SIMPLE PROJECTS

FROM ELECTRONICS TODAY INTERNATIONAL

VOLUME 2 PRICE $2.95*

metal detector
train controller
telephone bell extender
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transistor tester
selecta-game
breakdown beacon
loudness control
touch switch
courtesy light extender
rev monitor counter
auto amp
car alarm
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Contents

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086.P.670

INDUCTION BALANCE METAL DETECTOR

A really sensitive design operating on a different principle from that of other published circuits. This 'Induction Balance' metal locator will really sniff out those buried coins and other items of interest at great depths (depending on the size of the object).

"ANOTHER METAL LOCATOR," some of you will say. Yes and no. Several designs have been published in hobby electronics magazines around the world, some good, some downright lousy, but they have invariably been Beat Frequency Oscillator (BFO) types. There's nothing wrong with this principle – they are at least easy to build and simple to set up. The design described here works on a very different principle, that of induction balance (IB). This is also known as the TR principle (Transmit-Receive).

First a word of warning. The electronic circuitry of this project is straightforward and should present no difficulty even to the beginner. However, successful operation depends almost entirely upon the construction of the search head and its coils. This part should account for about three-quarters of the effort in construction. Great care, neatness and patience is necessary and a sensitive 'scope, though not absolutely essential, is very useful. It has to be stated categorically that sloppy construction of the coil will (not may) invalidate the entire operation.

IB Versus BFO

The usual circuit for a metal locator is shown in Fig. 2a. A search coil, usually 6in or so in diameter is connected in the circuit to oscillate at between 100 and 150 kHz. A second internal oscillator operating on the same frequency is included and a tiny part of each signal is taken to a mixer and a beat note is produced. When the search coil is brought near metal, the inductance of the coil is changed slightly, altering the frequency and thus the tone of the note. A tone is produced continually when the instrument is in use and metal is identified by a frequency change in the audio tone.

The IB principle, however, uses two coils arranged in such a way that there is virtually no inductive pick-up between them. A modulated signal is fed into one. When metal is brought near, the electromagnetic field is disturbed and the other coil picks up an appreciably higher signal.

Ideally the instrument is initially set up for no pick-up in the 'receiver' coil, but this is impossible in practice – the two coils are after all laid on top of each other. Another problem is that our ears are poor at identifying changes in audio level. The circuit is therefore arranged so that the signal is gated and is set up so that only the minutest part of the signal is heard when no metal is present. When the coils are near metal, a minute change in level becomes an enormous change in volume.

BFO detectors are not as sensitive as IB types and have to be fitted with a Faraday screen (beware of those which aren't – they're practically useless) to reduce capacitive effects on the coil. They are however, slightly better than IB types when it comes to pin-pointing exactly where the metal is buried.

Our detector is extremely sensitive – in fact a bit too sensitive for some applications! For this reason we've included a high-low sensitivity switch.

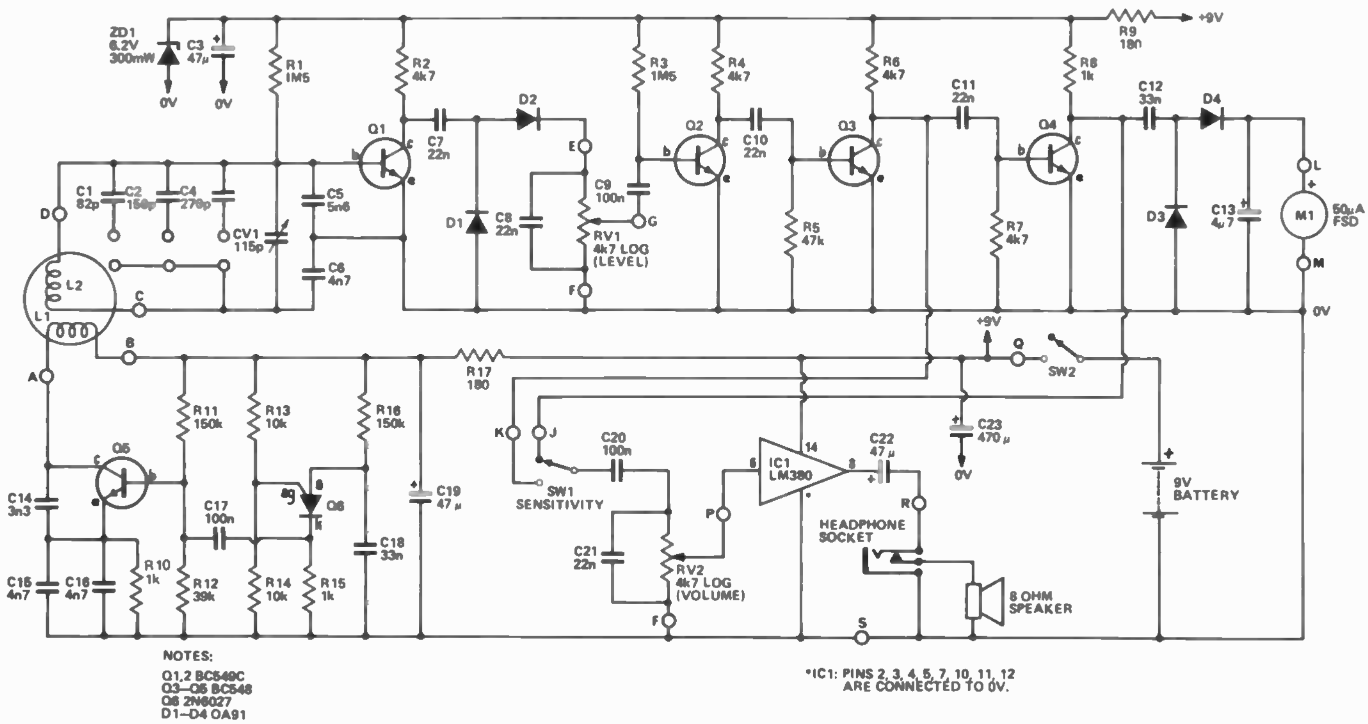


Fig. 1. Complete circuit of the metal locator. Note that though the electronics is simple using very common parts, the whole operation depends on the coil L1 and L2 which must be arranged so that there is minimal inductive coupling between the two. Note also that the leads from the circuit board to the search head must be individually screened and earthed at PCB.

You may ask why low sensitivity is useful. As a crude example, take a coin lying on a wooden floor: on maximum sensitivity the detector will pick up the nails, etc., and give the same readings as for the coin, making it difficult to find.

Treasure hunting is an art and the dual sensitivity may only be appreciated after trials.

Table 1 gives the distances at which various objects can be detected. These are static readings and only give an indication of range. If you are unimpressed with this performance you should bear two things in mind: first compare this with any other claims (ours are excellent and honest) and secondly bear in mind how difficult it is to dig a hole over 1ft of ground every time you get a reading. Try it — it's hard work!

Component Choice

We have specified Q1 and Q2 types as BC549C (highest gain group) for although lower gain transistors worked for us, they left little reserve of level on RV1 and really low gain types may not work at all.

RV1 is the critical control and should be a high quality type — it will be found that it has to be set very carefully for proper operation.

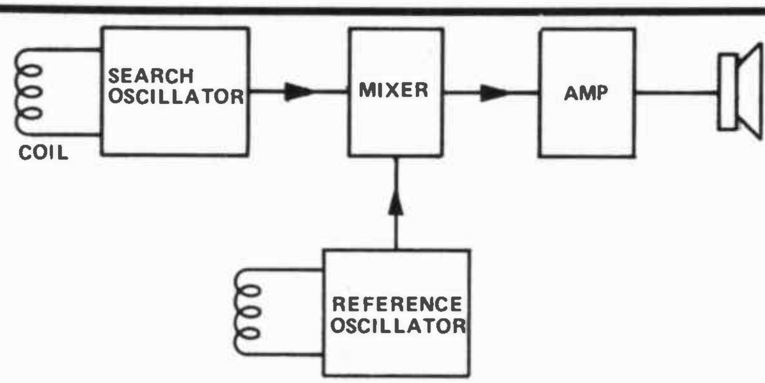


Fig. 2a. Block diagram of the common BFO type metal locator.

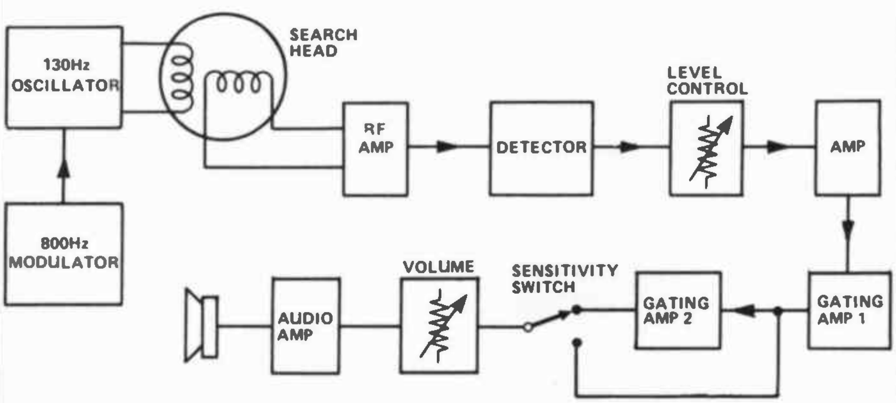


Fig. 2b. Block diagram of our IB design.

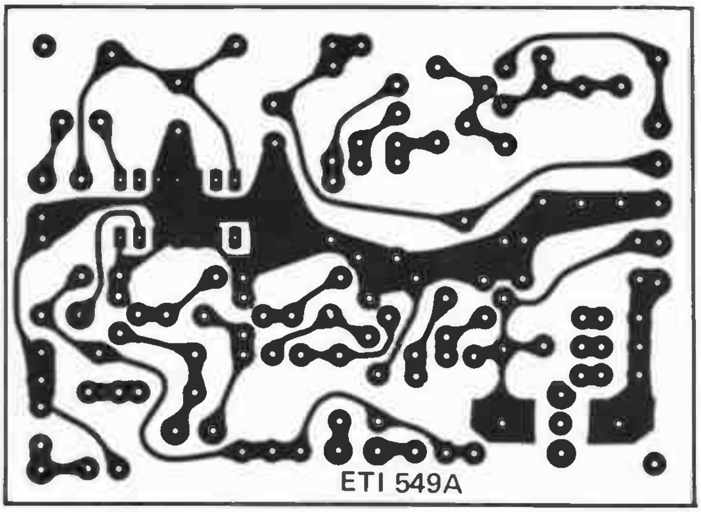


Fig. 3. Printed circuit layout. Full size 90 x 65 mm.

How It Works – ETI 549

Q5, Q6 and associated components form the transmitter section of the circuit. Q6 is a P.U.T. which operates as a relaxation oscillator, the audio note produced being determined by R16 and C18. The specified components give a tone of roughly 800 Hz.

Q5 is connected as Colpitt's oscillator working at a nominal 130 kHz; this signal is heavily modulated by C17 feeding to the base of Q5. In fact the oscillator produces bursts of r.f. at 800 Hz. L1 in the search head is the transmitter coil.

L2 is arranged in the search head in such a way that the minimum possible signal from L1 is induced into it (but see notes on setting up). On all the prototypes we made we reduced this to about 20 mV peak-to-peak in L2. L2 is tuned by C5 and C6 and peaked by CV1 and feeds to the base of Q1, a high gain amplifier. This signal (which is still modulated r.f.) is detected by D1, and D2. The r.f. is eliminated by C8 and connects to the level control RV1.

The signal is amplified by Q2 and then further amplified by Q3 which has no d.c. bias connected to the base. In no-signal conditions this will be turned off totally and will only conduct when the peaks of the 800 Hz exceed about 0.6V across R5. Only the signal above this level is amplified.

On low sensitivity these peaks are connected to the volume control RV2 (any stray r.f. or very sharp peaks being smoothed by C21) and fed to the IC amplifier and so to the speaker.

The high sensitivity stage Q4 is connected at all times and introduces another gating stage serving the same purpose as the earlier stage of Q3. This emphasises the change in level in L2 even more dramatically. Note that RV1 has to be set differently for high and low sensitivity settings of SW1.

Whichever setting is chosen for SW1. RV1 is set so that a signal can just be heard. In practice it will be found that between no-signal and moderate-signal there is a setting for RV1 where a 'crackle' can be heard. Odd peaks of the 800 Hz find their way through but they do not come through as a tone. This is the correct setting for RV1.

The stage Q4 also feeds the meter circuit. Due to the nature of the pulses this need only be very simple.

Since we are detecting really minute changes in level it is important that the supply voltage in the early stages of the receiver are stabilised, for this reason ZD1 is included to hold the supply steady independent of battery voltage (which will fall on high output due to the current drawn by IC1).

It is also important that the supply voltage to Q5 and Q6 does not feed any singal through to the receiver. If trouble is experienced (we didn't get any) a separate 9V battery could be used to supply this stage.

IC1 is being well underused so a heatsink is unnecessary.

Battery consumption is fairly high on signal conditions – between 60 mA and 80 mA on various prototypes but this will only be for very short periods and is thus acceptable. A more modest 20 mA or so is normal at the 'crackling' setting.

Stereo headphones are used and are connected in series to present 16 ohms to IC1 reducing current consumption.

The choice of an LM380 may seem surprising as only a small part of its power can be utilised with battery operation. It is however inexpensive and widely available unlike the alternatives (note it does not require dc blocking at the input).

Output is connected for an 8 ohm speaker and to headphones. Stereo types are the most common and the wiring of the jack socket is such that the two sections are connected in series presenting a 16 ohm load (this reduces current consumption from the battery).

Construction: Control Box

The majority of the components are mounted on the PCB overlay and the additional wiring is shown in Fig. 4.

Exceptional care should be taken to mount all components firmly to the board. Poor connections or dubious solder joints may be acceptable in some circuits – not in this one. Take care to mount the transistors, diodes and electrolytic capacitors the right way around.

The PCB is fitted into the control box by means of 6 mm spacers. The control box has to be drilled to take the speaker, the pots, switches, headphone jack and the cable from the search head.

The Handle Assembly

The handle we used was simply a broom handle with the end cut off at about 45°. After assembling the head, the handle can be glued on with epoxy. A small woodscrew can be used to hold it in place until dry. This should be done before final setting up of the coils – in case the screw cannot be removed after the glue has set.

The Coil

Remember this is the key to the whole operation. The casing of the coil is not so critical but the layout is.

It is best first to make the 6 mm plywood circle to the dimensions shown in Fig.6. A circle of thinner plywood or hardboard is then firmly glued onto this – it's fairly easy to cut this after glueing. Use good quality ply and a modern wood glue to make this.

This now forms a dish into which the coils are fitted.

You'll now have to find something cylindrical with a diameter of near enough 140 mm (5½in). A coil will then have to be made of 40 turns of 32 swg enamelled copper wire. The wire should be wound close together and kept well bunched and taped to keep it together when removed from the

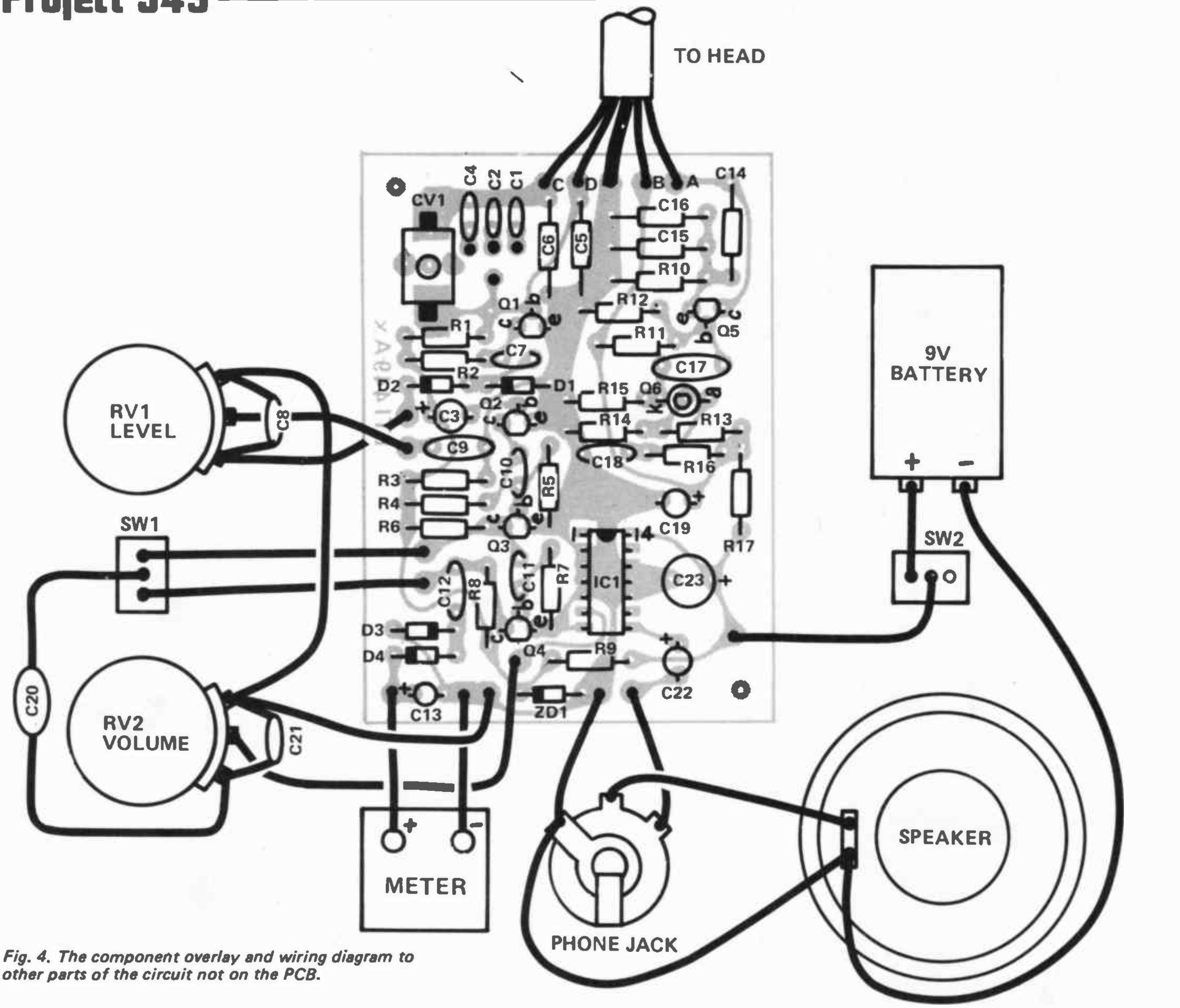


Fig. 4. The component overlay and wiring diagram to other parts of the circuit not on the PCB.

former. Two such coils are required. These are identical.

One of the coils is then fitted into the dish and spot glued in six or eight places using quick setting epoxy resin: see photograph.

L2 is then fitted into place, again spot glueing (*not* in the area that it overlaps L1). The cable connecting the coil to the circuit is then fed through a hole drilled in the dish and connected to the four ends. These should be directly wired and glued in place, obviously taking care that they don't short. The cable must be a four-wire type with individual screens — the screens are left unconnected at the search head.

You will now need the built up control box and preferably a 'scope. The transmit circuit is connected to L1. The signal induced into L2 is monitored; at first this may be very high but by manipulating L2 the level will be seen to fall to a very low level. When a very low level is reached, spot glue L2 until only a small part is left for bending.

Ensure that when you are doing this that you are as far away from any metal as possible but that any metal used to mount the handle to the head is in place. Small amounts of metal are acceptable as long as they are taken into account whilst setting up.

Now connect up the remainder of the circuit and set RV1 so that it is *just* passing through a signal to the speaker. Bring a piece of metal near the coil and the signal should rise. If it falls in level (i.e. the crackling disappears) the coil has to be adjusted until metal brings about a rise with no initial falling. CV1 should be adjusted for maximum signal, this has to be done in conjunction with RV1. The additional capacitors C1, C2 and C4 should be linked in, if the range is not available on CV1.

Monitoring this on a scope may mean that the induced signal is not at its absolute minimum: this doesn't matter too much. Now add more spot gluing points to L2.

You should now try the metal locator in operation. If RV1 is being operated entirely at the lower end of its track, making setting difficult, you can select a lower gain transistor such as a BC548 for Q2.

When you are quite certain that no more manipulation of the coils will improve the performance, mix up plenty of epoxy resin and smother both coils, making certain that you don't move

PARTS LIST — ETI 549

Resistors	all ½ W 5%
R1	1M5
R2	4k7
R3	1M5
R4	4k7
R5	47 k
R6,7	4k7
R8	1 k
R9	180 ohms
R10	1 k
R11	150 k
R12	39 k
R13,14	10 k
R15	1 k
R16	150 k
R17	180 ohms
Potentiometers	
RV1,2	rotary 4k7 log

Capacitors	
C1	82 p ceramic
C2	150 p ceramic
C3	47 µ 10 V electro
C4	270 p ceramic
C5	5n6 polystyrene*
C6	4n7 polystyrene*
C7,8	22 n polyester
C9	100 n polyester
C10,11	22 n polyester
C12	33 n polyester
C13	4µ7 25 V electro
C14	3n3 polystyrene *
C15,16	4n7 polystyrene *
C17	100 n polyester
C18	33 n polyester
C19	47 µ 10 V electro
C20	100 n polyester
C21	22 n polyester
C22	47 µ 10 V electro
C23	470 µ 16 V electro

CV1 115pF trimmer (modify board if necessary to suit connections)

Semiconductors	
Q1,2	Transistors BC549C
Q3-Q5	Transistors BC548
Q6	PUT 2N6027
D1-D4	Diodes OA91, OA95
IC1	Amplifier LM 380
ZD1	Zener 6.2 V 300 mW

Miscellaneous

PC board	ETI 549 A
Meter	50 µA FSD

Search head as per Fig. 6.
Two changeover slide switches.
Two knobs
Suitable case (158 x 95 x 50 mm)
Phone socket
Small speaker
9 V battery clip
Six by AA battery holder
Six AA batteries.

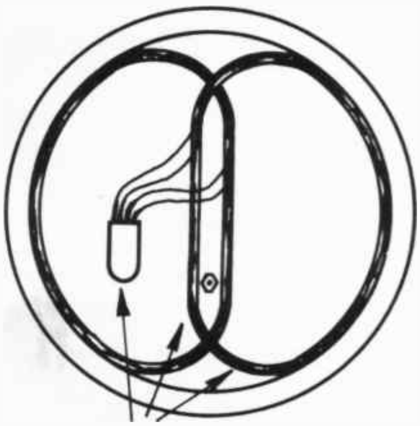
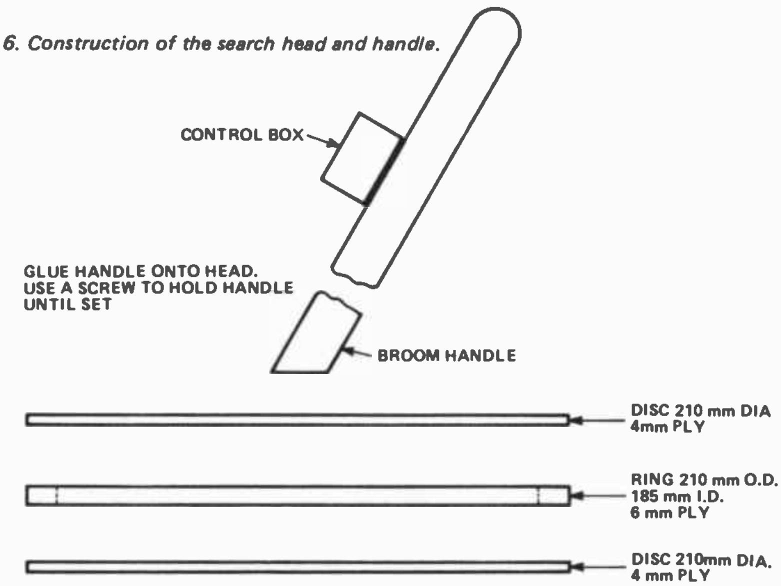


Fig. 5. Diagram showing the position of the coils in the search head.

Fig. 6. Construction of the search head and handle.



them relative to each other.

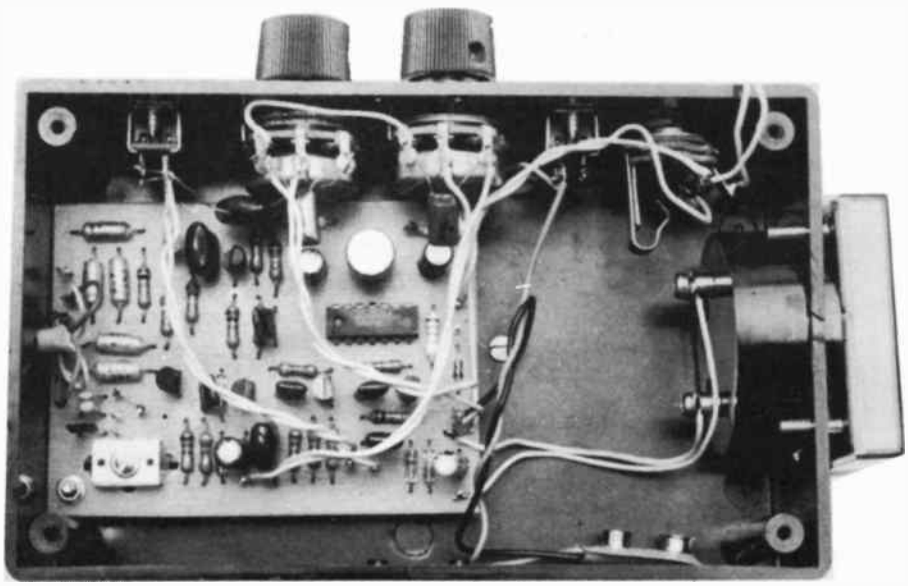
The base plate can then be fitted to enclose the coils, this should be glued in place.

If after glueing in place the balance between the coils is found to be not quite right it should be possible to glue a small piece of metal (such as a washer) somewhere on the head to cancel out the error.

Using The Metal Locator

You will find that finding buried metal is rather *too* easy. 95% will be junk — silver paper being a curse. The search head should be panned slowly over the surface taking care to overlap each sweep the sensitive area is somewhat less than the diameter of the coil.

This type of locator will also pick up some materials which are not metal



— especially coke. And it is not at its best in wet grass.

Think very carefully about where you want to search: this is more important than actually looking. The area you can cover thoroughly is very, very small, but his approach is far more successful than nipping all over the place. As an example of how much better a thorough search is, we thoroughly tried on 25 square feet of common ground (5ft x 5ft); we found over 120 items but a quick search initially had revealed only two!

Treasure hunting is growing in popularity and those who do it seriously have adopted a code; essentially this asks you to respect other people's property, to fill in the holes you dig and to report any interesting finds to museums.

Meter Circuit

Since the circuit is basically sensing a change in audio level, a meter circuit can be incorporated. For the very first indication from the 'crackle' your ears are likely to be more sensitive than the meter but thereafter it will come into its own.

This part of the circuit is optional and the components are not included on the board.

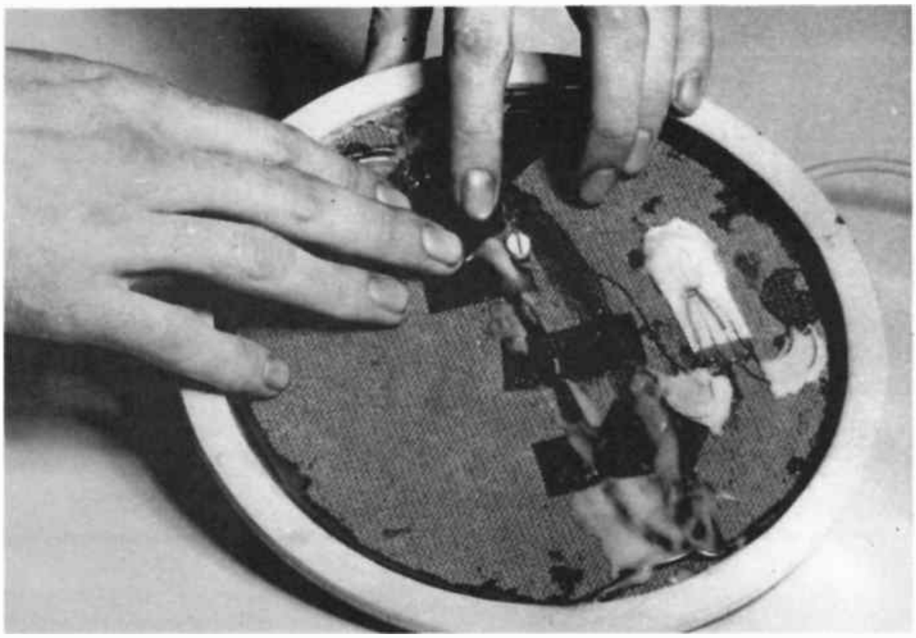


TABLE 1

OBJECT	20_c Coin	Beer Can	150 mm Square copper	150 mm steel rule	MAN S Gold Ring
HIGH SENS	200 mm	450 mm	550 mm	300 mm	200 mm
LOW SENS	150 mm	350 mm	400 mm	220 mm	150 mm

Train controller

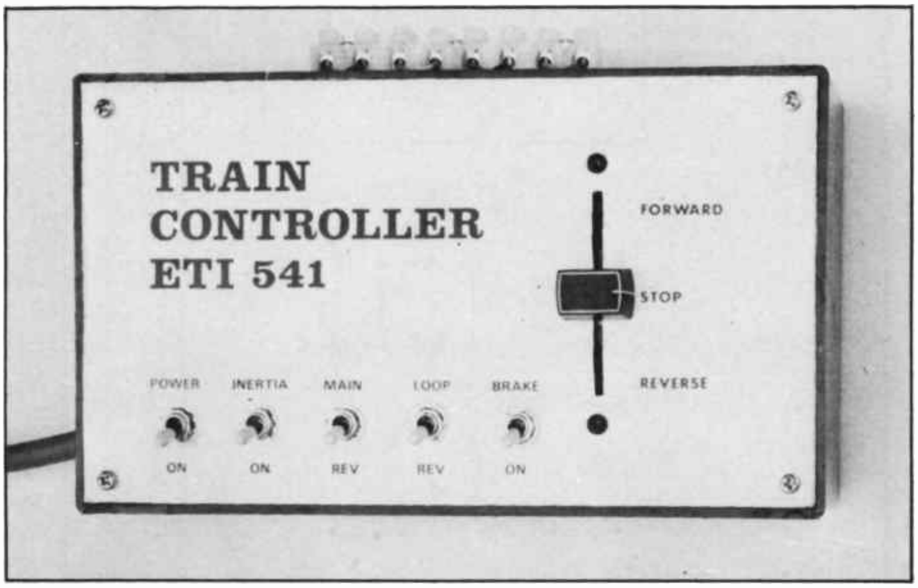
A simple project offering auto-reverse, inertia, emergency brake and loop track facilities.

MODEL TRAINS HAVE ALWAYS BEEN popular with both lads and dads — with dads perhaps coming first. Many a boy has complained "Daddy won't give me a turn". It seems there is some inexplicable attraction in playing trains which never dims with the passing years. A couple of our friends have recently decided to buy train sets — for the kids (they say). Our model train controller project was designed to give them many features that are not found in commercially available controllers (for roughly the same cost). Most commercial devices cost around $30 and consist of a transformer followed by a selenium rectifier, a high power rheostat and an automotive globe. Such controllers have numerous operating disadvantages mainly due to their very poor voltage regulation.

Our controller It may look a little complex but in fact it is very simple to build and quite inexpensive. If the full capability is used the features of the controller are:

- Forward or reverse control by a single slide potentiometer (centre for stop)
- Separate reversing switch for the main track
- Short-circuit proof
- Regulator-type control circuitry
- Emergency brake (which stops the train instantly regardless of the position of other controls
- Simulated inertia (gives more realistic starts and stops)
- The facility to operate with track loops

Loop operation Although not possible with simple controllers, loop operation adds much operating fun and realism to any model railroad and the feature is well worth including. A typical loop is shown in Fig. 1.and the operational problems of such a loop are as follows:



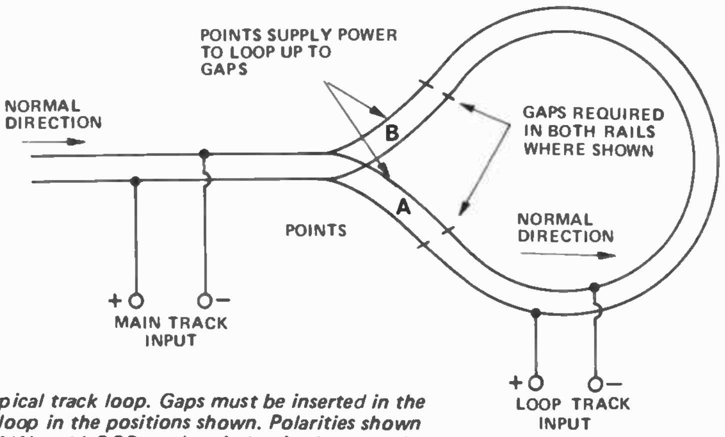


Fig. 1. A typical track loop. Gaps must be inserted in the rails of the loop in the positions shown. Polarities shown are with MAIN and LOOP track switches in the normal position.

If a train is approaching the loop and the 'main' and 'loop' switches are both set at normal, the polarity of the voltages to the track will be as shown. If the points are set so that the train enters the loop towards 'A' it will continue normally around the loop. If the points are now set to 'B' so that the train may

(Text continued on page 15).

Train controller

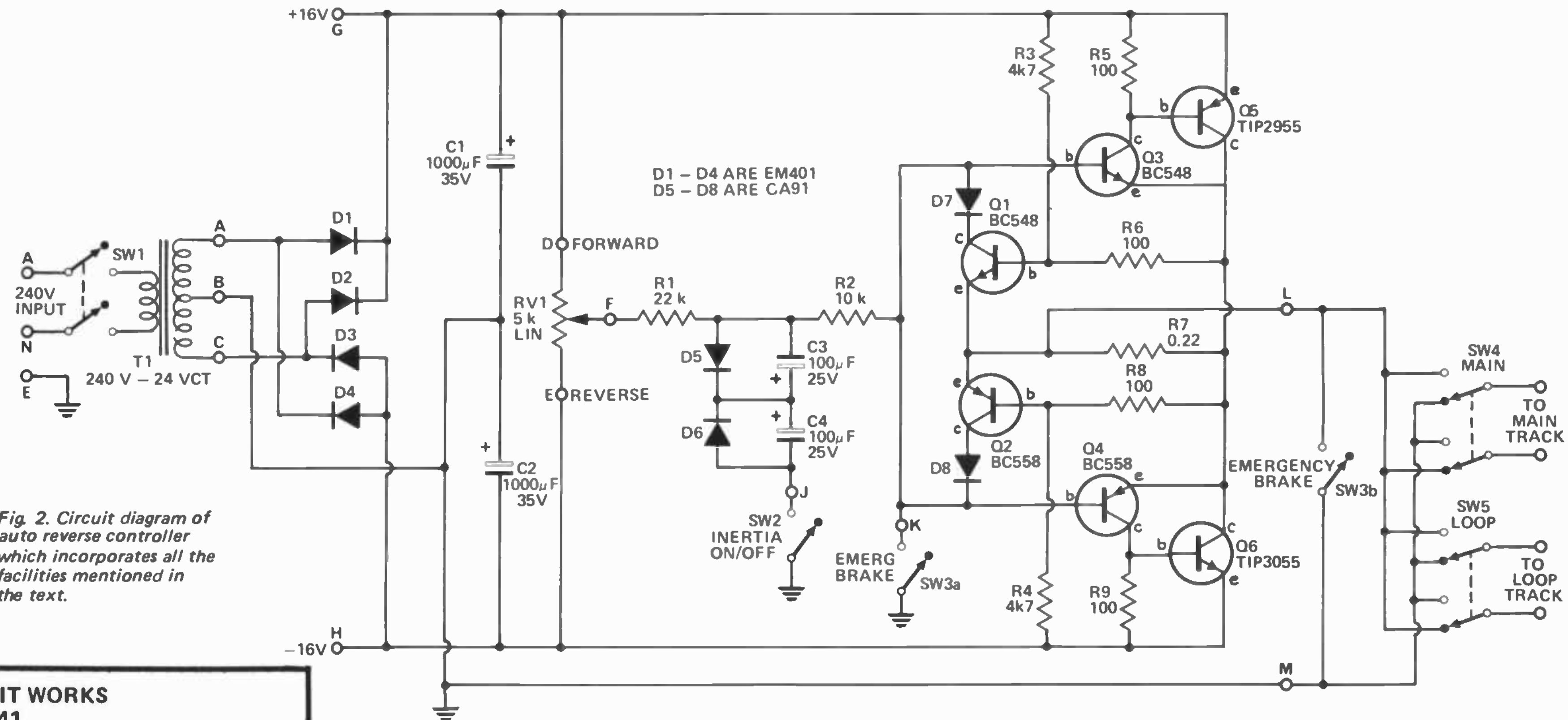


Fig. 2. Circuit diagram of auto reverse controller which incorporates all the facilities mentioned in the text.

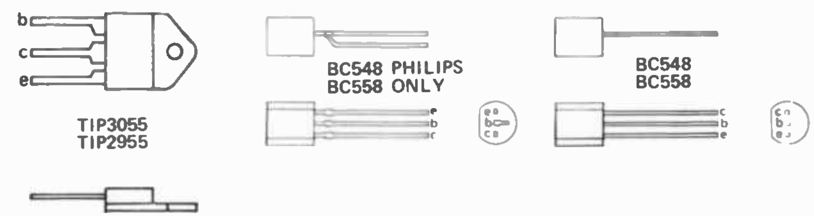
HOW IT WORKS
ETI 541

TRANSFORMER T1 reduces the 240 volt mains to a supply of 24 volts (centre tapped) which is then rectified by D1 to D4 to provide supplies of +16 and –16 volts dc. The speed control potentiometer is connected between these supplies so that its wiper may select any potential between plus and minus 16 volts, depending on setting.

The output of the potentiometer must be well buffered before it can supply enough power to run a train. This is achieved by transistors Q3 and Q5, for the forward direction (that is for output voltages between zero and +15 volts), and by Q4 and Q6, for the reverse direction (that is for output voltages between zero and –15 volts). The output voltage at the collectors of Q5 and Q6 will be about 0.6 volts closer to zero than the voltage at point 'K' (providing the voltage at point 'K' is more than 0.6 volts away from zero). This means that the control

PARTS LIST
AUTOMATIC-REVERSE CONTROLLER

Resistors			
R1	22 k	½ W	5%
R2	10 k	"	"
R3,4	4 k7	"	"
R5,6	100 ohm	"	"
R7	0.22 ohm	5 W	"
R8,9	100 ohm	½ W	"
RV1	5 k lin 45 mm slide potentiometer		



potentiometer will have a small dead band in the centre of its travel where the output voltage remains at zero. This is an advantage because it is frequently necessary to set the controller for exact zero output.

To protect the transistors from damage in the event of an overload or a short circuit, transistors Q1 and Q2 are used to monitor the output current (by measuring the voltage across R7) and the voltage across the output transistors. By this method the power dissipation in the output transistors is controlled such than when driving into a short circuit only about one ampere is available. Yet when set to about 12 volts, about two amps is available to drive normal loads. The diodes D7 and D8 are included to protect the transistors Q1 and Q2 against reverse bias which can occur under certain conditions.

To add the 'inertia' facility or 'momentum', as it is sometimes called the control voltage from RV1 is filtered by C3 and C4. This means that if the potentiometer is suddenly moved from stop to full forward (for example) the voltage applied to the transistor buffer rises only slowly. The train accelerates at a realistic rate without wheel spin. A similar action takes place when the train is stopped. If the controller is moved from full forward to full reverse the train will slow down and stop for a short time and then start off and increase speed in the reverse direction. The diodes D5 and D6 allow normal electrolytics to be used in this position.

If inertia is being used and an emergency situation occurs, eg train moving into a siding that it should not be entering, the brake facility may be used to short the track (SW3b) and also the input to the buffer stage (SW3a). The brake over-rides the speed control and by its use the train will be stopped in a much shorter distance than it would if the power were simply switched off.

When loops in the track system are used, as described in the introduction, a separate reversing switch is used to control the polarity in the loop with respect to the main line so that the train may go into and come out off the loop without any change in speed. The two controller outputs required for this mode of operation must each be reversible and this is performed by SW4 and SW5.

If a second controller is required for another train in the system then it may be built without the power supply. The second controller may be powered by linking the +16, 0 and −16 volt lines between the two controllers.

Capacitors
C1,2 1000 μF 35 V pc mounting electro
C3,4 100 μF 25 V pc mounting electro

Transistors

Q1, 3	BC548
Q2, 4	BC558
Q5	TIP 2955 *
Q6	TIP 3055 *

* with insulation kit

Diodes

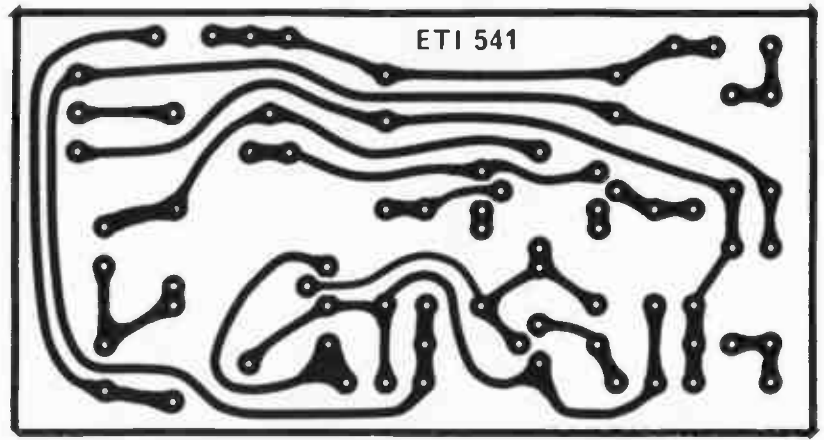
D1-D4	EM401 or similar
D5-D8	OA91 or similar

Miscellaneous
PC board ETI 541
Transformer PL24/20 VA or similar
SW1 toggleswitch DPDT 240 V rated
SW2 toggle switch SPDT
SW3-SW5 toggle switch DPDT
Plastic box 196x113x60 mm
12 Pc board pins
3 core flex, plug and clamp
Heatsink/support to Fig. 8.
8-way connector strip
2-way connector strip
2 6BA c/s screws & nuts 10 mm long
Front panel (Scotchcal)

FOR MANUAL REVERSE CONTROLLER
Delete
R4, R8 and R9
C2 and C3
Diodes D3-D8
Transistors Q2, 4 and 6

If no loops are involved in the track layout SW4 and SW5 can be deleted on automatic reverse controller and SW5 on manual reverse controller.

For a second controller delete T1, SW1, D1-D4 and the power cord in the second controller.



Printed-circuit board layout ETI 541 train controller. Full size 65 x 105 mm.

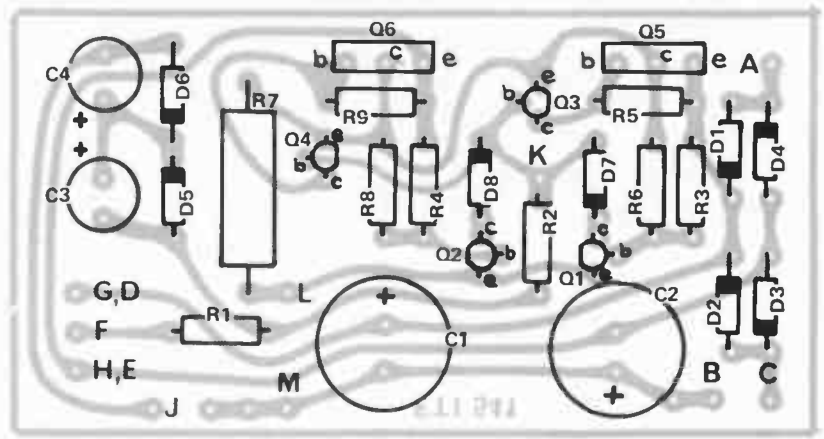


Fig. 3. Component overlay — auto reverse controller.

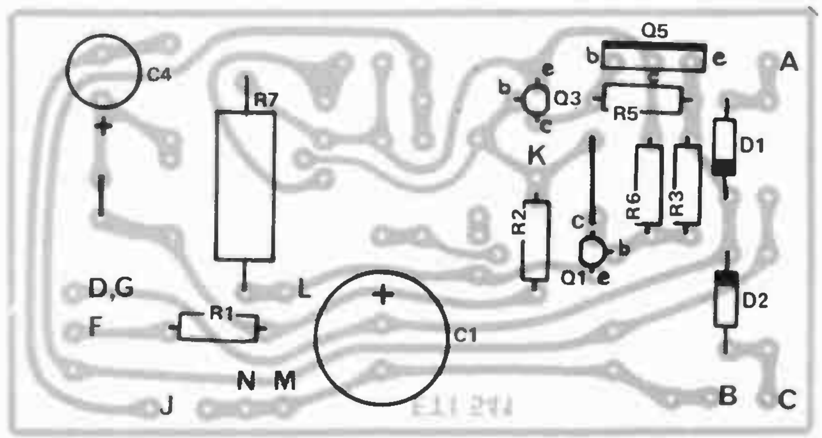


Fig. 4. Component overlay — simple controller.

Train controller

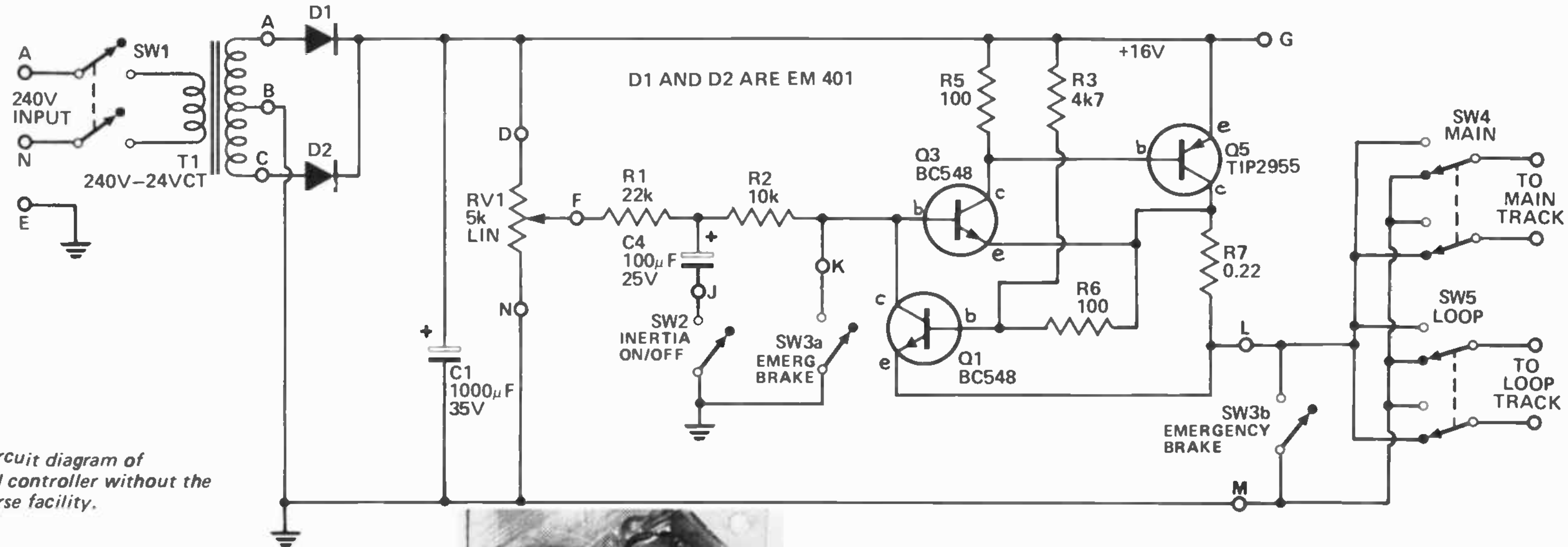
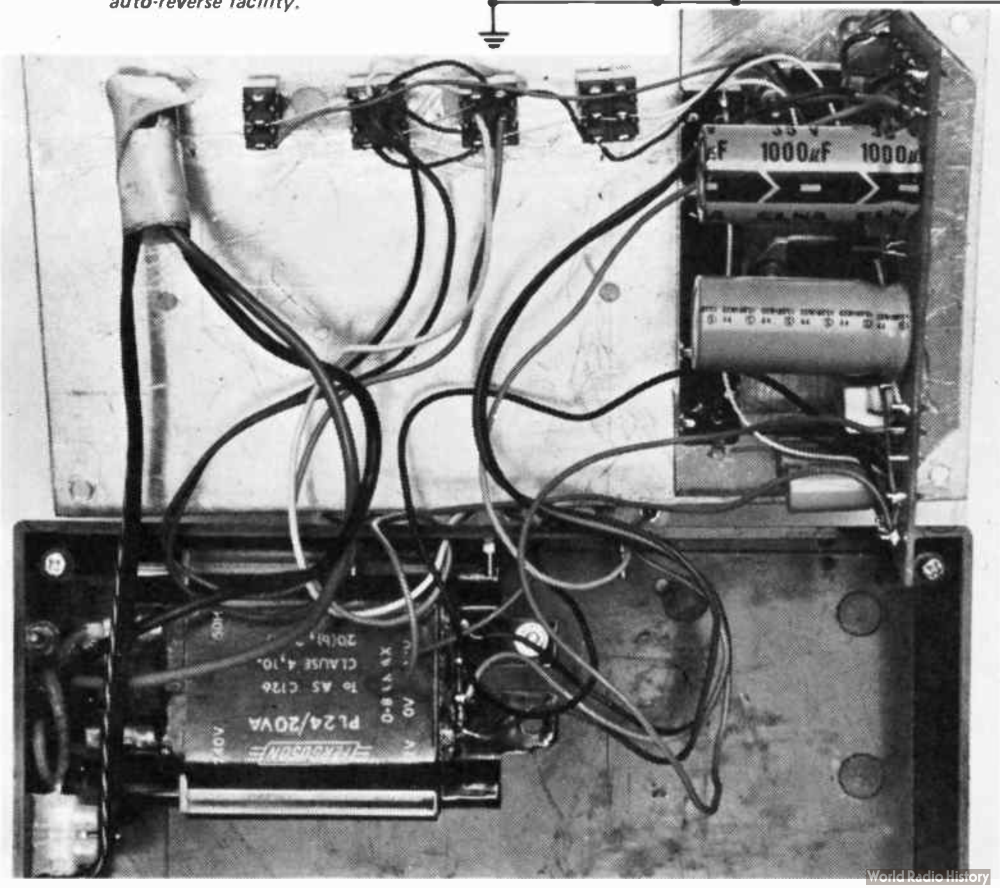
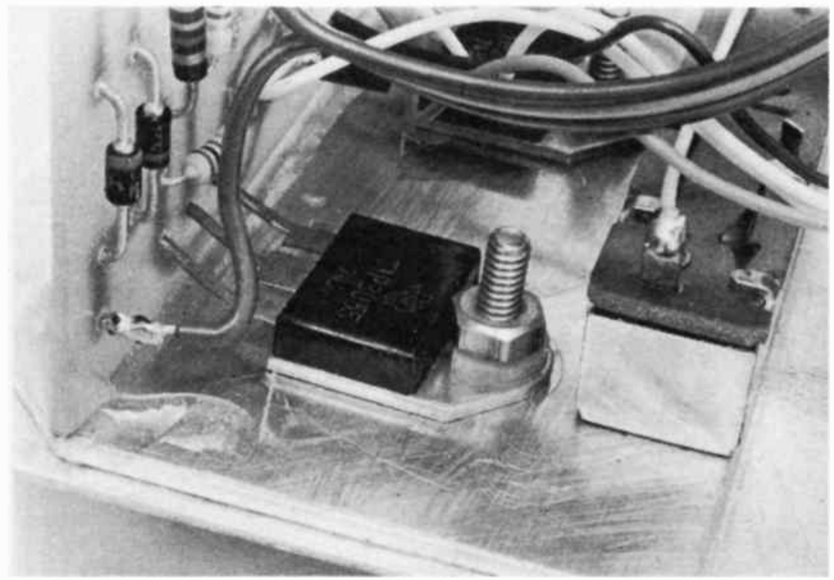


Fig. 5. Circuit diagram of simplified controller without the auto-reverse facility.





The power transistors are mounted to a bracket with countersink bolts. They can, if desired, be mounted directly on the front panel. Note how the pcb is mounted – by epoxying to the bracket.

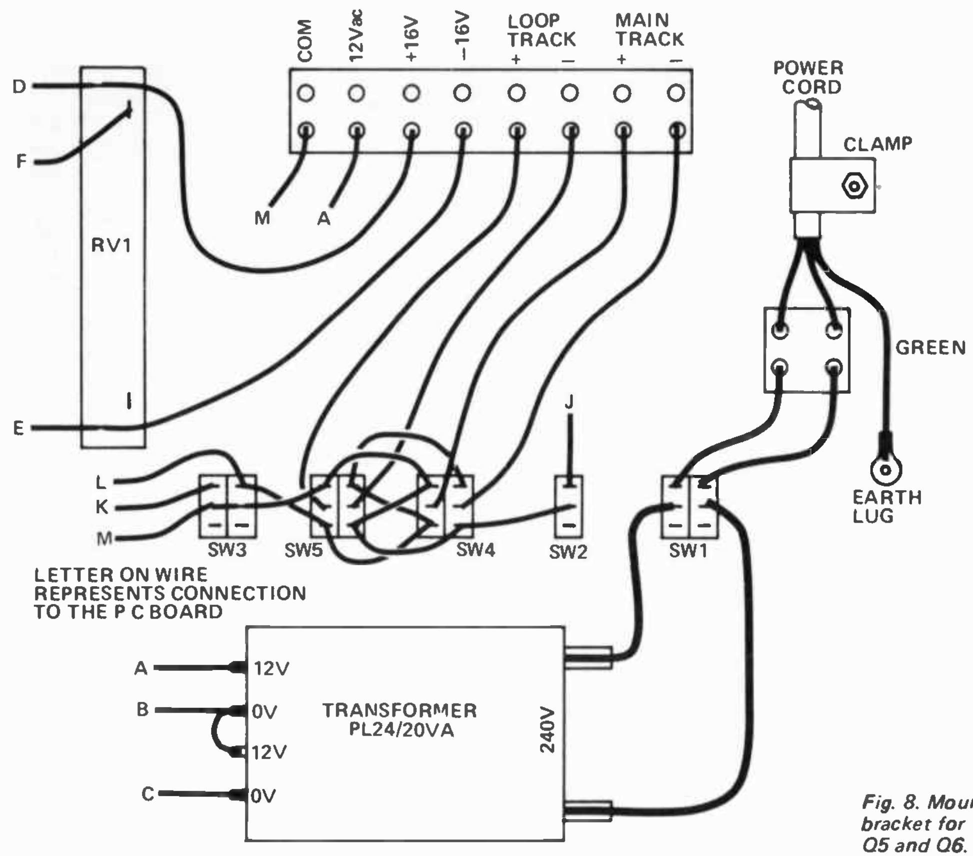


Fig. 7. Interconnection diagram for the auto-reverse controller given in the circuit of Fig. 2.

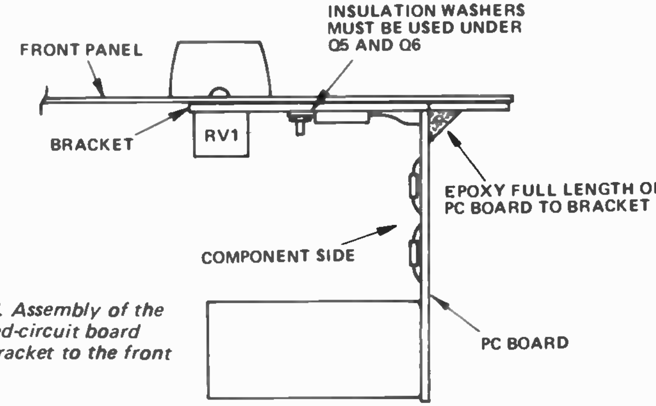


Fig. 6. Assembly of the printed-circuit board and bracket to the front panel.

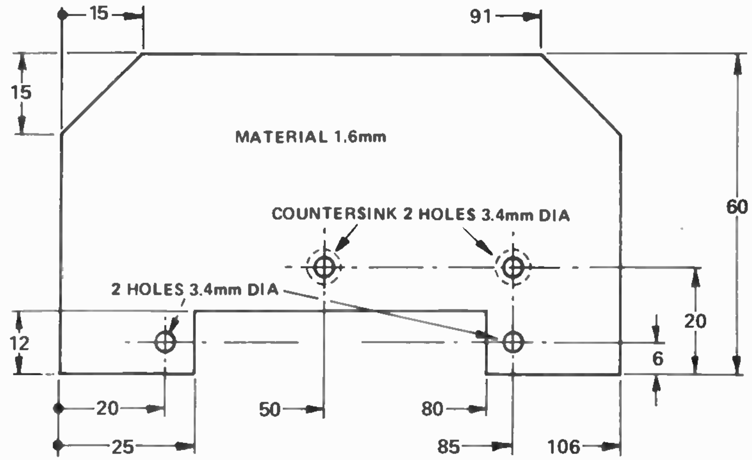
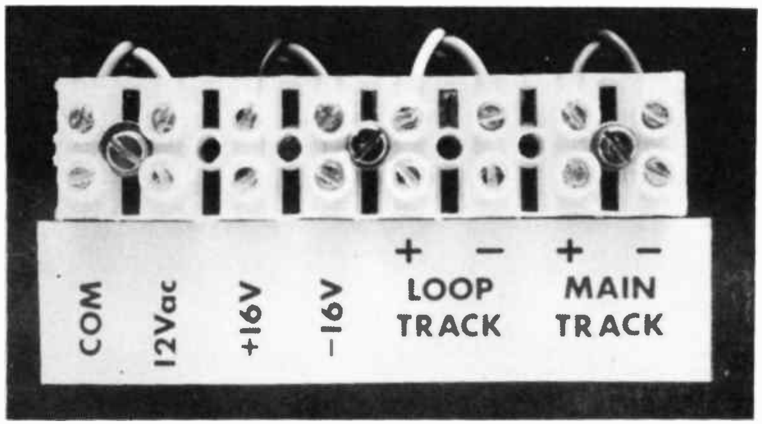


Fig. 8. Mounting bracket for transistors Q5 and Q6.



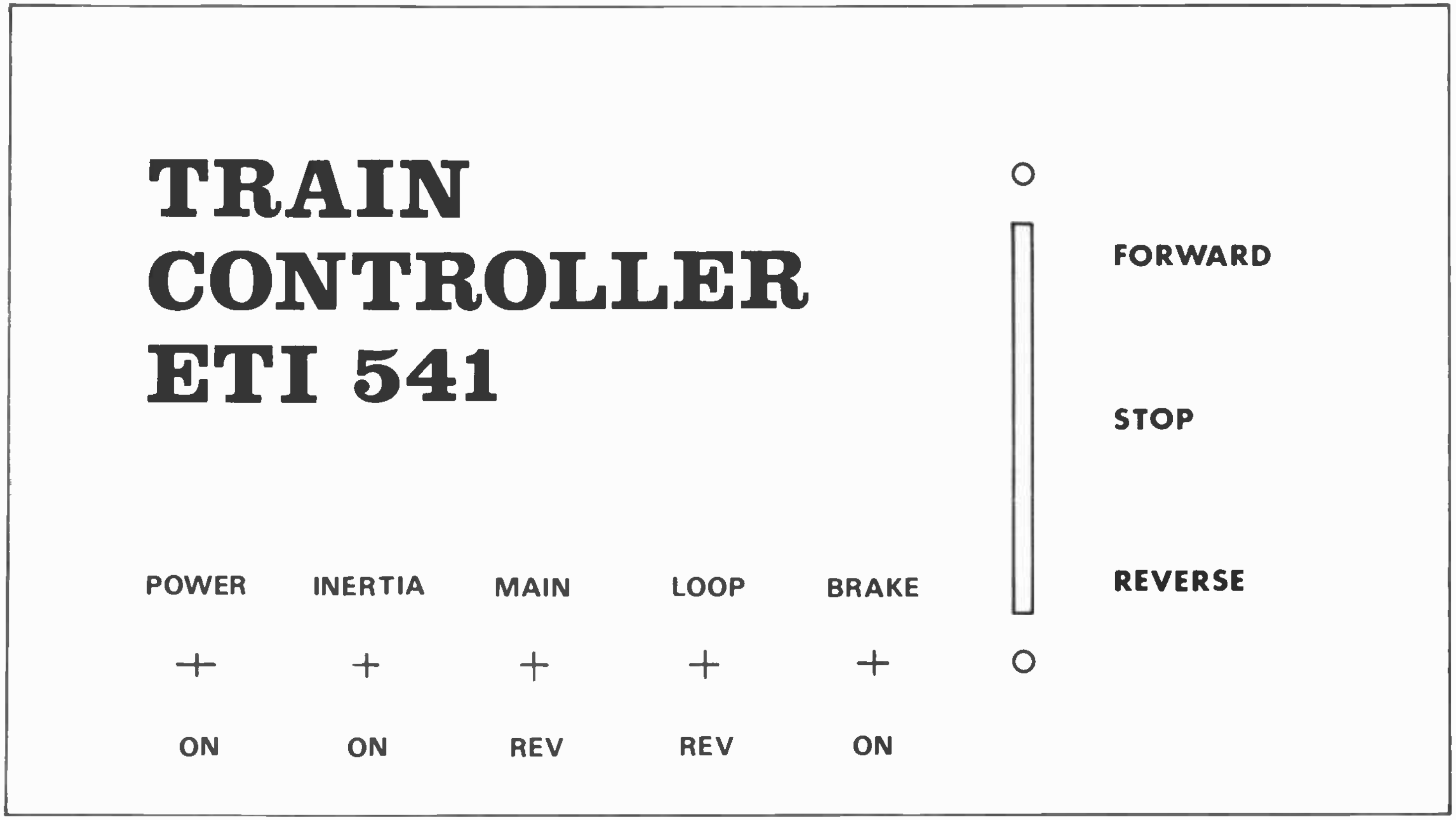
leave the loop then the train, once it passes the breaks in the track, will find the wrong polarity on the main track. It will be unable to continue in the same direction. To overcome this problem the main-track switch must be changed to 'reverse' whilst the train is within the loop. If the train enters the loop towards 'B' then the loop switch must be reversed before the train enters the loop. Once again the mainline polarity is reversed whilst the train is within the loop. Providing the section of the loop between 'A' and 'B' is longer than the train, loop operation will be simple and trouble free.

Simpler versions If all the facilities of the controller are not required then it may quite easily be simplified. If only a single direction is required from the throttle control then the same printed-circuit board and the circuit in Fig. 5. may be used. If loop operation is not required then the controller may be further simplified by deleting SW5 and the associated wiring.

CONSTRUCTION

We built our controller into a plastic zippy box with an aluminium lid. Some people may wish to build the controller into a complete control panel or some other box. This is quite acceptable as the method of construction is not criti-

Train controller



Give your Train Controller a professional look! Finished Scotchcal panels are available from ETI for $3.00 – plus self-addressed stamped envelope at least 120 mm x 200 mm. Please make cheques or postal orders payable to 'Scotchcal Offer' not Electronics Today.

Fig. 9. Front panel artwork. Full size 191 x 107 mm.

Fig. 10. Rear panel artwork.

cal. We suggest however that the printed circuit board specified be used as this greatly simplifies construction and minimizes the possibility of wiring errors.

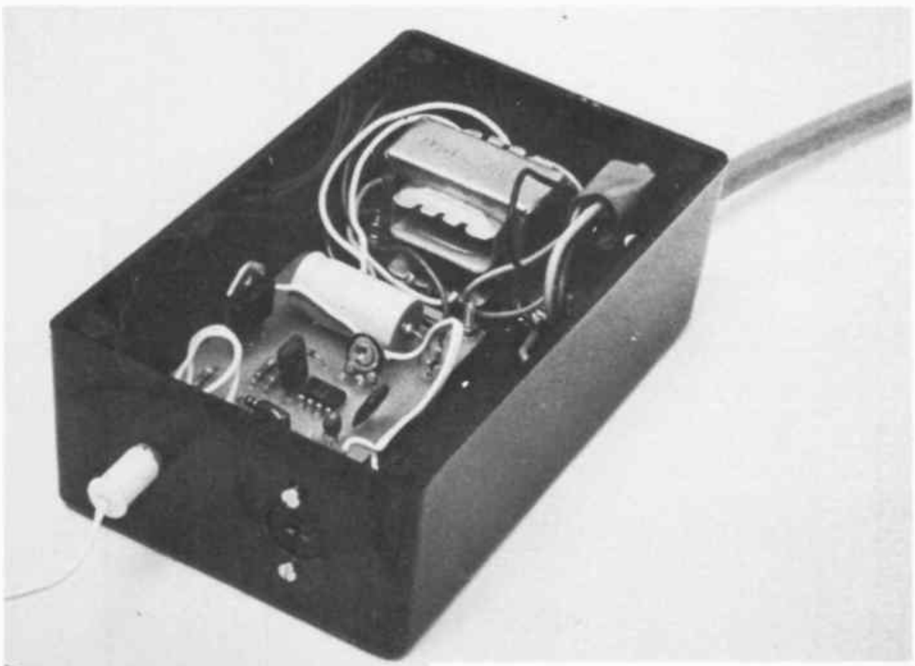
Assemble the components to the printed-circuit board in accordance to the relevant component overlay. Watch that the polarities of components such as diodes, capacitors, and especially transistors, are correct. Note that two different pin connections are available in the BC548 and BC558 transistors, depending on the manufacturer. The Philips type is the one shown on the overlays.

A small bracket was used to hold the printed-circuit board in such a way as to hide the two screws which hold the power transistor. If two extra screw-heads on the front panel do not worry you, then this bracket need not be used. Bolt the power transistor onto the bracket using the insulation kit provided. The Scotchcal panel (if used) should now be fitted to the front panel and all holes drilled and the slot for the slide potentiometer cut. Mount the bracket to the rear of the front panel by means of the slide potentiometer and its mounting screws and then mount the rest of the switches. Drill a hole through the side of the plastic box for the power cord and then fit the cord, the cable clamp and the transformer into the box. Then mount the terminal block to the box and drill small holes for the wires from inside the box to be terminated to it. Finally wire the complete unit and test it.

Once sure that the controller works as it should the board edge should be glued to the front panel (or bracket) with a little epoxy glue. Once this has dried, and you are sure that there is a seal all along the edge of the board, pour epoxy glue along the join so as to form a fillet of glue about 5 to 10 mm wide. (A piece of sticky tape at either end will prevent the glue from running out at the ends). Once the glue has dried the completed front panel assembly may be screwed into the box. Add the rear panel label and the unit is ready for use.

TELEPHONE BELL EXTENDER

This simple project allows you to leave the phone unattended as you move about the house.




MANY TIMES WHILE you're working in the garden the phone may ring and by the time it is heard, if it is at all, it is often too late to reach the phone. While the PMG will install a remote buzzer for you it has to be rented and for people who are hard of hearing it may not be loud enough.

This bell extender will allow you to add, without touching the phone, an external bell, buzzer or speaker anywhere it is desired. When using a horn loaded speaker the sound level is high enough to be heard over high ambient noise making it ideal for the industrial environment.

Adjustment

There are two controls to be set, these being sensitivity and volume. The volume can be set first by rotating RV1 until the tone starts then adjusting RV2 to give the desired volume. To adjust the sensitivity first tape the sensor coil to the underside of the phone and then adjust RV1 until the sound stops. Note however that it should be rotated slowly as C3 gives a delay on switch off. Check that picking up and replacing the phone does not operate the alarm then have someone ring you to check that the phone tone does. It may be necessary to experiment with the position of the pickup coil to get the best results.

Construction

While any construction method could be used we recommend that the PC board be used and the overlay in Fig.3 be followed. The pickup coil was made out of 0.125 mm enamelled wire, although the gauge is not important, with about 200 turns wound around a mandrel about 50 mm diameter. The mandrel can then be removed, the wires terminated to some thin plastic insulated wires (twin "bell" wire is ideal) and then the complete coil wrapped with plastic insulation tape.

We built our unit into a small plastic box using an external speaker. The unit can be mounted anywhere suitable, taking care however with the 240V wiring. The speaker used will depend on the volume required with a larger speaker producing more sound. If a horn speaker is used a very high sound level can be produced.

If it is required only to operate a buzzer the second IC can be altered to be an on-off device by deleting C5, R5, R6, D2 and RV2 and placing a link where C5 was.

TELEPHONE BELL EXTENDER

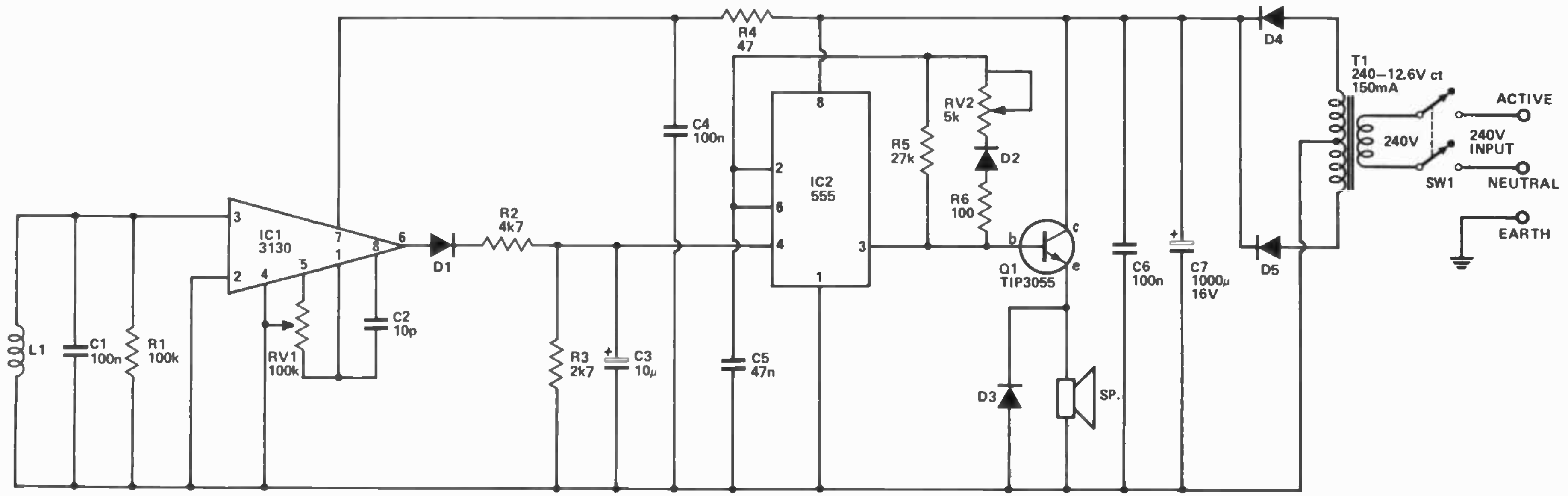


Fig. 1. Circuit diagram of the bell extender.

How It Works — ETI 547

Inside the telphone there is a solenoid which operates a striker which hits a pair of bells to give the ring tone. When it operates there is a high magnetic field generated and we detect this field to give the indication that the bell is ringing. To do this we use a coil wire under the telephone and use an IC to detect the presence of a signal. IC1 has its offset voltage adjusted by RV1 such that a slight positive voltage is needed to make the output go high. It is used in the open loop mode as a comparator only. The capacitor C1 is used to remove the unwanted higher frequency signals.

The oscillator used to operate the speaker is simply a 555 timer with a TIP3055 to buffer the output. The frequency is determined by C5 and the volume by RV2. Changing the volume does change the frequency slightly. Oscillation can however only occur if the voltage at pin 4 is greater than 0.6V. If the output of IC1 is low, R3 ensures that pin 4 is less than this voltage. However when the bell rings the output of IC1 oscillates high and low in time with the ring tone of the bell. This lifts pin 4 high, allowing IC2 to oscillate and C3 holds pin 4 for a short time to prevent the oscillator turning on and off at the ring tone frequency.

The power supply is a simple full wave rectifier with no regulation with IC1 being decoupled further by R4 and C4. Batteries could be used but the drain is reasonably high.

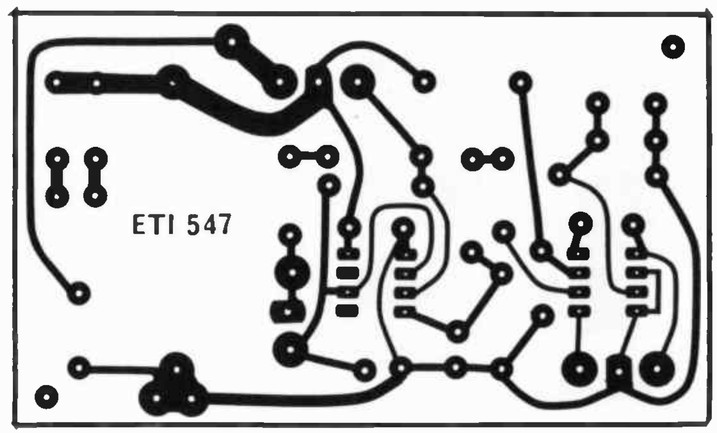


Fig. 2. Printed circuit layout.
Full size 91 x 53 mm.

PARTS LIST — ETI 547

Resistors	all ½W 5%
R1	100k
R2	4k7
R3	2k7
R4	47
R5	27k
R6	100
Potentiometers	
RV1	100k trim
RV2	5k trim
Capacitors	
C1	100n polyester
C2	10p ceramic
C3	10µ 16V electro
C4	100n ceramic
C5	47n polyester
C6	100n ceramic
C7	1000 µ 16V electro
Semiconductors	
IC1	CA3130
IC2	NE555
Q1	TIP 3055
D1-D5	1N4001
Miscellaneous	
PC board ETI 547	
Transformer 240V — 12.6 V ct	
Mains switch, 3 core flex	
Box, speaker, pickup coil	

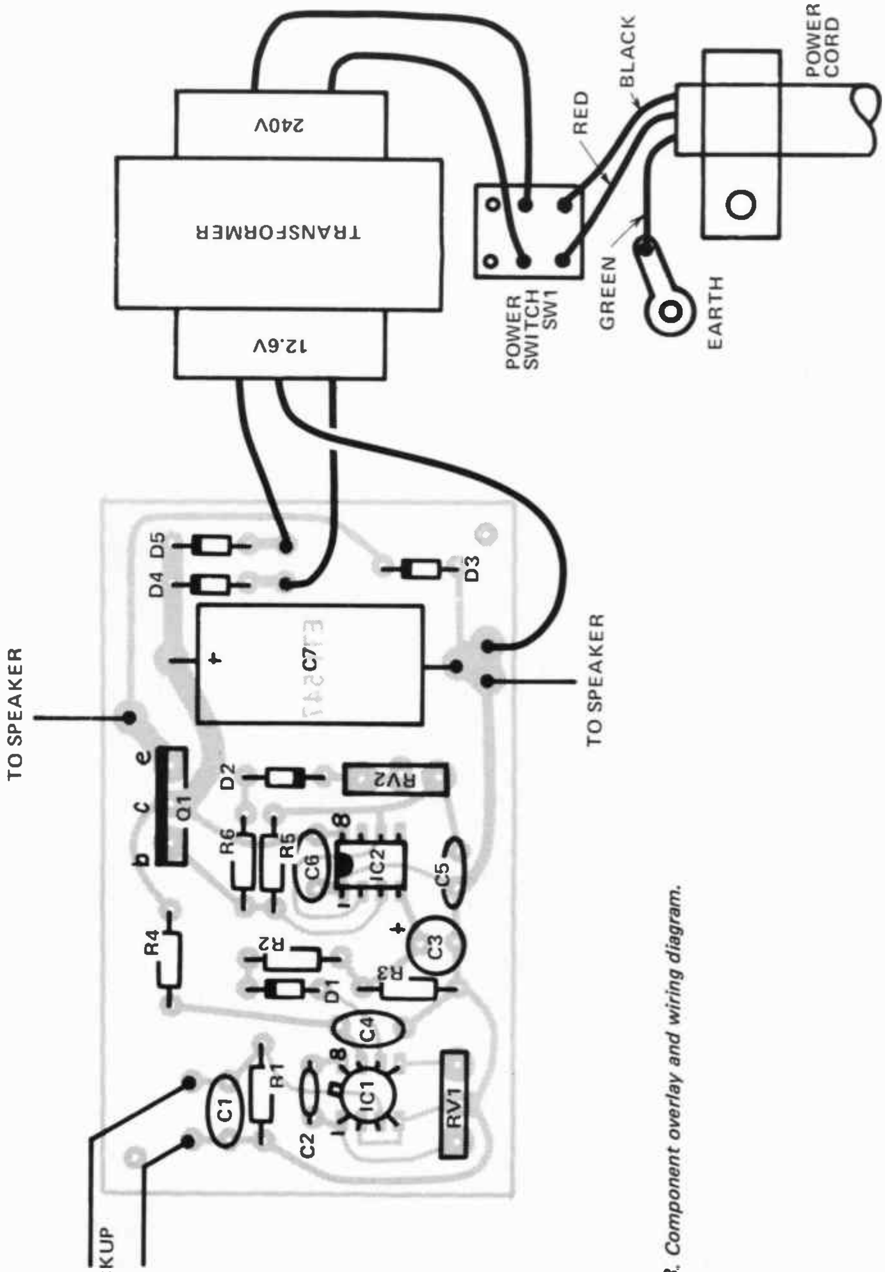


Fig. 3. Component overlay and wiring diagram.

PHOTOGRAPHIC STROBE

This project gives about seven times the light output of the High Power Strobe we published six years ago. It also has other advantages when used by the photographer . . .

THE HIGH POWERED strobe published back in August 1971 has been one of the most popular projects we have designed and it is still being built and sold. A lot of people have since asked if it can be used for photographic use (and if not how could it be modified).

The existing strobe has several problems in photographic use, the main one being insufficient light output. Other problems are that the electronics is all at mains voltage with no isolation, preventing the safe use of a remote push-button control, and that at high speed there is some jitter in the flash rate (since this is partially synchronized to the mains frequency).

This new unit has about 7 times the light output of the previous unit (this can be increased further if needed). The control circuitry is now isolated and the flash rate is steady as there is no synchronization with the mains.

All this however costs more: we have used a larger flash tube, the capacitors cost about $30, and the control circuitry is much more complex. However, if high power is needed the cost is worth while.

The front of the strobe with the perspex cover removed. The cover is necessary to prevent accidental contact with the mains voltages applied to the flash tube.

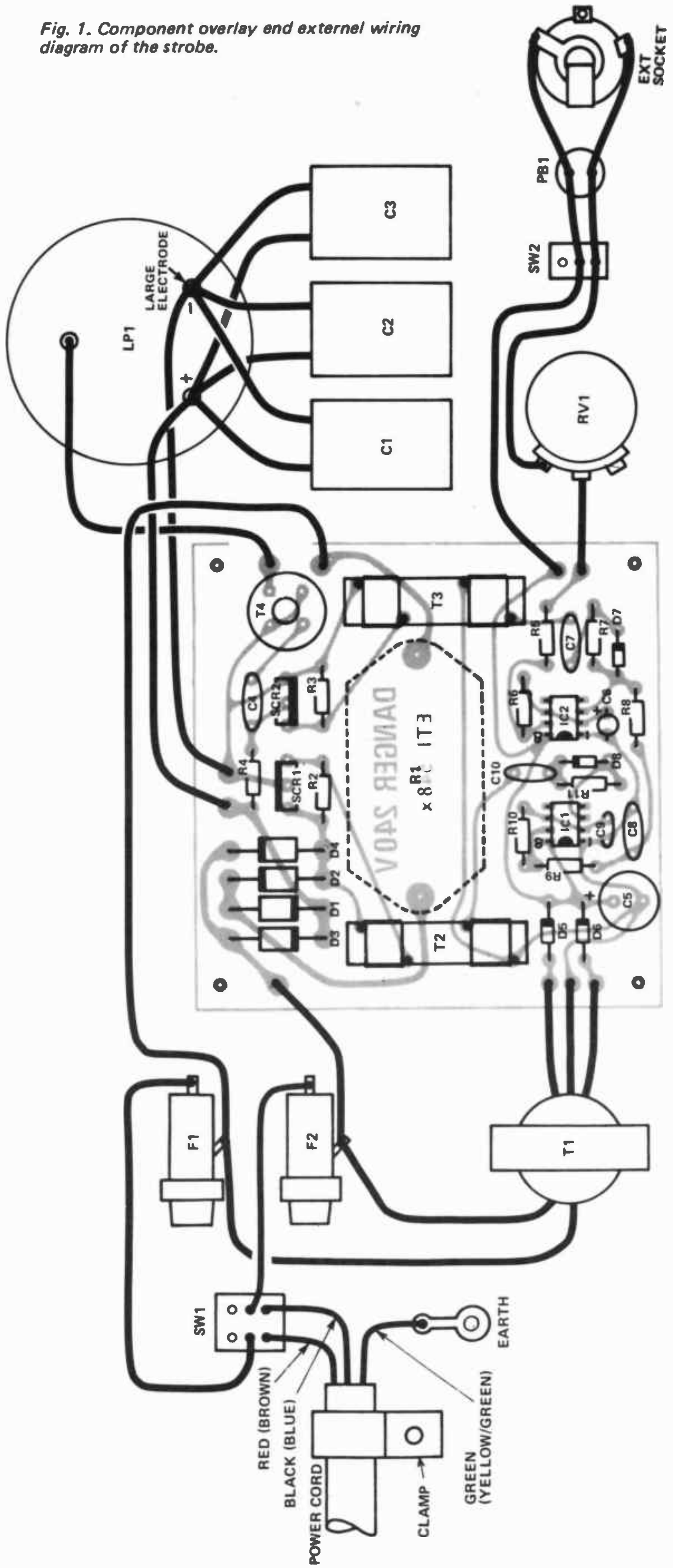


Fig. 1. Component overlay end externel wiring diagram of the strobe.

PARTS LIST – ETI 548

Resistors all ½ W 5%	
R1*	36 ohms 1600 W
R2, 3	1 k
R4	100 k
R5-R7	10 k
R8, 9	68 k
R10	33 k
R11	100
* standard jug element	
Potentiometers	
RV1	rotary 1M lin
Capacitors	
C1-C3	30 μ 250 Vac Plessey type 427/1/00813/002 30/250 V
C4	33 n 630 V polyester
C5	1000 μ 16 V electro
C6	1μ0 25 V electro
C7,8	100 n polyester
C9	2n2 polyester
C10	100 n polyester
Semiconductors	
SCR1,2	C106D, BT100A500R
D1-D4	1N5404
D5-8	1N4004
IC1,2	NE555
Miscellaneous	
T1	transformer, 240 V – 12.6 V CT
T2-3	pulse transformer, see Table 1.
T4	trigger transformer, TR-6KM
LP1	flash tube, FC6501
PCB	ETI 548
SW1	240 V switch double pole
SW2	single pole switch
PB1	push button (press to make)
F1,2	fuses and holders. 3A 250 V
Reflector	
Case	
Power cord and plug	
100 x 100 mm asbestos sheet	
five 25 mm metal spacers	
four 12 mm spacers.	

Construction

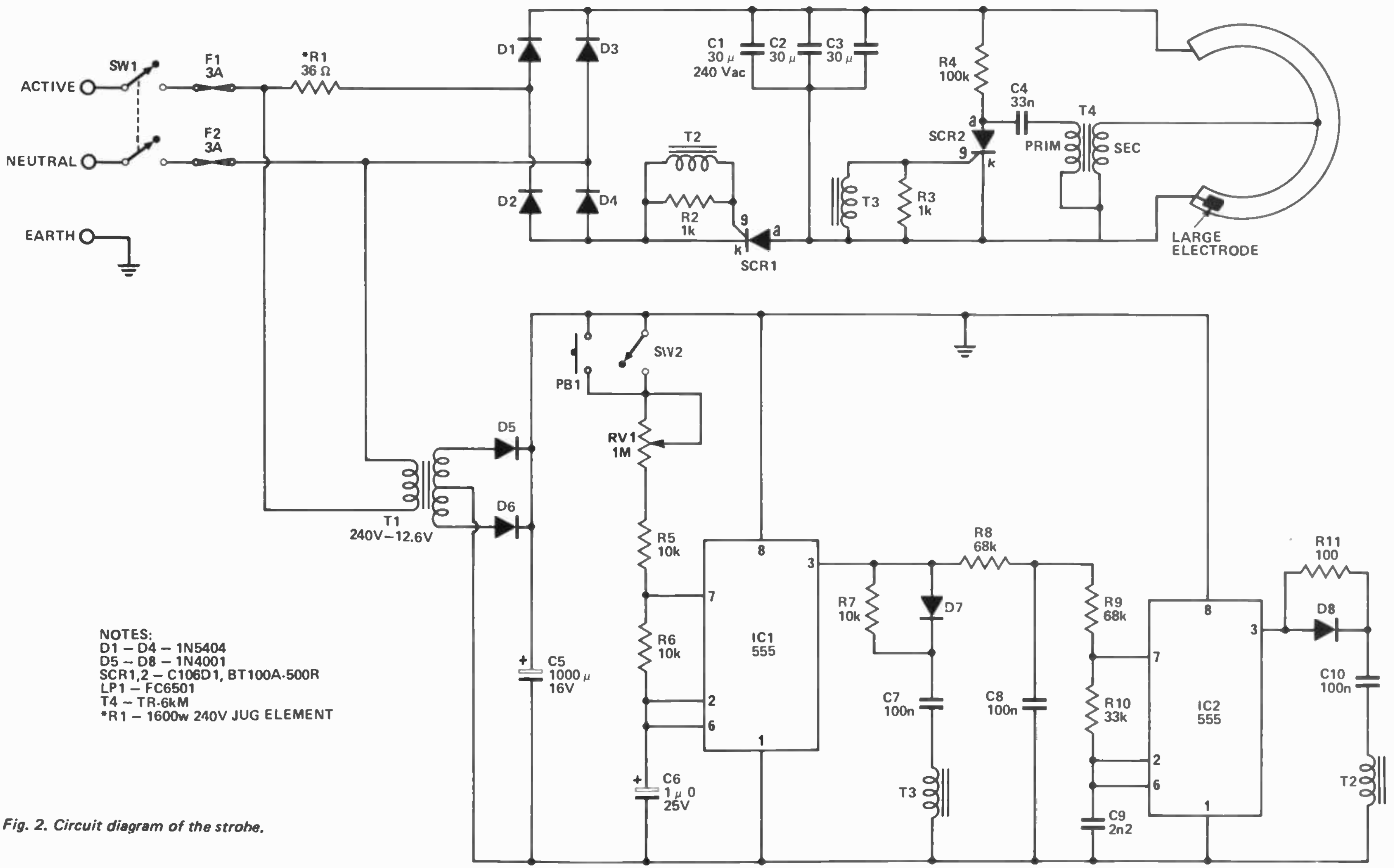
The first thing to remember with this project is that a lot of the circuitry is not isolated from the mains. Contact with these components can be lethal. Therefore be careful to ensure adequate clearances to keep these components from contacting the case and ensure all external metal surfaces are earthed.

We mounted the tube on three banana plugs which fit into sockets on a pc board (see Fig. 3). the pcb is in turn mounted on 25 mm spacers attached to the rear of the reflector. The three mounting holes shown for the spacers were positioned to suit our reflector – these may need to be varied to suit another reflector.

The pcb can be assembled with the aid of the overlay in Fig. 1. Ensure all diodes, electrolytic capacitors, ICs, and SCRs are oriented correctly. The pulse transformer can be wound as shown on Table 1 and soldered in place by its leads. Once the unit is checked the pulse transformers should be glued in to prevent the fine wires from breaking. The resistor R1, which is a jug element, is mounted off the board by 25 mm

(Text continued on page 24).

PHOTOGRAPHIC STROBE



NOTES:
D1 – D4 – 1N5404
D5 – D8 – 1N4001
SCR1,2 – C106D1, BT100A-500R
LP1 – FC6501
T4 – TR-6kM
*R1 – 1600w 240V JUG ELEMENT

Fig. 2. Circuit diagram of the strobe.

How It Works – ETI 548

To operate a flash tube it is necessary to apply to the ends of the tube a voltage of about 320 volts, with a capacitor also across the terminals. However, this is not sufficient. An additional high voltage pulse (6000 V) is required on a trigger lead. When this occurs the tube appears as a short circuit, discharging the capacitor rapidly. The amount of energy in each flash can be calculated by:

energy = $\frac{1}{2}CV^2$ joules

where C is the value of the capacitor in farads and V is the voltage across the capacitor in volts. For 90 μ and 340 V this gives about 5 joules. A normal flash uses 300 V and 300 μF or 13 joules.

The 240 V mains voltage is rectified by D1-D4 with R1 used to give some current limit. If SCR1 is "on" C1-C3 are charged up to 340 V dc. The SCR is used to allow the power to be switched on and off, which is necessary as the power must be switched off while the tube is triggered on (unless the series resistor is over 500 ohms, but a resistor of this value limits the flash rate). To generate the 6kV pulse the capacitor C4 is charged with 340 V via R4, and if the SCR 2 is triggered on it is discharged into the primary of the trigger transformer, T4, giving the 6kV needed.

Control of the SCRs is done by IC1 and IC2.

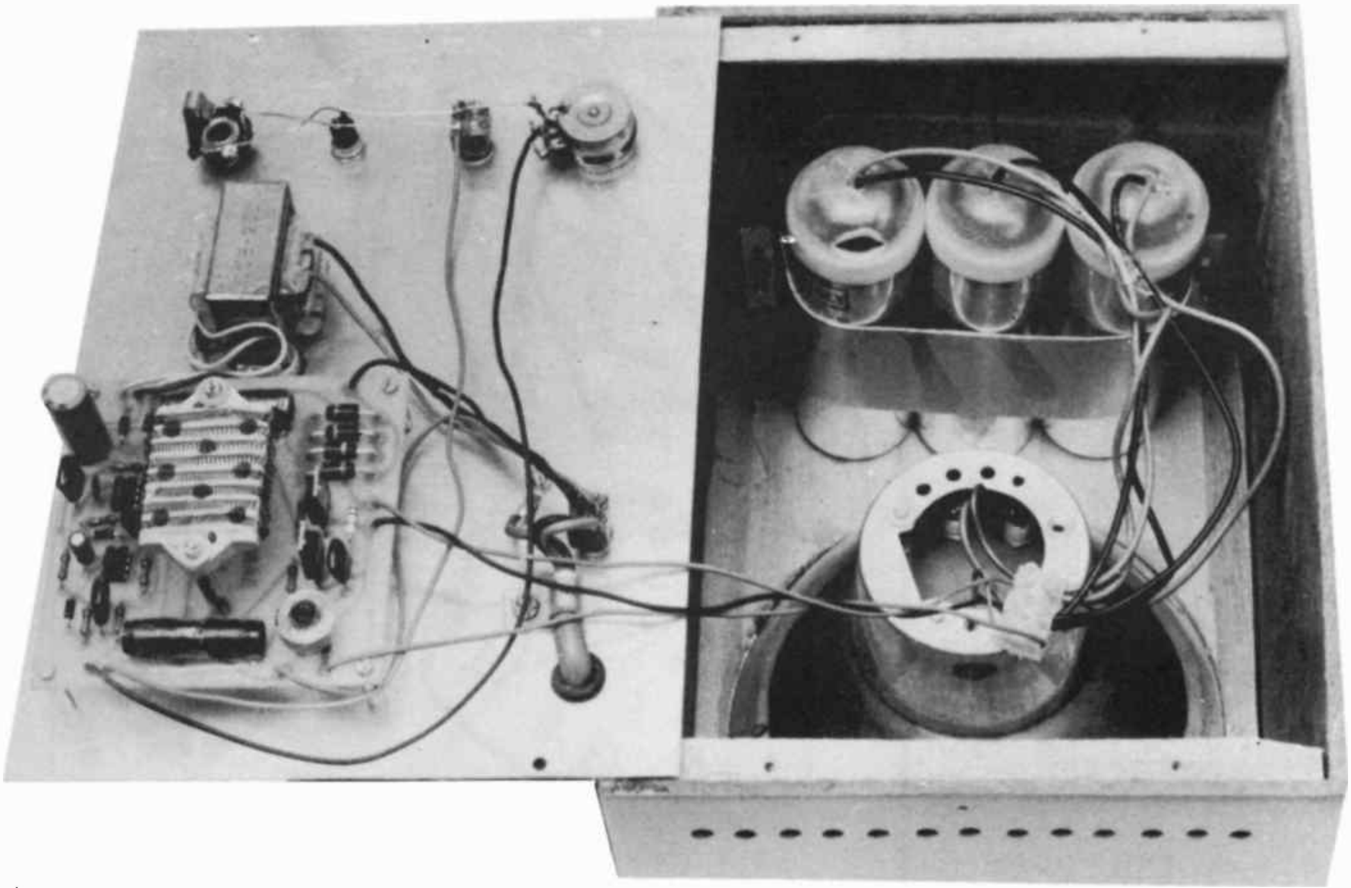
The mains voltage is reduced to 9 V dc by T1, D5,6 and C5, giving the isolation required. IC1 gives the timing of the flash rate which is variable from about 2 to 30 per sec. The output of IC1 is normally high (ie, +9 V) goes low for about 10 ms every flash. When the output goes high again the pulse transformer T2 transfers the transition in the form of a pulse into the gate of SCR2 causing the tube to be triggered. Resistor R7 and D7 prevent the negative transition triggering the tube.

When the output from IC1 goes high R8 and C8 provide about a 10 ms delay before IC2 starts oscillating at about 2 kHz. When it is oscillating the pulse transformer T3 keeps SCR1 on. Therefore the sequence of operation is as follows: IC2 oscillates for the duration between the flashes with SCR1 on and C1-3 is charged up. The oscillation stops for about 15 ms which ensures the SCR1 turns off (more than one half cycle) after which time the tube is triggered, discharging the capacitor C1-C3. This takes about 5 ms and after 10 ms the oscillator turns on again recharging the capacitors.

The oscillation can be started or stopped by SW2 or a push button can be used either local or remote as it is not at mains potential.

Fig. 3. This support is necessary when the sockets for the tube cannot be mounted directly on the back of the reflector. Dick Smith has some new reflectors which do away with the need for this support.

Fig. 4. Printed circuit layout. Full size 100 x 100 mm. Material used MUST be fibre glass due to the heat generated by R1.



long metal spacers to allow for cooling. If you plan to run the strobe at more than 10 or 12 flashes per second a piece of asbestos about 100 mm square must be placed between the resistor and the pcb to prevent heat damage. Similar protection should be given to any burnable substances (the wooden box, if used) near the resistor.

The external (to the pcb) wiring of the unit is also given in Figure 1. The mechanical layout depends on the reflector used and the facility you have for making or purchasing the box. ETI's previous strobe used a metal box behind the reflector to hold the electronics and this approach can easily be adapted. We couldn't find a ready-made box of the right size so we made a wooden box (three ply) with the reflector enclosed. The rear panel (which holds the electronics) is made of aluminium. If this approach is used a row of ventilation holes, about 6.5 mm diameter, should be provided along the top rear and the lower sides. If a metal box is used it will transfer enough heat through the walls without the need for the holes.

Whatever system is used remember again that the circuit is a 240 V (except for the control circuitry) and adequate clearance must be maintained and all external metal parts, including the reflector, must be earthed. Also **a piece of perspex must be fitted over the reflector to prevent accidental touching of the tube.**

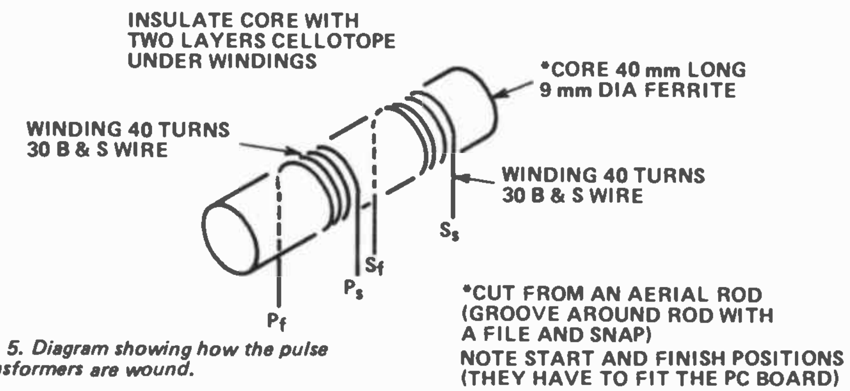


Fig. 5. Diagram showing how the pulse transformers are wound.

If the unit is intended for a disco the use of the switch SW2, the push button, and the external socket will not be needed and SW2 can be bypassed. Also increasing R5 to 39 k will reduce the maximum rate to about 16/sec.

DANGER

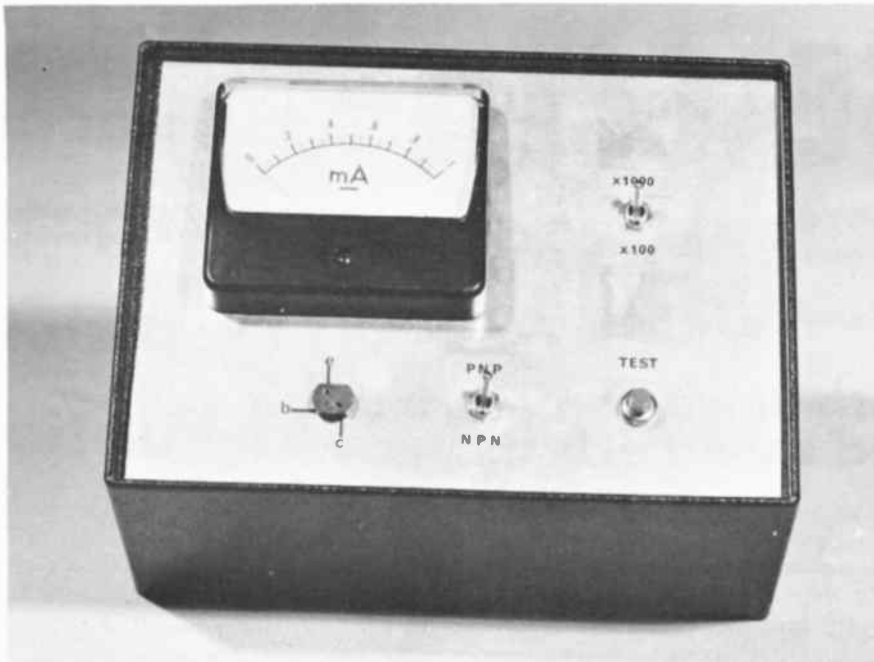
Stroboscopes are dangerous instruments — they can bring about epileptic fits in people who have a history of epilepsy and also in those who are disposed towards this trouble. There are cases of people who never knew of any epileptic disposition who, under the influence of stroboscopic stimulation, have had fits induced and thereafter have suffered from subsequent, non-induced fits.

Flash-rates in the order of 5 to 12 flashes per second are the dangerous rates in this respect. In the event of such an attack switch the strobe off immediately.

TRANSISTOR TESTER

PROJECT 222

Measure and test your transistors with this easily built device.



The transistor tester mounted in a metal case.

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

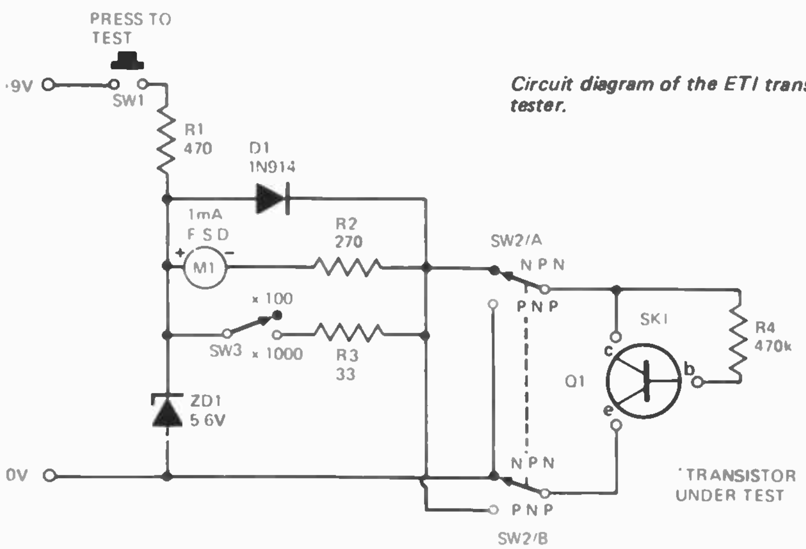
But semiconductors are easily damaged — by incorrect operating conditions — or by excessive application of heat when soldering.

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

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

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

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



Circuit diagram of the ETI transistor tester.

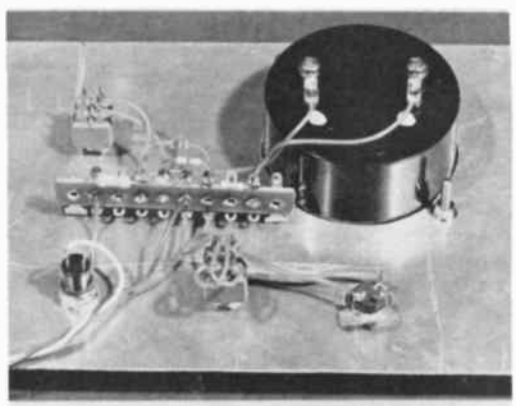
PARTS LIST — Transistor Tester — ETI 222

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

HOW IT WORKS

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

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



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

SELECTA-GAME

with on-screen scoring and sound effects

* tennis
* soccer
* squash
* practice
* optional rifle

This low-cost yet sophisticated TV game contains just one main IC plus a handful of other components yet out-performs virtually all other units currently on the market.

AT THE TIME WHEN TV games first appeared in Australia they retailed for around a hundred dollars and had fairly limited capabilities. Many of our readers requested a TV game project but our investigation showed that 20 to 30 CMOS ICs would be required. As the circuit is quite complex we felt that the chances of a hobbyist building such a unit without problems were small, and any problems encountered would have been likely to be beyond solution with the equipment and knowledge available to the average constructor. We therefore decided not to do the project until single-chip TV game ICs became available. We knew that these chips were being developed and that they would make the project much simpler from the constructional point of view.

This project is based on such a single-chip device type AY-3-8500 from the General Instrument Corporation. The chip offers a choice of six games together with on-screen scoring and sound effects. The games are tennis, soccer, squash, practice and two rifle games. The rifle games required a 'rifle' which has additional circuitry built into it. On page 34 we describe the circuitry of a gun available from Dick Smith which can be used with this project.

Some additional circuitry, including two extra ICs, is required to build the game but the complexity of the complete circuit is still greatly reduced by the use of this particular IC. In addition, the chip, although expensive, does allow the cost of the unit to be reduced considerably even though its performance is superior to many other games on the market.

Construction

The TV game employs some VHF circuitry which demands correct lay out if proper operation is to be obtained. For this reason the game should only be built onto the printed-circuit board specified.

Commence construction by installing the seven tinned-copper wire links and then the low-height components (resistors, diodes, etc). Next install the capacitors and the transistors. ICs 2 and 3 are CMOS devices and should only be removed from their protective packing when you are ready to install them. Handle them as little as possible and when inserted solder the power supply pins (7 and 14) first. The main IC is expensive and it is therefore recommended (but not essential) that a 28-pin IC socket be used to mount it.

The coils L2 and L3 should now be constructed as detailed in Table 1 and then soldered into position making sure that L2 is oriented correctly.

The rotary switch may now be mounted in the following manner: First solder 25 mm lengths of tinned-copper to each of the switch pins (14 in all). Now orientate the switch correctly and feed the wires through the respective holes in the printed-circuit board, press the switch down onto the board and solder all the wires to the tracks of the board.

Now prepare the push buttons, the 5-pin DIN socket and the phono socket by soldering 40 mm lengths of tinned-copper to each of the terminals. Feed the wires through the respective holes in the printed-circuit board but do not solder just yet.

The slide switches should also be prepared in the following manner: Cut 60 mm lengths of 20 gauge BS tinned-copper wire (largest gauge that will fit through the switch holes) and thread them through the holes in the switch pins so that pairs of poles are linked together. Centre the wires in the lugs and then solder them to the lugs. Now bend the wires down on either side and insert them in the holes provided in the printed-circuit board but do not solder at this stage.

Fit the front panel to the rotary switch (use a spacer washer) making sure that the board is square to the front panel and that there is enough clearance for the RF coil and the shield which have yet to be fitted. Attach the phono socket, the DIN socket and the push buttons to the front panel and then solder their leads to the board. Push the slide switches up against the front panel, line the switches up with the openings in the front panel and, making sure that the switch doesn't move, solder the leads to the board.

Now remove the front panel and

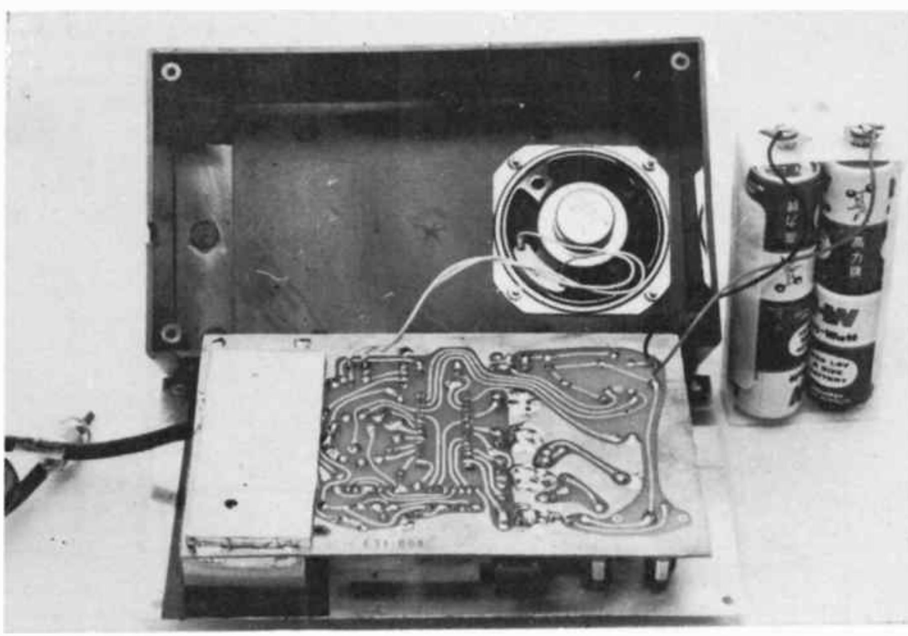
fit the 75-ohm output coax and the coax for the bats to the printed-circuit board. Feed the bat cables through rubber grommets in the front panel after first tying knots in them to prevent them being pulled through accidentally. Alternatively 3.5 mm jacks may be installed on the front panel for the bat outputs and the cables fitted with plugs so that they can be unplugged when the game is not being used.

Add the battery leads and connect the speaker by means of 150-mm long wires. Check all wiring and solder joints before fitting the main IC to its socket.

Before the shields for the RF stage are fitted the unit should be connected to a TV set and aligned and checked as detailed in the alignment section.

After alignment is satisfactorily completed fit the component-side shield using four short lengths of tinned-copper wire and then fit the copper-side shield by simply soldering it to the copper earth plane in four or five places. Make sure that the shields do not touch any other tracks, leads or components which would cause a short.

The alignment of the unit may now be peaked up if required. The front panel is normally at +7.5V due to the connections to the phono sockets and the shield is at 0V. Some plastic insulation tape should be used over the top of the shield or on the front panel to prevent shorting. Now fit the front panel and mount the assembly in the box. The batteries and speaker should be fitted into the bottom of the box under the printed-circuit board. Holes should be drilled in the box under the speaker to act as a grill to let out the sound from the speaker.



We initially used four "C" size batteries for power as the unit will work from about 5 to 8 volts. However to increase battery life 5 cells of either "C" or "AA" size should preferably be used.

If an external power unit is used either 6 or 7.5 volts dc will operate the unit and the 3.5 mm phone jack used should be used with the +Ve lead on the common terminal.

Alignment

Switch the TV set to channel 6 (5 or 7 could alternatively be used if channel 6 is used in your area), connect the TV game to the antenna input of the set and switch both units on.

Press the reset button on the game and tune coil L2 until the set appears to be receiving the signal. (At this time the picture may appear to be just a series of dots). Adjust the trimmer capacitor CV1 until the picture locks. Then it may be necessary to readjust L2 for the best picture.

When performing these adjustments it is best to use non-metallic tools so that the tuning point does not alter when the tool is removed.

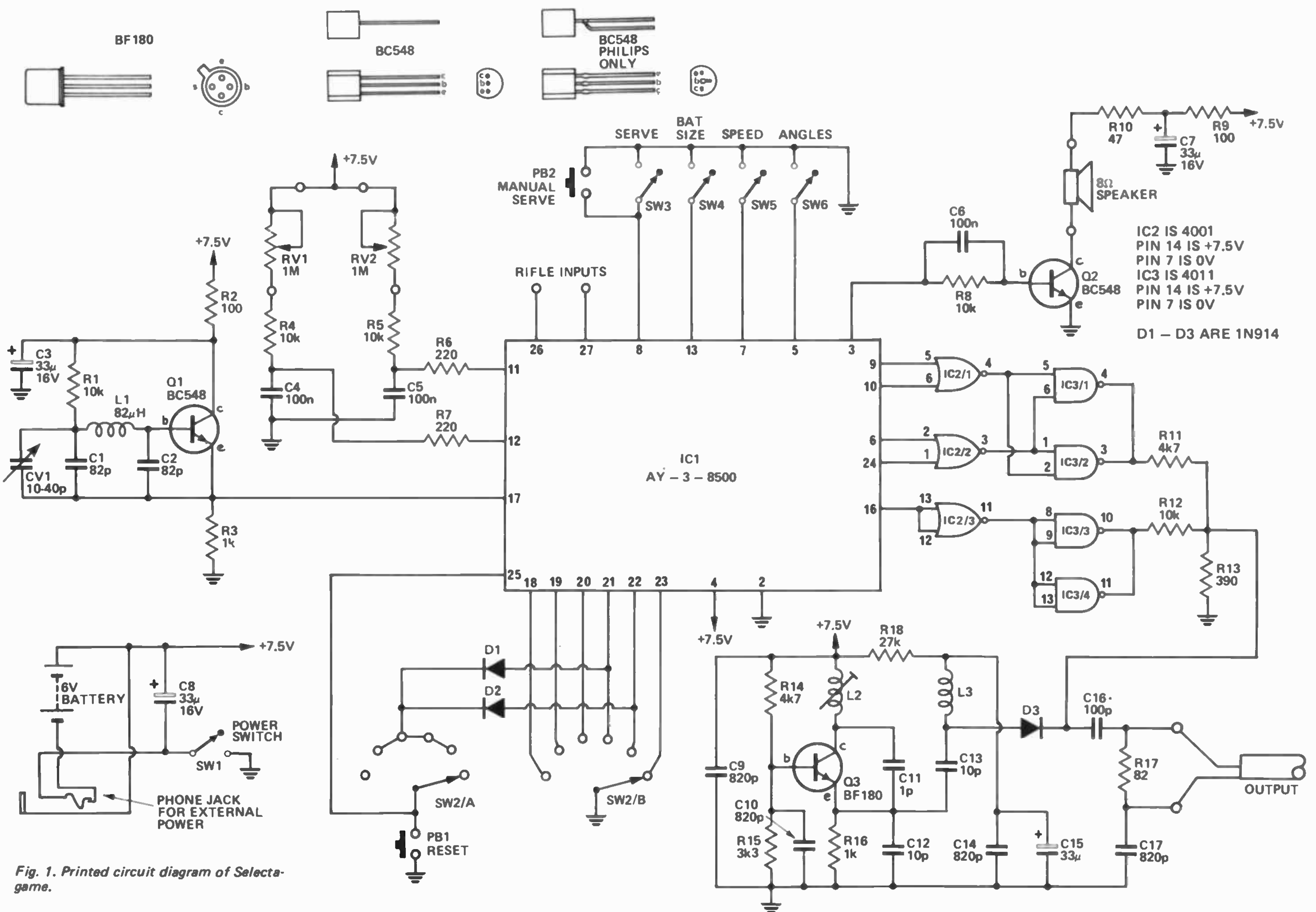


Fig. 1. Printed circuit diagram of Selecta-game.

How It Works – ETI 804.

Unfortunately the manufacturers don't give much information on how the main IC works – we are only told how to use it. The chip is obviously a digital IC (because there are two ball speeds, the rebound angles are defined and there is no provision for variable speed or bounce).

A 2 MHz oscillator is required for the chip to derive the synchronising pulses required for line and frame synchronisation of the TV set. This oscillator is provided by Q1 and its associated components with CV1 providing calibration.

The bats are simply one megohm potentiometers connected as variable resistors which effectively vary the charging time of capacitors C4 and C5. The capacitors C4 and C5 are discharged by the chip at each frame sync pulse and the time taken to charge again (as set by the bat pot setting) determines the vertical position of the bats on the screen. The bat size, ball speed, deflection angles and serve are simply selected by connecting the appropriate pin of the IC to '0' volts.

Outputs from the chip are left and right bat, sync, ball, score and sound – all on separate pins. The bats, ball and score outputs are combined by IC2/1,2 and IC3/1,2 to produce a composite video signal. The sync pulse is buffered by IC2/3 and IC3/3,4. The sync and information pulses are then added by R11, 12 and 13. The sound output is buffered by Q2 to provide the power necessary to drive the speaker.

So that the game may be fed into the antenna terminals of a TV receiver the video signal must be modulated onto an RF oscillator tuned to the desired channel (176 MHz for channel 6). Transistor Q3 and its associated components form the required oscillator. The oscillator is then modulated with the composite video by means of the diode modulator D3.

The oscillator and the modulator are screened by means of shields to prevent the RF from causing interference to other TV sets (and to prevent other TV sets from interfering with the game). These shields also minimise detuning effects when the hand is brought close to the oscillator.

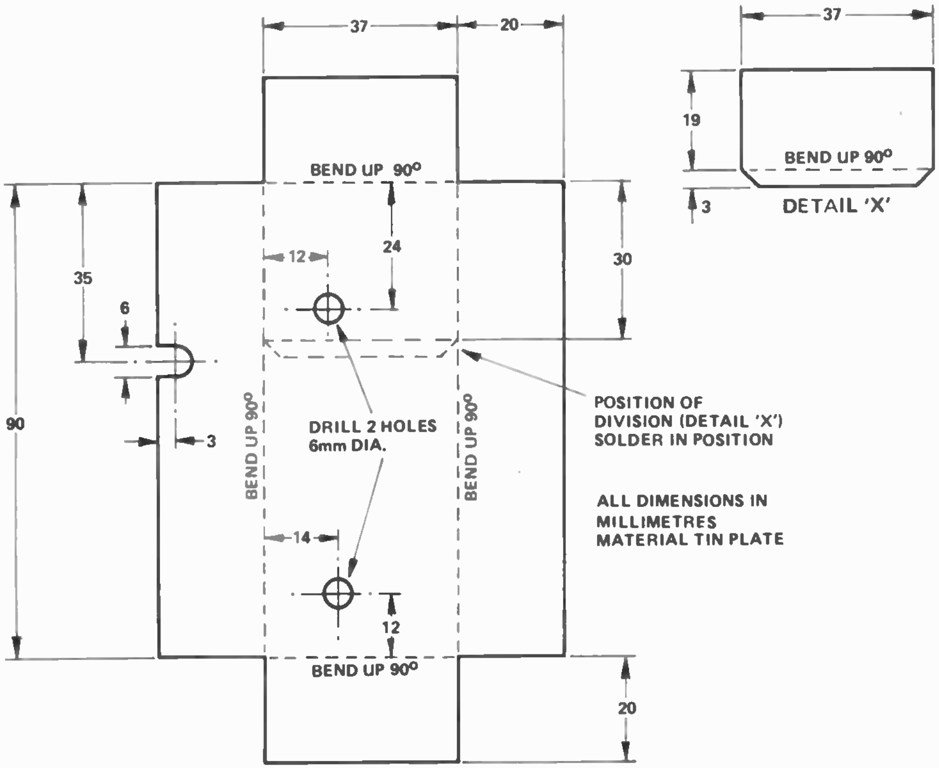


Fig. 2. Dimensions of shield on component side.

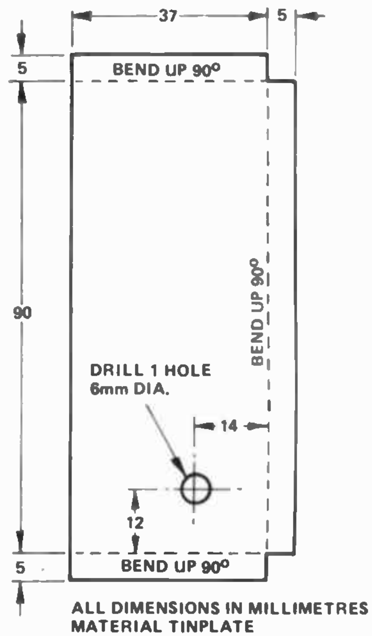
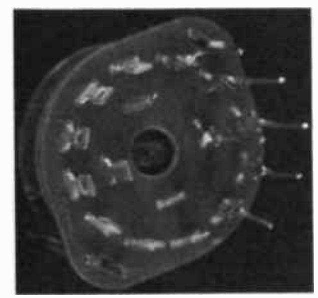
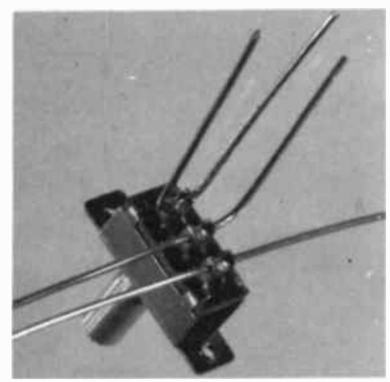


Fig. 3. Dimensions of shield on copper side.





Photographs showing wires attached to switches before installation.

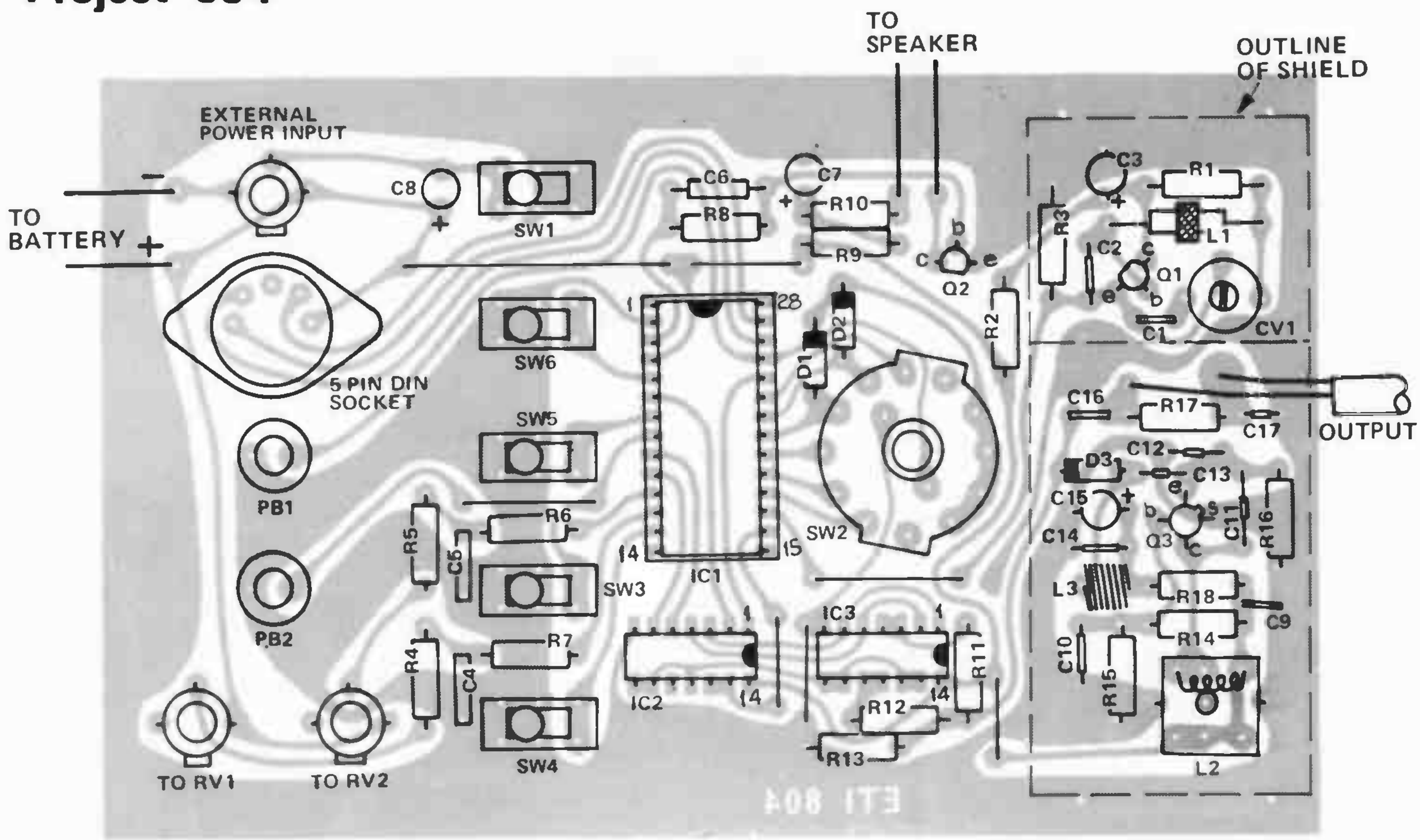


Fig. 4 Component overlay of Selecta-game.

PARTS LIST ETI 804

Resistors all ¼w 5%

R1	10 k
R2	100
R3	1 k
R4,5	10 k
R6,7	220
R8	10 k
R9	100
R10	47
R11	4 k 7
R12	10 k
R13	390
R14	4 k 7
R15	3 k 3
R16	1 k
R17	82
R18	27k

Potentiometers

RV1,2	1M lin rotary

NOTE: see modification Fig. 2 page 35.

Capacitors

C1,2	82 p ceramic
C3	33 μ 16 v electro
C4,5,6	100 n polyester
C7,8	33 μ 16 v electro
C9,10	820 p ceramic
C11	1p0 ceramic
C12,13	10 p ceramic
C14	820 p ceramic
C15	33 μ 16 v electro
C16	100 p ceramic
C17	820 p ceramic

Variable capacitor

CV1	10-40p

Transistors

Q1,2	BC548 or similar
Q3	BF180

Diodes

D1-D3	1N914

Integrated Circuits

IC1	AY-3-8500
IC2	4001 (CMOS)
IC3	4011 (CMOS)

Inductors

L1	82 μ H RF choke
L2	See table 1
L3	See table 1

Miscellaneous

PC board eti 804
2 pole 6 position switch
Five slide switches
8 ohm speaker
3.5 mm phone socket
5 pin DIN socket
Two miniature push buttons
Three knobs
One large box 196mm x 113mm
Two small boxes 83mm x 54mm
Single 'C" size battery holder der
28 pin IC socket

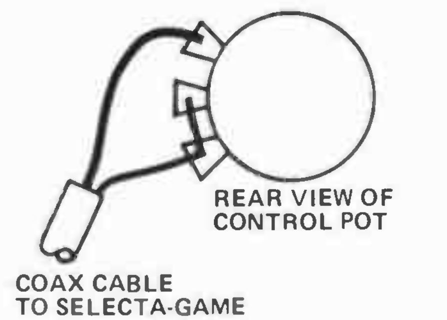


Fig. 5. Diagram showing wiring of control pot.

TABLE 1 ETI 804

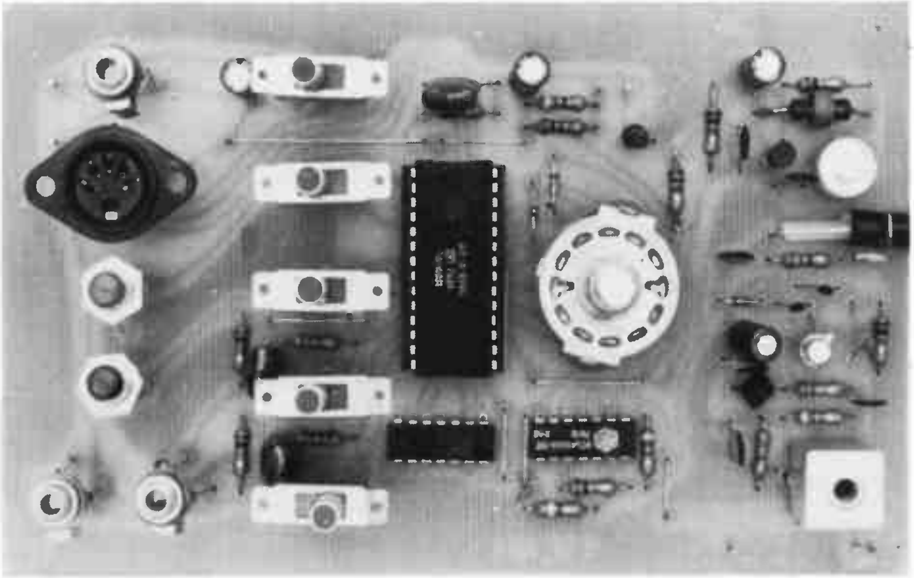
Winding details of coils L2 & L3

L2

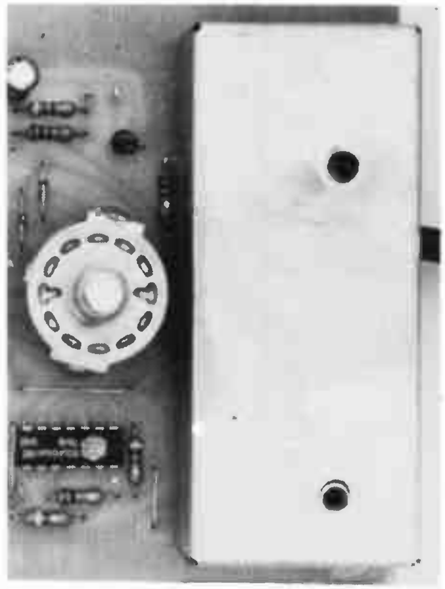
Former 5mm	Neosid 722/i
6 pin base	Neosid 5027/6 PLB
Can	Neosid 7100
Slug	Neosid 4 x 0.5 x 10 F29

Winding 4 turns close wound 24 B&S

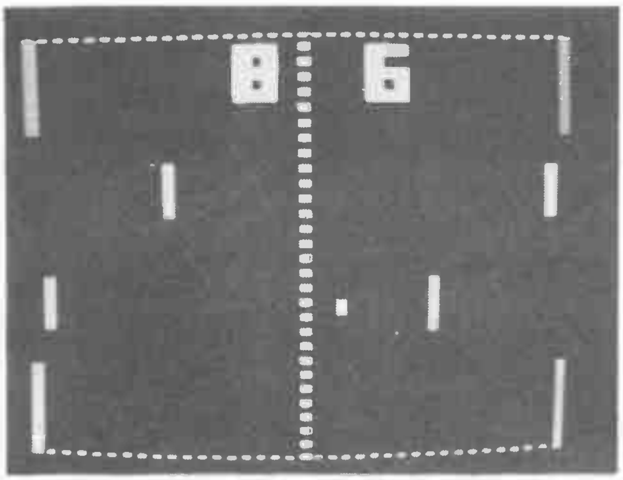
L3
6 turns 24 B&S wire close wound about 5mm diameter, air core. (wind on a former, ie a knitting needle or drill, then remove former)



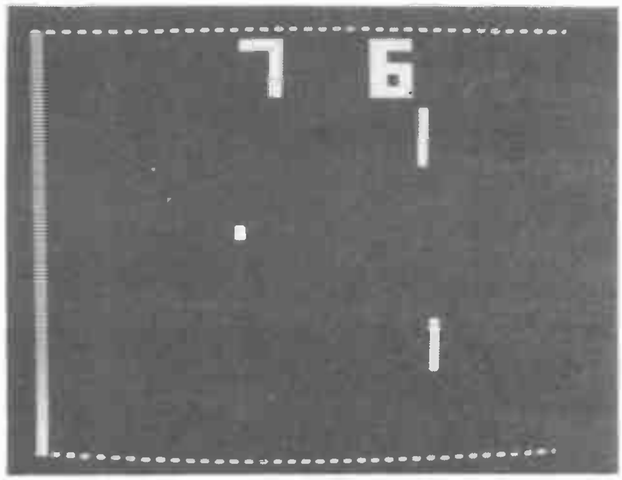
Photograph of completed board less shield.



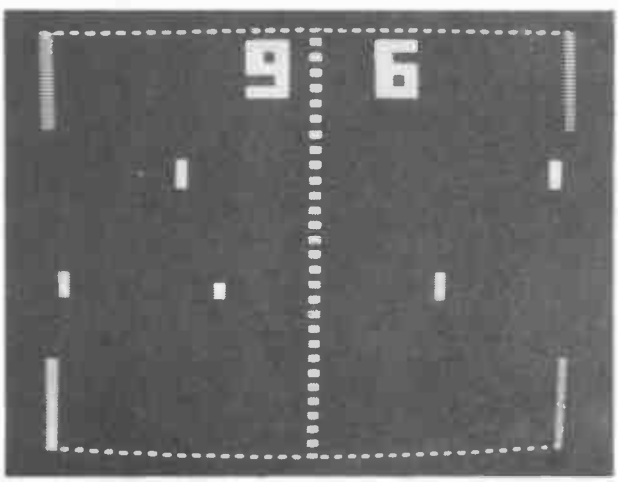
Photograph showing shield fitted. Note two adjustment holes



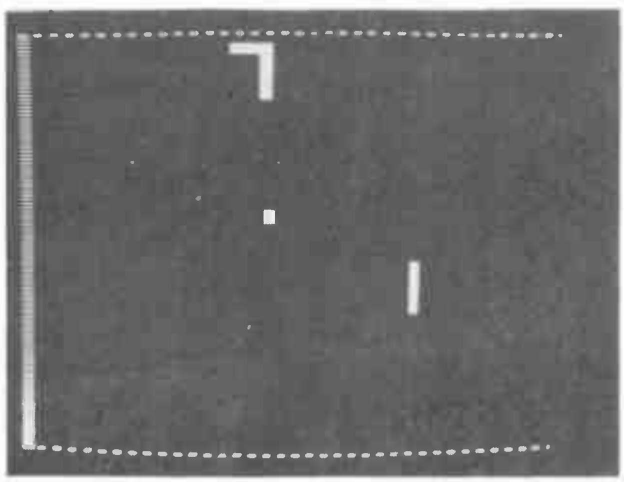
Soccer



Squash



Soccer with small bats



Practice

These photographs show some of the games that can be played.

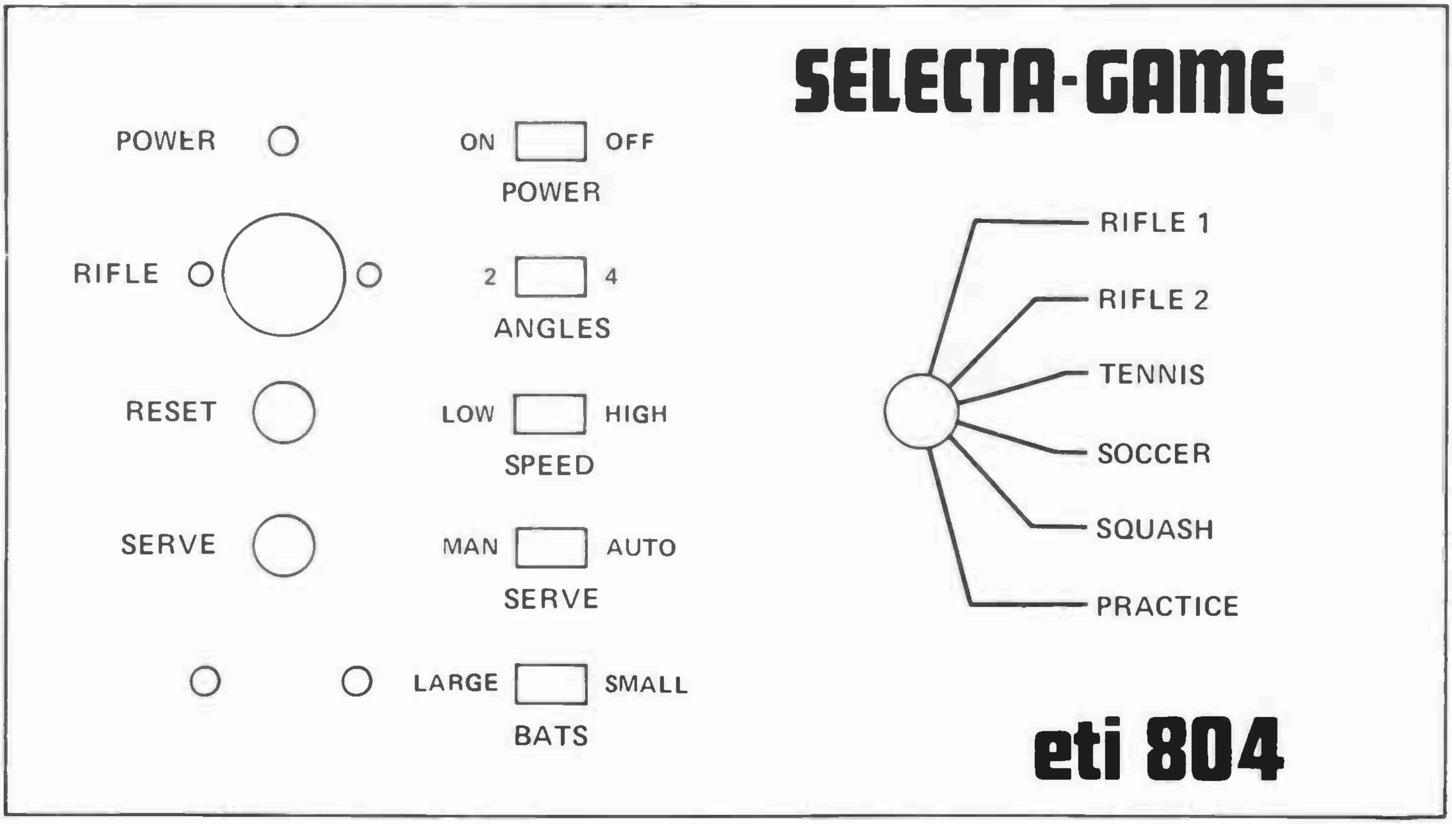


Fig. 6. Front panel layout. Full size 190mm x 107mm.

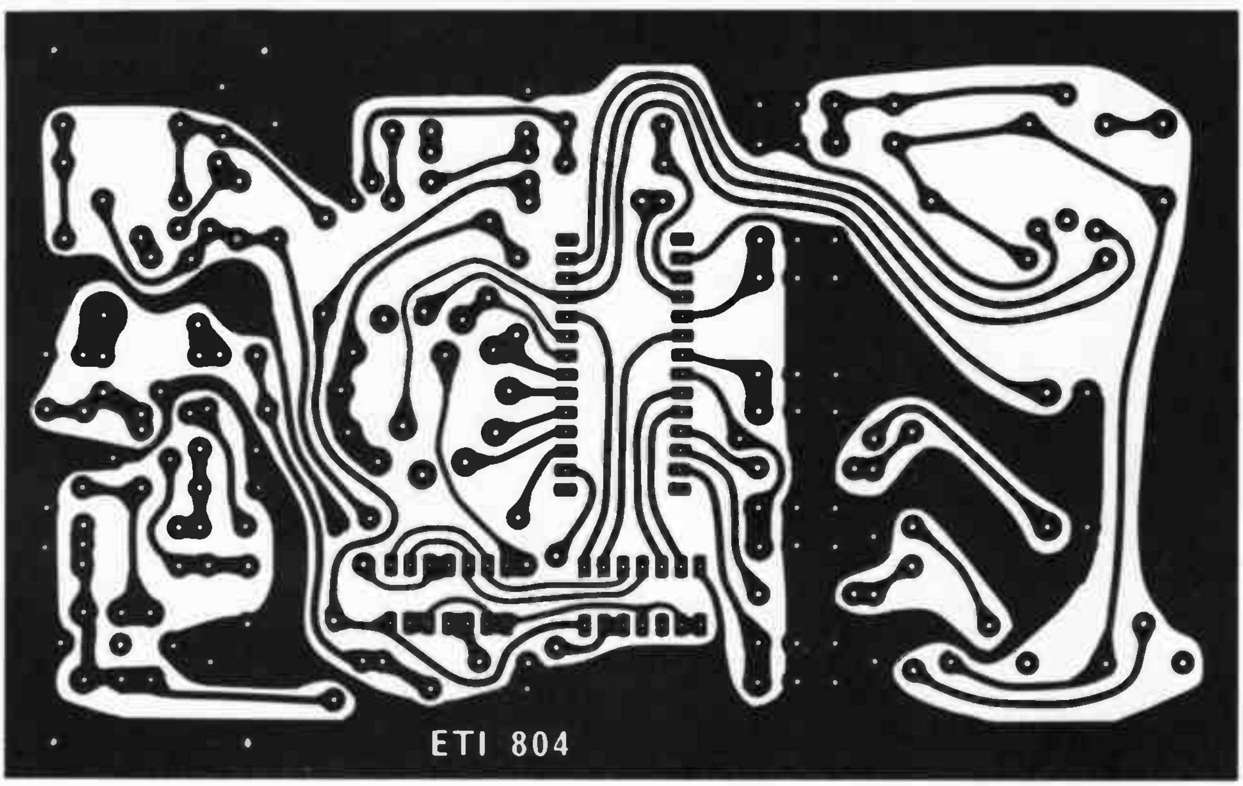


Fig 7. Printed-circuit layout. Full size 163mm x 102mm.

THE GAMES

1) Practice: The ball reflects off the end wall and the side walls – the player has to stop it exiting the screen on the right-hand side. This game is an electronic version of hand-ball or squash with only one player.
2) Squash: This game is like the practice game but now there are two players who take turns in hitting the ball. The bat has no effect on the ball when it's your opponent's turn.
3) Soccer: The ball reflects off all four sides of the pitch, except for the goal mouth. The goalkeeper defends this in the same way that the bats defend their court in the other games. The player has a second man on the field for soccer – the forward. This man will act like a bat when faced with a ball moving towards his own goal – the ball reflects towards his opponent's goal – but when the ball is moving in the right direction (towards his opponents side) the ball passes through him. However by careful positioning of the forward the ball can be made to deflect towards the goal.
4) Tennis: The game of TV Tennis is widely known and on Selecta-game the only unusual features are those listed in the specification.

SPECIFICATIONS – ETI 804

Output	**Picture: TV signal on channel 6 (can be set up on any other channel).** **Sound: Three audio tones indicate hit, bounce and score. Reproduced from a loudspeaker in Selecta-Game.**
Players' Controls	**Each player uses a single rotary control to position his bat/men on the screen. In the practice game one control operates; for tennis, soccer and squash two players each have a control. For the rifle games a special rifle is needed (not described in this article).**
Game Selection	**Basic Games:** **1) Practice 2) Squash** **3) Soccer 4) Tennis** **Other Games (these cannot be played without a special rifle):** **5) Rifle–1 6) Rifle–2**
Scoring	**On-screen scoring up to a maximum of 15 points.**
Other Features	**Two ball speeds** **Two bat sizes** **Two angles ± 20°; or four angles ± 20° & ± 40°.** **Manual or automatic service**

USING YOUR SKILL

With the 'Angles' switch at '2' the ball moves across the screen at ± 20° from the horizontal. When hitting the sides and walls of the court the laws of reflection are obeyed. When the ball hits the bat this isn't always the case: a ball hitting the top half of the bat will leave with an upward trajectory, and a ball hitting the bottom half of the bat will bounce downwards. This effect can be utilised by the skilful player – when the soccer forward is used to change the direction of the ball as it approaches the goal it usually beats the goalkeeper.

With the 'angles' switch at '4' the game becomes even more exciting. Now the bat has to be divided into quarters: starting from the top and working down the angles of the emerging ball are +40°, + 20°, –20°, –40°. And if you can cope with that try switching to small bats and high speed ball!

SELECTA-GAME

Many readers have asked us to design a gun project for the Selecta-Game. However this is not economically worthwhile if designed to our standards. Here we look at a commercially-available gun and give sufficient details for the experimenter to build up a similar unit.

SINCE PUBLICATION OF THE TV game project in November 1976 many thousands have been built by our readers. Many of these people have asked us to publish the rifle circuit for use with this unit. The trouble with designing a rifle or gun is that it involves mechanical work and optics. Also the quantity of light obtainable from the TV screen is very small and the differential between being on-target and off is very small.

We had therefore decided not to publish a rifle project but then Dick Smith gave us a plastic gun which included a pickup transistor and a lens.

What we have presented here is the gun and the circuit used in a commercial unit and it does work. Its limitations are that it will work only over a short range (about 1 metre) and the sensitivity control is extremely sensitive. Due to these limitations we decided not to present this as a complete project as we normally do but we are just printing the circuit to allow you to decide on your own means of construction.

If better optics are used longer range and less critical adjustment should result.

Modifications

The control pots on the Selecta-Game wear out quickly in continuous use unless wire-wound types are used. However, wire-wound pots of the correct value are not readily available, so we have designed a circuit which will allow 10 k pots (which are easily obtained) to be used. This involves modifying the game to add two transistors, two diodes and four resistors.

Some of the ICs do not like to operate on 6 V and as the batteries do not last long this has proven troublesome. Therefore we suggest you use a 9 V battery (or 6 x 1.5 V cells). This may change the internal adjustment slightly, necessitating re-alignment.

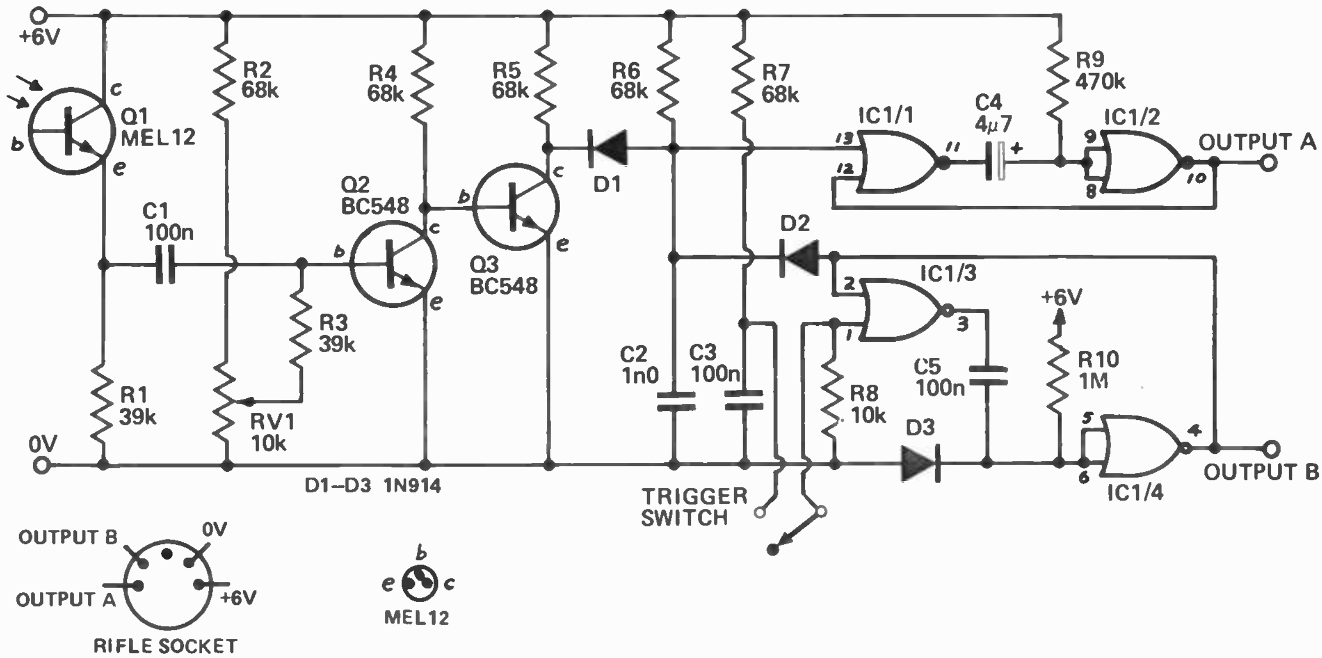
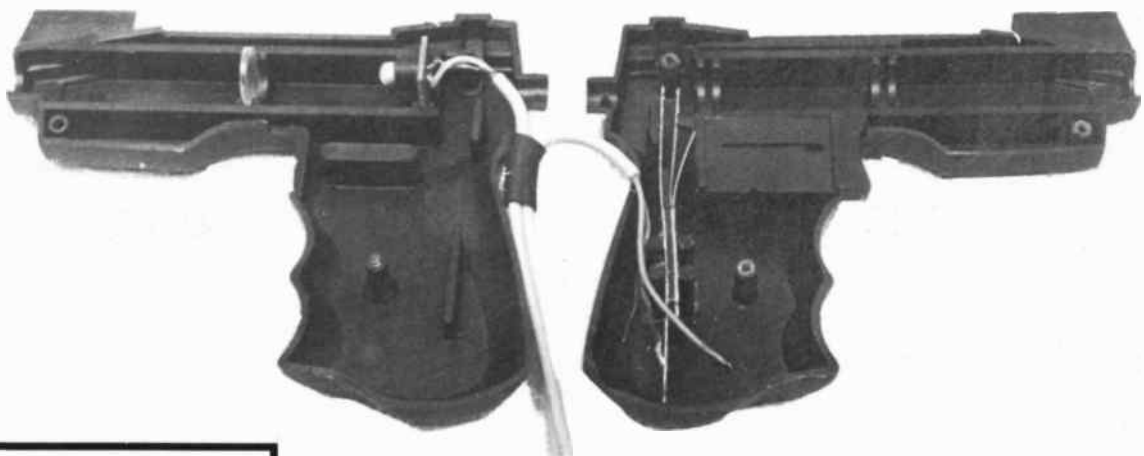


Fig 1. Circuit diagram of the gun.



This is the plastic gun assembly used in a commercial game. These guns (including lens and switch, but not the phototransistor) are available from Dick Smith Electronics

PARTS LIST
TV GUN

Resistors all ½ W 5%

R1	39 k
R2	68 k
R3	39 k
R4-R7	68 k
R8	10 k
R9	470 k
R10	1 M

RV1 Potentiometer 10 k lin rotary

Capacitors

C1	100 n polyester
C2	1n0 "
C3	100 n "
C4	4 μ7 16 V electro
C5	100 n polyester

Semiconductors

Q1	MEL 12 *
Q2,3	BC548
D1 - D3	1N914
IC1	4001 (CMOS)

* Q1 is part of gun.

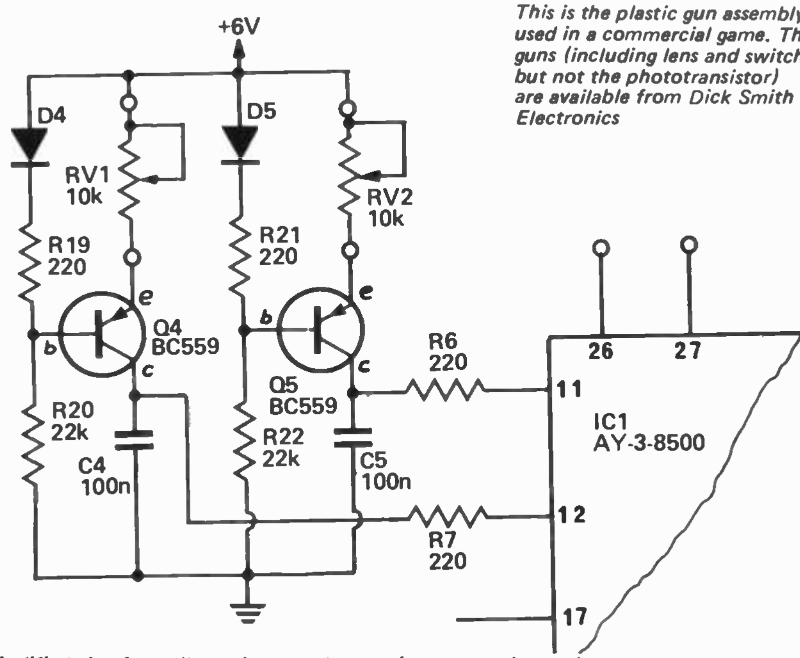


Fig 2. Modified circuit to allow wirewound potentiometers to be used.

Breakdown beacon

An essential device for any car owner — this project doubles as emergency flasher or trouble lamp.

THE BREAKDOWN BEACON IS A dual purpose device. It stands about 115 mm high and can be used atop a disabled motor vehicle as a flashing warning to other traffic — a highly desirable safety device. Alternatively it can be used as a non-flashing trouble light for finding and fixing faults at night. Its three rubber-sucker feet will hold it to the roof of a car, to the underside of a bonnet, or to any other convenient flat surface.

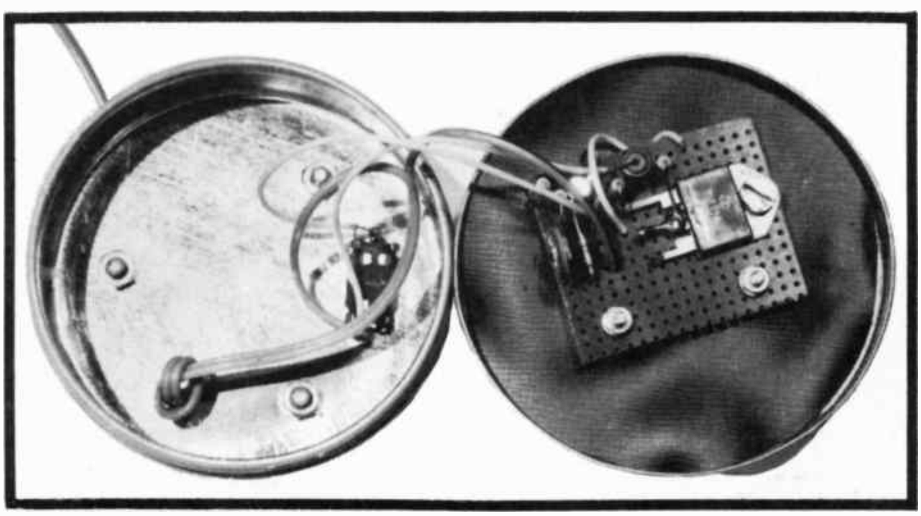
The circuit operates from the vehicle's battery and, as all electrical parts are isolated from the metal case, the same circuit can be used for cars with either negative or positive earth wiring systems. The beacon is fed from a plug pushed into the cigarette lighter socket — however as this plug is polarised, a beacon with a plug for negative earth cannot be used in a car with opposite polarity unless the plug connections are reversed.

Inside view of the completed unit. Note the plastic disc used to replace the normal airtight seal of the jar.

CONSTRUCTION

The nicest thing about the construction of this project is that first you have to eat half a pound of jam, in order to get the empty glass jar for the lamp housing. Other, less tasty, good jars about 70 mm dia. and 70 mm high with a twist off cap would do. You'll need also a round tobacco tin about 75-80 mm dia. and 30 mm high with a twist off cap. These two parts make up the case.

First solder the lids of the jar and the tin together, concentrically — outside to outside. Then before fitting the batten lamp holder fit the lamp to it and check that it will fit inside the jar when the jar is screwed into its lid. If it will, then mount the lamp holder by three bolts through both lids. Two of these bolts should be longer than the third as they will carry a piece of Veroboard. If the jar is slightly too short to accept the lamp holder and lamp — as was the case



Breakdown beacon

PARTS LIST – ETI 239

R1	Resistor	4k7	¼ watt
R2	"	47k	"
R3	"	4k7	"
R4	"	68	"
R5	"	1k	"
RV1	Preset pot	50k	
C	Electrolytic capacitor 10 μF at least 15 volts		
Q1	Transistor PNP BC 178 or similar		
Q2	Transistor NPN TI P33A or similar		
SW1	small on/off slider switch, single pole		

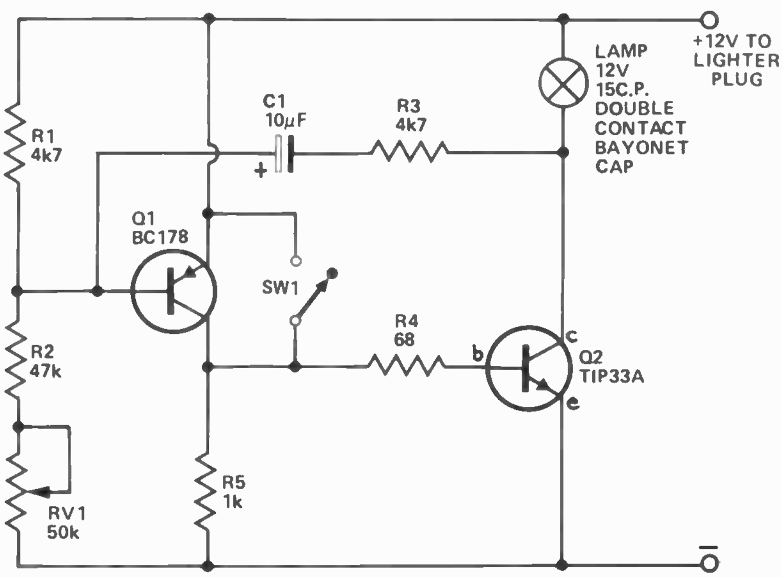
Lamp 12 volt automotive lamp 15 candlepower double contact cap.

Lampholder – to suit lamp, batten mounting, double contact bayonet catch type. (This is an electricians line not an automotive line. They are used for pilot lamps).

Tobacco tin, jam jar, or similar. Nuts and bolts, hook up wire.

Lead to battery – 7 m speaker extension lead.

Cigarette-lighter plug.



Circuit diagram of the Breakdown Beacon.

HOW IT WORKS

The circuit is an oscillator of a not very common type. It is *not* a multivibrator as both transistors conduct at the same time rather than alternately as in a multivibrator. Most 'explanations' of this type of circuit state that the circuit oscillates by a regenerative action from Q2 to Q1. This doesn't really explain how it works, so perhaps the following is a little clearer.

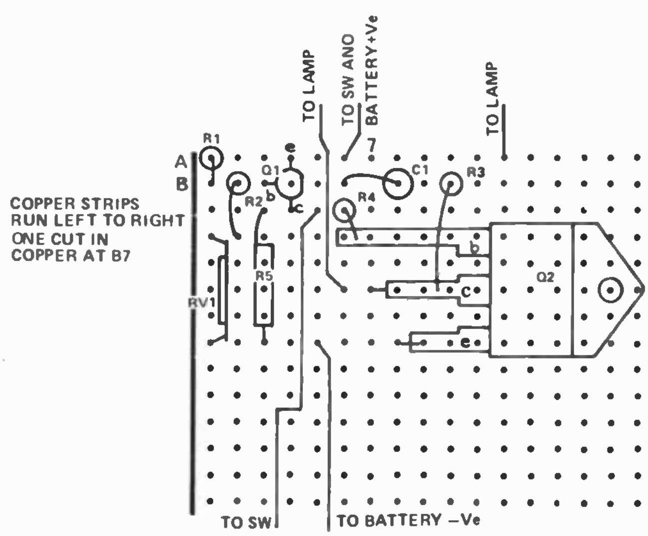
The setting of the pot RV1 is such that when power is first applied Q1 is turned on slightly. By varying RV1 the circuit can be made to 'lock' with the lamp on or off. In between these extremes the circuit oscillates. The setting of RV1 is not critical.

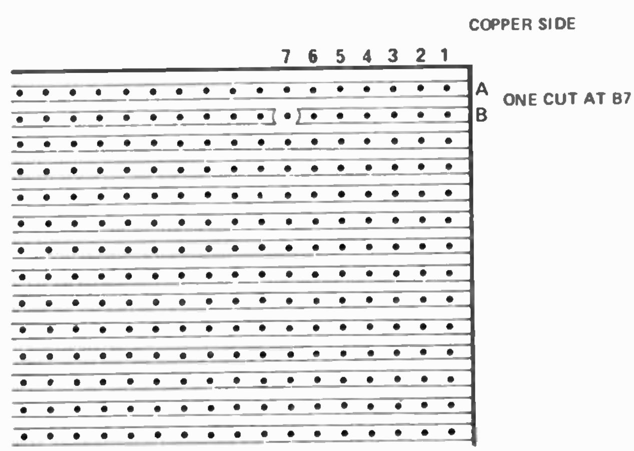
As said above, when power is applied Q1 turns on slightly. Current through Q1 feeds into the base of Q2 and turns it on. Capacitor C charges through R1, R3 and Q2. This increases the current through R1 and so lowers the voltage at the base of Q1 thus turning it on harder – hard enough to turn Q2 full on and light the lamp.

As C charges, the voltage at the base of Q1 rises and so tends to turn Q1 off, thus reducing the base current in Q2 and hence the current through the lamp. This increases the voltage across Q2 quite rapidly. As the voltage across the capacitor cannot be changed rapidly, the increase of voltage across Q2, i.e. the voltage change at the collector of Q2, is transferred through the capacitor to the base of Q1 – so turning it off. This turns Q2 hard off. The voltage at the collector of Q2 then rises rapidly to 12 volts, so the voltage at the base of Q1 is forced up through capacitor C, turning Q1 hard off.

Capacitor C then discharges round R1, the lamp, and R3 until, when fully discharged, Q1 turns on slightly and the cycle is repeated.

The switch SW1 (connected across Q1) is used to disable Q1 and so give a steady light when SW1 is closed.





Only one break in the Veroboard copper pattern is required – as shown in this diagram.

in the prototype — then cut a hole for the lamp holder through both lids, and fit the lamp holder so that its flange finishes up inside the tobacco tin. Spacing washers may be added if necessary. Again the lamp holder is secured to the lids with one short and two long bolts.

The electronic part of the beacon is constructed on 0.1 inch matrix Veroboard 45mm x 36 mm. Only one break needs to be cut in the copper strips — between the two leads of capacitor C. Only the outer legs of RV1, which is a medium size preset, are passed through the Veroboard. The centre leg is connected to either outer leg above the board and the excess cut off. Note that all resistors except R5 are vertically mounted. The upper end of R4 is soldered straight on to the base terminal of Q2, and the upper end of R3 is soldered straight on to the collector. A wire is also run from the collector terminal of Q2 through the board to the strip below it.

Another wire is run from the emitter terminal of Q2 to the negative rail which is the copper strip just below.

The Veroboard is mounted into the case below the lamp holder, using two of the lamp holder mounting bolts.

The switch SW1 is mounted on the bottom of the tobacco tin where it is out of the weather. The switch must be positioned such that it does not clash with the components on the Veroboard when the tobacco tin is screwed together.

The long twin-lead to the battery is run through the bottom of the tin (to prevent moisture entering) and connected to a cigarette-lighter plug taking care to wire with a polarity to suit the car system (positive or negative earth). Speaker extension lead is good for this purpose as it has polarity marking.

It is likely that the operation of soldering the two lids together will have destroyed the air-tight seals in the jar and tin; they should be replaced with a disc in the tin and a ring in the jar cut from fairly heavy plastic sheeting.

TESTING

Before connecting up make sure that switch SW1 is open — otherwise the unit will not flash.

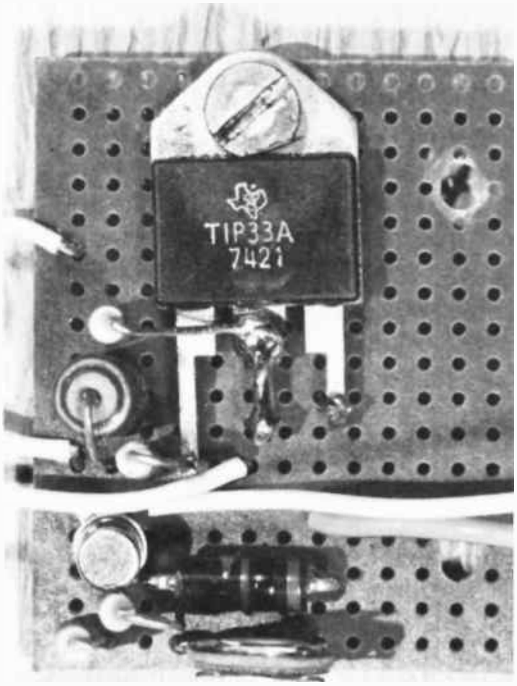
Connect the unit to the battery by inserting the plug into the cigarette lighter socket. It may now be found that RV1 needs some adjustment to make the circuit operate correctly, so don't be disappointed if the lamp does not light at first or alternatively, stays on all the time. The flashing rate may be altered by changing either C or R3 if thought necessary. About 70 to 100 flashes per minute is right.

The value of R4 shown in the circuit was selected to suit the transistor Q2 used in our prototype. If the lamp lights at less than full brilliance then R4 may be reduced until Q2 saturates and the lamp is turned on fully.

USE

The illustration shows the prototype with a clear glass 'lens'. This is ideal when the beacon is used as a trouble light — turned permanently on. However, if it is thought desirable to have an amber or red colour when the beacon is flashing, then it is a simple matter to make a sleeve of suitably coloured material to be dropped inside the jar.

A simple inexpensive project with an intriguing circuit — and it may save you a lot of trouble! Make one.



The completed board.

SIMPLE LOUDNESS CONTROL

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

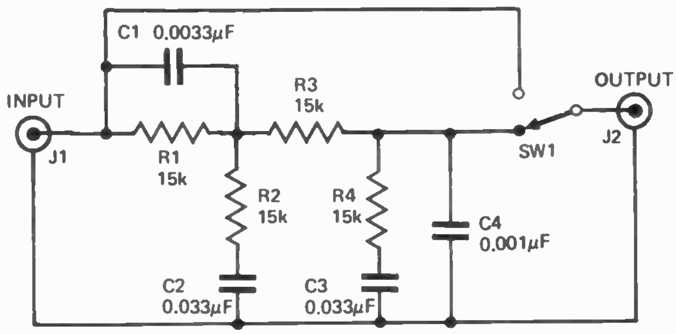


Fig. 1.

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

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

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

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

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

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

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

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

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

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

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

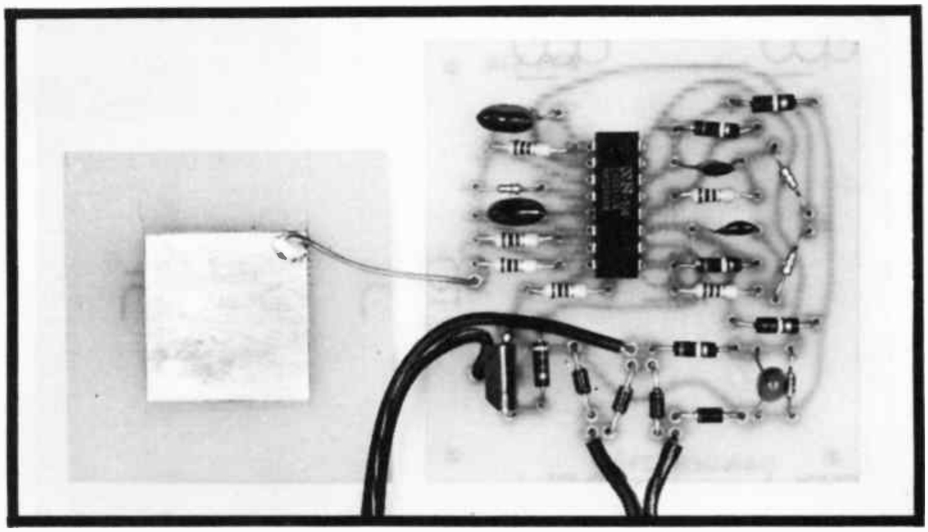
We would like to emphasize that this is a 'compromise' circuit. Ideally a loudness control must be designed specifically to suit the amplifier for which it is intended. Also the degree of loudness compensation should be related to the volume control setting.

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

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

Switch SW2 should be a double-pole double-throw type if stereo operation is required. ●

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.

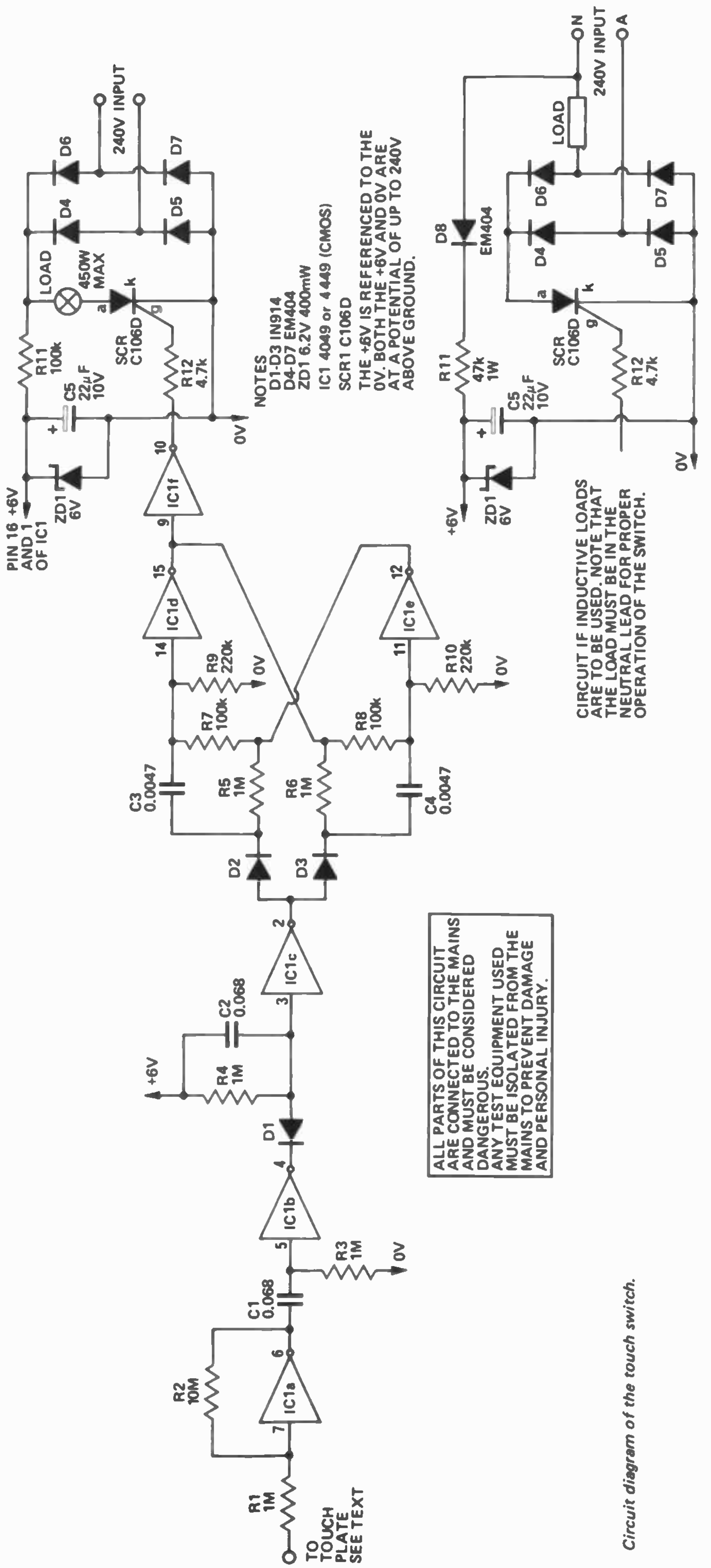
If the plate is too large or the lead connecting it to the circuit too long, stray capacitance to ground may be sufficient to prevent the switch operating. If the lead is more than about 50 mm long shielded cable should be used (shield connected to '0' volts not to ground). If a large plate is used the 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 globes) only. If an inductive 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.

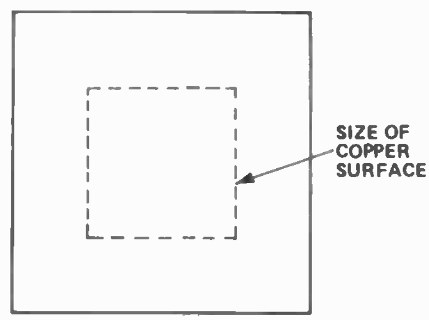


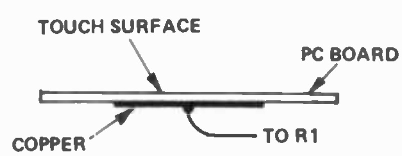
Circuit diagram of the touch switch.

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		
IC1	Integrated circuit 4049 or 4449 (CMOS) (do not use Philips ICs or the 4009) Note: IC1 4049 must be an 'A' series device. Do not use a 4049B.			
SCR	C106D It is recommended that a 2k2 half watt resistor be fitted between gate and cathode of the SCR.			
PCB	ETI 539			

Case to suit
For inductive loads change R11 to 47k 1W add D8 – EM404.





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.

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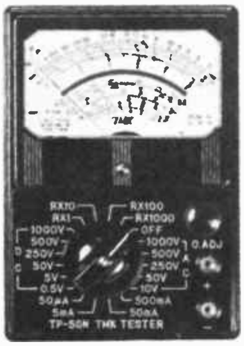

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TMK MODEL PL-436
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TMK MODEL 500
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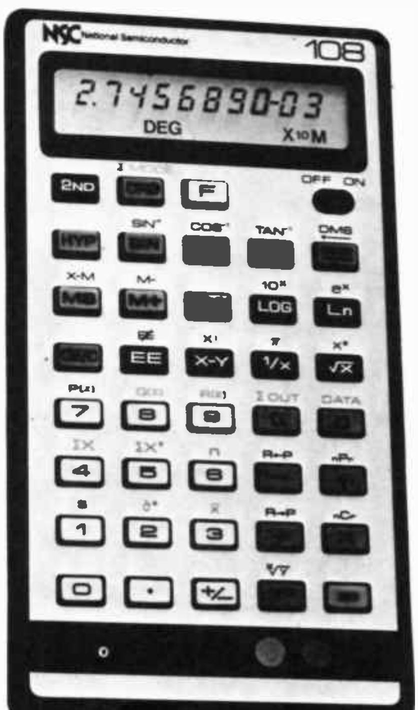

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HOW IT WORKS

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.

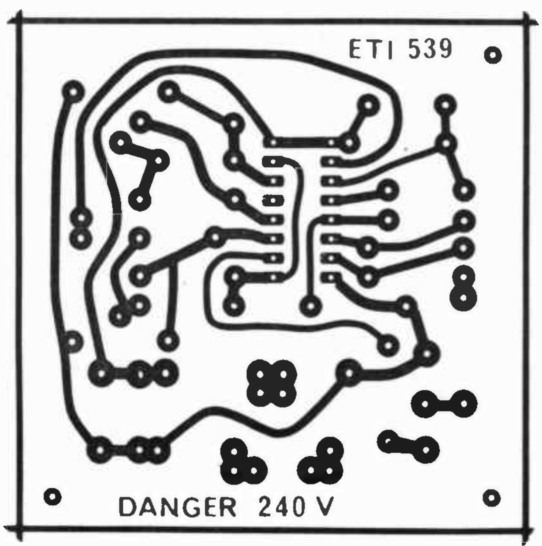
FLIP FLOP

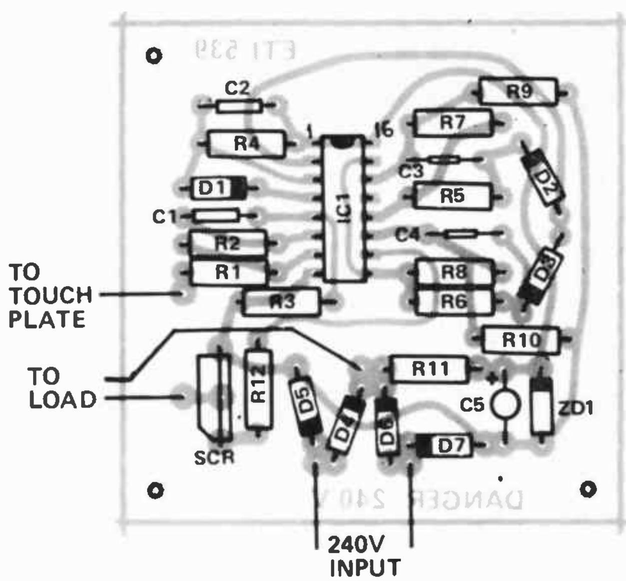
To meet our mode of operation requirement the circuit needs to be held on after the finger is removed from the plate and only switched off when the plate is touched a second time. Thus a toggle action is required and this is obtained by incorporating a flip flop formed by IC1d and IC1e. Cross coupling 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 should be used – don't try substitutes.

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





How the components are positioned on the board.

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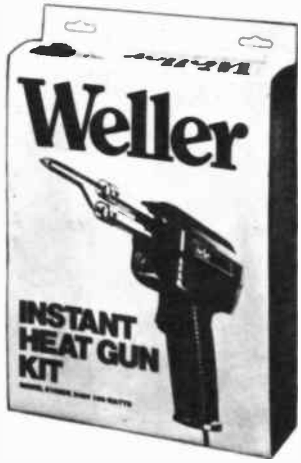

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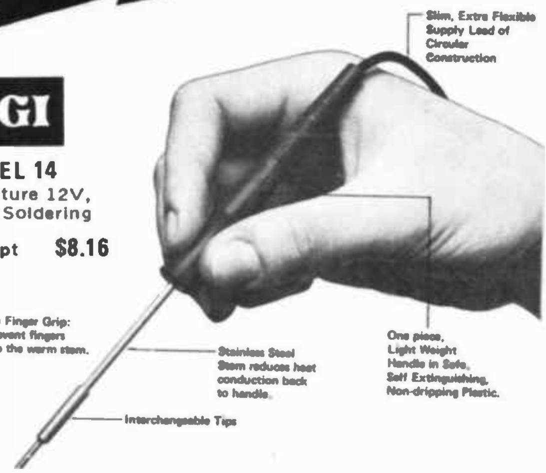

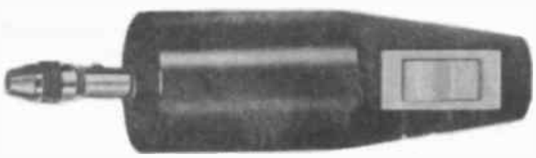

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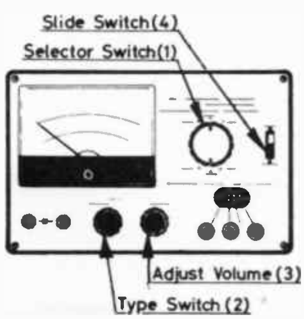

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PROJECT 232

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.

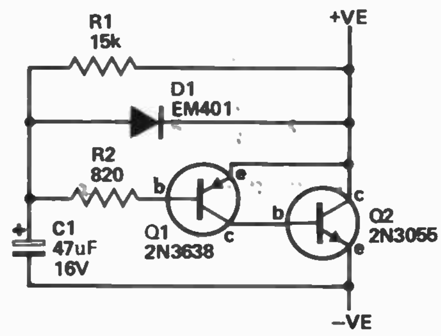
The value of C1 is chosen such that a useful light level is obtained for about four seconds, thereafter the light decreases until in about 10 seconds it is out completely With different transistor gains and with variation in current drain due to a particular type of car the timing may vary, but may be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

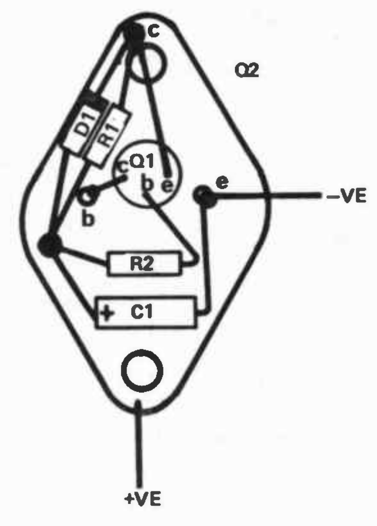
Due to the fact that the 2N3055 only conducts for a few seconds every so often, a heatsink is not required for cars fitted with a single lamp courtesy light. If your car has *more* than the usual amount of interior lighting operate the unit a number of times in fairly quick succession. Then, if the

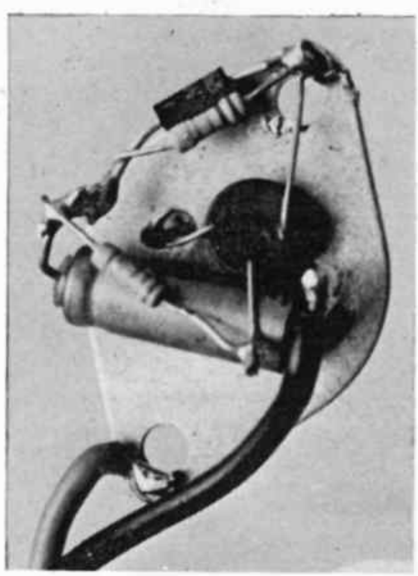


2N3055 gets too hot to touch, use a small piece of aluminium as a heatsink. This need should however be rare. ●

PARTS LIST
ETI 232

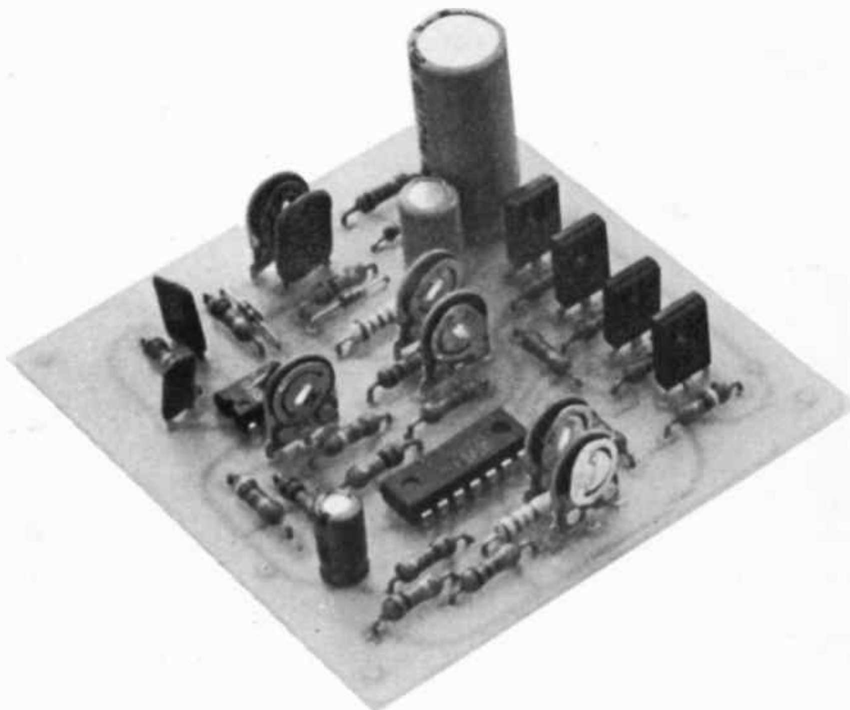
R1	resistor	15 k ½ watt 5%
R2	"	820 ½ watt 5%
C1	capacitor	47μF 16 volt electrolytic
D1	diode	EM401 or similar
Q1	transistor	2N3638 or similar
Q2	"	2N3055





REV. MONITOR – COUNTER

This design uses lights to indicate the upper and lower limits of ideal rev ranges, and also includes an optional analogue tachometer.



WE HAVE HAD many requests to publish the design of a digital tachometer for use in cars. However, a couple of factors make this less than a practical proposition.

The most important drawback is difficulty of reading the digital display. Many cars can rev out over a 5000 rpm range in less than two seconds; even with 100 rpm resolution this would have the second digit changing every 0.04 seconds.

Additionally, the simplest design principle — counting the number of pulses from the distributor over a period of time — would not offer acceptable resolution for a reasonable sampling rate. On a four-cylinder car, a two-digit readout, i.e. 100 rpm resolution, calls for a sampling time of 0.3 sec, while 3 sec is needed for a three-digit readout.

Analogue meters are easier to read but may be a little sluggish with cars which can rev out quickly in first gear. We therefore decided to design an analogue tacho and add three indicator lamps to give an instant indication or warning of engine speed. One of these is on below a set rpm indicating that the motor is below the ideal minimum, a second which is on between certain limits indicating the working range of the engine and the third comes on above a set rpm indicating too high an engine speed. All the limits are adjustable and by overlapping the limits five bands of engine speed can be indicated.

Where the vehicle is already fitted with a tacho, or one is not wanted, the lights can be used by themselves. This reduces the cost considerably, while the lights still give an indication of engine speeds and when to change gear.

Construction

The electronics can be assembled on the printed circuit board with the aid of the overlay in Fig 3. Due to the number of components, the use of the printed circuit board is recommended. The value of R4 should be selected from Table 1.

The mechanical arrangment for the lights and meter we have left to the constructor as variations in style required make it difficult to give any details.

Adjustment

The potentiometer RV1 should be adjusted to give stable readings over the entire rpm range. Calibration of the meter is done by RV2 and this should be done against a known instrument. The lights are adjusted by RV3, RV6, RV4 and RV5 (from the lowest to the highest limit) to whatever levels are required.

REV. MONITOR – COUNTER

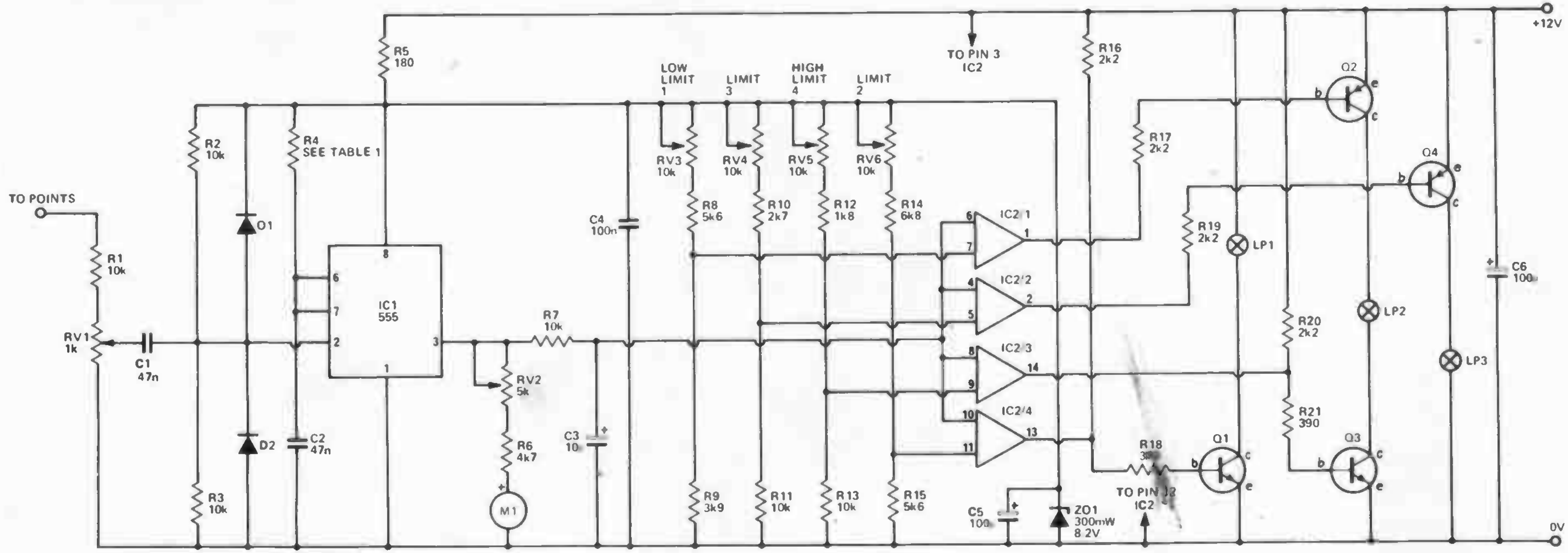


Fig. 1. Circuit diagram of the rev. monitor - counter.

How It Works – ETI 317

The pulses from the spark coil are used to trigger a 555 timer IC1. This is connected as a monostable where the pulse width is 1.1 x R4 x C2 seconds. Pin 2 is normally at about 4 volts and the input pulse causes this to drop to less than the 2.7V trigger point. The supply voltage for this IC is regulated to 8.2V by ZD1. The output of this IC is a positive pulse on pin 3 and this is used to drive the meter to give a readout of rpm.

The output is also filtered by R7 and C3 to give an output voltage which is proportional to rpm. IC2 is a quad comparator which compares this voltage with four preset levels. If the input voltage is lower than the set level the output of the comparator will high. The output of the LM339 is an open collector transistor and can only sink current and therefore appears as an open circuit when high.

The outputs of IC2 control the transistors Q1 to Q4 which handle the current required by the lamps. If the rpm is below the lower limit Q1 and Q3 will be on lighting LP1 but as Q2 is off LP2 will be off. Above the first limit Q2 will be turned on and so LP2. Above the next limit Q1 and LP1 will turn off, above the next Q4 and LP3 will turn on, and finally when the upper limit is reached Q3 will turn off LP2 leaving only LP3 on.

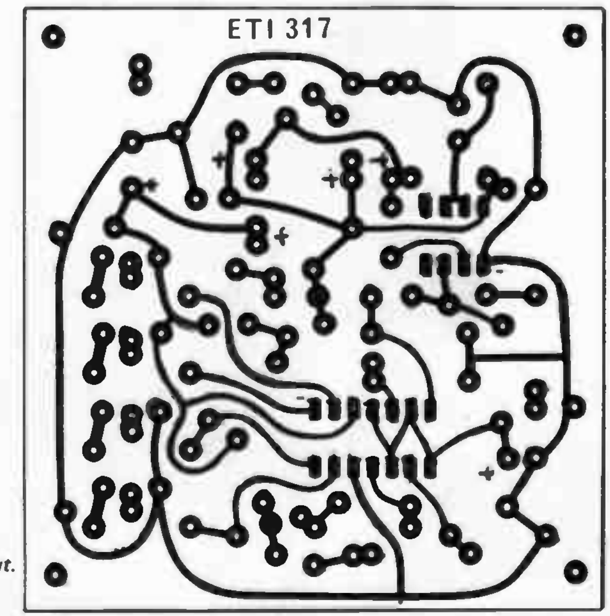


Fig. 2. Printed circuit layout. Full size 80 x 75 mm.

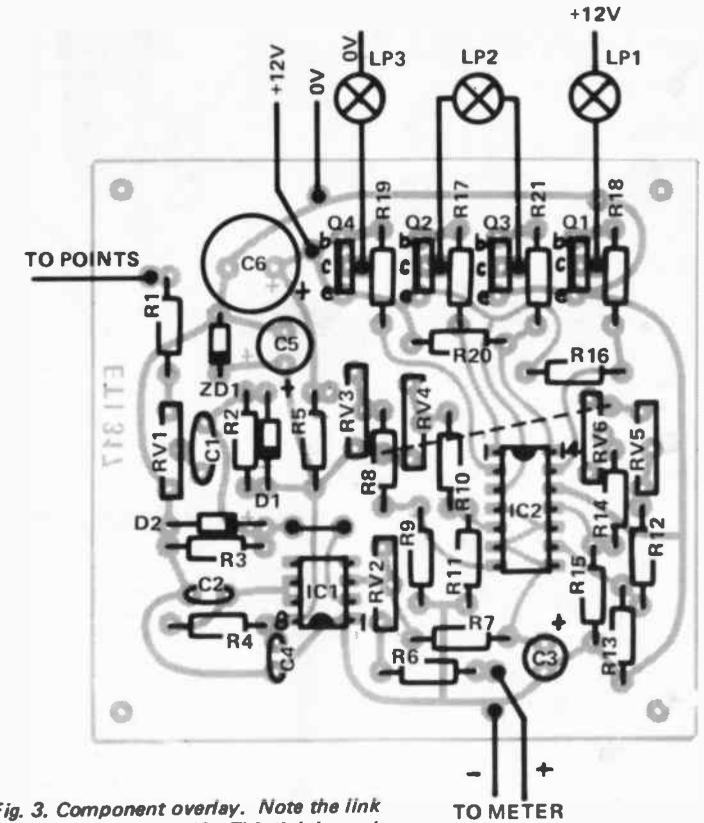


Fig. 3. Component overlay. Note the link between RV4 and RV6. This link is on the copper side of the pc board.

PARTS LIST – ETI 317

Resistors all ½W 5%

R1–R3	10k
R4	see table 1
R5	180
R6	4k7 *
R7	10k
R8	5k6
R9	3k9
R10	2k7
R11	10k
R12	1k8
R13	10k
R14	6k8
R15	5k6
R16,17	2k2
R18	390
R19,20	2k2
R21	390

Potentiometers

RV1	1k trim
RV2	5k trim *
RV3–RV6	10k trim

Capacitors

C1,2	47n polyester
C3	10µ 16V electro
C4	100n disc ceramic
C5	100µ 16V electro
C6	100µ 25V electro

Semiconductors

IC1	555
IC2	LM339
Q1	BD139
Q2	BD140
Q3	BD139
Q4	BD140
D1,2	1N914
ZD1	8.2V 300mW

Miscellaneous

PC board ETI 317
LP1–LP3 12V lamps (max. 250mA)
Meter 1mA FSD *

* Delete if tacho is not needed.

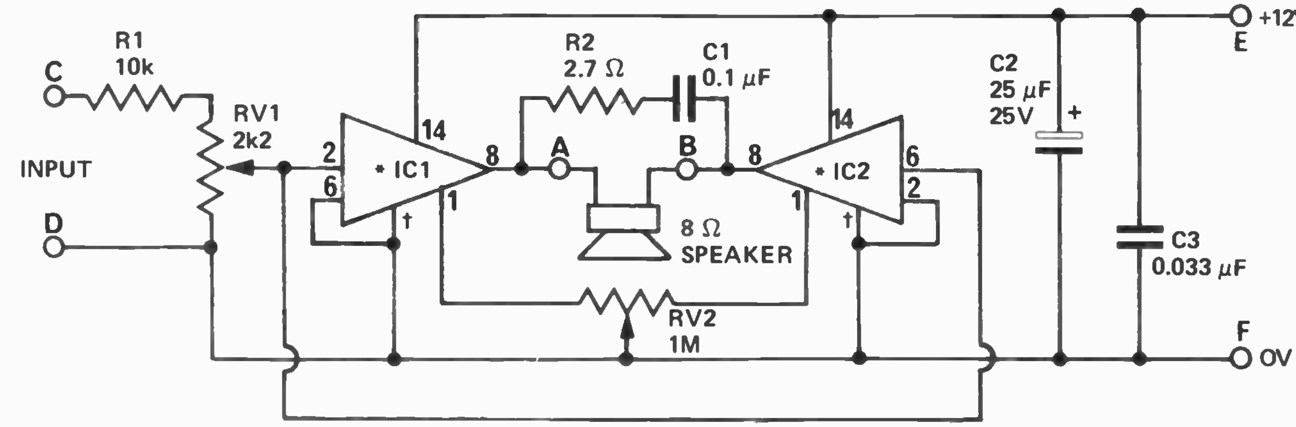
TABLE 1

Value of R4	Number of cylinders		
Max. RPM	4	6	8
5000	100k	68k	47k
6000	82k	56k	39k
7000	68k	56k	39k
8000	68k	39k	33k

AUTO-AMP

Boost portable radio output in your car.

eti
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.

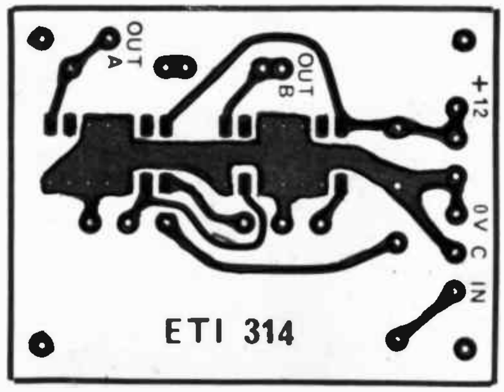


Fig. 2. Printed circuit board. Full size 50 x 65 mm.

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.

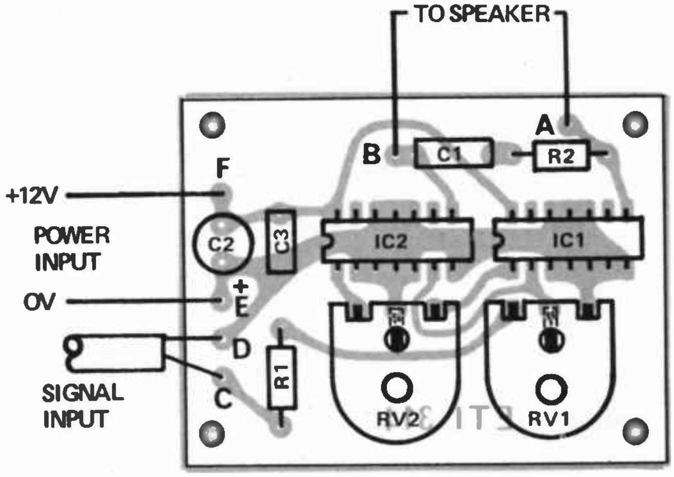


Fig. 3. Component overlay.

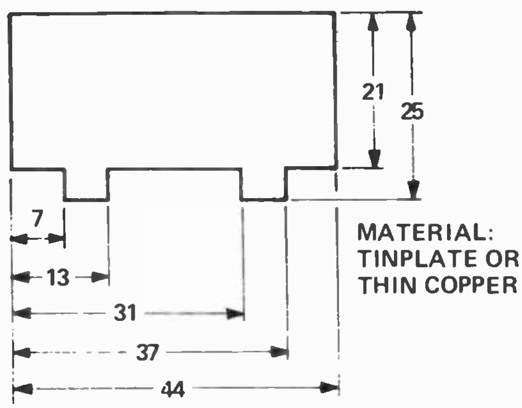
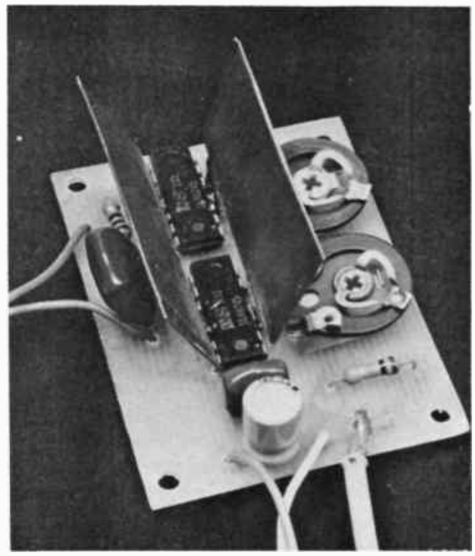


Fig. 4. Heatsink (two required) to be attached to either side of both IC's as shown in main picture.



SPECIFICATION

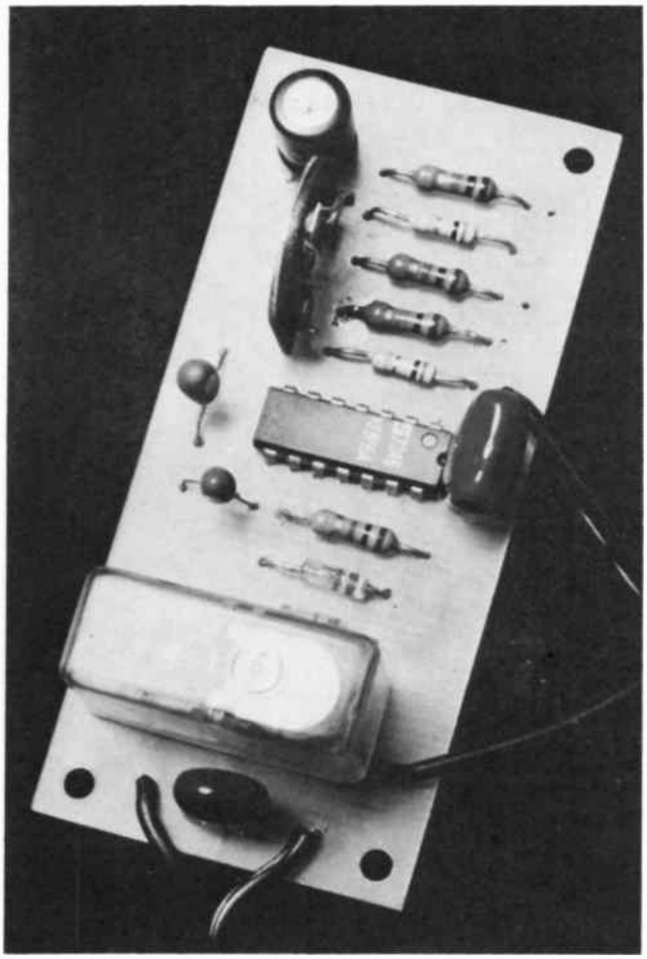
POWER OUTPUT		
12.6 volt supply 8 ohm load		5 watts
DISTORTION		
12.6 volt, 8 ohm, 1 kHz		
at 5 watts		3%
at 3 watts		0.5%
SUPPLY VOLTAGE		
Nominal		12 volts
MAX SUPPLY VOLTS	Speaker load	
LM380	8	15 volts
	16	22 volts
SPEAKER IMPEDANCE		> 7 ohms
FREQUENCY RESPONSE		
10 Hz – 100 kHz		$\pm^{0}_{3}$ dB
SENSITIVITY		
Maximum (no input attenuator) into 75 k ohm		50 mV

BATTERY TRAP

When soldering leads to AA size cells (the size used in pen torches) it is most important to remove the metal disc at the bottom of the cell, and solder directly on to the zinc case. These cells are designed to be used under compression, by the spring in a torch, and they depend on the compression to ensure good contact between the metal disc and the cell itself. Without the pressure – such as when a cell is soldered into circuit, it's easy to get a very poor contact or an actual open circuit

A.J. Lowe

PROJECT 313 CAR ALARM



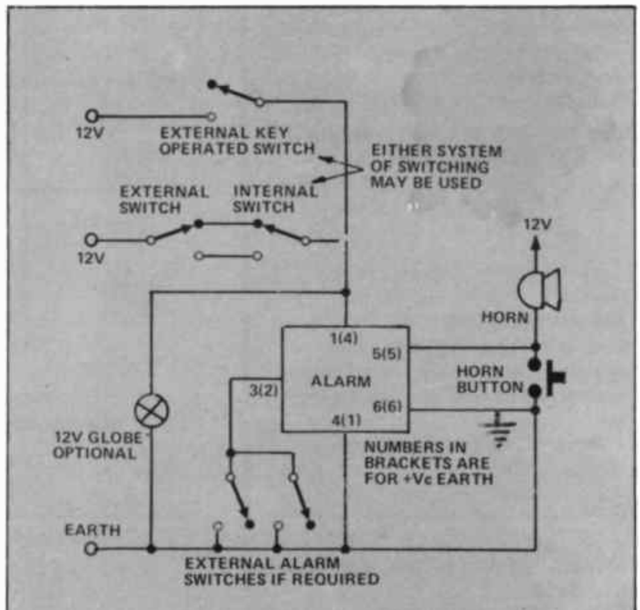


Fig. 2

Protect your car with this simple effective circuit.

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

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

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

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

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

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

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

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

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

In addition to the power sensing alarm mode other precautions may be

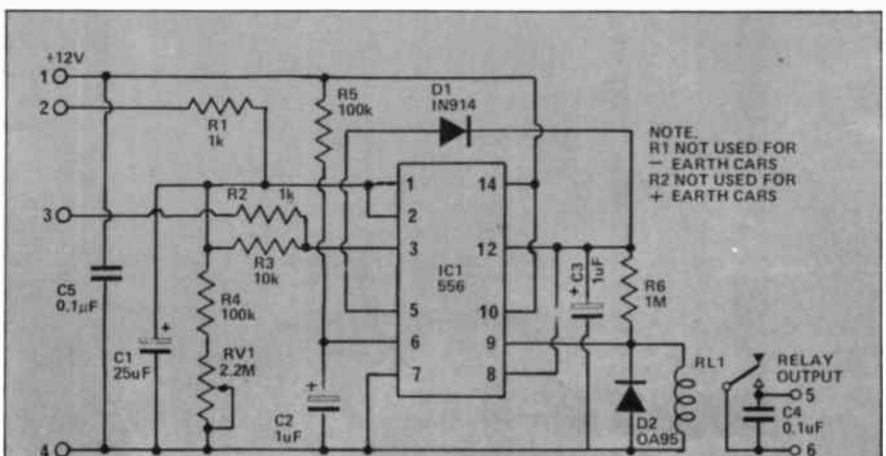


Fig. 1

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

CONSTRUCTION

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

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

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

PARTS LIST — ETI 313

R1,2	Resistor	1k ½watt 10%
R3	"	10k ½watt 10%
R4,5	"	100k ½watt 10%
R6	"	1M ½watt 10%
RV1	Potentiometer	2.2 meg
C1	Capacitor	25µF 25 volt electrolytic
C2,3	"	1µF 25 volt electrolytic
C4,5	"	0.1µF polyester
IC1	Integrated Circuit	NE556
D1	Diode	IN914 or similar
D2	Diode	OA95 (must be germanium)
RL2	Relay	12 volt 280 ohm coil, 6A contacts. Associated Controls type E3201 or similar.
PC board ETI 313		
SW1	Switch	SPST key operated
SW2,3	"	SPDT toggle (see text)
metal or plastic box to suit.		

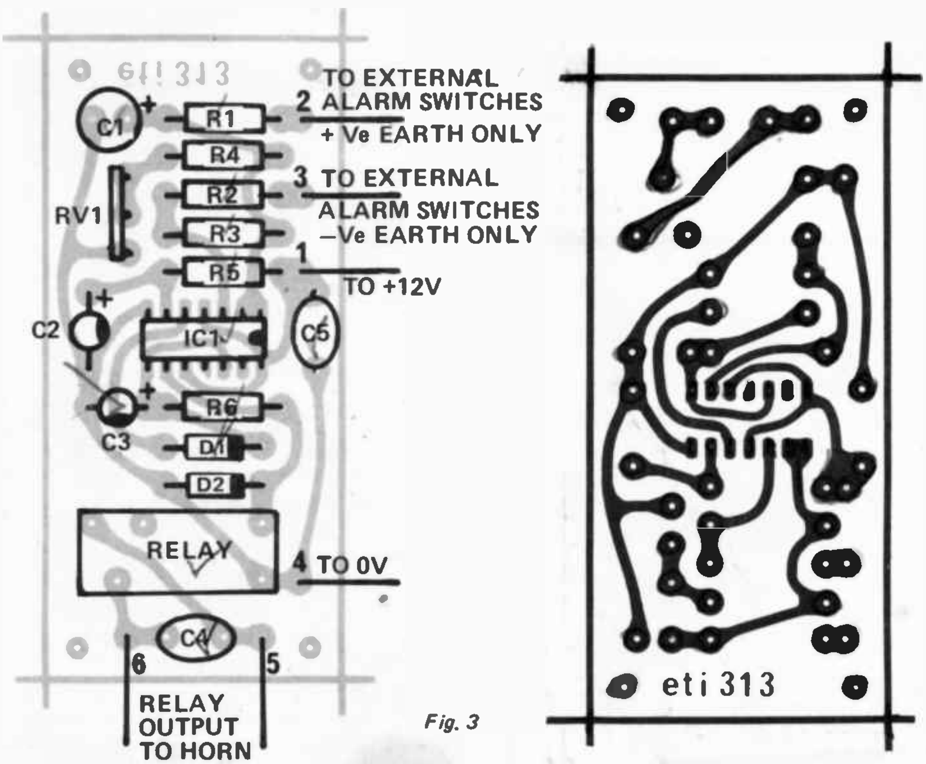


Fig. 3

PLEASE NOTE

When this project was originally published, some constructors experienced incorrect ON/OFF timing relay latching.

This may be caused by diode D2 in that, in some cases, it does not adequately limit the reverse voltage generated across the relay This reverse voltage may trigger the IC. This can be cured in one of two ways.

1. Replace diode D2 with an EM401 or similar. Break the track between resistor R6 and diode D2 and place a second EM401 diode across this break such that its cathode and the cathode of diode D2 are together.
2. Add a 200 ohm 1 watt resistor between the +12 volt line and the output (pin 9) of the IC.

HOW IT WORKS

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

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

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

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

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

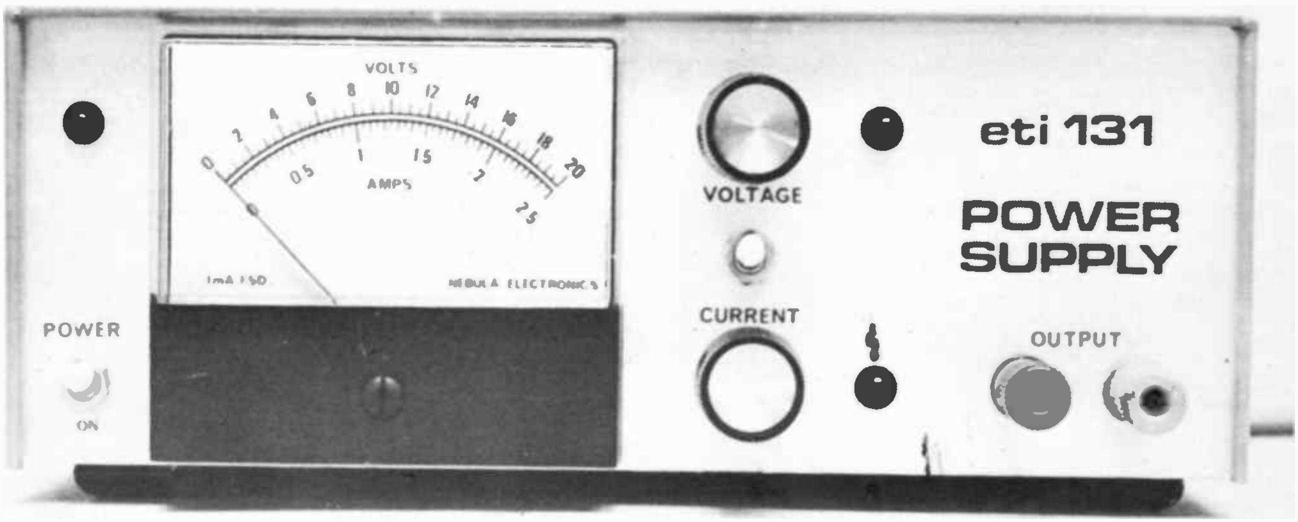
If the supply falls, the voltage on pin 3 will also fall. If it falls below the voltage at pin 2, the output will fall again to a low state and will stay there. The capacitor C1 will also be discharged via pin 1.

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

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

General purpose power supply

This versatile general purpose supply produces up to 2.5 amps from zero to 20 volts — or up to 1.25 amps from zero to 40 volts. Current limiting is adjustable over the entire range for either output option.



SPECIFICATION – ETI 131

20 VOLT VERSION	
VOLTAGE	
Output	0–20 volts
Regulation	< 20 mV (0–2.5A)
Ripple and noise	< 1 mV at 2.5A
CURRENT	
Output	0–2.5A (up to 18 V)
	0–2.0A (up to 20 V)
Limit	0–2.5A
Regulation	< 10 mA (0–20 V)
40 VOLT VERSION	
VOLTAGE	
Output	0–40 V
Regulation	< 20 mV (0–1.25A)
Ripple and noise	< 1.5 mV at 1.25A
CURRENT	
Output	0–1.25A
Limit	0–1.25A
Regulation	< 10 mA (0–40 V)

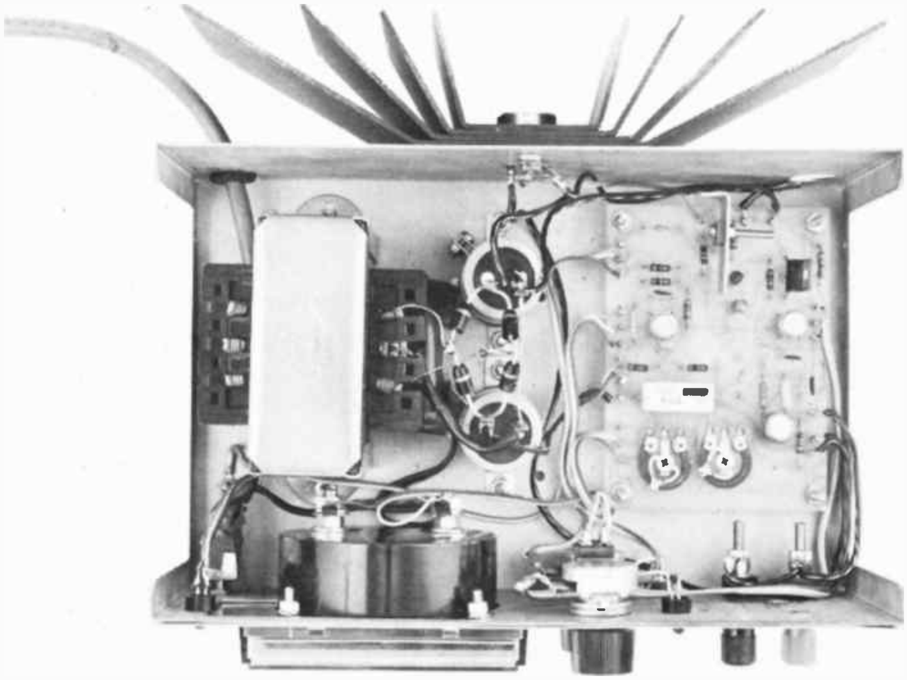
In both versions LEDs indicate voltage or current modes and the meter is switchable to read voltage or current.

AN IDEAL POWER SOURCE should supply a voltage which is adjustable over a wide range, and which remains at the set voltage regardless of line voltage or load variations. The supply should also be undamaged by a short circuit across its output and be capable of limiting the load current so that devices are not destroyed by fault conditions.

Two such supplies have previously been described in ETI. The first was a simple supply providing 0 to 15 volts at up to 750 mA. The second was a dual tracking supply providing ± 20 volts at up to one ampere. Both these supplies have been extremely popular, especially the simple one, and are still being built by many people. However there have been many requests for a supply having a greater output current capability than either of these previous designs could provide.

This project describes a supply that will provide 2.5 amperes at up to 18 volts (up to 20 volts at lower currents).

Alternately a few simple changes can make the supply provide up to 40 volts at 1.25 amperes. The supply voltage is settable between zero and the maximum available, and current limiting is also adjustable over the full range. The mode of operation of the supply is indicated by two LEDs. The one beside the voltage control knob indicates when the unit is in normal voltage-regulation mode and the one beside the current limit control indicates when the unit is in current-limit mode. In addition a large meter indicates the current or voltage output as selected by a switch.



Inside view of the completed 40 volt power supply. Note how the heatsink is mounted to the rear of the unit.

DESIGN FEATURES.

During our initial design stages we looked at various types of regulator and the advantages and disadvantages of each in order to choose the one which would give the best cost-effective performance. The respective methods and their characteristics may be summarized as follows.

The shunt regulator. This design is suitable mainly for low-power supplies — up to 10 to 15 watts. It has good regulation and is inherently short-circuit proof but dissipates the full amount of power it is capable of handling under no-load conditions.

The series regulator. This regulator is suitable for medium-power supplies up to about 50 watts. It can and is used for higher power supplies, but heat dissipation can be a problem especially at very high current with low output voltages. Regulation is good, there is little output noise and the cost is relatively low.

SCR regulator. Suitable for medium to high power applications, this regulator has low power dissipation, but the output ripple and response time are not as good as those of a series regulator.

SCR preregulator and series regulator. The best characteristics of the SCR and series regulators are combined with this type of supply which is used for medium to high-power applications. An SCR pre-regulator is used to obtain a roughly regulated supply about five volts higher than required, followed by a suitable series regulator. This minimizes power loss in the series regulator. It is however more expensive to build.

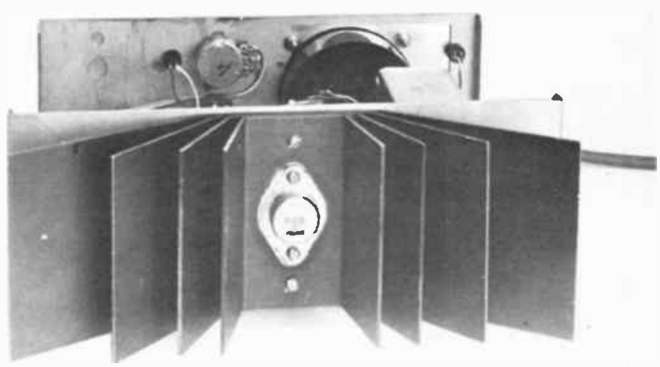
Switching regulator. Also used for medium to high-power applications, this method gives reasonable regulation and low power dissipation in the regulator but is expensive to build and has a high frequency ripple on the output.

Switched-mode power supply. The most efficient method of all, this regulator rectifies the mains to run an inverter at 20 kHz or more. To reduce or increase the voltage an inexpensive ferrite transformer is used, the output of which is rectified and filtered to obtain the desired supply. Line regulation is good but it has the disadvantage that it cannot easily be used as a variable supply as it is only adjustable over a very small range.

OUR OWN DESIGN

Our original design concept was for a supply of up to 20 volts at 5 to 10 amps output. However, in the light of the types of regulator available, and the costs, it was decided to limit the current to about 2.5 amps. This allowed us to use a series regulator — the most cost-effective design. Good regulation was required, together with variable-current limit, and it was also specified that the supply would be useable down to virtually zero volts. To obtain the last requirement a negative supply rail or a comparator that will operate with its inputs at zero volts is required.

Rather than use a negative supply



Rear view of the heatsink showing how it and the transistor are mounted.

HOW IT WORKS – ETI 131.

The 240 volt mains is reduced to 40 Vac by the transformer and, depending on which supply is being built, rectified to either 25 or 50 Vdc. This voltage is only nominal as the actual voltage will vary between 29 volts (58 volts) on no-load to 21 volts (42 volts) at full load. The same filter capacitors are used in either case. They are connected in parallel for the 25 volt version (5000 μF) and in series for the 50 volt version (1250μF). In the 50 volt version the centre tap of the transformer is connected to the centre tap of the capacitors thus ensuring correct voltage sharing between the capacitors. This arrangement also provides a 25 volt supply for the regulator IC.

The voltage regulator is basically a series type where the impedance of the series transistor is controlled in such a way that the voltage across the load is maintained constant at the preset value. The transistor Q4 dissipates a lot of power especially at low output voltages and high current and is therefore mounted on the heatsink on the rear of the unit. Transistor Q3 adds current gain to Q4, the combination acting as a high-power, high-gain, PNP transistor.

The 25 volts is reduced to 12 volts by the integrated-circuit regulator IC1. This voltage is used as the supply voltage for the CA3130 ICs and is further reduced to 5.1 volts by zener diode ZD1 for use as the reference voltage. The voltage regulation is performed by IC3 which compares the voltage as selected by RV3 (0 to 5.1 volts) with the output voltage as divided by R12 and R13. The divider gives a division of 4.2 (0 to 21 volts) or eight (0 to 40 volts). However at the high end the available voltage is limited by the fact that the regulator loses control at high current as the voltage across the filter capacitor approaches the output voltage and some 100 Hz ripple will also be present. The output of IC3 controls transistor Q2 which in turn controls the output transistor such that the output voltage remains constant regardless of line and load variations. The 5.1 volt reference is supplied to the emitter of Q2 via Q1. This transistor is in effect a buffer stage to prevent the 5.1 volt line from being loaded.

Current control is performed by IC2 which compares the voltage selected by RV1 (0 to 0.55 volts) with the voltage generated across R5 by the load current. If say 0.25 volts is set on RV1 and the current drawn from the supply is low, the output of IC2 will be near 12 volts.

This causes LED 2 to be illuminated as the emitter of Q1 is at 5.7 volts. This LED therefore indicates that the supply is operating in the voltage-regulator mode. If however the current drawn is increased such that the voltage across R5 is just above 0.25 volts (in our example) the output of IC2 will fall. When the output of IC2 falls below about 4 volts Q2 starts to turn off via LED 3 and D5.

The effect of this is to reduce the output voltage so that the voltage across R7 cannot rise further. When this happens the voltage comparator IC3 tries to correct for the condition and its output rises to 12 volts. IC2 then takes more current to compensate and this current causes LED 3 to light, indicating that the supply is operating in the current-limit mode.

To ensure accurate regulation the voltage sensing leads are taken to the output terminals separately from those carrying the load current.

The meter has a one milliamp movement and measures the output voltage (directly across the output terminals) or current (by measuring the voltage across R5) as selected by the front panel switch SW2.

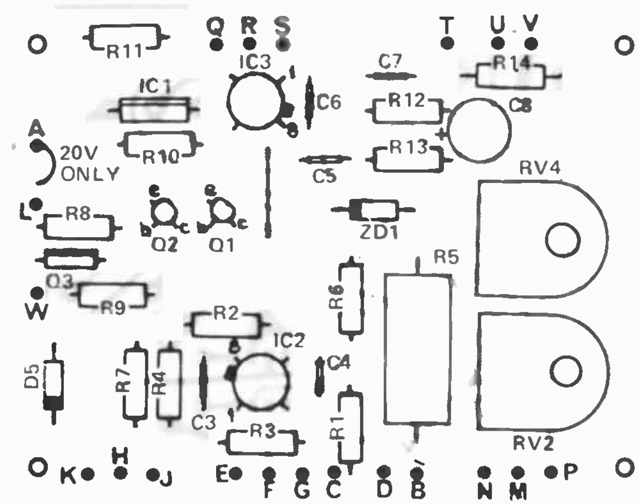


Fig. 3. Component overlay for the printed-circuit board assembly.

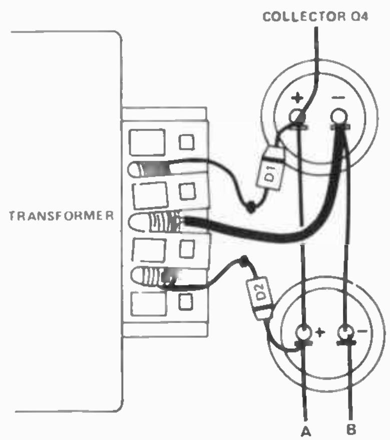
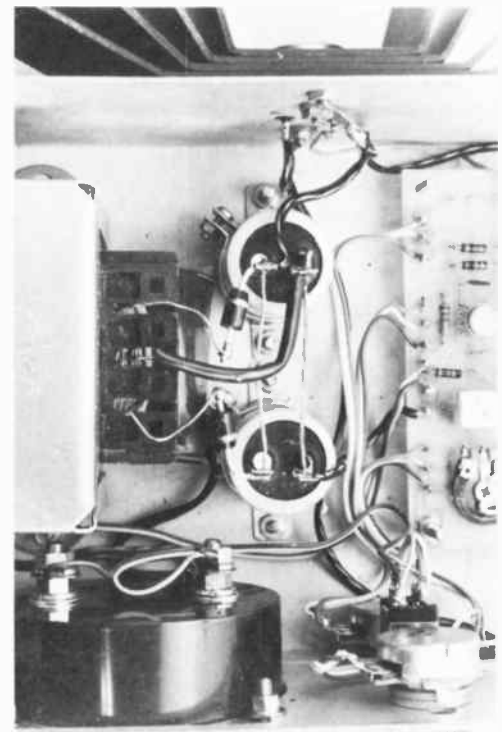


Fig. 4. How the supply is wired for the 20 volt 2.5 ampere version.



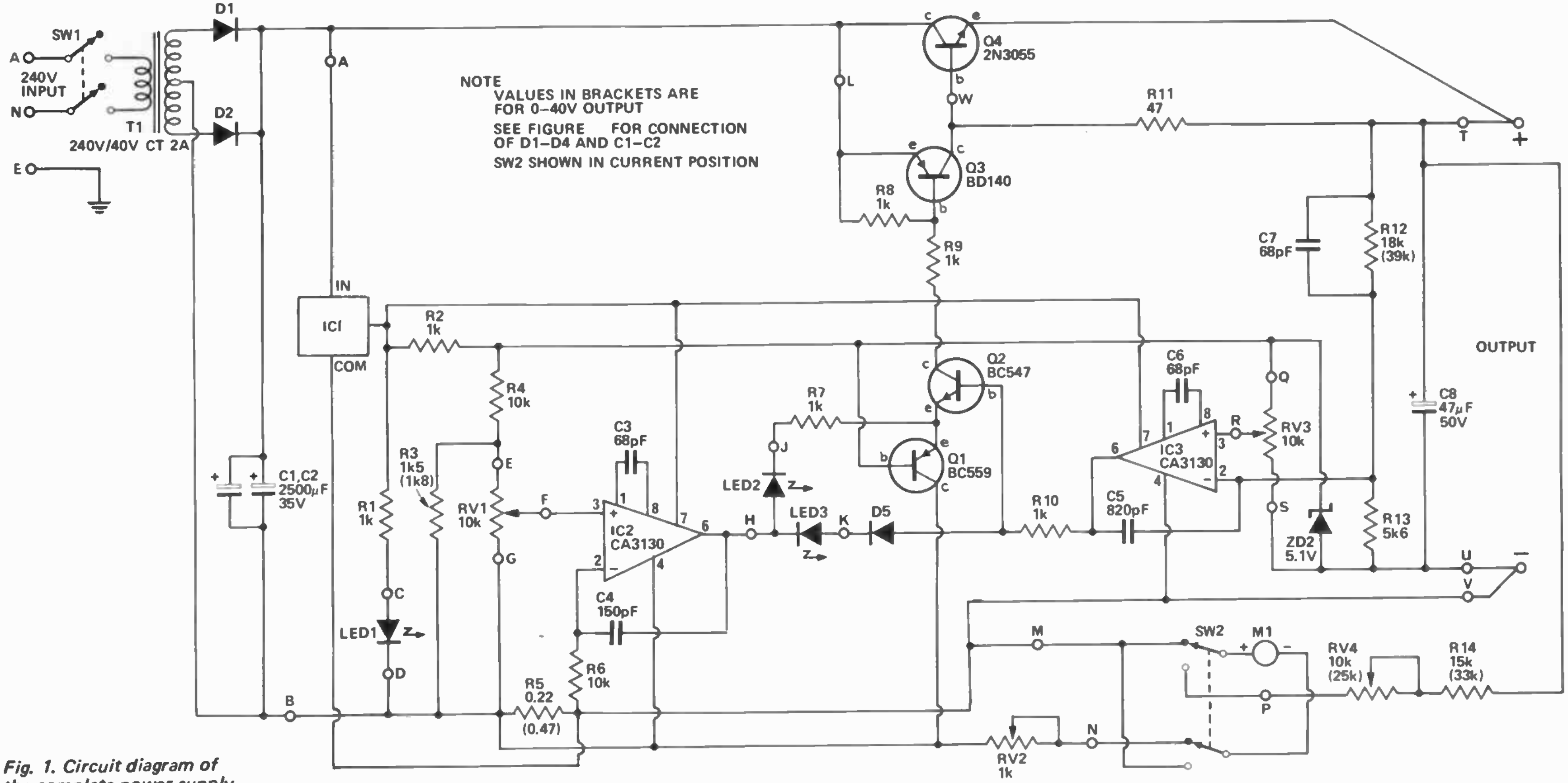


Fig. 1. Circuit diagram of the complete power supply 20 volt 2.5 ampere version.

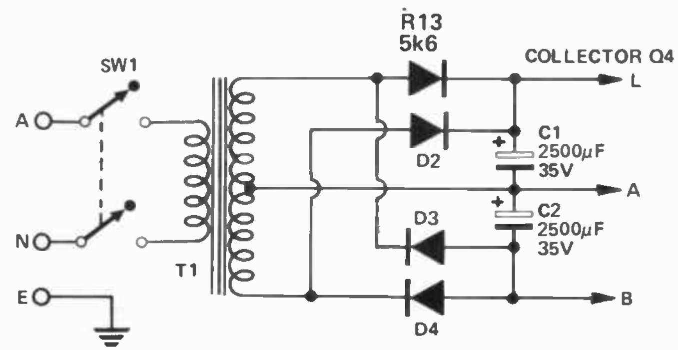
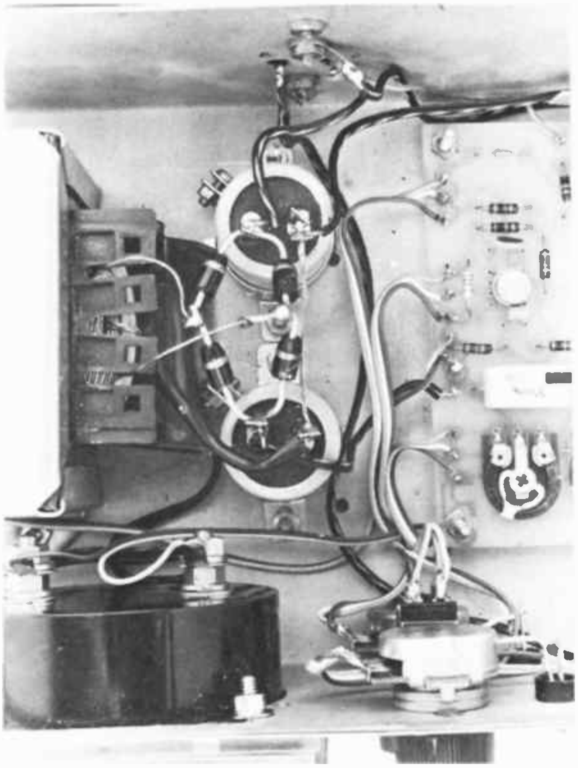


Fig. 2. Alternative rectifier and filter capacitor connections required for 40 volt, 1.25 ampere version.

RECONNECTED POWER SUPPLY FOR 40V 1.25A SUPPLY

General purpose power supply



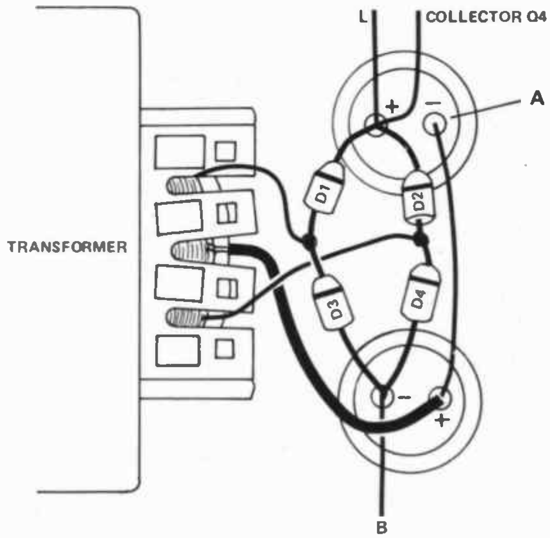


Fig. 5. How the supply is wired for the 40 volt 1.25 ampere version.

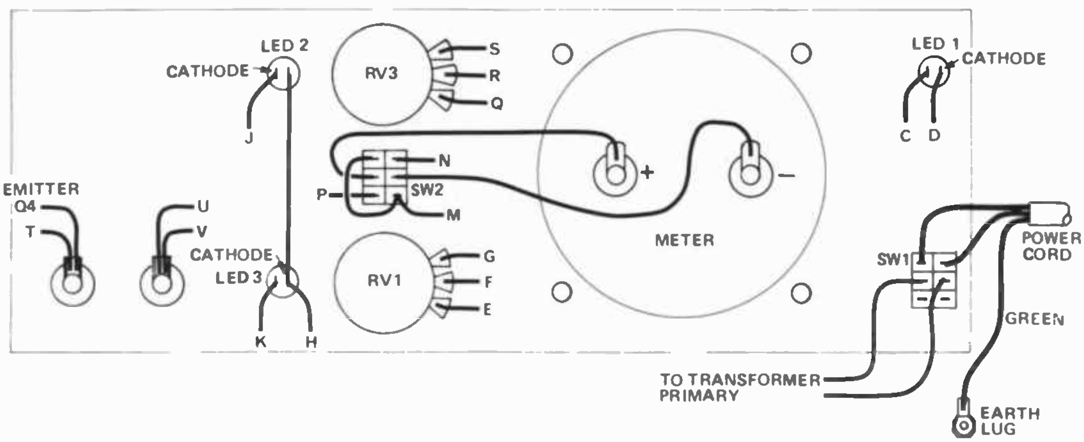


Fig. 6. Front panel wiring diagram.

rail we chose to use a CA3130 IC operational amplifier as the comparator. The CA3130 requires a single supply (maximum of 15 volts) and, initially, we used a resistor and 12 volt zener to derive a 12 volt supply. The reference voltage was then derived from this zener supply by another resistor and a 5 volt zener. It was felt that this would have given sufficient regulation for the reference voltage but in practice the output from the rectifier was found to vary from 21 to 29 volts and some of the ripple and voltage change that occurred across the 12 volt zener, as a consequence, was reflected into the 5 volt zener reference. For this reason the 12 volt zener was replaced by an IC regulator which cured the problem.

With all series regulators the series-output transistor by the nature of the design, must dissipate a lot of power especially at low output voltage and high current. For this reason an adequate heatsink is an essential part of the design. Commercial heatsinks are very expensive and sometimes difficult to mount. We therefore designed our own heatsink which was not only cheaper but worked better than the commercial version we had been considering — being easier to mount. However at full load the heatsink still runs hot as does the transformer, and under high-current low-voltage conditions the transistor may even be too hot to touch. This is quite normal as the transistor under these conditions is still operating within its specified temperature range.

With any highly regulated supply, stability can be a problem. For this reason in the voltage-regulation mode of operation, capacitors C5 and C7 are incorporated to reduce the loop gain at high frequencies and thus prevent the supply from oscillating. The value of C5 has been chosen for best compromis between stability and response time. If the value of C5 is too low the speed of response is greater — but there is a higher chance of instability. If too high

the response time is unduly increased.
In the current-limit mode the same function is performed by C4 and the same remarks apply as for the voltage case.

As the supply is capable of fairly high current output there is inevitably some voltage drop across the wiring to the output terminals. This is overcome by sensing the voltage at the output terminals via a separate pair of leads.

Whilst the supply was primarily designed for 20 volts at 2.5 amps it was suggested that the same supply could be used to supply 40 volts at 1.25 amps and that this would be of more value to some users. This may be done by changing the configuration of the rectifier and by changing a few components. Some thought was given to making the supply switchable but the extra complication and expense were such that it was not considered to be worthwhile. Thus you should simply decide which configuration suits your need and build the supply accordingly.

The maximum regulated voltage available is limited either by the input voltage to the regulator being too low (at over 18 volts and 2.5 amps) or by the ratio of R12/R13 and by the value of the reference voltage.

$$(\text{Output} = \frac{R12 + R13}{R13} \text{ V ref})$$

Due to the tolerance of ZD1 the full 20 volts (or 40 volts) may not be obtainable. If this is found to be the case R12 should be increased to the next preferred value.

Single turn potentiometers have been specified for the voltage and current controls because they are inexpensive. However if precise setability of voltage or current limit is required ten-turn potentiometers should be used instead.

CONSTRUCTION

The recommended printed-circuit board layout should be used as construction is thereby greatly simplified. Printed-circuit board pins should also be used for the 20 wire connections to the board. These should be installed first. The rest of the components may now be assembled onto the board making sure that the polarities of diodes, transistors, ICs and electrolytics are correct. The BD140 (Q3) should be mounted such that the side with the metal surface faces towards IC1. A small heatsink should be bolted onto the transistor as shown in the photograph.

If the metalwork as described is used the following assembly order should be used.

a) Mate the front panel to the front of the chassis and secure them together by installing the meter.

b) Fit the output terminals, potentiometers and meter switch on to the front panel.

c) The cathodes of the LEDs (that we used) were marked by a notch in the body which could not be seen when the LEDs were mounted onto the front panel. If this is the case with yours, cut the cathode leads a little shorter to identify them and then mount the LEDs into position.

d) Solder lengths of wire (about 180 mm long) to the 240 volt terminals of the transformer, insulate the terminals with tape and then mount the transformer into position in the chassis.

f) Install the power cord and the cord retaining clip, wire the power switch,

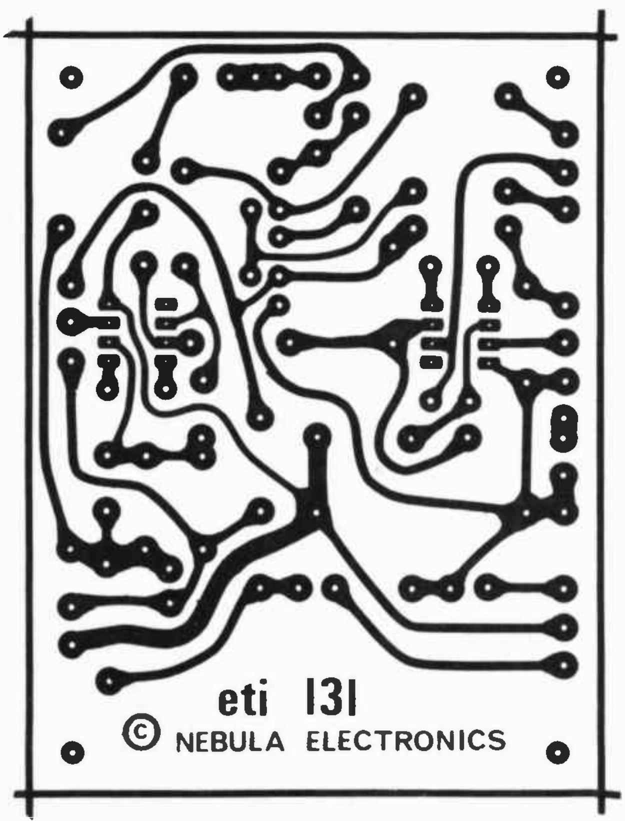


Fig. 7. Printed-circuit board layout for the power supply. Full size 100 x 75 mm.

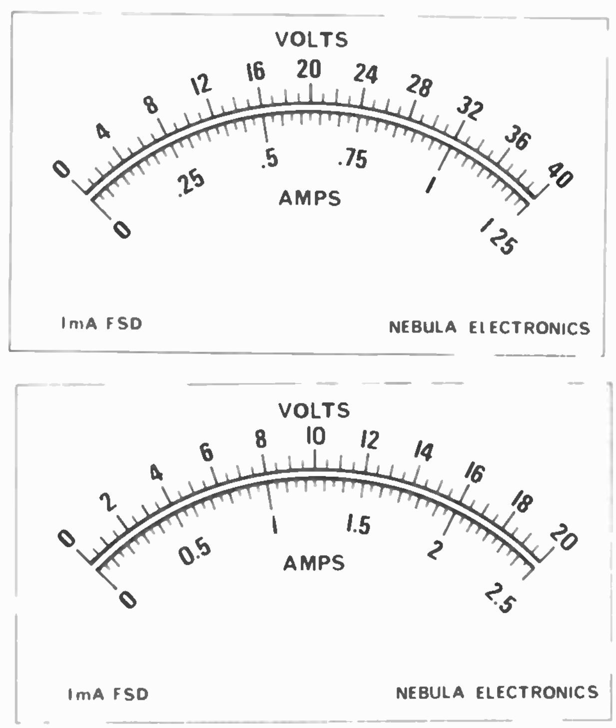


Fig. 8. Scales for the alternative meters for the unit shown full size.

General purpose power supply

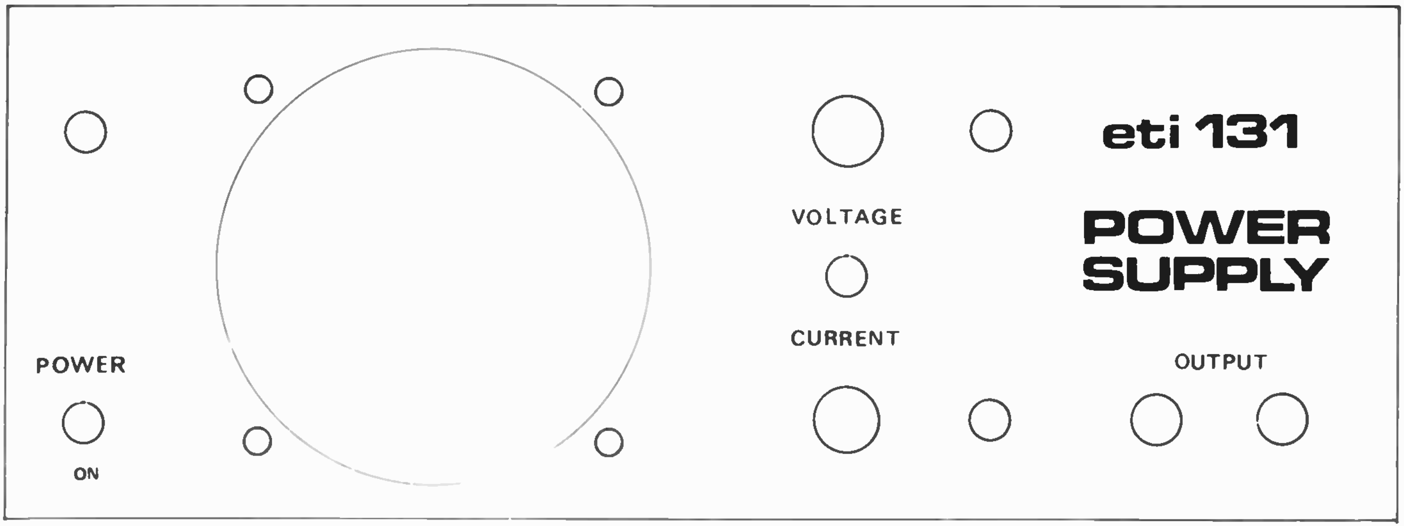


Fig. 9. Artwork for the front panel. Full size 224 x 82 mm.

insulate the terminals and then mount the switch onto the front panel.
g) Assemble the heatsink and screw it onto the rear of the chassis via two bolts — then mount the power transister using insulation washers and silicon grease.
h) Mount the assembled printed-circuit board to the chassis using 10 mm spacers.
i) Wire the transformer secondary, rectifier diodes and filter capacitors. The diode leads are stiff enough not to need any additional support.
j) The wiring between the board and the switches may now be made by connecting points with corresponding letters on the front panel diagram and component overlay diagrams.

The only setting up required is to calibrate the meter. Connect an accurate voltmeter to the output terminals and wind up the voltage control of the power supply until the external meter reads 15 volts (or 30 volts on the alternate arrangement). Switch the internal meter to read volts and adjust RV4 to obtain the same reading.

To set up the current reading first wind the supply voltage down to zero and connect an accurate ammeter across the output. Wind up the voltage control and observe that the current limit LED is on. Now adjust the current limit control so that the external meter indicates two amps (or one amp on the alternative unit). Now adjust RV2 so that the same reading is obtained on the internal meter when it is switched to the current position.

PARTS LIST — ETI 131A

Resistors

R1	—	1 k	½ W	5%
R2	—	1 k	"	"
R3	—	1 k5	"	"
R4	—	10 k	"	"
R5	—	0.22 ohm 5 W		
R6	—	10 k	½ W	5%
R7	—	1 k	"	"
R8	—	1 k	"	"
R9	—	1 k	"	"
R10	—	1 k	"	"
R11	—	47	"	"
R12	—	18 k	"	"
R13	—	5 k6	"	"
R14	—	15 k	"	"

Potentiometers

RV1	—	10 k lin rotary
RV2	—	1 k trim
RV3	—	10 k lin rotary
RV4	—	10 k trim

Capacitors

C1	—	2500 µF 35V electro
C2	—	2500 µF 35V electro
C3	—	68 pF ceramic
C4	—	150 pF "
C5	—	820 pF "
C6	—	68 pF "
C7	—	68 pF "
C8	—	47 µF 50V electro

Transistors

Q1	—	BC559
Q2	—	BC547
Q3	—	BD140
Q4	—	2N3055 (with insulation kit)

Diodes

D1,2	—	IN5404
D5	—	IN914

Other Semiconductors

ZD1	Zener Diode	5.1V 400 mW
LED 1,2	LED	5023 or similar
IC1	Integrated Circuit	LM341P-12
IC2,3	" "	CA3130

Miscellaneous

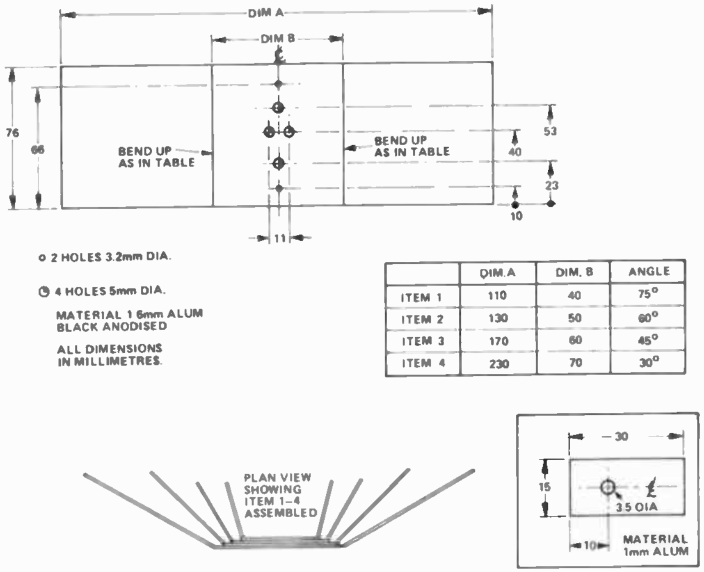
PC board ETI 131
Transformer 40V CT 2A A&R 5755
SW1,2 switch DPDT toggle
Meter 1 mA FSD scaled 0-20V, 0-2.5A
Chassis to Fig. 11
Cover to Fig. 13
Heatsink to Fig. 10
Front panel to Fig. 9
Two terminals
Power cord & clamp
Two knobs
Four 10 mm long spacers
20 PC board pins
Four rubber feet
nuts, bolts, washers etc.

PARTS LIST — ETI 131B

All parts for ETI 131A except

Change	R3	to	1 k8
	R5	to	0.47 ohm
	R12	to	39 k
	R14	to	33 k
	RV4	to	25 k

Complete kits of components for this project can be obtained from Nebula Electronics Pty Ltd, 4th Floor, 15 Boundary St, Rushcutters Bay (telephone 33-5850).



	DIM.A	DIM. B	ANGLE
ITEM 1	110	40	75°
ITEM 2	130	50	60°
ITEM 3	170	60	45°
ITEM 4	230	70	30°

Fig. 10. Heatsink detail.

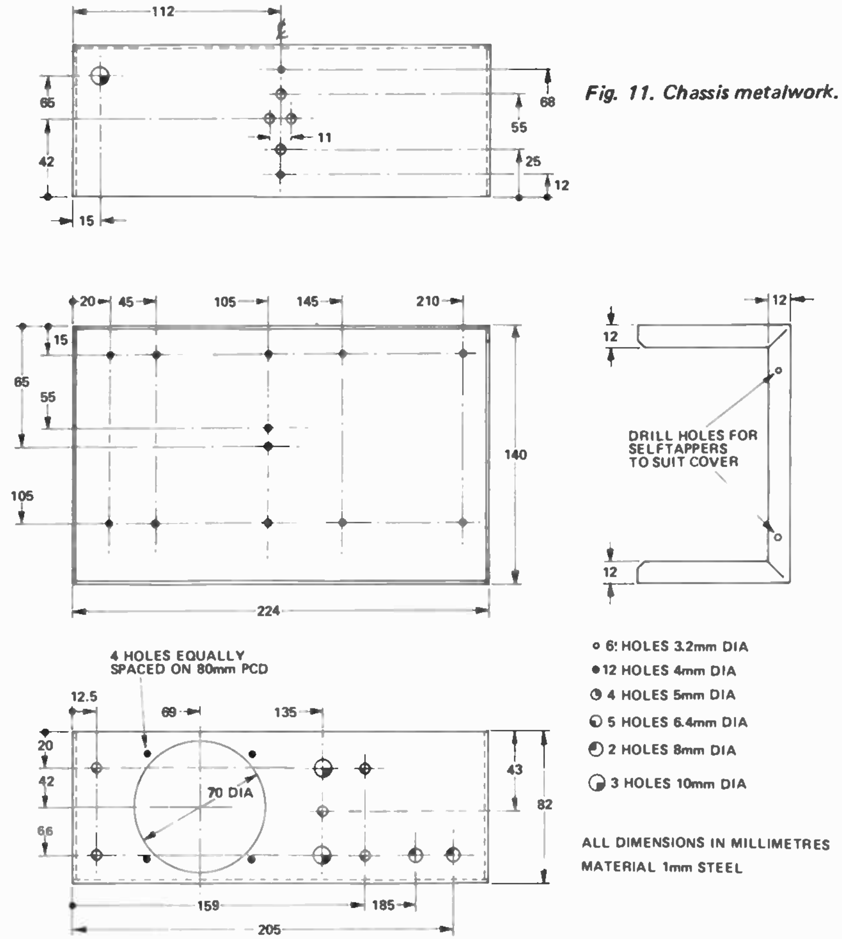


Fig. 11. Chassis metalwork.

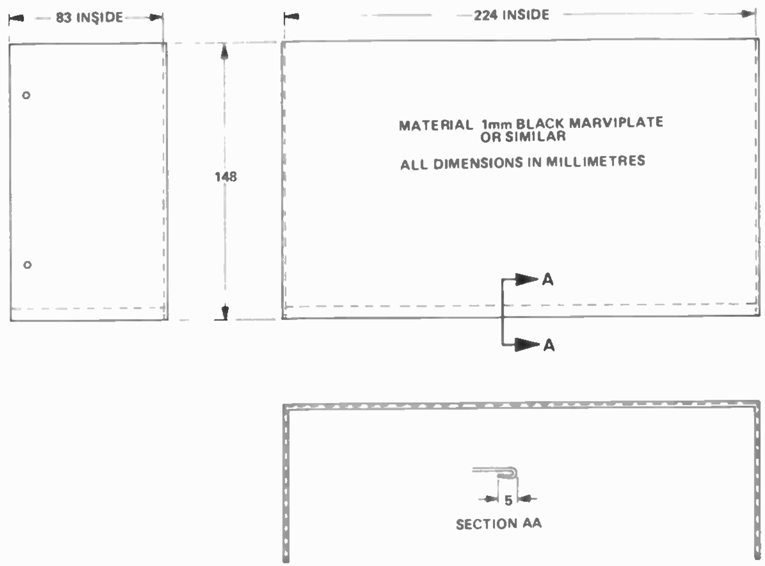


Fig. 13. Detail of metal cover.

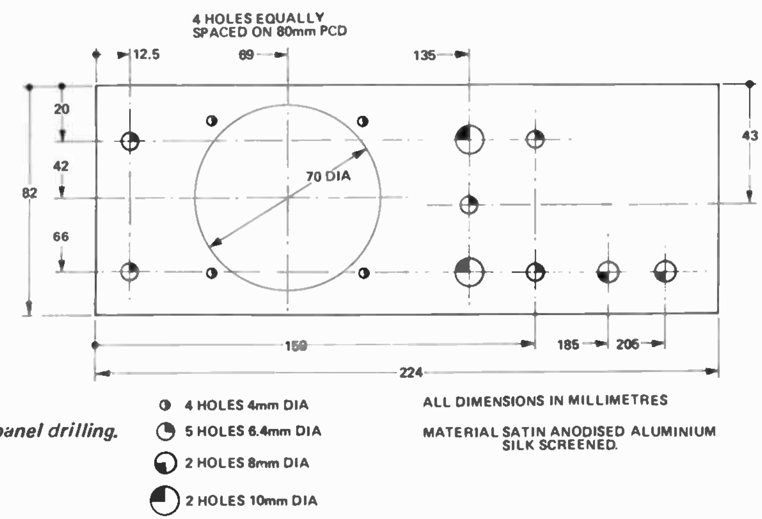


Fig. 12. Front panel drilling.

PROJECT 236

CODE PRACTICE OSCILLATOR

Essential equipment for gaining Novice Licence

NOW THAT the Novice Licence has finally been introduced, many young readers will want to learn the Morse Code. This is so because one of the Novice Licence requirements is the ability to send and receive Morse at the rate of five words per minute.

The first step in learning Morse is to obtain a means of practicing the code and the ETI 236 Code-practice set is specifically designed for that purpose. It may be used for practicing alone or with a friend. Practice with a friend is strongly advised as it is not much use knowing the code but transmitting it in a way that no-one else can understand.

An excellent way of learning is to purchase the "Archer" code record or cassette. These are available from any Tandy store and take you step by step through from simple character-code groups and gradually extends to include all characters. Both tape and record offer speeds of from 7 to 15 words per minute and, of course, these speeds will be entirely adequate to obtain the requisite 5 words-per-minute.

An important aid to learning is to memorise the way a code group sounds. For example the letter A is represented by the code group • —, this should be learned as the rhythmic sound didah – not as dot dash, or even as dit dah!

Finally there is no substitute for practice. Try to do at least half an hour to an hour a day. Don't worry about speed, this will come naturally, concentrate mainly on accuracy.

CONSTRUCTION

The oscillator is built onto one section of the ETI experimenter board as shown in the component overlay diagram. Take particular care to correctly orientate the IC, the electrolytic capacitor and the diode. The whole unit was built into a 100 x 165 x 300 mm plastic box which had an aluminium lid. Almost any box will do of course, but make sure that it is large enough to house the speaker you intend to use. We mounted our small 50 mm speaker to the back of the aluminium front panel.

Drill holes in the end of the box, for J1, 2 and 3, and fit them. Drill holes to mount the speaker, the phone and tape sockets and RV1 on the front panel. Note that we used two of the screws which secured the speaker to also secure the printed circuit board and that some holes must be provided for the sound from the speaker. Mount the components to the front panel and the printed circuit board and interconnect them as shown in Fig. 2. Note that the aluminium panel is connected to zero volts via the phone socket, the tape socket and the screw supporting the board, and that this screw is part of the connection between pin one of IC1 and zero volts. The battery is held into the bottom of the box by a piece of adhesive tape.

Practically any speaker may be used that fits your box. It is recommended, however, that 3 or 4 ohm speakers not be used unless the supply battery is changed to 6 volts instead of 9 thus not exceeding the output stage rating of the IC.

The International Morse Code.

A	• —	N	— •	1	• — — — —	=	— • • • —
B	— • • •	O	— — —	2	• • — — —	:	— — — • • •
C	— • — •	P	• — — •	3	• • • — —	;	— • — • — •
D	— • •	Q	— — • —	4	• • • • —	( )	— • — — • —
E	•	R	• — •	5	• • • • •	/	— • • — •
F	• • — •	S	• • •	6	— • • • •	Error	• • • • • • • •
G	— — •	T	—	7	— — • • •	Wait	• — • • •
H	• • • •	U	• • —	8	— — — • •	End of message	
I	• •	V	• • • —	9	— — — — •		• — • — •
J	• — — —	W	• — —	0	— — — — —	Invitation to transmit	
K	— • —	X	— • • —	.	• — • — • —		— • —
L	• — • •	Y	— • — —	,	— — • • — —	End of work	
M	— —	Z	— — • •	?	• • — — • •		• • • — • —

HOW IT WORKS – ETI 236

The oscillator is constructed around a 555 integrated-circuit timing chip. To better understand how we make this chip oscillate we must refer to the block diagram of the chip, Fig. 3. The two circuit blocks labelled as comparators each give either full output or zero output depending on which of the two inputs is greater than the other.

One of the inputs of each comparator in the 555 is connected to a voltage divider consisting of 3 equal-value resistors, connected in series between Vcc and zero volts. Thus when the voltage at pin 2 rises, so that it exceeds one third of Vcc, comparator 1 will change state. Likewise comparator 2 will change state when the voltage at pin 6 rises above two thirds of Vcc. The outputs of both comparators will of course revert to their original states when the voltages at pins 2 and 6 fall below the thresholds set by the divider chain.

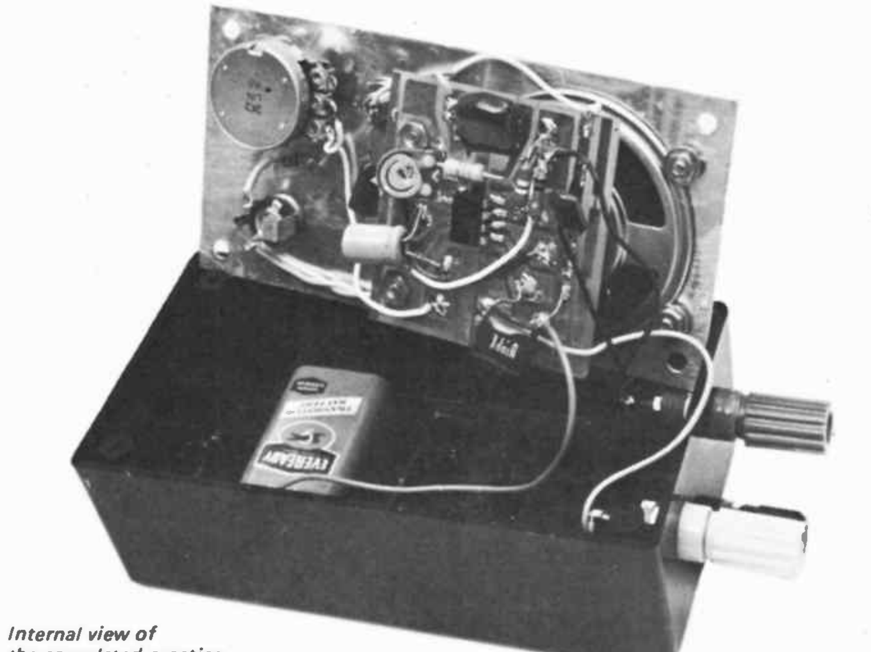
Both comparator outputs are fed to a flip flop which is forced into one state when the voltage at pin 2 falls below 1/3 Vcc and into the other state when the voltage on pin 6 rises above 2/3 Vcc. The output of the flip flop drives both a transistor and a high-level output stage in such a way that the transistor is turned off when the voltage at pin 2 is below 1/3 of Vcc, and on only when the voltage at pin 6 exceeds 2/3 of Vcc.

In our oscillator pin 2 and 6 are connected together and to capacitor C3 which charges via RV2, R3 and R2. When the voltage across C3 goes above 2/3 Vcc comparator 2 and the flip flop will change state turning on the discharge transistor. Capacitor C3 will be discharged (via RV2, R3 and pin 7) and when its voltage falls below 1/3 Vcc comparator 1 will change the state of the flip flop turning off the discharge transistor thus allowing C3 to charge again.

Thus the voltage across C3 will alternate between 1/3 and 2/3 Vcc with a frequency which depends on the values of RV2, R3, R2 and C3. With each change in state of the flip flop the output stage also changes state and since this is a relatively high current output we can extract sufficient power to drive a loudspeaker directly. Volume is controlled by RV1 and a phono socket is provided for private headphone listening.

Capacitor C2 provides filtering for the reference divider via pin 5 and an output for a tape recorder is taken from pin 7 and filtered and attenuated by R4 and C5 to produce a sawtooth output. Diode D1 is used to protect the oscillator from reversed battery connections when the unit is connected to other units operating on different supply voltages over a two wire circuit. If you intend to use your oscillator by itself only D1 may be omitted.

The Morse key is a normally-off switch. When it is pressed the Vcc circuit is completed and the oscillator functions. An ON/OFF switch is not included as power is only drawn when the Morse key is depressed.



Internal view of the completed practice oscillator.

PARTS LIST – ETI 236

R1	Resistor	10ohm	½W	5%
R2	"	10k	"	"
R3	"	33k	"	"
R4	"	390k	"	"

RV1 Potentiometer 2.2k
RV2 Potentiometer 50k trim type

C1	Capacitor	10µF 16 volt electrolytic
C2	"	0.1µF polyester
C3	"	0.022µF polyester
C4	"	0.1 µF "
C5	"	0.033µF "

D1 Diode EM401 or similar
IC1 Integrated Circuit NE555
Speaker 50 or 75 mm 8 ohm (to suit case).
J1,2,3 Binding posts 3 mm. RCA tape socket, 3mm jack socket, 9 volt battery, box to suit.

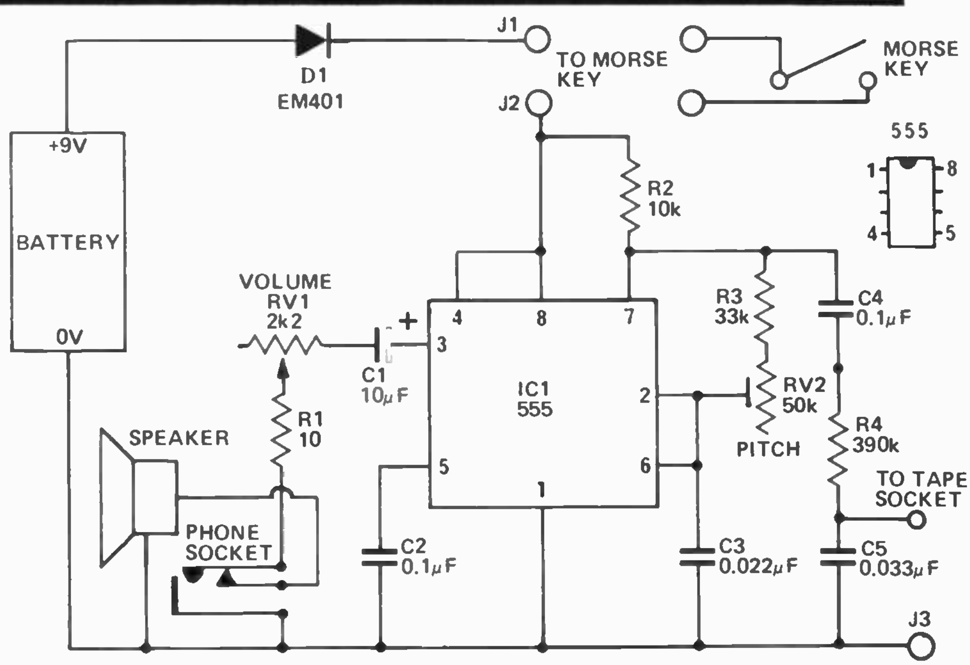


Fig. 1. Circuit diagram of the code practice oscillator.

CODE PRACTICE OSCILLATOR

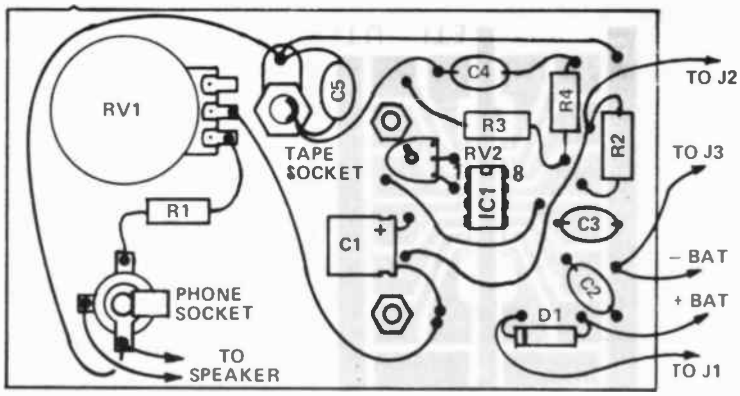
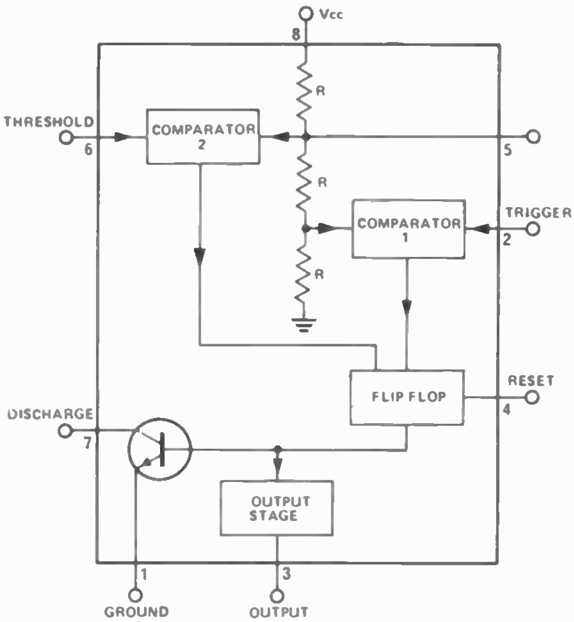
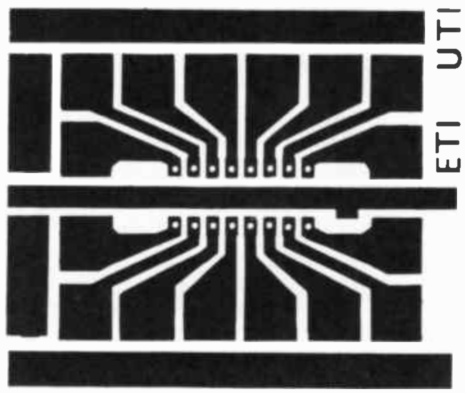


Fig. 2. Component overlay and interconnections.

Fig. 3. Internal arrangement of the NE 555 timer IC.





(Right) printed circuit board, shown full-size.

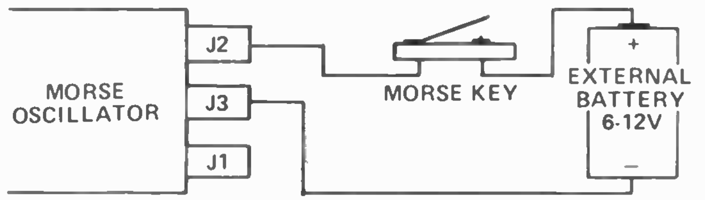


Fig. 4. Method of connecting an external battery to operate the oscillator.

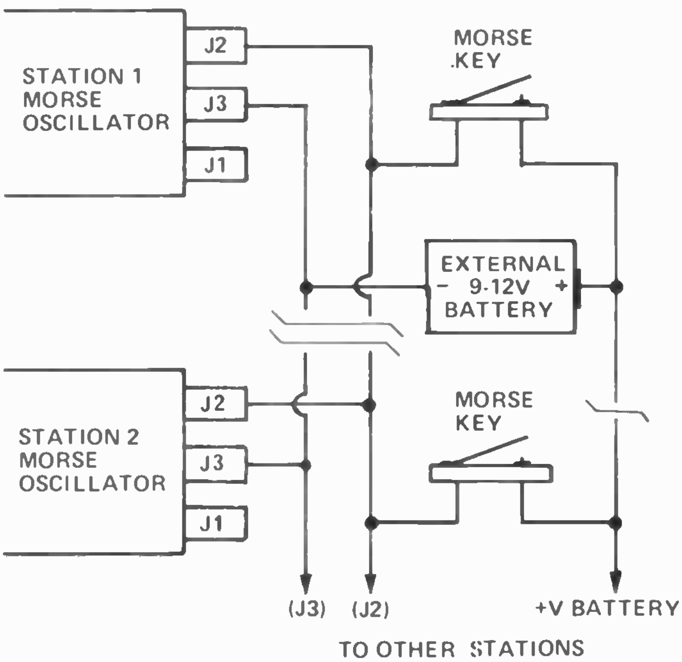


Fig. 5. For two way communication with a friend two oscillators are required connected as shown.

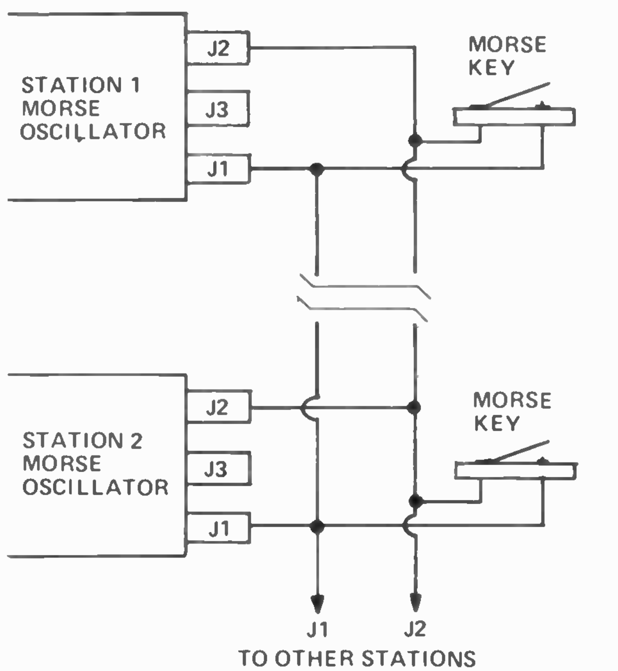


Fig. 6. Two way communication system using an external battery.

Emergency flash

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

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 Cl 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.

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

Emergency flash

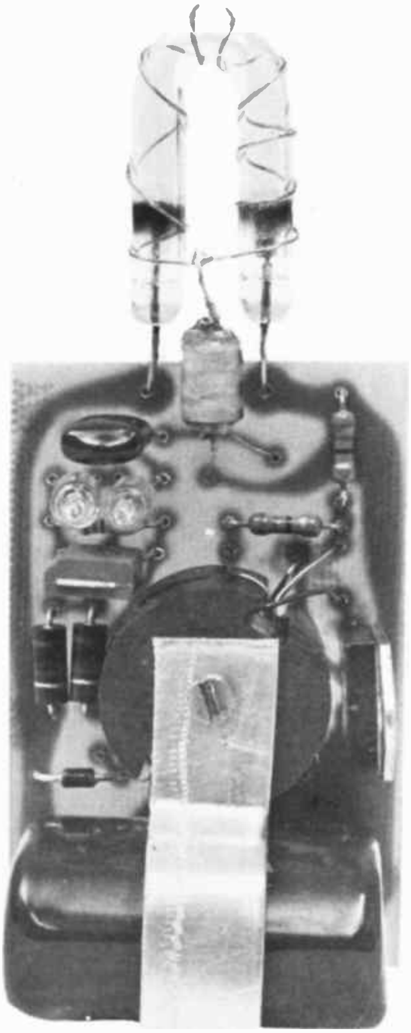


TABLE 1

Winding details transformer T1.

CORE	FX2240 (2 halves) plus single section bobbin to suit
SECONDARY (wound first)	150 turns of 0.315 mm wire
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.

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	EM408			
SCR1	C106D			

Transformer

T1	See Text
T2	TR-4 KN

LP1, LP2, Neon Lamps NE2 (75 v)
LP3 Flash Tube MPF 1210

PC Board ETI 240

Torch, Battery etc.

* For 6v operation change R1 to 470 ohm.

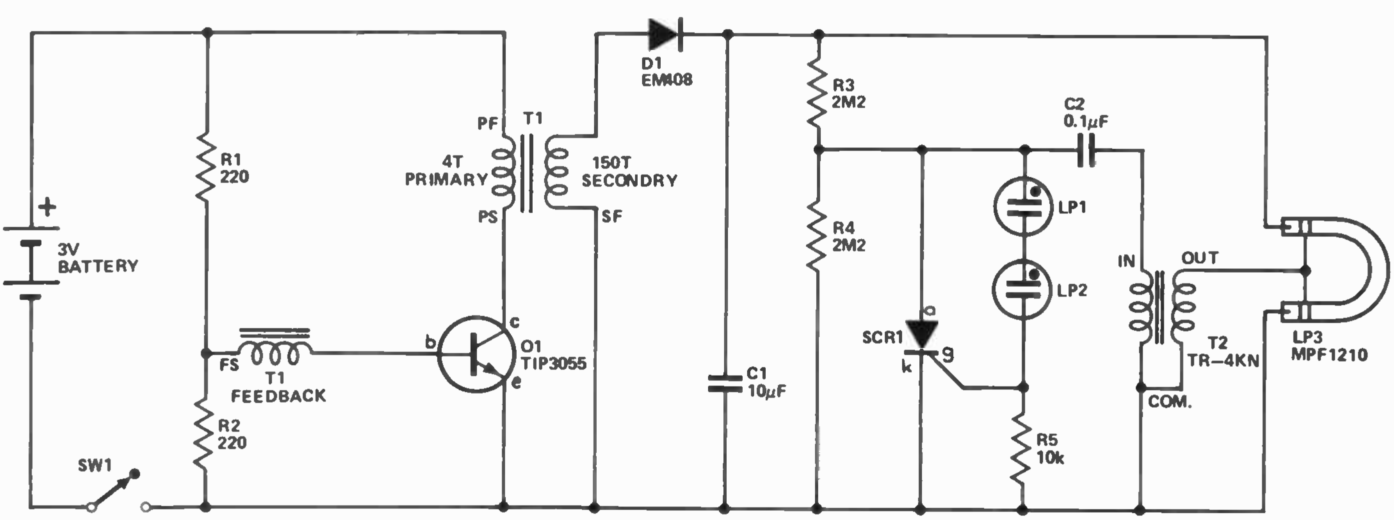


Fig. 1. Circuit diagram of the portable emergency flash.

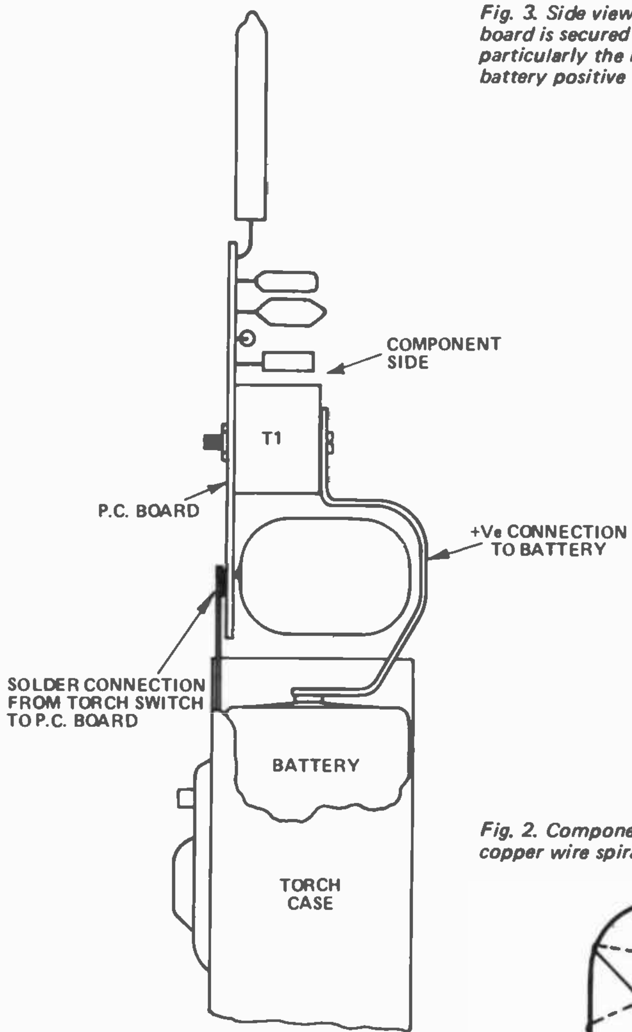


Fig. 3. Side view of the flash unit showing how board is secured into the torch body. Note particularly the bracket which connects to the battery positive terminal.

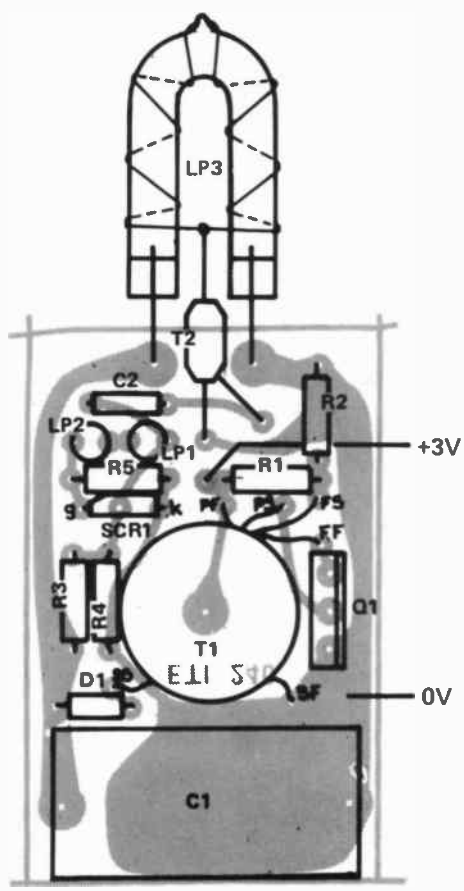


Fig. 2. Component overlay. Note copper wire spiral around flash tube.

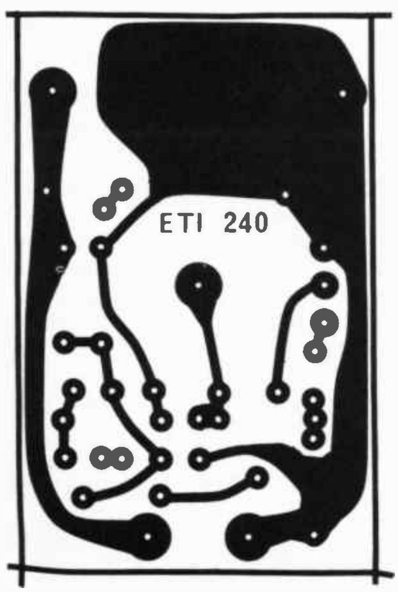


Fig. 4. Printed-circuit layout for the flash. Full size 73 x 47 mm.

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 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 charge 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.

eti PROJECT 525

DRILL SPEED CONTROLLER

Variable speed control maintains constant (adjustable) speed regardless of load.

THE SPEED controller described here allows infinite variation of speeds from zero to about 75% of full speed, and is provided with a switch to allow normal full-speed operation without disconnecting the drill from the controller. The controller has built-in compensation to maintain substantially constant speed regardless of changes in load.

It must be emphasized that the controller is connected directly to the mains without the use of an isolating transformer. Considerable care must therefore be taken with the construction.

As there are relatively few components used, no supporting tag strip or pc board is necessary. Only two "mid air" joints need to be made, and these should be carefully insulated to prevent any possibility of short circuits.

The SCR used is a stud mounting type and is mounted by using the solder lug, supplied with it, soldered onto the centre lug of the switch. For loads up to 3 amps, no other heat-sinking is required. If a plastic-pack SCR is used, a hole may be drilled through the switch lug and the SCR bolted directly to it. However in this case it is advisable to inset a piece of aluminium (about 25 mm x 15 mm) between the SCR and switch lug to act as a heatsink.

Remember that, since the unit operates at 240 Vac *all external parts must be earthed.* We used a plastic box with a metal lid. But we also used a cable clamp with a metal screw through the side of the plastic box. This screw *must* be earthed, along with the lid and the earth terminal of the output socket. The earth wire should be continuous. That is, it should go from one earth point through to the next and not by separate links. Two earth wires may be soldered to one earth lug. But under no account should two wires be secured under a single screw.

The aluminium lid on the (type UB3) box used is not strong enough for this application, especially when the hole for the output socket is cut. A new lid should therefore be made from 18 gauge steel or 16 gauge aluminium.

To further improve safety, it is suggested that a small amount of glue, lacquer or even nail polish, be used to secure each screw inside the unit.

With some SCRs it may be found that the trigger current supplied by R1 and R2 is insufficient. If this is the case an additional 10 k resistor should be placed in parallel with each resistor.

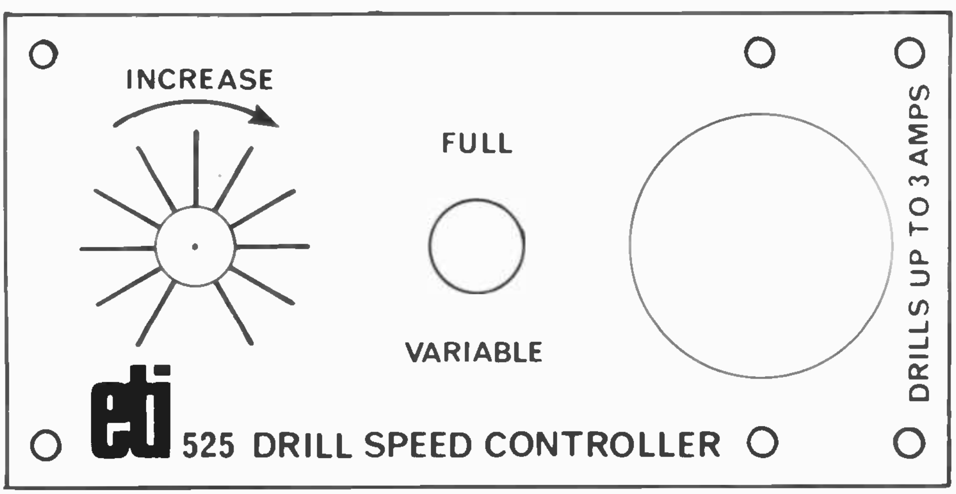
USING THE CONTROLLER

Plug the controller into the mains and the drill into the controller. Select either full speed or variable as required. Note that there is no ON/OFF switch provided on the unit and the normal switch on the drill is used for this purpose. When full speed is selected, the drill will run normally and the speed control on the controller will have no effect.

When variable speed is selected, the control will adjust the speed anywhere between zero and about 75% of full speed. There may be a dead zone at both low speed and high speed ends of the control. This is due to different drill characteristics and component tolerances within the controller.

At very low speeds the drill may run jerkily under no load. However as load is applied the speed will smooth out.

When the drill is used at less than full speed the cooling of the motor will be reduced as the cooling fan is on the armature shaft and also runs slower. Hence the drill will get hotter when used at low speeds, and extended periods of use in this mode should be avoided.



PARTS LIST ETI 525

R1,2	Resistor	10k 1W 5%
RV1	Potentiometer	2.5 k lin rotary
D1,2	Diodes	EM404 or similar
SCR1	S.C.R.	2SF28 or similar (400V, 10A, max 20ma gate trigger)
SW1	Switch	McMurdo type 475 or similar.

Box type UB3 or similar.
3 core flex and plug.
cable clamp
3 pin power outlet clipsal 415 or similar.

* Some SCRs used may have a higher than average trigger current and the unit may not operate. If so parallel the two 10 k resistor with additional 10 k resistor to increase the available trigger current.

HOW IT WORKS ETI 525

A universal motor, when running, produces a voltage which opposes the supply. This voltage, called the back EMF, is proportional to the speed of the motor. The SCR drill speed controller makes use of this effect to provide a certain amount of speed-versus-load compensation.

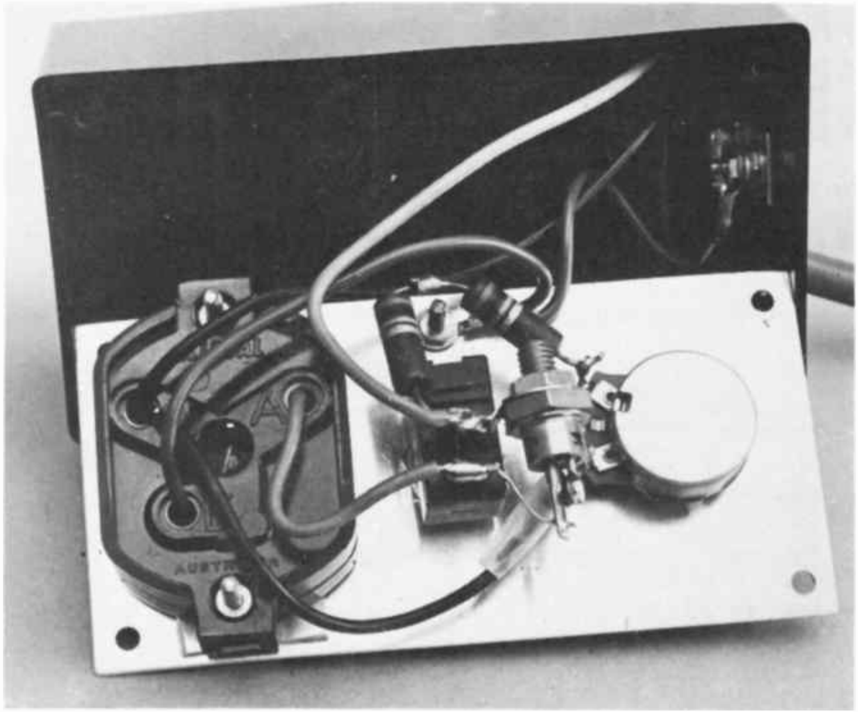
This controller uses an SCR (silicon controlled rectifier) to gate half-wave power to the drill motor. The SCR will conduct only when a anode (terminal A) is positive with respect to the cathode (terminal K), b/ when the gate (terminal G) is at least 0.6 volts positive with respect to the cathode, and, c/ when about 10 mA of current is flowing into the gate terminal. By controlling the level of the voltage waveform to the gate we effectively control the time at which the SCR turns on in each forward half cycle. By this means we effectively control the amount of power delivered to the drill.

Resistor R1, R2 and potentiometer RV1 form a voltage divider which provides a half wave voltage of adjustable amplitude to the gate of the SCR. If the motor is stationary the cathode of the SCR will be at zero volts and the SCR will turn on almost fully. As the drill speed increases, a voltage develops across the drill thus reducing the effective gate-cathode voltage. Thus as the motor speeds up, the power delivered decreases until the motor stabilizes at a speed determined by the setting of RV1.

Should a load be placed on the drill, the drill will tend to slow down, but as the voltage acorss the drill also drops, more power is delivered to the motor since the SCR firing-time is automatically advanced. Hence the speed, once set, is maintained relatively-constant regardless of load.

Diode D2 is used to halve the power dissipated in R1, R2 and RV1 by limiting the current through them to positive half-cycles only. Diode D1 protects the SCR gate against excessive reverse voltage.

In the full speed position the SCR is simply shorted out by SW1. Thus RV1 loses control and full mains supply is applied to the drill.



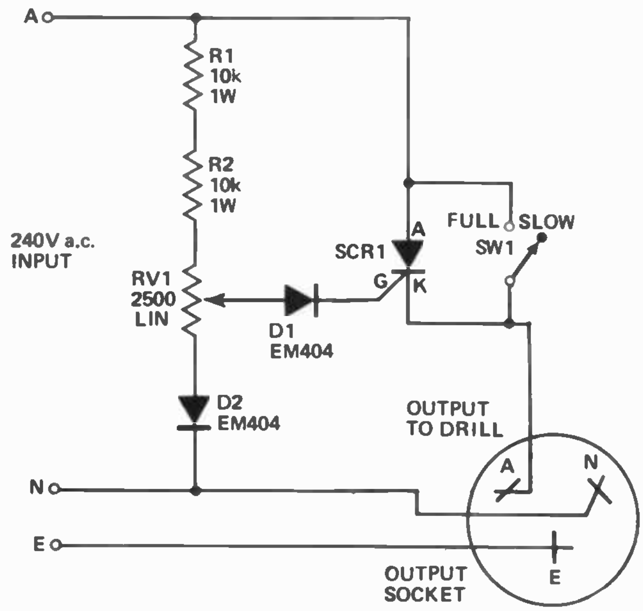


Fig. 1. Circuit diagram of controller.

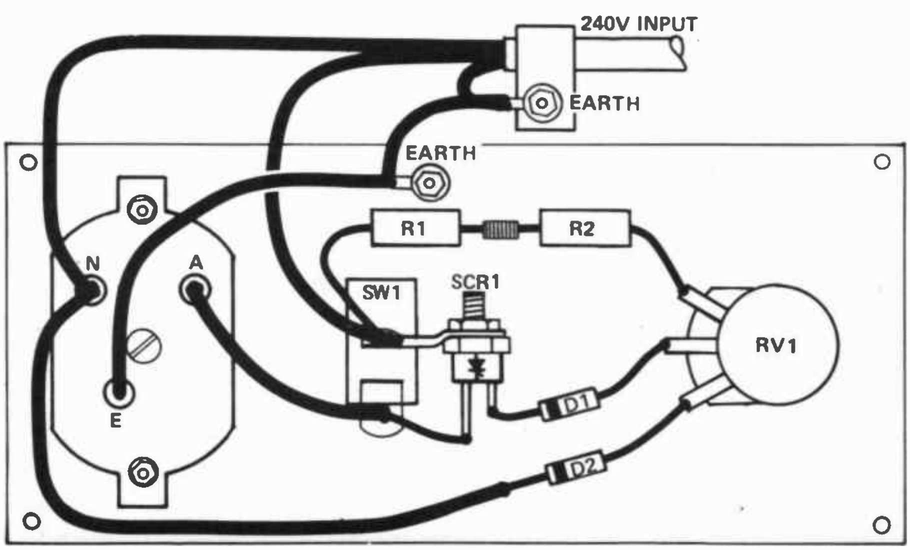


Fig. 2. Component layout — compare this drawing with photograph above.

THREE SIMPLE RECEIVERS

PROJECT 705 (A,B&C)

Biased diode; voltage multiplier; or solar powered — three simple but unusual receivers.

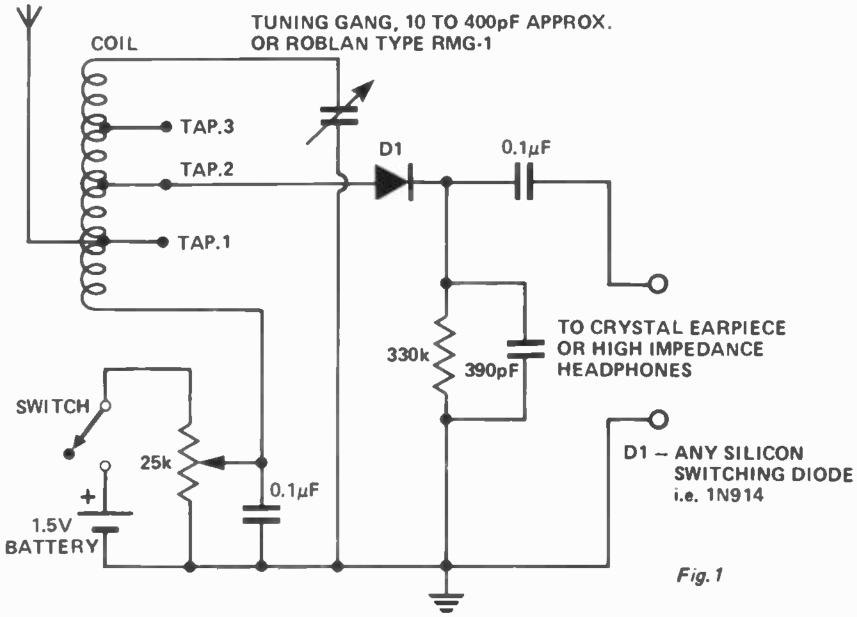


Fig. 1

BIASED DIODE CRYSTAL SET

THE CLASSIC "beginning beginner's" project is the crystal set — the workhorse of the pioneers and first popularised in the 1920's. For utter simplicity there is nothing to beat it. However, one can make various improvements and refinements on the basic circuit. One such refinement is shown in Fig. 1. In this version, a biasing voltage is impressed across the diode detector.

One failing of a basic crystal receiver (in which a diode is used as a detector) is that the diode will not commence conducting in the forward direction (from anode to cathode) until the anode-cathode voltage exceeds a certain (small) value. For germanium

VOLTAGE MULTIPLIER CRYSTAL SET

THE DIODE detector, as in a crystal set, is basically a special use of a rectifier circuit. Borrowing from rectifier circuitry, a 'voltage-multiplier' can be used to increase the output (the loudness in the headphones) of a crystal set. The circuit in Fig. 2 uses what is known as a 'Cockcroft-Walton' multiplier (after the original designers).

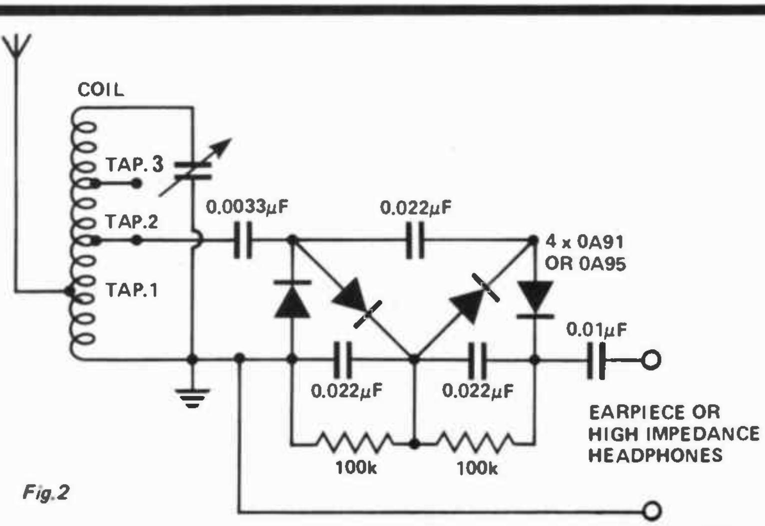


Fig. 2

Here, a voltage multiplication of four is obtained. You may wonder 'why not use a higher multiplication?'. The answer is that one runs into the ubiquitious 'law of diminishing returns'. For this application, a multiplication of four is all that is practicable as any further increase results in excess load being placed on the tuned circuit, reducing sensitivity and the ability to separate stations (selectivity).

The coil details are the same as for Fig. 1 in the Biased Diode Receiver (see Tables 1 and 2 on page 13). See also the comments in the project concerning use of the taps on the coil. The best diodes to use in this circuit are OA2 or OA5 germanium diodes as they have the lowest forward conduction voltage and are thus the most sensitive.

Construction is also simple, matrix board and pins may be used here again. This tuning capacitor was salvaged from an old broadcast receiver (only one gang being used).

diodes, this is between 200 and 400 millivolts (0.2 to 0.4 V), for silicon diodes it is between 0.6 V and 1.0 V. However, if the diode detector has a voltage almost equal to its forward conditioning voltage impressed upon it (called 'bias') then it becomes a more sensitive and efficient detector. This arrangement also reduces distortion.

Construction is simple and not critical. The unit may be built up on a matrix board as in our prototype – or assembled on tag strips.

Coil details are given in Table 1. Find the best tap for the diode and the aerial by experiment. The aim is to find the combination which gives the clearest signals for the best rejection of unwanted stations.

For short length aerials, say three to six metres of wire, tap high up the coil or across the full turns. Make the diode tap about half-way to three-quarters of the way up the coil in this case. For a long aerial, use the lower taps and tap the diode between one-quarter and half-way up the coil.

The tuning capacitor used was salvaged from an old valve-type broadcast receiver (only one of the three gangs is used) but any unit having a range of about 10 to 400 pF may be used.

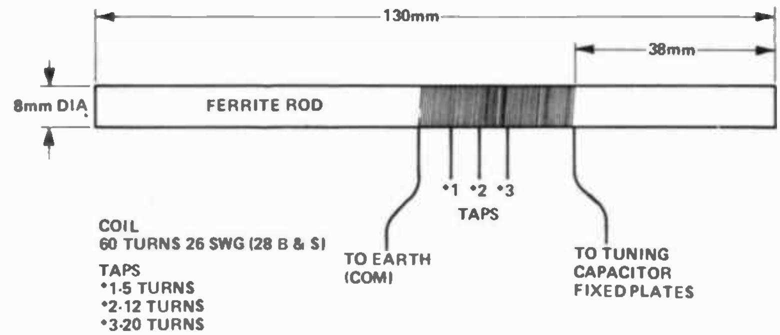
The best headphones to use for a crystal set are the high impedance type – having an impedance between 1000 ohms and 5000 ohms or more (if obtainable). Crystal earpieces may also be used but are not as sensitive as good headphones.

With the control potentiometer set at minimum, tune in a station that is not too strong but can be clearly heard. Advance the potentiometer slowly and an increase in volume and a reduction in distortion will be noticed. The point at which this occurs will vary from station to station but is not critical, there being some range of adjustment.

TABLE 1
For coils wound on cardboard former.
NUMBER OF TURNS FOR WIRE GAUGE

COIL DIA.	22 SWG	24 SWG	26 SWG	28 SWG	TAPS
1¼"				110	at ¼, ½ and
1½"			96	90	¾ of the turns.
1¾"		88	80	70	You may tap
2"	82	72	68	60	every ten turns
2¼"	71	64	60	52	if you wish
2½"	61	56	54	47	for more range
2¾"	54	52			of adjustment.

TABLE II Coil wound on ferrite rod



SOLAR-POWERED RADIO

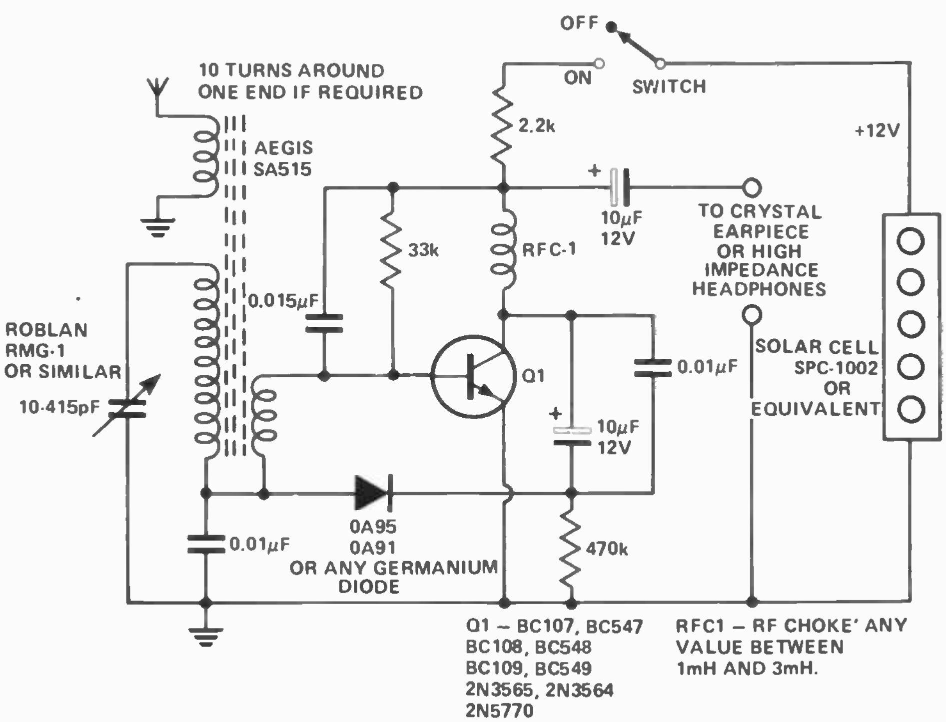


Fig.3. Solar powered reflex receiver.

SOLAR CELLS are dropping rapidly in price. They will continue to drop in price as they gain acceptance and use in more and more applications. Solar cells require no maintenance and the energy source (being the Sun) is free and presumably almost everlasting.

Modern solar cell arrays will deliver over one watt in bright sunlight from a single array, or about 200 milliwatts in cloudy conditions. A representative unit is the Solar Power Corporation's (USA) SPC-1002 (available from Joseph Lucas Pty. Ltd. in Australia). This consists of five wafers mounted on a printed circuit board, wired in series, and encapsulated. Output is about two volts. Similar units are available from other manufacturers.

The solar array can be used to drive a low-voltage radio receiver or to trickle charge rechargeable batteries such as the small nickel cadmium (Nicad) cells that are commonly available. These cells can be used to run a low voltage radio. Mercury cells, such as used in cameras, also make good low voltage power sources.

(Continued on page 73).

ONE-TRANSISTOR

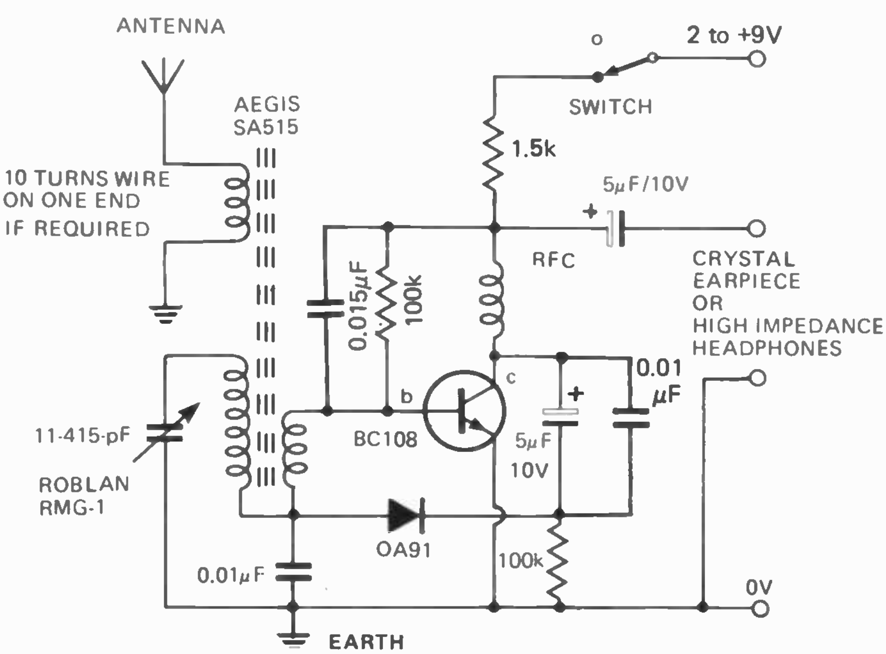


Fig. 1. Circuit diagram.

PROJECT 406

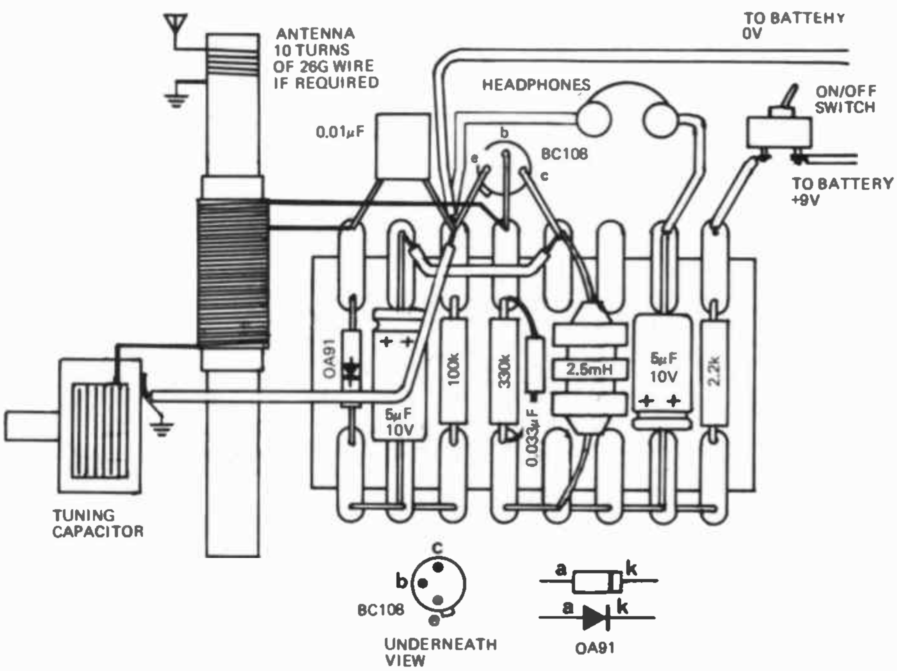


Fig. 2. The receiver may be built on tag strips or a piece of circuit board.

Here is a simple one-transistor receiver that will bring in broadcast stations with surprising clarity and strength. It can be made from readily available, cheap components, requires no adjustments, and will work straight off!

The circuit of the complete unit is shown in Fig. 1. A single transistor is used to amplify both the radio frequency signal picked up by the ferrite rod and coil antenna, and the audio signals recovered by the detector (OA 91 diode). This results in excellent sensitivity and selectivity ensuring that radio stations can be received at good strength and without interference.

CONSTRUCTION

The receiver can be constructed on a small piece of circuit board – as shown in Fig. 2. This can be mounted, together with the ferrite rod, tuning condenser, and battery and headphone connectors, on a piece of wooden board to which a panel has been screwed. This panel can be made from plywood, fibre-board, bakelite etc.

Two rubber grommetts should be fitted over the ends of the SA515 ferrite rod. These can then be fitted into the brackets (illustrated in Fig. 3) which are then screwed to the baseboard.

Take care when soldering the transistor into the circuit – leave this item until last.

ANTENNAE

The AEGIS SA 515 ferrite rod acts as a built in antenna – and – if you live in the metropolitan area of a city, the local broadcasting stations will be heard at good strength with this antenna alone. At night some interstate stations may even be heard!

In fact an external antenna will probably be a disadvantage in city areas, because the received signal strength from nearby stations may be so powerful that distant stations will be swamped.

However if you live in a country area, then an external antenna may well be necessary.

Figure 4 shows the general idea. A length of wire, from 20 ft. to 100 ft. long should be erected, preferably in line with the nearest broadcasting stations, and as high as possible.

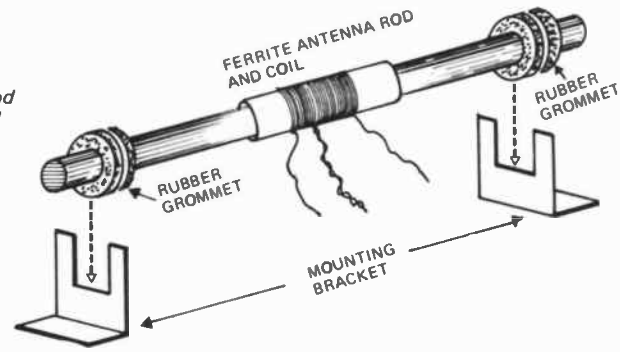


Fig. 3. The ferrite antenna rod and coil should be supported by two grommetts and small metal brackets.

Insulators should be used at either end. The type of wire is not important as long as it is strong enough to withstand wind forces etc.

An earth connection may also improve reception of weak signals. Use a length of metal rod or pipe, about two or three feet long, hammered into the ground. The surrounding soil should be kept moist. If mains water is available the water pipe will make a good earth – but ensure that it is a metal pipe. Many water systems are now being constructed using plastic pipes, and plastic water pipe is a remarkably poor conductor! ●

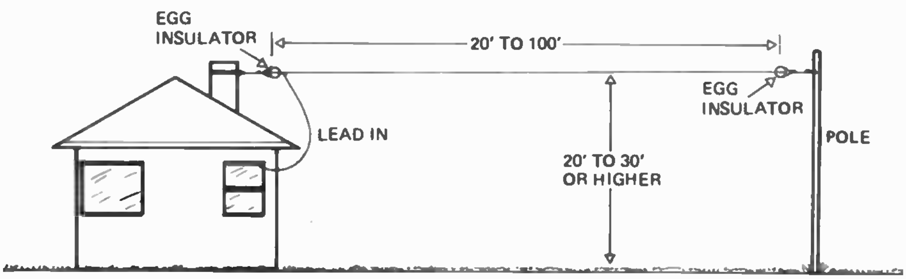


Fig. 4. How to make a simple antenna.

PARTS LIST ETI 406.

1 resistor 1.5k ½ watt, 10%
2 resistor 100k ½ watt, 10%
2 capacitors 5μF 10 volt electrolytic
2 capacitors 0.01μF
1 capacitor 0.015μF
1 transistor (Q1) BC107, BC108, BC109, BC547, BC548, BC549, 2N3564, 2N3565, 2N5770.
1 diode (D1) 0A91, 0A95 or any germanium diode
1 ferrite rod and coil – AEGIS type SA515 or similar
1 tuning capacitor 11-415 pF, Robland type RMG-1 or similar
1 nine volt battery and connectors
1 toggle switch – single pole single throw
1 RF choke, 1mH – 3mH
1 crystal earpiece or high impedance headphones
1 pointer control knob
Rubber grommetts, screws, plywood etc.

THREE SIMPLE RECEIVERS

(Continued from page 71).

The circuit in Fig. 3 is a simple one transistor 'reflex' receiver that can be run from any of the above power sources, or a combination of them. It has been especially designed for maximum sensitivity using a low voltage collector supply. This supply may be of any voltage from two to four volts – but no more – it oscillates above that.

The transistor, Q1, amplifies both the radio frequency signal picked up by the ferrite rod antenna coil and the audio signals recovered by the diode detector. Thus both RF amplification and audio amplification are achieved using the one transistor. Surprising sensitivity is obtained, no external antenna is necessary in metropolitan areas – it even receives 2JJ in inner city Sydney suburbs!

If you live in the country, an external antenna may be necessary. A length of wire 10 m or more long, mounted 5 m to 10 m high is usually adequate. An added winding, as shown in Fig. 3, provides coupling for the external antenna. An earth connection may improve reception also.

CONSTRUCTION

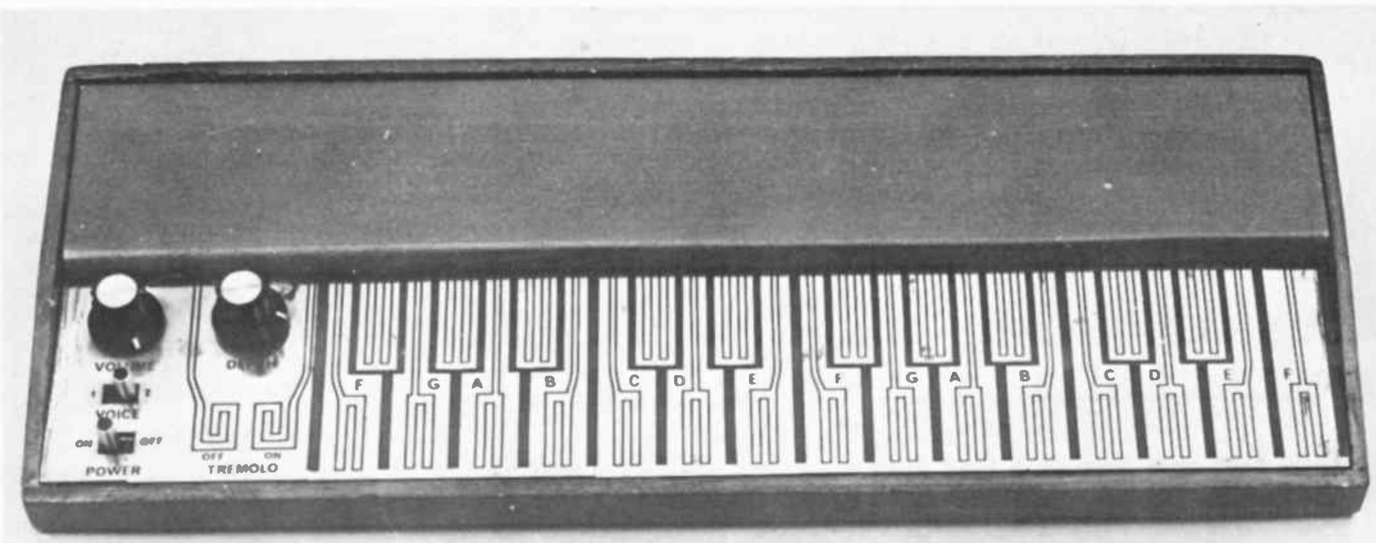
Construction is straightforward and non-critical. Matrix board and pins, or tag strips are used to support the small components. Two rubber grommets are slipped over the ends of the ferrite rod and the assembly tied down to the matrix board with short lengths of *insulated* hook up wire around the grooves in the grommets.

As we said at the beginning of this article, solar cell arrays are still expensive. However, like so many other electronic components the price may realistically be expected to fall dramatically as soon as demand increases. At present, the cost of an array varies from $20 to $50 plus – but this may well fall by a factor of ten.

In the meantime, why not build it and run it from Nicad or mercury cells. These have terminal voltage of about 1.2 V to 1.3 V per individual cell, so two or three in series may be used to power this receiver. Current consumption from a two volt supply is about 0.5 mA. Alternatively, ordinary dry cells may, of course, be used. ●

ETI MINI-ORGAN

With all the electronics on one pc board this organ is easy to build yet has features like touch keyboard, variable tremolo, two voices and a full two-octave range.



AN ELECTRONIC ORGAN IS A fascinating instrument which these days seems to be rapidly assuming the position in the home once occupied by the piano. Modern organs are, however, very expensive, ranging from around $1000 to $4000 – a price which puts them beyond the reach of most people. Lower down the scale in cost and performance are chord organs which although still polyphonic are fairly limited reed type instruments operated by a small blower. The name chord organ comes from the fact that the bass accompaniment is by means of buttons which generate the appropriate chord. Such instruments still may cost several hundred dollars.

The cheapest possible organ is the so called monophonic organ (only one note can be played at a time) which is usually little more than pocket sized and is played with a stylus.

Such an organ was described in the May 1974 issue of ETI and was enormously popular with our younger readers. So popular that we have been asked to update and improve this instrument without adding to the cost too greatly.

The first obvious improvement required is to devise a better keyboard arrangement as the stylus operation can only be described as somewhat of a nuisance. However the $100 of a full keyboard cost cannot be justified. As can be seen from the photographs the new keyboard is still of the touch type but has now been designed so that the organ is played simply by touching the appropriate key, as in a full scale instrument. Tremolo is also provided and this too is switched on and off by means of touch switches and a control is provided to adjust tremolo depth.

The next improvement is in the accuracy of the tuning, which in the previous instrument varied over the keyboard due to the one-only resistor used to increment between each note. In our new version tuning over the keyboard is much improved by using two resistors, where necessary in series or parallel, to obtain the nearest possible to the correct value of resistance. Finally the instrument is provided with two voices or stops which add greatly to the variety of the music which can be produced.

This little organ is relatively inexpensive to build, should provide a great deal of enjoyment and is musically and electronically educational.

(Main text continues on page 80).

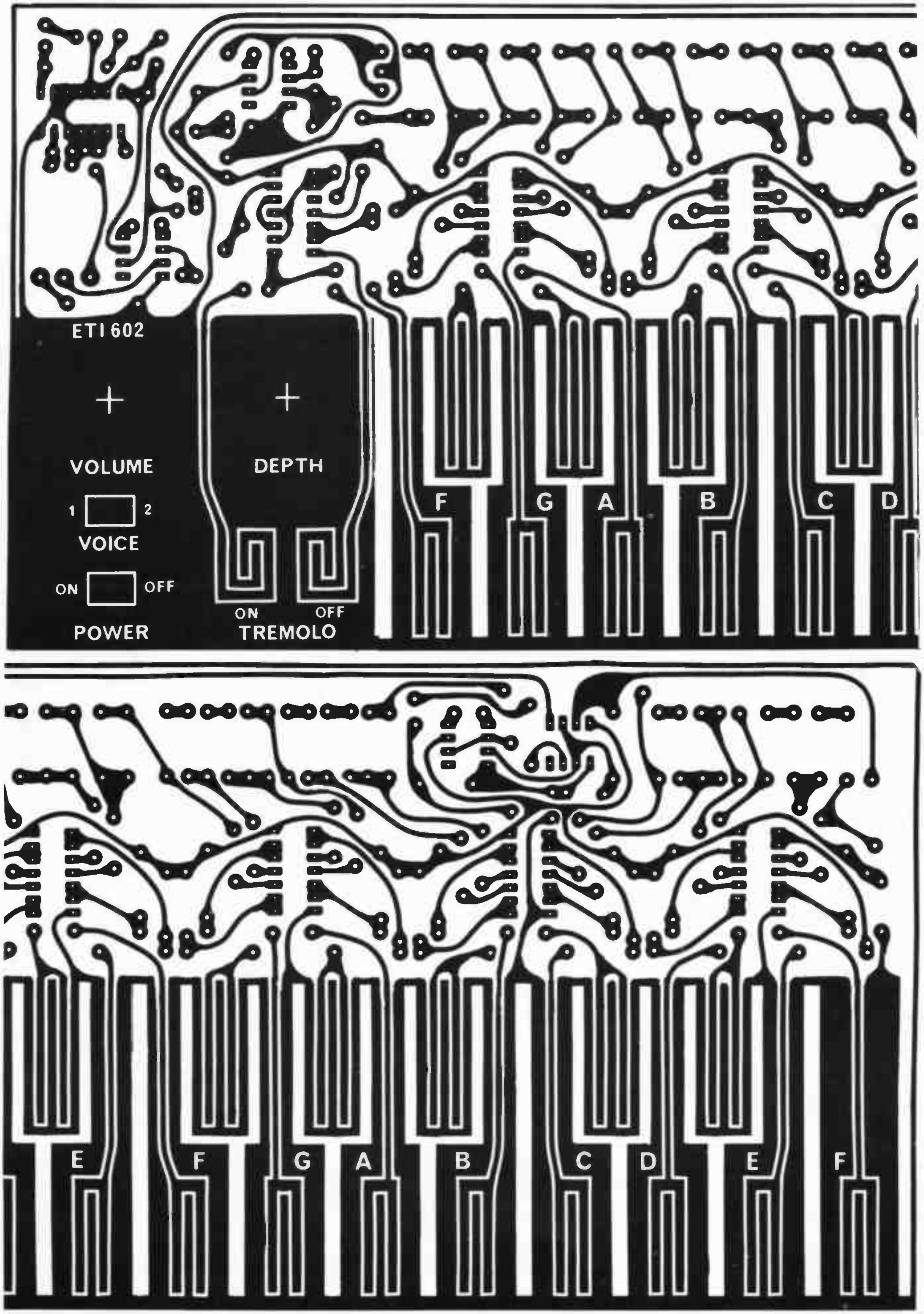


Fig 4 Printed-circuit board layout for the monophonic organ shown in two sections. Full size 345x120 mm.

ETI MINI-ORGAN

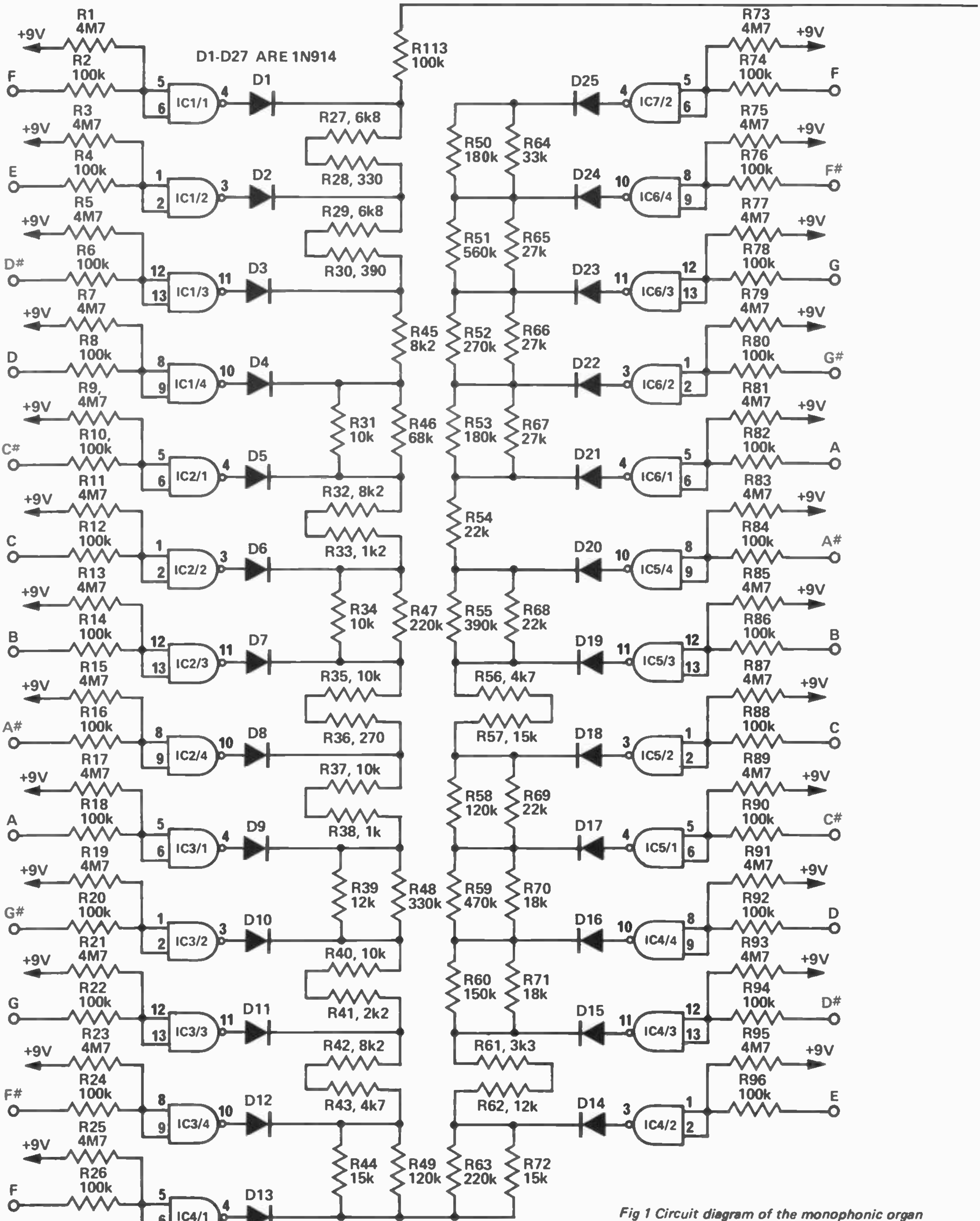
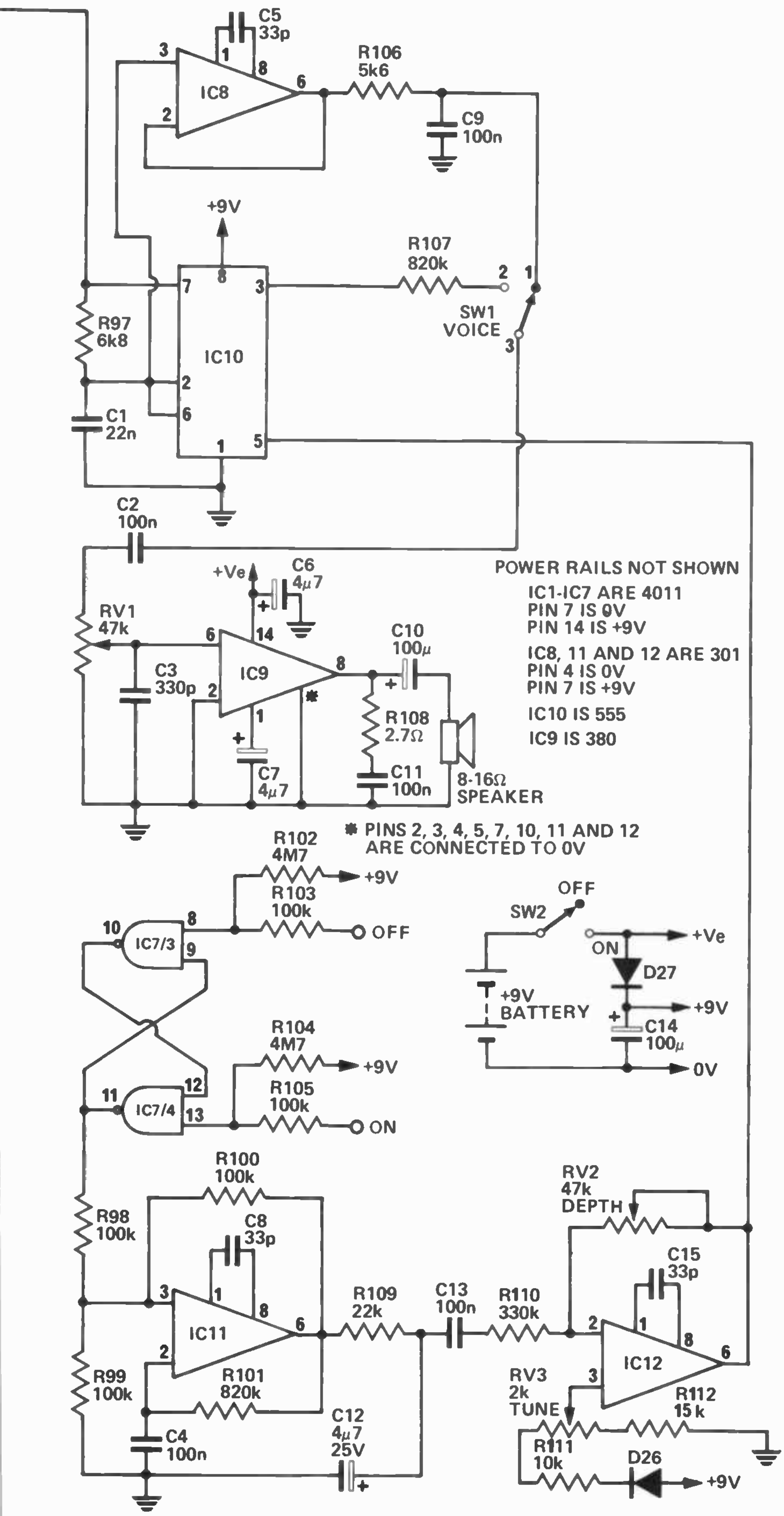


Fig 1 Circuit diagram of the monophonic organ



How it works ETI 602

Operation of the organ will be described by considering separately the five sections of which it is composed. These are:—

(a) Keyboard
(b) Oscillator
(c) Filter
(d) Output amplifier
(e) Tremolo circuit

(a) Keyboard. Unlike the previous organ the keyboard is operated by the contact resistance of the finger and not by a probe. Each key has a CMOS gate associated with it where both inputs to the gate are connected together and to the positive supply via a 4.7 megohm resistor. When the key is touched the inputs of the gate are pulled low (0V) via the 100 k resistor causing the output of the gate to go high. This pulls the corresponding point in the resistor chain high via the diode. Thus by selecting and touching different keys we connect various amounts of resistance between pins 2 and 6 of the 555 oscillator and the positive supply, thus enabling it and varying the frequency determining time constant circuit.

(b) The Oscillator. The oscillator is based on a 555 timer IC. The capacitor C1 is charged up via a section of the resistor chain (as by the keyboard) together with the resistor R113. When the voltage at pins 2 and 6 reaches that set at pin 5, the capacitor is discharged rapidly via R97 and an internal transistor connected to pin 7 of the 555. When the voltage across C1 has dropped to half that set at pin 5, the internal transistor turns off and the capacitor is allowed to charge up again — thus repeating the cycle and generating a sawtooth waveform across the capacitor. This waveform has a high harmonic content but is generated at a high-impedance point. A unity gain buffer is therefore used (IC8) to prevent this output from being loaded by the following circuitry. A second output of a narrow pulse waveform is available at pin 3 of the 555 and this is used to generate a second voice for the instrument.

(c) Filter. A number of different filters were tried but from a cost point of view it was difficult to justify anything more than a simple RC filter on the sawtooth which gives quite a pleasant flute-like effect. As the narrow pulse train sounds somewhat similar to strings

(Continued on page 79).

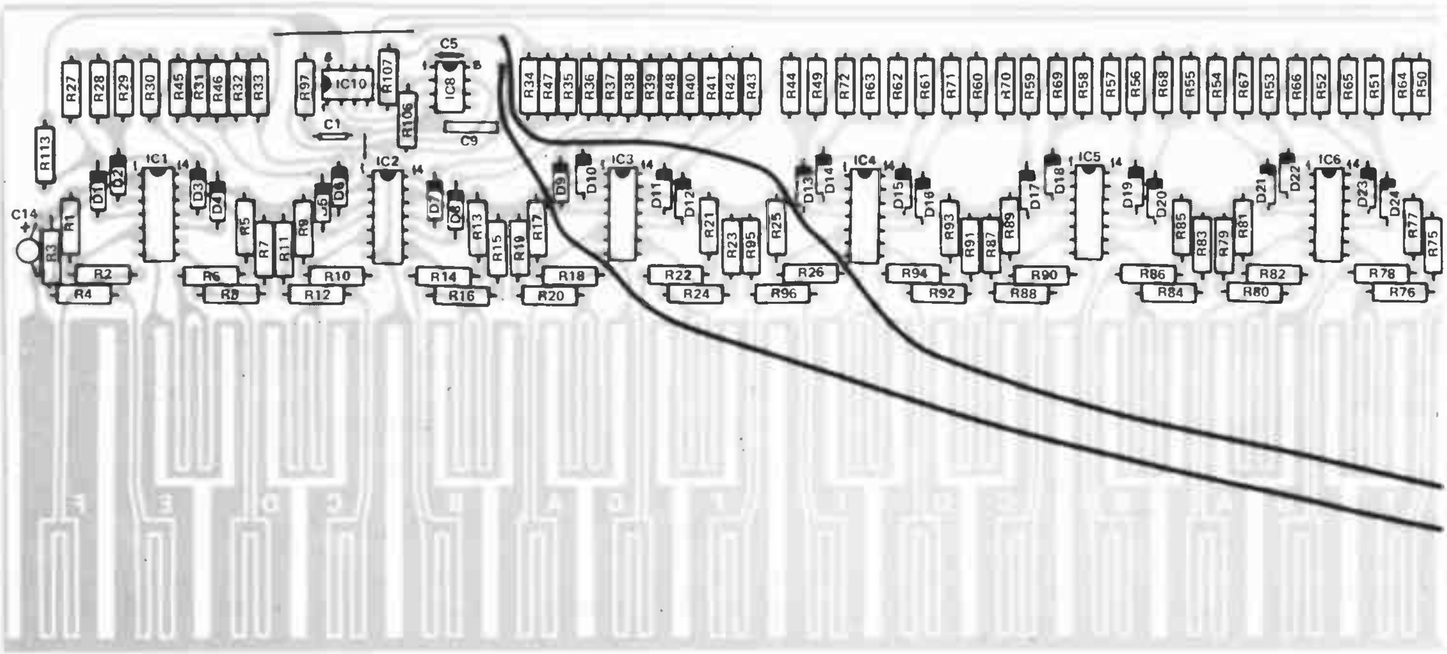


Fig 2 Component overlay and interconnection diagram

Parts List ETI 602

Resistors all ½W 5%

R1,3,5,7	4M7
R9,11,13	4M7
R15,17,19	4M7
R21,23,25	4M7
R2,4,6,8	100k
R10,12,14	100k
R16,18,20	100k
R22,24,26	100k
R27	6k8
R28	330
R29	6k8
R30	390
R31	10k
R32	8k2
R33	1k2
R34,35	10k
R36	270
R37	10k
R38	1k
R39	12k
R40	10k
R41	2k2
R42	8k2
R43	4k7
R44	15k
R45	8k2
R46	68k
R47	220k
R48	330k
R49	120k
R50	180k
R51	560k
R52	270k
R53	180k
R54	22k
R55	390k
R56	4k7
R57	15k
R58	120k
R59	470k
R60	150k
R61	3k3
R62	12k
R63	220k
R64	33k
R65,66,67	27k
R68,69	22k
R70,71	18k
R72	15k
R73,75,77	4M7
R79,81,83	4M7
R85,87,89	4M7
R91,93,95	4M7
R74,76,78	100k
R80,82,84	100k
R86,88,90	100k
R92,94,96	100k
R97	6k8
R98,99,100	100k
R101	820k
R102	4M7
R103	100k
R104	4M7
R105	100k
R106	5k6
R107	820k
R108	2.7Ω
R109	22k
R110	330k
R111	10k
R112	15k

Potentiometers

RV1	47k log rotary
RV2	47k log rotary
RV3	2k trim

Capacitors

C1	22n polyester
C2	100n polyester
C3	330p ceramic
C4	100n polyester
C5	33p ceramic
C6,7	4µ7 25V electro
C8	33p ceramic
C9	100n polyester
C10	100µ 16V electro
C11	100n polyester
C12	4µ7 25V electro
C13	100n polyester
C14	100µ 16V electro
C15	33p ceramic

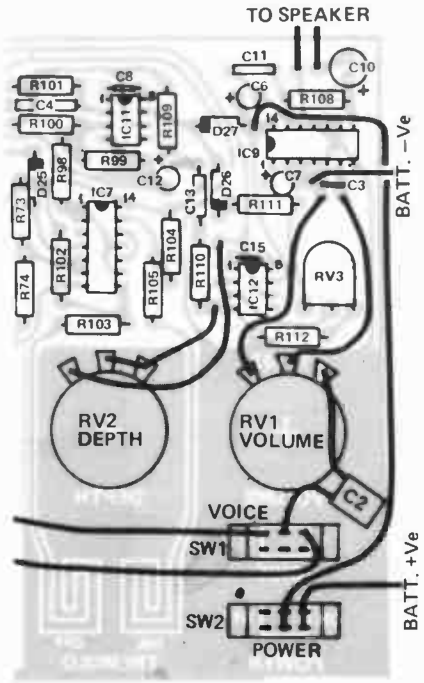
Semiconductors

D1-D27	1N914 or similar
IC1 – IC7	4011 (CMOS)
IC 8,11,12*	LM301 or 741
IC9	LM380,SL60745
IC10	NE555

*if 741s are used delete C5,8,15

Miscellaneous

SW1,2 — single pole, 2 position slide switches
PC board ETI 602
Two knobs
6 way AA size battery holder
Small 8 or 16 ohm speaker
battery clip
case to suit



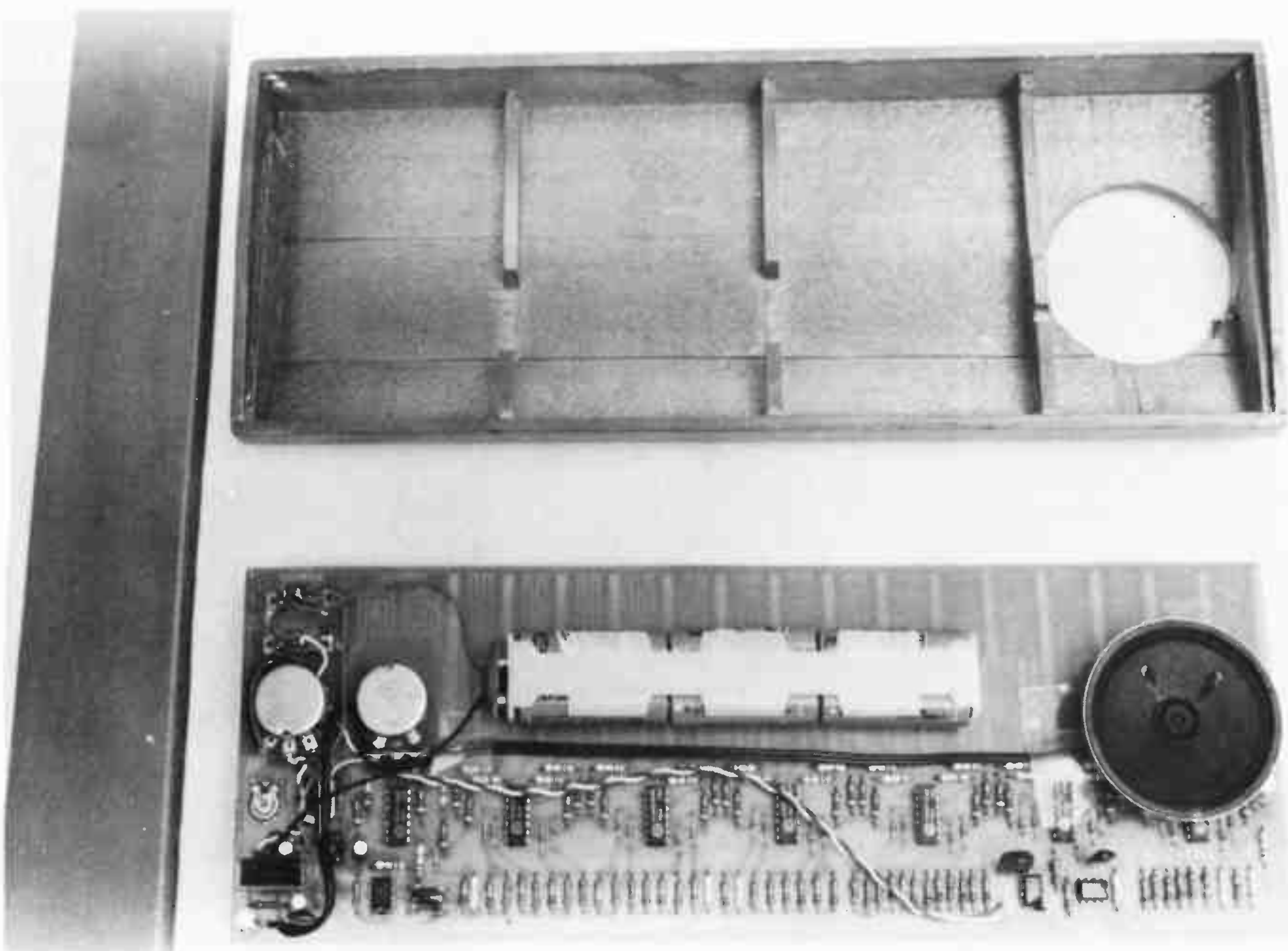
(How it works, continued from page 77).

it is merely attenuated to match the level of the filtered sawtooth.

(d) The Output Amplifier. The loudspeaker is driven by an LM380. Volume control is provided by means of potentiometers RV1 and the required voice is selected by means of switch SW1. The LM380 should be fitted with heatsink fins as detailed in the construction.

(e) The Tremolo Circuit. Tremolo is produced by means of a low frequency oscillator running at approximately 8 Hz (IC11). The oscillator can be turned on and off by means of the flip flop formed by gates IC7/3 and IC7/4. This flip flop is set to the 'on' or 'off' mode by means of touch switches which operate in exactly the same manner as the main keyboard. To increase tremolo frequency decrease R101 and vice versa.

The output from the tremolo oscillator is filtered by C12 and R109 to give a smoother waveform and the resultant waveform buffered by IC12. The gain of IC12 is adjustable by means of RV2 and this control therefore adjusts the depth of the tremolo modulation. The potentiometer RV3 is a trim potentiometer which effectively sets the output from IC12 to pin 5 of the 555 and thus the frequency of the organ. If it is required to shift the keyboard up or down an octave or so this may be done by changing the value of C1 by a factor of two. If the keyboard tuning is found to be skewed (when tuned correctly at the centre one end of the keyboard is low whilst the other is high) this may be cured by changing the value of R97. If it is sharp at the low end decrease R97 while if flat at the low end increase R97.



Design Features

As said earlier the major improvement in the organ is in the implementation of the keyboard by means of a finger touch system rather than the probe type used in the previous organ. This means that some electronics must be associated with each key to detect that it has been touched. Touch control is usually effected by the capacitive, resistive or 50 Hz injection methods, Whilst the capacitive method is the best of these it is also the most expensive and for this reason is not used. The 50 Hz injection method is also complex and thus the resistive method was considered to be the only practical way from a cost point of view.

As the keyboard is now played by the finger it also needs to be larger than in the original organ although still not quite as large as a full-size keyboard.

In the original organ an OM 802 was used as the tone oscillator. This was replaced by a 555 timer IC as this is cheaper and easier to use. The 555 has two outputs which can be used, a sawtooth wave and a narrow pulse. Both of these outputs are used in our design to provide different voices for the instrument. The sawtooth is filtered by means of a simple RC filter to remove some of the harshness due to the harmonic structure and the resultant voice has a rich flute-like sound. The pulse output is matched in level to the sawtooth by means of a resistive attenuator but is otherwise unfiltered. This voice has a string-like sound.

Filtering has been kept very simple, again from a cost point of view. If the constructor desires he may experiment with different filters in order to achieve different sounds. With conventional organs the stop-filtering is done for every octave of the organ to prevent undue tone and level changes at different frequencies. With the two octave span of this organ some change in tone and level must be accepted over the range of the keyboard when using simple filters.

As attenuating filters are used in the organ plenty of gain is required in the audio stage and for this reason an LM380 is used in the audio output stage to drive the loudspeaker.

Construction

The keyboard pattern is etched directly onto the printed-circuit board which also carries the rest of the electronics. As the copper of the keyboard would rapidly tarnish when continuously being touched with the finger it is necessary for the board to be either tinned or protected with some other plating process that will prevent tarnishing.

Commence construction by mounting the LM380 into position and then fit small heatsink fins, as shown in the photograph, to either side of the IC. Solder them to pins 3,4,5 on one side and pins 10,11 and 12 on the other. This should be done first as there is little room in this area of the board once other components are in position. Fit the two wire links and assemble the low-height components to the board as shown on the overlay.

Mount the remaining ICs last of all and take particular care not to handle the CMOS ICs excessively before insertion. Check the polarities of polarised components such as ICs, capacitors and diodes before soldering them into position.

To avoid having screws showing on the keyboard we glued the two switches into position with five-minute epoxy. Use a piece of printed-circuit board or metal behind each mounting hole to obtain extra glueing surface and extra strength. Mount the potentiometers and wire the complete board as detailed in the overlay diagram.

The complete unit should now be tested to ensure that all notes and functions are operating correctly before mounting into a suitable cabinet.

Playing the organ.

Although the new organ is played with the fingers as with a full instrument there are a few small playing differences which should be kept in mind.

Firstly the instrument is monophonic. That is, if two notes are touched simultaneously only the higher note will sound. Secondly, the fingers must be kept dry, as any moisture across a key will hold that note on when the finger is removed. If this does happen then the keyboard should be wiped with a clean dry rag. In stubborn cases a little methylated spirits on the rag will help.

Finally, it should be remembered that unlike a piano there is no "touch" to the instrument and hitting the key hard will not alter the sound. In this respect it is similar to a real organ and the player should get used to touching the keys smoothly and firmly with the flat part of the finger — not the extreme tip.

Frequency of Notes used

F	698.5
E	659.3
D#	622.3
D	587.3
C#	554.4
C	523.3
B	493.9
A#	466.2
A	440.0
G#	415.3
G	392.0
F#	370.0
F	349.2
E	329.6
D#	311.1
D	293.7
C#	277.2
C	261.6
B	246.9
A#	233.1
A	220.0
G#	207.7
G	196.0
F#	185.0
F	174.6

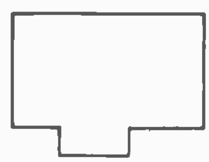


Fig 3
Details of heat sink shown full size, two required material tinplate or thin copper.

ACCENTUATED BEAT METRONOME

This metronome design accentuates one beat out of every bar to help with complex rhythms.

IT SEEMS THAT a sense of rhythm is acquired by aspiring musicians as they practise, rather than being an inborn ability. Many people don't have an 'easy' sense of rhythm, and the majority of people, if left to themselves in keeping a rhythm, will speed up or slow down slightly without realising it.

This project is an electronic version of the familiar mechanical metronome. However, we have used the potential of electronics to improve on the old design and have come up with one which will always accentuate a particular beat in the bar, e.g. 3/4 for waltzes. This can be a great benefit to those starting out in music, and can also help the more advanced musician with those awkward rhythms!

SPECIFICATION – ETI 604

Rate	1 / sec. to 15 / sec.
Beat	Off, 1–1 to 1–9
Output power 9 volt supply	8 watts peak
Output frequency	800 Hz, 2500 Hz
Power supply	6 – 15 volts dc

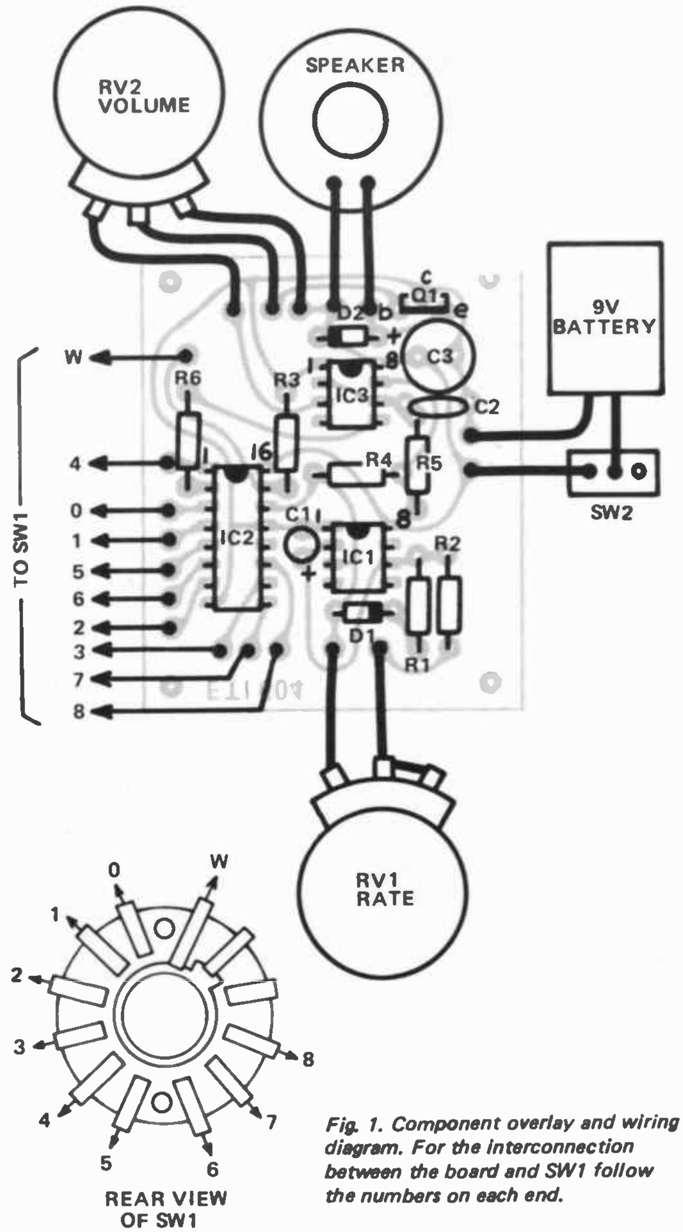


Fig. 1. Component overlay and wiring diagram. For the interconnection between the board and SW1 follow the numbers on each end.

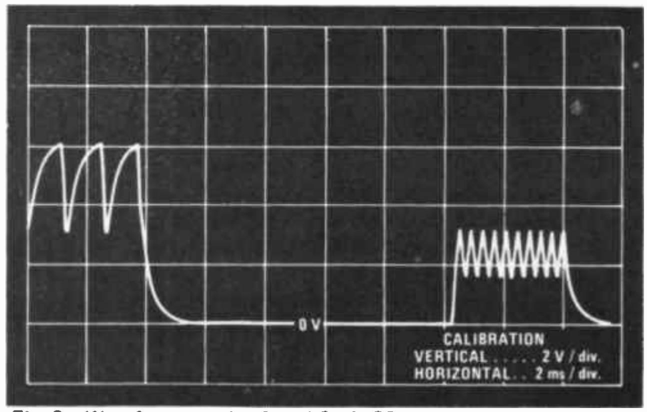


Fig. 2a. Waveform on pins 2 and 6 of IC3.

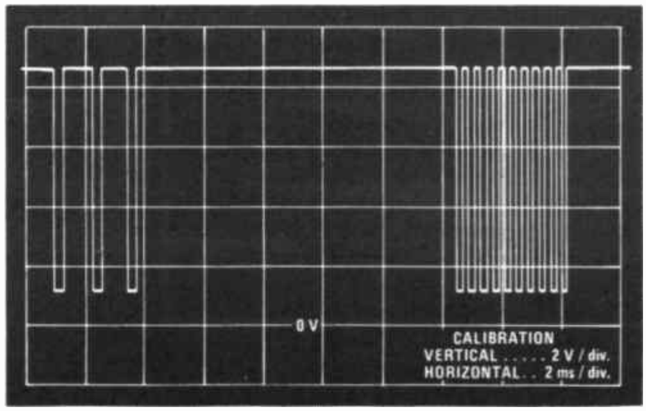


Fig. 2b. Waveform on pin 3 of IC3.

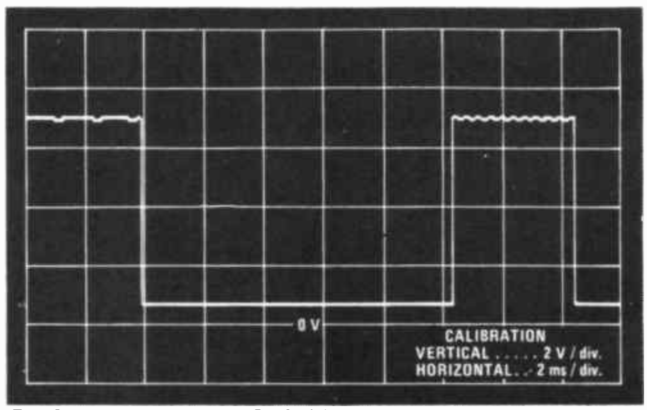


Fig. 2c. Waveform on pin 3 of IC1.
On these waveform diagrams the beat rate has been increased to show the two different outputs available.

PARTS LIST – ETI 604

Resistor	**all ½ W, 5 %**	**Semiconductors**	
R1	2k2	IC1	NE555 timer
R2	47k	IC2	4017 decade counter
R3	15k	IC3	NE555 timer
R4	1k	Q1	BD140 transistor
R5	15k		
R6	4k7	D1, 2	1N4004 diode
Potentiometers		**Miscellaneous**	
RV1	1M lin rotary	PC board ETI 604	
RV2	500 ohm lin rotary	Speaker	
		Plastic box	
Capacitors		6 way AA size battery holder	
C1	1µ0 16V	6 AA size batteries	
C2	22n polyester	3 knobs	
C3	100µ electro	SW1 single pole 11 position switch	
		SW2 single pole toggle switch	

Design Features

The metronome designs published so far simply use a dc pulse to drive the loudspeaker. The only way to change the sound of this type of output to give the accentuation required and to maintain an even beat is to change the amplitude. As this is not very satisfactory we decided to use a tone burst method instead.

Initially we tried a pulsed LC network which produced a very good sound but was a little complex and expensive so we finally decided on a pair of 555 timers. With this system we alter the tone frequency simply by

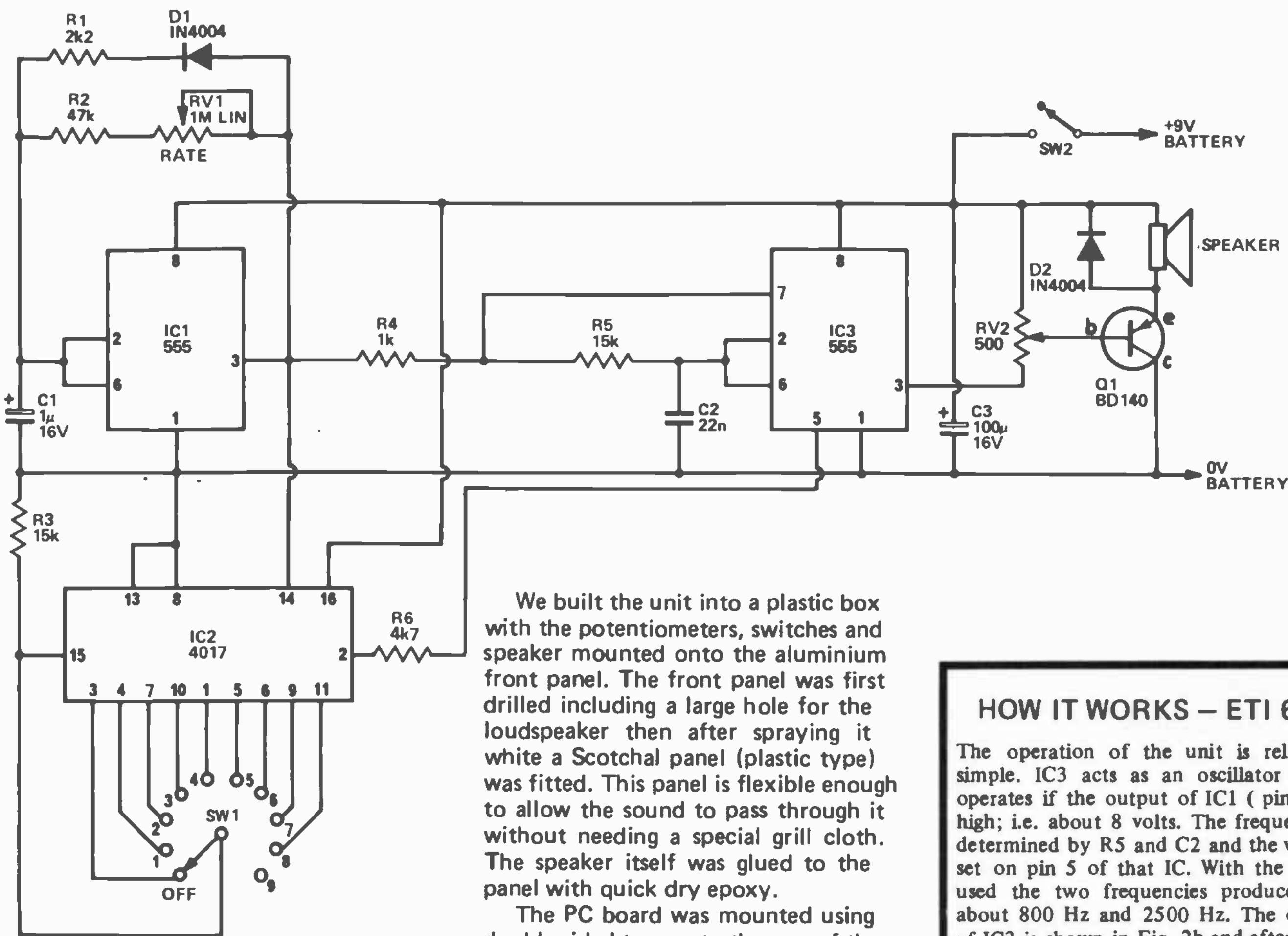


Fig. 3. Circuit diagram of the metronome.

varing the control voltage on the 555 driving the speaker. The other 555 timer is used to give the time between beats and the duration of the burst. A 4017 is used to count the beats and at the required time changes the control voltage of IC3.

When designing the PC board we considered mounting it on the rear of the wafer switch. However due to the number of different switches available we used wires to interconnect the switch to the PC board. The switch we used in the prototype was the OAK type as it was more readily available and also Australian made.

Construction

The unit is simple to build if the PC board is used. Assemble the board with the aid of the overlay diagram taking care to insert the transistor, ICs, diodes and the capacitors the correct way round. Some care should be taken in handling the 4017 IC; the pins should not be touched more than necessary and as well as it being the last component installed, pins 8 and 16 should be soldered first.

We built the unit into a plastic box with the potentiometers, switches and speaker mounted onto the aluminium front panel. The front panel was first drilled including a large hole for the loudspeaker then after spraying it white a Scotchal panel (plastic type) was fitted. This panel is flexible enough to allow the sound to pass through it without needing a special grill cloth. The speaker itself was glued to the panel with quick dry epoxy.

The PC board was mounted using double sided tape onto the rear of the speaker although it can be mounted in the rear of the box. The potentiometers, switches and speaker can be connected with hookup wire as shown in the overlay-wiring diagram. When connecting the battery ensure the polarity is correct as the unit will be damaged if it is reversed.

Late News

In our prototype we used nicad batteries which have a low internal resistance. Later we discovered when using standard dry cells that a slight irregularity occurred on the accentuated beat due to battery voltage fluctuations. If this is a problem with your unit it can be cured as follows:

1. Cut the PC board track between pin 8 of IC 1 and the point where the wire from SW 2 is joined and fit a diode (1N914 etc.), cathode to IC8, across the break.
2. Add a 100 µF 16 V capacitor across pins 1 and 8 of IC 1 (+ve to pin 8).
3. Add a 10 µF 16 V capacitor across pins 1 and 5 of IC 1 (+ve to pin 5).

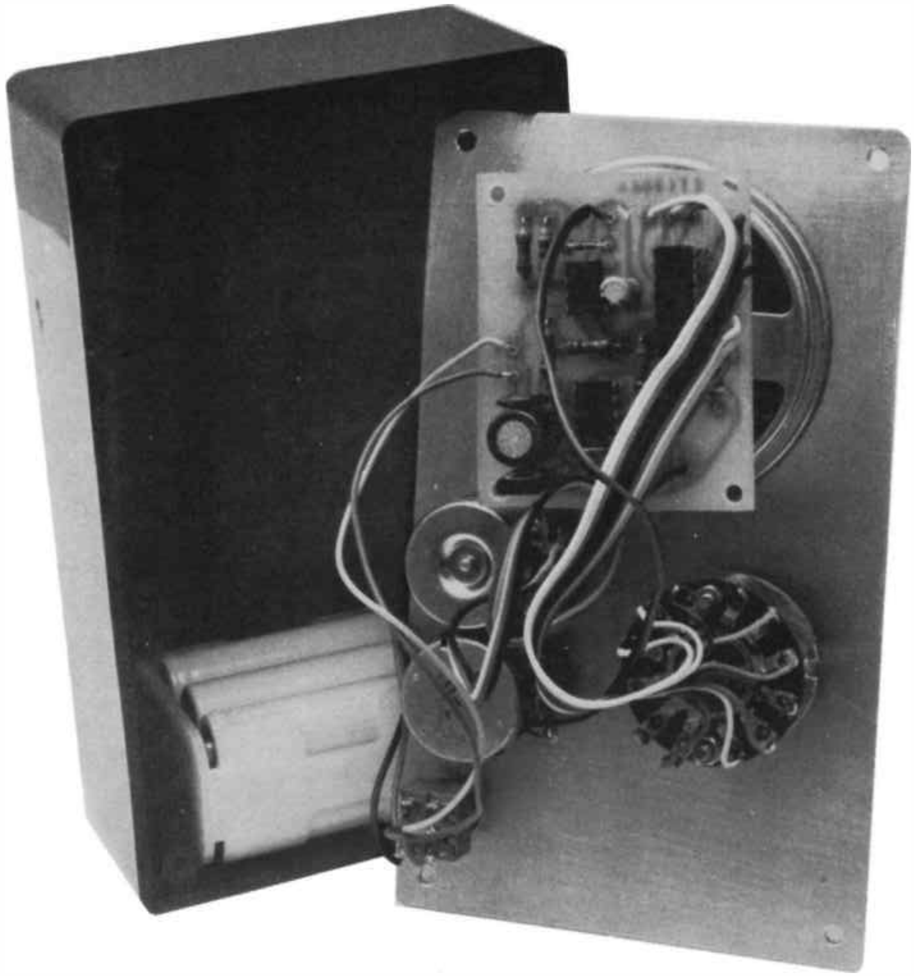
Alternatively, buy some nicads!

HOW IT WORKS – ETI 604

The operation of the unit is relatively simple. IC3 acts as an oscillator which operates if the output of IC1 (pin 3) is high; i.e. about 8 volts. The frequency is determined by R5 and C2 and the voltage set on pin 5 of that IC. With the values used the two frequencies produced are about 800 Hz and 2500 Hz. The output of IC3 is shown in Fig. 2b and after being attenuated (if required) by RV2, is buffered by Q1 which drives the speaker. The diode D2 is used to prevent reverse voltage from the speaker damaging Q1.

The first IC is used to generate the tone duration (about 4 ms.) and the time interval between beats. The interval is adjustable by RV1 while the tone duration is set by R1. Diode D1 isolates R1 in the interval period. The output of IC1 is shown in Fig. 2c.

The output of IC1 also clocks IC2 which is a decade counter with ten decoded outputs. Each of these outputs go high in sequence on each clock pulse. The second output of IC2 is connected to the control input of IC3 and is used to change the frequency. Therefore the first tone will be high frequency, the second low and the third to tenth will be high again. This gives the 9–1 beat. If the reset input is taken high the counter reverts back to the first state. We use this to limit the sequence length to less than ten by taking the appropriate output back to the reset input. If for example the 5th output is connected to the reset, the first tone will be high, the second low, the third and fourth high, then when the 5th output goes to a '1' it resets it back to the first which is a high tone. We then have 3 high and one low tone or a 3–1 beat. Actually the 5th output goes high only for about 100 ns. while the counter resets.



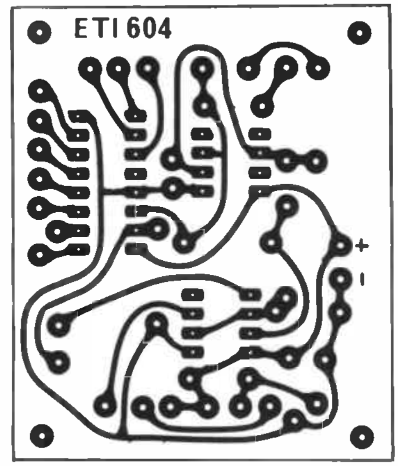


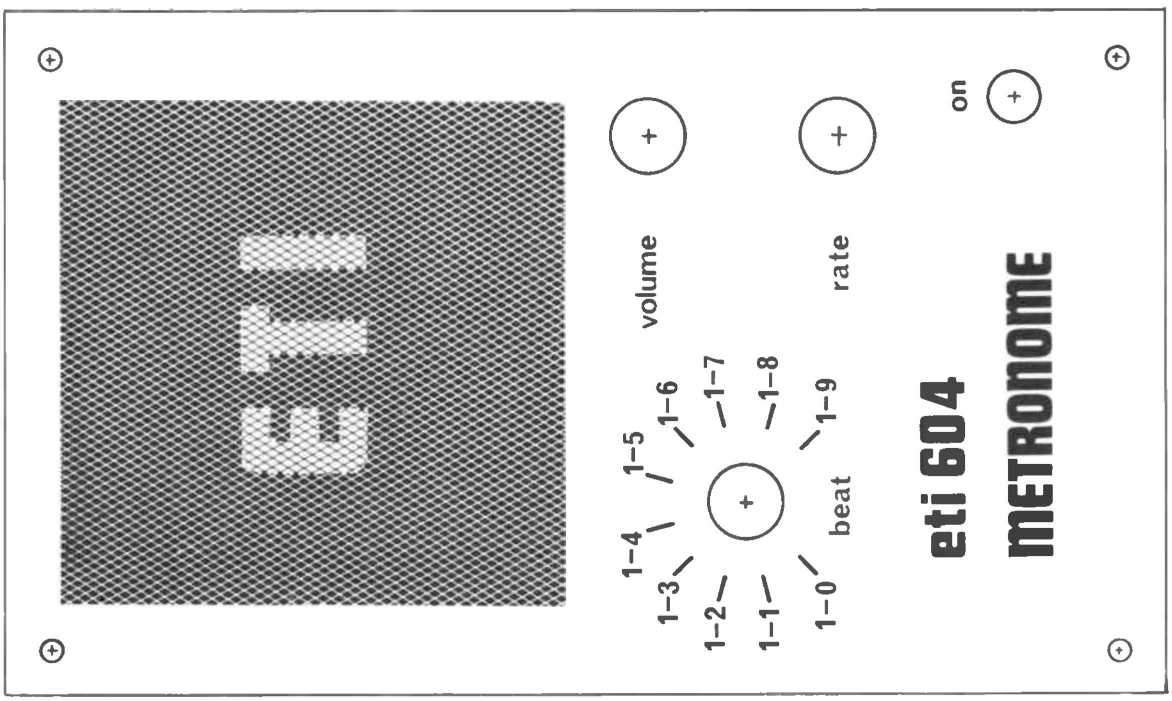
Fig. 4. Printed circuit layout. Full size 60 x 50 mm.

SCOTCHCAL OFFER

Scotchcal panels ready to stick on are available from Electronics Today at $3.00 each. Send order together with a stamped addressed envelope-size at least 160 x 100 mm.

Address to Scotchcal Offer 604,
Electronics Today,
15 Boundary Street,
Rushcutters Bay. 2011

Fig. 5. Artwork for the front panel shown full size.



ACTIVE ANTENNA

Simple broadband antenna covers 0.5 to 30 MHz — or can be used to boost single stations in the broadcast band.

eti PROJECT 708

SHORT wave listeners often have difficulty in installing a suitably adequate antenna — especially if living in a flat or home unit. Parents and neighbours may quite justifiably complain about large and unsightly structures. In addition there are difficulties in building an antenna which adequately covers the whole range of 0.5 to 30 MHz and there is also the problem of antenna portability if required.

DESIGN FEATURES

An efficient system consists of the antenna itself together with a transmission line to carry the signal to the receiver. The antenna and transmission line must be matched to each other if the maximum amount of signal incident on the antenna is to be transmitted to the receiver. However since the size of an antenna is related to frequency, one particular sized antenna will only be suitable for a limited bandwidth. Fortunately very efficient antennas are not always needed on the HF band due to the excellent sensitivity of modern day receivers.

A rod antenna has an impedance of less than 50 ohms at its tuned frequency and can therefore easily be matched into a 75 ohm coaxial cable. However if a quarter-wave rod antenna is used at frequencies lower than its natural resonance its impedance increases so that it cannot easily be directly matched into a 75 ohm cable.

Our solution to the problem of obtaining wide band operation with a simple rod antenna is to feed it into an active impedance converter before the transmission line.

An active impedance converter must have a very high input impedance and low input capacitance. At low frequencies the effective input impedance is the value of the biasing resistor, whilst at high frequencies (above 1 MHz) the effective impedance is that of the input capacitance. The converter must have high linearity but no voltage gain. If voltage gain were incorporated the converter would have to provide a high power output to avoid the possibility of inter-modulation occurring.

The number of transistors used have been kept to an absolute minimum as each transistor adds its own noise contribution to the signal coming from the antenna. Two transistors are used and these are both low-noise RF types.

One particular application for the antenna was to boost the level of the Sydney station 2JJ which is very low in level and cannot be received by an average car radio when driving around the city. When using the converter in a straight broad-band mode the reception from 2JJ was greatly improved but other strong stations overloaded the receiver producing some rather unpleasant distortion. For this reason the alternative circuit was developed to allow one particular station to be handled at maximum efficiency whilst with other stations away from resonance the converter impedance is lowered, thus reducing the output from stronger stations.

It must be remembered that if the signal level from a station is below the ambient-noise level it is impossible to improve the signal-to-noise ratio with any type of active antenna. For the short wave listener an occasional burst of noise is not so objectionable and the active antenna will give good results over the entire 0.5 to 30 MHz band. It must be remembered that when operating in a car the signal level from shortwave signals will be improved but the apparent noise level may also increase if it is raised above the masking of the ambient noise level in the car.

CONSTRUCTION

The use of a printed-circuit will greatly simplify construction and the pattern provided will suit the car or broad-band version by simply adding some components or deleting others as required for the particular version.

Broad-band SWL version

After the printed-circuit board is assembled in accordance with the respective overlay it is fitted into a small metal box (a diecast box is best as it may be more easily sealed against moisture) upon which a commercial car whip antenna is mounted as shown in the photo. Lead was placed in the bottom of the box so that the unit will not tip over easily and rubber feet were fitted to raise it above surface water when used outside. The coax is fed in through a hole in the bottom of one side and a water seal is maintained by fitting the cable through a rubber grommet. Once the unit is checked out it is a good idea to spray the inside of the unit with clear lacquer to seal against moisture.

For those who do not wish to purchase a commercial antenna a length of ordinary hook-up wire taped to a light wooden support or even taped to the wall is adequate. Make sure however that the wall is non-metallic and that the antenna is not close to any electrical wiring or other metallic structures.

Car or broadcast version

From Table 1 determine the number

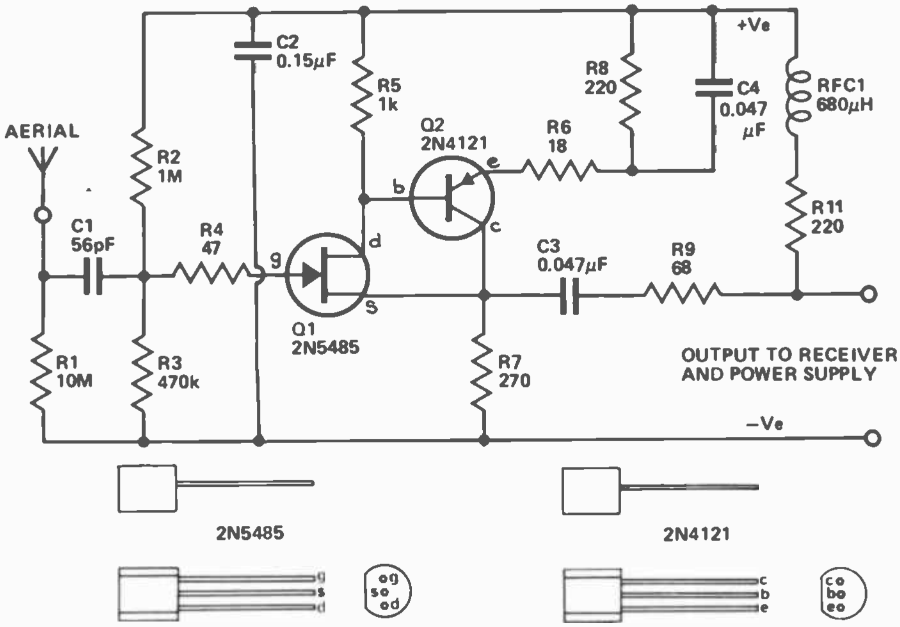


Fig. 1. Circuit diagram of the SWL version (0.5 to 30 MHz).

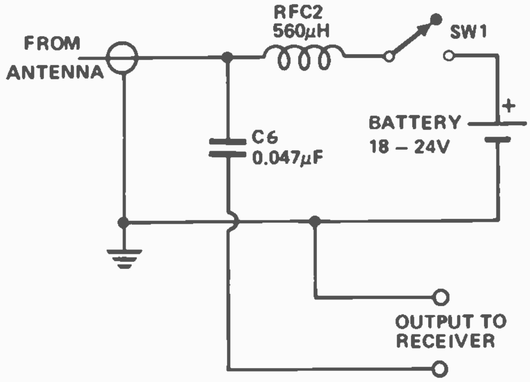


Fig. 2. Circuit for combining supply volts and antenna signal onto the coaxial feeder cable. Used with SWL version where long feeder cable is required.

PARTS LIST — ETI 708

R6	Resistor	18 Ω	¼ W	5%
R4	"	47 Ω	"	"
R9	"	58 Ω	"	"
R8,11	"	220 Ω	"	"
R7	"	270 Ω	"	"
R5	"	1 k	"	"
R3	"	470 k	"	"
R2	"	1 M	"	"
R1	"	10 M	"	"
R10	"	See text		
C1	Capacitor	56 pF	Ceramic	
C5	"	5-70 pF	Philips 2222 808 01001	
C3,4,6	"	0.047 μF	Ceramic	
C2	"	0.15 μF	"	
Q1	Transistor	2N5485 (FET) or similar		
Q2	"	2N4121 or similar		
RFC1	Radio frequency choke	680 μH		
RFC2	" " "	560 μH		
L1	See table 1			
SW1	Single pole single throw toggle switch.			
PC Board ETI 708				
coax cable				

HOW IT WORKS – ETI 708

In effect the active antenna consists of a rod antenna followed by a buffer amplifier which has a very high input impedance (to match the antenna) and an output impedance of 75 ohms to match the lead-in cable.

Signals picked up by the antenna are coupled to the amplifier via C1 the value of which has been kept small to attenuate any 50 Hz pickup on the antenna. Resistors R2 and R3 set the bias point for Q1 such that a four-volt drop is obtained across R7. The voltage gain is maintained at unity and the linearity improved by applying feedback from the collector of Q2 to the source of Q1. The function of Q2 is to provide a very low output impedance. Resistor R4 is used to suppress any parasitic oscillation which may occur to the high gain which both Q1 and Q2 have up to UHF frequencies. Resistor R9 increases the output impedance of the amplifier to match the 75 ohms of the coaxial cable.

In the broad-band version the supply current is fed to the unit via the coaxial cable – the shield being at earth. RFC1 and R11 appear as a very high impedance to the RF but as a low impedance of 250 ohm, to the dc. In effect it forms a low-pass filter in conjunction with C2. Capacitor C3 prevents the supply voltage from upsetting the bias conditions of the transistors. The signal is passed down the coax to the antenna circuit where C6 couples the signal to the receiver whilst blocking the dc, and RFC2 connects the dc supply to the coax whilst preventing the RF signals from entering the power supply.

In the broadcast version L1 and C5 form a parallel-resonant circuit that appears to one particular station in the broadcast band as a high impedance, and to the other stations as a much lower impedance. Thus the voltage developed at the input of the amplifier is a maximum at the frequency to which L1 and C5 are tuned, whilst the other stations are attenuated. Resistor R10, in series with the tuned circuit, sets a minimum value into which the short antenna works and so assures some response to the stations other than that tuned by L1 and C5. The value of R10 is best found by experiment as detailed in the text.

of turns necessary for L1 and wind it as detailed in Table 1. The coil L1 must be mounted close to the base of the antenna so that it can be connected to the antenna by no more than 75 mm of wire. The earth connection to the chassis must also be kept short and C5 should be mounted so that it is accessible for tuning.

A good place to mount the antenna is on the rear mudguard with the base protruding into the boot. The converter may then be mounted to an aluminium bracket which is secured to the car with the antenna base retaining bolt.

The converter should be fed with a 12 volts supply obtained from the accessory fuse in the fuse box.

On cars with generators that produce hash (interference) on the 12 volt supply an 820 microhenry choke, in series with the supply lead, and an 0.15 microfarad ceramic capacitor to ground (from where the two RFC chokes meet) should help.

SETTING UP

The transistor Q1 has quite a spread in parameters from one device to another and some circuit adjustment may be required for optimum performance. The voltage drop across R7 should be approximately one third of the supply voltage to the converter. That is, four volts for a supply of 12 volts. If necessary adjust this voltage by adjusting the value of R3. No other setting up is required on the SWL version.

In the car version temporarily place a link across R10, tune the receiver to the station which needs to be boosted and adjust C5 for maximum volume. This is best done when the car is parked in an area where poor reception is encountered. Resistor R10 is best selected by experimentation. A good starting value is 1000 ohms. Adjust R10 so that the stations to which L1 and C5 are *not* tuned are received free of noise. Too large a value of R10 will reduce the effectiveness of the tuned circuit. (see How it Works).

We found that an antenna length of two metres was suitable for the HF version and a one metre length was suitable for the broadcast band version.

TABLE 1

L1	Frequency	No of turns
	below 700 kHz	45
	700 to 950 kHz	34
	950 to 1200 kHz	26
	above 1200	20

CORE Philips potcore P18 series material 3B7 or 3H1, μe = 220 Part No 4322—022—24280 or 4322—022—24080
FORMER 4322—021—30270
CLIP 4307—021—20000
one each of core, former and clip required to assemble one complete coil

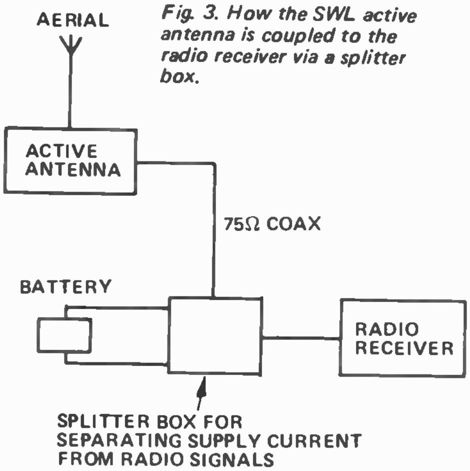


Fig. 3. How the SWL active antenna is coupled to the radio receiver via a splitter box.

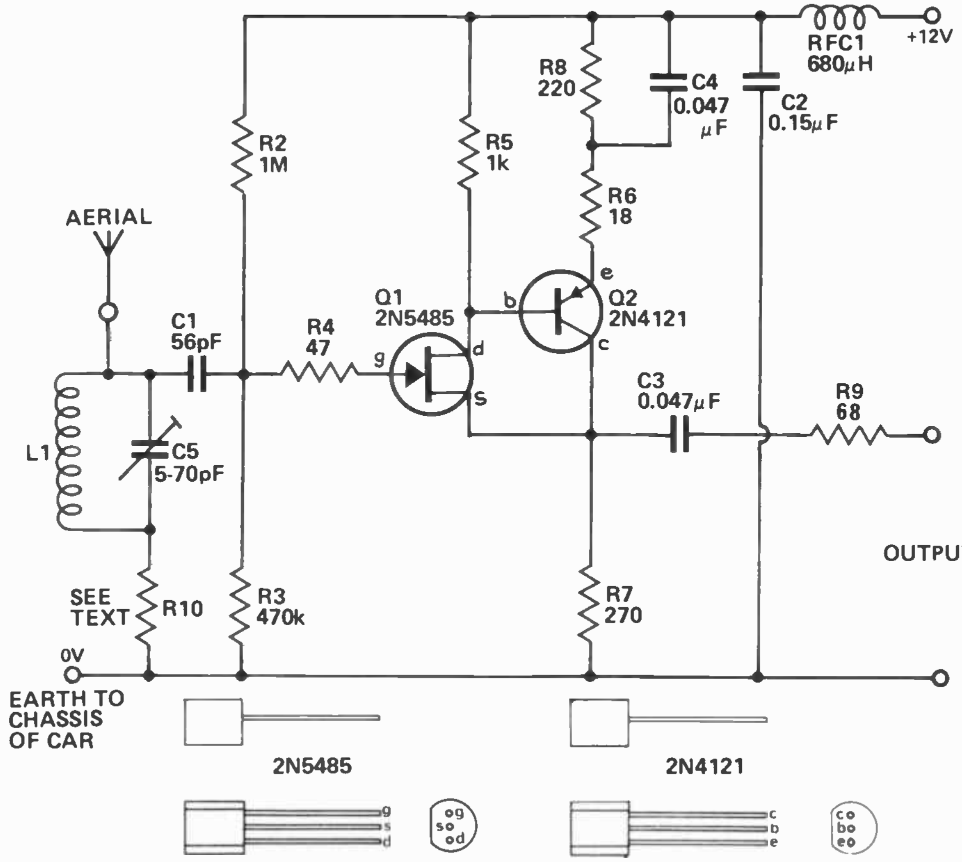


Fig. 4. Broadcast version has a tuned circuit, L1, C5 to attenuate stations other than the one tuned.

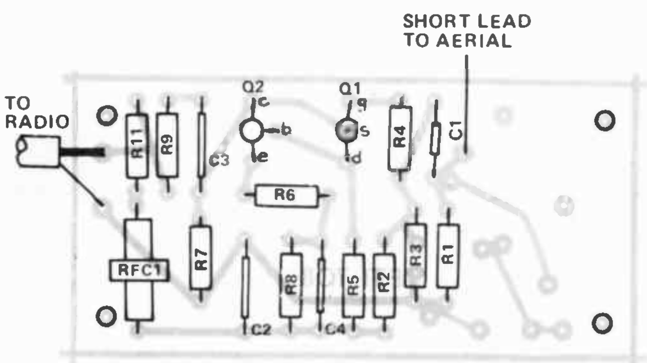


Fig. 5. Component overlay for the SWL version.

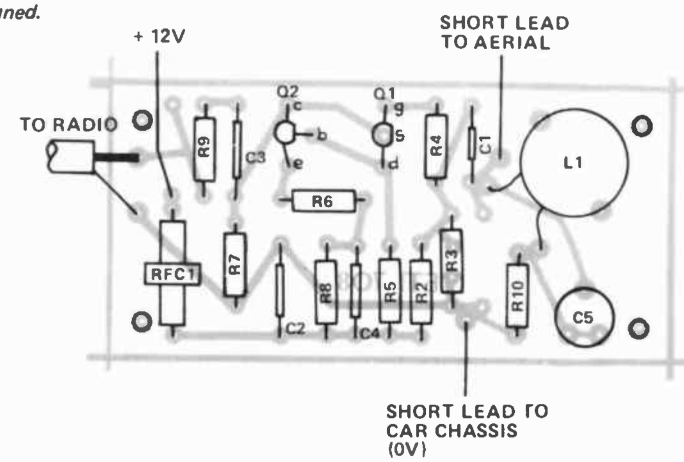
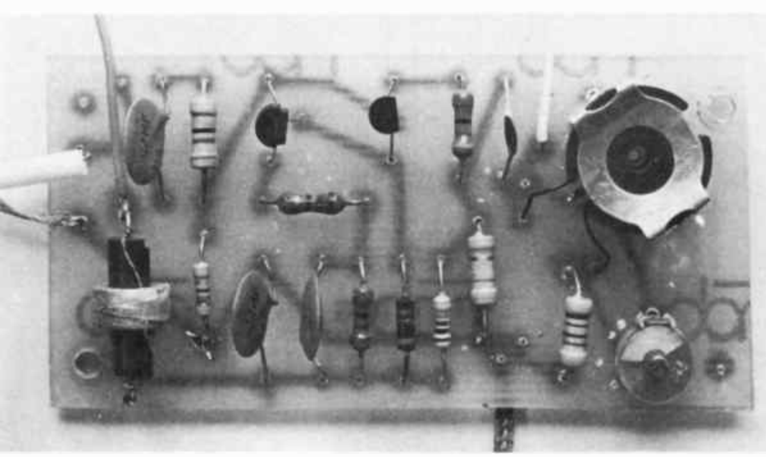


Fig. 6. The component overlay for the broadcast or car version. Note that the same printed-circuit board is used for both versions.



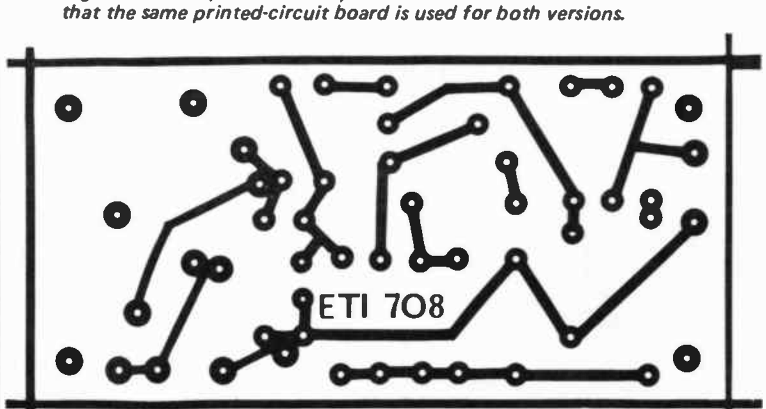
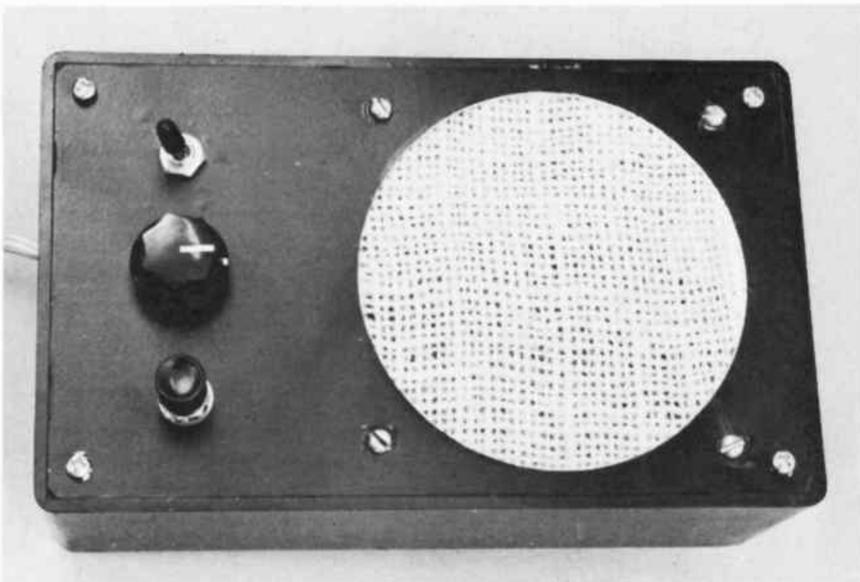


Fig. 7. Printed-circuit layout for both versions. Full size 92 x 46 mm.

◀ *How the finished board for the broadcast version appears.*

SIMPLE INTERCOMS



Three intercom systems using the LM380 audio IC.

AN INTERCOM SYSTEM is not only one of the most useful projects that one can build, it is also one of the easiest.

Commercial intercoms are of course readily available – often at prices even lower than one could build the units for oneself. Nevertheless a project of this nature is still more than justifiable for not only does it provide valuable experience but the system can also be built to suit one's exact needs.

In the ETI unit, as with most simple intercoms, a speaker doubles as both microphone and loudspeaker, its role being changed from one to the other by a pushbutton 'talk/listen' switch.

As a loudspeaker is not particularly efficient when used as a microphone, we have used a step-up transformer and LM 380 integrated circuit amplifier.

The transformer chosen is a 240 V/12.6 V centre-tapped device (of which only one half of the primary winding is used). The specification of this transformer is not at all critical and virtually any device having roughly the specified characteristics will do.

Whilst the circuit of a suitable power supply is shown (Fig. 4) current drain is low and battery operation may be used if the unit is not used very much.

CONSTRUCTION

Construction is very simple indeed and, as there are very few components, we suggest that the amplifier be built onto matrix board or similar. A heatsink is not required for the LM380, when working into a 15 ohm, be sure to obtain speakers having this impedance. Higher impedances will result in much lower power output, and lower impedance speakers (eg 8 ohms) will require the use of a heatsink.

The internal layout of the prototype unit is shown in Fig. 5. Note that we used the system connections shown in Fig. 2. This system requires (easily obtainable) single-pole push buttons but requires three interconnecting wires between station 1 and station 2. It also has the advantage that an

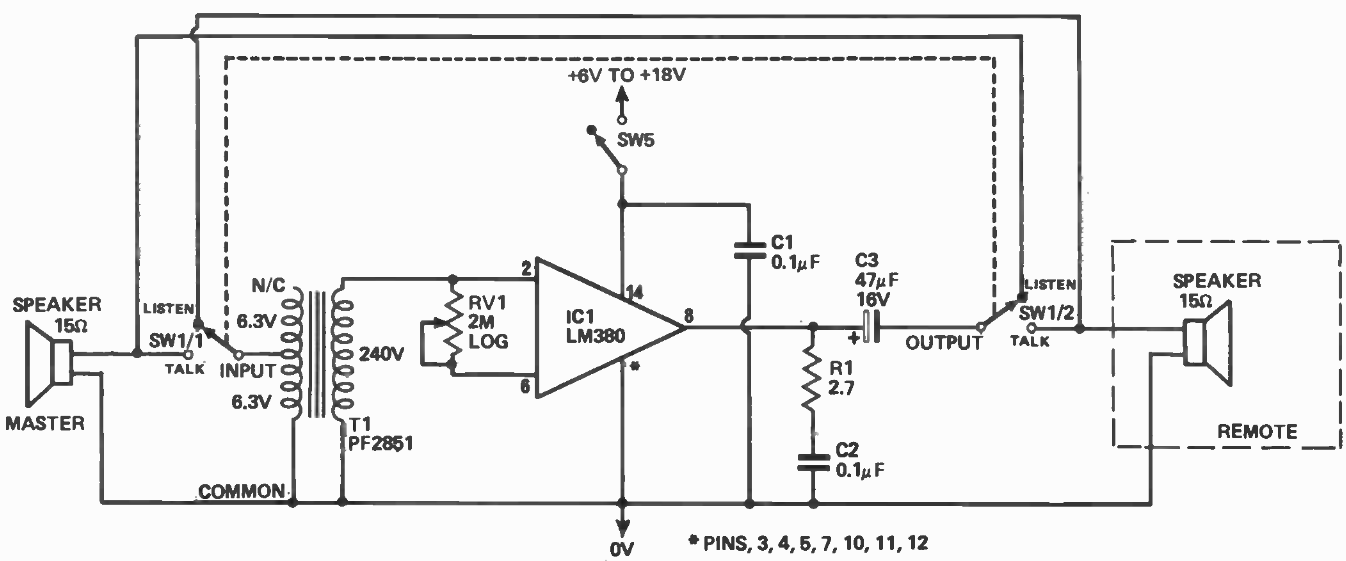


Fig. 1. About the simplest possible intercom, in this arrangement the master station listens to remote station at all times until TALK button is pressed.

output is heard only when the TALK button at either station is pressed.

The system shown in Fig. 1 only requires two wires to the remote station but has the disadvantage that station 1 is always listening to station 2 except when the talk button is pressed.

If two remote stations are required the system illustrated in Fig. 3 should be used. Again this requires three wires to each of the remote stations. Switch SW1 is the push-to-talk button and SW2 selects the required remote station.

We used a small 9 volt battery to power our unit but, if continuous use is expected, it would be wiser to use a larger battery. For example, the standby current is about 3 mA which would result in only about 150 hours operation from a small battery. The best battery system would probably be two 6 volt lantern batteries connected in series. Alternatively a simple power supply such as shown in Fig. 4 could be used. ▶

HOW IT WORKS ETI 234

The (approximately) 1 millivolt output from the speaker is stepped up by transformer T1. The transformer is a standard 240/12.6 CT type used in reverse, only half of the 12.6 volt winding is used. Alternatively either of the A&R audio transformers, as specified in the parts list could be used.

The output of T1 is connected directly to the non-inverting (+) input of the LM380 (pin 2) and also, via potentiometer RV1, to the (–) input. Since the input resistance of the IC is about 150 k, the signal level at the negative input is dependant upon the setting of RV1.

The IC, as with all differential amplifiers, amplifies the *difference* in signal level between its two inputs, pins 2 and 6. Thus RV1 effectively acts as a volume control.

With the connections shown on Fig. 1, the remote station speaker acts as a microphone, applying its output to T1. The output of T1 is amplified by the IC and applied to the MASTER speaker. Thus the master station is listening to the remote station at all times other than when SW1 is pressed.

When SW1 is pressed the master speaker becomes the microphone and the remote speaker receives the amplified signal from the IC.

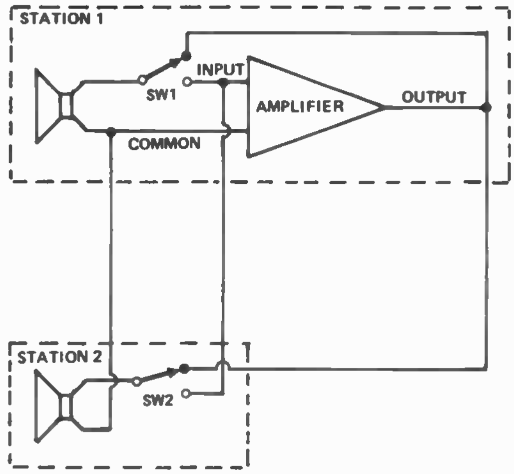


Fig. 2. This system gives privacy to station 2 but requires three wires between stations. The amplifier circuit is identical to that in Fig.1.

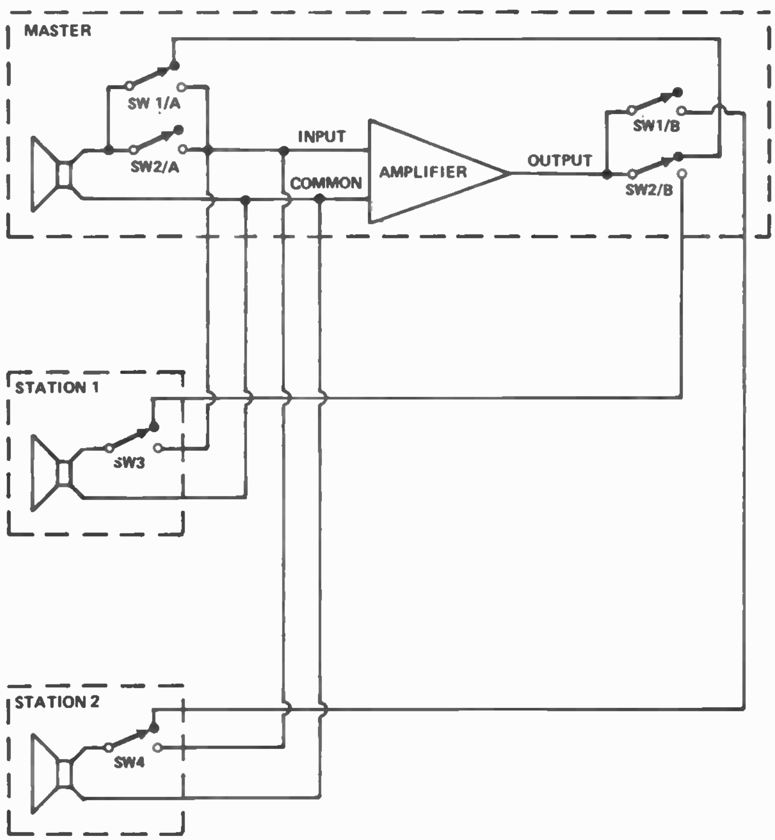


Fig.3. An extension of the previous system to a master and two slaves requires three wires from the master to each slave, and a more complex switching arrangement.

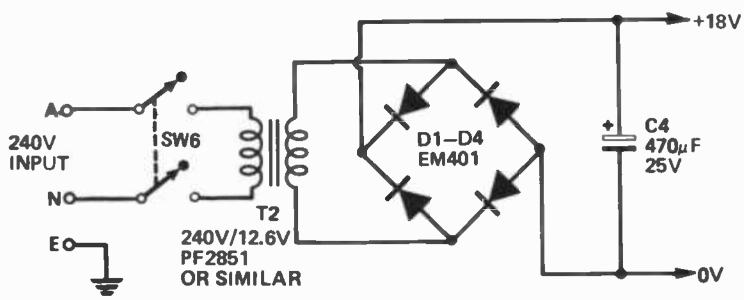


Fig. 4. A simple power supply for use with the intercom.

SIMPLE INTERCOMS

Fig. 5. The method of assembly may readily be seen from this internal view.

Parts List

R1	Resistor	2.7 ohm ½ watt 5%
C1, C2,	Capacitor	0.1µF polyester
C3		47µF 16 volt-electrolytic
IC1	Integrated circuit	LM380
T1	Transformer	240/12.6 volt centre tapped Ferguson type 2851 A & R type 6474 A & R E7/3.5 or E5/3.5 (or any 240/6.3 volt transformer you may have)
RV1	Potentiometer	2M log rotary

	System 1	System 2	System 3
SW1	DPDT pushbutton	SPDT pushbutton	DPDT pushbutton
SW2	—	SPDT pushbutton	DPDT pushbutton
SW3	—	—	SPDT pushbutton
SW4	—	—	SPDT pushbutton
SW5*	SPDT toggle	SPST toggle	SPST toggle

Loudspeakers 15 ohm 3" diameter Magnavox 3T or similar.
Six to 12 volt battery. *
Plastic or metal box, piece of matrix board, bolts and nuts etc.
* required for battery versions only.

Power Supply

D1-D4	Diode	EM401 or similar
C4	Capacitor	470µF 25 volt electrolytic
C5	Capacitor	25µF 25 volt electrolytic
T2	Transformer	240/12.6 volt CT Ferguson PF 2851, A & R 6474 or similar
SW6	Switch	DPST toggle 240 volt ac 1 amp.

CONSTRUCTIONAL METHODS

Veroboard, matrix board, printed circuits — or tag strips.

ELECTRONIC PROJECTS may be constructed in several different ways. The simplest by far is by using a printed circuit board. Boards, etched and drilled for specific projects are readily available from most of the kitset and component suppliers who advertise in this magazine. Alternatively, pc boards (as they are usually called) can be made at home.

Other methods of construction include matrix board, Veroboard and tag strips. The pros and cons of each method are described in this article.

VEROBOARD

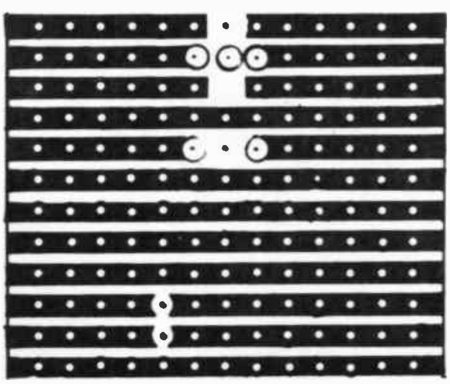
Veroboard is a commercial product specifically made for rapidly assembling prototype equipment, or for building one-off projects etc.

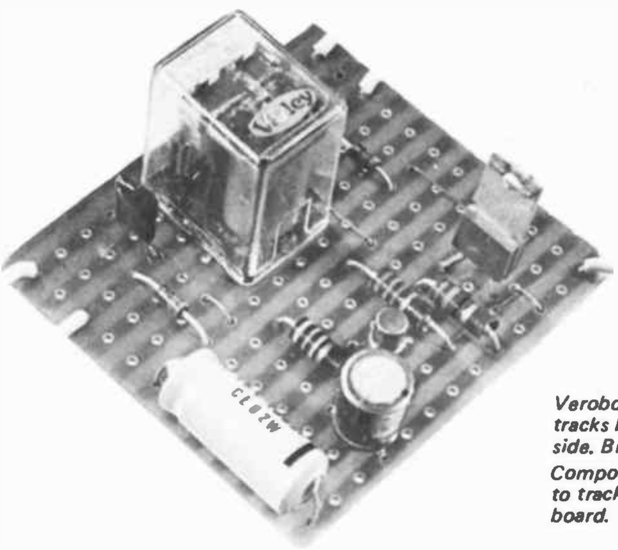
It consists of a high-grade laminated circuit board upon which parallel copper strips are bonded. The board is pierced by a matrix of holes, for inserting component. These holes may be at 0.1, 0.15 or 0.2 inch spacing. For miniature electronic work, incorporating integrated circuits, the 0.1 inch pitch is most commonly used, whilst for general electronics, the 0.15 inch pitch is very popular.

USING THE BOARD

To assemble a circuit using Veroboard, the components are inserted into the board such that they are interconnected by the copper strips in the desired pattern. Where a break in the copper strip is required a sharp drill (as shown in the illustration) or a 'spot face cutter', specifically made for this purpose, is used.

The components for a simple circuit may be placed on Veroboard in the same configuration that they have in the circuit diagram. This makes circuit





Veroboard — board has copper tracks bonded to non-component side. Breaks are cut where necessary

Component leads are soldered to tracks on copper side of board.

checking much easier and any faults are subsequently easier to find.

Most connections may be made directly to the copper strip but, where strong connections are required, or where many wires are to be terminated at the one point, Veroboard pins may be inserted to make secure terminals.

MATRIX BOARD

Whilst Veroboard is very suitable for one-off equipment that is to be used permanently, it's rather difficult to strip and use again.

Matrix board, is more suitable for re-use in mocking up first prototypes but may also be used for equipment of a more permanent nature.

Matrix board is perforated with holes, in the same way as Veroboard, but does not have the copper strips. To use it one inserts the components through an appropriate set of holes and makes connections by routing the component leads at the rear of the board or, by using tinned copper wire to link the components. This sounds pretty messy, but it is surprising how quickly circuits can be built up and – how neatly they can be made.

Where component leads or the tinned hook-up wire cross they should be insulated by a small piece of insulating 'spaghetti'. This does not need to be done as often as one would think and quite complex circuits may be assembled neatly, compactly and speedily.

Matrix board is available in 0.25 inch or 0.1 inch spacings. The latter is preferable for miniature electronic work. Turret pins and eyelets are also available at low cost if required. Thus the matrix board system is ideal for assembling experiments as well as of one-off special equipment.

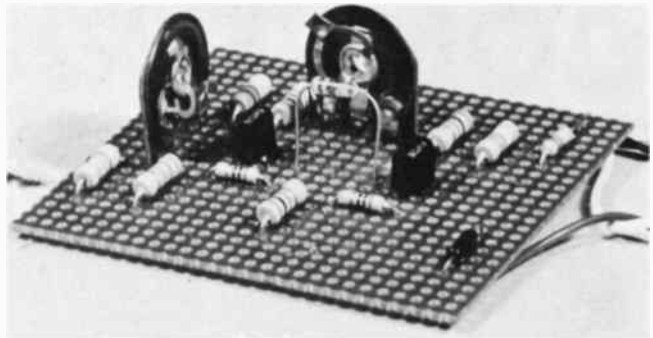
PRINTED CIRCUITS

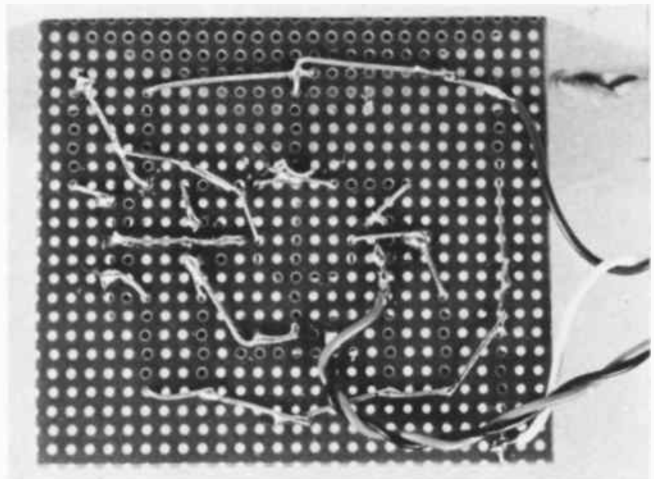
Printed circuit boards simplify electronic circuit building enormously – to the extent that some enthusiasts feel that it is degrading the hobby to that of 'painting by numbers' – but of course you can always make your own circuits, as explained here.

The boards are made of a phenolic resin or glass fibre laminated with a thin copper sheet bonded (generally) to one side.

Intercomponent wiring is formed by etching away the unwanted copper – so that only the required tracks remain. Holes are then drilled for the components which are mounted on the non-component side and their leads soldered directly to the copper tracks.

Most component and kit set suppliers stock printed circuit boards already drilled and etched for most popular projects. They also stock printed circuit board material for those who like to make their own boards.





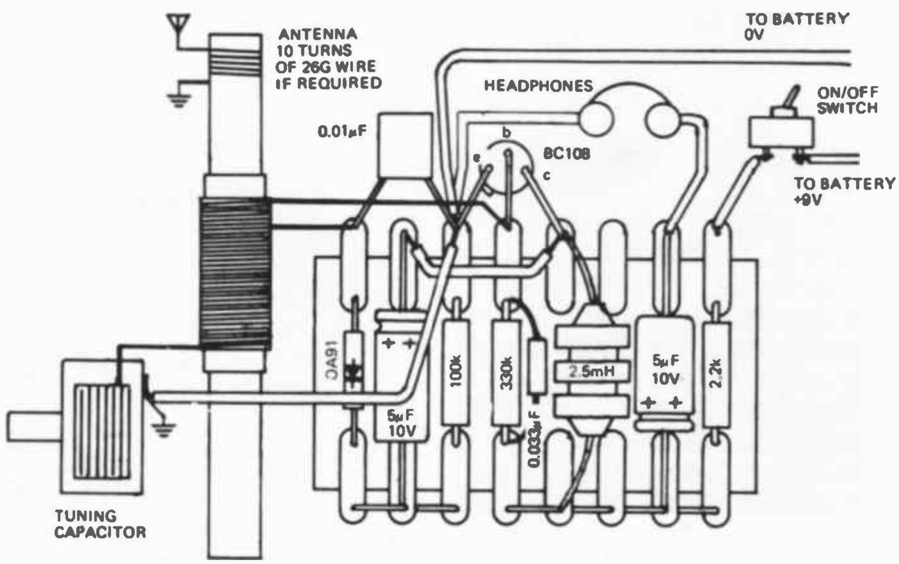
MATRIX BOARD – Components are inserted through holes and leads soldered on non-component side. Novices find matrix board easy to use as components and wiring can be positioned exactly as on the circuit diagram.

There are very many different ways of etching printed circuit boards. The method described here is virtually identical to that used by our own projects laboratory at ETI. We use this method as in our experience it is the simplest, least messy way of making professional looking boards.

Although printed-circuit boards can be prepared for etching by painting the design on the board with bituminous or other etch-resistant paint or ink, one of the so called photo-resist methods is preferable by far.

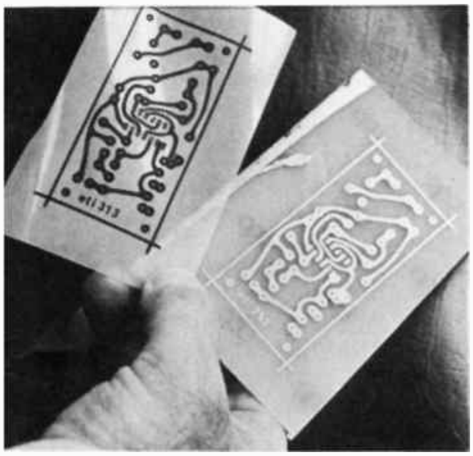
Two methods are used – **negative resist and positive resist.**

The negative resist method is very effective, it is commonly used commercially but requires a photographic negative of the printed-circuit layout, whereas the positive resist process does not. Hence, using positive resist, a step which may



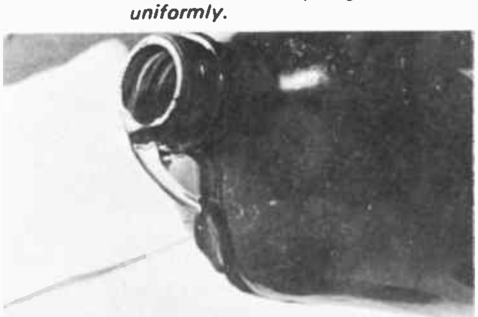
Tag Strips – construction is quick, cheap and simple. However the method is only really suitable for small scale projects as inter-tag wiring will otherwise be extensive and tedious. The method also wastes space. (Circuit shown is of a single transistor reflex receiver first published in our December 1971 issue).

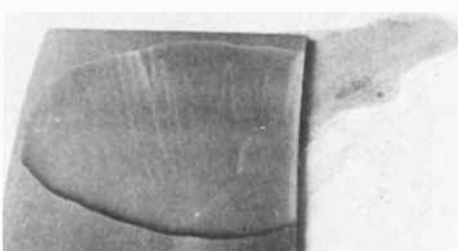
CONSTRUCTIONAL METHODS



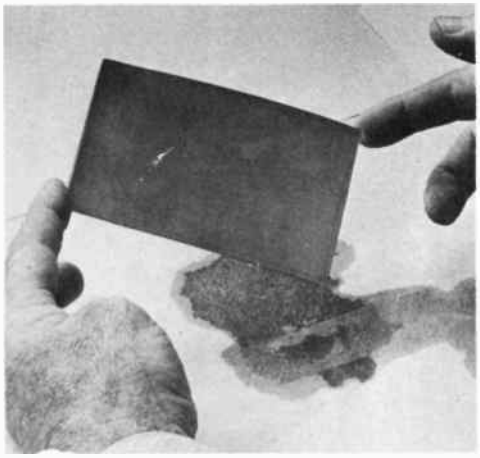
The artwork is prepared (full size) on a piece of transparent film using opaque PC board tape and pads. An original master is shown here together with an etched but untrimmed or drilled board.

The laminate should be thoroughly cleaned with paper towel and abrasive cleanser powder until the surface is uniformly bright, and wets uniformly.

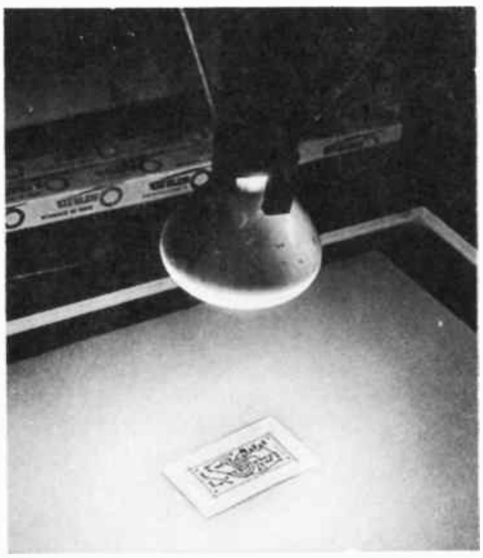




The prepared laminate is coated with a thin film of 'resist' and allowed to dry.



Excess resist should be drained off and the board dried in a dark and dust free place.



The artwork is placed on top of the copper side of the board and sandwiched between a piece of foam and a sheet of glass. The board should then be exposed to light with a high ultra violet content for a time as detailed in the text.

After exposure the resist is developed (see text) the board allowed to dry and then etched in ammonium persulphate or ferric chloride solution. The board here is seen when partly etched.

be difficult for some experimenters is eliminated.

The process described here is based on the CCPR12 positive resist and associated developer available in NSW from Circuit Components or from suppliers of printed-circuit board materials in other States.

HOW IT WORKS

The copper surface of the board is coated with resist and then exposed to light through a piece of translucent film upon which the desired circuit pattern has been layed out with opaque artwork tape and/or ink. When subsequently developed the resist that has been exposed washes away leaving an etch-resistant pattern of the required circuit. The exposed copper may be etched away with ferric chloride or ammonium persulphate.

THE ARTWORK

Materials are available from suppliers for making the so-called 'artwork'. This is the required pattern laid-out full size with opaque tape onto Mylar film. Tapes of various widths are available, together with stick-on transistor and IC pads. Such materials, although relatively expensive, greatly facilitate making artwork.

1. LAMINATE PREPARATION

(a) Allow an 8 mm border beyond the finished board perimeter to simplify handling.

(b) Scrub laminate thoroughly with a powdered abrasive cleaner using a new Scotchbrite pad or clean paper towelling and water. (Do not use sponge type kitchen pads or steel wool, due to their susceptibility to grease retention).

(c) Hold scrubbed laminate under running water and check that the copper surface 'wets' evenly all over. If a break appears, rescrub and retest.

(d) Dry with a clean piece of paper towelling, being particularly careful not to touch the prepared surface of the laminate with the fingers. (Skin oils will contaminate the surface and nullify the preparation). Then brush the surface with a 'soft', clean brush to remove lint, dust etc.

2. COATING THE LAMINATE

(a) Pour a small pool of resist in the centre of the prepared laminate and thinly smooth over the surface with a ½" to 1" paint brush. (Use a new brush and keep for use with CCPR 12 Resist only. Wash brush in methylated spirits, then in soap and water). A "streaky" appearance when wet usually settles evenly during the drying process.

(b) Place coated laminate in a preheated oven at 80 to 90°C (176 to 194°F) for 10 minutes. This will dry the resist sufficiently for exposure.
It is recommended that ovens using exposed or infra red elements not be used as the red light may prevent the photo-sensitivity from functioning. Where these and gas ovens are employed, bring the oven up to temperature and switch off, then place the prepared laminate in the upper section of the oven for 15 to 20 minutes.

EXPOSING

Now place the artwork in intimate contact with the prepared board by sandwiching the board and artwork between a sheet of polythene foam and a piece of thoroughly clean glass.

The sandwich must now be exposed to light. This can be done in several ways — two of which are described below.

(a) Direct sunlight may be used — the exposure time should be four to five minutes.
(b) Using 2 x 20 watt Sylvania type F20T12-BL fluorescent tubes (or Philips Actinic Blue Fluorescent tubes, both makes being 3900 angstroms) mounted on a twin batten unit at a distance of 250 mm. A master made on single matte film typically requires an exposure time of four minutes. The time will vary depending on the film used (clear, single matte or double matte) and the distance between the tubes and the work. Clear film typically halves the exposure.

DEVELOPING

(a) To 1 litre of water add 40 grams of CCPD16 developer crystals. Place the solution in a glass or plastic tray. (Do not use aluminium containers as this solution is alkaline and will be contaminated by the aluminium).
(b) Immerse the exposed laminate in the developer and rock gently, avoiding splash. Another very satisfactory method is to lightly brush over the surface, while fully immersed, with a clean paint brush.
The exposed areas should dissolve completely within two minutes. This developer is not flammable, but should be treated with care. Always wash hands and other exposed skin areas as soon as possible.
(c) Rinse the developed laminate under running water and dry off with a soft cloth, then allow to stand in free air to stabilise for approximately 30 minutes.
(d) Where a very hard finish is needed, post baking at 100°C (212°F) for five to 10 minutes is recommended. Allow laminate to fully cool before etching.

ETCHING

Two suitable etchants are:

(a) **Ferric Chloride:** Yellow lump (hydrated). Mix 1 kilogram with each litre of water. To speed dissolving, heat the water to between 75 and 85°C (167° — 185°F).
Ferric Chloride: Anhydrous. Mix 500 grams with each litre of cold water. Important, add the powder to the water slowly stirring continuously, as this process generates extreme heat.
An ideal etching method for one or two small boards is to use a plastic paint roller tray and plastic handled nylon bristle hand broom. Place the board on the draining board, and the *cold* ferric chloride in the reservoir, then sweep the ferric chloride up and brush over the surface of the resist. This should be done at approximately one stroke per second. This should give an etch time of four minutes with a fresh solution of etchant.
(b) **Ammonium Persulphate:** Dissolve 200 grams in half litre of water. This solution should be heated to 40°C (100°F) but not above 50°C (125°F) for etching. Form a "basket" of plastic tubing and use a continuous "dunking" action until fully etched. Constant agitation is essential and a fresh solution should etch in five to seven minutes. This is a particularly clean etchant, but does not etch as much area as the same volume of ferric chloride. Note that this particular etchant is extremely slow when used cold.

Warning: Avoid spillages. If spilt or splashed, wash from affected areas immediately otherwise damage will occur.
When etching is completed, wash off in running water, then strip the resist off with methylated spirits or lacquer thinners. However if required this resist may be left on the finished board as it does not greatly impede soldering.
The resist is not a flux, therefore an electrical grade cored solder should be used in final assembly.

Warning: Exercise caution when using all chemicals, do not smoke, do not use the resist, thinners or methylated spirits near naked flame, and on no account use any utensil which has been used with chemicals for food or drinking purposes. Good housekeeping is essential for good results — keep all utensils clean and dust free. ●

SOLVING PC BOARD PROBLEMS

	PROBLEM	PROBABLE CAUSE
(a)	Resist will not "take" in spots (breaking surface tension).	Laminate not cleaned properly.
(b)	Resist will not wash off exposed areas during development.	(1) resist under-exposed (11) developer too weak (111) oven temperature too high
(c)	Resist washes away during development.	(1) board baked at too low a temperature (11) baking time too short (111) developer too strong (1V) board overexposed or has been exposed to ultra-violet light prior to development.

RESISTOR COLOUR CODE

(standard carbon series)

RESISTORS of 1% tolerance sometimes have a five band code. The same colour codes are used but the first three bands represent the first three digits and the fourth band is the multiplier. With these resistors only a few of the standard values coincide with those of the four band coded resistors. For example 220 k is standard in four band code but 221 k is standard in five band code.

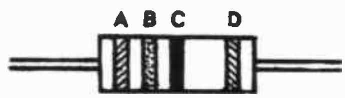
To read the colour code, hold resistor with code ring nearest to end at left hand side.

Colour	1st ring; 1st figure	2nd ring 2nd figure	3rd ring multiplier	4th ring tolerance
black	–	0	1	–
brown	1	1	10	±1%
red	1	2	10^2	±2%
orange	3	3	10^3	–
yellow	4	4	10^4	–
green	5	5	10^5	–
blue	6	6	10^6	–
violet	7	7	10^7	–
grey	8	8	10^8	–
white	9	9	10^9	–
silver	–	–	10^{-2}	±10%
gold	–	–	10^{-1}	±5%

No fourth colour indicates ±20% tolerance

Grade 1 ('high-stability') resistors are distinguished by a salmon-pink fifth ring or body colour.

Example: Resistor coded as A – grey, B–red, C–orange, D–gold indicates a value of 82 kilohms ±5%.



STANDARD VALUES

This table shows the preferred series of values in a decade.

RESISTORS and capacitors are generally made with the values and tolerances shown. For example 20% tolerance resistors are usually made in values of 10, 15, 22, 33, 47 and 68 – whether ohms, kilohms or megohms. Thus a nominally 47 k 20% tolerance resistor may have an actual value anywhere between 37k6 and 56k4. Note that International Standards now call for the suffix to be used in place of any decimal point. Thus a 4700 ohms resistor would in the past have been described as 4.7 k. Nowadays it should be described as 4k7, however many earlier circuits have not been changed and not all publications have adopted the new Standard.

Closer tolerance resistors such as 10% or 5% are not necessarily better it is merely that the manufacturers have weeded out projects falling outside the tolerance limits.

VALUES IN A DECADE

20%	10%	5 or 2%	1%							
10	10	10	100	133	178	237	316	422	562	750
		11								
	12	12	102	137	182	243	324	432	576	768
		13								
15	15	15	105	140	187	249	332	442	590	787
		16								
	18	18	107	143	191	255	340	453	604	806
		20								
22	22	22	110	147	196	261	348	464	619	825
		24								
	27	27	113	150	200	267	357	475	634	845
		30								
33	33	33	115	154	205	274	365	487	649	866
		36								
	39	39	118	158	215	287	383	511	681	909
		51								
	56	56	124	165	221	294	392	523	698	931
		62								
68	68	68	127	169	226	301	402	536	715	953
		75								
	82	82	130	174	232	309	412	549	732	976
		91								

POTENTIOMETERS

POTENTIOMETERS are made in many different forms for a vast number of applications. Factors which affect design are, for example, wattage and resistance range, whether the control is to be continually or intermittently adjustable, the 'law' of resistance and the variety of mechanical arrangements required.

POWER RATING

The maximum power which may be dissipated is specified for the condition where a voltage is applied across the end terminals continuously. However under certain conditions power dissipations much lower than this can cause damage. This is because the resistive element also has a maximum *current* limitation. Thus a potentiometer set to its lowest resistance could be damaged if excessive current were drawn via the slider terminal.

LAW

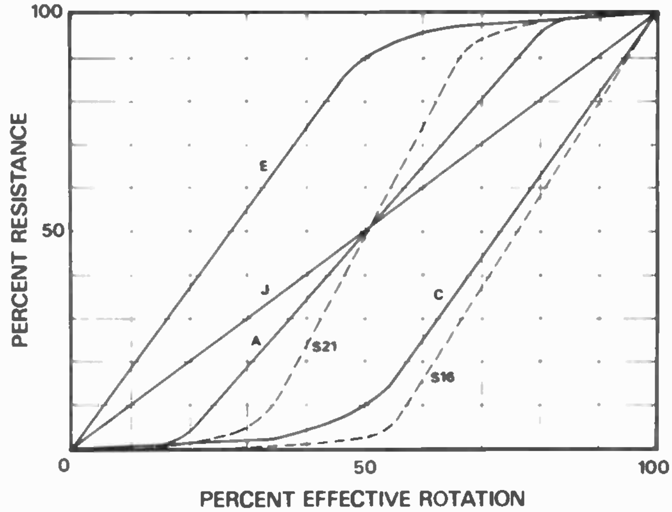
Potentiometers are constructed with various relationships of resistance versus rotation. Those most commonly used in Australia are:—

A linear
J linear
C logarithmic
E anti-log

The type of relationship (law) used is indicated by stamping the appropriate letter symbol on the body of the potentiometer, eg 10 kC is a 10 k ohm logarithmic potentiometer.

LOG OR LINEAR?

Most human perception is of a logarithmic nature (eg hearing, where a doubling of power is just perceivable). Hence logarithmic potentiometers are frequently used for volume controls as



Resistance/rotation curves for commonly used potentiometers.

the logarithmic change in resistance (versus rotation) is 'heard' as a linear level-change versus rotation. Logarithmic — potentiometers are not accurate, so, where an accurate mid-point setting is required, (for example in tone controls) they are seldom used except in cheaper equipment.

TAPPED POTENTIOMETERS

Tapped potentiometers are generally used where some form of frequency compensation versus rotation is required. They are often used in 'loudness' controls, (bass and treble frequencies boosted at low volume levels). Tapped potentiometers are usually specially made for a specific application. Because of this they are not generally available from hobbyist supply sources.

BALANCE CONTROLS

Balance controls are built with two separate elements connected such that each alters resistance in the opposite sense. Such controls are used where it is required accurately to balance the gain of a pair of amplifiers. Such accurate balance is not required in domestic stereo amplifiers and hence in this application a single gang potentiometer is generally used.

GANGING

Potentiometers may be obtained with two or three resistance elements driven by a common shaft. These are commonly used for volume and tone controls for stereo amplifiers.

SERIES AND PARALLEL CONNECTIONS

Resistors in series

$$R_{total} = R1 + R2 + R3 + \ldots$$

Resistors in parallel

$$R_{total} = \frac{R1 \times R2}{R1 + R2}$$

Capacitors in series

$$\frac{1}{C_{total}} = \frac{1}{C1} + \frac{1}{C2} + \frac{1}{C3} + \ldots$$

Capacitors in parallel

$$C_{total} = C1 + C2 + C3 + \ldots\ldots$$

TAG TANTALUM CAPACITORS

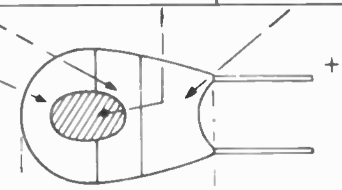
Because of their small physical size tag tantalum capacitors are ideal for miniature electronic work. They are more expensive than standard electrolytics though.

WORKING VOLTS	CAPACITANCE RANGE AVAILABLE
3	10 – 100 μF
6.3	6.8 – 47 μF
10	4.7 – 33 μF
16	2.2 – 22 μF
25	3.3 – 10 μF
35	0.1 – 6.8 μF

Tolerance ± 20%

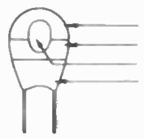
TAG TANTALUM CAPACITORS

CAPACITANCE IN μF				D.C. WORKING VOLTAGE	
COLOUR	1st RING	2nd RING	POLARITY and MULTIPLIER	COLOUR	VOLTS
Black	–	0	x 1	White	3
Brown	1	1	x 10	Yellow	6.3
Red	2	2		Black	10
Orange	3	3		Green	16
Yellow	4	4		Blue	20
Green	5	5		Grey	25
Blue	6	6		Pink	35
Violet	7	7			
Grey	8	8	x 0.01		
White	9	9	x 0.1		



N.B. – The above sketch shows the position of the coloured spot which serves both as multiplier and anode indicator.

EXAMPLE
6.8μF/25 volts



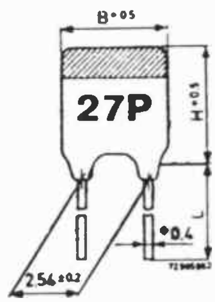
BLUE 6
GREY 8
WHITE 0 1
GREY

} 6.8μF

25 Volts

CERAMIC CAPACITORS

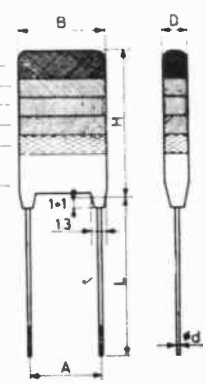
capacitance (pF)	marking	capacitance (pF)	marking	capacitance (pF)	marking
0.68	**p68**	5.6	**5p6**	47	**47p**
0.82	**p82**	6.8	**6p8**	56	**56p**
1.0	**1p0**	8.2	**8p2**	68	**68p**
1.2	**1p2**	10	**10p**	82	**82p**
1.5	**1p5**	12	**12p**	100	**n10**
1.8	**1p8**	15	**15p**	120	**n10**
2.2	**2p2**	18	**18p**	150	**n15**
2.7	**2p7**	22	**22p**	180	**n18**
3.3	**303**	27	**27p**	220	**n22**
3.9	**3p9**	33	**33p**	270	**n27**
4.7	**4p7**	39	**39p**		



POLY-CARBONATE CAPACITORS

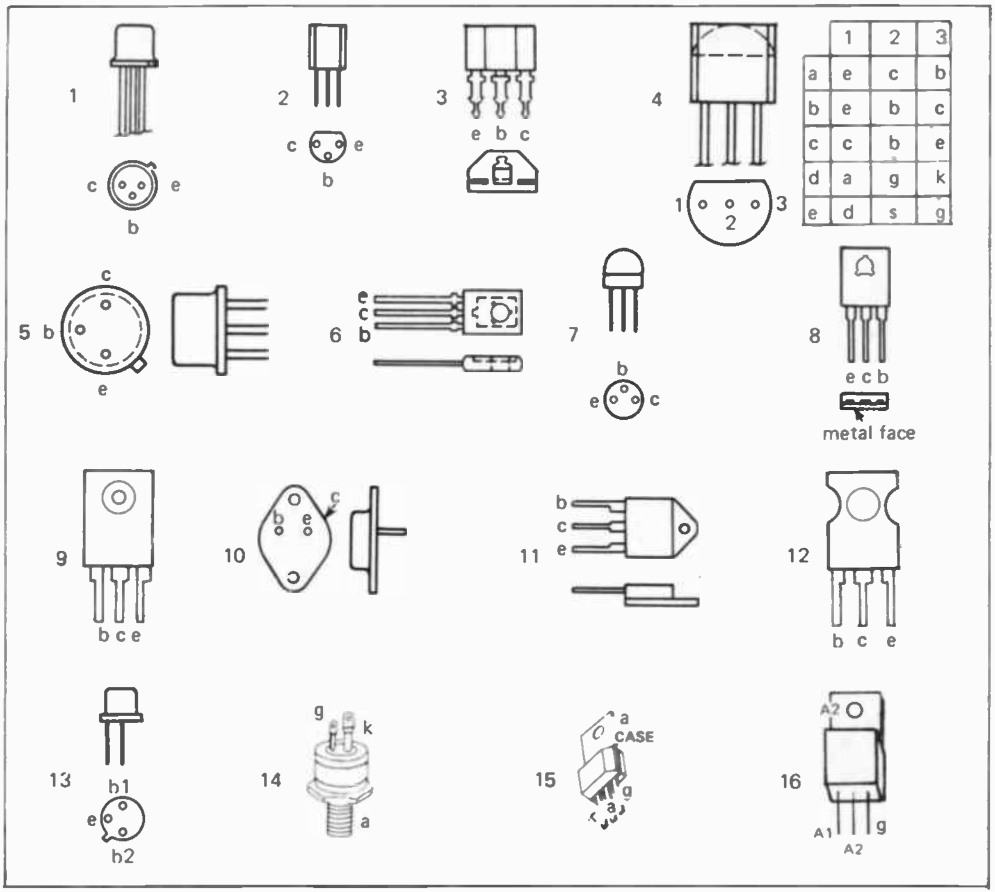
colour	1st figure of cap value	2nd figure of cap value	multiplying factor	capacitance tolerance	working voltage
black	–	0	1	±20%	
brown	1	1	10		
red	2	2	10^2		250 V
orange	3	3	10^3		
yellow	4	4	10^4		400 V
green	5	5	10^5		
blue	6	6			630 V
violet	7	7			
grey	8	8			
white	9	9		±10%	

body colour



TRANSISTOR CONNECTIONS

TRANSISTORS	CONNECTIONS
BC107	1
BC108	1
BC109	1
BC147	3
BC148	3
BC149	3
BC157	3
BC158	3
BC159	3
BC177	1
BC178	1
BC179	1
BC182K	4c
BC182L	4a
BC237	4c
BC238	4c
BC239	4c
BC307	4c
BC308	4c
BC309	4c
BC547	2
BC548	2
BC549	2
BC557	2
BC558	2
BC559	2
BD139	6
BD140	6
C30	14
C106	15
MJ802	10
MJ2955	10
MJ4502	10
MJE340	8
MJE340K	9
MJE2371	9
MJE2521	9
MJE2955	8 (K Suffix-9)
MJE3055	8 (K Suffix-9)
PN3638	4b
PN3643	4b
PN3644	4b
SC141	16
SC146	16
SC151	
TIP29	12
TIP30	12
TIP31	12
TIP32	12
TIP33	11
TIP34	11
TIP35	11
TIP36	11
TIP41	12
TIP42	12
TIP2955	11
TIP3055	11
TT800	5
TT801	5
2N2160	
2N2646	13
2N2647	13
2N3055	10
2N3638	7
2N3638A	7
2N3643	7
2N3644	7
2N5457 (MPF103)	4e
2N5458 (MPF104)	4e
2N5459 (MPF105)	4e
2N5484	4e
2N5485 (MPF106)	4e
2N5486	4e
2N5631	10
2N6027 (D13T1)	4d
2N6031	10



Note — Case 4 is used for various transistor configurations and the different connections are indicated in the table on the right of the case. For example, if connections 4c are indicated in the transistor list consult row c (far left on chart). The connections corresponding to pins 1, 2 and 3 are as follows, pin 1 is collector (c), pin 2 is base (b) and pin 3 is emitter (e).

Kits for ETI Projects

Several companies sell kits for the projects in this book.
Listed below are some names of companies we suggest you contact if you are seeking a kit for any particular project. Different companies specialize in different types of equipment so you may need to try several before you find the kit you want.

- Applied Technology Pty Ltd, 109-111 Hunter St, Hornsby, 2077. NSW.
- All Electric Components, 118 Lonsdale St, Melbourne, Vic, 3000.
- Dick Smith Pty Ltd, PO Box 747, Crows Nest, NSW. 2065.
- Nebula Electronics Pty Ltd, 15-19 Boundary St, Rushcutters Bay, 2011.
- Townsville Electronics Centre, 281E, Charters Towers Rd, Rising Sun Arcade, Hermit Park. 4812.

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