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Hobby Electronics

November '81

ISSN 0142-6192

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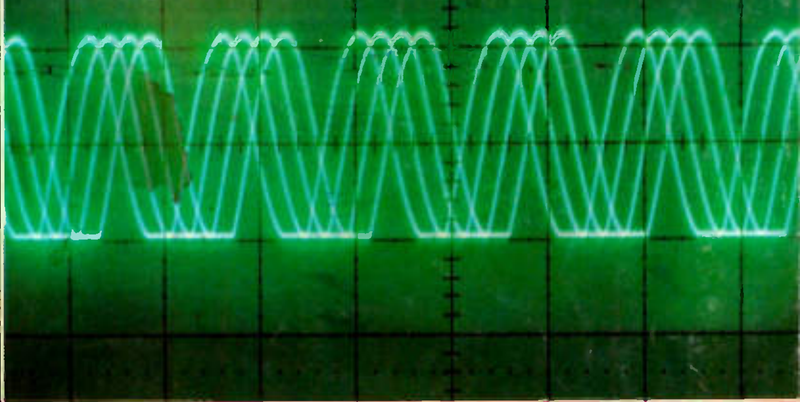
For A Down-To-Earth Approach To Electronics

Bumper Projects Issue! 11 easy-to-build projects

FOR THE MUSICIAN

ELECTRONIC MEASUREMENTS



• Electronic Metronome • Simple Stylus Organ • Scratch Filter •
• Component Substitution Box • Sound Level Meter • Frequency Meter •

FOR THE HOME

PHOTOGRAPHY

• Light Beam Telephone • VHF Radio • Fire Detector • Ticking Egg Timer •
• Flash Intensity Meter •

NOVEMBER 1981
Vol 3 No 13

Hobby Electronics

Editor: Hugh Davies
Senior Art Editor: Andrew Sawyer

PROJECTS

FEATURES

NEWS & INFORMATION

Scratch Filter — reduces the background noise of records

Project Supplement
— an extra five projects in
a free supplement

Keep the beat — HE style, with our Metronome project

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MONITOR

Special Notice

THAT VERITABLE FOUNDATION stona of the electronics world, Modmags Ltd (ie, us!) — *is Modmags Ltd no longer!* As of this very instant we are . . . (wait for it!)....

Argus Specialist Publications Ltd.

Yes, we know it's a bit of a mouthful but please label any communication with our new name from now on. The company address remains as it was.

Two-way Wrist Radio By 2000

A TWO-WAY wrist radio will become a reality by the year 2000 as a result of communication satellite developments, according to the Lockheed Missile & Space Company.

Lockheed engineers are building a 180 ft mock-up of an antenna to be placed in orbit by the Space Shuttle and unfurled in space like an umbrella. It would be a very sensitive receiver of low power transmissions from earth which would be re-broadcast at high levels.

So, a low power two-way radio perhaps worn on the wrist and using a simple antenna, could transmit voices using the satellite as a signal booster.

Diana's Replacement Coil

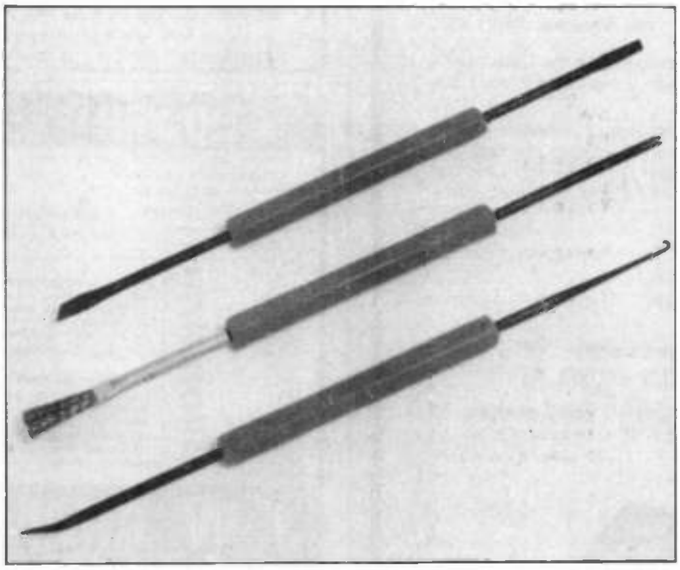
CRESTWAY ELECTRONICS LTD contacted us recently to tell us about a ready-built coil head which the company produces and thinks may be of interest to builders of the HE 'Diana' Metal Detector. The coil head is of vacuum formed plastic and is foam-filled to produce a strong yet light body. It directly replaces the original home-made coil head, we are told.

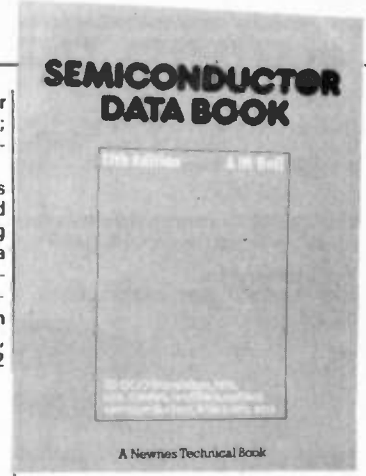
Readers can obtain their coil head for £9.85. This price includes VAT and p&p. Crestway Electronics Ltd, Woodhill Lane, Shamley Green, Guildford, Surrey (tel 0483 893236.)

Circuit Board Tool Set

THIS SET OF tools can come in handy if you build up circuit boards in the course of your hobby, for the set provides you with: a stainless steel brush for removing resin and oxidisation from boards; a fork for forming component leads and wire-wrapping; a knife for general cutting jobs; a hook for removing components after desoldering; a reamer for enlarging small holes in a board; and a scraper for cleaning component leads.

Each of the three tools is double-ended and insulated, and measures 180 mm, weighing 10 gms. The set is supplied in a plastic wallet and costs £3.74 including VAT and p&p, from Teleproduction Tools Ltd, Stiron House, Electric Avenue, Westcliff on Sea, Essex (tel 0702 352719).





Semiconductor Data Book

A NEW EDITION (the 11th) of Semiconductor Data Book (formerly known as Radio Valve and Semiconductor Data) has been published by Newnes Technical Books.

Within the book's pages you can find detailed information on over 10 000 transistors, FETs, UJTs, diodes, etc, including device outlines and pinouts.

At £5.50, the book represents a worthwhile investment to the electronics enthusiast, whether amateur or professional. Newnes Technical Books, Borough Green, Sevenoaks, Kent (tel 0732 884567).

In Car Entertainment?

ONE OF THE fastest growing markets in electronics over the last couple of years has been that of in-car entertainment. Power boosters and graphic equalisers seem to become more powerful and more abundant daily, and they all seem to be of foreign origin.

Circolec has released more news of what the company claims is the first British designed and manufactured 100 watt power booster and 7-channel graphic equaliser for in car hi-fi use. If you remember we first reported on the future introduction of the device back in the August issue.

The Bell and Ansell Quadrapower 100 is a four channel power booster (25 W RMS per channel) with frequency response of 35 Hz to 17 kHz. A bar graph LED display is provided on each channel and the graphic equaliser has seven frequency controls.

The booster/equaliser measures 166 mm by 54 mm by 148mm and will retail at £135.00. We hope to review a sample in a future supplement of Gadgets, Games & Kits. Circolec, 1 Franciscan Road, Tooting, London SW17 8EA (tel 01 767 1233).

Electronics News

New Cat From BI-PAK

BI-PAK Semiconductors' new catalogue landed in our pigeonhole recently and a very impressive publication it appeared, too. It's full of semiconductors, hardware, cases, test gear, books, etc, all to do with electronics.

You can obtain your own copy of the catalogue for £1.00 including 25p for p&p from BI-PAK Semiconductors, The Maltings, 63a High Street, Ware, Herts (tel 0920 3442).

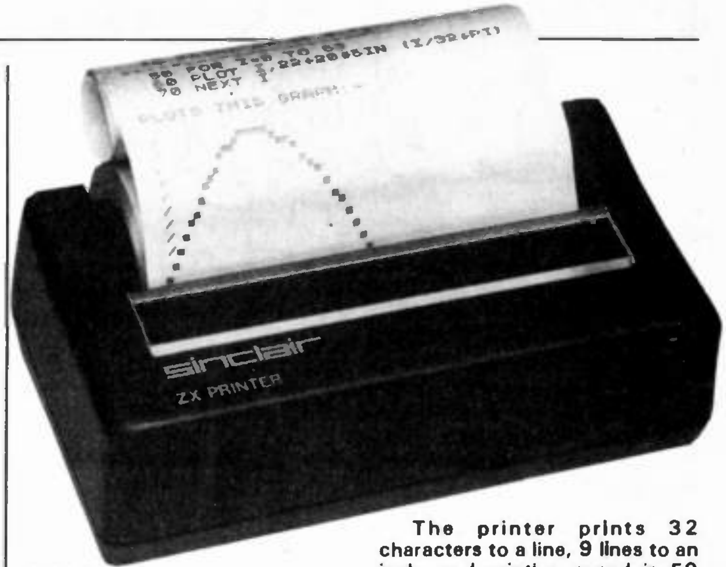
Breadboard '81

BELIEVE IT OR not, we have received a press release from ourselves, Modmags — sorry, delete that — Argus Specialist Publications Ltd, informing us when our company's electronics exhibition, Breadboard '81,is to be held. (The world, or rather Modmags — sorry, I'll probably get the sack for this — ASP Ltd, works in mysterious ways.)

Breadboard will be open for five days at the Royal Horticultural Society's New Hall, Greycoat Street, Westminster, London SW1:

Wednesday
11th November, 10am-6pm
Thursday
12th November, 10am-8pm
Friday
13th November, 10am-6pm
Saturday
14th November, 10am-6pm
Sunday
15th November, 10am-4pm

Cost of entry will be £2.00 for adults and £1.00 for children under 15 years of age and OAPs, although reduced rate advance tickets are also available — see page 45.



ZX Printer

SINCLAIR RESEARCH HAS introduced a printer designed to complement the existing range of ZX personal computers. Owners of the company's ZX81 and the ZX80 (with replacement 8K ROM) will now be able to obtain permanent copies of listings and computations.

The printer prints 32 characters to a line, 9 lines to an inch, and printing speed is 50 characters per second. A 65 foot roll of aluminised paper (enough to print over 250 full screens of text) is supplied with the printer and additional rolls cost £11.95 per pack of 5.

The ZX Printer is available for £49.95 including VAT from: Sinclair Research Ltd, 6 King's Parade, Cambridge (tel 0223 312919).

Errata

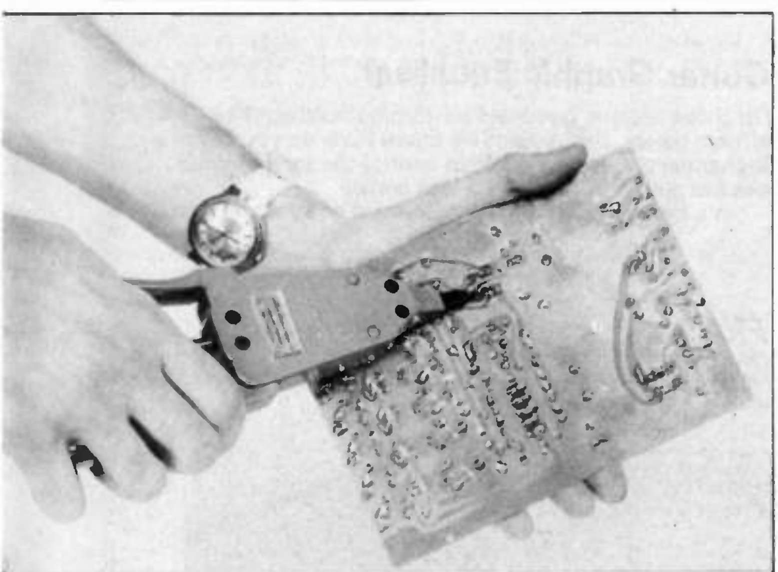
WE HEARD FROM a reliable source that a few gremlins got into the HE Ultrasound Alarm of the July '81 issue.

Firstly, with the component values shown, the transmitting oscillator runs at 400 kHz — not as specified (ie, 40 kHz). Increasing the value of C8 tenfold decreases the frequency by the same amount, thus C8 should be 10n. It was (naturally) a typing error!

The second problem is a bit more serious — it appears that some 4093 gates don't trigger in the IC3c position. If your project suffers because of this you can counteract it by: connecting a potential divider of two resistors from +9 V to 0 V (with a 4k7 resistor in the upper arm and a 22k in the lower arm); next disconnect the cathode of D3 (the side which originally connects to +9 V) and fasten it to the centre point of the above potential divider.

Lastly, R17 should be reduced in value to 22k to give a bit more drive to the output transistors.

In the HE 'Diana' Metal Detector of the September '81 issue, R11 was specified as 2M2; it should be 2k2 (*that darned typist!*).



Wire Shaper/ Cutting Tool

IF YOU'VE EVER put together a fairly complex printed circuit board (PCB), you'll know how tedious a job fitting the components can be — pick up pliers, bend leads, put down pliers, pick up side cutters, cut leads.

Eraser International's Hand Component Lead Cutter Model TP-3 lets you bend and cut leads in a single action. Although it looks awkward and cumbersome, it in fact comes to hand easily and operation is simple — insert the lead in the tool notch and squeeze the handles together. The lead is bent and cut in one.

The stroke of the movable blade can be lengthened to increase its cutting and bending force. When the fixed and moving blades become worn, they can be renewed.

The Model TP-3 Hand Component Lead Cutter is available from Eraser International Ltd, Unit M, Portway Industrial Estate, Andover, Hants SP10 3LU (tel 0264 513547/8).

Panasonic Speaks for Itself

PANASONIC BUSINESS SYSTEMS has introduced a talking calculator capable of storing and reviewing entries totalling up to 255 steps.

The JE-1650U offers all the usual features of a conventional 10-digit calculator with the advantage of audible confirmation of each number, function and result as it appears on the display.

With mains adaptor, it should appear in your high street for around £85 plus VAT.

NEXT MONTH IN HE — NEXT MONTH IN HE — NEXT MONTH IN HE

Hobby Electronics

Don't miss the December issue — out November 13th

We've got lots of projects to interest musicians next month:

Drum Synthesiser

Yes, you know the noise — a sort of cross between a bomb hurtling down, and a seagull. Well, this machine can make these *and* many more sounds to help you keep your rhythm. This one's a super project; easy-to-build, easier to use and what's more, we reckon it won't cost you any more than about £30 - that's about a fifth the price of commercial counterparts.

Organ Pedalboard

This project was designed to match the HE Electronic Organ (see HE May to August 1981). It's a 13-note, free-standing, foot-operated pedalboard (phew — what a mouthful), which can be plugged into the same amplifier as your organ, or it can be used with its own internal amplifier.

Now, although it's primarily intended to complement our organ, you can, of course, use it to accompany yourself while you play any other instrument. Thus you can have bass accompaniment to say, a guitar, flute, piano, or even the HE Drum Synthesiser.

Guitar Graphic Equaliser

For those electric guitarists who enjoy building their own effects boxes, this project's a must! How do you fancy a 6-channel graphic equaliser to control the tone of your electric guitar? All in a small foot pedal!

It's battery operated, easy-to-build and sounds great.

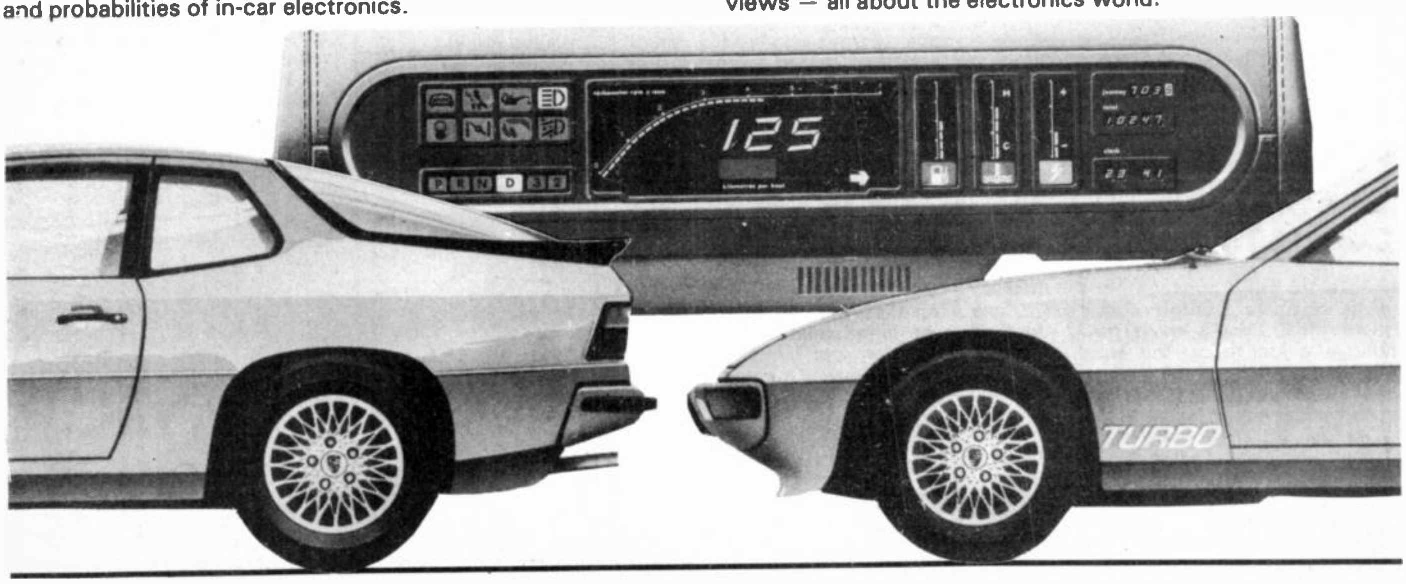
Car Electronics

There's no doubt that, although car manufacturers, overall, tend to be slow to change their ideas about the equipment that goes into their cars, they are at last waking up to the fact that electronics has a large part to play.

Guest writer Bill Mitchell tells you about the possibilities and probabilities of in-car electronics.

Plus

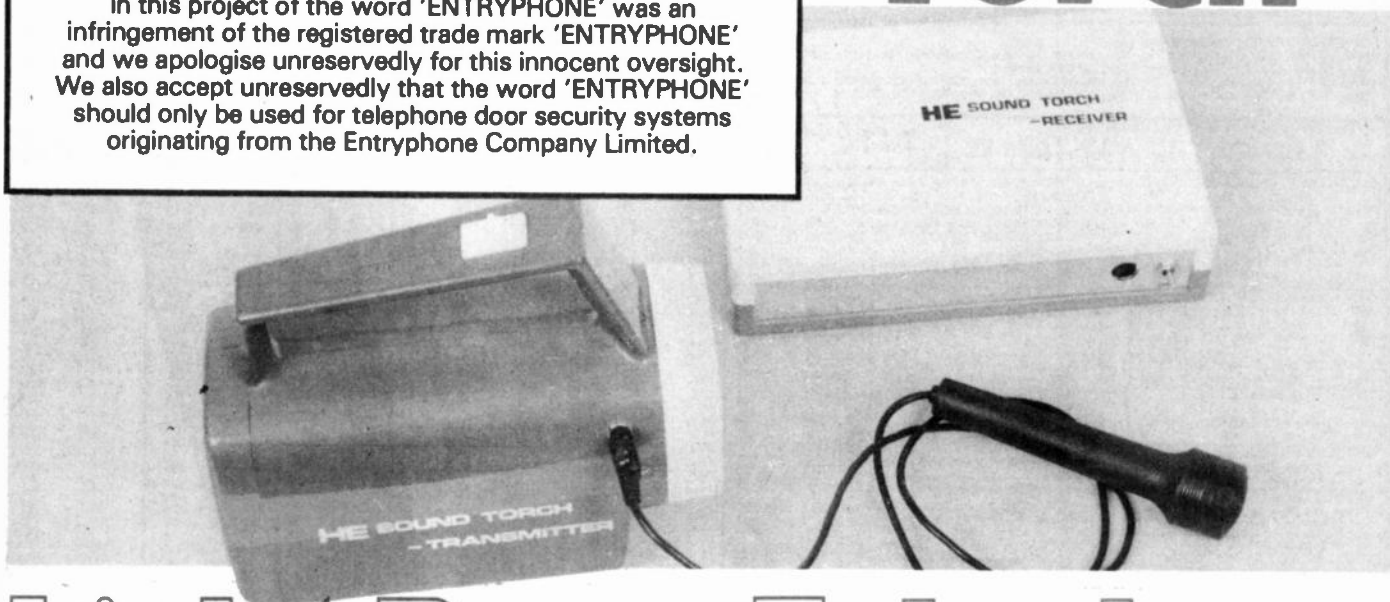
News and information, circuits, regular features, your own views — all about the electronics world.



Trade Mark Acknowledgement
October Project: ENTRYPHONE

'ENTRYPHONE' is a registered trade mark in the United Kingdom of the Entryphone Company Limited.
In the October issue of this magazine, we featured prominently a project for the assembly of a telephone door security device. This project and the design had no connection with and was not authorised by the Entryphone Company Limited.
We are now aware and accept that the use by the magazine in this project of the word 'ENTRYPHONE' was an infringement of the registered trade mark 'ENTRYPHONE' and we apologise unreservedly for this innocent oversight.
We also accept unreservedly that the word 'ENTRYPHONE' should only be used for telephone door security systems originating from the Entryphone Company Limited.

Sound Torch-



Light Beam Telephone

Communicate at the speed of light with our light beam telephone project

WITH THIS PROJECT you can talk at the speed of light indoors or out, night or day. You can even use a mirror and talk round corners. The transmitter consists of an Ever Ready torch modified to produce pulse width amplitude modulated signals. The use of pulse width modulation means savings in battery power and a high efficiency cool-running output stage. If the technical details don't interest you just put the circuits together and talk. There are no adjustments to make in use and the units need no setting up — provided you can point straight, that is!

The receiver uses an active load for the input phototransistor to compensate for a wide range of ambient light levels, and the filters remove high frequency hiss and cut down the interference from mains lighting.

Construction

Start construction with the receiver board first. **Figure 1** shows the circuit diagram of the receiver; its overlay is shown in **Fig.2**. Insert the wire links, followed by all the resistors, IC sockets and finally the taller components like capacitors, etc.

Insert the semiconductors into the printed circuit board (PCB) last of all, making sure you have them the right way round. When in doubt, check the pin-out against our drawings or manufacturer's data and cross-check with the circuit diagram. (Does the emitter really go there? .... etc).

Connections to the receiver board are straightforward; power supply, loudspeaker and phototransistor. If all is well you should hear a hiss as you apply power. Rotate the volume control — okay? Now point the phototransistor at a mains powered light; you should hear a hum which becomes a raucous squawk as you approach the light. If it all works, switch off and grin.

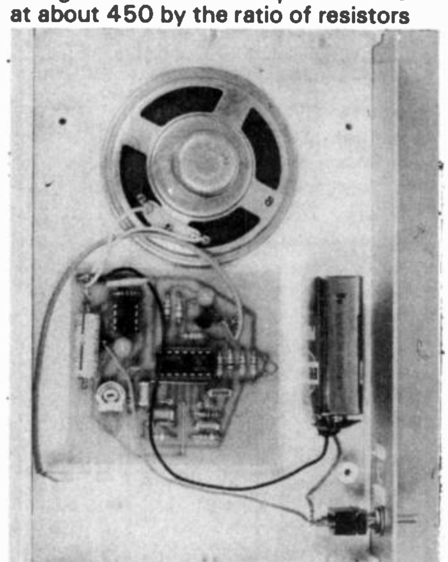
Mark and drill the case for the receiver to fit the on/off switch and the hole, to allow light through for the phototransistor. Now fit all parts inside the case.

The transmitter board is equally simple to assemble and the overlay is shown in **Fig.4** along with connection details. However, if you plan to use the same torch model that we did then solder IC3 directly to the PCB. Use of a socket in this position makes it impossible to fit the board into the case.

Use shielded cable for the microphone lead. We used a jack socket on the torch case and capacitor C4 must be soldered into place where the microphone lead connects so that one end of C4 goes to the jack socket top connection and the other end goes to the inner conductor of the shielded cable.

Similarly, mount C1 off the board with its negative lead connected with the wire from the PCB to the wire from the torch switch (O V) and its positive end connected to the positive conductor track on the PCB. The easiest way to do this is to solder it to the top end of R1. It may sound a little complicated but it's really quite easy, just follow **Fig.4**.

We used the microphone from an old cassette recorder. The earpiece insert from a 'surplus' telephone also works: you can even try using a loudspeaker. The gain of the audio amplifier is fixed at about 450 by the ratio of resistors



Internal view of the Sound Torch Receiver

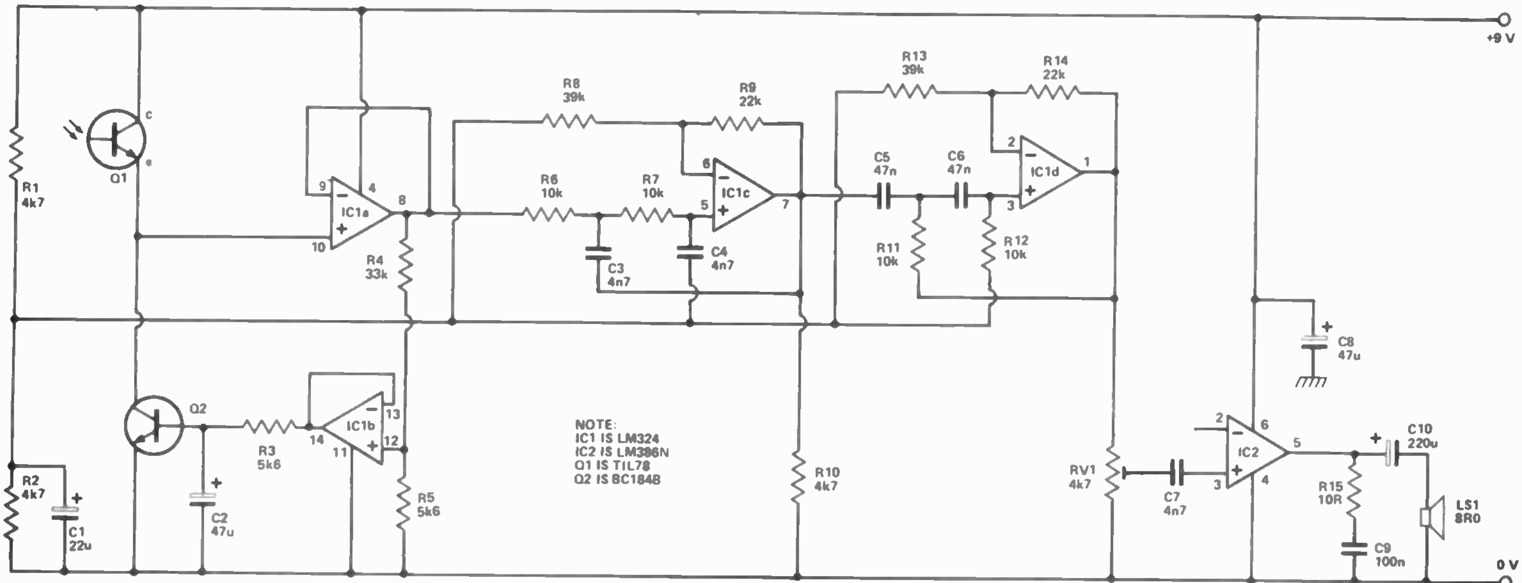
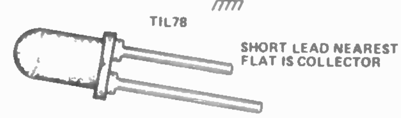


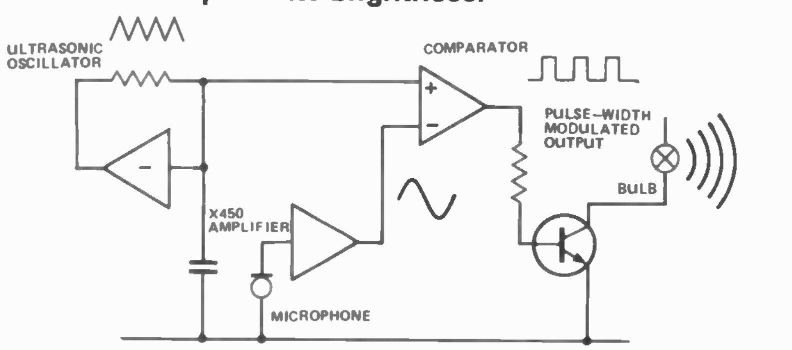
Figure 1. Circuit of the HE Sound Torch Receiver



How It Works

Sound Torch — Transmitter

The triangle wave output from the electronic oscillator is squared up by the comparator to drive the bulb at half-brightness. Amplified signals from the microphone cause the width of the comparator output pulses to expand and contract in sympathy with the voice signal and this controls the power to the lamp and its brightness.



Integrated ciruit IC1 and its associated components (resistors R1,2,3,4, and capacitor C3) form a 40 kHz oscillator. The triangle waveform from R3, C3 is fed to the input of comparator IC3. As the other input to the comparator from audio amp IC2 is at about 3 V, the comparator outputs a stream of square waves as the triangle wave input crosses this level. Signals from the microphone are amplified by integrated circuit IC2, which has a gain of about 450, and the resulting swing in output voltage causes corresponding changes in the width of the comparator output pulses.

Lamp driver transistor Q1 turns on when the comparator output is high ie, most positive. As the low level output of the comparator IC3 falls below 0.6 V the transistor turns off. This process happens so quickly that the bulb filament can hardly respond and we get the audio frequency modulation required while most of the 40 kHz chopping frequency is suppressed. The advantage of this system over a simple linear power amplifier is that very little power is lost in the switching transistor as it is only ever switched fully on or fully off. Low power dissipation means the transistor runs cool and no heatsink is required. The transistor chosen, ZTX650 has a high gain at quite high currents and is much more suitable than other power transistors like the BFY51, 2N3053 etc.

R7 and R8. To reduce the gain, increase the value of R8. You'll know you're overmodulating if you see the lamp flickering when you speak and you will hear the speech output from the receiver breaking up.

Don't expect hi-fi quality from the project — you won't get it, and alignment becomes critical as the distance is increased. Nevertheless you can have a lot of fun — just switch on and talk. By the way, a useful trick to get increased range is to use a lower voltage torch bulb. Because the average power input is reduced they don't burn out — we used a 3.6 V bulb without mishap.

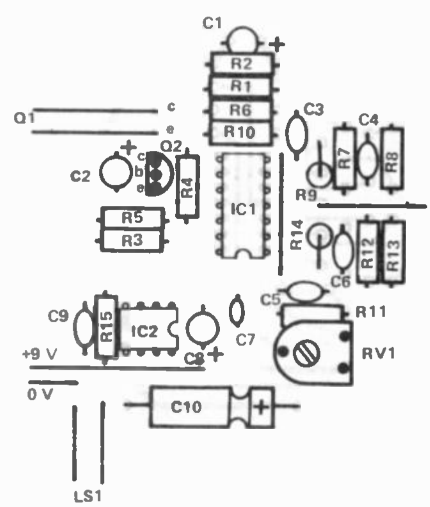
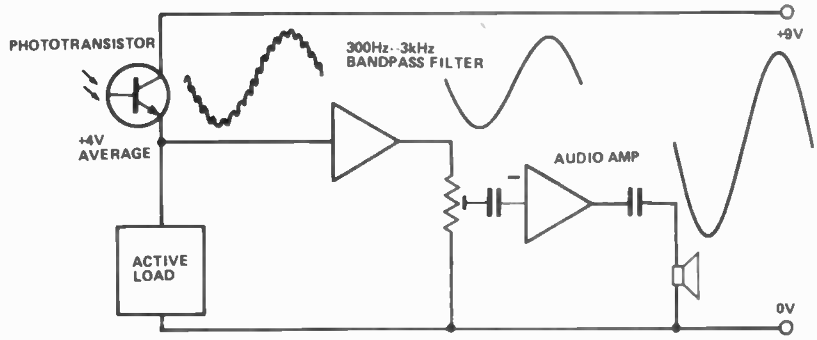


Figure 2. Overlay of the receiver PCB

How It Works

Sound Torch — Receiver

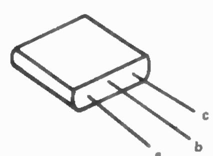
Changes in the light falling on the phototransistor result in corresponding changes in voltage. These are fed to a filter which removes high frequency hiss; the remnants of the ultrasonic oscillator signal; cuts down 100 Hz hum from mains powered lighting. The resultant audio signal is amplilfied and used to drive a loudspeaker or headphones.

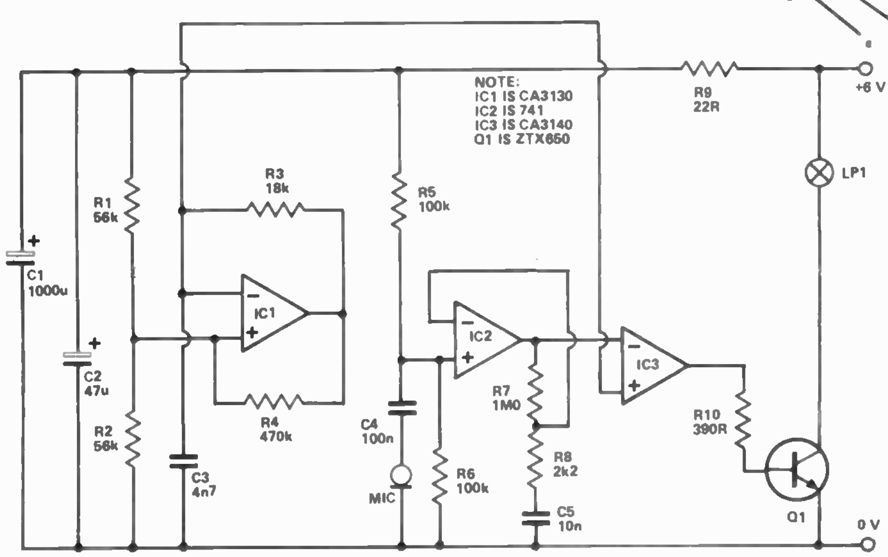


An active load based on IC1a,b and Q2 is used to compensate for the wide range of standing currents caused by changes in the ambient light level. This system will control the bias of Q2 in such a way as to try to keep its collector potential at 4 V with reference to ground. Capacitor C2 reduces the response of the circuit so that audio frequency signals are not suppressed. The audio frequency components are amplified and filtered to remove noise and hum by filters built around IC1c and d. Cut-off frequencies of about 300 Hz and 3 kHz were chosen which gives good results for speech. To increase the passband to 6 kHz just halve the value of C3, C4 to the nearest preferred value, 2n2, and keep all the remaining components unchanged. Audio signals may be taken directly from the output of IC1a. Resistors R10 and RV1 provide bias current for the amplifier outputs. Without them crossover distortion would occur causing very bad results.

The audio signals from IC1d are amplified by IC2 which drives a loudspeaker. Much of the circuitry needs a mid-rail bias and this is provided by R1, R2, C1.

Figure 3. Circuit of the HE Sound Torch Transmitter





Parts List

Sound Torch — Transmitter

RESISTORS (ALL ¼W, 5%)	
R1,2	56k
R3	18k
R4	470k
R5,6	100k
R7	1M0
R8	2k2
R9	22R
R10	390R

SEMICONDUCTORS	
IC1	3130 operational amplifier
IC2	741 operational amplifier
IC3	3140 operational amplifier
Q1	ZTX650 NPN transistor

CAPACITORS	
C1	1000u, 16 V electrolytic
C2	47u, 16 V tantalum
C3	4n7 ceramic
C4	100n ceramic
C5	10n ceramic

MISCELLANEOUS
Microphone
Jack plug and socket
Torch

Parts List

Sound Torch — Receiver

RESISTORS (All ¼W, 5%)	
R1,2,10	4k7
R3,5	5k6
R4	33k
R6,7,11,12	10k
R8,13	39k
R9,14	22k
R15	10R

POTENTIOMETER	
RV1	4k7 miniature horizontal preset

CAPACITORS	
C1	22u,16 V tantalum
C2,8	47u,16 V tantalum
C3,4	4n7 polyester
C5,6	47n polyester
C7	4n7 ceramic
C9	100n ceramic
C10	220u, 16 V electrolytic

SEMICONDUCTORS	
IC1	LM324 quad operational amplifier
IC2	LM386N power amplifier
Q1	TIL78 phototransistor
Q2	BC1848 NPN transistor

MISCELLANEOUS	
LS1	8R0 miniature loudspeaker

Case to suit

Buylines

All parts for this project should be readily obtainable from any of the mail order companies who advertise in HE. Approximate price of components will be £12 (excluding PCBs, case and torch).

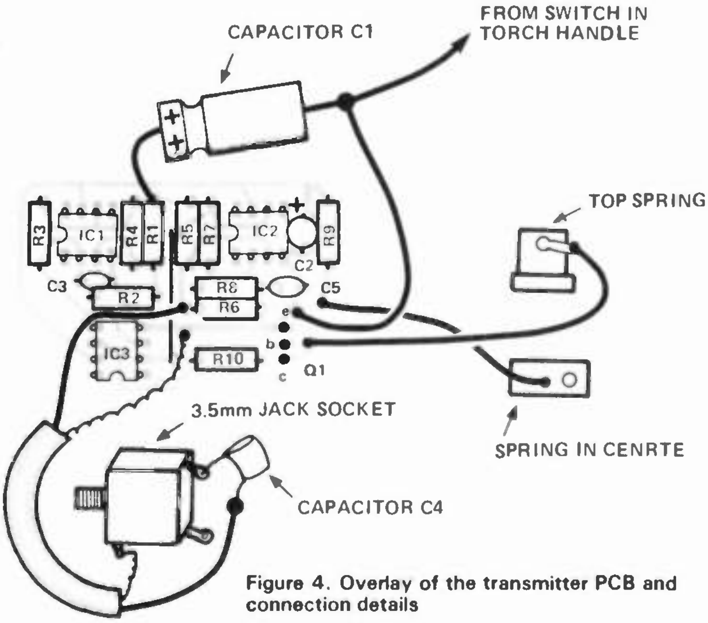
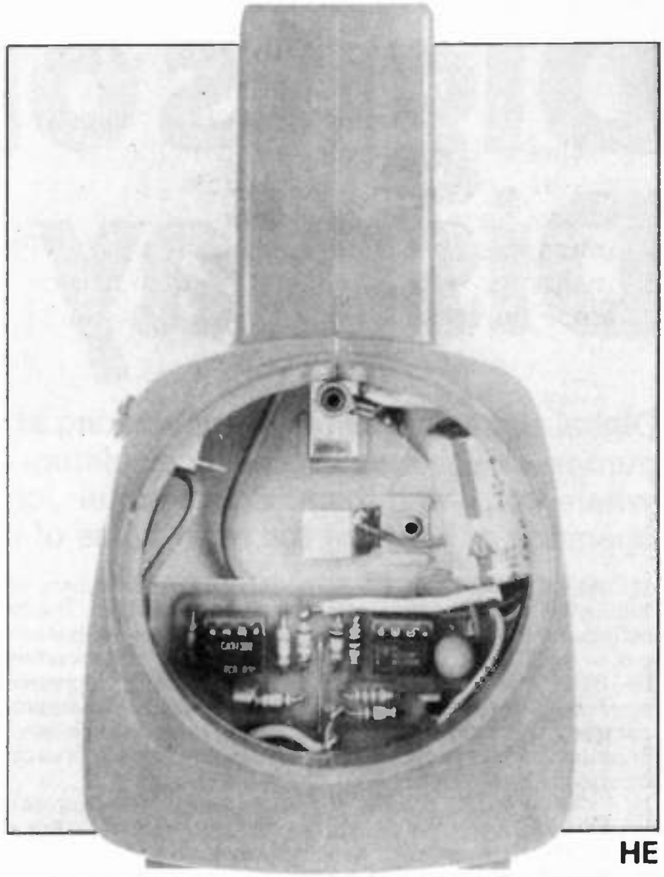


Figure 4. Overlay of the transmitter PCB and connection details



HE

No, it's not Jaws — just the HE Sound Torch Transmitter

Digits on Display

Digital electronic displays are winking at you wherever you go these days — petrol pumps, weighing machines, calculators and watches are just a few examples of where you'll find them. Guest writer John Gilliam describes the construction and operation of some of the main types of digital displays in use today

SLOWLY AT FIRST, then in leaps and bounds in recent years, electronics has become a readily accepted part of our lives. The main contributor to the recent acceleration has been the integrated circuit — the IC. Through its increasing complexity and miniaturisation it has enabled electronic equipment to become progressively more complex yet at the same time widely available. The electronic calculator and digital watch, despite being outstanding examples of advances in electronic microtechnology, are to many of us commonplace items.

A vital part of the process of our acceptance of electronics has been the way electronic circuits communicate with us. In this article we will look at some of the electronic devices that provide *visual* communication. Generically these devices are know as *electronic numeric displays,* and they can be divided into five main groups:

- light emitting diodes (LEDs)
- liquid crystal displays (LCDs)
- gas discharge displays (GDDs)
- vacuum fluorescent displays
- filamentary displays

Before dealing with each type we should first become acquainted with three terms used frequently when talking about electronic displays, namely:

- optical
- interface
- multiplexing.

Optical

From an optical point of view displays may first be divided into two types: active and passive. Most displays are of the active type which generate light, like the light emitting diode (LED). The passive types on the other hand only change the reflected light in the same way as print does when layed down on paper. An example of the passive type is the liquid crystal display (LCD).

The light generating types can be easily seen if the ambient (surrounding) lighting level is not too high and at night time they appear very bright. But as the sunlight becomes strong they suffer from 'washout' which can only be overcome by putting more power into the devices to make them brighter.

Passive types of display behave in the opposite way. They cannot be seen without a certain amount of ambient lighting and are most easily seen in bright sunlight.

Other optical characteristics that should be considered before choosing a display for a specific application are size, colour and format.

The size of the numeric displays discussed here ranges from character lights of 2 - 3 mm up to 9.5 mm. The smaller sizes are suitable for reading as far away as you would comfortably hold a book and are those used in watches and personal calculators. Most scientific instruments for use in a laboratory use displays with characters around 15 mm high. Applications for the larger types (say, 25 mm in height) are in such things as petrol pumps and weighing machines in shops.

As far as colour is concerned, displays with colours near the middle of the response of the eye are the best choice. Green and yellow displays are accepted as being 'easy on the eye' and therefore are most suited for sustained viewing in comfort. Any display which is not monochromatic (having more than one colour) — notably neon gas discharge displays — may be used with a coloured filter in front so that only that colour can be seen.

Three different types of format: formed character; 7-segment; and dot matrix, are shown in **Fig. 1**. By far the most commonly used today is the 7-segment type because of its ease of construction.

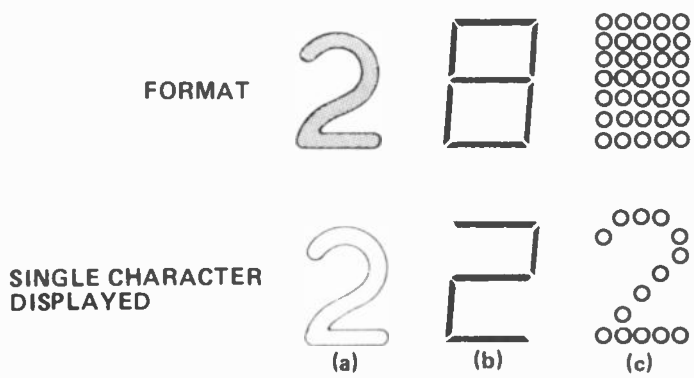


Figure 1. Examples of how characters are presented on electronic digital displays: (a) formed, (b) segmented, and (c) dot matrix

Interface

With regard to active and passive types of display it is not surprising to learn that passive displays require very little electrical power to drive them, which makes them suitable for portable equipment. Active displays require relatively high power — especially if they are to be seen in conditions of high ambient light.

In addition to the amount of power required when selecting a particular type of display you must be conscious of what a device requires in terms of voltage and current. Almost invariably the signal which turns the display on and off originates from an integrated circuit (IC) using TTL (transistor transistor logic) or MOS (metal oxide semiconductor) technology. The 'driving' capability of TTL is nominally 5 V and a few tens of milliamps. With MOS technology, this capability is 5-15 V and only microamps of current. Often an IC is found to be incompatible in voltage or current (or both) to drive a display directly, and for this reason special interface drive stages are used to link the display to the IC (see **Fig. 2**). The interface takes the form of a special IC or a discrete transistor circuit.

The driver stage itself performs a useful 'logical' interface. Display circuits usually work in pure binary or binary coded decimal. In simple terms, the code (known in digital language as the 'word') associated with each digit of the display comprises four parts or 'bits'. Its proper title is a four-bit word. The display, on the other hand, will require some combination of a seven-bit word. This logical transformation is performed by a driver called a decoder. **Figure 2** shows a schematic of this circuit — which interfaces both electrical and logical incompatibilities between the drive circuit and the display. Not surprisingly it is called a driver/decoder stage.

Multiplexing

Usually numeric displays are used in rows or registers of up to 10 digits, 4 and 8 being the most popular lengths. Indeed, many types of display are made with the required number of digits in a single envelope as well as individual digit versions.

In a register of more than two or three digits it is not economic to provide each segment of each digit with a separate correction and its own driver stage. By using a **multiplexing** technique fewer connections and fewer drivers are used as would otherwise be necessary. The multiplexing system shown in **Fig.3** makes a common connection between all of the same segments in the register. Each digit connection is still brought out individually. The number of drivers and connections to an 8-digit register is now only 15 instead of 64. The penalty for this saving in hardware is a complication in timing and drive power. Each digit has to be addressed (supplied power for a brief period) in turn and can only be addressed for an eighth of the time it takes to address the whole register. Thus each segment has its address period or time slot. During each time slot the particular pattern of segments to display the required digit is situated in the decoder. Since only one digit is turned on at any one interval how is it that the whole of the register appears to be activated at the same time? It is because the total time taken to address all of the digits in the register, called the field time or refresh time, has to be shorter than the persistence of vision on the retina of the eye if a flicker-free image is to be seen.

Finally if the image is to appear as bright as a statically addressed register then each digit must be made to pass eight times as much current (brightness is directly proportional to current) during its time slot. This requirement necessitates higher current ratings from the selection switches than if multiplexing were not used.

By now, you must be baffled by the technicalities of optical, interface and multiplexing! Things should become a little clearer as we look at the individual types of display, at their construction, materials used and their electrical requirements.

Light Emitting Diodes

The light emitting diode (LED) is a semiconductor junction diode similar in many ways to the germanium and silicon diodes now commonplace in solid-state electronic circuits. LEDs were originally made in one of two ways. The first was by forming a PN junction from gallium phosphide (GaP). The disadvantage of this method was that it readily saturated and was not very suited to multiplexed operations in which high currents were required. On the other hand, it was a low resistance material. The second was by forming the junction from gallium arsenide phosphide (GaAsP). This has a super-linear characteristic of light output against current but also has a high resistance. An improved LED was made by forming a PN junction in an epitaxial layer of GaAsP on a GaA (gallium arsenide) substrate. The disadvantage of this type of LED structure, however, was that the GaA substrate was opaque to the light generated at the PN junction. Therefore only light emitted in a forward direction was useful. Nowadays the super red lamp (**Fig.4**) uses GaP for its substrate which is translucent to the emission from the epitaxial layer above.

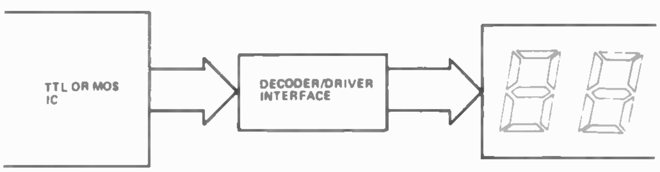


Figure 2. Position of decoder/driver interface stage between TTL or MOS logic and digital display

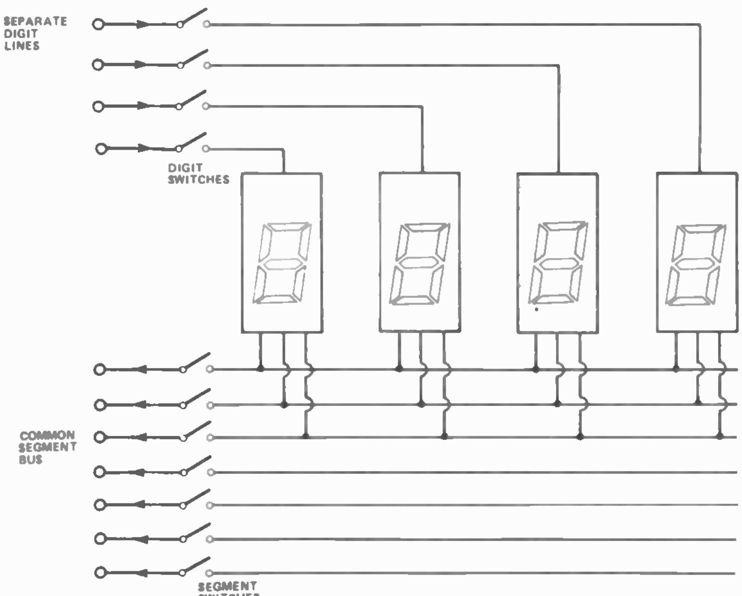


Figure 3. How the segments of a four-digit display are multiplexed. In practice all the switches are electronic and are contained within a single integrated circuit (multiplexing IC)

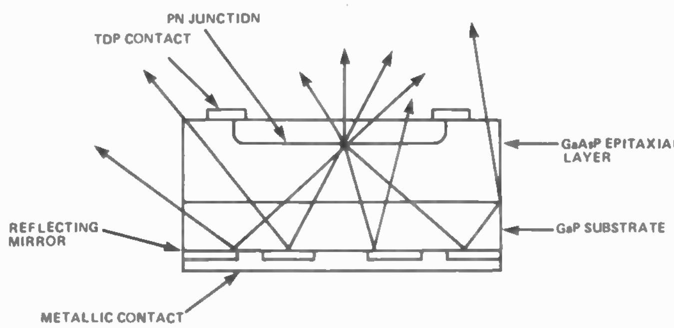


Figure 4. Section through high efficiency gallium arsenide phosphide (GaAsP) or gallium phosphide (GaP) LED

The high light output provided by this structure is optimised first by its mounting technique. The contact onto which the crystal is mounted is mirror polished, thus returning most of the incident light. Second, the display is made by using small dies (individual semiconductor chips) for each of the segments as opposed to the earlier monolithic (all-in-one) structure. This is not only an economical use of expensive material but allows light to emerge from the sides which in turn can be collected by a shaped light pipe and turned into useful emission (see **Fig.5**). Such a structure results in a LED which is a great improvement on its predecessors. Orange, yellow and green LEDs are made employing similar techniques.

LEDs have typical semiconductor diode characteristics with a knee voltage of about 1.5 V and an average current of about 20 mA/segment for a digit 20 mm high.

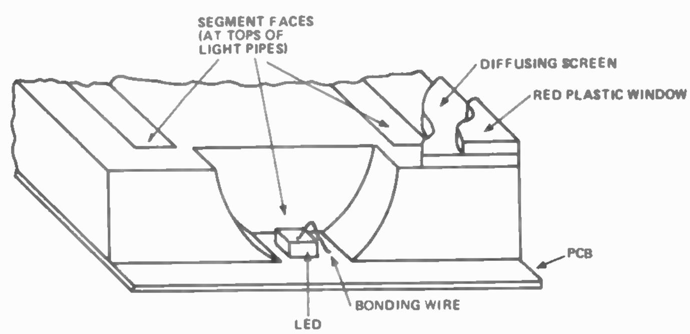


Figure 5. Section through a 7-segment LED display where light is transmitted to the segment faces by means of 'light pipes'

Liquid Crystal Displays

Liquid crystal displays (LCDs) are the most recent display technology to become established in high volume production. They are the only type of display to be discussed here which fall into the passive or non-light-generating type. They therefore have limited application to multiplexing although it should be said that the latest LCD materials give good results when multiplexed in short register lengths.

A simple cell showing the principle of the LCD is shown in **Fig.6**. The liquid, in a completely relaxed state, takes up an orderly organisation in which the molecules, which may be regarded as rod-shaped, all point in the same direction. If now a thin layer (say, 10 um thick) is trapped between glass plates, the inside surfaces of which have been specially treated, then the layers naturally take up the twist shown in **Fig.6**. The 'treatment' accomplishes two jobs. First, tin or indium is evaporated onto the glass to give the shape of the electrode structure required, typically a 7-segment display. Second, by a technique of rubbing or evaporating at a low angle, the surfaces of these electrodes exhibit a property by which the liquid crystal in immediate contact with the surface takes up the alignment laid down in the surface. Because the surface alignment of the top and bottom plate takes place at right angles, the molecules of the liquid take up the twist shown.

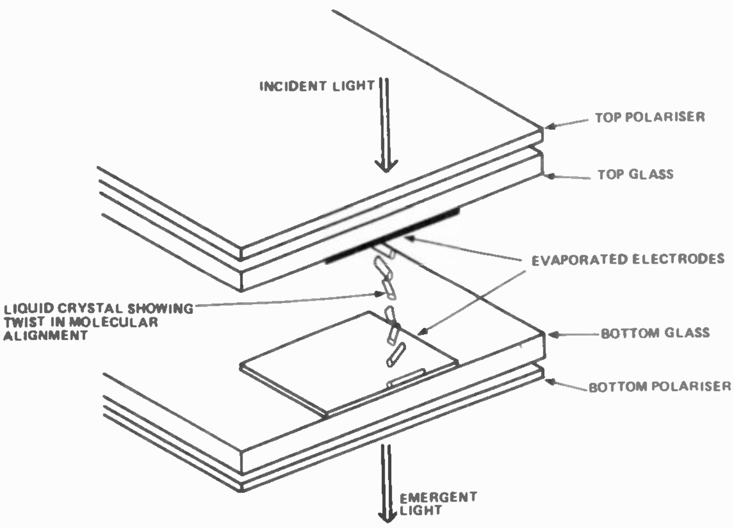


Figure 6. Operation of liquid crystal cell. Molecules of the liquid twist as shown when an electric field is set up across the cell. Under these conditions the passage of incident light becomes blocked

Now if light entering the cell is first passed through a plane polariser, then the plane of polarisation is twisted by 90° while passing through the liquid. If, as the light leaves the cell, it is passed through a second polariser placed at 90° to the first, then the cell will appear transparent. If now an electric field is set up across the cell, the molecule arrangement of the liquid is destroyed and light is blocked, giving an opaque deep blue or black colour.

The electrical characteristics of LCDs are ideal for interfacing to MOS integrated circuits; ie, they have negligible power consumption and require driver voltages anywhere between 2 and 20 V. These features make this technology well suited to battery-operated applications (ie, watches, calculators and portable instruments).

Gas Discharge Displays

A gas discharge display (GDD) generates light from the invisible plasma formed around a cathode electrode. The plasma is produced when a discharge path is established between the cathode and an anode, with both electrodes mounted in an atmosphere consisting mainly of neon at low pressure. The plasma is seen as a bright orange-coloured glow which entirely encloses the surfaces of the cathode electrode.

A typical GDD display is shown in **Fig.7**. Each digit consists of an anode electrode and seven cathode electrodes in the shape of seven segments. This structure is enclosed in a low-pressure neon atmosphere. A plasma discharge is set up between the anode and the selected cathode segments. The glow has a broad spectrum and several colours can be produced by filtering.

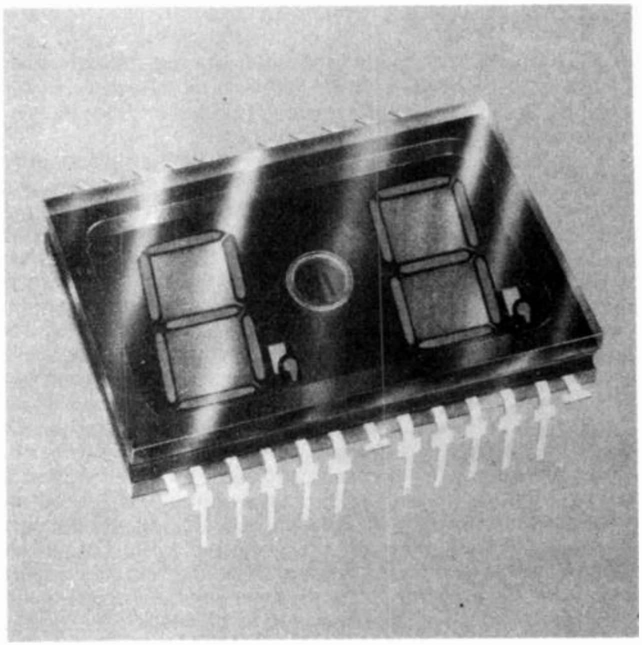


Figure 7. Example of typical gas discharge display (Mullard ZM1550)

Typically about 170 V is required to ignite the display (see **Fig.8**), and once ignited it requires a maintaining voltage of 130 to 150 V depending on the current. Below about 125 V the plasma is extinguished.

The device is not self-limiting in the amount of current it draws and therefore the drive circuit must have a defined current.

The presence of some argon in the neon helps to reduce the striking voltage, and the inclusion of a small amount of mercury vapour prevents sputtered material from fogging the viewing window or contaminating unselected cathode electrodes.

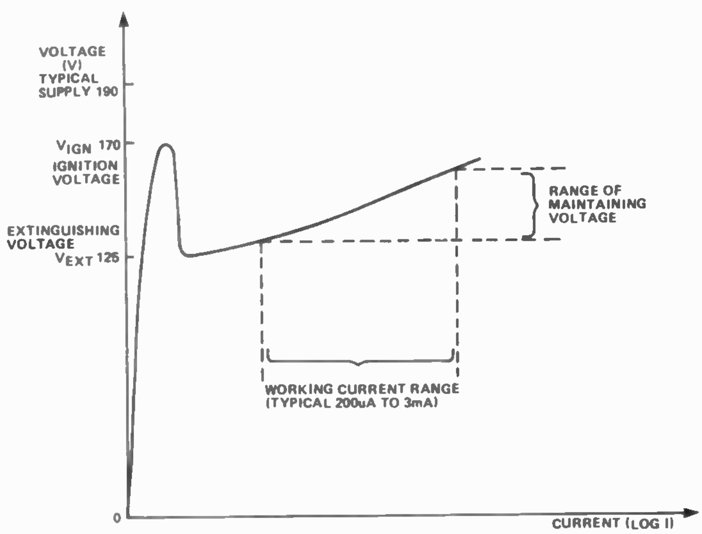


Figure 8. Typical electrical characteristic of a gas discharge display

Although GDDs require a high-voltage supply to strike them, the voltage required to select or extinguish individual segments is, for the device shown in **Fig.7**, only 30 V. Because the current consumption of each segment is only about 200 uA for a character 15 mm high, GDDs can be driven by MOS decoder circuits.

Vacuum Fluorescent Displays

The principle of operation of the vacuum fluorescent display is the same as the magic-eye indicator used in domestic radio receivers and tape recorders using thermionic valves (remember valves?). It incorporates many of the techniques used in the thermionic triode valve.

In its modern form of construction the vacuum fluorescent display is housed in a flat pack glass envelope, a section of which is shown in **Fig.9**. An electron stream is given off from a very fine oxide-coated filament placed just under the viewing window. The heater would not be noticed by the observer because of its fine construction and because it is only heated to a dull red.

A fine grid in front of each 7-segment array of anode elements controls the electron flow to the anode. The arrays of anode elements are coated with a special low-energy phosphor which glows with a pleasing blue/green light when it is bombarded with the electron stream. The stream itself is collected by the metal anode elements underneath. An individual character is lit by applying about 30 V to the required configuration of anode electrodes.

Throughout the register within the envelope all similar anode segments are connected to a common bus. At any time only one grid electrode is made positive, and this facilitates multiplexed operation of the device.

In addition to the flat pack construction, recent developments have been the introduction of multi-coloured displays by filtering from the relatively broad spectrum blue/green phosphor. Also,

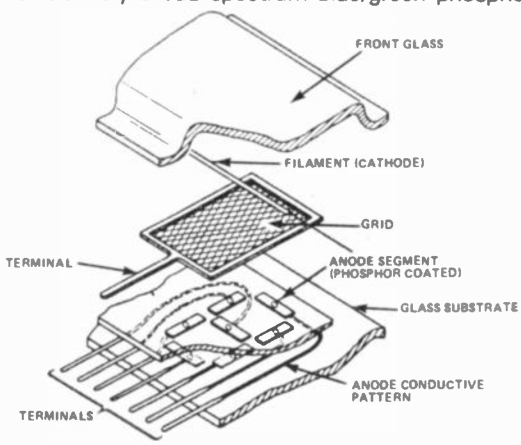


Figure 9. Typical construction of a vacuum fluorescent display (Futuba FDP)

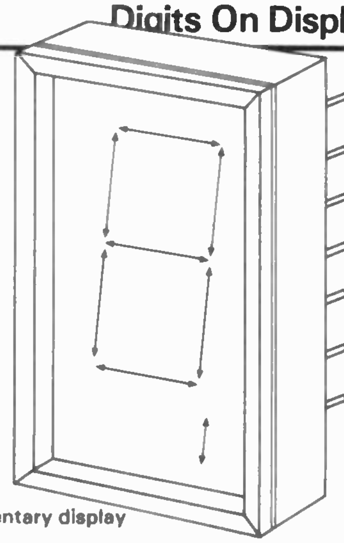


Figure 10. Typical filamentary display

screen printing techniques now used have helped to keep this type of device economical and more able to easily facilitate customised formats.

Filamentary Displays

Filamentary (incandecent) displays, perhaps the first 7-segment display technology, still account for a sizeable share of the market. The staying power of these displays comes from their unrivalled brightness (up to 10,000 lux) which allows them to be seen in the brightest ambients. Hence their durability in aero and marine applications, and also in petrol pumps.

In spite of their spindly appearance (see **Fig.10**), the filaments are made from a coiled length of tungsten wire. Unlike the domestic lamp the filament is run at a low temperature (typically 1500°C), and this gives it its long life — up to 100,000 hours. When filamentary displays are designed to emit white light, filters can be used to produce any colour. Each segment requires typically 15 mA at 5 V for a character height of 11 mm. **HE**

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A superb game, provides endless fun for children and adults alike. (WARNING – THIS GAME CAN SERIOUSLY EFFECT YOUR PAST-TIME.) It gives you 90 seconds to hit enemy craft. The elapsing time and 4 digit score is constantly displayed. Score is decremented if you hit a friendly ship or if enemy missile penetrates your defence.
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Scratch Filter

Hisssssssssssssssssssssssssssss ————————————————————————— ! That's what happens if you build this simple scratch filter and use it when you listen to noisy records. It can help to reduce surface noise picked up by record playing equipment

IF YOU HAVE a record collection, then you almost certainly have at least a few records that would benefit from the use of our scratch filter. The problem with disc recordings is that even if they are well cared for they inevitably show signs of wear in the quality of reproduction obtained. This loss of quality appears as a loss of treble response and a background of almost constant clicking and popping sounds. As these sounds consist largely of high frequency components it is possible to reduce them substantially using a filter having a response that attenuates high frequencies, but does not significantly affect lower frequencies. The price that has to be payed for the reduced noise is the slight loss of *wanted* treble signals as well. However, it is probably true to say that most people prefer noise-free reproduction even if there is a loss of treble output.

Construction

Following **Fig.2**, make up the Veroboard. Start by breaking the tracks of the board at the shown positions. You can do this with a Veroboard cutting tool, alternatively a ⅛" hand-held drill bit can be used for the job.

Next insert and solder the components one at a time, starting with resistors followed by capacitors and then semiconductors.

Mark and drill your chosen case, to fit the input and output sockets and the on/off switch. Two boards and two sets of input and output sockets are required for a stereo scratch filter, but the battery and on/off switches are common to both channels in this event.

Finally, wire up your project as shown in **Fig.2**.

Using The Filter

Ideally the scratch filter should be connected between the preamplifier and power amplifier stages of the hi-fi amplifier or receiver, and in many cases this will be possible using the 'tape monitor' facility. However, as the circuit has a high input impedance it is possible to connect it between a crystal or ceramic pick-up and the input of the amplifier, and this method should also give good results.

It is also possible to use the filter between a magnetic cartridge and the input of the amplifier, if you put a 100k resistor across the input of the filter, to give a suitable input impedance to match the cartridge. However, this method is not recommended since it will give a significant reduction in the signal to noise ratio of the system, and it is quite likely that stray pick-up of mains hum and other interference will be a problem.

Parts List

RESISTORS (All ¼ W, 5%)	
R1	1M0
R2	2M2
R3,4,5	4k7
CAPACITORS	
C1	100n polyester
C2	1u, 25 V electrolytic
C3	22n polyester
C4	3n3 polystyrene
C5	10u, 25 V electrolytic
SEMICONDUCTORS	
IC1	TL071CP low noise operational amplifier
Q1	BC109C NPN transistor
MISCELLANEOUS	
SW1	single-pole, single-throw toggle switch
Case to suit	
Veroboard, 24 hole x 10 strip	
Input and output sockets (SK1 and SK2)	
PP3-size battery + connector	

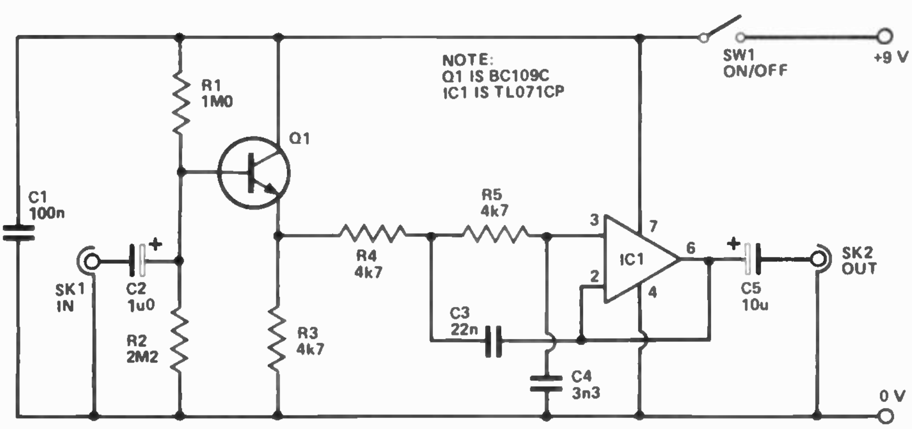
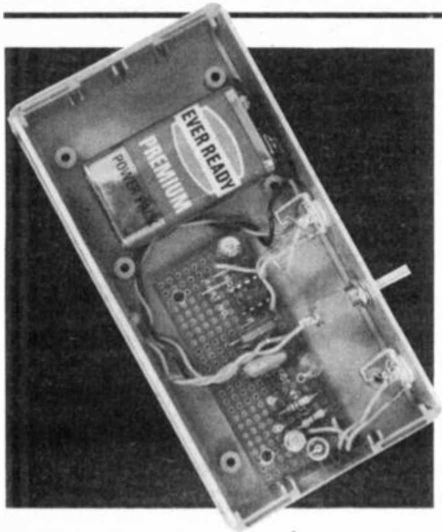


Figure 1. Circuit of HE Scratch Filter



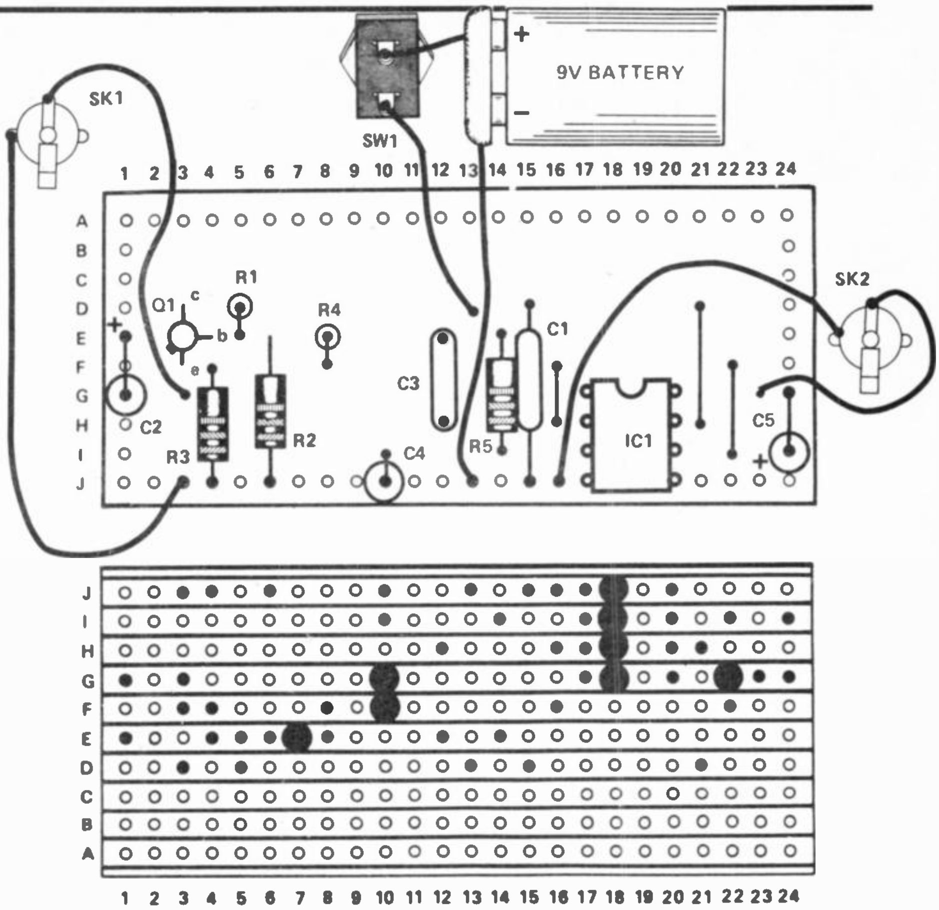


Figure 2. Veroboard layout, and underside view showing component locations and track breaks

Buylines

The TL071CP can be obtained from most of the mail-order companies which advertise in HE. All other parts are easily available.

Approximate price for components in this project (excluding case) will be £4.

How It Works

A sound signal, obtained from the cartridge of a record player, might have a 'flat' frequency response — so named because the output volume is level over a large part of the frequency spectrum. This output signal may contain surface noise from a worn record.

But noise (ie, surface noise) consists of high frequency components.

Passing the signal through a scratch filter gives an output signal amplitude which, above a corner frequency, decreases with increasing frequency. Thus unwanted surface noise is reduced in volume compared to the majority of the sound signal.

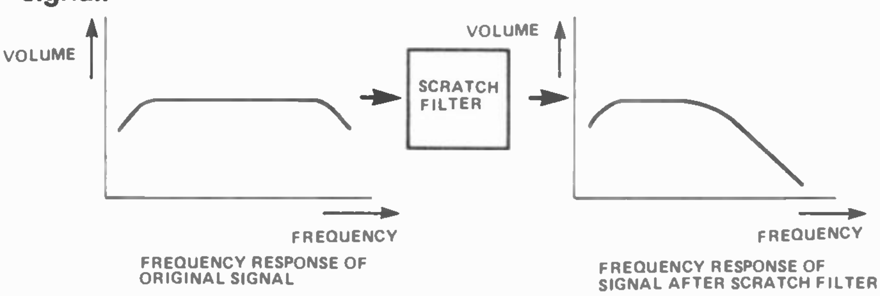


Figure 1 shows the circuit diagram of the filter, and this uses a conventional 12 dB per octave circuit (ie, above the corner frequency, doubling the frequency causes a four-fold reduction in gain).

Transistor Q1 is used as an emitter follower buffer stage at the input which gives the circuit a high input impedance of about 500k, and ensures that the filter is fed from a relatively low source impedance and gives the required response.

The filter circuitry uses R4 plus R5 in series, together with C4, to give a simple RC low pass filter action. Integrated circuit IC1 is used with 100% negative feedback from its output (pin 6) to its inverting input (pin 2) so that it acts as a unity voltage gain buffer stage, and prevents loading on the output from affecting the response of the filter.

A simple RC filter provides a roll-off rate of only about 6 dB per octave, and tends to give only a very gradual initial roll-off, with the ultimate 6 dB per octave roll-off only being reached well above the point where the response starts to fall away significantly. This gives rather poor performance in practice with only limited noise reduction and a small but significant loss of signals at middle audio frequencies.

This problem is overcome by the inclusion of capacitor C3, which has no significant effect on the circuit at low frequencies.

The situation is very different at higher frequencies where C4 produces significant losses through R4 and R5, resulting in the output voltage change being less than that at the junction of R4, R5, and C3. Although C3 is always less than 100% effective, it does now have some effect on the circuit, producing additional losses through R4 at high frequencies. HE

Your Letters

The Editor replies to a selection of your letters

APART FROM enquiries about projects published in HE, we also receive a variety of general technical enquiries unrelated to material published in the magazine.

By coincidence, two enquiries were received in August about hearing aids. The first letter came from H. Chester in Burton-on-Trent, who wanted to know where he could obtain ICs, microphones and earpieces suitable for building into the moulded cases of hearing aids. He also requested circuit details.

The second letter, from G.W. Tate in Bristol, is printed below.

Dear Sir,
On holiday last year, I met a man who, like myself, wore a behind-the-ear hearing aid. Besides this, he also had a home made, hand-held aid that he used at meetings, concerts etc. He claimed it was much better than the manufactured body-worn aids and only cost a fraction of these. It was of course much larger but as it was used only for special events that would hardly matter.

In your July issue you published an article on aids for the disabled. Deaf people are disabled too, so why not think up a few projects for us? If you really wanted to go to town you could work out an aid that would include a pick up from the loop system. If you think there are hardly enough of us to matter you should go to the audiology department of a hospital and you might be surprised how busy it is. And it isn't only older people who attend: there are children who haven't even started school.

In this instance I have only mentioned deaf aids, but if you went into the matter there is scope for quite a few other projects.

How about giving it a thought.
G. W. Tate
Shirehampton, Bristol

I am aware of how distressing deafness can be and I would not underrate it as a disability. The problem is that each case of deafness must be treated individually — and by a qualified medical specialist. If we published a simple 'HE Deaf-aid' how could it cope with so many degrees of deafness, frequency response impairments and so on? Apart from these practical problems, we would also run into difficulties with the health authorities — after all, none of us are medical specialists. As much as we'd like to help, our hands are tied on this matter.

A letter from South Africa next.

Dear Sir,
I have been reading and collecting your magazine right from the start, and always enjoy reading it.

It was with great interest that in the April 1981 issue you published the first part of an exciting new stereo system. Everything went perfectly until the June 1981 issue, in which you published the Amplifier Circuit Diagram, along with the PSU Diagram, and a parts list for the PSU Diagram, but no parts list for the Power Amplifier.

I appreciate you can buy a complete kit from Capricorn Electronics for £155, but this proves to be difficult if you are living in South Africa, even provided that exchange control allows for such a transaction to take place.

I awaited the July issue, to see if you had rectified your omission, but only found that the final wiring diagram was published.

I would appreciate it if you would prove the subtitle on your magazine — and show a down-to-earth approach to electronics — by publishing the parts list for the Power Amplifier, or by letting me have same per letter.
Thomas R. Bradley
Alberton 1450, South Africa

The Power Amplifier project, unlike most of our projects, was based on a pre-assembled module (two are used for stereo operation), as supplied by Capricorn Electronics. Readers who have not perfected their constructional technique might run into serious difficulty building up one of these modules, apart from the setting-up procedure required. We therefore decided to concentrate on the peripheral wiring of the modules to enable readers to obtain hi-fi results with little difficulty. For these reasons we do not intend publishing the usual parts list for this project.

Dear Sir,
Receiving Transmissions from UOSAT (HE Aug 81):

Is it possible to modify the short wave receivers in HE March 1980 and September 1981 to receive the "synthesised voice" telemetry from UOSAT (after its launch of course) on 145.825 MHz (FM)?

If a modification is not possible could you suggest a simple circuit which would receive these transmissions?
G. K. Fletcher
Northampton

Both the receivers that you mention are designed for short-wave operation only: the UOSAT transmissions will be on a very high frequency (VHF) waveband and a receiver specifically intended for VHF operation will be required. Another important requirement of the receiver is that of narrow bandwidth. The HE short-wave receivers operate on the principle of regeneration (see *Famous Names* in this issue for an explanation of this). Although quite sensitive, regenerative receivers have a wide bandwidth and might not sort out UOSAT's transmission from other transmissions close by on the waveband. (See also comments on reciever kit in *UOSAT Launch Imminent*, HE October '81, page 59).

Dear Editor,
Please would you put your next Index to Vol 3 of your great HE mag as a pull out in the centre page and add some DATA and JARGON with it so we can pull it out and put it in the back of the BINDER.
A. Ford
Chesterfield, Derbyshire

PS I look forward to every mag.

We think that your suggestion is an excellent one. Just give us some time to think up some appropriate 'data' and 'jargon'. (No free BINDERS on this page!)

Dear Sir,
Having just become interested in electronics, buying your magazine I am slightly confused as to the way some components in your projects are described. For example, in the Low Power Pilot Light project in this month's (September) edition the resistor R1 is described as 1M2 and R5 as 1k8, also the capacitor C1 as 1u0. In the diagram, R5 is shown as 1k2. Please could you explain these.
B. Mitcheson
Kettering, Northants

So many abbreviations and symbols are used in electronics that it would only lead to confusion if we defined every one in every project. For some general advice I'd recommend that you refer to Ian Sinclair's *Into Electronic Components* series (we've reached Part 4 — see page 48).

Dealing specifically with the components that you mention:

R1 1M2 means 1.2 million ohms resistance (1,200,000 ohms), with the M for million taking the place of the decimal point

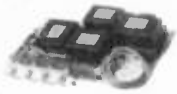
R5 1k8 means 1.8 thousand (kilo) ohms (1,800 ohms). For this one the k takes the place of the point. The value of R5 should be 1k2, as shown in the circuit in **Fig.2**. However, as the value is not critical in this circuit, 1k2 or 1k8 can be used

C1 1u0 means 1.0 microfarad or 1uF (0.000001 farads). The u symbol takes the place of the decimal point.

This practice of using the symbol in place of the decimal point is a practical one: tiny points have a habit of disappearing when printed in components lists and on components.

And we'll end it there for this issue. **HE**

MULLARD UNILEX

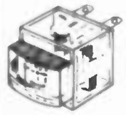


A mains operated 4 + 4 stereo system. Rated one of the finest performers in the stereo field this would make a wonderful gift for almost anyone. In easy to assemble modular form this should sell at about £30 — but due to a special bulk buy and as an incentive for you to buy this month we offer the system complete at only **£16.75** including VAT and post. FREE GIFT — buy this month and you will receive a pair of Goodman's eliptical 8"x 5" speakers to match this amplifier.

DELAY SWITCH

Mains operated — delay can be accurately set with pointers knob for periods of up to 2½hrs. 2 contacts suitable to switch 10 amps — second contact opens a few minutes after 1st contact. **£1.95.**

LEVEL METER



Size approximately ¾" square, scaled signal and power but cover easily removable for rescaling. Sensitivity 200 uA. **75p.**

½ PRICE CABLES! Flat P.V.C. covered mains cables — for lighting and power instalations.

SIZE	TYPE	100 Mtres	CARRIAGE
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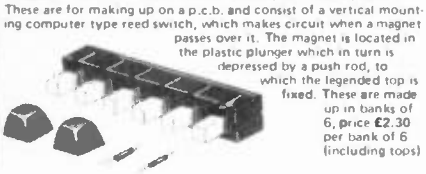
6mm	Single	£ 7.50	£2.50
4mm	Flat twim	£11.50	£3.50
6mm	Flat three core	£34.50	£4.50
16mm	Twin & E	£65 + £9.75	£10.00

INSTRUMENT BOX WITH KEY

Very strongly made (ply-wood sides with hard board top and bottom). This is black grained effect, vinyl covered, very pleasing appearance. Internal dimensions 12½" long, 4¼" wide, 6" deep. Ideal for carrying your multi range meter and small tools and for keeping them in a safe place. **£2.30.** Post paid if ordered with other goods, otherwise £1.00.

COMPUTER KEY SWITCHES (make your own keyboard)

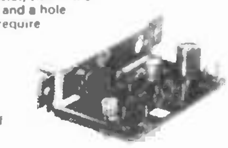
These are for making up on a p.c.b. and consist of a vertical mounting computer type reed switch, which makes circuit when a magnet passes over it. The magnet is located in the plastic plunger which in turn is depressed by a push rod, to which the legended top is fixed. These are made up in banks of 6, price **£2.30** per bank of 6 (including tops)



OUR CAR STARTER AND CHARGER KIT has no doubt saved many motorists from embarrassment in an emergency you can start car off mains or bring your battery up to full charge in a couple of hours. The kit comprises: 250w mains transformer, two 10 amp bridge rectifiers, start/charge switch and full instructions. You can assemble this in the evening, box it up or leave it on the shelf in the garage, whichever suits you best. **Price £11.50 + £2.50 post.**

GPO HIGH GAIN AMP/SIGNAL TRACER. In case measuring only 5⅛in x 3¾in x 1⅝in is an extremely high gain (70dB) solid state amplifier designed for use as a signal tracer on GPO cables, etc. With a radio it functions very well as a signal tracer. By connecting a simple coil to the input socket a useful mains cable tracer can be made. Runs on standard 4½v battery and has input, output sockets and on-off volume control, mounted flush on the top. Many other uses include general purpose amp, cueing amp, etc. **An absolute bargain at only £1.85.** Suitable 80ohm earpiece **69p.**

MINI MONO AMP on p.c.b., size 4"x 2"



approx. Fitted volume control and a hole for a tone control should you require it. The amplifier has three transistors and we estimate the output to be 3W rms. More technical data will be included with the amplifier. Brand new, perfect condition, offered at the very low price of **£1.15 each, or 10 for £10.00.**

12V FLUORESCENT LIGHTING

For camping — car repairing — emergency lighting from a 12v battery you can't beat fluorescent lighting. It will offer plenty of well distributed light and is economical. We offer an inverter for 21" 13 watt miniature fluorescent tube. £3.45. (tube not supplied).

SONY HI-FI SPEAKER CABINETS

Made for an expensive Hi-Fi outfit — will suit any decor. Resonance free cut outs for 6½" woofer and 2½" tweeter. The front is thick and stuck in after the speakers are fitted and the completed unit is most pleasing. Colour teak. Supplied in pairs, price **£6.90** per pair (this is probably less than the original cost of one cabinet) carriage £3.50 the pair

TANGENTIAL BLOW HEATER

2.5 Kw quiet, efficient instant heating from 230/240 volt mains. Kit consists of blower as illustrated, 2.5 Kw element, control switch and data all for **£4.95.** post £1.50

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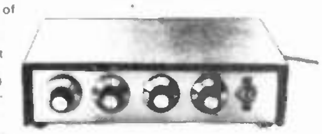
With 10 amp changeover switches. Multi-adjustable switches all rated at 10 amps, this would provide a magnificent display. For mains operated 8 switch model **£6.25**, 10 switch model £6.75, 12 switch model **£7.25.**

3 CHANNEL SOUND TO LIGHT KIT



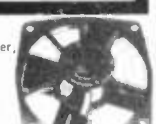
Complete kit of parts for a three-channel sound to light unit controlling over 2000 watts of lighting. Use this at home if you wish but it is plenty rugged enough for disco work. The unit is housed in an attractive two-tone metal case and has controls for each channel, and a master on/off. The audio input and output are by ¼" sockets and three panel mounting fuse holders provide thyristor protection. A four-pin plug and socket facilitate ease of connecting lamps. Special snip price is **£14.95** in kit form or **£25.00** assembled and tested.

THIS MONTH'S SNIP

COMPUTER PRINTER FOR ONLY £4.95

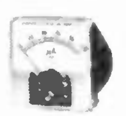
Japanese made Epson 310 — has a self starting, brushless, transistorised d.c. motor to drive the print hammers, print drum — tape forward/reverse and paper feed.
Complete in module form with electronics including Printer Synchro Signal Amplifier & Printer Reset Signal Amplifier. Brand new and with technical and practical data. **£4.95** post £1.25.
Data separately for **£1.00.**

EXTRACTOR FANS — Mains Voltage



Ex-computer, made by Woods of Colchester, ideal as blower; central heating systems, fume extraction etc. Easy fixing through panel, very powerful 2,500 rpm but quiet running. Choice of 2 sizes, 5" **£5.50.** 6" **£6.50.** post £1 per fan.

100uA PANEL METER



Japanese made (Shinohara Electrical) so very good quality, these have a full vision front, are approx. 2" square and come complete with mounting studs and nuts. A thoroughly reliable instrument usually retailed at over £4, offered at a snip price this month of **£2.85** or 10 for **£25.00.**

12v MOTOR BY SMITHS

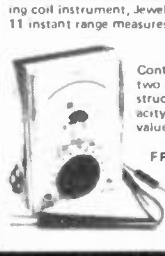
Made for use in cars, these are series wound and they become more powerful as load increases. Size 3½" long by 3" dia. These have a good length of ¼" spindle — price **£3.45.**
Ditto, but double ended **£4.25.**

EXTRA POWERFUL 12v MOTOR

Made to work battery lawnmower, this probably develops up to ⅛ h.p., so it could be used to power a go-kart or to drive a compressor, etc. etc. **£6.90 + £1.50** post.

MINI-MULTI TESTER

Deluxe pocket size precision moving coil instrument, Jewelled bearings - 2000 o.p.v. mirrored scale.
11 instant range measures: DC volts 10, 50, 250, 1000.
AC volts 10, 50, 250, 1000.
DC amps 0 — 100 mA.



Continuity and resistance 0 - 1 meg ohms in two ranges. Complete with test prods and instruction book showing how to measure capacity and inductance as well. Unbelievable value at only **£6.75 + 50p** post and insurance.

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RADIO MIKE
Ideal for discos and garden parties, allows complete freedom of movement. Play through FM radio or tuner amp. **£6.90** comp kit (Not licenceable in the U.K.)

FM RECEIVER

Made up and working, complete with scale and pointer needs only a speaker, ideal for use with our surveillance transmitter or radio mike **£5.85.**

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VENNER TIME SWITCH

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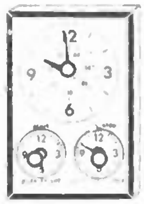
STEREO HEADPHONES

Japanese made so very good quality. 8 ohm impedance, padded, terminating with standard ¼" jack-plug. **£2.99** Post **60p.**



TIME SWITCH BARGAIN
Large clear mains frequency controlled clock, which will always show you the correct time + start and stop switches with the dials. Comes complete with knobs. **£2.50.**

SAFE BLOCK
Mains quick connector will save you valuable time. Features include quick spring connectors, heavy plastic case and auto on and off switch. Complete kit. **£1.95.**

6 WAVEBAND SHORTWAVE RADIO KIT
Bandspread covering 13.5 to 32 metres. Based on circuit which appeared in a recent issue of Radio Constructor. Complete kit includes case materials, six transistors, and diodes, condensers, resistors, inductors, switches, etc. Nothing else to buy if you have an amplifier to connect it to or a pair of high resistance headphones. **Price £11.95.**

SHORT WAVE CRYSTAL RADIO
All the parts to make up the beginner's model. Price **£2.30.** Crystal earpiece **65p.** High resistance headphones (gives best results) **£3.75.** Kit includes chassis and front but not case.

RADIO STETHOSCOPE
Easy to fault find — start at the arial and work towards the speaker — when signal stops you have found the fault. **Complete kit £4.95.**

INTERRUPTED BEAM
This kit enables you to make a switch that will trigger when a steady beam of infra-red or ordinary light is broken. Main components — relay, photo transistor, resistors and caps etc. Circuit diagram but no case. **Price £2.30**

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A high-note bleeper, push latching switch, plastic case and battery connector. Will scare away any villain and bring help. **£2.50** complete kit.

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Famous Names

Few of us are aware of the enormous contribution Edwin Armstrong made to the development of radio. Sadly, like many famous inventors, he was bedevilled by legal wrangling over his patents

THERE'S A VERY hallowed place in radio history not far outside New York City. After you escape from the confusion of Kennedy Airport, you cross the George Washington Bridge and take the green and pleasant Palisades Parkway, which points you towards upper NY State. Not far out, yet in wild, forested country, you'll see a transmitting aerial. Ask, and you'll be told that it is Edwin Armstrong's radio station.

On this side of the Atlantic we know the name of Marconi pretty well, and we could probably name a few other people associated with the development of radio and radar, but how many of us, hand on heart, could really place Edwin Armstrong? Yet of all the names which follow Marconi, his must be the most illustrious in radio history: radio, as we know it today, owes more to Edwin Armstrong than to anyone else.

Edwin Armstrong was born in Manhattan, New York, in 1890. His folks were well-to-do: his father a publisher, his mother a former schoolteacher, and between them they fostered in their son a fascination for the mechanical and electrical gadgets with which he was constantly surrounded. The turn of the century in New York was the age of the inventor. A steady stream of inventions were being registered at the US Patent Office, and each was eagerly seized on to be marketed and advertised. In many ways it was an inventor's paradise, but as many were to find out, the paradise had a few traps in it. Young Edwin caught the mood and at the age of 14, decided that he would be an inventor. The newest thing around was radio, and it was this field that Edwin chose, surrounding himself with coils and crystals, earphones and morse keys.

We know very little of what he did in those days, because like many inventors, he was shy and secretive. The next milestone in his career was his entry to Columbia University to study science and engineering — and to chalk his name on the list of radio pioneers long before his studies were complete. Radio at that time (about 1910) had very limited uses, mainly because of the very low sensitivity of receivers. Lee de Forest had just invented his Audion — a three electrode valve of the type we now call a triode, and this permitted some amplification of the feeble signals from a tuned circuit. At university, Armstrong was able to lay his hands on one of the first of these valves, and to start making use of it. Within a few months, he had made one of the major discoveries in radio — that of positive feedback.

First Milestone — Regeneration

The idea was simple enough. The primitive valve had a very low gain at radio frequencies. Armstrong hit on the idea of feeding the signal back to be amplified again, and he called the idea regeneration. A regeneration receiver was hundreds of times more sensitive than the average receiver of the day, so that Armstrong's invention was undoubtedly one of the milestones in radio progress. It was immensly successful and every radio, from then on, with any pretensions to sensitivity, incorporated regeneration. Armstrong himself had already found out that excessive positive feedback could cause oscillation, and so paved the way for all electronic radio transmitters to replace the crude spark-coil or alternator types which were then used.

It could have, and should have, been the moment of his greatest triumph, but it was soured in a way that was to haunt him for the rest of his life. His patents were challenged by de Forest, and judges and lawyers, ignorant of the principles involved, ruled that Armstrong's patents were invalid. To its great credit, the scientific community never accepted the legal judgement, and recognised Armstrong with every honour they could bestow. Many inventors from that day on, however, have regarded patent rights as a playground for lawyers and have preferred to get in first with the manufacturing of an invention rather than trust to their ability to profit from licensing agreements.

Second Milestone — The Superheterodyne

At the outbreak of war in 1914, Armstrong was appointed to the US Army Signal Corps to research into improved radio communications. Details of his work are not easy to obtain even now, because of the secrecy which surrounded the 'back-room boys', but one invention of this period is outstanding, and will probably remain so as long as radio is used. Until then, all radio receivers were either crystal sets, using no radio frequency amplification, or tuned radio frequency (TRF) receivers which used coils and capacitors to tune each amplifying stage to the frequency which was being received. TRF receivers are useful up to a point, but they have great disadvantages when large amounts of gain are needed. One disadvantage is that the tuning of each circuit has to be changed whenever a different frequency is wanted. Another is that even very small amounts of signal, if fed back from the output to the input, can make the receiver oscillate and so radiate interference. All this was solved by Armstrong's invention of the superheterodyne (superhet) receiver.

In a superhet receiver, each incoming frequency is tuned, amplified and then converted to an intermediate frequency (IF) by mixing it with a signal from an oscillator. The same IF is used no matter what the input frequency on that particular range happens to be. Tuning becomes easier because there are fewer variable tuned circuits, feedback is less of a menace because the signal which is most likely to feedback (the IF) is not at the same frequency as the input. It's difficult nowadays to imagine radio without superhet receivers: from the pocket transistor radio right through to the mighty radar receiver, all use Armstrong's superhet principle.

This work earned Armstrong more than fame. During the 1914-18 war, he had met David Sarnoff, founder of the Radio Corporation of America. (Armstrong had, in fact, married Sarnoff's secretary). Sarnoff was utterly convinced of the entertainment possibilities of radio, and he bought many of Armstrong's patent rights. In the early twenties, the sudden blossoming of radio as an entertainment medium meant a boom in radio manufacture, and made Armstrong a dollar millionaire because of the royalties which were paid by radio manufacturers.

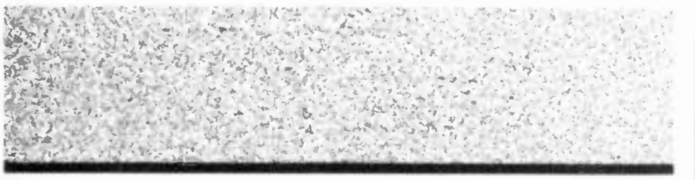
Third Milestone — Frequency Modulation

Despite his new wealth Edwin Armstrong remained withdrawn, and continued to work at Columbia University. His theme now was the elimination of radio interference, a topic which was to occupy him to the day he died. His work was fruitful: in 1933 he took out patents on the frequency modulation system — FM. The idea of modulating the frequency rather than the amplitude of a radio wave makes it possible to design receivers which are completely insensitive to the amplitude modulation caused by interference. At the time, though, only the Army Signal Corps really saw the usefulness of FM. Armstrong found himself with an uphill struggle to convince even his friends that his new system was capable of providing broadcasting of a quality totally unknown at the time. He began the construction of an FM transmitting station, using his own personal wealth. It swallowed over $300,000 and was completed in 1939 — just in time for the wartime economy drive to make it out of the question to operate the station, or for manufacturers to switch to making FM receivers. Frequency modulation was to prove its value in World War II, however, and once again, Armstrong worked in military research projects.

After the war, FM started to be accepted slowly. The problem was mainly cost, and what boosted sales more than anything else was the new craze for hi-fi which suddenly brought in its wake an appreciation of better quality radio broadcasting. These could have been the days of triumph for Armstong, but the nightmare which had haunted him from his early years was to recur. Once again, his patents were challenged in the courts, and he was put under the strain of trying to prove technical points to an audience of people who were technically ignorant and antipathetic to the quiet unassuming inventor. To add to his worries, his vast expenditure on FM was not yielding him any return, and in 1954, with his fortune spent and his brilliant invention being tossed about the courts by lawyers, Edwin Armstrong committed suicide.

He left behind him a monument as vast as any man can ever hope for. Every radio receiver and every FM transmitter in the world is the result of Edwin Armstrong's patient and little-publicised achievements. Only his name deserves to be better known.

HE



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Quick Project: Substitution Boxes

Capacitance and resistance substitution boxes can be the most useful items of electronic test equipment anyone can possess. This Quick Project gives details of how to make your own, both simply and cheaply

When developing and testing circuits a substitution box can save a lot of time spent looking through component storage boxes in search of particular resistor or capacitor values. You see, a substitution box is simply a case which contains a range of resistors or capacitors — selection of the desired value is with a switch (or switches). The selected component is connected to sockets on the front of the box, and from here it is connected into your circuit with a couple of test leads.

The circuit of Fig.1 shows a simple capacitor substitution box which gives a wide range of values. Not every preferred value is included, but using this unit it is possible to get reasonably close to almost any desired value, and the box is quite simple and inexpensive. In use, multiway switches SW1 or SW2 (as appropriate) are switched to select the desired component, and SW3 selects the correct multiway switch. Switching cannot be achieved using a single switch as a suitable component is not available. Switches SW2 and SW3 can be 12-way rotary types having their adjustable end stops set for 10-way operation.

A resistor substitution box can be produced instead, simply by replacing the capacitors with resistors having values of 1R, 2R2, 4R7, 10R, 22R, 47R, 100R, etc, up to 10M.

Figure 2 shows the wiring of the capacitor substitution box and is perfectly straightforward. The circuit can be housed in any suitable small plastic or metal case, but you must make sure the intended case has sufficient depth to take the components which are mounted on SW1 and SW2.

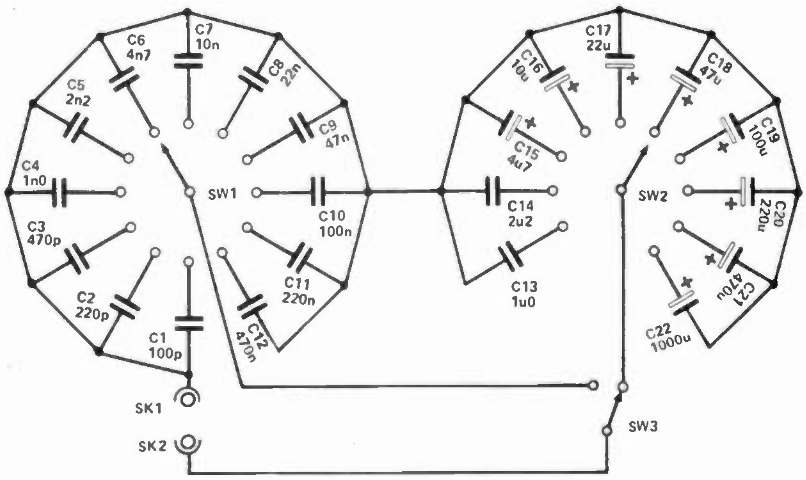


Figure 1. Circuit of an HE Capacitance Substitution Box. By replacing capacitors with resistors (see text) a resistance substitution box can also be made

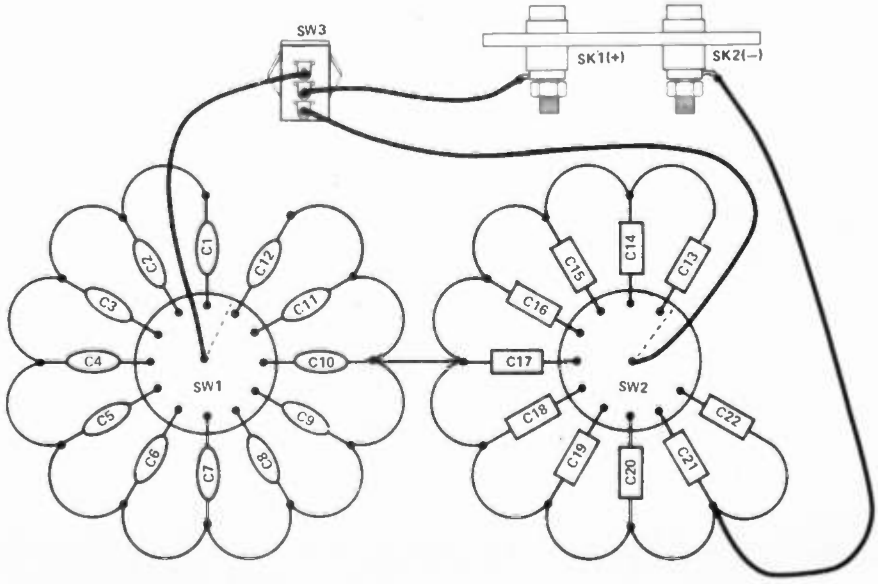


Figure 2. Wiring diagram of the Capacitance Substitution Box

Synthesiser Secrets

In this occasional series on the innards of musical synthesisers, Ron Keeley explains how sounds are made and how a synthesiser is capable of imitating them

THE FIRST PRACTICAL music synthesiser was built by Robert Moog: it used the special voltage controlled circuit elements developed by Moog to determine the musical qualities of pitch, tone and loudness. All synthesisers, except the more recently developed digital instruments, now use the voltage control technique because it permits fine and accurate dynamic control. Although it's not immediately obvious, it is this ability of a synthesiser to be *dynamically* controlled which makes the instrument a powerful one indeed, and it is worth considering this ability closely to understand why.

The problem of control goes back to the very beginning of electronic music synthesis. In 1952, the first synthesiser, RCA's Electronic Music Synthesiser, was built. It consisted of seven separate racks of equipment, each one *six feet high* . Music was synthesised by specifying seven characteristics for each note. These characteristics had to be encoded on a punched paper roll, much like an old-time pianola roll. Obviously, it was impossible for a musician to simply sit down at a keyboard (there wasn't one!) and actually play this complicated 'instrument'. That is to say, in the jargon of computer technology, it couldn't be controlled in 'real time'. There was a considerable delay (while a new section of paper was encoded and spliced in) in changing the sound of even one note: the synthesiser could obviously not be dynamically controlled.

Voltage controlled synthesisers, however, *are* controllable in real time - hit a key and a note sounds, turn a knob and it sounds different *instantly*. It's this facility for instant control which allows modern synthesisers to be played as real instruments, whether imitating more traditional instruments or creating new and unique sounds.

Making Music . . .

The three basic qualities of a musical sound — pitch, tone and loudness — are the 'handles' by which musical ideas can be grasped, and which are manipulated by composers to create an individual piece of music. By deciding that a melody will be played on, say, a violin, a composer is also deciding that: the melody will be played within a certain pitch range (see **Fig.1**);it will have particular tonal qualities (see **Fig.2**);and it will be within fixed limits of volume (see **Fig.3**). Had he selected a different instrument — a trumpet, for example — he would in effect be selecting different pitch, tone and loudness ranges.

The choice of an instrument determines the broad outlines of the music. The detail and colour, the fine texture, are each determined by the way the composer handles the pitch, tone and loudness capabilities of the instrument. He will actually compose the melody by writing down, in musical notation, the pitch of each note and its length; he may decide to vary the tonal quality by specifying that a certain passage should be played (again using the example of a violin) with the heel of the bow, rather than the flat, while loudness variations may be indicated on the score by words such as Piano (soft) or Fortissimo (very loud). In addition, a composer may decide to use one of the many techniques, such as portamento, staccato or pizzicato, which affect both tone and loudness.

. . . Electronically

If a synthesiser were to be used to play this particular melody,

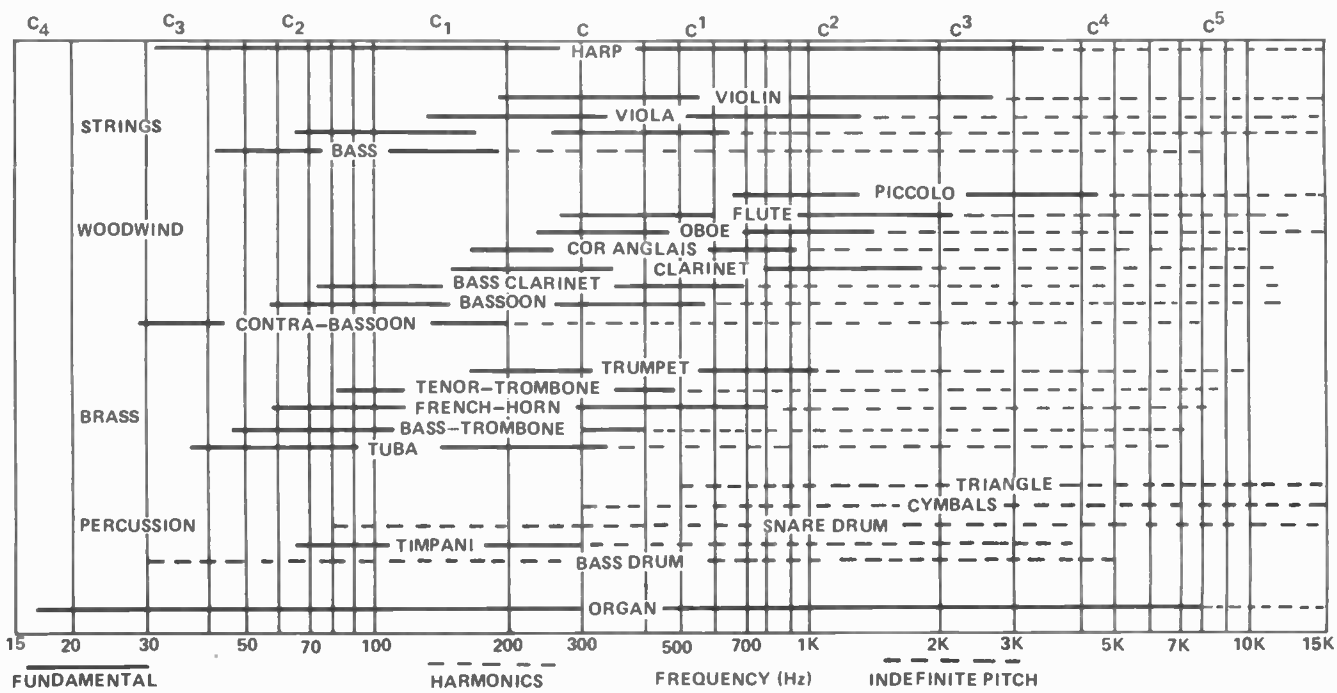


Figure 1. The frequency ranges of some instruments. The range of a synthesiser is wider than that of an organ

exactly as it was intended to sound, it would need to be a very complicated instrument indeed, and it would need a very clever synth-player, as well. Together they would have to duplicate *exactly* the musical qualities of the instrument to be imitated, right down to the minute changes in pitch, tone and volume that take place during even the shortest note, and all the playing techniques which are possible on that instrument.

In fact few synthesisers, if any, have the capability to imitate *exactly* any traditional instrument; most though, will permit a good synth-player to produce a close copy, depending on the exact facilities of the synthesiser — what can be controlled and how finely it can be controlled — and on the abilities of the player.

On the other hand, a musician or composer working directly with a synthesiser can specify musical notes or sounds that are totally beyond the range of any traditional instrument. These sounds, however, must still be thought of in terms of the three basic qualities of pitch, tone and loudness, because these are the three musical elements which a synthesiser can control.

Admittedly there is a small problem here, in that there is *no accepted way of describing synthesised sounds.* Can anyone, for example, suggest how they might write down, in any musical notation, the sound of a flying saucer whistling through the air, gradually changing into the sound of bird's wings flapping, as it passes from left to right?

Anyway, that's just something to be going on with! In the next part of this series we consider what is actually being controlled — starting with oscillators: voltage controlled oscillators (VCOs), of course!

HE

Figure 3. The loudness ranges of some traditional instruments

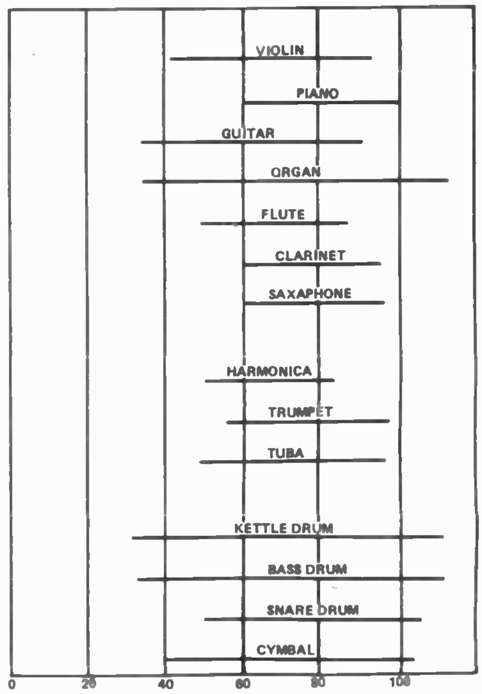
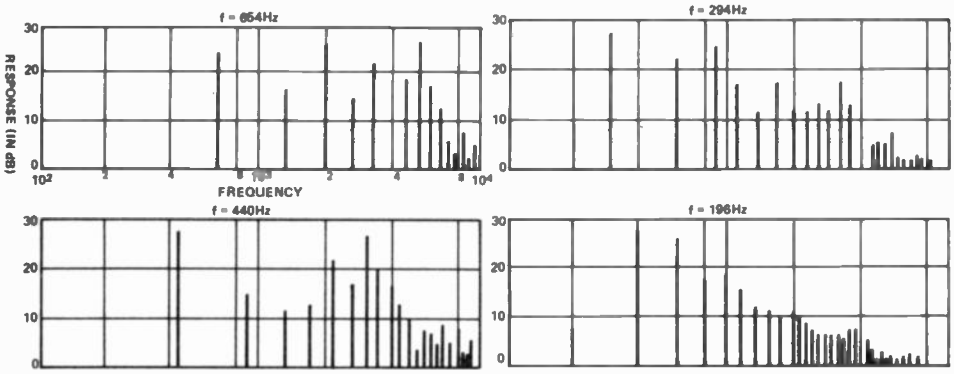
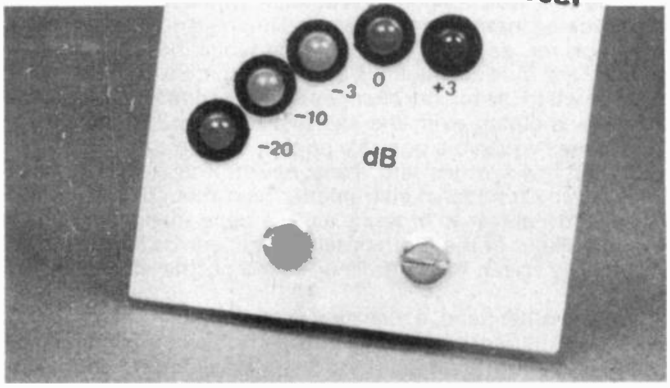


Figure 2. The harmonic content of the four open strings of a violin. Note that the fundamental frequency (F) is not always the loudest harmonic



LED VU Meter



If you require a quality VU meter to use with your tape recorder, or if you simply want a pretty audio display on the front of your hi-fi system, then build this five LED VU meter. Better still, build two for stereo

ORDINARY VU METERS respond to the *average* signal level, because they are quite slow to operate — we say they have a slow attack rate. This means that a signal waveform such as that of a piano or any other percussive instrument (ie, a waveform with a rapidly occurring initial peak followed by a long, average amplitude section) will produce a deceptively low reading on the meter. The signal peaks may thus be over-recorded and distortion will occur.

The HE LED VU Meter can be used as an inexpensive alternative to the ordinary type of VU meter, and it has the advantage of having a fast attack rate. Five LEDs provide indications at signal levels of: − 20; − 10; − 3; 0 and + 3 dB.

Construction

Build up the Veroboard as shown in Fig.2. Make all track breaks first, using a cutting tool or an ⅛" hand-held drill bit. Hold the cutting edge against the hole to be broken and twist gently clockwise until the track breaks in a clean circle. Make sure there are no loose bits of copper swarf. Insert and solder all components and links as shown.

The project can either be constructed as a self-contained item of equipment having its own case and power source (such as two 9 V batteries connected in series), or it may be possible to build it into the main equipment, depending upon individual circumstances and preferences. If built as a separate unit, an on/off switch must of course be included in the positive supply line.

In order to give RV1 the correct setting it is first necessary to apply a signal to the main equipment that corresponds to a 0 dB level, and then RV1 is adjusted for the lowest sensitivity that causes LED4 to light up.

Parts List

RESISTORS (All ¼ W, 5%)	
R1	15k
R2	2M7
R3	3k3
R4	56k
POTENTIOMETER	
RV1	100k miniature vertical preset
CAPACITORS	
C1,2	4u7, 25 V electrolytic
C3	100n polyester
SEMICONDUCTORS	
IC1	U267B bargraph driver
Q1	BC109C NPN transistor
D1,2	1N4148 diode
LED1-5	0.2" LEDs (3 yellow, 1 green, 1 red)
MISCELLANEOUS	
Veroboard, 24 hole x 10 strip	
LED panel clips	

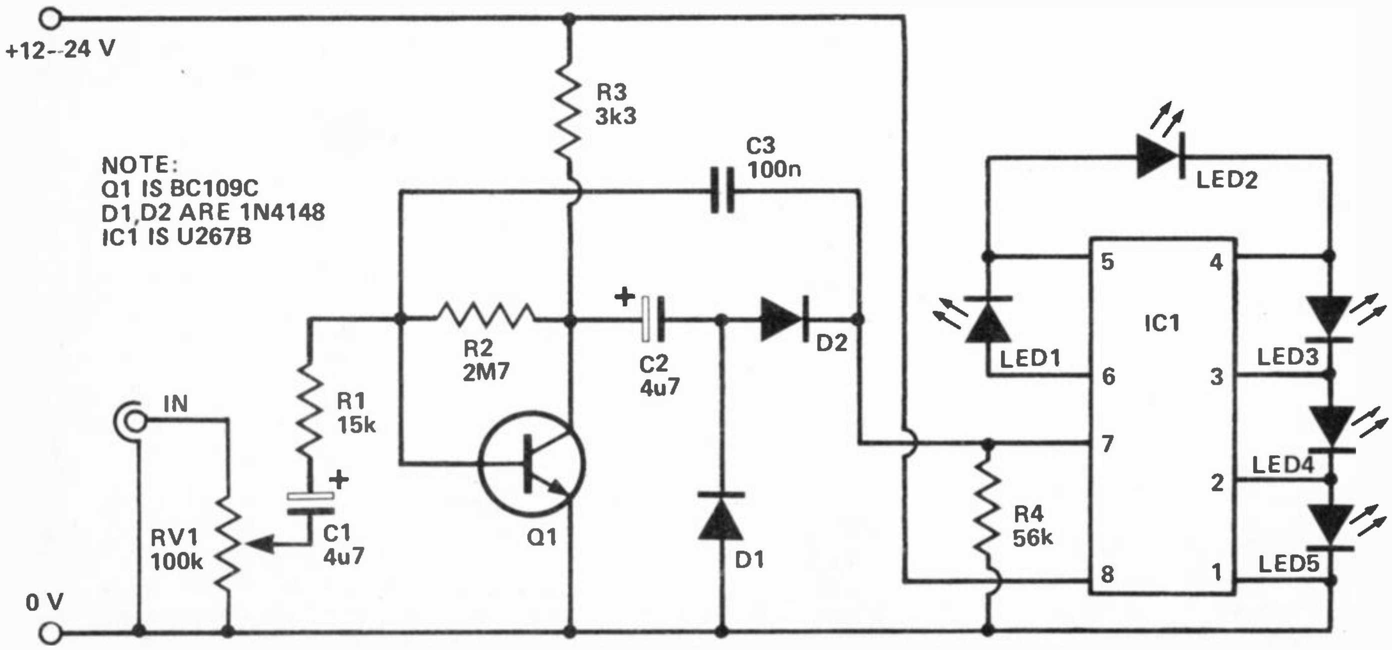


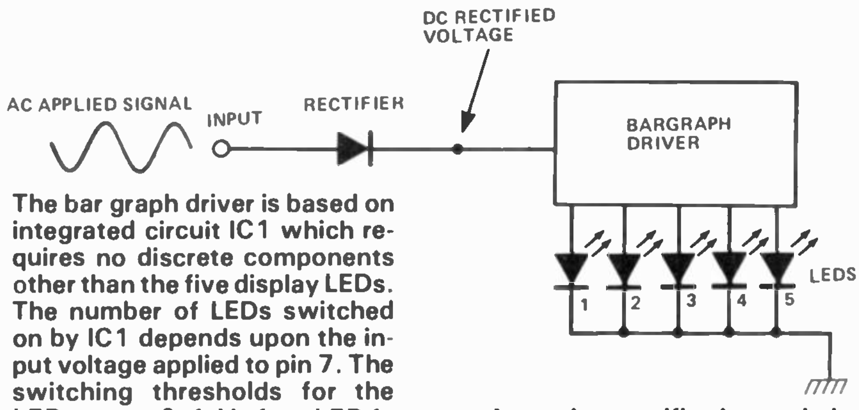
Figure 1. Circuit of the HE LED VU Meter

How It Works

The circuit consists of two basic sections — a rectifier (shown very simply as a diode) and a bar graph driver.

The bar graph driver requires a DC voltage. When no signal is applied to the project the DC voltage must obviously be zero. No LEDs are therefore lit.

As the amplitude of the AC signal increases from zero, so does the DC rectified voltage. As the rectified voltage increases the bar graph driver switches on each LED in turn, depending on the amplitude of applied signal.



The bar graph driver is based on integrated circuit IC1 which requires no discrete components other than the five display LEDs. The number of LEDs switched on by IC1 depends upon the input voltage applied to pin 7. The switching thresholds for the LEDs are 0.1 V for LED1, 0.32 V for LED2, 0.71 V for LED3, 1 V for LED4 and 1.41 V for LED5. This non-linear sequence is needed to give the five conveniently spaced VU levels, and the U267B is specifically designed for use in this type of equipment.

An active rectifier is needed ahead of IC1 to give a DC input voltage that is proportional to the peak level of the audio input signal. A simple passive rectifier circuit would not be suitable due to the forward voltage drop through semiconductor diodes. This would increase all the LED threshold levels by a similar amount, and would therefore alter their relative levels so that the unit would be hopelessly inaccurate. An active rectifier uses a high gain amplifier and generous negative feedback to effectively remove the forward voltage drop and thus give accurate results.

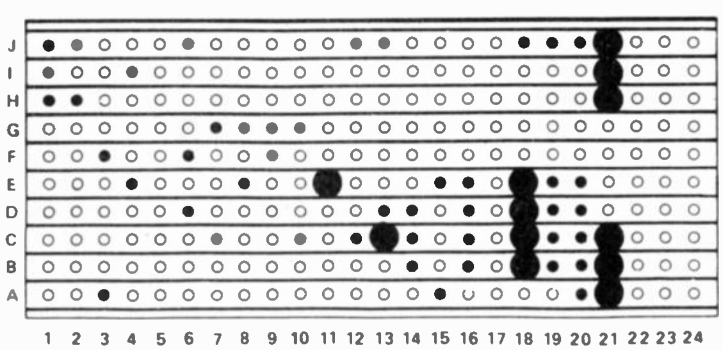
The amplifier is a straightforward common emitter stage which uses transistor Q1 in a conventional arrangement. The negative feedback is provided by capacitor C3 which also acts as a smoothing capacitor. The circuit has a fast attack time so that the unit responds properly to transients, but a slow decay time so that a comparatively long and clear indication is provided by such signals.

Preset RV1 is a simple variable input attenuator that enables the sensitivity of the unit to be set at the correct level. At maximum sensitivity about 200 mV RMS is needed at the input to give a reading of 0 dB. The circuit requires a supply voltage of between 12 and 24 V, and the current consumption is virtually constant at about 25 mA.

Buylines

The only component which you may have difficulty in obtaining is the U267B integrated circuit. This is available from Ambit Electronics Ltd. The other components are all common types.

Approximate price of all parts (excluding case) will be £7.



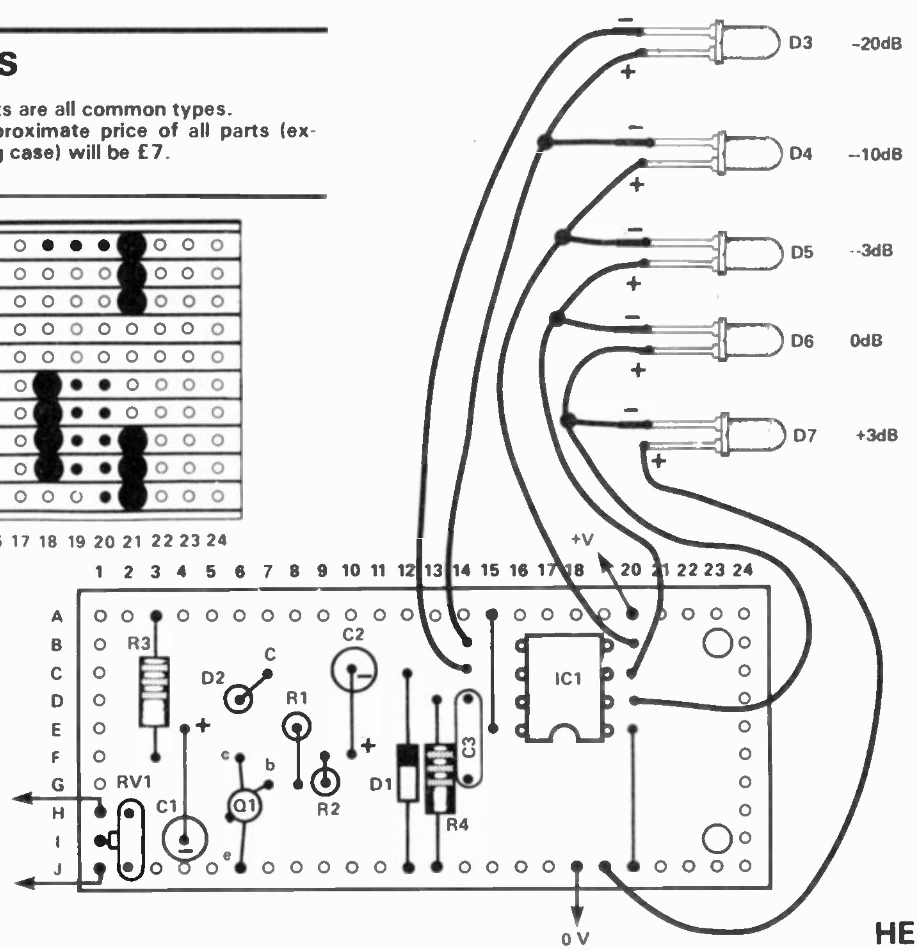
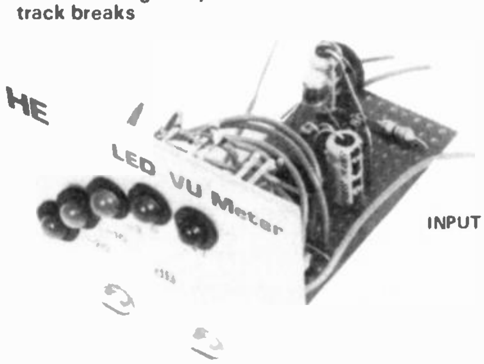


Figure 2. Veroboard layout, and underside view showing component locations and track breaks



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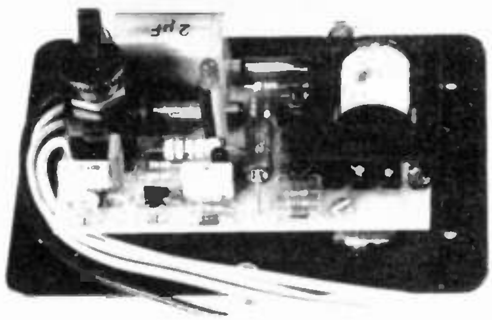
ELECTRONIC IGNITION KIT



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DIMENSIONS:

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Width	8.9 cm
Height	4.3 cm
Lead length	100.0 cm

TECHNICAL DETAILS

The basic function of a spark ignition system is often lost among claims for longer 'burn times' and other marketing fantasies. It is only necessary to consider that, even in a small engine, the burning fuel releases over 5000 times the energy of the spark, to realise that the spark is only a trigger for the combustion. Once the fuel is ignited the spark is insignificant and has no effect on the rate of combustion. The essential function of the spark is to start that combustion as quickly as possible and that requires a high power spark.

The traditional capacitive discharge system has this high power spark but, due to it's very short spark duration and consequential low spark energy, is incompatible with the weak air/fuel mixtures used in modern cars. Because of this most manufacturers have abandoned capacitive discharge in favour of the cheaper inductive system with it's low power but very long duration spark which guarantees that sooner or later the fuel will ignite. However, a spark lasting 2000µS at 2000 rev/min. spans 24 degrees and 'later' could mean the actual fuel ignition point is retarded by this amount.

The solution is a very high power, medium duration, spark generated by the TOTAL ENERGY DISCHARGE system. This gives ignition of the weakest mixtures with the minimum of timing delay and variation for a smooth efficient engine.

SUPER POWER DISCHARGE CIRCUIT A brand new technique prevents energy being reflected back to the storage capacitor, giving 3½ times the spark energy and 3 times the spark duration of ordinary C.D. systems, generating a spark powerful enough to cause rapid ignition of even the weakest fuel mixtures without the ignition delay associated with lower power 'long burn' inductive systems.

HIGH EFFICIENCY INVERTER A high power, regulated inverter provides a 370 volt energy source – powerful enough to store twice the energy of other designs and regulated to provide sufficient output even with a battery down to 4 volts.

PRECISION SPARK TIMING CIRCUIT This circuit removes all unwanted signals caused by contact volt drop, contact shuffle, contact bounce, and external transients which, in many designs, can cause timing errors or damaging un-timed sparks. Only at the correct and precise contact opening is a spark produced. Contact wear is almost eliminated by reducing the contact breaker current to a low level – just sufficient to keep the contacts clean.

TYPICAL SPECIFICATION

	TOTAL ENERGY DISCHARGE	ORDINARY CAPACITIVE DISCHARGE
SPARK POWER (PEAK)	140 W	90 W
SPARK ENERGY	36 mJ	10 mJ
(STORED ENERGY)	135 mJ	65 mJ
SPARK DURATION	500 µS	160 µS
OUTPUT VOLTAGE (LOAD 50pF EQUIVALENT TO CLEAN PLUGS)	38 KV	26 KV
OUTPUT VOLTAGE (LOAD 50pF + 500 KΩ EQUIVALENT TO DIRTY PLUGS)	26 KV	17 KV
VOLTAGE RISE TIME TO 20 KV (Load 50pF)	25 µS	30 µS

TOTAL ENERGY DISCHARGE should not be confused with low power inductive systems or hybrid so called reactive systems.

ildìng Site

Feature

›w when and where to use which type of connector?
›y lets you in on the secret

IRE about the many plug and socket con-
lly all they want to know is which sort of
:h application - do you use a jack plug and
amplifier, or can you put a phono socket
wer supply?
simple answer! It's largely a matter of
ɹus connectors are capable of connecting.
ɱ out, listed below are some of the more
ɟf plugs and sockets which you are likely to
ɔut aren't of any real significance to HE readers
e were to use any unusual connectors in one of
we would always say what it was.

ɹnnectors are used at the inputs and tape outputs of hi-fi
ɘrs. **Figure 1** shows a typical plug and socket. The socket
ɗirectly on to the metal case of the amplifier and this pro-
ɘ a good earth point for the inserted plug. The centre, signal,
ınection is isolated from the outer, but because the two are so
ɔse together and may easily short circuit if not wired carefully,
t's advisable not to use phono plugs and sockets for high current
(above say, 0.5 A) connections.

Phono plugs and sockets are good quality connectors and are ideal for audio work.

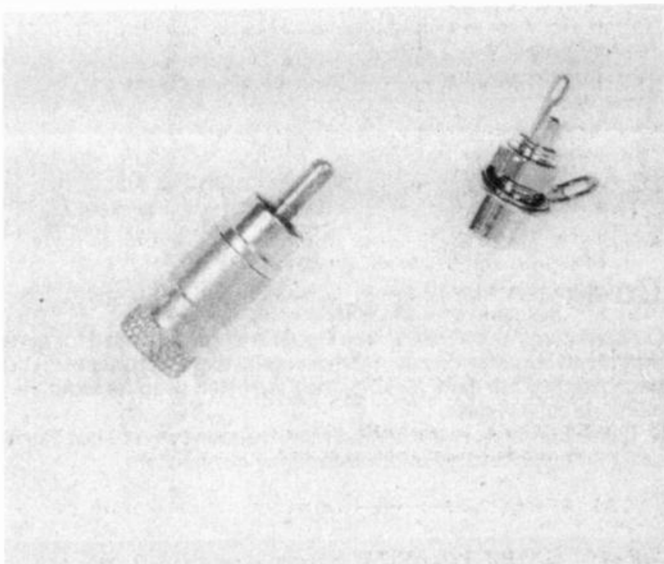


Figure 1. Phono plug (left) and socket. The socket bolts directly onto the case of the circuit.

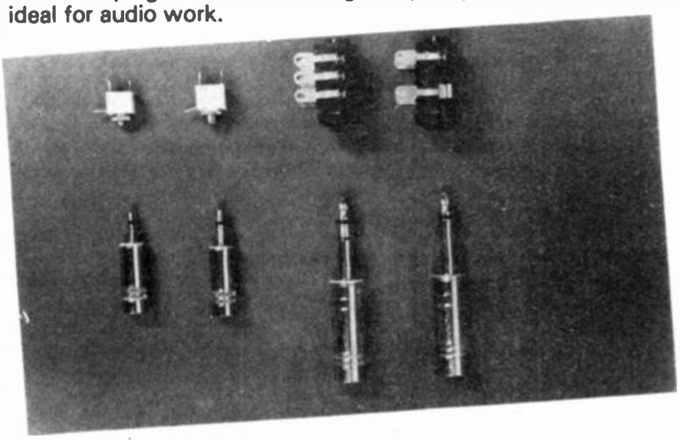


Figure 2. A selection of jack plugs and sockets. Mono and stereo ¼", 3.5 mm and 2.5 mm

Jack

There are three main sizes of jack connectors available to the hobbyist: ¼", 3.5 mm, and 2.5 mm (see **Fig.2**). The ¼" varieties are commonly used on guitar or microphone inputs to amplifiers etc, or headphone outputs. Mono (two connections ie, signal and earth) and stereo (three connections ie, left signal, right signal and earth) versions exist and the connectors can be used anywhere a fairly rugged and easily repairable connection is needed.

If a ¼" plug and socket is too big then either of the two smaller varieties, 3.5 mm or 2.5 mm, may provide an alternative. In all three types the internal connections are quite close together so jack connectors shouldn't normally be used in high current work.

DIN

A complete range of DIN plugs and sockets exist; from two connections to seven connections, a selection (two-, three- and five-pole) is shown in **Fig.3**.

Two-pole DIN plugs and sockets are the standard loudspeaker connectors on low power (up to about 30 W) amplifier outputs.

Three-and five-pole connectors are often used at the inputs and tape outputs of hi-fi amplifiers.

Because all connections are so close together in DIN connectors, two things should be remembered — they are not ideally suited to high current applications; and crosstalk (ie,interference from one connection to another) can occur.

DIN plugs and sockets make good quality and neat audio connectors.

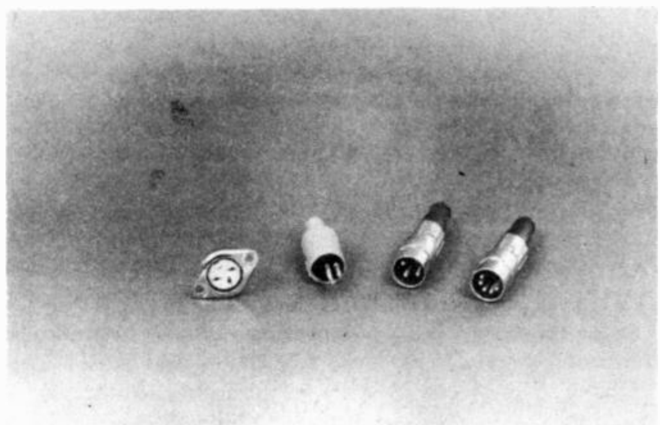


Figure 3. Two, three, and five pole DIN plugs with a typical socket

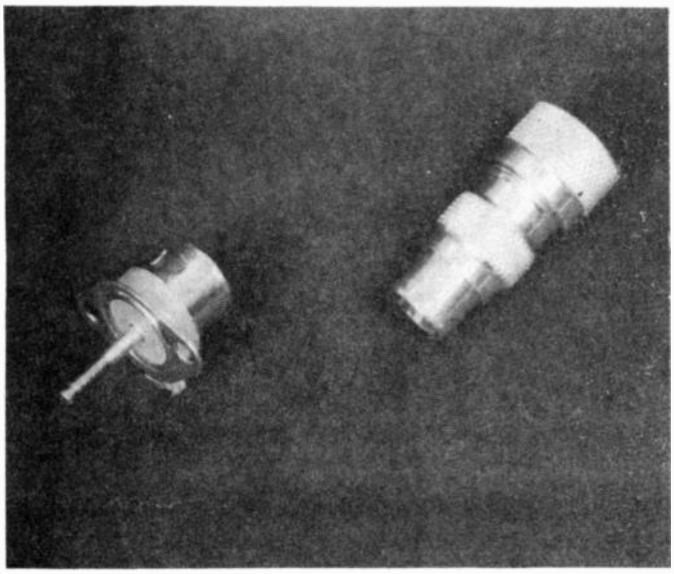


Figure 4. A co-ax plug and socket

Co-ax

Co-axial plugs and sockets (see **Fig.4**) are typically used for aerial downlead connections (ie, from an aerial to a TV, tuner etc.) but because they are quite reliable, they are often used for input connections to test gear.

These connectors are ideal in high-frequency work but can be used with success as audio frequency connectors.

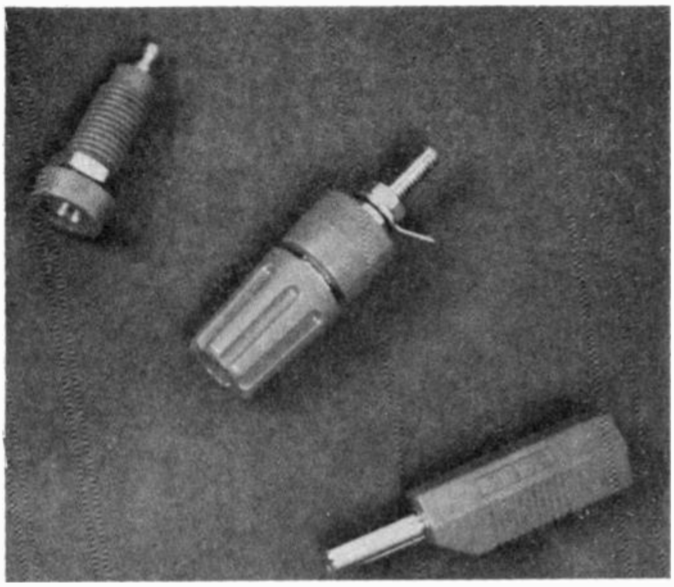


Figure 5. Two 4 mm sockets and a 4 mm plug

4 mm

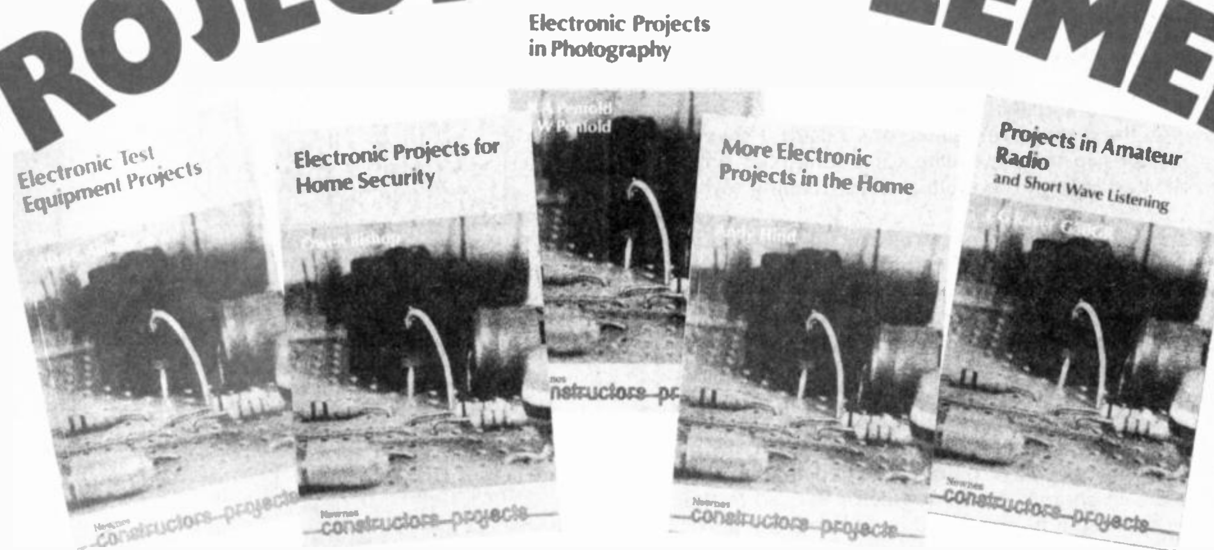
If you intend making connections to bench power supplies, multitesters, test gear etc, then this type of connector is ideal. The plugs and sockets are very robust and easy to connect (see **Fig.5**), and different coloured bodies are available to allow coded inputs and outputs.

Some types of 4 mm sockets have a screw down clamp, which will allow you to fasten a bared wire to the socket as well as a plug.

Oh well, time's up - see you next month!

HE

PROJECT SUPPLEMENT



In this free eight-page supplement we have five extra projects for you to build. They are reprinted from a series of new books, published by Newnes, for electronics constructors

Flashmeter

Penfold, R.A. and Penfold J.W. ***Electronic Projects in Photography*** **pp 63-69**

Determining the correct exposure when using electronic flash is not quite as straightforward as it might at first appear. Guide numbers give correct results only under certain conditions, and a substantial increase in exposure is normally needed out of doors, or in a large, dark room. In small rooms it is usually necessary to reduce the exposure. Even for an experienced flash photographer it is impossible to guarantee perfect exposure without repeating each shot at several aperture settings.

Using a flashmeter overcomes this problem, since the flashmeter measures the amount of light falling on the subject, and therefore shows what effect the surroundings are having on the exposure.

The circuit

The circuit diagram of the flashmeter appears in Fig. 12.1. Phototransistor TR1 and its load resistor R1 are used to produce a negative output pulse having an amplitude which is roughly proportional to the intensity of the light pulse received from the flashgun. The pulse of light from an electronic flashgun is only very brief, usually only about 1 ms, and sometimes very much less than this. The photocell circuit must therefore be capable of responding very quickly, as it must produce a pulse of virtually the same duration as the light pulse. The BPX25 silicon phototransistor seems to be perfectly adequate in this respect.

C1 couples the output pulse from TR1 to a simple rectifier circuit consisting of D1 and D2. These ensure that the pulse of current fed to the subsequent stage is not rapidly leaked away as the pulse decays. The subsequent stage is actually a Miller integrator which uses TR2, R2, C2, R3 and R4. Initially, reset switch S1 is briefly operated, so that TR2 gate terminal is taken to the negative supply potential. TR2 is then biased as a conventional common source amplifier, and C2 charges to the potential at TR2 drain terminal. C2 therefore tends to hold TR2 in this state when S1 is released.

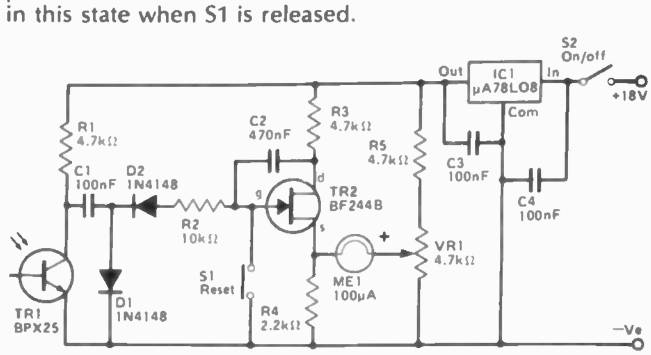


Figure 12.1

The circuit diagram of the flashmeter.

The negative pulse from the rectifier circuit when the flash is fired takes TR2 gate negative, and it causes C2 to steadily charge through R2. This negative signal at TR2 gate causes TR2 drain terminal to go positive, and this results in C2 charging at a virtually constant rate for the duration of the input pulse. Of course, the rate at which C2 charges is controlled by the amplitude of the input pulse.The final charge on C2 is thus dependent both upon the intensity of the light from the flashgun, and on the duration of the light.

It is essential that the circuit responds to both these factors, since they both have an effect on the exposure.

At the end of the pulse the integrator retains its new state, since C2 cannot discharge through the high reverse resistance of D2, or into the high input impedance of TR2. In practice the charge on C2 will very gradually leak away through these two paths, and through the leakage resistance of C2 itself. However, the circuit remains in the new state for a length of time which is more than adequate to enable a meter reading to be taken.

The meter is connected in a sort of bridge circuit, and VR1 is adjusted so that there is initially zero voltage across the meter, and accordingly it reads zero. When the circuit responds to the light pulse from the flashgun, TR2 source goes negative by an amount similar to the gate terminal, giving a deflection of the meter which is proportional to the change in voltage at TR2 source.

The circuit requires a stable supply voltage of about 8 to 10V. This is provided by a small monolithic voltage regulator from an 18V battery supply (the latter being provided by two PP3 batteries connected in series). An 8V regulator is used in the prototype simply because it happened to be at hand, but a 9 or 10V regulator could be used if one of these is more readily available than an 8V type. The current consumption of the circuit is only about 5mA.

Construction

The components, apart from the controls and batteries, are assembled on a 0.1in matrix stripboard which has 15 copper strips by 13 holes. The component layout of this board is shown in Figs. 12.2 and 12.3. There are no breaks in the copper strips incidentally.

Mount the finished panel in the case (after it has been wired to the rest of the unit) so that TR1 is mounted behind a hole of about 10mm diameter drilled in the case. TR1 should be positioned no more than about 10mm behind this hole. It is advisable to have a diffuser mounted over the hole, as the unit will otherwise be highly directional, producing inconsistent and unreliable results. The diffuser can consist of a thin piece of translucent white plastic, and some foods come packed in containers made from a suitable material. Thin paper is a suitable alternative, but it would be advisable to reinforce this with some perspex.

Adjustments and use

When the unit is first switched on, immediately depress S1 and adjust VR1 to zero the meter. The meter can be zeroed after each reading has been taken by means of S1. VR1 may need occasional readjustment to correct slight drift in the circuit.

To calibrate the unit it is necessary to find the points on the scale corresponding to one-stop intervals in light value. The most reliable way of doing this is by varying the flash-to-meter distance. Increasing the distance by a factor of 1.414 (the square root of 2) reduces the intensity by half, which is equivalent to the required one-stop intervals.

The meter should be set up in an average size room in a position where it is at least 1m away from any wall or similar reflective surface. The flashgun should be directly facing the light receiving surface. Half a metre is a suitable distance for the highest reading. The flashgun should be fired (as soon as the ready light comes on, to ensure repeatable results) and the meter reading noted. The flashgun should then be moved 0.707m (0.5m × 1.414) away from the meter and fired again, with the scale reading being noted. This procedure is repeated at distances of 1m, 1.414m, 2m, 2.828m, 4m, and so on, to give a scale covering 7 or 8 stops.

A calculator chart like the one shown in Table 12.1 can be drawn up to convert the scale readings into apertures for the various film speeds. in practice, the top line of this chart is marked with the meter readings for the various flash distances, and not the numbers shown in the diagram which are only given as examples. An alternative method is to remove the original scale from the meter, and replace it with a scale of numbers from 1 to 7 (or 8) marking the 1 stop intervals. These numbers are then used on the top line of the chart.

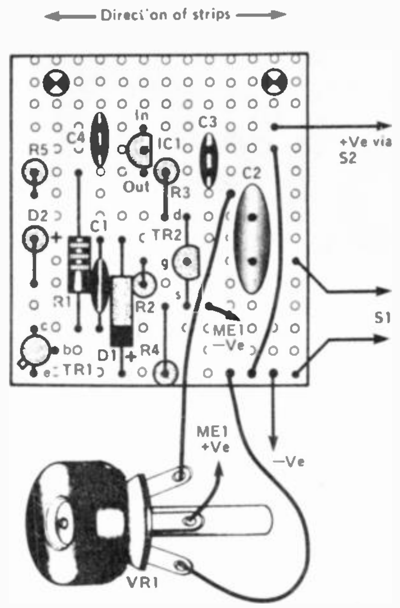


Figure 12.2
The 0.1in matrix stripboard layout for the flashmeter

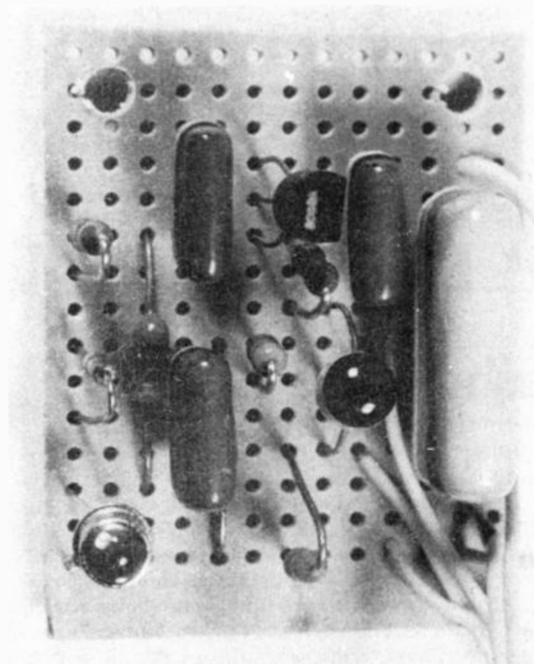


Figure 12.3
The flashmeter unit

ASA	20	27	35	43	51	60	69	77
25	11	8	5.6	4	2.8	2	1.4	
50	16	11	8	5.6	4	2.8	2	1.4
100	22	16	11	8	5.6	4	2.8	2
200	32	22	16	11	8	5.6	4	2.8
400	45	32	22	16	11	8	5.6	4

Table 12.1 Example of a chart based on a flashgun with a guide number of 14 (in metres) for a film speed of 100 ASA, used at the distances mentioned.

Initially the chart can be based on the guide number of the flash unit used for calibration, but it may be necessary to modify it slightly in the light of experience.

When calibrating the unit it may be found that the sensitivity is too high or too low, although this is unlikely as the range covered by the unit is somewhat more than is absolutely necessary. However, a lack of sensitivity can be corrected by using a thinner diffuser, or the value of C2 can be reduced. An excess of sensitivity can be corrected by adding more layers of material in the diffuser, or C2 can be increased in value.

Table 12.2 Components list for the flashmeter

Resistors (all miniature ¼W, 5%)	
R1	4.7kΩ
R2	10kΩ
R3	4.7kΩ
R4	2.2kΩ
R5	4.7kΩ
VR1	4.7kΩ lin. carbon
Capacitors	
C1	100nF, type C280
C2	470nF, type C280
C3	100nF, type C280
C4	100nF, type C280
Semiconductors	
TR1	BPX25
TR2	BF244B
D1	1N4148
D2	1N4148
IC1	μA78LO8 (8, 9, or 10V, 100mA regulator)
Switches	
S1	Push to make – release to break push button type
S2	SPST miniature toggle type
Meter	
ME1	100μA moving coil panel meter
Miscellaneous	
0.1in matrix stripboard	
Case	
Two PP3 size batteries and connectors to suit	
Control knob	
Wire, solder, etc.	

Fire Detector

Bishop, O. *Electronic Projects for Home Security* pp 30-33

This device warns of fire by detecting any excessive increase of temperature. It can be set to sound the alarm when the temperature exceeds 50°C (122°F), a temperature that is not likely to occur under normal weather conditions. Several sensors may be placed in strategic positions at various parts of the house.

How it works

The sensor is a thermistor, which is a rod of semiconducting material. As temperature increases, its electrical resistance decreases. In Fig. 4.1 the thermistor R1 and the variable resistor VR1 are joined as a potential divider. The potential at the input terminal depends on the values of R1 and VR1. For the average i.c. operating on a 12V supply a potential of 6V or lower is taken as a 'low' input. A potential above 6V is taken as a high input. There is variation between i.c.s in this respect and the threshold potential may lie anywhere between 3.6V and 8.4V for any given gate. This variation is taken care of by using a variable resistor in the circuit.

At 25°C, R1 has a resistance of 47kΩ. Assuming that VR1 is set to about 18kΩ the potential at the input is 3.3V. This is effectively a 'low' input. As temperature rises, and the resistance of R1 decreases, the input potential rises. At 45°C the resistance of R1 has fallen to about 21kΩ, producing a potential of 5.5V at the input. This is still a 'low' input. At 50°C, R1 has the value 17kΩ and the potential is 6.2V. This is a 'high' input.

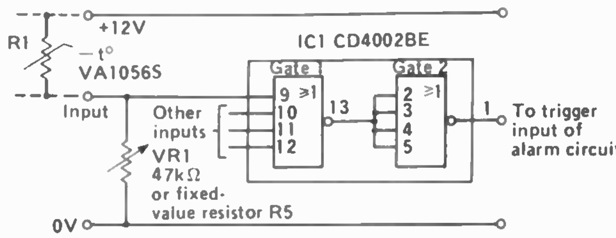


Figure 4.1

Heat detecting fire alarm detector circuit (thermistors R2, R3 and resistors R6, R7, R8 not shown)

Gate 1 is a 4-input NOR gate. For as long as all its inputs are low, (i.e. if any one or more of the thermistors connected to it becomes hotter than 50°C) its output goes low. This output is fed to the other gate in the i.c. which is wired so as to *invert* the output of gate 1. Consequently, fire causes the output of gate 2 to go high. This output is used to trigger an alarm to sound.

Construction

The first point to consider is whether this detector is to be built as a self-contained unit, or whether it is to be linked with the main domestic alarm system. A separate system gives the advantage that it can have its own distinctive alarm sound. One can then tell whether to telephone for the police or for the fire brigade! A disadvantage of the self-contained alarm is that it needs its own sound-generator circuit and its own power supply, both of which increase installation costs considerably.

Table 4.1. Components needed for fire alarm

Resistors	
R1–R4	VA1056S thermistor (4 off)
R5–R8	carbon resistors (⅓W or ¼W) approx. 18kΩ (see text) (4 off)
VR1	47kΩ required temporarily for calibrating
Integrated circuit	
IC1	CD 4002 BE dual 4-input NOR

Miscellaneous
0.1in matrix stripboard 63mm and 25mm (*Vero* 14354); terminal sockets (4 off); terminal pins for 0.1in matrix board 7 off; 6 BA bolts (2 off); 6 BA nuts (6 off); 6 BA shakeproof washers (2 off); connecting wire; solder.
(If the alarm is to be built as an independent unit, components will be required as listed in Table 2.1, 2.2 or 2.3, with the exception of R1)

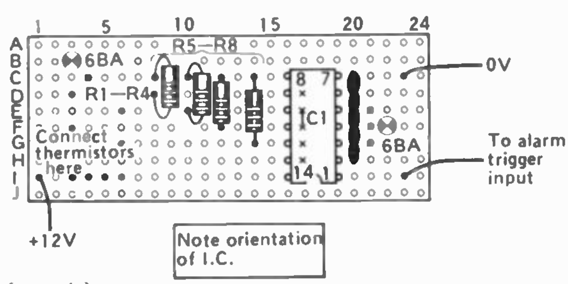


Figure 4.2

Layout of the circuit board for the fire alarm, on the underside of the board cut strips at C4, D17, E17, F17, G17, I17, (not C17, H17) E21, F21, G21
Solder blobs join six strips: C20 to D20 to E20 to F20 to G20 to H20

Since only one i.c. is involved construction is very simple. The layout of Fig. 4.2 provides for four thermistors. Each of these needs to be matched to the i.c. as described below.

Connect a thermistor to its input pin and to the 12V rail. Connect all other input pins temporarily to the zero volt rail. Temporarily connect a 47kΩ variable resistor to the input pin and the zero volt rail. Connect a voltmeter to the output of gate 2 (IC1, pin 1). The voltmeter should now read close to zero. Place the thermistor in a cup of water heated to approximately 50°C and leave it for about 1 minute to reach the same temperature as the water. The voltmeter may go high at this stage. Carefully adjust the variable resistor until you find the point at which the output changes from low to high. Disconnect the variable resistor *without altering its setting*. Use an ohmmeter to measure its resistance. Select a fixed-value resistor of equal value and solder this in position on the board (R5 to R8). The value of the variable resistor will probably not be exactly equal to one of the standard values for fixed resistors: select the next higher value, as this will ensure triggering at a temperature slightly less then 50°C. Finally check the circuit with the fixed-value resistor in place. The output of gate 2 should go high soon after the thermistor is placed in the warm water, and should go low a minute or so after removing it from the water.

The procedure should be repeated for each of the other thermistors in use. It may seem that this is an unnecessarily complex operation, when one could use four preset variable resistors instead. The chief danger in using variable resistors as a permanent part of the circuit is that if their settings should accidentally be altered, the fire alarm could be inactivated unknown to the user.

The four thermistors are placed in different parts of the house, where there is greatest danger of fire. In general they should be mounted high in the room, preferably close to the ceiling. Suitable places are just above any fireplace, cooker or central-heating boiler, and in any room in which there may be risk of fire (e.g. a hobby room). It is also worth while to place one at the top of the stairway. Each thermistor requires a twin lead to connect it to the alarm unit. If fewer than four thermistors are to be used, join the unused pins of IC1 to the zero volt pin.

Direct Reading Frequency Meter

Ainslie, A.C. *Electronic Test Equipment Projects* pp 50-55

Here is a simple design (Fig. 9.1) for a unit that will enable a 0–1mA meter to display frequency directly on a linear scale over the useful audio range of 20Hz to 20kHz. Measurements can be made on any waveform, with a sensitivity of less than 100mV. Applications apart from frequency measurement include tachometers and speedometers for cars.

Circuit

The input signal is amplified by IC1 (Fig. 9.2) to a level suitable for driving the Schmitt trigger IC2. Diodes D1 and D2 reduce the gain of IC1 for large input signals. Regardless of the input waveform, the output from IC2 is a series of pulses of the same frequency as the input.

A monostable is built around IC3, a 555 timer, triggered from the output of IC2. The output of the 555 on pin 3 is normally 0 volts, but when triggered by a pulse on pin 2, pin 3 goes high for a period dependent on the value of C5 and the resistor selected by S1. As the input frequency increases so does the proportion of time that pin 3 is high, increasing the deflection on the meter. Zener diode ZD1 ensures that the pulses passed to the meter are all of a defined level, the averaging of the meter movement then produces a deflection linearly proportional to the input frequency.

Timing of the monostable period is achieved by varying the voltage on pin 5 of the 555 with P1. This changes the overall period that pin 3 is high on all ranges and is used for calibration.

Construction

All of the components with the exception of the meter, S1 and R12/R15 are mounted on a printed circuit coard as in Fig. 9.3.

In Fig. 9.4, provision is made for using either eight or fourteen pin packages for IC1 and IC2. The pin numbers on the circuit are for eight pin devices which are mounted on the PCB in such a manner that pin 1 of the package fits into the hole drilled for pin 3 of the 14 pin package. Take care to locate the i.c.s correctly. Both the diodes and the electrolytic capacitors also have to be located correctly.

Solder pins are inserted into the board for the external connections, which can be made with instrument wire, although if the input leads are long it would be better to use screened cable.

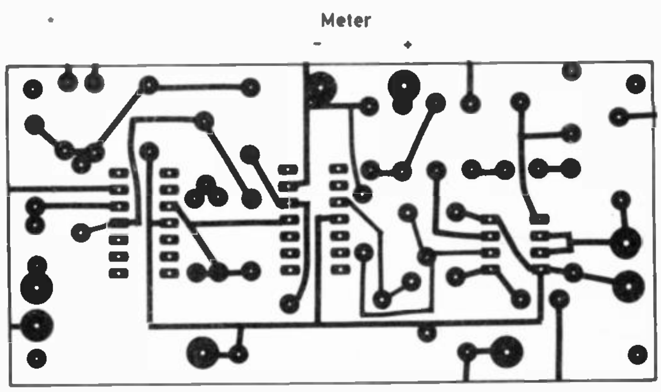


Figure 9.3
PCB layout

R12, R13, R14 and R15 are connected directly to the rear of S1 and in many cases the common connection can be supported on a spare tag on the switch.

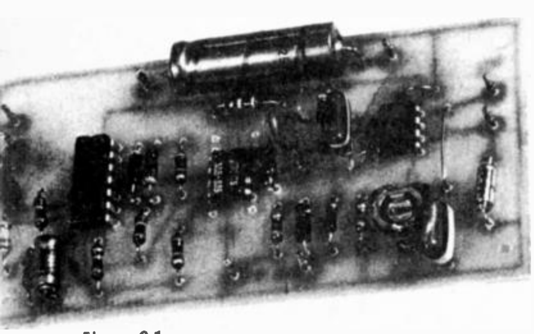
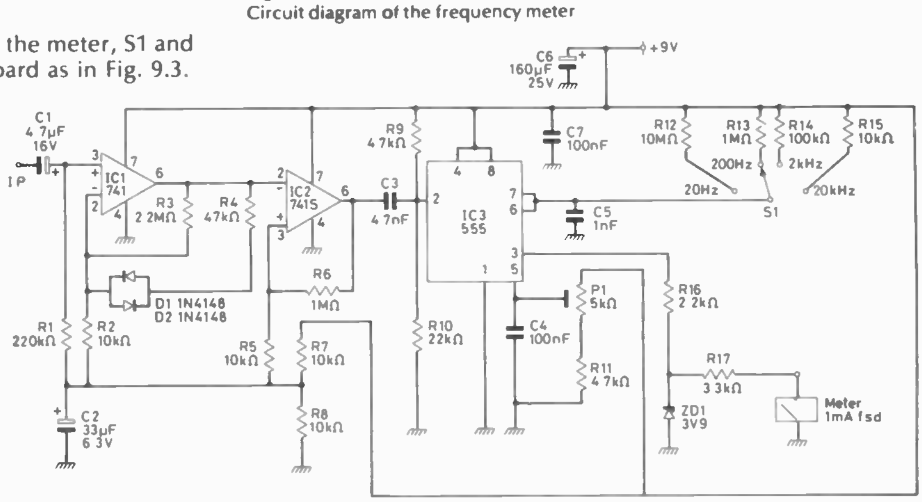


Figure 9.1
Direct reading frequency meter

Figure 9.2
Circuit diagram of the frequency meter



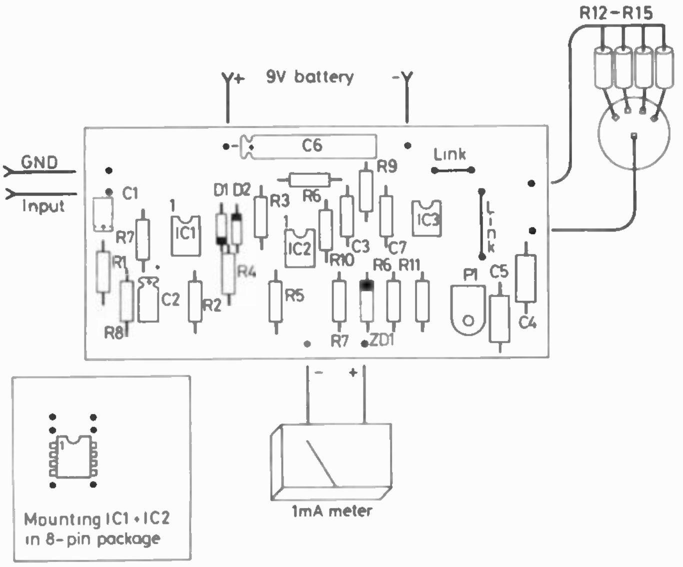


Figure 9.4
Component layout on the PCB

Virtually any convenient 1mA meter can be used or alternatively the frequency meter can be assembled as an add-on unit for a multirange meter set to the 1mA range.

Calibration

Only one calibration adjustment is needed to calibrate all of the ranges. This adjustment can be made at any frequency for which a convenient standard is available, P1 is trimmed so that the meter correctly indicates the input frequency.

50Hz mains derived from a low voltage isolating transformer is a standard available to all constructors, but is not really suitable as the 50Hz point is only one quarter f.s.d. on the 200Hz range.

N.B. BEWARE OF LIVE VOLTAGES AND POSSIBLE LIVE CHASSIS

Alternative calibration can be achieved by reference to a calibrated signal source, or an oscillator at 200Hz referenced to 50Hz mains by Lissajous frequencies on a CRO.

Use

Any signal above 100mV will be sufficient to trigger the meter which will then indicate the frequency of the applied signal. It is possible to use the instrument to indicate revolutions per minute by arranging contacts which close once per revolution (rotating magnet past a reed switch?) An extension of this would be to feed the meter from a phototransistor which would enable r.p.m. readings to be taken without contact if a contrasting line is painted on the rotating object. To eliminate the conversion from hertz to r.p.m. (×60) it is possible to recalibrate directly in r.p.m., convenient ranges achieved without changing any components other than resetting P1 being:

0 – 500 r.p.m.
0 – 5000 r.p.m.
0 – 50,000 r.p.m.
0 – 500,000 r.p.m.

Changing C5 to 10nF will change the ranges to

0 – 50 r.p.m.
0 – 500 r.p.m.
0 – 5000 r.p.m.
0 – 50,000 r.p.m.

It may be necessary to connect a capcitor of value 5μF across the meter to stop needle flutter on the lower ranges.

Table 9.1 Components for direct reading frequency meter

I.C.s			
IC1	741, 8 or 14 pin		
IC2	741S, 8 or 14 pin		
IC3	555		
Resistors			
R1	220kΩ	R10	22kΩ
R2	10kΩ	R11	4.7kΩ
R3	2.2MΩ	R12	10MΩ 5%
R4	47kΩ	R13	1MΩ 2%
R5	10kΩ	R14	100kΩ 2%
R6	1MΩ	R15	10kΩ 2%
R7	10kΩ	R16	2.2kΩ
R8	10kΩ	R17	3.3kΩ
R9	4.7kΩ		
(¼W unless stated)			
Capacitors			
C1	4.7μF, 16V		
C2	33μF, 6.3V		
C3	4.7nF		
C4	100nF		
C5	1nF		
C6	160μF, 25V		
C7	100nF		
Diodes			
D1	1N4148		
D2	1N4148		
Miscellaneous			
P1	5kΩ, 50mW		
S1	Four-way, two-pole *Lorlin*		
Meter	1mA or multirange meter on 1mA range		
PCB			

Ticking Eggtimer

Flind, A. *More Electronic Projects in the Home* pp 20-23

It was originally intended that this should be one of the simpler circuits in this book, but it was not to be! It was in fact for this project that the pulsed timer circuit explained in the previous project was originally developed, as the author likes his breakfast boiled egg timed to a slightly better tolerance than that available with most electrolytics; −50 to +100%! When one stops to think about it, there's quite a lot in an eggtimer circuit. In addition to the actual timer, an output tone generator is required to signal the completion of the timing period, and a second timer is needed to time the operation of this. One further objective was specified for the prototype. Your author tends to stagger down early in the mornings bleary-eyed and late for work, and a complex machine with lots of knobs and dials was strictly *out*! The final design was to have just two controls; a knob for setting the time, and a button to bash in order to start it. Even an on-off switch was ruled out.

The use of CMOS throughout solved the on-off switch problem, as when it's not running it draws no current. In the

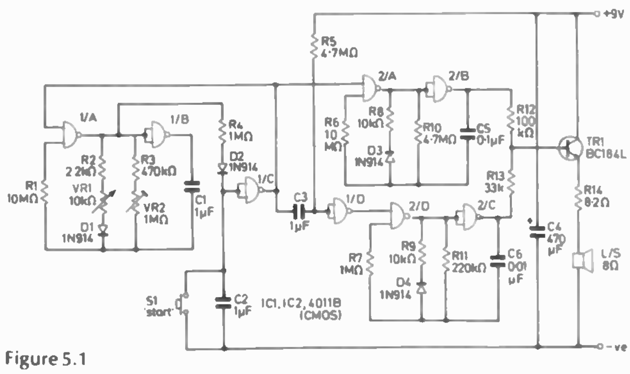


Figure 5.1
Eggtimer circuit

circuit of Fig. 5.1, IC1 A, B and C form the timer. Pressing S1 discharges C2 and sets the timer running, as with the timer circuit of the previous project. VR1 sets the oscillator's rate and is used as a calibrator to set the range. When the timer completes its run, IC1C's output goes low. This pulls IC1D's input low via C3, and its output goes high and stays high for about 5 seconds, until R5 manages to charge C3 sufficiently to take it low again. Whilst it is high the oscillator comprising IC2C and D is able to run, producing an audio tone. This completed the circuit as specified, but left two spare gates available in IC2. It seemed a shame to waste them, so they have been wired to form a second astable, IC2A and B, with a frequency of about 2 Hz, gated on whilst the timer is running. The outputs of the two astables are fed to the output stage, so the net result is a quiet ticking noise whilst the circuit is running, culminating in a 5 second bleep when the set time is reached. D3 and D4 cause the output to consist of short pulses rather than a square wave, as this greatly improves battery economy. R14 keeps the volume to a reasonable level; if you have a large kitchen reduce it, for sensitive ears increase it.

A large piece of *Vero* was used to hold all this circuitry, 24 strips of 50 holes. Fig. 5.2 shows the 48 breaks, and Fig. 5.3 the component layout, including 23 links. Wire VR1 to decrease resistance when rotated clockwise. VR1 and VR2 then both increase the period for a clockwise rotation. To set the circuit up, turn VR1 fully anti-clockwise (minimum period) and adjust VR2 to provide a time of just under one minute. Then check that VR1's maximum setting gives over 6 minutes. The control can then be calibrated by trial and error for times of 1 to 6 minutes. The current drawn by this circuit is minimal at all times, even when giving the output tone it is no more than 5mA, so a PP3 battery should last for a very long time.

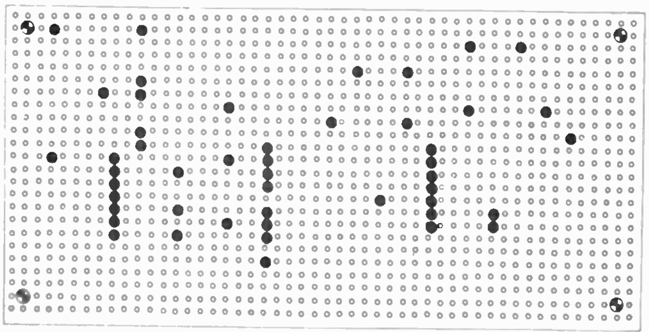


Figure 5.2

Eggtimer, copper side

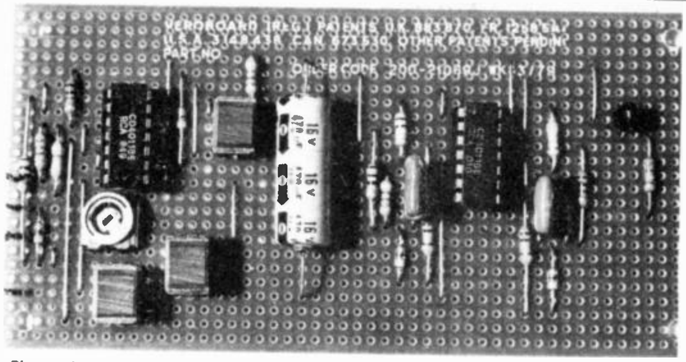


Figure 5.4

Ticking eggtimer

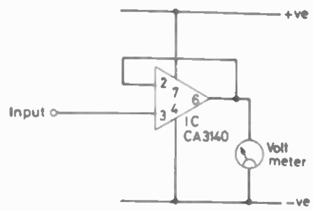


Figure 5.5

Using a CA3140 op-amp as a buffer to measure voltage at high impedance points

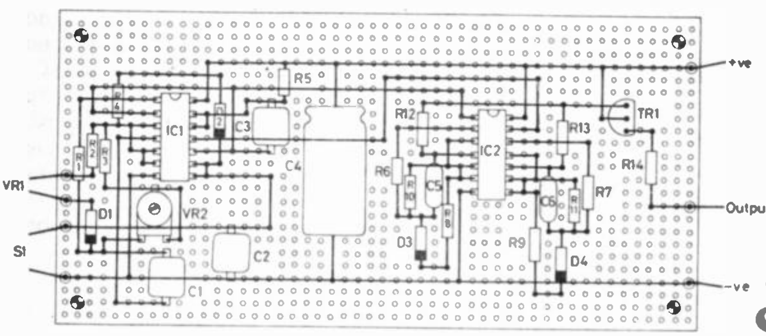


Figure 5.3

Eggtimer, component layout

The board completed is shown in Fig. 5.4.

A note on troubleshooting these timer circuits will probably not be amiss here. If they refuse to operate for any reason, probably the first test you'll want to make is whether there is a voltage present on the timing capacitor, and whether it is increasing when it should be. Unfortunately it can't be simply measured with a meter as the current drawn by most meters would discharge it immediately. The answer to this is to buffer the meter with a 3140 op-amp which has a CMOS FET input stage. Fig. 5.5 shows how to do this using a 3140 as a simple unity-gain voltage follower. No components are required apart from the op-amp itself, and the supply can be taken from the circuit under test. Note that the op-amp can only follow the voltage up to about 2V below the positive supply rail, but it can follow all the way down to negative rail.

Table 5.1 Components list for eggtimer

Resistors	
R1, R6	10MΩ
R2	2.2kΩ
R3	470kΩ
R4, R7	1MΩ
R5, R10	4.7MΩ
R8, R9	10kΩ
R11	220kΩ
R12	100kΩ
R13	33kΩ
R14	8.2Ω

Semiconductors	
D1, D2, D3, D4	1N914
TR1	BC184L
IC1, IC2	CMOS 4011B

Miscellaneous
0.1 in *Veroboard*, 24 strips of 50 holes
Switch, SPST push-to-make
2 × 14-pin DIL i.c. sockets
2½ in 8Ω loudspeaker

Potentiometers	
VR1	10kΩ linear
VR2	1MΩ sub-min. horizontal preset

Capacitors	
C1, C2, C3	1µF polycarbonate
C4	470µF 16V electrolytic
C5	0.1µF polyester
C6	0.01µF polyester

Super-Regenerative VHF Receiver

Rayer, F.G. ***Projects in Amateur Radio and Short Wave Listening*** **pp 83-90**

Regenerative circuits feed back part of the amplified signal into the aerial, or input of the regenerative stage, in correct phase to add to the original signal. This provides a considerable increase in sensitivity to weak signals. With a super-regenerative circuit, regeneration can be carried beyond the usual limits, because the stage is quenched, or repeatedly brought out of oscillation, at a frequency above audibility.

Because of the high sensitivity obtained by this method, super-regenerative receivers were very largely used for VHF reception, though they are now mostly replaced in commercial applications by superhet receivers. Thus a super-regenerative VHF receiver offers one of the simplest methods for the reception of VHF AM transmissions, and it can be adjusted to cover a wide frequency band with the minimum of difficulty.

Receiver circuit

This is shown in Fig. 11.1. Signal pick-up is by a short telescopic aerial, connected to L1, coupled to L2. L2 with T1 in parallel tune very flatly, and fully variable tuning is not required here. Signals are taken to gate 1 of the dual-gate FET, TR1. Gate 2 receives its operating voltage from the divider formed by R1 and R3, and R2 is for source bias. Output from this stage is from the drain to L3.

TR2 is the grounded gate super-regenerative detector, and operating frequency is determined by L4. VC1 is the panel operated tuning capacitor. T2 allows adjustment of band coverage.

Regeneration in this stage is controlled by the potentiometer VR1, which allows adjustment of the drain voltage (via R5 and L4). The source supply is through the radio frequency choke RFC, and R6. C5, R7, C6 and C7 are the quench network and for coupling of audio signals to the audio amplifier.

The latter is a relatively simple two stage circuit, TR3 and TR4, stabilised by direct current feedback through R9. This section will give moderate volume with a small 75Ω or 80Ω loudspeaker, and the output jack socket allows headphones (up to 2kΩ resistance) to be plugged in, silencing the speaker.

Operation is from a 9V or 12V battery supply. The latter can be two 6V battery holders, for four small 1.5V cells each, in series.

TR1 is not expected to provide significant amplification, but is intended to help isolate the aerial from the oscillating stage TR2. This reduces radiation. In addition, the power level at which TR2 operates is extremely low.

L4, made as shown, allows tuning from 110MHz to 180MHz. VC1 covers only a part of this total range, which is chosen by the setting of T2. So long as VC1 is of low value (5pF or 10pF) no reduction drive is necessary with it, tuning being sufficiently flat for control by means of a fairly large knob.

The optional capacitance Cx may not be wanted with some samples of TR2. Cx is not necessary when super-regeneration is obtained over the frequencies required. Where Cx has to be added, it is of very low value, and is made by looping a turn or two of thin insulated wire around a bare wire soldered to VC1.

Super-regeneration is indicated by a hissing noise arising when VR1 is advanced. This hiss ceases when a signal is tuned in.

Case preparation

The case is made from a universal chassis box 204 × 127mm (8 × 5in) and all assembly is on the flat plate, which serves as panel or front. The universal chassis sides are secured together with 4BA bolts and nuts. If the plate is to fit *inside* the flanges, as illustrated, then a little must be cut from two edges, or it may prove to be slightly too large.

First drill or punch holes for VR1 and VC1. Four countersunk holes are used to secure the two tag strips near VC1. Two countersunk holes also take bolts, with extra nuts or spacers, to allow the audio board to be fixed, as shown in Fig. 11.5. An aperture must also be cut to match the speaker cone. This can be done with an adjustable tank cutter; with a large screw-up punch; or by drilling a ring of small holes, removing the piece, and finishing off with a half-round file.

After construction, and having checked that the plate will fit inside the flanges, as mentioned, the front is completely covered with loudspeaker fabric or similar material. This is held taut by adhesive round the edges of the plate.

TR1 stage

Components for this occupy the top tag-strip in Fig. 11.2. L2 is 4½ turns of 28 swg wire, and L1 two turns, immediately against L2.

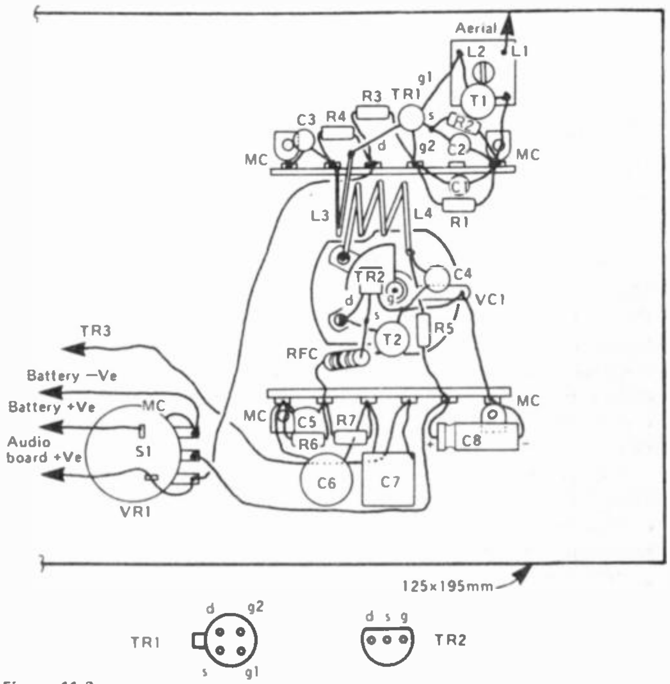


Figure 11.2

TR1 and TR2 stages

Connect C1 and R1 in parallel, from tag MC (metal panel) to the tag taking gate 2 connection from TR1. Similarly connect C2 and R2, for the source lead. Take gate 1 to the top of L2, and connect T1 across L2 here. L3 is a single turn of thin insulated wire, 12mm outside diameter, and C3 goes from here to MC. Connections to TR1, and to capacitors C1, C2 and C3, and to the coils, should be as short as can be reasonably arranged. L1/L2 is shown a little removed from the tag strip and TR1, in Fig. 11.2, to clarify connections. Positive for this stage runs from R3 and R4, at the anchor tag provided, as shown.

Fig. 11.3 shows the RF and detector stages assembled on tagstrips.

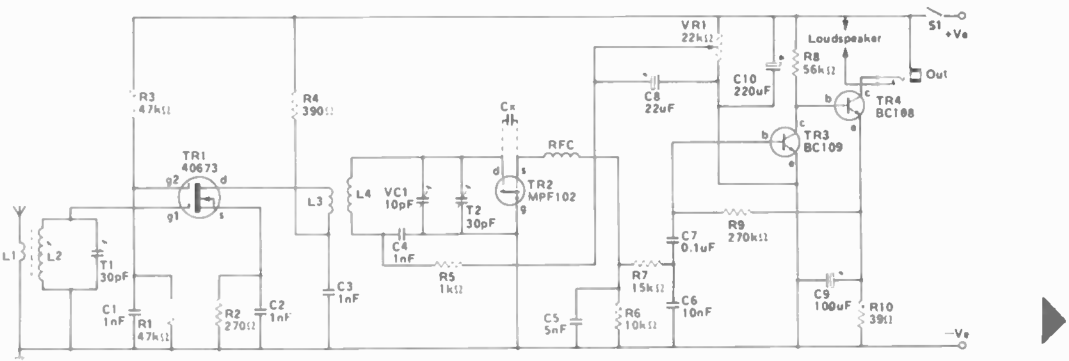


Figure 11.1

Circuit of the VHF receiver

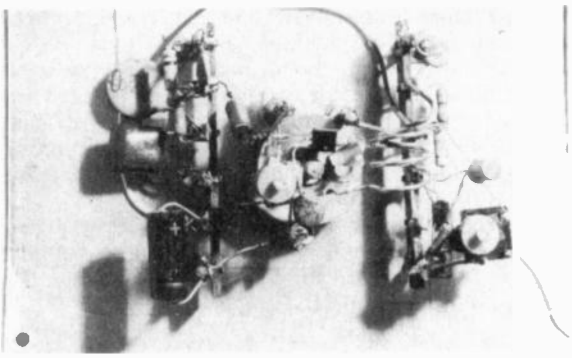


Figure 11.3 RF and detector stages assembled on VC1 and tagstrips

Detector stage

This is mainly centred on VC1, and leads to L4, C4, drain and gate of TR2, and T2, in particular, are as short as can be arranged.

L4 is three turns of 20 swg wire, wound on any object which will provide an outside diameter of 12mm. The coil is removed and turns spaced so that L4 is 15mm long. Solder one end to VC1 stator (fixed plates) tag as shown. Connect a stout lead from VC1 rotor (moving plates) tag to TR2 gate, joining on also C4 and T2. The free end of C4, and R5, go to the second end of L4. Solder TR2 drain lead to VC1 stator tag, and also T2.

The RF choke is 35 turns of 36 swg wire on an insulated former 4mm in diameter and 10mm long. Adhesive can be applied at the ends only. The choke is supported by stouter wires at its ends – one running to TR2 source (centre lead) and the other to the tag shown.

Other components are supported by the lower tag strip, Fig. 11.2. From here, leads run away against the panel to the centre tag of VR1, and to the base of the first audio amplifier.

Audio board

This is shown in Fig. 11.4. Do not overlook the essential strip break under R9.

The board is later fixed about 8mm to 10mm or so clear of the panel by means of bolts with extra nuts (Fig. 11.5). Check that the outermost strip, forming the negative return for TR3 emitter, C9 negative, R10, and C10 negative, is in good

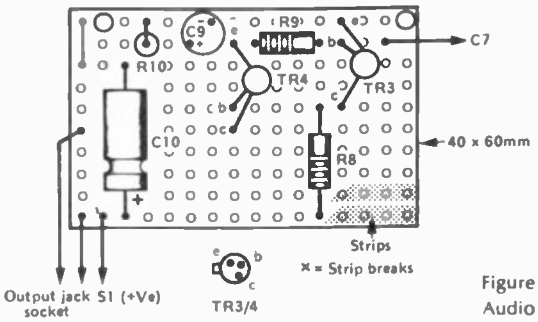


Figure 11.4 Audio amplifier board

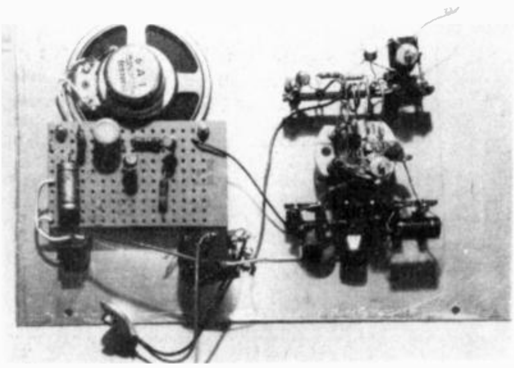


Figure 11.5 Speaker, audio board and other items

electrical contact with the metal panel. This is most easily done by securing a tag under the board, soldered to this strip. At the same time, check that the second strip (TR3 base, C9 positive, etc.) is not grounded by contact with the tag or nuts.

Table 11.1. Components for super-regenerative receiver

Resistors			
R1	47kΩ	R6	10kΩ
R2	270Ω	R7	15kΩ
R3	47kΩ	R8	56kΩ
R4	390Ω	R9	270kΩ
R5	1kΩ	R10	39Ω
(resistors 5%, ¼ watt)			
VR1	22kΩ linear potentiometer with switch S1		
Capacitors			
C1	1nF disc ceramic		
C2	1nF disc ceramic		
C3	1nF disc ceramic		
C4	1nF disc ceramic		
C5	5nF disc ceramic		
C6	10nF disc ceramic		
C7	0.1µF		
C8	22µF, 12V electrolytic		
C9	100µF, 6V electrolytic		
C10	220µF, 12V electrolytic		
VC1	Small 10pF air spaced short wave variable capacitor (Jackson C.804 type), or similar		
T1	Miniature 30pF VHF trimmer		
T2	Miniature 30pF VHF trimmer		
Transistors			
TR1	40673		
TR2	MPF102		
TR3	BC109		
TR4	BC108		
Miscellaneous			
Loudspeaker: approx. 60mm, (2½in) 75Ω or 80Ω			
Jack socket, 3.5mm fully insulated			
Telescopic aerial, about 430–600mm			
Two 6-way tagstrips (2 earthed)			
Board 40 × 60mm (1⅝ × 2⅜in) 0.15in matrix			
Small knob, large knob with dial			
204 × 127mm (8 × 5in) universal chassis box with extra 204 × 127mm plate (Home Radio, Mitcham)			
Coil former 10 × 4.5mm with VHF grade core			
Battery connectors, wire, etc.			

Negative circuits are completed also by a lead to the mounting bush of VR1, by the tags MC of the tag strips, and by the bush of VC1.

As the output jack socket is in the positive line, it must be a completely insulated type, or must be isolated from the panel by means of insulating washers. The actual position of tags varies somewhat. Wire the socket so that it completes the circuit from TR4 collector to the loudspeaker, when no plug is inserted. When a plug is put in the socket, the contacts supplying the loudspeaker are opened, and the circuit to the headphones is by the sleeve and tip contacts.

Adjustments

The aerial can be a hinged telescopic type fitted to the top of the case near L1/2, or a sliding-down type fixed to the side of the case here. The securing screws (or screw) must be insulated from the metal case. This can be done by placing a strip of Paxolin or other insulating material between aerial mounting and case, and passing the bolts through holes allowing ample clearance. Further insulation is of course necessary before putting on the nuts inside.

T2 is open for the higher frequencies mentioned, and closed to reduce frequencies. With VR1 advanced about two-thirds, a hiss should be heard in the loudspeaker. This shows super-regeneration is present. Without this, reception will not be obtained. When a transmission, or carrier, is tuned in, this hiss ceases. VR1 is adjusted for best results.

The best position for L3 was found with this turn between the turns of L4. Band coverage can be extended by changing L4 slightly. If necessary, Cx may be added as explained, but the capacitance used here is very small indeed.

The operation of a super-regenerative detector provides some degree of 'automatic volume control' effect. Because of this, and inherent damping and losses at these frequencies, no sharp resonant peak will be found for the setting of T1. **HE**

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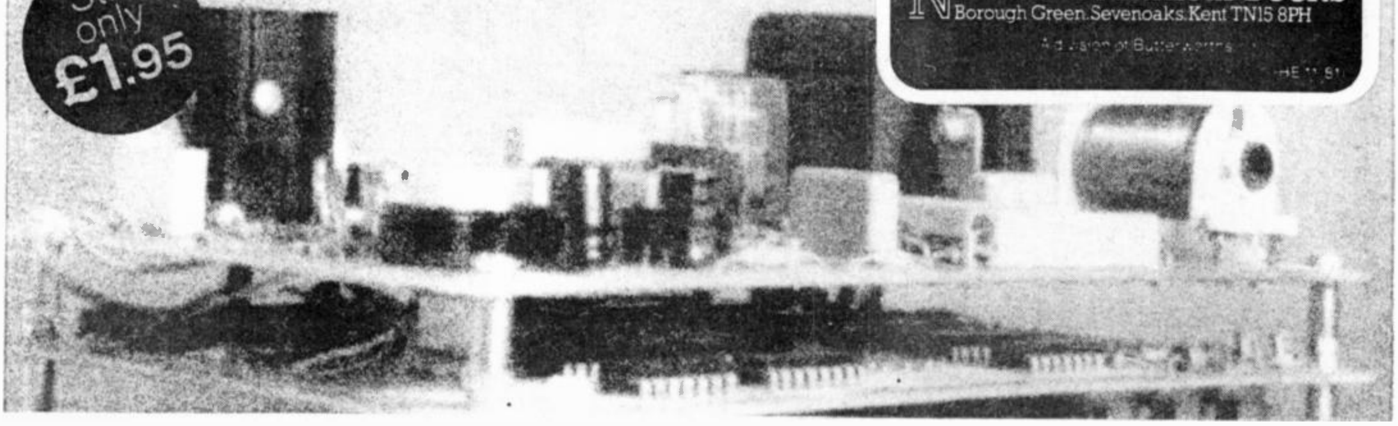

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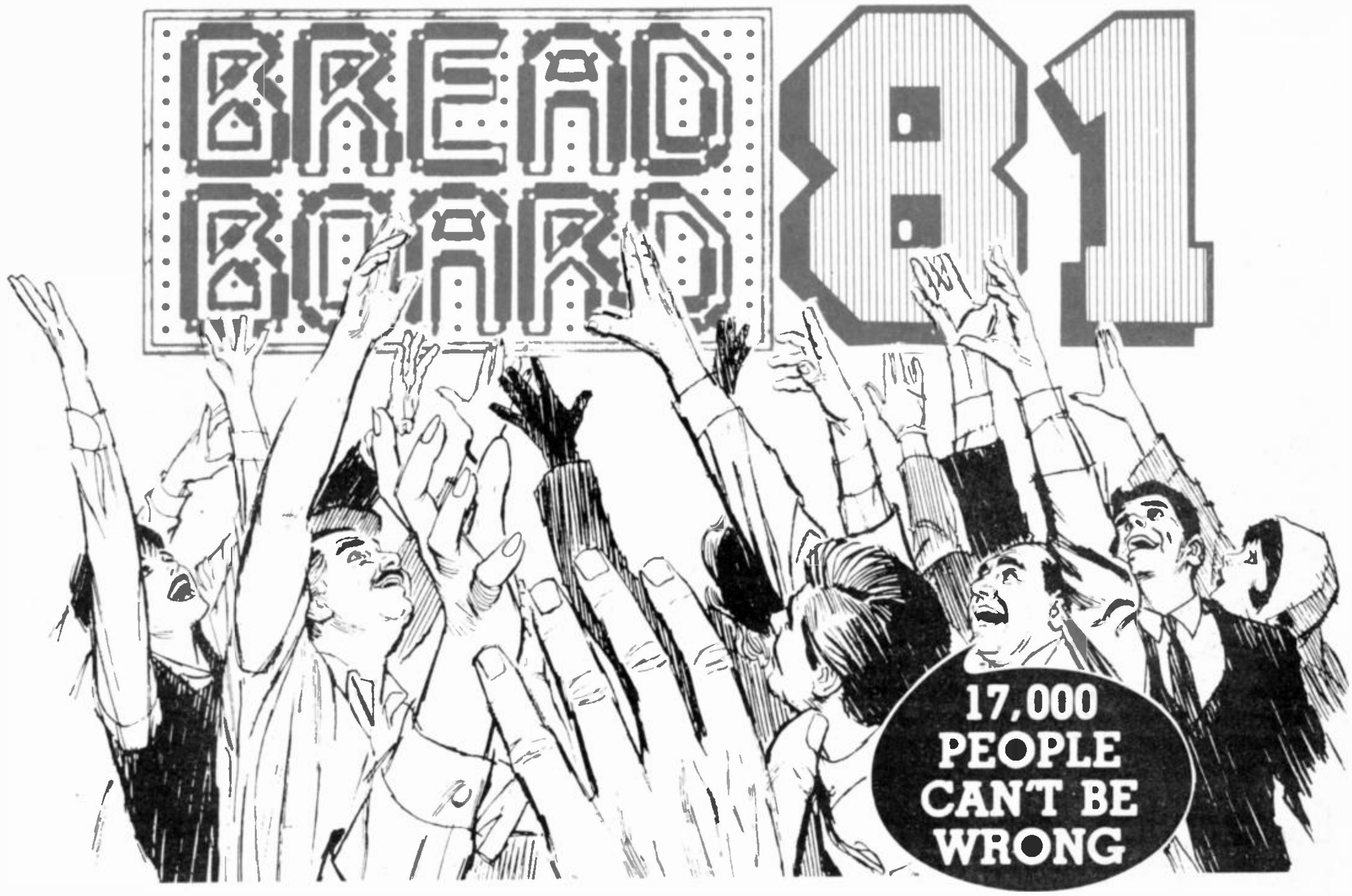

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Clever Dick

Just back from his summer holidays, Dick answers your queries

LAST MONTH I started with a long letter: I'll go to the other extreme this month.

Dear CD,
Do Ionisers work? Will you publish a circuit? Can I have a binder?
Richard Payne,
Coleme, Wiltshire

Answers: Yes. No. No.

Our thanks, by the way, to Colin Ashman in Suffolk, Christopher Bowman in Kent and James Mercer in Glasgow, who all said that they would like to correspond with Peter Degerlund in Finland. I'll pass your details on to him.

The next writer appears to be OK for formers but stuck for cores — if you follow what I mean.

Dear Intelligent Richard,
Can you tell me of anywhere that I could get some 5 mm coil formers, and suitable cores for 28 MHz AM working. Also screening can to suit. I've had no problems finding the formers and cans (thanks to Electrovalue) but I can't find the cores anywhere.
A. Docherty, 12 years
Brentwood, Essex.

We got on the line to Watford Electronics for this one. Watford supplies Neosid coil 'kits' comprising cans (13 mm by 13 mm by 14 mm high), formers and cores (about 4 mm diameter). These are sold together under the code number 722/1, for 36p. (You'll find Watford Electronics' address on page 9 of this issue.)

Help to Eton College is offered by the University of East Anglia in the next letter.

Dear Clever (or not quite so?. . .) Dick. Reference your column, September '81, and the Correspondence from Eton College, a Mr. Dick Gibbons, which poses the question as to the source of 3.5 mm stereo jacks and sockets. These can be obtained from Farnell Electronic Components, Canal Road, Leeds. Indeed, in their latest catalogue, there are listed two types of plug and a socket, all three pole (stereo) and 3.5 mm gauge.
I hope this information is of some use to Mr. Dick Gibbons, for we institutions of learning have to stick together!
R.M. Ames, Technician
University of East Anglia, Norwich.

PS. How about a binder, talking of togetherness!?

PPS. I have no connection with the above company, other than satisfactory trading relations.

Similar help from William Leung in Essex:

Dear CD,
I would like to comment on your reply towards Dick Gibbon's letter: "Rubbish!".
Have you ever tried Maplin? They supply a STEREO 3.5 mm jack plug for 25 pence (code HF98G).
William Leung,
Harlow, Essex.

PS. For me being so helpful, how about sending something in return? (hint! hint!)

Richard Smedley in Montgomery, Powys supplied the same information as William Leung but added: '. . . an in-line socket is available from Ross Electronics (No. RE-207) as part of an adaptor from a ¼" jack plug, priced 75p'.
William gets the binder because his letter arrived here first.

The on-going saga, starting with Ben Chaston's letter in the July '81 issue, goes on. (See last month's suggestion under CD from F.R. Maher.) We were looking for the shortest letter that could still make sense. Try this one for size:

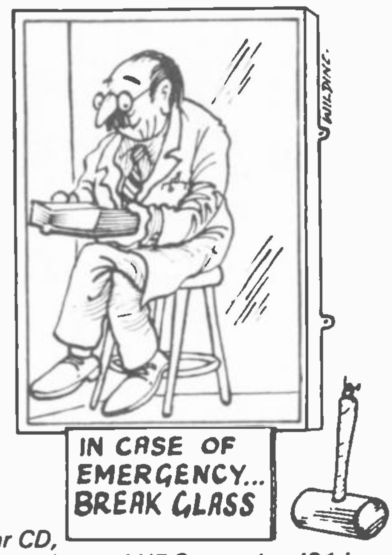
Dear CD,
Y?
A.J. Shave,
Bournemouth.

We'll give you one more issue before the winning entry is declared.

Dear CD,
Looking back through old issues I noticed that there was a short wave radio in March '79 with ranges from 0.5 to 30 MHz (I'm a CB fan). I built the project but to my dismay found an extra hole in my PCB where an aerial should be connected. I could find no description of this aerial so could you please advise.
A.J. Shave,
Bournemouth.

(Just a minute, what a coincidence: there must be two A.J. Shaves in Bournemouth.)

I tried this question out on the HE Team of Technical Experts. Silence at first but then one of them woke up. His advice was simply: 'Use a long length of wire!' (How long is a piece of string?)



Dear CD,
My purchase of HE September '81 is my first ever step into the fascinating world of Electronics, as I have only just begun to be interested in this subject. I find the magazine very interesting and am planning to purchase several of the advertised items.
I am 16 years of age, extending my education and am contemplating the idea of studying electronics in the near future.
I have a problem — I don't have sufficient money (but who does) and am surprised and gratified at some of the incredibly low prices in HE.
N. Ghedda,
London SW9.

PS. I am wondering if you would be able to send me a "project" for a MW & FM radio-receiver?

Funny you should say that — I've got the same problem: I don't have sufficient money either.
An AM receiver? (See the *Short Wave Receiver* project in the September '81 issue (copies available from us at HE if your newsagent hasn't got one).
An FM receiver? You must mean a VHF receiver. If so, see this month's special projects supplement.

Final letter coming up, flavoured with Latin.

Dear Ingeniosus Dicius,
Anything wrong with the GSR Monitor in June '79 edition of HE??
Gratias tibi ago,
A. Richardson,
Fareham, Hants.

I blew the dust off our '79 file, tracked down the GSR Monitor on page 8 of the June '79 issue but could find nothing wrong. (This project helps you to relax scientifically by monitoring your galvanic skin response.)

Stay lucky till the next issues. *Finis* for now. **HE**

Into Electronic Components

In Part Four of our beginners' series, Ian Sinclair unravels the mysteries of capacitors. He also describes some practical measurements

A CAPACITOR IS, as far as DC is concerned, a gap in a circuit which stops DC current from flowing. Even in the early days, several centuries ago, experimenters had found that a gap in a circuit could, with a bit of designing, store small quantities of electric charge. In those days, the idea of electrons had not been completely thought out, but the idea that electric current was a movement of something called electric charge was well established. The storage action of the gap then seemed quite reasonable — electricity tried to flow around the circuit, and when it came to the gap it piled up on one side, unable to move.

It's not quite so simple as that, but the idea serves us quite well. A big breakthrough in these early days was the invention of the 'Leyden Jar', a glass bottle coated with metal foil on its inside and outside surfaces but with no connection between the two metal coatings (Fig.1). This simple device was found to be capable of storing enough charge to give fatal shocks, and the inventors of that time promptly set about trying to discover what rules governed its action.

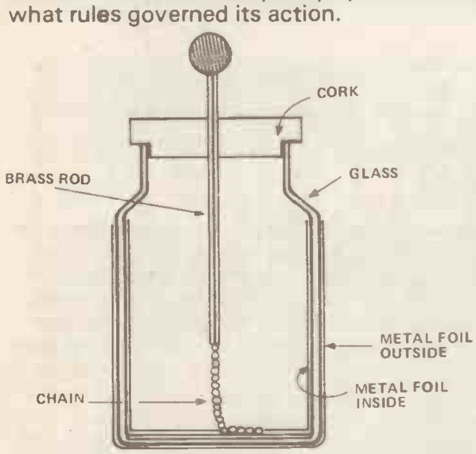


Figure 1. Classic Leyden Jar form of capacitor. Right up to the end of World War II, the Navy still measured capacitance in units called 'Jars'

These rules emerged slowly. The greater the surface area covered by the metal, the more electric charge could be stored. That one seemed reasonable. What was much less predictable was that jars made of *thin* glass stored much more electric charge than an otherwise identical jar made of *thick* glass. That put paid to the simple idea that electricity was a liquid and that it needed a large volume of jar for storage! Later yet, researchers discovered that the material in the gap between the metal sheets also played an important part. Obviously, it had to be an insulator, but insulators like glass were much more effective than air, and sulphur was much more effective than glass.

Coming back with a rush to the twentieth century, we make many types of capacitors by putting a thin film of metal on to each side of a thin sheet of insulator. The actual amount of capacitance we get from this arrangement is measured in units called farads, and the equation which enables us to predict just how much capacitance we can get from a given arrangement is given in Fig.2.

The units shown in Fig.2 are modern units, with area measured in square metres, and thickness in metres. The quantity e is called 'permittivity', and its value depends on the

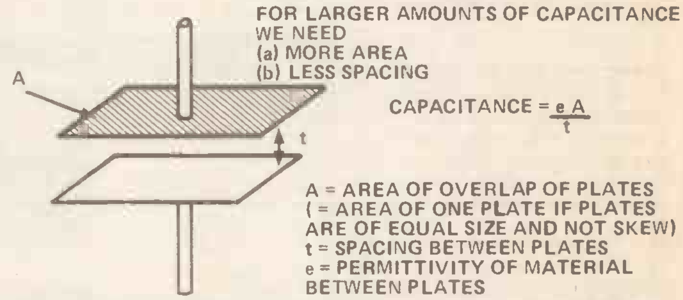


Figure 2. Parallel-plate capacitor, and the equation for capacitance

material that is used as an insulator. A vacuum has the lowest value of permittivity while insulators like ceramics have much higher values.

Sizing It Up

How do you measure the ability of a gap to store electric charge? It's not the world's easiest problem, and it's just as well that it was solved a long time ago, when experimenters measured the amount of charge that was stored in a capacitor when different voltages had been used to charge the capacitor. It should not come as a surprise to learn that we can store more charge by using a large voltage to push charge into the capacitor — it's rather like compressing gas into a cylinder. What is a pleasant surprise is that when we draw a graph of the amount of charge stored in this way plotted against the amount of voltage used to push the charge in, the graph is a straight line (Fig.3). When you get a straight-line graph, it means that there is a constant relationship between the quantities that are being plotted. Since this graph is of charge plotted against voltage, the straight line shape means that the ratio

$$\frac{\text{charge}}{\text{voltage}}$$

is constant.

Take another capacitor and repeat the measurements, and you again get a straight line graph, but with a different value of the charge/voltage ratio. Each different capacitor that you test gives a straight line graph, but with a different value of the charge/voltage ratio — and that ratio is the quantity that we call capacitance, measured in units of farads.

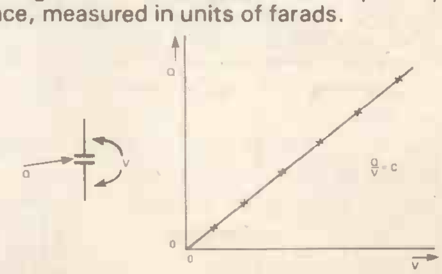


Figure 3. Capacitance, charge and voltage. Connecting a capacitor to a voltage results in a quantity of charge to be stored in the capacitor, and a graph of the amount of charge plotted against voltage is a straight line

King-size Farads

One of the unfortunate facts of life is that when you pick a set of measuring units, some will inevitably turn out to be much too large, and some too small. The farad is one of the very large ones, and a one-farad (1F) capacitor is not exactly an everyday value. The common values that we use are much smaller, so that we have units called microfarads (millionths of farads, symbol uF), nanofarads (thousandths of microfarads, symbol nF), and picofarads (millionths of microfarads, symbol pF).

Table 1 is a reminder of how much of each makes one of the next size up. The reason for using millionths in this way is that it makes it easier to convert from the practical units back to farads when we need to use farads in calculations.

1F = 1 000 000 uF	(MICROFARADS)	OR	1 uF = 1/1 000 000 F
1uF = 1 000 nF	(NANOFARADS)	OR	1 nF = 1/1 000 uF
1nF = 1 000 pF	(PICOFARADS)	OR	1 pF = 1/1 000 nF
	SO THAT 1 uF = 1 000 000 pF		

CAPACITOR SIZES CAN BE QUOTED IN ANY OF THESE UNITS, BUT WHEN COLOUR CODING IS USED, THE UNITS ARE ALWAYS PICOFARADS. MANY CAPACITORS MADE IN JAPAN COME WITH 'k' MARKINGS – THE k MEANS nF, SO THAT A 10k CAPACITOR HAS A VALUE OF 10 nF

Table 1. Capacitance units

On Charge

Now to the nitty gritty. When we connect a capacitor to a power supply, we are charging the capacitor. The amount of charge is calculated by multiplying the amount of capacitance by the amount of voltage, and if you used farads for capacitance and volts for voltage, the answer is in units called coulombs. It's a lot more convenient to use microfarads, nanofarads or picofarads, though, and by so doing end up with microcoulombs, nanocoulombs or picocoulombs of charge. For example, if you charge a 1 uF capacitor from a 20 V supply, the charge is just 20 uC (20 microcoulombs). If you charge a 5 nF capacitor to 12 V, the charge is 60 nC (60 nanocoulombs). If you charge a 220 pF capacitor to 10 V, the charge is 2200 pC (20 picocoulombs), which is the same as 2.2 nanocoulombs.

These stored amounts are very small — one of the problems that we have with electricity is that we can store only very small quantities. As a practical demonstration, take a 10 uF electrolytic capacitor and plug it into the Eurobreadboard. Connect the negative end of the capacitor lead (Fig.4) to the negative(–) of the 9 V battery, and also to the negative(–) input of the HE Multitester, switched to the 10 V range. Now touch the positive(+) lead of the battery to the positive(+) end connection of the capacitor. This will charge the capacitor — you don't have to hold the lead against the capacitor for more than a fraction of a second. Now hold the positive (red) probe lead of the HE Multitester on the positive lead of the capacitor. What do you get?

Right, the meter needle flicks up then falls back. The amount of stored charge in a 10 uF capacitor is just enough to make the needle of this very sensitive meter flick over — but that's all. A battery of the same size could keep the needle of the meter well over the scale until several generations of cows had come home. That's because batteries don't store charge — they push it around because of their chemical action.

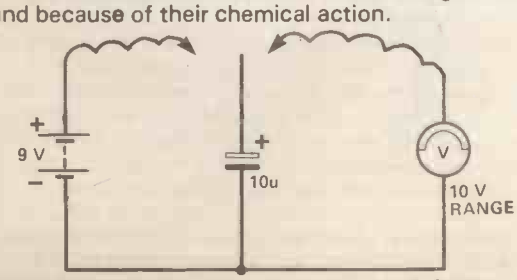


Figure 4. Simple method of charging a capacitor and measuring the charge voltage

Inside Information

Most capacitors are made in a straightforward way — they're just pieces of insulating material, with films of metal deposited on each side, and with connections made to the metal film (Fig.5). There are a lot of materials we could use, but the two favourites are mica and ceramic. Mica is an excellent insulator, and as it is dug up it cleaves like slate into flat sheets. Unlike slate, though, these sheets of mica can be split down into very much thinner sheets with very little effort, and so it's easy to make mica sheets which are less than one thousandth of an inch thick. We can coat these with metal by chemical methods (they are dipped into a solution made using silver, and end up with a silver coating), or by evaporation. Evaporation of metals is a more modern technique and has to be done in a vacuum. The metal that is evaporated is usually aluminium, and the technique is to hang a loop of aluminium wire on to a length of tungsten wire that can be electrically heated. The insulators are supported somewhere close by and the wire and insulators are covered with a jar. After the air is evacuated the tungsten wire is heated until the aluminium melts and evaporates. The aluminium condenses on to the insulator in an even coating, just what we need for a capacitor.

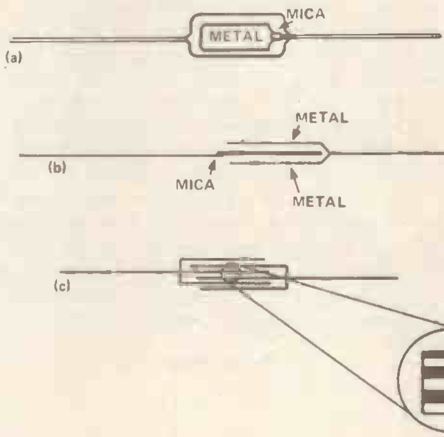


Figure 5. Mica capacitor construction: (a) top view, (b) side view, (c) multi-layer construction

Mica And Ceramic Types

Whatever methods are used, the mica and the ceramic types of capacitors are favourites for the smaller values of capacitance. Mica types, particularly the high-grade ones called silver-micas, are prized by the folks who build high-frequency radio equipment, because the capacitance values of mica capacitors are stable — they don't change much with age or temperature, and their values are not affected by changing the voltage across them. Ceramic types, by contrast, can be made with larger amounts of capacitance than their mica counterparts without being too bulky, but the value of capacitance of a ceramic is not nearly so stable, so that there are some jobs for which ceramic capacitors are never used, like oscillator resonant circuits (more of that next month). If you just want a capacitor to bypass some unwanted high frequency signals, though, a ceramic type is often useful.

Rolled Types

Another common construction is the rolled capacitor. This starts off as a long strip of flexible insulating material, traditionally paper, but nowadays usually some sort of plastic material. The strip is coated on each side with metal, using the evaporation technique described above, so that the strip is one long capacitor. To reduce the size, the metallised strip is then rolled up with another insulating strip into the familiar tube shape (see Fig.6). Rolling up with an additional length of insulator not only reduces the size, it increases the capacitance, so that we can make comparatively large values of capacitance this way — up to a microfarad or so — without the capacitor being unacceptably bulky. The name of the material that is used as an insulator is also used to describe the capacitor, so we get polystyrene, polyester, polycarbonate types specified for circuits. Unless you're a designer, the differences between them aren't too important, but try to stick to the type that is specified when you are building a circuit.

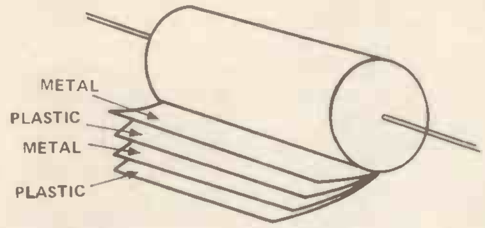


Figure 6. Tubular rolled capacitor construction

Electrolytic Types

The third important class of capacitor is the electrolytic, which is used a great deal in low-voltage circuits. Unlike all the others, which use entirely solid materials, the electrolytic capacitor uses a conducting paste as one of its connections. The principle is a fairly simple one. Since we can get greater amounts of capacitance by having very thin insulating layers, the electrolytic capacitor relies for its operation on the formation of a very thin film of insulator on a metal, rather than by thin metal films on either side of an insulator. The metal is usually aluminium (there are also tantalum electrolytic capacitors, but we'll stick to aluminium types for simplicity). For aluminium types the insulator is aluminium oxide, which forms as a thin hard film on the surface of the metal when the aluminium is placed in contact with a dilute acid and current is passed between the aluminium and the acid. This action, called forming, is necessary when the capacitor is constructed, and will sometimes also be needed if the capacitor has been stored unused for a long time. Because the insulator is so thin, and because the aluminium foil can be etched to give it a very large surface, very large amounts of capacitance, as high as one farad, can be obtained in comparatively small spaces.

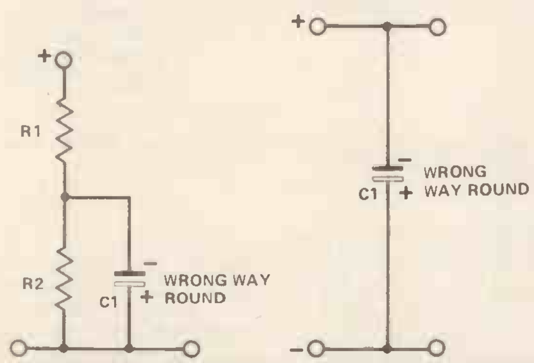


Figure 7. Wrongly-connected electrolytics: (a) probably harmless, because the resistors will prevent excessive current flow flowing, (b) wait for the bang!

The price we pay is polarisation and low voltage operation. Polarisation means that the capacitor must always be connected the same way round as it was in the circuit which formed it. This is why the leads are marked, so that you can connect it the correct way round into your circuit. What happens if you don't? The results can be spectacular. Reversing the connections will reverse the process which caused the insulating film to form on the aluminium, so that the film disappears. When that happens, the 'capacitor' just isn't a capacitor any longer: it's a conductor, and it will pass as much current as the circuit allows. If your circuit is like that shown in **Fig.7a**, there shouldn't be too much trouble because the resistor will limit the amount of current that will flow. If, however, the capacitor is strung directly between the positive and negative supply lines with nothing to limit the current, as it would be in a power supply (**Fig.7**), then one of two things will happen. The first is that the power supply will give out, so you'll have to replace a fuse or a diode or both. The second, distinctly more unpleasant, possibility is that the capacitor will *overheat and burst*, showering the circuit and probably you as well with corrosive acid paste that won't do either you or your circuit any good at all. The effect on a circuit board is like having a battery burst on it — messy. The noise is fairly spectacular too, but it's an expensive way of celebrating Guy Fawkes day. If you get any paste in your eye, wash it out at once with lots of cold water, then see a doctor.

Always watch, then, which way an electrolytic is connected. The trouble is that though they are always marked, different manufacturers mark their electrolytics in different ways. Some put a red dot at the positive(+) end, some put a black band at the negative (−) end. Some have a set of black arrows pointing to the negative end. If you are in any doubt, look to see if either one of the leads is connected directly to the outer case of the capacitor — this is almost always the negative lead.

The other problem which is associated with an electrolytic capacitor is that of leakage. Capacitors which are made in other ways are good insulators for DC — if you connect them to the most sensitive resistance range of the HE Multitester, which is the 20M scale, then after the capacitor has charged from the meter, there should be no noticeable needle deflection. You should expect a resistance reading of at least 1000M (1000 million ohms or megohms) for silver micas and ceramics, and most rolled capacitors have resistances of at least several hundred megohms. Electrolytics are quite different — they have much lower resistance values because the thin film of insulator is never quite perfect. There is always some contact between the conducting paste and the aluminium, so that a meter measuring current and connected in series with a charged electrolytic capacitor will always read some current.

Try out the circuit shown in **Fig.8**. Make quite certain that the electrolytic is the right way round, because the current will be a lot higher if it isn't. Start with the HE Multitester switched to its 50 mA range, and if there's no reading visible, switch to lower ranges in turn until you can read the leakage current. A good electrolytic may have a leakage current of only a few microamps, a poor one may have several milliamps. You will possibly find that the current is not constant. At the instant when you connect up, the battery inside the multimeter will charge the capacitor, and this causes a current which should rapidly die away. After a few seconds, however, if the current continues to change, this is probably because some more insulator is forming, increasing the resistance of the capacitor. An electrolytic which has not been used for some time will pass quite a lot of current (a few milliamps) for some time, but this current should eventually drop to the normal leakage level. What is 'normal' depends a lot on the capacitor value. In general, the larger the capacitance is (in uF), the more leakage you can expect. The existence of leakage current is a problem which we always have to remember when we have electrolytics used as coupling capacitors or in timing circuits such as those using the 555 timer integrated circuit.

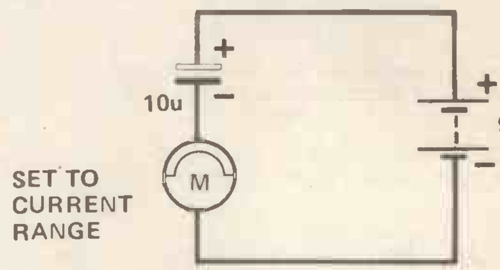


Figure 8. How to measure leakage current through an electrolytic capacitor

A Variable Quantity

There are nothing like as many circuits which need variable capacitors as those which need variable resistors, but the few that exist are important. One of these is the tuning of radio circuits — done by altering the capacitance in the tuning circuits. Variable capacitors used for this purpose consist of a set of fixed plates which mesh with another set of plates mounted on a shaft so that their relative positions can be altered without touching each other (see examples in **Fig.9**). At one time, the space between the plates was always air, but to make smaller variable capacitors having the same capacitance values, nowadays the space is normally filled with mica or plastic sheets which also prevent the plates from touching and shorting to each other. When variable capacitors of this type are used, the moving set of plates is always connected to the frame, and so earthed. This avoids the 'hand capacitance' effect which plagued radios in the old days — when the fixed plates were earthed, touching the control knob added a bit more capacitance to the circuit, and altered the tuning, so you could find that having tuned in a signal, you would lose it as soon as you let go of the control!

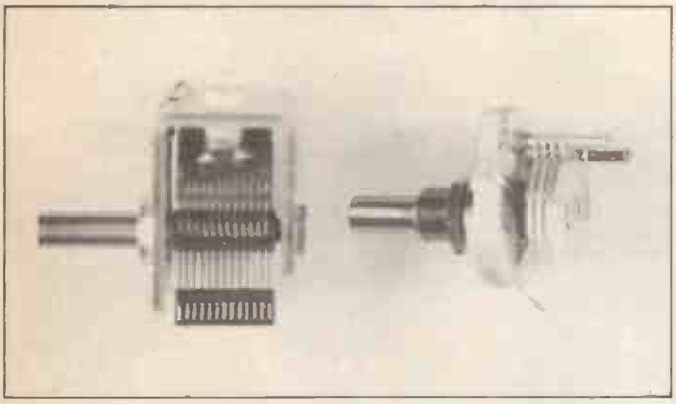


Figure 9. Variable capacitors: (a) miniature air-spaced type, (b) standard size air-spaced, (c) twin-ganged air-spaced capacitor: the two capacitors are on the same shaft so that their values change together, (d) a solid-dielectric variable capacitor — the material between the plates is a solid insulator

Trimmers are small versions of variable capacitors and are used rather more widely. They can be small versions of the tuning variables, or they can be 'postage stamp' or 'beehive' types. The postage stamp, or compression trimmer consists of a stack of thin sheets of metal sandwiched with thin sheets of mica, all held in a frame of plated metal, with an adjusting screw which has the effect of compressing the plates together. Alternate plates are connected, so that only two leads are used (Fig.10). By tightening the screw, the plates are clamped more tightly, the spacing between them is reduced, and the capacitance value becomes greater.

The beehive trimmer has a fixed set of circular plates into which another set can be meshed by screwing the top of the beehive shape clockwise, so increasing the area of metal that is overlapping, and so increasing the capacitance.

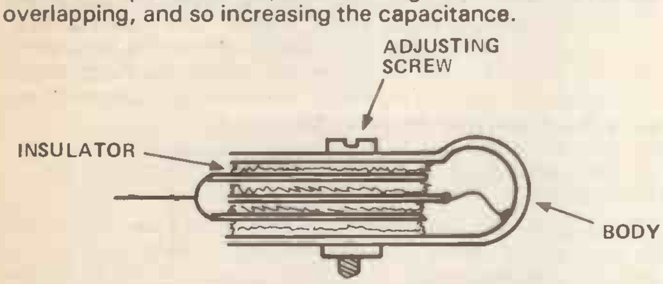


Figure 10. Operating principle of the compression trimmer — tightening the screw forces the plates closer together, so increasing capacitance

Fill 'Em Up, Joe

Charging or discharging a capacitor, like filling or emptying a bottle, takes time. There are two items that decide how long — the capacitance of the capacitor (a bigger bottle takes longer to fill or empty) and the resistance of the circuit through which the capacitor is charged (turn the tap to a dribble, and the bottle takes a long time to fill). We measure the time in units called time-constants, and the time-constant for a capacitor-resistor combination is the quantity

$$C \times R,$$

where C is the capacitance value and R is the resistance value.

Because of the way that units of capacitance and of resistance are defined, multiplying these two together gives units of time. If we multiply farads by ohms, we get the time-constant in seconds. A much more practical pair of units is nanofarads and kilohms, which gives time-constant in microseconds (us). For example, a 0.05 uF (which is 50 nF) capacitor charged through a 47k resistor gives a time-constant of

$$50 \times 47 = 2350 \text{ us},$$

which is 2.35ms.

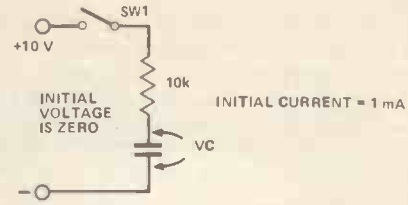


Figure 11. Charging a capacitor — the voltage across the capacitor is zero before the switch contacts are closed

Now, as it happens, the time-constant is not the time that it takes to charge or discharge a capacitor. Imagine a charging circuit for a moment (Fig.11) which at the instant you switch on sends a current of 1 mA into the capacitor. This current of 1 mA flows because when you first switch on, the voltage across the capacitor is zero, so that the whole 10 V of the circuit is across the 10k resistor — the result is that Ohm's law rules OK, and the current is 1 mA. By the time the capacitor is halfway charged, though, the voltage across it will be 5 V, and there's only 5 V left across the resistor. A voltage of 5 V across 10k can pass only 0.5 mA, so the rate at which the capacitor is charging is now only half of what it was at the start. By the time the capacitor has 9 V across it, there's only 1 V across the 10k resistor, and the current has gone down to 0.1 mA, making the charging rate only one tenth of what it was at the start. Charging up a capacitor is not like filling a pot with water, because the charging rate of the capacitor becomes less as the capacitor is charged. A graph of voltage plotted against time (Fig.12) shows that the capacitor never quite finishes charging, but gets as near as we need to being completely charged in a time equal to four time-constants. For example, if you have a 1 uF capacitor charging through 100k, then the time-constant is

$$1000 \times 100 \text{ us} = 0.1 \text{ seconds},$$

and we can reckon that charging is finished in four times this amount of time; that is, 0.4 seconds. This four times factor is not a bit of fancy theory, it's just a rule of thumb, and some folk take three times the time-constant instead of four.

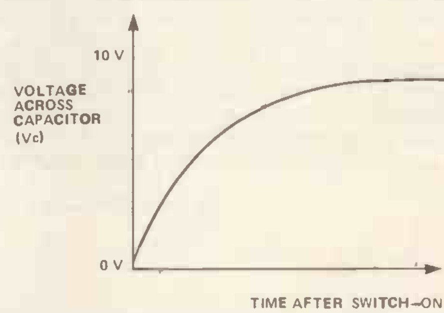


Figure 12. Graph of voltage/time for a capacitor charging in a 10 V circuit

Pretty much the same happens when a capacitor is discharged. The discharge is fast at first, but slows down so that complete discharge takes a long time, but for all practical purposes it's over by four time-constants. Take a look at the circuit in Fig.13. When the input, side A, is suddenly switched to + 10 V, side B of the capacitor also reaches + 10 V, because it can't charge immediately — charging would mean A being at + 10 V, B at 0 V. By the time four time-constants have pass-

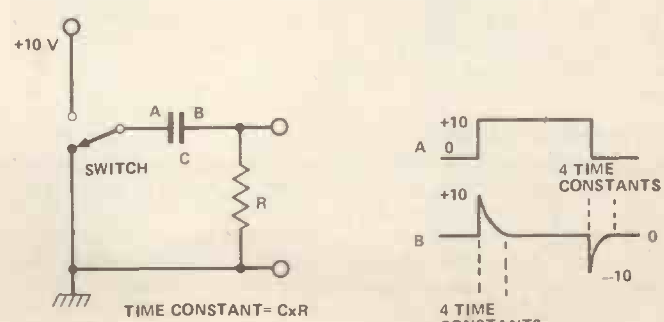


Figure 13. Demonstrating the effects of time-constants

ed, through, the capacitor *has* charged and the voltage at B is zero. When the input is switched back to zero, the voltage at B will go negative. The capacitor cannot discharge suddenly, so that when the voltage of side A drops by 10 V, the voltage of side B must also drop by 10 V as well, and that means dropping from 0 V to −10 V. By four time-constants have passed, though, the capacitor had discharged and the voltage at B is back to zero again.

Now look at the circuit in **Fig. 14**. When the switch is made, connecting the 10 V supply through the resistor to side A of the capacitor, the capacitor starts to charge through the resistor, and is completely charged, so that the voltage at A reaches +10 V, in four time-constants. When the switch setting is reversed, the capacitor discharges through the resistor, reaching zero again in another four time-constants.

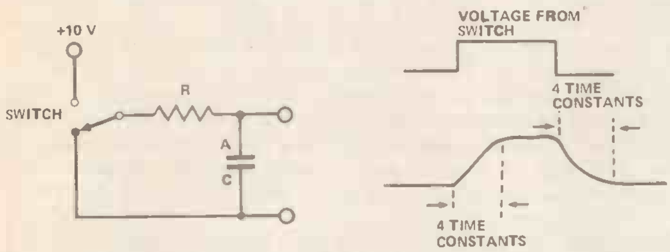


Figure 14. Circuit similar to that in Fig. 13, to demonstrate effects of time-constants. Here the positions of the capacitor and resistor have been swapped

We can't use the HE Multitester to measure the voltage across a charging capacitor with much accuracy because the meter uses current as well, but we can get some idea about what goes on by using a large value capacitor, such as a 100 uF, with 100k in series, as shown in **Fig. 15**. When you switch on, you can see the needle of the meter rise quite slowly to its maximum value because of the time needed to charge the capacitor. An even better demonstration is obtained by measuring the charging current. Using the circuit in **Fig. 16**, with the meter switched to the 25 uA range (50 uA selected, and the sensitivity switch in the VA/2 position), switch on, and watch the current start at a comparatively large value, then decrease over a time of several seconds. Four time-constants for this circuit is about 12 seconds, so you can check that the current has stopped changing after this time. It won't have gone down to zero, however, because of the leakage of the capacitor. In fact, if the electrolytic is a poor one, you may find the meter needle steady at about 18 uA.

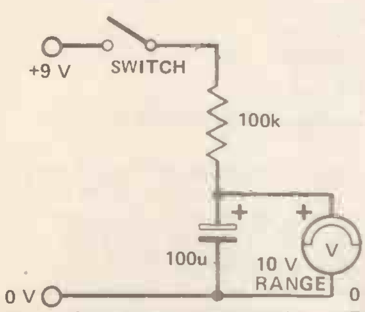


Figure 15. How to measure the voltage across a charging capacitor — this is possible only if the capacitor has a large value, because smaller values will have completed charging before the meter has had time to respond

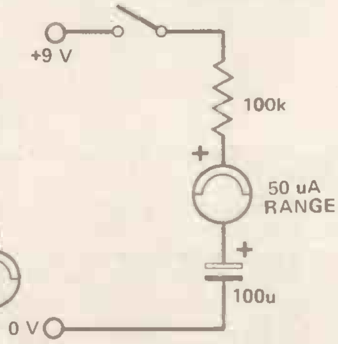


Figure 16. Circuit for measuring charge — and leakage — currents

Any Reactions?

That last part on charging and discharging gives you a flavour of what AC does to a capacitor. An AC voltage is alternately positive and negative so that a capacitor in an AC circuit is continually being charged and discharged. This causes a current to flow, an AC current, so that the capacitor seems to behave like a resistor (Fig. 17), allowing an AC current to flow when there is an AC voltage across it, and we can even use a form of Ohm's law to calculate the ratio of volts/amps, the units of which must be ohms. This quantity is called reactance, so that we don't confuse it with resistance which also uses units of ohms.

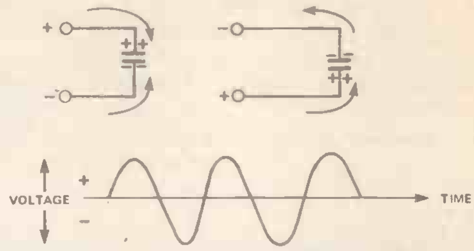


Figure 17. Effect of AC — the capacitor alternately charges and discharges for each direction of voltage, so that current flows continually

What's different? Well for one thing, reactance is for AC only. A resistance has the same value for AC or DC, but reactance is something that affects only AC circuits. For another thing, reactance is not constant. An AC voltage which has a high frequency will charge and discharge a capacitor more times per second than an AC voltage which has a lower frequency, so that the current is greater and the reactance lower for the signal with the higher frequency. **Table 2** shows values of reactances of various capacitor values at different frequencies — the equation for reactance Xc is given by:

$$X_c = \frac{1}{6.25 \times f \times C},$$

where f is frequency in hertz, and C is in farads.

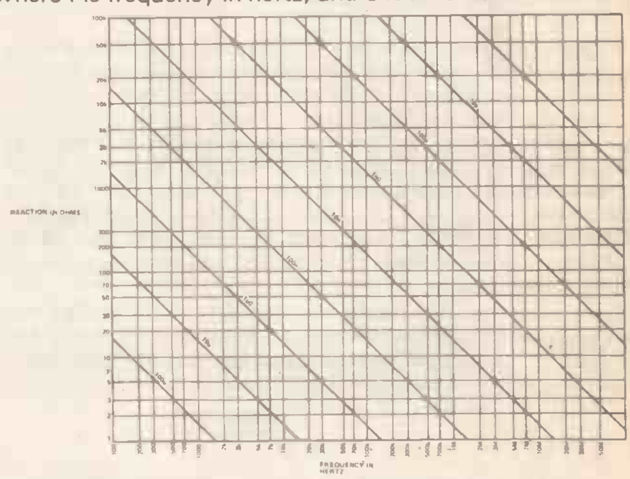


Table 2. Graph of reactance against frequency. To find the reactance of a capacitor at any frequency, select the line for capacitor value, find where it crosses the vertical (frequency) line, and look across to read the reactance value

Third point is that when the AC voltage gets going, the current through the capacitor does not reach its peak (maximum) value at the same time as the voltage across it reaches it peak value! The current peak appears a quarter of a cycle before the voltage peak **(Fig. 18)** because the rate of charging of the capacitor is fastest when the voltage across it is zero. This effect is called a 90° phase shift, and it appears wherever an AC voltage is connected across a capacitor to make AC current flow.

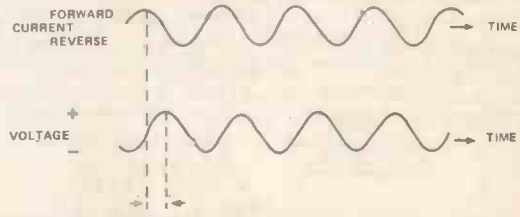


Figure 18. Waveforms of (a) current and (b) voltage for a capacitor connected to an AC supply. the peak current always occurs a quarter of a wave earlier than the peak voltage

Because these are AC effects, we can't demonstrate them with our meter and a battery — but we'll make reference to them later.

Next month, we get coiled up with inductors, inductance and inductive reactance, before we are transformed. Happy metering.

HE

Dictation Machines

Dictation machines are not just boring items of office equipment — without their development through the years, hi-fi records and cassette players would not exist. Guest writer Ted Jennings traces the history of dictation machines from first beginnings to present-day use and casts his eye to the future

THOMAS EDISON FIRST saw the possibility of recording a voice onto a soft wax cylinder medium in the late 19th century. It was quickly recognised that such a system could enable a person to dictate some of the more mundane office material (such as letters, reports etc) in the absence of a secretary or typist — the material could later be transcribed when a typist was available. Of course, once the cylinder had been recorded it was permanent, and had either to be filed for future reference or thrown away. (Actually, there was one method of erasing the cylinder for re-use — the typist, having completed the transcription, could put the cylinder onto a lathe-like machine and shave it clean!)

Although the prime use of dictation machines, in the early part of the 20th century, was in the office, manufacturers were quick to realise the potential of pre-recording music for the domestic market. Consequently a great deal of research was undertaken which culminated in a flat disc of hard material (the forerunner of modern records) which was suitable for recording music. Some readers will, no doubt, remember the playing equipment of the time — a gramophone with a winding handle and a large speaking cone.

The Birth Of Magnetic Tape

At this stage in the development of recording equipment, the market remained unchanged for a few decades. It was the possibility of a world war in the 1930s that spurred further research and development with the result that the first magnetic tapes were developed. This obviously created a new appraisal of recording media on the domestic and dictation machine market, with manufacturers such as Grundig and Philips (see **Fig.1**) pressing forward with their development of magnetic tape recording, while others like Dictaphone continued with the concept of cutting their own recordings onto a wax sleeve that was now thin and flexible.

It became clear in the period up to the early 1960s that magnetic tape was likely to be the medium which would eventually be adopted in the home and office.(Unlike other recording media tape can be easily re-used many times.) All manufacturers were pressing hard with the aim of becoming leaders in this field. Grundig and Philips were using a reel-to-reel principle on their dictation equipment and had started to manufacture their first transistorised machines. This transistorised equipment gave an inkling of the revolution in miniaturisation that was to follow.

One of the amazing anomalies of the 1960s was that Philips developed the compact cassette which became the set standard on the domestic market, but in the dictation machine market all the large manufacturers were each using their own media. The compact cassette — being small — opened up another market of pre-recorded music as occurred earlier with the record or disc. However, the main object of dictation machine manufacturers at this time was to provide facilities to make the typist's job easier.

a)

b)

Figure 1. Reel-to-reel dictation machines produced by (a) Grundig and (b) Philips

These included remote control (that is, a remote microphone which controls the functions of record, playback, start and back space), also a foot control and headphones that could be plugged in therefore leaving the typist's hands free. No effort was put into improving sound quality as this was considered unnecessary

During the 1960s most manufacturers placed greater emphasis on the domestic market and the production of quality sound machines, eventually leading to stereo and hi-fi equipment. However, Philips did not lose sight of the dictation machine market and by the end of this period had developed the

Figure 2. Some micro-cassette recorders available today

first mini-cassette machine — the Philips 85 — because it recognised the need for absolute portability. This machine opened up the possibility for recording while out of the office.

During the early 1970s Philips dominated over 60% of the dictation machine market. This domination was mainly the result of the proven reliability of the Philips 84 desk machine and the poularity of the mini-cassette machines. Philips also produced a mini-cassette adaptor for the desk machines so that mini-cassettes could be transcribed in the office without the need for two machines to transcribe two different types of tape media. Grundig held the second largest portion of the market with its machine, the Grundig Stenorette L, which operated on the reel-to-reel principle.

Move Towards Micro

Mini-cassette recorders have one main drawback: the reels within the cassette are rim driven, and so it is impossible to maintain a constant tape speed throughout the length of the tape. (This variation in speed can become apparent when a rim-driven cassette is transferred from one machine to another.) Because of this drawback and because the sound quality of some of the early machines was not particularly high, manufacturers began to look at ways of improving the overall quality of 'mini' cassette equipment. A breakthrough was made — in 1974 by Olympus the camera people — with the first micro-cassette machine, although at first the significance of this went unrecognised.

What Is A Micro-cassette?

Readers of the March issue of HE will know what a micro-cassette is — it is the smallest tape medium and an MC-60 micro-cassette will run for 1 hour at 2.4 cm per second, although many machines are dual speed and an MC-60 will run for 2 hours at 1.2 cm per second. The Olympus machine (Pearlcorder) was extremely small but it was considered at the time that the micro-cassette would have no significant influence on the domestic market because it would be impossible for tapes of this size to match the stereo or high fidelity standards. (How wrong preconceived ideas can be in this technological world!)

ple to produce constant speed (this was the proven form of drive used on all domestic cassette machines) but because micro-cassette recorders are pocket-sized (see **Fig.2**) they were considered to be fun machines rather than useful equipment.

At the end of the 1970s, Sony UK Limited decided the time was right to market two ranges of dictation machines, one using the standard compact cassette, and one using the micro-cassette. The high quality and reliability of the compact cassette machines (BM40 and B45) is comparable with that of other products from Sony and these machines were designed to bridge a gap until the general public because aware of the micro-cassette revolution. Also the BM45 compact cassette has a micro-cassette adaptor allowing the machine to play both tape media. Olympus had already increased its range of products although most of its machines fell between the domestic and the dictation machine markets. Also Sanyo, Mitsubishi and most other associated Japanese companies were making steady progress with micro-cassette dictation products.

Over the last decade portability has become part of life and from such machines as the Philips 85 we have seen great developments on the domestic front with stereo compact cassette machines that are only slightly larger than the compact cassette itself (for example, the Sony Walkman — see **Fig.3**.) These walk-about stereo machines are without doubt of superb quality and unenvisaged 10 years ago, but they are for playback only and of course, a larger machine is needed to record in stereo.

Consequently the next reduction in size must come with the change to micro-cassette from larger compact cassettes.

Figure 3. Sony Walkman — one of the many walk-about compact cassette players. These machines are restricted from further size reductions purely by the size of the tape media

With the dictation machine market very successfully priming the public with micro-cassettes, it only needed some development on the domestic market to make the micro-cassette the new international standard cassette. This year we have already seen some domestic micro-cassette machines with a very favourable response from the public, one of the most recent of thees being the AIWA CS-M1 (featured in Monitor in the September issue of HE and in the Gadgets, Games & Kits supplement of the October issue). (See also Fig.4.) These portable micro-cassette machines herald only the beginning of the next generation of tape playing equipment — they will be followed in the next year or two by micro-cassette machines for in-car use and finally high-quality mains machines for the home.

What Next?

The micro-cassette will probably be the last tape media used for recording. Already there is electronic equipment which 'talks' from a digital memory — it is only a question of time before selected storage of music or voice on plug-in microchips becomes possible.

How long? Dare I give an estimate of less than 10 years?

Figure 4. AIWA CS-M1 protable micro-cassette recorder/player. Just for good measure an AM/stereo FM radio is also featured

Quick Project: Simple Stylus Organ

If you want to make music — cheap, cheap music — this Quick Project is for you. For about a fiver you can build yourself a simple stylus organ

This easy-to-build project uses two 555 timers in conventional astable oscillator circuits.

Integrated circuit IC2 is an audio frequency oscillator. Its frequency is primarily controlled by the resistance between pins 2 and 7. Thus the setting of presets RV4-11 control the oscillator frequency and by touching a stylus (connected via limiting resistor R5 to pin 2), to each preset, different notes can be played.

Integrated circuit IC1 is a low frequency oscillator (running at approximately 3-10 Hz), the frequency of which is variable by RV1. The output of this oscillator is connected through depth control RV2 and limiting resistor R3 to the voltage control input (pin 5) of the audio frequency oscillator. A vibrato effect occurs.

Figure 2 gives details on how to build and wire up your project. We leave probe and keyboard details up to the builder — we used an old multimeter prod for a probe, and a piece of Veroboard into which the presets were positioned as the keyboard, but readers may like to use their own ingenuity at this stage.

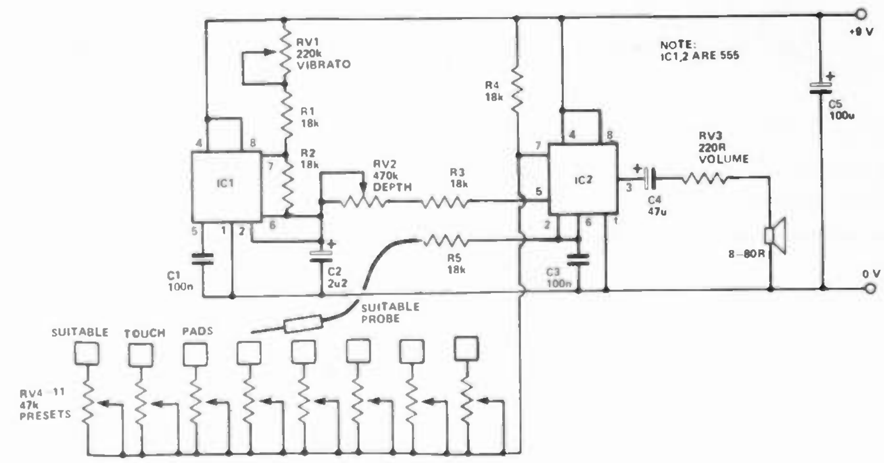


Figure 1. Circuit of Simple Stylus Organ

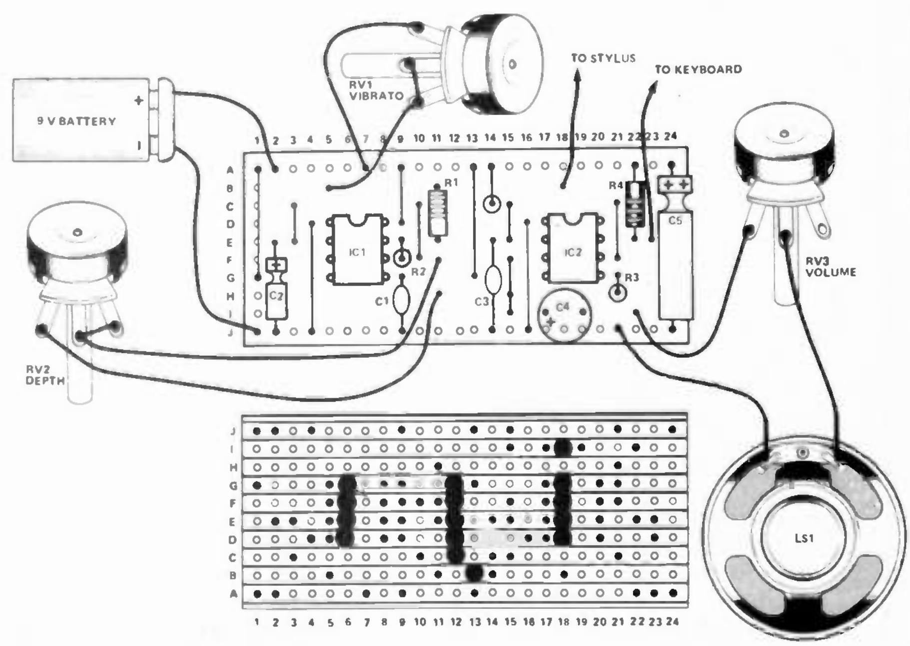
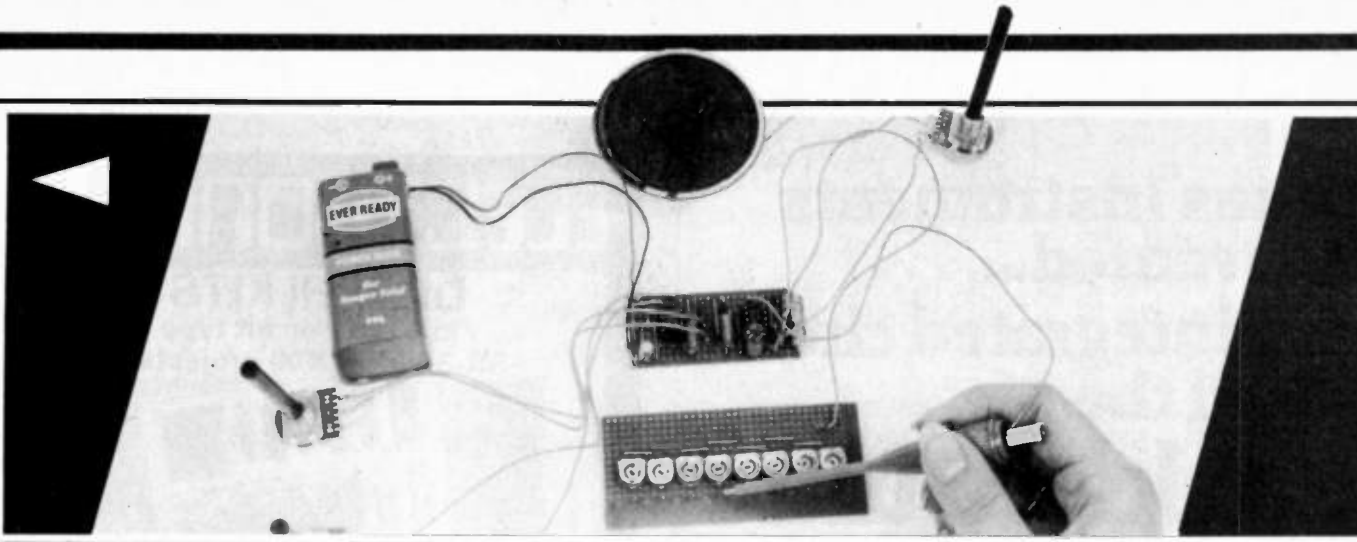


Figure 2. Veroboard layout, connection details and underside track break positions of the project



Touch Lamp Update

Readers may recall that in the HE Touch Lamp project of last month's issue, we stated that the How It Works section of the article would be printed in this November issue of HE

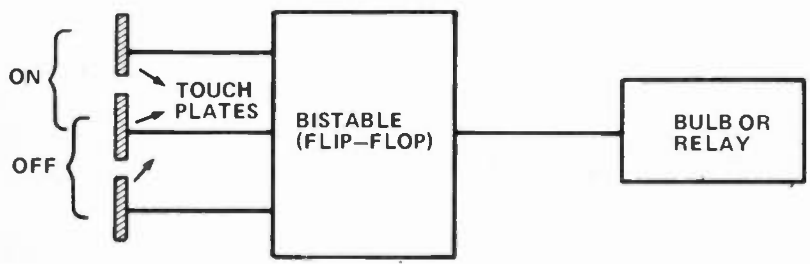
How It Works

The HE Touch Lamp circuit consists of a simple bistable. A common name for a bistable is a flip-flop, and this helps to explain the action of the circuit.

When the top two touch plates (the ON plates) are touched, the bistable is turned on and its output voltage goes positive (ie, it 'flips') and stays in this state.

When the lower two touch plates (the OFF plates) are touched, the bistable is turned on and its output voltage goes to zero (ie, it 'flops').

The output of the flip-flop is used to turn a bulb or a relay on and off.



The full circuit diagram is shown in Fig. 1 on page 51 of last month's HE. When power is first applied, the circuit takes up a state where transistor Q1 is biased into conduction by way of the load and resistor R1. This gives practically 0 V at the drain terminal of Q1, and transistor Q2 is therefore cut off as it receives no significant bias voltage via resistor R4. Both transistors are VMOS types and are therefore voltage operated — unlike ordinary bipolar devices which are current operated.

If the two 'ON' touch contacts are activated, the skin resistance of the operator is placed between Q2's gate and the positive supply rail. Although this resistance is almost certain to be very high, the high input impedance at Q2's gate ensures that the gate of Q2 is taken a few volts positive so that Q2 is biased into conduction. The load is therefore switched on.

Transistor Q2's drain terminal is now at a very low potential, and is further reduced by the voltage divider action of resistors R1 and R2 so that Q1 now becomes switched off. The voltage at the drain terminal of Q1 thus rises to virtually the full positive rail voltage, and Q2 will be biased into conduction by way of R4 when the operator's finger is removed from the touch contacts. This latches the circuit in the 'ON' state.

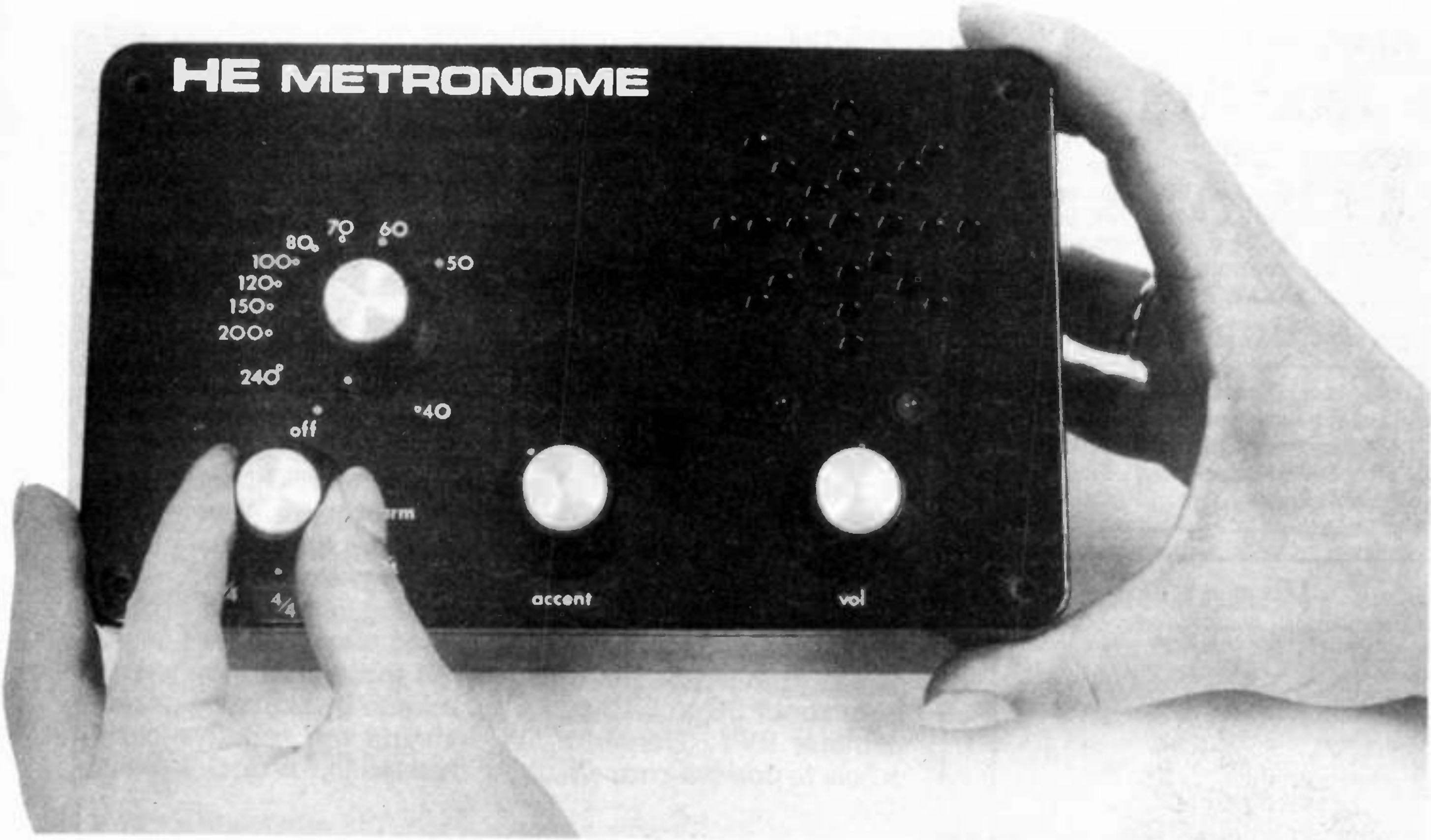
The circuit can be returned to the 'OFF' condition by touching the two 'OFF' contacts. This places the skin resistance between the positive rail and Q1's gate so that Q1 is biased into conduction. Its drain voltage falls back to almost zero so that Q2 and the lamp are both switched off. Transistor Q2's drain voltage rises to almost the full positive supply voltage again so that Q1 is latched in the on state as a result of the bias voltage received via R1. Thus the circuit stays in this state with the lamp switched off when the touch contacts are no longer operated.

The circuit can obviously be triggered from one state to the other indefinitely by operating the appropriate pair of touch contacts, and capacitors C1 and C2 are used to filter out any electrical noise which could otherwise produce spurious operations.

VMOS devices require no significant input current and will work at very low drain currents. This makes possible a circuit having a low stand-by current: the quiescent current consumption of this circuit is typically only about 1 uA.

HE

Metronome



Although the clockwork pendulum type of metronome has been around for many decades, we reckon that it is about time (pun intended) to replace it with a modern electronic counterpart

IF YOU PLAY a musical instrument, especially if you're a beginner, then a metronome can be a valuable aid to help you keep in the correct time.

Clockwork varieties of metronome are fine, but they can only keep a basic rhythm — the musician still has to keep a count of the beats in a bar. The HE Metronome, however, apart from keeping basic rhythm, can also play accented rhythms in 2/4, 3/4, 4/4 and 5/4 times. The pitch of the accent and

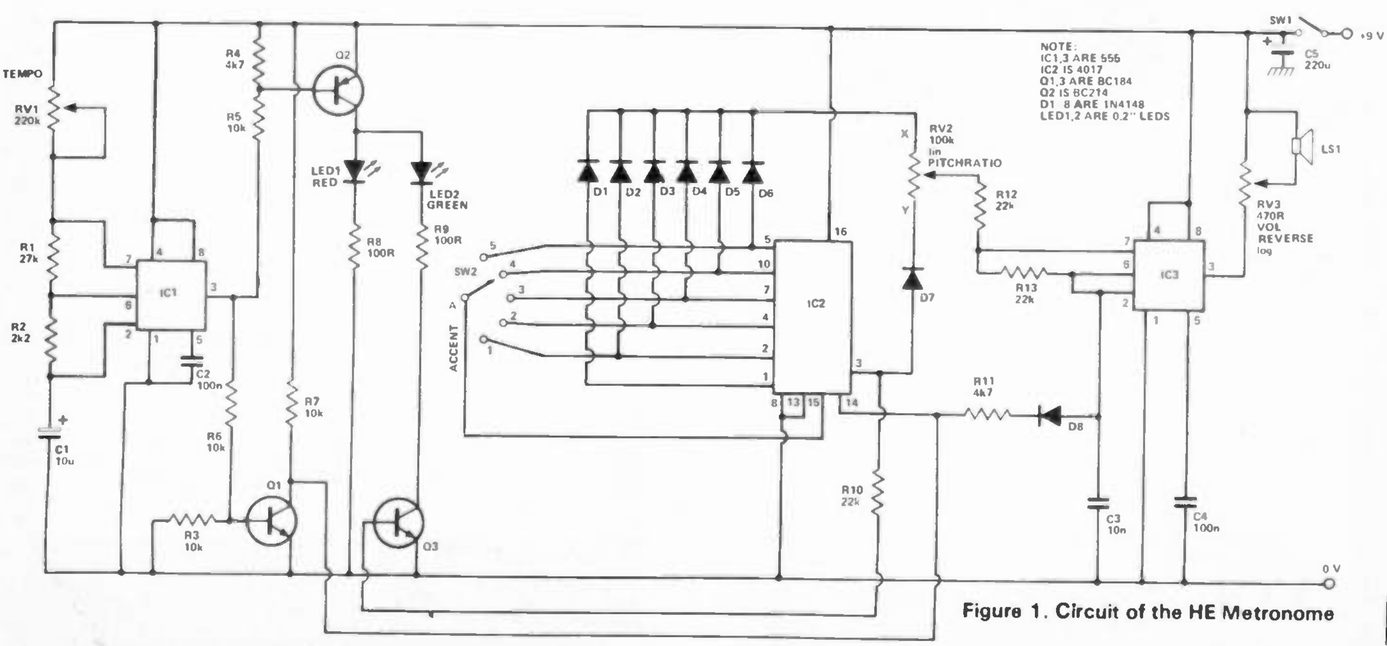


Figure 1. Circuit of the HE Metronome

main beat are fully variable, and beat rates of 50 to 240 beats per minute can be obtained.

As well as audible indication of time there is a visible indication supplied by two flashing LEDs — a red LED for main beat and a green LED for accented beat. Thus if you turn the volume right down so that no sound can be heard over the music, the musician can still keep good time with the help of the flashing LED beat indication.

Construction

Carefully following the details shown in Fig.3 make all necessary track breaks in the copper track side of the board. Use a Veroboard cutting tool: alternatively a small (about ⅛") hand-held drill bit can be used for this job.

Insert and solder all low-level components first, eg, resistors and diodes, in the positions shown in Fig.2. Fit links where indicated.

Next insert and solder capacitors followed by the remaining semiconductors.

Push in and solder circuit board pins where all off-board connections are to be made.

Now mark and drill the case to fit the three potentiometers, the switch and two LEDs.

Mark and drill a matrix of holes to form a grille for the loudspeaker. Glue the loudspeaker to the inside of the case using contact adhesive, but make sure you get no glue on the loudspeaker cone.

Fit the controls and LEDs to their correct places and then wire up your project as Fig.2 shows.

Buylines

Magenta Electronics has produced a full kit of parts for the HE Metronome, the price of which is £11.88. Please add 40p to cover p&p.

Parts List

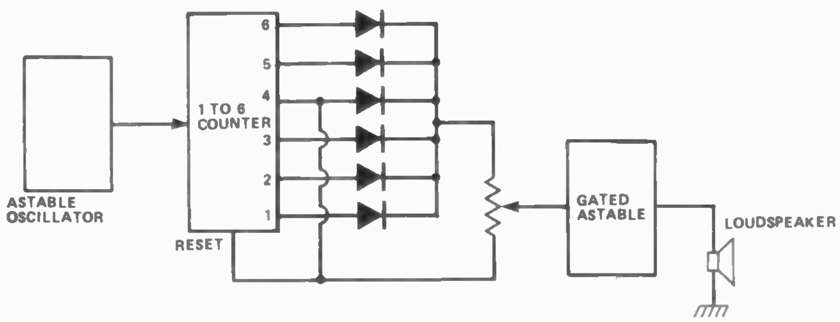
RESISTORS (All ¼W, 5%)	
R1	27k
R2	2k2
R3,5,6,7	10k
R4,11	4k7
R8,9	100R
R10, 12,13	22k
POTENTIOMETERS	
RV1	220k linear potentiometer with double-pole, double-throw switch (SW1)
RV2	100k linear potentiometer
RV3	470R antilog potentiometer
CAPACITORS	
C1	10u, 16 V tantalum
C2,4	100n polyester
C3	10n polyester
C5	220u, 16 V electrolytic
SEMICONDUCTORS	
IC1,3	555 timer
IC2	4017 decade counter
D1-8	1N4148 diode
LED1	0.2" red LED + clip
LED2	0.2" green LED + clip
Q1,3	BC184 NPN transistor
Q2	BC214 PNP transistor
MISCELLANEOUS	
SW2	2-pole, 6-way rotary switch
LS1	75R loudspeaker
Veroboard, 24 strip x 50 hole	
PP3-sized battery + clip	
Knobs and case to suit	

How It Works

An astable oscillator provides clock pulses for a 1 to 6 counter. On every positive pulse from the astable, the counter moves on to its next state, eg, 1 - 2 - 3 - 4 etc.

In our example output 4 of the counter is connected to the reset input so that whenever output 4 goes high the counter immediately resets to state 1.

The counter outputs of all six states are connected to one end of the potentiometer, but the state 4 output is also connected to the other end of the potentiometer. The frequency of the 'bleep' thus changes on the reset pulse. Varying the position of the potentiometer wiper alters the frequency difference between the reset and the other states.
Integrated circuit IC1 is a 555 operating in a familiar astable configuration. It generates a train of short negative clock pulses from pin 3. The frequency of these pulses is variable from about 50 to 240 beats per minute by adjusting potentiometer RV1. Transistor Q1 converts the negative clock pulses to positive ones which are then fed to the clock input of IC2.



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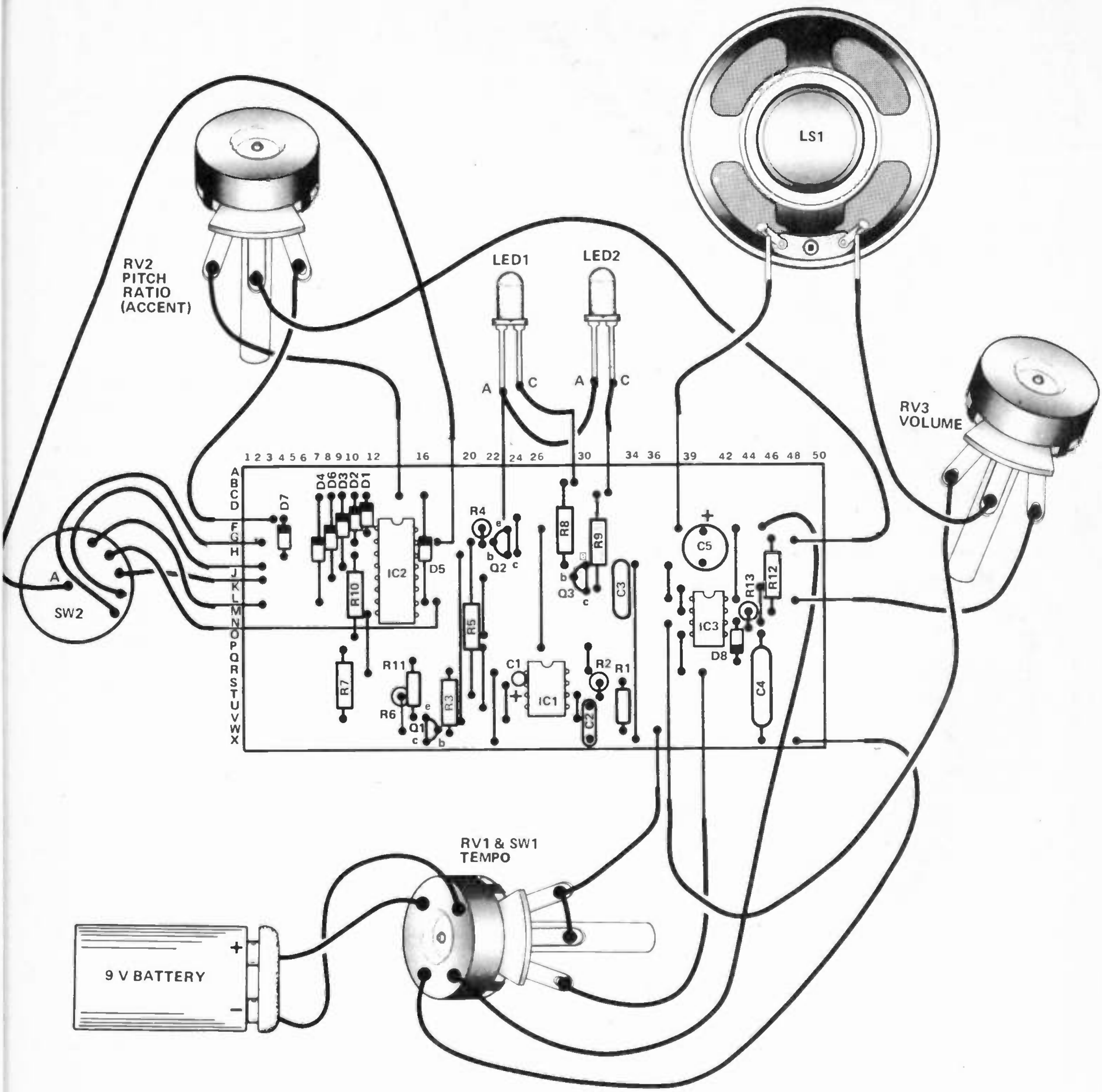
Switch SW2 allows the IC2 reset pin to be connected to one of its own outputs. These outputs are selected so that the IC will reset after 1,2,3,4 or 5 pulses.

Another 555 astable oscillator is used as IC3. It drives the loudspeaker via the volume control RV3. It can only oscillate when the voltage at pin 7 is taken high through R12 and RV2. The frequency of oscillation depends on the setting of RV2 and whether the high voltage is derived from D7 or D1-6.

Integrated circuit IC3 is also gated by the voltage derived from D8 and R11 which clamps pins 2 and 6 to 0 V except during the brief clock pulses. This produces a short 'bleep' of sound on each beat.

Light emitting diode LED1 is driven from IC1 and Q2, and flashes on every beat. Light emitting diode LED2 only flashes during the accented beat when Q3 is turned on by the first output of IC2.



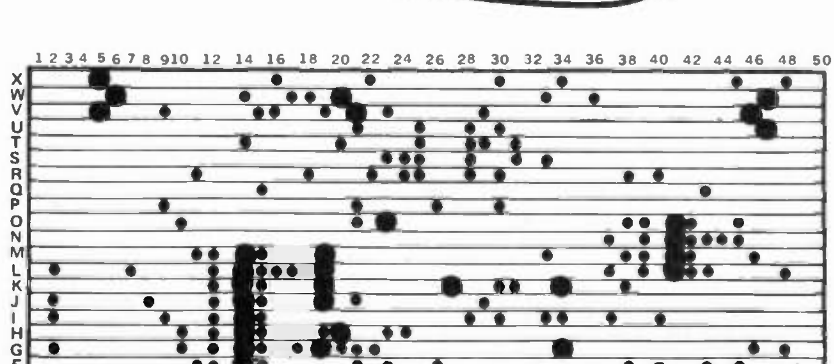


Figure 2. Veroboard layout, and underside view showing component locations and track breaks

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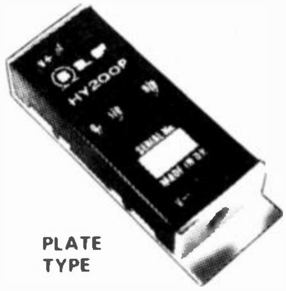
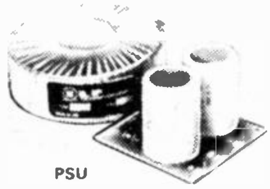


PLATE TYPE



PSU

BIPOLAR Standard, with heatsinks

MODEL NUMBER	OUTPUT POWER Watts rms	DISTORTION T H D Typ at 1kHz	DISTORTION I M D 60HZ 7kHz 4 1	SUPPLY VOLTAGE TYP MAX	SIZE mm	WT gms	PRICE	VAT	Without heatsinks MODEL NUMBER	SIZE in mm	WT gms	PRICE	VAT
HY30	15w 4 8Ω	0 015%	<0 006%	±18 ±20	76x68x40	240	£7.29	£1 09					
HY60	30w 4 8Ω	0 015%	<0 006%	±25 ±30	76x68x40	240	£8.33	£1 25					
HY120	60w 4 8Ω	0 01%	<0 006%	±35 ±40	120x78x40	410	£17.48	£2 62	HY120P	120x26x40	215	£15.50	£2 33
HY200	120w 4 8Ω	0 01%	<0 006%	±45 ±50	120x78x50	515	£21.21	£3 18	HY200P	120x26x40	215	£18.46	£2 77
HY400	240w 4Ω	0 01%	<0 006%	±45 ±50	120x78x100	1025	£31 83	£4 77	HY400P	120x26x70	375	£28.33	£4 25

Protection Load line momentary short circuit (typically 10 sec) *Slew rate* 15V μs *Rise time* 5μs
S N ratio 100db *Frequency response* (3dB) 15Hz 50kHz
Input sensitivity 500mV rms *Input impedance* 100kΩ *Damping factor* (8Ω 100Hz) >400

HEAVY DUTY with heatsinks

MODEL NUMBER	OUTPUT POWER	T H D	I M D	SUPPLY VOLTAGE	SIZE	WT	PRICE	VAT	Without heatsinks MODEL NUMBER	SIZE	WT	PRICE	VAT
HD120	60w 4 8Ω	0 01%	<0 006%	±35 ±40	120x78x50	515	£22.48	£3 37	HD120P	120x26x50	265	£19.84	£2 98
HD200	120w 4 8Ω	0 01%	<0 006%	±45 ±50	120x78x60	620	£27.38	£4 11	HD200P	120x26x50	265	£23.63	£3 54
HD400	240w 4Ω	0 01%	<0 006%	±45 ±50	120x78x100	1025	£38.63	£5 79	HD400P	120x26x70	375	£34 28	£5 14

Protection load line. PERMANENT SHORT CIRCUIT (ideal for disco group use should evidence of short circuit not be immediately apparent)
The Heavy Duty range can claim additional output power devices and complementary protection circuitry with performance specs as for standard types

MOSFET Ultra-Fi, with heatsinks

MODEL NUMBER	OUTPUT POWER	T H D	I M D	SUPPLY VOLTAGE	SIZE	WT	PRICE	VAT	Without heatsinks MODEL NUMBER	SIZE	WT	PRICE	VAT
MOS120	60w 4 8Ω	<0 005%	<0 006%	±45 ±50	120x78x40	420	£25.88	£3 88	MOS120P	120x26x40	215	£23.32	£3 50
MOS200	120w 4 8Ω	<0 005%	<0 006%	±55 ±60	120x78x80	850	£33.46	£5 02	MOS200P	120x26x80	420	£28.53	£4 28
MOS400	240w 4Ω	<0 005%	<0 006%	±55 ±60	120x78x100	1025	£45.39	£6 81	MOS400P	120x26x100	525	£38.91	£5 84

Protection Able to cope with complex loads, without the need for very special protection circuitry (fuses will suffice)
Ultra-fi specifications:
Slew rate 20V/μs *Rise time* 3μs *S/N ratio* 100db *Frequency response* (3dB) 15Hz 100kHz
Input sensitivity 500mV rms *Input impedance* 100kΩ *Damping factor* (8Ω 100Hz) >400

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MODEL NO	FOR USE WITH	PRICE	VAT
PSU30	± 15V combinations of HY6 66 series to a maximum of 100mA or *one* HY67 The following will also drive the HY6 66 series except HY67 which requires the PSU30	£4 50	£0 68
PSU36	1 or 2 HY30	£8 10	£1 22
PSU50	1 or 2 HY60	£10 94	£1 64
PSU60	1 x HY120 HY120P HD120 HD120P	£13 04	£1 96
PSU65	1 x MOS120 1 x MOS120P	£13 32	£2 00
PSU70	1 or 2 HY120 HY120P HD120 HD120P	£15 92	£2 39
PSU75	1 or 2 MOS120 MOS120P	£16 20	£2 43
PSU90	1 x HY200 HY200P HD200 HD200P	£16.20	£2 43
PSU95	1 x MOS200 MOS200P	£16 32	£2 45
PSU180	2 x HY200 HY200P HD200 HD200P or 1 x HY400 1 x HY400P HD400 HD400P	£21 34	£3 20
PSU185	1 or 2 MOS200 MOS200P 1 x MOS400 1 x MOS400P	£21 46	£3 22

All models except PSU30 and PSU [illegible]

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MODEL NO.	MODULE	DESCRIPTION/FACILITIES	CURRENT REQUIRED	PRICE	VAT
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†HY75	STEREO PRE AMP	Two channels, each mixing four signals into one + Bass/Mid-range/Treble	20mA	£10.75	£1.61
†HY76	STEREO SWITCH MATRIX	Two channels, each switching one of four signals into one	20mA	*To be announced*	
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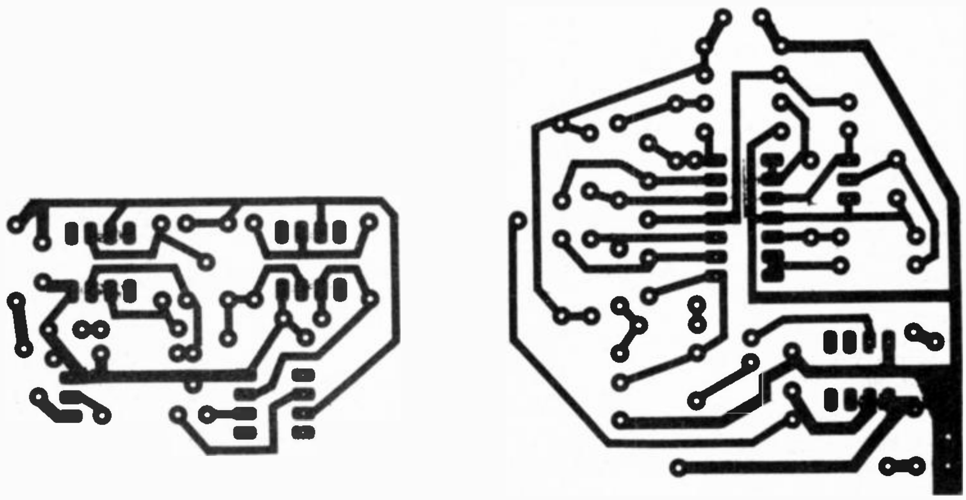

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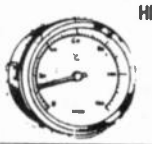

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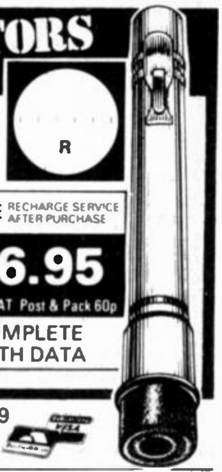

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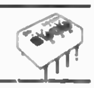

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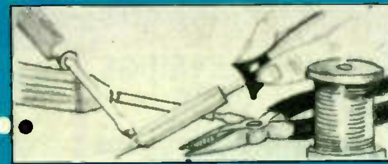

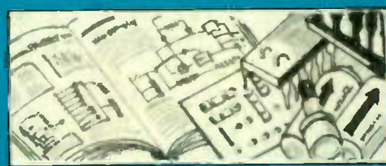


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