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ELECTRONICS TODAY INTERNATIONAL

PROJECT ELECTRONICS

Twenty six great projects for beginners from the publishers of ETI magazine

REVISED 4th EDITION

An ELECTRONICS TODAY INTERNATIONAL publication

ready for something more ambitious?

So you've built the projects in this book, and now the electronics bug has bitten you!

You're ready for something more ambitious?

To start you off on the right track, Dick has picked a selection of tools from his catalogue which are almost identical to those he used when he started building electronics projects. Dick considers the tools on this page are ideal as a start-up kit; of course, you may wish to add others to them, but with this basic set you're ready to tackle some really ambitious projects!

You'll find all these tools, and many more, in the current Dick Smith Electronics catalogue, or at any Dick Smith store.

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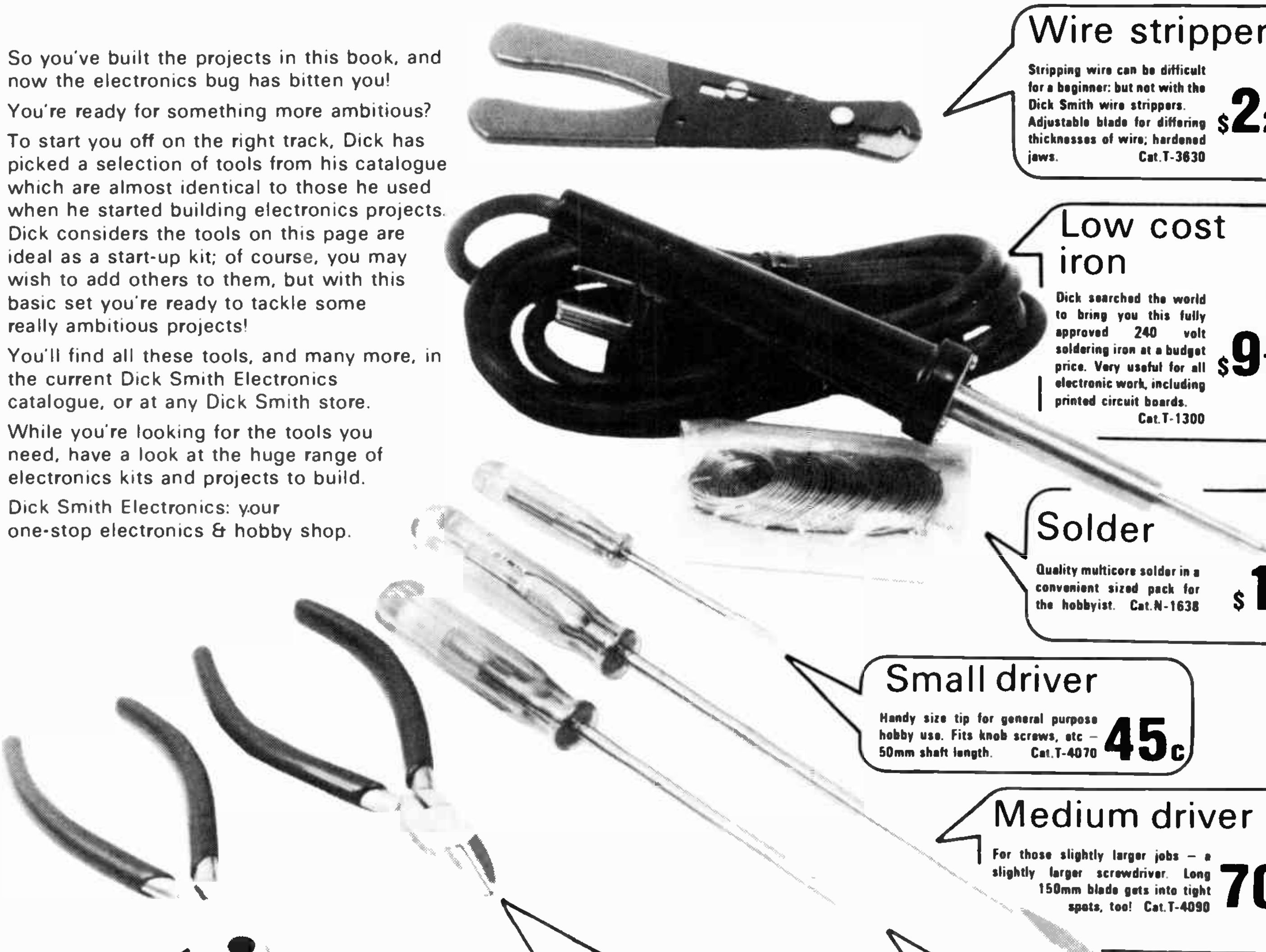

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PROJECT ELECTRONICS

An ELECTRONICS TODAY INTERNATIONAL publication

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Recommended retail price only.

THIS BOOK enables the electronics newcomer to construct a wide variety of fascinating electronic devices.

Its original concept came from Rowley Jones, industrial arts teacher at Galston High School in NSW, and Geoff George of the curriculum advisory section of the NSW Department of Education. Both saw a need for a series of projects designed and presented specifically for people learning to work with electronics for the first time. Electronics Today International became interested and agreed to design the necessary projects and to produce them in book form.

Rowley and Geoff's concept was to produce projects graded in complexity and ease of construction – of sufficient interest to appeal to people of all ages, but essentially to fulfil the needs of the schools' current three-segment technics syllabus in electronics.

Further requirements were that all projects should, where feasible, be presented in at least two different ways – i.e. buildable on Veroboard or tag strips, plus an optional printed circuit board method. All projects were required to be presented so clearly that no prior knowledge of electronics would be required or assumed. Nevertheless the text would be such that people who so wished could gain a deeper knowledge and appreciation of electronics and electronic circuitry.

All projects were to use the absolute minimum of low cost and readily available components, and these components where possible were to be interchangeable from one project to another. For safety reasons, all projects were to be powered from low voltage dry batteries.

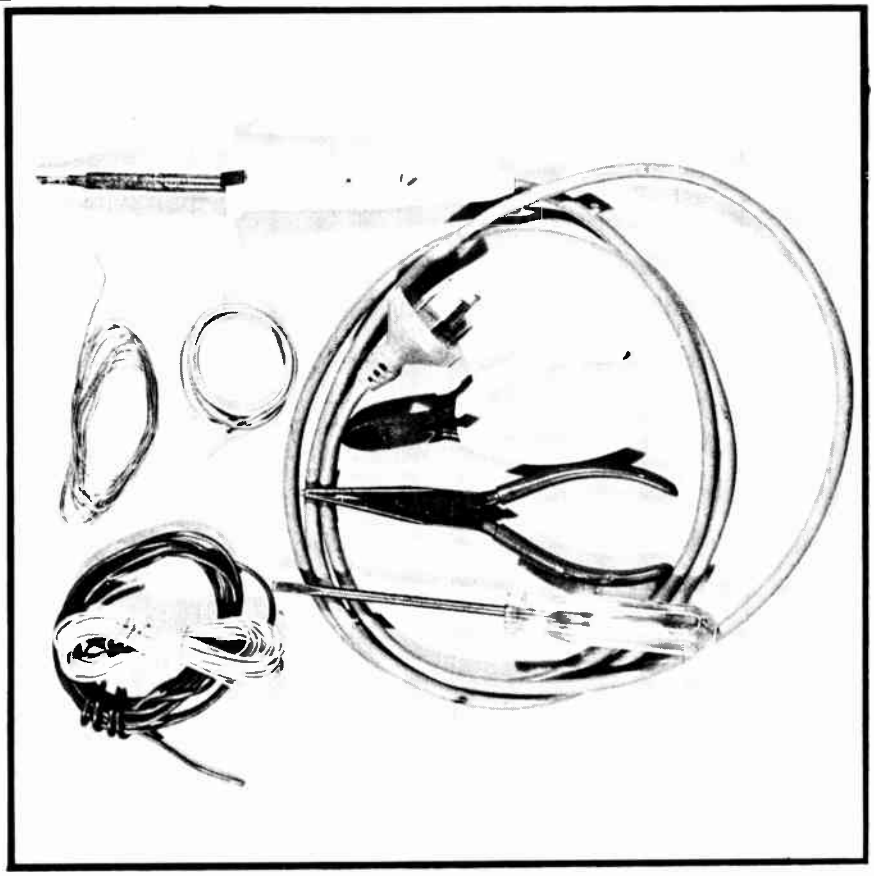
Designer Barry Wilkinson has met these objectives quite brilliantly. Many of the projects use virtually identical components to perform totally different functions – and four of the projects use exactly the same printed circuit board!

One project in this book is mains-operated. It has been included for general interest and we have described in detail the precautions that must be taken before building it. The NSW Dept of Education however advises us that construction of mains-powered projects is not at present permitted within the Industrial Arts syllabus. So if you are at school, do first obtain your teacher's advice before contemplating construction.

Collyn Rivers

Fourth edition – July 1980.

CONSTRUCTING ELECTRONIC PROJECTS



Basic tools required to commence building projects, together with solder and wire. The tools are from left to right. Adcola soldering iron, side-cutting pliers, long-nose pliers and small screwdriver.

VERY FEW TOOLS are required to get started on simple electronic project construction:

The first essential is a good soldering iron. We recommend the Adcola M70. The electrical element is rated at 19 watts and it has a 3.2 mm tip.

You will also need some resin-cored solder. It is really worthwhile buying a big reel and sharing the cost around. The saving is vast. Do not under any circumstances use plumber's solder or acid fluxes, nor anything except high grade 60/40 five-core resin solder. *If your usual supplier doesn't have it find one that does.*

Specify that you want 18 gauge or 20 gauge solder, not the 16 gauge more commonly available — the latter is a too heavy for today's miniature components and circuit boards.

Apart from solder you'll need some 20 or 22 gauge tinned copper wire, several lengths (different colours) of PVC covered hook-up wire (specify 7 x .010 or 10 x .010) and a length of 1 mm spaghetti-type insulation.

The above tools and supplies are all that you'll need to get going on many of the projects in this series. For more advanced work you'll need access to a drill, a set of drill bits, a couple of small files — one flat 150 — 200 mm and one round 150 mm or so. These will be needed to make small heatsinks, to mount completed boards in boxes and to fit switches etc.

You will also need two basic tools. These are a pair of 100 mm diagonal side cutting pliers, and a small (say 100 mm) screwdriver with a 3.2 mm blade.

THERE ARE SEVERAL different ways of building electronic projects.

The simplest by far is to use a printed circuit board. Boards, etched and drilled for specific projects are readily available from most kitset and component suppliers. These suppliers advertise regularly in magazines such as Electronics Today International. It is also possible to drill and etch your own boards.

Other methods of construction include matrix board, Veroboard and tag strips. This part of our series discusses the advantages and disadvantages of each method and shows how each technique is used.

VEROBOARD

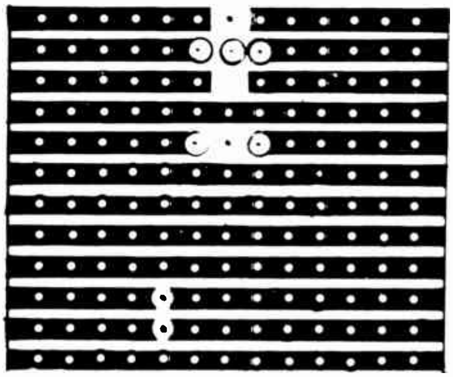
Veroboard is a commercial product made primarily for assembling 'one-off' circuits. It's made from a high grade insulating board with parallel copper strips bonded to it. Holes are punched right through at regular intervals.

The first stage in using Veroboard for a project is to cut breaks in the copper strips where shown. These breaks can be made by a sharp drill or with the 'spot face cutter' made specially for the purpose. When you come to make these breaks do remember that our Veroboard drawings show the board as you will see it when you hold the drill — that is from the copper side.

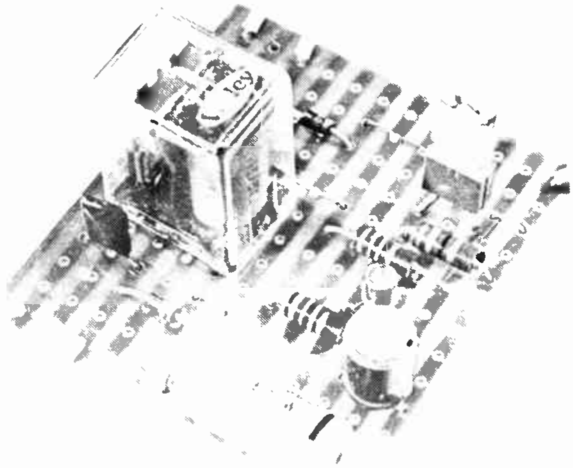
Do make quite sure that you put the breaks in the right places — it's very easy to make a mistake. Once you've made all the breaks, check and double check that they are totally clean. It is only too easy to leave a fine and only just visible 'whisker' of copper track remaining.

The components are mounted onto the board from the non-copper side. This may sound obvious but we have seen literally scores of boards that readers have assembled the other way round!

Put the components in so that they are spaced a few millimetres up from the board surface. This places less strain on the components and it's also easier



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.

to remove and replace them at any time. Some projects require wire links to be installed to join various tracks together – these should be put in before components.

Bend the component leads so that the bits don't fall out – then invert the board and solder them securely into place. Snip off any loose ends when the solder has completely cooled down.

Finally inspect the copper tracks very carefully to make certain that you don't have a blob or even a whisker of solder bridging across.

Wires leading to and from Veroboard should be treated in the same way as a component. That is the insulation should be stripped back a short way and the wire inserted through the board from the *non-copper* side. The wire should then be soldered to the copper track. DO NOT solder wires directly to the tracks without first taking them through the holes – the copper is only lightly bonded to the backing material and comes away if it is pulled.

An alternative and very neat method is to use Veroboard pins. These little pins are made specifically for the purpose, they fit into the holes on the copper tracks.

The advantages of Veroboard are that it is relatively cheap – and extremely versatile. You can buy half a metre of board and have enough for a dozen projects.

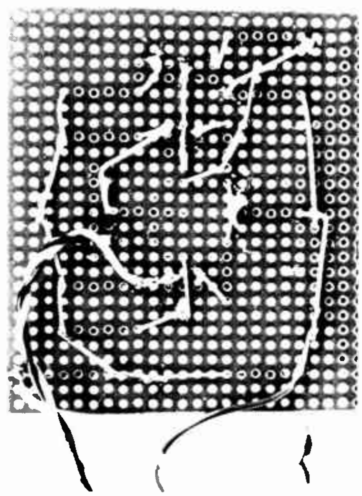
Its disadvantages are that projects built on Veroboard look a bit 'home-made'. Also, it is very easy to make errors when cutting the breaks, and the copper strips tend to pull away when one removes or replaces components. Nevertheless it is probably the best material yet devised for cheap and quick assembly of simple circuits and for this reason most of the projects in this series show a Veroboard layout.

MATRIX BOARD

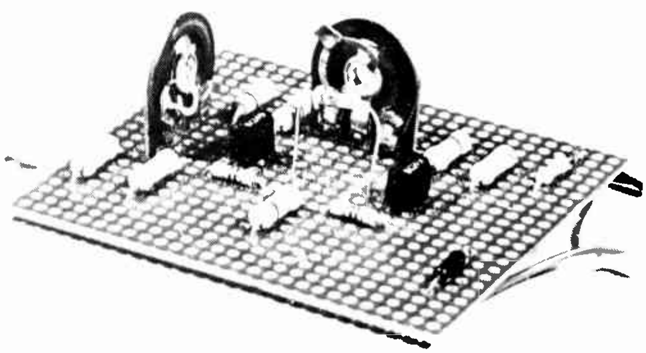
Whilst Veroboard is very suitable for 'one-off' equipment which is to be used more or less permanently it is difficult to strip and use again. Another simpler type of material known as 'matrix board' is more suitable if you intend pulling things apart.

Matrix board is an insulating board perforated in much the same way as Veroboard but without the copper strips. You use it by inserting the components through appropriate holes and make the necessary interconnections by joining the components (via insulated wire) across the back (non-component side) of the board. It all sounds a bit messy but it's surprising how quickly circuits can be assembled, and with a bit of care they look quite neat.

Another advantage of matrix board is that components and wiring can be placed exactly as shown on the circuit diagram. The main disadvantage is that the back of the board becomes a bit of a rat's nest if you try to build a complex circuit. Another minor drawback is that (as with Veroboard) the finished job doesn't look like a totally professional unit.



TOP: Matrix board – the component leads are interconnected on the non-component side of the board. BOTTOM: The components are simply pushed through the holes in the matrix board.



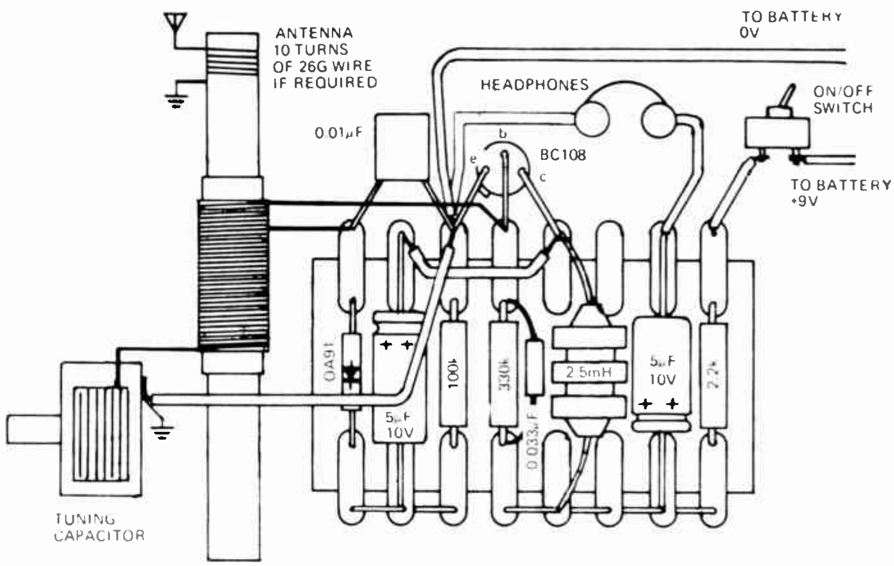
CONSTRUCTING ELECTRONIC PROJECTS

TAG STRIPS

Tag strips consist of a series of metal tags mounted on an insulating strip. The strips in turn are mounted on two or more further metal tags which are used to screw the whole lot down onto a chassis.

Component leads should never be wrapped more than three quarter – way round a tag. If you twist them right round you'll have an awful job trying to remove them, if you need to, at a later date.

Tag strip construction is quick, cheap, and simple. But the method is only really suitable for small scale projects as inter-tag wiring is otherwise extensive and tedious. The method is also wastes space.



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).

PRINTED CIRCUIT BOARDS

Printed circuit boards simplify electronic circuit building enormously – to the extent that some enthusiasts feel it is reducing the pastime to 'painting by numbers'. But if you feel *that* strongly about it you can always etch and drill your own boards!

The board material is made of phenolic resin or glass fibre with a thin copper sheet bonded to (generally) one face. Intercomponent wiring is formed by etching away the unwanted copper – so that only the tracks and component mounting pads remain.

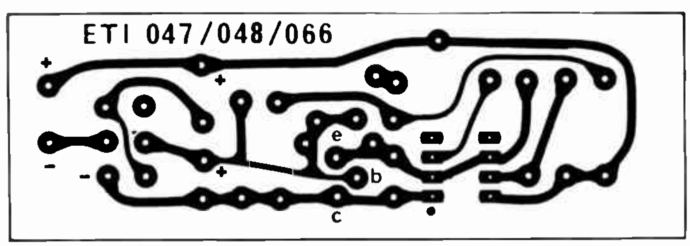
Holes are drilled for the components which are then inserted through from the non-copper side and their leads soldered directly to the copper pads.

Most component and kit set suppliers stock printed circuit boards already drilled and etched for most popular projects. They also stock circuit board material for those who wish to make their own boards. Board making is not difficult but it is a rather lengthy process. Board manufacture is beyond the scope of this article but for those who would like to tackle it Electronics Today International can supply a photo stat of a previous article showing how it is done – just send them a large stamped addressed envelope and a postal order or cheque for $1.00 – their address is 15 Boundary St, Rushcutters Bay, NSW, 2011.

Printed circuit boards have a number of significant advantages over other methods of construction. The biggest is that mistakes are less likely to occur. Most of the wiring is right there, etched onto the board, and the drilled pattern is such that in many instances components will *only* fit the right way round. The finished article looks professional – how most professional equipment is made.

The disadvantages are that printed circuit boards are more expensive than Veroboard or matrix board of the equivalent area. There is also less personal involvement unless you make your own boards – then there's a great deal more!

Our own view is that all methods should be mastered but that printed circuit boards are probably best for most projects.



Printed Circuit board pattern – such patterns are usually shown full-size. The black strips are the inter-connecting tracks between components and are formed by etching away the rest of the copper – see main text for full description.

SOLDERING

GOOD soldering is vital – most of the problems that beginners have with their first projects are due to poor joints. The following hints will aid you to become adept at soldering.

1. Purchase a good quality iron with a wattage rating between 15 and 25 watts.

2. Use only resin-cored solder (60/40 tin-lead content). Do not use acid flux.

3. A new, or worn, iron will need tinning. To do this let the iron get quite hot and file the tip smooth to expose fresh clean copper. Quickly, before the copper has time to discolour, apply resin-cored solder – it should flow all over the tip forming a shiny coating.

4. Keep your soldering iron clean. Wipe it frequently with a damp cloth or sponge.

5. Make sure the connection to be soldered is clean. Wax, frayed insulation, and other foreign substances will result in inferior joints.

6. With older components, or copper wire, it will be necessary to clean and tin the individual components before soldering them together (see 3 above).

7. Attach the wires to be soldered. Do not make more than a half turn in a lead to be soldered — twisting makes subsequent removal difficult.

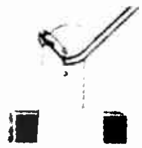
8. Heat the connection with the iron and apply the solder to the connection. Do not melt solder on the iron and carry it to the joint.

9. Keep the iron on the point until the solder just commences to flow on the connection. Too little heat results in a high-resistance joint (known as a dry joint). Too much causes component damage and evaporates the tin component, again causing a poor joint. This step requires practice.

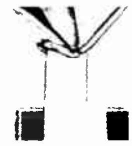
10. Let the solder harden before moving the connection. Then check for a smooth bright joint. A joint that has been moved will have a crystalline appearance, may have a high resistance and will fracture easily.

Good soldering is a matter of practice. If you follow the above hints, it will be only a matter of time till you are making professional joints.

Poor connections look crystalline and grainy, or the solder tends to blob.



Attach the wire.



Heat both the wire and the connection point.

Apply solder to both the tip and the connection.

Let the connection harden before moving the wire. Then check for a smooth, bright joint.

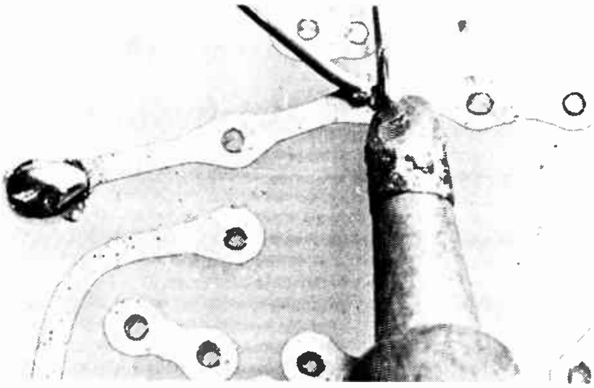
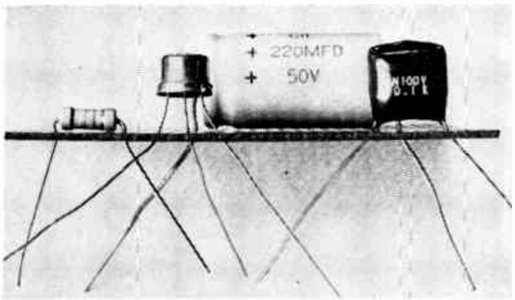


Fig.9. Apply the soldering iron to the joint so that the track and component wire are heated together for about two seconds, then apply the solder to the joint — NOT to the soldering iron tip.



When components are fitted to a board the leads should be splayed, as shown, to keep them in position prior to soldering. Position components so that values and voltage ratings may be seen. This facilitates later servicing.

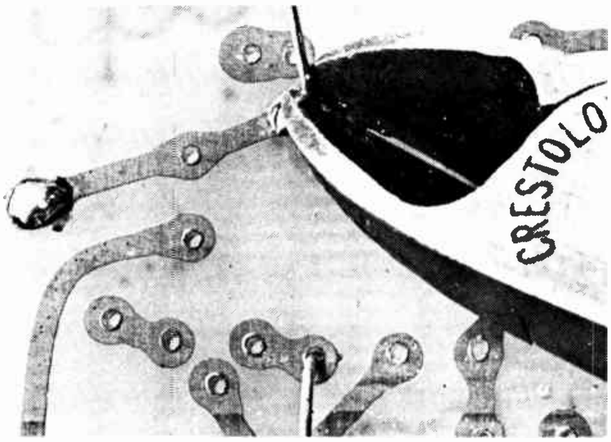


Fig.10. Allow the joint to cool completely undisturbed and then snip off the excess component lead. A joint that has been disturbed during cooling will appear crystalline and will probably be 'dry' (that is it will have a high resistance which will affect circuit operation).

How not to do it!

So much heat has been applied to this board, that in places the tracks have been damaged. In other places insufficient heat, or improper fluxing, has caused the surfaces to be not wetted properly. So much solder has been applied that one does not know where the tracks really are, or whether the joints are good or not! A kitset supplier would be quite justified in refusing to accept responsibility for a project, built this way and not working.

ELECTRONIC COMPONENTS

Electronic components are generally more rugged than they look. Most will withstand being dropped onto a bench, mildly overheated or subject to reasonable overloads for short periods of time. What many won't tolerate — even for a few microseconds — are voltages applied the wrong way round.

The following section of this series describes how components used in electronics are identified, how they must be handled and what particular forms of abuse are best avoided.

RESISTORS are probably the most commonly used of all electronic bits and pieces. Fortunately they are very cheap — as little as a cent-and-a-half each if you buy enough at a time.

As with all mass produced items it is impossible to manufacture resistors so that each one in a batch has *exactly* the same resistance. Manufacturers and users accept a system by which resistors are graded in terms of percentage variation from a mean value. For example all the resistors specified for the projects in this book are '5%'. This means their actual value will not differ by more or less than 5% from the nominal 'centre' value. Thus a nominally 100 ohm resistor may in actual fact have a resistance from 95 ohms to about 105 ohms. Projects are — or at least should be — designed so that they work with any combination of such tolerances. The failure of some design engineers to allow for this is one reason why published projects sometimes will not work without modifications.

You can substitute say a 2% resistor where 5% is actually specified — its value must be suitable for that circuit. It's possible that you could use a 10% or even a 20% tolerance resistor — but you would have to check its value beforehand using an accurate ohmeter. Chances are that it will be OK but you cannot be sure. (If you could be sure then it wouldn't be a 10% tolerance resistor would it!)

Resistors are generally available in tolerances of 1%, 2%, 5%, 10% and 20%. The 'tighter' the tolerance the more costly they are. We have specified 5% resistors throughout this series as they are massively cheaper and far more readily available than 1% or 2% types yet not much more costly than those of 10% or 20%.

Resistors are also rated by their power dissipating capacity. This is specified in 'watts' — often abbreviated to 'W'. With few exceptions we've used the most common type which are rated at ½ watt.

As resistors are physically small their resistance value is marked on them using an internationally recognised colour code. This code is shown elsewhere on this page.

Resistors are not 'polarised' — that is it doesn't matter which way round you put them in. They *can* be damaged by clumsy handling — generally through bending their leads too close to the main body of the component.

RESISTOR COLOUR CODE (standard carbon series)

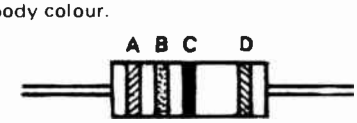
To read the colour code, hold resistor with code ring nearest to end at left hand side.

Colour	1st ring; 1st figure	2nd ring 2nd figure	3rd ring multiplier	4th ring tolerance
black	—	0	1	—
brown	1	1	10	±1%
red	2	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%.



The electronic symbol for a resistor

Typical ½ watt resistor. Note the colour coding bands.

Series and Parallel Connections

Resistors in series

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

Resistors in parallel

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

POTENTIOMETERS

These are essentially resistors of adjustable value. All consist of a resistance track connected to terminals at either end — and a movable slider which can be adjusted to contact any desired part of the track. This slider contact is also brought out to an external terminal.

Most potentiometers (or pots as they're often called) are made with the track moulded in a 300°-or-so arc. They are also made in 'straight line' form.

Potentiometers are made in various total resistance values. Each value is produced in a number of different forms. These forms concern the manner in which the resistance changes relative to the amount by which the slider is moved. The two most common forms are logarithmic and linear. A linear pot changes resistance in a manner directly proportional to the angle by the slider is moved. A logarithmic potentiometer varies resistance logarithmically as the angle is varied linearly.

In practice it's not as confusing as it seems. The 'curve' of the pot is specified in the project. Pots are marked with their resistance value and the 'curve' is shown usually as a single letter suffix after the value. A linear potentiometer is marked 'A' and a logarithmic pot is marked 'C'. If you get the wrong one it will still work but all the adjustment will be 'up at one end'.

Newcomers to electronics are sometimes puzzled by potentiometer connections. On all rotary potentiometers there are three terminals. The one in the middle is always connected to the sliding contact (shown as an arrow on the circuit). This leaves you with only two connections to sort out. If you get these back to front the project or whatever will work but the potentiometer movement will also be back to front. The remedy is simply to reverse the two outer connections.

There's not much to go wrong with potentiometers. Generally they either work or they don't. The ones that don't are so rare that one can almost discount the possibility.

The electronic symbol for a potentiometer (pot).

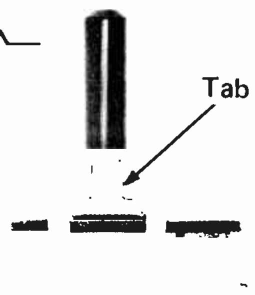
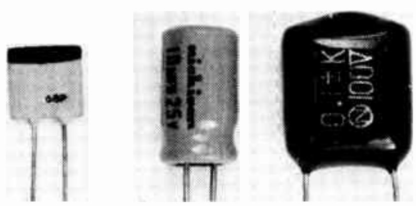


Fig. 2. Another common style is the tab-mounted pot. It has two tabs on opposite sides of the shaft which pass through corresponding panel slots, being secured either by twisting the tabs or laying them flat against the panel.

CAPACITORS

Capacitors come in a huge variety of shapes, sizes, types of construction, voltage ratings and values. The manufacturing tolerance on some capacitors is vast.

The two numbers that you must know about are the capacitance value — quoted in farads but always with a prefix such as 'u' (indicating that the actual number is so many millionths of a farad) because a farad is such a large amount of capacitance that it is never encountered — not in electronics at least.



Three types of capacitors, (left) ceramic, (middle) electrolytic, and polyester (right).

The second number of importance is the voltage rating. You must never use a capacitor rated at a lower voltage than specified but you can go upwards if you like. That is if the project calls for say a 10 uF 16 volt capacitor then you can use a 25 volt one if you have one around or that's the only one you can find.

Most capacitors are non-polarised. That is you can insert them either way round. But some *are* polarised. Electrolytics *always* are unless stated otherwise (i.e. some non-polarised electrolytics are made for special purposes). Tantalum capacitors generally are — and there are also a few others.

It's simple enough to tell. A polarised capacitor always has some definite marking showing which lead (or end) is which. A very common method is to print a black stripe or band around the negative end. Some manufacturers actually mark a '+' and a '—' sign on the respective ends.

Do make sure you use them the right way round. They won't work the wrong way — with battery powered circuits that's about the worst that *will* happen. But a wrongly connected electrolytic used at main voltage may well explode! Not quite as dangerous as it sounds, unless it happens close to your face, but effect is acoustically and messily spectacular.

Series and Parallel Connections

Capacitors in series

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

Capacitors in parallel

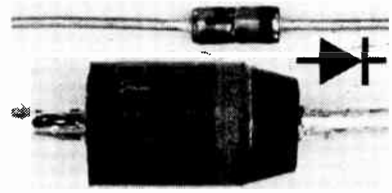
$C_{total} = C1 + C2 + C3 + \ldots$

DIODES

Diodes are generally rated in terms of voltage and current. It is always safe to use one with a higher rating than specified — but never the other way round.

Diodes are always polarised. There's *always* a right and a wrong way round. If you use one the wrong way round you will almost inevitably destroy it if it's in a circuit which is handling any appreciable power.

The polarity of a diode is marked in much the same way as a capacitor. There's usually a mark denoting the cathode end. (When drawn symbolically the cathode's the end shown with a horizontal bar). The mark may be a black band or a blob — but there always is a mark. If in doubt consult your parts supplier.



Two diodes. black band (top) and white band (bottom) indicate the cathode (—ve) end of the component Bands correspond to bar on symbol in circuit diagrams.

ELECTRONIC COMPONENTS

You can check whether or not a diode has been destroyed by measuring its resistance with an ohmmeter. If it's OK it will have a massively higher resistance in one direction than the other. Keep your fingers off the leads when your measuring or all you'll do is to measure the resistance of your fingers — which will be much less than that (in one direction) of the diode!

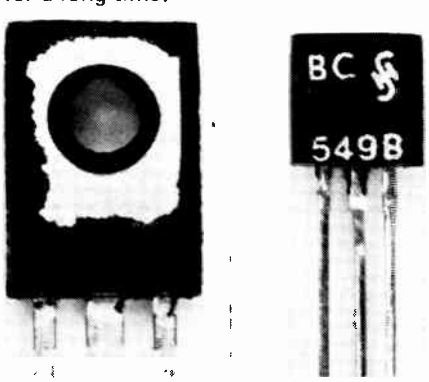
TRANSISTORS

For most purposes a transistor is either the right one or it's not. Don't try substituting another type which some-one says is 'just the same'.

A transistor has only one 'right-way-round'. The pins must be inserted as shown on the component overlay. If you get them the wrong way round there's a good chance of destroying the transistor the moment power is applied.

So there's only one correct way to insert a transistor but incredibly not all transistors having the same type number have the same pin connections. We have included a chart on page 82 of this publication showing the various connections for the transistors used. Do make quite sure that you have the correct one, and that if two or more types are shown that you have identified the connections relating to your particular device's brand.

Transistors can be damaged by using excessive heat when soldering. Our own view is that this is an exaggerated problem. We have yet to see one so wrecked but would accept that it is possible if a soldering iron is held against the leads for a long time.



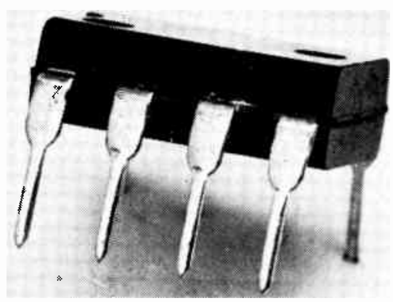
Two transistors. To the left is BD140. Note metal backing for heat dissipation. Right a BC549, Philips type with bent centre lead, which has different pin configurations than other transistors of the same type. Check in the back of this book for connections.

INTEGRATED CIRCUITS

Like transistors most integrated circuits (ICs) are stronger than they look.

The biggest problem with them is that once soldered in it's the devil's own job to get them out again. Because of this it's well worth while spending a bit more on any project (which uses ICs) to install IC sockets. These are little plastic sockets which have identical pin connections as the ICs and into which in turn the IC is plugged. It's not always worth while because some ICs are so cheap that the socket costs more than the IC but they are worth considering for use with expensive devices.

Integrated circuits must be soldered in the right way round. They always have some identification — usually in the form of a small scallop in one end of the case. Again, pin numbers are generally marked on the case. They should be inserted exactly as shown in our overlay drawings. Do make sure they are the right way round before soldering because as we've said once in they're very hard to get out again.



A typical 8 pin dual-in-line (DIL) integrated circuit.

CMOS ICs are a bit different. These are very tough — once soldered in — but are a bit fragile until then.

In particular CMOS ICs are very easily damaged by quite small static charges. They are always packed by their various manufacturers in such a way that they are protected against static, usually by insertion into a conductive plastic foam, aluminium foil etc. When building a project using CMOS always leave the CMOS components until last of all. Handle them as little as possible — never touching the pins with your fingers.

Once removed from their packaging install them in the board as quickly as possible — making sure they're the right way around.

Finally solder first those pins on the CMOS IC which are connected to the power rails. In the projects shown in this series these pins are numbers 7 and 14. Once this is done any static charges will be dissipated via the other components on the board. That's why you solder them in first.

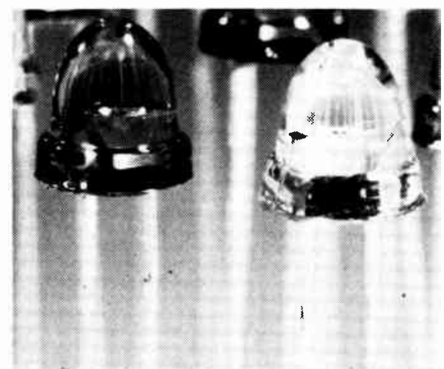
LIGHT EMITTING DIODES

Often known as LEDs (pronounced 'ell-ee-dees!). These are solid-state light emitting devices. They are made in various colours but most suppliers stock only red or green.

Used correctly, LEDs go on for ever — we don't think anyone's worn one out yet. But they must be used at the correct voltage and the voltage limits are fairly tight. They are polarised so you must have them the right way round. They are not usually damaged by wrong polarity — they just won't work.

The polarity is marked either by a black mark close to the cathode (–ve) lead or sometimes by having the cathode lead shorter than the anode. So don't cut the leads back unless you can identify them afterwards.

DON'T ever test an LED by wiring it across a battery. The only simple way to test one is to insert it in a circuit known to work.



LED's are usually red, green or yellow, some are clear but glow red.

LOUDSPEAKERS

Several of the projects use a small speaker drive unit. The unit chosen is not usually critical.

Drive units are made in varying levels of quality, size and impedance. For all the projects except the Hi-Fi Speaker, quality is unimportant. Frankly we'd go for the cheapest you can find! Impedance is specified in each project parts list.

Speakers are not polarised — you may connect them either way round.

You are not likely to damage a speaker using any of the projects in this series. If the speaker doesn't make a noise it's fairly sure you've got a dud one. Check by touching the leads momentarily across a 1½ volt cell NOT the nine volt one used in this series. If the speaker is working it produces a loud click. Don't leave the cell connected for more than a fraction of a second or you'll end up knowing that the speaker was working but isn't any longer!

RELAYS

There's not much that can go wrong with a relay. They'll usually only fit onto a printed circuit board one way round because their pin connections are assymetric. They usually have transparent cases so you can see if they're working. If you have a non-working project in which the relay contacts can be seen to open and close as specified it's almost certain that your connections to or from the actual contacts are incorrect. The pins are not generally connected to the contacts as they appear to be — so if in doubt check them with an ohmmeter or the continuity tester described in our first project.

BATTERIES

With few exceptions all the projects in this series run off standard nine-volt dry batteries. We have chosen Eveready's type 216 because they are cheap and readily available.

It should be noted though that the 216 battery does not have sufficient energy to drive some of the larger projects (such as the basic amplifier) for more than a short period of time. It is therefore preferable to replace the battery with a larger capacity unit once the project has been proven.

Before connecting up the battery make certain that you have the leads from the battery or battery clip connected to the board the right way round. Many electronic components will be instantly destroyed if you connect the power up back to front.

Battery polarity is always clearly marked — either by a '+ve' and a '—ve' sign or by the words 'positive' and 'negative'.

Unlike most other electronic bits, batteries go through a period between working and not working. A partially 'flat' battery may cause some strange effects to occur in many circuits so if in doubt either check the voltage with a voltmeter or replace by a battery known to be good. You must check voltage with the battery connected in circuit and the device switched 'on'. If the battery voltage is less than about 8.9 volts it should be replaced.

HOUSING THE PROJECTS

None of the projects in this series except the Hi-Fi Speaker show metalwork details. This enables individual constructors or groups to use their ingenuity.

As a general rule it's easier to work with aluminium than with steel — but steel's a lot cheaper. Letraset may be used very effectively to label front panels — but it's far too costly for individuals to use as it's only sold by the sheet.

An American product called AMI-CAL is available for around $5.00 a pack and this contains a quantity of pre-set words, symbols and letters made specifically for the purpose.

The finish on aluminium panels can be improved by etching them in a caustic soda solution. To obtain the best effect:

1) Do all marking out on the back of the panel.
2) Drill holes two ways — small pilot hole from front to back. This minimises the problem of getting rid of the 'flash' which arises round the holes while drilling. Removing flash often leaves scratches, and it is better that these be on the back of the panel than the front.
3) Rub the front of the panel with medium grade emery cloth to rid it of all unwanted marks and scratches. The emery should be rubbed only in one direction for the final rubbing. This leaves the aluminium with a bright matt finish. From this point on, avoid touching the front of the panel.
4) Attach a length of thin plastic string or tubing to the panel by tying it through one of the panel holes.
5) Prepare a caustic etching solution. Have about 300 ml of hot water ready in a glass or plastic dish (The plastic throw-away food containers are ideal). Measure out about 30 grams of caustic soda then pour the caustic soda very, very slowly into the hot water. The strength of the solution is in no way critical. Now, by means of the plastic string, lower the panel into the solution, leaving one end of the string hanging out of the dish. It will fizz fiercely and the solution will get hotter — but all is well.
6) About 3 minutes later remove the panel, rinse it under a cold water tap, and wipe it clean. Rinse it again thoroughly, and if it looks okay — dull matt all over, it's finished. Hang it to dry.

A panel finished this way has a satin chrome look to it, and does not retain finger marks the way untreated aluminium does.

MAINS VOLTAGES

Virtually all the projects in this series have been designed to operate from low voltage batteries. This is because mains voltage is potentially lethal. It is only too easy for experienced constructors accidentally to touch a 'live' component and if you do so whilst standing on a concrete floor or touching earthed material — for example a metal-topped work bench fitted with metal water taps — you will become a statistic.

Experienced hobbyists know this and take safeguards. They install a rubber mat — sit on a wooden stool — use a bench with an insulated surface (such as wood or Formica) they keep one hand in their pocket whilst working on live equipment.

The novice will not be aware of such precautions. So don't tackle any mains-operated project without adequate supervision from an experienced person.

PROBLEMS?

— See page 80

CONTINUITY TESTER

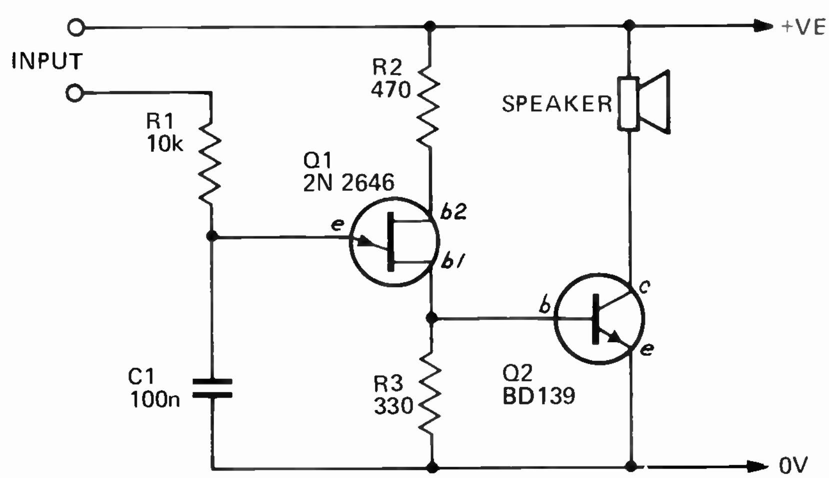
This very effective and versatile device checks the continuity of electrical and electronic circuits and components.

THE NEED FREQUENTLY ARISES to check for electrical continuity between various parts of a circuit, or to check whether or not a component is open circuit.

Sometimes this can be done by using a battery and buzzer or globe — but often this technique cannot be used as the circuit or circuit component will be unable to withstand the relatively heavy currents involved. For example it is not possible to test the continuity of a 250 mA diode if the testing circuit draws an amp or so!

Unlike most other continuity testers ours gives an indication of continuity over a resistance range from zero to many thousand ohms — and provides a rough indication of the amount of resistance via an audio tone the pitch of which is inversely proportional to resistance. Below 1000 ohms or so the tone is constant — above that the tone falls in pitch as resistance rises.

As the assembly drawing and accompanying picture shows, there are so few components that the device is best assembled onto a single seven-way tag strip. The speaker may be of any physical size, and of eight or fifteen ohms impedance. However, if you have an 80—100 ohm speaker (these are often used in small transistor radios) the circuit can be simplified yet further. Just wire the speaker in place of the resistor R3 and omit Q2.



Circuit diagram of complete unit.

How to use the tester

Make sure no power is applied to the circuit under test — if testing car wiring for example first disconnect the vehicle's battery.

To test for continuity just touch the probe wires across the circuit or component to be checked. The tester will produce the same pitch note for any resistance between zero and about 1000 ohms. Check this by testing firstly a short length of wire — and secondly a few resistors of known values.

If the resistance is more than 1000 ohms or so the tester will emit a note the pitch of which is inversely related to the resistance. The higher the resistance the lower the pitch. Again check a few higher value resistors so that you become familiar with the pitch to expect.

HOW IT WORKS ETI 041

Basis of the unit is a unijunction transistor (Q1). The testing probes are connected between the emitter of the unijunction – via a 10k resistor – and the positive rail.

If there is reasonable continuity between the probes, capacitor C1 charges via R1 until the voltage across it reaches a certain level. At this point the unijunction 'fires' causing the capacitor to discharge via R3. Capacitor C1 then charges again and once again the unijunction 'fires'.

This cycle is repeated at a rate dependent upon the time it takes the capacitor to charge. This in turn is a function of the resistance between the testing probes.

As the unijunction oscillates, a corresponding pulse will appear across R3. This pulse is applied to the base of transistor Q2 which amplifies the pulse to a level where it is sufficient to energise the loud-speaker.

If a suitable 80 or 100 ohm speaker is available this may be wired in place of R3 and transistor Q2 omitted.

Diodes should be checked by touching the probes across both directions. One way should produce a high pitched note – in the other direction you should hear either nothing or a very low pitched note.

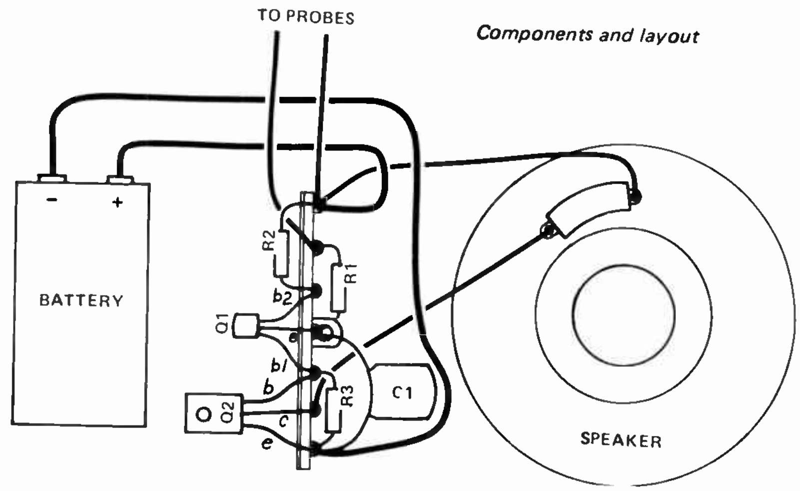
Experiment with various components known to be good so that you become familiar with the unit's operation.

Testing probes are connected to that point on the circuit marked 'input'. They may be made simply by stripping the insulation back an inch or two on the leads coming from the tester – or small crocodile clips may be attached to the leads.

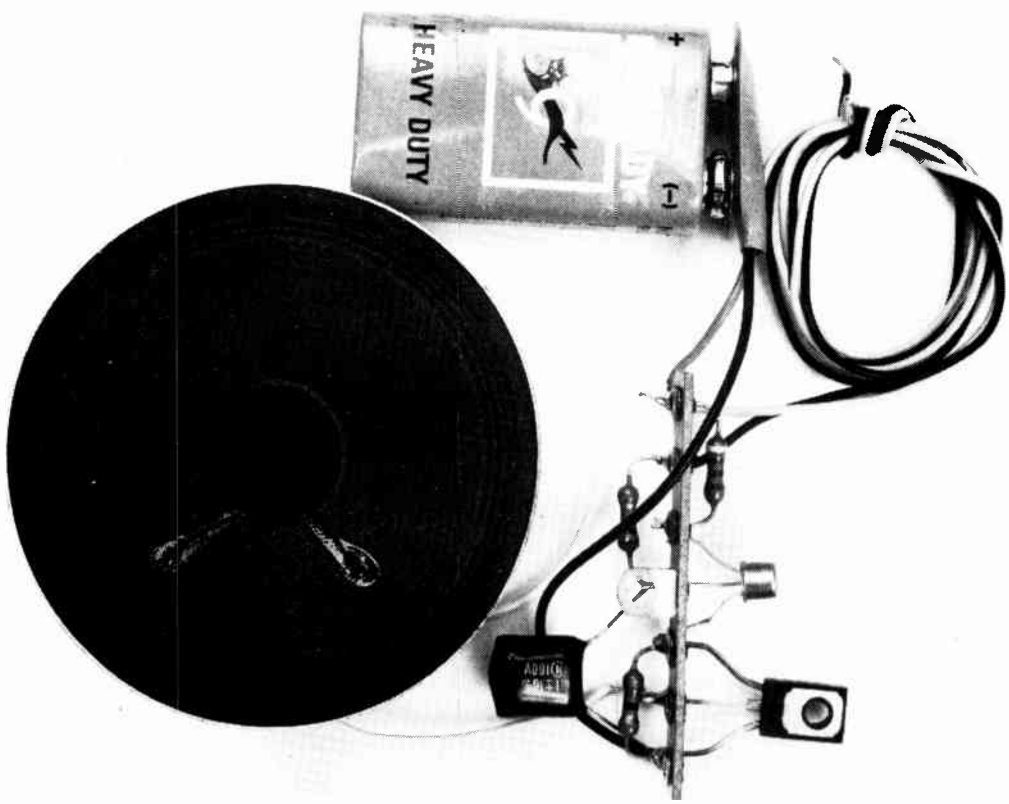
PARTS LIST
ETI 041

R1	Resistor	10 k ½ W 5%
R2	"	470 ohm
R3	"	330 ohm
C1	Capacitor 100 n polyester	
Q1	Transistor 2N2646	
Q2	"	BD 139 or similar

Speaker 8 · 15 ohm (but see main text)
Tag strip 7-way
Battery 9 V plus clip



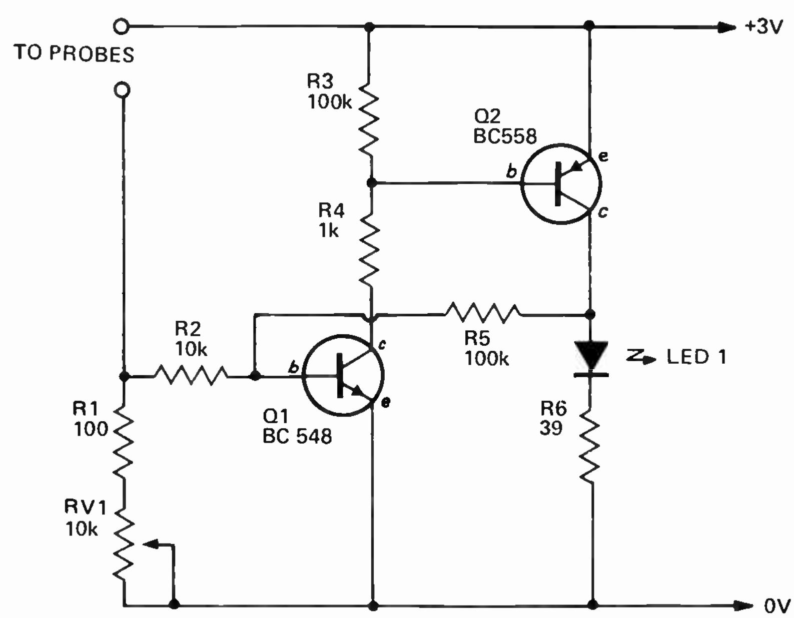
Components and layout



The continuity tester assembled

SOIL MOISTURE INDICATOR

Grow better plants electronically! This unit tells you when to supply water — and when not to.



PLANTS VARY considerably in their moisture requirements, but, in general, most plants need a cycle in which they are watered fairly heavily when the soil's moisture content falls below a certain fairly dry level. This is particularly true of grass.

Experiments have shown that if the optimum watering cycle can be provided, plants will frequently achieve growth that far exceeds the norm.

To a large extent the electrical resistance of a soil is directly related to its moisture content so it is fairly easy to devise a circuit which provides an indication of moisture content.

The unit shown here is a 'go-no go' tester. It has an external probe which is pushed momentarily into the soil directly adjacent to the plant to be checked. If the moisture content is adequate an LED will light up — if not it won't!

Potentiometer RV1 adjusts the moisture content point at which the LED will light. Some experimentation will be required to obtain the initial settings.

The circuit has been so arranged that virtually zero current is drawn when the probe is not in use — because of this there is no need for an on/off switch — the unit is thus ready for use at all times.

Layout is not at all critical and other layouts and forms of construction may be used if required — for example as one single unit with the probe extending from one end. Potentiometer RV1 could also be removed from the position shown and replaced by a small 10 k rotary potentiometer mounted on the other end of the case. A pointer knob and calibrated scale could be added to enable the unit to be used to monitor plants with different moisture requirements.

The probe itself should consist of two metal strips or prongs separated by an insulating material. We used a short length of double sided printed circuit board for the prototype but you may feel it worthwhile making a more elegant version.

Probe length should be 100-150 mm. Probe width and spacing is not critical.

When assembling the unit do make certain that the LED is connected the right way round. The cathode lead (that shown as the horizontal bar in the circuit drawing) will be identified by a 'flat' adjacent to it on the body of the component — or by the cathode lead being shorter.

Unlike most of the other projects in this series, this unit requires only a three volt supply. We have shown it operating from two 1½ volt (AA) cells. However the current drawn is very low so smaller cells could be used if necessary.

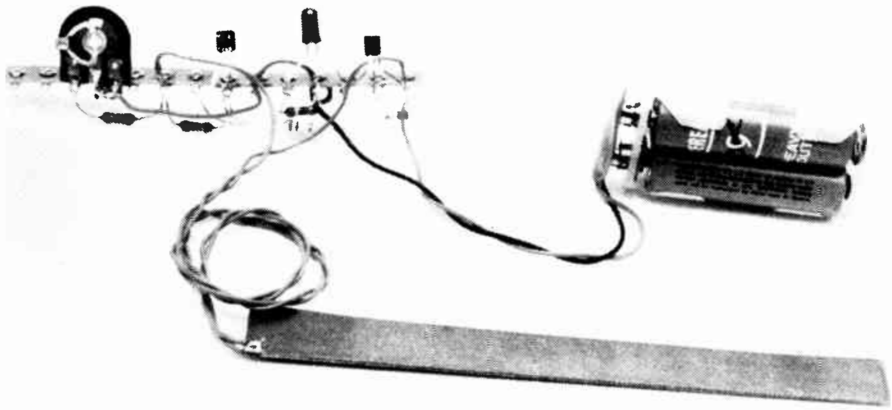
A nice touch would be to use a green LED rather than the red ones normally in use.

HOW IT WORKS – ETI 042

The circuit monitors resistance from 500 ohms to approximately 50 k and causes an LED to light up when the probe encounters resistance below any preset level within that range.

If resistance is lower than the level preset, Q1 is turned on – turning on Q2, and thus energizing the LED. Resistor R5 provides positive feedback to Q1 – this causes the circuit to operate with a 'snap action'.

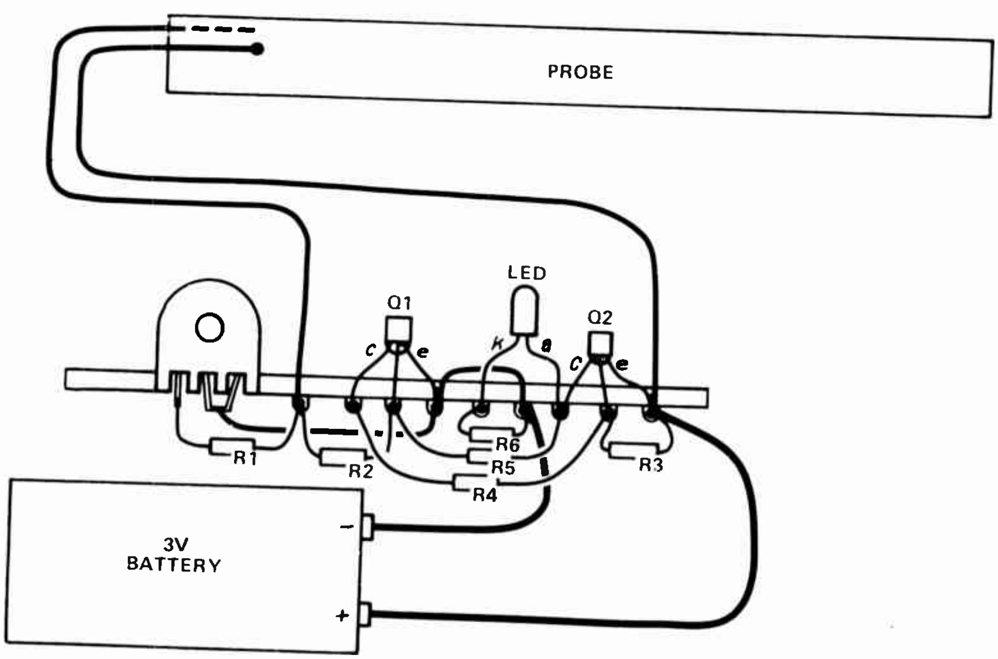
Current drain when the unit is not in use is negligible – the prototype unit drew less than 2 nanoamps. Because of this no on/off switch is required.



PARTS LIST – ETI 042

R1	Resistor	100 ohm	½W	5%
R2	"	10 k	"	"
R3	"	100 k	"	"
R4	"	1 k	"	"
R5	"	100 k	"	"
R6	"	39 ohms	"	"
RV1	Trimpot	10 k		
Q1	Transistor	BC 548		
Q2	"	BC 558 (or similar)		
LED 1	Light emitting diode (preferably green)			

Tag strips
Battery clip
Two AA cells
Twin battery holder
Probe



Component arrangement. Note connections of transistors. The probe shown here is made from a small section of double sided PC board. One wire (dotted) leads to the obscured side, the other (solid) connects to the uppermost side.

HEADS OR TAILS

Learn about the laws of chance and various random phenomena with this interesting electronic multivibrator circuit.

IF YOU TOSS a coin a dozen times and it comes up heads every time — what are the chances of it coming up heads the thirteenth time. Thirteen to one against? Or fifty/fifty?

If you said it was thirteen to one against, imagine putting that coin in your pocket and repeating the experiment with the same coin in a week's time. What then are the odds? If they're not fifty/fifty — why not?

Here's an interesting circuit which will enable you to experiment with similar chance or randomness effects.

The circuit is one of the basic building blocks of electronics. It is called a 'multivibrator' and consists of two transistors which alternatively switch each other on and off.

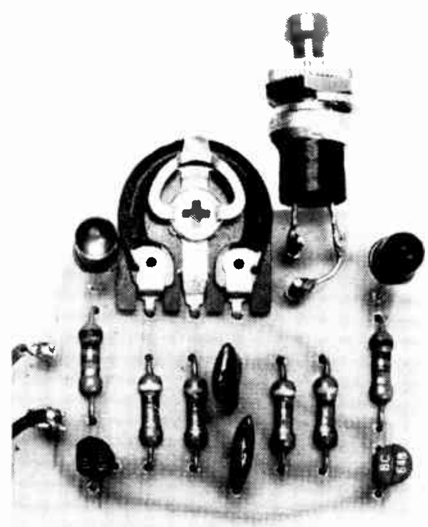
When the pushbutton is held down the multivibrator switches to and fro at 700 or so oscillations per second (i.e. 700 Hz).

When the button is released the circuit will assume one of two possible states. Either Q1 will be conducting and Q2 shut off — or vice-versa. The transistor that is conducting draws sufficient current through its associated resistor (R1 or R6) to cause the light emitting diode (LED) to light.

Note the circuit is totally symmetrical and that the two transistors are cross-coupled. If corresponding components are exactly matched there is precisely equal probability that either transistor will be on when the button is released.

In practice, electronic components never *are* absolutely identical, so RV1 has been included so that the circuit can be adjusted for total symmetry. Alternatively RV1 may be adjusted so that the effect of bias can be observed. If more precise control is required, RV1 may be made smaller (10k or so). It may be necessary to pad out R2 or R5 to enable the circuit to be balanced with the smaller value of RV1 in circuit.

To alter the flash rate change the value of capacitors C1 and C2. Increasing these to 10 uF will reduce the rate to approximately once per second and a half. If electrolytic capacitors are used make sure that the positive terminals are connected to the transistor collectors (marked 'c' on Q1 and Q2).



Construction

As the circuit is simple and symmetrical it lends itself to asembling onto a pair of 6-way tag strips. Alternatively the unit may be assembled on a small printed circuit board — as shown in Fig 2.

Do make sure that the transistors are the right way round — likewise the

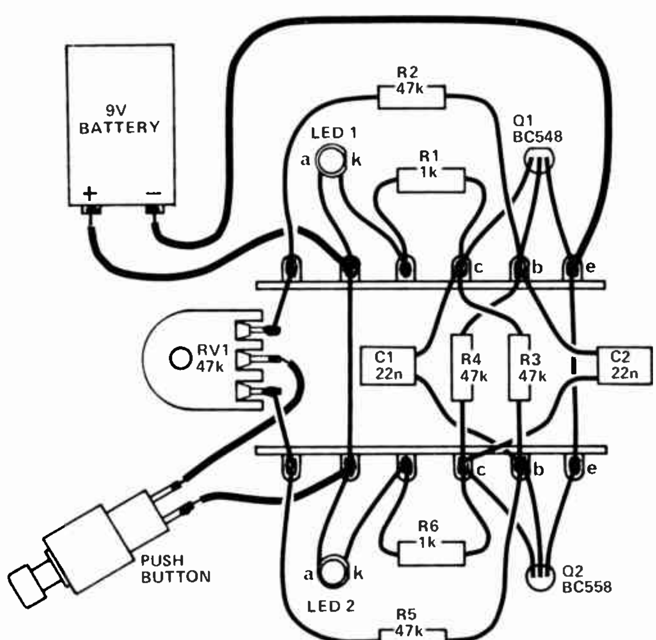


Fig. 1. Layout of the tag strip version.

HOW IT WORKS – ETI 043

This circuit may be considered as a multivibrator, when the button is pressed, and as a flip flop, when the button is released. If initially we consider the circuit with R2,R5,C1 and C2 deleted we have a standard flip flop. If Q1 is on it robs current from the base of Q2, thus turning it off. Transistor Q1 will be held on by the current through R6 and R4. However, if Q2 is on, the reverse is the case. Thus only one of the transistors can be on at any time – never both.

The addition of R2,R5 and C1,C2 will not alter the above, providing the push button is not pressed. However if the button is pressed the current through R2 and R5 will try to turn on both transistors.

Take the case where initially Q1 is on and Q2 is off. The voltage on the collector of Q1 will be about 0.5 volts and the voltage on Q2 collector about seven volts. We therefore have about 6.4 volts across C2 (as the base of Q1 is at about 0.6 volts). When the button is pressed Q2 will turn on and its collector will drop to 0.5 volts.

However a capacitor cannot instantly change its voltage and the base of Q1 will therefore be forced to -5.9 volts which turns off the transistor. Capacitor C2 then discharges via R2 and R4 until the base voltage is again at +0.6 volts when Q1 will turn on again. This however forces the base of Q2 to -5.9 volts (due to C1) thus turning Q2 off. This process continues back and forth until the push button is released. The circuit then stops in the state it was at the instant of releasing the button.

To add bias to the circuit RV1 can be adjusted to change the discharge time of C1 or C2 by up to 50%. In this case the two transistors will not be on for equal times and the results will be biased towards one side.

LEDs are included in the collector circuits of each transistor to indicate which transistor is on. If, for display purposes, a slower-running unit is required the values of C1 and C2 may be increased. If both are 10 microfarad electrolytic capacitors the rate will be about 1.5 seconds. Make sure if electrolytics are used that the positive terminal is connected to the collector of the transistor.

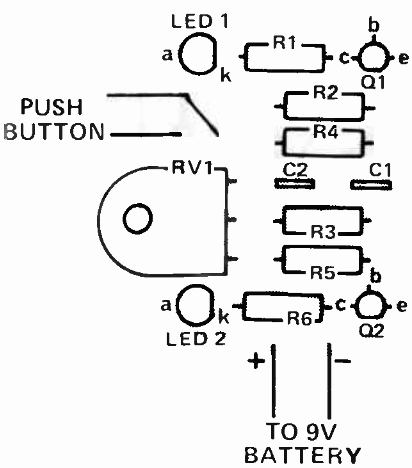


Fig. 2. Layout of the printed-circuit board version.

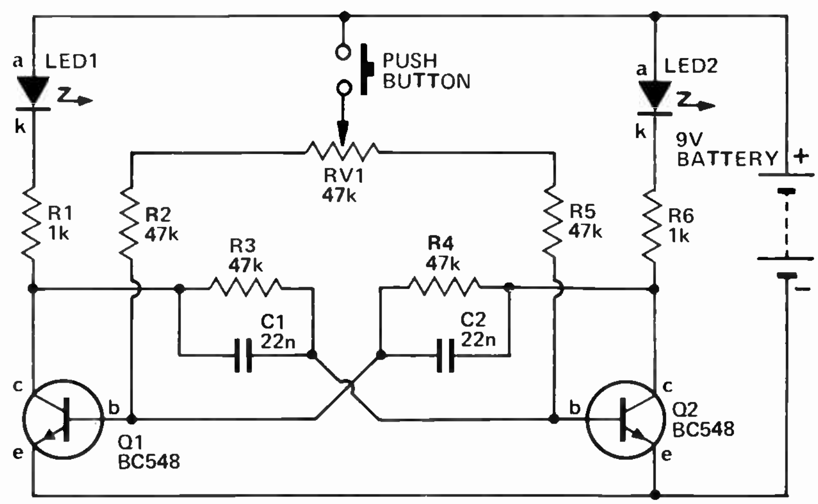


Fig. 3. Circuit diagram of the unit.

PARTS LIST – ETI 043

R1	Resistor	1 k ½w 5%
R2-R5	Resistor	47 k ½w 5%
R6	Resistor	1 k ½w 5%
RV1	Potentiometer	47 k trim type
C1,2	Capacitors	22n polyester
Q1,2	Transistors	BC548
LED 1,2	Light emitting diodes	

Push button press-to-make
9V battery clip
Two 6 way tag strips

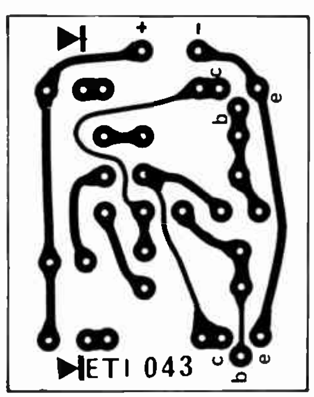


Fig. 4. Printed circuit board layout – full size 40 x 50 mm.

LEDs – the latter will have their cathode terminals (k) marked in some way. Usually this will be via a small flat on the body of the LED adjacent to the cathode lead. Some LEDs are marked simply by having the cathode lead shorter than the anode, so don't cut the leads until you're sure you know which is which!

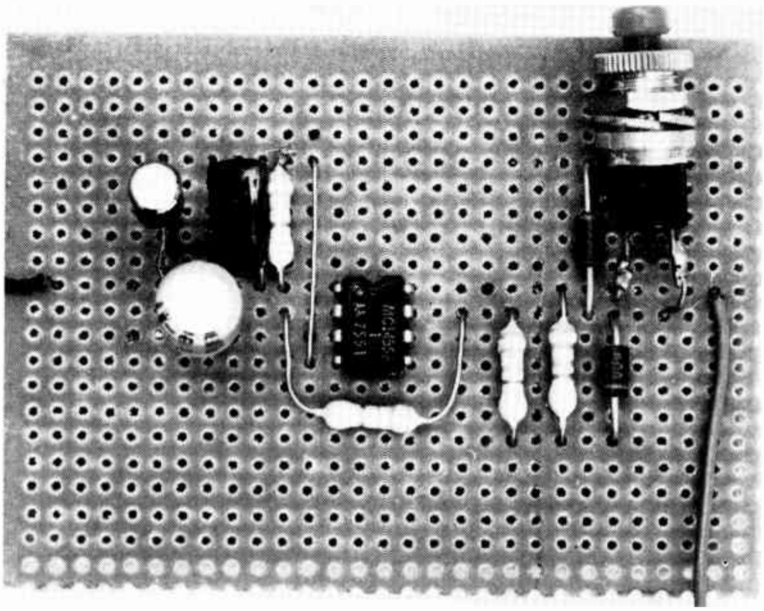
Don't switch on until you have double checked that all components are the right way round. A transistor or LED may be destroyed if wrongly connected. Also double check the battery connections – a reversed battery may also destroy the semiconductors.

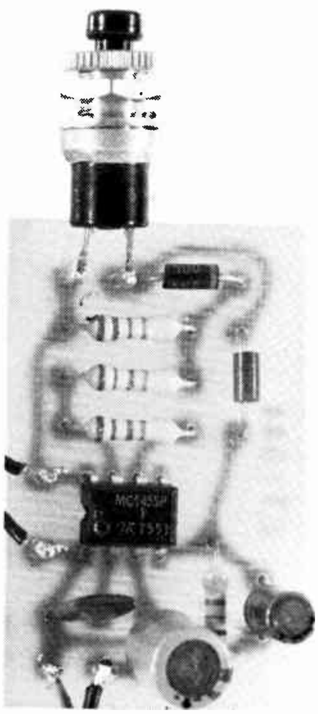
This is a very simple circuit and providing it is wired as shown it will work first time – if only one LED (or neither) flashes it is virtually certain that one or both LEDs are faulty.

TWO TONE DOORBELL

A simple circuit based on the 555 integrated circuit used in both timing and oscillator modes of operation.

THIS ELECTRONIC DOORBELL IS based on the 555 integrated circuit. The device is widely used in many types of timers and as a simple oscillator. In this project both operations are used. When the button is pressed the 555 oscillates at one frequency (tone), when the button is released the tone changes and the IC continues to produce this second tone for a predetermined period. Thus by pressing the control button once a two-tone doorbell sound is produced by the speaker driven directly from the integrated circuit.





Construction

The circuit is very simple and contains only a few parts. It may be very quickly assembled on a piece of Veroboard. However any other method may be used if desired as the layout is not critical.

Veroboard has copper tracks on one side and these must be cut in ten places as shown in Fig. 2. The tracks are cut by using a small drill bit, rotated by hand, to clear the copper from around the hole. Note also that two holes are cleared between the integrated circuit pins, as pins 2 and 6 must be linked on the track side of the board. Clearing these holes eliminates any possibility of the link shorting to the track through the centre of the pins.

The integrated circuit, diodes, and the electrolytic capacitors must be mounted the correct way around. The overlay shows the distinguishing marks on each component, and the component must be placed so that the marks on the component are the same way as on the overlay diagram.

Whilst the push button on our unit is shown mounted onto the board it would normally be mounted remote from the board and a pair of leads would need to be run from the board to the remote button. We used a small nine-volt battery to power our unit but as the current drain is about five milliamps at all times a battery eliminator or separate power supply would need to be used in permanent installations.

HOW IT WORKS – ETI 044

The two-tone doorbell project is based around the 555 timer IC which is made to operate as an oscillator at two different frequencies. The second frequency is held for a fixed time before the unit switches off.

The 555 IC has a number of functional circuit blocks within it. The first of these are two level detectors. The first level detector is set to operate when the voltage at pin 2 rises above 6 volts (two-thirds of the supply voltage) and the second level detector is set to operate at 3 volts (one third of the supply voltage). If both pins 2 and 6 are higher than their respective threshold voltages the output from the IC at pin 3 will be 'low' at about 0.5 volts. If both pins 2 and 6 are lower than their respective thresholds the output of the IC will be 'high' at about 8.5 volts. The case where pin 2 is higher than its threshold and pin 6 is lower than its threshold is not defined and the output could be in either a high or low state. The only remaining possibility is where both pins are somewhere between 3 and 6 volts. In this case the output will not change from its previously set state.

When the output of the IC is caused to go low, an internal transistor connected between pin 7 and ground is turned on thus effectively shorting pin 7 to ground (pin 1). There is also a reset input (pin 4) available but we will leave the explanation of this for the moment.

Operation of the doorbell may be described as follows: The capacitor C2 initially charges towards plus nine volts via resistors R2, 3 and 4. However the top of the capacitor is connected to both pin 2 and pin 6 of the 555 timer IC. Hence when the voltage on the capacitor reaches 6 volts both comparators will be above threshold and the output of the 555 at pin 3 will go low and the internal transistor will switch on, shorting pin 7 to ground. However pin 7 is connected to the junction of R3 and R4 and C2 will therefore now be discharged via R4. When the voltage on C2 falls below 3 volts the output will go high again, the transistor will turn off, and C2 will commence charging again via R2, 3 and 4. This sequence continues thus producing a triangular waveform across C2 and a pulse train at pin 3. The pulse train output from pin 3 is coupled to the loudspeaker via C3 which prevents the dc component of the voltage from reaching the speaker.

The triangular waveform is produced by C2 charging from 3 to 6 volts and then discharging from 6V to 3V.

The time for C2 to charge from 3V to 6V is:–

$$T_c = 0.69\,(R2+R3+R4) \times 22 \times 10^{-9} \text{ seconds}$$
$$= 1.5 \text{ milliseconds}$$

and the discharge time from 6V to 3V is:–

$$T_d = 0.69\,(R4) \times 22 \times 10^{-9} \text{ seconds}$$
$$= 0.5 \text{ milliseconds}$$

The total time for a complete cycle is therefore about 2 milliseconds and since frequency is the reciprocal of period

$$f = \frac{1}{P} = \frac{1}{2 \times 10^{-3}}$$
$$= 500 \text{ Hz}$$

When the button is pressed resistor R2 is shorted out by the push button and this reduces the charging time to

$$0.69\,(R3 + R4) \times 22 \times 10^{-9} \text{ seconds}$$
$$= 1 \text{ millisecond}$$

The total period whilst the button is pressed is about 1.5 milliseconds equivalent to a frequency of 667 Hz. That is the pitch is higher whilst the button is pressed.

Lastly we must consider the effect of the circuitry connected to the reset terminal. If the voltage on this terminal is less than about 0.8 volts the output of the IC will go high and the oscillation will stop. When the button is pressed capacitor C1 is charged up to about 8.5 volts via diode D2 allowing the oscillator to start, whenever the button is pressed it shorts out resistor R2 via diode D1 and the output of the oscillator will be 667 Hz. When the button is released the lower frequency is produced immediately and C1 begins to discharge via R1. After about ¾ of a second the voltage across C1 will have dropped below 0.8 volts and the oscillator will stop. The output will therefore be the higher tone whilst the button is pressed followed by ¾ second of the low tone after the button is released.

The two diodes are needed to isolate the two control functions which are performed by the one push button. If a two-pole push button were to be used the functions could be isolated and the diodes would not be required. However two-pole push buttons are not generally obtainable and the diode approach was therefore used.

If a different pitch tone is required R2,3,4 or C2 may be altered in value. The new frequencies may be calculated using the formulae given above. If a longer period is required for the second tone this may be obtained by increasing the value of C1. (Decrease the value for a shorter second tone).

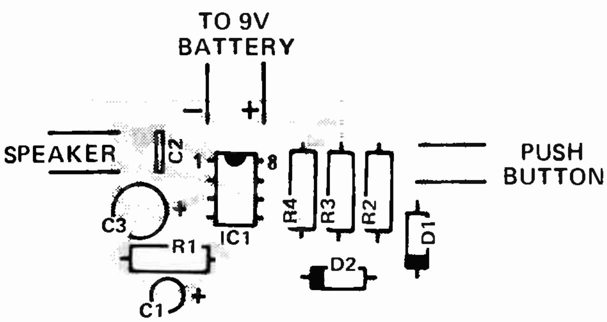


Fig. 4. This overlay shows how to fit components to the printed-circuit board.

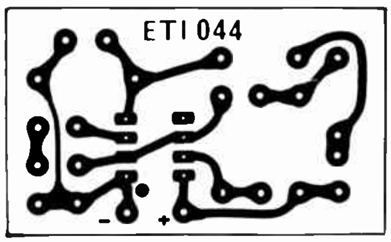


Fig. 5. Printed-circuit board layout (copper side). Full size of this board is 50mm x 30mm.

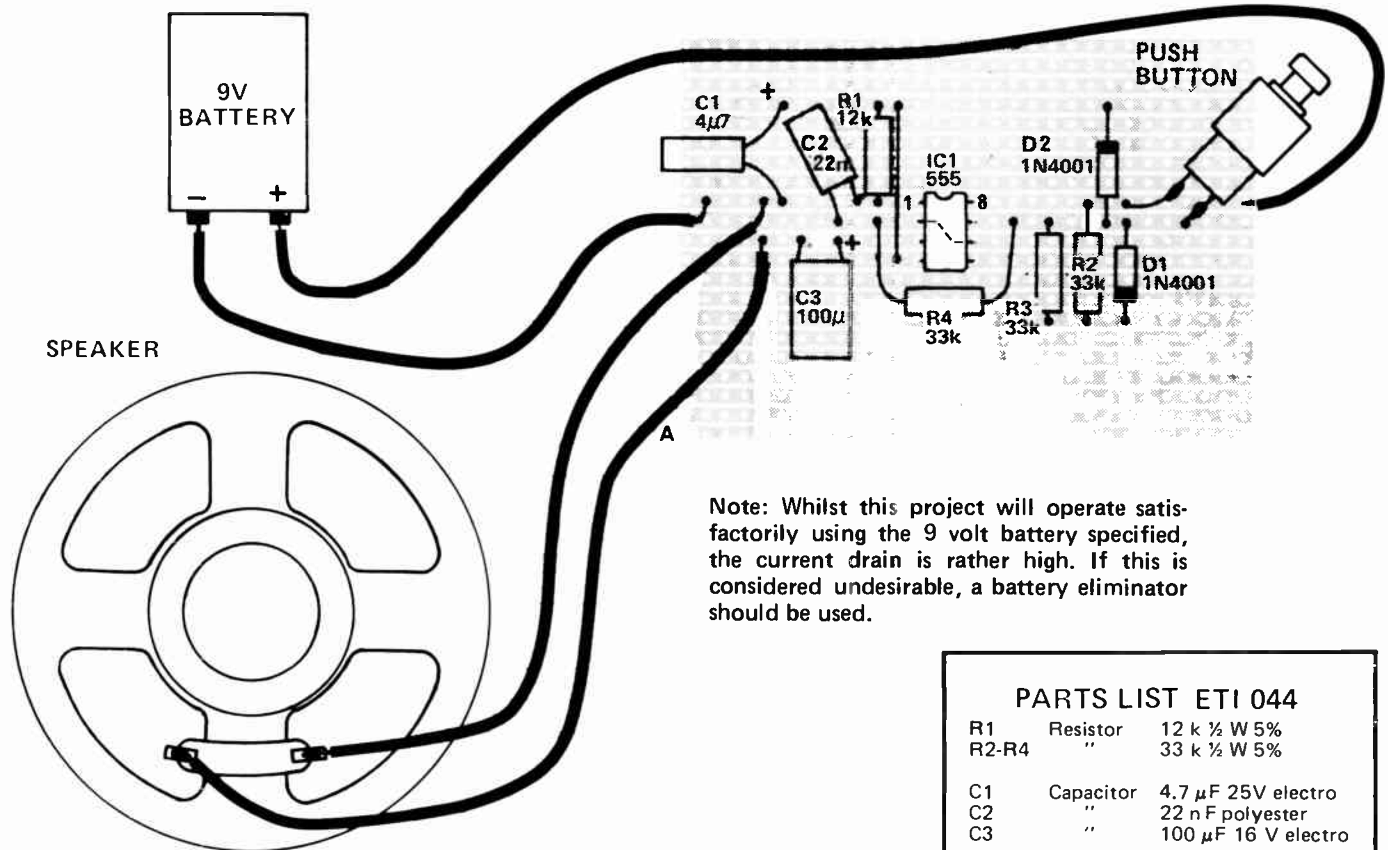


Fig. 1. Use this diagram to fit the components or wire the unit. Note the wire link between R1 and IC1 and the link between pins 2 and 6 of IC1. The link is on the track side of the board.

Note: Whilst this project will operate satisfactorily using the 9 volt battery specified, the current drain is rather high. If this is considered undesirable, a battery eliminator should be used.

PARTS LIST ETI 044

R1	Resistor	12 k ½ W 5%
R2-R4	"	33 k ½ W 5%
C1	Capacitor	4.7 μF 25V electro
C2	"	22 n F polyester
C3	"	100 μF 16 V electro
D1,2	Diodes	1N4001
IC2	Timer	555

Speaker 8–100 ohm
Push button – press to make
9 V battery
Battery clip
Veroboard or PCB ETI 044

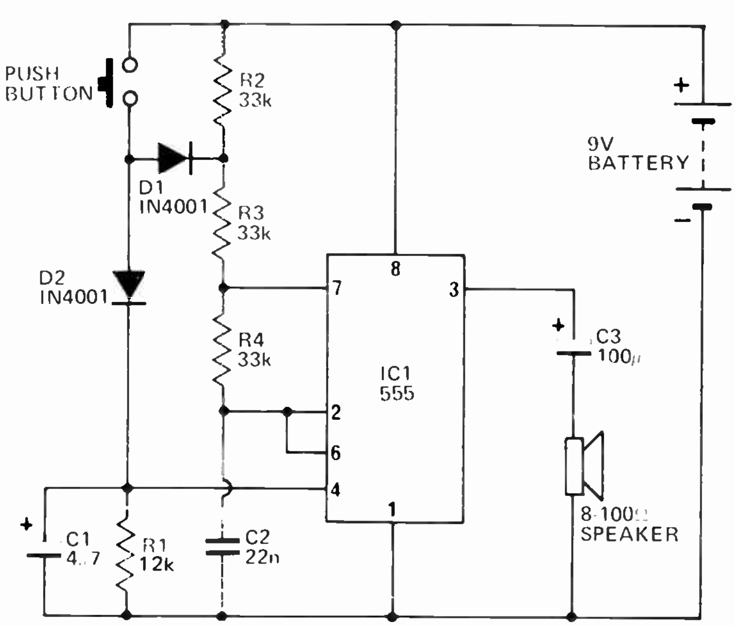


Fig. 3. Circuit diagram of the two-tone doorbell.

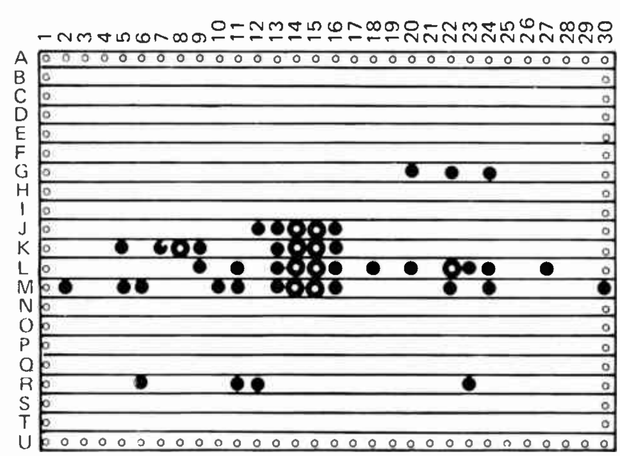


Fig. 2. The pads with holes through them indicate where the Veroboard track must be cut with a small drill as detailed in the text. The solid dots indicate where components are soldered to the tracks.

500 SECOND TIMER

Electronic timer is adjustable from a few milliseconds to approx 500 seconds it sounds an alarm at the end of the preset period.

MOST TIMING DEVICES ARE clockwork mechanisms which ring a bell at the end of a preset period. They are relatively cheap and reliable but often difficult to build into existing equipment or adapt to specific needs.

The timer described here has none of these limitations. It is small and light so it may readily be built into existing devices — and the actual warning device may be mounted remotely from the timer itself.

Timing is adjustable (by RV1) from a minimum of a few milliseconds to a maximum of approximately 500 seconds. At the end of the preset period the loudspeaker will produce a loud warning tone.

The circuit is based on the ubiquitous 555 timer IC. This is used here not only as part of the timing circuit but also as an oscillator to generate the warning tone at the end of the preset period.

As with most other circuits in this book the components may be assembled on Veroboard or on the printed circuit board designed for this project. Usual care must be taken to ensure that the main components are located exactly as shown in our drawings.

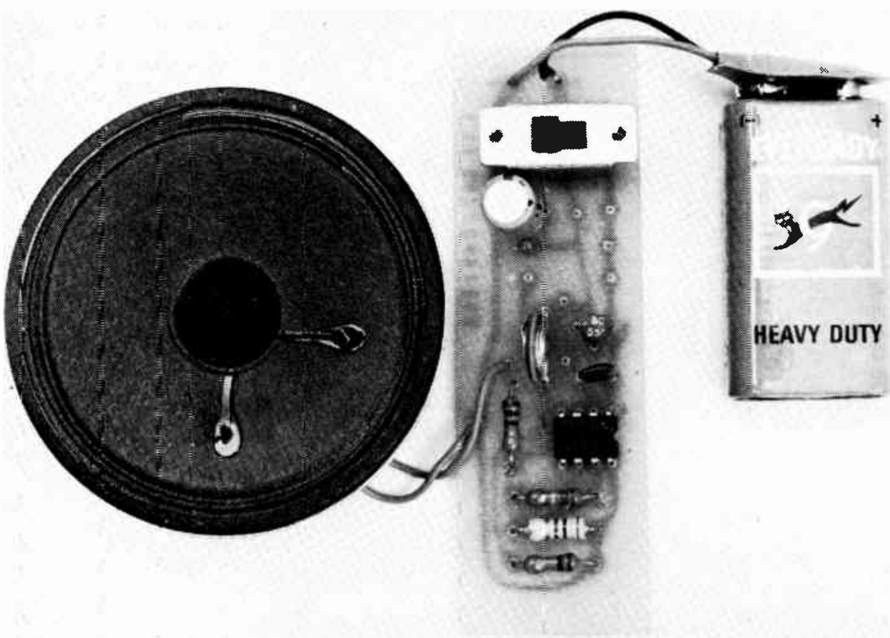
Notes:

Switch SW1 must be a double pole unit as specified. If desired this switch may be removed from the board and connected via a suitable length of multicore cable.

The timing potentiometer may also be located at a distance from the unit in this case it will be better to replace the small preset unit with a ½ watt rotary unit.

If more accurate control is required over a limited range simply reduce the value of RV1 from the specified 5 M to 1 M or less (experiment with fixed value resistors until you have the required result then substitute a suitable value potentiometer).

The speaker and the battery may also be mounted away from the circuit board. If this is done you may find that at the end of the preset time the warning signal starts at a low volume. This may be remedied by connecting a 10 nF capacitor across pins 1 and 8 of the 555 IC.



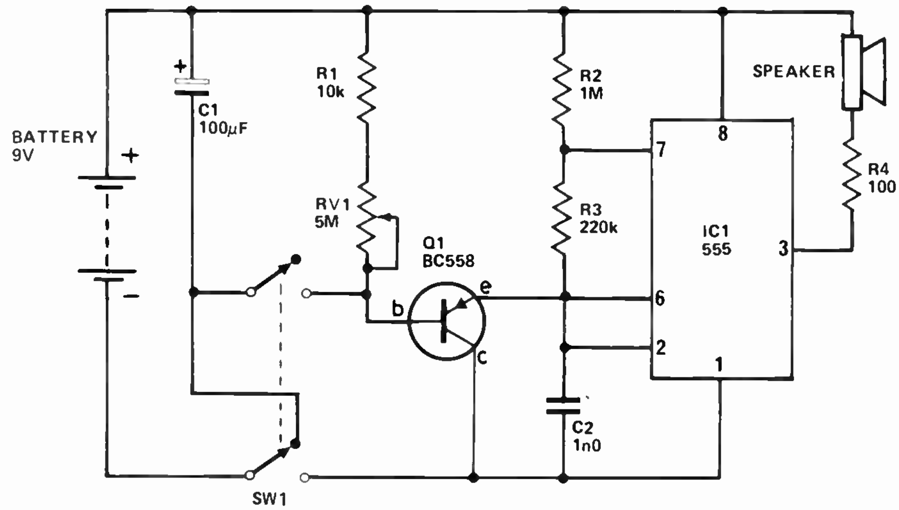
HOW IT WORKS – ETI 045

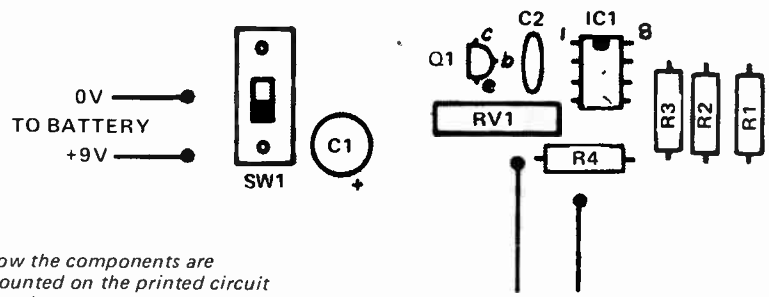
The unit produces a warning tone at a preset period after switching on. The delay period is dependent upon C1/R1 and RV1 and is adjustable from a minimum of a few milliseconds to a maximum of approximately 500 seconds.

The 555 IC will oscillate if a voltage greater than 2/3rds of the voltage across the device is applied to pins 2 and 6. When it oscillates it produces a square wave which is turned into an audible warning tone by the loudspeaker.

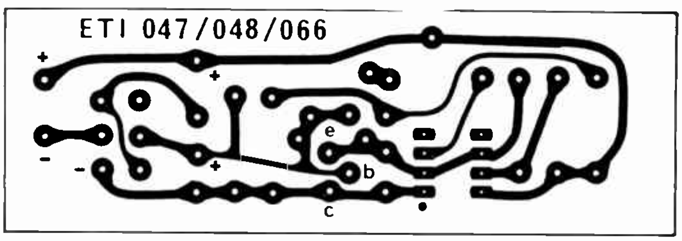
In its 'switched off' state the circuit is arranged such that the 100 uF capacitor C1 is connected across the battery and is thus normally fully charged. When the timer is energised i.e. by closing SW1, C1 discharges via transistor Q1 at a rate determined by the bias resistors R1 and RV1. Thus the emitter of Q1 is held at a low voltage, in turn clamping pins 2 and 6 of the 555 IC below the '2/3rds' level

As the capacitor slowly discharges, the voltage at pins 2 and 6 slowly rises until the '2/3rds' level is exceeded. As soon as this occurs the 555 commences to oscillate thus producing the warning tone.





How the components are mounted on the printed circuit board.

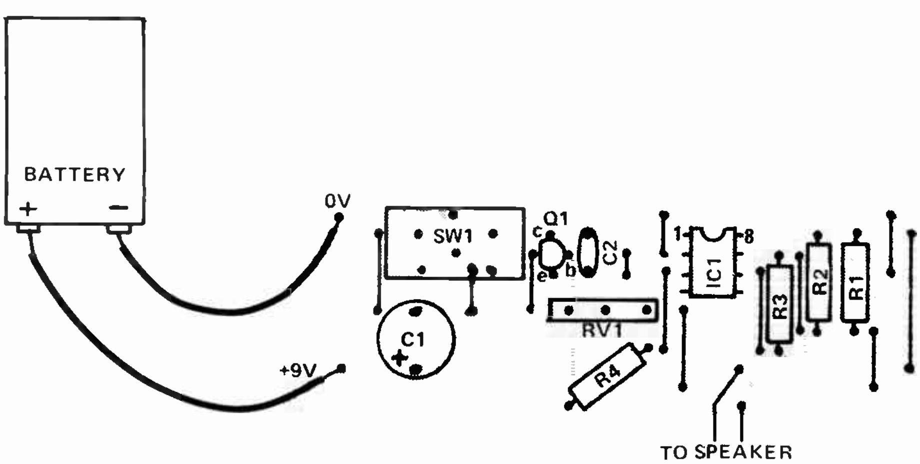


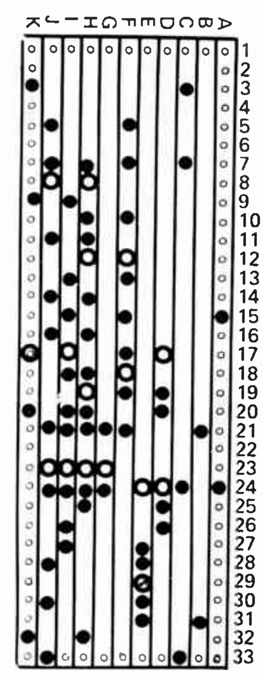
Printed circuit board layout – this board is also used in other projects in this series.

PARTS LIST ETI 045

R1,	Resistor 10 k ½ W 5%
R2,	Resistor 1 M ½ W 5%
R3	Resistor 220k ½W 5%
R4	Resistor 100 ohm ½ W 5%
RV1	Trimpot 5 Meg
C1	Capacitor 100 µF 16 V electrolytic
C2	Capacitor 1n0 polyester
Q1	Transistor BC 558 or equivalent

Slide switch dpdt
PC board ETI 048 or Veroboard
Battery 9 volt plus clip
Speaker 8 or 16 ohms.





MORSE PRACTICE SET

Here's an up-to-the-minute version of a Morse practice set.

THE MORSE CODE was the original telegraphic code — a slightly modified version -- still known as the Morse Code — is used today. Today's version differs in some respects from the original but it's a truly international code recognised by all countries.

The great advantage that Morse Code has over speech communication is that it has a far greater chance of being read correctly in poor reception conditions. This is because it consists of a sequence of dots and dashes of fixed pitch and providing one is familiar with the Code it is possible to interpret the sequences correctly in reception conditions that would render speech quite unrecognisable.

A really experienced operator can transmit and receive Morse at speeds as high as 60 words a minute (that's about a third of the rate of normal speech). Most operators work slower than that — twenty to twenty five words per minute is usual for radio amateurs — many of whom still use Morse regularly.

Interest in learning the Morse Code was re-aroused recently in Australia following the introduction of the Novice Licence. This scheme enables people to enter amateur radio without having to obtain the high level of technical proficiency necessary to hold a full Licence.

One condition of obtaining the Novice Licence is proficiency in sending and receiving Morse at a rate of not less than five words per minute. This is a very slow rate and it is perfectly feasible to reach this speed within a week or two of starting given a fair amount of practice.

The project described in this article is an oscillator designed specifically for Morse Code practice. It is based on the same 555 IC used in many other projects in this series.

Construction

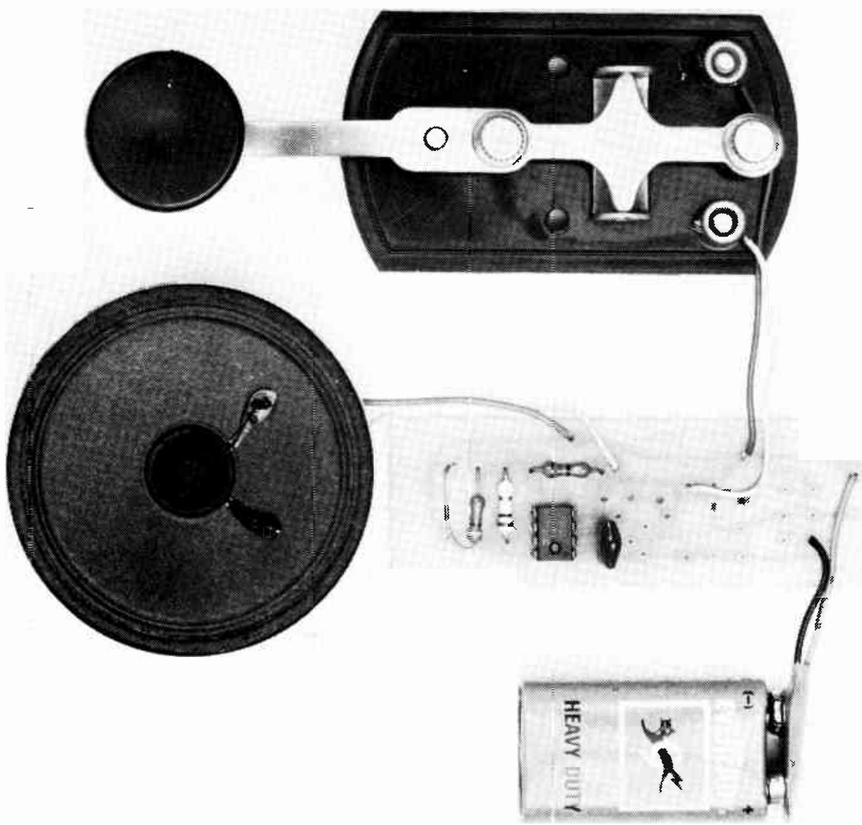
Apart from the battery, speaker and Morse key — all of which are located away from the main circuit — the oscillator requires only one 555 IC plus four other components. These may be mounted on a short strip of Veroboard.

An alternative approach is to use the printed circuit board shown in this article. This (ETI 047/048/066) is a multi-purpose board designed to be used also for the Buzz-board Game, Boiling Water Indicator and 500 Second Timer published in this series.

The layout of the Morse Code oscillator is in no way critical. If desired the speaker may be located hundreds of metres away from the oscillator. If you make up a pair of these units you can establish a simple two way telegraph link.

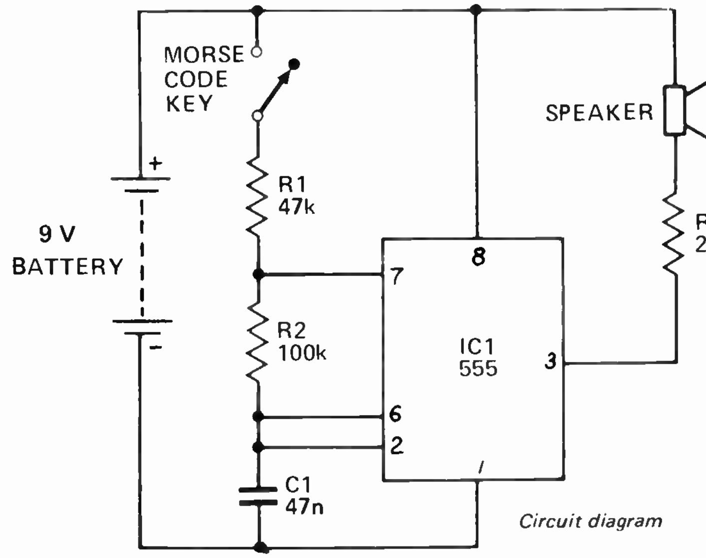
The Morse key may be purchased quite cheaply from many electronic component suppliers. Alternatively a key can be made using a strip of springy brass with a suitable knob mounted on one end.

If desired the pitch of the unit may be changed by varying the value of capacitor C1. Increasing the value will decrease the pitch — and vice-versa.

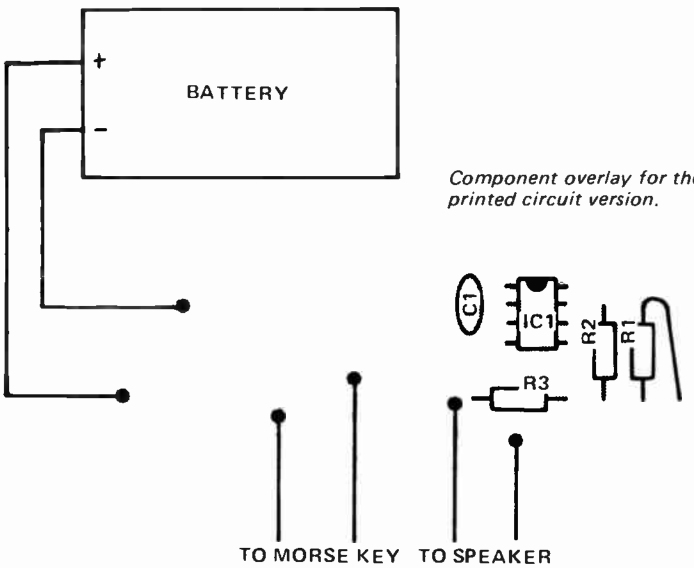


HOW IT WORKS – ETI 047

When the Morse key is pressed down current flows through resistors R1 and R2 thus charging up capacitor C1. When the voltage across C1 reaches the required 2/3rds battery voltage level, the 555 conducts – discharging C1 via R2 until the voltage is 1/3 Vc. The cycle is continuously repeated whilst the key remains depressed thus causing a tone to be generated by the loudspeaker.



Circuit diagram

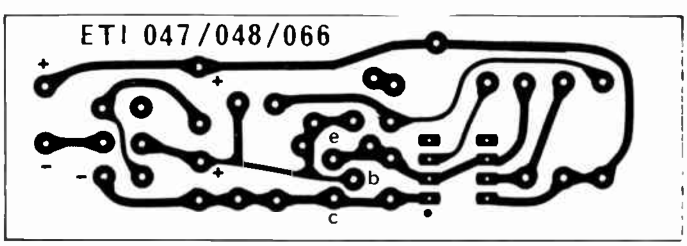


Component overlay for the printed circuit version.

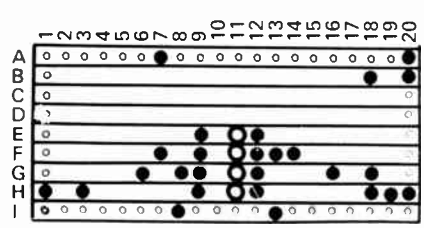
PARTS LIST - ETI 047

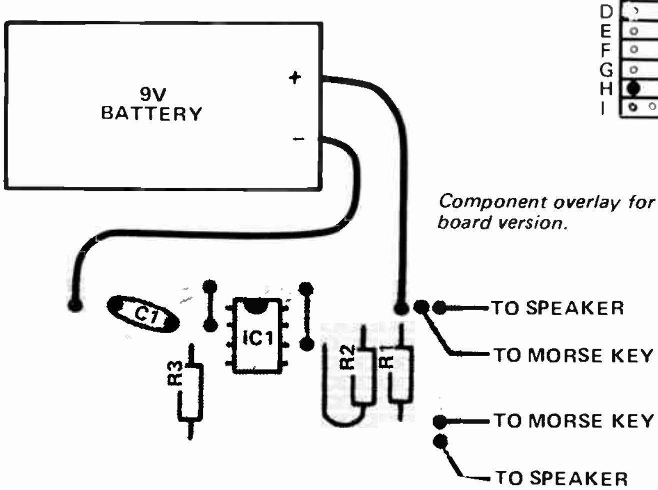
R1	Resistor	47 k	½ W	5%
R2	"	100 k	"	"
R3	"	22 ohm	"	"
C1	Capacitor	47 nF polyester		
IC1	Integrated circuit 555			

Printed circuit board ETI 047 (or Veroboard)
Battery nine volt plus clip
Morse key



Note the printed circuit board for the Morse code practice set is also used in several other projects.





Component overlay for Vero-board version.

Note:

One 'dah' should be equal to three 'dits' in length.

The space between parts of the same letter should be equal to one 'dit'.

The space between two letters should be equal to three 'dits' (or one 'dah).

The space between two words should be equal to six 'dits'.

THE MORSE CODE

A	di-dah
B	dah-di-di-dit
C	dah-di-dah-dit
D	dah-di-dit
E	dit
F	di-di-dah-dit
G	dah-dah-dit
H	di-di-di-dit
I	di-dit
J	di-dah-dah-dah
K	dah-di-dah
L	di-dah-di-dit
M	dah-dah
N	dah-dit
O	dah-dah-dah
P	di-dah-dah-dit
Q	dah-dah-di-dah
R	di-dah-dit
S	di-di-dit
T	dah
U	di-di-dah
V	di-di-di-dah
W	di-dah-dah
X	dah-di-di-dah
Y	dah-di-dah-dah
Z	dah-dah-di-dit
1	di-dah-dah-dah-dah
2	di-di-dah-dah-dah
3	di-di-di-dah-dah
4	di-di-di-di-dah
5	di-di-di-di-dit
6	dah-di-di-di-dit
7	dah-dah-di-di-dit
8	dah-dah-dah-di-dit
9	dah-dah-dah-dah-dit
0	a long dah, or dah-dit, or dah-dah-dah-dah-dah

BATTERY SAVER

Most of the projects in this series are powered by nine-volt batteries. Here's a project which will enable them or other similar devices – to be powered from your car's 12 volt system.

Here, the unit is shown ready for encapsulating.

VERY MANY battery operated electronic devices, tape recorders, record players, transistor radios etc. operate from nine volt batteries – as do most of the projects in this series.

If you use any of them in your car then rather than continually buying and replacing batteries why not build this adaptor which enables you to run them off the vehicle's 12 volt supply?

Although the majority of tape recorders etc do require nine volts a few run from six or four and a half volts so the unit shown here has been designed so that you can modify it accordingly as required – simply choose the components from the alternatives given in Table 1.

CONSTRUCTION

There are so few bits in this project that it's perfectly practicable to solder them directly onto the 3055 power transistor as shown in our construction assembly photograph. Note particularly the bands marking the cathode (negative) leads on the zener diode ZD1, the EM401 diode and the 10 μF capacitor.

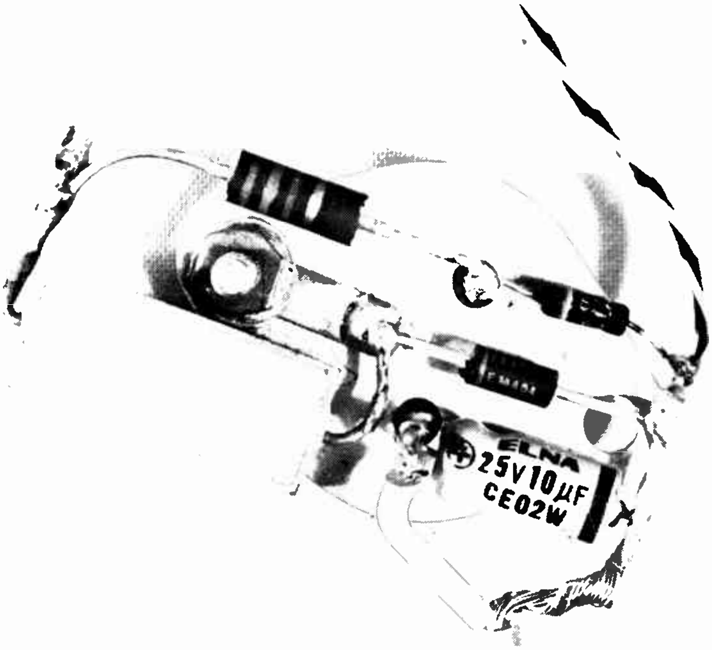
The 3055 power transistor specified is much larger than is really needed, but 3055s are cheap. There's no point in using a smaller transistor that costs more! Apart from which the 3055 has so much sufficient reserve capacity that no heat sink is required.

The finished unit can be mounted in various ways – the simplest is to put it in a small plastic box and encapsulate it in epoxy resin. But first check that all joints are correctly soldered and ensure that the unit works satisfactorily – because once that resin sets it's irreversible by most means short of dynamite.

USING THE UNIT

The unit has been designed so that it will not be damaged if the output is accidentally short circuited. Nevertheless a *continuous* short must not be applied as this will cause the 10 ohm resistor to overheat.

An external socket is fitted to many appliances so that they can be powered from a supply such as this. If no socket is fitted to your unit then one should be obtained – you can buy them quite readily from most component suppliers. Do note though that plugs and sockets intended for nine volts are not interchangeable for those meant for six volts, the centre pins are of different diameters. Make sure you obtain the type which has a contact for disconnecting the internal battery when the power supply is plugged in.



PARTS LIST

R1	resistor	220 ohm ½ watt 5%
R2	resistor	10 ohm 5 watt 10% (see How it Works)
C1	capacitor	10 µ 25 volt electrolytic
ZD1	zener diode	BZY88C10 (or equivalent)
D1	diode	EM401 (or similar)
Q1	transistor	3055

Note: component values quoted are for nine volts output — see Table 1 for other voltages.

HOW IT WORKS

Transistor Q1 acts as a variable resistance, dropping the supply voltage down to the required regulated output. The output of this transistor is controlled by zener diode ZD1. Resistor R1 supplies current for the correct operation of ZD1 and also provides base current for Q1. The 10 ohm series resistor prevents damage to Q1 if the output is short circuited.

Diode EM401 safeguards the unit against the 12 volt input being connected the wrong way round. If you are using a polarised plug then this diode may be left out. Again if you're certain that you won't short the output from the unit you can omit resistor R2 — replace it by a wire link.

As explained in the main text, all components are soldered directly onto the main power transistor. The complete assembly is then encapsulated in polyester or epoxy resin.

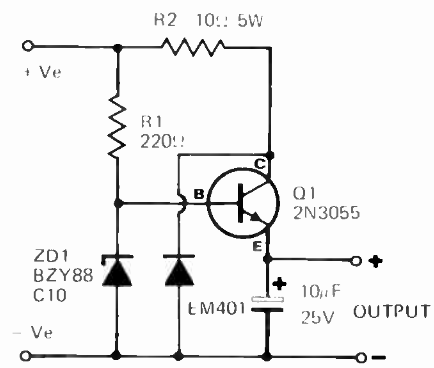


TABLE 1 Output Volts	ZD1	R1 (12V) ohms
9	BZY88C10	220
6	BZY88C6V8	470
4.5	BZY88C5V1	470

BUZZ BOARD

Test your steadiness of hand with this updated version of an old game of skill.

THIS PROJECT is a sophisticated version of a simple game in which the player attempts to pass a small metallic loop along a bent wire path without making contact with that wire.

In its simplest form there are no electronics at all: the 'circuit' consisting primarily of a battery and buzzer. The simple version works quite well but there is no facility for varying the difficulty of the game, short of bending the metal contacting loop.

The version shown here has a time delay built-in. This is adjustable so that the 'buzzer' will sound only if the loop contacts the wire for longer than the set time – and this time is adjustable from zero to a little less than one second.

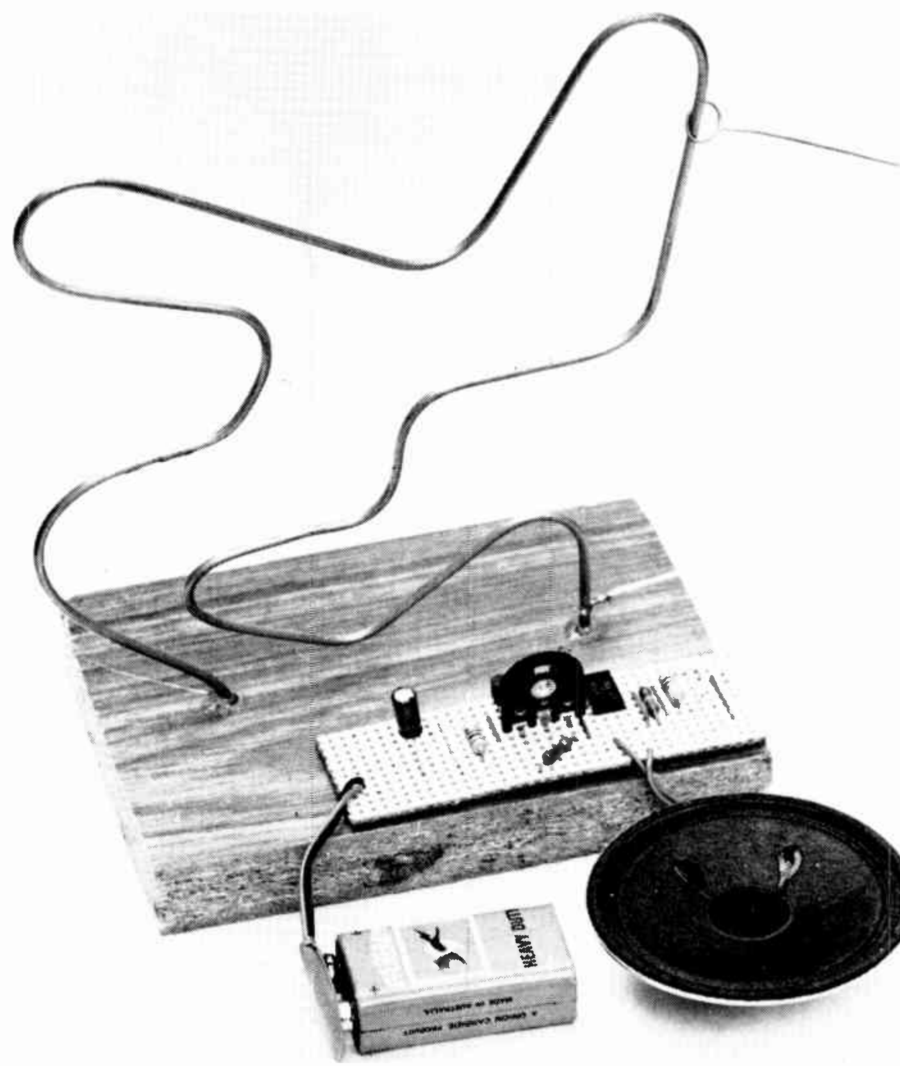
In many ways the circuit works similarly to the Timer described in ETI project 045. The reader may find it interesting to compare the two circuits.

CONSTRUCTION

As with most circuits described in this series the unit may be built up on Veroboard or the printed circuit board shown here. The external wire path should be made of heavy gauge bare wire – fencing wire or a straightened out coat-hanger for example. This path can be as long as you reasonably like – certainly several hundred metres if you want to make the game really tough!

The metallic sensing loop again should be made of heavy gauge wire or tubing. Unlike the simpler form of this game a low resistance contact between the loop and the wire is not essential – so it doesn't matter too much if either becomes a little tarnished.

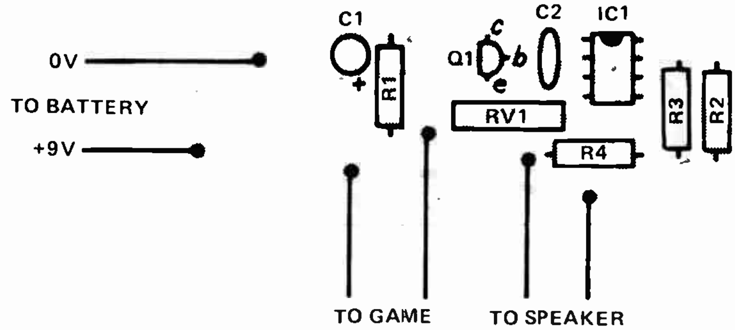
If required potentiometer RV1 may be removed from the board and located in any convenient manner. In this event it will probably be more satisfactory to replace it by a conventional ½ watt rotary potentiometer.



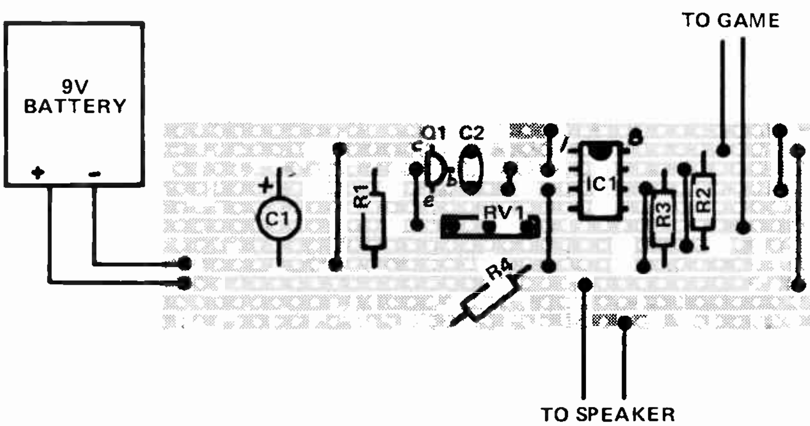
HOW IT WORKS — ETI 048

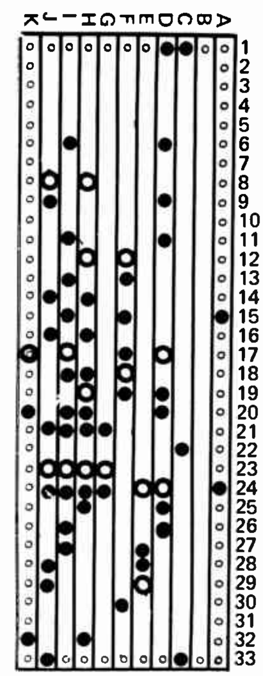
Transistor Q1 holds the voltage on pins 2 and 6 of the 555 IC below 2/3rds of the battery voltage whilst the game contacts are not made. This action prevents the 555 IC from oscillating.

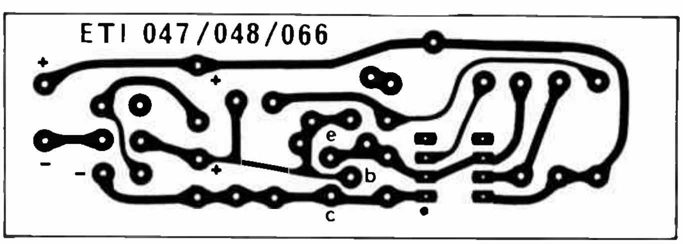
If the game contacts are made, capacitor C1 charges up via the potentiometer RV1. After a period (determined by the setting of RV1) the charge on C1 becomes high enough to bias Q1 to cut off. This action allows the 555 to commence oscillating thus producing a tone in the loudspeaker.



Here's how the components are located in the printed circuit board version of the game.







The PCB used in this project is also applicable in projects 047, 048 and 066. It is an ETI general purpose 555 PCB.

PARTS LIST — ETI 048

Resistors all ½ W 5%

R1,2	1 M
R3	220 k
R4	100 ohms

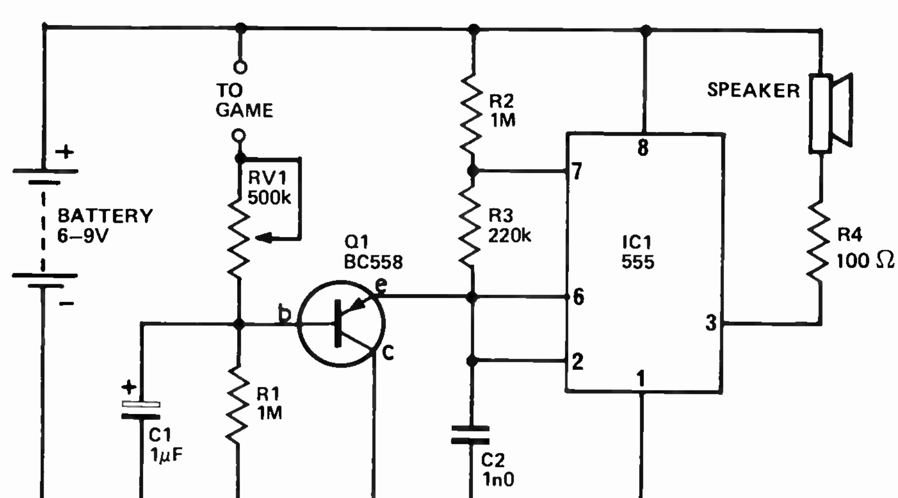
RV1 Trimpot 500 k

Capacitors

C1	1 μF 16 V electrolytic
C2	1n0 polyester

Q1 Transistor BC 558 or similar
IC1 Integrated circuit 555

Speaker 8-15 ohms any size
Printed circuit board ETI 048 or Veroboard
Nine volt battery and clip.



BASIC AMPLIFIER

A simple amplifier for the experimenter based on a discrete component. This useful unit also teaches the basics of audio power amplifiers.

ALL THE PROJECTS described in this series so far are self-contained – that is they need no additional amplifiers or other major bits and pieces to enable them to be used.

In this part of the series however we have included several projects each of which requires an amplifier stage for its operation. These projects are:–

ETI 062 AM tuner
ETI 063 Bongo drums
ETI 064 Intercom

Rather than building individual amplifiers into each of these projects we have designed one basic amplifier which may be used for any or all of them. This amplifier may also be used for experimental purposes.

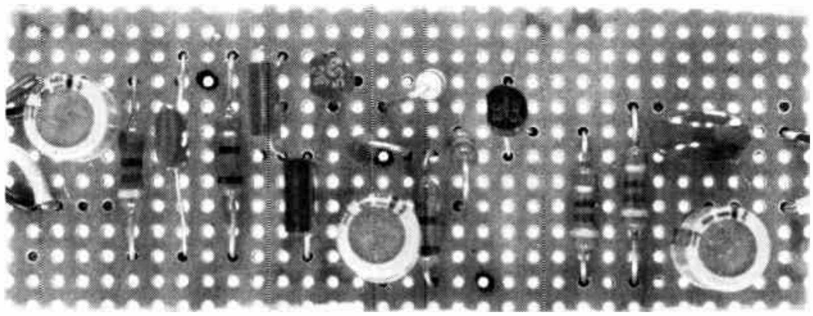
A basic amplifier can be designed in many different ways.

The simplest is to use many 'single-chip integrated devices' currently on the market. These devices are obtainable with power outputs from 0.5 watt upwards – and very few additional components are required. BUT – circuit layout can be critical with some of these devices. A wire or two out of place and the amplifier may oscillate, often destroying the IC as it does.

Other devices called 'hybrids' are available. These are combinations of ICs and transistors (within a single package) and are available with power outputs up to 100 watts. They work well but are far too expensive for uses such as this – and for most experimental purposes their very high power outputs are not required.

CONSTRUCTION

The design we have used therefore is the traditional one of using 'discrete' components (that is, separate resistors, capacitors, transistors etc). Both circuitry and operation are basically similar to high power audio amplifiers; and the circuit is more stable than most IC designs.



How the completed unit looks when constructed on Veroboard.

As with most of the projects in this series the unit may be constructed on Veroboard or on the specially designed printed circuit board. It is of course easier to build on the pc board and mistakes are less likely to be made.

If Veroboard is used the tracks must be cut in the places shown – by rotating a small drill bit in the appropriate hole until the track is cut completely through. Before cutting make *quite sure* that each hole is in the right position.

SPECIFICATIONS

Output Power into 8 ohms	500 mW
Frequency Response	45 Hz – 300 kHz
Output Impedance	≏ 3 ohms
Gain	33 dB
Input Impedance	33 k
Input Sensitivity	500 mV

Whichever method of construction is used do make quite sure that you follow the appropriate component layout absolutely. Make sure that components are the right way round. For example electrolytic capacitors usually have a wide black line adjacent to the negative lead. On the overlay drawings the positive lead is marked by a '+' sign.

Note that the BD139 and BD140 transistors have a metal surface on one face (shown as a heavy line on our overlay drawings). Do make sure that you insert these transistors as shown – if you don't they'll probably burn out when you connect the battery!

Finally make a thorough check to ensure all components are in the right position and the right way round, that all solder joints are sound and that you have no solder 'bridging' between tracks.

Finally connect the battery. The red lead from the battery clip is positive.

This amplifier should ideally be run from a larger capacity (but still nine volt) battery than those recommended for other projects in this series. If a small capacity battery is used a 100 microfarad capacitor (or larger) should be connected across the battery

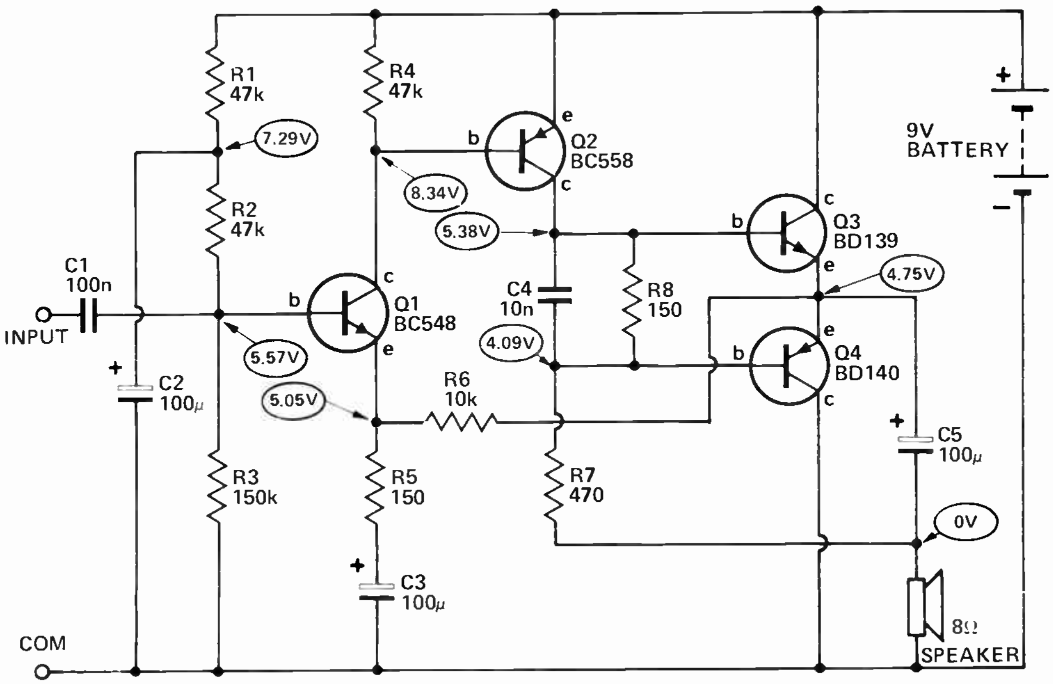


Fig. 1. Circuit diagram of the amplifier.

HOW IT WORKS – ETI 061

The operation of the amplifier may best be explained by dealing with it as three separate sections.

a. The amplifier Q2.
b. The buffer Q3,Q4.
c. The comparator Q1.

With any transistor the current flowing into the base determines the amount of current flowing in the collector circuit. The ratio of the magnitude of the collector current to that of the base current which controls it is known as the beta (β) of the transistor and values for this of 40 to 400 are typical. With a beta of 40 the collector current will be 40 times the current injected into the base. However when the transistor is used as an amplifier a problem occurs due to the fact that the relationship is not perfectly linear and this gives rise to a phenomenon called distortion (ie the output is not a perfect replica of the input).

Transistor Q2 is used as such an amplifier to increase the level of the signal voltage at the input. However although the voltage of the input signal has been increased transistor Q2 cannot supply sufficient power on its own to drive the speaker. Transistors Q3 and Q4 therefore are used to buffer the output of Q2 so that the speaker can be driven. (A buffer provides a voltage gain of slightly less than one. This provides current gain, and therefore the signal power is increased but not its voltage level .

However, as we said before there is some distortion. To overcome this we take a portion (the level is reduced by R5 and R6) of the output signal back to transistor Q1, where it is compared to the input signal. If the two signals are not identical the transistor Q1 controls the transistor Q2 in such a way as to reduce the error, and hence this reduces the distortion.

The speaker is driven from the output of Q3 and Q4 via C5, which prevents the dc component of the output from appearing across the speaker. The resistor R7 provides the load for transistor Q2. This resistor (R7) is returned to the top of the speaker so that a more constant voltage appears across it as the output swings up and down. Doing this helps transistor Q4 handle the negative signal swings and also increases the gain of transistor Q2.

Resistor R8 is used to set up the bias voltages for Q3 and Q4, as no current will flow until there is 0.55 volts between base and emitter of each transistor. This helps to reduce another form of distortion known as crossover distortion which occurs in stages made up of two transistors in the circuit used for Q3 and Q4. Capacitor C4 is incorporated to prevent the possibility of high frequency oscillation.

The dc biasing of the amplifier (that is the dc operating point at the output) is set by the divider chain R1,R2 and R3 which sets about 5.6 volts at the base of Q1. Capacitor C2 prevents any variations in the supply rails from reaching the base of Q1. Transistor Q1 then acts as a comparator and maintains the voltage at its emitter at 0.55 volts less than that at its base. This sets the output voltage to about 4.75 volts on a nine volt supply.

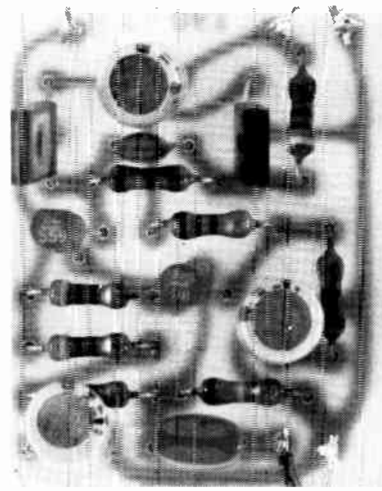
The frequency response on the high frequency side is determined by the characteristics of the transistors themselves and is about 300 kHz. At the low end there are three RC networks which determine the response. The main one is output capacitor C5 together with the speaker resistance which gives a -3 dB point at about 200 Hz – quite adequate for small speakers. Increasing C5 to about 470 microfarad will extend the low end to about 50 Hz if required. The other networks are C3 with R5 (50 Hz), and C1 together with R3 in parallel with R2 at about 10 Hz.

terminals to lower its impedance. This will enable higher power outputs to be obtained from the amplifier before distortion sets in.

If built up exactly as described this amplifier will have a substantially flat response from 200 Hz to 300 kHz. That is, it will amplify all frequencies within this frequency range by the same amount. If desired its range can be extended down to 45 Hz by changing capacitor C5 from the 100 uF specified to 470 uF.

You can use this amplifier to drive the ETI 088 speaker project (also in this series) or any similar high efficiency speaker. Big speakers are generally more efficient than small ones – so the bigger the speaker the higher the volume will be!

The amplifier may be driven from a record player as long as it has a ceramic *not* a magnetic cartridge – the ETI 062 AM tuner – the ETI 063 Bongo drums – any cassette recorder etc etc. The main requirement is that the input device must have an output somewhere between 100 mV and 500 mV.



Parts List ETI 061

R1,2	Resistors	47 k ½w 5%
R3	Resistor	150 k ½w 5%
R4	Resistor	47 k ½w 5%
R5	Resistor	150 ½w 5%
R6	Resistor	10 k ½w 5%
R7	Resistor	470 ½w 5%
R8	Resistor	150 ½w 5%
C1	Capacitor	100 nF polyester
C2,3	Capacitors	100µF 16V electro
C4	Capacitor	10 nF polyester
C5	Capacitor	100µF 16V electro
Q1	Transistor	BC548
Q2	Transistor	BC558
Q3	Transistor	BD139
Q4	Transistor	BD140

Speaker 8-16 ohm
9V Battery
Battery clip
1.2" x 3.2" Veroboard 0.1" or
PC Board ETI 061

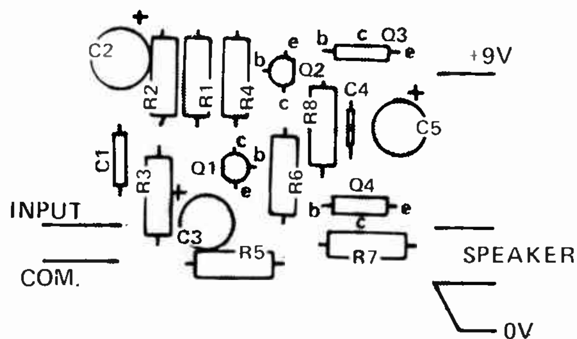


Fig. 5. This overlay shows how to fit components to the printed-circuit board.

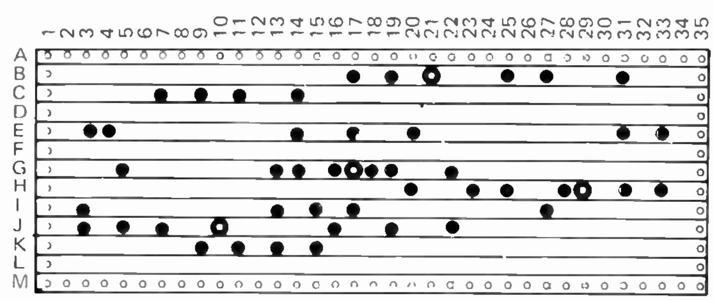


Fig. 3. The pads with holes through them indicate where the Veroboard track must be cut with a small drill as detailed in the text. The solid dots indicate where components are soldered to the tracks.

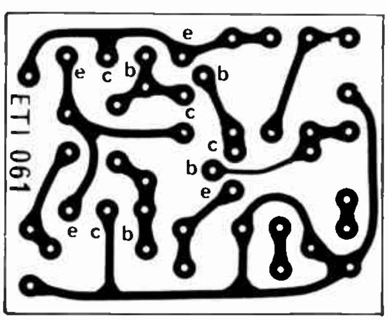


Fig. 4. Printed-circuit board layout (copper side). Full size of this board is 40mm x 50mm.

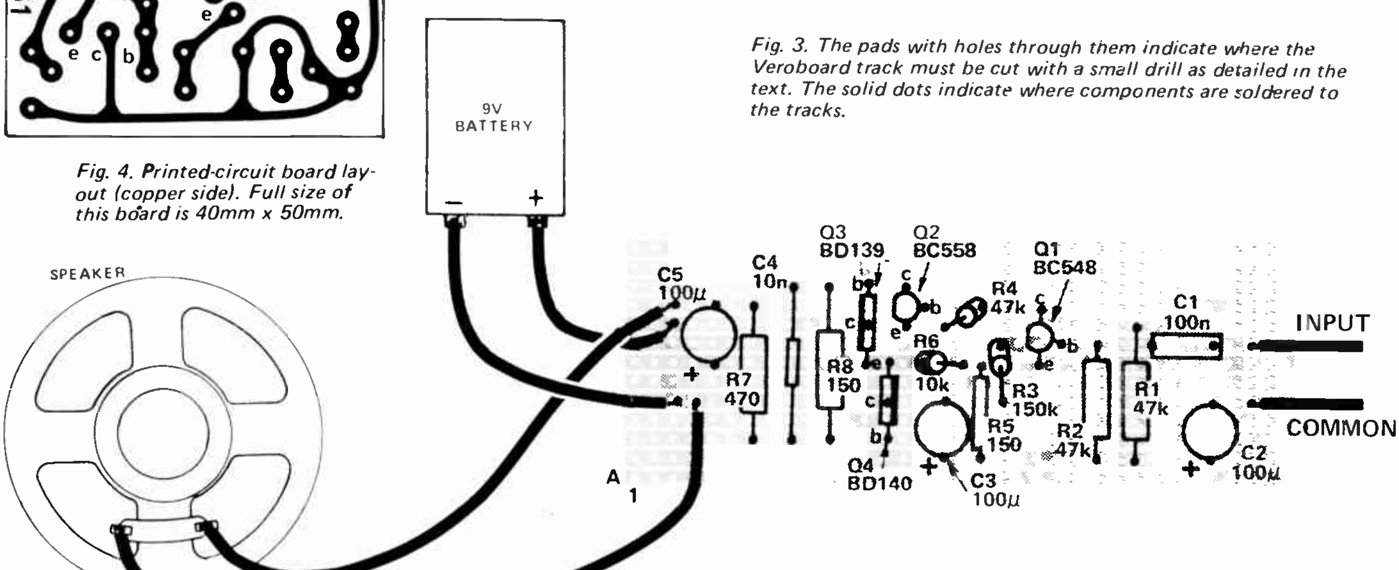
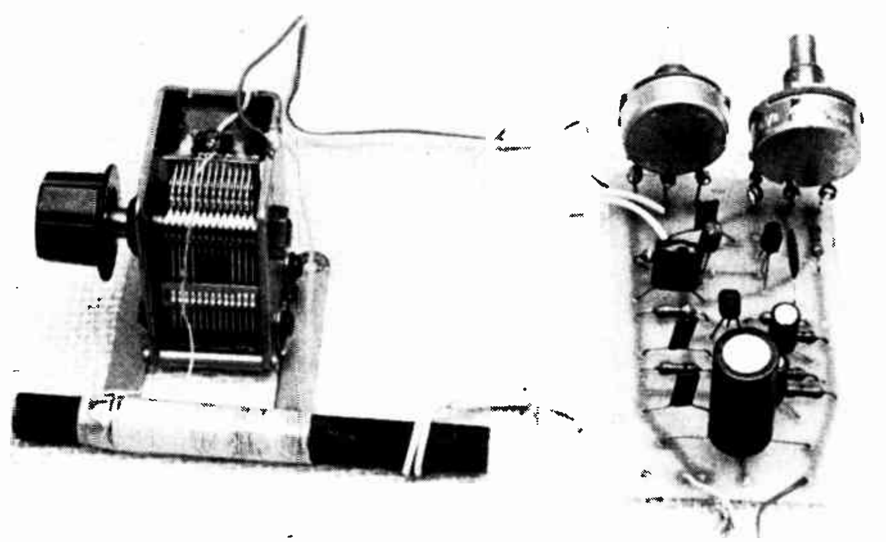


Fig. 2. Use this diagram to fit the components or wire the unit.

SIMPLE AM TUNER

One of the most exciting projects for the beginner to build is a broadcast-band receiver. If you have already built the ETI 061 amplifier then you are half-way there.



THIS simple yet very effective AM radio receiver is intended to be used in conjunction with our ETI061 amplifier. The radio may also be connected to any existing hi-fi amplifier or system.

Unlike most simple radios, this unit has its own inbuilt antenna. This consists of a ferrite rod approx 6 mm in diameter and between 100 mm and 200 mm in length.

To make the antenna simply wind about 75 turns of 26 SWG insulated wire neatly around one end of the rod. Secure the ends of the winding with sticky tape.

The tuning range covered depends on the value of the tuning capacitor and the number of turns wound around the ferrite rod. Most tuning capacitors adjust from 0 - 415 pF and our coil was wound to suit one of these. Tuning capacitors adjustable from 0–180 pF are also in common use and if you use one of these simply wind on about 30% more turns.

To raise the highest tuneable frequency simply remove turns. As an interesting experiment why not wind on more turns than you know you need (start with 100 or so) and then remove five turns at a time to see what happens.

We have added an optional feedback circuit to this radio. This circuit increases the radio's ability to separate stations that are close together in frequency. It also increases the amplification of the circuit.

In many areas this part of the circuit will not really be required – it can be omitted at first and then added if the radio will not adequately separate stations.

The components concerned are:–
Resistor R1
Potentiometer RV2
Capacitor C3
T2 – two turn coil on ferrite rod.

If the feedback circuit is not used simply omit the above components. If it is used T2 should be made by twisting a couple of turns of wire around the ferrite antenna rod at the opposite end from the main coil.

General construction is straightforward as long as the layouts shown here are used. The unit should be assembled on Veroboard or pc boards – it is not advisable to try to build it using tag strips or other methods.

When housing the finished project do remember that radio waves won't readily pass through metal – so make the enclosure out of wood – or use a suitable plastic case.

Potentiometer RV1 is an 'RF gain' control. Both this and the feedback control potentiometer (RV2) should be turned up until slight distortion is heard – and then backed off a little bit. In practice it will usually be found that RV2 will not need resetting once the initial optimum point has been found.

The output from the receiver appears

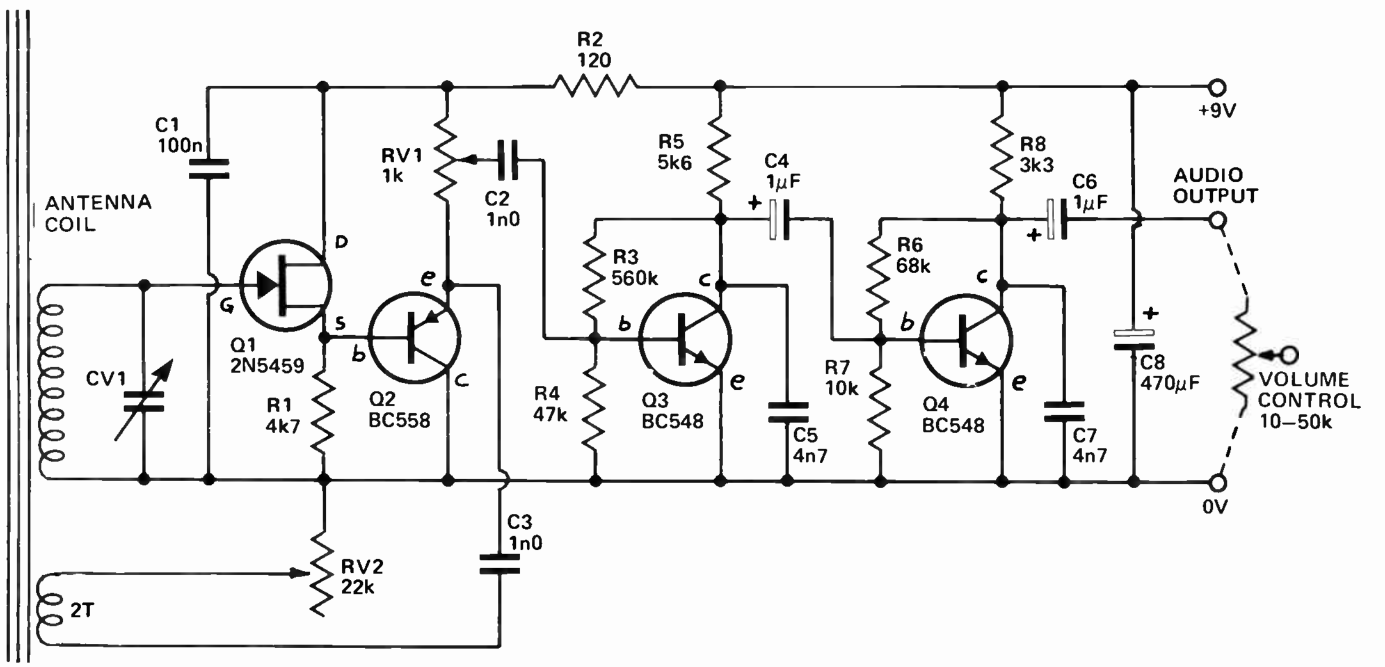


Fig 1. Circuit diagram of the tuner.

How It Works – ETI 062

The antenna coil and the tuning capacitor form a resonant circuit which has a low impedance to all frequencies except that of the station that is to be received, thus the antenna picks up all signals but only the particular signal required will appear at the gate of Q1.

Transistor Q1 is a 'field effect transistor'. Field effect transistors (often abbreviated to FETs) have a very high input impedance. The one used here is connected as a 'source follower' the voltage at the source follows the voltage at the gate except that the source voltage is about two volts dc higher. The purpose of this FET is to act as a buffer between the antenna coil and the rest of the circuit.

Transistor Q2 is used simply to remove any load from Q1 — necessary to prevent Q1 oscillating. The voltage gain of the circuit is unity up to the emitter of Q2.

Transistor Q3 amplifies the signal from Q2 and, due to the bias point chosen plus the action of capacitor C5, acts as a detector (it rectifies the signal). This has the effect of blocking the radio-frequency signal – the signal passed on to the next stage is an audio waveform which corresponds to the audio signal fed in to the transmitter at the radio station.

The signal at this point is still quite small so transistor Q4 provides additional amplification.

To avoid the cost and complexity of automatic gain control we have instead included a manual RF gain control.

A small portion of the signal from Q2 is fed back to the antenna via C1 and the two turn coil. This increases receiver sensitivity. The radio will oscillate if RV2 is turned up too high – maximum sensitivity occurs just before oscillation.

PARTS LIST ETI 062

R1	Resistor	4k7	½ W 5%
R2	"	120 ohms	" "
R3	"	560 k	" "
R4	"	47 k	" "
R5	"	5k6	" "
R6	"	68 k	" "
R7	"	10 k	" "
R8	"	3k3	" "
RV1	Potentiometer	1 k	lin rotary
RV2	"	22 k	lin rotary

(Above pots should preferably, but not essentially have plastic shafts, non-metallic knobs must be used)

C1	Capacitor	100 n	disc ceramic
C2,3	"	1n0	ceramic
C4	"	1 μ F	16 V electro
C5	"	4n7	polyester
C6	"	1 μ F	16 V electro
C7	"	4n7	polyester
C8	"	470 μ F	16 V electro
Q1	Transistor	2N5459	
Q2	"	BC557, 558 or 559	
Q3,4	"	BC547, 548 or 549	

CV1 Variable capacitor 0-180 or 0-415 p

Antenna rod

PC board ETI 062

across the point marked 'audio output' and the 0 V line. A screened lead and suitable jack plug should be connected to these points so that the radio signals may be fed into the ETI 061 amplifier – or your home hi-fi system.

A volume control may be added by connecting the output of the radio to the amplifier via a potentiometer (anything between 10 k and 50 k will do).

Battery voltage is not critical – the radio will work well from any voltage from about 9 V to about 15 V.

This is an essentially simple circuit and if built as shown should work first time. If the unit does not work check all connections, particularly transistor connections, check that the tuning capacitor's moving vane is not shorting to the fixed vanes. If the feedback circuit does not seem to work – reverse the two-turn coil on the ferrite rod.

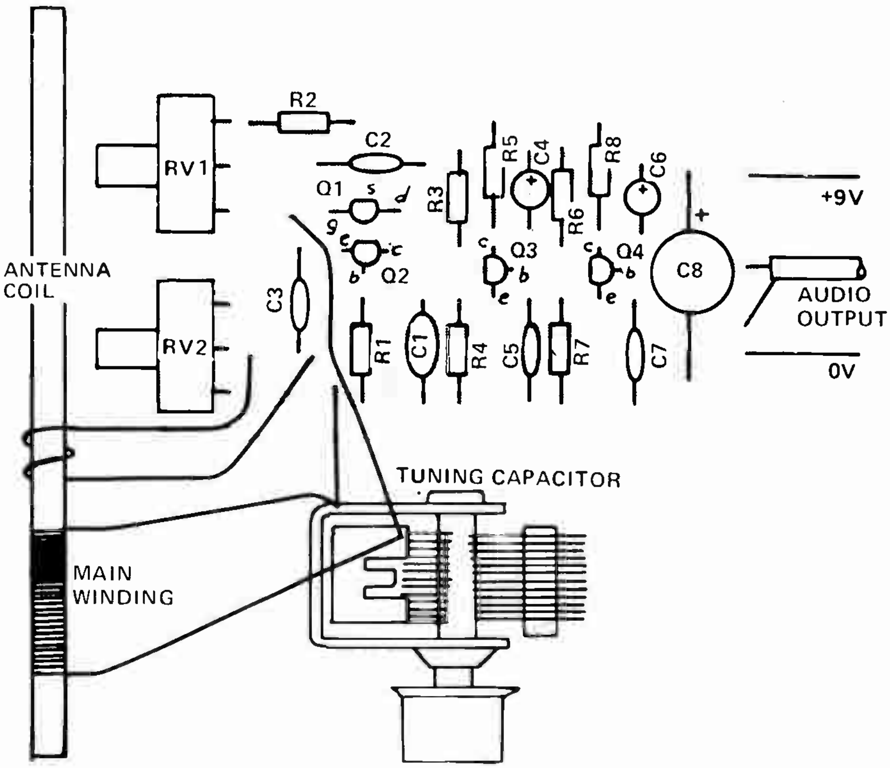


Fig 2. Component overlay using the PCB.

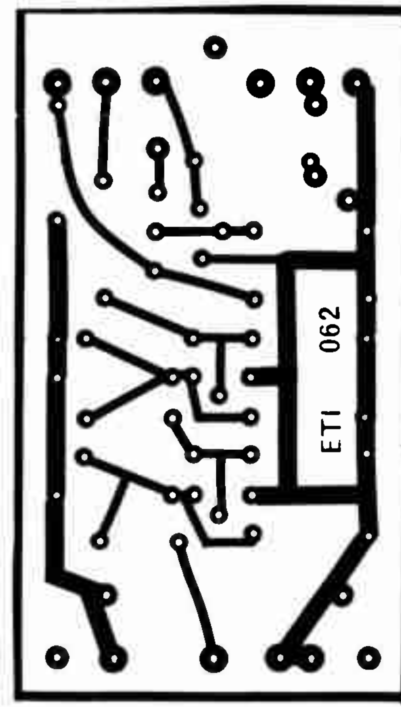


Fig 3. Printed circuit board layout for the tuner. Full size 90mm x 50mm.

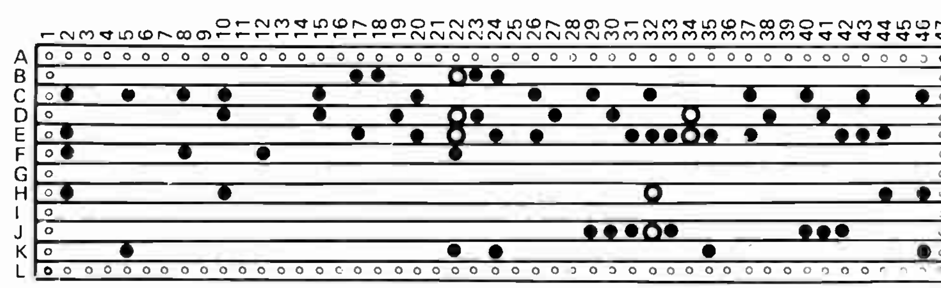


Fig 5. The underside of the Veroboard showing the breaks in the tracks (circles) and the solder joints (dots).

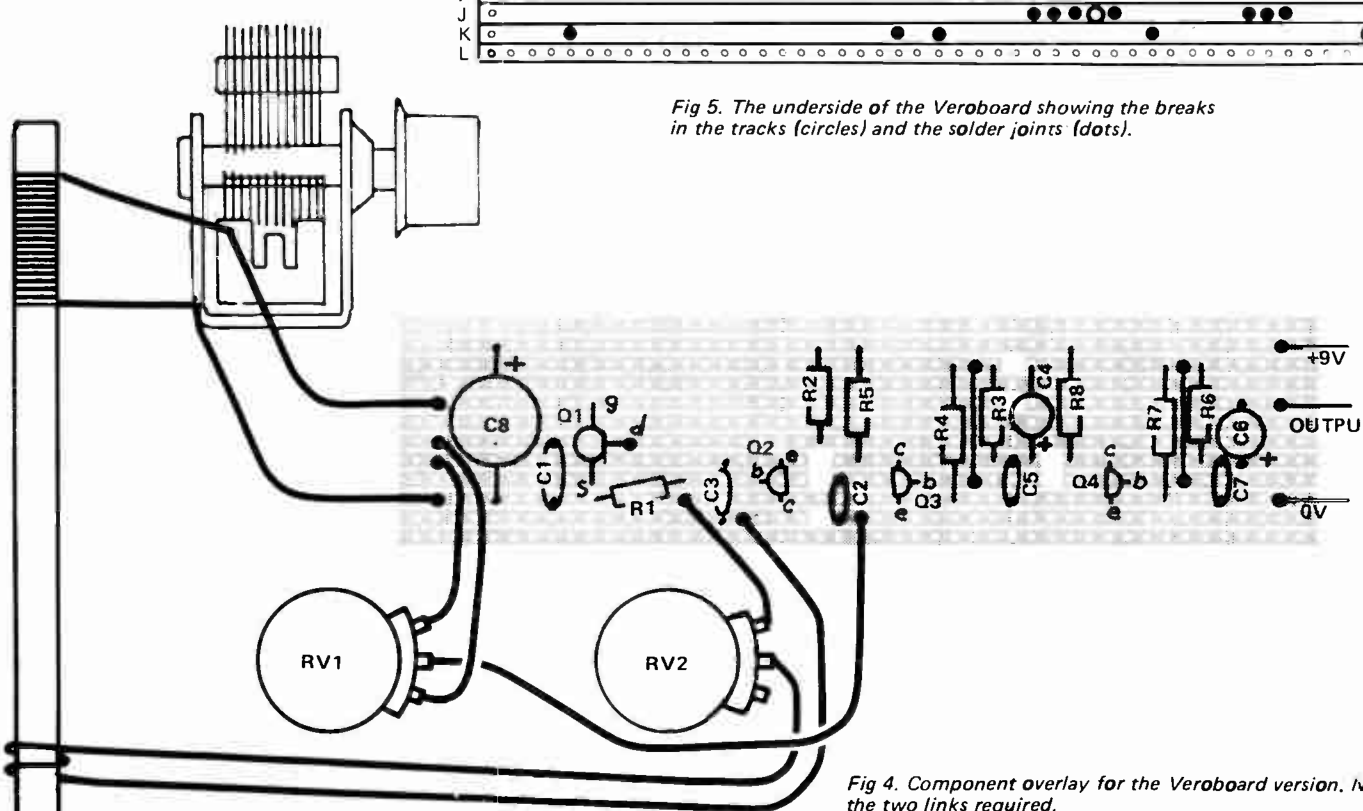
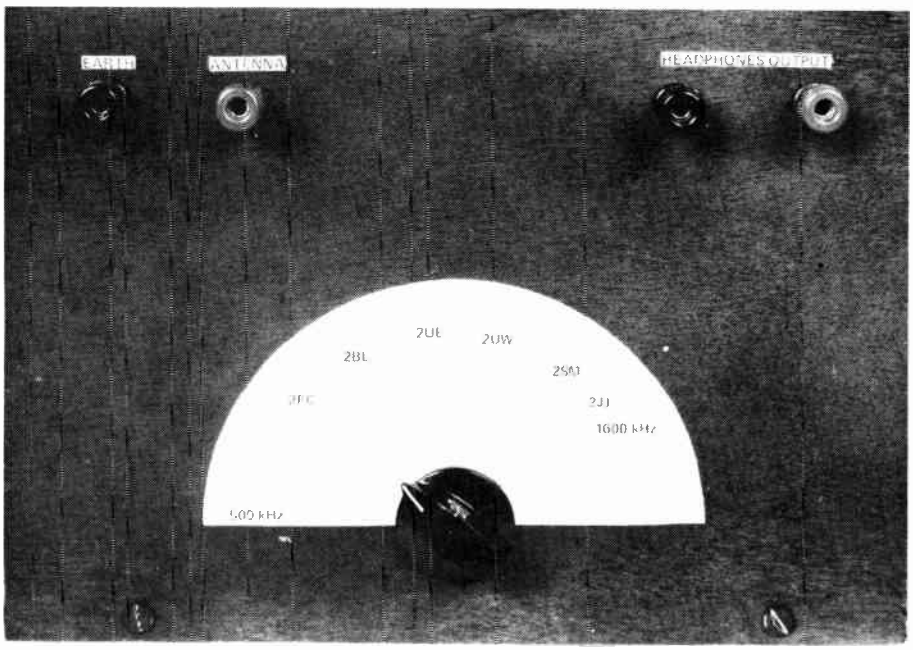


Fig 4. Component overlay for the Veroboard version. Note the two links required.

TWO CRYSTAL SETS TO BUILD

The crystal set was once every radio/electronics hobbyist's 'starter' project. Perhaps it should be returned to its former popularity. Beginner or not try these two now.



We built our crystal sets on a chipboard base with plywood front panel, all sprayed matte black.

"IN MY DAY", said the old timer in his quavering rasp, "we built crystal sets with spider-wound coils and galena-and-catswhisker crystal detectors and listened to the stations on 2000 ohm Brown's headphones".

In deference to the old gent, we won't mention the era but that was a pretty hot-shot (read 'sophisticated') set-up in his day.

Modern beginners in electronics are more likely to cut their teeth on a project that includes at least one integrated circuit or a handful of transistors plus the usual resistors and capacitors.

Some hobbyists subscribe to the view that, if you haven't built a crystal set *(and* got it going!), then you haven't *lived.*

HOW IT WORKS

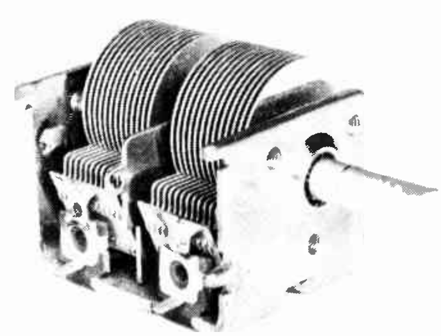
The crystal set basically consists of a tuned circuit, which selects the wanted station, and a detector, which separates the sound (music, speech etc) from the radio transmission, producing an audio voltage which is then impressed on the earpiece or headphones. This audio voltage is an exact copy of the sound from the radio station which has been superimposed on the radio signal at the transmitter.

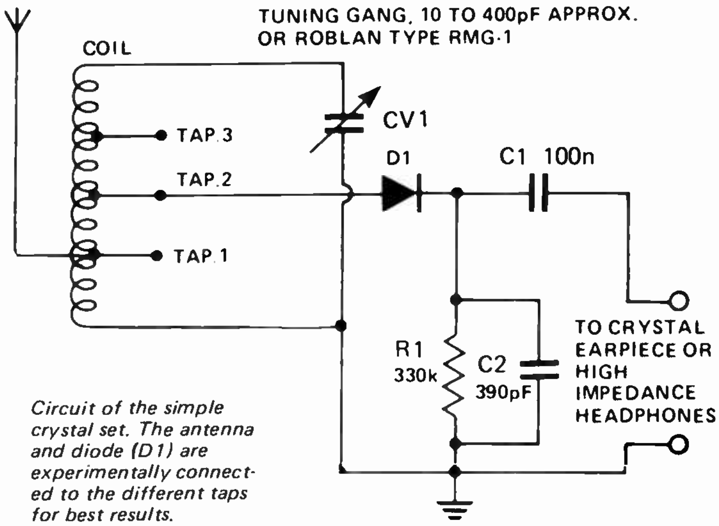
The aerial receives all the electro-magnetic radiation (radio waves) in your area. These signals have to be separated somehow, and the one station you're interested in must be sorted out from the mess, otherwise, the signal will be hopelessly lost in the scramble of thousands of stations.

To select one station at a time we use a tuned circuit consisting of a coil of wire connected to a tuning capacitor. Signals picked up by the antenna cause the tuned circuit to 'resonate'. That is, signal currents close to a particular frequency will be greatly magnified, while those away from that frequency will be reduced, or attenuated.

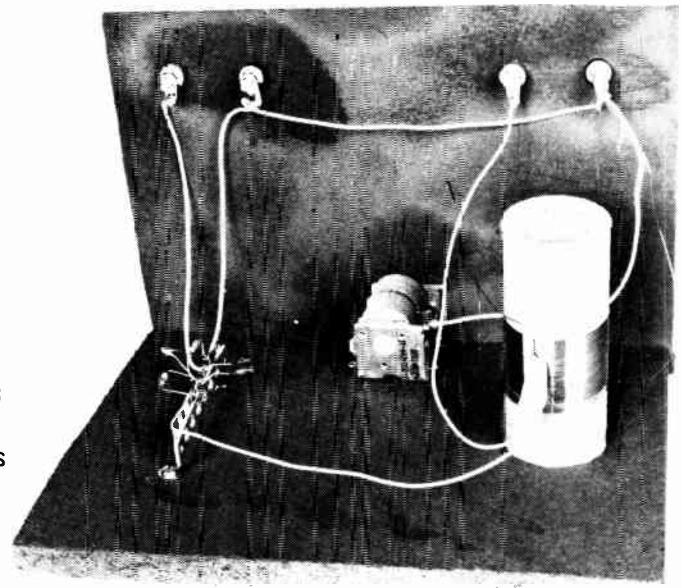
In our tuned circuit, the frequency of resonance is determined largely by the number of turns on the coil, its diameter, and the value of the tuning capacitor. One way to tune the circuit over a range of frequencies is to use a fixed coil and make the capacitor variable. This is what we have done as components are convenient and readily obtainable. The variable capacitor enables us to tune the frequency range of interest, about 550 kHz to 1.6 MHz. Increasing the capacitance (plates more in mesh) decreases the resonant frequency; with the plates more out of mesh (less capacitance) the resonant frequency is increased.

Dual-gang tuning capacitors like this one are the most commonly available type. Only one section is used for these projects. The fixed plates are insulated from the frame and connection is made to the terminal on the side (either one). The earth connects to the frame.





Circuit of the simple crystal set. The antenna and diode (D1) are experimentally connected to the different taps for best results.

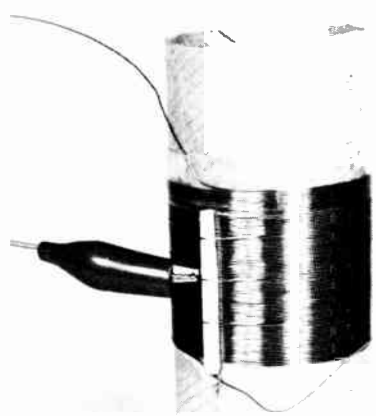


RIGHT: Rear view of the crystal set showing placement of components and interconnections. The dial on the front panel was cut from cardboard and lettered with rub-down lettering (see opposite page).

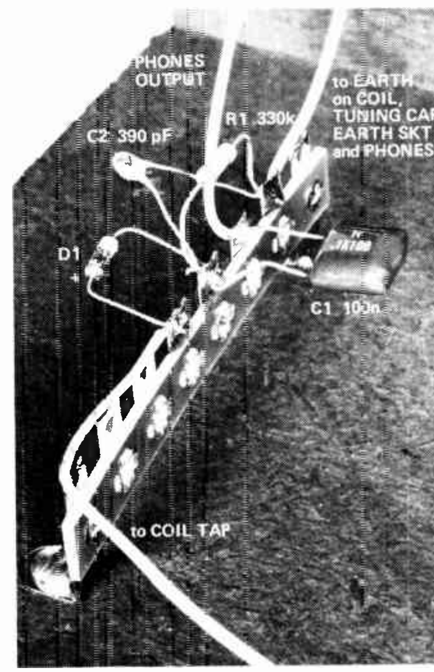
Now different stations can be selected, removed from the mess, and passed on to the detector. The size of the coil and the range of the capacitor must be selected to give a frequency coverage over the range of stations that you want to listen to.

Since tuned circuits are not perfect — nothing ever is in electronics! — frequencies close to the resonant frequency are also passed to the detector. The ability of a tuned circuit to select only one frequency is called its 'selectivity'. Our crystal set has a rather poor selectivity, but it's adequate for our purposes.

After the signal has been selected, it is fed to the diode detector. At this point it is a high frequency radio signal, called a carrier, with the audio (music etc) superimposed or 'modulated' onto it. If this signal was fed directly to an earpiece, nothing would be heard as the earpiece cannot respond to the radio frequency signal. The diode "rectifies" the signal, leaving a half-wave radio



We wound the coil for these projects on a former cut from a cardboard mailing tube. The matchstick is slid under each of the turns to be tapped. Clean the enamel from the wire at each tap to get a good connection.



The components for our crystal set were mounted on an eight-lug tag strip screwed to the baseboard.

PARTS LIST - ETI 266

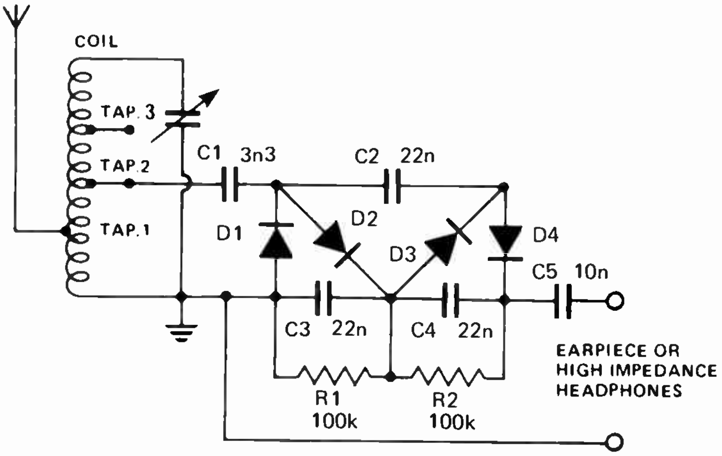
R1	330k ½W, 5% resistor
C1	100n greencap capacitor
C2	390p ceramic capacitor
CV1	tuning gang approx. 10-400p, Roblan type RMG1 or similar, see Shop-around, p. 83.
D1	OA90, OA91, OA95, OA202 or similar germanium diode
Coil	see text

Crystal earpiece or *high impedance* headphones; miniature jack socket to suit earpiece or terminals to suit headphones; screw terminals for aerial and earth connections; base board and front panel (see text).

TABLE 1 — NUMBER OF TURNS FOR WIRE GAUGE

COIL DIA.	22 SWG	24 SWG	26 SWG	28 SWG	TAPS
30 mm				110	at ¼, ½ and
40 mm			96	90	¾ of the turns.
45 mm		88	80	70	You may tap
50 mm	82	72	68	60	every ten turns
55 mm	71	64	60	52	if you wish
65 mm	61	56	54	47	for more range
70 mm	54	52			of adjustment.

22 SWG IS FRACTION LARGER THAN ·71MM
24 SWG IS " SMALLER THAN ·56MM



The voltage-multiplier crystal set provides more volume in your earphones.

signal which varies in amplitude with the audio signal. The fixed capacitor from the diode to earth 'shorts out' or 'bypasses' the RF signal, leaving the audio which is then fed to the earpiece.

In the first circuit, a single diode is used which gives good results, especially in areas with a local station, and is very easy to construct. The second circuit uses a more complex 'voltage multiplier' detector. This multiplies the signal level by four, increasing the volume in the earpiece. This circuit is commonly seen in high voltage power supplies.

CONSTRUCTION

We built our two crystal sets on a chipboard base fitted with a plywood front panel. The tuning knob, terminals for the antenna and earth, and the earphone socket are mounted on the front panel.

The tuning capacitor we used was a common type available from most suppliers. This is the most expensive part in the set and a variable capacitor from a discarded mantle or floor-model radio will do equally as well. Some tuning capacitors may have two sections. If you obtain one of these 'dual-gang' capacitors, only use one section.

Various coil sizes can be used and we have given a table for different former sizes and wire gauges. All these coils will work equally well on formers made of cardboard, plastic or wood. We used a cardboard mailing tube.

Winding the coil is easy, but rather tedious. Anchor the wire at one end of the former with adhesive tape, or threaded through two holes, and start winding. The coil must be 'tapped' at ¼, ½, and ¾ of the winding. To do this, slide a piece of match stick under the other turns, as shown in the photo. When the coil is finished, fasten the end as you did the start. You could coat the ends with five minute Araldite to hold the windings in place. Carefully scrape the enamel off the wire at the tapping points.

The other components can be mounted on a tag strip, as we have done, and flying leads with small alligator clips taken to the tapping points on the coil.

GETTING THEM GOING

The performance of your crystal set will depend on the length and height of the antenna and the distance from the station. Remember, crystal sets are very crude devices compared to modern radios, and require long antennas, especially if you live a long way from a station.

An antenna can be made by running a long wire from the eaves of your house to a tall tree or mast, as shown in the accompanying illustration. The wire can be any gauge as long as it can support itself, and can be insulated or uninsulated. NEVER run an antenna wire near or above mains electricity wires.

An 'earth' usually helps reception. This can be provided by driving a metal stake into the ground to a depth of about one metre or attaching a wire to the house water pipes. NEVER attach an earth to a gas pipe or the house wiring earth.

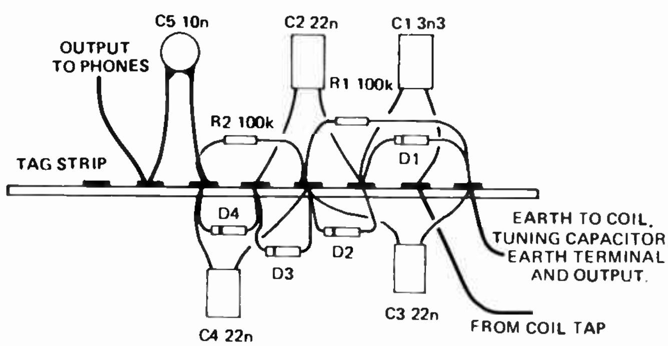
The optimum position for connecting the antenna and diode to the taps on the coil is best found by experiment and will be affected largely by the size of the antenna.

Have fun with your crystal sets!

PARTS LIST - ETI 267

R1, R2	100k ½W, 5% resistor
C1	3n3 ceramic capacitor
C2–C4	22n ceramic capacitor
C5	10n greencap capacitor
D1–D4	OA90, OA91, OA95, OA202 or similar germanium diode
CV1	tuning gang, approx. 10-400p, Roblan type RMG1 or similar, see Shop-around, p.83.
Coil	see text

Crystal earpiece or *high impedance* headphones; miniature jack to suit earpiece or terminals to suit headphones; screw terminals for aerial and earth connections; base board and front panel (see text).



As with the simple crystal set, we mounted the components for the voltage-multiplier crystal set on an eight-lug tag strip. We have supplied a drawing as it is clearer than a photo in this instance.

SIMPLE INTERCOM

This intercom uses the ETI 061 amplifier module. It will work effectively over distances of several hundred metres if required.

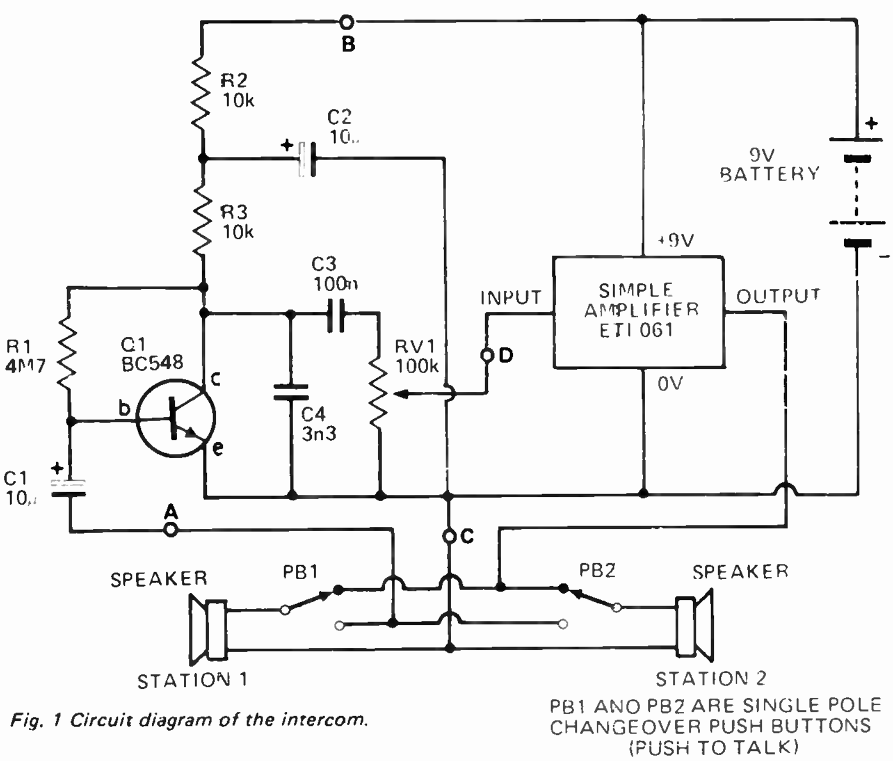


Fig. 1 Circuit diagram of the intercom.

How It Works ETI 064

Conventional moving coil loudspeakers double as speakers and microphones in each station. As they are not very efficient used like this we have added a single common emitter transistor amplifier to boost the output about 40 dB (100 times) before feeding it into the ETI 061 amplifier.

The collector load for Q1 is R2 and R3 with capacitor C2 to prevent supply voltage variations getting into the output. The dc biasing for Q1 is provided by R1 which causes the output of Q1 (collector) to stabilise at about 2V. The actual voltage depends on the β (gain) of Q1.

The output is adjustable by RV1 to provide adequate volume without incurring feedback.

HERE is an intercom unit based on the basic amplifier plus a handful of further components. It is a versatile little unit that provides two-way communication over any distance ever likely to be required.

To save the cost of both microphones and loudspeakers we have used a single loudspeaker at each end and these double as microphones. Almost any 8 ohm or 16 ohm speakers may be used. Units of two to three inch diameter are readily available for not much more than a dollar or so. For the best performance these units should each be mounted in a small enclosure. The size and shape of the enclosure is not particularly important. An open backed box about the size of a shoe box would be fine.

The system may be converted for use as a baby crying alarm simply by wiring a toggle switch across the 'push-to-talk' push button at the desired station.

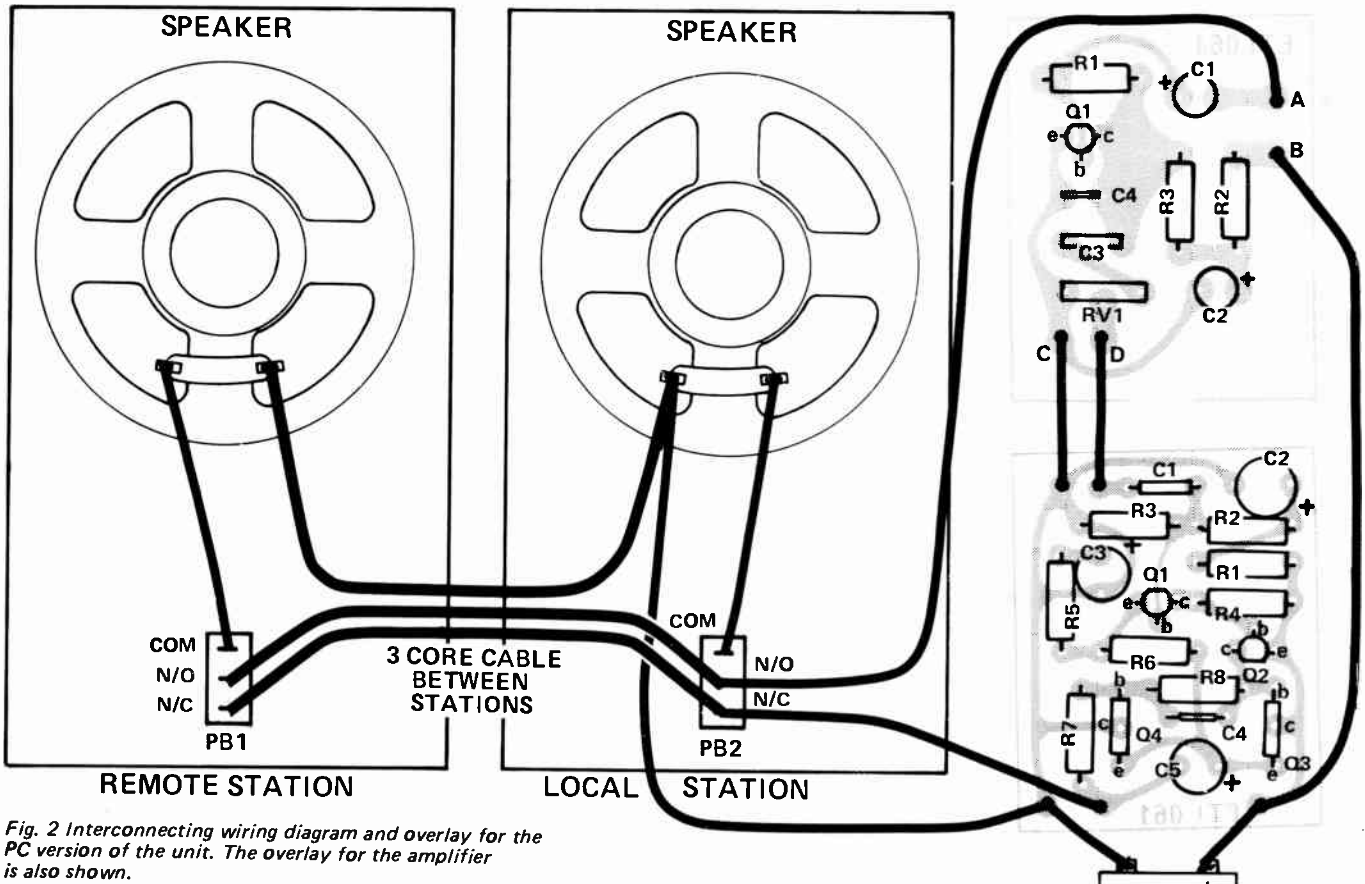
Construction

The ETI 064 intercom consists of the previously described 061 amplifier and a handful of extra components – the latter being mounted separately on printed circuit board, Veroboard or tag strip – as desired. The 061 amplifier should be assembled as shown on pages 32–34 of this book.

The two separate assemblies should then be interconnected as shown in Fig. 2. The two speaker switches should be located whever convenient – either on the speaker enclosures or any position that is handy when using the units.

Three wires are used to connect the two speaker stations together. The wire used is not critical – bell wire or similar will be fine. Twist the wires together along their entire length to prevent picking up unwanted noise. About ten twists per metre is sufficient.

One nine volt supply is used to drive the complete unit – i.e. the simple amplifier draws into power from the battery used in the intercom. Note however that as the unit is 'on' all the time a nine volt battery eliminator should preferably be used in place of the battery shown. Suitable eliminators may be built following plans previously published in ETI or bought for a few dollars from almost any electrical supply store.



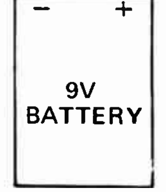
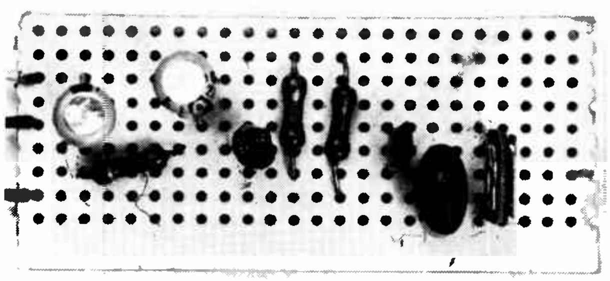


Fig. 2 Interconnecting wiring diagram and overlay for the PC version of the unit. The overlay for the amplifier is also shown.

PARTS LIST – ETI 064

R1	Resistor	4M7	½ W	5%
R2,3	Resistors	10 k	½ W	5%
RV1	Potentiometer	100 k	trim type	
C1,2	Capacitors	10 µF 16 V electro		
C3	Capacitor	100 nF polyester		
C4	Capacitor	3n3 polyester		
Q1	Transistor	BC548		

2 push buttons with single changeover contact
2 speakers 8 or 16 ohm
PCB ETI 064 or Veroboard 1" x 2.5"
Suitable boxes
Amplifier module ETI 061



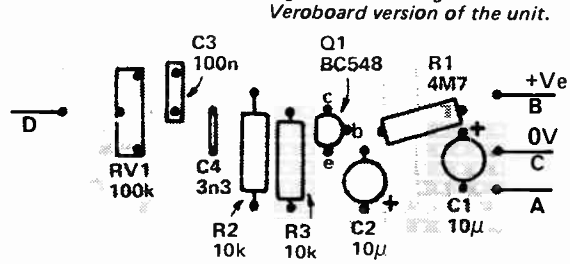


Fig. 4 Use this diagram to wire the Veroboard version of the unit.

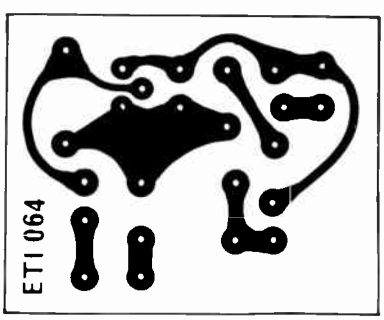


Fig. 3 Printed circuit board layout. Full size 50mm x 40mm.

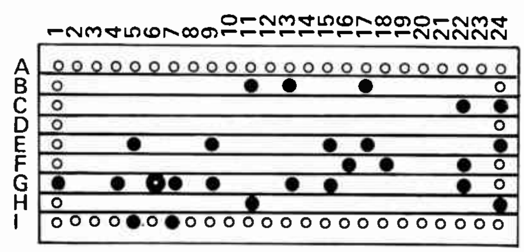


Fig. 5. Cut the Veroboard track in the place indicated by the other pad with the hole. The other dots are where soldered connections are made.

TEMPERATURE ALARM

This simple project uses a 555 and a few other components to sound an alarm when a preset temperature is sensed.

THIS IS A SIMPLE BUT VERY versatile temperature monitor which can be used in two different ways:

1. To warn if temperature exceeds a preset level.

2. To warn if temperature falls below a preset level.

The unit may be used to monitor temperature in fish tanks, laboratory ovens and/or water baths, incubators, cooking vessels, etc.

The temperature at which an alarm is given is adjustable over a range pre-determined by the combined values of the components RV1 and R1. RV1 is a potentiometer which is used to adjust the final 'set point' (the temperature at which the alarm is given).

Actual temperature sensing is done by a device called a 'thermistor'. This is basically a resistor in which the resistance value varies with changes in temperature. Thermistors are obtainable in innumerable shapes, sizes and temperature ranges.

The unit may be built so that a small loudspeaker provides an audible warning when the set limit is reached.

The unit may be constructed so that the warning takes place as temperature exceeds the set limit – or so that the warning takes place as temperature falls *below* the preset level.

All that is required to convert either unit from one mode of operation to the other is as follows: both theprinted circuit board and Veroboard layouts show alternative positions for R1 and the thermistor leads. Each alternative is marked appropriately. Thus to use the circuit in the 'over-temperature' mode just insert R1 into the position marked 'over-alarm' and connect the thermistor to the 'over-alarm' positions. Naturally only one R1 is required.

Figure 1 shows the unit with loudspeaker set up to warm if the temperature exceeds the limit preset by RV1.

Building the unit

Constructional method is not at all critical -- we show the unit made up on Veroboard and also on a printed circuit board for those who wish to use this simpler and more elegant method.

The thermistor should be mounted in the end of a short length of thin-walled glass tube and sealed with epoxy resin. Thermistors can actually be

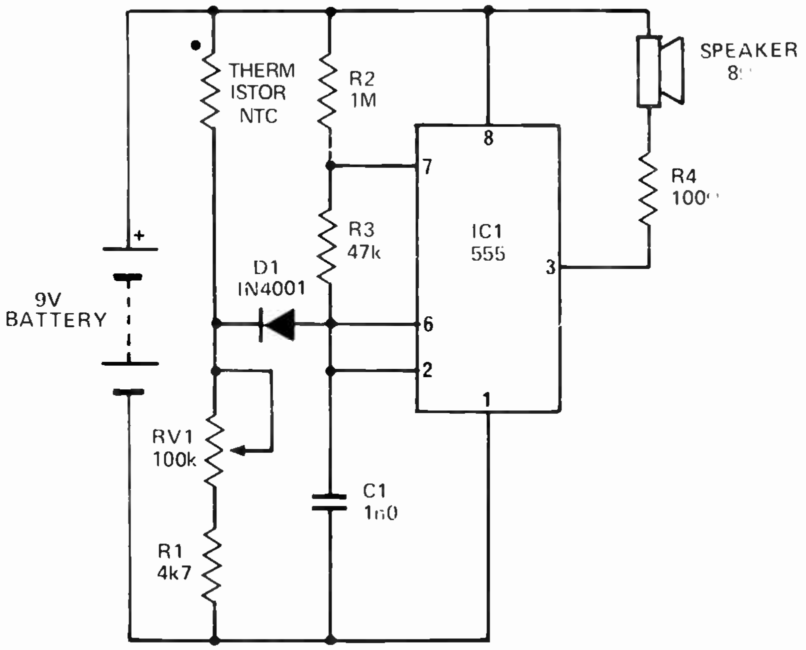


Fig. 1. Basic circuit provides audible warning if temperature exceeds set point adjusted by RV1. See text if opposite operation is required.

bought commercially already mounted in this way — but they're expensive.

There are two reasons for sealing the thermistor in the manner described above. Firstly, if the thermistor is not sealed electrolytic action will very quickly dissolve the thermistor leads — our first one lasted just one day! Secondly, if the thermistor is used to monitor the temperature of an open element such as a heating jug there is a very real danger of the thermistor or its leads contacting mains voltage. If the thermistor is used solely for monitoring air temperatures then no sealing is of course required.

As outlined above, the combined values of R1 and RV1 determine the temperature at which the unit triggers. Table 1 shows roughly what the combined resistance should be for various triggering temperatures. Thus for the unit to operate at high temperatures the 100 k potentiometer and the 4k7 resistor specified will enable the set point to be adjusted from about 20°C to about 82°C.

If finer control is required then the 100 k potentiometer could be replaced by a 25 k potentiometer and R1 increased from 4k7 to 75 k.

HOW IT WORKS ETI 066

Temperature is sensed via a thermistor. This is a resistor which varies its resistance as temperature changes. The one chosen for this application is a NTC (negative temperature coefficient) type in which resistance falls as temperature rises. The resistance at 25 $^{\circ}$C is about 47 k falling to about 3 k at 100 $^{\circ}$C. This thermistor forms a voltage divider with RV1 and R1.

The familiar 555 IC is the basis of the unit. The IC will oscillate if pins 2 and 6 are allowed to exceed approximately 2/3rds of the supply voltage, however the voltage divider along with diode D1 can prevent this and while it does so the alarm will be off.

As temperature increases thermistor resistance falls and the voltage begins to rise at the junction of D1, the thermistor and R1. When the voltage reaches 2/3 V_S — 0.6 V the 555 begins to oscillate and causes the loudspeaker to sound (at about 1.2 kHz). If an 8 ohm speaker is available then R4 must be included. However if an 80 ohm speaker is available then R4 may be left out — the sound will then be much louder.

Figure 1 shows the unit set up to sound an alarm as temperature exceeds the set point. If an alarm is required as temperature falls below the set point then the position of the thermistor, and the combination of RV1 and R1 should be reversed — i.e., so that the thermistor is connected to the negative supply rail.

PARTS LIST ETI 066

Over-alarm

R1	Resistor	4k7	½ W	5%
R2	”	1 M	”	”
R3	”	47 k	”	”
R4	”	100 Ω	”	”

RV1 Potentiometer 100 k Trim type

Thermistor 47 k (25 $^{\circ}$C) Philips type 2322 642 11473

C1 Capacitor 1n0 polyester

D1 Diode 1N4001

IC1 555 Timer

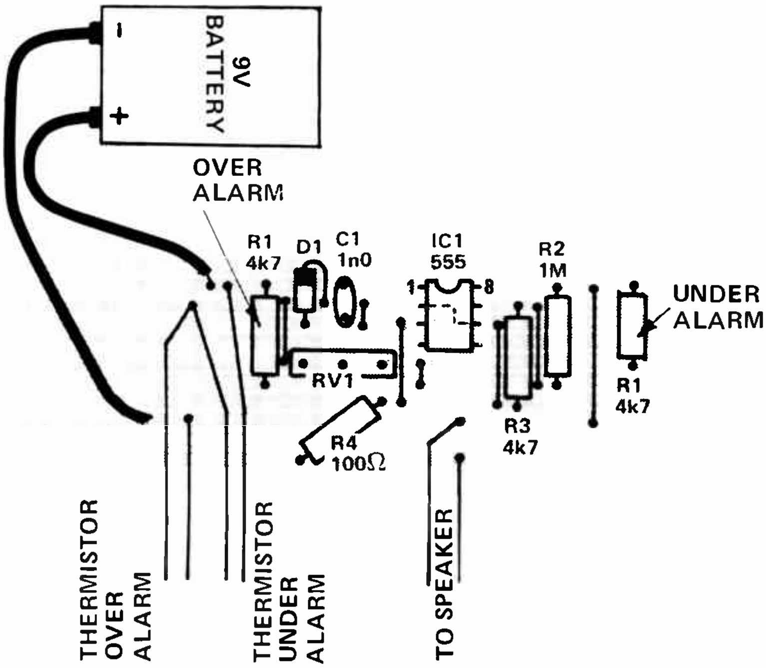
Speaker 8 Ω

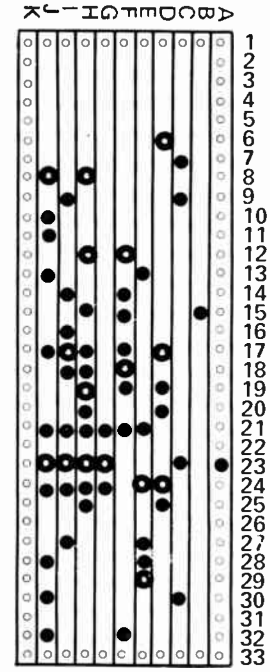
PC board ETI 066
or Veroboard 3.3 × 1.1″
9 V battery

TABLE 1

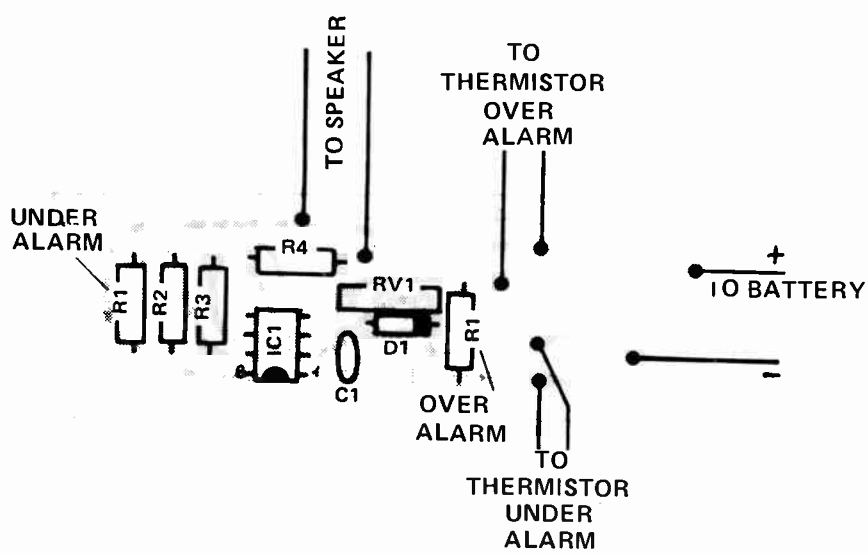
APPROXIMATE VALUES FOR R1 + RV1 FOR VARIOUS TEMPERATURES

Temp $^{\circ}$C	Over Alarm	Under Alarm
25	75 k	22 k
35	50 k	15 k
45	30 k	10 k
55	18 k	7k5
65	10 k	5k2
75	6k5	3k8
85	4 k	2k7
95	2k5	2k

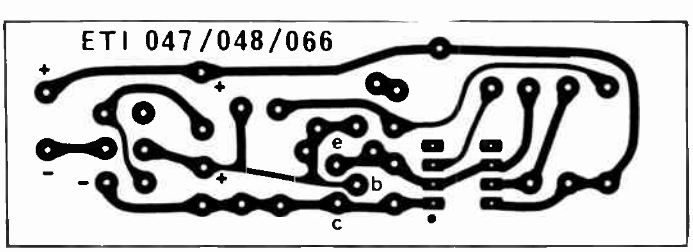




This is how the components are mounted on the Veroboard version. Note particularly that two alternative positions are shown for resistor R1 – the position chosen depends upon whether 'under alarm' or 'over alarm' operation is required. Similar comments apply to the pc board version shown on the right.



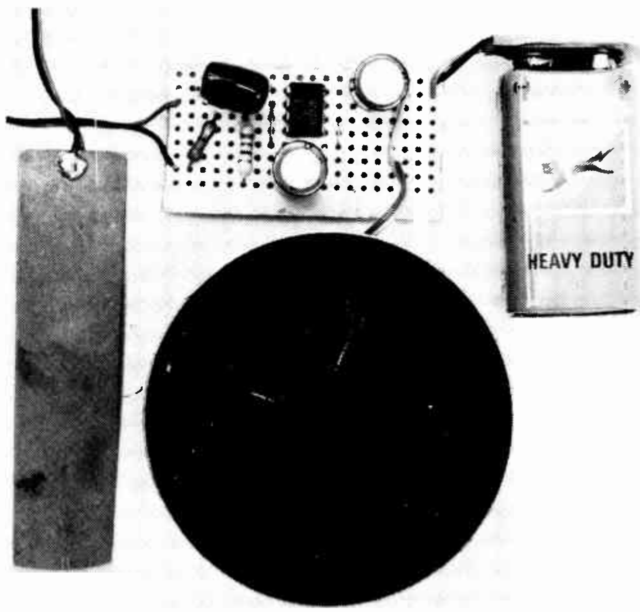
Here's how the components are mounted on the pc board version.



The multipurpose PCB used in this project is also employed in projects 047, 048 and 066.

SINGING MOISTURE-METER

Unit checks soil moisture content and sings the answer!



THIS PROJECT is a 'fun' version of the ETI 042 moisture detector described earlier in this series.

Its function is similar – that is it provides an indication of the moisture content around a plant's root structure. But whereas the earlier version gave a 'go no-go' indication via a light emitting diode, this one sings a note the frequency of which is proportional to moisture content!

Although the circuit is different from the previous version, the operating principle is basically similar and we suggest you read the first project again before starting to build this one.

The circuit used here once again relies on the fact that the resistance of soil varies very considerably with changes in moisture content. We have used this effect to cause the 555 to oscillate at a frequency more or less proportional to moisture content. The output of the 555 drives a loudspeaker thus producing a tone proportionate to moisture. The output of the 555 IC is quite high – sufficient to drive a loudspeaker directly without the need for extra amplification.

CONSTRUCTION

Layout is not critical, and if desired, forms of construction other than the two shown may be used. Probe details are as the previous version.

If desired a miniature speaker may be used instead of the one shown – the impedance must still be somewhere between 4 and 16 ohms.

The output tone range may be changed by altering the value of capacitor C1. Increasing the value will lower the tone.

PARTS LIST – ETI 067

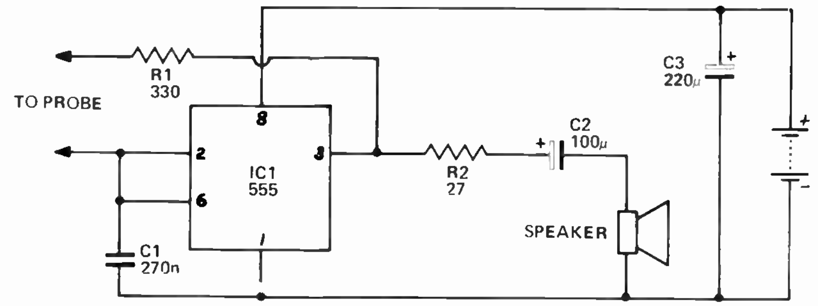
R1	Resistor	330 ohms ½watt 5%
R2	"	27 " " "
C1	Capacitor	270 n polyester
C2	"	100 uF 16 V electrolytic
C3	"	220 uF 16 V electrolytic
IC1	Integrated circuit 555	

Printed circuit board ETI 067
or Veroboard
Nine volt battery and clip

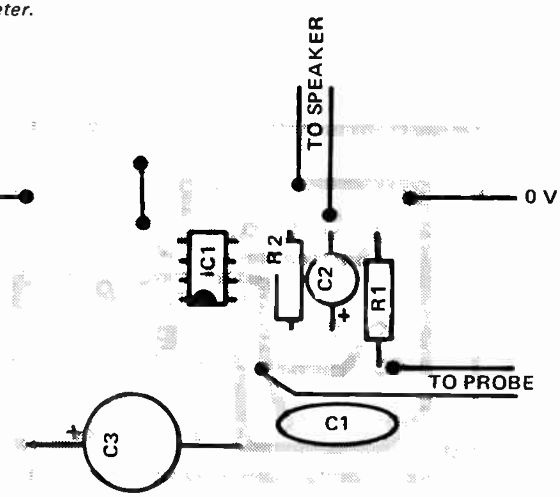
HOW IT WORKS ETI 067

The circuit is that of a basic 555 timer IC connected as an oscillator. The frequency of oscillation is determined by the time constant of the probe resistance and capacitor C1. The lower the resistance the shorter the time constant and thus the higher the tone.

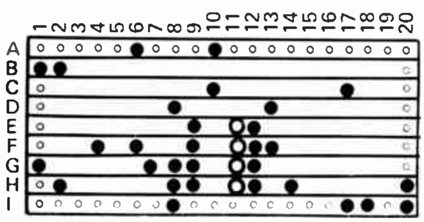
We have designed this circuit in such a way that ac current passes through the probe — there is no dc component and because of this no electrolysis should occur.



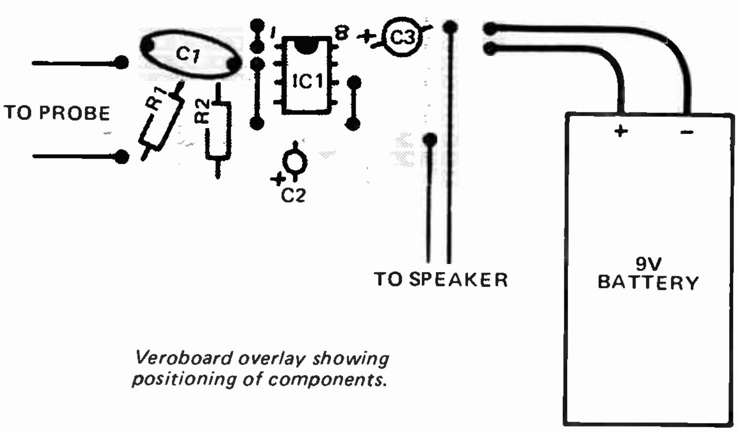
Circuit diagram of meter.



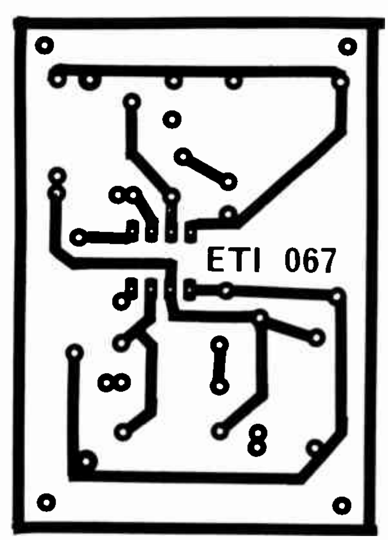
Component overlay of PCB unit. Note orientation of the IC (555)



Drilling details of Veroboard.



Veroboard overlay showing positioning of components.



The PCB shown full size. This PCB is used for other projects not described in this book. Not all holes are used.

TAPE NOISE LIMITER

Cut down tape hiss by adding this unit to your cassette recorder.

DESPITE the small size, the performance obtainable from a cassette tape in a good recording deck is quite remarkable. In fact the latest top quality decks are so good that it is difficult to tell the difference between the recording and the original sound.

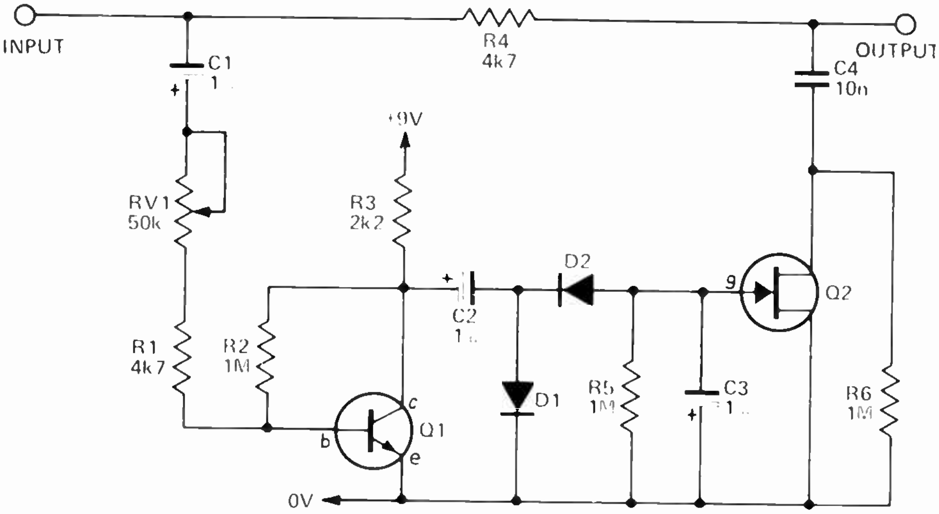
Unfortunately this is not true of the cheaper units — in which 'tape hiss' can be very prominent. Tape hiss is caused by random irregularities in a tape's surface coating. The effect is common to all tapes but some are marginally worse than others.

The annoying characteristic of tape hiss delayed the acceptance of cassette tape recorders in hi-fi systems for some years until the advent of the Dolby system which was primarily developed as a cure for the phenomenon.

The Dolby system is often misunderstood *it only works if the cassette tape itself has been recorded using the Dolby process* — and few commercially produced tapes are. Unless the tape cassette says specifically that it is Dolby processed then it's not! You can of course record your own tapes using Dolby if you own a Dolby machine.

To overcome this limitation a number of cassette recorders are fitted with noise reduction circuitry which reduces the level of hiss on non-Dolby recordings. Most of these noise reducing circuits work by progressively reducing all high frequency signals when the output level falls below a preset minimum. Above that minimum level all sounds are allowed through because tape hiss cannot be heard once the sound level is substantially louder than the hiss. This effect is called 'acoustic masking'.

The circuit described in this project is a simple but very effective unit which may be used with any cassette recorder which is connected to a hi-fi system.



The unit should preferably be connected between the cassette recorder and the amplifier input — using short lengths of screened cable and suitable connecting plugs. If you really know what you're doing it may be actually built into the tape recorder or amplifier. Alternatively it may be connected between the pre-amplifier and power amplifier on those units which are so separated (note that many apparently integral amplifiers still have 'pre-amp out' and 'power-amp in' connectors on the rear panel. These connectors are normally bridged by 'U' shaped links— which should be removed to enable this unit to be plugged in).

CONSTRUCTION

As with most projects in this series you can use either Veroboard or the special printed circuit board shown here.

Take the usual precautions about inserting components the right way round — taking particular care with the field effect transistor Q2. Note that the cathode lead of the diodes (shown as a horizontal bar on the circuit diagram) will be identified on the component by a black band or similar marking.

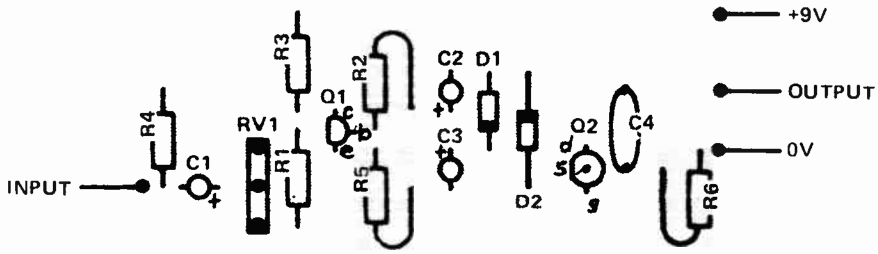
Unless the leads between this unit and the tape deck and amplifier are very short it is advisable to connect it via screened cable. Note that the 0V line shown on the circuit is also the 'earthy' side of the input/output connections.

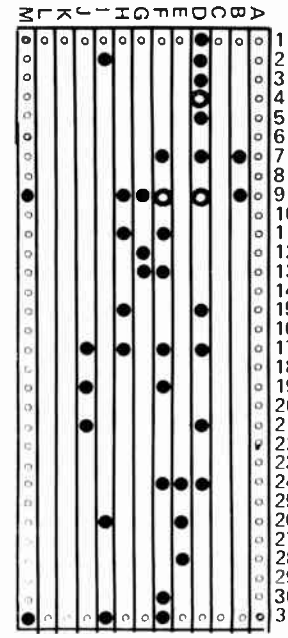
To set up the unit simply choose a recording with a longish quiet passage and then adjust RV1 for the best compromise between tape hiss reduction and minimum loss of high frequency programme content.

NOTE: If you listen only to hard rock — where there aren't any quiet passages — then this unit will be of little value to you. Its main effect is to reduce annoying tape hiss during otherwise quiet programme material.

SPECIFICATION

Input level –	up to 2 Vrms
Min level for flat response –	about 10 mV
Input impedance	depends on Q1 gain but > 4.7 k
Output impedance	impedance driving the input + 4.7 k
Output impedance of drive device	– preferably 600 ohms.



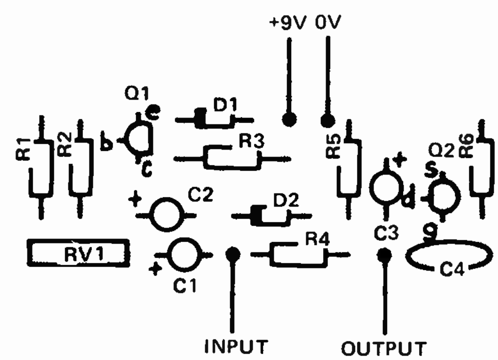


Component layout of Veroboard version.

PARTS LIST
ETI 071

R1	Resistor	4k7	0.5 W	5%
R2	"	1M	"	"
R3	"	2k2	"	"
R4	"	4k7	"	"
R5,R6	"	1M	"	"
RV1	Potentiometer 50 k trimpot			
C1-C3	Capacitor	1 uF	25 V	
C4	"	10 n polyester		
Q1	Transistor	BC548		
Q2	"	2N5459		
D1-D2	Diode	1N914		

Nine volt battery and clip
Veroboard or pc board ETI 071.



Component layout of printed circuit board version.

Note difference in order of source(s) and drain (d) of Q2 in the Veroboard version and pc board version of this project. This is in fact correct as the source and drain of this transistor are interchangeable in this circuit.

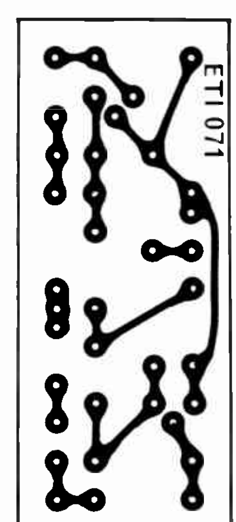
HOW IT WORKS

The circuit passes all frequencies (without attenuation) if the incoming signal is above a set minimum level. Signals below the preset minimum are progressively attenuated from 1 kHz upwards. The maximum attenuation of about 10 dB is applied at approx 10 kHz.

Resistor R4 and capacitor C4 form a filter in which Q2 is used as a variable resistor with the degree of resistance dependant on gate voltage. Thus, if the input voltage is at or near 0V then Q2 appears as a low resistance and C4 is in circuit. If on the other hand the input signal is higher than (say) four volts negative, Q2 has a very high resistance and C4 is effectively out of circuit.

The voltage applied to the gate of Q2 is that derived from Q1 – after rectification by D1 and D2. Transistor Q1 amplifies the input signal and with RV1 in minimum position, input signals above 10 mV or so will cause Q2 to be off.

Increasing RV1 raises the level below which high cut will occur. The change from full to zero cut occurs over a range of approx 5 dB input level change.



Foil pattern for pc board – shown full size.

TWO-OCTAVE ORGAN

Although cheap and simple to build, this monophonic electronic organ is tunable, covers a full two octave range, and has an adjustable tremulo control.

HERE'S A PROJECT where you can well and truly utilise your ingenuity!

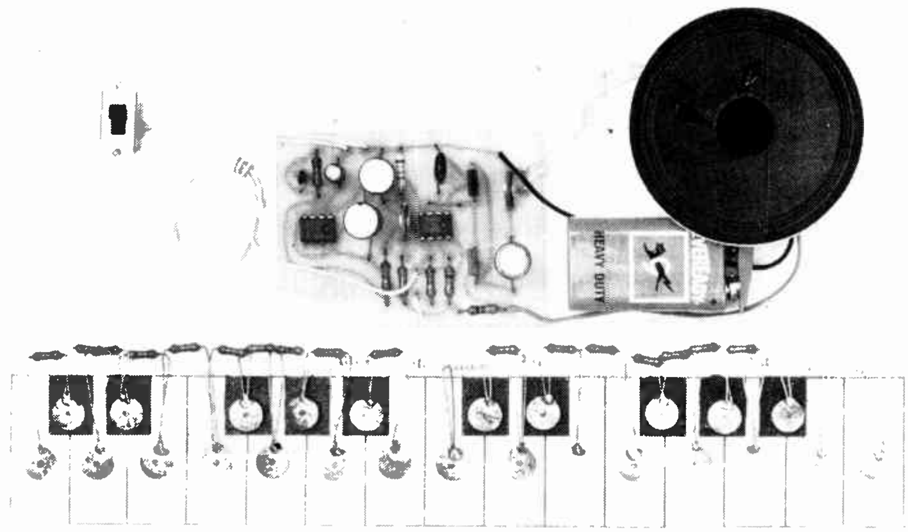
A monophonic organ is limited in its scope simply in that only one note can be played at a time — that is you cannot play chords. In practice this is not as big a limitation as it might seem and a monophonic organ of this type will provide a great deal of pleasure and amusement for youngsters and older people who quickly find how easy it is to play.

The organ covers the range from C (262 Hz) to C (1047 Hz), with 12 notes per octave (that is it includes sharps and flats).

The frequency (pitch) of each note is determined by an associated resistor in the chain R8 through R31. We have made some minor compromises in that we have used standard readily available resistor values nearest to those actually required to obtain the exact pitch for each note. The pitch errors are quite small but if you need the pitch to be *exact* all you need to do is to wire additional resistors in series or parallel with the appropriate chain resistor until the exact pitch of that note is obtained.

The overall pitch is adjusted by potentiometer RV1 and the volume by potentiometer RV2. Tremulo may be switched in or out by switch SW1. The depth of tremulo may be altered by changing resistor R2.

As shown in our main circuit drawing and component overlays the circuit includes two output transistors (Q1 and Q2) and a loudspeaker. This enables the unit to be totally self-contained. Nevertheless it has been so designed that you can run it directly into our own basic amplifier (ETI 061) and loudspeaker (ETI 088) or in to any other suitable amplifier or hi-fi system. If you wish to use an external system as suggested above simply leave out Q1 and Q2, change C6 to 1.0 μF, and increase RV2 to 10 k. The positive end of C6 should be connected directly to pin 3 of IC2 and the input to the amplifier or hi-fi system taken from the point on RV2 which is currently wired to the speaker.



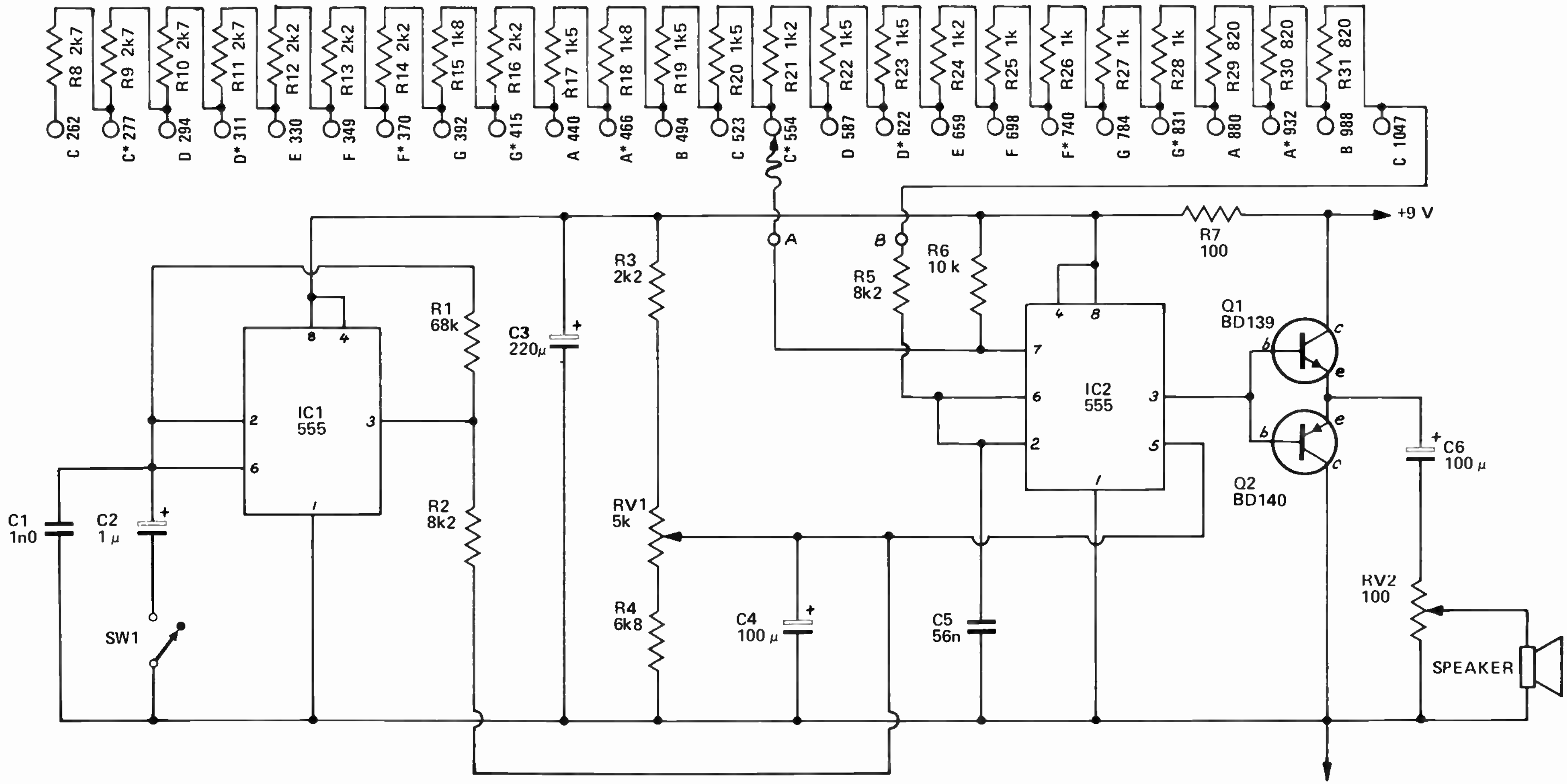
Construction

The organ consists of two main assemblies, plus a battery or other nine volt power supply, and a loudspeaker.

Main board construction is quite straightforward — the usual precautions must be taken to ensure critical components are inserted the right way round and do check for solder bridges, particularly if you are using the Veroboard method of construction.

The second assembly is the keyboard. Here you have unlimited potential for modification. We have shown what we believe to be the cheapest possible construction — 25 pins stuck into a piece of heavy cardboard! But if you want to, you can build up a far more elaborate affair using proper metal or woodworking techniques.

The requirements for the keyboard are very basic. You need to arrange some way by which one common wire may be caused to touch any one of a series of contacts. Our prototype shows a very basic way indeed. We have a series of drawing pins stuck into a piece of heavy cardboard with a keyboard pattern drawn on. The common wire is connected to a sharp probe and you simply touch the drawing pin heads with this probe. If this basic method is used a suitable probe can be made by Aralditing a needle into the end of an old ball point pen. Note that the probe handle must be insulated to prevent 50 Hz mains voltage included in one's body modulating the pitch. A more elaborate way would be for each key to be sprung in such a fashion that when depressed it touched a common strip running right along the front of the keyboard. If you have the facilities for so doing, yet another way is to etch a keyboard on a strip of pc board material.



Circuit diagram of complete unit.

HOW IT WORKS

Firstly consider IC2. This is a 555 oscillator circuit which oscillates at a frequency determined by whatever resistor in the chain R8 to R31 is selected. These resistors have been selected to give the closest possible approximation to the standard spacing between notes. These resistors may be padded or others added in series if an exact scale is required.

The output of IC2 is approximately a square wave. This is buffered by Q1 and Q2 before driving the loudspeaker. The control circuitry is decoupled by R7/C3 from the nine volt supply to prevent load fluctuations varying pitch. Potentiometer RV1 adjusts the overall frequency of the circuit thus acting as a pitch control.

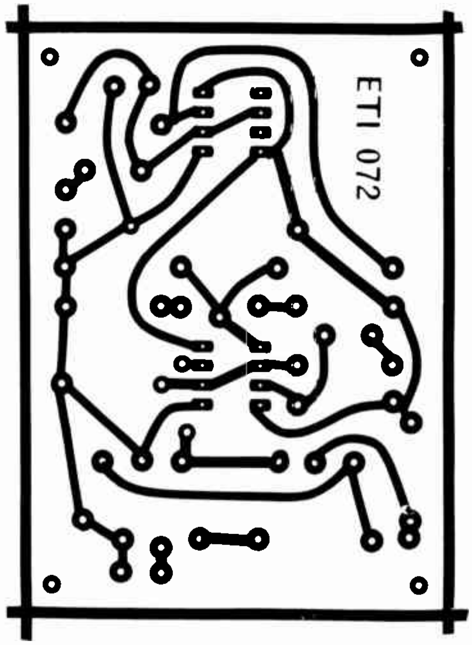
Tremulo is generated by IC1. This IC oscillates at either 5 Hz or 5 kHz depending on the position of SW1. When switched to the 5 Hz position the output is applied to pin 5 of IC2 thus modulating the output of that IC. Capacitor C4 'kills' the output when IC1 is switched to the 5 kHz position. The reason for this apparent anomaly is that it is desirable for the tremulo oscillator to be running at all times – whether tremulo is switched in or not – to eliminate the minor change in overall pitch otherwise caused by the load of IC1 being switched on or off.

When completed, the chain of resistors should be soldered in place. Do make sure you have good sound soldered joints as the failure of any one joint in this chain will prevent the organ from operating.

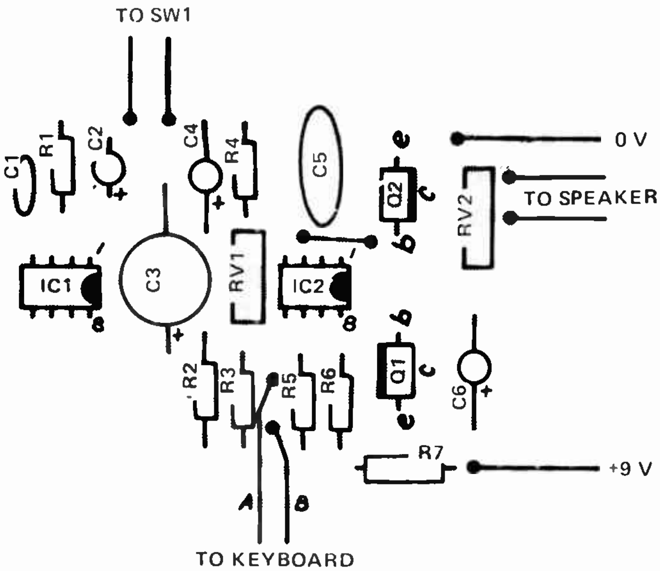
Finally connect the two assemblies together, connect up a battery and away you go!

Some refinements may be made — as with other projects in this series it is possible to delete the trim potentiometers currently shown located on the circuit board, replacing these with larger rotary potentiometers located remotely.

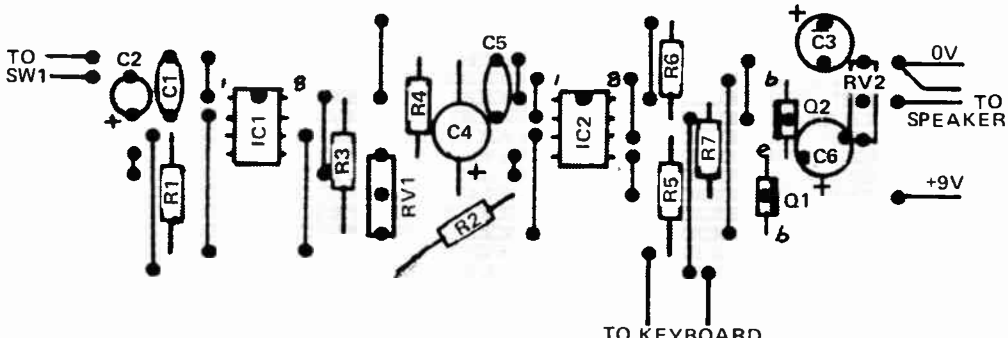
Resistor R2 may be changed to vary the depth of tremulo or replaced by a potentiometer (10 k in series with a 3k3 resistor) to allow immediate adjustment.



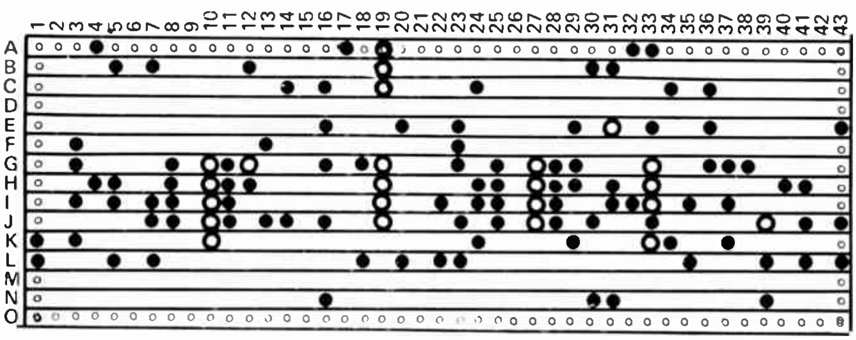
Printed circuit board layout — shown here full size.



Component overlay for printed circuit board version.



Overlay for Veroboard version.



Drilling details for Veroboard.

PARTS LIST

Resistors		
R1	68k	½ W 5%
R2	8k2	" "
R3	2k2	" "
R4	6k8	" "
R5	8k2	" "
R6	10k	" "
R7	100 ohms	" "
R8-R11	2k7	" "
R12-R14	2k2	" "
R15	1k8	" "
R16	2k2	" "
R17	1k5	" "
R18	1k8	" "
R19-R20	1k5	" "
R21	1k2	" "
R22-R23	1k5	" "
R24	1k2	" "
R25-R28	1k	" "
R29-R31	820	" "
RV1	Trimpot 5k	
RV2	" 100 ohm	
Capacitors		
C1	1n0 polyester	
C2	1 uF electrolytic 16 V	
C3	220 uF " "	
C4	100 uF " "	
C5	56 n polyester	
C6	100 uF 16 V electrolytic	
IC1/IC2	integrated circuits 555	
Q1	transistor BD139	
Q2	transistor BD140	

Printed circuit board ETI 072 or Veroboard
SW1 single pole switch
Nine volt battery and clip
Small speaker

LED DICE

A simple dice circuit using the 555 timer IC and a digital-logic device of the CMOS family.

THIS CIRCUIT MAY be used for several different purposes. It consists of a 555 timer IC connected so that it produces a series of pulses.

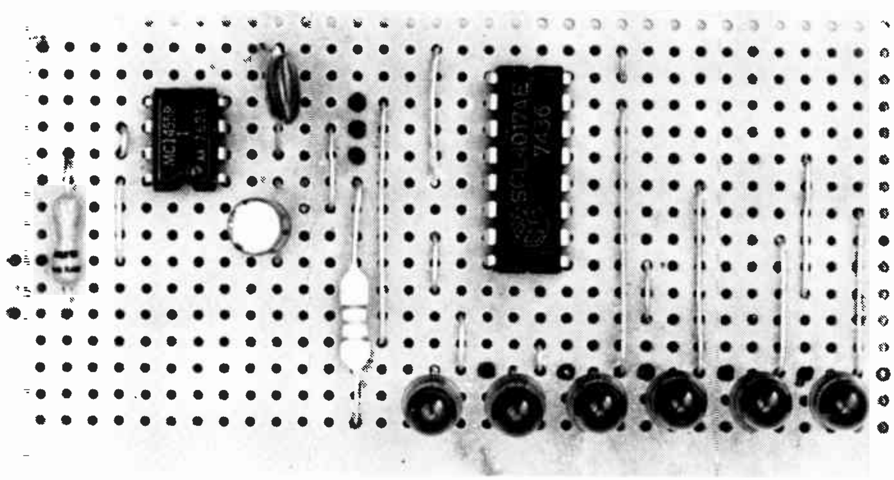
These pulses are fed into another integrated circuit — known as a decade counter — which switches the pulses from the counter sequentially from one counting section of itself to the next. The seventh counting section of this IC is connected back to the first so that when the device is pulsed by the 555 timer it 'goes round and round'.

Each counting section of the IC is brought out to a separate pin and in the project described here a light emitting diode (LED) is connected to each of the first six of these pins. Thus when power is applied these LEDs will be sequentially energized, each flashing on momentarily.

The component values chosen here causes the 555 timer to produce pulses at the rate of 6500 per second (6500 Hz). This is far too fast for the eye to follow so that when the circuit is energized (by pressing the push button) all LEDs appear to be on at the same time.

As the IC cycles through its six states each LED will be on for the same interval of time, thus each LED has an identical probability of being alight when the push button is released. This being so, the LEDs may be numbered from one to six and the device used as an electronic dice.

A further and quite different effect can be obtained by slowing down the 555 oscillator's clocking rate. If the rate is brought down to 10-25 Hz (this is done by increasing the size of capacitor C1) the LEDs will flash sequentially at a slow rate. By doing this an illuminated LED will appear to move quickly across from one end of the row of LEDs to the other. You may have seen a (probably) electro-mechanical version in shop window displays etc.



The completed Veroboard version of the unit.

The number of LEDs may be increased from six to a maximum of ten quite easily. Details of how to do this are included elsewhere in this project.

Construction

The integrated circuit decade counter (IC2) belongs to the family of electronic components known collectively as CMOS (an abbreviation of Complementary Metal-Oxide Semiconductor). The name is derived from the manufacturing process. CMOS devices are widely used in digital electronic circuits and range from the very simple to the extraordinarily complex. For example some CMOS calculator integrated circuits may contain upwards of 5000 transistors in a package half the size of a postage stamp!

CMOS devices are very rugged in use but they can be easily damaged by static electricity before they are soldered in. To protect against this they are supplied inserted into electrically-conductive plastic foam, aluminium foil or special containers which short all the pins together.

DON'T remove the CMOS IC from its protective packing until you are quite ready to insert the IC into the circuit. All other components should be soldered in first leaving the CMOS IC last of all.

Try to handle the IC without touching the pins, and solder into place quickly and cleanly using a light-weight soldering iron.

The layout of the project is not critical but we suggest you follow our Veroboard or printed circuit board unless you have some experience in board design.

The integrated circuits have a notch or dot at one end. When inserting the ICs make sure you follow the orientation shown on our component overlay drawings. Make sure also that the electrolytic capacitor is inserted the right way round.

Light emitting diodes will have their cathode (k) terminals marked in some way. Usually this is via a small flat adjacent to the cathode lead — or the cathode lead may be shorter than the other. Do make sure that you insert these LEDs the right way round — if any LED fails to light when the button is pressed it's odds on that the LED is the wrong way round.

HOW IT WORKS – ETI 068

When the push button is pressed the capacitor C1 is charged up via resistor R1. When the voltage on C1 reaches two thirds of the supply voltage (6 volts) a detector within the IC switches on an internal transistor in the IC, which shorts the capacitor to ground and discharges it until the voltage drops below one third of the supply voltage. When this happens another detector turns off the discharge transistor. The cycle now repeats, as the capacitor is allowed to recharge.

The time to charge the capacitor C1 from one third to two thirds of the supply voltage (that is from 3 to 6 volts with a 9 volt supply) is 150 microseconds (0.69 x 10,000 x 22 x 10^{-9} secs). The discharge time is only about 2 microseconds, due to the fact that the discharge transistor (internal to the IC) is a very low resistance when it is turned on.

While the capacitor is being discharged the output of IC1 (pin 3) drops from +9 volts to 0V and then returns to +9 volts when Cl is released. Thus during each discharge period a narrow pulse is generated at the output of the IC. That is, we have a 2 microsecond wide pulse every 150 microseconds which corresponds to an output frequency of about 6600 Hz.

The display for the dice is formed by six LEDs which are driven by IC2. This IC is a digital device and is a decade counter (it counts to ten) and a decoder in one package. It has ten outputs, one only of which is high (+9 volts) at any one time and all the others are low (0 volts). It also has a clock input and a reset input. When the reset is taken high the device is set to the state where the first of the outputs is high.

The output of IC1 is connected to the clock input of IC2 and every time there is a pulse from IC1 the output of IC2 which was high, will go low and the next output will go high (providing that the reset input is low). Thus the "high" shifts through the ten outputs of IC2 in sequence, at the same rate as the input pulses from IC1. The sequence of ten outputs recycles whilst there are input pulses.

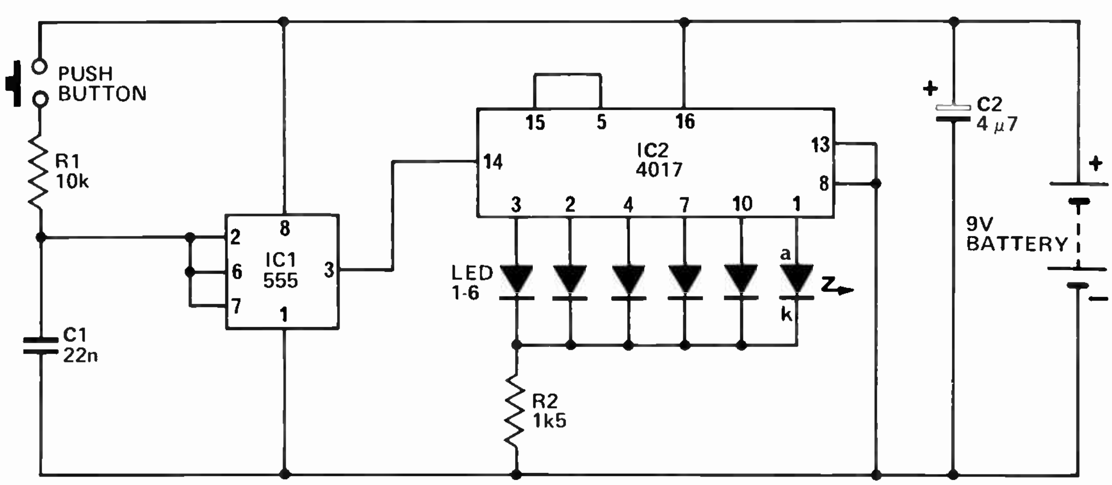
However a dice has only six surfaces so we require IC2 to count by six, rather than by ten. This is quite easily performed by connecting the seventh output of the IC back to the reset input. Now when the counter is clocked from output six to output seven, seven goes high and resets the counter. Once the counter resets, the high is removed from output seven and the counter, back at output one, is free to count again. The time taken to do this is only about 100 nanoseconds (0.000 000 1 sec) and is therefore very difficult to see on an oscilloscope.

The outputs one to six of IC2 are each connected to the anode of an LED. The cathodes of the LEDs are all connected in parallel, via a common current-limiting resistor, to 0 volts.

To sum up the operation, when the button is pressed IC1 commences oscillating at 6.6 kHz and this clocks IC2 such that each of the LEDs is lit in sequence – the cycle repeating about 1000 times per second. When the button is released the oscillator will stop and one LED only will be lit. Human reactions are not nearly fast enough to be able to stop the dice at any specific point. The results will therefore be completely at random.

For checking purposes the action may be slowed down by putting a high value resistor across the terminals of the push button (even just a finger across the terminals will do). This will cause the oscillator to run at a low speed so that the changing of the LEDs can be seen.

Fig. 1. Circuit diagram of the LED dice.



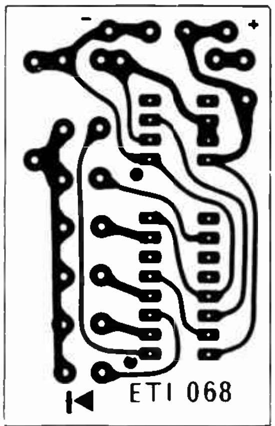


Fig. 2. Printed-circuit board layout for the LED dice. Full size 55mm x 35mm.

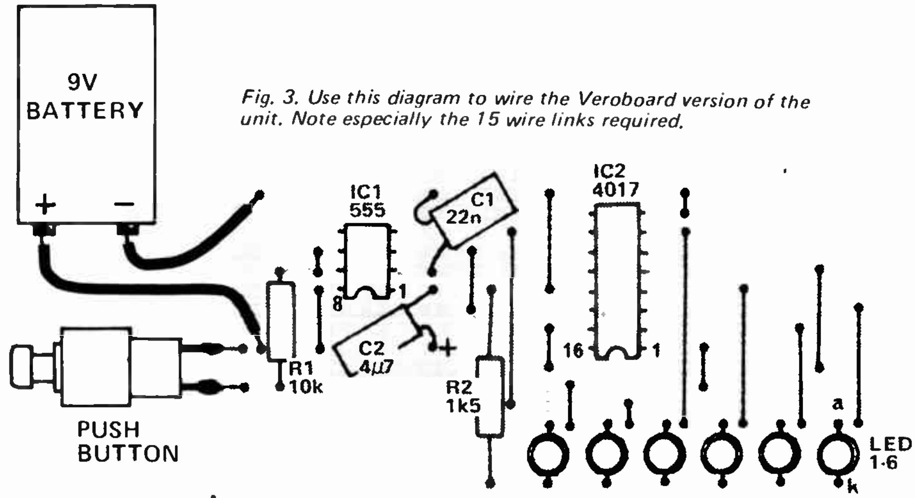


Fig. 3. Use this diagram to wire the Veroboard version of the unit. Note especially the 15 wire links required.

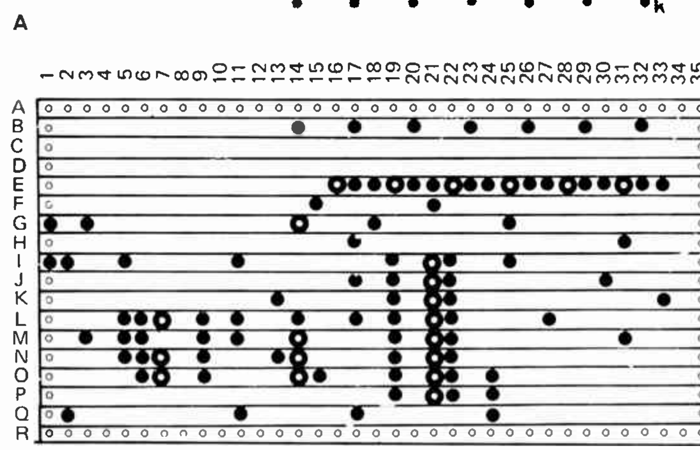


Fig. 4. Cut the Veroboard track in the places indicated by the pads with holes. The other dots are where soldered connections are made.

PARTS LIST – ETI 068

R1	Resistor	10k ½w 5%
R2	Resistor	1.5k ½w 5%
C1	Capacitor	22nF polyester
C2	Capacitor	4.7µF 25V electro
IC1	Timer	555
IC2	Counter	4017 (CMOS)
LED 1-6	Light emitting diodes	

Push button – press to make
9V battery
Battery clip
1.5" x 3.5" Veroboard 0.1" or
PC Board ETI 068

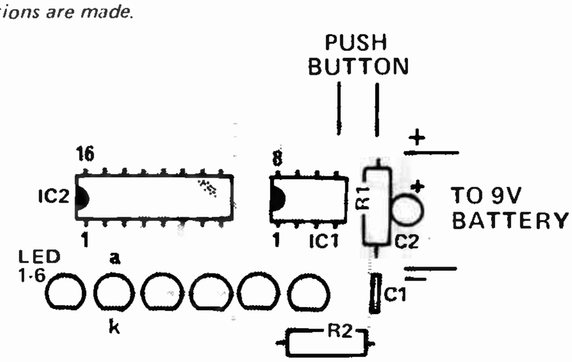


Fig. 5. How the components are mounted to the printed-circuit board.

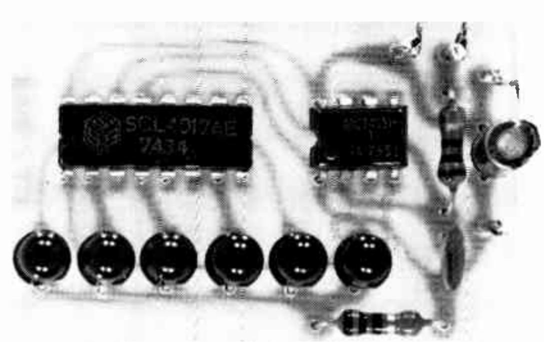
EXTENDING THE LEDs

The number of LEDs may be increased (or decreased), to a maximum of ten if you want the circuit to 'cycle' continuously.

Referring to the main circuit diagram the 'first' LED is the one furthest left. The remainder then flash in sequential order from left to right. In other words the LEDs don't flash in an order corresponding to the pin numbering (don't ask us why – we don't design ICs!) – rather they flash in pin order 3 – 2 – 4 – 7 – 10 – 1 – 5 – 6 – 9 – 11.

To alter the number of LEDs simply disconnect the existing link between pins 5 and 15 of IC2, add or take away the LEDs required and connect the pin of the next output in sequence back to pin 15. For example to increase the LEDs to eight just connect the two extra LEDs to pins 5 and 6, and then connect pin 9 to pin 15. If you wanted only three LEDs then you'd take out the LEDs shown connected to pins 7 – 10 – 1 and connect pin 7 to pin 15.

If you want the circuit to count up to ten connect pin 15 to negative and delete the link shown between pin 15 and pin 5.



The completed printed-circuit board version of the LED dice.

TACHO

Car tachometer circuits are generally complex and expensive devices. But here's one that can be put together for only a few dollars!

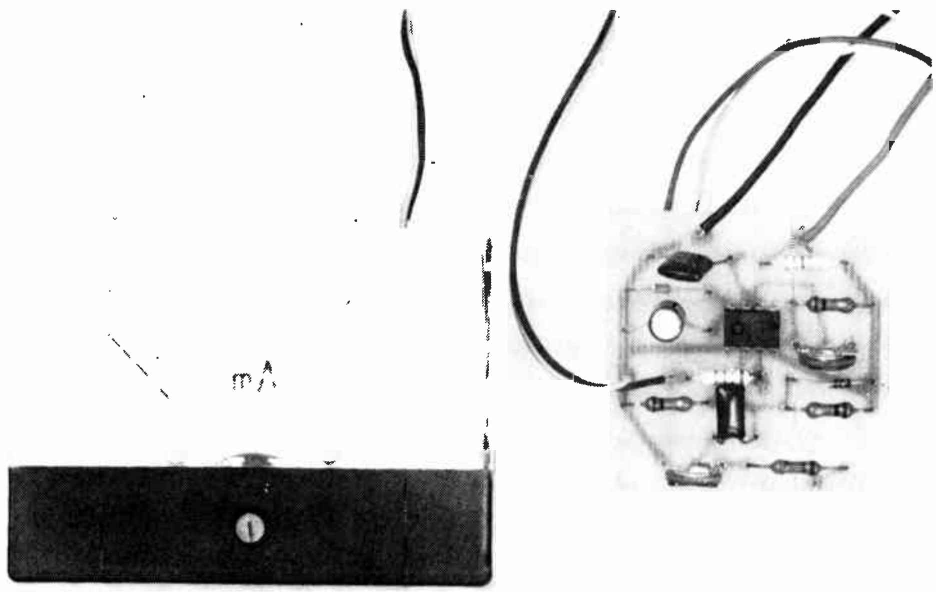
UNTIL TEN OR SO YEARS AGO, car tacho's were cumbersome mechanical devices usually driven via a flexible cable from skew gearing attached to the shaft of the vehicle's dynamo — or sometimes via the distributor shaft.

The advent of transistor technology changed all this and since then almost all car tacho's are electronically operated.

The basic principle is much the same for all electronic tacho's. An electrical signal taken from the low tension side of the distributor is converted into a voltage proportionate to engine rpm and this voltage is displayed on a meter calibrated accordingly.

Most car tacho's are complex and expensive devices — but here's one with a difference! It is simple yet extremely effective. Its simplicity is due to our using one single integrated circuit rather than the more conventional multiplicity of individual transistors.

The unit will operate on both positive and negative earth vehicles and will also operate successfully and without modification with most types of electronic ignition systems as well as the more common electro-mechanical systems.



Construction

As there are so few components, construction is very simple and straightforward. Do make sure though that the 555 IC is soldered in the right way round — ditto the two diodes. Compare your work against our layout drawing as a final check.

Any type of meter that has one milliamp full scale deflection can be used. This is a very common type of instrument and you should be able to obtain one new or secondhand with no difficulty. Ideally you should choose one that has 180° or 270° movement but these tend to be rather expensive. The meter size should be chosen to suit your proposed housing.

When the meter has been assembled connect it to the vehicle's battery and connect the input to the contact breaker side of the coil. The only satisfactory way to calibrate the unit is to persuade a friendly garage to connect up their own tacho at the same time and compare readings — or to check the unit on another car already fitted with a tacho. If you do it the latter way bear in mind that if yours is a four cylinder car then you must check using another four cylinder car, etc.

Another but slightly less satisfactory way of calibrating is to ascertain, from the vehicle's specification, the engine speed per thousand rpm in top gear and calibrate accordingly.

Potentiometer RV2 is used to adjust calibration - the value specified provides a range of adjustment suitable for virtually all vehicles. The adjustment is, however, rather coarse. If the tacho is to be exclusively on one vehicle it is possible to reduce the value of RV2 to 25 k or lower. If this is done it will probably be necessary to increase the value of R4 accordingly.

Before making the final calibration adjust RV1 to eliminate any false triggering — check at all engine speeds. This unit may be used with either positive or negative earth vehicles — simply connect the battery leads as shown. Note however that this unit cannot be used with 6 volt systems — so for those owners of early model VWs and BMWs we're sorry but . . . .

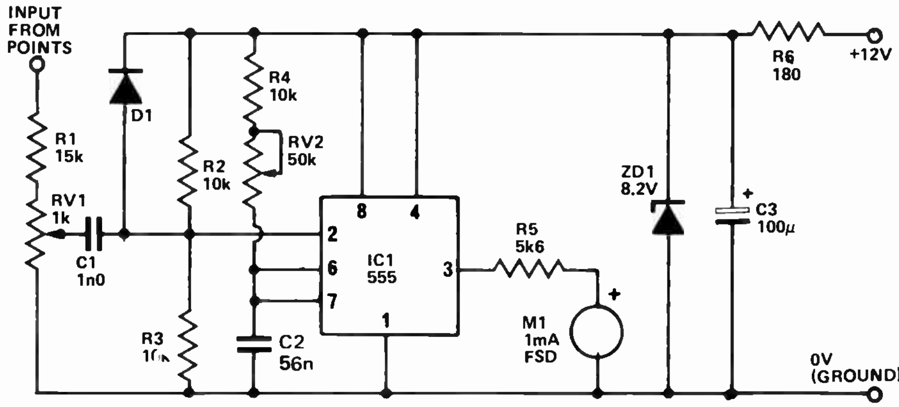


Fig. 1. Circuit diagram of the tacho.

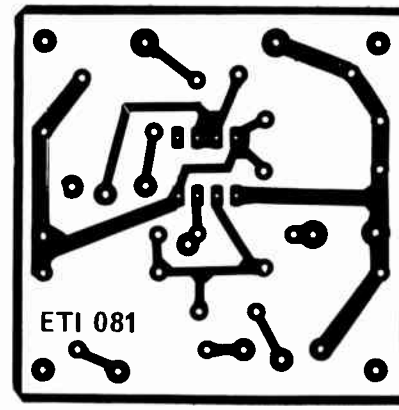


Fig. 2. Printed circuit layout. Full size 50 mm x 50 mm.

How It Works — ETI 081

The 555 timer IC is used as a monostable which, in effect, converts the signal pulse from the breaker points to a single positive pulse the width of which is determined by the value of R4 + RV2 and C2. The mathematical formula is T = 1.1 x R x C where R = R4 +RV2 (the section of RV2 in use) and C = 5.6 x 10^{-9} (Farads), and T = pulse length in seconds.

Resistors R2 and R3 set a voltage of about 4 volts at pin 7 of IC1. The IC is triggered if this voltage is reduced to less than approx 2.7 volts (1/3 of supply voltage) and this occurs due to the voltage swing when the breaker points open.

An adjustment potentiometer RV1 enables the input level to be set to avoid false triggering.

Zener diode ZD1 and the 180 ohm resistor stabilize the unit against voltage variations.

PARTS LIST ETI 081

R1	Resistor	15 k	½ W 5%
R2-R4	"	10 k	" "
R5	"	5k6	" "
R6	"	180 ohms	" "
RV1	Trim Potentiometer	1 k	
RV2	" "	50 k	
C1	Capacitor	1n0 polyester	
C2	"	56n polyester	
C3	"	100 μ 10 V electro	
D1	Diode	1N914	
ZD1	Zener	8.2 V 300 mW	
IC1	Timer	555	

PC Board ETI 081
Meter 1 mA FSD

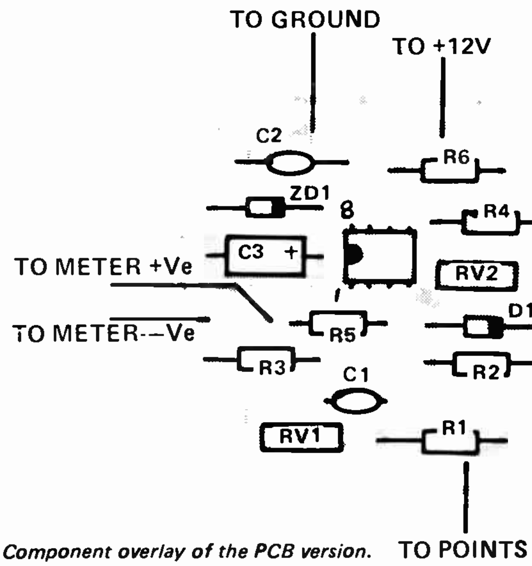
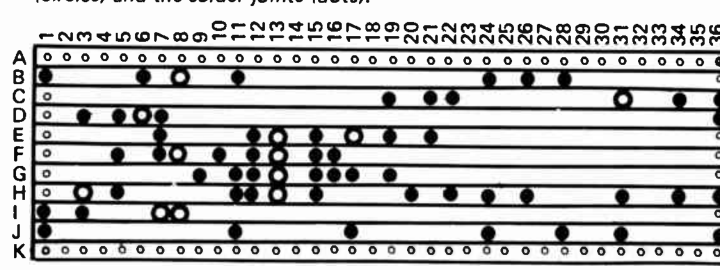


Fig. 3. Component overlay of the PCB version.

Fig. 4. The underside of the Veroboard showing the breaks in the tracks (circles) and the solder joints (dots).



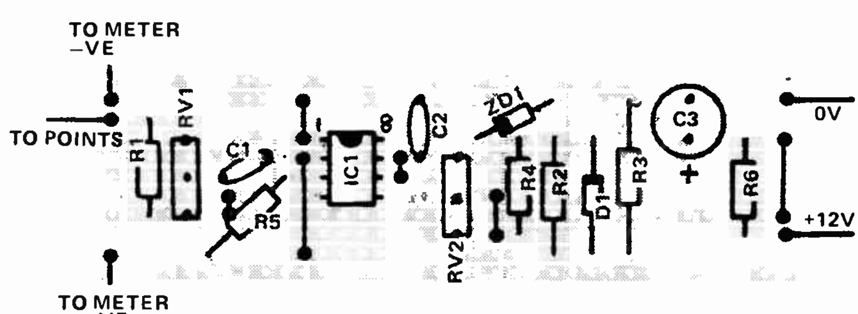


Fig. 5. Component overlay for the Veroboard version.

OVER-REV ALARM

Safeguard your engine with this 'over-rev' modification to the ETI 081 tacho.

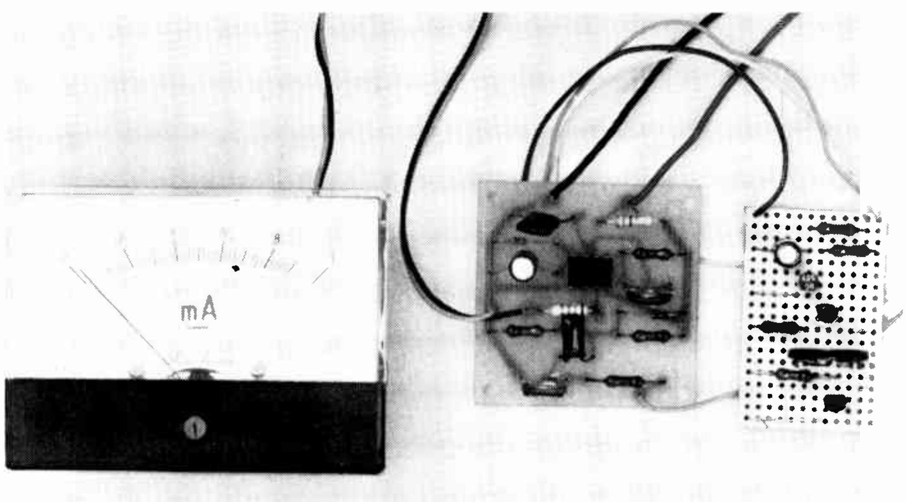
MANY AN ENGINE has been damaged or at least severely stressed by over-revving. And even though a tachometer may be fitted it is still only too easy to over-rev during the heat of a traffic light Grand Prix! Or when negotiating a slippery patch of mud in a four wheel drive.

So here is an add-on modification to our ETI 081 project which sounds a (very!) audible alarm if a preset rev limit is exceeded.

The device can be assembled on a short offcut of Veroboard – or the printed circuit board shown here. Power is taken from the tacho unit.

An unusual feature of the device is the audible alarm. This is a solid-state unit which emits a loud high-pitched note. Various units are available. We have specified two or three alternatives in the parts list.

The Over-rev indicator can also be used as a warning that you are exceeding a preset speed if you install a micro-switch which is actuated by the gear lever in top gear only. This switch should make and break the 12 volt supply to the unit. This arrangement only works satisfactorily with manual transmission vehicles as there is no fixed relationship between engine revs and road speed with automatics.



The components for the over-rev alarm are mounted on the board seen on the right of the main tacho board.

INSTALLATION

The extra board should be located close to the main tacho board. The +12 volts and 0 volt lines should be connected to the same points on the tacho board. The +8 volt line should be connected to the junction of the tacho's R4 and R6. The remaining line should be connected to the junction of pin 3 of IC1 and R5.

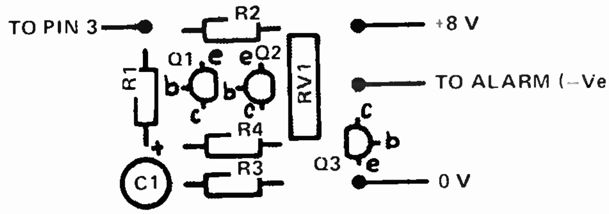
The Sonalert (or similar) should be mounted in any convenient place where it can readily be heard. Remember it may sound loud when the car's stationary but it has to be heard over a surprisingly high noise level when the engine is revving hard.

Set RV1 to cause the alarm to sound at whatever limit you desire (a good guide is 5% lower than the vehicle manufacturer's max. rpm recommendation).

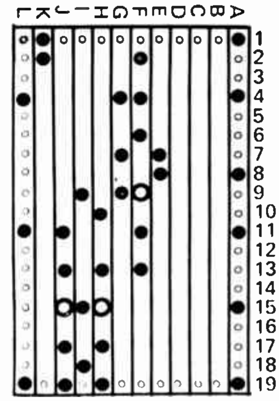
HOW IT WORKS – ETI 085

This unit must be used with the tacho described in ETI 081. The output from IC3 (of the tacho) is a series of positive pulses where the repetition rate is dependent upon engine rpm.

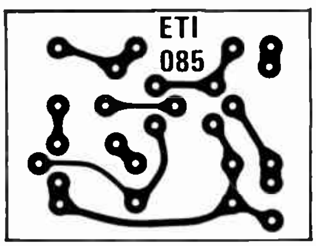
The pulses are filtered by R1 and C1 into a dc voltage varying with engine rpm from zero to about 8 volts. This voltage is compared against a voltage set on RV1 by the differential amplifier Q1 and Q2. If this is greater than the RV1 voltage Q3 will be turned on thus energizing the Sonalert.



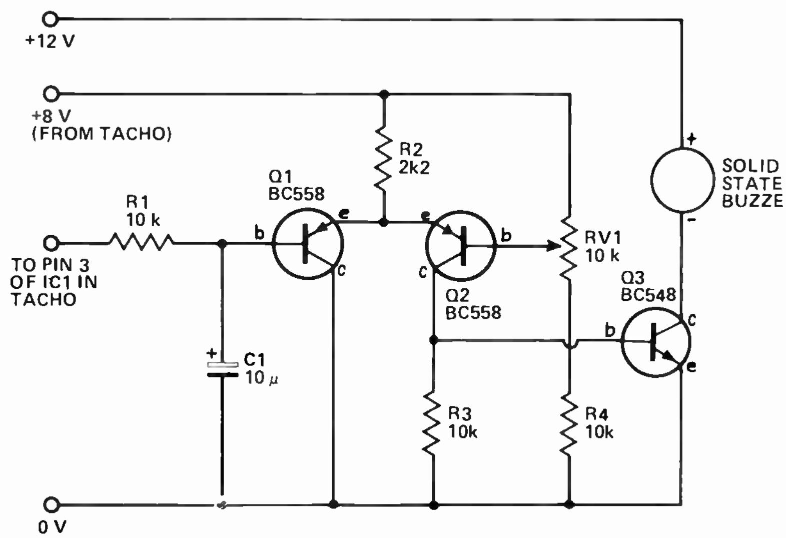
The printed circuit component overlay. Make sure all transistors are installed in the correct position corresponding to the overlay.



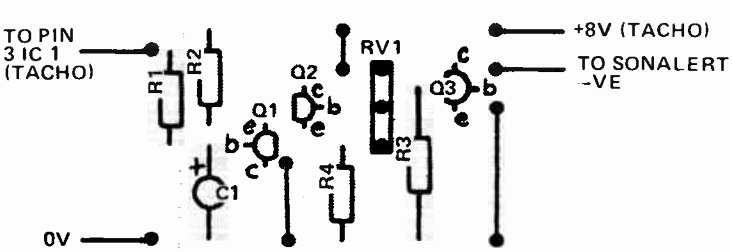
Drilling details for Vero-board of over-rev alarm. Dots mean solder points while hollow circle indicates a hole cutting the copper track.



Printed circuit board layout – full size.



Circuit diagram of add-on unit – note that a connection must be made from the +ve side of the solid-state buzzer to the +12 volts.



Veroboard component overlay. Note polarity of transistors and the capacitor.

PARTS LIST

R1,R3,R4	Resistor	10k	½ Watt 5%
R2	Resistor	2k2	½ Watt 5%
C1	capacitor	10 μF 25 volt electrolytic	
RV1	trimpot	10 k	
Q1-2	transistor	BC558	
Q3	"	BC548	

Solid state buzzer – Sonalert, Soanlert, Solid state buzzer L-7009 or similar

Printed circuit board ETI 085
Or Veroboard

INTRUDER ALARM

How to build and install your own intruder alarm system.

IN MOST COUNTRIES an unfortunate by-product of increasing living standards is a concomitant increase in the rate of crime. This phenomenon has upset many previously held views of the causes of crime (particularly burglary) which were commonly regarded as being linked with poverty rather than affluence.

But no matter what cause, if you live in a biggish city your chances of being burgled are high – and becoming higher to the point where an effective burglar alarm system is a necessity in some suburbs.

A few commercial organisations produce top quality reliable alarm systems – but their cost may well exceed $750 particularly if they're commercially installed. It is however perfectly feasible to build and install your own system for a mere fraction of this cost. And what's more the system may well prove superior in performance and reliability to most of the commercial devices.

A good home alarm system should be battery operated – it's only too easy to cut power off from outside – it should work reliably for a long time, and it should not give false alarms.

The alarm system described here meets these requirements. To a large extent it does so because we have designed it using CMOS technology.

CMOS integrated circuits draw much less power than other types, the total current drawn by our system is less than one milliamp – except when an alarm occurs. CMOS is not affected very much by electrical noise, so there is less chance of false alarms being caused by energy induced in the signal leads from lightning flashes (a common failing of many systems). Finally, CMOS is very rugged and reliable once it is soldered into the circuit.

ALARM MODE

The ETI 082/528 system has three operating modes.

Break-ins are detected by micro-switches or reed relays fitted to each door and window so that the switch contacts are closed when the door or window is closed. All switch contacts are wired in series so that the 'loop' is broken if any door or window is opened – or the connecting wires cut. The loop is connected between the 'external loop' and 'common' terminals shown in wiring diagram.

SILENT ENTRY

The unit has a timing circuit which allows one designated door to be opened and closed without setting off the alarm for (approximately) 30 seconds after the alarm is switched on. It also allows the occupier 30 seconds to switch the alarm off after he has re-entered the house. The switch protecting the silent entry door is not included in the overall switch loop. It has its own silent entry circuit and the switch for this is connected across the 'silent entry' and common lines – see wiring diagram.

EMERGENCY

This circuit enables any number of push buttons, fire, smoke or gas detectors etc to trigger the alarm. You can also install emergency pushbuttons close to the front door and/or beside the bed so that an alarm can be initiated at any time. Switches for this mode must have 'normally open' contacts. They should be wired across the 'emergency' terminals.

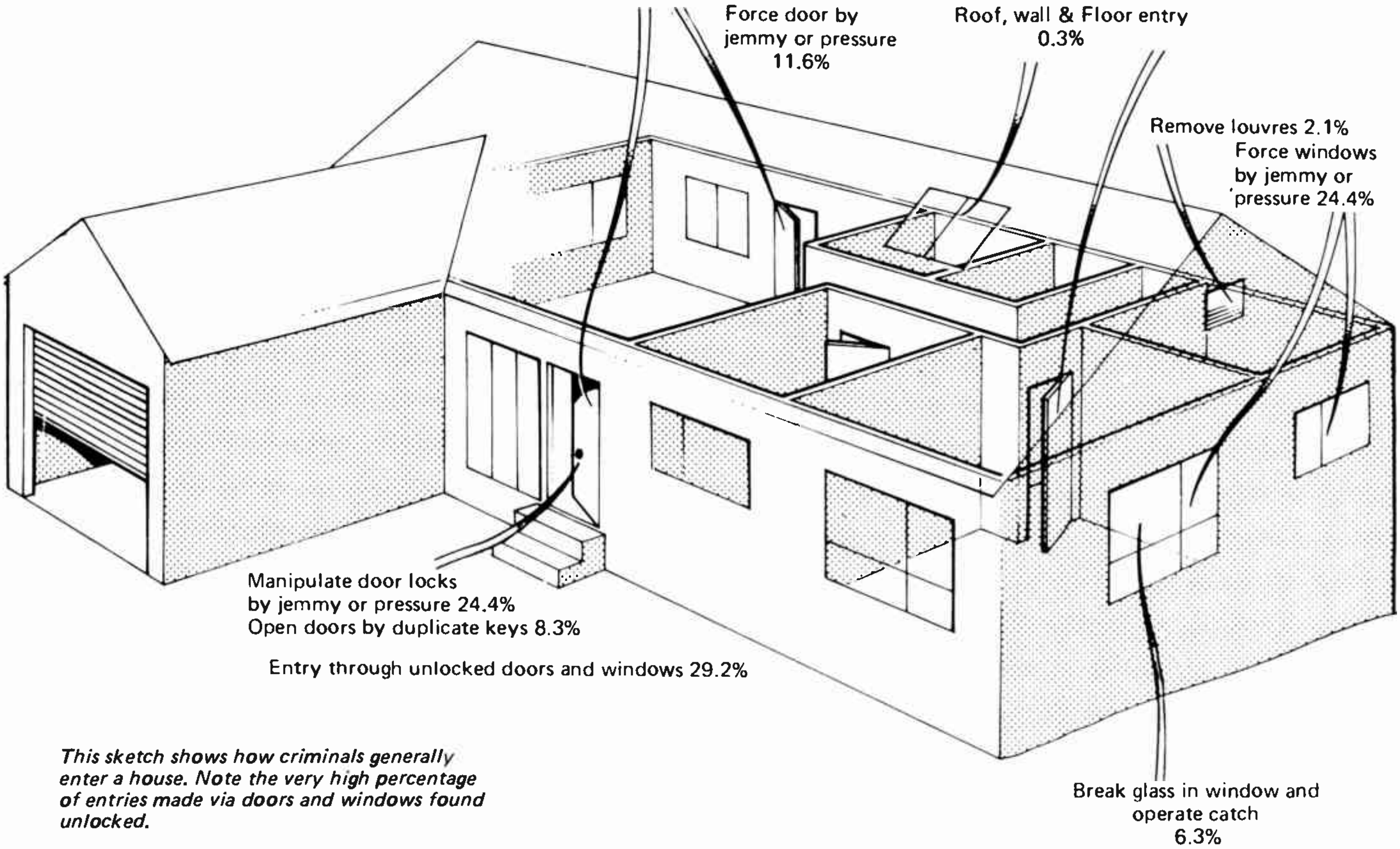
CONSTRUCTION

This project is best assembled on the printed circuit board shown. Make sure that all diodes, tantalum capacitors and the transistor are the right way round before soldering. DON'T solder the CMOS IC in place until you are sure that all other components are in their right positions and connections soldered.

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

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

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



This sketch shows how criminals generally enter a house. Note the very high percentage of entries made via doors and windows found unlocked.

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

Our illustration shows the most common ways in which burglars attempt to break in. The methods are surprisingly simple — 37 percent just walk in through a door.

For most premises, it is necessary to install sensing devices on front and rear doors, garage entrances, windows, large ventilators and skylights.

A very small proportion of break-ins are made by removing cladding materials from the walls or roof — and very occasionally entry will be made through the floor. Although few premises are broken into like this, it is usually possible to find a strategic passage or zone through which an intruder will pass — i.e., the door into the master bedroom, the area around a safe, etc. It is a simple matter to locate sensors in these areas and include them in the alarm circuit.

The ETI 082/528 alarm is specifically intended for 'closed loop' operation for its main alarm loop. A number of switching devices — all held closed in the 'safe' position — are wired in series. If any switch is opened, or if the series loop is cut in any way, the alarm will be activated.

MAGNETIC REED SWITCHES

The simplest and most reliable switching device for alarm installations is the magnetic reed switch.

This consists of a pair of ferromagnetic contacts in a small hermetically sealed glass enclosure.

The switch reeds are cantilevered from the ends of the glass tube and overlap slightly at the centre, with a small air gap between them.

When a magnet is brought near the reed switch, the attracting forces increase and overcome the stiffness of the reeds, bringing them into contact with each other. When the magnet is removed, the contacts reopen. The relative distance for pull-in is always less than for drop-out. This is a valuable feature for alarm movements of doors and windows will not cause false alarms.

Reed switches purchased for alarm installations must be of a type specifically intended for the purpose — standard reed switches are not suitable. If standard reed switches are held closed for a long time, they tend to remain closed when the magnet is removed.

Many professional security companies install reed switches and magnets encased in plastic mouldings. Whilst these mouldings are neat and simple to fit, it is better to conceal both reeds and magnets within the framework of the doors and windows.

We have shown various methods of locating the reeds and magnets (note that the magnet is always fixed to the moving part of any door or window frame).

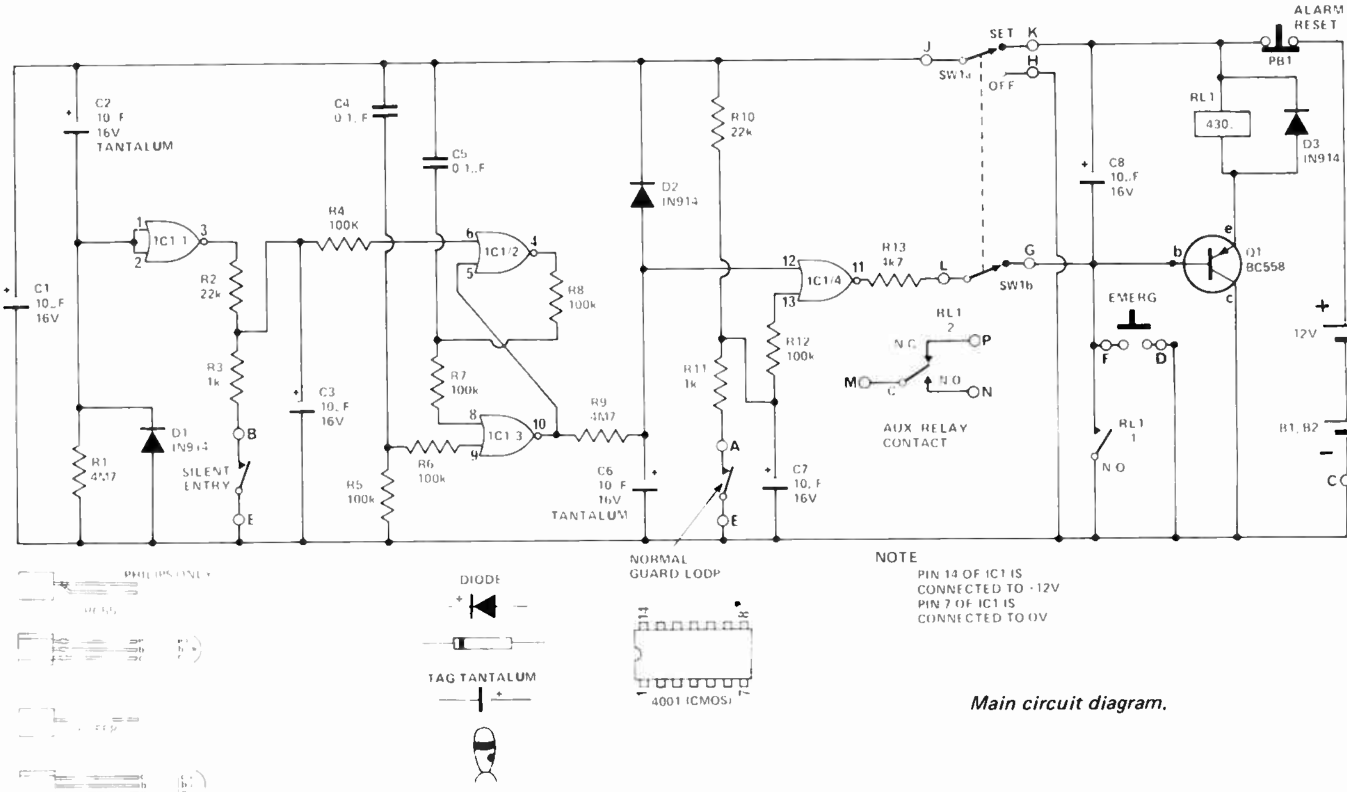
Although magnetic reed switches are surprisingly rugged, care must be taken when bending or cutting the external connecting leads. If these have to be bent, hold the reed as shown. Do the same if the connections have to be shortened.

All the reed switches are connected in series (except the one fitted to the 'silent entry' door). Use 23/0076 wire and make quite certain that all connections are properly soldered.

Close all protected doors and windows and check the series resistance of the loop with an ohmmeter. The resistance should not exceed a few ohms. If it does, check all connections for dry joints.

Connect the circuit as described earlier. Connect the leads from the 'silent entry' door switch to the appropriate input on the board.

INTRUDER ALARM



Main circuit diagram.

HOW IT WORKS

The alarm has three different modes of operation.

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

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

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

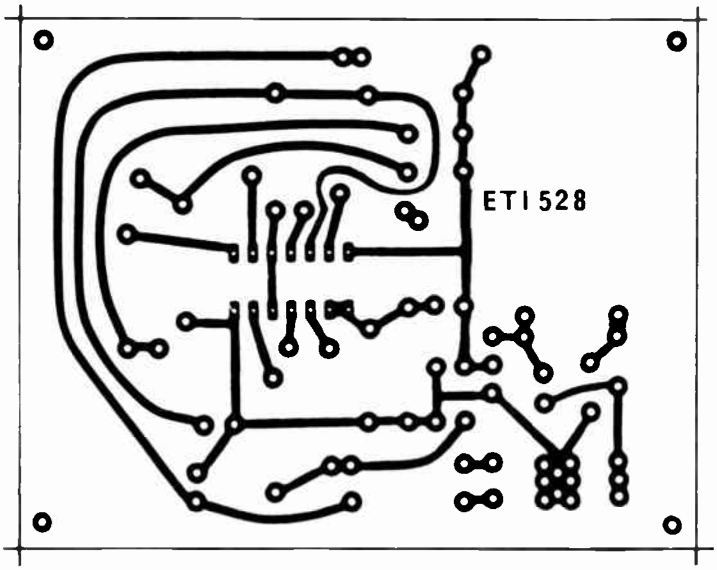
After this 30 second period, opening the silent entry door will present a "1" to pin 6 which will cause the flip-flop to change state. Closing the silent entry door will now have no effect and the flip-flop will remain set.

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

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

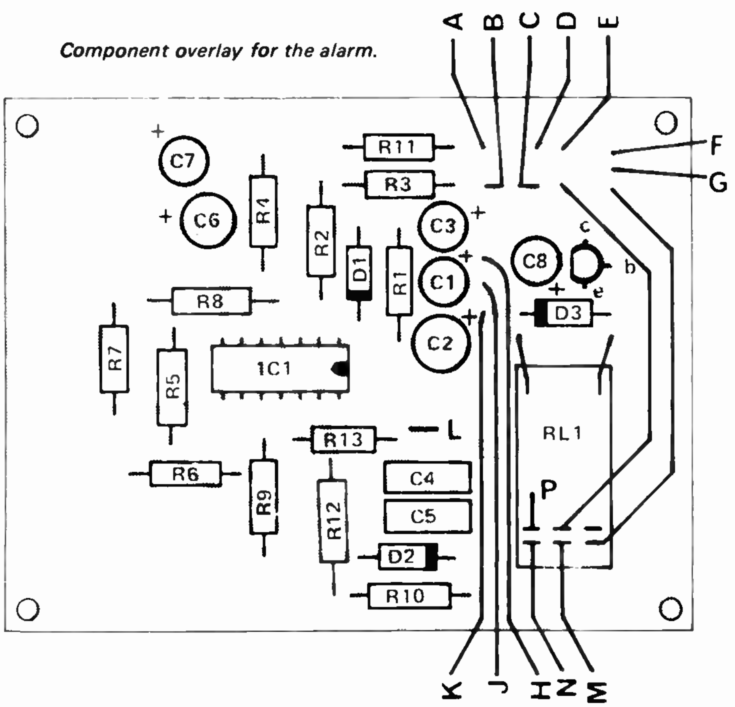
When the emergency switch is closed the base of Q1 is taken to zero and the relay closes and latches. This action will take place regardless of whether the alarm is enabled or not.

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



Printed circuit board layout. Full size is 90 mm by 70 mm.

Component overlay for the alarm.



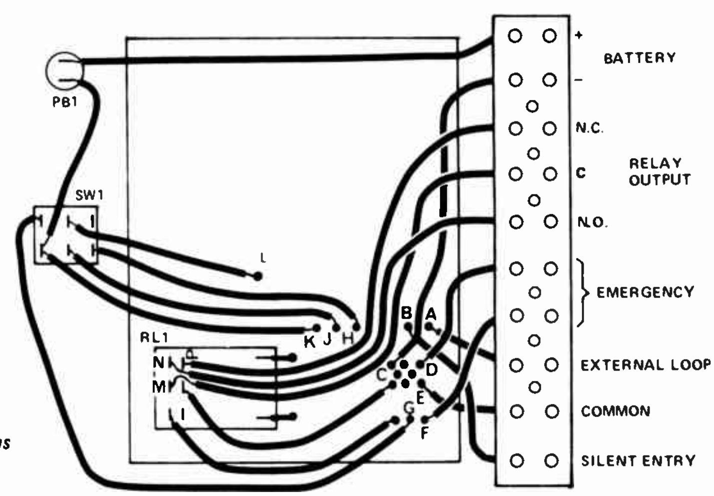
PARTS LIST 082/528

Resistor				
R1,R9	4M7	ohm	¼W	5%
R2,R10	22k	ohm	¼W	5%
R3,R11	1k	ohm	¼W	5%
R4,R5,R6				
R7,R8,R12	100k	ohm	¼W	5%
R13	4k7	ohm	¼W	5%
Capacitor				
C1,C3,C7,C8	10μF 16v electrolytic			
C2,C6	10μF 16v tag tantalum			
C4,C5	0.1μF polyester.			
Diode				
D1,D2,D3	1N914			
Transistor				
Q1	BC 558, BC 178 or equivalent			
Integrated Circuit				
IC1	SCL4001A, MC14001 etc			
SW1 switch	DPDT subminiature			
PB1 switch	Push button switch NC.			
RL1 relay	Miniature cradle relay, 430 ohm coil, two c/o contacts.			

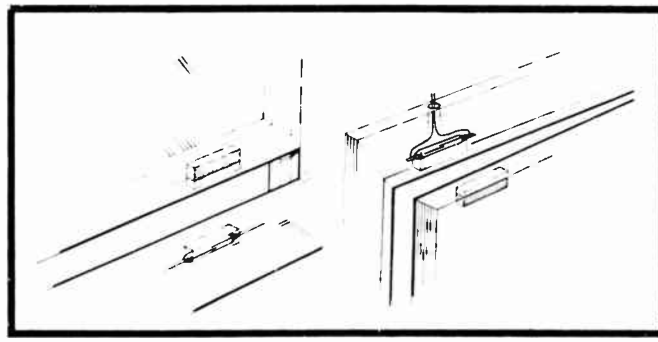
PC board ETI 528
10 way nylon terminal block, two 6 volt lantern hookup wire.

Note: This project is basically similar to ETI 528 first published in Electronics Today International in January 1975. For this reason we have given the project the joint number – ETI 082/528.

The details shown here are an expanded version of the original article – hence nothing is to be gained by trying to obtain the original.



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



Set the reed switch into the window frame and the magnet in to the moving part.

To protect a door set the reed switch into the architrave.

EMERGENCY SYSTEMS

The emergency alarm push-buttons should now be installed. These switches should be mounted on the architraves of the front and rear doors. They enable the occupant to set off the alarm if a caller forces his way into the house when the door is opened. Although this is not a common event, the emergency switches provide elderly or timid people with a feeling of security.

Use good-quality bell pushes and connect in parallel across the emergency inputs on the circuit board.

Fire alarm sensors are also wired across the emergency input connections of the alarm unit.

The fire sensors should be mounted in the ceiling of rooms in which there is a fire hazard – kitchen, living room, rooms with electrical or other heating appliances, or where people smoke; they should be installed in the roof of the garage – especially if this is attached to the house – laundry, workshop, etc.

Wire all fire sensors in parallel and connect across the emergency input on the alarm unit.

OTHER DEVICES

Many other types of intruder sensing devices can also be included in the system. Pressure mats, for example, can be placed under carpets in strategic passageways – or even under the doormat. The mats contain a large number of normally open contacts, some of which will close when the mat is trodden on. These mats are 'emergency' inputs.

Infra-red beams can be installed if required. These and other commercially available intruder detectors use a change-over relay output stage. The appropriate change-over relay contacts should be connected in series with the normally closed loop.

WARNING SYSTEMS

The intruder alarm itself should be reasonably accessible to people entering and leaving the premises via the 'silent entry' door, but well-hidden from the sight of an intruder.

The intruder alarm output stage is a relay which latches when an alarm signal is received.

For household use, a good-quality 12 volt alarm bell will be adequate. Being mechanically resonant devices, bells have a very high conversion efficiency of electrical to acoustical energy; in fact, the average 12 volt bell draws less than 500 milliamps and can be heard several hundred feet away.

Good sirens can be heard well over half-a-mile away, but they draw a lot of power and also cost more than a good bell. Small, cheap sirens cannot be recommended. An excellent unit to build is Electronics Today project ETI 065.

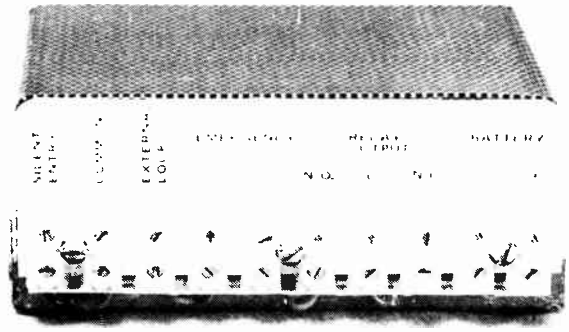
If at all possible, householders should make mutual arrangements with neighbours to contact the police if the alarm is heard. Similar arrangements should also be made so that neighbours can switch off the alarm after the police arrive.

The alarm bell should be mounted unobtrusively, high up in an inaccessible place. The leads to the bell should be run in 40/0076 (to reduce voltage drop) and concealed from view. We strongly recommend that a separate 12 volt battery be used.

Notes:

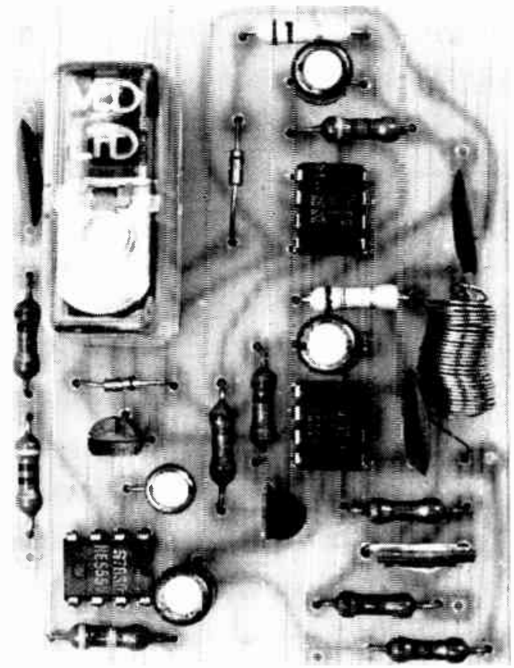
One approach is to connect the alarm output relay to switch on a number of floodlights. It will be necessary to drive a heavy-duty contactor to carry the lighting current. Intense lighting will dissuade an intruder as thoroughly as an audible warning, and it's less traumatic for the awakened householder. Where business premises are concerned, the bell should also be retained.

The installation of an intruder alarm should only be *part* of a co-ordinated campaign to dissuade burglars. There are a number of simple precautions that should also be used. Details of these are contained in an excellent series of leaflets obtainable from the Crime Prevention Bureau of your local police headquarters.



CAR ALARM

Safeguard your — or your family's car with this effective easy-to-install alarm.



A STAGGERING number of cars are stolen each year. Some are stolen by professional thieves — and if one of these wants your car sufficiently enough then there's little that will stop them — alarms or otherwise.

But the majority of cars are not taken by professionals — they are stolen by people who use them for only a few hours — and then abandon them. Only too often in a vandalised state.

So if you fit a good reliable alarm it's odds-on that you will dissuade all but the most determined criminal.

Many different types of car alarm are currently available. The simplest have a sprung pendulum cantilevered out from an enclosure. If the car is moved, the pendulum moves against its spring restraint and causes two electrical contacts to come together — thus triggering the alarm. This type is simple and effective but very prone to false alarms.

Another type of alarm consists of little more than a self-latching relay which is triggered by a series of switches mounted in the vehicle's doors, hood, bonnet etc. It's very simple in operation but installation is a major job on many cars.

Yet another type sounds an alarm if the ignition is switched on before the alarm is disabled. Most thieves are aware of this type and often bypass them by disconnecting existing ignition wiring and running a new lead directly from the vehicle's battery to the coil.

A further class of alarms is rather cleverer. These detect a voltage drop anywhere in the vehicle's electrical system — caused for example by the interior light coming on when a door is opened, pressing brake pedal and thus energising the stop lights, starting the engine etc etc.

The alarm described in this project works this way. It is also very easy to install. You simply connect it to any point which is normally 'live' at all times — such as the clock or the starter solenoid. We have added a facility which causes the alarm to be triggered if an external triggering point is earthed.

To comply with noise pollution regulations we have included a circuit which automatically turns the alarm off about 45 seconds after it has been triggered. The alarm is then automatically reset.

Almost all thieves are deterred by knowing that an alarm is fitted so we have included an LED (light emitting diode) which flashes once per second when the alarm is set. This LED should be mounted in a prominent place where it can be seen from outside the car.

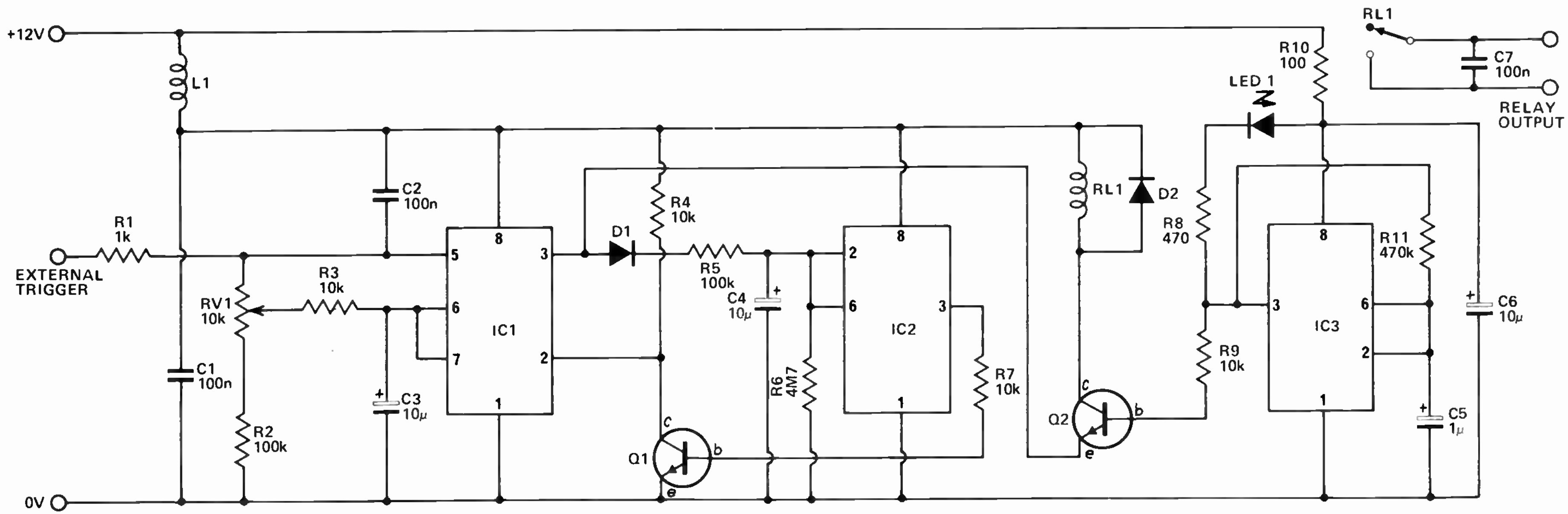
Don't be deterred by the alarm's apparent complexity. As long as you build it using our printed circuit board layout you will not encounter any difficulties. L1 is a coil made of about 30 turns of 26 B&S wire on a 6mm former. The former can be removed after winding (neither the number of turns nor gauge of wire is critical). The completed board should be housed in a metal box which itself should be well earthed to shield the unit from electrical interference.

The alarm output is a pair of relay contacts capable of switching up to six amps. These may be used to switch the existing horn — or preferably to switch power to an additional alarm horn mounted in an inaccessible position. The alarm pulses at roughly one second intervals.

INSTALLATION

Installation is a simple process. The unit must be connected to the vehicle's 12 volt supply at a point which is normally energised at all times. The supply to the electric clock (if fitted) is a good and usually accessible place. Failing this find a point on the main fuse box or starter solenoid switch which comes directly from battery. Do *not* connect directly across the battery as the unit relies upon voltage drop across the battery *and* connecting cables for its operation.

Main text continues on page 67.



HOW IT WORKS
ETI 084

The alarm works by detecting a voltage drop anywhere in the vehicle's electrical system. Its operating principle is rather complex but we trust it can be followed if one reads this section several times!

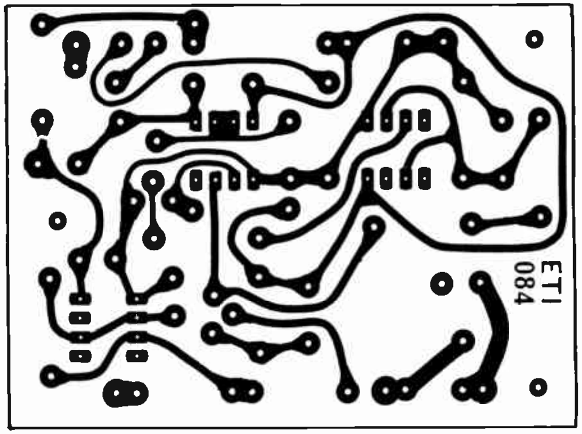
All three ICs are 555 timers used for various functions. Pin 5 of IC1 is the 2/3rd reference level — that is if the voltage on pin 6 exceeds that voltage on pin 5 the IC will be triggered. Potentiometer RV1, which is connected to pin 5, is adjusted so that a voltage slightly lower than this appear on pins 6 and 7. These two pins are the upper threshold level and the internal discharge transistor of that IC. The lower threshold level is established by pin 2 which is connected to +12 volts via R4. Pins 6 and 7 are decoupled to the zero volt line by C3.

If any load is placed on the vehicle's 12 volt supply — to which of course the alarm system is connected — a voltage drop must occur even if only momentarily. This negative going signal will cause the 2/3rd voltage of pin 5 to fall relative to the upper threshold level voltage (which is maintained at a steady level by capacitor C3). If the 2/3rd voltage does fall below the upper threshold level then the output on pin 3 will drop to about 0.6 volts thus initiating the alarm sequence.

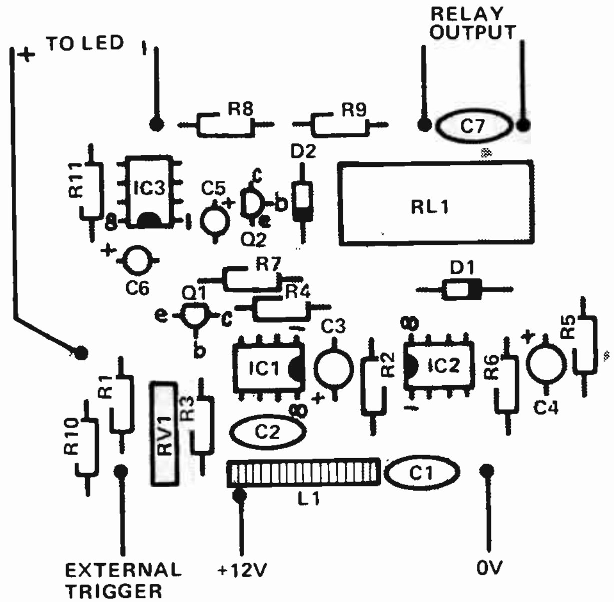
IC3 is an oscillator running continuously at 1 Hz — this signal is also used to energise the dashboard mounted LED to warn that the alarm is set. The 1 Hz signal drives the base of Q2 which in turn drives the output relay RL1. The emitter of Q2 is normally held at a level around 12 volts unless the alarm is activated — when, as described above — the output on pin 3 of IC1 drops to about 0.6 volts taking the emitter of Q2 with it and thus allowing Q2 to pulse the relay.

A timing circuit switches off and resets the alarm after (approximately) 45 seconds. Capacitor C4 is held at about 12 volts via D1 and R5 and as this voltage is applied to pins 2 and 6 of IC2 the output of that IC is 0V. When the alarm is triggered, C4 is allowed to discharge slowly via R6. When the voltage on pins 2 and 6 falls to about four volts (this takes about 45 seconds) the output of IC2 goes high. This turns on Q1 thus resetting IC1 which in turn shuts off the alarm. Capacitor C4 then recharges and after three seconds or so the alarm is completely reset and if needed can be re-triggered.

The alarm sequence will also be initiated if the 'EXTERNAL TRIGGER' point is connected to the zero volt line. Thus bonnet or boot opening may be detected by installing mercury tilt switches etc.



Printed circuit board pattern — shown here full size.



Component layout — printed circuit version.

PARTS LIST

Resistors

R1	1k	½	watt	5%
R2	100k	"	"	"
R3,4	10k	"	"	"
R5	100k	"	"	"
R6	4M7	"	"	"
R7	10k	"	"	"
R8	470 ohms	"	"	"
R9	10k	"	"	"
R10	100 ohms	"	"	"
R11	470k	"	"	"

Potentiometers

RV1 10k trim pot

Capacitors

C1,2	100n disc ceramic
C3,4	10 uF 25V electrolytic
C5	1 uF 25V "
C6	10 uF 25V "
C7	100 n disc ceramic

Semiconductors

IC1-IC3	555
Q1,2	BC548
D1,2	diode 1N914
LED 1	light emitting diode
RL1	relay 12 volt 280 ohm coil, 6A contacts type E3201 or similar

Printed circuit board ETI 084
Coil L1 see text
Metal box to house unit.

Text continued from p65

The connection to the 12 volt supply must be via a switch secreted somewhere outside the vehicle. Key switches are obtainable for this purpose from most locksmiths, hardware stores, kit set suppliers etc.

The LED should be mounted in a prominent place and it is worth adding a window sticker advising that an alarm is installed.

It's really well worthwhile installing a loud and distinctive horn just for this unit — and mounting it in an inaccessible place. All you need to do is connect one side of the horn to the 12 volt supply — via heavy duty wire — and the other side to one side of the relay contacts. The other side of the relay contacts is then taken to earth.

Apart from its ability to be triggered by voltage changes the alarm will also be triggered if the 'EXTERNAL TRIGGER' point is touched to the zero volt line. Thus you can arrange for a microswitch or mercury tilt switch to be fitted to the bonnet and/or boot to trigger the alarm if either are opened. You can of course protect the boot or bonnet in a possibly more useful way simply by installing inbuilt lights which are energised as the boot or bonnet is opened — the electrical load will then trigger the alarm in the usual way.

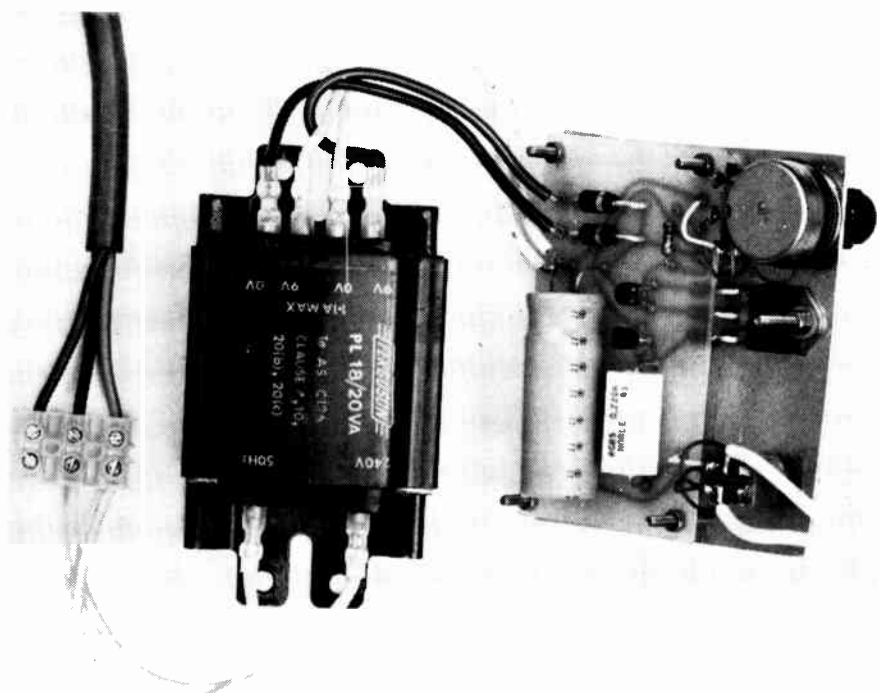
NOTES: Although apparently complex the circuit is not critical in any way. If C4 or R6 are substantially different from the values specified then the 'alarm sounding' time will be other than the nominal 45 seconds. Apart from that though no component is particularly critical.

Some 'electric' clocks have clockwork mechanisms which are wound up every minute or so by an electric motor or solenoid. You can tell if you have one of these because they emit a clearly audible 'clonk' every time they wind. These clocks may trigger the alarm because the winder draws power from the vehicle's electrical system. This can usually be cured by connecting a 100 ohm resistor in series with the clock and a 1000 uF capacitor across the clock terminals. Both must be mounted as close as possible to the clock.

Once the unit is installed switch it on and adjust RV1 so that opening a door (thus energising the interior light) will trigger the alarm.

TRAIN CONTROLLER

Many train sets have battery operated controls. This project uses the household mains power and has variable speed, forward/reverse and current limit.



MODEL TRAINS are usually powered by a transformer which converts the mains 240 volt 50 Hz supply to about 12 volts. A wirewound rheostat or a series of switched resistors then reduces the voltage to obtain the speed required. A rectifier circuit is included on all but the cheapest models as the trains must be run from a DC supply so that polarity may be switched to obtain forward and reverse motion.

The traditional supplies described above are heavy and expensive to build and adequate short circuit protection is not often included. It's not at all uncommon for rolling stock or metal oddments to fall across the rails and thus short out the supply. But many older type controllers are either not protected at all – or have merely a fuse which blows each time a short occurs – which may be quite often.

Because of these problems and objections there is a growing tendency towards electronic control.

We must emphasise at this point that this unit is mains operated. There is no more danger in building this unit than in wiring a three-pin plug – but if you know nothing at all about mains circuits do consult an experienced person during construction and particularly before connecting it to the mains.

We must also emphasise that the type (or class) of transformer specified MUST be used. In Australia, at least, the law requires that where the secondary side of a mains energised circuit is likely to be touched then the transformer used must be constructed to an Australian Standard known as C126. Included within this specification are the requirements that the mains input connections be shielded, that they be on the opposite side of the transformer from the output, that specially heavy insulation be used (in that the primary winding is kept right away from the secondary winding) – and so on.

The things are so safe that it's virtually impossible to have an accident – short of dropping it on your foot!

An interesting feature of the deisgn is that we have included automatic current limiting. This means that the unit is totally short-circuit proof. No matter what load is placed across the rails the current will be limited to a presettable value. Nothing will overheat or burn out – even if you short them out for a week.

Speed is controlled by potentiometer RV1. This may be a conventional rotary unit as shown here – or it may be a sliding type. Sliding potentiometers are now readily available from most electronics and kit set suppliers. They don't cost much more than rotary potentiometers – but are harder to mount as you need to cut a long slot to take the moving control arm.

Switch SW1 enables you to select forward or reverse. Whatever form of construction you choose, this switch should be located close to the speed control.

Construction

The unit may be built into a metal or wooden enclosure. It is essential that the transformer be securely screwed down and that ample ventilation holes be provided next to the transformer base and also above the transformer itself – or at least close to it.

The power cord must be connected to the transformer via a terminal block – not connected directly. The power cord must also be clamped to the enclosure by a metal clip. It is not sufficient (or legal) to just tie a knot in the cord. If a metal case is used it is also necessary to take another connection from the earth point on the terminal block to the metal case. The connection to the case must be made via a screw which is clamped by a nut and spring washer – and a second nut which clamps the earth lead. If a metal lid is used this too must be earthed separately, using the same methods.

Transistor Q2 has to handle the total power drawn by the load: it is of a type known as a 'power transistor'.

Unlike other transistors, power transistors are unable, by themselves, to dissipate the heat that they generate. It is necessary to clamp them to some form of metal 'heatsink'.

The first and possibly simplest way is to mount the completed circuit board onto a larger aluminium or steel plate (remember to space the board off the plate so that nothing short-circuits), and then to clamp the transistor to this plate. The one drawback is that if you do this you MUST insulate the transistor from that plate electrically but not thermally. This may be done by inserting a very thin piece of mica or teflon between the two. A piece about 0.002" is more than thick enough.

Another way is to arrange for *Q2 and its heat sink* to be located away from the main circuit board and electrically insulated from the case. The actual choice of method is not too critical: just bear in mind that the heat sink is 'live', albeit at only 12 volts, and that part of the circuit.

Neither the switch SW1 nor the potentiometer need necessarily be mounted on the board or metal plate as shown. We have shown this way for convenience only.

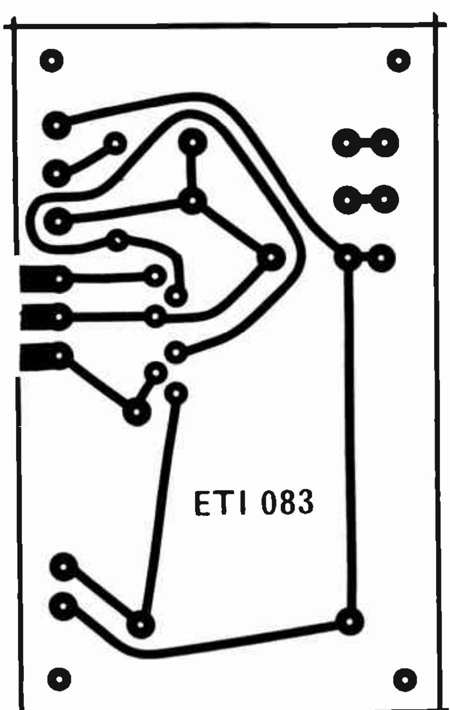
When assembling the board do take careful note of the polarity of the diodes. Put them in just as shown on the overlay drawing. Note also the polarity of the capacitor.

Notes: The components chosen will allow the circuit to be used continuously at currents of up 2.5 amps. We have set the current limiting circuit to clamp at about this level. The clamping level is controlled by resistor R2 – the higher the value the lower the clamping level.

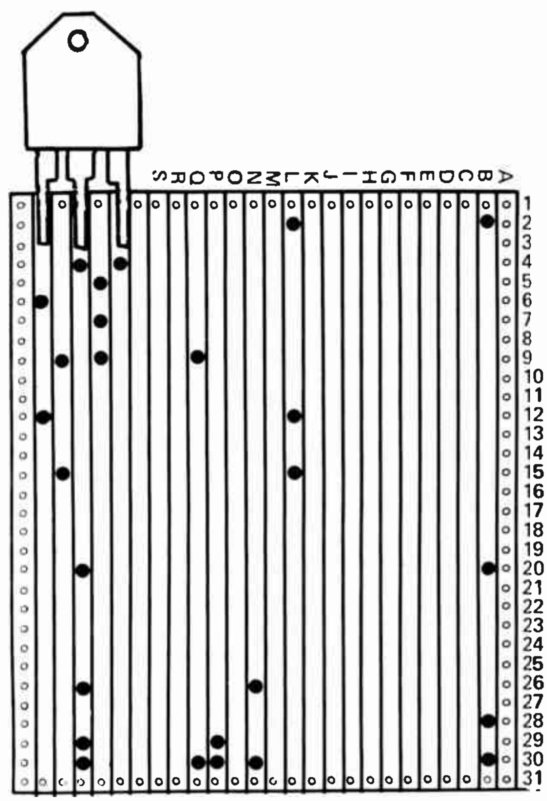
Thus if R2 is increased to 0.47 ohms the unit will clamp at about 1.5 amps. No matter what.

In our parts list we recommend that you use a Ferguson type PI 24/20VA transformer. If you decide to use another brand do make absolutely sure that it is built to Australian Standard AS126. DON'T take someone's word that it is. If it meets the Standard it will say so on it, and/or accompanying literature.

Resistor R2 can be made from a short length of resistance element from a toaster or jug if you find a proper resistor hard to obtain.

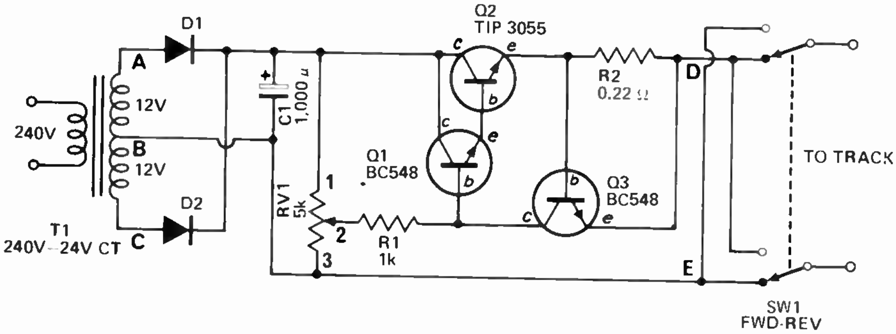


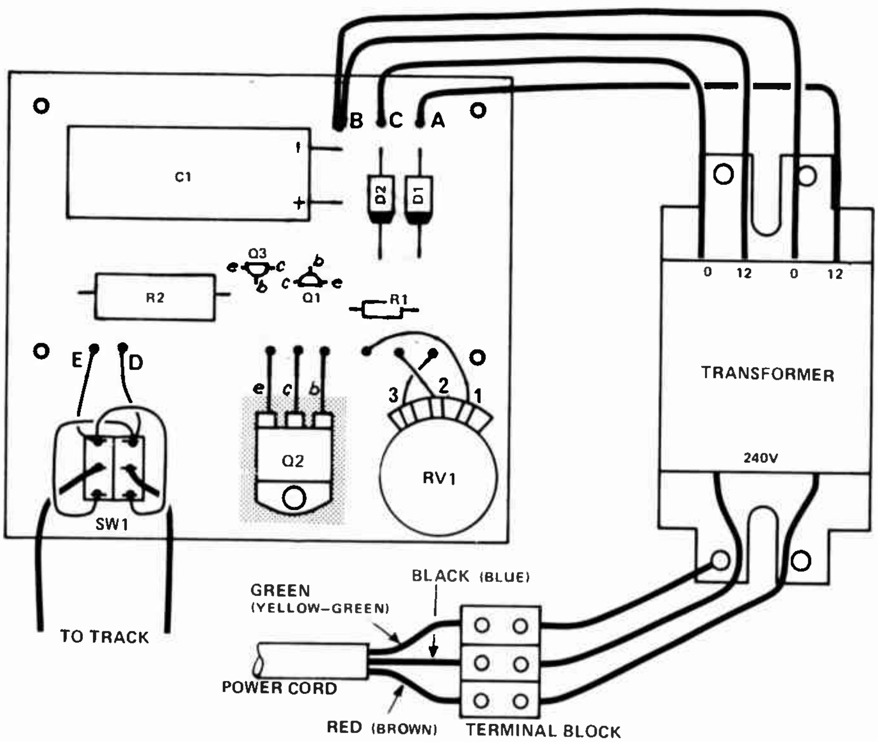
Printed circuit board pattern (shown here full size).

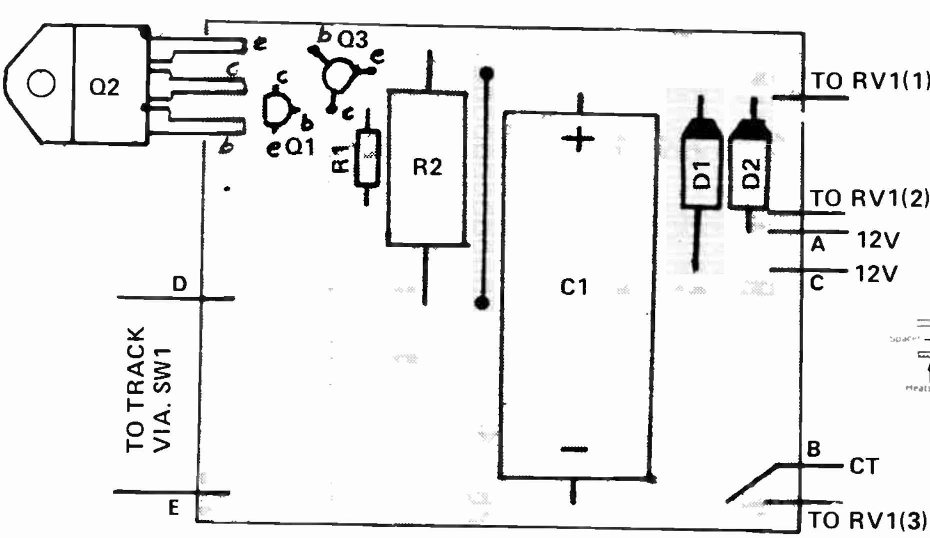


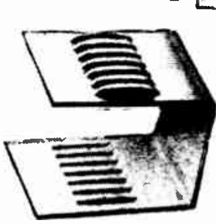
Veroboard solder connections – note no break holes are required in this board.

TRAIN CONTROLLER









This is a typical heatsink for small power transistors. (20 mm x 20 mm). It can easily be bolted on to the rear of the transistor – heat sinks such as this may be bought from most component suppliers – or made up from a short strip of copper or aluminium.

HOW IT WORKS – ETI 083

The 240 volt 50 Hz supply is reduced by transformer T1, rectified by D1 and D2 and filtered by C1. Transistors Q1 and Q2 form an emitter follower controlled by RV1. Transistors Q3 and R2 act as a current limiter, clamping to about 2.5 amps with the value of R2 shown.

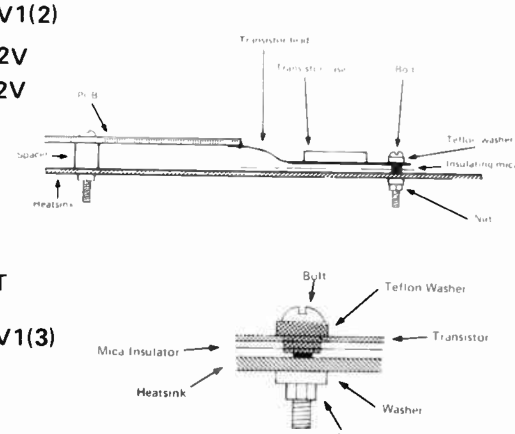
A heatsink must be used for Q2, and as the tab of this transistor is connected to the positive rail it must not touch any other part of the circuit.

PARTS LIST

R1	Resistor	1k ½ watt 5%
R2	"	0.22 ohm 5 watt 5%
RV1	Potentiometer 5k (linear)	
C1	Capacitor 1000 uF 25 volt electrolytic	
Q1	Transistor BC 548	
Q2	"	TIP 3055
Q3	"	BC 548
D1,2	Diodes	1N5401 (3A-100V) or similar

Transformer 240 volt input, 12 + 12 volt output at 20 VA. Ferguson type PL24/20VA or similar.

Switch double pole double throw toggle type Printed circuit board ETI 083 or Veroboard. Power cord, terminal block, cord clamp.



These two drawings show how the heatsink attached to Q2 may be insulated. Note that the transistor should be mounted tight against the heatsink to increase thermal conductivity.

FM ANTENNA

Build your own FM antenna from readily-available materials.

AUSTRALIA'S FM broadcasting system is now well and truly in operation. At the time of writing (March 1977) the ABC has FM transmitters operating in Adelaide, Melbourne, Canberra and Sydney and there are plans to extend the service to the remaining capital cities.

Apart from the ABC's network, two co-operative broadcasting stations (2MBS-FM and 3MBS-FM) are in operation – in Sydney and Melbourne respectively and several smaller stations are either in operation or about to become so both in the capital cities and also in country areas.

The introduction of this service has in turn generated large sales of FM tuners and tuner amplifiers, and very many transistor radios with an FM band are now on sale.

Most recently-made radios or tuners have a small 'ferrite' antenna built-in for AM reception but it is not practicable to build-in a 'ferrite rod' FM antenna. Some transistor radios have a telescopic antenna which doubles for AM *and* FM but for good FM reception it is necessary to connect a more efficient system.

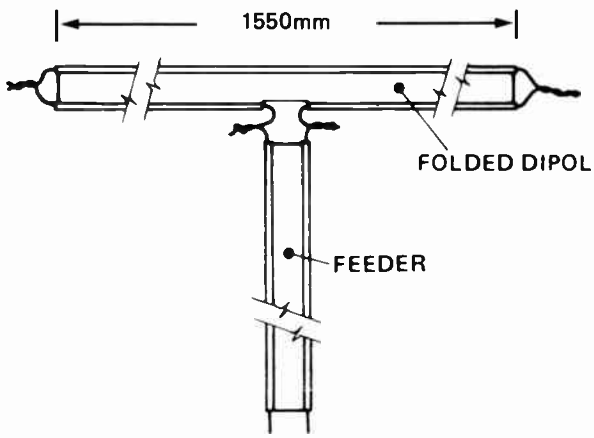


Fig. 1. This simple folded dipole may be constructed from a short length of 300 ohm ribbon tied in position or tacked to suitable pieces of wood or hardboard.

SIMPLE FOLDED DIPOLE

If you live in a good reception area – that is within 5-10 km of the transmitter and there are no major obstructions along the way – then a simple folded dipole will probably be all you need. Figure 1 shows how to make a folded dipole antenna using a length of 300 ohm ribbon feeder – this is one of the two types of cable used to connect FM and TV antennas to their sets; it is readily obtainable from component suppliers, TV installers etc. Use a further length of 300 ohm feeder to connect the antenna to the set.

THREE ELEMENT YAGI

Figure 2 shows a more elaborate arrangement. This is a three element Yagi array. It produces about twice as strong a signal as the simple folded dipole – as long as it's pointing more or less in the direction of the transmitting antenna.

The Yagi array may be made exactly as shown – or modified to suit available materials. The essential points are to keep all dimensions as shown (to within 5 mm or so), and to ensure that the two halves of the receiving (centre) dipole are insulated from each other. You can use a wooden centre pole rather than the 25 mm tubing shown in our drawing if you wish.

The ABC's FM broadcasts are transmitted in such a way that for best reception the dipole/s should be mounted horizontally. At the time that this project was written (March 1977) 2MBS-

FM ANTENNA

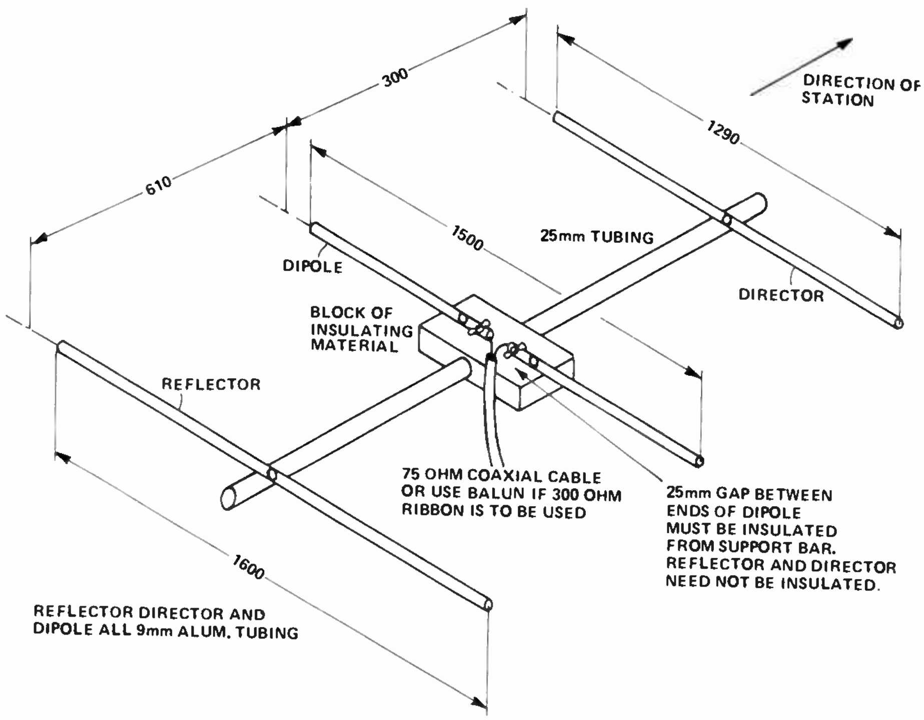


Fig.2. Main details of three element antenna – constructional methods may be altered but dimensions should be kept as shown.

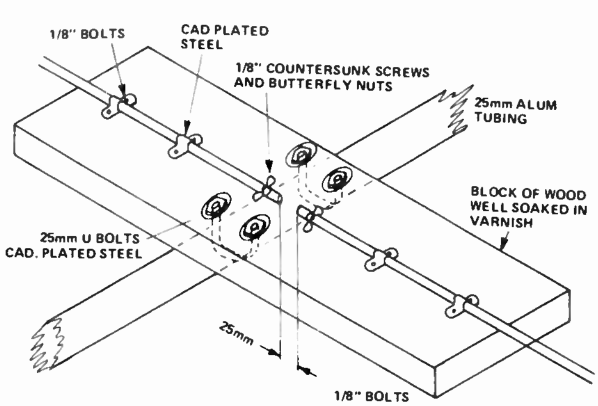


Fig.3. Expanded view of centre part of Fig. 2.

FM was transmitting such that the receiving antenna was best mounted vertically! We understand however that 2MBS-FM will be changing to the horizontal system very soon.

If possible locate the antenna at the rear of your house so that it is away from the road and passing traffic.

There are two ways of connecting this antenna to the FM receiver. The better way by far is via a length of 75 ohm co-ax cable. Unfortunately co-ax costs about $1.50 a metre so unless you are fairly affluent, or the run is quite short, it is cheaper to connect an 'impedance matching balun' to the antenna (connect it across the same points to which you would otherwise connect the co-ax) and then run 300 ohm ribbon from the other end of the balun down to the receiver. If you use 300 ohm ribbon try to keep it at least 100 mm from any nearby metal and twist it five or six times each metre – this reduces the possibility of 'ghosts' being picked up by the ribbon itself.

The receiver may have two FM antenna input sockets. These will be marked '75 ohm' and '300 ohm' respectively, so connect your feeder lead accordingly.

Seventy-five ohm/300 ohm baluns may be obtained from most TV parts suppliers. They cost about $2.50.

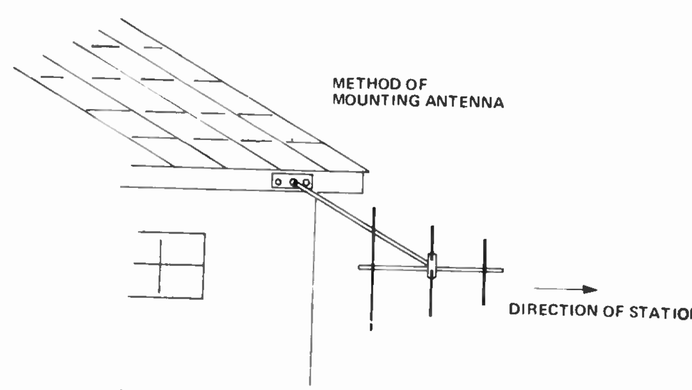


Fig.4. How the antenna may be mounted. Elements should point in main direction of station – final position should be determined by moving around until maximum signal strength is obtained.

OVER LED

Unit flashes a light when your hi-fi system is overloading.

MOST PEOPLE ARE aware of distortion when they turn up the volume control on their hi-fi system too far — but rarely know the cause.

Nine times out of ten the distortion is caused by 'clipping'. That is, the amplifier has insufficient reserve power to handle the peak music 'transients' at the volume required. During such peaks — which may demand power outputs of 100 watts or more — the amplifier is driven into overload and as a result the music peaks are clipped.

A few modern amplifiers are equipped with peak limit indicators. These consists of a 'VU' meter or an arrangement of lights which flash when the peak limit is exceeded. Peak limit indicators are interesting devices because they show very effectively just how much power is required for realistic non-distorted reproduction (much less than you might think for most of the time and a very great deal more occasionally).

The 'Over-Led' indicator described here flashes a warning light if the power level at which clipping occurs is exceeded. It can be built into any existing hi-fi amplifier — or made as a separate unit.

Two completely independent channels are shown so that each channel of a stereo system may be monitored separately. Nevertheless we have designed the unit so that you can make it up if you want to use it to monitor just a single channel (mono) system.

Figure 1 shows one complete single channel — there are leads coming from the speaker terminals of one channel, and there is one LED. If you look at

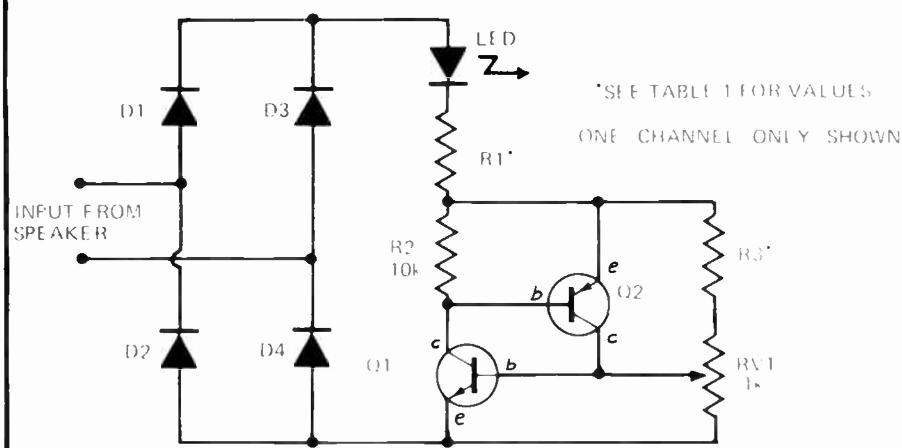


Fig. 1.

the component overlay board shown in Fig 2 you will see that there are two identical sets of components. Each set of components is for one channel. So if you want to build a single channel version just build up half of the board. If you know someone else who is building up a single channel unit you can cut the board in half and share the cost.

CONSTRUCTION

Usual precautions. Make sure all the diodes are the right way round, particularly the LEDs. The LEDs won't be damaged (in this circuit) by wrong polarity — but they won't work. Note that the values of R1 and R3 must be chosen specifically for each application from Table I. Most speakers used in hi-fi systems are 8 ohms but do check first to see. The finished board may be mounted as you wish. It's very small — our component overlay is shown here full-size and can be mounted inside most existing amplifiers. The LEDs can be located so that their tips just protrude through holes in the front panel. LEDs last for ever so you can secure them permanently in position — once you're sure the device is working!

The leads shown on the drawing as 'input from speaker' are connected across the amplifier's speaker terminals. Polarity is not important but make sure you don't mix up the leads between channels. It's best to twist each pair to make sure.

Another way of housing the 'Over-Led' is to build one into each speaker so that each has an LED visible near the top of the front panel — or mounted in a small separate enclosure sitting on the top of each enclosure. If you do this simply connect the input to the speaker leads where they enter the speaker enclosure.

CALIBRATION

The best way to calibrate this unit is to connect an audio oscillator across both input channels of your amplifier. Then, with the amplifier's volume control set low, adjust the oscillator to 1 kHz sine wave. Set both RV1 trimpots on each channel so that their wipers are nearest R3. Increase amplifier volume until you hear a sudden harshness of tone — i.e. the onset of clipping.

Don't leave the volume control at this setting for more than a second or two since few amplifiers or speakers can tolerate sine-wave inputs at this level for extended periods. Once the clipping point has been established, turn the volume down and then up again momentarily meanwhile adjusting both RV1s until the point is reached where each LED just comes on.

Repeat this procedure a few times finally arriving at settings where the LEDs come on just before clipping.

If you don't have access to an audio oscillator you can use a record which has a track of a solo instrument such as a flute. A recording of the human voice is also very effective. In such cases follow the procedure described above.

NOTE: This is an updated version of a project originally published as ETI 417 in Electronics Today International August 1973. The original version used transistors which are now less readily available than those shown here.

PARTS LIST — ETI 087

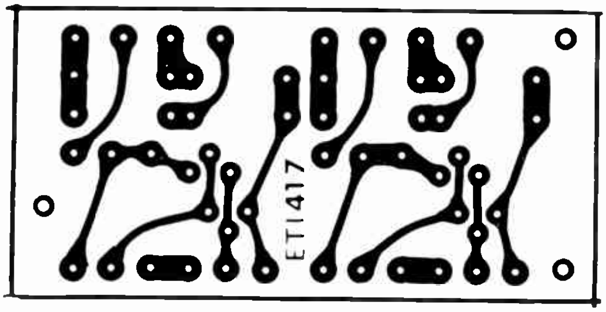
Note: one set required per channel.

R1 resistor see Table 1.
R2 resistor 10 k ½ watt 5%
R3 resistor see Table 1

RV1 trim potentiometer 1 k

D1-D4 diodes EM401 or similar
Q1 transistor BC548
Q2 transistor BC558

LED light emitting diode FLV110, MV5025, HP4403 or similar
Printed circuit board ETI 417
(1 only required — each board has provision for two channels).
Or Veroboard.



Printed circuit board layout — shown full size.

TABLE 1

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

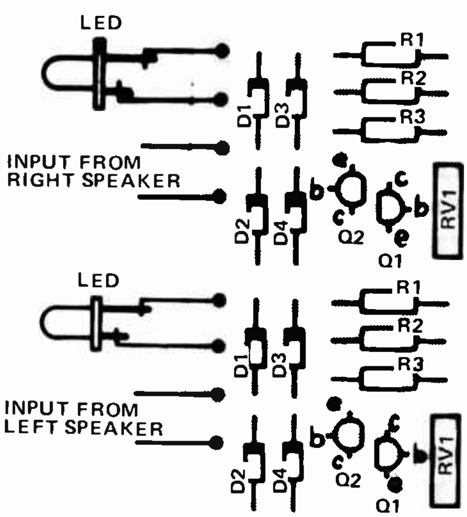
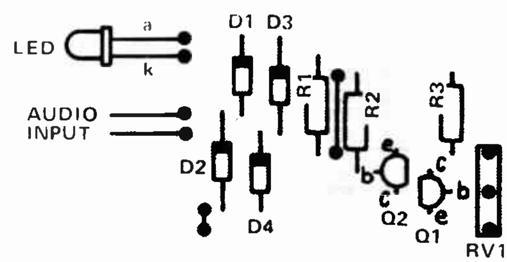
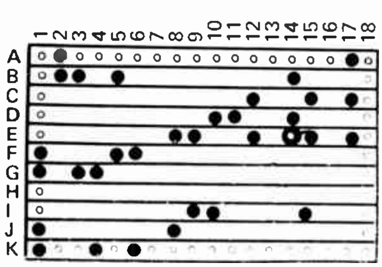


Fig. 2. This is the component overlay of the printed circuit version. Note that the board contains two separate but identical circuits.





This is the drilling details for the Veroboard version. Do make sure that the breaks required (shown as black dots) are clean, and that no 'whiskers' remain.

HOW IT WORKS

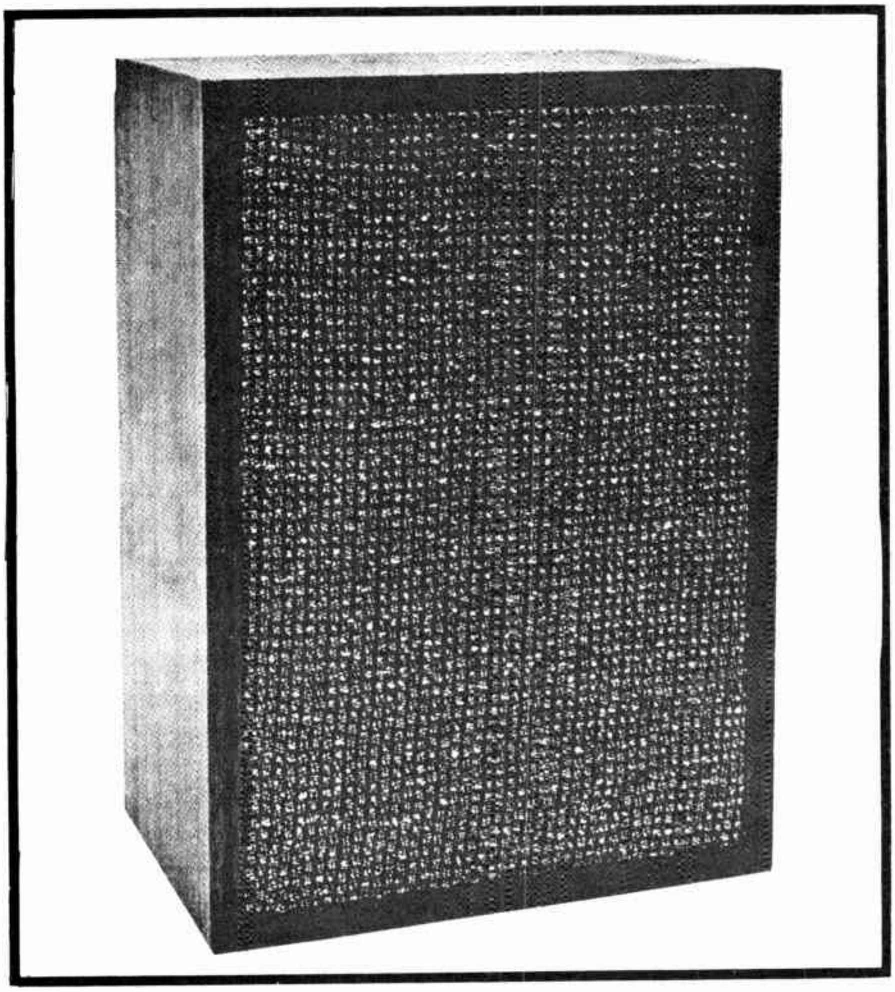
The output of each amplifier channel is bridge rectified by D1-D4 so that both positive and negative transients may be detected.

Transistors Q1 and Q2 are (together) equivalent to a sensitive gate SCR. If the voltage at Q2's base is more than about 0.6 volts above its emitter, Q1 and Q2 will each turn hard on and latch on, until the current through them falls to zero.

When transistors Q1 and Q2 are on, the current flowing through them also flows through the LED causing it to light up. Resistor R1 limits peak current through the LED to about 100 mA.

The range of calibration potentiometer RV1 is set by R3. The values of R1 and R3 should be chosen from Table 1. These values are not critical. If your amplifier's output is other than shown the nearest values will do.

Project 088



HI-FI SPEAKER

This hi-fi speaker can be built for only a few dollars yet has true hi-fi performance.

THE WAY a loudspeaker sounds is very largely determined by the inter-action between the actual speaker drive unit/s and the enclosure in which it is housed. Unless the design is right the resultant sound will be unsatisfactory — regardless of the quality or cost of the drive unit used.

This point can be taken yet further. Some of the very best speakers made, costing hundreds of dollars each, and some of the very worst, use absolutely identical drive units.

It's not not so much the drive units that matter — it's knowing what to do with them!

Providing the basic design is correct it is perfectly feasible to build good sounding speakers at quite low cost — as this project proves. The enclosures described are suitable for 150 mm or 175 mm diameter speakers of the 'wide-range' type. We chose the Philips AD 7061/W8 which is quite inexpensive, but almost any other wide-range speaker of similar characteristics and dimensions will do.

Most small speakers have a response which falls away at both the bass and treble ends of the audio range. It is for this reason that the more costly units have additional bass and treble drive units. Nevertheless the response of any simple unit can be greatly improved by adding a simple circuit which attenuates (cuts down) the mid-range. The effect is that bass and treble will now be reproduced at the correct level relative to the mid-range. Maximum sound output will be reduced slightly but the quality is enormously improved.

Construction

The enclosures should preferably be made from particle board — this is an easily worked 'dead' material, ideal for our purpose because of its inherent ability to dampen resonances. Use 13 mm board or thicker. If thicker, retain the *inside* dimensions shown on the drawings.

The box should be both glued and screwed together with the front panel temporarily in position so that the box is held square. When the glue has thoroughly set, sand the corners to obtain a smooth finish and then cover the box with wood-grained contact paper. Allow sufficient width of paper so that it may be folded around the inner edges and back a couple of centimetres or so onto the inner faces. The edges will be held firmly in place when the front and rear panels are fitted.

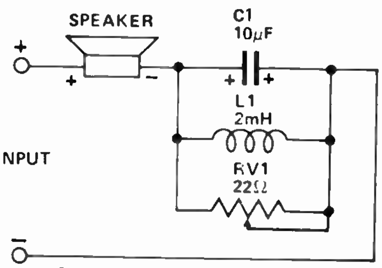
Screw the drive unit onto the rear of the front panel and then cover the panel with speaker cloth or any other material that is transparent to sound. Fit the front panel into position and secure by driving a few thin tacks through the front panel and into the cleats. The heads of the tacks may be hidden by driving them below the surface using a nail or centre punch.

Compensating network

The compensating network should be mounted directly into a hole cut in the rear panel and the choke glued onto the panel alongside the potentiometer. The bipolar electrolytic capacitor is mounted across the terminals of the potentiometer. The choke is connected to the same terminals. The whole network is then wired in series with one of the speaker leads — it doesn't matter which one.

Adjust the potentiometer for the most level response. Once adjusted you'll be surprised just how good this simple speaker sounds.

Note: The attenuating network described in this project will greatly improve the performance of *any* low priced speaker in which a single drive unit is used.



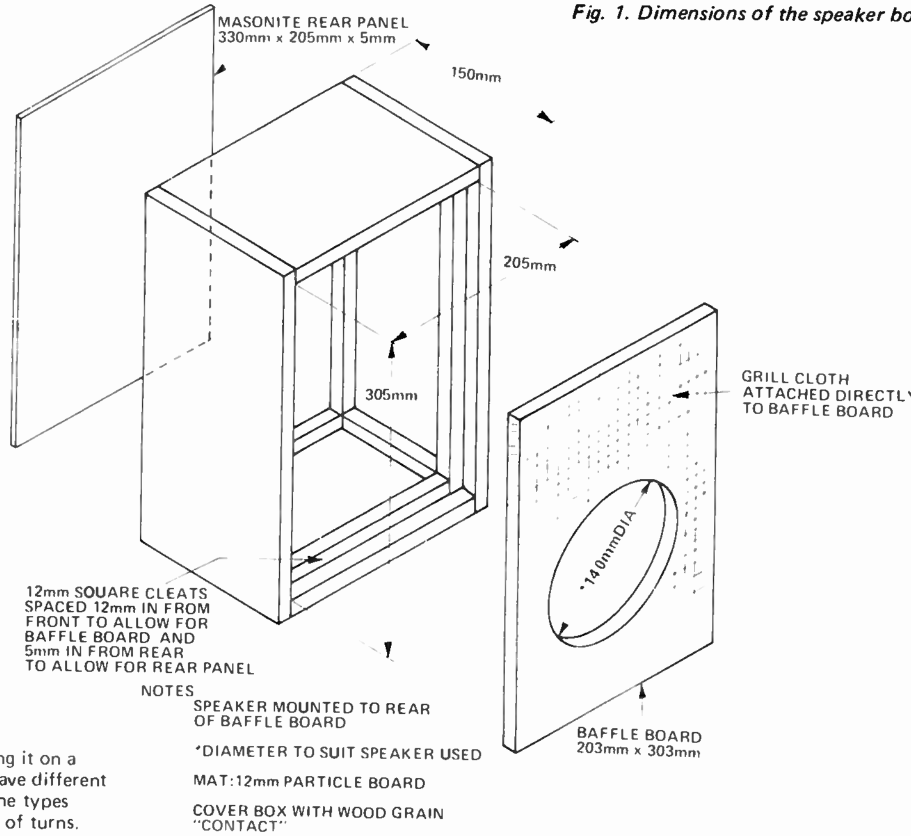


Fig. 1. Dimensions of the speaker box.

MAKING THE COIL

The 2 mH choke is most easily constructed by winding it on a Philips Elcoma P26 ferrite pot core. These P26 cores have different permeabilities which are marked on the core. Any of the types listed below may be used with the appropriate number of turns. Wire gauge is not critical. Anything over 0.4 mm, up to the maximum shown in the table may be used for any type core.

Do not use a bolt to hold the two halves of the cores together; use the Elcoma clip and then glue the completed coil into position.

TABLE 1

CORE TYPE	NO OF TURNS	MAX WIRE GAUGE
A_L 1600	20	1.0 mm
μ_e 330 or AL1000	55	0.8 mm
μ_e 220 or AL630	70	0.63 mm
A_L 400	70	0.63 mm
μ_e 150	65	0.5 mm
μ_e 100	80	0.5 mm
A_L 250	90	0.5 mm
μ_e 68	95	0.5 mm
A_L 160	110	0.4 mm

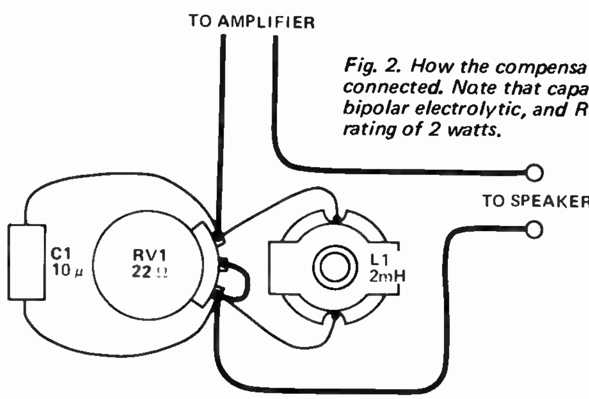
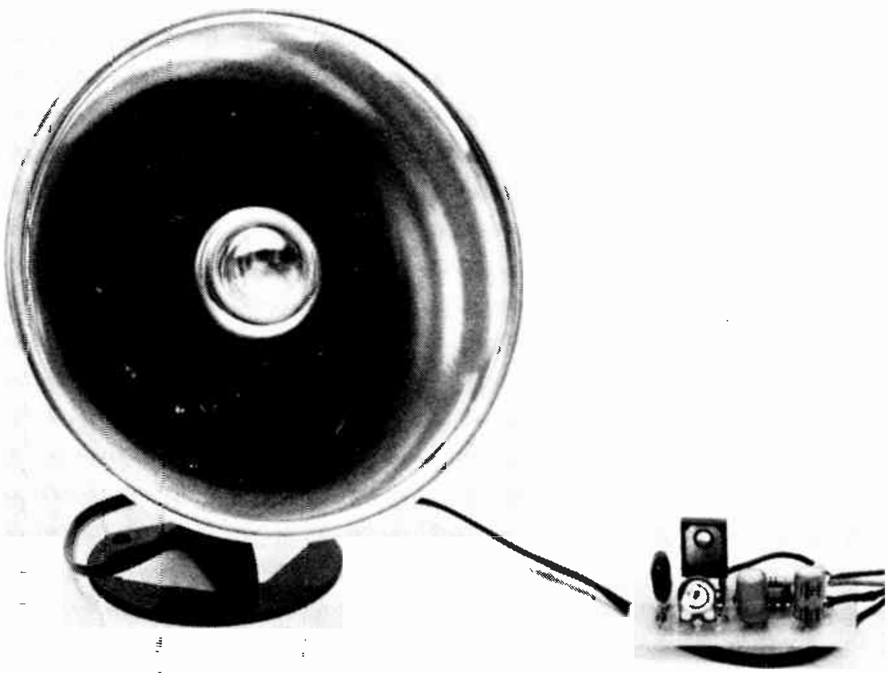


Fig. 2. How the compensation network is connected. Note that capacitor C1 is a bipolar electrolytic, and RV1 has a minimum rating of 2 watts.

Project 065

ELECTRONIC SIREN

Electronic siren has choice of two ear-shatteringly loud sounds.



ALARM SYSTEMS traditionally use electro-mechanical bells. Such bells are relatively cheap and, because of their high efficiency in turning electrical energy into sound, they make a lot of noise for their power consumption. They do however transmit their warning in all directions, including upwards and backwards – thus a great deal of their sound energy is wasted.

Sirens on the other hand are always less efficient than an electromechanical bell but can be made so that most of their energy output is directed in a wide angled conical shape.

Most sirens use a motor driven turbine-like fan to generate the sound. They are rugged and fairly efficient but have the disadvantage that their pitch can only be varied slowly due to the inertia of the revolving parts.

Most experimenters have at some-time or another attempted to build an electronic siren using a loudspeaker output. The electronics is quite straightforward, there are many different circuits which may be used. However conventional loudspeakers (used in various other projects in this series) are very inefficient – they convert less than 2% of the electrical input into sound – and hence are not suitable.

Fortunately one class of loudspeakers is different. These are known as 'horn-loaded' types and have an efficiency between 25% and 50%. Horn-loaded speakers are used in public address systems and a few (very expensive types) are used for hi-fi.

Such speakers are made by a number of different companies and the one we have specified is widely available. It may however be substituted by another type of similar characteristics. Do not necessarily expect your local electrical or hi-fi store to be able to supply one – they may not have even heard of them. The main sources are the specialised kit set suppliers.

We have designed the siren so that it may be used to generate either a continuously rising and falling note or a 'hee-haw' sound similar to that used by police vehicles.

CONSTRUCTION

There's not much of it since most of the electronics consists of a pair of 555 timers used as oscillators. You can use either Veroboard or the printed circuit board shown here.

A possible cause of confusion and failure to work is that transistor Q1 is manufactured with two quite different connection configurations. Either type (i.e. TIP 2955 or MJE 2955) is equally suitable but do check our transistor connection data page first to make sure you have the right configuration.

The siren will work from any dc supply between six volts and fifteen volts. It must however be a large battery as the current drawn is between 100 and 250 mA. The higher the voltage the louder the siren will be – but power consumption will increase accordingly. (This unit will not operate satisfactorily, if at all, using the 216 batteries specified for other projects in this series).

The pitch of the siren may be altered by changing C3. Deleting C2 will change the siren from its normal output to a 'hee-haw' output.

PARTS LIST – ETI 065

Resistors ½ watt 5%

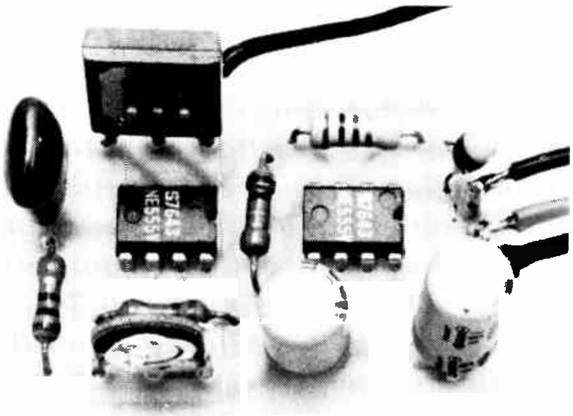
R1	1 M	"	"
R2	10 k	"	"
R3	27 k	"	"
R4	100 ohm		"

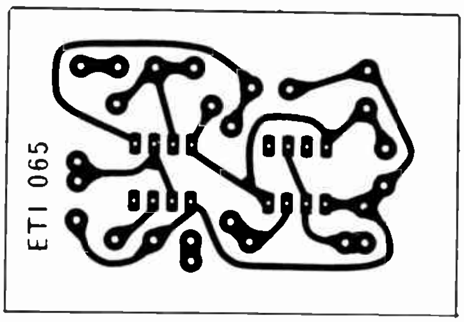
Potentiometer
RV1 5 k trimpot

Capacitors
C1 470 n electrolytic 16 V
C2 100 u electrolytic 16 V
C3 33 n polyester
C4 100 u electrolytic 16 V

Semiconductors
IC1/IC2 NE555
Q1 MJE2955 or TIP2955

Printed circuit board ETI 065
or Veroboard
8 ohm horn speaker Bestek B1-55 or similar



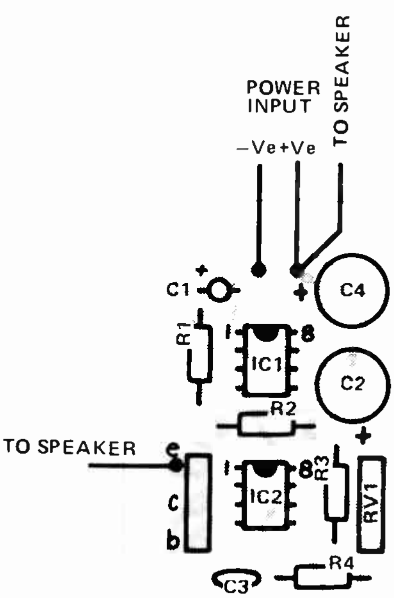


Printed circuit board full size 60 x 40 mm.

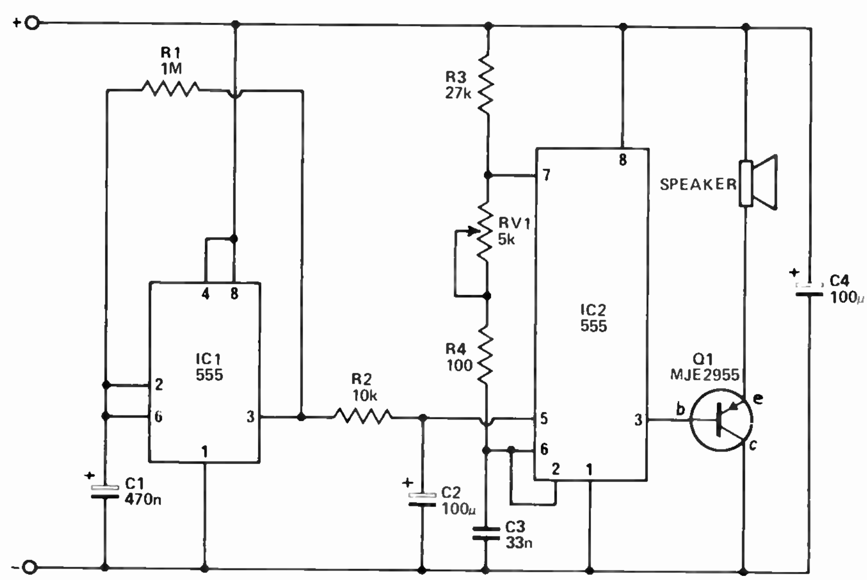
HOW IT WORKS – ETI 065

The 555 integrated circuit IC2 oscillates and drives transistor Q1 which is connected as an emitter follower. This transistor drives the speaker with a pulsed waveform. The mark-space ratio (i.e. the on-off ratio) may be altered by RV1, which thus acts as a volume control.

IC1 oscillates slowly – around 1 or 2 Hz and this modulates the control voltage of IC2 thus changing the frequency of that IC. If capacitor C2 is deleted then the siren will provide a 'hee-haw' output.



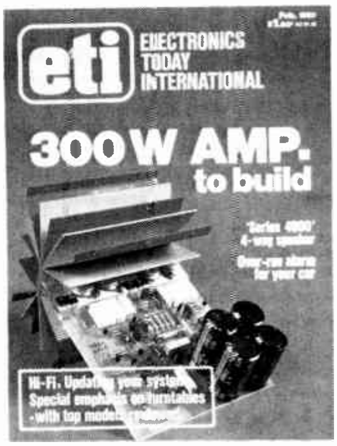
Component overlay. Note polarity of electrolytic capacitors and 555 IC's.



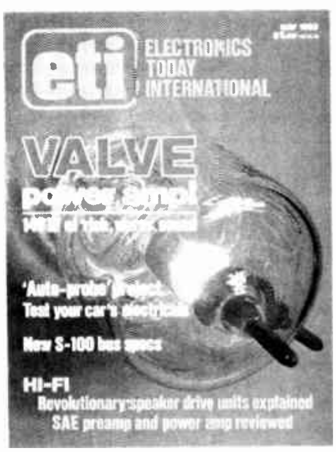
Circuit diagram of sirens.

eti ELECTRONICS TODAY INTERNATIONAL

Australia's dynamic electronics monthly



PROJECT ELECTRONICS was produced by the publishers of Electronics Today International — Australia's dynamic electronics monthly.
Each issue of Electronics Today International contains several fascinating easy-to-build projects ranging from complete working lasers, geiger counters and metal detectors to massive 300 watt guitar amplifiers and loudspeakers.



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HELP!
See page 80

PROBLEMS?

Here's the answers to the questions we are most frequently asked about building electronic projects — and what to do if you really can't get one to work.

SUFFIXES 'k', 'm', 'M' etc after component values indicate a numerical multiplier or divider — thus

Multipliers

k = X 1000
M = X 1000 000
G = X 1000 000 000

Dividers

u = ÷ 1000 000
n = ÷ 1000 000 000
p = ÷ 1000 000 000 000

Where the numerical value includes a decimal point the traditional way of showing it was, for example, 4.7k. Experience showed that printing errors occurred due to accidental marks being mistaken for decimal points. The Standard now calls for the ex-suffix to be used in place of the decimal point. Thus a 4.7 k resistor is now shown as 4k7. A 2.2 uF capacitor is now shown as 2u2 etc.

Some confusion still exists with capacitor markings. Capacitors used to be marked with multiples or sub-multiples of microfarads — thus 0.001 uF, 470 uF etc. Markings are now generally in sub-multiples of a Farad. Thus —

1 microfarad (1u) = 1×10^{-6} F
1 nanofarad (1n) = 1×10^{-9} F
1 picofarad (1p) = 1×10^{-12} F

O V on our circuits in this book means the same as −ve (an abbreviation for 'negative'.

Unless otherwise specified all components in our drawings are shown as seen from above — note however that component manufacturers often show them as seen looking *into* the pins.

Pin numbering of ICs — with the IC held so that the pins are facing away from you and with the small cut-out downwards pins are numbered anti-clockwise starting with pin number 1 at bottom right.

The thin line on a battery schematic drawing is positive (+ve or just +).

Two or three circuits have typical voltages marked on various points. These are for general interest and to assist fault finding. Note that variations may occur due to component tolerances and the loading effect caused by the meter.

If a circuit won't work the most probable causes of trouble in the most probable order of occurrence are:—

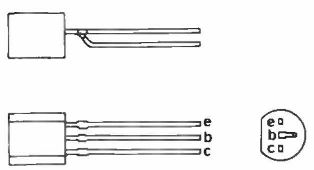
(a) Components inserted the wrong way round or in the wrong places.
(b) Faulty soldering.
(c) Bridges of solder between tracks (particularly with Veroboard) — breaks in Veroboard omitted — and/or whiskers of material bridging across Veroboard breaks.
(d) Faulty components.

If all else fails write to us for help.

You **must** enclose the **original** of the small **'HELP'** coupon (bottom right, page 79). Under no circumstances will we accept photostats of this coupon (we will send you a further coupon with our reply in case you have any further problems). Queries must be limited solely to the project as printed. We cannot help you modify it for any other application nor advise you if it has been built other than shown.

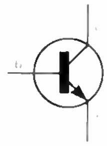
COMPONENT CONNECTIONS

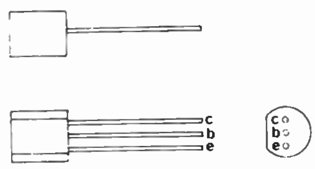
TRANSISTORS



Philips
Siemens

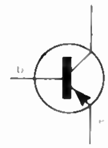
BC 548
BC 558
BC 559
BC 549

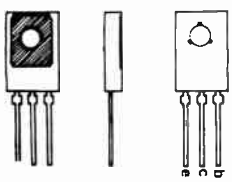




Non – Philips
" Siemens

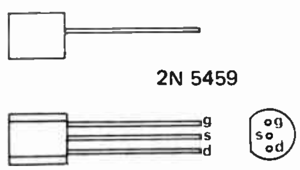
BC 548
BC 558
BC 559
BC 549



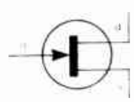


BD 139
BD 140

FIELD EFFECT TRANSISTOR (FET)

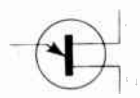


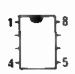
2N 5459



UNIJUNCTION TRANSISTOR

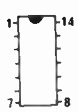
2N 2646



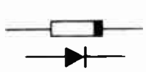


IC 555

TOP VIEW



IC 4017

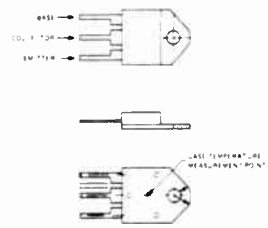


IN 4001
IN 5401

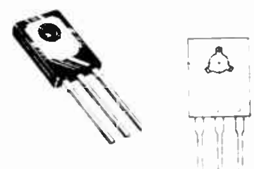
IN 914

TIP 3055

TIP 2955



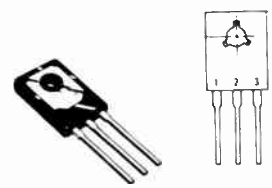
MJE 2955



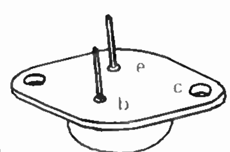
Case 90-05

MJE 3055

PIN 1 EMITTER
2 COLLECTOR
3 BASE



HEAT SINK
CONTACT AREA
(BOTTOM)



2N 3055

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SCRs — C103B $1.16 ea. C106Y1 70¢ ea. C106D1 $1.08 ea. C122E $2.56 ea.

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NOTE: Prices current and stock available at time of publication (June 1980).

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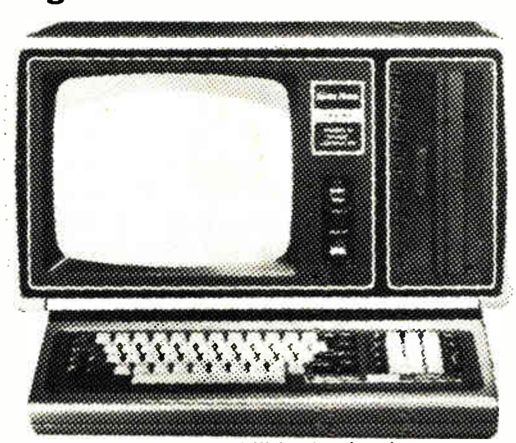

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