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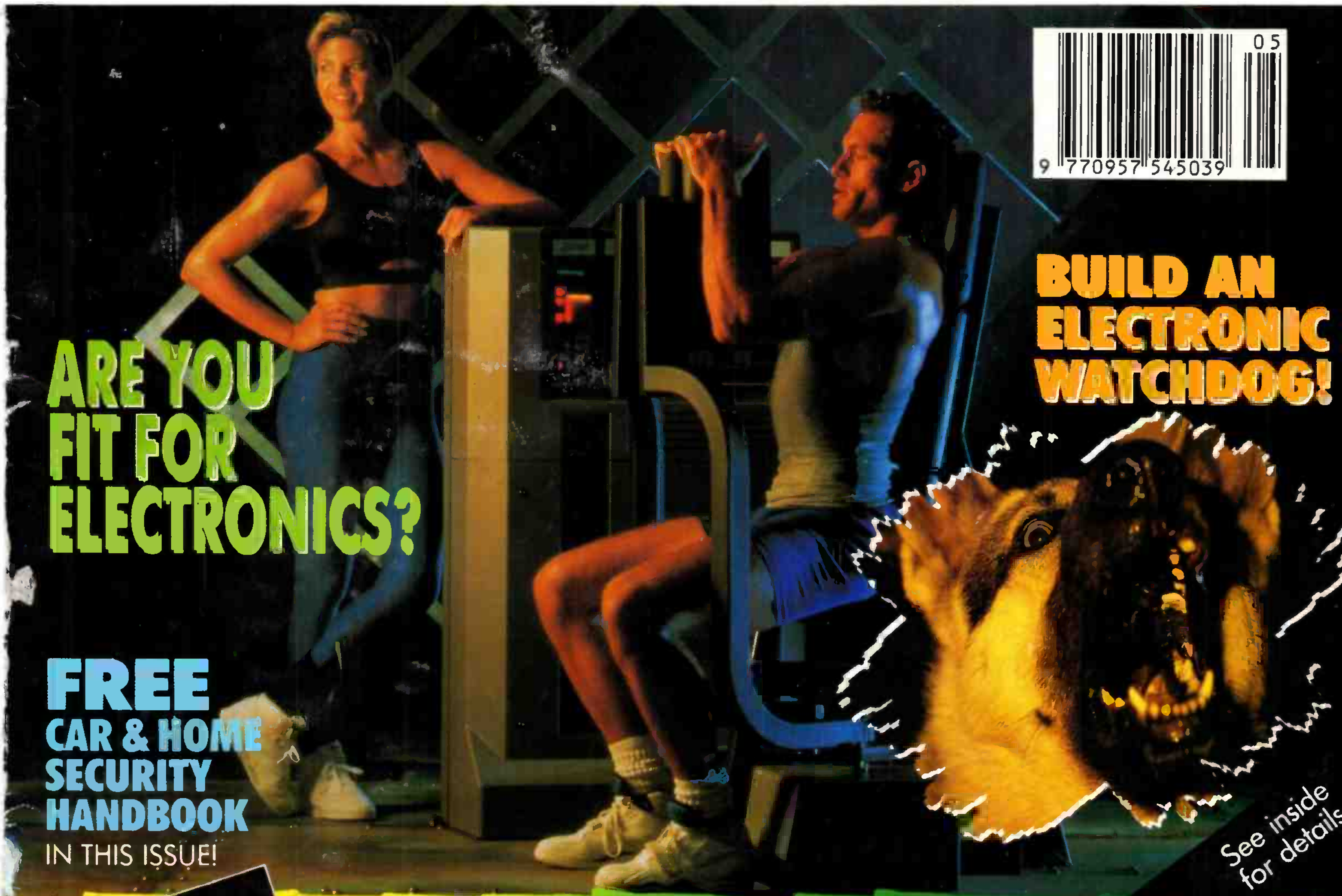
No. 53

ELECTRONICS

The Maplin Magazine

MAY 1992 £1.60



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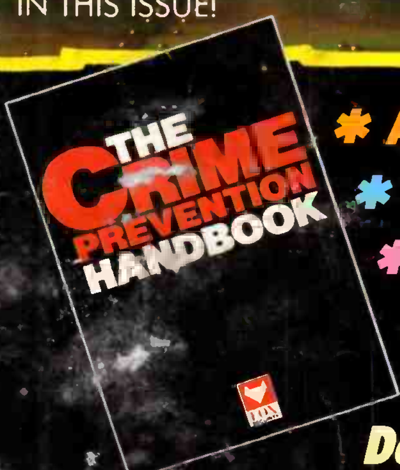

* Amazing easy-to-build morse decoder project
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4000 count digital display 1.5% basic dc volts accuracy 2.9% basic ac volts accuracy 1.5% basic ohms accuracy Fast continuity beeper Diode Test Sleep Mode Three-year warranty	V Chek™ Capacitance, .001 to 9999 µF 4000 count digital display 0.9% basic dc volts accuracy 1.9% basic ac volts accuracy 0.9% basic ohms accuracy Fast continuity beeper Diode Test Sleep Mode Three-year warranty	V Chek™ Min/Max recording with relative time stamp Continuity Capture™ Capacitance, .001 to 9999 µF 4000 count digital display 0.9% basic dc volts accuracy 1.9% basic ac volts accuracy 0.9% basic ohms accuracy Fast continuity beeper Diode Test Sleep Mode Three-year warranty

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The New Series 10.

PHILIPS

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EDITORIAL

Hello and welcome to this month's issue of 'Electronics'! In the projects line-up, there is an ingenious Continuity Tester, not only does it provide an indication of open circuit/short circuit, but also indicates the resistance between the test probes by means of a multicolour LED and a buzzer! On the features front, a new series deals with how to 'Finish Off' your projects; explaining various techniques so that they look 'professional'.
Sealed lead-acid batteries provide an excellent source of power in many demanding applications, we have designed a complete Sealed Lead Acid Battery Charger project, based around an easy to use module. If you have ever wondered whether your microwave oven is performing as it should, then Jim Garrod's feature on 'What do you really know about your Microwave Oven' will answer your questions.
If you are concerned about security, the Electronic Watchdog project will be of interest; a digitised dog bark is replayed in response to any noise in the vicinity of the unit. The bark (there is a choice of two) is very realistic, a potential thief will probably not want to find out if the dog is real or not! Keeping on the subject of security, there is a free copy of 'The Crime Prevention Handbook' included with this issue.
Finally all that remains for me to say is that I hope you enjoy reading this issue as much as the 'team' and I have enjoyed putting it together for you!

R D Ball

ABC 33,837

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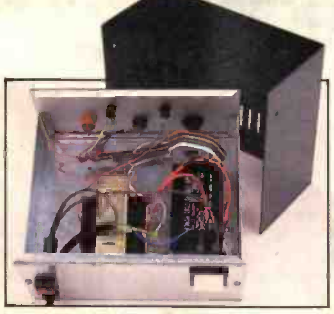
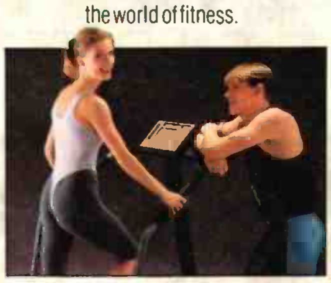
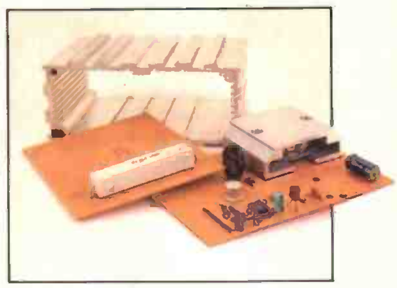
PROJECTS



FEATURES





REGULARS

Apologies to David Holroyd, whose name was omitted from his feature on the QEII bridge, which appeared in the January issue of 'Electronics'.

Prices shown in this issue include VAT at 17.5% (except items marked NV which are rated at 0%) and are valid between 3rd April 1992 and 30th April 1992.

NEWS Report

What's in a Number?

We thought you would like to know that MIPS Computer Systems, a US chip manufacturer, has informed the world that its new 64-bit, R4000 RISC chip can address 18·4 quintillion bytes. Translated that is 18, 446, 744, 073, 709, 551, 616. More facts and figures? Well, have you ever wondered what comes after a terabyte? It's a petabyte, one of which equals 1,000 trillion bytes. Meanwhile, following an agreement between Siemens and IBM, the companies have jointly released the first of their 64M-bit DRAM chips. The memories are capable of storing 67,108,864 bits of information – equivalent to more than 3,000 A4 typewritten pages! (So do we now know why the sales of supercomputers are soaring?)

Alcatel has overtaken AT & T to become the world's largest telephone equipment supplier. The following three in the ranking league table are Northern Telecom, Siemens and Ericsson.

No Sex Please

Mercury Communications' Group Director has given vent to his thoughts about a closer Europe. "For most people," he says, "the idea of a European heaven would be British police, French food, an Italian lover, German engineering and Swiss organisation. Hell would be British food, French Engineering, Italian organisation, German police and a Swiss lover."

Computer Outrages

Computing problems such as hacking, viruses and accidental failure affect more than half of industrial and commercial companies, at an estimated annual cost of £1·1bn, says UK Technology Minister Lord Reay. The figures are supplied by the National Computing Centre who apparently surveyed some 8,000 companies, with just 900 firms responding. Over half of the respondents reported major security breaches in the past five years, ranging from hacking, software viruses and such physical inconveniences as theft, lightning and flood. The suggested deterrent – apart, that is, from sending for Lord Reay – is to join the NCC security watch service.

Yet another DTI Minister, John Redwood, is concerned about security. "Beating the burglar should be made easier," he says "with the ending of some restrictions on radio alarms. As a result, long-range radio alarms which previously could only serve as a back-up to wire systems provided by a PTT, can stand alone as alarm systems. With no wires to cut, the alarms can provide a higher degree of security than traditional alarm systems."

Delay that Call

It is not just Oftel who is kicking BT following the release of its latest profit figures. The £1,000 per second profit reported by BT has been ritualistically highlighted in the media as being the unacceptable face of a private monopoly. In point of fact, the corporation reported flat trading in the last quarter and expects the near term prospects to continue to be depressed by competitive and regulatory pressures in the absence of any significant growth in turnover. Despite higher user discounts, the volume of internal calls declined – offset in part by the controversial new directory charges imposed a year ago. Even so, perhaps as a last desperate fling, Oftel responded to the profit figures by launching a consultative document covering the regulation of BT's prices. Oftel is proposing a continuation of price controls after the present agreement expires next year.

Certainly there would seem to be scope for such a review. Do you realise that local calls are 66% cheaper than standard rate, and a hefty 75% cheaper than peak rate? Off-peak trunk calls work out at 33% cheaper than standard rate, and 50% cheaper than peak rate. No wonder Maplin double-mans its phones after 1pm.

Advanced and High Definition Television

The European Commission is doing its best to jump-start advanced TV services in Europe. The Commission is proposing a package of about £560 million over a five year period to promote the launching of a number of wide-screen channels in the various language markets in Europe. The package would pave the way for the introduction of European High Definition TV on a commercial basis in the mid-nineties. The Commission also warned satellite operators not to get into disputes over standards which could mean extra costs for consumers.

In the meantime, Pacific Bell is claiming to make the first live HDTV broadcast over fibre optic cable. The company says that the new technology will help speed the development of HDTV, which needs a bandwidth of some 70MHz, speeding its introduction into the family home.

Mouse on the Run

Mice are on the loose in the computer world. The new Rexel cordless mouse, which aims to speed the inputting of commands to desktop PCs, frees the user from the restraint of working a few inches away from the screen, and neither does he have to clear the desk completely to run the rodent's tail. Details: (0296) 81421.

No More Ringing (round) the Changes!

Maplin's Publications Department, that goodly bunch of people responsible for bringing you this magazine and the ever-fattening catalogue, have recently invested in a new Desktop Publishing (DTP) system. Initially, this will be used to prepare 'Electronics', your favourite electronics magazine, but it is hoped that eventually the catalogue will also be produced using this system as well.

The system, which centres around an Apple Macintosh Quadra 700 computer, is expected to bring many advantages to the department. Apart from leading to improved magazine presentation, the DTP system will save time, money and materials. In the past the magazine artwork, comprising photographs, drawings and text setting were literally 'pasted-up' on large pieces of card; this time consuming process will now be done on a large monitor screen – releasing much more time for creative work. Word processed text and computer generated drawings for the magazine are ported across from the existing PC local area network via a gateway PC, straight into the Quadra 700. Photographs are scanned into the computer by means of an Agfa Focus Colour scanner; previously, all sorts of tedious camerawork had to be done to get pictures to the correct size!

Some pretty nifty software is required for all this to work, currently the Quadra 700 is running QuarkXPress, Adobe Photoshop and Adobe Illustrator. The powerful Quadra 700 is based on the Motorola 68040 processor, runs at 25MHz, has 8Mb RAM and a 160Mb hard disc. Storage capacity on the Quadra is by no means small, but since DTP is a memory hungry process, mass storage is provided in the form of a Micronet re-writable optical disc drive, each disc alone holds 650Mb! The different type-faces (fonts) are held on a Toshiba CD-ROM drive, allowing instant access to virtually any type-face currently available.

When the final magazine pages are ready, they are supplied to a 'repro house' on 45Mb removable hard discs. The magazine pages are then 'run out' on a very high resolution image setter, which produces a set of positive films (similar to overhead projector slides but much higher quality!). These are then express delivered to our printers in Wales, where the films are used to make the plates for the printing press.

Girls Wanted

All Britain's girls are being targeted with the message that engineering is an excellent career for women. The campaign is triggered by the Engineering Council with a specially designed poster. By organising a wide-ranging distribution of the poster, the Council hopes that girls – and boys too – will, every day, and in different environments, come across our message that women have a place in engineering. "It is sad," the Council says, "that women are missing out on the excitement, the challenge and the rewards of a career in engineering, and that industry is missing out on the contribution of women within the engineering team."

Pass the Parcel

The Royal Mail Parcelforce service is making use of the Vodafone Mobile Data Service to help track deliveries of its customers' parcels and to provide instant 'conformation of delivery'. The system allows delivery details to be transferred between the vehicles and the Parcelforce computer centre over the Vodafone cellular network. Installed in each cab is a hand-held terminal, a cellular data link control, a modem and a Vodafone mobile telephone.

Gluttons for Punishment

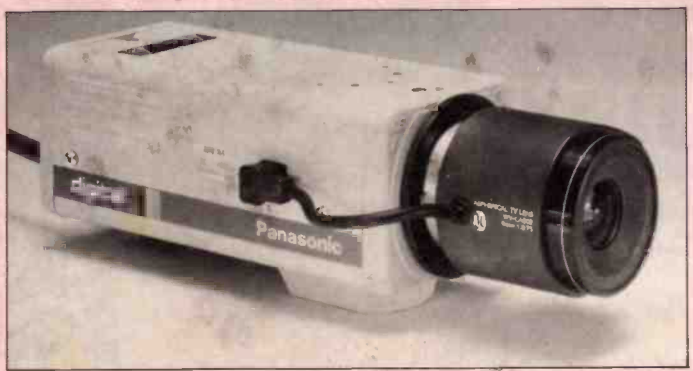
National Health staff excluded, some of the most poorly paid qualified people, considering all the studying and going to university involved prior to starting their career, are electronics engineers, especially while they're still young. The larger manufacturing corporations are notorious low wage payers, even if you are involved in developing some top secret military project. Even so, according to the industry paper Electronics Weekly, 24·3% of their readers would vote conservative in the next election, while 34·8% 'don't know'. Labour came out bottom of the list, after the Liberal Democrats. To quote one liberal's view: "The Tories won't spend any money and Labour won't have any money to spend and wouldn't know what to do with it if they did." Things are so bad apparently that "If help is not given the technology will be lost for ever," (80·9% thought training and education is hopeless), and "Government should keep out of industry altogether," and one *Managing Director* would put his faith in Screaming Lord Sutch and The Monster Raving Looney Party. The message would seem to be that any future government must, since modern society leans heavily on the science of electronics, look after its engineers, and not just those in the electronics industry.

Sky Issues Warning

British Sky Broadcasting (BSB) has issued a warning to potential satellite customers – don't buy an old BSB 'Squarial' system. Apparently thousands of old BSB systems are being sold in the UK through sole traders every week, but these units will only receive Sky's channels until the end of the year, after which they will be of no use for Sky viewers. Unsuspecting customers are believed to be paying anything up to £150 for the equipment and, in many cases, are not being made aware of the system limitations.

Sky's six channels are available on 60cm dish systems via the Astra satellite and on cable. Meanwhile, Sky should be celebrating soon. It seems that BSkyB could be moving out of a £7 million a week loss, into a break-even situation. In the last three months of 1991, Sky reported more than 300,000 dish sales. About 2·2 million homes are now linked to satellite dishes.

Focus on High Performance Cameras



Panasonic Business Systems have introduced a new Digital Signal Processing, ½in. CCD colour camera – the WV-CL350 – which will provide high quality colour output in very low light conditions. The product's horizontal resolution of more than 430 lines, coupled with a minimum scene illumination of 3 lux (f1·4) achieves high picture quality. The camera's advanced CCD includes a microlens on each of the 390,000 pixels which provides increased sensitivity. Recommended retail Price, £645. Details: (0344) 853940.

Meanwhile, a highlight of the Maplin Professional Supplies stand at NEPCON '92 is the Maplin Sub-Miniature Monochrome CCD Video Camera (Order Code ZA35Q). At just £129.95, the unit is capable of producing a black and white picture from both normal and infra-red illumination in the region of 940nm wavelength. Full details on page 280 of the 1992 Maplin catalogue.

It's all in a Chip

In many US states telephone network operators are introducing a system that indicates to a called party the actual telephone number of the caller, before they even pick up the phone. At first it was considered that the major application for this facility was that it would be possible, at last, for users to quickly track nuisance callers (heavy breathers and such), and so make such calls a thing of the past. However, the computer industry is now gearing up to use the facilities for network security, inbound call logging, and many other applications.

Referred to as 'Caller Number Delivery' or 'Caller Identification Service', the system works by sending the caller's number encoded as a 1200bps, FSK data stream inserted between the first and second rings to the called party. The data is in serial simplex, binary asynchronous format. Sierra Semiconductor are the first company to launch a single-chip Caller ID device, the SC11210, which integrates all the components required, including receive amplifier, detector and FSK demodulator into one *8-pin* DIL package which can cost less than \$2 each in bulk orders of 10,000 to equipment manufacturers.

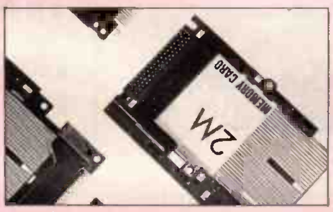
The chip is intended to be used in special feature phones or extra display units standing by the side of the phone, which show the caller's number. Sierra, who are probably better known for their modem devices, have included the chip into their modems. These can decode the caller ID and then send ASCII characters back to the host for display.

The system is now a standard or default installation on many lines in the US. To maintain privacy, you can call the phone company to request that your ID is not sent when you dial out. A future improvement will allow users to dial a PIN number which will be passed on to the called equipment. In this way the called party will know who the caller is by this number if they are calling from a payphone.

For network managers, the Caller ID has eliminated the need for modems with dial-back security, as the host can now check the identity of the caller before answering the line. When we asked BT about the possibilty of introducing this system in this country, they didn't seem to know what we were talking about.

The Incredible Shrinking RAM

All electronics and computing enthusiasts know that the cost of read/write memory, of ever-increasing capacity, is dwindling – but 8 megabytes in a space the size of a *credit card*? No way – or is there? Well now there is and to prove it, Japanese company Panasonic are now marketing them! To put things into perspective, ten years ago hard disc drives were being sold, intended for use with the business microcomputers of the time, for huge amounts of money – and some of these could hold no more than a measly 5Mb – a pathetic figure by modern standards. Goodness knows how much 8Mb of static RAM would cost then, not that there were many microprocessors around which could address that size of memory! Fortunately for Panasonic, there are now devices that can. Their new memory cards are available in a variety of capacities (from 8Kb to 8Mb), and the line-up includes SRAM, OTPROM, MaskROM, EEPROM and Flash cards (no, not the sort you used at infant school!).



Potential applications are many; imagine a notebook PC without one of those delicate disc drives – and then imagine how small it could be (keyboard not withstanding!). Other uses include low-cost games cards (for those machines so beloved by today's teenagers), electronic bulletin boards, office and factory automation, security applications, household appliances. The list goes on!

These low-cost cards require only a compact interface connector, and have a very low power consumption. The coin-shaped memory back-up battery has a life of around 5 years; an additional rechargeable battery will ensure that memory is not lost when the primary battery is replaced. Due to the fact that the system is all-electronic, access time is around 150 times faster than that of a floppy disc (configure an 8Mb card as a RAMdisc and you're laughing!).

Is BT's Number Up?

BT is also facing mounting criticism over its intention to implement, for Easter 1994, an extra digit (probably '1') after the initial '0' to all of the 30 million or so subscriber numbers. Given that there is, on the horizon, a single European numbering scheme, pressure is mounting on the UK telecomms authorities to delay the scheme.

With the authorities again reviewing the role of BT and, in particular, BT's tariffs, BT has decided to promote its charity contribution of £1·2 million. Much of this sum goes towards making life easier for the disabled – the corporation has just opened a new £4 million exchange for deaf customers. 'Typetalk' is the name for the new national service, which will allow deaf and speech-impaired customers to communicate by text communication with voice users. The BT good deed programme covers people with disabilities, people in need, environment, economic regeneration, arts and education. Details: (071) 356 5392.

Just in Time

UK IT industry newsletter 'Computergram' has revealed the news that Casio Computer Company has launched a \$150 watch that, time apart, also measures your blood pressure in about 30 seconds. There is no mention whether you purchase it from your local jeweller or pharmacy.

Bargain PCs

The PC price war continues unabated with both Apple and Dell slashing the prices of their PCs by up to 40%. However, whether this news will help the 92% of UK managers who are intimidated by computers and feel uncomfortable with the technology is not known. The BIM report suggests that 55% of managers see lack of training and support as the major obstacle, while 50% see jargon as being the chief problem. More comforting for the PC industry though is the finding that only 3% of respondents felt that IT would not have much of an impact on work in the future.

Events Listings

31 March/29 May. DNA Fingerprints, Science Museum, London. (071) 938 8000. First of a series of exhibitions giving an insight into recent developments in science, technology and medicine.

1/2 April. Virtual Reality '92, London. (071) 931 9985.

1/8 April. The Hannover Fair. The big one. Take extra walking boots. (081) 688 9541.

7/10 April. The Which Computer? Show plus Communications '92. NEC, Birmingham. (081) 940 3777.

8 April/31 May. Catching the Action, MOMI. London. (071) 928 3232. A look at the early sequence photographers who paved the way for the coming of cinema.

11/25 April. International Science Festival, Edinburgh. (031) 556 6446.

13/15 April. Cable and Satellite '92, Olympia, London. (081) 940 3777.

24/26 April. The Third MIDI Music Show, Hammersmith, London. (081) 549 3444.

12/14 May. The Portable Computer Show, Olympia, London. (081) 868 446.

Also watch out for:
July 1992. Pop Video Experience, MOMI. (071) 928 3232.

Please send details of events for the Diary Listings to The Diary Editor, 'Electronics'.

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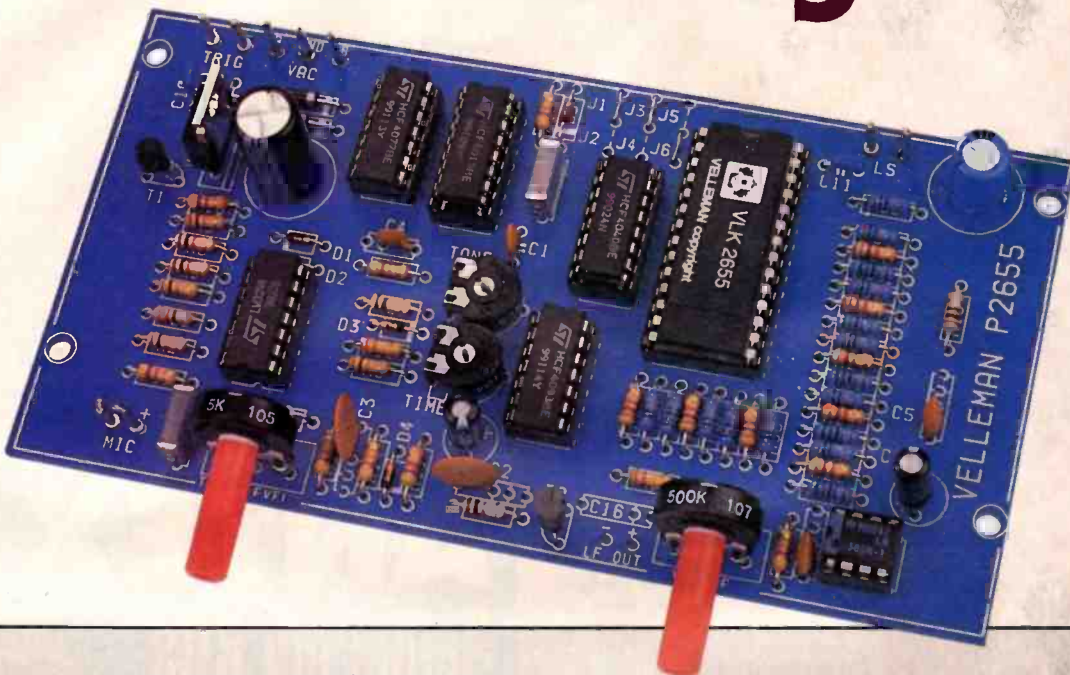
Review

by Chris Barlow

Electronic Watchdog



The basic idea behind the Velleman Watchdog is that while an electronic siren will deter most burglars, some still persist with the break-in. However, a furiously barking dog should make him or her think twice about continuing the attempt, and hopefully scare the villain off. For a variety of reasons it is not always possible or desirable to keep a real dog in the home, and since only its bark is required, it can be replaced by some electronics! This concept dates back to the early days of sound recording using gramophone records and tape recorders. Although quite effective, these mechanical systems suffered from long term reliability, i.e. record, stylus, tape, tape heads and motor wear. Only in recent years, with the introduction of digital solid state technology, has it been possible to significantly improve this situation, see Figure 1.

How Do You Get a Dog Inside an Integrated Circuit?

First find your dog and make it bark. Then, using a microphone to pick-up the sound, convert the analogue signal into a digital data format. Finally, store this in a non-volatile memory IC. Don't worry, Velleman have already done all this for you, and this specially programmed device is included in the kit (IC4, VLK2655). It has sufficient storage capacity for two different dog barks which are selected using links J1 or J2 on the printed circuit board (PCB).

How Do You Get the Dog Out of the IC?

To replay the dog barks, the Read Only Memory (ROM), IC4, must have each of its memory locations accessed sequentially. This is achieved by using a 12-stage ripple counter, IC3, the count rate of which is governed by the frequency of the clock signal generated by N4 of IC2. This frequency is set by the value of capacitor C4, and the combined values

FEATURES

- ★ Choice of two different barks
- ★ Reacts to environmental noise
- ★ External trigger input
- ★ Loudspeaker and audio output
- ★ AC or DC Power supply input
- ★ Does not need feeding

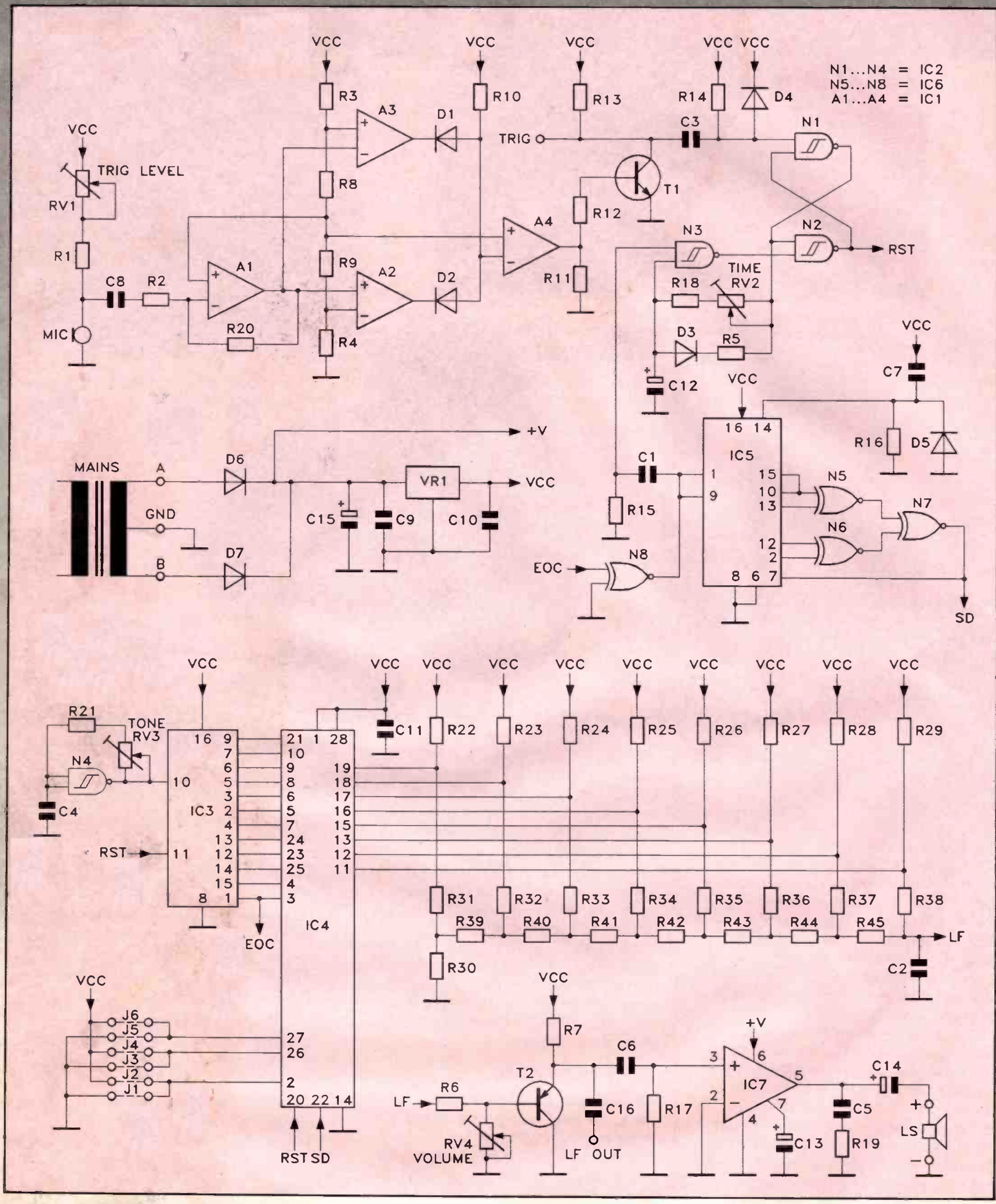


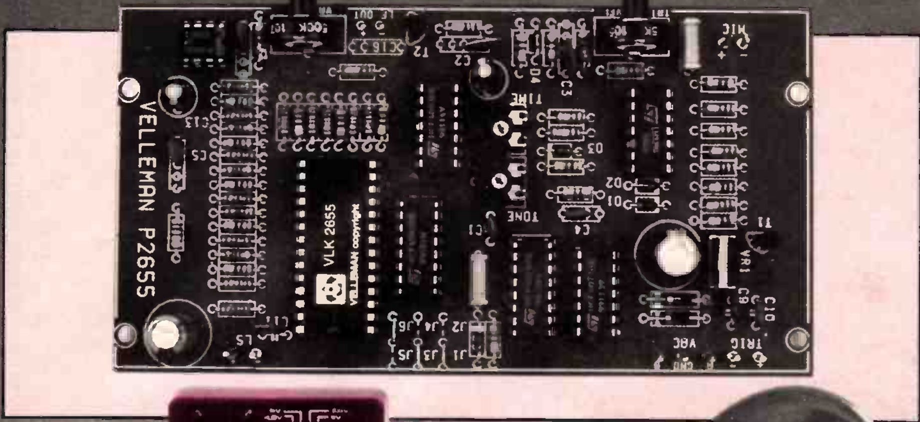
Figure 1. Circuit diagrams.

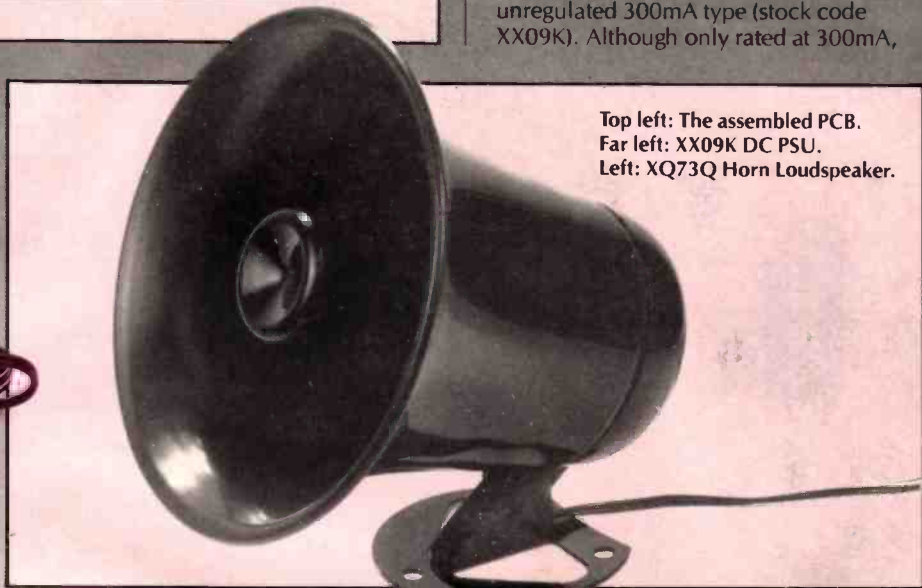
of the two resistors R21 and RV3. On their circuit diagram, Velleman refer to RV3 as a 'tone control'; a more accurate description would be 'replay speed control'.

As IC4 steps through its memory locations, the digital recording is reproduced as a stream of eight-bit data patterns. These have to be converted back into the original analogue waveform before audio amplification can take place. This digital to analogue conversion is achieved by using a network of resistors R22 to R45, with the final audio product (LF) appearing across C2. This signal then passes through a potential divider comprising R6 and RV4, where RV4 is used to adjust the volume of the barking. An audio buffer transistor, TR2, is provided which allows both the on-board amplifier IC7 and an external amplifier to be driven simultaneously.

As the on board amp is capable of producing quite a loud bark on its own when connected to a suitable loudspeaker, Velleman have omitted the LF output coupling capacitor C16 from their kit. Should you wish to fit one, a 100nF polyester layer capacitor (Maplin stock code WW41U) will make the audio signal available at the LF output terminals. In the Velleman instruction booklet it is stated, 'If you are sure that the [external] power amplifier already has a capacitor at the input, then you may fit a wire link for C16.'

DON'T DO THIS! For the small additional cost of an extra capacitor, you ensure that the amplifier you intend using,





Top left: The assembled PCB.
Far left: XX09K DC PSU.
Left: XQ73Q Horn Loudspeaker.

or any amplifier you may use in the future, will be isolated from the DC component of TR2.

What Causes the Dog to Bark?

The Electronic Watchdog, just like a real dog, responds to acoustic stimulus, though of course no electronic device could hope to achieve the same degree of sensitivity over such an extreme frequency range as a real dog can perceive. However, by employing the use of a highly sensitive electret microphone insert, Velleman have made their unit very responsive to environmental noise. The degree of microphone sensitivity is set by the trigger level control RV1.

To activate the digital circuits, the audio signal produced by the microphone must be amplified and converted into a trigger pulse. This is achieved by the amplifiers A1 to A4 (IC1), and the resulting DC trigger pulses are fed to TR1 which acts as a transistor switch. This allows the connection of an extra external trigger pulse, which can be produced from a wide variety of electronic sensors, i.e. infra-red motion, smoke, heat, pressure mat, vibration, or a complete security system. The output of TR1 is connected to the digital circuits via C3, and this produces a narrow pulse which initiates the digital sequence of events. For each trigger pulse the 'dog' will bark for a predetermined length of time before returning to its surveillance mode. The bark duration is set by RV2, and can be varied from approximately 4 to 37 seconds. If you require the dog to keep barking for as long as the external trigger is grounded (active), Velleman direct you to replace C3 with a wire link.

The Kit

The Velleman kit is contained in a substantial plastic packing box and includes all the electronic components necessary to construct the finished PCB assembly. To assist in its construction, three separate instruction booklets are provided; these being English and continental building information and multi-lingual component identification. Not included in the kit though is the mains power supply transformer or loudspeaker. This is because of the differing requirements that may be placed upon the basic unit in any given situation, more about this later.

PCB Assembly

The assembly instructions provided with the kit are brief, and assume a certain amount of constructional knowledge on the part of the kit builder. If you require additional information about soldering and assembly techniques, they can be found in Maplin's own 'Constructors' Guide', stock code XH79L. Removal of a misplaced component will be fairly difficult, so *please* double-check each component type, value, and its polarity where appropriate, before soldering! The PCB has a legend to help you correctly position each item; see the back page of the Velleman English building booklet.

Power Supply

Owing to its relatively high standby current (75mA maximum), the Watchdog is not suited to long term battery operation. The two recommended supply methods are from 240V AC mains supply transformer, or a 9 to 12V unregulated DC power unit. The transformer specified by Velleman has an 8–0–8V secondary at 400mA; Maplin cannot supply a transformer with this precise specification but recommend 6–0–6V at 500mA (stock code WB06G). When using mains transformers you *must* follow all the relevant safety precautions to avoid electric shock! For this reason, it is much safer and more convenient to use a ready made DC power supply, such as the unregulated 300mA type (stock code XX09K). Although only rated at 300mA, it nevertheless is more than capable of supplying the quoted 400mA maximum peak current consumed by the Watchdog when barking. Both sets of power supply connections are shown in the wiring diagram, see Figure 2.

Loudspeaker

The range of loudspeakers to choose from is vast, but whichever you choose, it only has to match, or exceed, the following specifications:

2 Watts, 4 or 8 Ohms, Low-cost round or elliptical.

The Maplin catalogue has a large section dedicated to loudspeakers, and several are suitable for the Watchdog project, here are just a few:

3 Watt	elliptical	GL16S
6 Watt	elliptical	GL17T
3 Watt	low-cost	YJ16S
6 Watt	low-cost	GL12N
5 Watt	mylar	YN01B
10 Watt	mylar	YN02C

To improve the acoustic performance of any of the above speakers, they must be housed in a suitable cabinet. For convenience and durability, the 10 Watt horn speaker (stock code XQ73Q) offers high sound output without the need to be placed in an enclosure.

Wiring

The only wire included in the kit consists of two short lengths of tinned copper wire used for the PCB links ('jumpers' J1, J2, J3, and J6). The amount and type of additional off-board wiring is determined by your

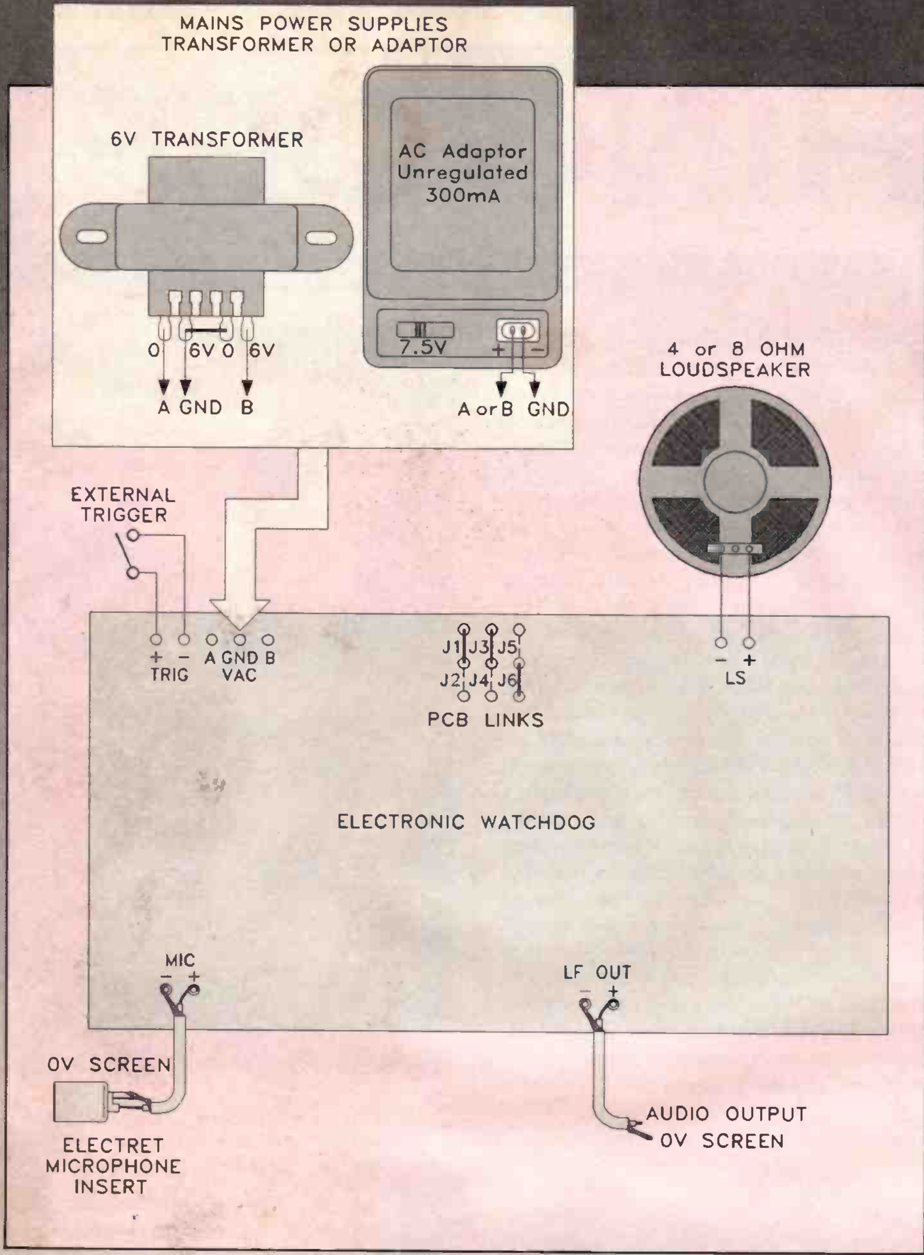


Figure 2. Wiring diagram.

particular installation requirements. Once again, the Maplin catalogue has a section which covers a large range of cables and wires. Here are just a few that could be of use in this project:

3-Core 3A Mains cable black XR01B (sold per metre)

Zip connecting cable XR39N (sold per metre and ideal for loudspeakers)

Single-core lapped screen cable black XR12N (sold per metre and ideal for general audio connections)

Hook-up wire (7/0·2) black BL00A (sold per ten metre pack for general interconnections)

A wiring diagram showing all the interconnections is given in Figure 2. When using mains cable, follow all the normal safety precautions to avoid electric shocks.

Testing

The test procedure given in the Velleman instructions are very basic and do not involve the use of any test equipment. However, if you do decide to take some instrument readings you might find a significant difference between your results and those given in the Velleman booklet! This is because the type of power supply, loudspeaker and test meter used will influence the measurements you obtain. In addition, the individual specification and tolerance of the components used in the kit will have a combined effect on the results. The following test results were obtained using a +12V DC power supply, 4 Ohm speaker load and a digital multimeter:

Velleman Technical Data	**Maplin Test Results**
Supply current:	
standby, 75mA	16mA
barking, 400mA max	270mA max

VELLEMAN ELECTRONIC WATCHDOG PARTS LIST

RESISTORS		
R1	330Ω	1
R2-5	10k	4
R6	200k	1
R7-9	1k	3
R10-13	4k7	4
R14-17	47k	4
R18	220k	1
R19	10Ω	1
R20	2M2	1
R21	56k	1
R22-29	2k7	8
R30-38	100k	9
R39-45	51k	7
RV1	4k7 (or 5k) Preset	1
RV2	2M2 (or 2M5) Preset	1
RV3	22k (or 25k) Preset	1
RV4	470k (or 500k) Preset	1
CAPACITORS		
C1	100pF Ceramic	1
C2,3	10nF Ceramic	2
C4	3n9F Ceramic	1
C5,6	47nF Ceramic	2
C7,8	100nF Poly Layer	2
C9-11	100nF Monores	3
C12,13	10μF Electrolytic	2
C14	220μF Electrolytic	1
C15	1000μF Electrolytic	1

SEMICONDUCTORS		
D1-5	1N914 (or 1N4148) Diode	5
D6-7	1N4000 Series Diodes	2
TR1	BC547 (or BC548, BC549)	1
TR2	BC557 (or BC558, BC559)	1
IC1	324	1
IC2	4093	1
IC3	4040	1
IC4	VLK2655	1
IC5	4015	1
IC6	4077	1
IC7	386	1
MISCELLANEOUS		
	DIL Socket 8-Pin	1
	DIL Socket 14-Pin	3
	DIL Socket 16-Pin	2
	DIL Socket 28-Pin	1
	PCB Pins	10 (8 used)
	Wire Links	3
	PCB	1

The Maplin 'Get-you-Working' Service is available for this project.
The above items are available in kit form only.
Please note that specific project items (e.g. IC4, PCB) are not available separately.
Order As VE85G (Velleman Kit K2655) Price £29.95.

FINISHING OFF

PART ONE
by David Smith

In the next few seconds, you are going to make a decision; the outcome of which will depend on your personality – i.e. whether you are the sort of person who likes to finish off a project by trying to make it appear as professional-looking as possible, or the sort that 'couldn't care less what it looks like, as long as it works!' To the latter, GOOD-BYE! To the rest of you, read on.

Most of you reading this magazine will have built, or perhaps are about to build in the near future, an electronic project of some kind. Unless you have bought the project as a kit (with a case included), you will probably be designing and housing it yourselves, in addition to choosing the control knobs and switches. It is with these thoughts in mind, that this series of articles has been produced.

Presentation is Everything

All too often a project, be it for yourself or for someone else, can end up as a disappointment; not because it failed to work, but because when completed it didn't look 'professional' enough. You may then ask "what do we mean by that statement?"

Take a look at Photos 1(a) and 1(b). Each shows the same finished project housed in a plastic case. (As you may have guessed, it is only a fictitious project.) However, Photo 1(a) illustrates the way in which many people may have finished it off, whereas Photo 1(b) shows just how much of an improvement can be achieved with a little extra thought and effort. It is not the *only* way to finish off a project – of course, there are many others. However, before we proceed any further, I would like to point out that there is no intention whatsoever to degrade 'DYMO' labelling *per se*, or any of the other components shown in this illustrative photograph, come to that! They are used erroneously here, and purposefully so, simply to show how *not* to utilise them. Furthermore, there is no point in any of us even trying to emulate the superb finishes that are offered on many professional products. Manufacturers pay out enormous sums of money for all sorts of machinery in order to obtain such quality. If there

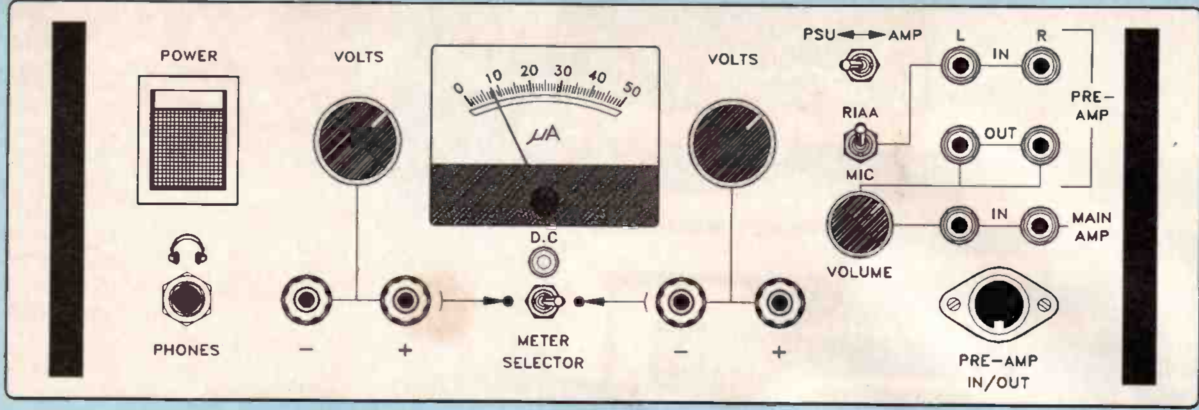
1a

1b

Photo 1(a). Example of poorly-made control box.

Photo 1(b). Example of well-made control box.

A small selection of the cases (and accessories) from the extensive range featured in the 1992 Maplin Catalogue.



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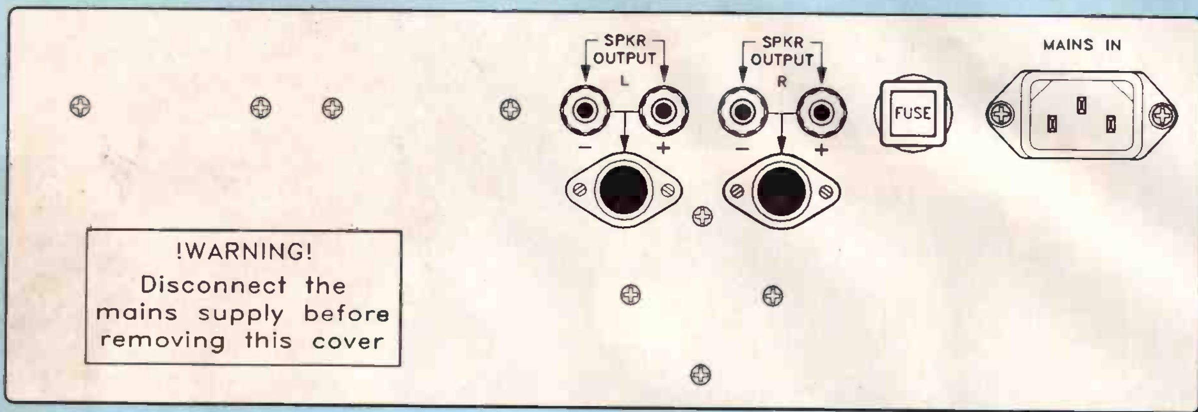

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Figure 1. Front view of the completed test amplifier/PSU.
Figure 2. Rear view of the completed test amplifier/PSU.

was a cheaper way, they would certainly pursue it. They do, of course, recoup this investment by selling their merchandise in rather large quantities. No need to be despondent though; there is a large variety of products on the market available to the amateur constructor that will enhance a project's appearance enormously. We will be taking a look at many of these over the next few months.

So, let's get started by examining a project that will help us to study, in more depth, the various aspects of design and constructional techniques that are required if we want to achieve a more professional-looking finish to our end product.

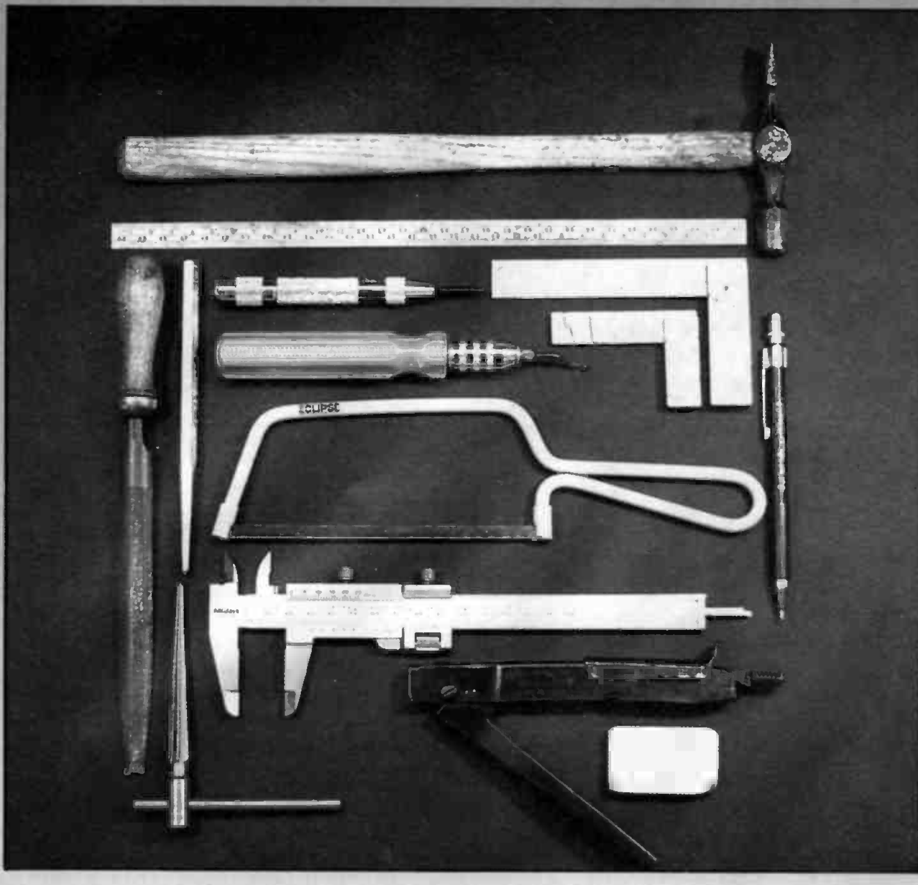
We are going to build a high-quality stereo bench test amplifier and power supply unit, the front and rear views of which are shown in Figures 1 and 2 respectively. The power amplifier is capable of delivering up to 15W RMS per channel. There will also be a stereo preamplifier, with both microphone and phono inputs, and a power supply unit capable of supplying a variable output voltage from 1·2V to 30V, at up to 500mA. However, on our project, there will be two independently-controlled outputs, each capable of supplying up to 300mA. The voltage available at each output can be monitored independently via a meter and selection switch. All inputs and outputs will be brought out to either the front or rear panels, thus allowing access to all the facilities on offer. The electronic hardware is based around Maplin kits. The kits in question are: a stereo preamplifier (LM68Y); two 15W power amplifiers (YQ43W); and a power supply module (LK90X). Specifications for each kit are given in Table 1. The finished project will be housed in a suitable metal case, so let us start by choosing just such a case.

A Case in Point

Choosing a suitable case in which to enclose your project can be difficult, with so many types to choose from. However, they generally fall into

PREAMPLIFIER	
Input impedance:	47kΩ approx.
Input sensitivity	
RIAA Preamp:	200mV output for 5mV RMS input @ 1kHz
Mic Preamp:	400mV output for 5mV RMS input @ 1kHz
Max. input voltage	
RIAA Preamp:	230mV input for 9V RMS output @ 1kHz
Mic Preamp:	115mV input for 9V RMS output @ 1kHz
Total harmonic distortion:	0·005%
Output load impedance:	Not less than 5kΩ
Power requirements:	30V at 3mA rising to 30mA max
Frequency response:	30Hz to 20kHz ±2dB
MAIN AMPLIFIER	
Supply voltage with no signal:	36V absolute maximum
At full power:	24V min. (for 14W into 4Ω): 30V maximum
Short circuit duration:	Continuous
Thermal characteristics:	Shuts down at 110°C (case temp)
Total harmonic distortion:	0·1% (0·1W to 10W)
	<5% (10W to 14W)
Input sensitivity:	250mV for full power out
Frequency response:	10Hz to 140kHz (−3dB)
POWER SUPPLY	
Output voltage range:	1·5V to 30V DC
Ripple rejection:	80dB
Output current	
Single output:	500mA
Dual output:	300mA each output
Short circuit protection:	Built into the regulator IC's

Table 1. Specifications of kits used in this project.



two categories, i.e. metal or plastic.

Initially, you should think about the environment that your project is likely to be used in. You have to determine if it will be a hostile one, such as beneath a car bonnet, or in a factory where it may get covered by chemicals or spray. If this is so, then you need to consider using one of the specialist range of Maplin cases that have a neoprene washer fitted around the lid. This is used to protect the electronics housed inside from any contamination. They are also fully waterproofed, and are manufactured from a self-extinguishing, light grey thermoplastic material, which is highly resistant to impact, heat, chemicals and atmospheric agents. There is also one model which has a clear plastic lid. This enables you to see inside the case, whilst still keeping the contents safe – ideal for situations where you have to read a digital display, or check a meter.

Next, your case should be robust enough for its intended purpose. If your project is likely to be subjected to rough treatment, there are some really sturdy cases available, although these do tend to be less attractive. For projects destined for use around the home, it would be better to choose a less technical-looking box. Of course, if you are living alone, you only have yourself to please, so feel free to build that electronic egg-timer into a 19in. rack system!

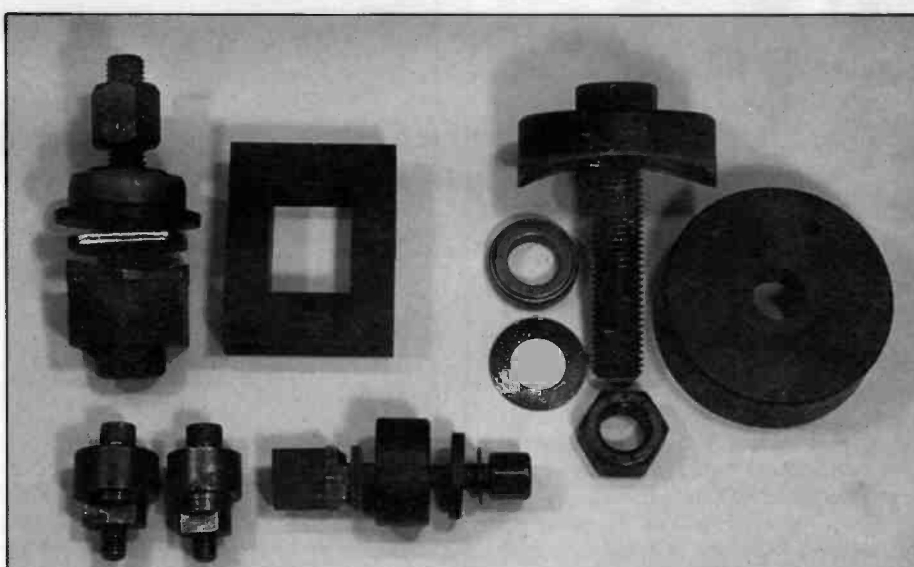
Speaking of 19in. rack systems, Maplin sell an extensive range. If you don't know about 19in. rack systems, these are basically a type of enclosure which conforms to a worldwide industrial standard, having a set of fixing holes that are placed 19in. apart. This enables every rack-mounting case, of the correct width, to fit into any 19in. rack, anywhere (assuming of course that there is enough space in the rack to accommodate the unit's height!) The front panel height is described as being so many 'U's high, where 1U = 44mm, 2U = 88mm, 3U = 132mm, 4U = 177mm, and so on.

The enclosures are of a high quality, and have many add-on accessories to choose from. If you are constructing a piece of equipment aimed at the professional market, be it broadcasting, the theatre or the music industry, then you should seriously consider building such a project into a 19in. enclosure. This will make it easier for the end-user to integrate it with existing equipment.

In addition to 19in. rack systems, many other cases are available which incorporate a number of internal slots or mouldings. These enable printed circuit boards to be fitted either horizontally or vertically. If you have such a case, and it has slots travelling in the direction opposite to the way you want them to travel, then PCB guide adaptors (e.g. Maplin order code YR72P) are available to rectify the problem. These, however, are only suitable for certain types of cases – so check the latest Maplin catalogue for details.

If you are building a project that runs off the mains supply, and only utilises a minimum number of components (such as a power supply for low voltage equipment), then consider using one of the PSU boxes which has an integral 13A plug as part of the moulding.

So what criteria were used to choose the enclosure for our example project? Well, initially we thought that it would have to withstand a reasonable amount of knocks and scuffs, because it is destined for use as a piece of bench test equipment. Therefore, it was decided that a metal case would be appropriate. The overall size of the case was determined, by first assessing the size of each PCB board that had to be fitted inside, and secondly by taking into account the space required for all the various controls, plugs and sockets which were needed on the outside. It was also useful to choose a case which offered a separate inner chassis. This is because internally, space is limited and it would be easier to pre-assemble and wire up each part of the project before fitting it into the main case. Hardware for enclosures is abundant; Maplin offer a large selection of feet, handles, ventilation grilles, hinges, trim and much more, which



Above: A selection of metal-working tools.
Right: A selection of chassis cutters.

will enhance the appearance of your project. Obviously, handles and hinges must be strong enough to take the full weight of your case, and ventilation grilles must be large enough to let through sufficient amounts of cooling air.

Should a case prove heavy to lift, then carrying handles are a useful addition. Generally, a 19in. enclosure always has handles fitted, to enable it to be pulled out of a rack at any time. Interestingly, because of this fact many manufacturers now fit handles, as standard, to their consumer products, in order to make them look professional. So, with a little careful thought, there is no reason why you should not enhance the appearance of your own project by doing the same. They may not be entirely necessary, yet it is surprising how much visual impact they can provide. You may have noticed that the project we are about to build has handles fitted to the front panel. In this case, they are not *absolutely* necessary, but I think you will agree that they do augment the overall appearance of the design. To be fair, they could provide some protection to the switches and meter if this piece of test gear is accidentally dropped onto its face, or has some other large piece of equipment pressed up against it whilst it is on the work bench.

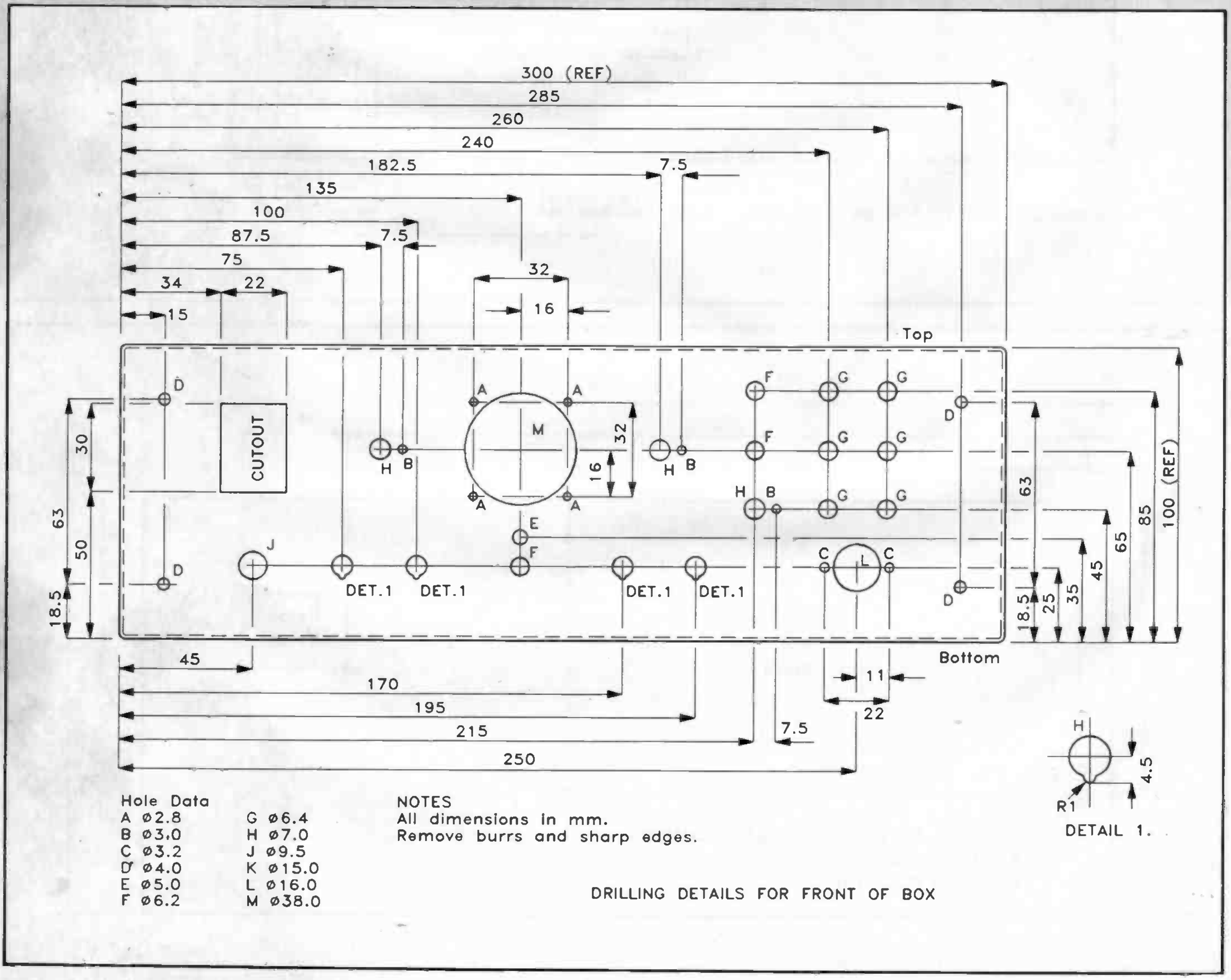
Regarding the choice of case colours, these tend to be fairly neutral. There is nothing wrong with this of course, and most people find the range of colours offered quite suitable for their needs – so don't worry too much if a manufacturer cannot supply the colour you prefer for your project. In a future article, we will be taking a closer look at how to choose the correct colour scheme for your project and how, if necessary, you can go about changing the colour of an enclosure to suit your preference.

Drilling Holes

You could be forgiven for thinking that when it comes to drilling holes, there is very little to be said on the subject. However, one of the most glaring faults on home-made equipment is the positioning of holes; not only in their relative position to each other, but also their lack of accuracy when drilled. It is a fact that, when drilling a line of holes, a discrepancy of only 1mm can sadly mar, what could have otherwise been, a first-rate project. Family or friends may often find it difficult to ascertain why a project looks less than professional in its appearance – the reason could well be inaccurate hole drilling. So how do we go about attaining a higher degree of accuracy? Even if you have been very careful in measuring and marking exactly where each hole should be (see Figures 3 to 5 inclusive), you will find that as soon as you place the drill onto any surface, it will have a tendency to skid about on the work-piece. To counteract this trend, you will need the help of a centre punch. Maplin sell both a manual (FA67X) and an automatic one (FS96E). To use the manual model, place the tip of the punch carefully over the point where the hole needs to be drilled, and give it a sharp tap with a small hammer. This will make a small indentation in the surface of the box. Now when the drill is rotated on that same spot, it is less likely to slip sideways.

If you're using a hand drill, it is important to continue rotating the drill in the *same* direction at the instant you break through to the other side of the work piece. I say this, because a manual drill becomes much harder to rotate at this moment, and there is a temptation to make life easier by reversing the direction of the drill, in order to remove it. This is bad practice, and

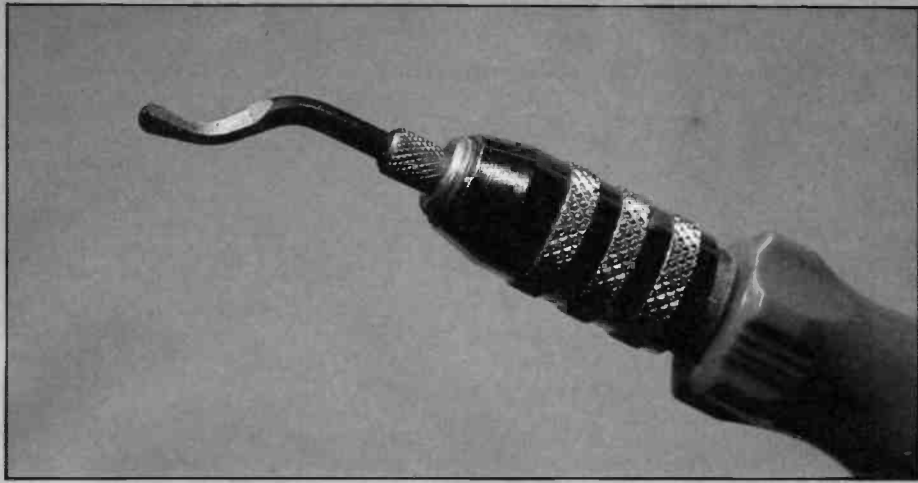
Figure 3. Drilling details for the front of the case (Case Code No. XY49D).

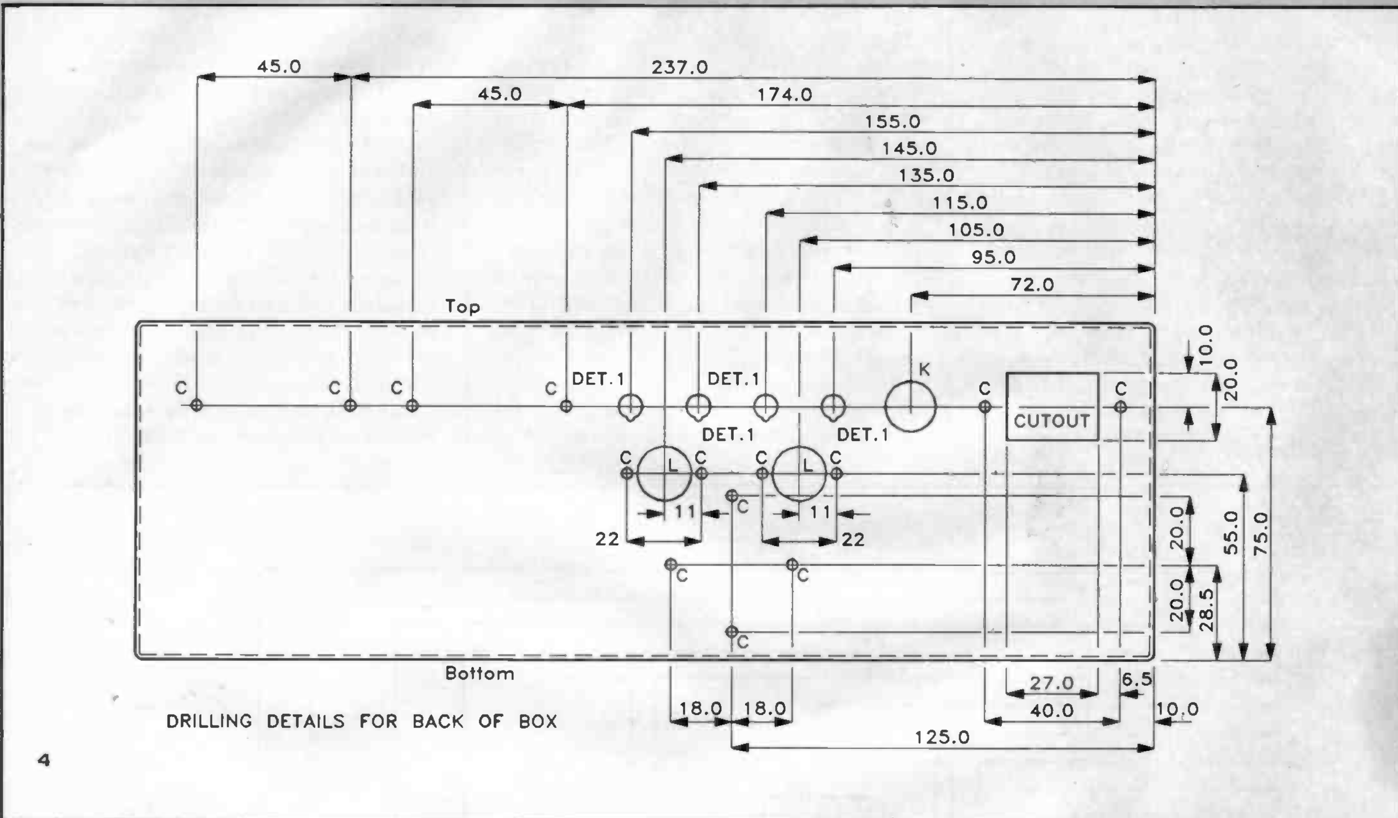


will certainly result in a jagged edge being formed around the hole. Of course, if you are using an electric drill to perform this task, then you will not have this problem. Ironically, it is because electric drills make the drilling of holes so easy, that there can be a tendency to allow the drill to rotate within the hole for far too long a period, thus creating a slightly larger hole than intended.

If it is a fairly large hole that you

Right: Photo 2. A special tool used for deburring holes.
Figure 4. Drilling details for the rear of the case.
Figure 5. Drilling details for the metal inner chassis.





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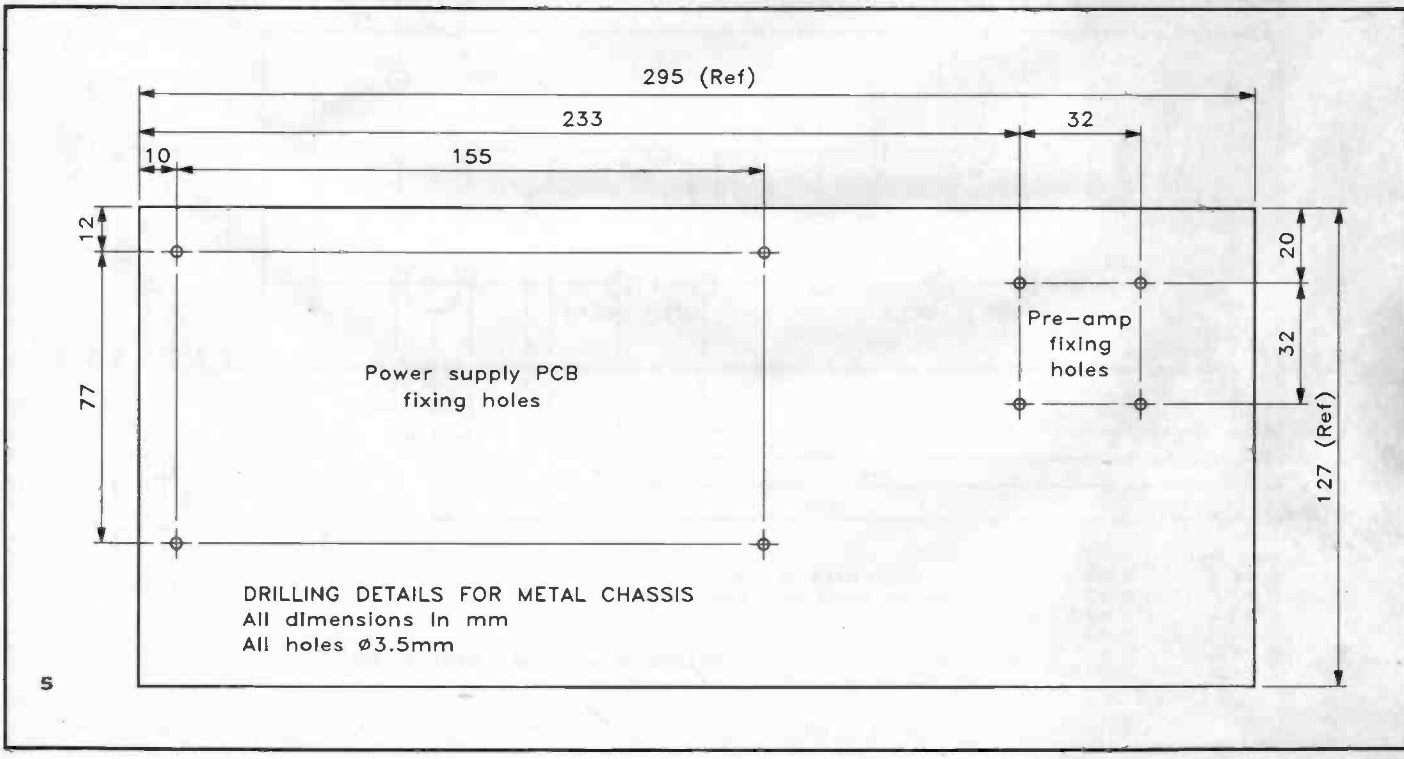

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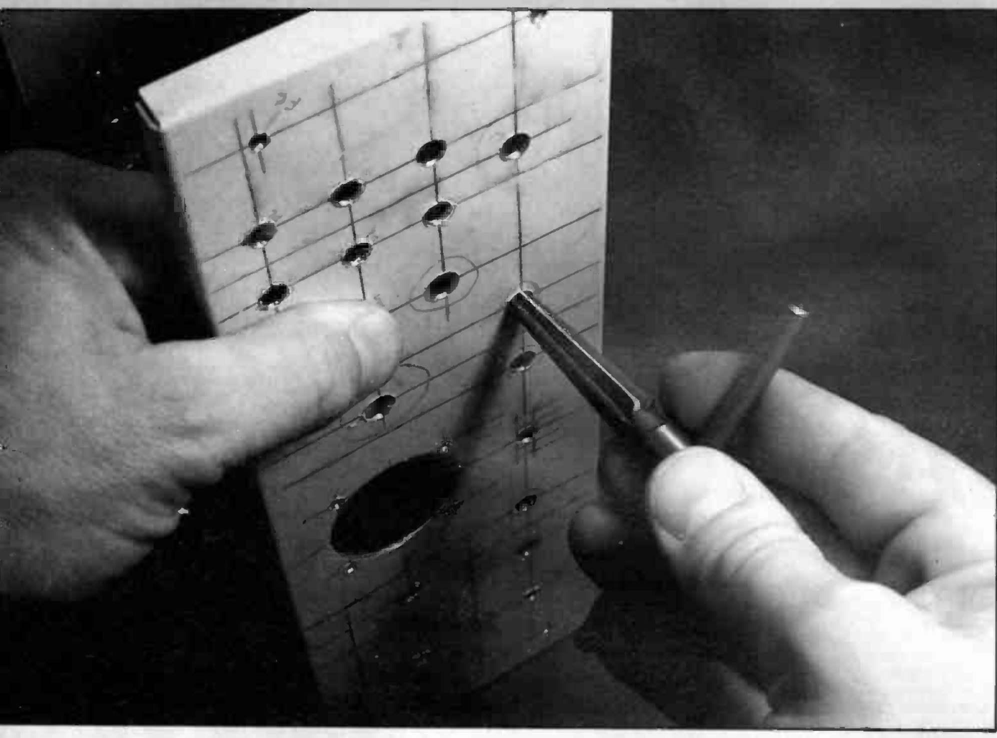
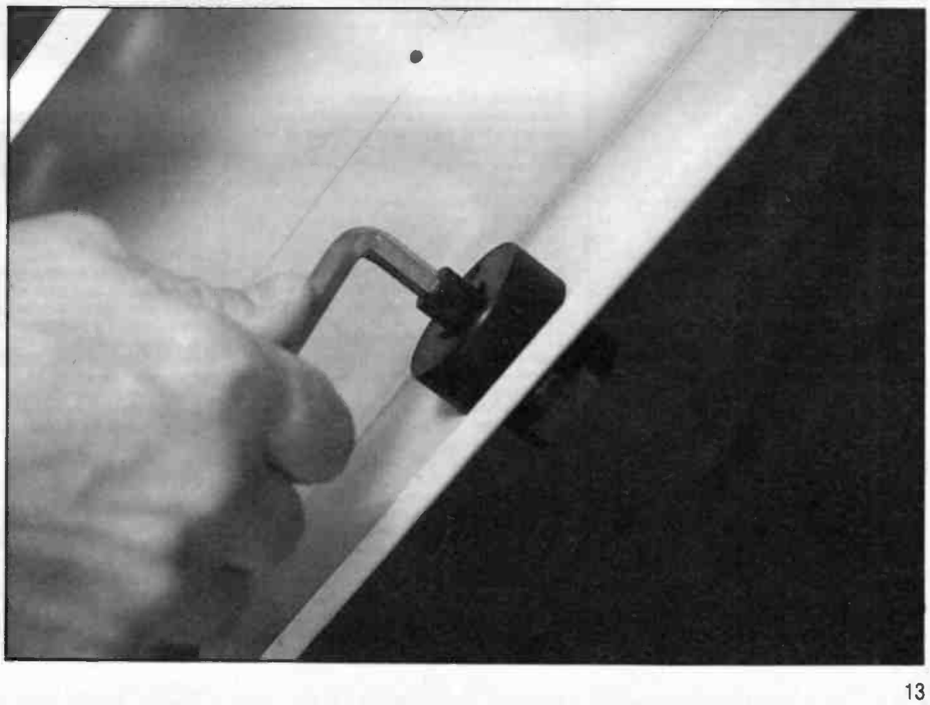
wish to make, you need to initially drill a pilot hole using a much smaller bit. For example, if you require a hole with a diameter of 10mm, first make a hole of only 2mm, then enlarge it with a 6mm bit, followed by a a 10mm bit. Progressing up in steps like this produces not only a more accurate hole, but also causes less damage to the work-piece. Try the two methods on a scrap piece of metal, and see the difference! After drilling the hole, a closer inspection may reveal that it is still not clean around its edge. Little jagged splinters may be sticking out, and the finish around the hole can look fairly rough close-up. To help clean it up, there is a knife made especially for this purpose, which consists of an unusually-shaped rotatable blade fitted on a thick handle (shown in Photo 2). The idea is that you place the knife blade into the hole, and rotate it around the edge of the hole a few times to cut away any jagged bits. These knives can be expensive and a much simpler method, though nevertheless just as effective, is to use a drill bit. It has to be a few millimetres larger than that of the hole you wish to clean up, and the trick is to seat the drill bit into the hole and give it a few turns, as shown in Photo 3. The sharp cutting edges of the bit act as a knife and thus clean up the edges of the hole. This should be done to both sides of the hole.

Sometimes you will need to provide a hole that is of a size impossible to cut with the range of drills you have in your possession. For those eventualities, buy yourself a reamer. This effective device (shown in Photo 4), is used for opening holes out to non-standard diameters. Maplin sell a hand operated one (FG11M) which will cover holes from 3mm up to 12mm (⅛in. to ½in.). It is made from carbon-chrome alloy steel, and may also be useful in hole deburring.

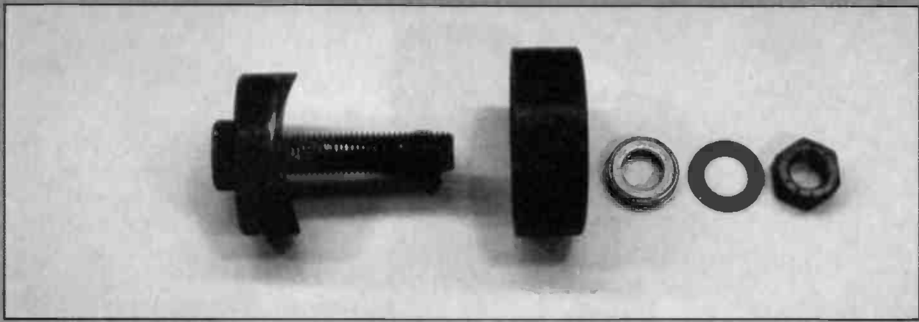
Of course, sometimes even the largest twist drill in your collection will prove to be too small for certain jobs. Take, for instance, the hole required to accommodate the panel meter on our project, which requires a panel cut-out of 38mm (1·5in.). We could, of course, drill a series of small holes in a circular pattern and then, using a small file, cut between the holes. This is a very time-consuming method, which would also leave an exceedingly jagged hole. We would then have to spend yet more time filing it clean.

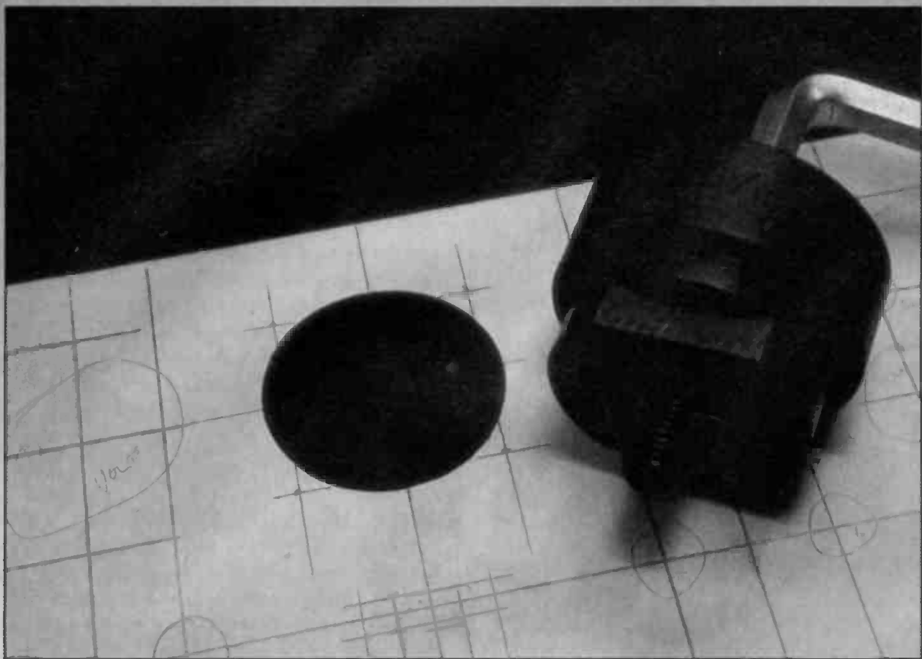
Another, perhaps easier, method would be to drill a single hole large enough for a hand nibbler to fit through, and then cut your way around the circumference of the meter hole. The hand nibbler that Maplin supply (FG09K) will not only cut metal to any shape, but can also be used for trimming and notching. It has a maximum thickness cutting capacity of 0·6mm (for sheet metal) or 1·6mm (for soft metal). However, the best way to cut the 38mm hole for our meter is to use a chassis cutter (shown in Photo 5). These may be expensive, but wow! – do they save you time and energy! If you haven't come across one before, a chassis cutter is a multi-part device consisting of a cutter, cutting guide, washer, nut and bolt (see Photo 6). Some of the heavier duty chassis cutters feature a ball-race which makes turning their nut (or allen key) that bit easier. When cutting the meter hole, first drill a pilot hole to take the cutter's bolt.





Right: Photo 3. Deburring a hole using a high-speed twist drill, slightly larger in size than the hole in question.
Below: Photo 4. Using a reamer to enlarge a hole.
Bottom right: Photo 5. Using a circular chassis cutter to cut a hole for the panel meter on the front of the case.





Left: Photo 6. A circular chassis cutter showing its various parts.
Bottom left: Photo 7. This shows how clean the panel meter hole has been cut, using a circular chassis cutter.

Then, once you have assembled its various parts on either side of the metalwork, carefully check they are in the correct order before finger-tightening the bolt. The cutter assembly will now grip the metal sheet securely, so all that is left to be done is to give the nut a few turns until the cutter breaks through to the other side – and hey presto!, the job is finished. Photo 7 shows the standard of finish attainable. As I say, chassis cutters do not come cheap, and perhaps £20 to cut one hole in a piece of metal may seem a bit much to pay; but remember that you have the cutter for life and, over the years, it will more than pay for itself in saved time and effort – and provide beautifully cut holes at the same time! Chassis cutters are available from all good tool shops, and come in a variety of shapes and sizes.

Next month we will be concentrating on the inside appearance of our project, and in building the actual kits. In the meantime, you have a case to drill! So take your time, and remember – accuracy is vital if you want your project to take on that all-important professional finish.

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HITACHI CSK 702E Car Radio/Cassette with RDS, Dolby, 30 presets etc. Removable for security. Cost £400. Any reasonable offers? Tel: Ian (071) 274 5602.

LM13P PROXIMITY DETECTOR. Completed and working. Also an LW83E ultrasonic detector, completed but not working. Both items in good condition, £8 each. Write to: M. Hyland, 45 Amberton Road, Leeds, LS8 3AJ.

FOR SALE, 6 channel alarm panel (YH57M, 1991 Maplin catalogue) New, unused and boxed. Battery included. £70 o.n.o. Write to M. Hyland, 45 Amberton Road, Leeds, LS8 3AJ.

OSCILLOSCOPE AND AF SOINAL GENERATOR, £50. Tel: (081) 472 5929.

FOR SALE: Collins In-Car Subwoofer Tube (inc. Amp) £75. MAPLIN Disco unit, Part Assm., Box slightly damaged, £120. Tel: Giles (0272) 623611 evenings.

REVOX A77 (7½/15 ips) recently serviced, £250. NJD Logic 4000 Lighting Controller, £100. Citronic CS300 Turntable inc. Stanton 500 cart. £85. Various Maplin Stereo Mixer Modules (assembled). Tel: John (0359) 51258.

GIANT CLEAROUT! Long list of unused components including ICs, capacitors, resistors, some in large quantities. All at bargain prices. Send S.A.E. for list to: M. J. Dean, Blenheim, Walton Lane, Bosham, Chichester, West Sussex, PO18 8QF.

MASSIVE CLEAROUT! HITACHI 20MHz Scope £100. Signal Generator £100. 4A digital bench PSU £80. Frequency counter £100. 7 Pairs Bancho pliers £50. Modern Amateur Electronics manual, 3 volumes £50. Over 1000 ICs with 128 drawers £100. Over 10,000 capacitors and other components £100. All above £500. For details, Tel: (0638) 750661 after 7pm or at weekends.

SCOPEX 4D10A 10MHz Dual Beam Oscilloscope £130. Heathkit V-7AU multimeter £23. Portable stereo graphic equaliser £25. Ultrasonic remote control switch £17. Computer-compatible cassette recorder £16. Tel: (0502) 566026.

LED OSCILLOSCOPE/SIGNAL INJECTOR MODULE, built but requires case. Green display, battery operated. £19 and £5 post. 137 The Crescent, Slough, Berkshire, SL1 2LF.

FOR SALE, JVC Double Cassette Mechanism. Full logic switching of all functions. Full auto reverse on both decks. Sendust heads. £50. Tel (0254) 760003.

PANASONIC NV850 Hi-Fi VCR with recent new 5-head drum, pinch roller and belts. Converted for Nicam reception. Remote control included. £175, or will exchange for IRD satellite receiver (not Amstrad). Tel: (0272) 685767 evenings (Bristol).

SONY ICFSW7600 RECEIVER. 150 to 29995kHz and 76 to 108MHz, SSB, 4 way tuning. Used about 4 hours. Not suitable for me. £140. Tel: (0475) 23008.

TYPE 317 OSCILLOSCOPE, Tektronix, made around the sixties, round CRT, excellent condition and working order. £30. Tel: (0628) 781971 (Maidenhead).

MAPLIN XG93B audio signal generator, 10Hz to 1MHz. 1991 price was £89.95 – with manual £42. Advance E2 RF Signal Generator, 100kHz to 100MHz with manual £24. Marconi RF voltmeter £14. Much other Test Gear. Early valve books and manuals. P/Ex. considered. Tel: (0425) 610669 (Hants).

RETIRED ENGINEER has for disposal the following: Maplin stereo amplifiers (150W MOSFET, 50, 15W). All complete; with PSU and metal cabinets. Beomaster 901 tuner/amp, HA1397 20W stereo amp, Telefunken 301 tuner/amp, speakers, record decks. Offers to: C. J. Gates, 97 Craven Road, Newbury, Berks., RG14 5NI

WANTED

ELECTRONICS ENGINEER REQUIRES: Loan or purchase of service manuals and circuit diagrams for any type of keyboards/organs, especially Wersi. Tel: Brian (0493) 728923.

SIX MULLARD TDA1028 and four TDA1029 audio switch ICs (these are obsolete). F. D. Cosgrove, 59 Fenton Road, Bournemouth, BH6 5BS. Tel: (0202) 432973.

ARCHIMEDES MOUSE! Only mechanical parts needed – just base will do. Must be in good condition/working order. For more information. Tel: (0754) 767890 after 4pm, or at weekends.

INFORMATION OR CIRCUIT for Computadrum, for connecting up to manual triggers and a memory sequencer System – for GCSE Electronics project. Please write to: Simon Fraser, 165 Baldwins Lane, Croxley Green, Herts.

MUSICAL

RESONANCE 1: Cassette tape of classic masterpieces reinterpreted on synthesisers by David Howard and Alan Wilson. £7.50 (and 50p for P&P) from: David Howard, 61 Fountayne Street, York, YO3 7HN.

KORG 13-NOTE PEDAL BOARD with flight case. Self-contained unit (not MIDI). With control box. Will enhance any keyboard. £120. Tel: James (0202) 391252. Answerphone.

COMPUTER

BRING YOUR COMPUTER STORAGE UP TO DATE. Optical disc drive with 800Mb capacity. Rewritable (WORM). £300 Tel: (0254) 760003.

FERRANTI A400 COMPUTER (IBM Compatible). Six slots, CGA video, 5¼in. floppy, 25Mb HD, two power supplies. Needs attention £100. Tel: (0254) 760003.

BLANK EPROMs: 2716, £2; 2732, £2. Keyboard/parts from CBM PET, £6. Keyboard from Lynx+ Terminal, £5. Push switches + caps, 10p each. Tel: John (0704) 530323. Weekdays after 4pm.

PC MULTI-PROCESSOR universal cross-assembler, over 20 processors included. Tel: Darren (0908) 542542 after 6pm.

MICROSOFT WINDOWS GRAPHIC ENVIRONMENT. For PC-XT or PC-AT running MS-DOS 3·1 or later. Price £130. Original installation disks with user manual. Send a S.A.E. to: Martin, 11a Barkhams Lane, Littleport, Ely, Cambs., CB6 1NN.

CLUB CORNER

TESUG (The European Satellite User Group) for all satellite TV enthusiasts! Totally independent, TESUG provides the most up-to-date news available (through its monthly 'Footprint' newsletter, and a teletext service on the pan-European 'Super Channel'). It also provides a wide variety of help and information for its members. For further information, contact: Eric W. Wiltsher, TESUG, Rio House, Stafford Close, Ashford, Kent, TN23 2TT, England.

THE BRITISH AMATEUR ELECTRONICS CLUB (founded in 1966), for all interested in electronics. Four newsletters a year, help for members and more! UK subscription £8 a year (Junior members £4, overseas members £13.50). For further details, send a S.A.E. to: Mr. H. F. Howard, 41 Thingwall Park, Fishponds, Bristol, BS16 2AJ.

ELECTRON UK – the electronics club for the enthusiast, now welcoming new members!! News, views, competitions, projects and loads more. For more information, send a S.A.E. to: Electronics UK, 48 Lancing Park, Sussex, BN15 8RF.

A readers forum for your views and comments. If you want to contribute, write to: **The Editor, 'Electronics – The Maplin Magazine' P.O. Box 3, Rayleigh, Essex, SS6 8LR.**

Dear Editor

AIR YOUR VIEWS

STAR LETTER

This issue, C. Panteli from Streatham, London, receives the Star Letter Award of a £5 Maplin Gift Token for his letter, on pre-recorded sounds for alarms in cars.

Meow, Woof!

Dear Maplin Mag,
I have a suggestion for a future project, where the existing Maplin speech playback system could be incorporated into a car alarm system, whereby pre-recorded sounds would be emitted instead of the usual siren etc. The difference being that animal noises could be replayed instead. How many times have we heard a car alarm go off and not bother to even look out of the window, believing it to be just another false alarm? The memories could be programmed with a range of specific sounds which could be custom made by the owner, so that if the car is tampered with and the owner is in earshot he/she will recognise the sound of their own car.

In this very issue there is a review of a Velleman kit called the 'Watchdog' which is along the lines you suggest, but is mainly for use as an aid to home security. Basically it imitates the barking of a large, excited dog supposedly situated somewhere in the house. Whether such a thing is applicable to a car alarm is debatable, since I suspect less people take any notice of barking dogs than of squeaking car alarms, unless they were trying to get into a house which might supposedly contain such a dog!

More Satellite Please

Dear Ed,
Congratulations on a great mag! I find the DIY projects excellent, and although I haven't attempted any, I find the ideas most interesting. Now to the main point of my letter. With the huge number of people with satellite systems, would it be possible to include projects for satellite buffs, as there aren't any in the satellite mags!
J. Evans (South Wales).

Thanks for writing – glad you're enjoying the mag. So without any more ado, let's get straight to the heart of your letter. If you're referring to pirate decoders (for Filmnet, etc), please forget it – or we'll find ourselves knee-deep in lawsuits, like another electronics magazine who did just that a couple of years ago! It wouldn't be worth it for Filmnet anyway – see last month's 'News Report'. However, if you have any specific ideas, or even designs, for satellite-related projects (such as tunable sound demodulators, SECAM to PAL transcoders and the like), then 'Electronics' would like to hear from you – there's no influence like public opinion! The above invitation does not just apply to satellite projects, of course. Interestingly, TESUG (The European Satellite User Group) is publishing details of an extremely low-cost motorised upgrade for 80cm fixed dishes – their address is given in 'Club Corner', see Classified section on page 14.

Crossing the Bridge of Time

Dear Sir,
The April Maplin Magazine arrived at exactly the right moment, just as I had resurrected my 1950's RC bridge, built to a 'Radio Constructor' design. Although it worked, and was convenient to use, I can no longer purchase Government surplus 60/1·5V HT/LT batteries to power the valve oscillator. I have had to use two power supplies instead.
Ray Marston's bridge energiser was just what I required, so having changed a DAF91 valve for a 741 op amp and fitting a PP3 battery, my bridge is usable again.
It is the first time that I have built a circuit from your magazine, on the same day that it arrived. Keep up the good work!
J. M. Chapman, Bradford.

There's a Bug in my Power Supply!

Dear Sir,
I would like to congratulate you for publishing Mr. Woodgate's brilliant series on Power Supplies. I have now altered your program to run on my Amstrad PCW8512, and have run it with the inputs given in Figure 12 with good results. Up to now, I have used a program based on an article by J. C. S. Richards in the August 1981 and March 1992 issues of *Wireless World*. After the good results with your Figure 12 inputs, I tried Mr. Richard's design example in which he gives results based on his prototype. The results of your program compare well with his readings, except for the reservoir capacitor's RMS ripple current, which is different by about 100% – can you please explain why this should be?
Roy Almond, Maidenhead.

John Woodgate replies:
I have tracked down the program line responsible for the ripple current, and it turns out to be an error of very long standing in typing in Mr. English's original program! Luckily, no reservoir capacitors have failed due to excessive ripple current in the meantime!
Basically, it is an error in calculating the ripple voltage, and the reason that the ripple voltage print-out is correct is that it is convenient in programming, for it to be calculated twice, in lines 510 and 1200. So line 510 should read:

```
510 VR=VM−VN:VR=FNround(VR,2)
```

The opportunity arises to make three more improvements. Deleting the single quote marks from line 880 (which mean PRINT in BBC BASIC) prevents one line of the print-out overrunning the page on LTR listing paper, if the error message comes up. So line 880 now reads:

```
880 IF RM>IA PRINT "SECONDARY CURRENT EXCEEDS RATED VALUE!!"
```

Also, it is necessary to reset flags in line 1050, otherwise reruns from the menu page do not work correctly:

```
1050 A=GET AND &DF:IF A=82 CLS:nopflag=TRUE:wflag=FALSE:rflag=FALSE:PROCindata:ENDPROC
```

Finally, line 600 needs attention, otherwise the DC output voltage regulation of doubler circuits is given unlikely values. Here, it is simplest to add another line as well:

```
600 IF TY=4 DCR=200*(SQR(2)*VS−VL)/VL:ELSE DCR=100*(SQR(2)*VS−VL)/VL

605 DCR=FNround(DCR,1)
```

This all goes to prove Woodgate's corollary to Murphy's Law, which is: 'Anything that cannot possibly go wrong, actually can'!

Totally Confused by Peritel

Dear Sir,
With reference to 'Electronics' issues February/March '91, thank you for the recent series on deafness related to electronics. I include some suggestions you might like to consider in the future.
As a deaf person I have a need for a very small amplifier which I could clip to my clothing or carry in a pocket. Many hobbyists would, I'm sure, like to produce such a device for their deaf relatives, and some deaf people like myself might have a go themselves!
How about more details about Peritel connections? I am grateful for the table on page 49 of the June/July '91 issue, but it would have been better magnified about 3 times! We do not all have telescopic vision. I feel many readers, including myself, would like a much longer article and more information about the use of this plug and socket system, and the parts you currently stock and how to use them.
For instance, how can pin 1, Audio Output B, be mono *and* stereo right *and* independent B at the same time? How is red video distinct from green? Even I may be a duffer, but I would really appreciate full details *with examples* of wiring a TV to one or two VCRs, stereo amplifier and other possible applications of the Peritel plug system.
E. Vernon King, Truro, Cornwall.

Firstly, if you can wait for the July issue 55 (out on June 5th), you will find therein the 'Microsonic' project, a small battery powered listening device such as you describe which includes AGC. For the Peritel problem, we are planning to compile a feature about interconnecting TVs etc. fairly soon, precisely because of the trouble people have dealing with these connectors. For instance, a brief explanation for the cited pin 1 problem is that it could be used three different ways depending on the equipment using it; mono sound TV or VCR, NICAM stereo TV or VCR, or a satellite receiver simultaneously fetching two sound channels in two different languages. Complicated, isn't it?

More Ready Made Chokes

Dear Sir,
As you suggested I have measured the inductance of some more reels of enamelled wire 'as supplied' from Maplin, with the following results: YN82D, 20 swg, 2·3mH; YN83E, 22 swg, 5·96mH; YN84F, 24 swg, 14·67mH. The figures are not really that accurate as the coils were resonated with a 1% tolerance capacitor for the measurement.
N. P. E. Wheeler, Sutton, Surrey.

You may remember that in last month's 'Air Your Views' Mr. Wheeler informed us that an 18 swg reel of ECW bought from Maplin was as near as possible to 1mH in value, and could be used in its entirety as an air cored choke.

Wrong Way Round?

Dear Editor,
I think that you have made an error with the nomenclature of valves ECC82 and ECC83 in your review of the Velleman K4000 stereo valve amplifier. In all the amplifiers that I have encountered that used that range of pf valves, the high gain preamplifier would normally be type ECC83, whereas the phase-splitter would use type ECC82.
J. B. Adams, West Midlands.

Alan Williamson replies: You are quite correct in stating that an ECC83 would normally be the input buffer, with the ECC82 being used as the phase-splitter, but not in this case. I can only assume that the reason behind this is that the K4000 was originally developed without the ECC82 input buffer. It was then found that the amplifier was 'input sensitive', so an ECC82 was added to the circuit.

LOW RESISTANCE CONTINUITY TESTER

FEATURES

- ★ Provides 3 Ranges of Resistance Indication
- ★ Buzzer indicates Lowest Resistance Range

APPLICATIONS

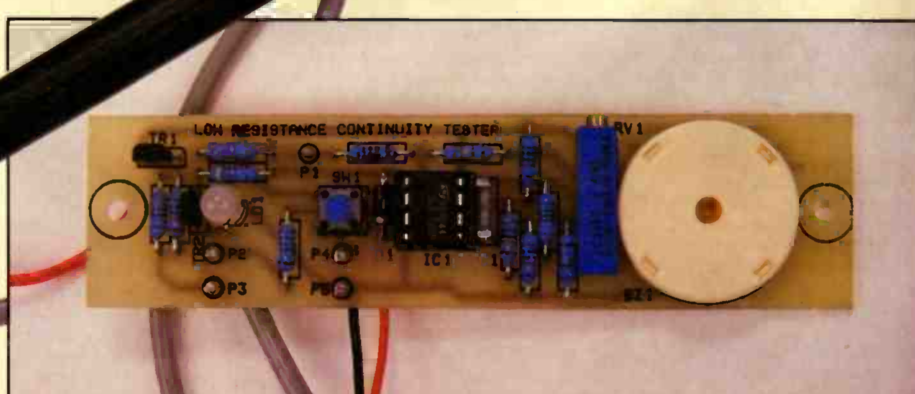
- ★ Tracking Faults
- ★ Continuity Testing
- ★ Testing Components

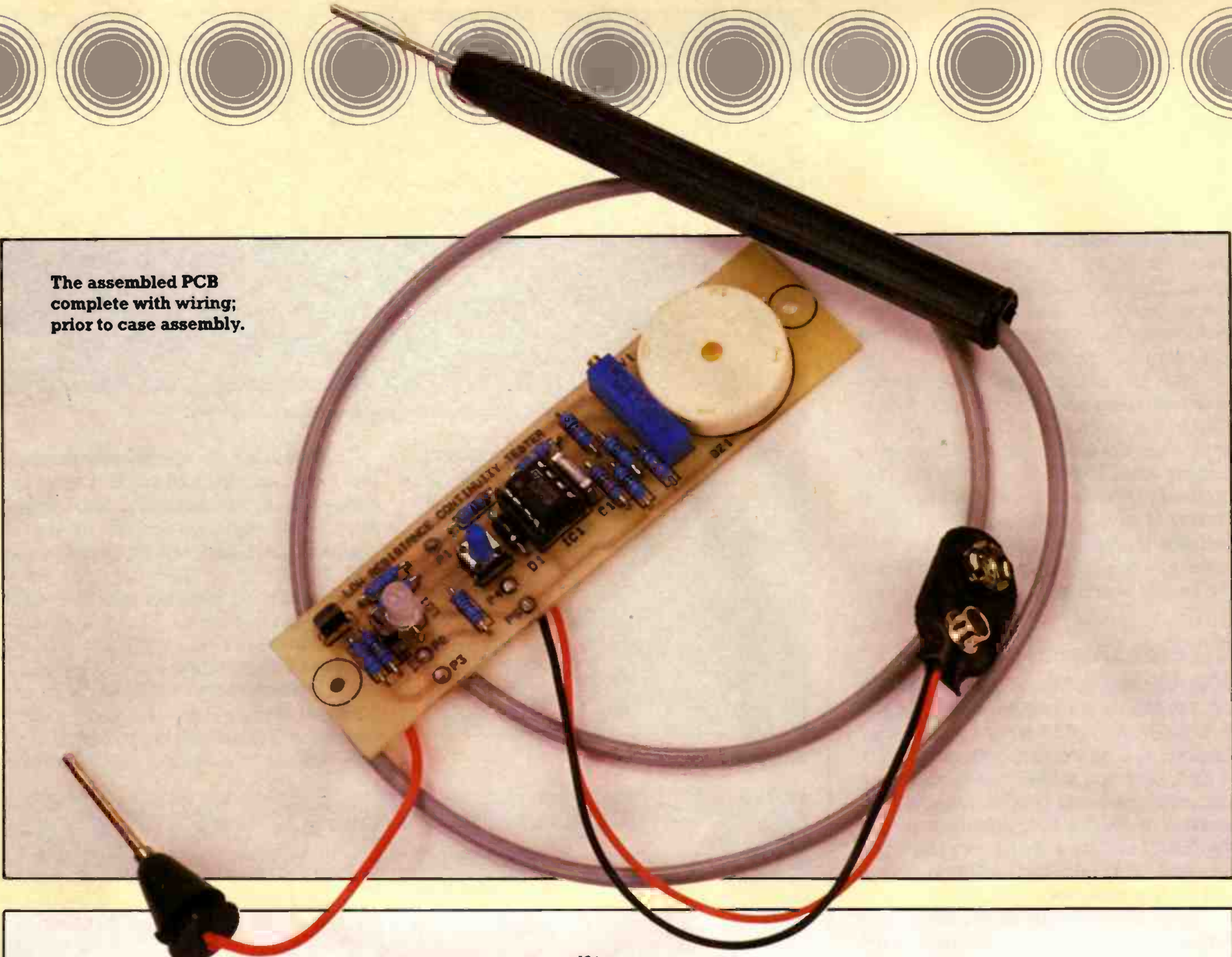
by W.H. Cornwell

◀ The finished Low-Resistance Continuity Tester.

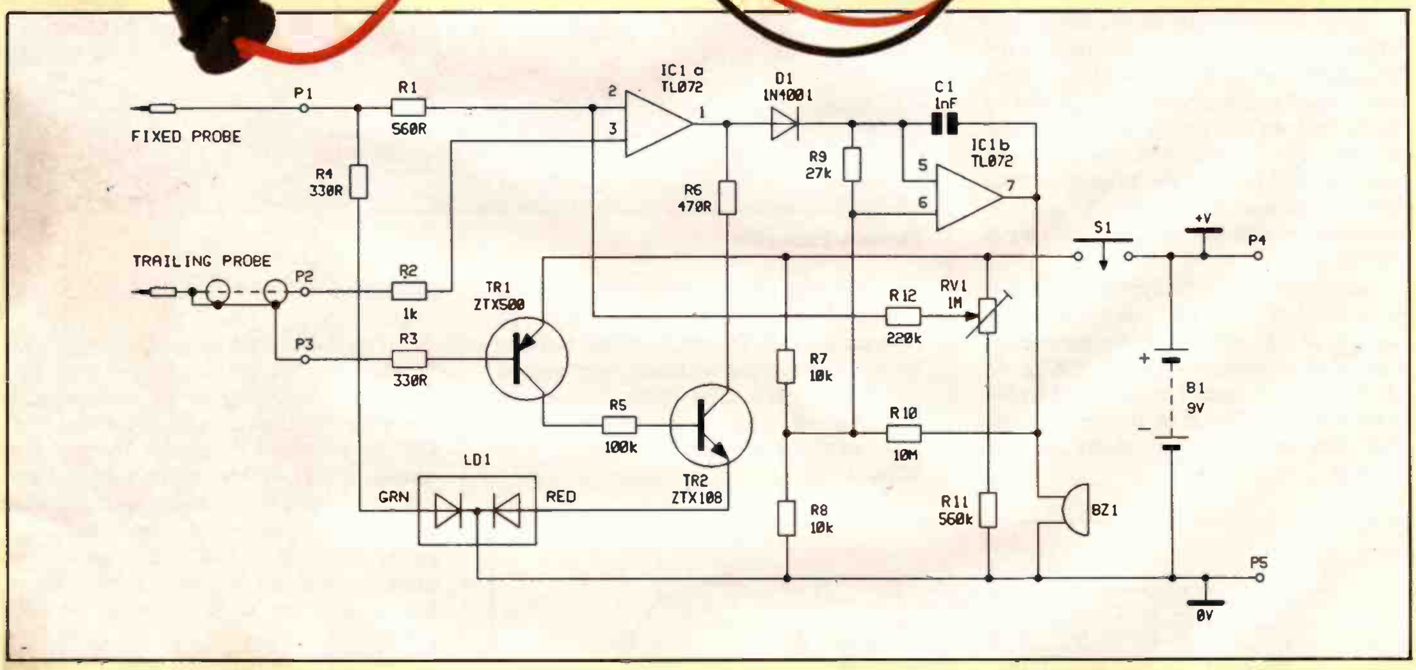
Figure 1. Circuit Diagram of the Low-Resistance Continuity Tester. ▶

The finished PCB.





The assembled PCB complete with wiring; prior to case assembly.



This combined low resistance, continuity and 'megger' tester deviates from the more familiar type of instrument by indicating, at a glance, one of three ranges in which the value of the resistance falls. A multicoloured LED is used as the visual indicator together with a continuity bleep, operating over the three ranges as follows:

Indication	Resistance between probes
Red	5kΩ to around 100MΩ
Orange	300Ω to 5kΩ
Green	0·5Ω to 300Ω
Green and 'bleep'	Short-circuit (0Ω) to 0·5Ω

The LED glows red to indicate a very high 'leakage' resistance, and this range is ideal for testing insulation, capacitor dielectrics and even skin! High-resistance testing of this sort is known by many as 'meggering' (from 'megohm').

When the resistance across the probes is somewhat less (around 5kΩ or less), the LED appears to glow orange (in actual fact, the individual red and green LEDs in the single package are simultaneously turned on). This middle range is ideal for indicating dry joints, the resistance of switch contacts and connectors, semiconductor junctions and so on. The lower threshold of this range is around half an ohm, which makes it better than even a good multimeter for some applications – these can be somewhat vague when measuring resistances of below 1Ω.

The lowest range of 0 to 0·5Ω is shown by the LED glowing green with a simultaneous bleeping. This range is basically the standard 'continuity test', and the bleeper is included to make certain kinds of test easier, that is where it is not convenient for the operator to look at the unit's LED, either because the application of the probes is fiddly and requires concentration, or the item to be tested is in an awkward or confined space. This is equally true of testing many connections with, say, a multi-way plug-block where contact resistances of this low order are anticipated.

The unit is built into a compact case of the type also used for our Logic Probe. One of the unit's probes is built into the case while the other is fixed to the end of a flying lead. Although a button must be pressed to operate the unit, the quiescent current is very low (in the order of 4mA), and the testing current is a mere 9mA (although this does depend on whether the buzzer is active or not).

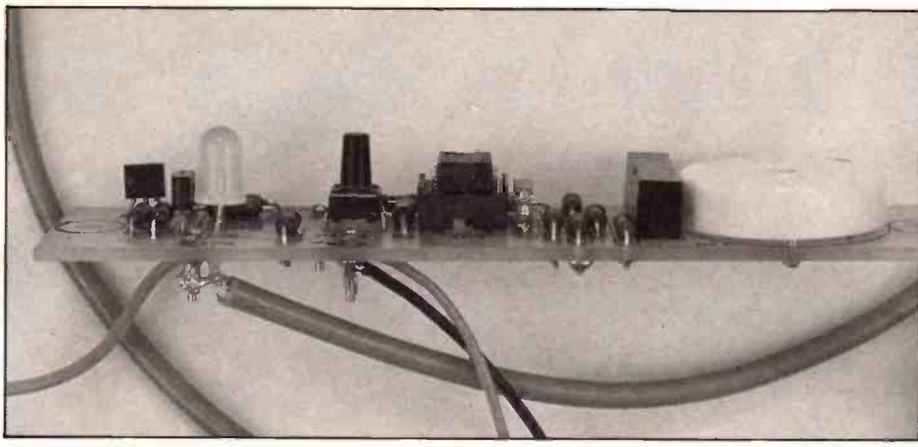


Photo 1. Side view of the finished PCB, showing nylon washer under SW1.

Circuit Description

With reference to Figure 1, it can be seen that the circuit is based around IC1a and b, a TL072 dual JFET-input op-amp. The diagram is a bit confusing to understand at first, until you realise that it combines various stages each of which specifically handles a particular resistance range. The TL072 is chosen for its very low input bias and offset currents, reducing errors, and its fast slew rate.

IC1a has no negative feedback and therefore acts as a straightforward comparator. When the unit is powered up by S1, the fixed probe at P1 is pulled to the 0V rail via the green portion of LD1 and R4. P1 is then effectively at 0V potential while the probe is open circuit (not connected to anything), and is communicated to the inverting ('−') input of IC1a via R1.

Similarly the trailing probe at P2 and P3 is held at +V via the base/emitter junction of TR1 and R3, while connected to the non-inverting ('+') input of IC1a via R2. With its '−' input negative and its '+' input positive, IC1a is in 'positive saturation' and its output is nearly at +V potential.

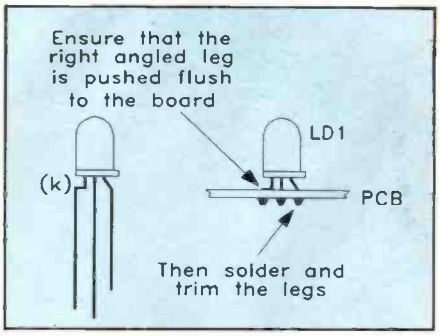


Figure 3. Fitting the LED.

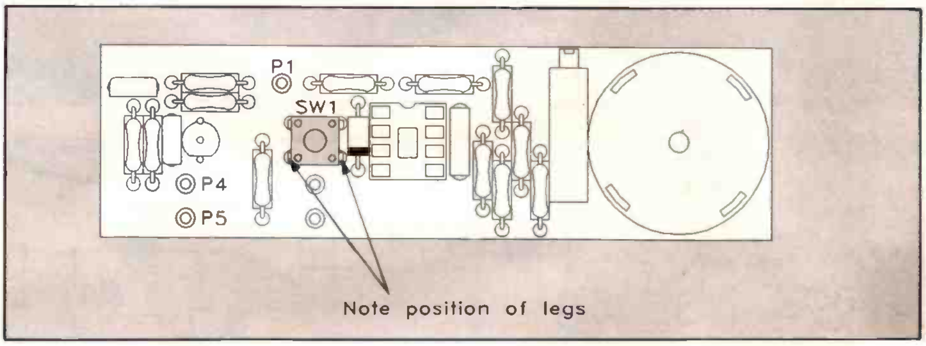


Figure 4. Fitting SW1.

This has two effects. One is that the oscillator part, IC1b, is disabled by clamping diode D1 which, while forward biased, prevents it oscillating and sounding buzzer BZ1. The other is that the collector of TR2 is provided with a positive supply directly from the output of IC1a.

With nothing even remotely conductive between the probes, LD1 remains extinguished. However, if a high resistance is present between the probes, a small current flows from P1 (negative) to TR1 base via P3 and R3. TR1 is a common-emitter amplifier with its emitter directly connected to +V, and is configured to supply bias current to TR2 via current-limiting resistor R5. The combined current gains of TR1 and TR2 are sufficient to amplify the small probe current and illuminate the red portion of LD1. R6 is a current-limiting resistor protecting IC1a, TR2 and LD1 in this event.

The red portion remains switched on for the majority of the remainder of the operating range, up to the point where the very low resistances are indicated. For the medium resistance ranges, the orange colour is derived by there being sufficient current flowing through the probes (and therefore the resistance under test) to directly illuminate the green portion of LD1, via limiting resistor R4, in addition to the already lit red portion.

If the inter-probe resistance is reduced further to virtually nothing, a point will be reached where the voltage difference between P1 and P2 will become equal. This will be close to half the total supply voltage, as determined by LD1, R3, R4 (of equal values) and the base/emitter junction of TR1, all contributing in series to form a potential divider. A small negative offset is then added to the non-inverting input of IC1a, enough to cause it to change state by being fractionally lower than its inverting input. This is the function of bias chain and preset R11, R12 and RV1.

When IC1a changes state its output goes negative (close to 0V), depriving

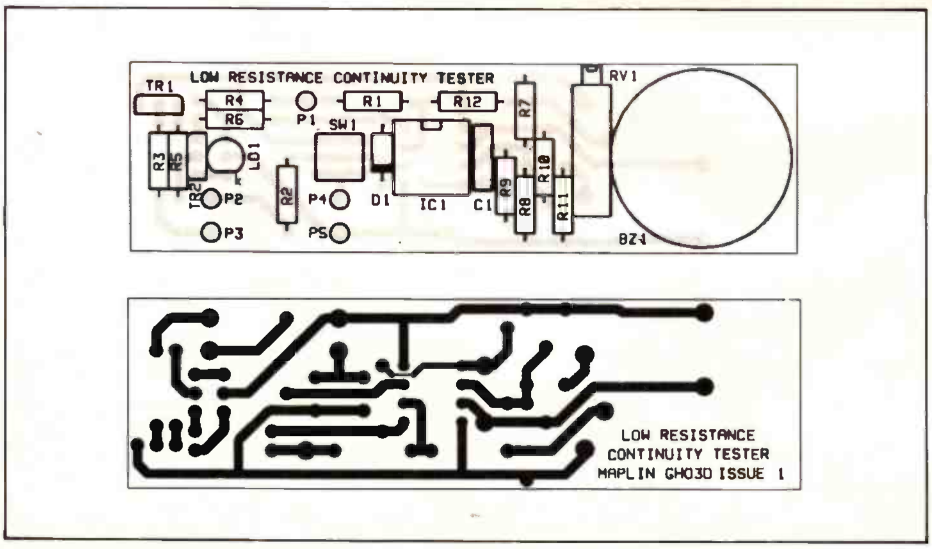


Figure 2. PCB legend and track.

TR1 of supply current and extinguishing the red portion of LD1. At the same time this releases IC1b by reversing D1, allowing it to oscillate.

The oscillator formed around IC1b is of the typical square-wave generator type using an Op-amp as the active component. A divider, R7 and R8, holds the Op-amp at a DC reference of half the supply level. A small amount of positive feedback is provided between IC1b output and its non-inverting input at pin 6 by R10. This achieves a 'gentle' Schmitt trigger response to voltage changes at its inverting input, pin 5. Oscillation is derived from the use of R/C components R9 and C1, where the integrating effect of C1 gives the same effect as that used with a multivibrator.

The whole circuit is powered by one 9V PP3 size battery, and switch S1 is a push-to-make type to ensure that the unit is not left on by accident, running down the battery.

Construction

The PCB supplied in this kit is a high-quality single-sided glass fibre type. Its legend is reproduced in Figure 2, and should assist you in correctly positioning each component.

Construction of this project is fairly straightforward, although beginners should refer to the Constructors' Guide (supplied with the kit) for sound practical advice on general electronic assembly and soldering. Apart from correct soldering, the most critical factor in project construction is the orientation of semiconductors (for example diodes, transistors and ICs) and 'polarised' components (e.g. electrolytic capacitors). As with misplaced components, incorrect orientation can cause severe damage to the project; at best the PCB and/or component could be damaged if desoldering has to take place. The best course of action is to check, and double-check if necessary, before finally soldering the components in place – and then check again before powering up the circuit.

Start construction with the resistors and capacitor first, observing the correct values and ensuring that they fit flush against the PCB. Do not fit RV1 at this stage, as this will obstruct the fitting of the other resistors.

Diode D1 should be oriented correctly and soldered next; it is important to match the stripe on the legend with the stripe on the diode body. LD1, the light-emitting diode, should be inserted so that the flat on its case matches that shown on the corresponding outline. The correct way of fitting LD1 is shown in Figure 3.

The IC socket can now be fitted; be careful to align the locating notch on the socket with that shown on the legend. Do not fit the IC at this stage, to prevent any

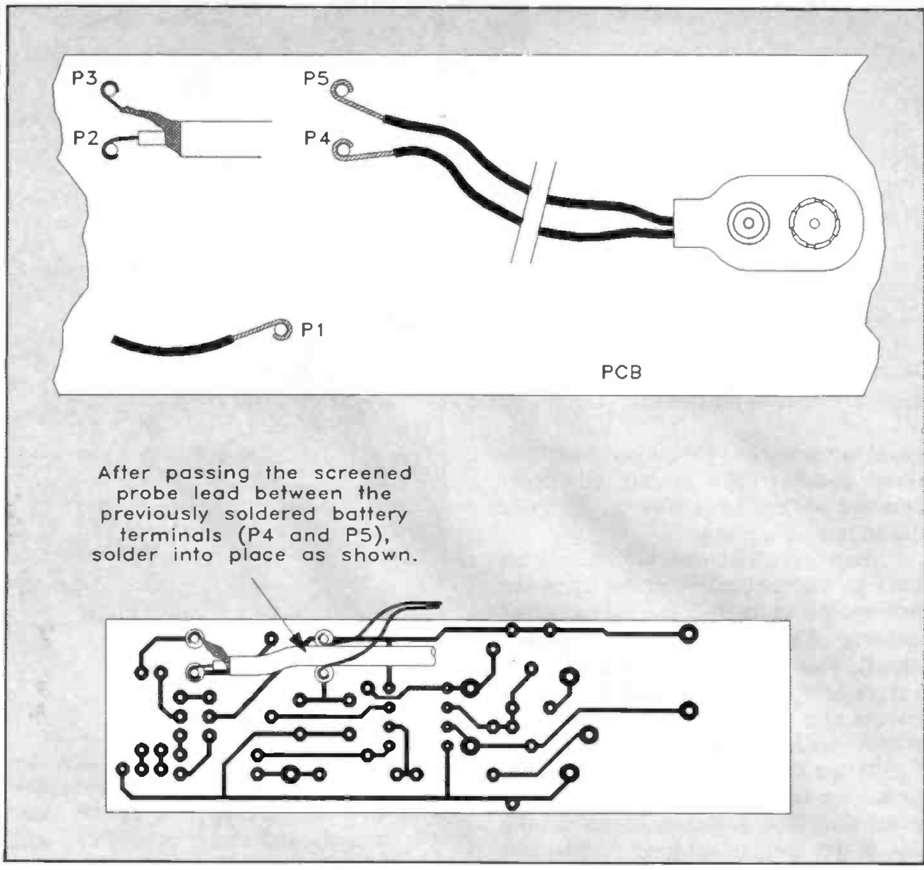


Figure 5. Wiring up the probes and battery connector.

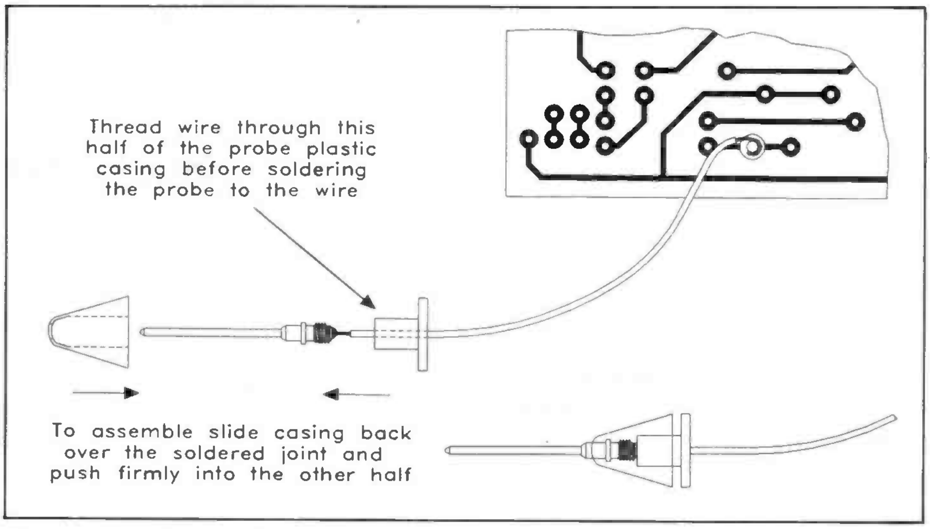


Figure 6. Assembling the fixed probe.

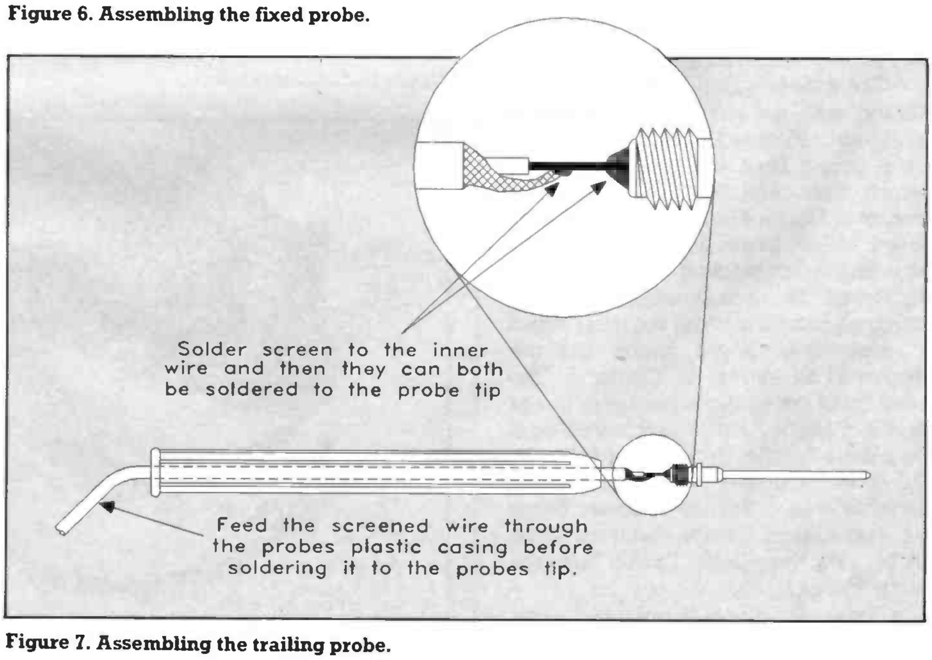


Figure 7. Assembling the trailing probe.

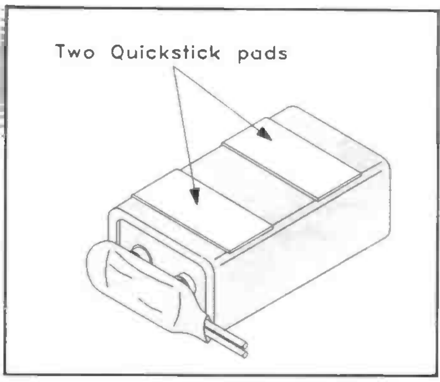


Figure 8. Preparing the battery.

possible damage. Following this, the piezo sounder BZ1 should be flush-mounted against its outline on the PCB, and soldered in place.

Transistors TR1 and TR2 should be fitted so that the outline of the transistor matches that of the PCB legend (note that one side of each transistor has rounded edges). This is very important, as these components MUST be connected the correct way round. Note that TR1 is a ZTX500, while TR2 is a ZTX108.

At this stage RV1, the 18-turn cermet preset, can now be inserted and soldered in position. The adjusting screw on the side of this component must correspond with the markings on the legend.

SW1, the push-button, should be fitted next, as shown in Figure 4. It must be raised 1mm above the PCB, and to ensure that the bottom of the switch has something to rest on, a 6BA nylon washer should be inserted between the switch and the PCB – PRIOR to inserting the pins of the switch through the PCB! (see Photo 1). The switch is raised above the PCB so that there will be a better switch action through the membrane.

PCB pins 1 to 5 are used to connect the battery clip and the various connections to the probes. The pins should be pushed through the board as far as they will go, from the legend side, so that they poke through to the track side, where they can be soldered in place.

After the pins have been soldered in place, the battery connector leads can be soldered in place, as shown in Figure 5. The positive (red) wire should be soldered to P4, while the negative (black) wire should be soldered to P5.

The probes can now be connected, starting with the fixed probe, which is soldered to P1 (see Figure 5). Pull off the metal probe from the plastic surround (which slots into the case). With reference to Figure 6, solder the end of the probe to an 80mm length of hook-up wire. Before connecting its other end to P1, thread the wire through the plastic surround, before pushing the latter home.

Now the second probe can be prepared, as shown in Figure 7. The metal tip of the probe is similar to that of the fixed probe, and is unscrewed from the plastic handle. Strip 10mm from the end of the screened cable, and connect the inner wire to the outer screen. These are then soldered to the metal tip of the probe, and the plastic handle screwed tightly back on.

The other end of the screened cable should now to be attached to the PCB.

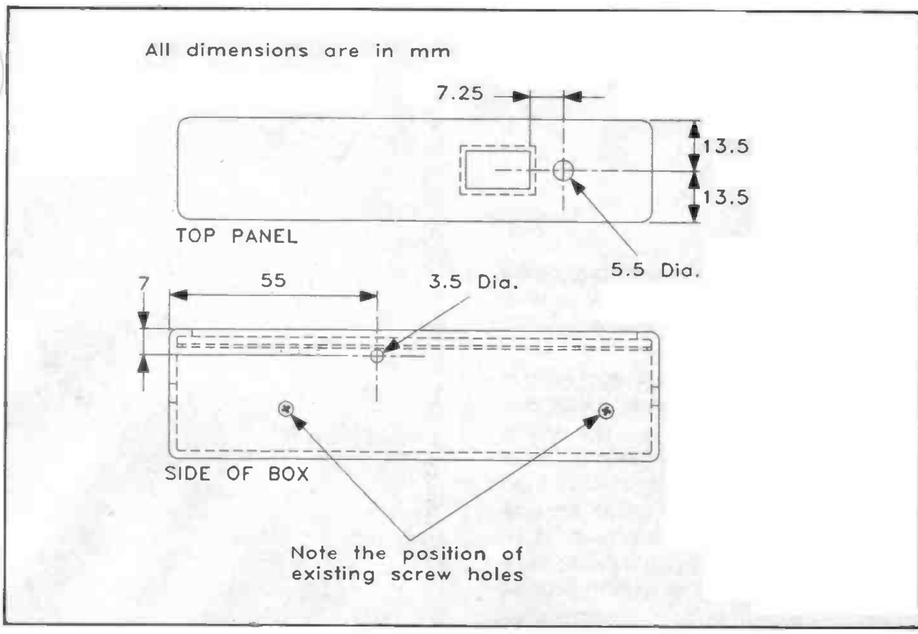


Figure 9. Case drilling details.

Again, strip 10mm from the end of the screened cable, and 5mm from the inner wire. Make sure that the wires are not touching, and tin the ends. Pass the screened lead through the battery connector leads, and seat it between P4 and P5 – as shown in Figure 5. Solder the braid to P3, and the inner wire to P2, referring once more to Figure 5.

Finally, fit IC1 into the 8 pin DIL socket, taking care to align the notch on the IC with that marked on the socket.

Final Assembly

Before connecting the battery it is a good idea to make a last check that all of the components are correctly positioned and soldered. After satisfying yourself that all is OK, plug in a fresh battery and hold the probes together; if SW1 is pressed at the same time, the device should 'bleep', while the LED glows green. If it doesn't, you will need to adjust RV1 until it is just above the low-resistance threshold level – while pressing down SW1 and holding the probes together. If there is still no result, check your work again.

The two quickstick pads are used to prevent the battery from making contact with the PCB. It is only necessary to attach one side of each to the battery, leaving the backing still attached to the other side, as shown in Figure 8.

It is now necessary to drill two holes in the case: one on the front, to allow the LED to be seen; and another on the side, to allow easy adjustment of RV1. Drilling details are shown in Figure 9.

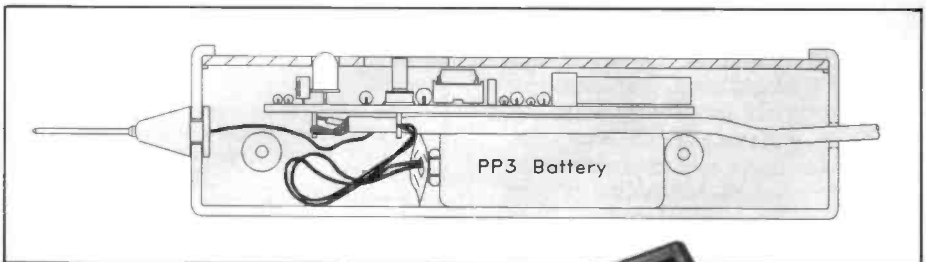


Figure 10. Final assembly.

The finished Low-Resistance Continuity Tester.

When the front hole has been drilled and cleaned, the membrane can be fitted. Be very careful when positioning this item, because it sticks very well !

Before fitting the PCB inside the box, ensure that the pillars, already fitted to one side of the case, are fully tightened. If the unit has to be dismantled later on, much effort could be saved!

When fitting the PCB (see Figure 10), make sure that the trailing lead is fed through the correct hole, and position the fixed probe in place. The PCB rests on top of the pillars inside the case, as can be seen from the diagram. There is sufficient space inside for the battery to be slid underneath the PCB. Note that the wiring should be tucked away to one side, preventing it from being damaged.

Finally, secure the case using the four screws provided.

Calibrating Procedure

To calibrate the unit properly, a resistance of 0·5Ω is needed. This resistance can be easily made by connecting two 1Ω resistors together in parallel. This is shown in Figure 11.

With the 0·5Ω resistance connected between the two probes, the threshold of the green LED and the piezo buzzer can be set. This is done (as before) by pressing SW1 while adjusting RV1. RV1 should be adjusted so that the LED and piezo buzzer are operating at their threshold levels (i.e. at the immediate points when the buzzer *just* sounds, and the LED *just* changes from amber to green).

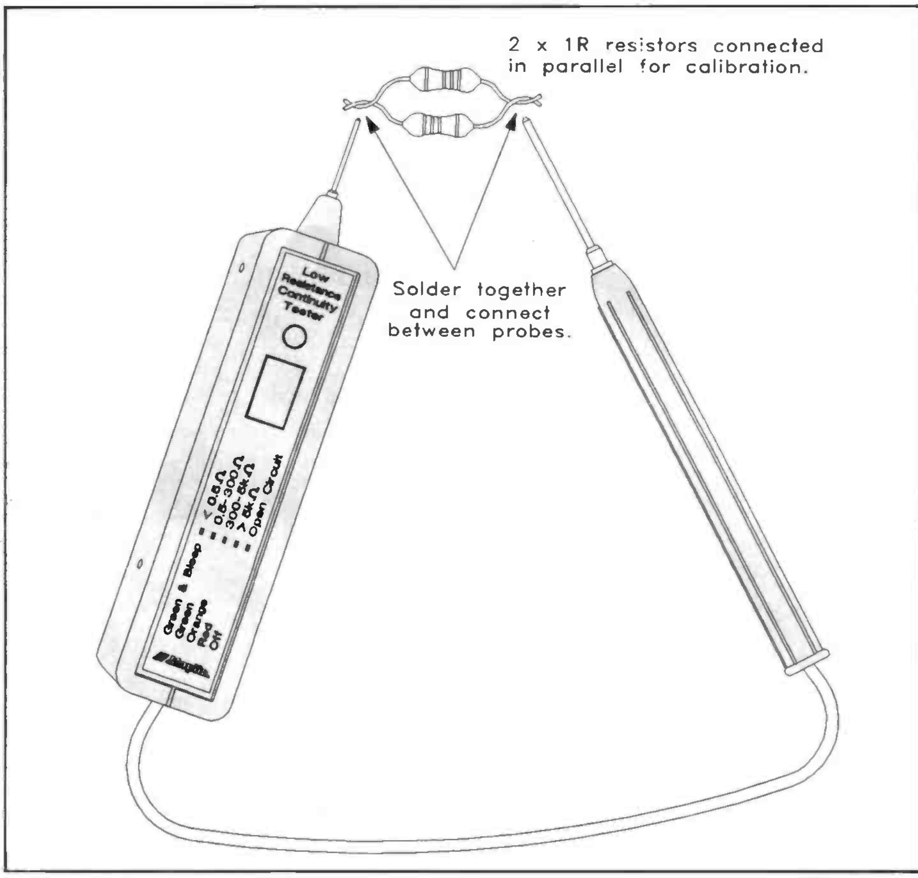


Figure 11. Calibrating the tester.

The unit should now be calibrated and can be tested to show its different states. If the unit is operated while the two probes are each held in either hand, the LED should glow red. This is because the human body has a resistance of approximately 1MΩ – and the red LED will indicate any resistance of 5kΩ or over.

If the probes are touched together, the green LED and the piezo sounder should operate together. If any resistance of between 0·25Ω and 5kΩ is connected between the probes, the LED should appear to glow amber.

CONTINUITY TESTER PARTS LIST

RESISTORS: All 0·6W 1% Metal Film (Unless specified).

R1	560Ω	1	(M560R)
R2	1k	1	(M1K)
R3,4	330Ω	2	(M330R)
R5	100k	1	(M100K)
R6	470Ω	1	(M470R)
R7,8	10k	2	(M10K)
R9	27k	1	(M27K)
R10	10M	1	(M10M)
R11	560k	1	(M560K)
R12	220k	1	(M220K)
RV1	1M 18-Turn Cermet Preset	1	(UH29G)

CAPACITORS

C1	1nF Polyester Layer	1	(WW22Y)

SEMICONDUCTORS

D1	1N4001	1	(QL73Q)
LD1	Multi-Colour LED	1	(YH75S)
TR1	ZTX500	1	(QL60Q)
TR2	ZTX108	1	(QL44X)
IC1	TL072	1	(RA68Y)

MISCELLANEOUS

BZ1	Piezo Sounder	1	(JH24B)
S1	Tactile Click Sw. Type A	1	(JR89W)
	Solder Test Prods	1 Pair	(FK32K)
	Logic Probe Box	1	(JX57M)
	PP3 Clip	1	(HF28F)
	Veropin 2145	1 Pkt	(FL24B)
	PCB	1	(GH03D)
	Membrane/Label	1	(ZF40T)
	Sgl. Core Screened Cable	1m	(XR12N)
	Hook-up Wire 16/0·2mm Red	1 Pkt	(FA33L)
	DIL Socket 8 pin	1	(BL17T)
	Quickstick Pads	1 Strip	(HB22Y)
	6BA Nylon Washer	1 Pkt	(BF84F)
	1Ω Resistor (See Text)	2	(M1R)
	Instruction Leaflet	1	(XT57M)
	Constructors' Guide	1	(XH79L)

The Maplin 'Get-You-Working' Service is available for this project.

The above items are available as a kit, which offers a saving over buying the parts separately.

Order As LP51F (Int' Continuity Tstr) Price £8.95.

Please Note: where 'package' quantities are stated in the Parts List (e.g. packet, strip, reel etc.), the exact quantity required to build the project will be supplied in the kit.

The following new items (which are included in the kit) are also available separately, but are not shown in the 1992 Maplin Catalogue.

Cont Tester Label **Order As ZF40T Price £1.65.**

Int Cont Tester PCB **Order As GH03D Price £1.65.**

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Leicester Office World Building, Burton Street.
London 146-148 Burnt Oak Broadway, Edgware.
120-122 King Street, Hammersmith.
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MAPLIN STORES NATIONWIDE.

April Competition

Maplin constantly scours the world for interesting new products. For the month of April we have managed to find a bumper crop of *four* new and very different items not available through our catalogue. Unfortunately the gremlins have crept into our printers, and not all of the products reviewed here are actually on sale!

To compensate our readers for this poor service we are awarding *five* prizes of a whole year's subscription to 'Electronics – The Maplin Magazine' (added to your current subscription, if you already subscribe) to the first five readers to identify THREE of the products described below as not genuinely available, and to tell us in no more that 50 words which ONE of these life enhancing products Maplin should include in the next catalogue.

Cleaner Beer is Here

The first item received for evaluation was the Electronic 'Clearbeer' Line Cleaner. Cloudy beer is the curse of the drinking classes, and pipe cleaning is the curse of the publican's profits. It is said beer pipes have to be cleaned once a week, and during the process all the beer in them is lost. (It often seems to end up in the Maplin local – *Ed.*)

Now 'Clearbeer' is here. Using a low frequency radio signal transmitted through a coil fixed around the outside of the beer line, the properties of deposit-forming molecules are changed. The molecules have their chemical composition and atomic structure changed to render them 'unsticky', and thus they do not adhere to beerline walls or glass sides.

The current version does not place the coils directly into either the glass or the beer, although the glass based version currently under development will be a pocket sized beer clearer.

At present the system is only available to the licensed trade, but the advantages of reducing 'fobbing' is said to save up to 85% of current beer cleaning costs. Easy to fit, all the system needs is a plug, a barrel and a pipe, and a clear pint results every time – electronically.

Atomic Water Power

Our second wonder gadget takes advantage of the breakthrough of research into nuclear fusion at the JET laboratories in Oxford. The fusion reaction, of bringing atoms together rather than splitting them, is the basis of the sun's energy source and is seen by many as the key to our future energy problems. The JET people have now managed to control the massive heat problem and marshal the experiment. Their first application is the 'Fusilier', a fusion powered car. This vehicle looks rather like an over-sized buggy with a hood. It has been seen around the M.I.R.A. test tracks near Oxford and is attracting much interest. The Fusion generator uses conventional hydrogen obtained from tap water. The reaction is used to generate power directly within the batteries, and speeds of up to 60mph, with a range of 40 miles, are reported.

Electronically, the heat reducer and exchanger are very novel. These use the very latest herom diaphonors to reduce the fusion temperature to a level which the specially reinforced battery case can handle.

Simplest solution of all to a complex problem though was the electronically controlled fuel inlet. This is an electronic version of the humble water tap, which responds to a fall in the inter-baric pressure in the fusion chamber and introduces more water to the reaction.

Scientists are almost as excited about this electronic tap as about the rest of the car. They see this as being the tap of the future, with a simple shout across the bathroom or shower turning the tap on and setting it to the right water pressure and temperature. Cheap travel and an easy, early bath – electronically!

Build Better Brain Cells

A device to expand creative potential and improve brainpower has been under extensive test in the Maplin office. (Nothing much happened yet though – *Ed.*)

The 'Dreamer' is a pocket brainwave synthesiser. Much has been written about brain patterns, and making use of the 80% of our brains which supposedly lays dormant. As is well-known, most brain activity occurs in the brain stem, with our mid brain being very under used. But no longer. The 'Dreamer' moves cyberspace in such a way that consciousness, and with it, awareness are expanded. The benefits of a wider vision, expanded mind and liberated brain power are almost indescribable. The user will respond to new situations with objectivity, clarity of thought and be able to rapidly enter a profound state of meditation.

The 'Dreamer' is the size of a small personal cassette player and comes with headpiece and full instructions. The effect is maximised by using it in conjunction with the special supplied glasses to ensure total involvement. It has to be used on a regular basis however, and results are said to start coming forward after just a few sessions.

All rather like having your own meditation guru with you all day – electronically. Far out, man.

Record What You Missed Tomorrow

The final item to be looked at by Maplin is the V.D.T.R. This very simple device will revolutionise the receiving of radio and other signals. Putting the latest electronic technology into a compact space, the device captures radio waves transmitted up to seventy-two hours previously.

Initially this had been scoffed at as just another useless discovery. But the new dish aerials accompanying V.D.T.R. will enable radio signals transmitted up to *seven days* previously to be captured.

The properties of radio waves are similar to those of light. Given that much of the light we receive was transmitted many years ago, it is easy to see how much potential was recognised by world leaders such as Mitzepointo of Japan.

The initial picture quality is reported to be high, with few problems with frequency losses. This is said to be due to the excellent storage capacity and propagation benefits of ionospheric entrapment, which has occurred naturally for many millions of years.

The Video Time Delay Receiver (V.T.D.R.) will plug directly into the SCART input of a modern television, and with a forecast transmission span of –60 hours, it should be possible to set the video *after* the show is finished, and still see it – electronically.

Which *three* of the above are not bona fide, genuine and available products?

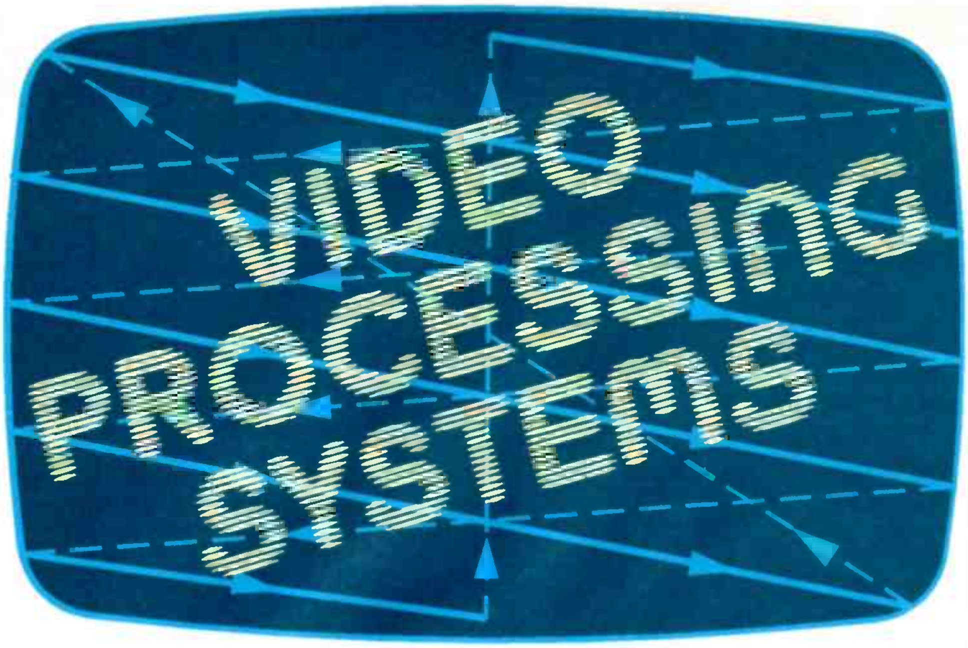
A. The 'Clearbeer' line cleaner;

B. The 'Fusilier' fusion powered car;

C. The 'Dreamer' brain enhancer;

D. The Video Time Delay Receiver.

Please send your *three* answers, plus in not more than 50 words why it might be a good idea that Maplin should sell any *one* of the above products, on a postcard or back of a sealed envelope to: 'Subscriptions Competition', The Editor, Electronics – The Maplin Magazine, P.O. Box 3, Rayleigh, Essex SS6 8LR. The contest closes on 31st May 1992. The first five entries drawn from the well-worn editor's hat will be eligible for a prize, subject to the originality of the Maplin product suggestion. Please note however, that multiple entries will be disqualified.



Video Processing Systems

Part Two by J. A. Rowan

Following 'black-and-white' TV, colour television was obviously the next step onward. Much research had been done by the film industry into human colour vision, and into the minimum requirements of representation of colour. We all 'know' nowadays that any colour we can see may be made from a suitable mixture of 'the three primary colours'. This is not in fact true, but it is the case that the vast majority of colours that occur in nature and art can be simulated by a mixture of three suitably chosen colours. The colours that cannot be synthesised in this way are very highly saturated (very deep), and are usually found only in paint manufacturers' catalogues. Neither is there one set of primary colours, except in the sense that the three chosen must be a red, a green and a blue to maximise the range of synthesised colours. The standard phosphors chosen for colour CRTs in Europe are not, in fact, the same as those used in America and Japan, and some rather dubious Far-Eastern TVs use the wrong set.

Colour TV brought with it a major problem. It was not practical to run a second TV standard at the same time as the monochrome one, nor did anyone want to have to convert between colour and monochrome signals. In short, the colour system had to have two types of compatibility with monochrome: a colour transmission must be receivable by a monochrome TV with minimal picture degradation, and a monochrome transmission should appear as a good monochrome picture on a colour TV. In addition, of course, the colour signal had to fit into the existing transmission channels, i.e. it could not occupy any more bandwidth, or use a very much larger signal level. The colour picture had to start life as individual red, green and blue pictures, and, in a colour TV, had to arrive at the CRT in that form. In the meantime it had to behave largely as a single monochrome picture, particularly in respect of bandwidth required. The British television system allows 5·5MHz bandwidth for a monochrome picture, and somehow the three 5·5MHz colour pictures must also fit into this same bandwidth.

This appears to be impossible, and of course it is. But the human eye uses different sensors for brightness information and colour, and has far fewer for colour. This means that if the RGB signal is restructured so that it consists of a brightness signal and separate colour information, the latter can have a much lower bandwidth without perceived loss of picture quality. By a curious coincidence, this is just the kind of signal which will satisfy the two compatibility requirements. A monochrome receiver can simply ignore the colour information and display the brightness, or 'luminance' signal (abbreviation 'Y', for no very obvious reason), and if no colour information is supplied to a colour set it will display only the black and white luminance. But how do we fit in the colour when the luminance signal fills the entire 5·5MHz available?

There is no totally satisfactory solution to this problem, but the system first adopted by America, and then by about half of Europe, was to interleave the colour information with the high frequency components of luminance. A spectral display of a luminance signal will consist largely of clumps of sidebands around multiples of horizontal line frequency, with decreasing levels at higher frequencies. Colour information will have a similar structure, and can be dropped into the gaps between clumps of luminance sidebands, as illustrated in Figure 1. A 'comb filter' can in theory be used later to separate the two parts of the signal to allow reconstruction of the original red, green and blue pictures.

Deriving the Colours

Those who remember their simultaneous equations will know that three independent quantities may be recovered from any three linear algebraic equations which contain combinations of those quantities, providing certain conditions are met. Thus the Red, Green and Blue (RGB) values of a colour signal may be represented in many different ways, but always by three other values. Much computer graphics software, for example, will allow colours to be specified in RGB, YMC (Yellow, Magenta and Cyan, the secondary colours) or HSV (Hue, Saturation and Value) form.

In this latter system, the value quantity corresponds to video luminance, the hue tells us which colour is specified, and the saturation determines how 'deep' is the colour, varying from fully saturated through more pale

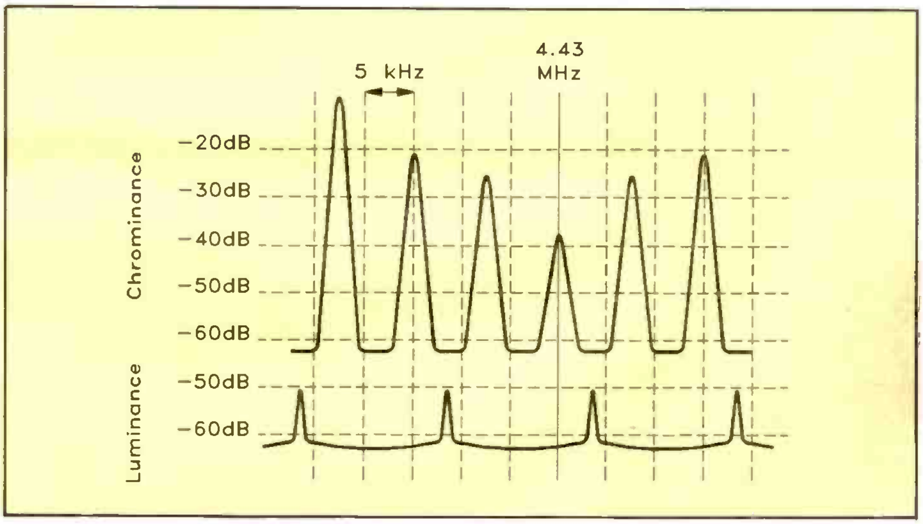


Figure 1. Expanded view of luminance and chrominance colour bar spectra around subcarrier frequency. Note that although the luminance peaks are 15·625kHz apart, those of chrominance are spaced at half of this, 7·8kHz. This is due to the PAL inversion, which causes adjacent lines to be different and therefore the fundamental frequency of the Fourier series to be half line frequency. This is the reason that PAL subcarrier frequency is close to a multiple of a quarter line frequency rather than a half as in NTSC. The 25Hz offset from an exact multiple is small enough that the spectra interleave fairly well over the entire chrominance bandwidth.

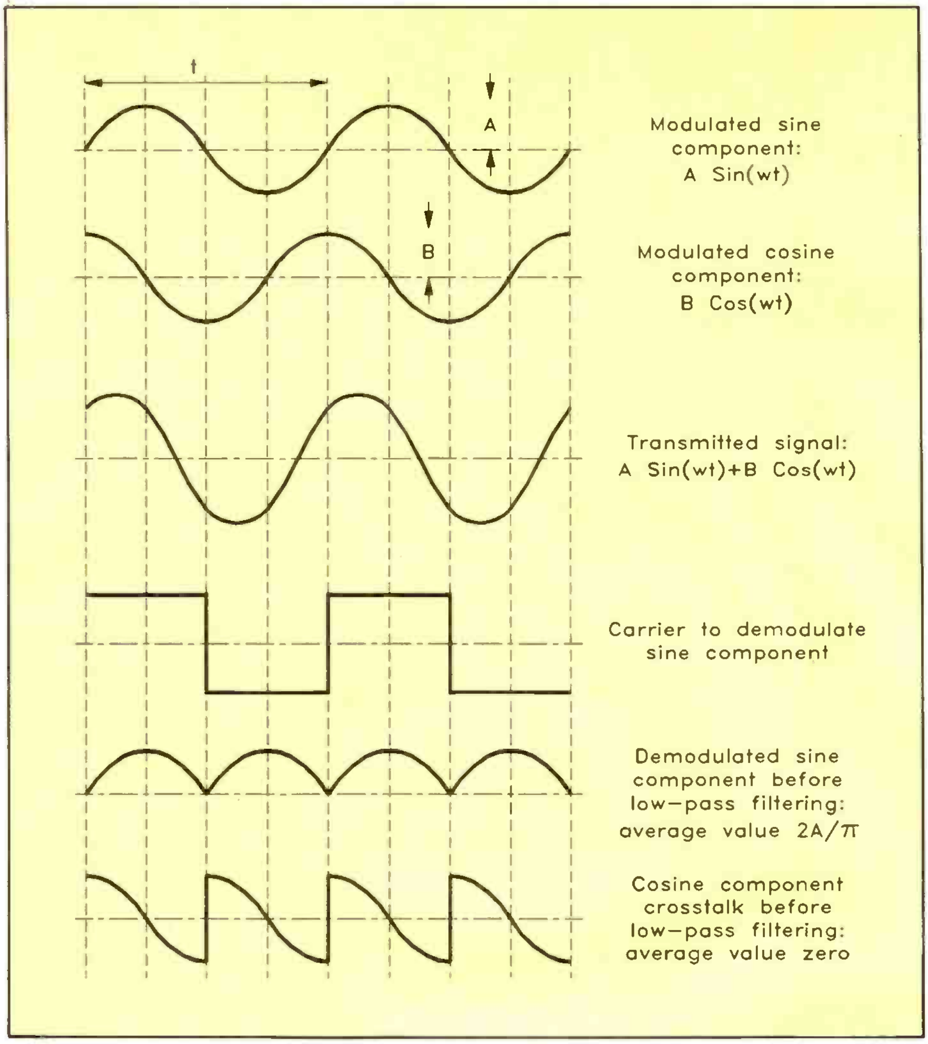


Figure 2. Quadrature amplitude modulation principles. Quadrature Amplitude Modulation is a technique for transmitting two independent signals in one channel, modulating sine and cosine waves of a single carrier frequency with the two information signals and adding the resulting signals together. Since the peak values of a sine wave occur at the zero-crossing points of its associated cosine wave, then in theory each original information signal may be recovered without crosstalk from the other. In practice, separation can be quite good but to achieve this, the demodulating carrier must reproduce the original modulating carrier to within a degree or two of phase. A periodic reference is required to maintain this kind of stability in a crystal oscillator, and in a PAL or NTSC video signal this is sent just after the horizontal sync pulse, before the picture information begins. An oscillator in the colour decoder is locked to this reference, or 'colour burst', and two oscillator outputs at 90° to each other are used to synchronously demodulate the chroma information.

tints to zero, which corresponds to a black, white or grey colour. The compatibility requirements imply that a saturation of zero should result in a zero colour signal, and one way of achieving this is to represent saturation by the *amplitude* of a carrier wave, and hue by the *phase* of the carrier. This carrier is known as the colour subcarrier, so as not to be confused with the RF carrier used to actually transmit the television signal. The more usual, equivalent view of this system is that the colour information consists of a combination of two sine waves in quadrature, the sine waves being amplitude modulated by two independent 'colour difference' signals, as shown in more detail in Figure 2. In the British system, these two signals are red minus luminance (R–Y, also known as V) and blue minus luminance (B–Y, or U), which explains the colour difference term.

The luminance signal must correspond to the brightness of a monochrome signal, and tests were carried out to determine the contributions of the primary colours to the human perception of brightness. Luminance was then defined as comprising approximately 30 per cent red information, 59 per cent green and 11 per cent blue. The equations connecting RGB with YUV are therefore:

$$Y = 0{\cdot}3R + 0{\cdot}59G + 0{\cdot}11B$$
$$U = B-Y = 0{\cdot}89B - 0{\cdot}3R - 0{\cdot}59G$$
$$V = R-Y = 0{\cdot}7R - 0{\cdot}59G - 0{\cdot}11B$$

For a monochrome picture, R = G = B = Y, and both colour difference signals are zero. In fact, for various technical reasons, early colour cameras and tele-cines (machines to convert film pictures to video) had four pick-up devices, for R, G, B and Y, but it was soon possible to dispense with the luminance channel and synthesise Y from the three colour signals. Figure 3 shows how the deduced three primary colours, mixed in the proportions outlined above, produce the staircase luminance signal for the colour bar test pattern, and is also of course the monochrome 'grey scale' if the colour is turned off.

The American Method

The NTSC system, as used by North America, Japan and numerous smaller countries linked with them, began use at the end of the Fifties. It was, naturally enough, based on the existing monochrome 525 line, 60 field/second system. The colour difference signals are called I and Q, which both contain differing proportions of R–Y and B–Y. Again, being linear combinations, I/Q and R–Y/B–Y representations are equivalent, and either pair can be easily obtained from the other. Research had shown that the colour sensors in the human eye were further differentiated into two types, which occur in different numbers. The NTSC colour difference signals were chosen to correspond with the observed response of these two types of sensor, and the bandwidths of I and Q correspond with the observed resolution of the eye of the two colour ranges of the sensors. This level of refinement was not felt necessary in PAL, the German variation of NTSC, and adopted by Britain and about half of the rest of the non-NTSC world. PAL colour difference signals are simply R–Y and B–Y, and are carried with equal bandwidth (1·3MHz) throughout the system. Luminance is derived from RGB in the same way for PAL as NTSC.

The PAL Alternative

Actually PAL exists because of a major shortcoming of NTSC. The critical dependence for correct colour hue on the phase of the colour subcarrier means that the stability of the encoding and decoding subcarrier frequency must be at least that of a quartz crystal, and even then a phase reference is required on each horizontal line. This

“The basic difference between PAL and NTSC is the inversion of the R–Y colour component on alternate lines, and corresponding inversion during RGB reconstruction in the receiver for PAL.”

is still not really good enough, and NTSC is prone to hue errors which are partly generated at the TV studio and partly appear during transmission and reception. An error of only two or three degrees of phase can render flesh tones unrealistic, and NTSC television sets have front-panel phase adjustment (hue) controls. The basic difference between PAL and NTSC is the inversion of the R–Y colour component on alternate lines, and corresponding inversion during RGB reconstruction in the receiver for PAL. Any phase error causes *opposite* errors in hue on

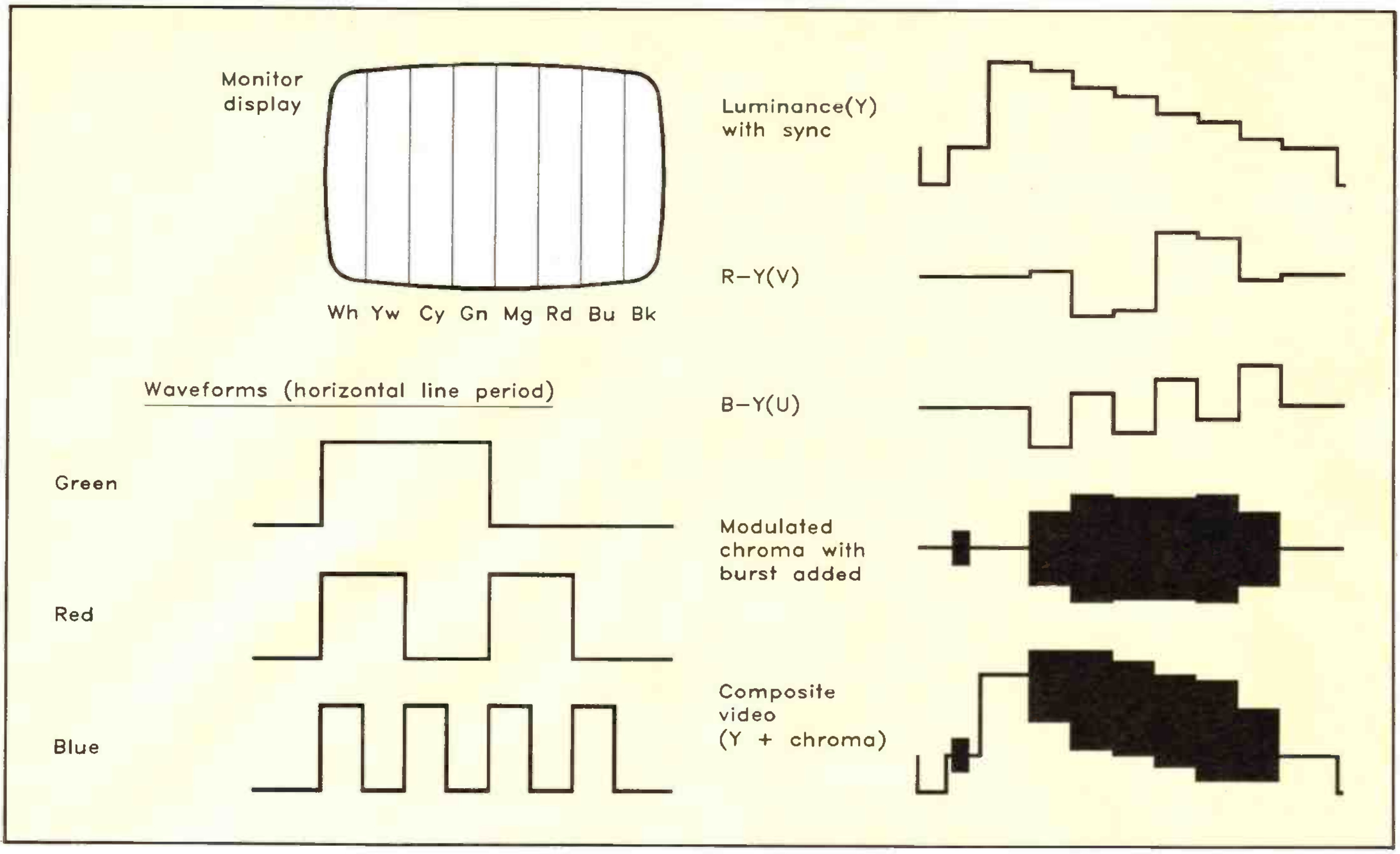


Figure 3. PAL encoding of 100% modulation colour bar test signal, showing the various component signals.

alternate lines, and so, at normal viewing distances, these errors are averaged out by the eye. The correct hue is seen, but with a small reduction in saturation, which is subjectively far less disturbing than a hue error. In fact, if the receiver does use comb filter techniques for colour decoding (it is not actually necessary) then the averaging is done in the filter, and the displayed colour is already corrected.

But there is always a price, though the disadvantages of PAL (after 'Phase Alternation, Line' by the way) are quite subtle and affect manufacturers and TV production staff rather than viewers.

> *"The trade-offs associated with PAL and SECAM are actually related to the use of AM versus FM in the colour signal."*

The choice of colour subcarrier frequency for NTSC (not after 'Never Twice the Same Colour', but 'National Television Systems Committee') was based on two requirements. Firstly, the sidebands of colour information had to interleave with those of luminance, and secondly, the subcarrier itself should be as unobtrusive as possible on monochrome TVs. A uniform high frequency luminance signal appears as a row of dots on each television line, and a large coloured area of the picture would cause the superimposed colour subcarrier component to appear as just such a high luminance frequency. The dot pattern is unavoidable, but the arrangement of the dots on successive lines and fields makes a great difference to their visibility. The NTSC frequency, an odd multiple of half line frequency, was chosen so that the dots formed diagonal lines and actually cancelled out on successive frames as much as possible. Human persistance of vision helped reduce the apparent dot visibility. Unfortunately, the PAL inversion caused these diagonal lines not to cancel, and to become vertical and highly visible if a similar strategy was used. The solution chosen thirty years ago was to take an odd multiple of a quarter of line frequency (1135/4, to be exact) and then add 25Hz. It solved the dot-pattern problem and probably seemed like a good idea at the time, but it has since made life very hard for manufacturers of digital video processing equipment.

French Connection

The third major colour TV system is the French SECAM. Standing for 'Sequential With Memory' (well it does in French anyway), it is another 625 line 50 field/second system. While PAL is very similar to NTSC, except for the V phase alternation, SECAM follows NTSC only as far as the Y/R–Y/B–Y point. The 'System Essentially Contrary to the American Method', then, frequency modulates a subcarrier with either U or V on alternate lines, after high frequency pre-emphasis. The lower perceived resolution of colour allows this technique, where the FM signal of the line before (using a one-line delay, which is the 'with memory' aspect) is demodulated along with that of the current line to recover the two colour difference signals. The reduced vertical colour resolution of this method is actually no worse than that of PAL, since the latter is almost universally decoded using a one-line delay to achieve comb filtering. In effect, the PAL colour information in adjacent lines is averaged, leading to a similar loss of resolution to that of SECAM.

The trade-offs associated with PAL and SECAM are actually related to the use of AM versus FM in the colour signal. The SECAM signal is insensitive to subcarrier amplitude and phase errors and, as will be seen later, this makes video recording and playback much easier, as well as allowing a more loose specification of some broadcast transmitter and receiver characteristics. SECAM encoding and decoding does not rely on crystal stability for the subcarrier, and therefore frequency tolerances are much wider. The SECAM subcarrier is not, in fact, related to line frequency, and U and V

> *"Much worse, two SECAM pictures cannot be combined in any way, since FM signals do not mix in a linear way and cannot be switched without severe disruption. Even quite simple special effects such as dissolves and wipes are impossible."*

use different subcarrier frequencies. On the other hand, SECAM subcarrier is present on all parts of all pictures, causing a much more extensive dot-pattern on monochrome sets. Monochrome areas of picture do have a reduced subcarrier level, but this cannot be zero as an FM demodulator must be fed with a continuous signal. Much worse, two SECAM pictures cannot be combined in any way, since FM signals do not mix in a linear way and cannot be switched without severe disruption. Even quite simple special effects such as dissolves and wipes are impossible. Until fairly recently, much of this type of processing in SECAM countries was done in PAL, the transcoding to SECAM being carried out when the programme was in its finished form ready for recording or transmission. Most PAL engineers found this rather amusing.

“All three colour transmission standards were designed for encoding and decoding once only. Modern multi-pass, post-production techniques were not even dreamt of in the Fifties and Sixties.”

Further Effects

Even PAL has limitations in this respect, and many processes cannot be carried out on composite video. Any change in picture size, position or orientation would, at the very least, lead to severe subcarrier phase and/or frequency errors, and the resulting picture would be unusable. Such manipulations must be carried out with the colour information in the form of baseband U and V signals, and the resulting altered picture then re-encoded into PAL. There had always been a demand for relatively simple zoom and rotation effects on film to become available to video producers, and eventually electronics technology advanced to a point where this became economic. Cameras and tele-cines, however, produced a coded signal and video recorders recorded it. This led to multi-layer effects which repeatedly coded and decoded the picture, with further degradation of picture quality occurring each time.

All three colour transmission standards were designed for encoding and decoding once only. Modern multi-pass, post-production techniques were not even dreamt of in the Fifties and Sixties. Most productions were shot with multiple cameras, the director selecting which camera to use at any moment and the final video output being transmitted live. Important events could be archived by simultaneously recording onto film, but even this was not done routinely. Video recorders were originally developed to solve the problem of having several different time zones in the U.S., and early VTR editing was done with a razor blade, as with audio tape, purely to select highlights, remove errors or trim running time. The use of VTRs as a production tool, with special effects added long after the original material was shot, was a technique that developed slowly, along with the technical advances which could actually produce the effects. Simple mixes and wipes were easy to do with NTSC and PAL coded signals, and much editing was simply a matter of joining together shots recorded at different times or in different places. It was only when the new digital effects appeared that additional coding and decoding was required, and the limitations of the transmission standards were brought sharply into view.

A Tangled Web

The major problem is that of separating the luminance signal in composite PAL or NTSC video from the modulated colour information, or 'chroma'. Comb filters do a reasonable job but not a perfect one, since a comb response is simply a set of notches at regular intervals and looks much like a full-wave-rectified sine wave. If all picture information consisted of vertical lines, then the concept of interleaving the luminance and chroma would be valid. A comb filter could be used to totally suppress either one or the other, since the spectra of both signals would consist only of multiples of line frequency. In practice, diagonal lines and movement in the picture cause sidebands to appear around these multiples, which overlap with each other and have width, and therefore cannot be suppressed by comb filtering. Crosstalk then occurs between the 4·43MHz chroma (in PAL) and luminance frequencies in that region. Figure 4, showing the frequency spectrum of PAL colour bars, identifies this region.

The practical result of this is familiar to all of us as a bright, 'sparkling' appearance in areas of picture containing regular, fine detail, and as coloured *moire* patterning on diagonal stripes, notably on the lapels of striped coats and jackets. Tiny amounts of this crosstalk occur on all sharp luminance transitions, but are not normally objectionable after one decoding process. Other defects of coding and decoding include errors in the relative horizontal position of luminance and chrominance, 'ringing' added to picture edges by low-pass filtering, and inaccurate modulation and demodulation leading to increased flicker and decreased saturation. Most of these problems exist at quite low levels but, with several passes through encoders and decoders, possibly not all in perfect adjustment, the resulting picture defects can accumulate to unacceptable levels.

Investigations were carried out into the possibility of passing Y, U and V signals separately to inter-connect television production equipment. Three cables, or other transmission channels, would be required, but this was not a serious difficulty within one geographical location. Cameras could easily be modified to supply YUV signals, since the latter already existed within the camera PAL encoder, but video tape recorders were a different matter. All high quality VTRs were of the 'direct colour' type, that is, they recorded PAL composite video as a single wideband signal. The pressure for a new recording system was there, however, because YUV recording would allow an entire production to be made without any encoding or decoding, except for the final conversion to PAL for transmission. Suddenly, SECAM didn't seem so funny any more.

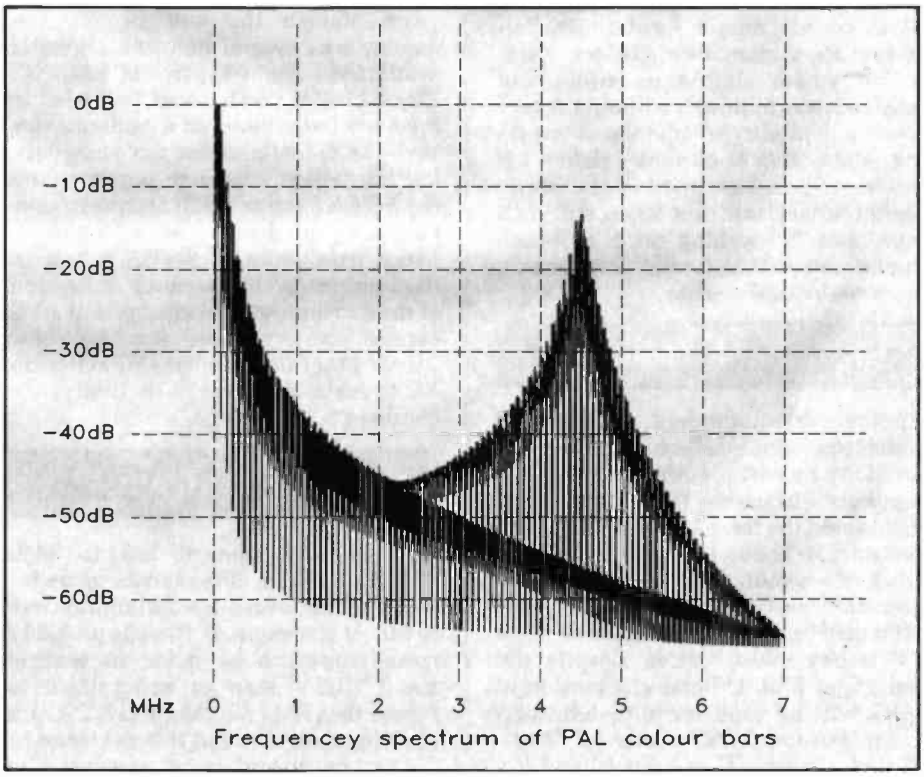


Figure 4. Frequency spectrum of the PAL colour bar test signal.

Digital to the Rescue

YUV recording had existed for about ten years, as both Sony and Matsushita (Panasonic/JVC) had developed YUV recorders for electronic news gathering, but the picture quality was inadequate for general broadcast use. Both companies continued development, however, and their second-generation metal particle tape systems are now being adopted by some British broadcasters in place of their ageing C format direct colour VTRs. More and more non-broadcast production facilities are re-equipping with one or other of these systems to replace low band or high band U-Matic editing systems (see the forthcoming article on video recording), bringing not only greater flexibility but dramatically improved picture quality. Manufacturers of vision mixers and other video processing equipment rushed to produce YUV versions of their PAL ranges. Digital video equipment, almost all of which already used YUV internally, quickly sprouted appropriate input and output connectors, allowing encoders and decoders to be bypassed.

To further complicate matters, the high-speed digital technology that had brought film techniques to video didn't seem to know where to stop. An international digital YUV interface standard appeared amazingly quickly, along with a corresponding VTR format, and it was soon possible for analogue video to vanish soon after leaving the camera's optical sensors, never to be seen again until a digitally coded PAL signal was supplied to the transmitter. All camera processing, recording and post-production work could be carried out digitally with no significant loss of picture quality, regardless of how many generations of recording were involved. A composite (PAL coded) digital format, D2, followed soon after as a cheaper alternative where simple recording and playback was required, without the processing flexibility of component working. Matsushita is currently delivering machines based on another composite digital format, this time using half-inch tape, and is working on a half-inch digital component format. Presumably Sony is doing the same.

MAC Packs More In

Another video standard, or group of standards, which has received a lot of publicity recently is MAC. Newspaper reporters discussing the Sky/BSB war mentioned the term a great deal, almost certainly without the faintest idea of what it meant. Its future is now uncertain, but it is still being heavily promoted as a possible satellite or cable TV transmission format, despite the setback at BSB. Officially, a version of MAC will be used for high-definition TV in Europe. MAC stands for Multiplexed Analogue Components, and is a way of avoiding many of the problems of PAL in terms of picture quality and flexibility while retaining a single transmission channel. Broadly speaking, the luminance and one colour difference signal are carried on each line as in SECAM, but they are transmitted sequentially rather than simultaneously. This is achieved by time-compressing luminance to two thirds its original length, and the colour difference signal to one third. Thus both signals still fit the 52μs active video period, leaving 12μs to carry synchronising information, several sound channels and some data.

The drawback, and of course there must be one, is that a larger bandwidth is required to carry the MAC signal, about 8·5MHz for the particular variant used by BSB. The sound and data packet of standard MAC is extremely flexible, and can carry varying numbers of high, medium and/or telephone quality sound channels, with optional use of error correction and NICAM. MAC, because of the necessity for fairly complex processing to recover the original picture, is well suited to scrambling in various ways, allowing 'conditional access' or control over which receivers can actually decipher a transmission. MAC can be displayed by any modern TV that has an analogue RGB input, usually a SCART connector, since transcoding YUV to RGB is simple and produces no additional picture degradation.

A minor non-broadcast format variation is YC, usually called 'S-video' by the manufacturers. This is a two-channel compromise between PAL and YUV and consists of a luminance signal and a modulated chroma signal. Only a small modification to PAL equipment is necessary to use or produce YC, and again it avoids the luminance/chrominance separation problem. It is a development of the 'dub' signal as used between U-Matic recorders for many years, though the dub chroma frequency was several hundred kilohertz rather than the 4·43MHz of PAL YC. The 4·43MHz version was first tried to my knowledge between a camera and a portable U-Matic about ten years ago, but has recently become popular with the S-VHS ('super VHS') recorders now becoming available. The wider luminance bandwidth of S-VHS is lost in the luminance/chrominance separation of most ordinary TV receivers, but a YC connection preserves it. The new 'Hi–8' 8mm tape format also relies on YC to make the most of its luminance bandwidth.

HDTV Nonsense

And so we come at last to high definition TV, a lifesaver for a newspaper editor with a few column inches to fill. At the moment, there is probably more money to be made in writing about HDTV than in using it. It is agreed that PAL, SECAM and NTSC are showing their age, and that the trend in TV sets is toward larger screens. The occasional 36 inch TV on display in a shop certainly shows up the limitations of PAL in this respect. So we need a TV system capable of giving much improved picture quality, don't we? Well, looking at TVs in most homes, and at the ready acceptance of the rather appalling VHS playback picture, you may wonder. As you may remember, a certain Mr Sugar was rather dismissive of the genuinely superior picture quality of MAC, so are we really going to pay ten times as much for a huge TV which will at first show a very limited range of high definition material? And who will make it?

It goes without saying that most TV sets will come from the Far East, as they do now, but what about the production equipment? It is already possible to buy a full range of HDTV equipment based on 60Hz standards, and if Europe were to settle on one of these then our manufacturers would stand little chance of competing with the established Japanese products. Europe is currently working hard to make up lost time, and hopes that its own manufacturers will have an easier time if a 50Hz standard is developed, and it will be the Japanese who will then have to catch up. In an effort to build up a bigger lead still, the European standard is to be another MAC variation, ostensibly because it will allow a gentler upgrade path with considerable compatibility with existing receivers. So again we are heading for at least two different world standards, with the problems of standards conversion arising all over again.

Meanwhile the Americans have thrown in another large spanner. They have no wish to be swamped by Japanese imports either, and, sharing the NTSC standard already, they are more vulnerable than Europe. Their answer is to build on their experience of digital video and bypass analogue HDTV altogether, going straight for a digital HDTV transmission standard to run at first in parallel with NTSC and ultimately replace it. They confidently expect the system to be in operation within five years, and are dismissive of both the present Japanese systems and of the European HD-MAC proposals.

So there we have it, a quick look at current TV standards and an even quicker look at several possible futures. It would take a brave person to bet money on the situation at the end of this decade, and it is quite likely, by the time this article reaches you, that the goal posts will have been moved again. As far as home video goes we have little to worry about for quite some time, since even the S-VHS system is currently priced out of the reach of most people. The cheapest good-quality VTRs cost about 20 times as much as the most expensive standard VHS recorders, and only the broadcast format models offer a recording time long enough for a feature film anyway, so there. The next part in this series, then, will go a little more deeply into boring old PAL, with a look at some of the basic techniques required for almost any processing work.

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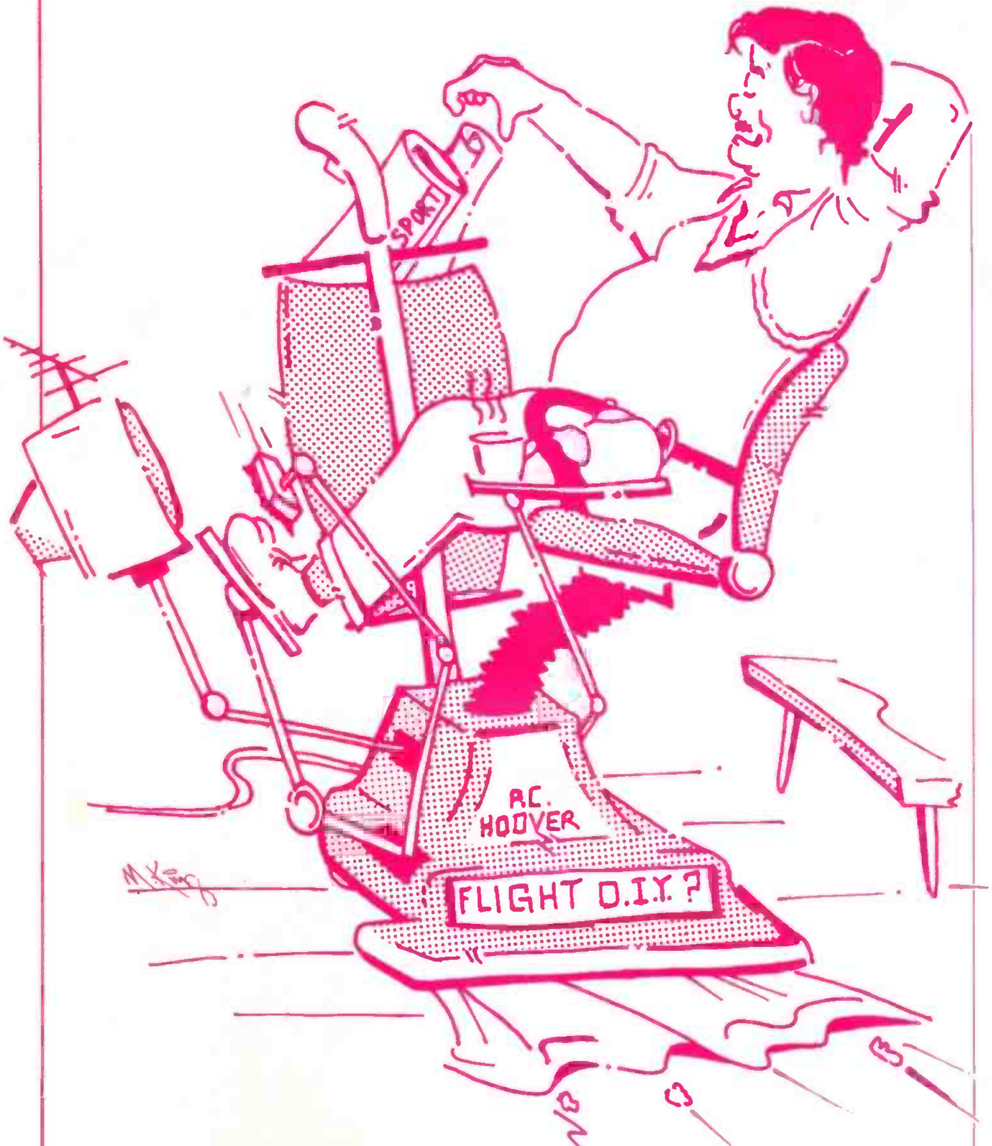


I sit down to write this having just finished the vacuum cleaning. Although calling itself the 'Junior' model, Mrs PC's vacuum cleaner is a powerful beast, hungrily devouring everything in its path including the flakes of white paint which it knocks off the corners of skirtings and edges of doors. As far as PC can make out, it is a purely electrical machine, completely devoid of processors, RAM, ROM, or anything else interesting. It is a modern vacuum cleaner, not more than a year or two old, and one would have thought that by now it would contain at least one 16-bit processor plus a few sensors to automatically adjust the height of the rotating brushes, depending on whether the floor surface was carpet or lino. With a small keyboard and display built-in, any spare processing capacity could be used for a host of useful tasks; to suggest a menu for the evening meal, to work out the figures for your tax form or to run your football pools forecasting programme whilst you work.

But why, you may ask, is PC reduced to doing humble housework? Well, having been made redundant for the second time in his career (with little prospect at his advanced age of finding another job), it seemed only fair – with an unaccustomed amount of spare time on his hands – to offer to assist the better half in the running of the household. Mind you, dusting and vacuuming is about the limit of PC's contribution, unlike a younger colleague of his, redundant while still far from pensionable age. Unlike Mrs PC, his missus goes out to work, so he does all the housework and cooking, as well as a little subcontract development work in his home laboratory. PC assists him occasionally (with the development work that is, not the housework), and also earns a copper or two writing this column every month. But don't get the idea that you could earn your living by writing electronic chat columns too, there just aren't enough magazines wanting them, to support even one writer – and anyway I thought of it first!

But, to return to vacuum cleaners, regular readers may recall me mentioning Charlie, who ran a radio sale and repair shop (and unofficial radio club) in K------- Road when PC was a lad. Now Charlie sternly refused to let his wife have a vacuum cleaner, insisting she make do with a carpet sweeper. On being asked why, he insisted "Next time you empty the bag, just look at what comes out – you'll find it's 90% carpet." Evidently his northern canniness objected not so much to the cost of a vacuum cleaner as to the inevitable cost of a replacement carpet in due course. Bearing this in mind, on emptying the bag the other week, PC expected to find that the contents were the muddy purplish brown colour you get on mixing together all the colours in a water-colour paint-box, reflecting the range of different colour patterned carpets around the house. But to my amazement, the contents came out a dusty light grey colour! True, if you looked hard enough, you could see traces of the tint of the red self-colour bedroom carpet, but PC is not going to give up the vacuum in favour of a carpet sweeper just yet. After all, the bedroom carpet has been there seventeen years and looks good for another seventeen, by which time we shall probably have long retired to a little cottage in the countryside.

Yours sincerely,

Point Contact

Ideal for beginners – No soldering required.

All You Need to Build Your Own

FUN TRONICS PROJECT No6

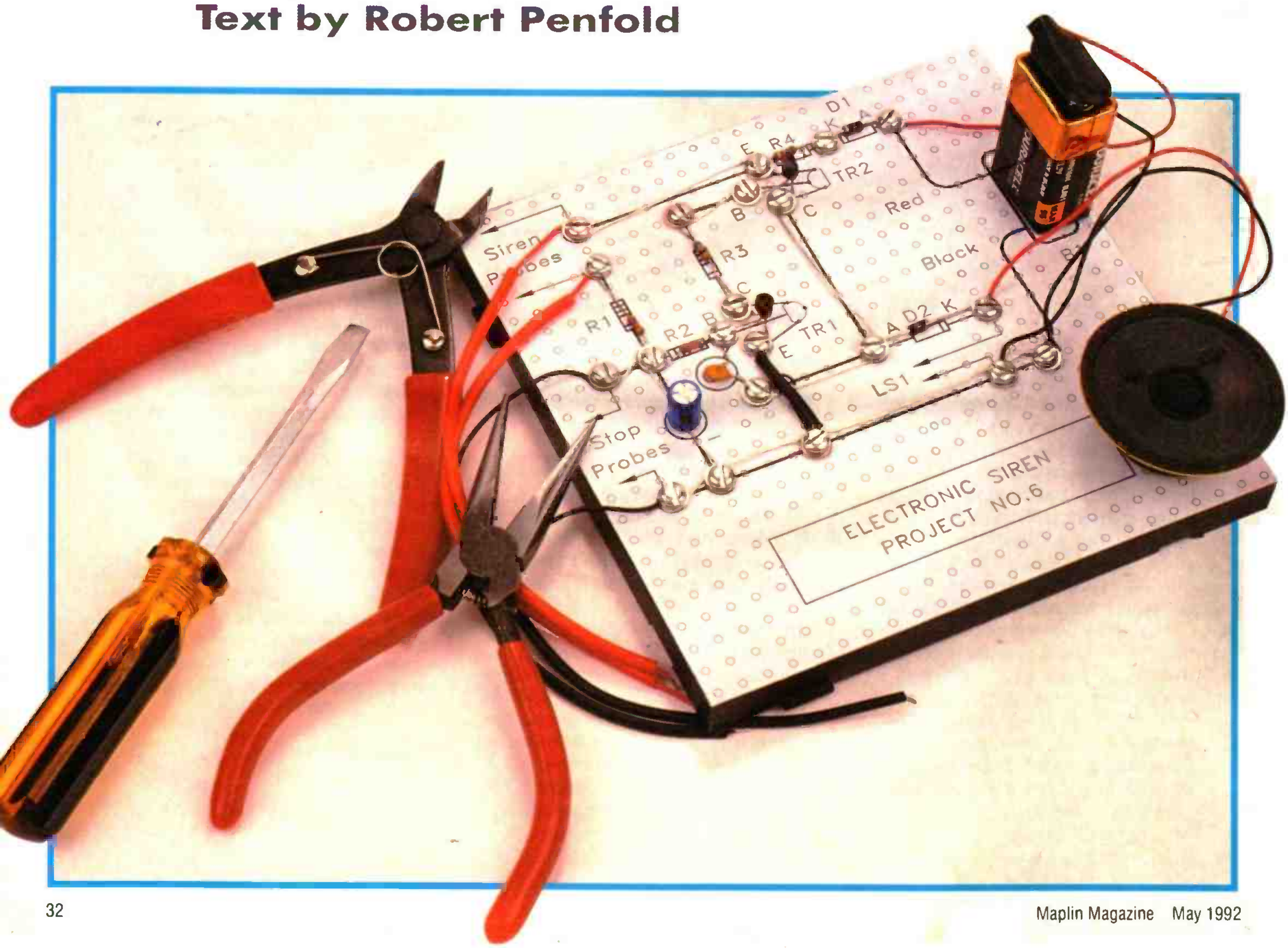
ELECTRONIC SIREN

Text by Robert Penfold

If there is one sound that is recognised by almost everyone, it is the wailing of a siren. The police and other emergency services use them, they are found in burglar alarms – and people even stop and start work to them! At one time, sirens were mechanical devices, but these days it is more normal for them to be based around electronic components. The electronic siren featured here is a low-power type that is unlikely to annoy the neighbours. However, this little unit is ideal for use with model cars and similar applications. It provides a sound that varies in pitch; you can control this pitch by closing a switch to increase it, or by opening a switch to reduce it. This enables a useful range of siren sounds to be produced.

How it Works

This project, like 'The Flasher' featured last month, relies upon the charging and discharging of capacitors to work. The other similarity between this project (the circuit of which is shown in Figure 1) and last month's is that both are basically just simple oscillators; the difference is that in this case, the oscillator operates at a much higher frequency (i.e. delivers more 'pulses' of electricity per second).



LS1 is a loudspeaker, which is connected at the output of the oscillator. Despite its small size, LS1 works in exactly the same way as the loudspeakers that you find in everyday equipment, such as radio and television sets; these devices simply convert electrical signals into equivalent sounds. The pulses from the oscillator produce a simple tone from the loudspeaker. When operating at a low frequency you hear what are really a rapid series of 'clicks', rather than a pure audio tone. This is due to the way in which your hearing works, and not to any change in the operation of the siren at these lower frequencies.

Most oscillators consist of an amplifier with 'feedback' from its output to the input. Feedback, as used here, works along the same lines as acoustic feedback, which results from having a loudspeaker (output) too near the microphone (input) from which it is being driven. This acoustic feedback 'loop', responsible for the characteristic 'howling' sound, is brought about when some of the output signal is 'fed back' into the input. In the case of this project, TR1 and TR2 form a simple amplifier, and C2 provides the feedback from input to output.

The oscillating frequency of the circuit is determined mainly by two components. These are C2 and R2. C2 charges and discharges, in much the same way as the capacitors in last month's project. A higher frequency depends on a smaller value of capacitor, which can supply a faster rate of charge and discharge. Of course, the opposite applies as well.

Normally the left-hand end of R2 would be connected to the positive supply rail. In this case it is connected to R1 and C1, which form a simple capacitor – resistor timing circuit. With the 'siren' probes connected, C1 starts to charge via R1. As the charge present on C1 increases, more current flows through R2 into the base of TR1. This has much the same effect as making the value of R2 steadily lower, and it speeds up the charge/discharge rate of C2. This is heard as a steady rise in the pitch from the loudspeaker. If the probes are separated, C1 discharges into R2 and TR1. The pitch from the loudspeaker then falls. To sum up, the pitch of the oscillator is controlled by the voltage on C1; this is a simple example of a voltage controlled oscillator (VCO). These circuits are often used in synthesisers and other electronic musical instruments.

By touching the 'stop' probes, C1 is quickly discharged and the circuit is stopped from oscillating; this is a quick way of halting the siren. Simply waiting for C1 to discharge through R2 and TR1 can take quite a long time!

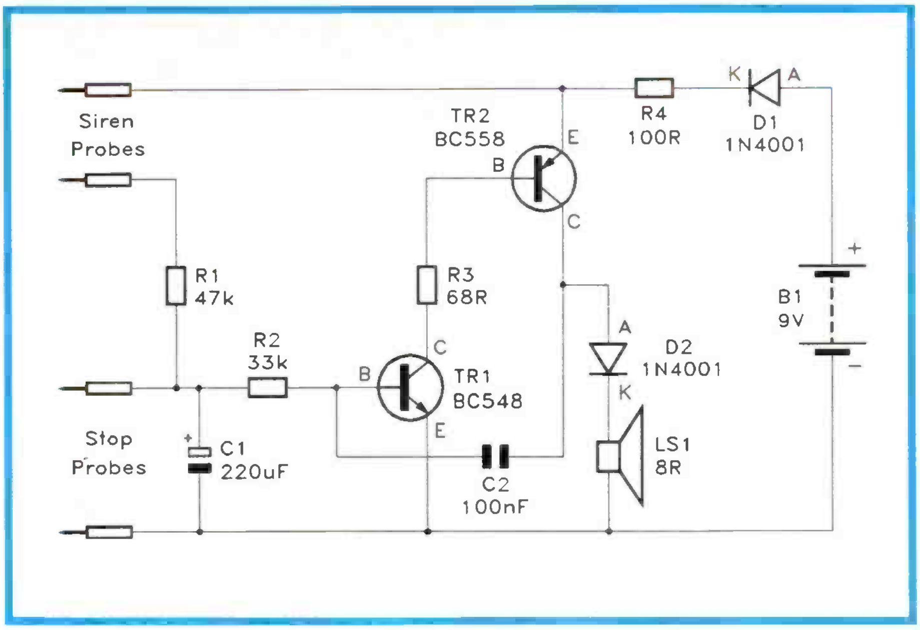


Figure 1. The Electronic Siren circuit diagram.

R4 is needed to ensure that the current flow into the circuit is limited to a safe level. D1 is the protection diode included in all 'Funtronics' projects. If you should fit the battery round the wrong way it will block the flow of electricity, preventing any damage to the other components.

Getting it Together

Firstly, read through this section and then *carefully* follow its instructions, one step at a time. Refer to the photographs of the finished project if this helps.

1. Cut out the component guide-sheet provided with the kit (which is a full-size copy of Figure 2), and glue it to the top of the plastic board. Paper glue or gum should be okay. Do not soak the paper with glue, a few small 'dabs' will do.

2. Fit the link-wires to the board using the self-tapping screws and washers provided. The link-wires are made from bare wire. Loop the wire, in a *clockwise* direction around each screw to which it must connect, taking the wire under the washers. Do not fully tighten a screw until all the leads that are under it are in place, and do not over-tighten the screws, otherwise the plastic board may be damaged. Be careful not to trap the bodies of any components under washers when tightening the screws.

Just below TR1, one wire crosses over another, and it is very important that these wires do not touch together. For this reason, some sleeving is supplied in the kit to cover the bare wires.

3. Recognise and fit the components, in the order given below, using the same method as for the link wires. Cut the components' wires so that they are just long enough to loop around the

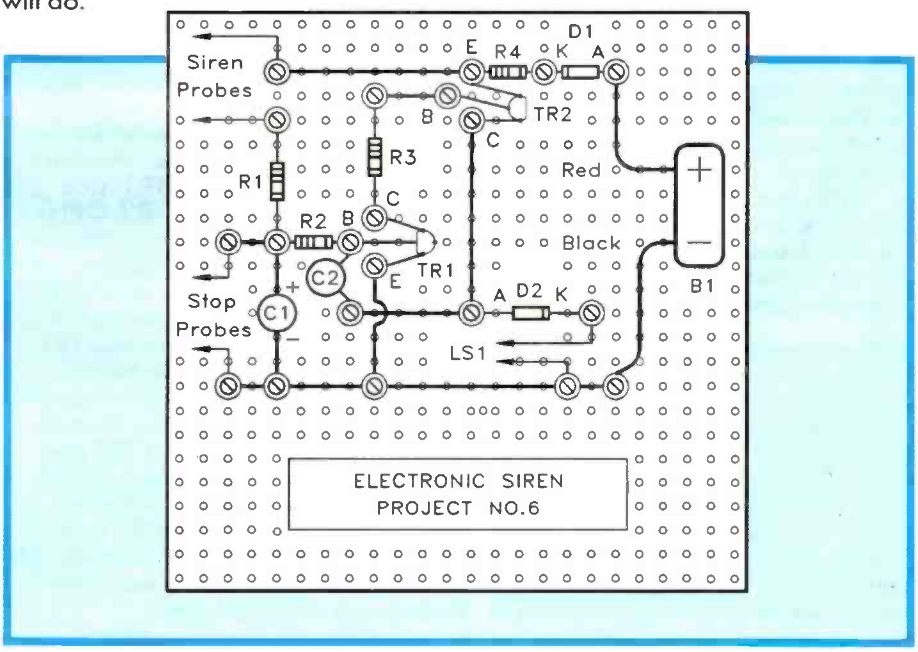


Figure 2. The component guide-sheet for the Electronic Siren.

screws; otherwise long leads left flapping around may touch each other (this is known as a 'short-circuit') and stop your circuit from working. This is particularly important in the sections of the board around TR1 and TR2.

Components

a) The first components to be fitted are Resistors R1,2,3 and 4. These are small sausage-like components having a leadout wire at each end, and several coloured bands around their bodies. These coloured bands represent the value of the resistor; the resistor colour code is featured in the Constructors' Guide (which is available from Maplin; XH79L Price 25p). For each resistor, the colours (and value) are as follows:

Resistor	Band Colours	Value
R1	yellow, violet, orange	47k
R2	orange, orange, orange	33k
R3	blue, grey, black	68Ω
R4	brown, black, brown	100Ω

For each resistor, there is a fourth band, coloured gold, which tells us how near to the given value the resistor is likely to be (in this case, there may be a difference of 5% or less) This fourth band is known as the 'tolerance' band, while the first three bands, shown in the above table, tell us the value of the resistor. Unlike diodes or transistors, it does not matter which way round resistors are connected.

b) Next, fit the two diodes D1 and D2. These are small tube-like components having leads at each end of their black bodies They must be connected the right way round (In other words, diodes are 'polarised' components). Its 'polarity', which tells us the way in which it must be positioned, is indicated by a white (or silver) band close to one end of the body. The circuit symbol and connections for these components are shown in Figure 3. They should be fitted so that this band lines up with the band on the drawing of the diode on the guide-sheet.

c) C1 looks like a little tin can with two wires coming from the base. With most capacitors it does not matter which way round these wires are connected, but this is

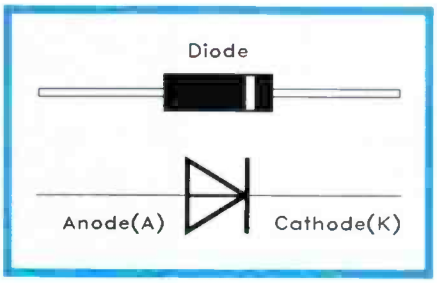


Figure 3. Diode symbol and connections (D1, D2).

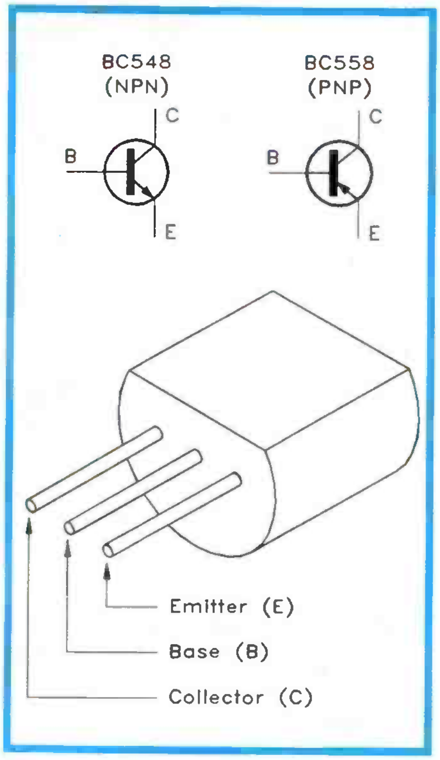


Figure 4. BC548/BC558 transistor circuit symbols and lead identification (TR1, TR2).

an electrolytic type which *must* be fitted the right way round. In other words, electrolytic capacitors are 'polarised' components. On the guide sheet, '+' and '–' signs are used to show which way round C1 should be connected; markings on the capacitor itself indicate its polarity. The actual component might have markings on only one side of the case (probably identifying the '–' lead). If you know which lead is the '–' one, you will know that the other must be the '+' one! C1 should have its value of 220μF included amongst its markings.

d) C2 must now be fitted. This component looks like a tiny disc with two wires coming out of one end. Unlike C1 above, it does not matter which way round C2 is connected.

e) TR1 and TR2 should be fitted to the board next; these have a small black plastic body and three leadout wires. They are marked with their type numbers, which are 'BC548' in the case of TR1, and 'BC558' in the case of TR2. Other markings may also be present; you will have to get used to picking out the important markings on chips and transistors (and ignoring the others!). You must ensure that TR1 and TR2 are fitted to the board correctly. Figure 4 shows which lead is which for each, making this task easy. Note that TR1 and TR2 are different types of transistor (NPN and PNP; see Funtronics Project No.2, in the January 1992 issue of 'Electronics', for further details). This means that the unit will not work if they are swapped over.

f) The loudspeaker (LS1) is a type of component that we have not used in previous 'Funtronics' projects. It is the largest (and heaviest) component supplied in the kit (except for the board, of course). It can be identified by its black paper cone, which is about 50mm (or so) across. The cone is the part of the loudspeaker that literally pumps out the sound-waves as it moves backwards and forwards. Be careful not to damage the cone, which is made from a delicate paper-like material; sticking a finger through it might not stop the speaker from working, but will not improve its performance either!

LS1 may be connected either way round; use two pieces of insulated wire to connect it to the board. Use wire strippers to remove about ten millimetres of insulation from both ends of each lead. Connect the wires to the tags on the loudspeaker first. The wire is multi-stranded, which means that the metal core consists of several very fine wires. The bare ends of the leads should be twisted together to prevent the wires from splaying apart and breaking off – in addition to making them easier to deal with. Thread each multi-strand wire through the hole in the corresponding tag, loop it back on itself, and then twist it tightly to make a reliable connection. It *is* a good idea to use some glue, or a lump of 'Blu-Tack', to fix the rear of the loudspeaker to a vacant area of the board; it is *not* a good idea to leave a delicate component such as this simply hanging loose from the board!

g) The probes are made up from four pieces of insulated wire (two coloured red; two coloured black) and four pieces of hollow insulated sleeving (also coloured red and black). The wire is also

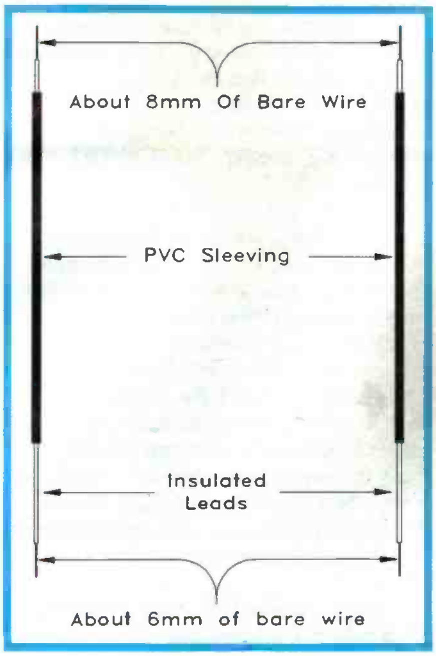
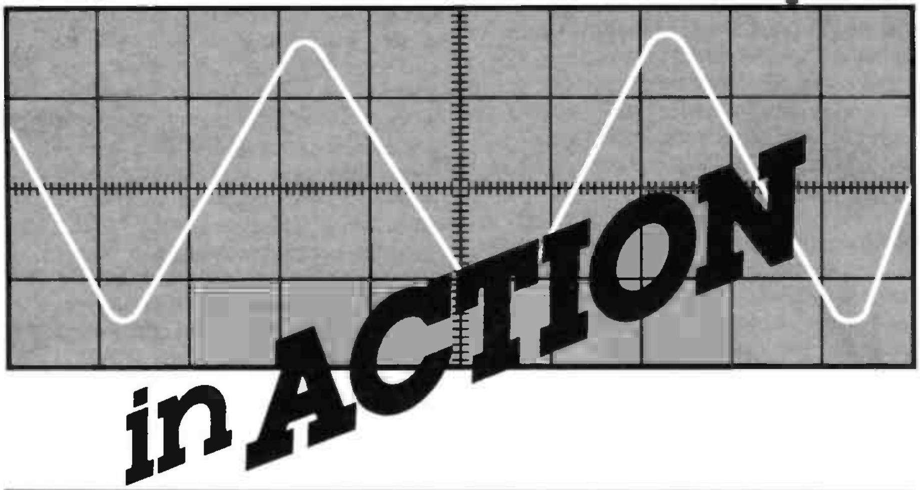


Figure 5. Preparing the probes.

Continued on page 39.

The Oscilloscope in ACTION



Part 1 by Graham Dixey, C.Eng., M.I.E.E.

Of all the instruments available for the experimenter in electronics, the cathode ray oscilloscope, or CRO for short, is undoubtedly the most useful. It is capable of a wide range of measurements, albeit usually by an indirect method, but its real power lies, of course, in its ability to display the actual form of the wave of voltage or current being investigated. To make the best use of this versatile instrument, it is necessary to understand fully the reason for, and the use of, all of the front panel controls. Then one may go on to consider the great variety of tests, the exotic as well as the obvious, for which it can be used. It is this writer's experience, as a lecturer in further education, that many users of the CRO, whatever the stage reached in their studies, invariably fail in some of the above objectives. One of the commonest faults is a lack of understanding of the 'sync' controls; the result is an unsteady display which the student endeavours to stabilise by 'twiddling' every knob in sight – with predictable results! Thus, a difficult situation turns into an impossible one. Frustration also arises when the screen remains obstinately blank immediately after switch-on. This again produces a bout of knob twiddling, which may or may not be successful. Failing the appearance of that reassuring green line, the 'scope' may then be pronounced as faulty, often an incorrect diagnosis. The aim of this series is to show that all of the controls of the average CRO, one that is affordable by most amateurs, have a logical function and are there to help rather than hinder its application. We shall also describe some of the many ways – beginning with the simplest – in which the CRO can be used.

But first an introduction to the instrument itself.

The Cathode Ray

This is the original name for the electron beam and is, of course, how the instrument got its name. This ray or beam is generated in what is called an 'electron gun' assembly, which can be seen in the simplified diagram of a cathode ray tube shown in Figure 1. The electrons are generated within the gun by heating an oxide-coated, cylindrical nickel cathode to a temperature high enough for electrons to be freely emitted from its surface. The aim of the gun (no pun intended!) is to generate free electrons and to accelerate them at high velocity down the axis of the tube towards the phosphor coating at the screen end. The accelerating force is a series of highly positive potentials applied to electrodes known as anodes. These large positive voltages exert a considerable force of attraction on the lightweight electron. During its passage down the axis of the tube, in the direction of the screen, the beam is acted upon in several ways.

(a) It is focused by an anode arrangement (which also provides the accelerating force mentioned above) known as an 'electrostatic lens' so as to form a small dot when it reaches the screen.

(b) Its intensity (determined by the number of electrons in the beam) is controlled by an electrode known as a control grid. This is responsible for the brightness level of the display.

(c) The position of the beam is controlled horizontally by the potentials applied to a pair of plates known as the X deflection plates, or simply X-plates. Similarly, its vertical position is controlled by the potentials on a pair of Y-plates.

The first two of these functions are performed by front panel controls known as FOCUS and BRIGHTNESS, respectively. Figure 1 shows that these controls are potentiometers in the high voltage chain supplying the tube's potentials. In addition, as will be seen in due course, the intensity can be controlled by a signal applied to a special terminal known as

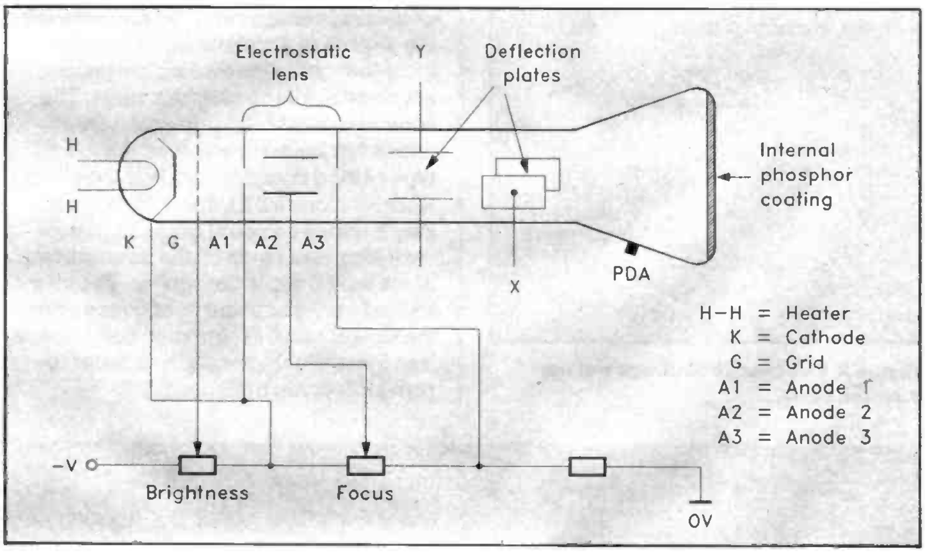
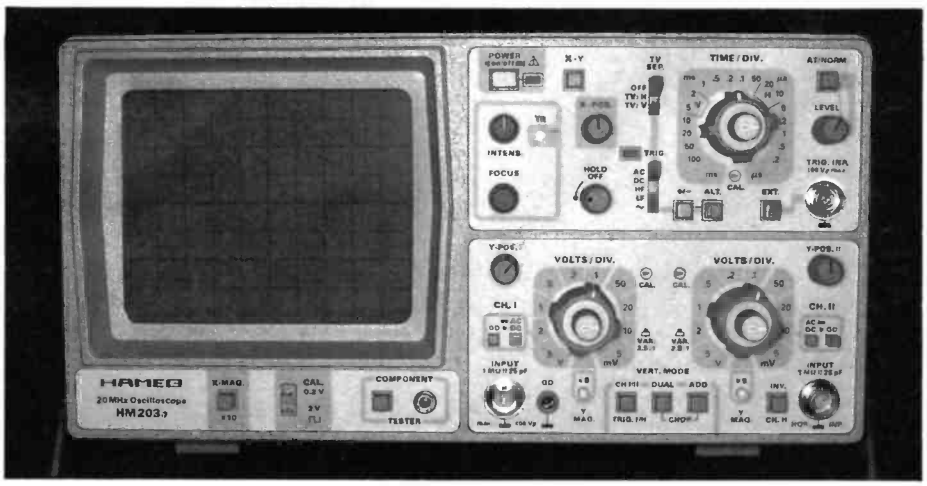


Figure 1. A simplified view of the cathode-ray tube.



Front panel layout of typical small modern dual-trace oscilloscope, in this case, the Hameg HM203–7.

Z-MOD or something similar, this being internally connected to, and giving direct access to, the control grid.

The third function, that of deflection, is performed in two ways – either by front panel controls known as the X-shift and Y-shift controls, or by the signal(s) being examined. We shall now look at this mechanism in greater detail.

Deflecting the Beam

The method of deflecting the beam in the types of cathode ray tube used in oscilloscopes is known as electrostatic deflection. This is different from the technique used in television tubes, in which the beam is deflected electromagnetically. There is a good reason for this because of the quite different geometry of the two types of tube, the angle of scan and so on.

In an electrostatic system, voltages are applied to pairs of plates between which the electron beam passes. These voltages are usually in 'push-pull', that is if a positive voltage is applied to one plate of the pair, a corresponding negative voltage is applied to the other plate. The principle is based on a law well-known to every schoolboy, namely "opposites attract, while like repel." Thus, the electrons, being negatively charged, are attracted to the positive plates, and repelled by the negative plates. The

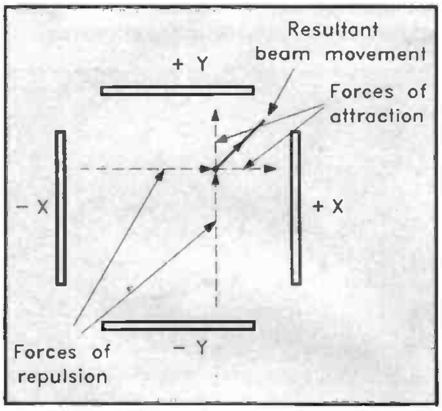
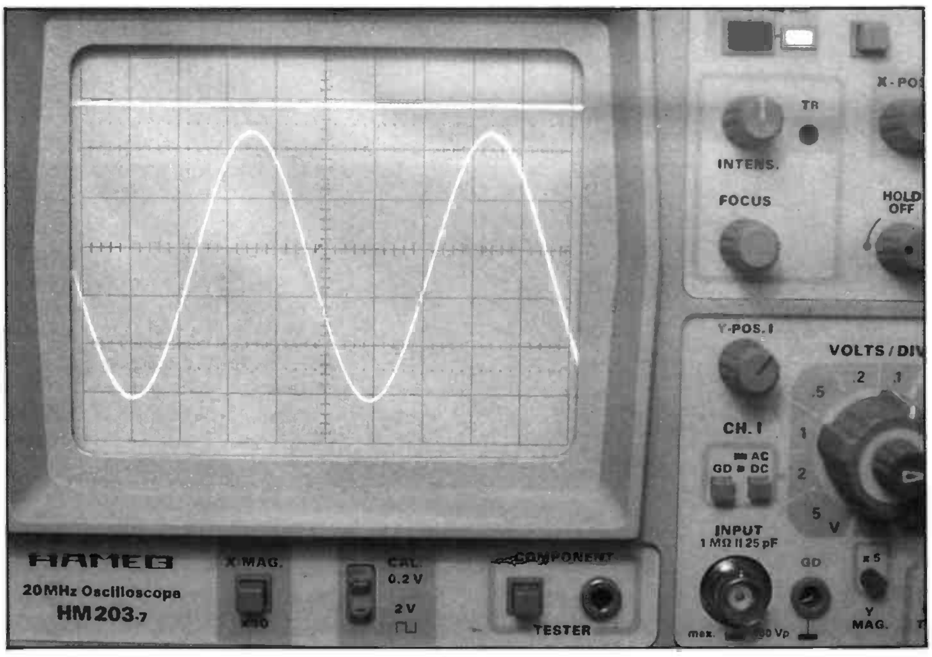


Figure 2. Electrostatic deflection of the electron beam.

beam is, therefore, deflected to one side or the other in the case of the X direction, or up or down in the case of the Y direction. This is shown in Figure 2, where the beam is being simultaneously deflected upwards and towards the right by the voltages shown on the plates. It makes no difference whether the voltages on the plates are 'shift' voltages from the front panel controls or 'signal' voltages; the term signal is used loosely for the present.

The electron beam, when it passes between the deflection plates, is now moving at very high velocity and, hence, with substantial kinetic energy. Under such circumstances, a considerable deflecting force must be exerted by the plates in order to cause it to deviate from its path in the required direction. This means that the voltages applied to the deflecting plates have to be quite high. This leads to the concept of 'sensitivity', which is expressed in V/cm (volts per centimetre; in some older tubes, volts per inch). A figure of 20V/cm implies a lower sensitivity than one of 10V/cm, since the former case states that 20V is required between the plates for every cm of deflection of the beam, as measured at the tube face. A typical display area is 10 × 8cm, so that, with the sensitivity figure quoted, a deflection voltage of +100V is needed for full deflection in the X direction and +80V for full deflection in the Y direction.

It is possible to reduce the value of deflecting voltage required by reducing the degree of accelerating force prior to deflection and providing the major accelerating force after this stage. The latter is provided by a special type of anode just before the screen itself. This type of tube is said to use 'Post Deflection Acceleration' (PDA). The special anode may comprise a spiral graphite path of very high resistance on the inner surface of the tube prior to the screen. The idea behind such a scheme is, of course, that the slower moving electrons now require less force to act upon them in order to provide a given deflection.



The timebase (X) controls for the Hameg CRO.

The Screen

The inside of the screen is coated with one of a number of possible phosphors which have the property that they will fluoresce when bombarded by the high energy electrons. A phosphor may be classified by its 'persistence', which is also related to the colour it produces when it glows. Its persistence is its ability to continue glowing after the electron beam has moved on. This 'after-glow' may decay very rapidly as in 'short persistence' tubes, moderately as in 'medium persistence' tubes, or very slowly indeed, as in 'long persistence' tubes. The colours of the three types of display are blue, green and orange, respectively.

Short persistence tubes are useful for observing very high-speed phenomena; medium persistence tubes are used in most general purpose oscilloscopes, while long persistence tubes are useful for observing very slowly recurring phenomena, and this type is commonly used in certain types of radar.

Some examples of the phosphors used are:

Willemite, which gives a green display; zinc beryllium, which gives a yellow display; zinc oxide, which gives a blue display, and zinc sulphide/zinc beryllium, which gives a white display. It might be asked what happens to all of these electrons when they have reached the screen and done their work? They presumably cannot simply remain there, otherwise a massive negative electrical charge would build up in no time at all. The answer is that they are conducted back into the electrical supply to the tube by means of a grey conductive coating (perhaps known as aquadag) which is sprayed around the inside of the conical section of the tube envelope and connected electrically to the final anode. There is, as one might have expected, a complete electrical circuit for the electrons in the beam, from their emission from the cathode surface, their passage down the tube, to their collection at the final anode and back into the DC supply.

The Time Base and X-Deflection Waveform

Since there are two deflection systems, known as X and Y, there must be two deflecting voltages, one for each set of plates. In practice the voltage applied to the Y plates is an amplified version of the signal being examined. The voltage applied to the X plates is then a voltage that regularly sweeps across the tube, from left to right, at a rate that has a time relationship to the periodic time of the Y signal. The easiest relationship to consider is when the sweep time exactly equals the periodic time of the Y signal. Exactly one cycle of the latter signal will then be displayed. This is demonstrated in Figure 3 from which one can easily see that the total deflecting force is proportional to the instantaneous sum of the separate X and Y voltages.

At the start of the sweep the X voltage has a maximum negative value –

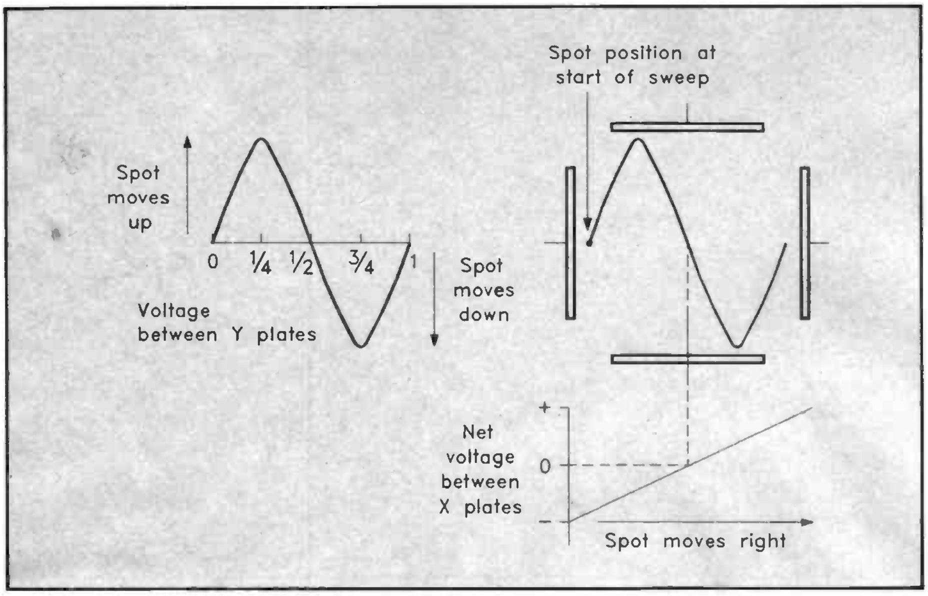
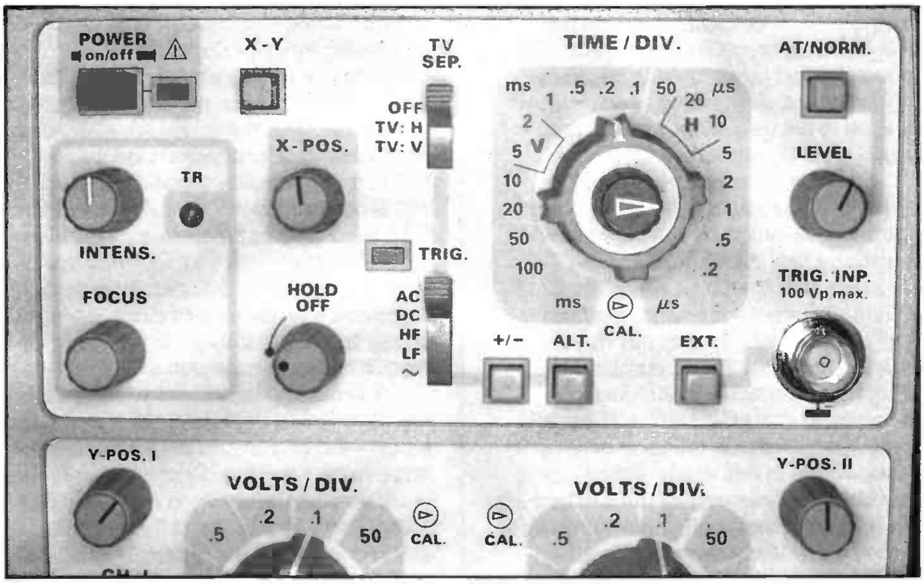


Figure 3. Simultaneous deflection of the beam to trace out a sine wave signal.

holding the beam at the left-hand edge of the display – while the Y signal is zero, giving no deflection, either up or down, in the vertical direction. As the X deflection voltage rises linearly, the beam moves from left to right while, at the same time, the sinusoidal Y signal (in this example) rises in a positive direction. When the beam is a quarter of the total distance across the tube face, the Y signal will be at its peak amplitude. Hence, when the beam is half way, the Y signal has returned to zero; when it is three-quarters of the way, the Y signal is at a maximum negative value; and, finally, when the beam is at the right-hand edge of the display, the Y signal is back to zero again. At this point, the X deflection voltage rapidly returns (flies back) to the starting point ready for the next sweep; the next cycle of the Y signal is exactly ready to start so the two signals act in perfect syncronisation to provide a steady display.

It is not too difficult to project this idea further for cases where the Y signal frequency is an exact multiple or sub-multiple of the X (time base) frequency. The display will always be steady but showing a greater or lesser number of cycles.

The shape of the X deflection voltage is important. It should rise as linearly as possible otherwise it will introduce a horizontal distortion into the displayed waveform. Its 'flyback' period, that is



The Y amplifier controls for the Hameg CRO.

when it is returning to the left-hand side of the screen between sweeps, should be as nearly zero as possible. Since it cannot be precisely zero, any visible trace of the returning beam is 'blanked out' by applying a negative voltage to the tube grid, known as a 'blanking pulse' during the flyback period. The sweep and blanking waveforms are shown in Figure 4.

The circuit that generates the X waveform is a sawtooth generator, known as the 'time base circuit'. In order to be able to examine a wide range of signal frequencies, it must also be able to be adjusted over a wide frequency band with a range switch. A fine, continuously variable frequency control may also be provided. Each of the settings of the switched time base control is calibrated in time/cm; for very low speeds this can be in s/cm, through ms/cm for moderate frequencies up to μs/cm for high to very high frequencies. For a typical CRO, the actual range covered by this control might be from 0·2s/cm to 0·2us/cm, in steps of 1–2–5. A further control that may also be provided is 'X-expansion', which can normally be switched between two values, '1X' (normal operation) and, say, '5X' or '10X' (expanded trace). In the latter case, the time base frequency is multiplied by 5 or 10 in order to show a portion of the display that would appear in the 1X mode, for closer detailed examination.

Synchronising

The time base generator is essentially a free-running circuit, which means to say oscillating and producing output continuously. As such there is unlikely to be an exact, integral relationship between its frequency and that of the waveform being observed. One could, of course, try adjusting the fine time base frequency control until the two frequencies matched. This ought to give a stationary display; however, such a precarious relationship is unlikely to last long and a 'drift' of the display will soon occur. What we need is a way of forcing the time base to fall into step with the signal frequency. This is what we mean by 'synchronising', and there are several ways of achieving it. Essentially it involves triggering the time base oscillator from the signal itself (internal triggering mode), or from another time related signal (external triggering mode).

It is also possible to trigger the time base from either the positive (+) or negative (–) edge of a waveform by means of a ± 'slope' control, usually a selector switch. The terms 'positive' and 'negative' in this context do not refer to absolute positive or negative voltages

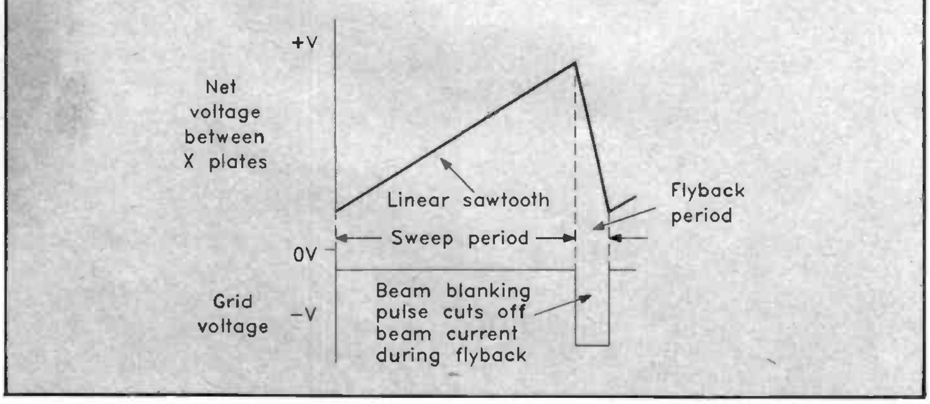


Figure 4. The X sweep and beam blanking waveforms.

but to waveforms that are rising from a lower to a higher voltage, or vice versa, respectively. Another very important control associated with synchronisation is the 'level' control. This controls the amplitude at which the trigger input is effective in causing synchronisation to happen. For example, in the waveform of Figure 5(a) the level control could be adjusted to trigger at either point A or point B, giving the displays seen in Figure 5(b) or (c) respectively.

Another possible mode is 'single shot', sometimes referred to somewhat cryptically as 'bright line off'. In this mode the time base oscillator does not free run at all. In the absence of a triggering signal there is no display – hence the 'bright line' is off! Whenever a suitable trigger signal is received, the time base makes just one sweep, displaying whatever is applied to the Y plates. Nothing further happens until another trigger signal is received. This mode is useful for capturing 'one-off' events. Each time the event occurs it is displayed. With the free-running, repetitive sync mode, the random signal could appear anywhere on the screen, depending upon its time relation to the free-running scan, and would often be missed altogether.

Some oscilloscopes provide the option of automatic triggering or normal operation, selected by a switch marked something like 'AT/NORMAL'. The 'AT' mode is a simple one, in which the CRO effectively presets the variables for the operator. All that the operator has to do is set the time (X) and amplitude (Y) controls (as well as shift controls) correctly, and the CRO will take care of the synchronising; the level control is inoperable in this mode. This mode is reliable for simple uses of the CRO, which really means most routine measurements. Setting the selector switch to the 'NORMAL' position puts the CRO into the other mode, where the operator has to set-up the sync functions as described above.

There are also special cases for triggering. One of these is 'line triggering', in which a voltage at line frequency (that is, mains frequency) is picked off and used to trigger the time base. This is useful for showing signals that are 'line synchronous', whether actually at the 50Hz standard or some multiple of it. A case in point is where it is required to look at small amounts of residual ripple, normally at 100Hz, from the rectifier systems in power supplies. Synchronism is guaranteed, even when the ripple voltage is so small that, by itself, it would not be large enough to synchronise the display.

Other triggering facilities that may be found on even inexpensive CROs are 'TV/VIDEO' (whose application is obvious) and 'HOLD OFF', which allows triggering at critical points in complex signals. A more detailed discussion of these is best deferred until a more suitable time.

The Y Amplifiers

The signal to be examined will rarely be of a large enough amplitude to drive the Y deflection plates directly. In order to provide a display of ample size, all signals can be amplified, the actual gain being switch selectable over predetermined, calculated ranges. Each position of the Y gain control is calibrated in volts/cm, as is the actual tube, allowing amplitude measurements to be made. In fact for the smaller signals this control will be marked in mV/cm. With a typical CRO the Y gain controls may cover the range from 5mV/cm up to 20V/cm in a 1–2–5 sequence. With this degree of sensitivity it is possible to display a signal of only 50mV peak-to-peak (17·68mV rms) at full screen amplitude.

It is usual to provide two alternative signal coupling modes for the Y amplifier inputs – AC and DC. In the former case a large value coupling capacitor is inserted in series with the signal to block any DC component. This is useful for when it is desired to examine a relatively small AC signal that is superimposed on a large (by comparison) DC signal, such as might be the case in the direct connection to the collector of a transistor amplifier stage. The disadvantage of having a capacitor in series with the signal is seen when square waves, especially at low frequencies, are displayed. The time constant formed by this coupling capacitor and the input resistance of the amplifier produces an effect known as differentiation, the result of which is that the tops and bottoms of the square wave have a slope, in extreme cases of marked exponential form, instead of being horizontal. The same switch that selects the AC or DC input often has a third position marked GND, which allows the amplifier input to be disconnected from the signal source and grounded. This is used as a means of 'zero setting' or zero calibration of the input when making DC measurements. All of which will be discussed in due course.

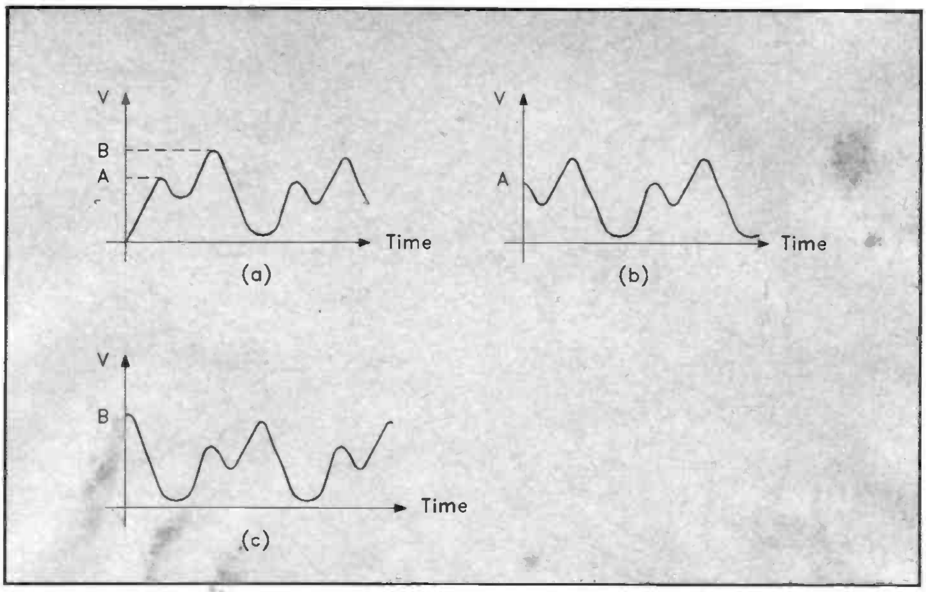
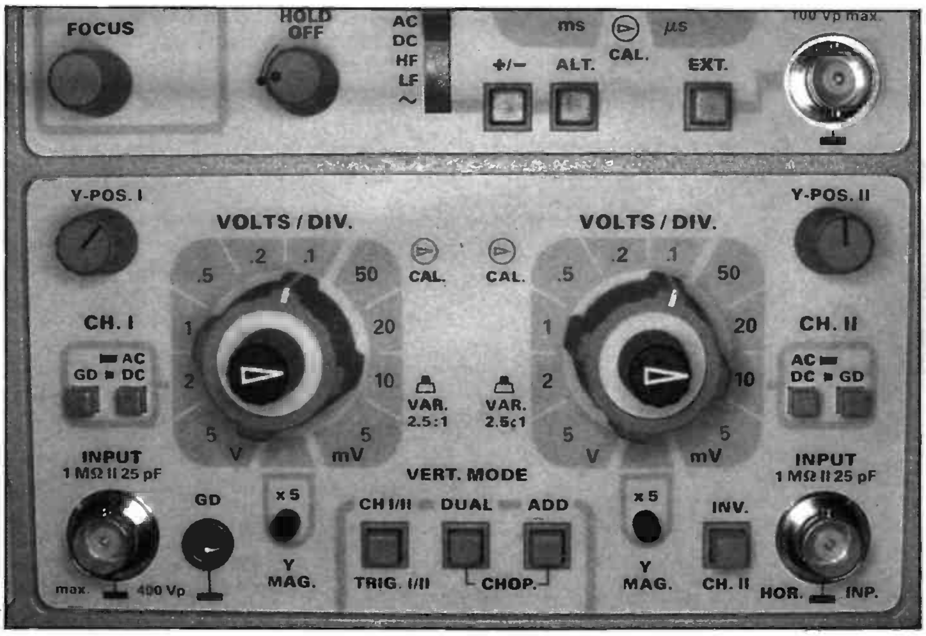


Figure 5. Use of the 'LEVEL' control to set triggering point.

Dual-Beam and Dual-Trace CROs

In a true dual-beam CRO there are two completely independent electron guns and, hence, two totally separate beams. Because such tubes are very expensive to manufacture, many modern tubes use a single gun and single beam, which is effectively shared on some sort of time basis between the two Y amplifiers



The CRO set up correctly, in terms of brightness and focus, to display two cycles of a sine wave.

to emulate dual-beam operation. Furthermore, these dual-trace CROs can allow the simultaneous display of signals which are not time synchronous, provided that the sync signal source can be switched along with the beam input source. Unfortunately this facility is often not available. The dual-trace CRO usually offers two types of beam-switching, either of which can be selected at will. They are described as follows.

The Dual Chopped Mode

A balanced multivibrator is used that connects each signal in turn to the Y plates, but for very short time periods only. In other words, each signal is 'chopped' at a frequency usually of about 100kHz. The persistence of vision, coupled with the persistence of the phosphor, deceive the eye into seeing a continuous trace, except where the frequency of the Y signal approaches that of the chopping waveform. For this reason, the chopped mode is best used exclusively for observing low frequency waveforms.

The Dual Alternate Mode

Here the two Y signals are displayed on alternate, complete, sweeps of the time base. The sampling rate depends upon the time base speed selected. Therefore at low frequencies it is possible to see the effect in action. This mode is, then, best used at high frequencies where again persistence of vision and the phosphor produce a steady display.

The diagrams of Figure 6(a) and (b) illustrate the principles behind these two modes of beam switching.

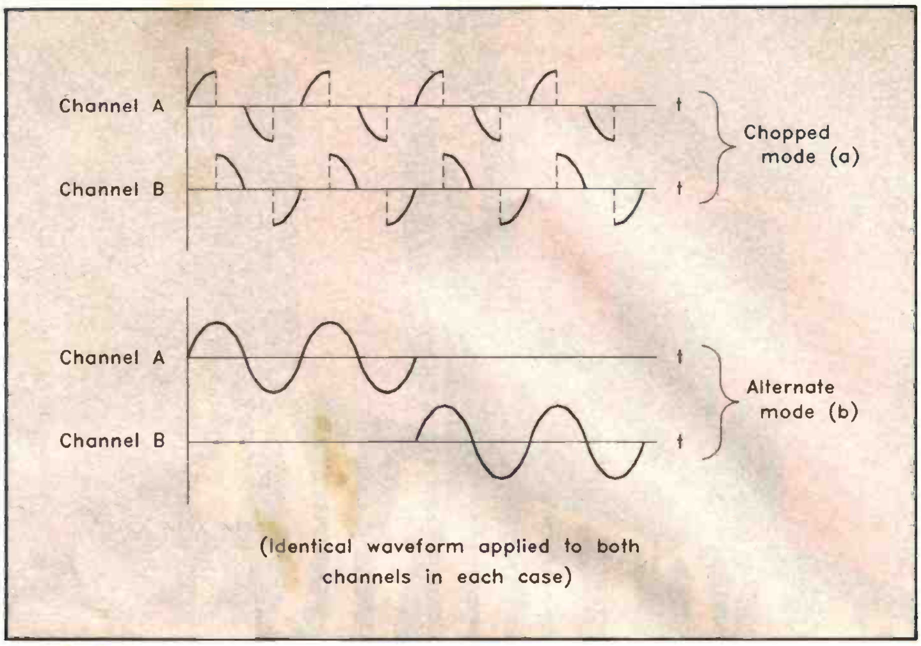


Figure 6. Manner of beam switching for (a), chopped and (b), alternate modes.

The X-Y Mode

In this mode of operation the time base is disconnected from the X plates, which are driven instead from the output of one of the Y amplifiers. This gives the intriguing possibility of having both X and Y systems driven from a pair of (somehow) related signals, frequently sine waves. This leads to the ability to investigate and measure this relationship, specifically with regard to their relative frequencies and phase angles. These are the oft quoted 'lissajous' patterns, more of which later.

That concludes this discussion of the features of a typical modern dual-trace oscilloscope. In Part 2 we shall see what good use we can make of such facilities.

Funtronics continued from page 34.

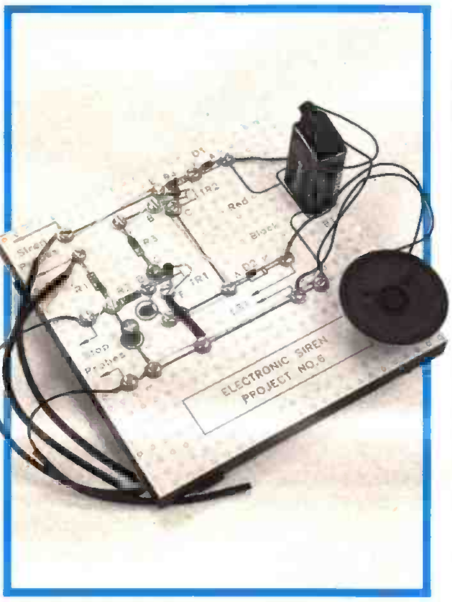
multi-stranded and should be prepared as in (f) above. The probes should be made up as shown in Figure 5 – use wire strippers to remove the insulation where shown. Connect the four wires to the screws on the board marked 'Probes' – the two red wires should go to the screws marked 'Siren Probes', while the two black wires should go to the screws marked 'Stop Probes'. Sleeving of the appropriate colour is slid over each of the four wires, forming the body of each probe.

h) Lastly, fit the battery connector and battery, B1; the connector must be attached to the board with its coloured leads the correct way round.

The battery connector has two press-stud clips on a piece of plastic and two wires coming from it, coloured red and black. The red and black leads should be connected as shown on the layout sheet. The 9V PP3 type battery should be connected to the battery connector, it will only fit properly one way round.

Testing and Use

When the battery is first connected to the circuit, the circuit should do nothing. If the bare ends of the two red 'siren' probes are held together, there should be some clicks from the loudspeaker after a short delay. The frequency of the clicks should steadily rise until a 'tone' is heard. If the probes continue to be held together, the pitch of the sound will steadily increase for a time, but will eventually stop at a fairly high pitch. Separating the probes should result in the tone starting to fall. You can therefore vary the pitch in the required way by alternately touching together and disconnecting the 'siren' prods.



The finished Electronic Siren.

Touching the bare ends of the 'stop' probes together should result in the output being cut off at once.

If the unit fails to work, it is likely that D1 or D2 have been fitted around the wrong way; also check the connections to TR1 and TR2. If the unit works, but seems to be a bit erratic, check that C1 has not been fitted round the wrong way round.

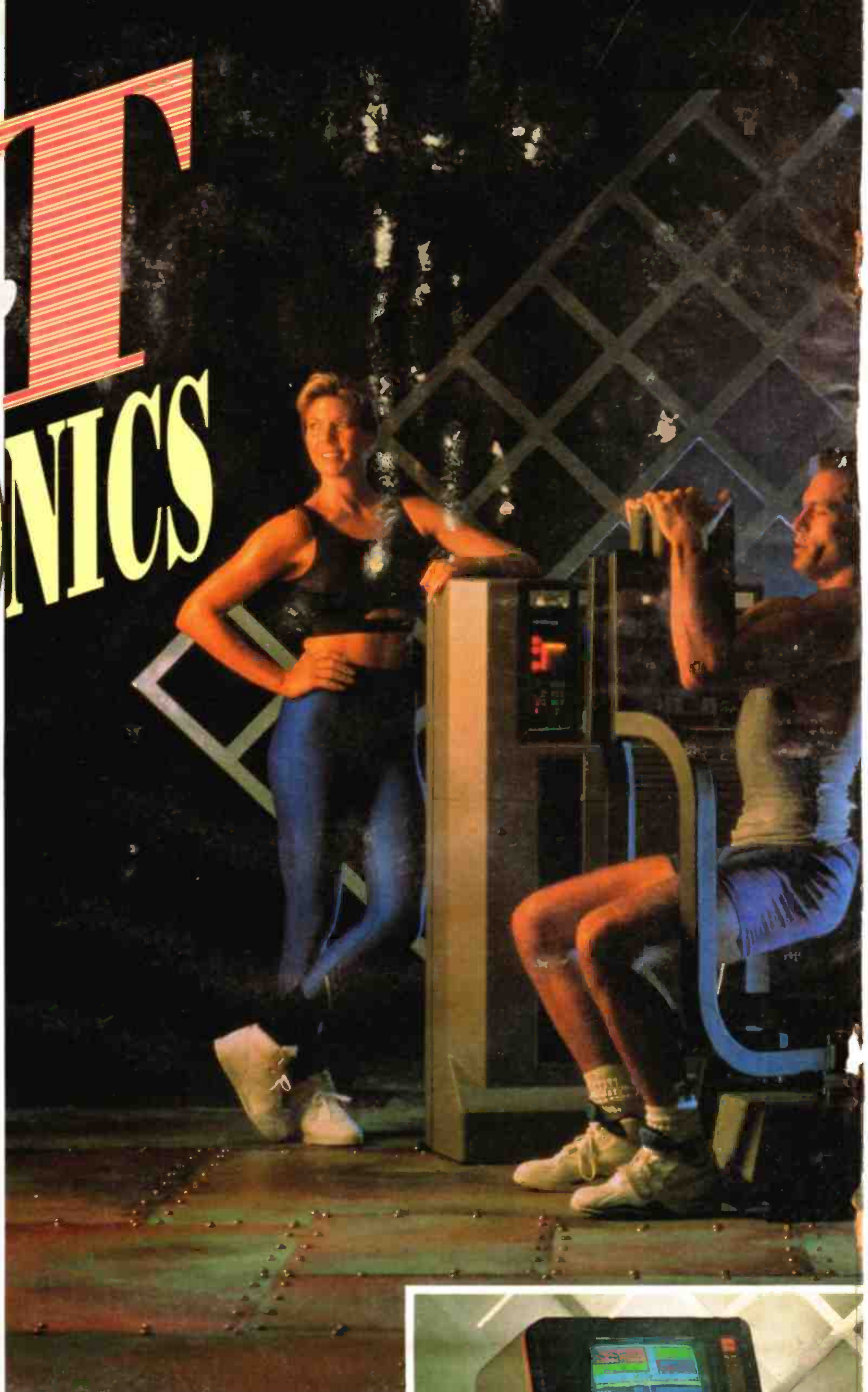
Using this Project as a Capacitor Checker

The unit can be used to check most capacitors by connecting them in place of C2. If they work, the unit should oscillate. Values higher than 100nF should give lower frequencies, while values of below this figure should give higher frequencies. Note that with very small capacitors (around 100pF or less) the unit might not function properly. Therefore, it should not be used to check capacitors with such low values.

Availability

The Funtronics Electronic Siren is available from Maplin Electronics, through our chain of regional stores, or by mail order, **Order Code LP97F Price £3.95.**

Fit for ELECTRONICS



by David Holroyd

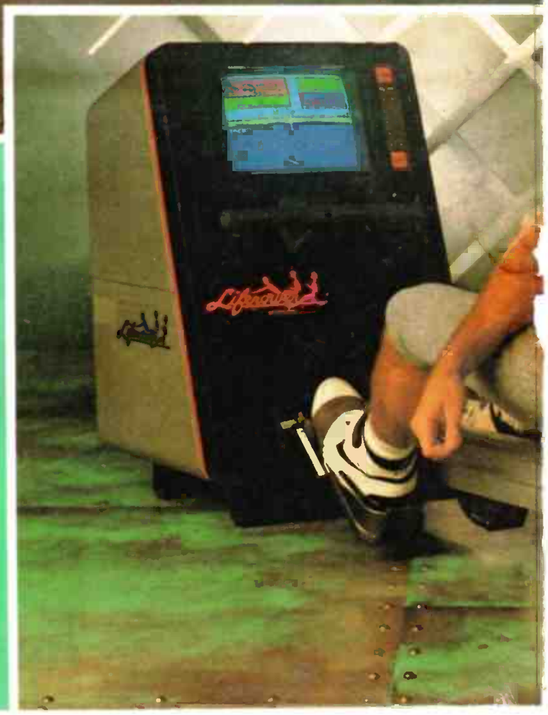
The benefits of electronics are all around us. The latest area of our lives to make this claim is that of fitness. Thanks to the introduction of modern electronic technology, fitness is now more interesting, more accurate and probably more effective. Home or gymnasium exercising has mushroomed over the last few years to become big business. It now attracts the interest of all the leisure giants, with new international operators appearing seemingly every week. Deciding the particular exercise required by an individual is now a much more sophisticated and scientific process. The latest forms of Gym or Health Club have staff who will calculate the desired level of exercise for a range of options; these may be, for example, the maintainance of muscle tone, a desire to build muscles or a determination to reach certain performance targets. The aim of any exercise programme is to provide a varied and comprehensive régime, which exercises all of the major muscle and body function areas.

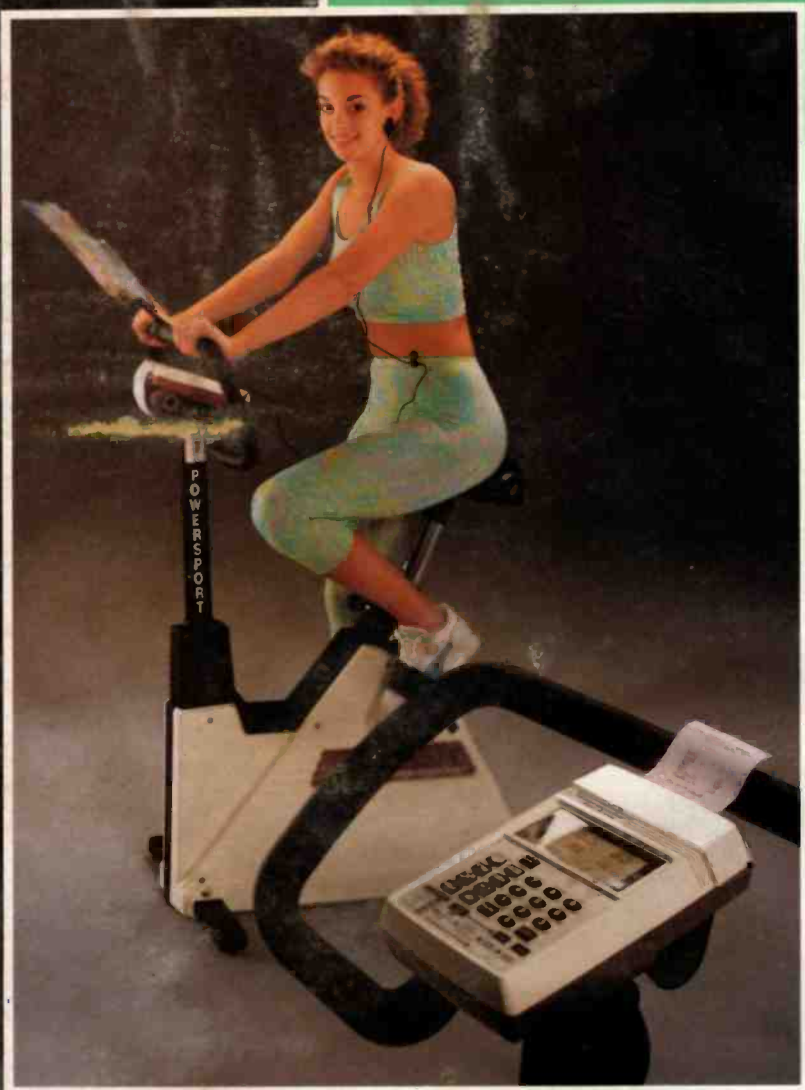
The state-of-the-art gym of the present is a far cry from the dingy weight-training room of city back-alleys. Fitness centres will now include not only the customary weight and strength apparatus, but also an increasing range of electronic extras and equipment.

Weighing up the Benefits

The first area of electronic interest will be the apparatus used for measuring what has happened. Gone is the simple 'go till it hurts and a bit more!' method of assessing limits. There are now a range of products which use either predetermined exercise levels or bio-feedback to tell the user if the chosen exercise programme is right for him/her.

The Life Fitness Lifecircuit (shown in Photo 1) is an example of the programmed exercise variety. Essentially, it is a strength-testing machine based around parallel weights. The difference is, that after having tested strength (rather like the fairground punch ball!), it then informs the user as to the best workout weight. It also gives a personalised machine usage programme that will provide the greatest benefit to that particular user.





This takes into consideration not only the user's performance, but also the frequency of machine usage. As each repetition or programme of use is performed correctly, a comprehensive LED panel shows the level of resistance, converted into pounds. The system then uses this information to compile an exercise programme, ensuring a correct balance of maximum effort repetitions. These will have been determined from the initial strength test.

A system which uses the Bio-Feedback variety of exercise limit assessment is the Cateye Ergociser, shown in Photo 2. This is a sophisticated exercise bike, with a pulse-rate sensor transducer which is attached to the user's ear-lobe. The pulse rate is then related to the exercise programme selected, and the degree of torque (or work-load) applied to the pedals by the machine is adjusted accordingly. A 'beep' sounds when the user's pulse rate approaches a 'danger' level, which is calculated by the machine's on-board computer for each individual trainee. Should this value be exceeded, the torque will fall off, thereby preventing injury. Up to 6 programmes are available, including a fitness test, and each is medically approved. The most sophisticated Ergociser adds a personal identifier card, so that the characteristics, personal profile and exercise record of each individual user can be instantly fed into it. Every 30 seconds the display is printed out, and thus a record of the workout including speed, work rate and pulse is available.

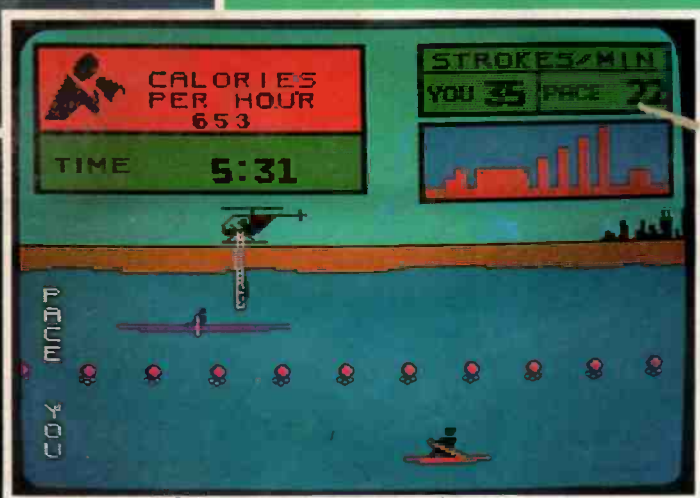


Photo 1 (top left): Life Fitness Lifecircuit.
Photo 2 (top right): Cateye Ergociser.
Photo 3 (left): Life Fitness Liferower. Inset shows screen display.

Rowing without Water

The advantages of feedback systems are increased safety, more effective workouts – and greater user motivation, as a result. It is this quest to make exercise interesting that has led to some fascinating improvements to the three most common appliances; the rowing machine, the treadmill and the exercise cycle.

For example, the Life Fitness Liferower, shown in Photo 3, incorporates an easy-to-read colour monitor, displaying performance information, as well as a graphical representation of the rower. The more competitive have the option of racing against a computer-generated opponent, also shown graphically on the screen.

The ComputeRow from Universal, shown in Photo 4, has an informative battery of LEDs which show exercise modes, time taken and distance covered, as well as stroke power/cadence and work rate (shown as watt-seconds on each stroke, and the total number of calories). The ComputeRow, like the Liferower, features a race simulation option. It also has a switchable 'beep'

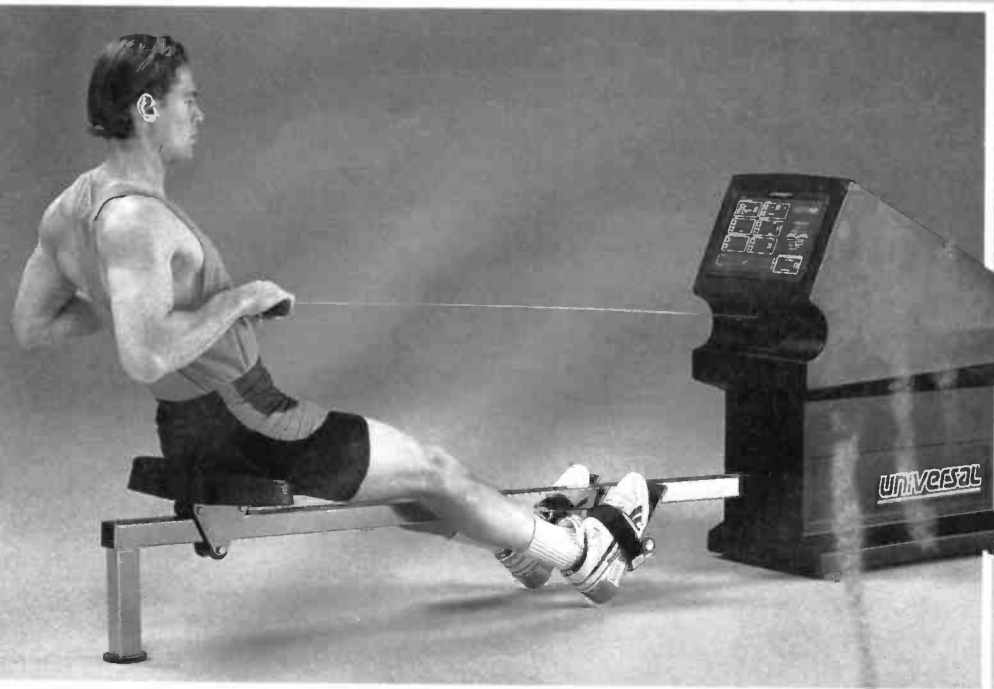


Photo 4 (left): Universal ComputeRow.
Photo 5 (below left): Tectrix ClimbMax 150.
Photo 6 (below centre): Universal TREDEX.
Photo 7 (below right): Life Fitness Lifecycles, linked together in 'competition' mode.
Photo 8 (right): Universal AerobiCycle. Inset shows control panel.

with a adjustable period. This enables the rower to keep correct timing, thereby maintaining cadence. Unlike the Bio-feedback machines, the rowing machines merely provide feedback on a predetermined activity. The exact exercise programme will have either been set by a trainer, or by experience.

Jogging Up the Cliff-face

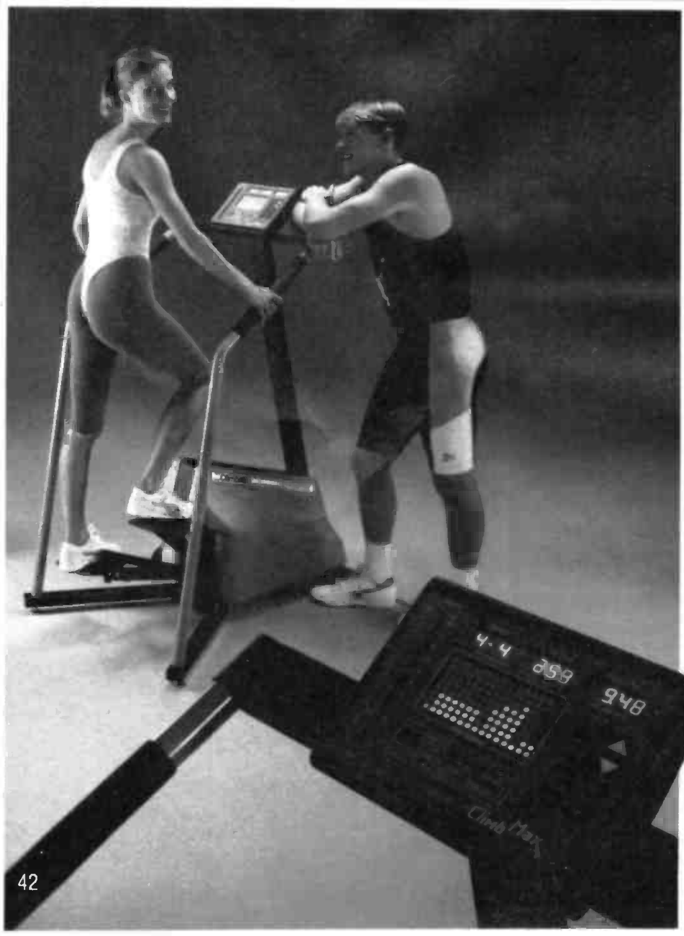
The humble running, or stepping, machine has moved from being a pad on wheels into a computer-aided exercise station.

The Tectrix ClimbMax (distributed in the UK by PowerSport) uses stepping as the basis of exercise, as can be seen from Photo 5. It features 9 automatic programmes, each with 9 levels of difficulty (giving 81 programmed choices). The system also includes a facility to link up between 2 and 8 machines, providing a competition facility which may be of great benefit within a club environment, for example. The LED-festooned control panel on the unit will also state the number of floors that have been climbed, along with the computation of calories burnt and distance covered.

The TREDEX system from Universal (shown in Photo 6) uses that most unique of punishments – jogging or running – as its basis for exercise. The display panel in use here shows distance, gradient, speed, pace and time. This machine also has an I/O port, which allows the use of a remote control. This device introduces up to 20 different individually programmable protocols, and can be used by a remote operator, for example the group trainer of a club or training group. The remote can also disable the user control panel of each Tredex, if desired. A photo-electric beam introduces an emergency shut-off to deal with mishaps. The mains-powered motor drives a non-stretch running belt, which can run at speeds of between 1 and 10 mph, in 0·5 or 0·1 mph graduations.

Exer-Cycle

The final piece of apparatus to be livened up by electronics is the humble exercise bike. As well as information about your energy activity, the most sophisticated models now feature in-built road simulation programmes, which regulate the resistance to pedalling so that the effects of different terrains (e.g. hills, flatlands, etc.) can be recreated. Up to five of the Life Fitness Lifecycles (shown in Photo 7) can be networked together via the Liferacer system. This allows competitions to take place, a 26in. colour monitor screen showing, graphically,



the performance of each individual as well as the relative positions of the racers and an aerial view of the racetrack. Such an arrangement provides extra interest and enjoyment for the group of users.

The popularity and universal nature of exercise bikes means there are more variants. The Universal AerobiCycle, shown in Photo 8, is a bio-feedback variant using an ear-lobe pulse measuring transducer (as previously discussed). All relevant information is available, displayed by means of LEDs on the control panel. This information includes the pulse rate, distance travelled, speed, time and calories burnt. 40 different workloads are available, which simulate cycling on different terrains. The unit also has several pre-programmed exercise modes; steady climb (constant resistance, a 'hill' simulation, a mode which matches the workload to the rider's pulse rate – and even a fitness test! The entire unit, in common with the Rowing Machines, is powered by the exercising of the trainee (along with a low-voltage battery), and the system can thus be used independently of a mains power supply.

Changing Lifestyles

The green revolution means that fitness and exercise are now regarded as common, and indeed necessary. For many engineers and managers, regular exercise is essential if they are not to be worn down or injured through the stresses and strains of their jobs.

With stress likely to be the executive killer of the nineties, the fitness industry boom is set to continue. It is interesting to note the increasing application of electronics in this field, and the benefits that such a technology provides. Not only is it making fitness safer and more effective, but it helps to make enjoyable a potentially dull range of life enhancing activities.

Acknowledgements

Acknowledgements are due to Jason Brown of Powersport (tel. [0656] 661164), Dugie Butler of Life Fitness Ltd (tel. [0353] 666017) and Craig Stokoe of Universal Gym (Europe) Ltd (tel. [0277] 221122).

ELECTRONIC IGNITION

PART ONE
BY MIKE HOLMES

Introduction

The electro-mechanical ignition system that has been used to fire the fuel/air mixture in an internal combustion engine for several decades, and which is familiar to home mechanics everywhere, has practically been replaced by electronic methods in recent times. Some of the reasons for this are not quite as obvious as you might suppose, but certainly, as with everything else, a modern electronic alternative is superior to its electro-mechanical ancestor, to be fair though, the latter has had a lot going for it, it originally replaced a method so archaic as to be unbelievable.

Automotive Ignition – a Brief History

Earliest motor cars, or in fact anything using the new-fangled 'gas' engine (many of which were also used for powering agricultural machinery), of slightly over a century ago had to make do with a device comprising a thin-walled copper tube with closed ends, supported in the middle with a porcelain insulator or some-such similar item. The insulator screwed into the cylinder head, like a modern plug – indeed the word 'plug' probably originates from this time.

To start the engine, the outside end of the tube is heated with the flame of a spirit burner until glowing. Then attempts can be made to get the engine going, using a starting-handle. When the fuel/air mixture arrives at the other end of the tube, on the inside, in the right quantities (a bit of a juggling act), it should (hopefully!) burn. Once the engine is warmed up and running, the spirit burner can be put out and thereafter the temperature of the tube will be maintained by the heat of internal combustion, in the same way that the engine of a model aeroplane keeps its 'glow-plug' hot.

Not surprisingly, while the 'gas' engine was still only a few years young, engineers thought hard about improving this less than ideal situation. It was only a question of time before the electrically powered 'hot wire' type of ignition, a 'glow-plug' then, was pressed into service for the petrol engine. The trouble with glow-plugs however, is that the wire burns away quite quickly and a stock of spares must be carried around at all times.

Then, just prior to the turn of the century, a method was devised which, though it seems obvious now, must have taken a good deal of working out at the time. It was reliable in operation like nothing else previously, it was sophisticated, it was state of the art. It was spark ignition.

The advantages included much easier starting – simply energise the system and crank the handle. Also, because the plug was no more than a spark gap at the 'business end', and the electrodes were far more robust than thin wire or copper tube, it had a working life hitherto unseen.

From the engine designers' point of view it raised two important possibilities:
1. The moment of ignition of the fuel/air mixture could be precisely controlled. Previously, the combustion chamber had to be designed to prevent the 'charge' igniting prematurely during compression, a shape which did nothing for efficiency (or 'performance', if you like).
2. Engines with multiple cylinders could be catered for just as easily as singles. Prior to this engines were mostly a single cylinder type – the ignition paraphernalia for just one was usually quite enough to cope with.

There are basically two types of electro-mechanical spark ignition systems: the magneto, and what's called coil ignition. The only difference is that the magneto also generates its own electric power to operate. With coil ignition the power supply is external. In the beginning, there was only the magneto. In the 1920's, the Americans pioneered coil ignition, which used power hitherto generated exclusively for 'ancillaries' – lights and so forth. The power supply comprised a DC generator in the form of a dynamo, with a 'back-up' for the periods when the dynamo couldn't provide the necessary current – an 'accumulator' (a battery). In Europe there was great resistance to coil ignition, especially amongst the British, who thought it 'too gimmicky'. Customers wouldn't buy a car if it had coil ignition – manufacturers had to revert to the magneto in order to be able to maintain sales. Would you believe that such a respected manufacturer as Rolls Royce couldn't shift their latest sports-tourer until they had put a magneto back into every car? Such was the resistance to change. Perhaps there is a modern parallel here, about customers (and mechanics) being frightened of the complexity of fuel injection...

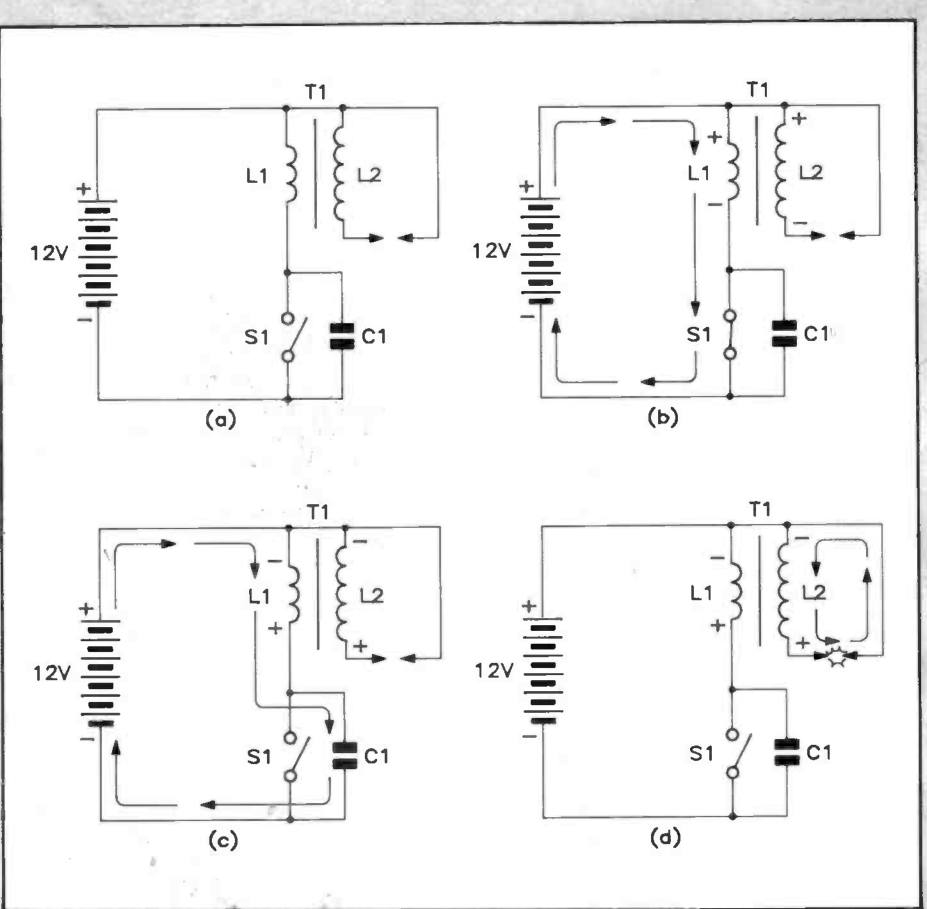


Figure 1. Sequence of activity in contact breaker ignition system.

Spark Ignition – the Principles

An electric arc is an electric current flowing through a gas, which for the purposes of this discussion, is air. Air, as with most 'insulators' resists the flow of electric current. If forced, it 'ionises' as electrons begin to move between molecules. As with any other resistor, this molecular friction generates heat – from the amount of energy required to cause air to succumb, quite a lot of heat. The arc is a white/blue colour, and hot enough to start a fire.

It is worth describing how the electro-mechanical ignition system operates first, since there is no substantial difference between it and any electronic equivalent – they all have to do the same thing, make a spark. We shall start here and work backwards.

Air needs a little persuading in order to carry an electric current and produce an arc. At normal atmospheric pressure it is not all that difficult, but still requires a high voltage to 'break down' the air between a pair of electrodes. The narrower the gap, the easier it is. However, whilst it is quite easy to bridge a gap of 0·02 inches (a typical spark plug gap) in 'open air', it is much more difficult inside the combustion chamber. This is because air ionises more easily the thinner it is (the typical demonstration is an electric arc in a glass vessel with a vacuum pump attached), it correspondingly becomes more resistive the more dense it is, like inside the combustion chamber of an engine. Universally, the fuel/air mixture is compressed before ignition, the main reason being that this releases more energy on combustion (but also because the piston, being a reciprocating part linked to a revolving part, can't help itself). The upshot of all this is that it is more difficult to bridge the gap to produce a spark in consequence, requiring a very high voltage to do so, which accounts for the 25 to 35kV HT voltage range typical at the plug's 'live' end. I labour on this point because it causes problems for the design of electronic ignition amplifiers, as will be seen later.

Obviously it is impractical for this sort of potential to be produced and controlled directly from some engine driven generator, so instead a step-up transformer is used, which is where the coil comes in. All the generation and timed-switching is done at a more manageable low voltage, and is converted by the coil to the necessary high voltage.

Actually the system is cleverer than that. The sequence shown in Figure 1a to 1d reveals the system to be a form of 'flyback converter'. Figure 1a shows the components of a mechanical system 'at rest'. With switch S1 open, nothing is happening. When S1 closes in Figure 1b, current flows in the primary winding L1 of T1, the ignition coil. T1 has a laminated steel core and a finite time is taken for this core to reach magnetic saturation, by which time the primary current will also be at a maximum. This maximum is set by choosing a DC impedance for L1 by using resistive wire, or else it will attempt to short-circuit the supply after the core saturates! For 12V systems the impedance is chosen for a maximum current of around 3·5 to 4A, as a typical value.

In Figure 1c, S1 opens and unwanted effects take place in its vicinity, but we'll ignore them for the moment. Suffice to say that as the magnetic field collapses, it attempts to maintain the current flow in L1 in the same direction, and at the same time induces a current in L2. Because L2 has many more turns than L1, its output voltage is much higher. In the characteristic manner of flyback converters, the coil will attempt to output the same amount of power that went into it. If a path on the primary side is denied it, then the only recourse is to find an outlet on the secondary side.

The 'load' is the plug air gap, which basically doesn't want to know at first, but the coil will keep pushing the voltage up until the gap is bridged. If the total power input was 50W and the output reached 30kV then the gap current is initially 1·6mA. However, once the arc is started, the voltage level required to maintain it can reduce substantially allowing a greater current flow and a nice healthy spark. This is indicated in Figure 1d.

The snag is that a smaller representation of this activity also appears across the primary, L1. The effect is an initial pulse of up to several hundred volts. At the point of breaking the circuit, the mechanical switch S1 has a very narrow gap between its contacts which might be measured in microns. Such a gap is easy for a couple of hundred volts to bridge; the coil expends all its energy in producing an arc between the switch contacts, and there is none left for the plug. If you want to prove the effect for yourself try it with the coil of a relay, a pair of test leads and a battery.

So this is where the other clever bit comes in, the third component in the set-up, C1. To this day it is still called a 'condenser', a very old-fashioned name for a capacitor. Its function is to momentarily take over from the switch. As

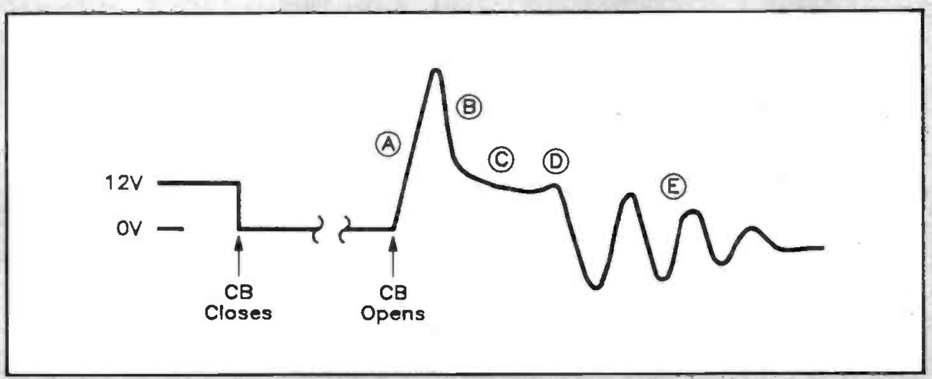


Figure 2. Voltage waveform from Figure 1 at coil primary.

S1 opens, current flow is diverted into C1, charging it. The idea is that by the time the primary voltage reaches a high level, the contact gap is unattainably wide, forcing the coil to go for the plug gap instead. This has two main disadvantages: 1. it consumes some power which might otherwise contribute to the spark, and 2. it slows down the rate at which the HT level can increase, the output of which takes on more of a milder ramped pulse shape rather than a true pulse. The value of C1 is critical: if too small, it will encourage switch arcing; if too large, it will absorb too much power and defeat the whole object. 220nF is usually about right. Switch arcing and power loss still occur, but at acceptable levels.

A third anomaly is that, after the main pulse has occurred, what you are left with is L1 and C1, with the supply as a common terminal, forming a tuned circuit which 'rings' or resonates slightly. Figure 2 shows the voltage waveforms associated with this series of events.

It was mentioned that the ignition coil has an in-built DC impedance to limit current flow while the contact breakers are closed. During this time the coil is drawing its maximum power of 45 to 50 watts, to no effect other than that this manifests itself as heat. Consequently an ignition coil has been safeguarded against this, and hence is almost universally constructed as shown in Figure 3. It is supported in the centre of an aluminium can, which is filled with oil. An ignition coil is, therefore, a liquid cooled component.

Advantages of Electronic Ignition

The first two problems are practically solved by electronic switching, the third by using the coil in a different way. There are other problems that can be solved at a stroke, like mechanical wear.

The heel of the moving half of a contact breaker wears on the distributor cam. The contact surfaces become damaged, developing a hole or pit in the positive side and a raised 'pip' on the negative surface, as the inevitable arcing causes metal to migrate from one surface to the other. The lumpy result causes irregular timing and bad separation, but it may be possible to 'rescue' them with the skillful application of a fine stone.

Then there is the (sometimes better than dreadful) mechanical auto-advance mechanism, with its centrifugal bob-weights, springs, cam contours and vacuum assist device. To be fair, in practice a mechanical system which is both well designed *and* 100% fit is difficult to beat, even by an electronic equivalent, but sooner or later wear takes its toll, affecting engine efficiency, and so it needs periodic examination and correction or even replacement.

But owners put off having the car serviced until it desperately needs it because of 'exorbitant' garage bills. In the meantime the vehicle is wasting valuable fossil fuel and polluting the atmosphere in a way that it wouldn't if properly tuned. Also of concern to car manufacturers, under pressure to reduce pollution and fuel consumption, is the D.I.Y. home mechanic tinkering with his engine. If he knows what he is doing then fine. If he doesn't...

Consequently factory set and maintenance free electronic ignition, and carburettors with security blanking plugs sealing off the vital bits, prevent unauthorised hands fiddling with these and getting it wrong. And you thought it was all done for your benefit. It also explains the lack of really meaningful information in the modern Owner's Handbook. 'Refer servicing to your dealer, or warranty is void', and that sort of thing. Basically it means slapped wrist to the potential D.I.Y'er.

Why do Ignition coils always look like this? See Figure 3 for an explanation.

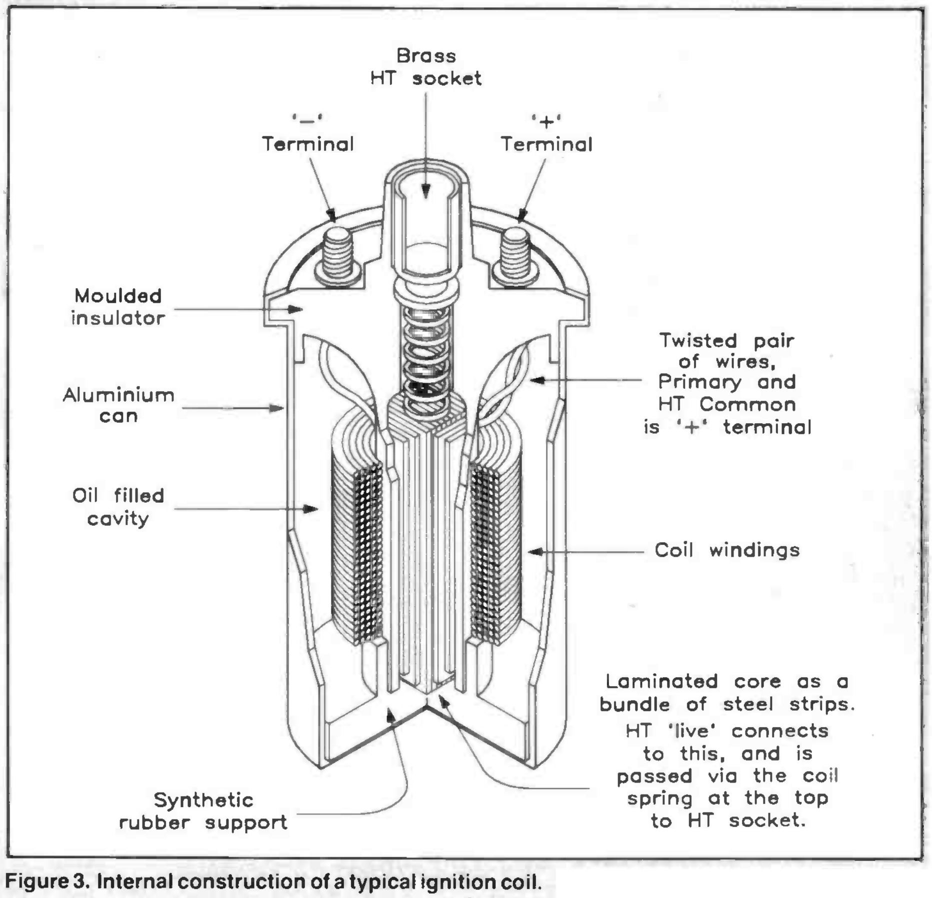
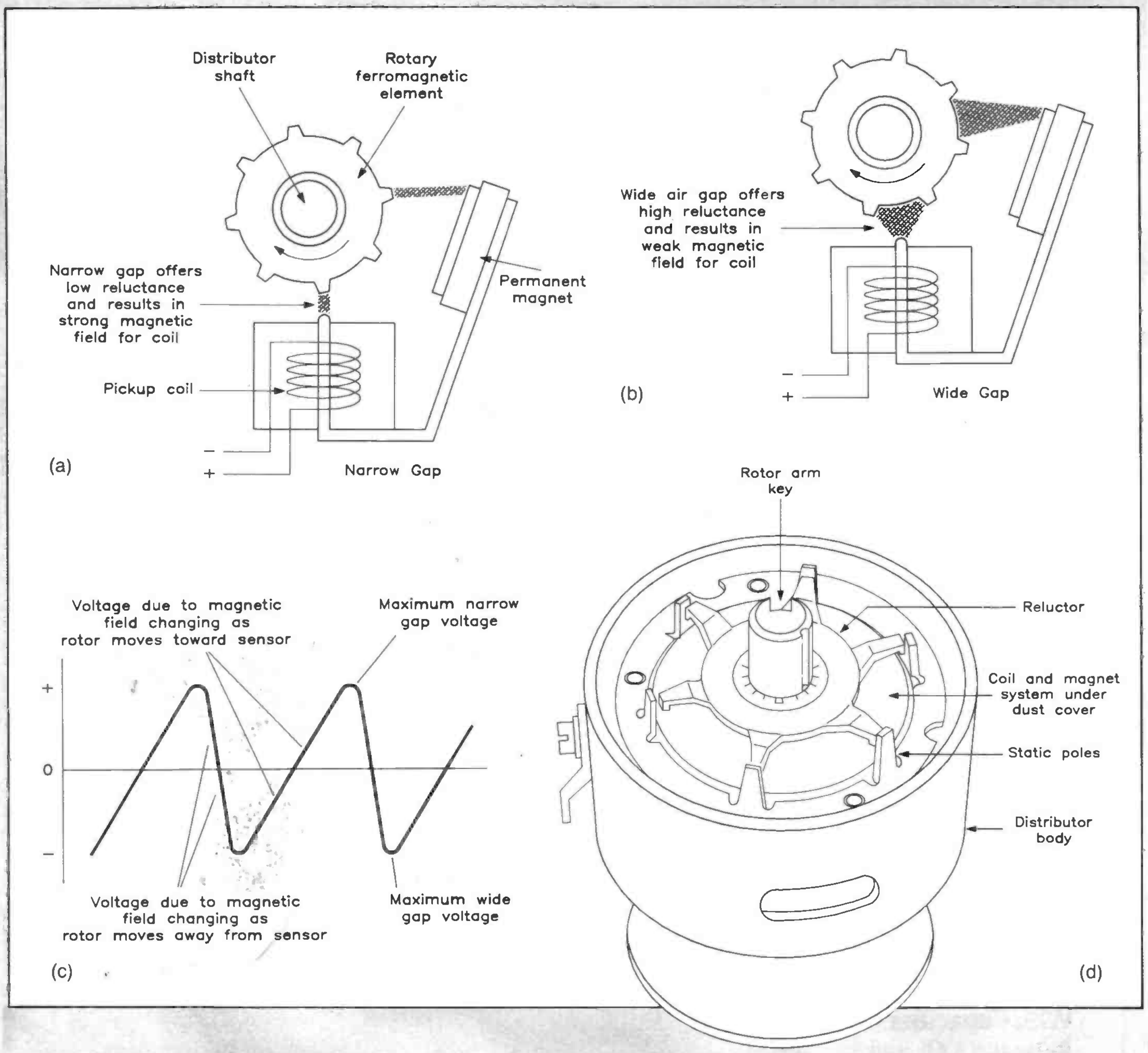


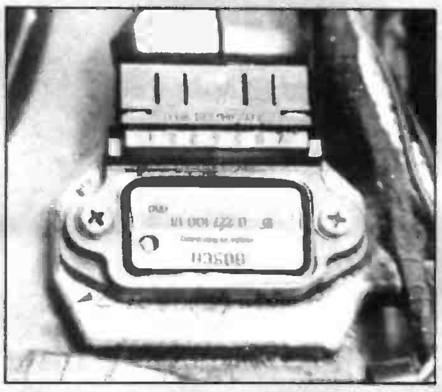
Figure 3. Internal construction of a typical ignition coil.



Electronic Ignition – How It Works

The good news is that electronic ignition for the average modern car has boiled down to a recognisable standard formula, with a long track record of reliability. The bad news is that if it *does* go wrong, you can't fix it yourself. Having a circuit diagram is no help (which you won't be able to get hold of anyway); both the sensor and the amplifier are sealed in resin and you can't get inside without destroying them. And assuming you could get into the amplifier you will most probably find thick film resistors bonded straight onto a ceramic base which they share with other micro-mount components and a very specialised custom chip, with which you will be able to do nothing.

Actually the history of transistorised ignition goes back as far as the 1960's. Unfortunately semiconductors of the time, being made of germanium instead of silicon, were somewhat fragile, requiring that special 'beefed-up' ones be manufactured to cope. Consequently electronic ignition was expensive and usually only found attached to similarly unaffordable sports cars.



Micro-electronics technology. This commercial ignition amplifier is as small as a matchbox.

Timing Sensors

In the 1970's, solid state ignition with three versions of timing sensor proliferated. The simplest was the so called 'transistor assisted ignition', which still required a mechanical switch. The second type had an opto-electric timing sensor, which might use either visible light or an infra-red coupler. Here the beam is interrupted by a rotating shutter with blades like a fan. The third type uses a magnetic sensor.

Many of these were available as after-market 'bolt-on' kits for both cars and motorcycles. After some twenty years only one type has come out on top as the simplest and most reliable – the magnetic sensor.

The sensor generates an electric pulse which triggers the amplifier, which in turn drives the coil primary. Figures 4a and 4b show the now archetypal, standard design in operation. Here a permanent magnet couples to a ferromagnetic element which is mounted on the distributor shaft and rotates with it. As this element rotates, the strength of the field varies, being largest when the air gap is smallest. The time varying magnetic field induces a current in the coil which is proportional to the rate of change of the magnetic field, and which outputs a voltage waveform as illustrated in Figure 4c. Each time one of the teeth, or ridges, on the rotor passes under the coil's axis, one of the sawtooth shaped pulses is generated. The rotor has one tooth for each cylinder and the voltage pulses correspond to the spark time of the relevant cylinder. Figure 4d shows an

Continued on page 54.

LEAD-ACID BATTERY CHARGER MODULES

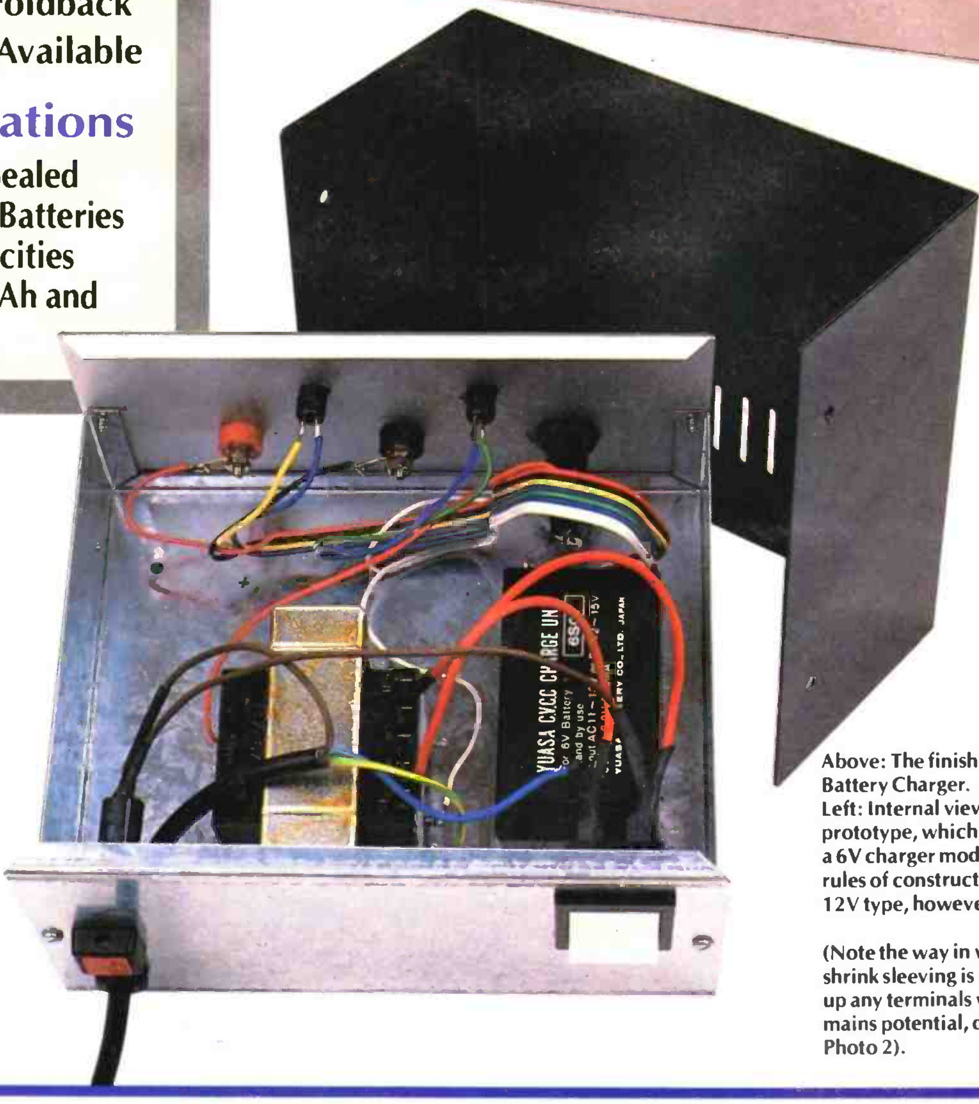
by Gavin Cheeseman

Features

- Available for 6V and 12V
- Output for Power On Indicator
- Output for Charge Indicator
- Charge current up to 500mA
- Current Foldback
- Two Kits Available

Applications

- Charging Sealed Lead-Acid Batteries With Capacities Between 1Ah and 8Ah



Above: The finished Lead-Acid Battery Charger.
Left: Internal view of the prototype, which is based around a 6V charger module. The same rules of construction apply to the 12V type, however!

(Note the way in which heat-shrink sleeving is used to cover up any terminals which are at mains potential, detailed in Photo 2).

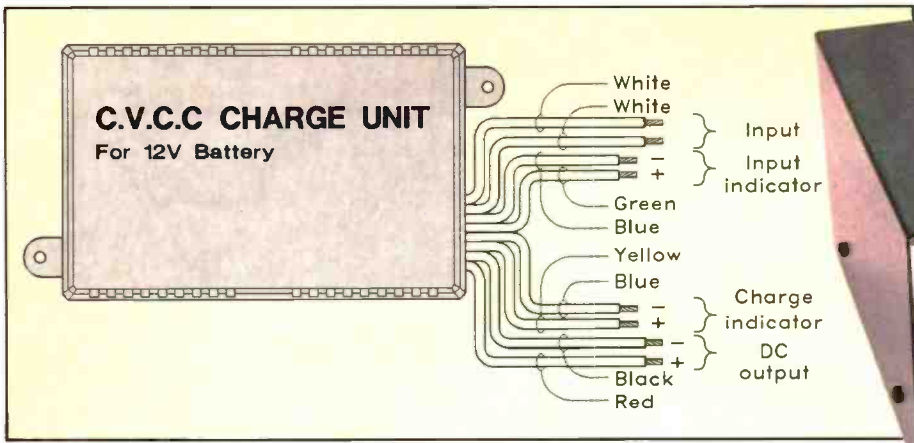
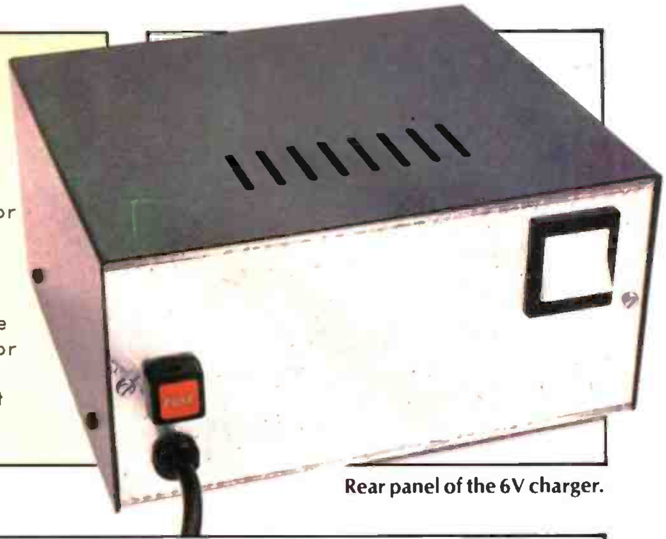


Figure 1. Module lead-out.



Rear panel of the 6V charger.

Two types of lead-acid battery charger module are available from Maplin Electronics; one of these (JY65V) is for charging 6V batteries, while the other (JY64U) is suitable for 12V types (see Table 1). Each charger features a regulated output suitable for charging sealed lead-acid batteries (rated at between 1Ah and 8Ah) at up to 500mA, and has outputs for 'power on' and 'charge' indicators. The units feature current foldback and may be used for cyclic or trickle charging. The chargers operate from a low voltage AC supply and may be powered directly from a suitable transformer.

Figure 1 shows the input and output connections for the charger module; these are made via an 8-wire ribbon cable. Each charger requires an AC input within a specific range; this is between 11 and 13V RMS for the 6V charger, or between 17 and 19V RMS for the 12V version. It is important that the input voltage is kept within these limits, as far as possible, to maintain the correct output level. In addition, it is essential that the maximum input voltage rating is not exceeded as this could damage the unit. It should be noted that the charger is only suitable for charging batteries which have capacities between 1Ah and 8Ah – the unit is not suitable for use with batteries outside this range.

Two Battery Charger Kits Available

Two different kits of parts are available (one for 6V batteries, the other for 12V batteries), each of which contains the basic hardware necessary to build a mains-powered lead-acid battery charger; as well as the module, the kit includes the necessary mains step-down transformer, case, fuse, indicators and so on.

Parameter	**6V Charger**	**12V Charger**
Input	AC 11V to 13V (15VA)	AC 17V to 19V (20VA)
Output Current	700mA	500mA
DC Maximum Continuous Load Current	525mA	375mA
Operating Temperature Range	0 to 45°C	0 to 45°C
Charge Indicator Cut-off Current	245mA	175mA
Applicable Battery Range Dimensions	6V 1 to 8Ah	12V 1 to 8Ah
Dimensions	71 (Max 78)×45×25mm	71 (Max 78)×45×25mm

Table 1. Specifications of charger module.

12V VERSION	
Supply Voltage	Mains (240V AC RMS)
Output Current	525mA Maximum
Charge LED Cut-off Point	175mA
Suitable 12V Battery Capacity	1 to 8Ah
6V VERSION	
Supply Voltage	Mains (240V AC RMS)
Output Current	700mA Maximum
Charge LED Cut-off Point	175mA
Suitable 6V Battery Capacity	1 to 8Ah

PLEASE NOTE: *Never* apply 240V mains directly to the input of the charger *module* – or severe damage will result. Always use a suitable step-down transformer.

Table 2. Specifications of prototype finished chargers.

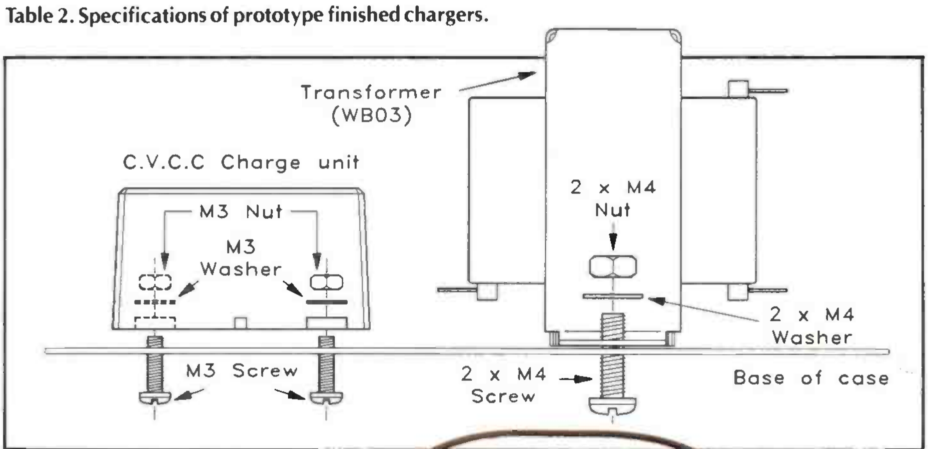


Figure 2. Assembly diagram.

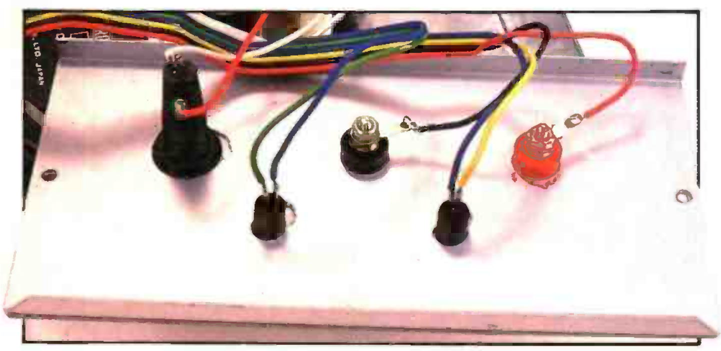


Photo 1. Detail of wiring behind front panel.

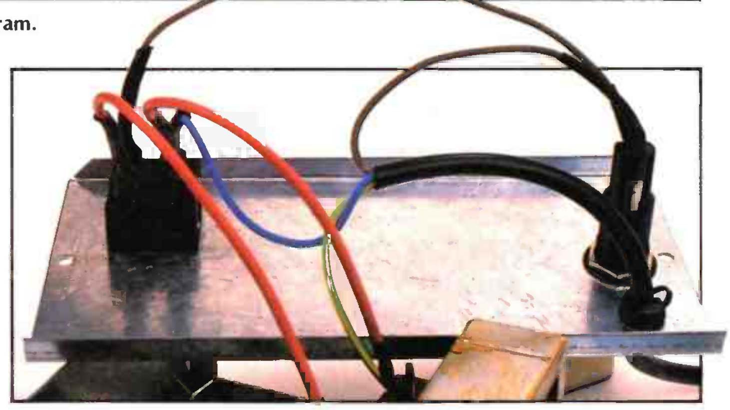


Photo 2. Detail of wiring behind back panel.

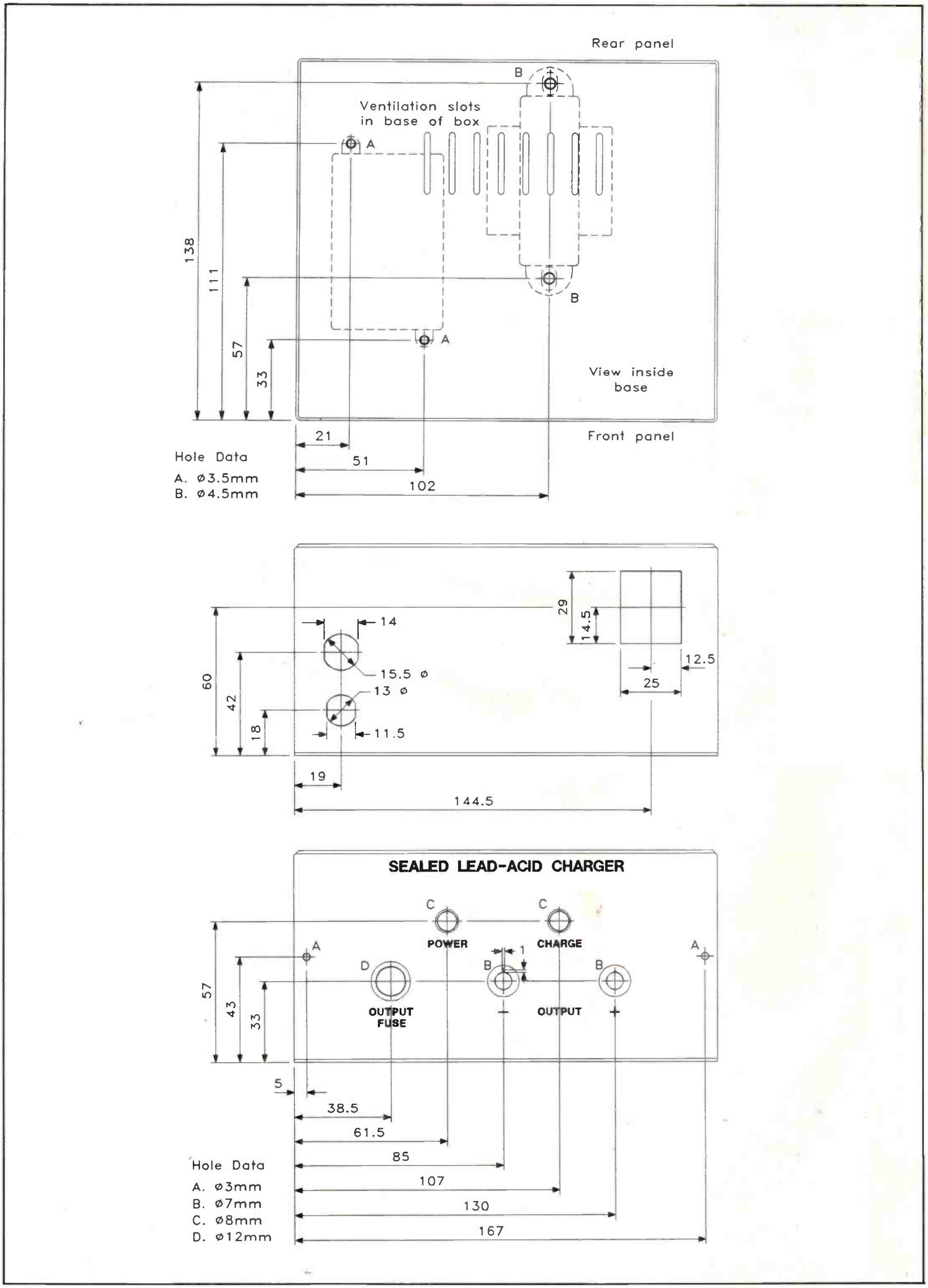


Figure 3. Drilling details.

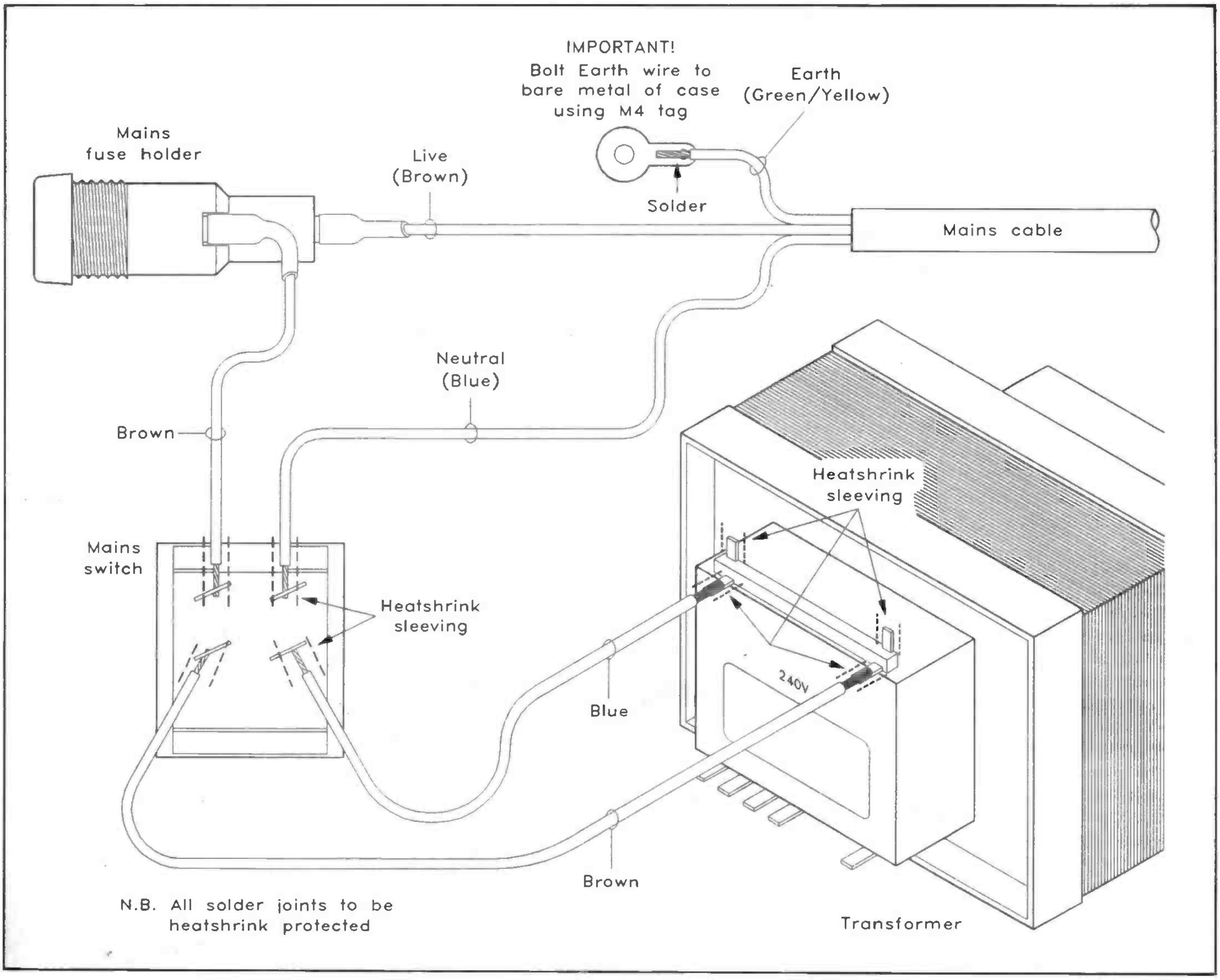


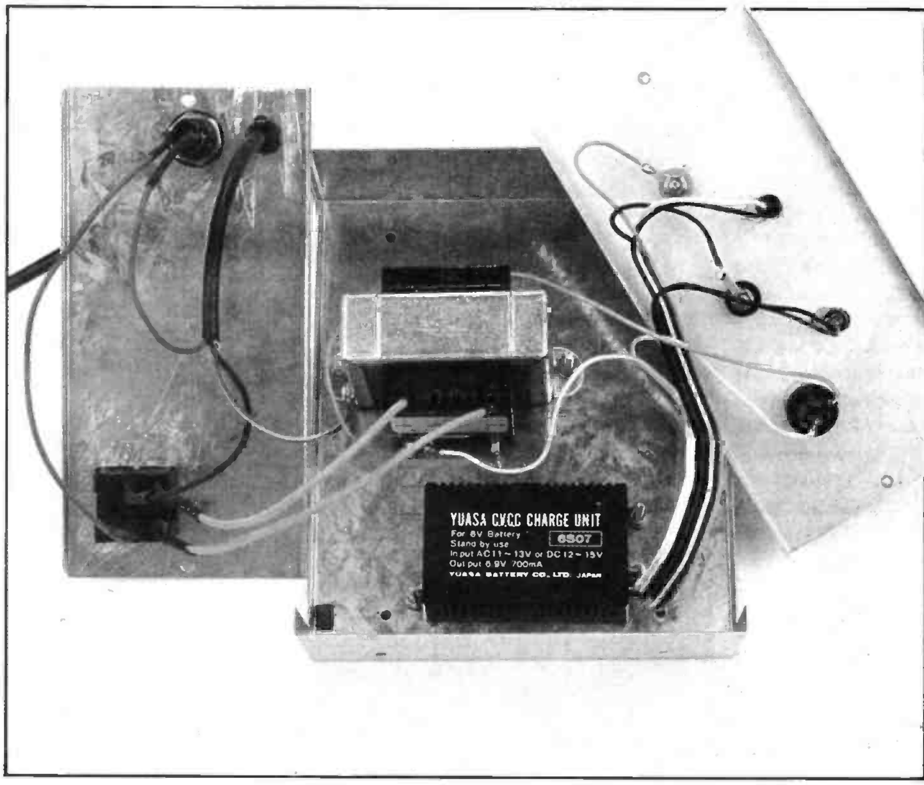
Figure 4. Mains connections, showing wiring to the mains fuseholder, switch, transformer primary and so on.

Construction

Because the module is pre-manufactured, very little construction is required – the unit needs only to be mounted in a box and wired up to the various inputs and outputs. Figure 2 shows how to assemble the charger, while Figure 3 shows the drilling details for the case.

The transformer is mounted in the box using 2 × M4 nuts, bolts and washers, and these should be tightened so that the transformer is completely stable and does not move around in the case. Figure 4 shows the wiring to the mains (primary) side of the transformer; for safe operation, this diagram MUST be followed exactly. The earth lead (green/yellow) is soldered to an M4 solder tag, which must be anchored to the case using an M4 nut, bolt and washer. The earthing tag must be bolted down as securely as possible – *this is an essential safety measure.* It is also important to make sure that all bare wires and terminals carrying live mains are adequately insulated; a length of heat-shrink sleeving is included in the kit for this purpose.

Also supplied in the kit is a strain-relief grommet, which should be clipped around the mains lead and inserted into a



Internal view of the 6V charger, showing inter-wiring.

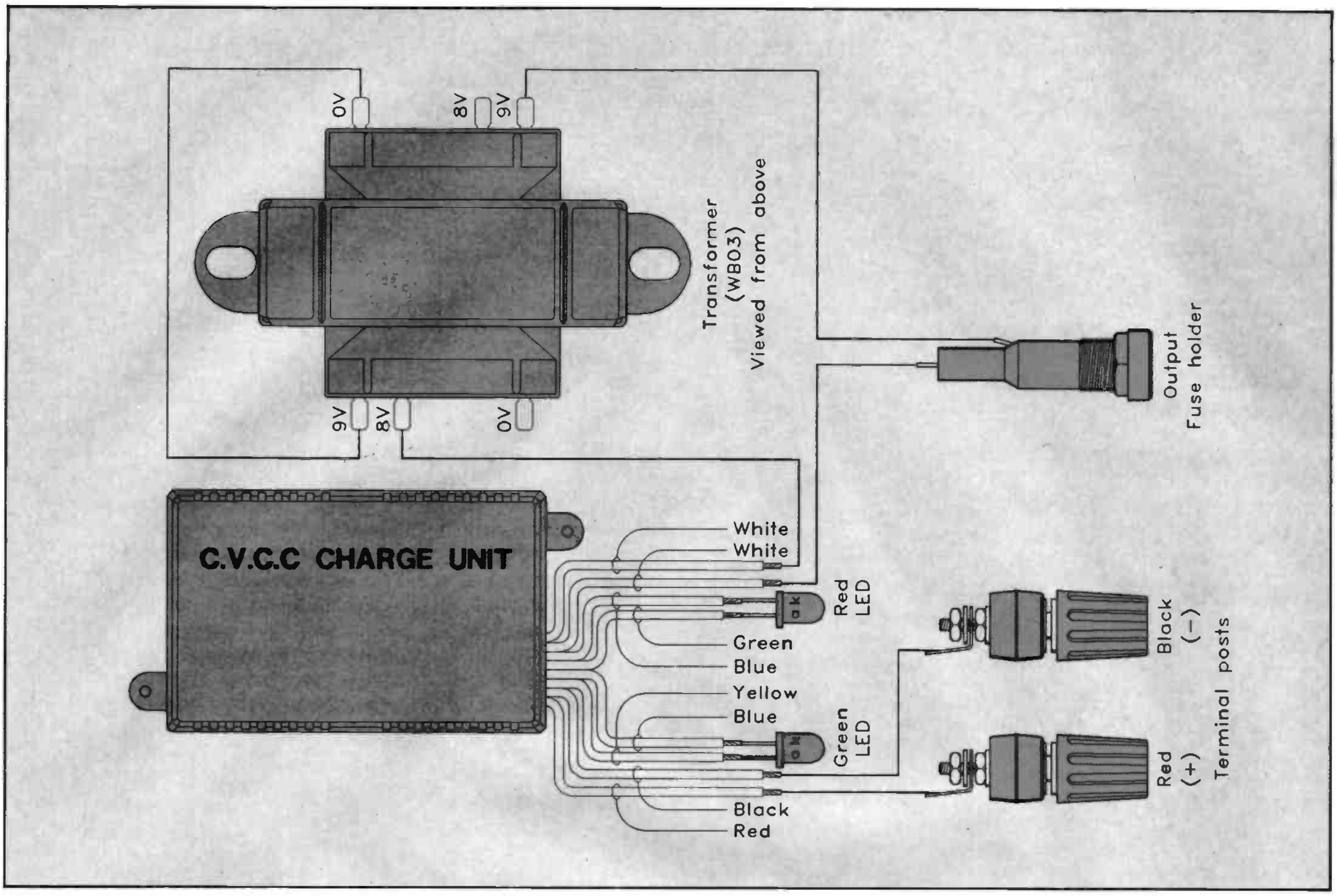


Figure 5. 6V charger – low voltage wiring information.

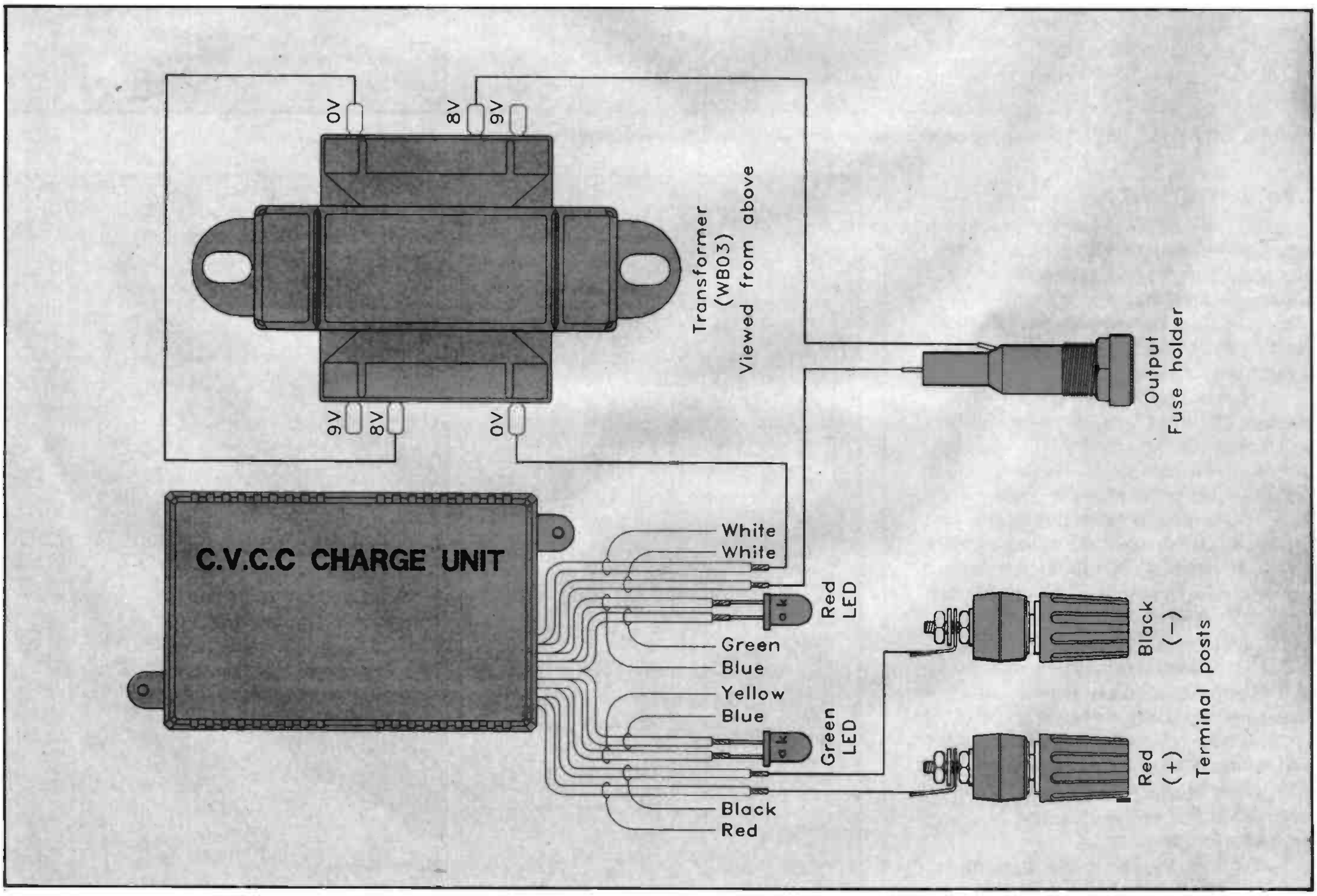


Figure 6. 12V charger – low voltage wiring information.

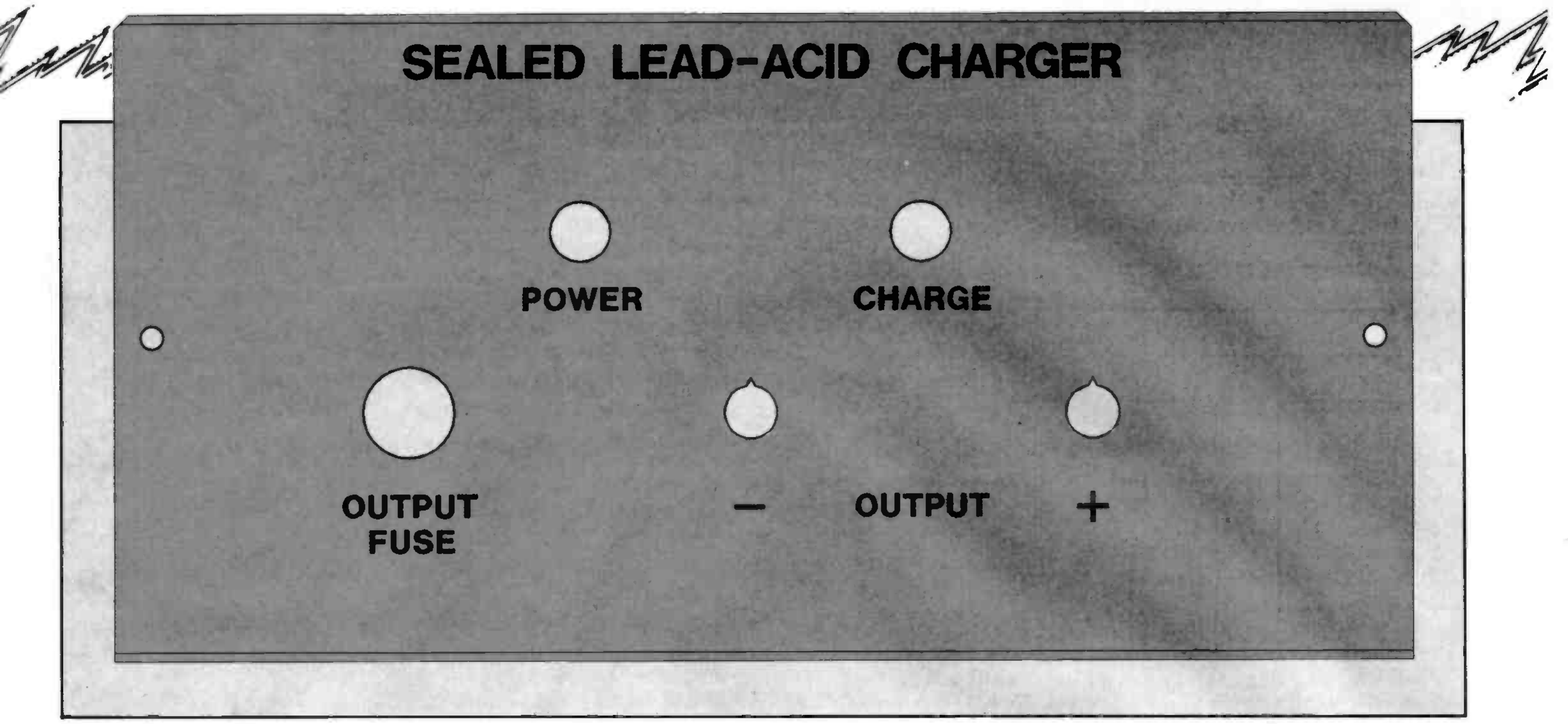


Figure 7. Suggested front panel layout.

cable entry hole drilled in the back panel. This will prevent the mains lead from coming into contact with the metal case, and stop the cable from being tugged out of the case accidentally. The grommet is quite a tight fit and may require some effort in pushing it into position.

Figures 5 and 6 show the wiring from the secondary side of the transformer to the charger module; note that the wiring of the 6V unit is different to that of the 12V unit. The battery charger wires are colour-coded for identification purposes. The charger output is wired to binding posts on the front panel; the red lead from the charger module is wired to the red binding post while the black wire goes to the black binding post. The power-on indicator LED (red) and charge indicator LED (green) are both mounted on the front panel. Both are held in place using the LED clips supplied in the kit. Photo 1 shows the wiring behind the front panel.

The unit has both a primary and a secondary fuse. The 1¼in. mains fuseholder is mounted on the back panel of the case (see Photo 2) and should be fitted with a 100mA fuse. The secondary fuseholder, mounted on the front panel of the case, is a 20mm type, and should be fitted with an 800mA fuse. One of each type of fuse is supplied in the kit. Please note that the charger should *always* be disconnected from the mains before changing the fuses. Figure 7 shows a typical front panel layout, while Figure 8 shows how to mount the fuseholders. Figure 9 shows how to mount the terminal posts.

Testing

Before applying power to the unit, double-check your work to make sure that everything is in place and wired correctly. Make sure that the box lid is in place before testing the unit. *Always* disconnect the mains supply before attempting any work on the charger or removing the case lid – remember that MAINS VOLTAGE CAN KILL.

Connect the charger to the mains supply and switch on the unit via power switch S1, located at the rear of the case. The red 'power on' LED on the front of the unit should illuminate, confirming that the unit is powered up. Temporarily connect a piece of wire between the charger output terminals (TB1 and TB2) to act as a shorting link. During the period that the wire is connected, the 'charge' LED should illuminate. If all is well, the shorting link should be disconnected – the charger is now ready for use.

When connecting a lead-acid battery to the charger, it is important that the connections are of the correct polarity; the red binding post is connected to the positive (+) side of the battery, while the black binding post is connected to the negative (–) side of the battery. To test

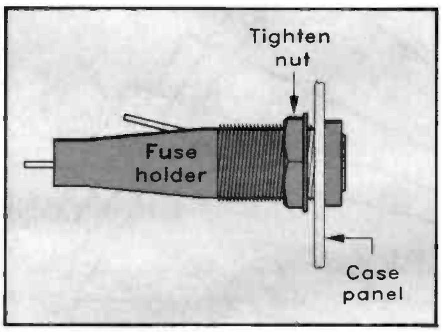


Figure 8. Mounting the fuseholders.

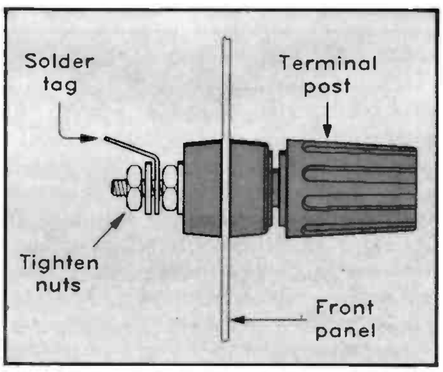


Figure 9. Mounting the terminal posts.

the unit fully, a multimeter, set to read current, may be connected between the red terminal on the charger and the positive (+) terminal of the battery; a direct connection is made between the negative (–) terminal of the battery and the black terminal on the charger. The charge current can then be monitored and this should be around 500mA initially (up to 700mA for the 6V charger) for a fully discharged battery, or between 0 and 10mA for a charged battery. When a new battery is charged up for the first time, this rule may not be followed, the charge current fluctuating in an unpredictable manner. The current values stated are only approximate and may vary considerably, depending on the type and condition of the battery. PLEASE NOTE: *never* connect a multimeter, set to read current, directly between the negative and positive terminals of a lead-acid battery, as this may cause irreparable damage to the meter. The charge LED is only intended to give an approximate guide to the charge condition, indicating when the charge current is above a preset threshold (see Table 1). The unit will continue to charge the battery below this threshold at a lower current, and in this case the charge LED will not be illuminated.

Using the Charger

The charger is suitable for use with 6V and 12V sealed lead-acid batteries with capacities of between 1Ah and 8Ah. It is not suitable for use with batteries outside this range. When in use, the charger should be positioned in a well-ventilated area allowing free air-flow around the unit. The ventilation holes in the box should not be obstructed as this may result in overheating. Although reasonable care has been taken to ensure that the charger is safe, it is recommended that the unit is not left unsupervised for long periods during the charging process. The mains supply should, of course, always be disconnected when the charger is not in use.

6V SEALED LEAD-ACID BATTERY CHARGER PARTS LIST

SLA Charger 6V	1	(JY65V)
Tr 9V 1½A	1	(WB03D)
Steel Case 1608	1	(XJ28F)
LED Red 5mm 2mA	1	(UK48C)
LED Green 5mm 2mA	1	(UK49D)
1¼in. Clickcatch F/H	1	(FA39N)
Large Term Post Black	1	(HF02C)
Large Term Post Red	1	(HF07H)
SR Grommet 5R2	1	(LR48C)
DPST Rocker	1	(YR69A)
Isoshake M4	1 Pkt	(BF43W)
Isoshake M3	1 Pkt	(BF44X)
Pozi Screw M4 × 20mm	1 Pkt	(JC75S)
Pozi Screw M3 × 20mm	1 Pkt	(JC71N)
Steel Nut M3	1 Pkt	(JD61R)
Steel Nut M4	1 Pkt	(JD60Q)
Heat Shrink CP 32	1m	(BF88V)
Fuseholder 20 Flush	1	(KU33L)
Fuse 20mm 800mA	1	(RA03D)
Fuse 1¼ A/S 100mA	1	(UK58N)
LED Clip Convex 5mm	1	(UK14Q)
Min Mains Black	2m	(XR01B)
Isotag M4	1 Pkt	(LR63T)
16/0·2 Wire 10m Black	1 Pkt	(FA26D)
Heat Shrink CP 64	1m	(BF90X)
Instruction Leaflet	1	(XT73Q)
Constructors' Guide	1	(XH79L)

12V SEALED LEAD-ACID BATTERY CHARGER PARTS LIST

SLA Charger 12V	1	(JY64U)
Tr 9V 1½A	1	(WB03D)
Steel Case 1608	1	(XJ28F)
LED Red 5mm 2mA	1	(UK48C)
LED Green 5mm 2mA	1	(UK49D)
LED Clip Convex 5mm	2	(UK14Q)
Min Mains Black	2m	(XR01B)
1¼in. Clickcatch F/H	1	(FA39N)
Large Term Post Black	1	(HF02C)
Large Term Post Red	1	(HF07H)
SR Grommet 5R2	1	(LR48C)
DPST Rocker	1	(YR69A)
Heat Shrink CP 32	1m	(BF88V)
Fuseholder 20 Flush	1	(KU33L)
Fuse 20mm 800mA	1	(RA03D)
Fuse 1¼ A/S 100mA	1	(UK58N)
Isoshake M4	1 Pkt	(BF43W)
Isoshake M3	1 Pkt	(BF44X)
Pozi Screw M4 × 20mm	1 Pkt	(JC75S)
Pozi Screw M3 × 20mm	1 Pkt	(JC71N)
Steel Nut M3	1 Pkt	(JD61R)
Steel Nut M4	1 Pkt	(JD60Q)
Isotag M4	1 Pkt	(LR63T)
16/0·2 Wire 10m Black	1 Pkt	(FA26D)
Heat Shrink CP 64	1m	(BF90X)
Instruction Leaflet	1	(XT73Q)
Constructors' Guide	1	(XH79L)
OPTIONAL (Not in Kit)		
16/0·2 Wire 10m Red	1 Pk	(FA33L)
16/0·2 Wire 10m Black	1 Pk	(FA26D)
4mm Croc Clip Black	1	(HF23A)
4mm Croc Clip Red	1	(HF24B)
Charger Clip	2	(HF26D)
Large Battery Clip Red	1	(FS86T)
Large Battery Clip Black	1	(FS87U)
13A Nylon Plug	1	(RW67X)
2A Fuse Plug	1	(HQ31J)

The Maplin 'Get-You-Working' Service is available for these projects.
The above items are available as kits (excluding Optional), which offers a saving over buying the parts separately.
Order As LP91Y 6V Lead Acid Chgr Price £29.95.
Order As LP73Q 12V Lead Acid Chgr Price £29.95.
Please Note: where 'package' quantities are stated in the Parts Lists (e.g. packet, strip, reel etc.), the exact quantity required to build each project will be supplied in the kit.

Electronic Ignition Part One continued from page 47.

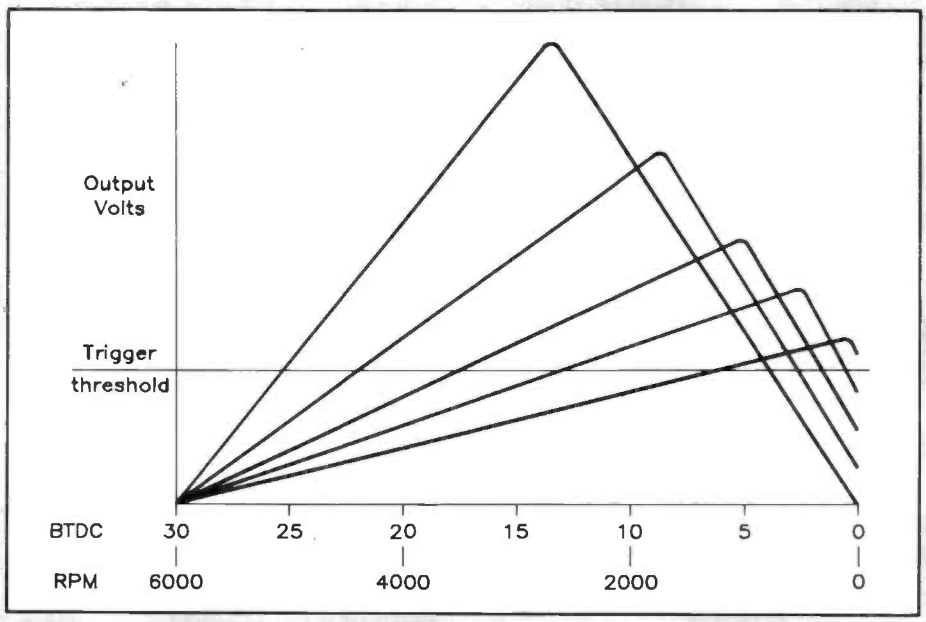


Figure 5. Auto-advance plot using waveform of Figure 4c.

advanced example of this idea following exactly the same principle, except that the rotor is a 'star' shaped wheel and the static magnetic system has a corresponding number of poles, in this case six of each, for a six cylinder engine.

Auto Advance

One reason why this triggering method has come out on top over rival designs is simply due to one staggering implication. Because the system is magnetic; it is, in effect, a very simple AC generator on a small scale, and its output is, therefore, proportional to the driven speed. What this means is that at slow rotor speeds the output voltage is low, while for higher speeds the output is also higher by a proportional amount. If the trigger threshold of the amplifier's input is voltage dependent, then triggering can be made to occur at the required point anywhere on the leading slope of the output waveform. Figure 5 shows how, from different output levels as produced by corresponding rotor speeds, the trigger level is near the peak of the slope if the output is low, and near the beginning if it is high. At a stroke, what we have here is, by way of an added bonus, an automatic ignition advance mechanism, and this with just one moving part – the rotor!

The Need for Ignition Advance

While the fuel/air mixture in the combustion chamber burns at a constant rate, the engine as a whole however is required to operate over a range of crankshaft speeds. For this reason the moment of ignition must occur earlier at higher r.p.m. Full combustion of the fuel gas must occur during the period where the piston has full leverage on the crankshaft, and at high revs the burn actually needs to begin well in advance of this point; at lower speeds, not so much, at idle, hardly at all. The magnetic reluctance type of ignition timing sensor achieves this auto advance action in a much more linear manner than do compromised mechanical or electronic methods, and barring the odd rare mishap such as a screw coming loose, once set it does not need readjustment – for anyone

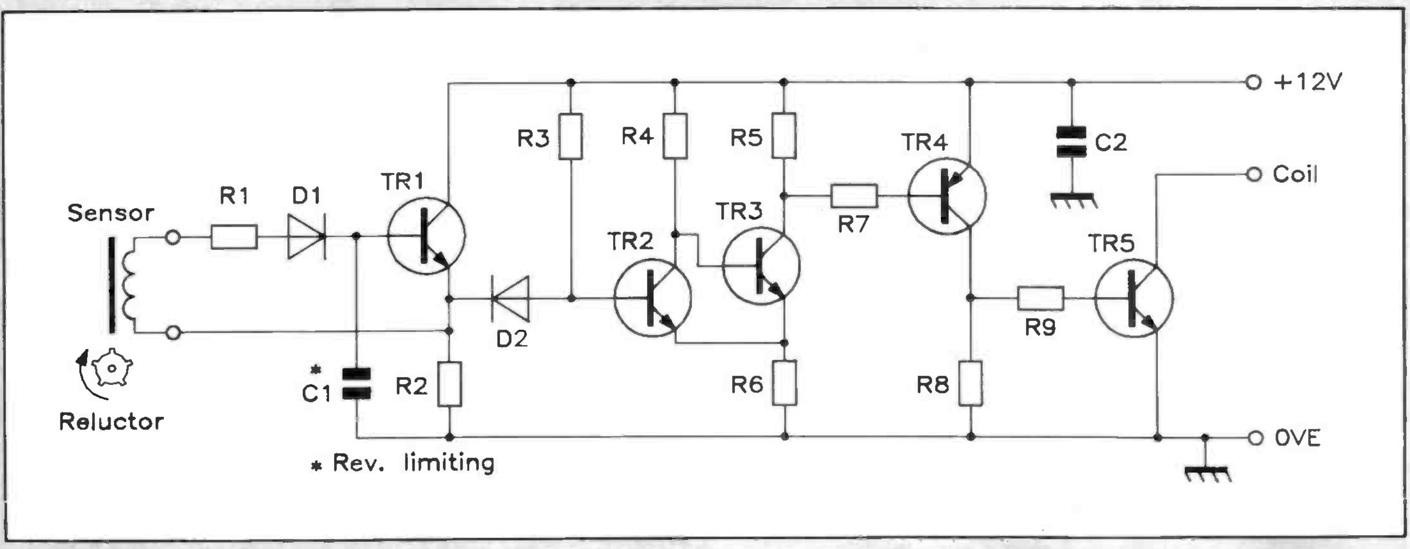


Figure 6. Essential ignition amplifier for a magnetic reluctor based system.

who has personally endured the long drawn out process of ignition re-timing, the subtleties of the operation do not need re-iteration!

Furthermore, since this requirement has already been taken care of by the sensor, it makes the amplifier much simpler. Otherwise electronic advance might take the form of frequency sensitive 'switches' selecting from a range of time delays, the minimum number of which is two in the crudest example of such a system. More than this requires rather more logic gates, or a microprocessor. Instead the magnetic reluctor allows the use of a comparatively very few transistors to produce an amplifier.

The Electronic Ignition Switch

Obviously the heart of an electronic system which simulates the action of a mechanical switch to operate the coil primary in the 'traditional' way is a transistor, and you might suppose that any power transistor able to carry the maximum on-time current of the primary will suffice. But oh dear me no. Remember that the primary potential is sufficient to produce an arc across the mechanical switch, and that the ignition coil as a whole, primary included, must be allowed to generate however high a voltage is necessary to bridge the plug gap? We are therefore obliged to use a high voltage power transistor, with a V_{ce} rating of several hundred volts, and such devices are notoriously inefficient, which means to say that the current gain (H_{fe}) is very small, measured in tens or less rather than hundreds.

The usual biasing method is to use a base bias resistor which typically connects directly between the transistor's base and the supply rail, and this resistor can be formidably beefy to provide the necessary bias current for the transistor to do its job properly, with the attendant power consumption and heat dissipation problems. I have actually seen one design where the base bias resistor is no more than 9·2Ω!

No, that wasn't a printing error. It's an illustration of how extreme base biasing may have to be to ensure that the switching transistor achieves a saturated 'on' state, essential to get the maximum available voltage across the primary of the coil and therefore the maximum primary current. Suppose, in a worst case example, that our transistor has an H_{fe} of 3 @ 1A (yes, just 3 – although fortunately latest devices are better than that now), but then in order to conduct 4A this value reduces to say <2. To ensure adequate biasing we assume a current gain of 1·5, and choose a base bias resistor with a value of 4Ω, taking into account a base/emitter forward drop of 1V. This resistor is then sinking 2·6A and dissipating 28 watts; has to be removed from the rest of the amplifier to avoid cooking it to death, and be provided with its own heatsink!

Even in the case of the aforementioned design using the 9·2Ω component, the resistor is of the high power, metal encapsulated type (see the resistors section of Maplin's 1991 catalogue for examples) and is screwed to the outside surface of the amplifier's die-cast case.

In comparison the power dissipation of the actual switching transistor is not very much at all, which seems almost perverse. This is because it performs a switching action; it is either on or off. Which leads us to the next criterion, namely ensuring that the transistor commutates (switches off) as fast as possible. This is necessary since the coil needs to be switched off quickly in order to develop its high tension output (a slowly switched ignition coil fails to make a spark).

High Speed Switching

Figure 6 shows the essentials of a typical ignition amplifier as used with a magnetic reluctance type of timing sensor. To summarise so far, TR5 is the inefficient, high voltage power transistor switch for the coil, and R9 is the base bias resistor. In this case the bias current originates from TR4, which is controlled by a schmitt trigger comprising TR2, TR3, and resistors R3 to R6. The schmitt trigger is essential to produce the fast edged switching waveform from the slower changing input, provided by TR1.

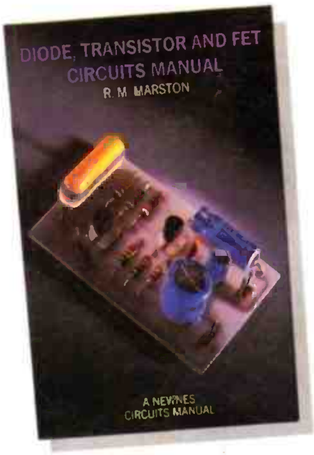
TR1 is the basis of the input stage which incorporates the input level threshold as indicated in Figure 5. This consists of diode D1 and the base/emitter junction of TR1 itself, which together will not begin to conduct until the applied level is >1·2V. This signal is of course the ramp shaped output from the sensor coil and you can see now that while the amplitude of the ramp is variable, the input threshold is constant. D1 also blocks the negative going part of the input waveform, which is superfluous, while R1 is a current limiter to protect D1 and TR1 in the event that for example the input is accidentally connected to the supply while the power is on.

Protection for the engine's mechanical bits can be provided by including C1, which acts as a 'rev limiter'. While it is charged quickly via D1, this charge leaks away slowly via the base/emitter of TR1 due to this device's current gain offering a relatively high impedance, and in consequence the waveform at TR1's emitter takes on a more triangular shape. As engine speed increases the mean average DC voltage drop across R2 also increases until a point is reached where even the lowest level of the waveform exceeds the low threshold of the schmitt trigger; the amplifier ceases to operate and no sparks are generated.

C1 also affords some RF filtering, but it might be surprising to learn that the input leads are rarely screened. The sensor coil is of such low impedance that this is unnecessary and in any case since both these wires are run together as a pair, any externally induced current will be equally present in both, cancelling each other out.

In Part 2 we shall look at a design for a real working ignition amplifier of this type, providing a more detailed insight into the principle and some of the practical problems which must be overcome, and introduce transistor assisted and capacitive discharge ignition.

NEW BOOKS



Diode, Transistor and FET Circuits Manual

by R. M. Marston

This is primarily a manual of circuits based on 'discrete' semiconductor components such as diodes, transistors, FETs and associated devices, and as such, it presents a total of over 340 carefully selected and outstandingly useful practical circuits, diagrams, graphs and tables. It deals with its subject in an easy-to-read, down-to-earth, non-mathematical but very comprehensive style.

Throughout the volume great emphasis is placed on practical 'user' information and circuitry, and this book, like others in the series, abounds with useful ideas and data. All of the semiconductor devices used in the practical circuits are modestly priced and readily available types, with universally recognised type numbers.

Contents include basic diode circuits, special diode circuits, transistor principles, transistor amplifier circuits, transistor oscillators and astables, transistor audio amplifiers, transistor circuit miscellany, FET principles, JFET circuits, MOSFET circuits, VMOS circuits, unijunction transistor circuits.

The manual is specifically aimed at the practical design engineer, technician and experimenter, but will also be of interest to the electronics student and the amateur.
1991. 247 pages. 215 x 138mm, illustrated.

Order As WZ18U (Diode/Trans Manual) £12.95 NV

Preamplifier and Filter Circuits

by R.A. Penfold

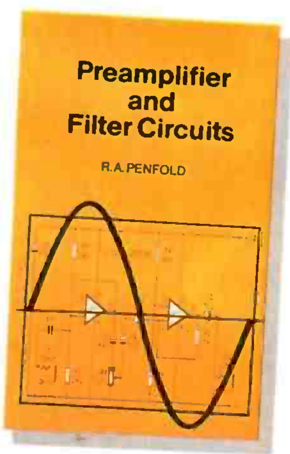
This book provides both circuits and background information for a range of preamplifiers, together with tone controls, filters and mixers etc. to go with the amplifiers. The use of modern, low noise operational amplifiers and a specialist, high performance audio preamplifier IC results in designs having excellent performance but which are still quite simple. All the circuits featured can be built at quite low cost, for just a few pounds in most cases.

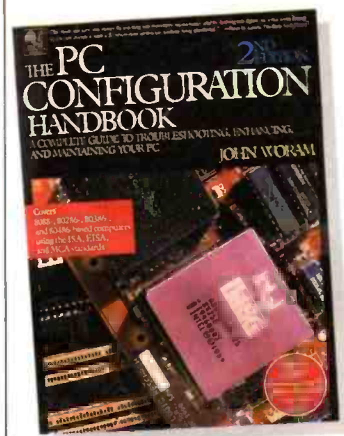
The preamplifier circuits include those for microphones covering low and high impedance and crystal types; magnetic cartridge pick-up preamplifiers with RIAA equalisation; crystal or ceramic cartridge pick-up preamplifiers; a guitar pick-up preamplifier and a tape head preamplifier for use with cassette systems.

The other circuits include an audio limiter, which prevents overloading of power amplifiers; passive and active tone controls; PA highpass and lowpass filters; 'scratch' and 'rumble' filters; loudness control; audio mixers and volume and balance controls. In fact, everything you need to put together your own, custom preamplifier system.

No physical construction details are provided for the circuits, only the circuit diagrams. The intention is that the circuits are selected and combined on stripboard or home-made PCBs, so the book is not suitable for absolute beginners. On the other hand the circuits are pretty simple, and you do not need much previous experience of project construction in order to tackle them. Where appropriate any setting-up procedures and notes on any tricky aspects of construction are provided.
1991. 92 pages. 178 x 110mm, illustrated.

Order As WZ19V (Preamps & Filters) £3.95 NV





The PC Configuration Handbook

A Complete Guide to Troubleshooting, Enhancing and Maintaining Your PC

Second Edition

by John Woram

No matter what your level of computer literacy, there is little likelihood that the expression 'the computer is down' needs to be explained. We've all heard it, and probably more than once. The words conjure up a vision of a petulant machine gone on the micro-equivalent of a sit-down strike. Perhaps it will be up and running later on, once some gifted technician can be found, who can persuade the machine to behave itself.

Eventually we learn that the computer is back in operation. What we don't learn is that the trouble really wasn't the computer's fault at all, instead some operator error caused it to perform in an unexpected way. It then became necessary to shut down the system while that error was traced, isolated and corrected. Meanwhile, the machine took the blame.

It is conceivable that the computer really was down, but the odds are overwhelmingly against it. In fact, the computer is one of the most reliable machines ever made. It has almost no moving parts, so there is very little to get out of alignment. Its electronic components do not demand periodic adjustment. And, since it really has no brain of its own, it just can't make its own mistakes; indeed, it can't make its own anything. It does only what it's told, nothing more, nothing less. Given a minimal amount of care and a decent operating environment, it should provide years of trouble free, error free service.

No one can say that computers never break down of course. Some components may indeed fail now and then, yet, far more often, a 'computer is down' situation can be traced to a human error. And while that may make the problem less frustrating, it does make it much simpler to solve. However, an actual hardware failure may require the services of a skilled service person, but on the other hand an apparent failure may require nothing more than a moment's attention by the user.

Even if you would prefer not to make any repairs yourself, your ability to make a well-informed diagnosis will go a very long way toward helping to get your computer back up and running quickly. Whatever diagnostics you can do yourself will likely save a service engineer's time and your money. Packed full of detailed information, this book is recommended. American book. 1990. 744 pages. 235 x 175mm, illustrated.

Order As WZ16S (PC Config Book) £26.99 NV

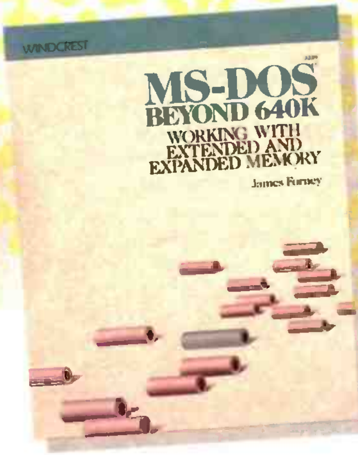
MS-DOS Beyond 640K

Working with Extended and Expanded Memory

by James Forney

Have you reached the 640K RAM limit of your machine when trying to run a large application? With some relatively inexpensive hardware and software investments, you can give your computer expanded and/or extended memory, and gain the ability to run larger applications, create multiple simultaneous work environments, maintain larger files, and more. This book will help you eliminate the guesswork in upgrading your machine, giving you a clearer picture of all the alternatives and options available, and enabling you to get a better idea of what is right for you.

More memory? Who needs it? Does it really matter what kind of system you start with? These might seem like silly questions, worthy of silly answers. However, while the questions might seem to beg the obvious, there are no simple answers. These are complex subjects that address complex problems, in some cases requiring the best that seemingly disparate



technologies have to offer.

For those who think they need more from their computer, the answers they need may be simple ones and surprisingly inexpensive to implement, in some cases for less than £50. For others, the answers they require will be more complicated, and of course the cost will be higher but need not be paid out all at once, but taken in stages as your wants and needs increase, with very little waste along the way. It is for these varied and ever changing needs that this book is dedicated, sorting out the options and examining at least some representative solutions. American book.
1989. 250 pages. 235 x 188mm, illustrated.

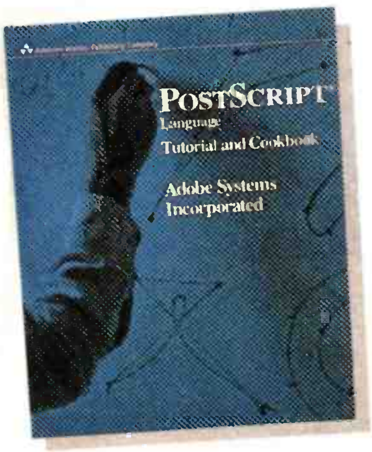
Order As WZ23A (Beyond 640K) £19.05 NV

PostScript Language Tutorial and Cookbook

Adobe Systems Inc.

PostScript®, a revolutionary, device-independent page description language, is quickly becoming the industry standard for printing high-quality integrated text and graphics. It is a powerful, flexible language that has the ability to efficiently describe the appearance of text, images, and graphic material on the printed page. Already PostScript has been incorporated into some of today's most innovative printers, including the LaserWriter from Apple.

Now, from Adobe Systems Incorporated, the company that invented PostScript, here is the definitive introduction to this exciting



language. The PostScript Language Tutorial and Cookbook is a thorough and clearly written guide to PostScript that outlines the features and capabilities of the language and shows practical ways to create useful PostScript programs.

Using numerous annotated examples and short programs, the tutorial provides a step-by-step guided tour of PostScript, highlighting those qualities that make it such a unique and powerful language.

The book is a companion to the *PostScript Language Reference Manual* reviewed in 'Electronics' issue 51. Adobe Systems Incorporated are located in Palo Alto, California, and was formed in 1982 to meet the growing need of business and industry for high quality printing of text and graphics. Their first product, PostScript, has been incorporated into laser printers by Apple, Allied Linotype, QMS and Dataproducts, and PostScript is fast becoming an international standard for DTP and publishing generally. American book.
1985. 243 pages. 234 x 187mm, illustrated.

Order As WZ13P (PostScript Tutorial) £16.95 NV

Computer Studies

The Complete Course Text – Third Edition

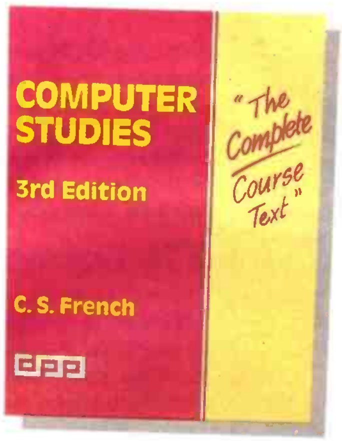
by C.S. French

Are you still one of the as yet unconverted who cannot think of one solitary reason why *you* should need a computer? What's all this fuss about computers anyway? Who cares? Aren't they more trouble than they're worth? A common trend is for anyone, once they have started, to wonder how on earth they managed before. Others can't seem to get into it at all, and may find themselves with a handicap in the computer orientated workplace. Perhaps you need some computer studies, assuming you haven't done these already at school.

What are 'Computer Studies'? If you want a full answer to this question, then do no more than read this book. As a short answer, Computer Studies deal with the features of computers and ways and means of using them so as to provide a basis for understanding the *impact* of computers on individuals, organisations and society in general.

This impact is huge, and is by no means at a peak yet. There are many activities associated with handling information, from generation to production, such as using a library or producing a bill. All such activities fall under the general heading 'Information Processing' (IP). Similarly, in the same way that the telephone and TV have automated some information processing activities, computers, telecommunications and other technology associated with automation comes under 'Information Technology' (IT). This supports activities involving the creation, storage, manipulation and communication of information, together with their related methods, management and applications.

While it's true that computers have made many established human tasks redundant, it's also true that they generate an enormous amount of work, albeit of a different kind. Raw data, much of it hitherto unobtainable without a lot of human time and



expense – so much so that it was not considered worthwhile to attempt extracting it in the first place, though it would have been nice to have – is now spewed out by the ton in minutes, and has to be interpreted, collated and sorted by human beings.

The text has been designed for use in independent study or in conjunction with school, college etc., and is of a level which meets GCSE, BTEC, RSA and City and Guilds standards, and includes questions and answers exercises.
1990. 531 pages. 245 x 189mm, illustrated.

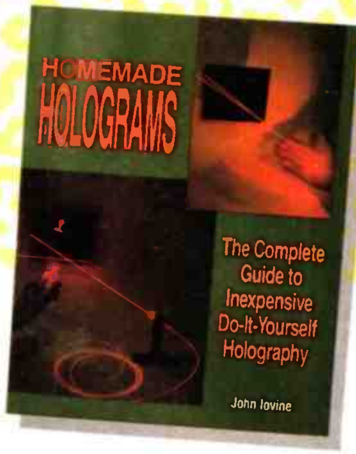
Order As WZ26D (Computer Studies) £7.95 NV

Homemade Holograms

The Complete Guide to Inexpensive Do-It-Yourself Holography

by John Iovine

Holograms are becoming rather more commonplace today. Many credit cards are embossed with a hologram to prevent forgery, and many supermarkets use a laser scanning system at the checkout to ring up bar coded merchandise using a holographic lens element, so most people now either possess a hologram



or have seen the technology in use at first hand.

Although holography can be traced back to 1947, its evolution has been slow. This is not to say that it hasn't progressed to the point where the existing technology can't be used for purely artistic pursuits, because it has. In fact the 'holo-artist' has kept the interest in holography alive.

While in the early '70s the field was dropped because some of the problems weren't as easy to solve as at first thought, much has happened since and many companies are taking an interest again, and for the innovator there is still much more scope for experimentation than has already been explored.

Some holography books leave the reader with the impression that their material is definitive. While quite an amount of information has been amassed over the years, which can overwhelm a beginner. The basic principles of hologram photography remain simple and direct. The amassed information usually concentrates on optimising particular details of the set-up or equipment rather than describing a new innovation.

This book provides a solid foundation in holography, describing how to produce various types of holograms from the simplest to the more elaborate. The equipment is innovative and simplified, for instance a large and very heavy 'sand table' is not, contrary to popular belief, essential, and the book describes plans for a small, lightweight table of only 20lbs, easy to construct, set-up and dismantle and transport. In addition there are plans to construct suitable lasers if required and simple magnetic optical mounts and component holders designed for use on the lightweight table.

Written in a very easy to understand style, and includes a simple introductory explanation of how holography works. Projects are included allowing you to continually improve your technique, and there are guidelines for the safe disposal of chemical waste, and a complete source list of publications and holographic equipment suppliers is also included. American book.
1990. 240 pages. 234 x 183mm, illustrated.

Order As WZ25C (Homemade Holograms) £11.95 NV

Design and Application of SEQUENTIAL LOGIC

PART FIVE

by Graham Dixey C.Eng.,M.I.E.E.

Synchronous MSI Counters

It will be remembered from last time that a synchronous counter is one where all the flip-flops that are required to change state between successive counter states do so all at once. This action is normally effected by clocking all flip-flops at the same time but using gating, or some other means, to permit only those flip-flops which have to change to do so. In a previous part of this series we looked at the design of semi-discrete synchronous counters using these principles. This mode of operation is inherently faster than that of asynchronous or 'ripple through' counters since, in the latter, changes in the states of the flip-flops occur sequentially. Thus, time has to be allowed for all state changes to be completed. In both TTL bipolar and CMOS technologies a good variety of synchronous MSI counter chips exist, freeing the circuit designer from the chore of designing a counter entirely from scratch. However, many of the basic principles are common to both and by using the 74HC series one is getting the best of both worlds. In this, Part Five, I shall restrict myself to a few counter chips in the 74 series, whether they be TTL or CMOS versions is immaterial.

TTL Counter Chips

There are a number of devices variously described as 'programmable' or 'presettable'. Perhaps the latter is a better term generally, though the former may be considered to be more appropriate where the counter is in a computer control loop, with software defining the counter length and its initial and final states. One such chip is the 74161, whose pin-out appears in Figure 1.

The 74161 is a 'binary modulo–16 synchronous presettable unit-cascadable counter'. It is capable of up-counting only. Being a modulo–16 counter, the output can be any state in the range 0-15. The initial value at which counting commences also lies within this range, and it can be set into the counter by applying a 4-bit binary input of this value to the LOAD INPUTS and performing a 'load' operation. The LOAD INPUTS are designated as L1, L2, L4 and L8, these numbers indicating the column weightings (1, 2, 4 and 8) of the binary input. A short transition to 0V at the LOAD terminal loads this value into the counter. The LOAD terminal must be returned to the high state and held there while the counter is in operation. This is illustrated in Figure 2.

The chip is supplied with three 'control' pins, known as P, T and CLEAR. These are all taken high to allow counting to take place. The functions of P and T are in one sense the same; taking either of them low during the counting sequence stops the counter. Thus either of these inputs permits an 'OR decision' as to when the counter stops – a useful facility. The counter retains its current value when this happens. Inputs P and T can be considered as start/stop controls for the counter. In addition the input T is used as the 'carry in' line when units are cascaded to form multi-stage counters. If at any time the CLEAR pin is taken low, the counter is immediately cleared. One may see the following as a typical sequence.

(i) Initial value applied to LOAD INPUTS.
(ii) Negative pulse applied to LOAD terminal.
(iii) Controls P and T taken high; counting commences.
(iv) Counter counts up at clock rate.
(v) P and/or T taken low to stop counter.
(vi) Clear pulse applied to clear the counter.

In some circumstances steps (iv) and (v) above may be considered as alternatives, that is the counter may be stopped at the required point in the sequence, as in a 'timing out' operation, or the counter may be cleared when the final state is reached, as in continuous counting.

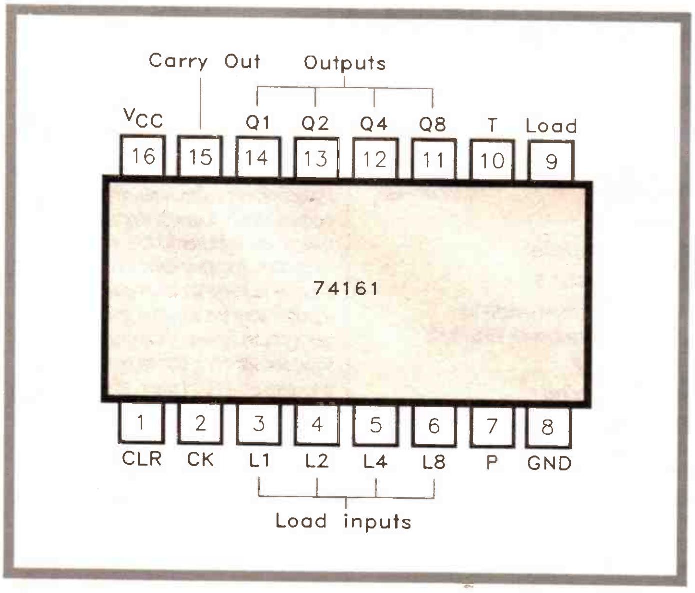


Figure 1. Pin-out for the 74161 synchronous counter IC.

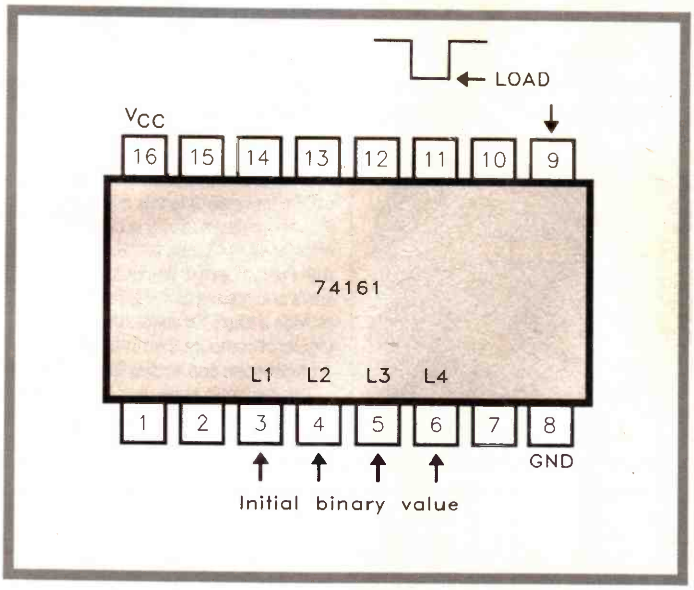


Figure 2. Loading the initial state into the 74161 counter.

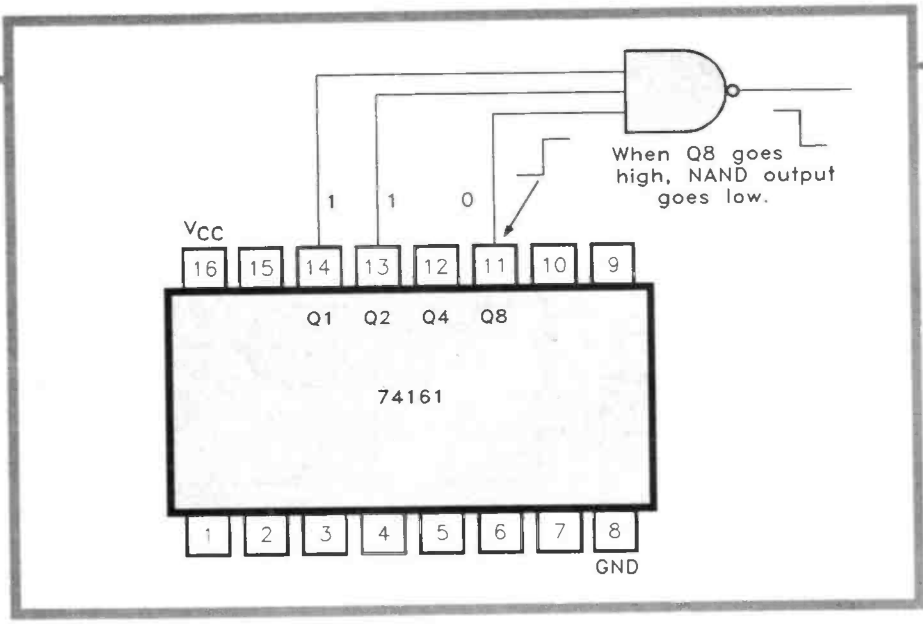


Figure 3. Detecting the final state of the counter.

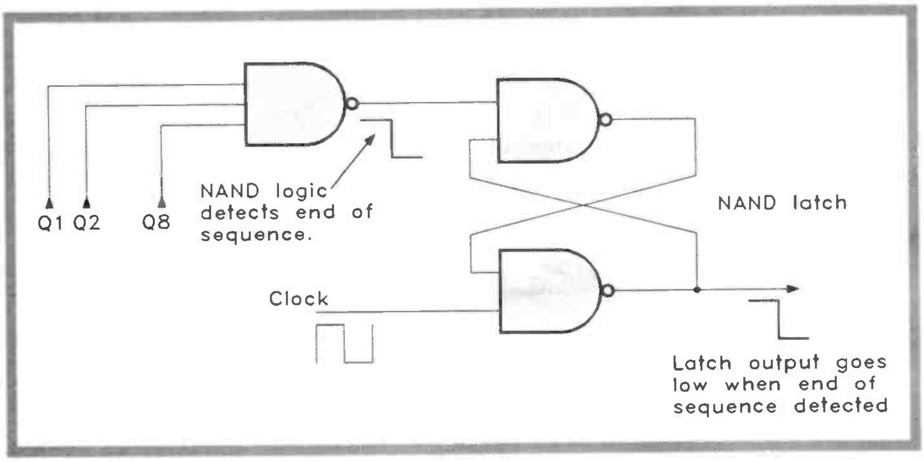


Figure 4. Generating an end of sequence pulse.

Design of a Modulo 'Less-Than-N' Counter

As an example, let us use this chip to design a counter of length *less* than the maximum. There are three possibilities.

(a) Start at zero; finish < 'n'.
(b) Start > zero; finish = 'n'.
(c) Start > zero; finish < 'n'.

To illustrate these three cases, consider a counter of length 16, that is occupying the states 0-15 inclusive.

Using case (a) above, we might start the sequence at 0 and terminate it at 9, so obtaining a decade counter (with states 0000-1001). For case (b) the counter might start at six and terminate at 15, also a decade counter but with states 0110-1111.

Finally, we could illustrate case (c) with yet another decade counter whose ten states were 3-12 (i.e. 0011-1100). There are, of course, numerous possibilities. The latter two, although being decade counters in the sense that they will divide the input frequency by 10, are 'unweighted' counters, since they do not generate the denary integers 0-9 inclusive but merely 10 unique states.

Example 1

Consider a divide-by-12 counter with the sequence 0-11.

The initial state = 0000 (0)
The final state = 1011 (11)

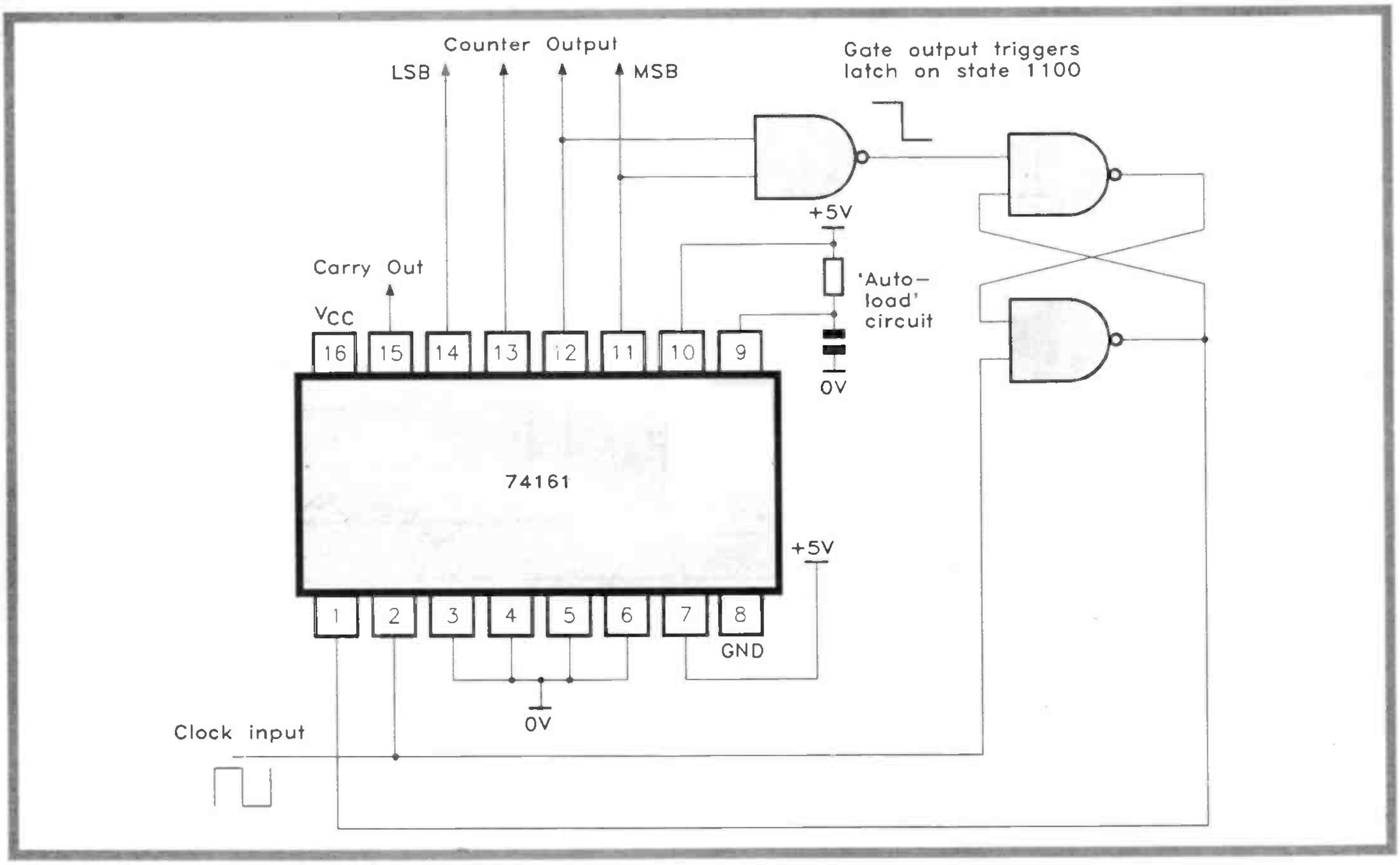


Figure 5. Using the 74161 to count continuously. Initial value (0000) is loaded automatically.

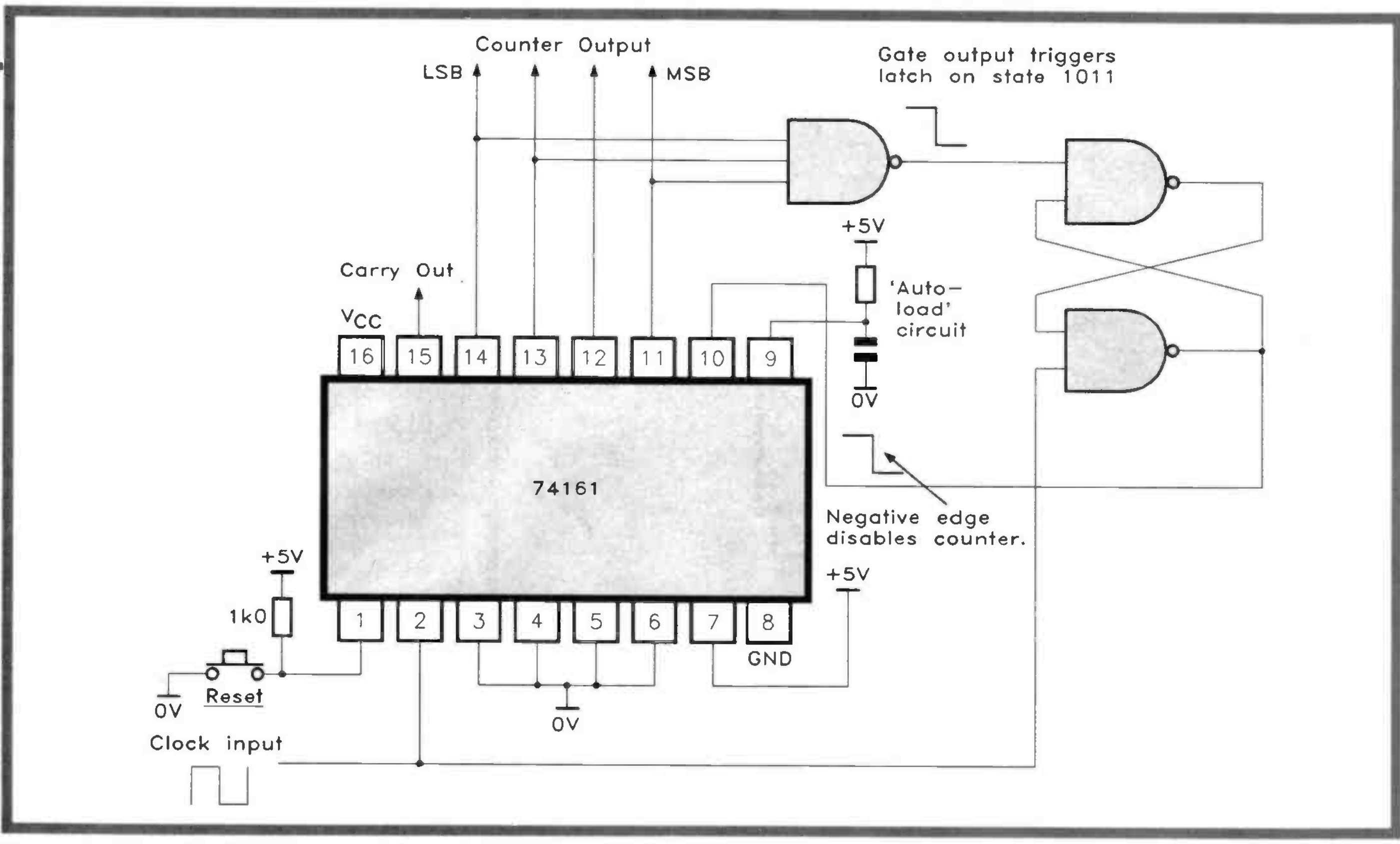


Figure 6. Using the 74161 to provide a 'single shot' counting sequence. Counter is disabled by output of latch connected to control pin T.

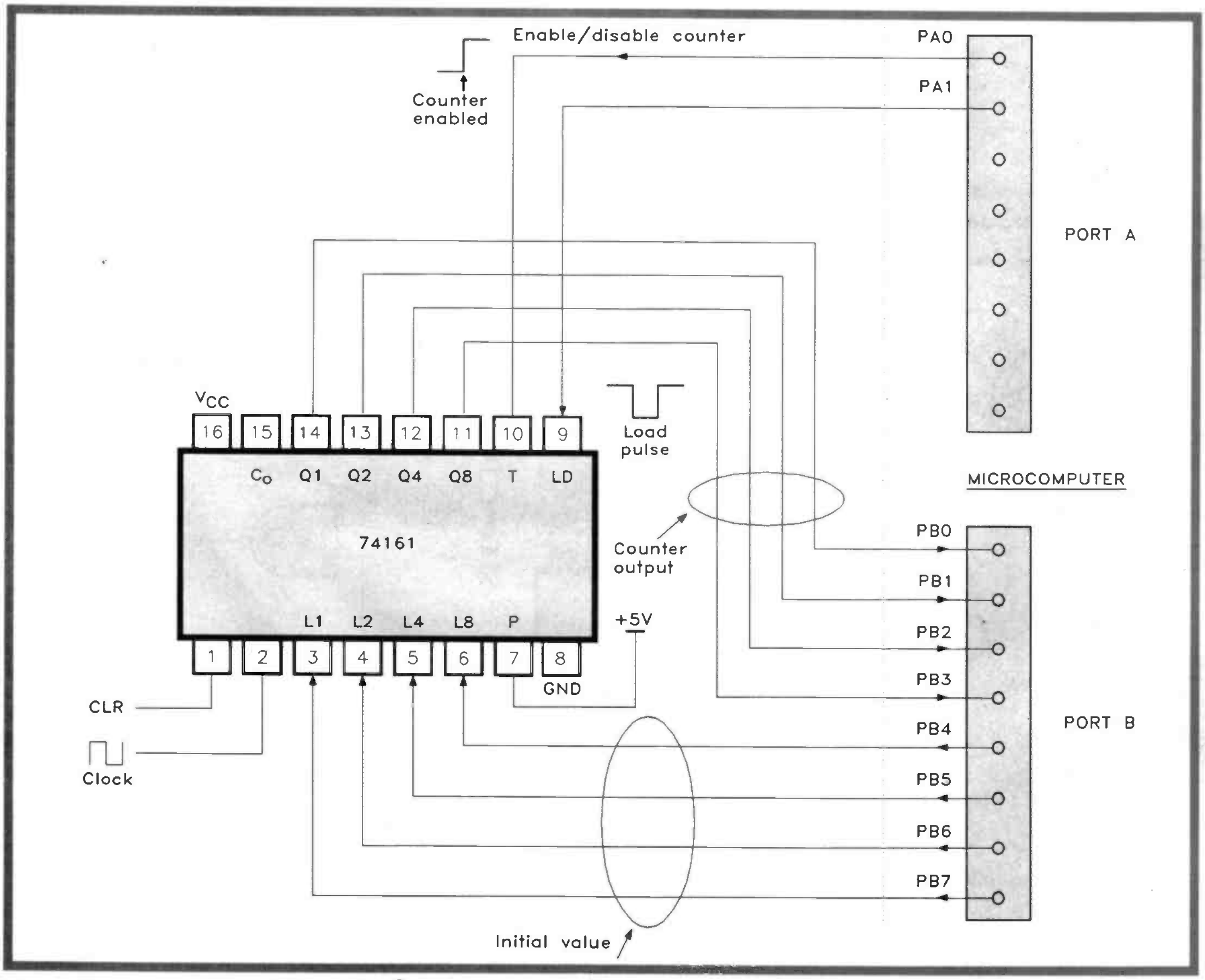


Figure 7. The 74161 controlled by software. This allows very flexible operation of this device with parameters such as sequence length and initial and final values easily determined.

The initial state, 0000, must be provided so that it can be loaded into the counter via the four LOAD pins, L1-L8. The easiest way of doing this is simply to hardwire these four pins to zero volts. A more flexible scheme would be to use a DIL switch to these inputs, since this would allow the ready selection of any initial value merely by flicking the appropriate switches up or down.

We now need some means of loading this initial value into the counter. We know that what is required is a brief transition to 0V at the LOAD terminal (pin 9). There are several ways of doing this, depending upon the circumstances.

(i) We could load the initial value manually, by means of a push-button switch, for instance. This would really only be usable where a single run of the counter was made. A repeat run would require the inhibit to be lifted and the counter re-loaded manually. On the whole not a very attractive scheme.

(ii) We could generate the LOAD pulse by a software routine, in the case already mentioned where the counter operates within a computer control system. Obviously, this won't apply except in these special cases.

(iii) We could make the system 'boot up' its own initial value when the power is first applied. This is achieved by means of an RC time constant connected to the LOAD pin; the capacitor goes to 0V and the resistor to the positive supply. At switch on, the capacitor is uncharged and the LOAD pin is, therefore, at 0V. The loading of the initial value occurs at this time. As the capacitor charges up, the logic level at the LOAD pin rises from logic 0 into the logic 1 region. This lifts the inhibit on the counting operation and provided that there are no other inhibits (on P, T or reset), the counter will start counting up.

What is needed next is a means of detecting when the final state of the counter, in this case 1011, has been reached. Examination of this binary number reveals that the three 'ones' in it are unique to this state, considering only previous states for comparison. Their occurrence can, therefore, be used as a means of detecting this state. All that is needed to achieve this is to gate these three particular outputs (8, 2 and 1) with a 3-input NAND gate, whose output will remain high for all previous states, but will go low when this particular state is reached (Figure 3). It is essential to latch the output of the gate for a period long enough to allow the reversion to the initial state to be completed. This technique was explained in Part Two, in connection with the design of asynchronous counters, and is shown again in Figure 4. This assumes that the intention is, in fact, to re-initialise the counter prior to starting a fresh sequence. The NAND gate output can be used in several possible ways, including the following:

(a) To drive the reset line low to reset the counter.

(b) To disable the counter by driving the P or T input low.

The first of these methods can be used to produce continuous counting, but if this method is used, we must allow the counter to go momentarily into the 'n + 1' state and gate this to generate the reset. If we use the 'n' state by mistake (in this case 1011), we shall never actually see this state since, as soon as it is detected by the NAND gate, it will be cleared. This is exactly the same principle as was used to determine the end of sequence for the asynchronous counter designs in Part Two. Thus, in this case, since the final state is to be 1011, we must use the NAND gate to detect the appearance of state 1100. The gate will thus be connected to pins 11 and 12 of the 74161 to achieve this. This system, with the auto-load

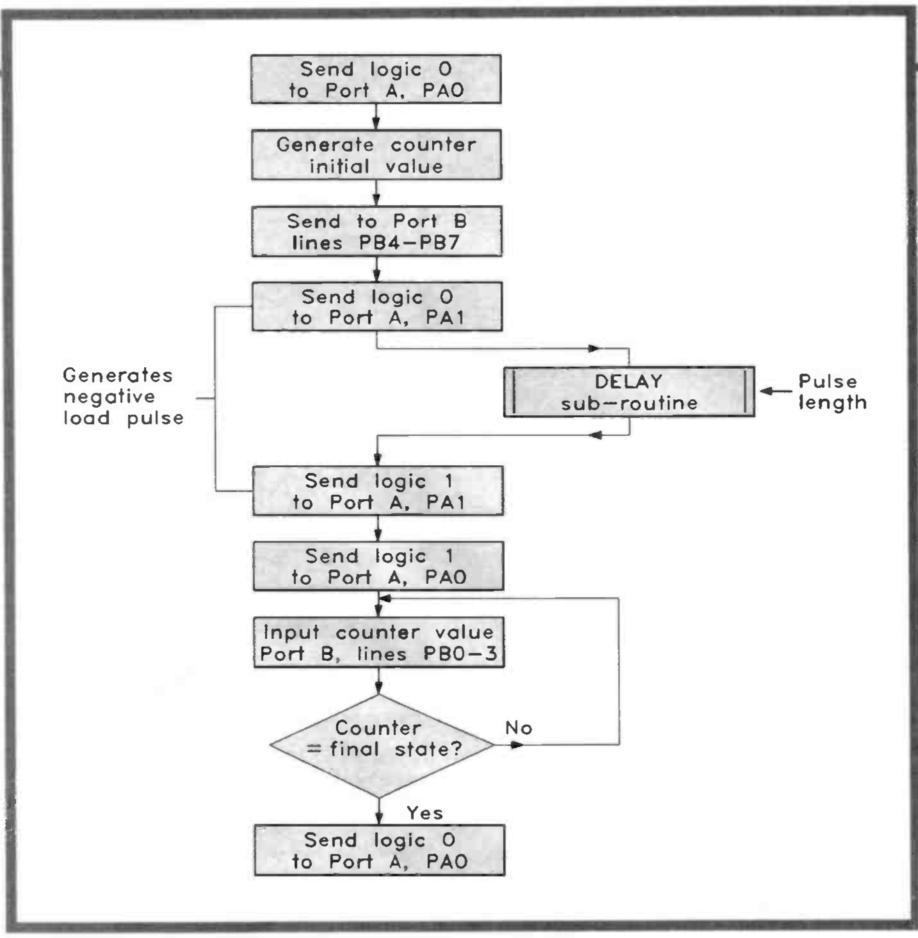


Figure 8. Flowchart for the system of Figure 7.

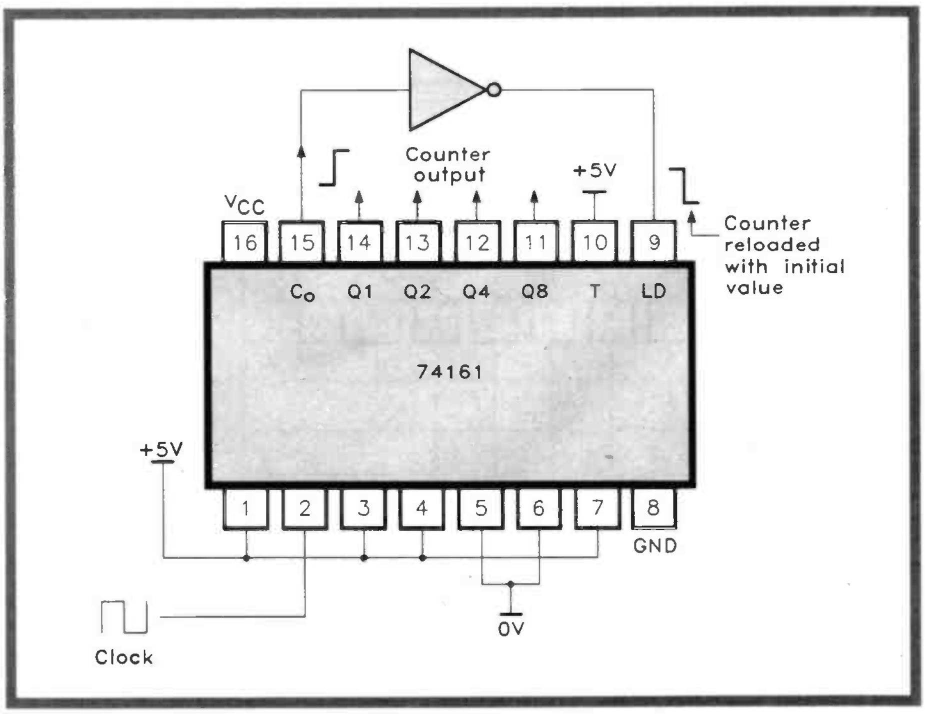


Figure 9. A divide-by-12 counter using the 'carry out' to reload the initial value.

mentioned above, is shown in Figure 5.

Naturally, if we consider option (b) above, we find that we are looking at a single-shot system in which the counter runs until the final state is detected and then stops. We need only gate the actual final state (1011) and use this to drive T, say, low. The counter is disabled and waits in this state for further action. This scheme is shown in Figure 6.

The possibility of using a computer to generate the control pulses has been mentioned and Figure 7 shows the interconnections for such an idea. The software is described by the flowchart of Figure 8. The sequence is as follows.

At the beginning of the program, control input T is held low by the logic level out of Port A, line PA0. This prevents the counter running.

Next a binary number equal to the required initial value is generated and output on Port B, lines PB4-PB7. This is, of course, applied to the load inputs L1-L8.

A load pulse is then generated by software to appear on Port A, line PA1. This loads the initial value into the counter.

To run the counter the logic level on the T control input is raised to logic 1. As the counter runs, its 4-bit output is input at Port B, lines PB0-PB3. A program scans the values on these lines until the end of sequence value is detected.

When this happens, the logic level on line PA0 is returned to logic 0 to stop the counter.

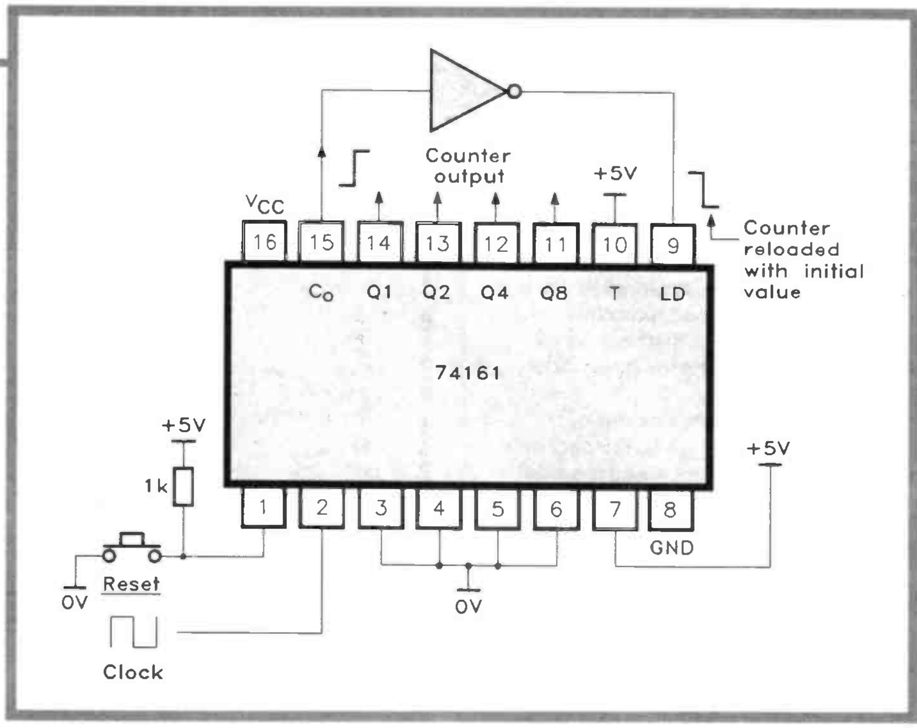


Figure 10. The 74161 as a divide-by-16 counter with manual, asynchronous reset facility.

Since a counter, by definition, counts the number of clock pulses received, such an application as this, with the counter stopping after a certain number of pulses have been received, permits the identification of such a number even though they may be received asynchronously, that is at totally random instants of time. Such a program, or at least that module of it concerned with detecting the end of sequence, would probably be interrupt driven in order to free the computer for other work.

Example 2

Now consider the case of a counter which starts at a non-zero value and runs to the maximum value. When it reaches this, it generates a carry of one at the CARRY OUT terminal, pin 15. If we invert this carry we can use it to drive the load terminal low. The initial value is reloaded

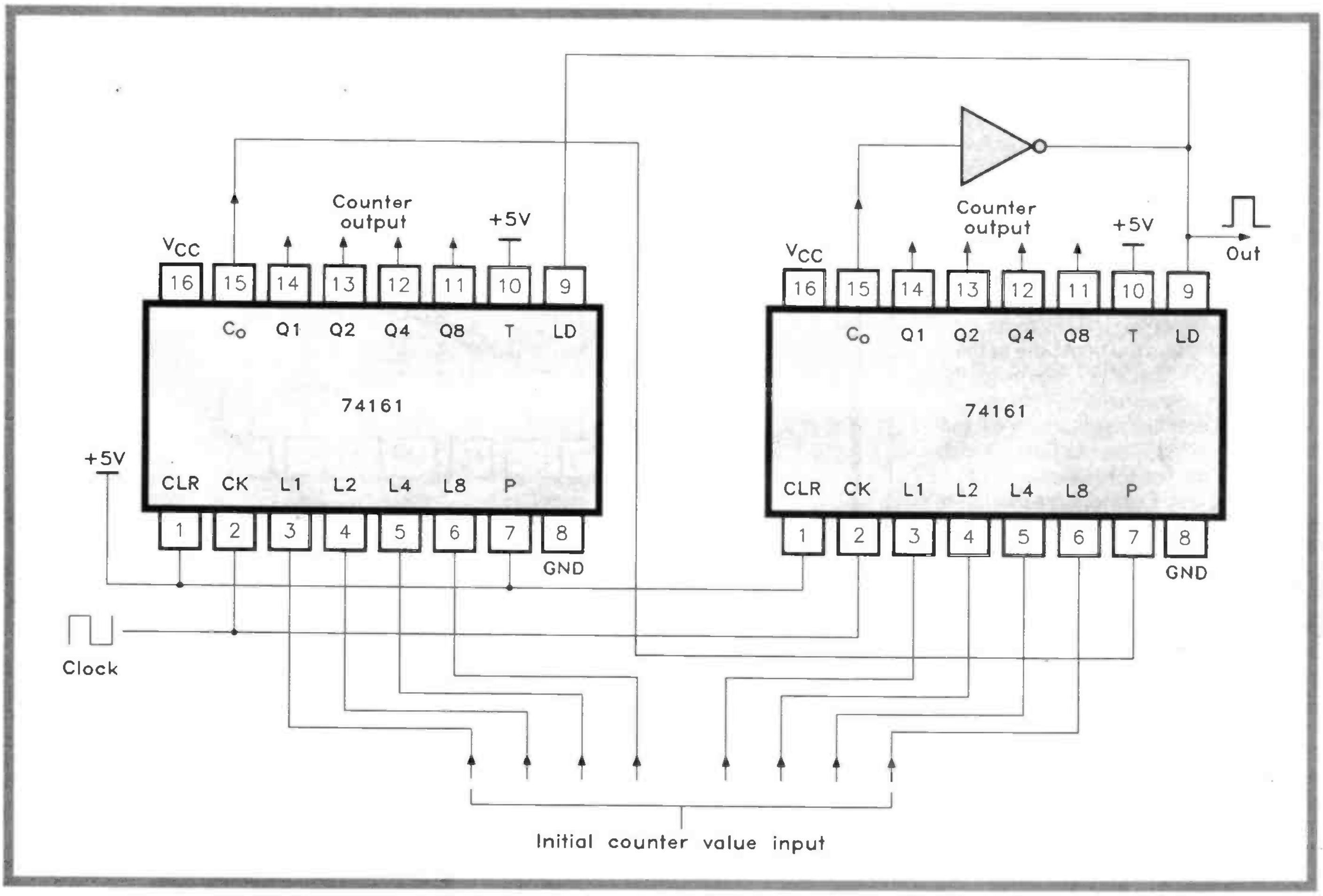


Figure 11. Cascaded arrangement for providing an unweighted count up to modulo 256, using a pair of 74161s.

and the counter starts its sequence again. This repeats indefinitely and is shown in Figure 9.

Example 3

Finally, Figure 10 shows how the 74161 can be used to obtain the full count of 16 (0000-1111), again using the inverted carry to reload the counter. The reset line is used as an asynchronous manual reset. That is, its operation will reset the counter to 'all zeros' whenever it is used.

Cascading the 74161

It was mentioned earlier that this counter can be cascaded by connecting the CARRY OUT pin of the first chip to the P control pin of the second. A circuit showing two of these chips cascaded appears in Figure 11. Both P and T pins of the first chip, as well as the T pin of the second, must be held high. Both chips are clocked simultaneously but only the first counts up initially, the second chip being disabled by the low logic level on its P pin. When the first chip reaches its final state (all ones), the next clock pulse will reset it and generate a logic one at the CARRY OUT pin. This logic level will be passed to the P pin of the second chip, lifting the inhibit. It will then register a single count, at which point the first chip enters another sequence; as soon as it does, so the CARRY OUT returns to logic 0 and the second chip is inhibited once more. From this we may deduce that the second chip registers one count for every complete sequence of the first one. When the second stage of the counter has completed its sequence it too generates a carry at its pin 15. This carry out can be used, after inversion, to provide a negative going LOAD pulse to the LOAD pin (pin 9) of the second stage. The initial value is re-loaded into the counter and the new sequence starts.

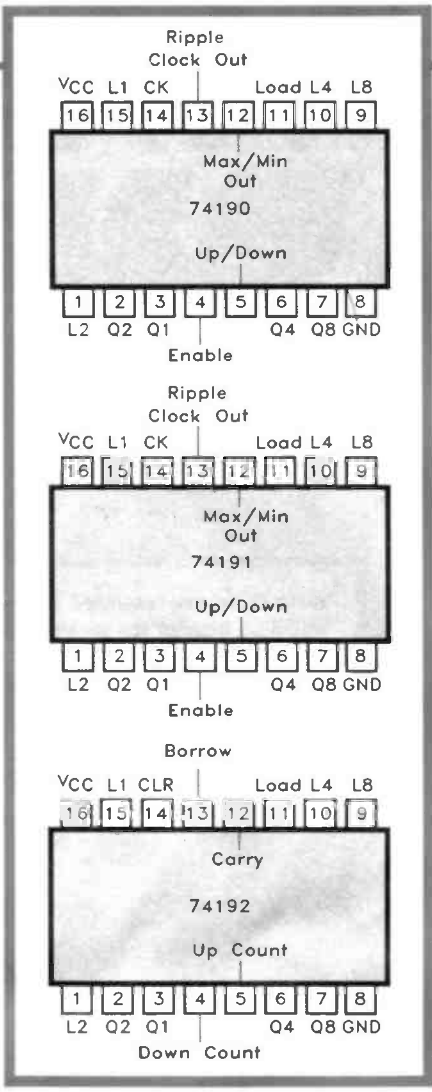


Figure 12. Pin-out diagrams for some synchronous up/down counter ICs.

Except where the initial value is 'all zeros', the resulting 8-bit sequence will be unweighted, since the state of the counter after the first clock pulse will not register 'one' but some higher number. For example, if the initial state loaded into the counter is 20, then the first input pulse will increment the counter to 21, the next will increment it to 22, the next to 23 and so on. In this example, there is an 'offset' to each number in the sequence, which is equal to 20. Such an output will need to be decoded if it is to be the numerical equal of the number of pulses input to the counter; this is not always the case of course. To avoid such complications, the counter can always have its length shortened from the 'top end' i.e. start at zero and detect an end of sequence state in the manner described previously. The price to pay for this is the extra hardware (or software).

Up/Down Counters

All of the circuits, in common with most MSI counter chips, count in the up direction only. However, there are a few ICs that can be made to count in either direction, by using separate UP and DOWN clocks or by altering the logic level on a control pin. Examples of these are the 74190 (Decade up/down counter), the 74191 (Divide-by-16 up/down counter) and 74192, another decade counter but with more flexible facilities. All of these counters are of the presettable type so their count sequences can be modified according to one's requirements. Their pin-out diagrams are shown in Figure 12, while Figure 13 shows the 'bare bones' of a connection diagram for cascading several 74192s so as to count up or down on a true decade basis, that is the lowest order chip records the units, the next the tens and the next highest the hundreds and so on for as many decades as you wish to add. The essentials of the latter circuit are as follows.

(a) All clear pins are taken to a common CLEAR (reset) line.

(b) All load pins are taken to a common LOAD line.

(c) Separate UP and DOWN clocks are catered for; a positive clock edge on these terminals will increment or decrement the counter respectively. No other logic is needed except that where one clock terminal is in use and the other should be held high.

(d) For all chips, cascading is achieved by linking CARRY to UP, and BORROW to DOWN terminals.

(e) The counter can be loaded with parallel data by using the load inputs of all chips. Loading will occur on the LOAD line going momentarily low in the usual way.

The above discussions should have shown the general approach to making up counters of any required length from available MSI counter chips. The particular features of these counters, their presettability for example, have also been demonstrated. In the next issue we shall look at the many forms in which 'registers' appear, and see how we can produce our own, using both individual flip-flops and available MSI devices.

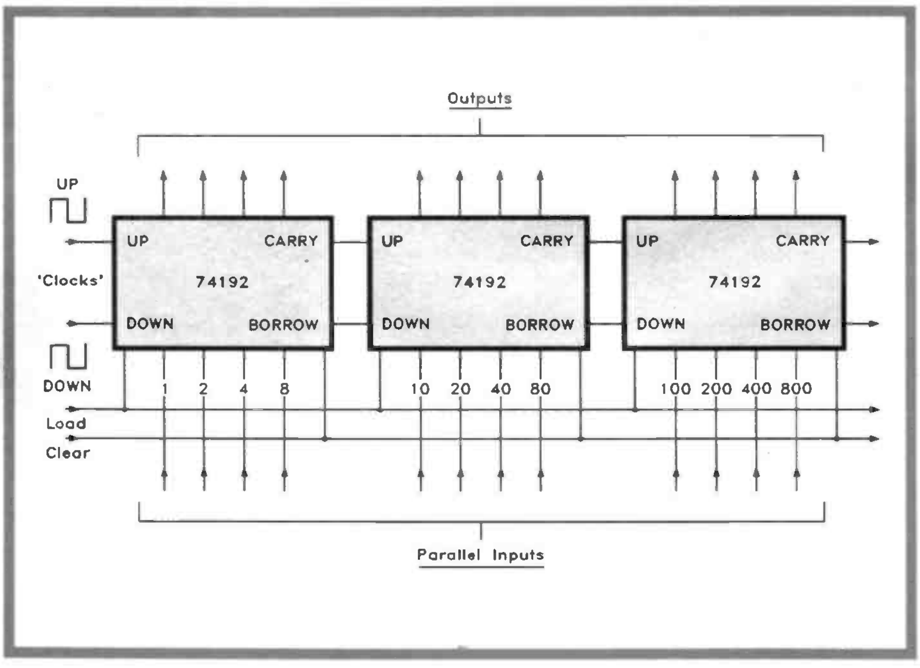


Figure 13. A three-decade synchronous counter using the 74192.

DATA FILE

78/79 VARIABLE REGULATORS

'Data Files' are intended as 'building blocks' for constructors to experiment with and the components suggested, provide a good starting point for further development.

In continuation of last month's Data File, we look at 78/79 series variable regulators in this issue of 'Electronics'. These useful devices enable a low-cost medium-current variable power supply to be constructed from the minimum of components.

Load Regulation

To get the best performance from a regulator (assuming that adequate supply decoupling is used) a couple of important factors must be borne in mind, namely power dissipation and differential voltage.

The differential voltage can be found from Table 1 by subtracting the specified minimum output voltage from the minimum input voltage. This differential voltage must be maintained at all times –

500mA positive (left) and 1A negative (right) variable voltage regulator PCBs.

VARIABLE VOLTAGE REGULATORS – ±5V to ±30V, 500mA to 1A

Regulator/ Stock Code	Voltage	Current	Transformer/ Stock Code	PCB/ Stock Code	Rectifier/ Stock Code	C1/ Stock Code	C2/ Stock Code	C3/ Stock Code	VR1/ Stock Code
µA78MGUIC WQ78K	+5V to +30V	500mA	0-17,0-17 WB07H	Yes YQ54J	W0-01 QL37R	1000µF 63V JL26D	10µF 50V FF04E	100nF BX03D	10k Hor. UH03D
µA78GUIC WQ79L	+5V to +30V	1A	0-17,0-17 WB07H	Yes YQ54J	W0-01 QL37R	2200µF 63V JL29G	10µF 50V FF04E	100nF BX03D	10k Hor. UH03D
µA79GUIC WQ94C	−2·23V to −30	1A	0-17,0-17 WB22Y	Yes YQ55K	W0-01 QL37R	2200µF 63V JL29G	10µF 50V FF04E	100nF BX03D	10k Hor. UH03D

All transformer secondaries connected in series as follows: WB07H, secondary 1 tap 10 linked to secondary 2 tap 0, take output from secondary 1 tap 0 and secondary 2 tap 15. For WB22Y: secondary/taps 1/10 linked to 2/0, take output from 1/0 and 2/17.

Table 1. Variable regulated DC power supply options, based around ready-made Maplin PCBs.

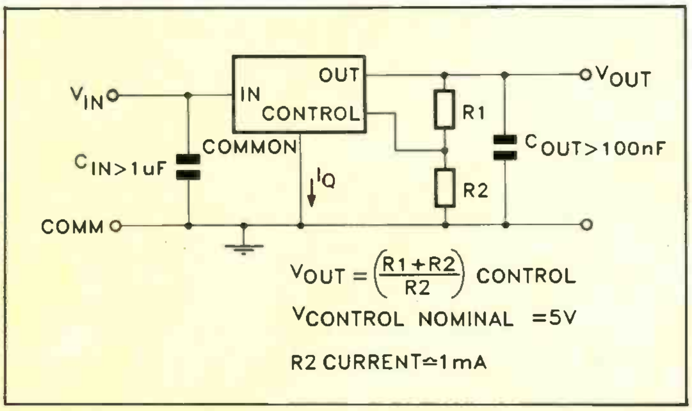


Figure 1. Application circuit for 78/79 series variable voltage regulators.

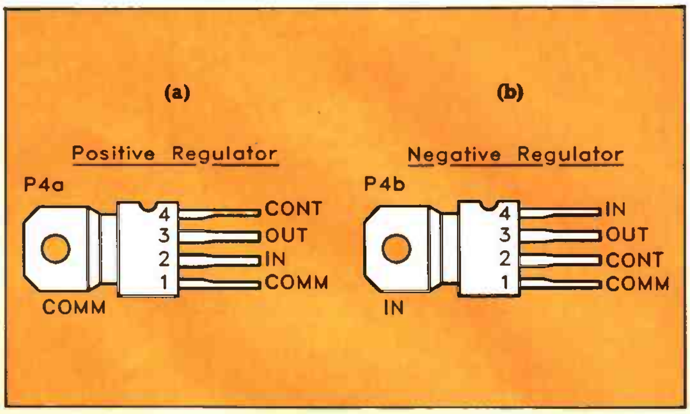


Figure 3(a) Pin-out and case style for 78 series variable voltage regulators. (b) Pin-out and case style for 79 series variable voltage regulators.

otherwise regulator 'drop out' (loss of regulation) may occur. Worst-case values must always be assumed for a variable power supply.

Power dissipation of the regulator can be calculated by multiplying the differential voltage by the current. The maximum power dissipation of a TO220 package is approximately 2 watts without heatsink, and around 18 watts with an infinite heatsink. In comparison, a TO92 package can only dissipate around half a watt without a heatsink.

To keep the heatsink to a minimum size, and obtain maximum current from the regulator, the input-to-output voltage must be kept to a minimum (without the regulator 'dropping out' during the power supply's ripple troughs). This will in turn reduce power dissipation, and therefore the heat output. It may therefore be necessary to use a transformer with a higher VA rating than the minimum requirement to improve the load regulation (this is the case with 78/79 series variable regulators working at maximum output voltage).

The basic circuit configuration for the 78/79 series variable regulators is shown in Figure 1.

PCBs Available

Two PCBs are available, which simplify the construction of variable power supplies around these devices. One (YQ54J) is intended for use with positive voltage devices, while the YQ55K PCB is suitable for negative voltage variable regulators; suitable component values for each individual regulator are given in Table 1. The circuit diagrams for the power supplies based around 78/79 series variable voltage regulators shown in Figures 2a and 2b. The pinouts of each device are shown in Figures 3a and 3b. Figures 4a and 4b show the connections to the positive and negative regulator PCBs. Table 2 shows the additional hardware (including the heatsink/ mounting bracket) required. Note that for positive regulators, the mounting tab is at the same potential as pin 1 (ground); for negative regulators the tab is at the same potential as pin 4 (input). Bearing this in mind, caution should be exercised when mounting the device on an earthed heatsink; an insulated mounting kit should be used if the tab is not at the same potential as the heatsink. Suitable mounting kits (listed in Table 3 below) were discussed in some detail in last month's Data File. Please note that the HQ81C mounting bracket will not provide adequate heatsinking at high power dissipations.

Suitable transformers are featured in Figure 3. WB07H is a 34VA type (suitable for the 500mA variable regulator), while WB22Y is a 68VA type (suitable for use with 1A variable regulators). Note that there is plenty of safety margin to ensure adequate load regulation. Apart from the differing power ratings, both transformers have identical multi-tapped secondary windings; these are shown in Figure 5a.

Figures 5b and 5c show how the windings are connected, for the 500mA regulator and 1A regulators respectively.

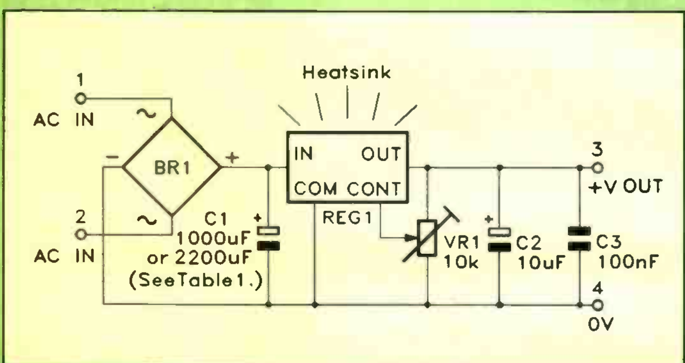


Figure 2a. Circuit diagram of 78 variable voltage regulator (positive).

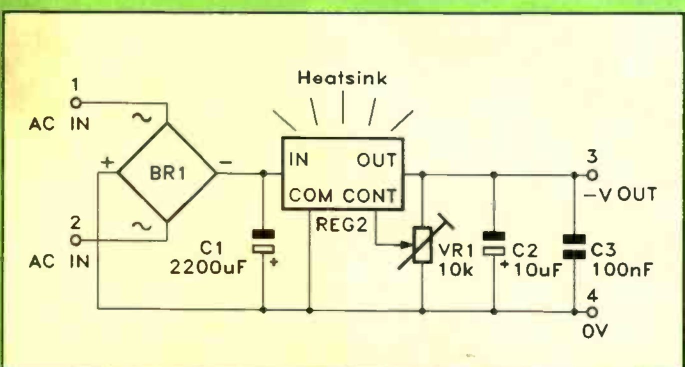


Figure 2b. Circuit diagram of 79 variable voltage regulator (negative).

Some General Notes on Heatsinks

Basic Heatsink Calculation

Heatsinks, which can be found in the 'Semiconductors' section in the Maplin Catalogue, are rated universally in terms of temperature rise per watt of power dissipated (°C/W). The lower the figure, the smaller the temperature rise will be from a given heat energy source (e.g. transistor or regulator IC), and the more reliable the electronic system will be. However, the trade-off for a heatsink with a lower thermal rating is increased bulkiness and cost, and so it is good practice to determine the optimum heatsink for a particular application, rather than just to choose one which could well be over-specified.

A very quick 'rule of thumb' calculation can be made by dividing the maximum allowable temperature rise by the power dissipation of the device and adding 10% (i.e. multiply by 1·1) to the total (for safety, as it is a simple calculation):

$$\frac{T_{MAX} - T_A}{V_{DIFF} \times I} \times 1{\cdot}1 = TR$$

Where:

T_{MAX} = maximum allowable temperature (°C)

T_A = ambient temperature (°C)

V_D = differential voltage

TR = thermal rating of heatsink, expressed in °C/W

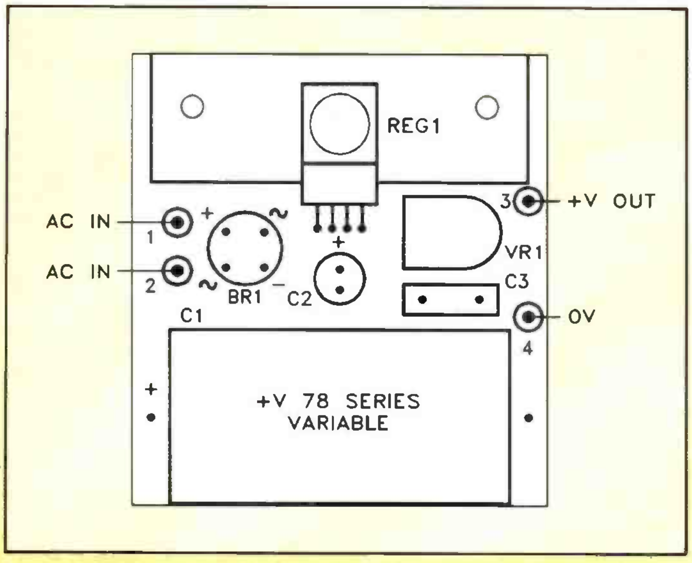


Figure 4a. Component overlay 78 series (positive).

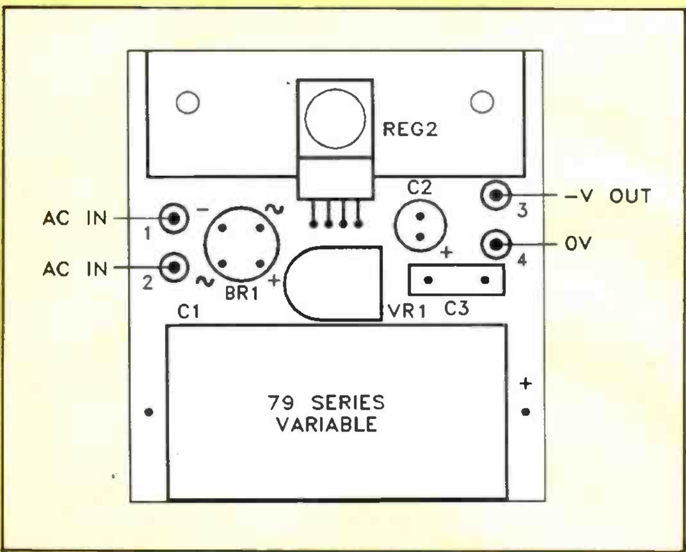


Figure 4b. Component overlay 79 series (negative).

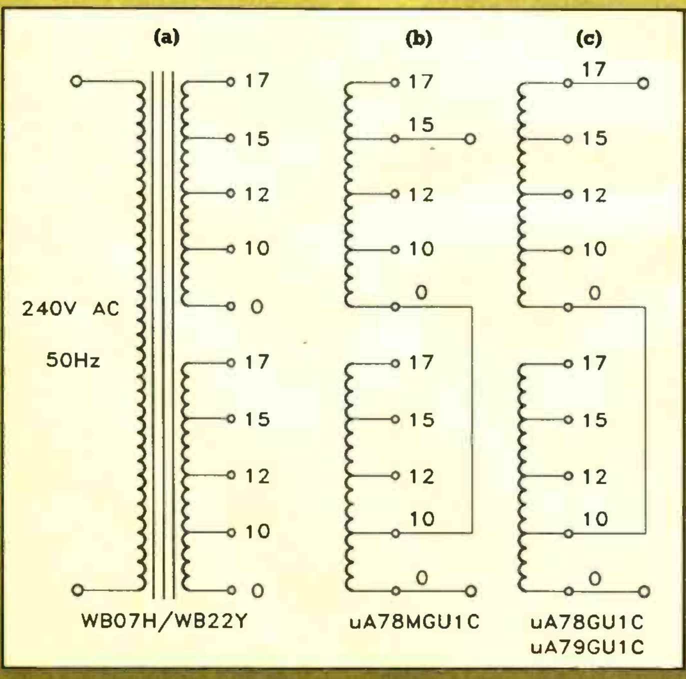


Figure 5(a) Secondary winding configuration of WB07H (34VA) and WB22Y (68VA) multi-tapped transformers. (b) Wiring WB07H transformer for use with 500mA variable voltage regulator. (c) Wiring WB22Y transformer for use with 1A variable voltage regulators.

Pins 2141	1 Pkt	FL21X
8W Hi-Fi Heatsink	1	HQ81C
Screw M3 × 10mm	1 Pkt	JY22Y
Nut M3	1 Pkt	JD61R
Shake Washer M3	1 Pkt	BF44X

Table 2. Hardware list.

If a mounting kit is required then an M2·5 × 10mm screw, nut and shakeproof washer will be required in place of the M3 hardware used to fix the regulator IC.

Note: a mounting kit WILL be required for a negative output voltage regulator.

Insulator TO220	1	QY45Y
Short Bush TO66	1	JR78K
Screw M2·5 × 10mm	1 Pkt	JY30H
Nut M2·5	1 Pkt	JD62S
Shake Washer M2·5	1 Pkt	BF45Y

Table 3. Optional mounting hardware.

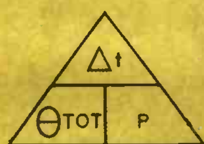
Example:

$$\frac{60°C - 25°C}{(8V \times 1A)} \times 1{\cdot}1$$

= 3·977°C/W (physically larger, or smaller °C/W number)

In most applications this type of calculation is all that is necessary, but in some circumstances a more accurate calculation is required to include the thermal resistance, θ (theta), of the device and mounting arrangement.

Thermal resistance is a useful concept as it has broadly similar properties to electrical resistance and can be modelled on Ohm's Law, where heat flow is analogous to current, and temperature is the equivalent of voltage. This can be seen from the 'formula triangle' shown below.



where:
Δt = change in temperature,
t = (max t − ambient t)
P = heat dissipation (watts)
θtot = °C/W = t / P

Series thermal resistances are added together in the same way as conventional electrical resistors:

$$\theta tot = \theta 1 + \theta 2 + \theta 3 + ... + \theta n$$

Thermal resistance in parallel is calculated in the usual manner of 'sum over product', or by using the reciprocal method:

$$\frac{\theta 1 + \theta 2}{\theta 1 \times \theta 2} = \theta tot \text{ or } \frac{1}{\theta 1} + \frac{1}{\theta 2} + \frac{1}{\theta 3} = \frac{1}{\theta tot}$$

Typical thermal resistances that will be encountered:

θjc = junction to case
θcs = case to (heat)sink
θsa = (heat)sink to air
θtot = total thermal resistance

These thermal ratings can generally be found in the manufacturers data.

Other more complex thermal calculations (e.g. for air flow / forced cooling) are really beyond the scope of this article.

78/79 SERIES VARIABLE VOLTAGE REGULATORS

The Maplin 'Get-You-Working' Service is not available for these projects.
These projects are not available as kits, however, PCBs are available.
0·5/1A Vareg Pos PCB Order As YQ54J Price £1.48.
0·5/1A Vareg Neg PCB Order As YQ55K Price £1.48.

MODERN BRIDGE CIRCUITS

Part 2 by Ray Marston

Ray Marston continues his study of modern bridge circuits by looking at precision L-C-R types.

Last month's opening part of this three part series took an in-depth look at the Wheatstone resistance-measuring bridge and showed how it can be adapted to function as a simple 'service'-type L-C-R bridge. This month Part 2 investigates modern 'precision' L-C-R bridges, and presents the circuit of a practical 18-range laboratory-standard instrument.

'Precision' C and L Bridges

All 'precision' C and L bridges incorporate facilities for balancing both the resistive and the reactive elements of test components. The basic principles of the subject are detailed in Figures 13 to 15.

Any practical capacitor has the equivalent circuit of Figure 13a, in which C represents a pure capacitance, R_s represents dielectric losses, R_p the inductance of electrode foils, etc. At frequencies below a few kHz L_s has (except in high value electrolytics) negligible practical effect, but R_s and R_p cause a finite shift in the capacitor's voltage/current phase relationship. This same phase shift can be emulated by wiring a single 'lumped' resistor in series or in parallel with a pure capacitor, as in Figures 13b and 13c.

A similar story is true of inductors, which can, in terms of phase shifts, be regarded as 'negative' capacitors. Either device can, at any given frequency, be treated as a pure reactance, X, that is either in series or parallel with a single 'loss' resistor (r_s or r_p), as shown in Figures 14a or 14b. The ratio between r and X is normally called 'Q' in an inductor, or 'D' or the 'loss factor' in a capacitor; one of its major effects is to shift the device's voltage-to-current phase relationship, ϕ (pronounced phi), from the ideal value of 90° to some value between zero and 90°; the difference between this and the ideal value is known as the loss angle, δ (pronounced delta) of the phasor diagram. Another major effect of Q or D is to shift the components impedance (Z) away from its pure reactance (X) value. All the formulae relevant to the subject are shown in Figure 14.

Figure 15 lists the relationships between phase and loss angles and the Z/X-ratios of both series and parallel equivalent circuits at various decade-related Q and D values. Note that components with Q values of 10 or more, or D values of 0·1 or less, have similar Z and X values. Thus, a coil with a Q of 10 and an 'X' of 1000Ω at a given frequency can be said to have either a 100Ω series (r_s) or a 10,000Ω parallel (r_p) resistance; in either case, it gives a loss angle of 5·71 degrees and an impedance that is within 0·5% of 1,000Ω at that frequency. Also note that series and parallel 'equivalent' circuits produce significantly different Z/X-ratios at low values of Q.

The relevance of all this is that, at any given frequency, the true X, Q, and D values of a capacitor or inductor can be deduced by measuring the device's

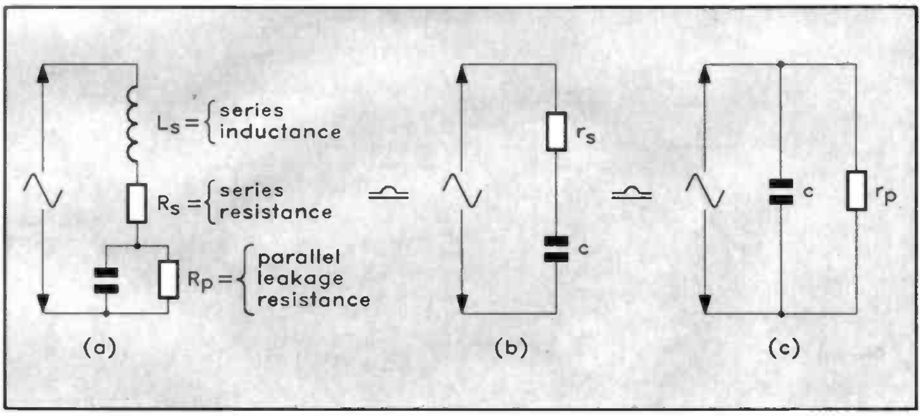


Figure 13. Absolute (a) and simplified series (b) and parallel (c) equivalent circuits of a capacitor.

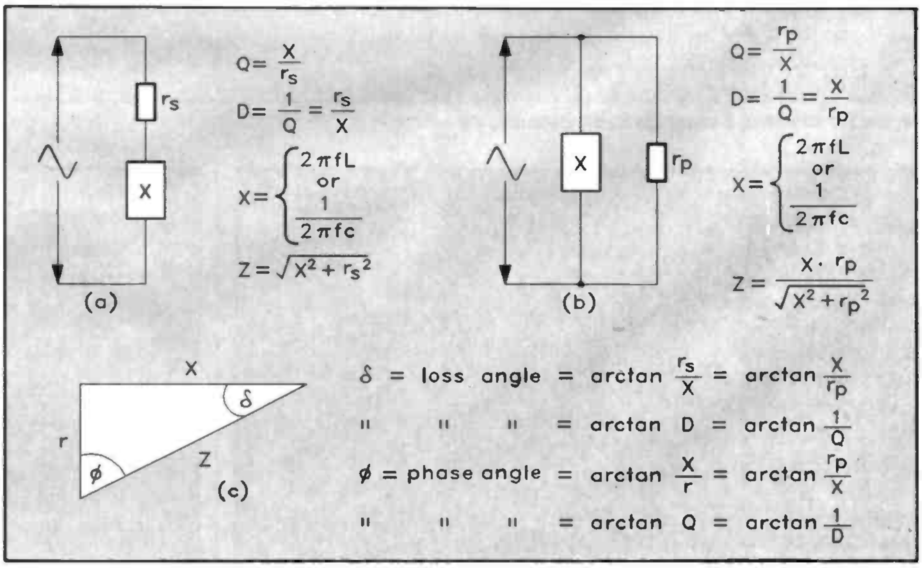


Figure 14. Any capacitor or inductor can be represented by a series (a) or parallel (b) equivalent circuit, which determines its phasor diagram (c).

Q	D	Phase angle ϕ	Loss angle δ	Z/X – ratio	
				Series circuit	Parallel circuit
∞	0	90°	0°	1.000	1.000
1000	0.001	89.94°	0.06°	1.000	1.000
100	0.01	89.43°	0.57°	1.000	1.000
10	0.1	84.29°	5.71°	1.005	0.995
1.0	1.0	45°	45°	1.414	0.7071
0.1	10	5.71°	84.29°	10.05	0.0995
0.01	100	0.57°	89.43°	100.0	0.0100

Figure 15. Relationship between Ø, δ, and Z/X-ratio in series and parallel equivalent circuits at various values of Q and D.

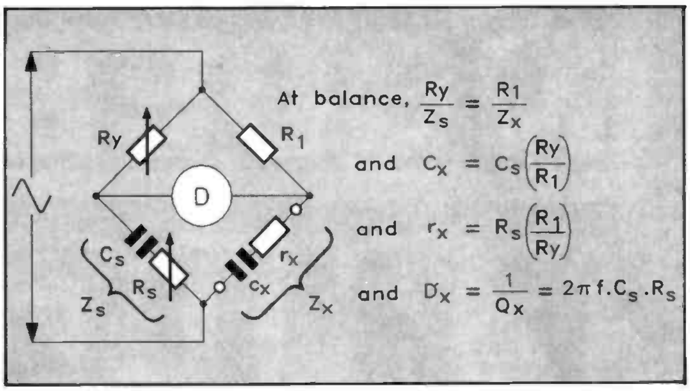


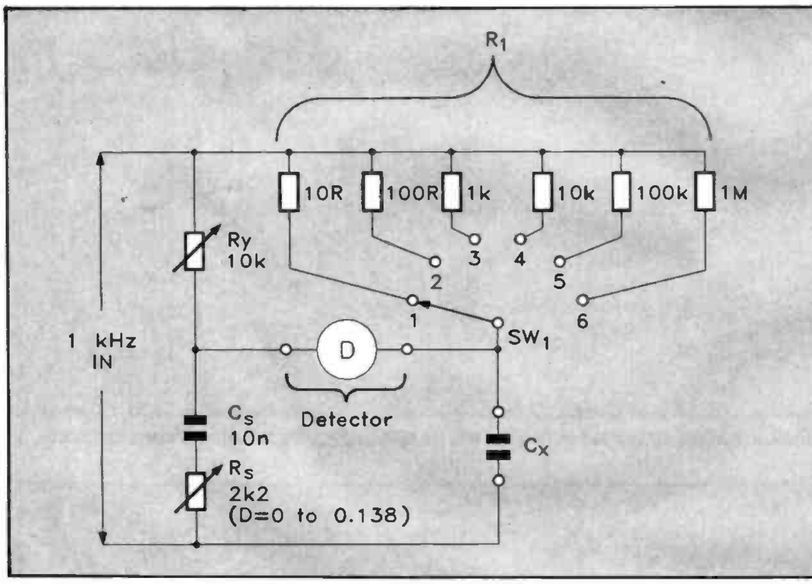
Figure 16. Basic de Sauty capacitance bridge.

impedance and loss angle, and it is this principle that forms the basis of most precision 'C' or 'L' measurement bridges. The best known precision 'C' measurement bridge is the de Sauty, which is shown in basic form in Figure 16; it is at balance when $Ry/Z_s = R_1/Zx$, and under this condition the values of Cx, rx, and Dx are as shown in the diagram. The bridge is balanced by using Ry and R_s to balance the AC voltages and phase shifts on the detector's left side with those on its right.

Figure 17 shows a practical de Sauty bridge that spans 1pF to 10μF in 6 decade ranges. This is a very sensitive design in which roughly half of the AC energising voltage appears at each end of the detector at balance; the detector can thus take a very simple form (such as 'phones' etc). R_s enables nulling to be obtained with Cx capacitors with D values as high as 0·138 (equal to a Q of 7·2); any capacitor with this high a value should be scrapped. If desired, R_s can be calibrated directly in D values, since (in this design, at 1kHz) D = 0·001 per 15·9Ω of R_s value.

The two best known 'L' measurement bridges are the Hay and the Maxwell types of Figures 18 and Figure 19. These work by balancing the inductive phase shift of Lx against a capacitive shift of the same magnitude in the diametrically opposite arm of the bridge. The Hay bridge uses a series equivalent (C_s-R_s) balancing network, and is useful for measuring high-Q coils (it can be very inaccurate at Q values below 10, as implied by the formulae of Figure 18). The Maxwell bridge uses a parallel equivalent (C_s-R_s) balancing network, and is useful for measuring coils with Q values below 10. Note that the Q values referred to here are those occurring at the test frequency of (usually) 1kHz; a coil that has a high frequency Q of 100 may have a Q of 1 or less at 1kHz.

Figure 20 shows a practical inductance bridge that spans 10μH to



SW_1 Range	Bridge Range	R_1 Value	Z_x at full-scale at R_s=0
1	0–10uF	10R	15.9R
2	0–1uF	100R	159R
3	0–0.1uF	1k	1590R
4	0–10nF	10k	15.9k
5	0–1nF	100k	159k
6	0–100pF	1M	1.59M

Figure 17. Sensitive 6-range de Sauty capacitance bridge.

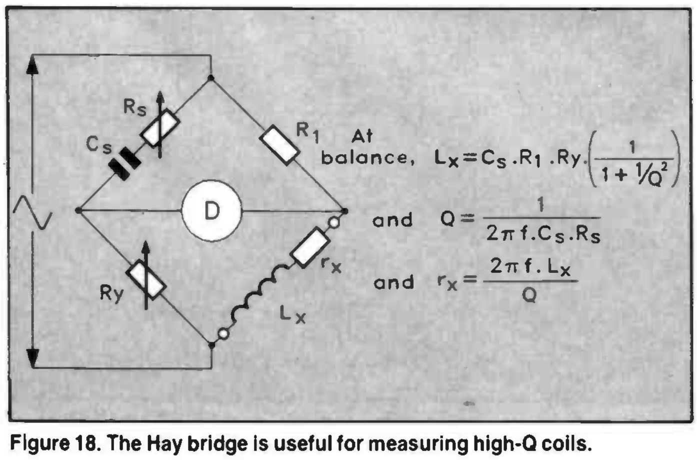


Figure 18. The Hay bridge is useful for measuring high-Q coils.

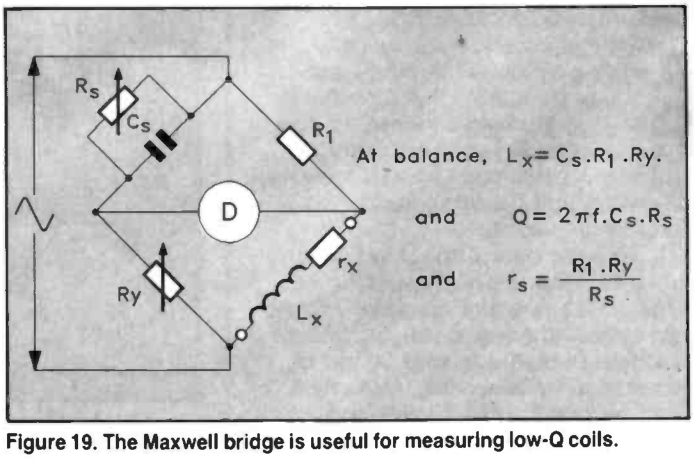
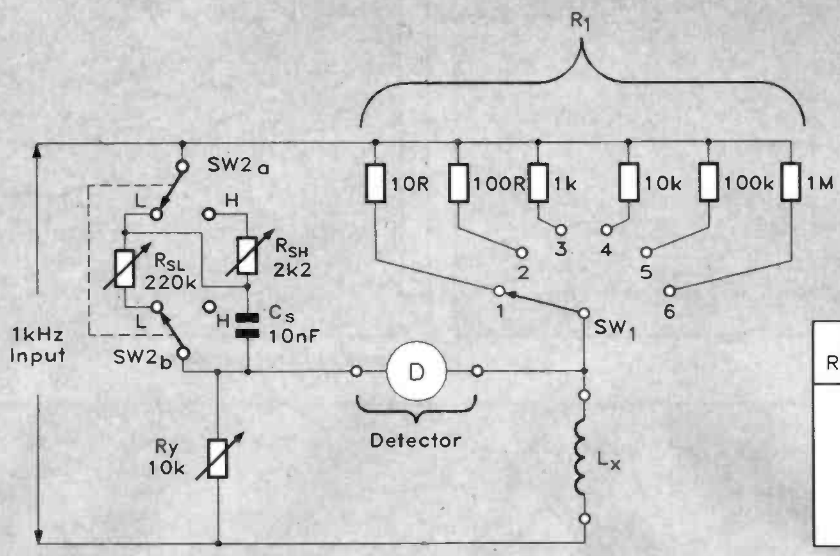


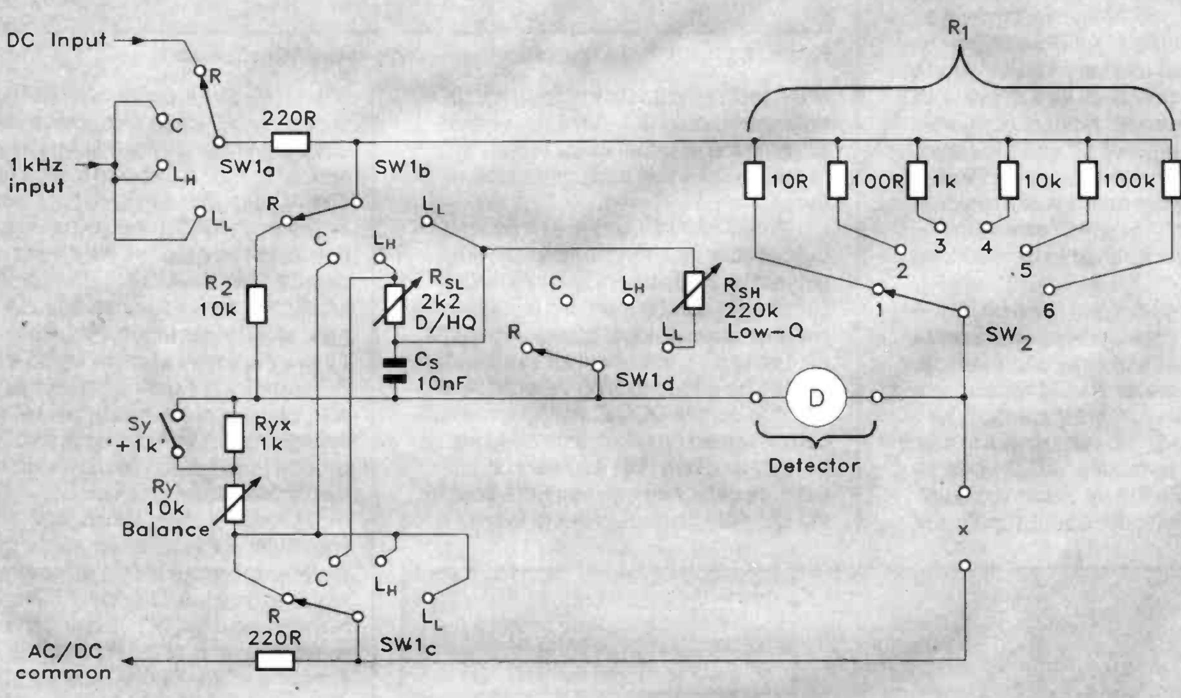
Figure 19. The Maxwell bridge is useful for measuring low-Q coils.



SW1 Range	Bridge Range	R1 Value	Zx at 1kHz at full scale
1	0–1mH	10R	6.2R
2	0–10mH	100R	62R
3	0–100mH	1k	620R
4	0–1H	10k	6.2k
5	0–10H	100k	62k
6	0–100H	1M	620k

Note : High–Q(R_{SH}) range = 7.2 to ∞
Low–Q(R_{SL}) range = 0 to 13.8

Figure 20. 6-range Hay/Maxwell inductance bridge.



NOTE : D (R_{SL}) range = 0 to 0.138
High – Q (R_{SH}) " = 7.2 to ∞
Low – Q (R_{SL}) " = 0 to 13.8

SW1 Position	R1 Value	Bridge Range R	C	L
1	10R	0–10R	0–10uF	0–1mH
2	100R	0–100R	0–1uF	0–10mH
3	1k	0–1k	0–0.1uF	0–100mH
4	10k	0–10k	0–10nF	0–1H
5	100k	0–100k	0–1nF	0–10H
6	1M	0–1M	0–100pF	0–100H

Figure 21. Sensitive 18-range laboratory-standard L-C-R bridge.

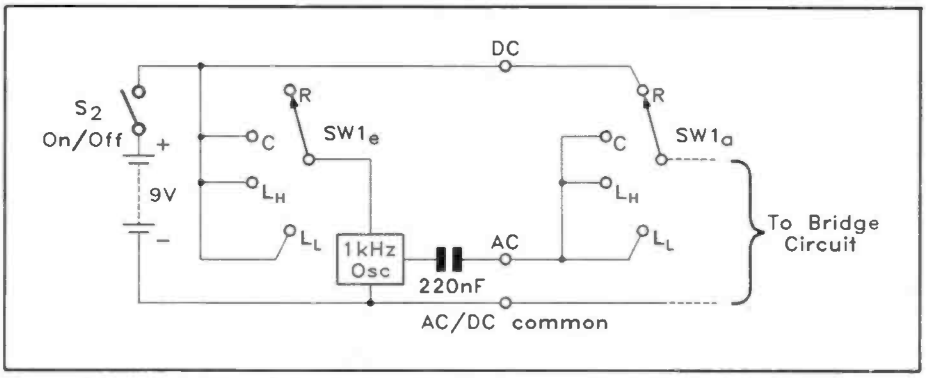


Figure 22. Built-in energiser for the L-C-R bridge.

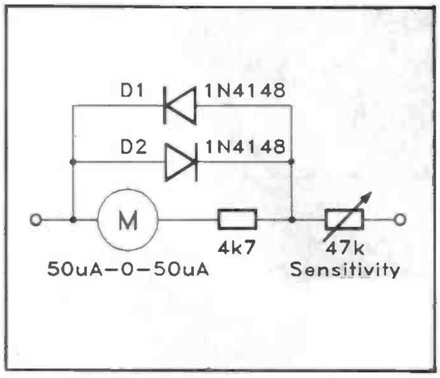


Figure 23. DC null detector.

100 Henrys in six ranges; it uses a Hay configuration for high-Q measurements (with SW_2 in the 'H' position) and a Maxwell layout for low-Q ones (with SW_2 set to 'L'). This is another sensitive design, in which the AC voltages at either end of the detector are close to the half-supply value at balance, and can use a very simple type of detector.

A Precision L-C-R Bridge

Figure 21 shows a precision 18-range L-C-R bridge that combines the circuits of Figures 20 and 17 with last month's Figure 6, to make a highly sensitive design that can use very simple types of balance detector (such as a multimeter on the DC-driven 'R' ranges, or phones on the AC-energised 'C' and 'L' ranges. This circuit's 'Y' null-balance network is modified by the addition of resistor Ryx and switch Sy, which enable the coverage of each range to be extended by 10%.

When this bridge is used on its 0 – 100pF range considerable errors occur due to the effects of stray capacitance, and measurements should thus be made by using the 'incremental' method, as follows: first, with no component in place across the 'x' terminals, null the bridge via Ry and note the resultant 'residual' null reading (typically about 15pF); now fit the test component in place, obtain a balance reading (say 83pF), and then subtract the residual value (15pF) to obtain the true test capacitor value (68pF).

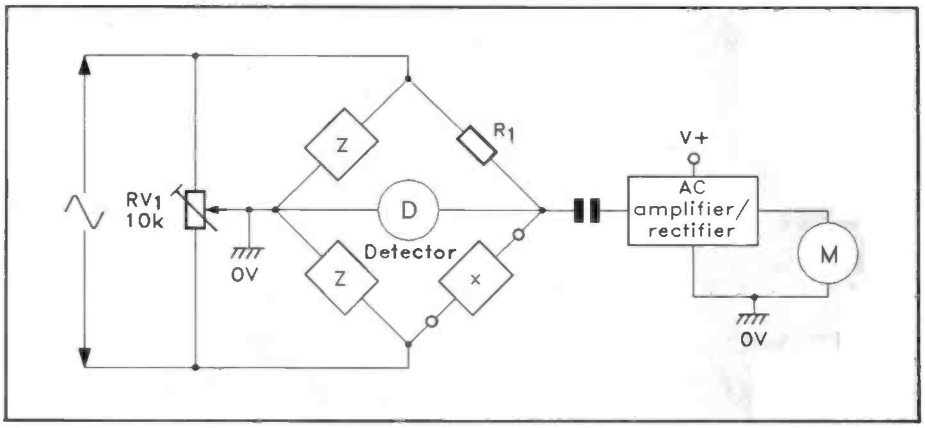


Figure 24. Provision of a Wagner earth and single-ended AC null detector.

The Figure 21 circuit can either be built exactly as shown and used with external energising and null-detection circuitry, or can be modified in various ways to suit individual tastes. Figure 22, for example, shows how an extra wafer (e) can be added to SW_1 to facilitate the use of a built-in DC/AC energiser (which can be based on last month's Figure 12 design. Similarly, DC and AC null-balance detectors can easily be built-in; the DC detector can take the form of a $50\mu A - 0 - 50\mu A$ meter, with overload protection given via a couple of silicon diodes and sensitivity adjustable via a series resistor, as shown in Figure 23. The AC detector can take the form of any single-ended AC analogue millivoltmeter circuit; in this case the 'low' input of the detector and the left-hand 'detector' junction of the bridge can both be grounded to chassis, as shown in Figure 24, which also shows how the AC energising signal can be fitted with Wagner earth, which enables the energising signal to be balanced to ground (via RV_1), to eliminate unwanted signal breakthrough at null.

One of the most important modifications that can be made to the circuit concerns the bridge's resolution, which is only about ±1% of full-scale in the basic design, this being the readability limit of the Ry balance control's scale. Figure 25 shows how resolution can be improved by a factor of ten, to ±0·1% of full-scale, by replacing the Sy-Ryx-Ry network of Figure 21 with the switched-and-variable 'Ry' network of Figure 25; switch Sy enables the RVy variable control to be overranged by 50%. This high-resolution circuit is best used by first switching Sy and SWy to '0' and adjusting the bridge's range controls to give a balance on RVy only; this gives a good guide to the test component's value; a final balance can then be read on a more sensitive range via the full range of 'Ry' balance controls.

Next month's concluding part of this series presents a variety of 'special' bridge circuits, including easily built resistance-matching and ratio-matching types that enable resistors to be matched or duplicated to within ±0·003%.

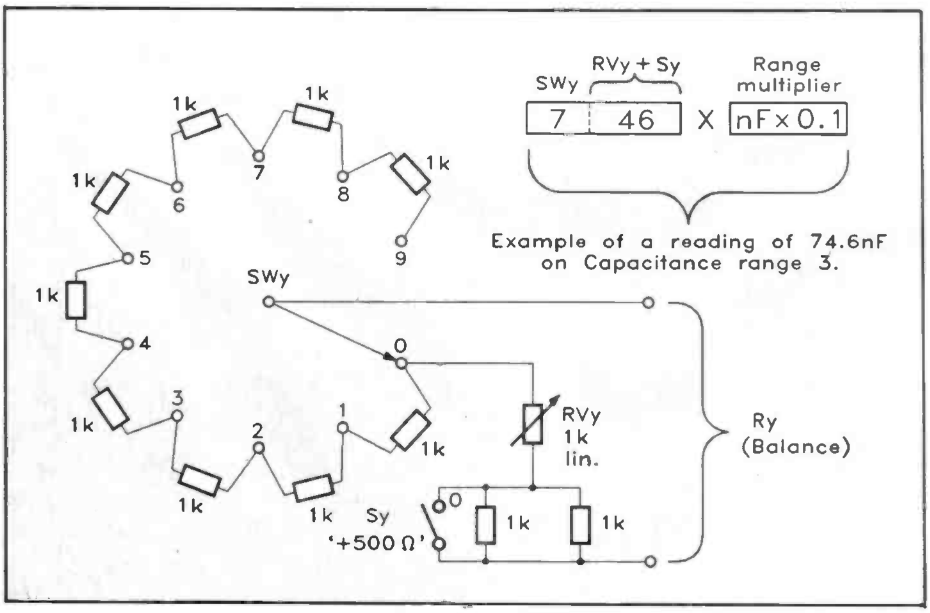


Figure 25. This circuit can be used to raise the null resolution (readability) of the L-C-R bridge to ±0·1% of full scale.

MAPLIN'S TOP TWENTY KITS

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2.	(3)	◆	Car Battery Monitor	LK42V	£ 7.95	Magazine	37 (XA37S)
3.	(4)	◆	Courtesy Light Extender	LP66W	£ 2.75	Magazine	44 (XA44X)
4.	(6)	◆	Mini Metal Detector	LM35Q	£ 6.45	Magazine	48 (XA48C)
5.	(8)	◆	L200 Data File	LP69A	£ 3.95	Magazine	46 (XA46A)
6.	(5)	◆	MOSFET Amplifier	LP56L	£19.95	Magazine	41 (XA41U)
7.	(9)	◆	TDA7052 Kit	LP16S	£ 4.45	Magazine	37 (XA37S)
8.	(7)	◆	Vehicle Intruder Alarm	LP65V	£ 9.95	Magazine	46 (XA46A)
9.	(12)	◆	1/300 Timer	LP30H	£ 4.95	Magazine	38 (XA38R)
10.	(10)	◆◆	Partylite	LW93B	£10.25	Catalogue	'92 (CA09K)
11.	(11)	◆◆	Low Cost Alarm	LP72P	£12.95	Magazine	45 (XA45Y)
12.	(1)	◆	LED Xmas Star	LP54J	£ 6.25	Magazine	48 (XA48C)
13.	(13)	◆◆	MSM6322 Data File	LP58N	£11.45	Magazine	44 (XA44X)
14.	(15)	◆	PWM Motor Driver	LK54J	£ 9.95	Best of Book	3 (XC03D)
15.	(14)	◆	IBM Expansion Sys	LP12N	£18.25	Magazine	43 (XA43C)
16.	(16)	◆◆	LM383 8W Amplifier	LW36P	£ 7.45	Catalogue	'92 (CA09K)
17.	(-)	RE-ENTRY	I/R Prox. Detector	LM13P	£ 9.95	Projects	20 (XA20W)
18.	(17)	◆	TDA2822 Amplifier	LP03D	£ 6.95	Magazine	34 (XA34M)
19.	(-)	RE-ENTRY	15W Amplifier	YQ43W	£ 7.45	Catalogue	'92 (CA09K)
20.	(20)	◆◆	LM386 Amplifier	LM76H	£ 3.75	Magazine	29 (XA29G)

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The descriptions are necessarily short. Please ensure you know exactly what the kit is and what it comprises before ordering, by checking the appropriate project book, magazine or catalogue mentioned in the list above.

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NEXT issue

In next month's super issue of 'Electronics – the Maplin Magazine', there are some really great projects and features for you to get your teeth into! The June issue is on sale 1st May 1992, available from Maplin's regional stores and newsagents countrywide, and of course by subscription (see page 30 for details). To whet your appetite, here's just a taster of *some* of the goodies on offer:

FINISHING OFF

Looks at how the internal appearance of kits can be improved, with reference to the 'Benchmaster' project. The article also gives good practical advice on kit-building, and the management of wires and cables.

DATA FILE

Next month's Data File features the L9801 high-side driver, an IC that can switch 25A (peak) at 16V or less. Controlled by either TTL or CMOS logic inputs, this chip is suitable for use with either inductive or resistive loads. Just the thing to replace those troublesome and inefficient relays!

ELECTRONICS IN IGNITION

Mike Holmes discusses the design and testing of an effective 'homebrew' electronic ignition system.

SIGNAL INJECTOR/TRACER

Resident audiophile Alan Williamson describes this simple yet essential piece of test equipment. A few hints are also given on how best to use it.

ENVIROSYNTH

Is the current recession causing you insomnia? Do you find it difficult to relax during rest periods? If so, this low-cost kit is for you. The Enviro-Synth produces a range of 'surf' and 'breeze' sounds that may be extremely soothing to those suffering from the stresses supplied free with modern living! The sound can be easily tailored – ideal for those who require realistic sound effects.

ELECTRONICS IN AVIATION

Modern cockpit instrumentation is looked at in this special feature.

Plus of course there's all the usual features for you to enjoy!

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Review

by Gavin Cheeseman

Morse Decoder

The Velleman Morse decoder.

Morse code is one of the most effective methods of long-distance radio communication, and contact can often be established using this system under conditions where other transmission modes would fail. Although much commercial traffic uses more advanced methods of telegraphy, there is still a large amount of Morse code on the short-wave bands.

Morse code was devised in 1837 by Samuel Morse, in collaboration with Alfred Vail, for the telegraphic transmission of information. The messages were sent as a series of DC currents, controlled by a push-to-make switch (now known as a Morse key). The period for which the key was held down gave either the 'dot' (short period) or the 'dash' (long period). Combinations of dots and dashes represented the actual letters of each word that was sent. At the receiving station these periodic DC currents would then be converted into a sound using an electromagnetic device. The original code was revised in 1844, and again in 1851 when an international conference combined four similar codes into the system we know today as the Morse code. Table 1 shows the international Morse code, together with the corresponding phonetic equivalent. In radio communication, the dot is represented by a tone of short duration and the dash by a tone of long duration.

Those people interested in amateur radio will know that Morse code is a requirement of the UK amateur radio class 'A' licence. Learning the Morse code can be very time-consuming and requires a lot of practice.

The Velleman Morse Decoder enables Morse to be converted into readily understandable alphanumeric form, which is displayed clearly on a large LCD panel. For those who wish to learn Morse, the decoder can also make a useful practice aid. The decoder operates over a wide range of audio frequencies and picks up the Morse from the speaker of a radio receiver using an on board electret microphone.

FEATURES

- ★ Liquid Crystal Display (LCD)
- ★ Adjustable Centre Frequency
- ★ Adjustable Sensitivity
- ★ Adjustable Lock Range
- ★ Low Voltage Operation
- ★ Compact Size

Circuit Description

Figure 1 shows the circuit diagram of the decoder. Incoming signals from the microphone are fed to a phase-locked loop (PLL) tone decoder, which is based around IC2. At this point, RV2 sets the input sensitivity. IC2 effectively compares the frequency of the incoming signal with that of its internal clock, producing a logic output when the two frequencies are approximately the same. The clock frequency is set by variable resistor RV3, while the capture range is adjusted by RV4. The output from IC2 is fed to IC1, which is a 'One Time Programmable' (OTP) microcontroller. This device translates the Morse code into a format suitable for driving the LCD, the contrast of which is set by preset resistor RV1. Diodes D2 and D3 act as a rectifier, allowing for either an AC or DC power supply input. The rectified supply voltage is smoothed and decoupled by capacitors C12, C8 and C9, before being passed to voltage regulator VR1. T1 drives LD1, which indicates when the phase-locked loop circuit has locked to a tone of the correct frequency.

The Velleman Morse decoder, set up with ancillary equipment.

Letter	Code	Phonetic
A	.-	di-dah
B	-...	dah-di-di-dit
C	-.-.	dah-di-dah-dit
D	-..	dah-di-dit
E	.	dit
F	..-.	di-di-dah-dit
G	--.	dah-dah-dit
H	....	di-di-di-dit
I	..	di-dit
J	.---	di-dah-dah-dah
K	-.-	dah-di-dah
L	.-..	di-dah-di-dit
M	--	dah-dah
N	-.	dah-dit
O	---	dah-dah-dah
P	.--.	di-dah-dah-dit
Q	--.-	dah-dah-di-dah
R	.-.	di-dah-dit
S	...	di-di-dit
T	-	dah
U	..-	di-di-dah
V	...-	di-di-di-dah
W	.--	di-dah-dah
X	-..-	dah-di-di-dah
Y	-.--	dah-di-dah-dah
Z	--..	dah-dah-di-dit

Number	Code	Phonetic
1	.----	di-dah-dah-dah-dah
2	..---	di-di-dah-dah-dah
3	...--	di-di-di-dah-dah
4	....-	di-di-di-di-dah
5	.....	di-di-di-di-dit
6	-....	dah-di-di-di-dit
7	--...	dah-dah-di-di-dit
8	---..	dah-dah-dah-di-dit
9	----.	dah-dah-dah-dah-dit
0	-----	dah-dah-dah-dah-dah

Punctuation	Code	Phonetic
Full stop (.)	.-.-.-	di-dah-di-dah-di-dah
Comma (,)	--..--	dah-dah-di-di-dah-dah
Question mark (?)	..--..	di-di-dah-dah-di-dit

Procedure signals	Code	Phonetic
Error (eight dots)	....	di-di-di-di-di-di-di-dit
Preliminary call (CT)	-.-.-	dah-di-dah-di-dah
Wait (AS)	.-...	di-dah-di-di-dit
Break sign (=)	-...-	dah-di-di-di-dah
Fraction bar or stroke (/)	-..-.	dah-di-di-dah-dit
End of message (AR)	.-.-.	di-dah-di-dah-dit
End of work (VA)	...-.-	di-di-di-dah-di-dah
Invitation to transmit (K)	-.-	dah-di-dah

Table 1. The International Morse Code.

Construction

The kit contains everything necessary to build the complete decoder module, including the PCB and Liquid Crystal Display (LCD). It is recommended that you check and familiarise yourself with the components before attempting construction. It is recommended that the components are fitted in the order suggested in the instruction leaflet supplied with the kit. The mounting of the display module requires some care – it is important that the links are soldered to the correct pads; each pad on the display module should be linked to the

Band	Frequency	Morse section of band
160 metres	1·81MHz to 2·00MHz	- - - - - - - - - -
80 metres	3·5MHz to 3·8MHz	3·5MHz to 3·6MHz
40 metres	7·00MHz to 7·10MHz	7·00MHz to 7·04MHz
30 metres	10·10MHz to 10·15MHz	10·10MHz to 10·14MHz
20 metres	14·00MHz to 14·35MHz	14·00MHz to 14·10MHz
17 metres	18·068MHz to 18·168MHz	18·068MHz to 18·100MHz
15 metres	21·00MHz to 21·45MHz	21·00MHz to 21·15MHz
12 metres	24·89MHz to 24·99MHz	24·89MHz to 24·92MHz
10 metres	28·00MHz to 29·70MHz	28·00MHz to 28·20MHz

Table 2. UK HF (short-wave) amateur radio frequency bands on which Morse code may be received.

Q-Code (A modified version of the International Q-Code, used in amateur radio):

QRG	Frequency
QRK	Signal strength
QRM	Interference from other stations
QRN	Interference from atmospherics, static, etc.
QRO	High power
QRP	Low power
QRT	Close-down
QRX	Stand by
QSB	Fading
QSL	Verification card
QSO	Radio contact
QSP	Relay message
QSY	Change of operating frequency
QTH	Location

Standard Abbreviations

BK	Signal used to break transmission
CFM	Confirm
CL	Closing down station
CQ	General call to all stations
DE	Used to separate callsign of station called from that of calling station
K	Invitation to transmit
NW	Now
R	Received
RPT	Repeat

Informal Abbreviations

ABT	About	GE	Good evening
ADR	Address	MNI	Many
AGN	Again	PSE	Please
ANT	Antenna	RX	Receiver
CONDX	Conditions	SRI	Sorry
CUD	Could	TNX	Thanks
CUAGN	See you again	TX	Transmitter
DX	Long distance	VY	Very
ES	And	WX	Weather
FER	For	73	Best regards
GB	Goodbye		

R-S-T Code – (Used to indicate quality of reception)

Readability

R1	Unreadable
R2	Barely readable – occasional words distinguishable
R3	Readable but with considerable difficulty
R4	Readable with practically no difficulty
R5	Perfectly readable

Signal Strength

S1	Faint signal, barely perceptible
S2	Very weak signal
S3	Weak signal
S4	Fair signal
S5	Fairly good signal
S6	Good signal
S7	Moderately strong signal
S8	Strong signal
S9	Extremely strong signal

Tone

T1	Extremely rough hissing note
T2	Very rough 'AC' note, no trace of musicality
T3	Rough, low-pitched 'AC' note, slightly musical
T4	Rather rough 'AC' note, moderately musical
T5	Musically modulated note
T6	Modulated note, slight trace of whistle
T7	Near 'DC' note, smooth ripple
T8	Good 'DC' note, just a trace of ripple
T9	Purest 'DC' note.

Additional Suffix

X	The note appears to be crystal controlled
C	Note 'chirps'
D	Note drifts in frequency
K	Key clicks present

Table 3. Typical codes and abbreviations used in amateur radio Morse transmissions.

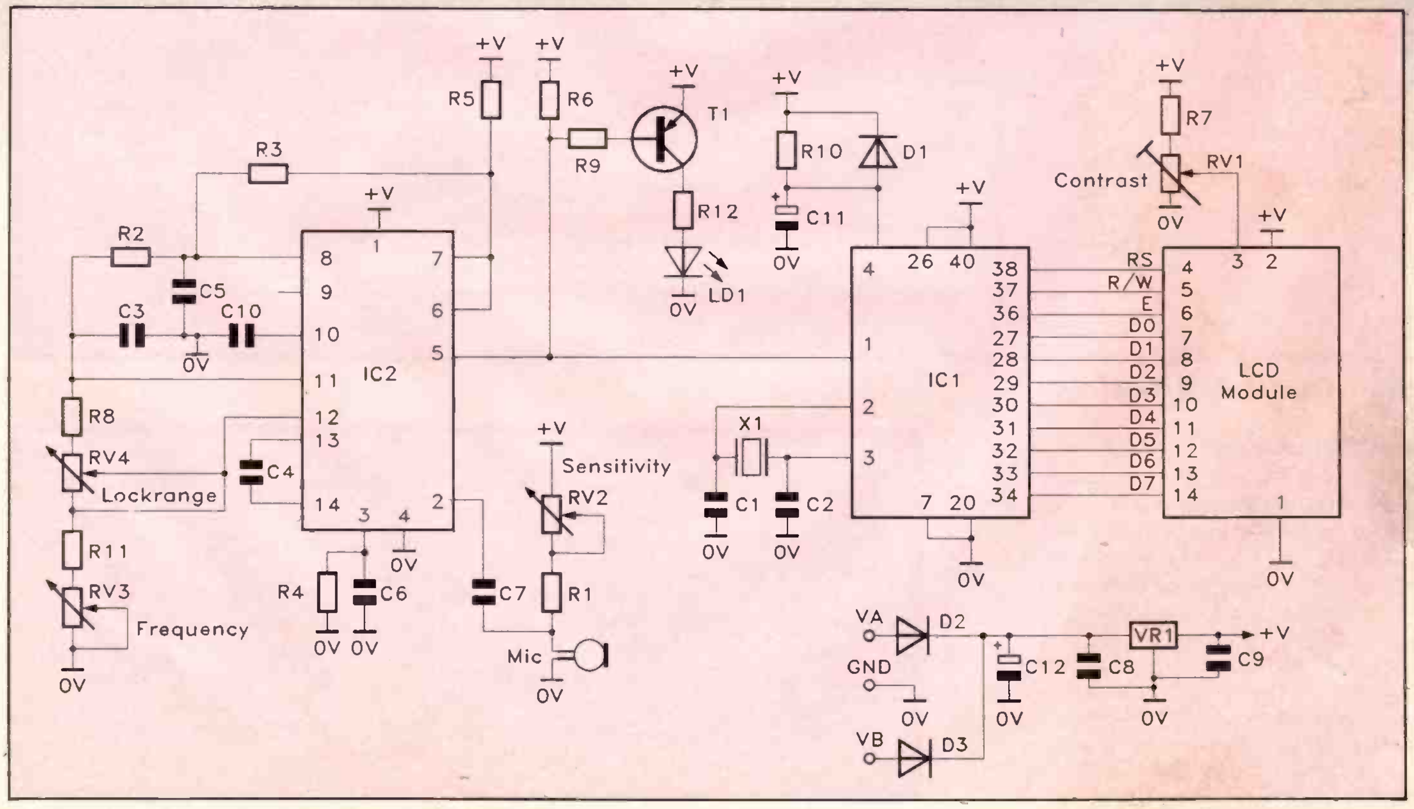


Figure 1. Circuit diagram.

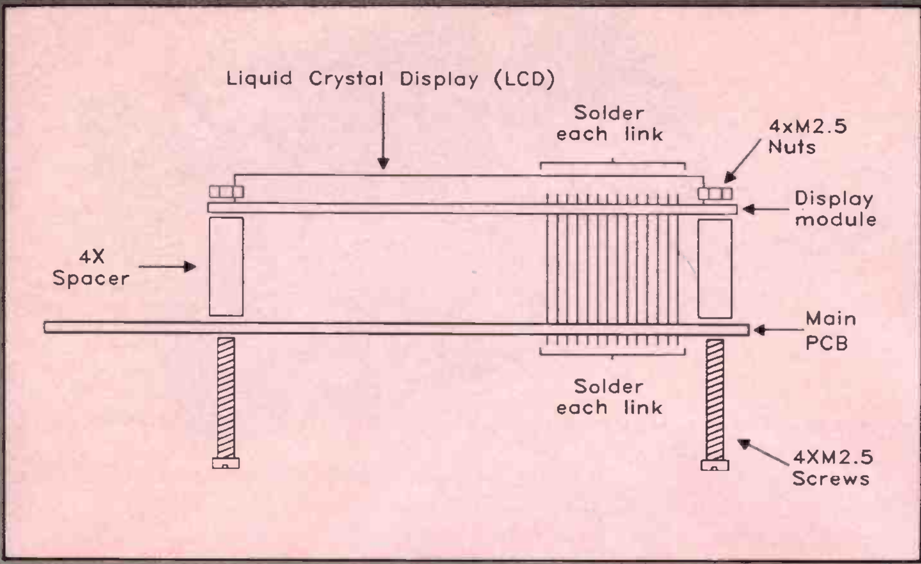


Figure 2. Mounting the display module.

corresponding pad on the main PCB. The correct method of mounting the display module is shown in Figure 2. The microphone may either be mounted on the appropriate PCB pins directly or via screened cable (see Figure 3). Please note that the '–' pin on the microphone should be soldered to the earthing tag on the microphone case. Any screened lead used to connect the microphone should be kept as short as possible to prevent the introduction of unwanted external noise onto the input (otherwise there may be a tendency for the unit to occasionally produce garbled characters). This point is particularly important if this unit is used in proximity to transmitting or computer equipment.

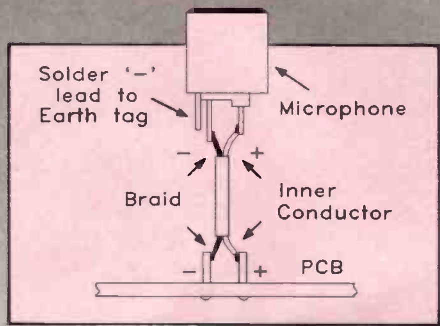


Figure 3. Microphone wiring information.

Testing

Before testing the module, it is recommended that you double-check your work to make sure that there are no dry joints or solder bridges. The module requires a DC power supply of between 9V and 12V at 100mA. The +V rail is connected to either pin VA or pin VB, while the 0V rail is connected to the middle pin, marked on the PCB legend with a 0V symbol. Alternatively, an AC supply (7 to 8V RMS at 150mA) can be used. Figure 4 shows the different power supply configurations.

Apply power to the module and set all of the variable resistors to their centre positions. You will require a source of Morse code, either locally generated by a Morse key and oscillator, or from a radio receiver. When the unit is initially powered up, the word VELLEMAN will be displayed on the LCD. Position the microphone close to the Morse code source so that there is a strong signal for the unit to work from. Adjust the 'frequency' control (RV3) until LD1 flashes in time with the Morse code. The 'lockrange' (RV4) and 'sensitivity' (RV2) controls can then be adjusted for minimum interference. After a short adjustment period the received characters should be displayed on the LCD, the contrast of which can be changed by varying preset RV1. Obviously the characters received during this adjustment period will be lost.

Using the Decoder

To achieve the best performance from the decoder, it is necessary for the Morse signal to be as clean as possible. This allows the maximum amount of information to be decoded with a minimum of corruption. For correct decoding, the Morse characters must be spaced reasonably correctly; this is not normally a problem with Morse transmissions that are electronically generated, but in the case of manually sent Morse, the spacing can sometimes be variable. As a result words can sometimes run together without any spaces. This is not a real problem and it is usually still possible to pick out the words.

Morse code can be heard on most parts of the short-wave band, particularly the amateur radio bands, a list of these is given in Table 2. Many of the stations transmitting in Morse code use an abbreviated form of text to increase the speed at which information is sent. A list of the more common abbreviations used in amateur radio are shown in Table 3. The International Q-Code consists of a series of questions and statements facilitating the fast and efficient exchange of information. In amateur radio, the Q codes are often used as nouns and this is

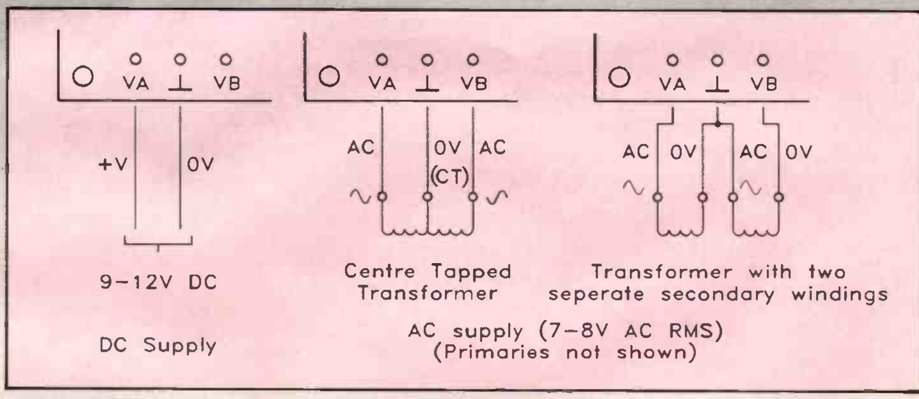


Figure 4. Power supply wiring for DC or AC supplies.

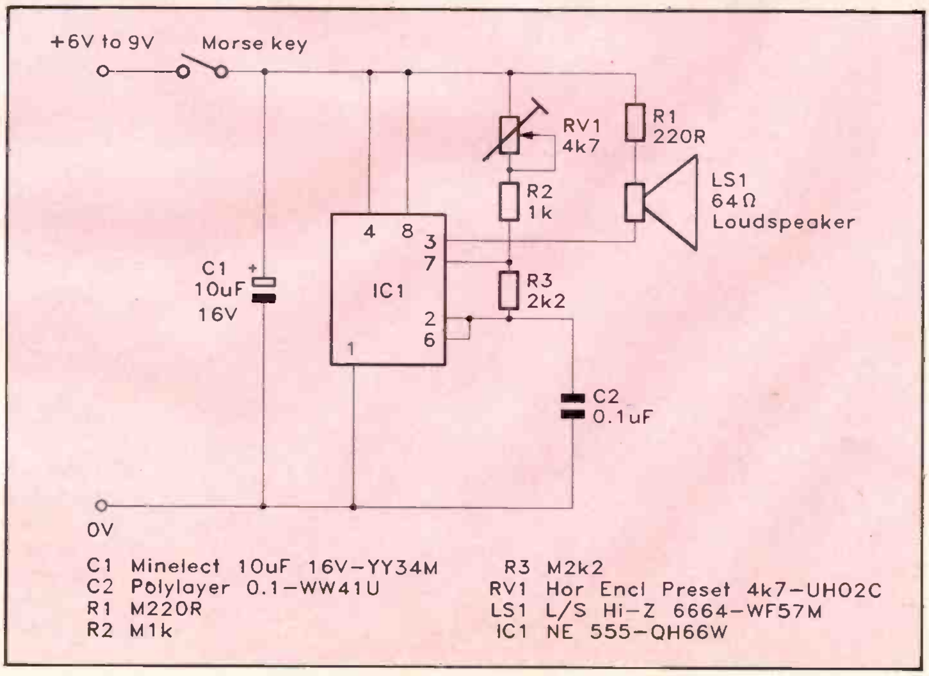
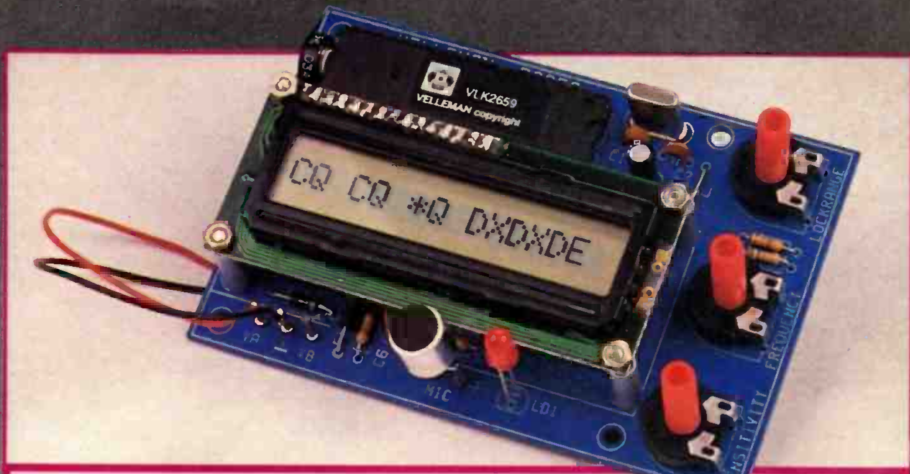


Figure 5. Simple practice oscillator.

the form shown. The R-S-T code is used to indicate the quality of the received transmission; here, the terms 'AC note' and 'DC note' are derived from the effect of the transmitter or receiver power supply on the final output. A poorly decoupled power supply with high levels of AC ripple may modulate the radio frequency signal, reducing its final quality. A properly decoupled power supply at both the transmitter and receiver ends goes a long way towards producing a pure tone at the receiver output.

The majority of Morse code on the short-wave bands is transmitted using the CW (Continuous Wave) mode, which involves the switching on and off of a radio frequency carrier. A CW transmission recovered on a standard AM radio receiver sounds like a series of clicks and is not suitable for decoding. It is therefore necessary to demodulate the signal; the easiest method to achieve this is to use a Beat Frequency Oscillator (BFO). The BFO beats with the original CW signal producing an audible tone that can be decoded easily. Many communications receivers are fitted with a BFO as standard. In a few cases, the Morse code is transmitted in the AM mode and in this case no BFO is required. The unit's frequency control allows the centre frequency of the decoder's phase-locked loop to be adjusted to that of the tone from the receiver, while the lockrange control adjusts the capture range of the decoder. RV2 allows the sensitivity of the unit to be adjusted to a suitable level, so that the decoder responds to the Morse tones from the receiver or practice oscillator while rejecting as much surrounding noise as possible.



Specification of review kit:

Power Supply Voltage:	9V to 12V DC (or 14V to 16V AC RMS [with centre tap])
Power Supply Current:	100mA DC (150mA AC RMS)
Centre Frequency:	Variable 700Hz to 1·9kHz
Dimensions:	105 × 70 × 28mm

The Velleman Morse decoder is also useful for those wishing to learn the Morse code. The unit may be used to check that the transmitted Morse is being sent correctly with adequate spacing, and also to double-check that the correct characters are being received. As a result, this project could be invaluable during the early stages of learning Morse.

When the decoder first receives a stream of Morse code, there is an adjustment period, during which incorrect characters (the letters 'T' and 'E' in particular) may be displayed. During this period, the decoder is adjusting to the speed and style of Morse code being sent. As soon as the unit has 'locked in' to the Morse stream, it then starts to display the correct characters. If the speed of the Morse changes, the decoder may take some time to compensate. In some cases it may be beneficial to reset the decoder by removing power from the unit for a few seconds.

A simple square-wave oscillator suitable for practice purposes is shown in Figure 5. The tone produced by this oscillator is far from ideal but is suitable for beginners. For those people who are serious about learning Morse code, a much more suitable oscillator kit is available, **order code LM48C Price £20.95.** This oscillator provides a stable sinusoidal tone and has its own built-in noise generator to simulate an authentic off-air sound.

VELLEMAN MORSE DECODER PARTS LIST

Resistors		
R1	150Ω	1
R2	100k	1
R3,4	470k	2
R5,6,7	4k7	3
R8	47k	1
R9	10k	1
R10	1k	1
R11	15k	1
R12	330Ω	1
RV1	4k7 Vertical Preset	1
RV2	470Ω (or 500Ω) Rotary Potentiometer	1
RV3	22k (or 25k) Rotary Potentiometer	1
RV4	100k Rotary Potentiometer	1
Capacitors		
C1,2	15pF Ceramic	2
C3	10nF Ceramic	1
C4	33nF Ceramic	1
C5,6	47nF Ceramic	2
C7	100nF Polyester Layer	1
C8,9,10	100nF Resin Dipped Ceramic	3
C11	10μF Radial Electrolytic	1
C12	470μF Axial Electrolytic	1
Semiconductors		
VR1	7805 Voltage Regulator	1
D1	1N4148 (or 1N914) Diode	1
D2,3	1N4001 Diode (or Equivalent)	2
T1	BC557 (or BC558, BC559) Transistor	1
LD1	Red LED	1
IC1	VLK2659	1
IC2	XR2211	1
Miscellaneous		
	LCD Module	1
	6MHz Crystal	1
	K2659 PCB	1
	Electret Microphone	1
	PCB Pins	10 (5 Used)
	40 Pin IC Socket	1
	14 Pin IC Socket	1
	M2·5 Screw	4
	M2·5 Nut	4
	15mm Spacer	4
	M3 Screw	1
	M3 Nut	1
	Wire Links	15
	Instruction Manual	1
	Component Identification Booklet	1

The Maplin 'Get-you-Working' Service is available for this project.
The above items are available in kit form only.
Please note that project specific items (e.g. PCB) are not available separately.
Some of the components may be substituted with different items; these alternatives are listed within the relevant brackets.
Order As VE89W (Velleman Kit K2659) Price £59.95.

Watt do you Really know about your Microwave Oven?

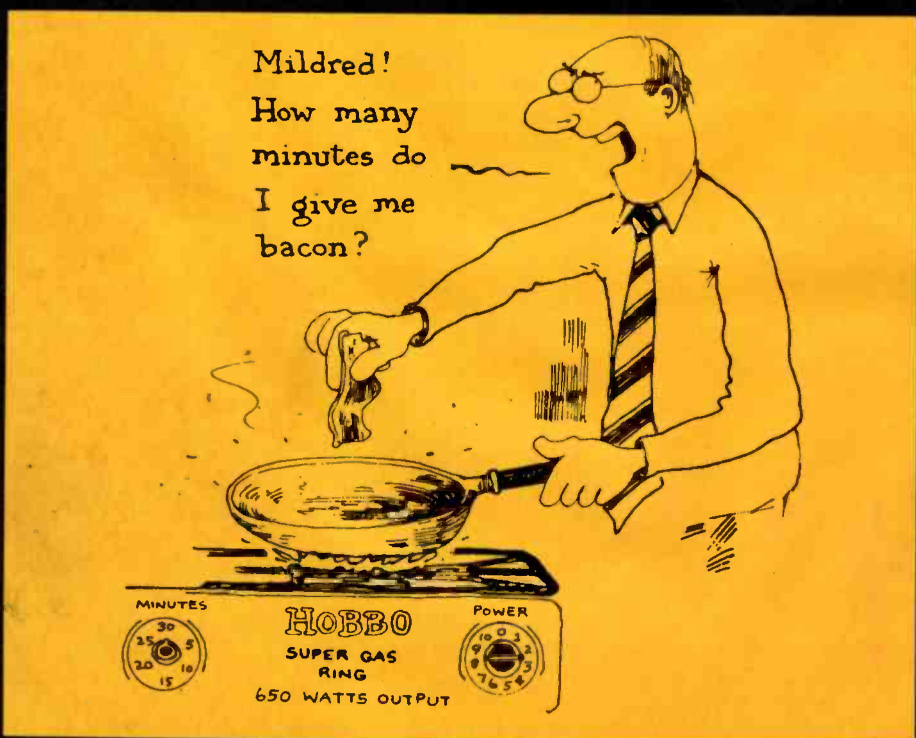
by Jim Garrod

Watts Where in your Microwave Oven

Let us first refresh our memories about the way in which microwave energy does culinary work, and then we will look at energy distribution (evenness of heating) and some tests which can show the efficiency of an oven in this respect.

Although the variable power output of a microwave oven is different from the variable temperature of a traditional oven, most cookbooks cling to traditional notions and treat both the same. As explained in a previous article, the effect of the microwave energy depends on the ratio of oven power to the amount of food in the oven, and a change in either of those factors will vary the effect in a similar way. As a result, altering food quantity has much the same effect as altering power level. Most people don't see it that way at all, but it is a fact that you must have clear in your mind if energy distribution is to make sense. Abandon the idea of all-round temperature; within the food itself, there can be numerous fields of activity, each of which could be a heat source. This fact gives a clue as to why the shape and nature of the food can influence the way it heats, and it suggests that there may never be a microwave oven which can heat everything evenly.

Every microwave oven has a heating pattern of its own; its 'fingerprint' so to speak. One way of demonstrating this is to cut a piece of cardboard to fit the floor, or the turntable tray, of an oven. By saturating it with water, and partly drying it out by running the oven, you can reveal this pattern. It is essential that you watch while this is going on, otherwise you may fully dehydrate the cardboard and leave the oven running without any work to do, which is bad for it. This test is perhaps not as meaningful as it may seem to be, because the effect with a sheet of cardboard cannot be relied upon to indicate what will happen with food. For after all, how often does food come in such a shape?



If hobs had timers, they would also need the timing charts and guides which are normally associated with microwave ovens. People would then bother more about getting the timing right than getting the cooking right!
This Rupert Besley Cartoon was originally printed in 'Microwave for Certain'.

Chocolate Drops and Flashing Lights

Over the years, salespeople have used various party tricks to give the impression that their ovens cook evenly. For example, they have arranged chocolate drops on a plate to show that they all melt simultaneously when the oven is run. What they haven't revealed is that the heating pattern would have been ruined if two or more of those chocolate drops had been in contact with each other, or if the plate had occupied more than about a third of the available space.

Others have moved neon lamps around oven cavities to show that the microwave energy would cause them to light, wherever they were placed. This demonstrated the suitability of their ovens for anyone wanting to light neons but, alas sadly, did not indicate their efficiency when it came to cooking food, in any shape or form.

To illustrate the point, it doesn't matter where you site a cup of water in a microwave oven – most of the energy will 'home in' on it, and it will eventually boil. It may boil faster in some positions than in others, and if it is in the oven with something else, its share of energy will depend on what that other object is, and where it is.

Different substances and shapes exercise varying degrees of 'pull'. Try heating an ice cube beside a wine glass of water, or a potato beside a saucer of jam. The latter is particularly interesting – note the effect, and beware of touching the jam when you lift it out! Its sugar content will have attracted most of the energy away from the potato, and it will have been drawn to the periphery of the shallow form of jam in the saucer, rather than its centre. This is a characteristic known as the 'edge effect'.

The Approved Test

Energy distribution is usually stated as a percentage figure, which does not seem to make sense. It means that the temperature rise has been sampled at several points in the cavity, and all but the largest and smallest increases disregarded. The smaller is then expressed as a percentage of the larger. This is the distribution figure for the oven, and the higher the percentage the better. It appears that few manufacturers publish their standards, but with one famous brand, 65% is the limit for a used oven. In general, anything above 80% is pretty good – but I am prepared to state that a 100% result would be a fluke!

Here's How to Carry it Out

Heat five containers of water, arranged like the dots of a domino across the normal cooking area of the oven cavity. If you have a model fitted with a turntable, the cooking area refers to the tray. Thermal cups, such as those used in vending machines, are ideal for this test. Starting temperature and heating time are not important; what does matter is that the containers and water quantities are identical. Start with cold water, stir it in each container, and carefully note the five temperatures on a layout drawing. With a turntable, remember to provide one of the containers with a reference mark to avoid later confusion. Temperatures must be accurate to within one tenth of a degree, so use a good thermometer. Heat long enough to make an appreciable difference in temperature of, say, ten degrees. Quickly check final temperatures, and note these alongside the respective initial temperatures.

Now select the largest and smallest increases. To arrive at the percentage, simply divide the smaller figure by the larger, and multiply the result by one hundred. This test can make you aware of 'hot' or 'cold' spots in your oven, but realistically you must not expect the water temperatures to rise at the same rate. A moderate degree of uneven heating is perfectly acceptable, because temperatures will tend to even out by heat conduction while energy is being applied, and afterwards during the flywheel effect rundown, or 'standing time' as the cookery people like to call it.

You could carry out this test to see just how bad the energy distribution is for a turntable model with its tray standing still, although there is little point in doing so unless the oven can actually be used in such a mode, in which case the oven will have a stirrer fan in addition to its turntable. Many owners have such models, but do not realise that extra space can be made available by immobilising the tray. This can be done, provided that the centre drive piece lifts out.

A known hot-spot can sometimes be applied to an area of food which can benefit from it. Many caterers get to know the heating characteristics of their ovens and use them to their best advantage in this way. Do remember that the instructions supplied with microwave ovens usually state that food should not remain in the same position for its full term of heating or cooking. It should be moved around, and turned over where possible – perhaps more than once. Microwave energy is inherently uneven, but with most ovens, a proper understanding and correct use will ensure that this is of no consequence.

What's Watt in your Microwave Oven

Unlike other appliances, microwave ovens are rated according to their output, and not their input (or consumption). The stated 'wattage' is the power available to do the work – I wonder how a vacuum cleaner, for instance, would be rated using the same method. There seems to be about 500W of heat and noise alone coming from the one in my workshop!

The RF output of your microwave oven is about half its power consumption, the rest being converted into heat, light, sound, and motion. You can easily measure this output, provided that you have an accurate thermometer. Basically, what you do is measure the temperature rise of a precise quantity of water over a precise period of time. Certain details have to be as specified in the standard appropriate to your oven and, as you may have read in Issue 45 of 'Electronics', there are now two standards.

First, lets deal with the one which applies to most of the microwave ovens around – the Japanese Industrial Standard (J.I.S.). This uses two separate litres of water, and a heating time of two minutes. The temperature rise in °C is then multiplied by 70 to give the power output in watts.

Here is the detailed procedure. Carefully measure the water into low mass (non-metallic) containers. Its temperature must be 20°C (±5°). Stir it, note the actual temperatures to within an accuracy of one tenth of a degree, and stand the two containers in the oven where the food normally goes. Heat for two minutes, which you must time *accurately*, and NOT by using the oven timer (set this in excess)! Within thirty seconds of removing the power, stir the water, and note the respective temperatures. Subtract these from the starting temperatures, add together the results, and divide by two to arrive at the average temperature rise. Multiply this figure by seventy to arrive at the output, in watts J.I.S.

There are two things to watch. The heating period must not include the two seconds which your magnetron takes to warm up, so if you start timing when you start the oven, make up for it by leaving the power on for two seconds at the end. Then there is mains voltage to consider.

> “Mains voltage can seriously affect the output of a microwave oven; the drop in output power (expressed as a percentage), could numerically equal six times the percentage drop in supply voltage.”

Check it with a good multimeter – but beware; some digital meters may give a reading that may be too high. This can be avoided by using a meter with a 'true RMS' weighting on its AC measurement ranges. If the output test is to be fair to your oven, you must carry it out at a time when your mains voltage is within 1·5% of normal (on load).

Mains voltage can seriously affect the output of a microwave oven; the drop in output power (expressed as a percentage) could numerically equal six times the percentage drop in supply voltage. In practical terms, this means that if your supply is down 5%, things can take 30% longer than normal to cook. It does vary from one oven to another, so there is no hard and fast rule. I have known a 240V oven to produce energy on a supply of only 198V, but I have found others which have gone down to nothing (stopped oscillating) at 215V. UK mains supplies are permitted to deviate by no more than 6% from the nominal voltage of 240V.

The wattage ratings of the more recent microwave ovens are about 15% higher than the J.I.S. values (for the same power) and are measured according to a standard of the International Electrotechnical Committee, known as IEC 705.

The test procedure is basically similar, but you must use half-litres instead of litres, heat for one minute instead of two, and start at 10°C (±1°) instead of 20°C. When the power output has been calculated (using the method used previously), multiply it by 1·15. Although alternative timings and calculations are specified by some manufacturers, the end result will be the same. The essential elements of the two standards are their respective water loads and initial temperatures.

> “If your oven output is low, due to a fault or the ageing of components, can you do something to improve it?”

If you find, for example, that your 650W oven is pushing out only 600W, there may be no cause for concern – it could have been like that when it left the factory. The output of an oven cannot be adjusted, and even specimens of the same oven may differ due to varying component tolerances. A manufacturer's standard for an oven in the field can be ±15% of the nominal power output. While full measure output is obviously desirable, it pales into significance when you realise that it is but one of six (or more!) variable factors which could upset the timings that most people use.

If your oven output is low, due to a fault or the ageing of components, can you do something to improve it? Frankly no, unless you are trained in microwave oven work. The innards of a microwave oven are a prohibited area for everyone except those who are skilled in that particular area of work. Surprisingly, the greatest danger is not from microwave energy, but from the magnetron power supply, which generates high voltages at a low impedance. They are lethal, and engineers who work with them have to be strictly disciplined and know *exactly* what they are doing. This explains why you may find it impossible to buy even a lamp for your oven, if it means that you have to remove the cabinet to fit it. There is a law against putting the public in danger by selling them such items.

If you are thinking of going into the microwave repair business, you cannot do better than use 'Microwave for Certain' (see 'Electronics' issue 45 for an introduction to this book) as a primer, just as service engineers do when they train with 'Waveguide' on the Isle of Wight.

If this book gives you an appetite for a Waveguide training course, there will be a discount of £15.00 (plus a VAT saving) if you can show that you have bought a copy of the book, available from Maplin as stock code WT50E, for only £4.45.

Contact Waveguide Training and Publications for details of the three day training course. It can cost as little as £259.00 plus VAT (including good food and accommodation). The address is 33 Carter Street, Sandown, Isle of Wight PO36 8DQ. Tel: (0983) 404342 Fax: (0983) 408058.

CAGED. BUT SHOULD IT BE HUNG?

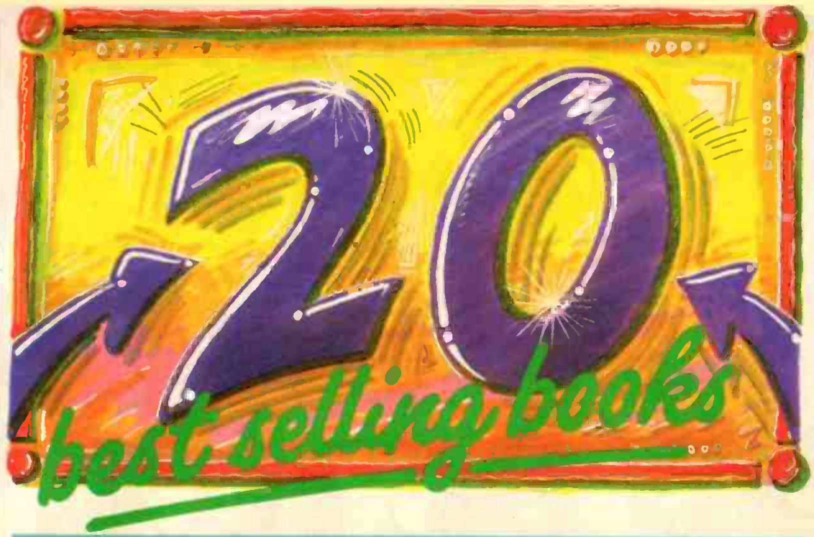
On reflection, yes! Our Mains Inspection Lamp has a hook (better than Frank Brunos) at the top, allowing you to hang it, leaving both of your hands free to get on with those important tasks like work, instead of hunting for a place to put the light. An additional feature is the simple but effective reflective strip that is found on the bright orange protective bulb cage surround.

Complete with a 4·5 metre long power cable and with an on/off switch fitted to the blue handle, this lamp is ideal for working conditions where extra light is needed such as your garage, workshop or garden shed, etc.

ZC19V Inspection Lamp £5.95 Inc. VAT (plus £1 handling charge by post), and available from Maplin shops nationwide. All you need to do, is add a 13A mains plug (available as unbreakable rubber type HL58N only £1.60), and a 60 watt max bulb and there you glow!

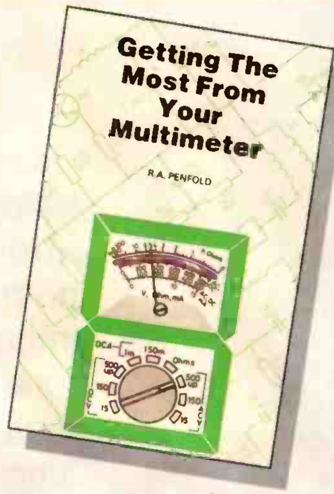
Inspection lamp... Inspect our price!

These are our top twenty best selling books based on mail order and shop sales during February '92.
Our own magazines and publications are not included in the 'chart' below.



The Maplin order code of each book is shown together with page numbers for our 1992 catalogue. We stock over 250 different titles, covering a wide range of electronics and computing topics.

Number ONE



Getting The Most From Your Multimeter
by R. A. Penfold
A unique, and very useful book, showing you how to best use your multimeter.
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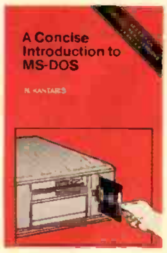
2 — NO CHANGE

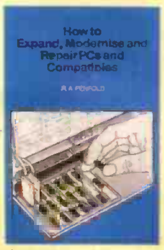


A Concise Introduction to MS-DOS, by N. Kantaris. *(WS94C) Cat. P101.* Previous Position: 2. **Price £2.95.**

3 — ▲

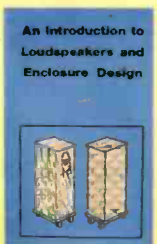
IC555 Projects, by E.A. Parr *(LY04E) Cat. P85.* Previous Position: 4. **Price £2.95.**

4 — ▼



How to Expand, Modify and Repair PC's and Compatibles, by R.A. Penfold. *(WS95D) Cat. P104.* Previous Position: 3. **Price £4.95.**

5 — ▲

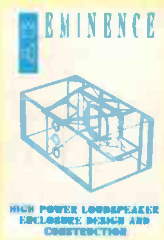


An Introduction to Loudspeakers and Enclosure Design, by V. Capel. *(WS31J) Cat. P87.* Previous Position: 6. **Price £2.95.**

6 — ▼

Power Supply Projects, by R.A. Penfold. *(XW52G) Cat. P83.* Previous Position: 5. **Price £2.50.**

7 — ▲



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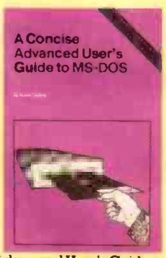

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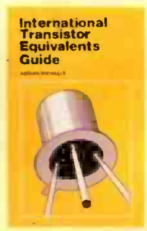

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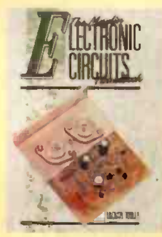

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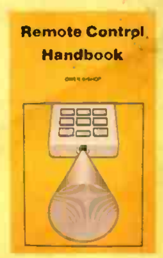

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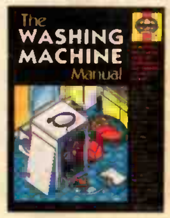

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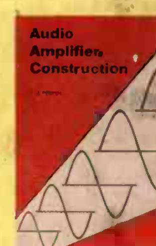

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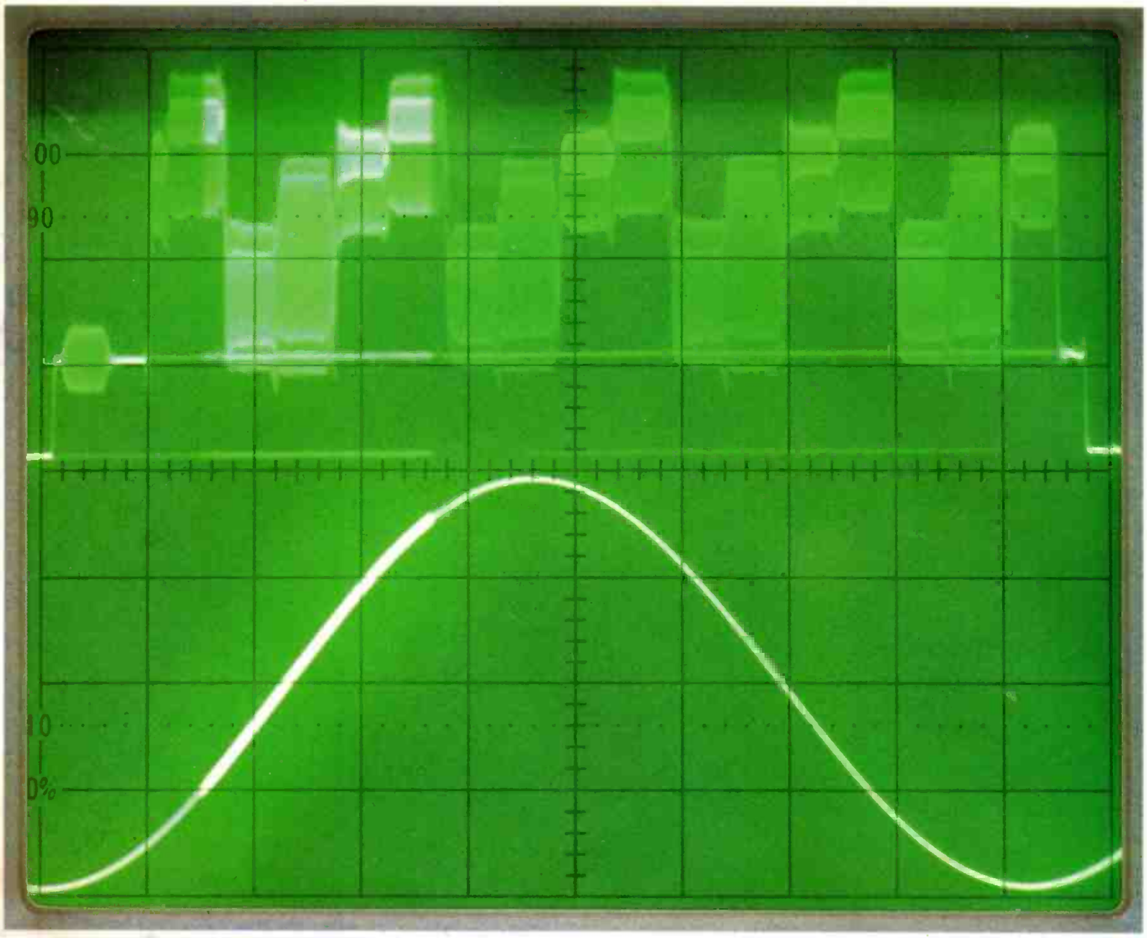

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