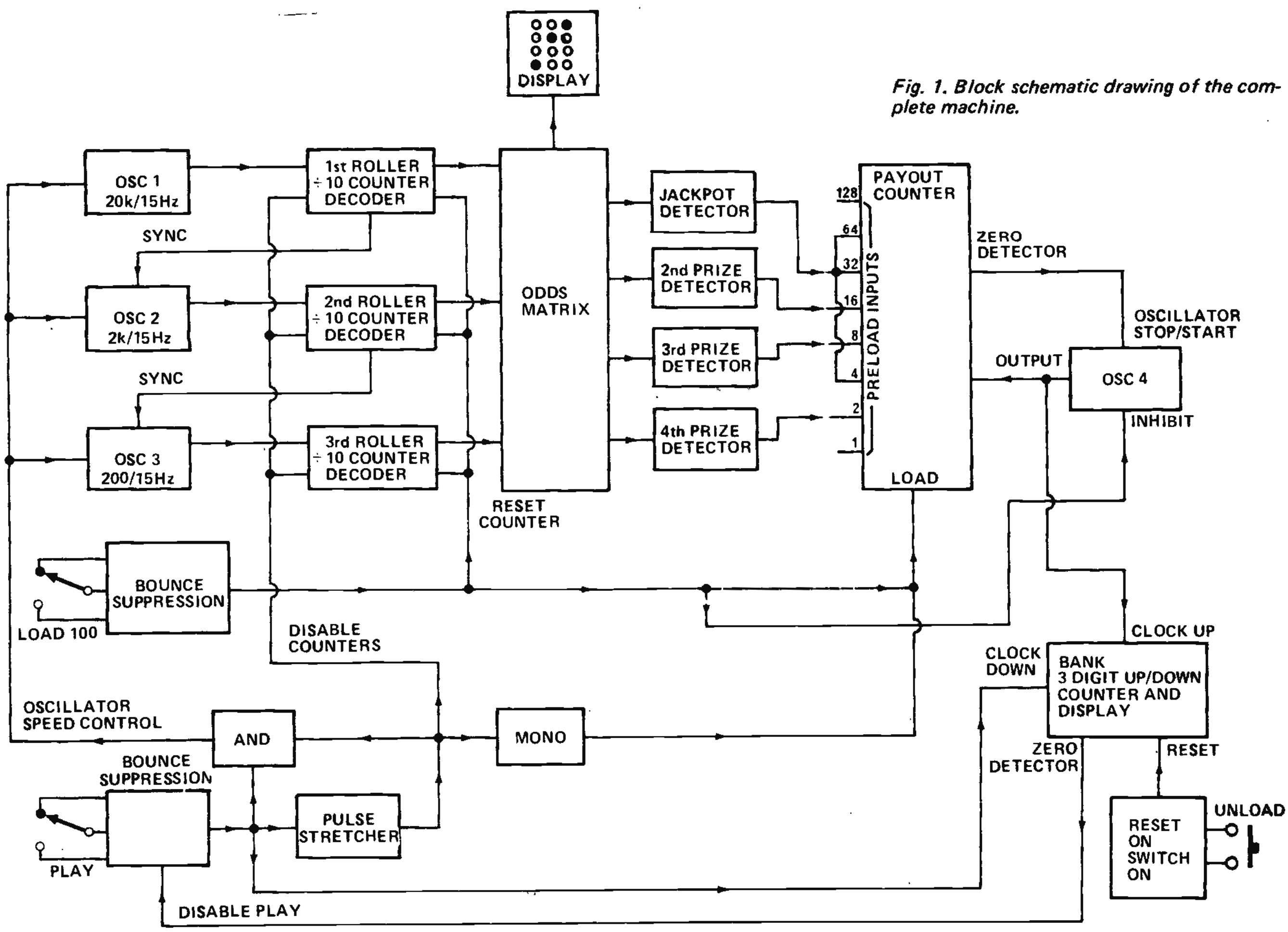


Fig. 1. Block schematic drawing of the complete machine.

OVER THE PAST YEARS we and other magazines have published many electronic games and puzzles ranging from very simple to very complex. We have published mainly simple ones since many complex games like noughts and crosses are expensive and have limited appeal since once the routine has been found the machine can always be beaten.

Here however is a rather more complex game — but one that cannot be beaten in the conventional sense.

The poker machine described here works similarly to a conventional mechanical machines with which most people are familiar. It requires no skill and can be enjoyed by all types of people.

So that the machine does not contravene gaming laws no coin slot or tray is used, instead we use a three-digit display to show the status of the game. Every time the handle is pulled one unit is subtracted from the display or "bank" and if a winning combination is obtained then the appropriate number is added to the bank. To start the game 100 is added to the bank by pressing the load button (which would be a key switch if money was involved). The game finishes when you like by pressing the unload button or when the bank reaches zero.

PRINCIPLE OF OPERATION

Each wheel of the conventional one arm bandit has been replaced by a decade counter which has ten separate outputs which represent positions on the wheels. These three counters are allowed to be clocked rapidly for a random period (time the handle is pulled for) and then stopped. The final state of the counters determine if a prize has been won.

With three decade counters the total possible combinations is 1000. Therefore if we use 10 different "symbols" on each wheel the chances of a prize would be 100/1 (10 possible wins each at 1000/1). Therefore like a normal machine we weight the rollers by having less than 10 "symbols" and having some symbols repreated more than once on each roller. The table below gives the number of times each symbol is on each roller and a breakdown of the odds of each prize.

Detectors are used for each winning combination and these set the appropriate value (2, 8, 16 or 100) into the payout counter. At this time, oscillator 4 starts up and clocks this counter down to zero.

The output of oscillator 4 also adds the appropriate number into the bank, which is a three digit up down counter. When the play lever is initiated one unit is subtracted from the bank. When the bank reaches zero, further play is inhibited.

Initially on switch-on the bank is reset to zero and it can be reset at any time by pressing the unload button. To commence play the load button

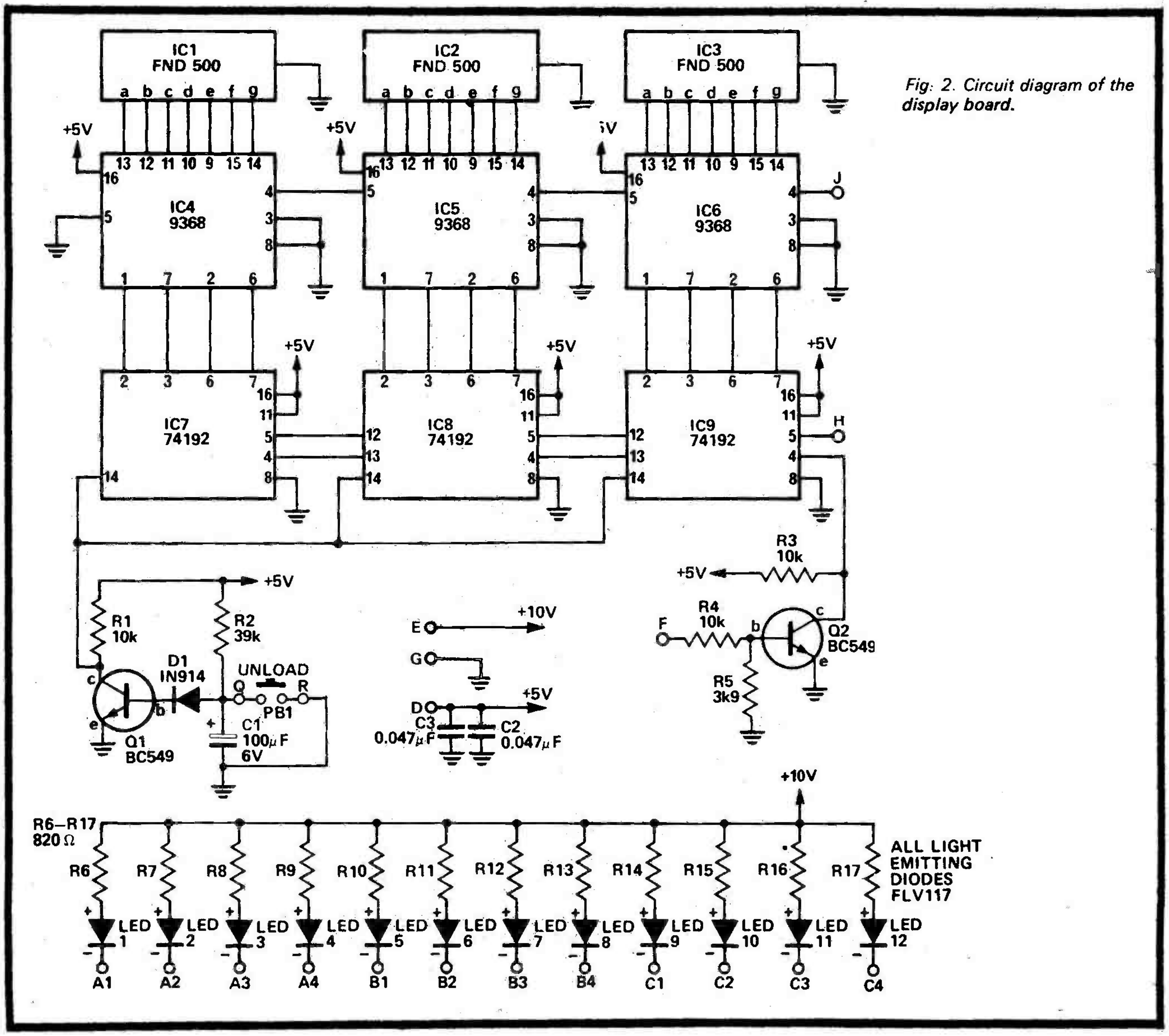


Fig. 2. Circuit diagram of the display board.