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No. 56

ELECTRONICS

The Maplin Magazine

AUGUST 1992 · £1.60

Britain's Best Selling Electronics Magazine

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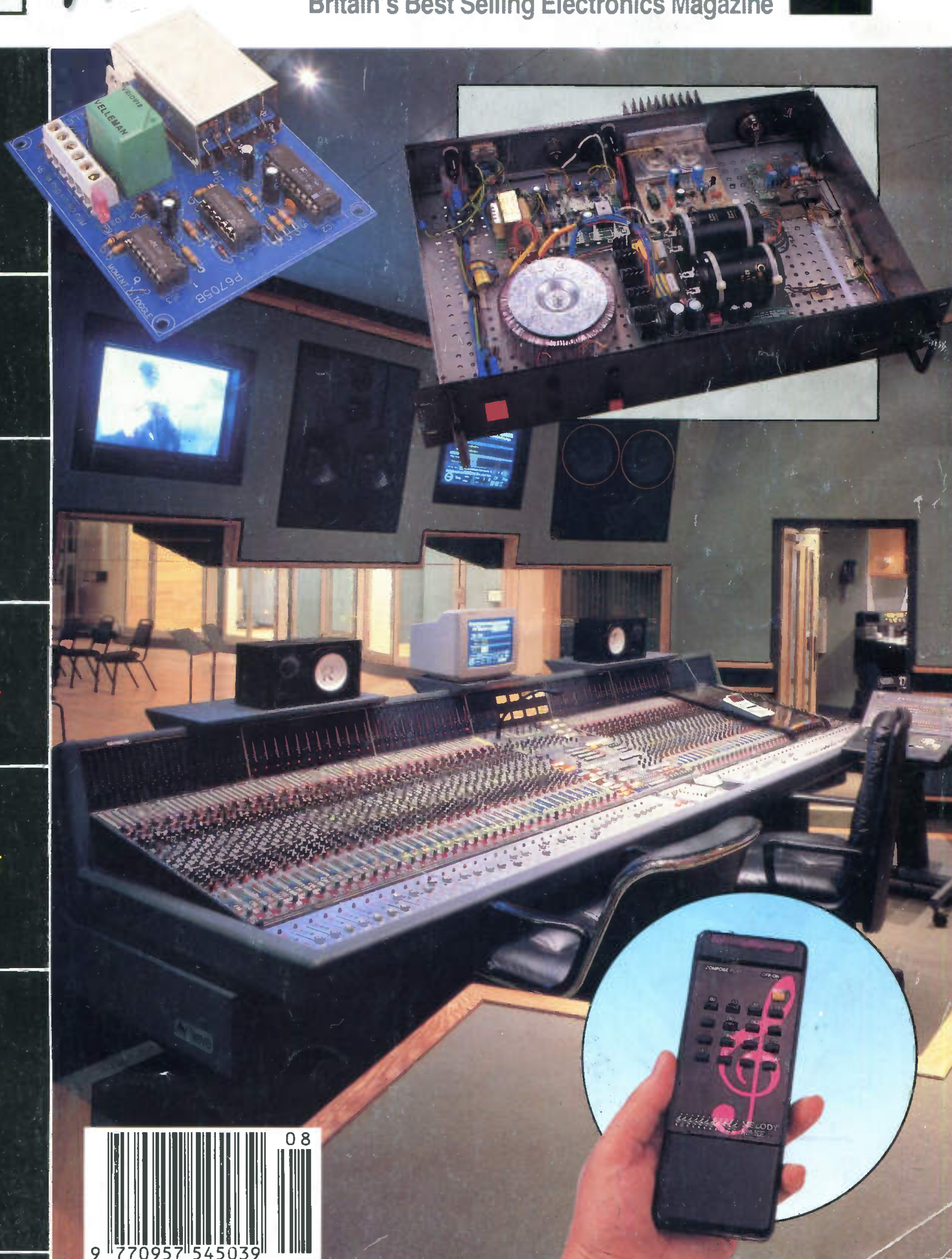

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The New Series 10.

PHILIPS

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EDITORIAL

Hello and welcome to this month's issue of Britain's best selling electronics magazine! Two months ago in the News Report pages, we reported that a desktop publishing (DTP) system had been installed in the editorial offices of 'Electronics'. The first results of this new system can be seen on pages 8 to 15 of this issue! Over the coming months, more and more pages will be produced by DTP, then eventually, the entire magazine.

A great deal of time and effort is involved in every stage of the magazine production – to ensure that you, the readers, get what you want! From initial concept ideas, project design and writing of features, to artistic presentation and publication; each and every person who is involved in its production is proud of their contribution. 'Electronics wouldn't be what it is today without your support, so please write in stating your likes and dislikes! Whether it's about the type of projects, the colour of the pages, the subjects of feature articles or the style of writing, we'd like to hear your comments – see page 71 for the address!

It is hoped that in the near future, we will let you into a few of the secrets on how projects in the magazine are designed, developed and published – watch this space!

So until next month, all that remains for me to say is I hope that you enjoy reading this issue as much as the 'team' and I have enjoyed putting it together for you!

R D Ball

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- **Editor** Robert Ball
- **Project Development** Chris Barlow, Gavin Cheeseman, Tony Bricknell, Alan Williamson.
- **Technical Authors** Mike Holmes, Martin Pipe.
- **News Compilation** Alan Simpson, Steve Waddington.
- **Technical Illustrators** Paul Evans, Lesley Foster, Ross Nisbet, Nicola Hull.
- **Production Co-ordinator** Alan Wraight.
- **Print Co-ordinator** John Craddock.
- **Advertising Co-ordinator** Kathy Peters.
- **Publications Manager** Roy Smith.
- **Development Manager** Dave Goodman.
- **Advertising Manager** Vic Sutton.
- **Drawing Office Manager** John Dudley.
- **Art Designers** Peter Blackmore, Jim Bowler.
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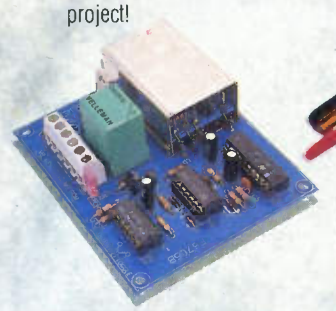
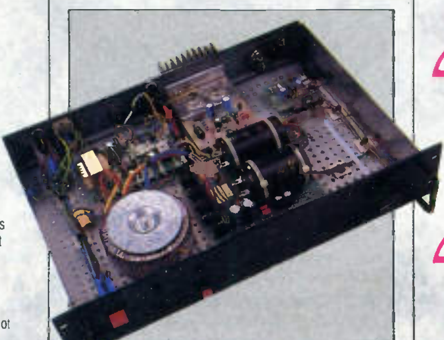
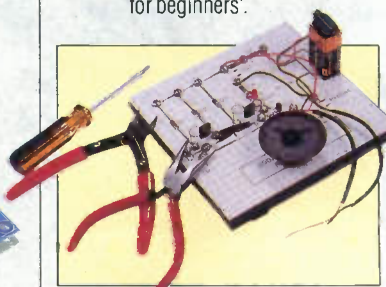
PROJECTS







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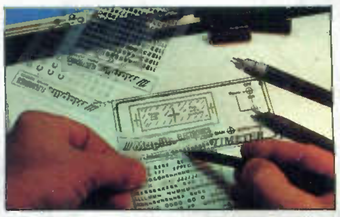


REGULARS

Prices shown in this issue include VAT at 17·5% (except items marked NV which are rated at 0%) and are valid between 3rd July 1992 and 31st August 1992.

NEWS Report

At Last! Satellite Programs Worth Watching?

Following on from last month's 'Stop Press' report on the German 'Videodat' satellite data broadcasting service, we can now reveal that the required decoders are now available in this country. Satellite equipment manufacturer Cambridge Computer Limited (based in Scotland, would you believe?) are exclusively importing the Wiegand Video Data Systems-developed decoder units, and the required software. The decoder is inserted in between the baseband output of a satellite receiver tuned to Pro 7 (a German channel broadcasting via Astra), and any computer fitted with a serial port (and, preferably, a hard disc drive). The service, which has been in use for over a year, opens up an entire new world of possibility with regard to cheap-rate data transmission (far less expensive than a modem and phone line!). In fact, over 25,000 decoders are already in use in Germany.

To ensure that no unauthorised users intercept possibly confidential information, the Wiegand system incorporates comprehensive security arrangements. Data can be distributed, therefore, to as many or as few users as required. As a result, publishers, financial service providers, news agencies and educational establishments are expressing an interest in using the system. However, Cambridge Computer's sales and marketing manager, Alan Oxley, comments: "Most UK demand for the service is likely to come from PC users looking to access Shareware and related computer information". Indeed, Eric Wiltsher, head of TESUG (The European Satellite User Group), reports that a huge amount of Commodore Amiga and PC public domain software is available. Interestingly, TESUG is the first UK organisation to make use of Videodat – as reported last month, it will be electronically publishing its excellent 'Footprint' satellite newsletter via this exciting new medium. 'Electronics' hopes to compile a feature on Videodat soon, but in the meantime the new decoder and related software are available from Cambridge for £120 excluding VAT (and satellite receiving equipment). In addition, some services may require a subscription.

Making an Impact on Your Computer

From the States – where else – comes the news that a company is marketing a new form of security log-on. Not so much a encrypted password, more a matter of a lip imprint. But whether love-bytes will ever replace a kilobyte remains to be seen. To make your physical log-on even more intimate, a menu of mouths for computer interface purposes comes with the program. Apparently leading choices are Julia Roberts and Mick Jagger.

A Monopoly on Power, but Not a Monopoly on Telecomms

An even more powerful challenge comes from the National Grid who are joining the rush to obtain a public telecommunications operator's licence from the DTI, to provide both voice and data services. National Grid which is owned by the twelve English and Scottish Regional Electricity companies, has set up a separate company, Telecom Electric to offer high-quality, secure telecommunications services to major companies. The Grid owns and operates the high voltage (400,000 and 275,000 volt) electricity transmission system across England and Wales balancing the supply and demand on a day to day basis.

Thinking Aloud

A less than comforting comment comes from the industry 'thinker' Joseph Weintraub, president of Thinking Software. He believes that programs will eventually move beyond mimicking human conversation and into the realm of thought. It is important however, he adds, that we humans keep close to the electricity supply.

Minitel Steps Closer

France Telecom owned Transpac Network Services has taken a step closer to bringing us the French videotex service Minitel. By providing links into the Minitel network via the Minitelnet gateway service, UK information providers and users can add to the six million Minitel terminals in use in France. These provide 105 million hours of services per year from some 1.7 billion calls covering 17,000 French information services.

Paperless Fax

The Body Shop have made moves towards a further reduction of the use of paper throughout their shops and offices. To make the company increasingly environmentally sound, all fax machines have been switched to the 'paperless' variety.

Employing technology from Smartlink, faxes are now both transmitted and received by the firm's multi-tasking computers, eradicating the usual paper copy. Paperless faxes have been available since the mid-eighties, but, though avoiding the waste of unnecessary paper, they are not totally environmentally flawless, since the computer must be left powered-up to enable faxes to be received twenty-four hours round-the-clock, regardless of whether they are otherwise actively employed!

Europe's Most Advanced Toll System Comes to the UK

The new Queen Elizabeth II Bridge, together with the two earlier tunnels, that together make up the Dartford River Crossing has (so far) eliminated the once familiar congestion faced by drivers on the M25 London Orbital when passing under the Thames estuary 'twixt Kent and Essex. Now Dartford River Crossing Ltd. has invested more than £2 million in an electronic system that will further minimise delays. By registering an account with the river crossing company, users are able to join the new DART-Tag scheme.

The most technically advanced electronic toll system in the country, DART-Tag consists of a windscreen-mounted, microwave-transponder tag that is interrogated by an antenna at the toll gate. The antenna, linked to a complex computer system, identifies the uniquely pre-programmed tag and, assuming the user's account is in credit, gives a green light and the lane barrier raises almost without the driver having to stop. If account credit is running low, an amber light shows. Should the user have run out of credit or the tag be used illegally, a red light prevents passage through the Toll Plaza.

The system was installed and manufactured by a French firm, CSEE Peage, and is rated as the most technologically advanced of its kind in Europe. Detailed design, supervision, testing and commissioning was undertaken by engineering consultants Mott MacDonald.

As well as increasing traffic throughput on the United Kingdom's busiest toll crossing, DART-Tag's objectives are to reduce the amount of cash collected, counted and transported, and to offer a better service to freight operators and the travelling public. DART-Tag is arousing considerable interest amongst other UK toll operators, with the Mersey Tunnel having already opted for a similar system. The system at Dartford has already become a show-piece, the basis perhaps for private tolled-motorways or any eventual road pricing scheme in the United Kingdom.

Easy-PC Extension

Building upon a British Design Award and a track record in CAD design, Number One Systems Ltd. are set to launch a second generation Printed Circuit Board (PCB) Drafting Package. Easy-PC Professional, proposed as a more sophisticated version of the popular Easy-PC, is to be released shortly.

Number One Systems Ltd. is now well established as a leading technical software house. Circuit simulators, analysers and design tools all feature in their product lists of electronic design packages.

Easy-PC Professional links with a digital and analogue simulator, allowing the user to draw a schematic, simulate it, modify it and then lay out a PCB. Maintaining all the functions of Easy-PC, Easy-PC Professional also includes a powerful design rule checker, identifying any tracks which form a short circuit or are simply too close together.

A close relationship between the schematic layout and PCB is formulated by the package. Transferring from schematic to PCB, the user is provided with a 'rat's nest' type layout. Components must then be placed and tracks routed. Such a system eliminates errors and the need for meticulous checking. Providing the original schematic is entered correctly, the final PCB design should be accurate.

The 11,000 users of Easy-PC are offered the chance to upgrade to the Professional version for £75, leaving those who have not yet had the pleasure to part with £195. For further details contact MPS Sales on (0702) 554171.

BT at Sixes and Sevens

BT, says 'Communications News', has lost count of the number of access or private lines it has operating out there. It seems that all too often, their engineers forget to complete the necessary documentation when putting in (or removing) direct lines from customers premises. And users frequently move and lose track of their phones. Also, thanks, to the not infrequent file transfer to ever bigger databases, BT fears that there may be more cases such as the well publicised overcharging of BP and the Metropolitan Police. With Oftel calling for accurate figures, BT are undertaking a nation-wide audit or, as they put it, a 'reclassification job'. The good news is that BT will overlook any undercharging and actually refund any overcharging. But they'd better take care. Faced with higher charges resulting from this audit, users may not just shrug as before, but turn to Mercury or one of the emerging cable telephony operators.

Legal History Made in Swindon

A computer dealer from Swindon has been fined £1,000 for dealing in the sale of mail-order pornographic software.

Mr Vinson Pike pleaded guilty to possessing pornographic disks when he appeared before the town's magistrates recently. The case, brought about by the police after they spotted one of Pike's advertisements in a computer magazine, was thought to be the first of its kind; computer software has never before been placed under the restrictions of the Obscene Publications Act.

During the hearing, counsel for the prosecution revealed that, when officers raided Pike's premises, they seized around 150 disks depicting acts of sexual deviancy.

New Slimline Camcorder Zooms in from Canon

Canon has introduced the UC1 Hi – a 10:1 zoom, ultra compact camcorder using the Hi-band format for enhanced image quality. Costing just under £1,000, the 690gm unit can be easily carried in a handbag or briefcase. Small enough to be held in one hand, and featuring an in-built wireless controller which doubles as a handgrip, the picture stability is ensured making it easier to track and film subjects. All in all, a far different generation to those bulky, weighty camcorders that we once were happy to lug around.

Watch Out – Computer Freaks About

It seems that BT and its fellow PTTs are under a new threat from thieves who break into computers, steal credit card and phone call card numbers, and then use them to make illegal purchases. What has been described as a network of up to 1,000 crooked computer whizz-kids has been accessing bank records running up massive bills on accounts in the US. To make matters worse, the numbers are displayed on computer magazine bulletin boards. The local police suspect that, because many of the spoils include BMX bikes, stereos and computer games, the villains could be high tech school children. They could be right!

Rock While You Sway

London Underground, as part of a 120 million update, is planning to make it possible to listen to the radio and receive paging messages while in transit. This will be achieved by installing a low loss leaky feeder cable around the entire network. Radio signals will be fed into the network and allowed to leak out from any point allowing signals to be picked up by radios or pagers. So if you happen to be delayed on your way to Heathrow from Golders Green, you can either use your pager to ask your airline to delay departure, or settle down to an extensive session of Capital Radio!

Customers First

BT has issued a series of customer-first service initiatives. To make sure we are aware of the occasion, the new BT logo was unveiled on the top of the BT Tower in London. The new benefits include: extended office opening hours; closer monitoring of appointments; and the giving out of names when answering calls. However, BT is not entirely convinced that the new scheme will be 100% successful. The new code includes a new, faster, more efficient complaints-handling system. Possibly one of the first complaints received was that from a certain North London subscriber, who just happens to be part of the 'News Report' team, who awoke one morning to find his phone cut off. Having convinced BT operators that it was *not* a case of non-payment of his phone bill, he eventually spoke to an engineering manager. The line, he was told, had been cut off on the request of a certain letting company who had quoted his home/office number. BT had dutifully complied leaving the subscriber minus a phone line. Hopefully procedures will now be changed with some positive form of authority being demanded by BT before they pull the plug. As the BT slogan says, 'The Customer Comes First.' (However in this case the power of the publication prevailed. Normal services were restored within half-an-hour).

City of the Future

Apart from helping to organise Euro Disneyland, IBM has developed a prototype of an information station for the 'electronic city of the future'. Located at the Expo '92 world fair in Spain, the station responds virtually instantaneously to requests for information about the location, description and availability of places and articles. It interacts with users in a variety of ways – through pictures, text, voice and touch – allowing them to do such things

© The Walt Disney Company 1992.

as leave messages for others, make restaurant reservations and even enter contests. Futurists speculating on the Information Age foresee stations of this sort sprinkled throughout the 'wired' cities of tomorrow – in shopping malls, supermarkets, office buildings, on the streets (like today's public telephones), and in homes – providing virtually immediate access to an entire universe of information about almost everything.

Reducing Eye Stress

By the end of 1992, governments will be required to have passed legislation complying with the European Community directive on good working practices for VDU users. In an attempt to meet these new EC guidelines, a company from Stockport has put forward an inexpensive solution to the problems of VDU glare.

Computer User Spectacles, marketed by Cabot Safety, improve screen contrast with the aid of polaride-filter-type lenses and so thus reduce eye stress. As an added benefit, the spectacles have been tested to BS2092 and can be worn in hazardous areas as a basic eye impact protector.

The fashion conscious will be relieved to know that the unisex spectacles are styled in a sleek aviator frame and can be fitted with a choice of polycarbonate lenses for use with either green or amber screens. For further details contact MPS Sales on (0702) 554171.

Sorry, Numbers Still Don't Add Up

With Mercury Comms having second thoughts, there is still a glimmer of hope that the threatened new UK telephone numbering plan, due to be introduced on 3rd April 1994, may at best be postponed. Mercury, a member of the Telecomms Numbering Advisory Board, believes that further time for discussion is necessary.

Actually public and business users alike would be more hopeful if it was the driving force, Oftel's Sir Bryan Carsberg, who was having second thoughts. As it is, London numbers will change from 071 to 0171 while Aberdeen will become 01224. The move may well increase the numbering capacity of the UK phone network some tenfold, but it will also increase users' irritation for what many commentators see as an unnecessary and costly change.

Jumbo Sized

Digital Equipment has announced Gigaswitch, a unit which acts as a high-speed crossroads for DEC's PC LANs, FDDI networks and VAX and Alpha systems. Gigaswitch platform can make over six million dynamic connections per second, with a potential aggregate throughput of 3·6G-bits/sec.

And Then There Were Two

On the international front, Mercury's parent Cable & Wireless is merging its Personal Communications mobile phone network with the US West Inc. rival Unitel. The only PCN competitor now left in the UK field is Hutchison Telecom.

Environmentally Friendlier Batteries

For many years battery manufacturers have added mercury to their products to increase power. Kodak have now launched the world's first, full power battery which does not have mercury added during manufacture.

Despite the fact that the current Kodak 'Xtralife' and 'Photolife' battery ranges are already well below European guidelines, Kodak has confirmed its commitment to the marketplace and its environmental programme by making a considerable investment in research and development. An investment which has its roots firmly planted in Kodak's desire to penetrate the £156 million battery market.

The new batteries are now available through retail outlets and include all the popular sizes.

Last Orders Please!

Olivetti are in the running to install 50,000 PCs in some 9,000 McDonalds stores. Maybe McDonalds should take note of a new speech recognition development from Toshiba. Using a synthesised voice, orders could be taken down, computerised and duly served – untouched by human hand or voice!

PICTURE CAPTION CHALLENGE

This month's picture caption goes topical. No prizes for correct guesses, not even the BMW (sorry), but what is going on here?

- ★ BT's latest recruit to help dig cabling tunnels.
- ★ Publicity stunt to encourage visitors to London Zoo.
- ★ Globe trotting yuppie rabbits eagerly awaiting the opening of the channel tunnel.

None of these. Rabbit is the logo of the newly announced Telepoint Telephone System from Hutchison. From the end of last month, Hutchison has been rolling out its Rabbit Telepoint network across the North of England. Come October, the company expect to have a nation-wide service operating throughout major towns and cities in the rest of the country. The basic package, Rabbit, priced at £189.99, includes a handset, park and charge connection to the Rabbit network, and subscription for the first quarter. Or you can, of course, just carry on using the now ample numbers of public call boxes around the country. Hutchison is also launching a national UHF and satellite based paging network in the UK.

Events Listings

July '92 to January '93. Pop Video Experience, MOMI. (071) 928 3232.

19 July. Colchester Radio Amateurs Annual Mobile Rally, Sport and Leisure Centre, Brinkley Lane, Colchester. (0376) 502502.

20/24 July. ElectroTech '92, NEC, Birmingham. (0483) 222888.

13 September. Farnborough Air Show, Society of British Aerospace Companies. (071) 839 3231.

22/24 September. Image Processing Exhibition, Birmingham. (081) 868 4466.

22/24 September. Comex, Wembley, Middlesex. (081) 778 3343.

23 September. Interactive Multi-Media Loughborough University, IEE. (071) 240 1871.

29 September/1 October. Euro Teleconference '92, Wembley, Middlesex. (0234) 212988.

6/8 October. Voice '92 (Computer telephony and voice automation), Olympia, London. (081) 877 9007.

20 October/1 November. British International Motor Show, NEC, Birmingham. (0483) 222888.

Till 31 October. 'Friendly Invasion', RAF Museum, Hendon. (081) 205 9191.

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

INFRA-RED CODE-LOCK

Text by Gavin Aire

In any security system, the quality of the locking device determines the level of difficulty presented to an intruder attempting to gain access. Ordinary mechanical key or combination locks are vulnerable as direct physical access to them is often possible. This makes picking the lock or trying different combination codes a distinct possibility. However, with an electronic remotely controlled code-lock, an additional level of security is provided since no direct access to the locking device is necessary. In such a system the transmitter key generates an electronic code, which is then picked up and decoded by the receiver lock.

A very sophisticated integrated circuit (IC), capable of handling a total of 60,000 possible codes, has been used in the design of the system. The method of transferring the code from key to lock could use any of the following systems; AC induction, ultrasonics, radio frequencies, or infra-red. In this particular kit, infra-red was chosen as it offers good immunity from many of the unwanted external influences.

The Transmitter

As can be seen from the circuit diagram reproduced in Figure 1, the transmitter appears to be deceptively simple in its design. This is because the majority of electronic functions are handled within IC1, a MM57410N code generator/ decoder. It is equipped with twenty terminal pins for connections to the rest of the circuit, although not all of these are used in this particular application. The positive power supply is fed to pin 2, with the negative connection on pin 10. Pin 18 is used to place the IC into its code generating (high), or decoding (low) modes. Ten pins (1,3,4,5,6,11,12,13, 19,20) are reserved for setting the code value. Each of these can be placed in one of three different conditions, greatly increasing the total number of possible code combinations. The code is fed out on pin 8 of the IC as a serial data stream. To ensure that the entire code is sent each time power is applied, a reset pulse is

The key-ring sized transmitter unit.

Features

- ★ 60,000 possible code combinations
- ★ Transmitter housed in key-ring box
- ★ SMD components already mounted
- ★ Tx/Rx LED display
- ★ 10 amp toggle or momentary-action relay

Applications

- ★ Remote arm/disarm of alarm systems
- ★ Electric door catch release
- ★ Garage door opener
- ★ Remote power switch

Technical Specifications

TRANSMITTER
60,000 possible code combinations
Transmit range 10 metres
Housed in key-ring box
SMD components pre-mounted
LED indication of transmission
Power supply: 4 LR44 button cells

RECEIVER
60,000 possible code combinations
Receive range 10 metres
Output mode: toggle or momentary
Relay output: 10A at 12V DC
LED display for receive and output status
Power supply: 2 × 9V AC or 10 to 16V DC
Supply current: 100mA

generated by R2 and C2 on pin 17. The rate at which the code is transmitted is determined by the timing components, R1 and C1, on pin 16.

To drive the red LED, LD1, and the infra-red transmitter, LD2, transistor T1 is used as a saturated switch. It is turned on when pin 8 of IC1 is high, thus modulating the red and infra-red LEDs with the serial code data.

Transmitter Construction

Included in the transmitter kit is an instruction booklet which lists the complete step-by-step construction details. The Surface Mount Devices (SMD) are already bonded to the transmitter PCB, leaving only seven additional standard components to be fitted to the board. However, care must be taken not to damage any of the SMDs when soldering or cutting off the excess component leads. The step-by-step building instructions are easy to follow, and construction should proceed smoothly. The only items that require mechanical preparation are two small metal strips, which form the battery holder.

Transmitter Testing

Before testing can commence you must first carefully install four LR44 type button cells, which are not included in the kit (Maplin Order Code FM28F). It is of great importance that you are very careful in observing the correct polarity of each cell in the battery and that the total polarity matches the PCB markings. It might be necessary to bend the battery strips a little, in order to obtain a sufficient pressure on the cells.

For the initial tests, the default code is sufficient until you require to change it to your personalised code – see 'Defining the code'. The default, or standard, code condition exists while all the code connections of IC1 are in the 'open' position (not soldered to an adjoining pad). At this stage, it is not possible to perform any conclusive infra-red transmission tests; to do this would require a known working receiver module. However, since the red LED, LD1, is modulated by the generated code it should light up every time that SW1, the push switch, is pressed. Once in the key-holder box, the circuit board and the cells are held securely in place by the battery cover.

The Receiver

As can be seen from Figure 2, the infra-red receiver circuit has a more complex structure, incorporating several integrated circuits. The infra-red signals from the transmitter are detected and converted back into electronic signals by the infra-red detector diode D1. However, these signals are at a very low level and require boosting if the code-lock system is to work successfully over a reasonable distance. This is achieved by IC1 which contains four operational amplifiers, shown in Figure 2 as A1 to A4.

The final amplified signal is taken from the output of A3 and is connected

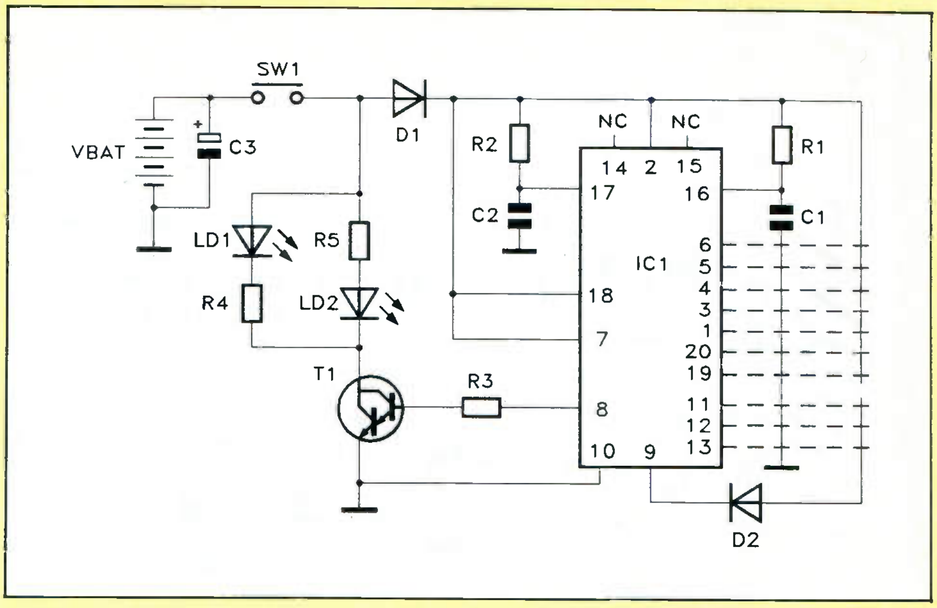
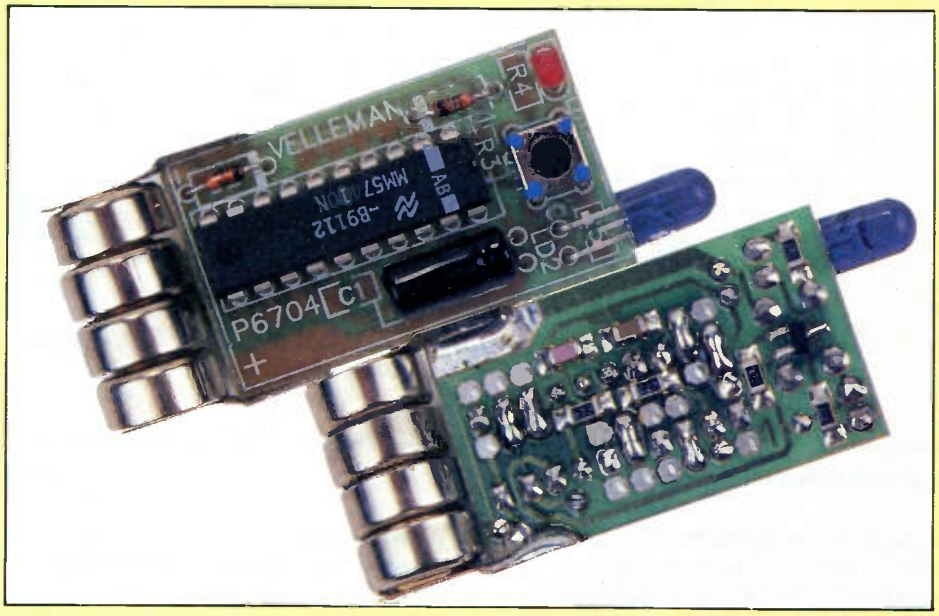
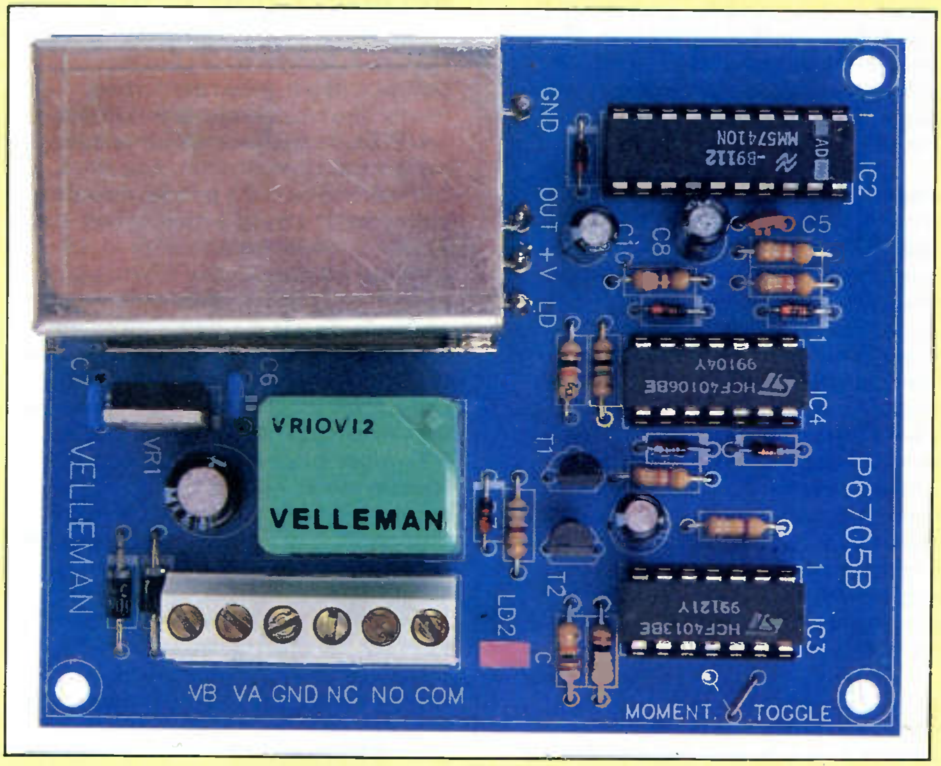


Figure 1. Transmitter circuit diagram.



Component and solder side views of the assembled transmitter PCB.



The assembled receiver PCB.

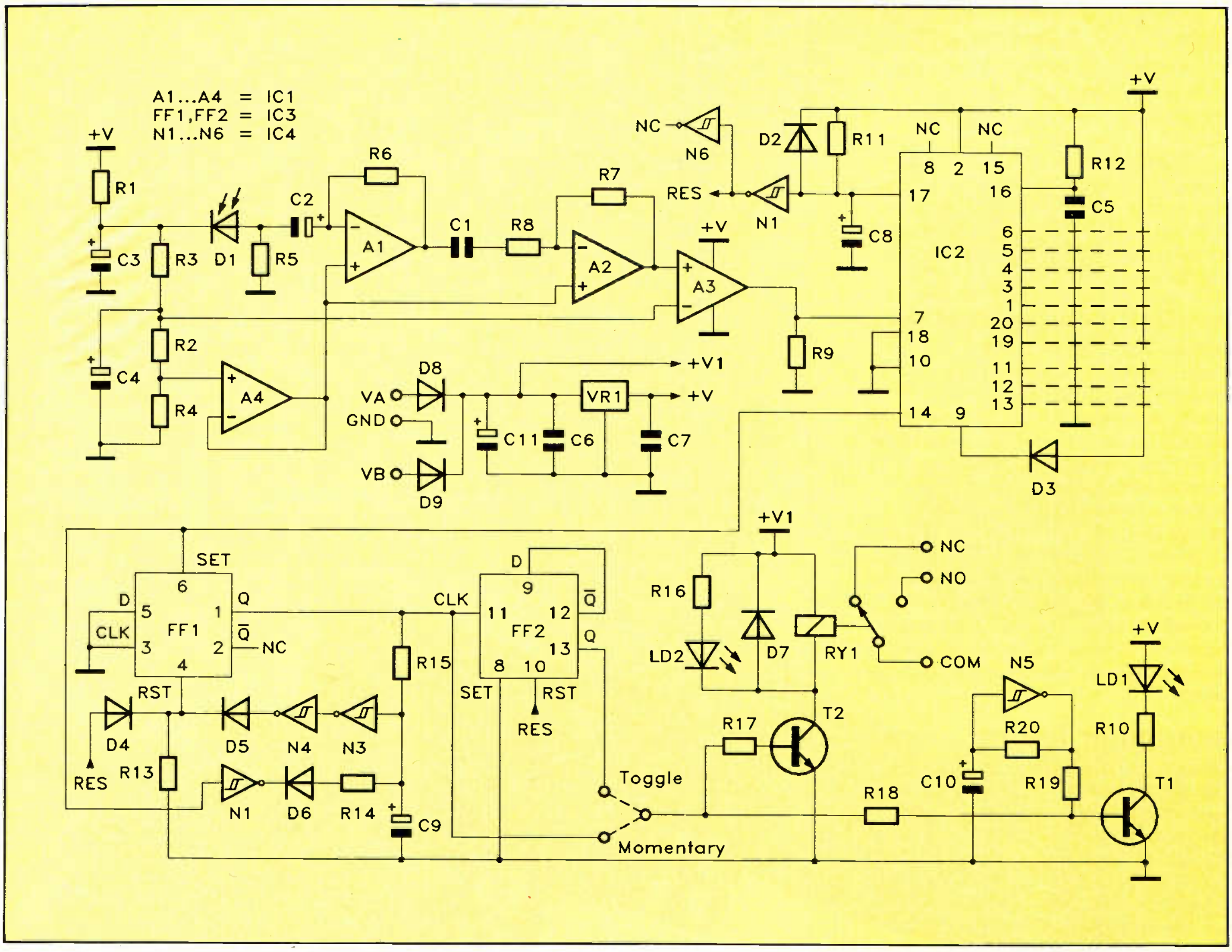


Figure 2. Receiver circuit diagram.

to the 'code input' (pin 7) of IC2, another MM57410N. In its receive mode, this IC compares the data signal applied here to the code value set on its programming pins (1,3,4,5,6,11,12,13,19,20). When a positive code match has been found, the logic state of pin 14 is flipped over. The rest of the receiver circuit is concerned with processing this change of logic state so that it can switch the relay and indicators.

Both momentary and toggle switch actions are available from the outputs of the dual D-type flip flop FF1 and FF2 (both contained within IC3). A 'high' logic state, from the mode selected, is used to forward-bias transistors T1 and T2. T1, the receive mode indicator switch, is normally turned on and off at a regular rate controlled by N5, a Schmitt inverter contained within IC4. This causes LD1, a red LED, to flash, indicating that the receiver is on and ready to receive an infra-red code transmission. In the momentary switch mode this indicator will be permanently lit while a valid code is being received. However, when the toggle mode is selected and a valid code received, it will stay permanently lit until the code is re-transmitted.

The relay, RY1, and T2, the transistor switch that controls indicator LD2, are normally turned off. In the 'momentary' mode, RY1 will be activated and LD2 will light while a valid code is being received. When the 'toggle' mode is selected and a valid code is received, both will stay permanently active until the code is re-transmitted.

Receiver Construction

Included in the receiver kit is an instruction booklet which lists the complete step-by-step construction details. The receiver circuit is split into two PCBs; a small preamplifier board and a larger main decoder PCB. Once built and checked over, the preamp module is placed inside a metal screening box. This is done to reduce the possibility of stray electrical noise swamping the infra-red receiver and causing unwanted switching problems. Two PCB configurations are described and, depending on the physical constraints of your intended installation, one of them should prove more applicable than the other. The first method can be used where space is no problem, and involves mounting the metal boxed preamp module directly onto the main decoder PCB, as shown in the photograph of the receiver. The second method should be used where not enough room is available to accept both PCBs. In this case, the small preamp module is separated from the main board. No specific case is supplied, as its design will vary with your requirements. The clear plastic cases supplied with the transmitter and receiver will do at a pinch, though. If you opt for this approach you could paint them in the colour of your choice, leaving a clear unpainted area for the view of the infra-red receiving device.

Receiver Testing

To test the functions of the receiver you will require a suitable power supply, a multimeter and an infra-red code-lock transmitter. Before commencing the tests you must set the operating mode link to either the momentary or the toggle position. For the initial testing the default code is sufficient. This default, or standard, code condition exists while all the code connections of IC2 are in the 'open' position (i.e. not soldered to an adjoining pad). This code pattern must be matched to that transmitter if the lock is to function.

Either low voltage AC or DC can be used to power the unit, and the connections are made using screw terminals on the PCB. If you want to run the unit off the 240V AC mains supply, you must use a step-down transformer with a 9—0—9V centre-tapped secondary winding capable of providing 100mA. The Maplin sub-miniature type (Order Code WB01B) is well suited for this task. The secondary of this transformer should be connected to the PCB terminals as follows; connect the two end wires to VA and VB, and the centre wire to GND. If a DC power supply is to be used, it should be capable of providing 100mA at +10 to +16V. This voltage should be applied to VA or VB, the negative connection being made to the GND terminal.

The current consumption is approximately 20mA with LD1 flashing in the receive mode, increasing to 77mA when activated by the infra-red code transmitter. These figures were obtained when running the unit off a +12V regulated power supply. Check that both LD1 and LD2 are lit and that the relay RY1 clicks. Finally, test the range of the code-lock system, which under ideal conditions should be approximately ten metres.

Defining the Code

Up until now, the default code has been used during the testing of the code-lock system. However, this code value is only one out of the possible 60,000 that can be set by the user. In other words, even if someone else has a similar infra-red transmitter key, that person still only has a one in 60,000 chance of having the same code.

On both the transmitter and receiver PCBs, the code ICs have ten programming pins (1,3,4,5,6,11,12,13,19,20). Each pin can be placed in one of three possible conditions:

1. Not connected to any other solder pad.
2. Soldered to the pad positioned on the outside of the IC pin.
3. Soldered to the pad positioned on the inside of the IC pin.

The exact positioning of these pads are clearly shown in the supplied instruction booklets. You can make the code pattern as symmetrical or as random as you like, but do check that the patterns match on both receiver and transmitter PCBs.

Installation

Before installing the code-lock system, you should first determine whether its power requirements can be supplied from an existing source, or if a separate AC/DC power supply is necessary. Another important consideration is the switching action of the relay and its electrical characteristics. For safety reasons, it is strongly recommended that the 240V AC mains is NOT applied directly to the relay terminals on the receiver board. In most vehicle and building applications, the infra-red receiver will probably be located behind glass. The type of glass used can possess quite different degrees of transparency at infra-red wavelengths, and this will ultimately determine the distance over which the system will work. The range can also be adversely affected by strong sunlight, or other infra-red sources.

Applications

Although not infinite, the possible number of applications is just too great to cover in a single article. As a result, only four of the more popular uses have been highlighted.

Probably the most popular use of the infra-red code-lock is as a remote arm/disarm switch in vehicle and home security systems.

Another very popular application is as an electric door catch controller, and Maplin can supply a solenoid-activated mortice lock release mechanism (Order Code YU89W).

The system could possibly be used in conjunction with a garage door opener, enabling you to gain access as you approach the doors.

General remote power switching of AC and DC currents not exceeding 10A, and at voltages less than 50V, is relatively simple and safe to use for lighting or motor control.

TRANSMITTER PARTS LIST

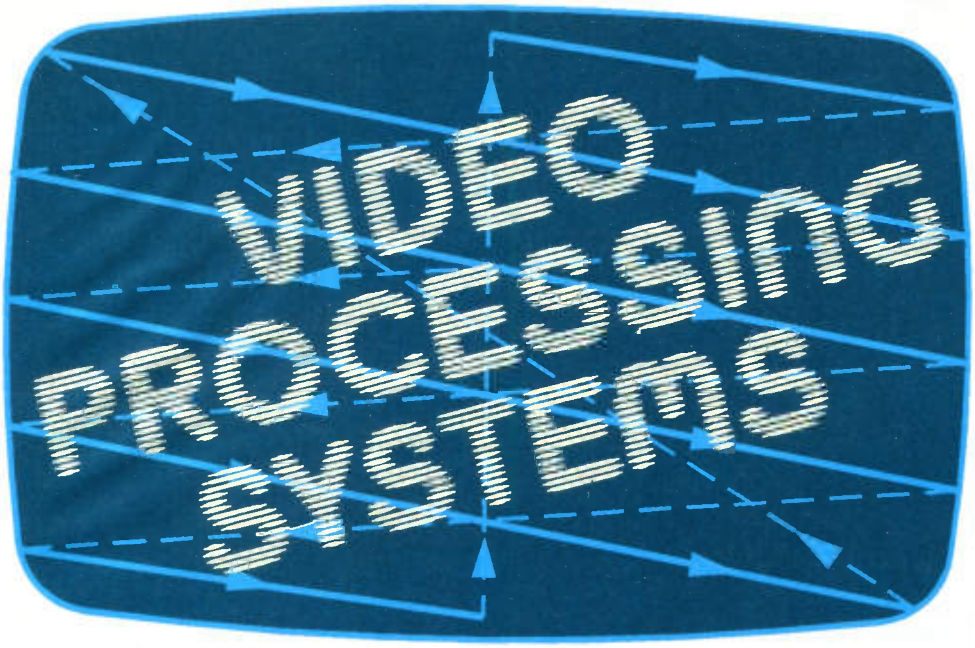
RESISTORS		
R1,2,3,4,5	All surface-mounted devices (SMDs)	5
CAPACITORS		
C1,2	SMDs	2
C3	47μF 16V Electrolytic	1
SEMICONDUCTORS		
IC1	MM54710	1
TR1	Darlington SMD	1
D1,2	1N4148	2
LD1	Subminiature red LED	1
LD2	CQW15 Infra-red LED	1
MISCELLANEOUS		
	PCB	1
	Case, with battery cover	1
	Sub-miniature tactile push-to-make switch	1
	Material for constructing battery terminals	1 Sheet
	Construction/user guide	1
OPTIONAL (Not in Kit)		
	LR44 Button Cell	4 (FM28F)

RECEIVER PARTS LIST

RESISTORS		
R1,2	47Ω	2
R3,4,17, 18,19	10k	5
R5	100k	1
R6,7,20	1M	3
R8	33K	1
R9,14	470Ω	2
R10	270Ω	1
R11,12,13	47k	3
R15	470k	1
R16	680Ω	1
CAPACITORS		
C1	4n7 Ceramic	1
C2,8,9,10	1μF 25V Electrolytic	4
C3,4	22μF 25V Electrolytic	2
C5	33pF Ceramic	1
C6,C7	100nF Monolithic Ceramic	2
C11	470μF 16V Electrolytic	1
SEMICONDUCTORS		
LD1,2	Rectangular Red LED	2
D1	BPW41 IR Receiver Diode	1
D2,3,4, 5,6,7	1N4148	6
D8,9	1N4000 series rectifier diodes	2
TR1,2	BC547 (or equivalent)	2
IC1	LM324 quad op amp (or equivalent)	1
IC2	MM57410	1
IC3	4013	1
IC4	40106	1
VR1	7806 voltage regulator	1
MISCELLANEOUS		
	14 pin DIL socket	3
	20 pin DIL socket	1
	PCB pins	8
	6-way screw connector	1
RY1	Single pole changeover relay	1
	Preamp PCB	1
	Main PCB	1
	Screening components for preamp PCB	2
	Construction/user guide	1
OPTIONAL (Not in Kit)		
	Case (presentation box supplied in kit could be used – see text)	
	Power supply components	

The Maplin 'Get-You-Working' Service is available for this project, see Constructors' Guide or current Maplin Catalogue for details.
The above items (excluding Optional) are available in kit form only.
Order As VE09K (Infra-red Code-Lock Rx) Price £24.95.
Order As VE10L (Infra-red Code-Lock Tx) Price £16.95.
Please Note: Some parts, which are specific to this project (e.g. MM57410 ICs, the PCBs) are not available separately.

The two kits are sold separately as you may require more transmitter keys than receiver locks.



Part Five by J.A.Rowan

Video Tape Editing

Video production systems come in all shapes and sizes. The simplest have two VTRs, a monitor and very little else. One of the VTRs must be an edit recorder and the other either an edit recorder or player. A few VTRs have a built-in edit controller, but normally a separate controller is used, usually made by the VTR manufacturer. The controller can operate both machines, and can shuttle and pause them. At any time, 'in' and 'out' points may be marked on the source tape or the recording tape, three out of the four points defining the position and length of the edit. A rehearse mode is available, and if selected after the 'in' points have been defined, then both machines will rewind some distance before those points, and begin to run. The picture monitor and sound amplifier are attached to the edit record machine, and while the VTRs are approaching the 'in' points then the sound and video from the record tape are output. At the 'in' point the outputs are taken from the source tape, the effect being to preview the edit. If the result is satisfactory, the controller can issue the command to go ahead, and exactly the same sequence is followed again. This time the edit recorder switches over to record at the 'in' point and the edit is made. If an 'out' point was set, then recording will end there, otherwise the operator must stop the VTRs at a suitable time.

Despite the simplicity of this system, many types of video programme may be put together on it. Obviously there are severe limitations; the only possible transition between shots is the cut, and of course this also applies to the sound track. To move on to effects such as wipes and mixes, we require much more equipment. In addition to a vision mixer, a sound mixer and a third VTR, two timebase correctors and a more complex edit controller are necessary. Some planning at the shooting stage is also necessary, to ensure that two segments which must be mixed together are recorded on separate tapes. With non-broadcast VTRs, an additional recording generation if dubbing off is required will usually be unacceptable.

The three-machine edit suite is normally much more complex than the two machine type. Timebase correction and the use of a vision mixer means that genlock is involved, and the video cabling can start to get out of hand. Most colour picture monitors have at least two video inputs, and to minimise costs these are normally cabled up to display different sources. The play VTRs must normally receive sync feeds from their TBCs, and a small computer and/or caption camera is usually included for titles and logos. Often, additional lower-cost VTRs float around to make low-band U-Matic or VHS copies, or occasionally to make use of source material on these formats.

Very few such systems actually have an up-to-date wiring diagram, which is not a problem until a piece of equipment breaks down or a new item is added. Such a diagram makes life a lot easier, not only for the system manager but also for visiting engineers. Paying an engineer while he draws up such a diagram before he can begin diagnosis of a system fault is an expensive way of obtaining one.

It is difficult to generalise about the three machine-system. Many types of VTR have a built-in TBC available either as standard or as an option. This is usually the cheapest method of timebase correction but is also the least versatile. Individual or dual stand-alone TBCs usually have field and frame freezes and sometimes other digital effects. They can also usually be used with any VTR type and can, for example, allow a VHS recorder to be used as a source to the mixer. To go a stage further, dual TBCs are available with digital mix, wipe and other effects, doing the job of a simple vision mixer. This approach again limits versatility, but may be a good solution where money is very tight.

Computerised VTR Control

The other main area of complication in the three-machine system is that of VTR control. Now, not only 'in' and 'out' points must be selected for an edit, but the source machine or machines must be specified. If a mixer transition is required between the two source VTRs then the edit controller must of course keep the first machine running until the transition is complete. In addition, sometimes the sound must be cross-faded from one VTR to the other, and sometimes it will continue from one machine throughout. In addition, the facility to rehearse just

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one edit is somewhat limiting, particularly where more than one source machine is involved. All these factors led to the use of fairly sophisticated edit controllers, based on computers, where more than one source VTR was needed. These were fairly expensive machines about ten years ago, as they were dedicated pieces of hardware.

Then it was realised that the new PC had all the necessary computing power to handle the task, although it could not actually talk to VTRs. Today, many edit controllers are simply DOS-based PCs with custom software and with interface cards to drive popular VTRs. This is a little easier with VTRs that use a serial communication system. When most edit VTRs had huge multi-pin connectors to talk to their edit controllers, Sony began to use a serial protocol between their BVU series U-Matics. One machine could actually take control of another so that a two machine edit suite did not require a separate controller. Then Betacam machines appeared with the serial port, and other manufacturers started to get in on the act. After a while, it was possible to buy a little box to attach to the multi-pin connector of an old-style VTR to convert it to the serial protocol. Mind you, a little care was needed, as there were a number of 'dialects' of the protocol, and not all VTRs responded to the same commands in quite the same way.

'Off-line editing' is the process of copying the original tapes made on an 'expensive' format onto VHS or low-band U-Matic. The time-consuming process of actually deciding all the edit points and transitions can then make use of relatively cheap VTRs without tying up a very expensive edit suite, possibly for days. All the edit decisions can be stored on a computer disc which can then be taken into the expensive suite along with the original master tapes. The disc is loaded into the same edit controller, which is now driving the expensive VTRs. The edit list is run, and all that needs to be done is to operate the vision mixer and other effects units as required, and to change source tapes when prompted by the controller. This technique relies on both edit controllers knowing precisely where a given shot is on a tape, and makes use of SMPTE time code. High-band U-Matics and all better machines have a dedicated time-code track on the tape on which an audio-frequency data signal is recorded. This identifies individual frames, and on direct colour machines even indicates the eight-field sequence. It can be read over a wide range of tape speed, although at very slow speeds there may be some difficulty. In many machines it is supplemented by a similar code inserted into a blank video line in the vertical interval. This can be read at slow speeds and even while the tape is stationary, although there is a problem at high speed. By selecting which is read according to tape speed, such a VTR always knows where it is.

In addition to driving VTRs, edit controllers may be found doing other jobs. If they could control vision mixers they could automate the editing process still further. There are vision mixers which can be fully remotely controlled but they are usually very large and expensive. Some of the smaller ones may allow a single effect to be remotely triggered, and most TBC/mixers and digital effects units will also do this. The edit controller usually has one or more 'GPIs', or General Purpose Interfaces. These are usually just pairs of switch contacts which can be programmed to close at a certain time during the edit sequence, and are used to trigger effects which produce transitions between the two source VTRs.

Sound Editing

Now, a word or two about audio. Like most traditional video engineers and manufacturers I have almost totally ignored sound. The main reason for this is that for almost all purposes other than the very simplest, audio is normally treated in a different way from video. Many shots do not have meaningful accompanying sound, and often voice-overs or background music are added to the finished programme. We accept a cut as a natural transition between two successive pictures, because it simulates the way our eyes automatically close as we move our heads quickly to look in a different direction. Try it. But we are not accustomed to sound behaving in the same way, and a sudden change in sound level or composition seems dreadfully wrong. Even a mix between successive sounds from different scenes is unnatural, as we are only accustomed to hearing this kind of thing happen between records at a disco. A great deal of effort in video production goes into making the accompanying sound track appear natural and unobtrusive. Except for the canned laughter, of course.

So, as in most kinds of video production, the sound is handled separately as it always was with film, often being recorded on an audio tape recorder rather than on the VTR. When all is said and done, a VTR is a video tape recorder, and a good-quality audio system takes up an unacceptable amount of space in a machine which must usually be made as small as possible. Where sound quality is of any importance, then a separate audio recorder is vital. To ensure synchronisation, time code is normally also recorded, and this allows editing of the sound to be independent of the accompanying video. Indeed, a broadcast or major industrial TV production may well have its sound and vision edited by different companies. In a three machine edit suite, then, there will normally be a separate sound system, usually containing at least one multi-track recorder. Depending on the nature of the programme material normally handled by the suite, there may be one or more stereo machines and a mixer of varying complexity. The video edit controller may well also drive the multi-track, and can be used to dub across from the video source tapes under time code control.

"As in most kinds of video production, the sound is handled separately, as it always was with film. . .where sound quality is of any importance, then a separate audio recorder is vital."

Yet More Gadgets

There are many other pieces of equipment which may be found in a video system. Routing switchers, equalising distribution amplifiers, rostrum cameras, timecode generators, source encoders . . . the list is nearly endless, and it would take a fair-sized book to mention and describe them all. Some devices are likely to appear only in very large studio complexes, others might turn up in the smallest edit suite if there is a special need for them. I have tried to keep to the essentials, the VTRs, vision mixers and so on which must exist in just about any video system. One category of equipment which is already widespread, and becoming more so, is that of digital video. This includes timebase correctors and other devices which digitise video, process it and then turn it back into an analogue signal, and also things like paint systems and character generators, which originate the video in digital form.

Standards Conversion

Possibly the first application that really needed digits was that of NTSC/PAL standards conversion. Yes, it is possible to point a 50Hz camera at a 60Hz monitor, and this was how the first standards conversions were done. But a lot of work had to go into reducing the resulting 10Hz flicker, and at best the performance was very poor. There had to be a better way.

There were basically two problems to solve: NTSC has about 485 active lines per frame compared to 575 for PAL, and there are 30 NTSC frames for every 25 in PAL. Early converters simply left the NTSC lines hanging in the PAL frame, with black borders at the top and bottom, and just threw away every sixth field. This looked pretty bad but was better than the camera/monitor technique. To fill up the PAL active video area it was necessary to generate extra lines: about one new line for every five original lines.

Similarly, to convert in the other direction, it was necessary to lose about one line in six. These requirements could be met by repeating or dropping lines, but then sloping lines would become jagged and vertically moving details would appear to change size. A better way is to construct *new* lines from two or more of the old ones, a process called 'interpolation'. The simplest technique is to use just two original lines, and to take from each a certain proportion such that the total adds up to unity. The proportions used depend on the position of the new line compared to the two original lines. Where the new line is in the same place as an old one, the latter is used unchanged. Figure 1 shows this technique as applied in early 525/625 converters, where an exact 5:6 line ratio was used. A slightly better prediction of the correct video for the new line can be obtained by using smaller proportions of additional original lines that are further away from the new line's position. Unfortunately the prediction becomes worse if the picture content changes dramatically within the group of old lines used, and a better solution is still to use the further lines only if they are reasonably similar to the close ones.

For each original line used, a minimum of one complete video line of digital storage must be provided, along with a hardware multiplier. However, because PAL and NTSC line periods are quite similar and a complete field must be gained or lost occasionally, much more storage is needed in order that new lines are available when required. A complete field must be stored, and even then it will be

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necessary, some of the time, to turn one input field into the other field for output. The next level of sophistication would require that more than one field was stored in order that new fields could be obtained from the originals by interpolation in a similar way to the lines. This would in general result in smoother motion, but at the cost of the increased storage

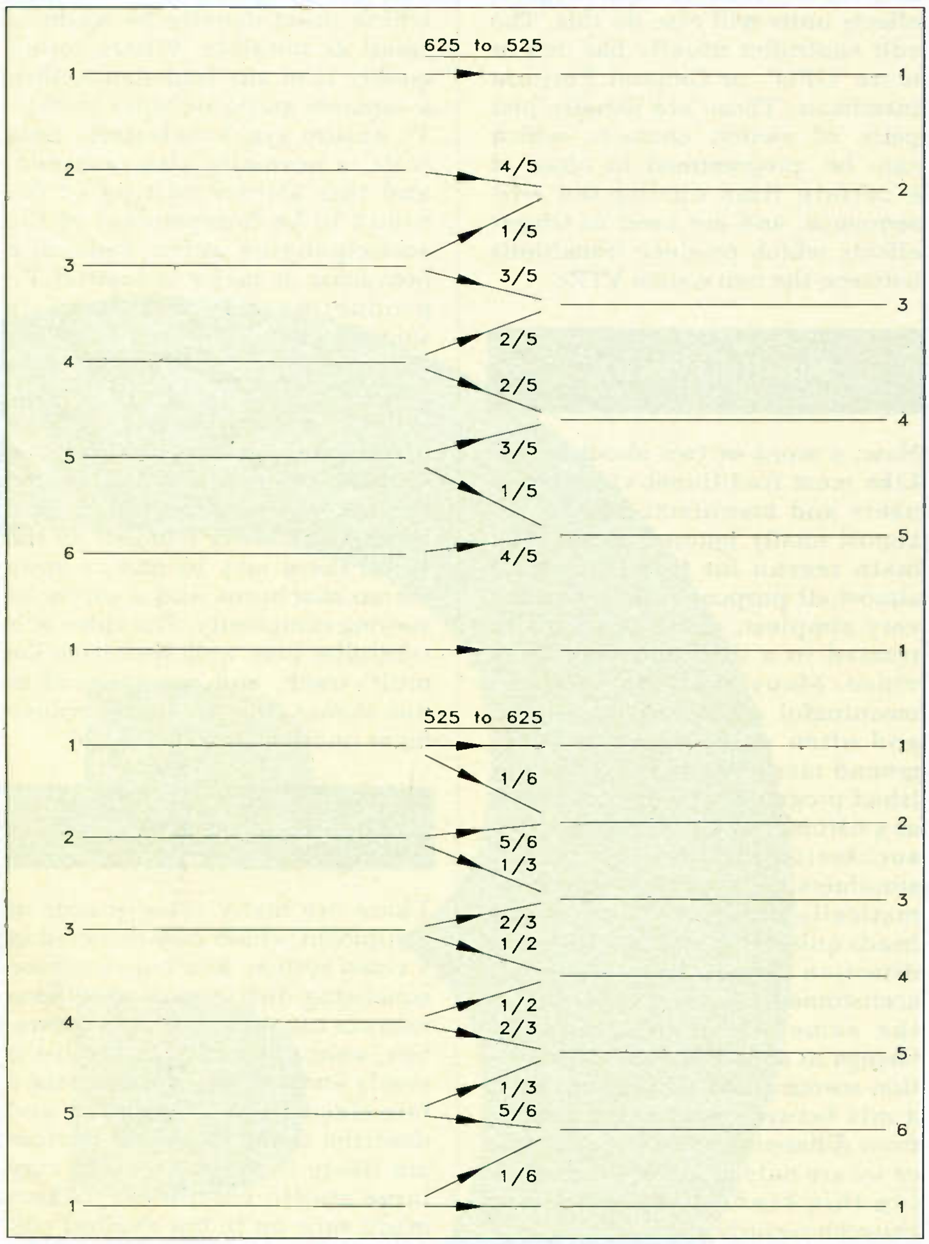

Figure 1. Line interpolation in standards conversion. Fractions show proportions of original input lines in each interpolated output line.

and a further set of multipliers. Similarly, still better prediction would be possible with more input fields from which to create the new fields. Finally, the system should adapt its processing depending on how similar one field is to the next, in other words depending on the amount of motion occurring in the picture.

The current state-of-the-art in standards conversion uses such motion-adaptive processing, and interpolation from up to four original fields. The results are quite good, unwanted artifacts of detail and movement being fairly small, but the machines are extremely expensive. The IBA and the BBC have been very prominent in this field – since most conversion involves American material destined for the European market, the Americans have never really needed high quality standards conversion! A few years ago, when production of 'Dallas' went over from film to video, the BBC were initially supplied with PAL tapes. The picture quality was so poor that even the viewers noticed, and the BBC received many complaints. This led to the BBC requesting NTSC copies of the tapes, since they were able to do a much better conversion job than the 'Dallas' producers. There are quite a few 'low-cost' standards converters around now, and many of the small companies advertising NTSC/PAL conversion of VHS tapes use one of them. Do not expect the same performance from these machines as from a broadcast-quality converter, and if you do want to hire a camcorder while on holiday in America, try hard to find a company offering a PAL unit.

Timebase Synchronisers and Correctors

The synchroniser also fulfilled a long-felt need when it finally became practical. Most national broadcasters have a central television studio complex and a number of regional studios. The BBC is no exception, and often accepts regional contributions to live programmes from TV Centre. The BBC has always been reluctant to disturb its Network output, and has never been very willing to put on air a source that was not synchronous with its main sync pulse chain. Before the days of synchronisers, the answer was 'Natlock', a weird and wonderful system of locking regional centres to TV Centre. The regions operated from sync generators whose master clock could be varied in response to audio tones. These were transmitted by telephone line from sync comparators at TV Centre and would maintain timing at the regional station such that its video was received synchronous with TV Centre video. Given telephone line conditions in the UK, it was a precarious system, and it was not unknown for lock to be lost during a transmission.

Today it is a routine matter to connect a line from a remote studio to a digital synchroniser, and to have the regional video re-timed to local video quietly and reliably. Synchronisers are now cheap enough to be used in large outside broadcasts: cameras at far corners of race tracks and golf courses can be taken synchronously without the need for a genlock feed, and this becomes very important if the camera video comes via a short microwave or infra-red link. We are quite accustomed to seeing live pictures from a Grand Prix racing car: how do you genlock the camera? Synchronisers are a little different from other digital machines in that very low values of picture degradation are required. While other digital video equipment is expected to be fairly transparent in operation, a synchroniser is required to cause little more distortion than a piece of cable. Because of this, synchronisers are often operated at higher clock rates and use more data bits per sample than most other digital video equipment. Synchronisers may also lose their inputs at any time and are usually designed to deal with this event in a reasonable way. Most synchronisers have the option of either switching to black or freezing on the last good frame or field of video, rather than displaying a frame of digital garbage as a timebase corrector may well do in similar circumstances.

A timebase corrector appears to do much the same kind of job as a synchroniser. Why are there two different machines? In fact, there are more than two. To begin with, a single TBC will not work with all VTRs. A direct colour VTR must have a TBC that digitises composite PAL video, and such a TBC cannot handle heterodyne colour video where sync and subcarrier do not have the correct frequency relationship. The heterodyne TBC not only has a lower bandwidth than the direct colour unit, but it cannot handle the unstable chroma from a direct colour VTR. A TBC for a component VTR, of course, must have three separate channels. The synchroniser is nearest in architecture to the composite coded TBC, but since it operates on stable video it does not need the very complex input clock generator of the latter, nor does it have to deal with moving-head playback as discussed in the last article. It would be possible to conceive of a single unit that would do all possible jobs, but it

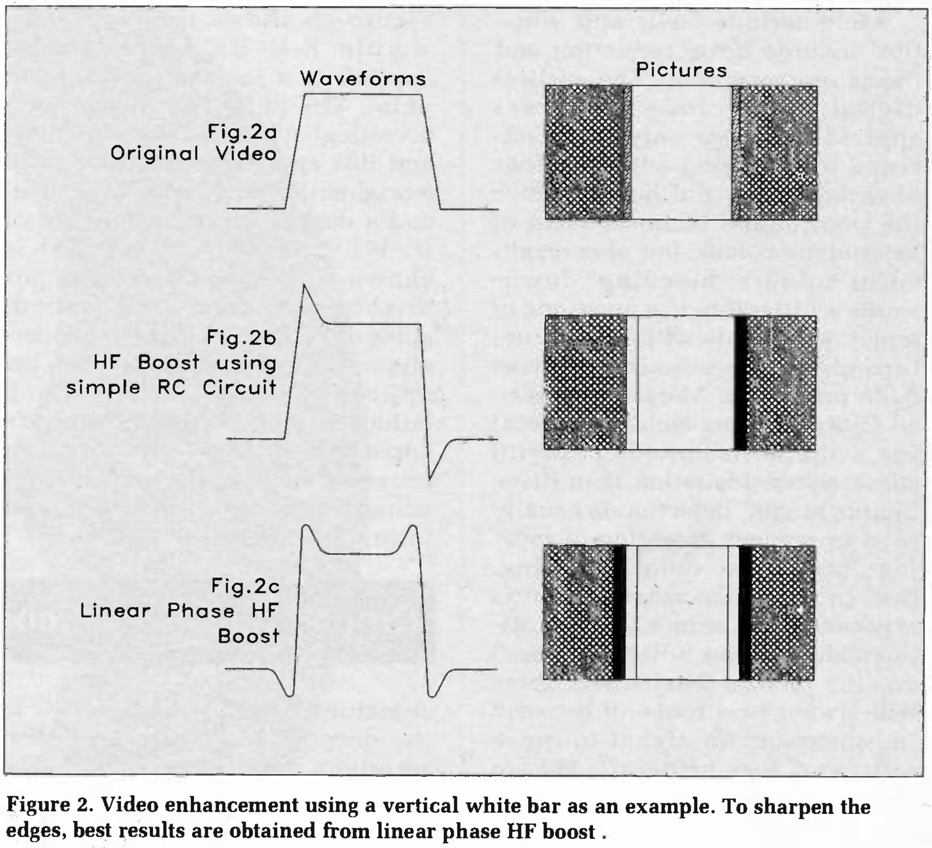

Figure 2. Video enhancement using a vertical white bar as an example. To sharpen the edges, best results are obtained from linear phase HF boost .

would basically be a collection of individual digital machines bolted together and would be extremely expensive. It makes much more sense to build machines exactly suited to particular tasks.

Having said that, many digital machines have a variety of standard or optional extras. Freezing video is easy to do: just stop writing to memory. Most TBCs have this facility, and can display either of the fields or the complete frame. The frame will have better resolution but if there was any movement in the picture at the time it was frozen then the two fields will be different and considerable flicker will occur. Displaying one field twice, as mentioned in the first article, will cause some jitter, and many TBCs have the facility to interpolate adjacent lines of one field to create a new second field. The picture then looks quite steady. Some TBCs can turn off some sample bits, reducing the number of possible voltage levels that can be represented. This is called posterisation, and gives the picture a 'cartoon' appearance. Retaining the value of one pixel for several times its usual period, and over several lines vertically, is called 'mosaic' and represents a deliberate large reduction in resolution. It is often used in a small patch to obscure part of a picture, for example the face of an informer in an investigative programme. False colours can be obtained by changing the chroma values of the picture, often to a new value depending on the luminance level.

More serious 'bells and whistles' include noise reduction and image enhancement. The earliest digital noise reduction was applied to colour only, and consisted of averaging adjacent lines of chroma. This did help improve the poor signal to noise ratio of heterodyne colour, but also resulted in colours 'bleeding' downwards a little. If two generations of replay were made with this feature turned on, the colour shift was quite noticeable. More sophisticated CNRs (Chroma Noise Reducers) use a similar technique but with successive fields rather than lines. Simple motion detection is usually used to prevent averaging of moving chroma, to avoid smearing. Bear in mind that noise reduction is not magic: it cannot actually distinguish between noise and small moving picture details, and there will always be a trade-off between improvement in signal-to-noise ratio and loss of detail. Where noise reduction is switchable and has more than one setting, all possibilities should be tried on the actual programme material to decide which looks subjectively best. Do not expect video specifications to be met with noise reduction enabled.

Similar comments apply to 'image enhancement'. This catch-all term is usually used in video circles to mean an apparent improvement in resolution, either horizontal, vertical or both. Obviously, fine detail cannot simply be generated where it did not previously exist, but detail edges which do already exist can be made sharper. Some steps are taken to avoid emphasising noise, but these cannot be completely effective. Image enhancement has always been necessary in cameras, and until very recently was always carried out using analogue techniques. With sound, any method of boosting high frequencies will produce the effect of an increase in treble. With video, the importance of phase response means that only a few techniques are acceptable. Figure 2b shows the result of a simple R-C HF boost circuit applied to a rectangular line-rate pulse. The pulse would represent a vertical white bar in a picture, and this approach would result in a brighter left-hand edge to the bar, and a dark line just to the right of it. What is actually needed is shown in Figure 2c, both edges brighter and dark lines on both sides of the bar. Applied in moderation, this technique makes the bar appear sharper. Too much enhancement makes the picture appear as 'all edges' and increases noise unnecessarily, and ideally enhancement needs to be adjusted to suit the programme material.

> *"Occasionally, small dropouts occur in large flurries and for a few seconds the picture appears to writhe about rather oddly, as the DOC almost correctly replaces the missing video."*

Dropout Compensation

A standard feature of any TBC is the dropout compensator. Video recorders have dropouts just like audio machines, and some machines have built-in correctors. On the principle that one video line is quite like the next, a sudden loss of playback signal will cause the video output to switch over to the video from the previous line. This is usually carried out in a VTR by using a 64µs glass delay line to hold the RF signal from the last line. The same technique was used in early TBCs with only a few lines of memory, but today the replacement video is likely to come from the whole previous field. The main advantage is apparent when a really bad dropout occurs, many lines long. A line-based dropout compensator (DOC) will repeat the same line over and over again, hardly a good concealment technique, while the field-based DOC stands a good chance of filling the gap with video quite similar to what should be there. Built-in TBCs often use line-based DOCs as many do not store a complete field. It is sometimes possible to see, on broadcast TV, a momentary chunk of a field become a single repeated line, as the new high-recording-density component VTRs suffer very badly when they hit large dropouts. Occasionally, small dropouts occur in large flurries, and for a few seconds the picture appears to writhe about rather oddly, as the DOC almost correctly replaces the missing video. The DOC of a separate TBC must be fed with the off-tape RF signal from the VTR, as dropout detection relies on monitoring the RF level continuously. This, of course, adds yet another cable to the system.

Shrinking Pictures

TBCs have for some time been blurring their distinction from digital video effects (DVE) machines. Low-bandwidth DVEs intended for use with heterodyne colour VTRs can easily be fitted with TBC front ends, and TBCs with a frame of memory can manipulate the stored video in various ways, usually with the aid of an optional control panel and internal processing board. The simplest effects are those that consist of moving the video around or inverting it vertically or horizontally or both. The counters supplying the memory read address simply start from different values than did the write counters, or some or all of the count occurs downward instead of upward. Actually changing the size of the picture is more difficult, and involves similar interpolation techniques to those required for standards conversion. TVs are now available which can key a small version of the picture from one channel into the main picture which comes from another. Their compression circuits normally operate by simply dropping pixels and lines, which is acceptable for this domestic application but is not good enough for professional purposes.

"TVs are now available which can key a small version of the picture from one channel to the main picture which comes from another. They normally operate by simply dropping pixels and lines, which is acceptable for this domestic application but is not good enough for professional purposes."

Consider, for example, a white fence against a black background. Suppose it appears as part of a digitised picture at such a size that black and white pixels alternate. If the picture is now compressed to half-size by dropping alternate pixels, then the fence will become either solid black or white. If the camera were to move slightly then the fence would appear to change from one to the other. If the fence was not vertical but tilted slightly to one side, it would appear as broad horizontal bands of black and white. If it was vertical but the spacing did not quite fall on alternate pixels, then it would appear as broad vertical bands. All these unnatural effects are due to 'aliasing', or attempting to represent a high frequency using a sample rate that is too low. The answer is to restrict the maximum input frequency used, in this case to filter the digital video so as to remove spatial frequencies which are too high to be properly represented by the reduced number of pixels. In a sampled system, filtering and interpolation are equivalent, and filtering our fence would reduce it to a solid block of mid-grey. This is the correct result, since if we were to see such a fence in real life at a distance too great to resolve its individual bars, it would appear as a grey block to our eyes.

Compressing or expanding a picture, then, involves building new pixels from the originals, varying the number of source pixels used according to the compression ratio. For 'quarter size' compression, actually producing a picture half the height and width of the original, the processing is easy. Good results can be achieved by simply averaging adjacent pixels and adjacent lines to reduce the number of active pixels to a quarter of the original number. Many TBCs therefore offer quarter size compression, but not any other sizes. A DVE offering a full zoom range must be much more complex, containing a number of delays and multipliers to implement the wide variety of digital filtering characteristics required. Both vertical and horizontal filters are required, the latter using a number of one-line delays.

Rotation adds further complexity. To build any given output pixel, the position of the corresponding point in the original picture must be calculated. This will rarely fall exactly on a pixel in the original picture, and so the value of the output pixel must be calculated from the surrounding input pixels, according to the exact position of the calculated point of origin among them. If compression occurs as well, then the appropriate filtering must be taken into account. If all that sounds complicated, it is, and you might now appreciate why it takes your turbo-charged 80486 so long to rotate and scale bit-mapped graphics. 'Three-dimensional' DVEs are more complex still. The 3D designation means that as an object moves away, it gets smaller. So any rotation 'into' the screen means that different compression ratios, and therefore different filtering, must be applied to each group of pixels from the original picture. The largest and most expensive DVEs can 'wrap' a picture around an object like a wineglass or a doughnut. Obviously the pixel address calculations are a little more involved here than with a simple rectangle. Finally, remember that output pixels need to be generated at a rate of 13·5MHz in most current DVEs. Puts that 'blindingly fast' spreadsheet recalculation into a bit of perspective, doesn't it?

Character and Paint Generation

There is very little to say about the digital origination machines, the character generators and the paint systems. They basically consist of a frame of memory with video output, genlock and, usually, PAL coding capability. Most home computers can do these jobs to

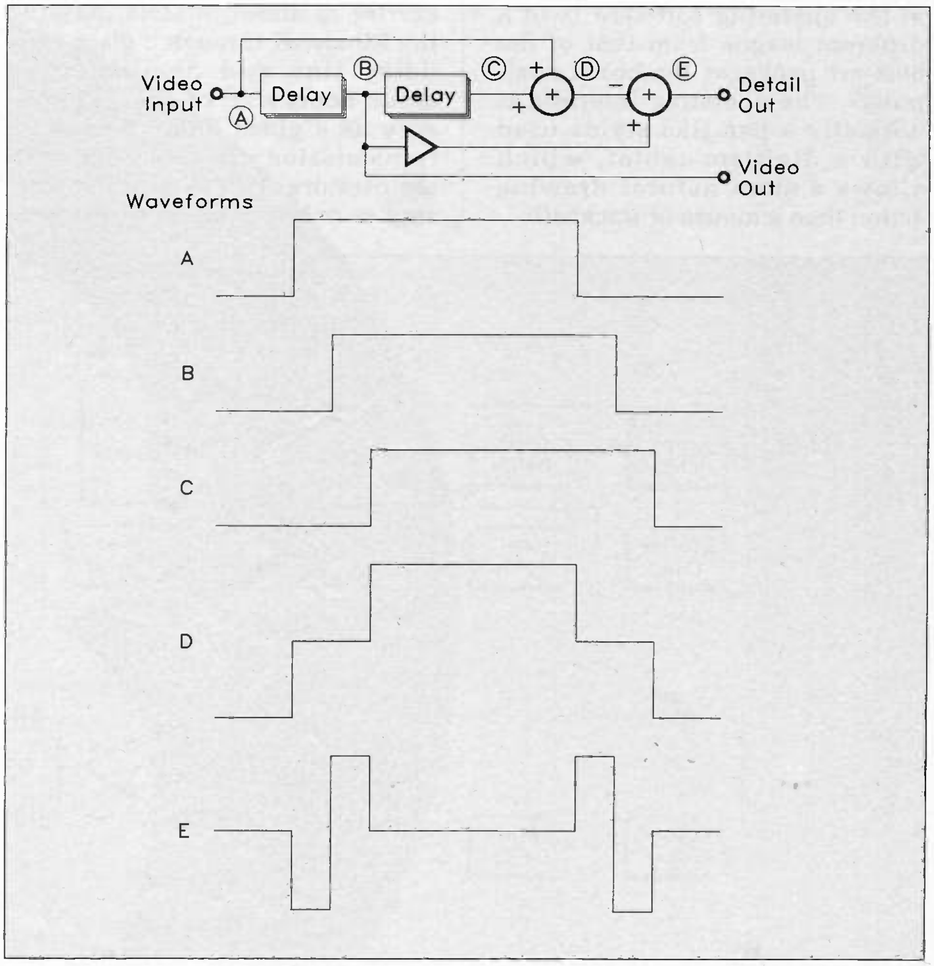

Figure 3. The principle of image enhancement to achieve the requirement of Figure 2c.

some degree, and would be quite adequate for amateur work, such as supplying titles for wedding videotapes. In general, DOS-based PCs cannot be used as they do not operate on any broadcast TV line standard, although there are specialist (read expensive) video adapters made for them that will allow this. Computers designed to operate with standard TVs or video monitors, such as the Archimedes, can do the job with their built-in video circuits, although genlock and PAL coding must be added. Video titling software packages are available for these machines which simulate most features of the professional machines. For good-quality pictures, at least 16-bit YUV or 24-bit RGB digital video is necessary, along with resolution of 575 pixels vertically by at least 700 pixels horizontally. Broadcast standard character generators usually have between 1500 and 2000 pixels per line. Extensive anti-aliasing techniques (basically digital filtering) are normally used to prevent 'stepped' edges and to make curves look as smooth as those from camera captions.

Paint systems almost always include character generation. Their usually very high price reflects software rather than hardware costs, and the sophistication of the operating software is in a different league from that of the best art packages for home computers. The operating interface is normally a pen-like stylus used with a digitiser tablet, which allows a more natural drawing action than a mouse or trackball.

The next and final article in this series will take a closer look at the digital timebase corrector, covering various analogue and digital circuit techniques, with a brief look at sampling principles and problems.

Picture Enhancement

The technique normally used for high-frequency emphasis with linear phase response is shown in Figure 3. Two delays are used, and the normal and delayed signals are added as shown to generate the enhancement, or 'detail' signal. This may be added as desired to the original signal, though it should be noted that this detail signal is delayed by one delay period relative to the original input. Usually, therefore, the output of the first delay is treated as the un-enhanced signal and the actual generation of the original signal (in the camera or wherever) needs to be advanced to compensate. A similar technique is used for both vertical and horizontal enhancement, the vertical delay unit being one complete line. In analogue circuitry this is quite difficult to implement, and is normally achieved by using the original signal to amplitude modulate a carrier of about 30MHz, passing the RF signal through a glass 64µs delay line and demodulating again. Some kind of AGC is necessary as a glass delay varies its transmission considerably with temperature. This system is necessary as only a glass block can provide this much delay, and the signal it carries must have a high frequency.

The detail signal is usually further processed before being added back into the original video. Three techniques are commonly used to

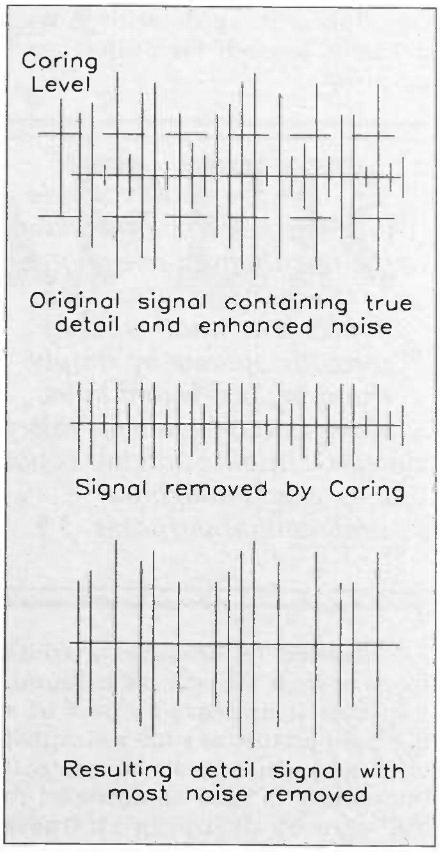

Figure 4. Noise reduction of an enhanced signal by 'coring'.

minimise enhancement of noise: coring, level dependency and comb filtering. Coring means the removal of low-level signals from around the zero-volt level of an AC signal, as shown in Figure 4. If this

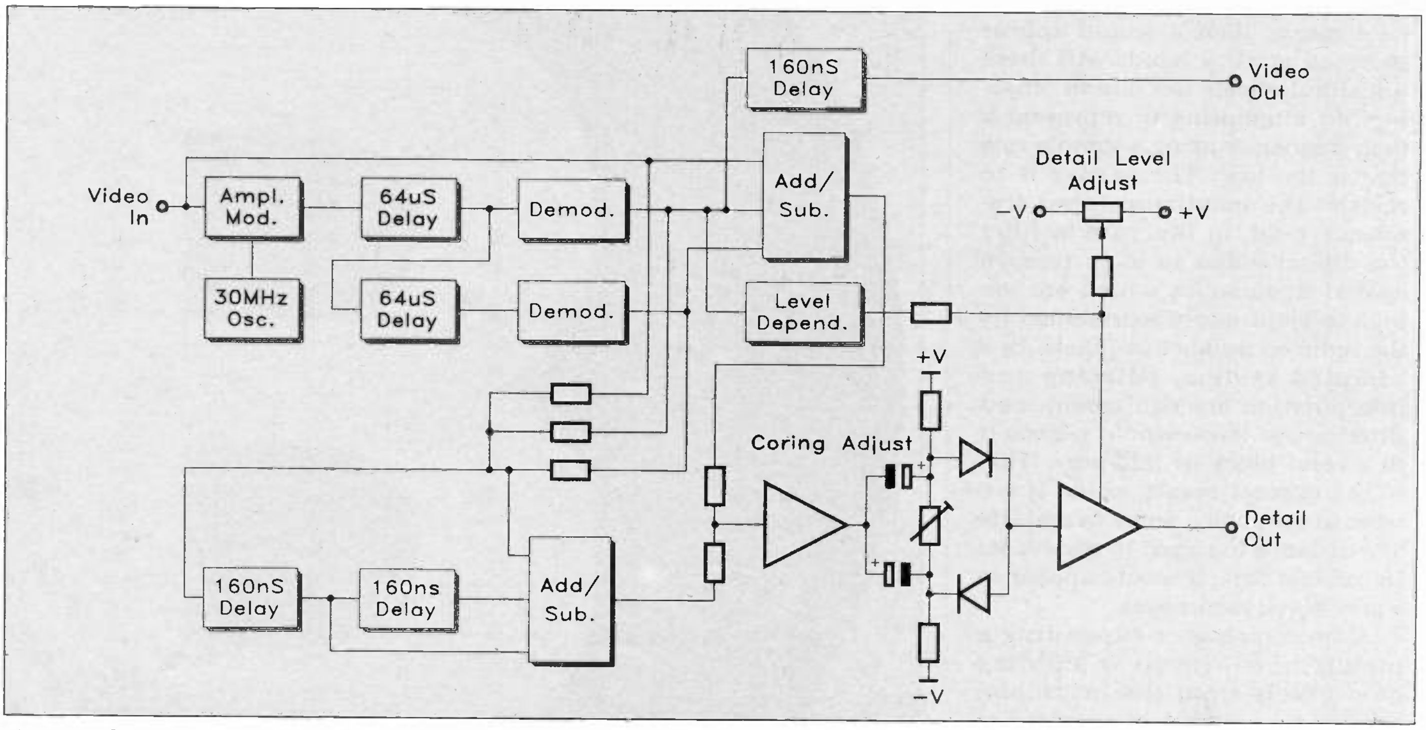

Figure 5. Block diagram of an analogue H and V enhancer.

circuit is correctly adjusted, it should remove much of the noise without affecting genuine edge enhancement. It is usually achieved using two diodes with adjustable bias as shown in Figure 5, the complete enhancer. Level dependency is the reduction or removal of detail correction at video levels near black, as noise is not only subjectively worse then but in a camera any noise from the early stages at low light levels would be amplified considerably by the gamma corrector. Level dependency should fade out enhancement at lower video levels rather than shut it off abruptly, as the latter will give rise to very odd effects with enhanced details shown against a graduated background. Comb filtering is used only with horizontal enhancement, and is an attempt to affect only edges that are repeated on successive lines i.e. vertical lines. A very simple implementation is normally used. Since one- and two-line delayed video is available if vertical enhancement is also being used, then two or all three signals are added together before horizontal enhancement is carried out. This does not completely eliminate non-vertical picture information but it does diminish it, and any edge appearing on one line only stands little chance of its derived detail signal making it through the coring circuit.

The same techniques may be applied to digital video. Now a delay is very simple to achieve, though of course it must be a multiple of the clock period. Addition of signals is simple, though for level adjustment a fast ROM is likely to be cheaper than a hardware multiplier working at video clock speed. Coring is also most easily implemented with a ROM. Black and white clipping will be required to ensure that 'wrap-around' of an overflowed adder does not produce a silly result.

How Genlock Works

The genlock system obviously depends on the particular TBC solution chosen. Dual TBC/mixers need no genlock, if no additional mixing facilities are used. VTRs with built-in TBCs have a socket or a pair of loop-through sockets for a genlock reference, as do standalone TBCs. Professional cameras usually have a genlock socket on the head, or a loop-through on the control unit if one is used. Where all the equipment has loop-throughs, it is tempting just to hook them all together. Non-broadcast equipment rarely has high enough input impedances to do this with more than three or four units without considerable loss at subcarrier frequency, which can reduce subcarrier stability in less-well-designed genlock circuits. A much better, though more expensive, idea is to use a distribution amplifier to send the genlock reference separately to each unit. This has the further advantage that one cable or piece of equipment can be removed or replaced without the necessity of retiming half the system.

The question arises at some point as to where the genlock reference comes from. The broadcast requirement for frequency stability means that the master reference must be a fairly sophisticated and very expensive sync generator. Indeed, most UK broadcasters use atomic frequency standards. For a small studio, absolute frequency accuracy is not too important, as long as all equipment is able to lock to it. Most vision mixers (other than the very smallest) and TBCs, and just about all professional cameras have reasonably good sync generators built-in, and any of these units in a system can be considered as a genlock source as far as frequency stability goes. However, if picture video is used as a reference then some fairly primitive genlock circuits may vary in timing a little as video APL varies. It is safer, then, to use a steady signal such as colour bars or colour black (also known as black and burst, or black video). Most vision mixers and some TBCs provide a colour black output.

The process of system timing depends on the master reference source. Where the vision mixer is the source, then all other units are adjusted for correct timing at the mixer. Where one of the video sources is the master reference, then the other units including the mixer are adjusted to match it. Where the mixer has a built-in timing aid, then in the latter case the mixer is first adjusted to the indicated point with the master source selected and then the other inputs are selected and adjusted in turn. Once the system has been correctly timed, some of its cables become critical in that changing their lengths will upset system timing.

Basically, these are the cables 'between' the genlock reference source and the vision mixer, that is, all of the genlock wiring and the cables from the genlocked units to the mixer. Non-critical cables include those from VTR to TBC (both video out and sync in) and mixer outputs to record VTRs. Cables to monitors are not critical provided they are not then looped-through to become inputs to the mixer. Such a practice is not unusual if the equipment being monitored has only one video output and cannot supply a second monitor feed.

MAPLIN'S TOP TWENTY KITS

POSITION			DESCRIPTION OF KIT	ORDER AS	PRICE	DETAILS IN	
1.	(1)		MOSFET Amplifier	LP56L	£19.95	Magazine	41 (XA41U)
2.	(3)		Live Wire Detector	LK63T	£ 4.25	Magazine	48 (XA48C)
3.	(2)		L200 Data File	LP69A	£ 3.95	Magazine	46 (XA46A)
4.	(4)		TDA7052 Kit	LP16S	£ 4.45	Magazine	37 (XA37S)
5.	(8)		1 300 Timer	LP30H	£ 4.95	Magazine	38 (XA38R)
6.	(7)		Vehicle Intruder Alarm	LP65V	£ 9.95	Magazine	46 (XA46A)
7.	(6)		Courtesy Light Extender	LP66W	£ 2.75	Magazine	44 (XA44X)
8.	(5)		Car Battery Monitor	LK42V	£ 7.95	Magazine	37 (XA37S)
9.	(9)		Mini Metal Detector	LM35Q	£ 6.45	Magazine	48 (XA48C)
10.	(12)		IBM Expansion Sys	LP12N	£18.25	Magazine	43 (XA43C)
11.	(10)		Stroboscope Kit	VE52G	£11.95	Catalogue	'92 (CA09K)
12.	(11)		Low Cost Alarm	LP72P	£12.95	Magazine	45 (XA45Y)
13.	(13)		PWM Motor Driver	LK54J	£ 9.95	Best of Book	3 (XC03D)
14.	(–)	RE ENTRY	TDA1514 Power Amplifier	LP43W	£16.45	Magazine	40 (XA40T)
15.	(–)	RE ENTRY	LM386 Power Amplifier	LM76H	£ 3.75	Magazine	29 (XA29G)
16.	(14)		Partylite	LW93B	£10.25	Catalogue	'92 (CA09K)
17.	(15)		MSM6322 Data File	LP58N	£11.45	Magazine	44 (XA44X)
18.	(18)		Digital Playback Kit	LM85G	£14.25	Magazine	31 (XA31J)
19.	(17)		8-Bit I O – RS232	LP85G	£16.95	Catalogue	'92 (CA09K)
20.	(–)	NEW ENTRY	SSM2016 Amplifier	LP44X	£12.75	Magazine	41 (XA41U)

Over 150 other kits also available. All kits supplied with instructions. *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.*

Melody Maker

Design by Nichola Ring
Text by Nichola Ring
and Martin Pipe

FEATURES

- ★ 47 Note Memory
- ★ 15 Pre-programmed Songs
- ★ Minimal Wiring
- ★ Hand-held Case with Integral Keypad and Battery Compartment

It looks just like an ordinary TV remote control, but is in fact a fun musical instrument intended for young children to gain experience in playing simple tunes. The choice of a hand-held case was made for its compact size and integral keypad, which is used to play the musical notes G3 to G5, and to operate the replay and reset functions. By using an advanced integrated circuit (IC), the total component count and wiring of the project has been kept to a minimum.

Circuit Description

As can be seen from the circuit diagram in Figure 1, only a few additional components are required to support IC1, a UM3511A melody generator. This chip forms a complete logic-controlled tone system and its high-tech circuitry is contained in an eighteen pin Dual-In-Line (DIL) plastic package, shown in Figure 2. The individual pin designation and description is provided by Table 1, with the IC's electrical characteristics appearing in Table 2. A more detailed breakdown of the whole system is shown in the block diagram, Figure 3. The positive three volt power supply, which is required by each stage of the circuit, is applied to pin 18 (V_{DD}), with the common ground return on pin 9 (V_{SS}). This power is derived from two 1·5V AA type batteries connected in series; the positive is connected to PCB terminal P1, and the negative to P2. The positive supply is switched by S1; when in its 'on' position, power is applied to the whole circuit causing the red LED indicator, LD1, to light.

The operating frequency of the master oscillator is set to approximately 64kHz by R4, which is connected between pins 7 and 8. This frequency is used as a time base for the tone, rhythm and tempo generators. To select a stored song or enter your own tune, the IC supports a 4 row by 4 column keyboard on pins 10 to 17. The sixteen keys are continuously scanned to provide the fifteen musical notes, the stored songs, or the replay function.

The tone generator is a programmed divider. Its range of 15 notes spans from G3 to G5 and is controlled by the stored data in either RAM or ROM, as selected by the multiplexer. Switch S2 on pin 2 is used to select either the 'PLAY' or the 'COMPOSE' mode. In the 'play' mode (pin 2 high) the ROM is selected, allowing access to the 15 songs held inside the

Specification of Prototype

DC Power Supply:	3V (2 × AA)
Standby Current:	2mA
Average Play Current:	4mA
Note Scale:	15 Notes (G3 to G5)
Replay Note Capacity:	47 Notes (Compose RAM)
Programmed Songs:	15 Songs (Play ROM)

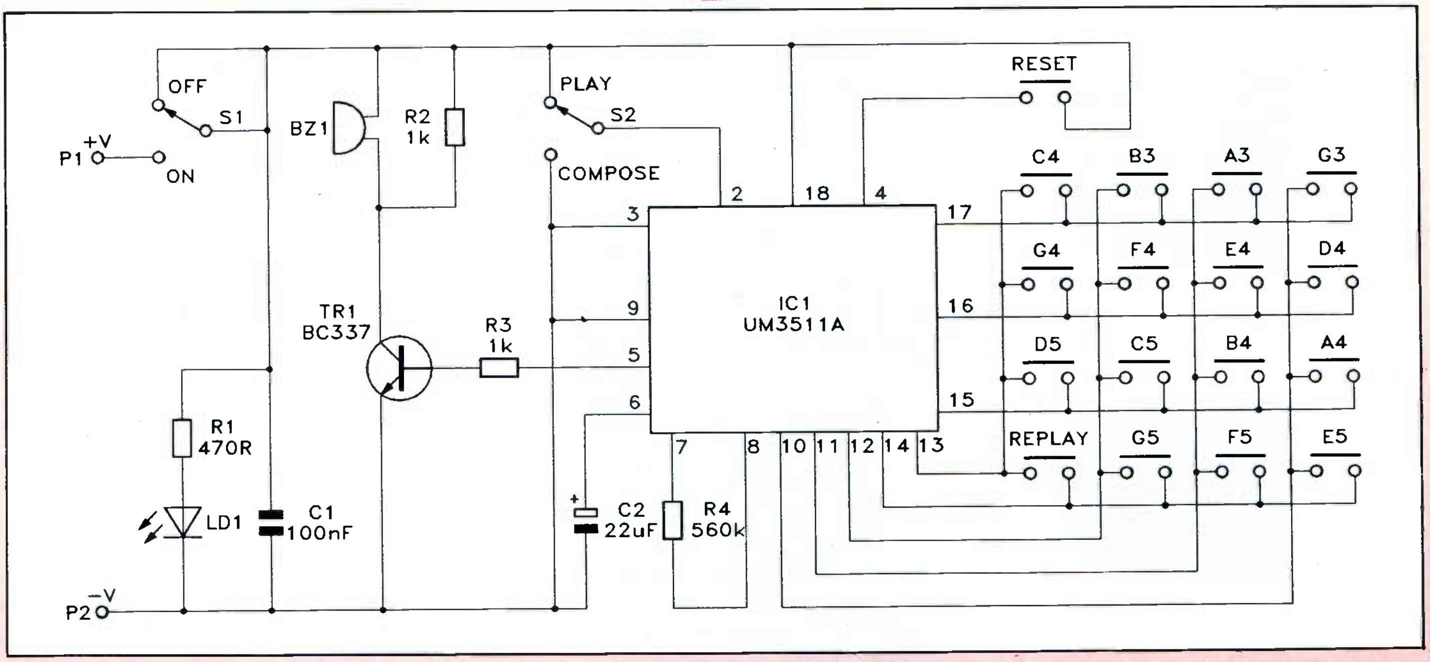

Figure 1. Circuit diagram.

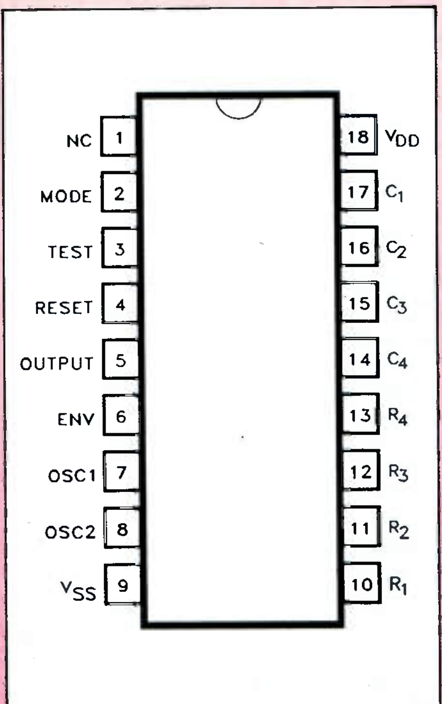

Figure 2. Pin configuration.

Pin No.	Designation	Description
1	NC	No connection
2	MODE	Plays a song if this pin is connected to V_{DD} Composes a song if this pin is connected to V_{SS}
3	TEST	This pin is used for testing. In normal operation, this pin should be either open or grounded
4	RESET	Clears all address data if connected to V_{DD}
5	OUTPUT	Audio output
6	ENV	Enveloping circuit terminal
7	OSC 1	A resistor is connected between P7 and P8 as an oscillator
8	OSC 2	
9	V_{SS}	Negative power supply
10	R_1	Keyboard row line 1
11	R_2	Keyboard row line 2
12	R_3	Keyboard row line 3
13	R_4	Keyboard row line 4
14	C_4	Keyboard column line 4
15	C_3	Keyboard column line 3
16	C_2	Keyboard column line 2
17	C_1	Keyboard column line 1
18	V_{DD}	Positive power supply

Table 1. UM3511A pin description.

Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit
Operation Voltage	V_{DD}		2·4	3	5	V
Stand-by Current	I_{STB}	OSC halting $V_2=V_7=V_{SS}$ $V_6=V_{DD}$	–	–	10	μA
'H' Input Voltage	V_{IH}		$V_{DD} - 0{\cdot}2$	–	V_{DD}	V
'L' Input Voltage	V_{IL}		V_{SS}	–	$V_{SS} + 0{\cdot}2$	V
Frequency Deviation Per Lot	$\Delta F/F$	$V_{DD} = 3V$	−10%	–	+10%	
Frequency Stability	$\Delta F/F$	$\frac{F_{OSC}(3{\cdot}3V) - F_{OSC}(2{\cdot}7V)}{F_{OSC}(2{\cdot}7V)}$	–	–	20%	
Output Current	I_O	$V_O = 0{\cdot}8V$	200	–	–	μA
ENV Drive Current	I_{ED}	$V_{DD} = 2{\cdot}7V, V_6 = 0{\cdot}7V$	150	–	–	μA

Table 2. UM3511A Electrical characteristics.

chip, see Table 3. When in the 'compose' mode (pin 2 low) the RAM is selected, allowing you to enter your own tune into memory (47 notes maximum) and then replay it as many times as you like. This memory can be cleared by using any of the following three methods: (a) operating the reset key on pin 4; (b) switching from compose to play using S2; or (c) interrupting the power using S1. The beat and tempo generators are also programmed dividers with their timing data stored in memory. The exact sequence of events, in both play and compose modes, is detailed in the flowchart shown in Figure 4.

The envelope modulator has three inputs and one output. It receives the output of the tone generator, which is then modulated by the tempo and up/down

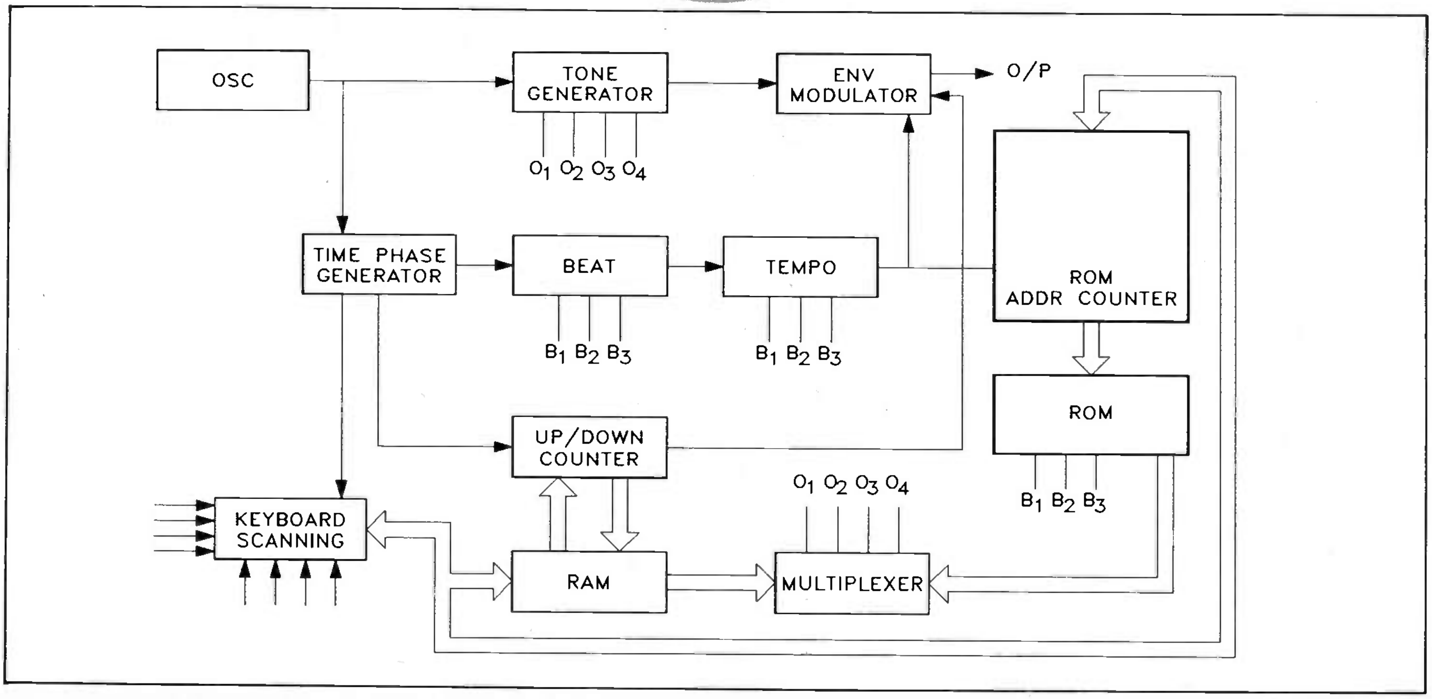

Figure 3. Block diagram.

SONG NUMBER	KEYPAD	TITLE
1	G3	HUSH LITTLE BABY
2	A3	TWINKLE, TWINKLE, LITTLE STAR
3	B3	LONDON BRIDGE IS FALLING DOWN
4	C4	DREAM OF HOME AND MOTHER
5	D4	CHRISTMAS CAROL
6	E4	ARE YOU SLEEPING
7	F4	THE FARMER IN THE DELL
8	G4	IN A PERSIAN MARKET
9	A4	MARY HAD A LITTLE LAMB
10	B4	LONG, LONG AGO
11	C5	SANTA LUCIA
12	D5	LITTLE BROWN JUG
13	E5	BUTTERFLY
14	F5	THE TRAIN IS RUNNING FAST
15	G5	CLOSE ENCOUNTERS OF THE THIRD KIND
	REPLAY	Play all songs from 1 to 15

Table 3. Song list.

counter triggering signals. Each note played will now have a sustained duration, set by the value of the capacitor C2 on pin 6. The resulting audio product appears on pin 5 and is buffered by TR1 before driving the piezo sounder, BZ1.

PCB Construction

The PCB supplied in the Maplin kit (Order Code LP94C) is a single-sided, fibreglass type, and a copy of its printed legend is shown in Figure 5. This should assist you in correctly positioning each component, as removal of a misplaced item is quite difficult. Please double-check each component type, value and its polarity where appropriate, before soldering!

The sequence in which the components are fitted is not critical. However, the following instructions will be of use in making these tasks as straightforward as possible. For general information on soldering and assembly techniques, please refer to the Constructors' Guide included in the kit. Because of the restricted space inside the hand-held case, three of the taller components must be pushed over so that they lay flat on the surface of the PCB. The following components have had their outlines printed on the legend in a way that reflects this fact: C1 (100nF ceramic disc capacitor); C2 (22μF 16V electrolytic capacitor); TR1 (BC337 transistor).

It is usually easier to start the assembly with the smaller components. Begin with the resistors R1 to R4, saving the component lead offcuts for bridging the six link positions on the PCB. The battery power connections use two small PCB terminal pins installed at P1 and P2.

Next, install the two capacitors C1 and C2. When fitting the polarised electrolytic capacitor C2, ensure that the lead nearest the negative symbol (−) on this component goes away from the positive sign on the legend. In addition, please remember to mount both capacitors against the PCB as previously described.

When installing TR1, ensure that its rounded edges are facing away from the surface of the PCB. There is insufficient headroom for the UM3511A IC1 to be fitted into an IC socket, so please make *absolutely* certain that the notch on the IC matches the block on the legend. When mounting LD1, ensure that its shorter cathode lead is located at the hole marked 'K' and that its flat base fits squarely on to the front edge of the PCB. Next, fit the two slide switches S1 and S2 making certain that the body of each switch squarely meets the front edge of the PCB.

Finally, install BZ1, ensuring that it is as close as possible to the surface of the board. This completes the assembly of the PCB and you should now check your work very carefully, making sure that all the solder joints are sound. IMPORTANT NOTE! The solder side of the circuit board must not have any trimmed component leads standing proud by more than 1mm (this relates particularly to the four wire links in the keyboard area), otherwise the rubber keypad could be damaged. The completed prototype PCB assembly can be seen in Photos 1a and 1b.

Box Preparation and Final Assembly

The origin of the hand-held case (Order Code ZA00A) dates back to the development of the NICAM stereo TV tuner kit (Order Code LP19V) and is supplied with the following component parts:

1. Front half of case, with holes for 36 keys and a battery compartment.
2. 22-way conductive rubber contact keypad.

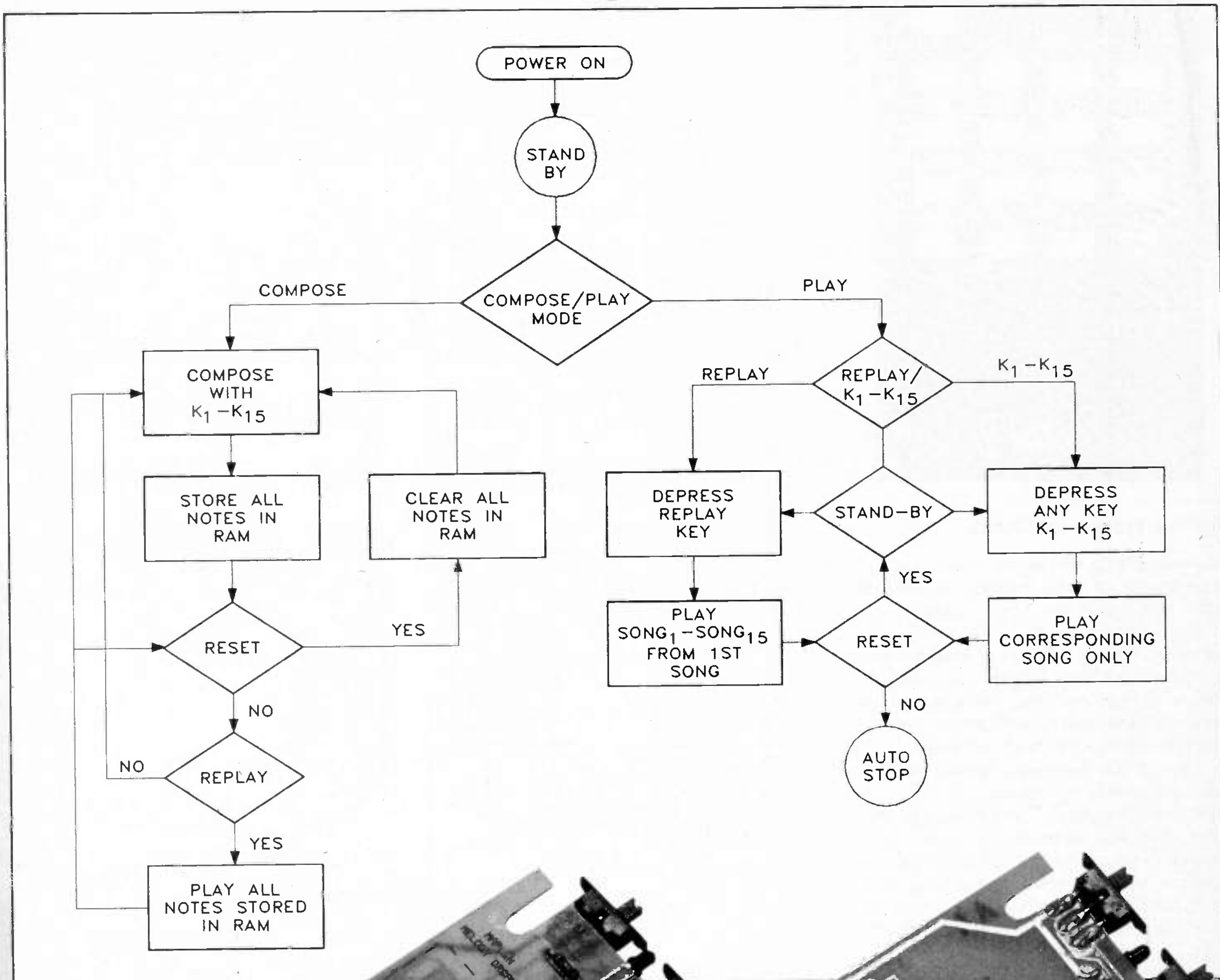

Figure 4. Operating flowchart.

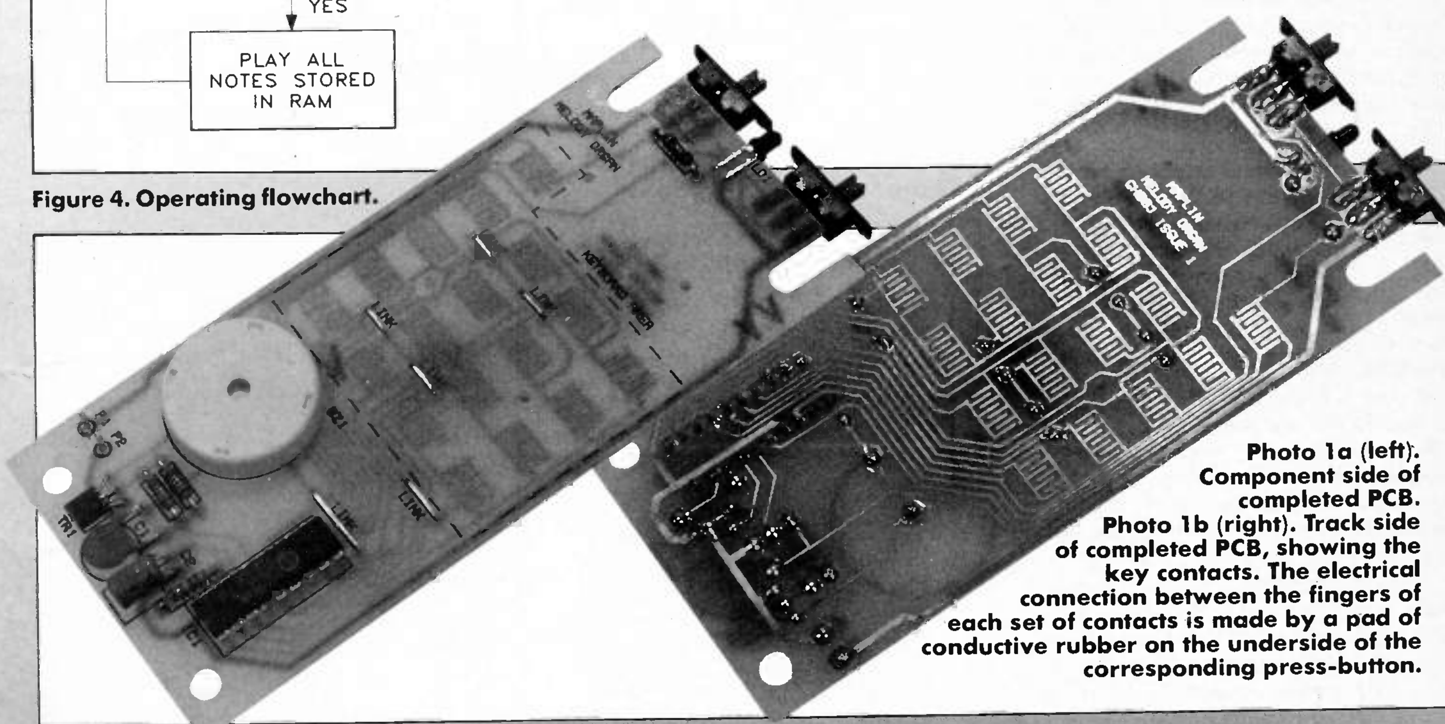

Photo 1a (left). Component side of completed PCB. Photo 1b (right). Track side of completed PCB, showing the key contacts. The electrical connection between the fingers of each set of contacts is made by a pad of conductive rubber on the underside of the corresponding press-button.

3. NICAM keypad front panel.
4. Back half of case, with four fixing holes and battery door.
5. Set of wired battery spring terminals.
6. Four countersunk self-tapping screws.
7. Red-tinted transparent end window.

To modify the case from its original intended use into the housing for the Melody Maker requires preparation work. The front half of the case doesn't require any preparation. However, the back half and the transparent window does require a small amount of drilling. The exact positioning of these holes is very important, as they must be in alignment with the PCB mounted components S1, S2 and BZ1.

The Melody Maker only uses 17 keys, so the 22-way keypad must be cut to size, as shown in Figure 6. Take care when cutting to remove ONLY the two brown, two green and one yellow key, leaving the pattern of wanted keys as shown. The panel used to identify each valid key position and cover over the unused ones is shown in Photo 2.

The next stage is to prepare the label for the keyboard. It must be stated straight away that this item will require time to prepare properly. It may be rushed – but

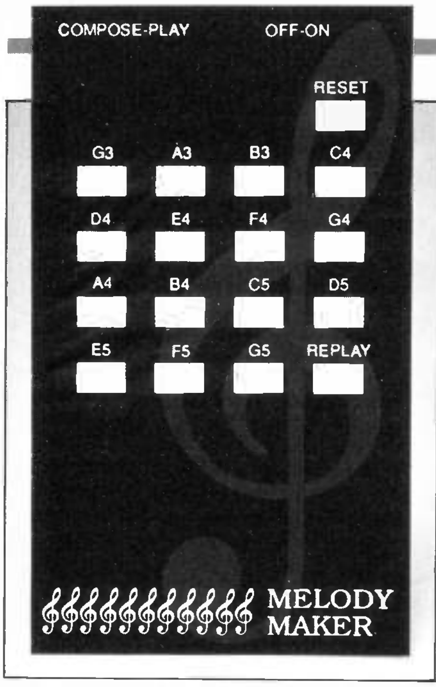

Photo 2. Front panel label.

you will end up making mistakes, and the appearance of your Melody Maker will suffer as a result. The label is supplied cut to the right size for the case and is self-adhesive, having a backing material that is peeled off just before mounting it. Before that can be done, the holes for the seventeen keys will need to be cut out – a job that will require much patience!

To cut out the keys, you will need a ruler (preferably a steel one) and a sharp craft knife or scalpel. If you have a plastic ruler, you will need to be even more careful, or your ruler may be damaged. In addition, you will need to put some stiff card, hardboard or a piece of wood on your table to prevent scoring it with the knife.

Place the label on the temporary work surface, and line up your rule horizontally with the top of the uppermost row of keys. To make your job easier, the areas to be cut out are shown as white rectangles. While holding the rule (and therefore the label under it) steady, cut the label at the intervals corresponding to where the buttons will protrude through – as shown in Photo 3. Take time while you do this; do not overshoot or the end result will look bodged! When you have completed this action for the top of the row, do it for the bottom – and then repeat the entire procedure for the other three rows and the single button.

When all of the horizontal cutting has been done, carry out the same action vertically for the sides of the key cut-outs. Rotate the panel on your work surface if it will be any easier for you to cut. When you have finished the knife-work, press out the unwanted material, taking care not to tear the label. Satisfy yourself that the label doesn't need any more cutting, by placing it on the Melody Maker's keypad and checking that all the holes line up. Peel off the backing material and after lining it up, firmly stick the label to the front of the case.

The red-tinted end window, having originally been supplied with a remote control unit, does not come pre-drilled to

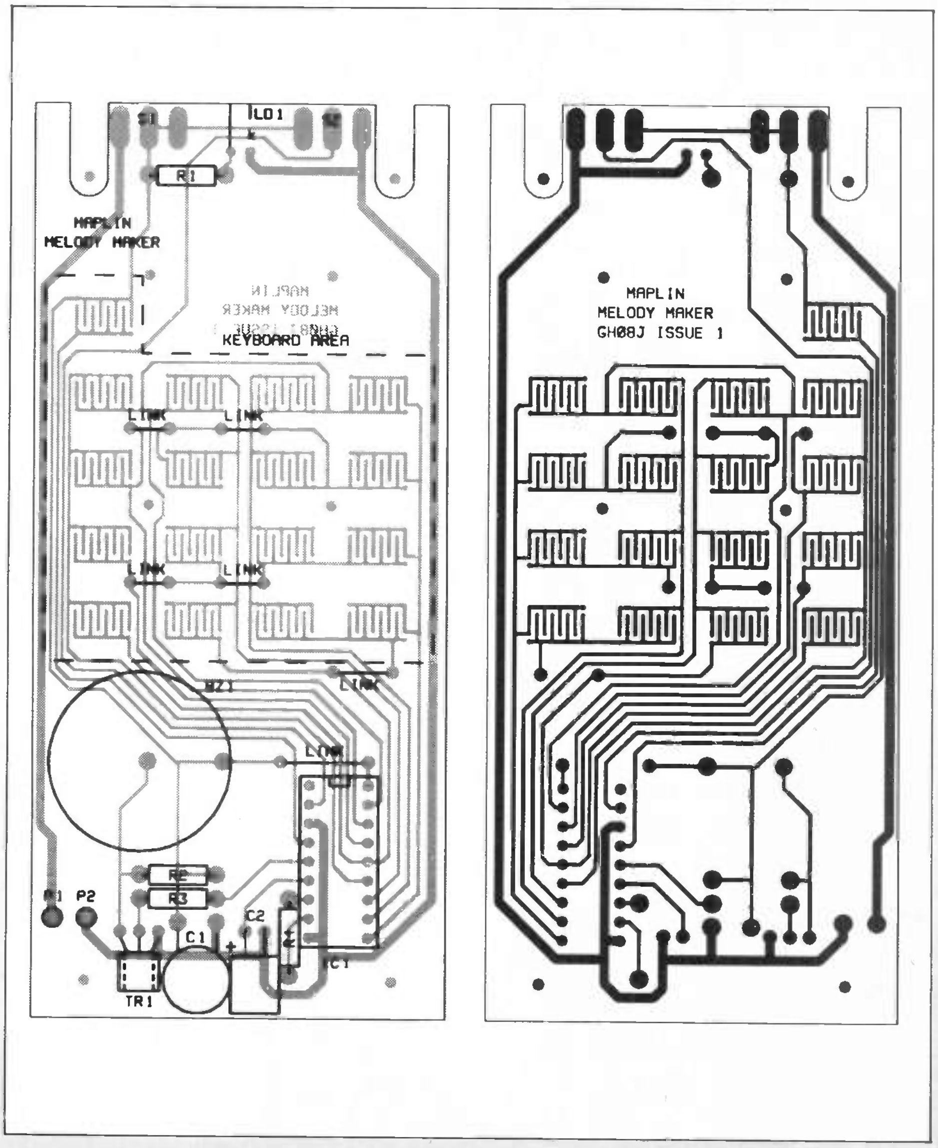

Figure 5. PCB legend and track.

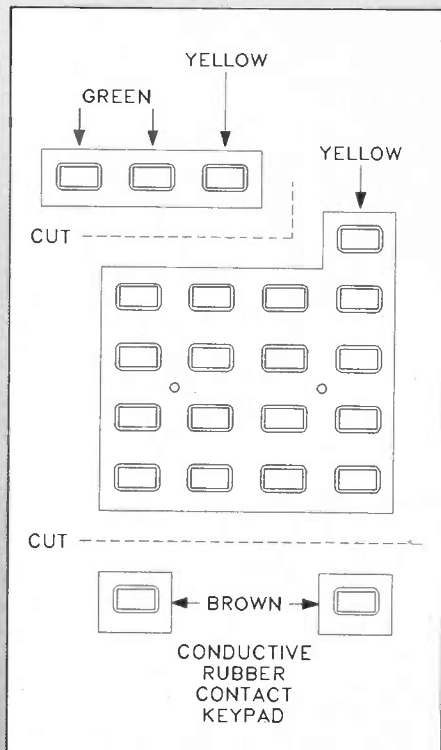

Figure 6. Keypad preparation.

accept the two slide switches of the Melody Maker, yes, you've guessed it – you've got to make them! However, do not despair as it is fairly straightforward. The drilling details of these rectangular holes are given in Figure 7; the rectangles to be cut out should now be marked onto the end window. The best way to prepare the holes is to use a fine drill bit (using a low-powered PCB drill here, if you have one, would make the job considerably easier) of 1mm diameter. Drill two holes for each switch, and enlarge them with a 2mm drill bit. For each position, use a needle file to expand the two holes into each other and form a slot of the size that you originally marked out on the end window.

The final hole to be drilled is a 5mm hole on the back of the case, so that your masterpieces can drift sweetly away from the piezo sounder and be heard by all in earshot. Dimensions for this hole are given in Figure 7.

Next, fit the completed keypad and PCB assembly into the hand-held case as follows:

1. Push fit the battery spring terminals into the front half of the case, as shown in Figure 8.

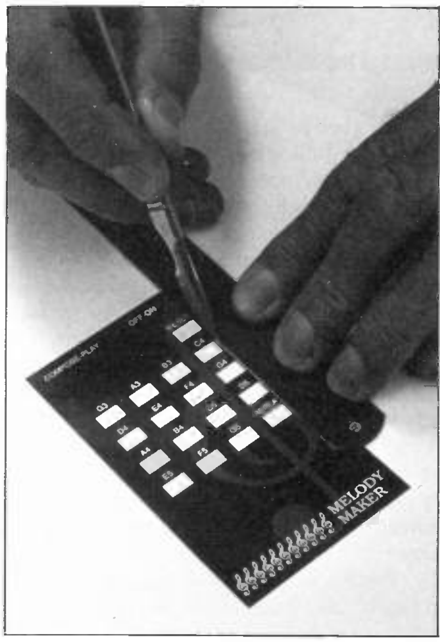

Photo 3. Keypad panel preparation.

2. Push the buttons of the rubber contact keypad through their corresponding holes in the front half of the case.
3. Ensuring that it is the correct way round, place the transparent window over the two slide switches.
4. Locate the PCB over the keypad and push into place (see Photo 4).
5. Connect the red (positive) battery wire to P1 and the black (negative) to P2.
6. Secure the back half of the case using the four countersunk screws.
7. Remove the battery cover.

This completes the assembly of the Melody Maker and it should now resemble the one shown in Photo 5.

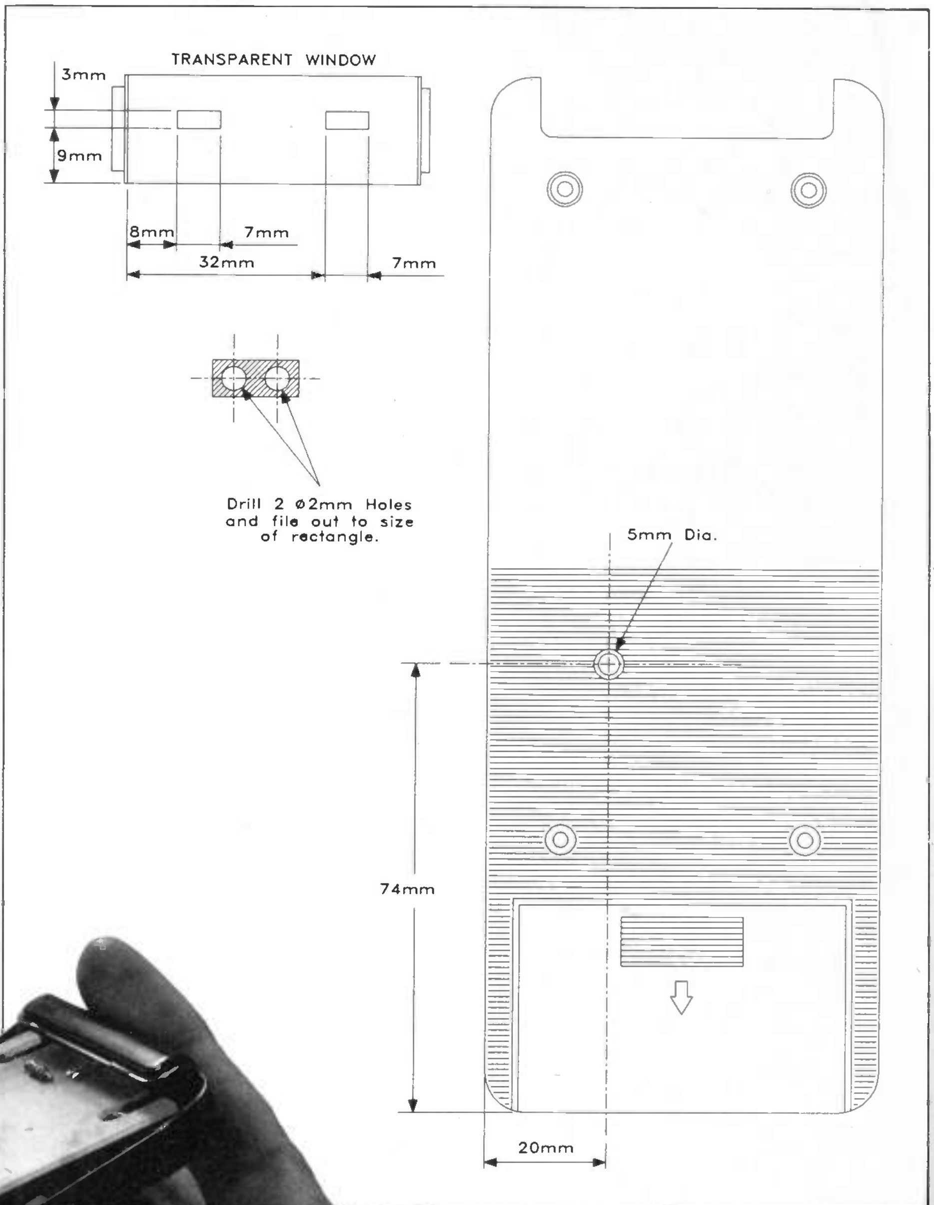

Figure 7. Case drilling details.

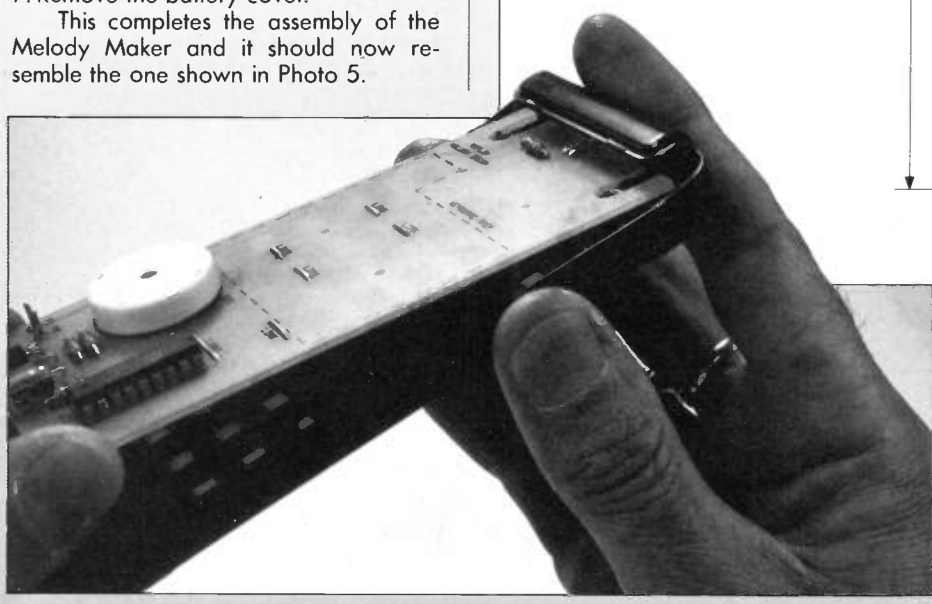

Photo 4. Installing the PCB.

Testing

All the DC tests are made using a multimeter and the two 1·5V AA type batteries required to power the unit. The readings were taken from the prototype using a digital multimeter; some of the readings you obtain may vary slightly, depending upon the type of meter employed. Before you commence testing the unit, set the two slide switches to the 'OFF' (S1) and 'PLAY' (S2) positions.

The first test is to ensure that there are no short circuits on the power rail before you install the two AA batteries. Set your meter to read kΩ on its 20kΩ resistance range, and connect the test probes to the wired pair of battery terminals. With the probes either way round an infinitely high reading should be obtained until S1 is set to its power 'ON' position, causing the reading to drop down to a minimum of approximately 4kΩ.

Next, install the two AA batteries, ensuring that both are fitted the correct way round as shown by the outlines inside the battery compartment. To monitor the supply current, set your meter to read DC mA and place it in series with one of the batteries. Ensuring that the power is switched on and LD1 is lit, observe the current reading which should be approximately 2mA in the standby mode (no songs playing). Check that S2 is in the 'play' position, then press the replay key and observe the current reading, which should increase to approximately 4mA while the songs are being played. With S2 in its 'compose' position, the current should be 4mA only when the note keys G3 to G5 are pressed or when the notes are replayed. This completes the DC testing of the Melody Maker. Now disconnect the multimeter from the unit, secure both AA batteries and fit the battery compartment door to the back of the case.

Using the Melody Maker

The Melody Maker is designed to operate from a 3V power source consisting of two 1·5V AA batteries. However, there is a wide range of AA type batteries, the quality of which is usually related to the initial cost. Relatively inexpensive zinc-carbon batteries (Order Code FK55K or JY63T) will provide sufficient power to operate the Melody Maker over a

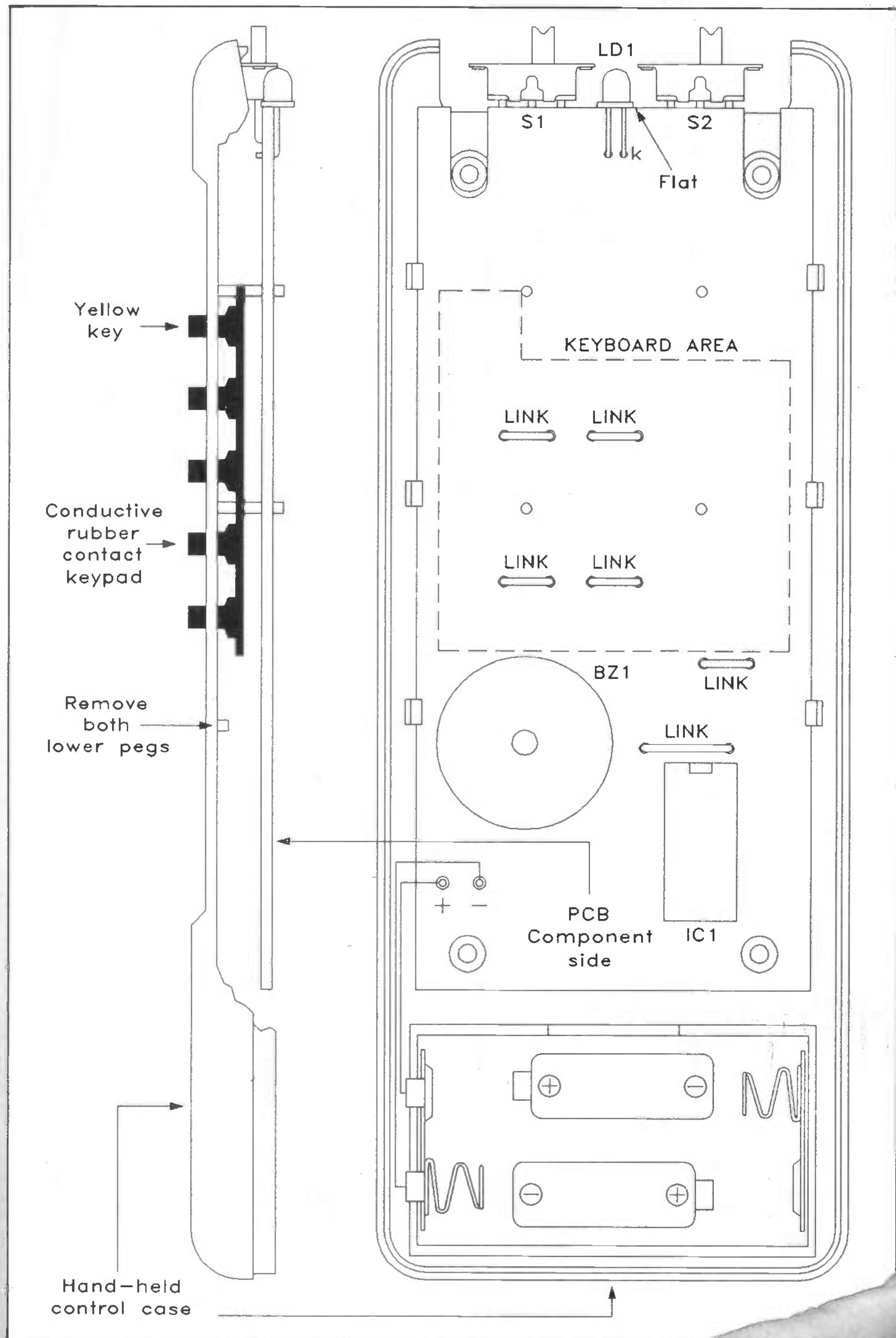

Figure 8. Keypad and PCB installation.

reasonable time period, but this can be greatly extended if the more expensive alkaline type (Order Code FK64U or JY48C) are used. When powered up, the voltage condition of the batteries is displayed by a red LED indicator. As they begin to run down, this LED will start to dim. At this point the Melody Maker will still work, but with a slightly reduced performance. Changing the batteries at this point is strongly recommended.

In its 'play' mode, any one of the 15 built-in songs (see Table 3) can be accessed by pressing the keys G3 to G5, and if the 'replay' key is pressed then all 15 will be played in sequence. At any time, the yellow 'reset' key can be used to stop the song and return the Melody Maker to its standby condition.

In its compose mode, the keys G3 to G5 are used to enter your own songs into a memory, which has a maximum storage capacity of 47 notes. The digital recording process starts when the first key is pressed, and the maximum rest time between notes has a default duration of four seconds. Your song can now be replayed as many times as you like by simply pressing the 'replay' key, and additional notes can be entered as soon as the song finishes. If you exceed the capacity of the memory you can still play notes, but they will not be stored and only the previous 47 notes will be retained. The memory is wiped clean by pressing the 'reset' key, or switching the power off, or switching from compose to play.

Finally, here are three songs for you to key in and experiment with.

Song 1. Baa Baa Black Sheep
C4 C4 G4 G4 A4 B4 C5 A4 G4
F4 F4 E4 E4 D4 D4 C4 G4 G4 G4 F4 F4
F4 E4 E4 E4 D4
D4 G4 G4 F4 F4 F4 F4 E4 E4 E4 D4
C4 C4 G4 G4 A4 B4 C5 A4 G4
F4 F4 E4 E4 D4 D4 C4

Song 2. Jingle Bells
E4 E4 E4 E4 E4 E4 E4 G4 C4 D4 E4
F4 F4 F4 F4 F4 E4 E4 E4 E4 E4 D4
D4 E4 D4 G4 E4 E4 E4 E4 E4 E4
E4 G4 C4 D4 E4 F4 F4 F4 F4 F4 E4 E4
E4 E4 G4 G4 F4 D4 C4

Song 3. God Save the Queen
C4 C4 D4 B3 C4 D4 E4 E4 F4 E4 D4 C4
D4 C4 B3 C4 G4 G4 G4 G4 F4 E4
F4 F4 F4 F4 E4 D4
E4 F4 E4 D4 C4 E4 F4 G4 A4 F4 E4 D4 C4

Photo 5. Completed Melody Maker.

MELODY MAKER PARTS LIST

RESISTORS: All 0·6W 1% Metal Film			
R1	470Ω	1	(M470R)
R2,3	1k	2	(M1K)
R4	560k	1	(M560K)
CAPACITORS			
C1	100nF 16V Minidisc	1	(YR75S)
C2	22µF 16V Minelect	1	(YY36P)
SEMICONDUCTORS			
IC1	UM3511A	1	(UR05F)
TR1	BC337	1	(QB68Y)
LD1	Mini LED Red	1	(WL32K)
MISCELLANEOUS			
S1,2	SP Slide Switch	2	(FF77J)
BZ1	PCB Piezo Sounder	1	(JH24B)
P1,2	Pin 2145	1 Pkt	(FL24B)
	Nicam IR Tx Case (with rubber keypad buttons)	1	(ZA00A)
	PCB	1	(GH08J)
	Front Panel	1	(KP48C)
	Instruction Leaflet	1	(XT59P)
	Constructors' Guide	1	(XH79L)
OPTIONAL (Not in Kit)			
	Alkaline AA Battery	2	(FK64U)

The Maplin 'Get-You-Working' Service is available for this project, see Constructors' Guide or current Maplin Catalogue for details.

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

Order as LP94C (Melody Maker Kit) Price £11.95.

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.

Melody Maker PCB **Order As GH08J Price £2.75.**

Melody Maker F/Panel **Order As KP48C Price 98p.**

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VARIOUS

TELEPHONE DUAL OUTPUT ADAPTORS for BT 4-Way line, £1.80 each plus 40p towards P&P. William Goss, 9 Ranelagh Gdns, Southampton, Hants, SO1 2TH.

ELECTRONIC COMPONENTS, selling due to leaving country. Send S.A.E. to James Bellarby, 13 Westfield Rd, Stonehaven, Kincardineshire, AB3 2EE.

MAPLIN LASER & CONTROLLER in perfect condition, £65 o.n.o. Plus P+P. Tel: Ian, (0623) 25277.

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LOUDSPEAKER UNITS for sale, pairs, woofers to tweeters, also Maplin graphic and noise reduction units both built and working. More details? Tel: Steve, (0272) 352702.

MUSICAL

MAPLIN 61 NOTE KEYBOARD unused, £25. + Postage. Tel: (051) 677 3670.

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COMMODORE AMIGA 68020/68881 accelerator card with 2Mb 32-bit RAM. Up to 400% speed increase. Fits A1500/B2000, £250. A2300 Genlock (internal) £60. Selection of original software. Tel: (0945) 587980.

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

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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 S.A.E. to: The Secretary, Mr. J. S. Hind, 7 Carlyle Road, West Bridgford, Nottingham NG2 7NS.

WANTED

EXPANSION PORTS A-B on the Amstrad portable PPC 512/640. Does anyone have a pin-out or circuit diagram? What addresses are available for users? Any help gladly appreciated! Tel: Paul, (0737) 768467.

WANTED CONSTRUCTION MANUAL for 'Heathkit' C1–1080 Gas Analyser, purchase or swap for 'Heathkit' C1–2065 Charging Tester manual. Contact: C. Lewis, 48 Martyns Ave, Seven-Sisters, Neath, West Glamorgan, SA10 9DS.

WANTED COPY OF SIGNETICS 1085 Linear LSI data and applications manual or photocopy of article pages 9 to 198 (balance amplifier). Frank Cosgrove, Tel: (0202) 432973.

SGS M108 CHIPS (Sound Generator), previously available from Maplin but now obsolete. I need one of the chips badly enough to be severely ripped off! Tel: Richard, (0252) 510664, evenings.

MONOPHONIC SYNTHESISER WANTED ETI 4600, Elector Formant, Moog, Oberhiem, etc. Must be cheap. Tel: (081) 692 8129.

WANTED SCRAPPED OR BROKEN Sinclair Z88 for parts. Please contact: Stephen Waddington, Tel: (081) 686 7582 or at 1A Warrington Court Croydon, CR0 1BH.

WANTED UV EXPOSURE BOX for PCB making, also other items, i.e. Mini-Drillstand; EPROM programmer serial type for PC; sheet feeder for Canon BJ10e Bubble-Jet. Tel: Mel, (0533) 419742 after 6.30pm.

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 September issue is on sale August 7th, available from Maplin's regional stores and newsagents countrywide, and of course by subscription (see page 55 for details). To whet your appetite, here's just a taster of some of the goodies on offer:

WAVEFORM GENERATORS

A new series in which Ray Marston reveals the secrets of oscillators and pulse generation, starting with an in-depth look at the basics. Practical circuits are given, including that of a 15Hz to 150kHz sine/square wave generator based around a Wien circuit.

PARALLEL INTERFACE RELAY UNIT

This ingenious project allows any computer equipped with a 'Centronics' parallel interface port to control eight relays – opening up many possibilities of control and automation.

CD-ROMS

Stephen Waddington discusses the technology behind this impressive computer mass storage medium, which is now being used in areas as diverse as engineering, insurance claims assessment and desktop publishing.

FUNTRONICS MUSIC MAKER

We just couldn't end the series on a sour note – the last Funtronics project for the time being is a simple ten-note music generator!

BROADBAND ISDN

The Integrated Services Digital Network has been heralded as a major step forward in the integration of telecommunications networks, including television, voice and data communications. Frank Booty explains why, and describes the system architecture.

BBC TO PC FILE CONVERSION

Hands up all those with a BBC computer. Right then – all those of you who've since upgraded to a PC keep their hands held aloft. Leave those arms pointing skyward until the September issue of 'Electronics', in which you will find details of a serial link across which you can 'zap' all those files from old machine to new!

OMNICOM REVIEW

For those of you who work from home, have a large number of telephone equipment (modems, faxes, answerphones etc.) or simply want to stay a few leaps ahead of the Joneses, the answer to your prayers could well be the BABT-approved Omnicom FS1515 Telephone Exchange, which will provide you with up to 5 extensions from a single exchange line – enough for a small business. Apart from supplying installation details, Joe Fuller gives us a fascinating insight into the unit's electronic design.

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

'ELECTRONICS – THE MAPLIN MAGAZINE'

BRITAIN'S BEST SELLING ELECTRONICS MAGAZINE

FACSIMILE DEVELOPMENTS

by Frank Booty

In the '80s, the use of facsimile (fax) grew explosively in the industrialised countries. Indeed, between 1979 and 1987, fax production increased by a factor of about 40, according to market researchers Frost and Sullivan. In both 1987 and 1988 the market doubled in size for each year. Today, half of the installed base is in Japan, while Japanese fax manufacturers comfortably dominate the world market with a share of some 95%.

According to market researcher Dataquest, the compound annual growth rate for unit shipments of fax in the total European market for the period 1985 to 1989 was 103·2%, while the predicted CAGR for 1990 to 1994 is 7·6%. The European installed base is expected to continue to grow, but at a more gradual rate. By the end of 1989, the fax installed base in Europe had nearly doubled to 3·0 million units, and is forecast to grow to 7·5 million units by the end of 1994.

Fax shipment growth slowed down in the UK, Sweden and the Netherlands in 1989. These are countries where fax was easily adopted, and a high ratio of installed fax machines to working population was achieved (in comparison with other European countries).

In technology, volume production and price, the Japanese manufacturers have been in the lead. Most European and US companies in the fax market sell Japanese manufactured faxes on an OEM basis. Canon and Panasonic (Matsushita) maintained their strong positions as European market leaders in the fax arena. In 1989 Canon maintained the number one position with 18·7% of units shipped, while Panasonic gained 16·8% of the market. Competition stemmed mainly from Ricoh, Oki, NEC, Toshiba and Murata, with each company holding between 6·0 and 8·0% of the market.

Frost and Sullivan sees the market undergoing a transformation, from a technology-driven to a user-driven one, for two key reasons: a near saturation of new users in large corporations, and the rapid growth of placements in medium sized companies; and a downwards flow of technology which has allowed new models at a relatively lower end to import features from the higher end machines of the earlier generation.

Any location that has a public switched telephone network (PSTN), dial-up telephone line and fax machine capability that conforms to *Comite Consultatif International de Telegraphie et Telephonie* (CCITT) standards can send and receive documents. As a consequence, says Dataquest, current market growth is being driven by the attraction of a growing community of fax users, increasing machine reliability and ease of use, and also by decreasing equipment prices.

A Pitney Bowes' 9000 fax machine giving vital service to BR's Red Star communications operations.

The acceptance of CCITT standards has allowed fax equipment to communicate on a worldwide basis over the standard PSTN. It is noteworthy that PSTN tariffs are frequently less expensive than the transmission costs of other text messaging services. Indeed, fax is now perceived as a commodity office product in the medium size to large business. Sales effort is now targeted at instilling this perception in the mind of the office purchaser in smaller businesses.

Most stand-alone fax units sold in Europe are imported from Japan. However, some companies have manufacturing/assembly plants in Europe, notably Alcatel in France. Previously, Alcatel had a monopoly in the domestic market with its own Thomfax range, but it now manufactures fax machines of Toshiba design.

In 1990 Olivetti Office formed a joint

venture with Sanyo and Mitsui known as *Olivetti Sanyo Industriale* (OSI) to design, manufacture and market fax products specifically for the European market. The machines are produced in southern Italy, and cater for the low to mid volume sectors of the fax market.

Since its entry into the US fax market in April 1982, Pitney Bowes has had a strong market presence. One of its main areas of expertise lies in fax networking, which allows Pitney Bowes to address the needs of organisations and adapt software packages to suit individual communications and network requirements. It was one of the first fax companies to offer relay and relay broadcast capability with other (non Pitney Bowes) machines through the use of hard disk memory.

It was the first company to make available remote diagnostic and corrective capabilities throughout its range, and also the first to introduce non-volatile disk mass memory. In 1984 it announced a proprietary error correction and detection standard, which is still superior to even the latest CCITT scheme.

Fax equipment is generally sold either by PTTs or by big name telecomms and office equipment companies selling direct or through their distribution channels. The trend is moving increasingly towards distribution of fax machines through office equipment rather than telecomms distribution channels. Fax has proved to be a successful complement to the former's product range, and in turn this channel has achieved volume sales for fax manufacturers.

The national PTTs retain strong supplier positions in all countries, but in many cases their market share is being eroded. Many of the Japanese manufacturers, which also manufacture photocopiers, have now entered Europe under their own brand names. For instance, Toshiba and Ricoh now sell direct via their established photocopier distribution channels as well as through their appointed European distributors.

In terms of technology, vendors have been compelled on the one hand to upgrade and expand their high end products, which are typically sold to the larger corporations, and on the other to shift attention to the smaller business market segments and differentiate their products to secure a competitive edge. Innovation in the use of technology has resulted in dramatic improvements in the price/performance of fax products over the past five years. Vendors have invested heavily in enhancements that have improved image quality through higher resolution, grey scale and error correction capabilities; achieved communication cost savings through the use of higher modem speeds and data compression techniques; improved print quality through the use of new print technologies such as laser print engines; and added functionality through the incorporation of memory and programmed value added features such as broadcasting, store and forward messaging and secure reception.

Another emerging technology, says Frost and Sullivan, is the high end market for increased features at the departmental level. This is largely the result of the growth in office decentralisation, and implies efficient networking of satellite fax machines through an intelligent hub to optimise and control traffic.

An Olivetti Office OFX 330 AC fax machine aimed at the low to mid volume European market.

Dataquest considers that fax is acting as a springboard for innovative products and services. The key question is, how does the traditional fax manufacturer take advantage of these innovations?

As intimated earlier, Dataquest expects the dramatic growth of the European fax market to slow down in the next few years as markets begin to mature. While medium-sized to large, and also some small, companies have quickly recognised the benefits of fax, Dataquest anticipates that penetration of small companies will generally be more gradual. Replacements are expected to become significant from now on.

Dataquest envisages new features becoming popular, such as store and forward facilities, plain paper printing, remote diagnostics and adjustments, RS232C data ports, etc. As fax users become more aware of the potential advantages of high-end features, they are expected to upgrade from mid-range to high end machines.

The popularity of low-end machines will continue, but in order to stabilise prices, mid-range features will be incorporated into this category. The trend – as foreseen by Dataquest and Frost and Sullivan – will be towards a gradual split in the market between high and low-end machines.

Plain paper fax, using laser and light emitting diode (LED) printing technologies, is expected to become very popular from 1992 to 1993 onwards, and move towards being a standard offering on high-end machines. Indeed products are now on the market, for example Fujitsu's Faxjet, which is basically a feature-rich fax linked to an existing laser printer.

Colour fax is not expected to become common in the next few years except in specialised high cost applications. Currently the hardware is expensive, and transmission costs are high due to the very long transmission time.

Personal Computer (PC) fax cards, which allow a PC to send PC generated text, are thought by Dataquest to offer a potential to the stand-alone PC user. It is expected to appeal to PC users wishing to send text directly from their PCs regularly, rather than to those seeking a substitute for the stand-alone fax machine.

However, this particular sector has yet to see an acceptable product and is not expected to take off for some time, if at all. The potential for fax on local area networks (LANs) however, where a fax server allows all PC users to access the fax facility, is considered by Dataquest and others to be great. Although the necessary software was not initially user friendly, work has been undertaken to improve the difficulties. Reception of faxes at an individual's PC can also be expected in the future, which will render fax on LANs as an attractive option.

Many integrated fax and copier products have been launched in Europe (for example the Xerox 3010 fax and copier), but pricing and reliability are key issues in determining the uptake of this type of product. However, there is as yet no competitive pricing of the products, as the equivalent products are still cheaper individually.

Back in 1987, a number of cellular radio operators began offering hardware enabling fax to be used with car cellular equipment. However, little impact has been made due to the poor quality of the cellular network making the successful transmission of faxes difficult. Furthermore, the communication is usually expensive as the modem speed drops due to the poor line quality, thus raising transmission time in the high cost cellular network. An alternative fax service to cater for motorists (commercial salesmen for instance) is becoming common at petrol filling stations.

Fax has not penetrated the domestic environment, except where business is conducted from the home. Currently, the potential appears limited: prices are high, even for low-end machines, and although fax has made an impact in the business culture, its function in the home is not apparent to users. Little success has been achieved through the retail and mail order distribution channels. However, if these should develop, and price levels for low-end machines drop accordingly (and dramatically), a domestic market could evolve.

Vendor strategies are directed at identifying the feature combinations most attractive to potential target groups. To support activities across the board from the low to the high-end, vendors have aimed at establishing distribution channels geared both to target group penetration and maximising national coverage. The high-end segment has typically comprised key corporate or institutional accounts, supported by a direct sales force having the technical qualifications required, in particular, for service support. Japanese vendors have been setting a high priority on setting up strategic alliances and manufacturing capacity in Europe to maintain – or gain – an insider position on the market for '1992' (in reality January, 1993). This factor is sure to become increasingly important.

Group IV will initially be targeted at heavy fax users – large organisations with heavy international usage – rather than the mass market. Group IV's enhanced performance will only be achieved if both communicating machines are of this group. Thus, initially, return on investment will only be assured when the receiving machine is known to be Group IV. An example of a Group IV fax terminal is the HF 2403 launched by Siemens last year.

Such are the technological developments in Group III machines that their performance is approaching that of Group IV. Despite major backing from such major PTTs as France Telecom and Deutsche Telekom, Group IV has not taken off as quickly as many had hoped. Group IV equipment remains costly, and depends on the availability of ISDN or other digital networks – hence its adoption will probably be gradual.

The CCITT study group VIII proposed a new analogue standard, Group IIIbis, which offers similar transmission speeds to Group IV but without the optimisation coding and high resolution. It also adds a 56/64K-bit/s interface to a standard Group III machine. All this will help to keep the costs of the total machine down. The advantage is that these machines will be able to support transmission speeds from 4,800 bit/s to 64K-bit/s on digital or ISDN circuits.

The CCITT have been busy working to respond to the requirements of faster fax transmission. T.3, T.4 and T.30 specifications were drawn up in response to the request for a high speed modem for use with Group III fax. Various approaches were considered by Study Group 17, based on existing modulation techniques and standards. US vendors were interested in seeing a half duplex modem standard and were trying to get it standardised on that basis. Some wished to pursue a subset of the V.32 echo cancellation techniques, while others were very keen on half duplex.

Pitney Bowes' 9000 model can transmit and receive in as little as 6·3 seconds, utilising new standards in error correction.

One of the ideas was to base a standard around the V.34 proposals. Instead, the V.33 modem standard was adopted as the basis of the V.17 fax modem standard. It is not actually a modem definition as it lacks certain elements, for example, there is no description of an interface to a terminal. It is a model scheme for use by fax systems.

The CCITT is the body which has established standards for fax. As these were agreed early and adhered to by manufacturers, compatibility was ensured. This has allowed fax to become the most popular text communications medium. In summary, the CCITT has established recommendations for protocol and transmission standards, scans per millimetre and scan direction.

MARKET VIEW

Unlike many other existing vendors and new entrants to the UK market, Pitney Bowes sells direct to the end user, with a fax-only sales force. There is no intention of using a dealer channel in the UK. Fax is also sold direct by the company in the USA, Austria, Australia, Canada, Germany, Switzerland, Finland, Sweden and Ireland. Sales are handled through dealers in 50 other countries.

Companies with larger, more complex fax applications and networks are Pitney Bowes' primary targets – those businesses and organisations to whom fax is an essential and integral part of their business communications system. Occasional fax users are not principal targets of the company.

However, there are advantages for the smaller company in using Pitney Bowes equipment when dealing with larger organisations which have Pitney Bowes fax embedded in their communications infrastructure. These include reduced transmission times with the network, and error correction and detection facilities superior to CCITT standards.

The company questions whether the benefits offered by Group IV fax technology really justify the current high purchase prices. Most organisations say 'no' for the short term, especially since the new, high modem speed Group III machines which cost considerably less than Group IV models but can achieve transmission speeds as fast as 6 seconds per page.

Customer interest tends to lie more in enhancing the network and improving the quality of received transmissions. This is an area where Pitney Bowes concentrates time and resources, in terms of the research and development of laser plain paper technology.

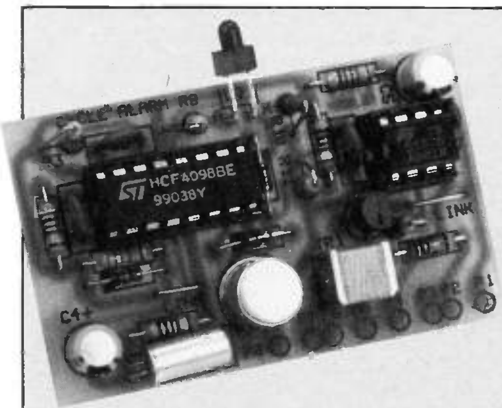
Pitney Bowes claims to offer the only Group III fax product line in the market today which uses (virtually) identical operator prompts and function keys across the entire range. This feature is intended to simplify operation and training for all customers who require more than one system within their organisation.

Two communications interface software options are offered: terminal interface and dual network interface. The former allows users to create documents on any computer or data terminal that will produce ASCII code, and send it electronically from the terminal to a compatible Pitney Bowes fax machine for

Continued on page 31.

On the make with Maplin!

Three exciting new projects for you to build



Arm your bike!

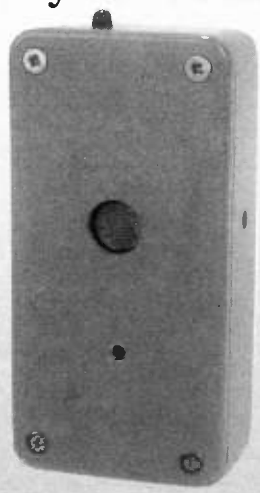
An easy to construct alarm kit that will 'arm your bike' against potential theft. Sensors will be triggered should your bike be tampered with, and the sounder will emit a very loud 110dB 'screech' for 2 minutes (assuming your battery is in tip-top condition).

The case can be made tamper-proof, and a flashing red LED will indicate that the alarm is armed. An optional handlebar mounted switch, which should be easily available from your local bicycle supplier, allows the siren to be used as a momentary warning signal and personal attack alarm.

With an increase in thefts of vehicles of all kinds, an alarm of this type makes great sense for your bike and at only £14.95, makes great sense for your money!

LP76H (Cycle Alarm Kit) £14.95

Would you know an open and shut case if you saw one?



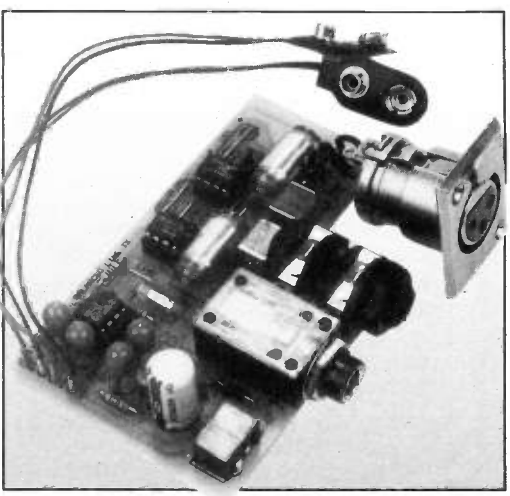
A variety of applications requiring a light-operated alarm can be satisfied with this extremely low-priced but effective 'Peep Alarm' kit.

A typical application for this alarm would be to indicate that a case or cupboard is open, or to give a warning when the door of a dark-room is opened, or a light switched on.

The alarm is designed to give a purely local indication, and is not audible over long distances. It will operate in an environment where there is a significant increase in light level.

LP50E (Peep Alarm Kit) £6.95

The great stage leveller



Long cable runs invariably suffer from hum and noise pickup; the Audio Balanced Line Driver has been developed to overcome such problems. The unit is ideal for connecting on-stage instruments, such as synthesisers and guitars, to balanced line inputs on a mixing desk many metres away. Similarly, a balanced stage 'foldback' feed may be provided from an unbalanced mixer output.
A number of additional parts may also be required, see issue 49 (XA49D) of 'Electronics' for full details.

The Maplin 'Get-You-Working' Service is available for all three of the projects featured on this page, for full details see the Constructors' Guide or the current Maplin Catalogue.

LP49D (Audio Balanced Line Driver Kit) £14.95

Where can you get them?

Maplin stores nationwide: Birmingham, Brighton, Bristol, Cardiff, Chatham, Coventry, Glasgow, Leeds, Leicester, London (Edgware and Hammersmith), Manchester, Newcastle-Upon-Tyne, Nottingham, Reading, Sheffield, Southampton, Southend-on-Sea. Ring 0702 552911 for further details. For all Mail Order purchases add £1.00 p&p. All items are subject to availability, all prices include VAT.

Maplin The positive force in electronics

CREDIT CARD HOTLINE 0702 554161. Mail Order to; P.O. Box 3, Rayleigh, Essex, SS6 8LR.

The Oscilloscope in ACTION

Part 4 by Graham Dixey, C.Eng., M.I.E.E.

In normal use, that is when displaying a waveform, the electron beam in the cathode ray tube is deflected in the X direction by a regularly recurring, linear sawtooth, waveform. At the same time, the signal whose shape is to be examined is applied to the Y plates. The resultant deflecting forces, acting on the electron beam in the two directions, produces an accurate display of the Y waveform. This is a direct consequence of driving the beam in a linear fashion from left to right.

Suppose instead that some other waveform is applied to the X plates, the sawtooth wave being disconnected. This will obviously produce a display whose nature will now depend upon the type of signal that has been applied to the X plates. While there are obviously many possibilities, the method most commonly used is to drive both the X and Y deflection systems with sinusoidal signals. When this is the case, the display produced is determined by the relative amplitudes, frequencies and phase angles of the two sinewaves. Assuming that the amplitudes can be approximately equalised by adjusting the Y gains, the attention can then be focused on their relative frequencies and the phase relation.

Lissajous Figures

The type of display produced by simultaneously driving the X and Y systems with sinewaves is termed a 'Lissajous figure'. The mode that allows this type of display is the X–Y mode, this being switch-selectable on the front panel of the CRO. One of the Y inputs then functions as an X input instead, and allows the use of that Y amplifier as a means of adjusting the amplitude of the X drive. The mechanism which produces a Lissajous figure is shown in Figure 1.

Figure 1(a) shows the path traced out by the spot when it is deflected by a pair of sinusoidal voltages of the same frequency and phase. It is assumed that the amplitudes are also identical. The points marked A, B, C, D and E in both the X and Y directions are points that are coincident in time. For example, both waveforms start at point A and both terminate at the point E. The positive peaks both occur at instant B, while the negative peaks both occur at the instant D. The result is that the spot traces out a diagonal, straight line path on the face of the tube. The deflection voltages are 'in step' with each other.

However, when the waveforms are 90° out of phase as in Figure 1(b), the voltages are no longer in step. For example, at point A, when the Y waveform is zero, the X waveform is at a positive maximum; the spot has no Y deflection but maximum positive X deflection. The result is that the spot is at the centre right-hand side of the tube. Ninety degrees later, when we are considering point B, the Y deflection is maximum positive while the X deflection is zero; the spot is now at the top centre of the tube. Continuing this argument would lead to the inevitable conclusion that the path of the spot was a perfect circle.

Since 0° and 90° are not the only possible phase relationships, it follows that there must be many other possible patterns. Some of them are shown in Figure 2, in which Lissajous figures for all phase angles in 45° steps from 0° to 360° are represented. Note how the pattern varies as the angle changes from 0° to 180°. First it is a diagonal line sloping right, then passes through being an ellipse at the same angle to being a circle. After which, it becomes an ellipse at the alternative slope, and finally a straight line at this slope.

This seems to imply a specific relationship between the proportions of the Lissajous figure and the value of the phase angle. This is true, and is stated in Figure 3.

In this figure, the dimension A is the width measured at the mid-point when the X and Y shift controls have been used to centre the display exactly on the graticule. Dimension B is the extreme width of the figure, which is easily measured by using the Y shift control only. The Y shift is first used to align the left edge of the figure on the major X axis; the distance of this intersection of the X axis from the centre of the graticule is then read off and noted. The Y shift

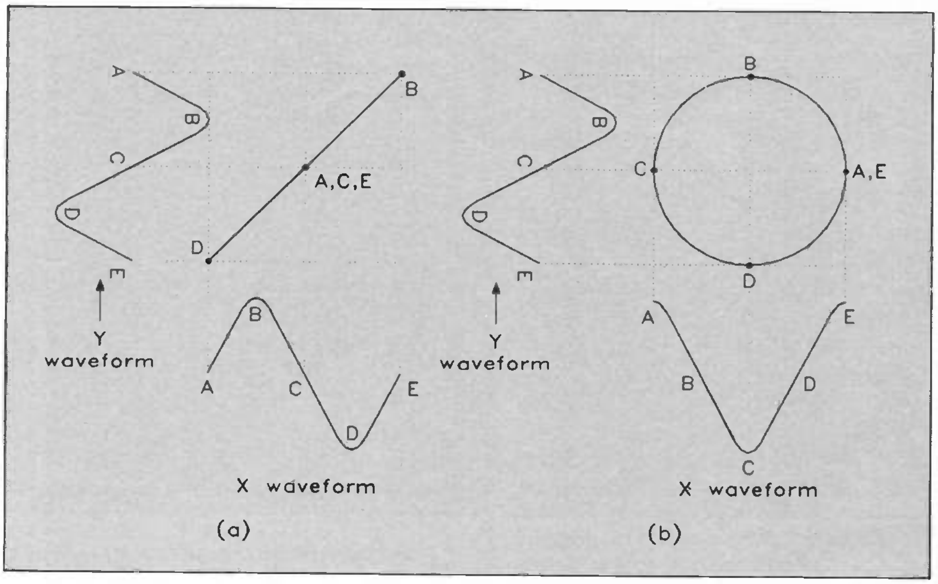


Figure 1. (a), Lissajous figure for 'in-phase' sinewaves of equal frequency; (b), the Lissajous figure for the same waves when 90° out of phase.

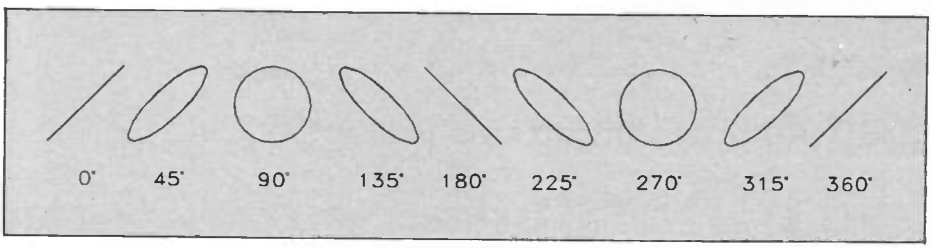


Figure 2. Lissajous figures for phase angles between 0° and 360°.

control is then used to position the right hand edge of the figure in a similar fashion so that it cuts the X axis. Its lateral distance from the graticule centre is also noted. The sum of the two distances measured is the dimension B.

Try applying this formula to the specific cases of the angles 0° and 90°. For a phase angle of 0°:

$0° = \sin^{-1}(A/B)$

From which it is evident that A must equal zero (since $\sin 0° = 0$), the figure therefore being a straight, diagonal line. For a phase angle of 90°:

$90° = \sin^{-1}(A/B)$

From which $A = B$ (since $\sin 90° = 1$) and, hence, the figure must be a circle.

Although the above assumes that both signals are of equal amplitudes, they do not necessarily have to be so for the method to work. Even if they differ greatly in amplitude, all that is necessary is to adjust the Y gains until the figure occupies a large, and hence easily measurable, proportion of the screen area. During the course of plotting the phase/frequency relationship of a network for example, it will be found that the phase angle changes markedly as does the signal amplitude. This point often worries newcomers to the Lissajous method, who think that if the Y gain control is constantly being adjusted it must, in some way, affect the validity of the measurement. The fact is that it makes no difference at all. The measurement depends solely upon the *relative* values of the dimensions A and B, and this relation does not change when the gain in either direction is changed.

In general, this method of measuring phase angle is quicker and more accurate than the double-beam method discussed in Part 3 of this series. It is useful to employ this method in plotting the amplitude/frequency and phase/frequency relationship for an amplifier or network, using a set-up similar to the one shown in Figure 4. The network is supplied with a constant amplitude, variable frequency input from a signal generator. The output of the network is connected to an analogue electronic voltmeter, and the dB scale on this

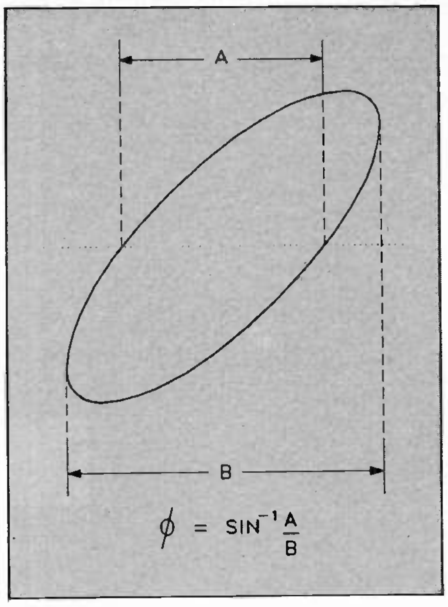


Figure 3. Using the proportions of the Lissajous figure to measure phase angle.

instrument is used to record the relative output level directly. The datum for these measurements is often the decibel reading (sometimes conveniently set to 0dB) at a frequency of 1kHz. The CRO X input is connected across the input of the network; the Y input monitors the output of the network. The X-Y mode is selected and the gains are adjusted for a sensible size display. The readings of the voltmeter and the dimensions A and B of the Lissajous figure are recorded over the required range of frequencies. A column for phase angle is provided and this is filled in later when the calculations using the formula given previously have been carried out. The two responses can then be plotted, usually on log./lin. graph paper.

X and Y Signals of Different Frequencies

The use of Lissajous figures is not limited to the measurement of phase angle differences between signals of the same frequency, by which in practice we mean the relative phase of the same signal at different points in a system or network. When two signals of *different* frequencies are used to deflect the beam in the X and Y directions, some very interesting patterns appear. Stationary, or very near stationary, patterns occur when the ratio of the two frequencies is the ratio of two integers such as 1:2; 2:1; 3:2; 5:2, etc. Some of the patterns possible are shown in Figure 5. There is a specific logic to these patterns that allows the exact numerical relationship between the X and Y frequencies to be determined. This is illustrated in the general case in Figure 6.

Provided that the display can be persuaded to slow down sufficiently (it has a tendency to rotate in the horizontal plane), counting the number of 'lobes' in each direction – giving integers A and B – allows the numerical relation stated above to be established. What this means in practice is that if one of the frequencies is an unknown and the other is known, then the unknown can be determined! It is usual to use an accurately known or accurately calibrated source for

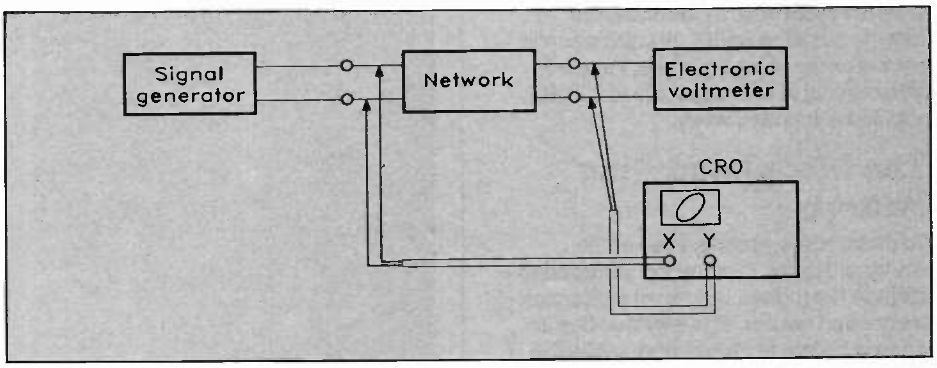


Figure 4. Using the CRO, with Lissajous figures, to measure the amplitude/frequency and phase/frequency characteristic of a network.

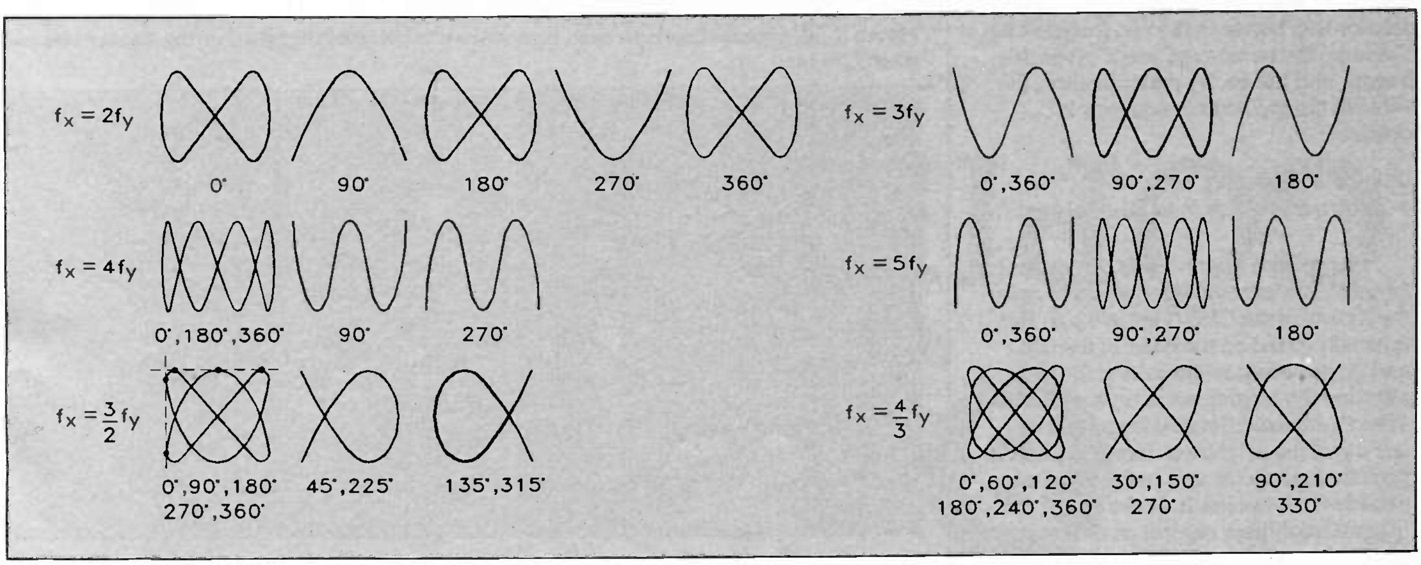


Figure 5. Some possible Lissajous figures obtained when the X and Y frequencies have specific integral relationships.

the known frequency, such as a signal generator. The frequency of the latter is carefully adjusted to obtain a stable and recognisable pattern. The best pattern, if it can be achieved, is the 1:1 circular pattern. The greater the difference between the known and unknown frequencies, the more difficult the method is to use.

The use of Lissajous figures as a means of measuring frequency predates the arrival of the digital frequency meter by many decades. Obviously nobody in their right minds would use a CRO to measure frequency if they had a digital instrument available. However, very often the latter simply isn't available, especially in an amateur context, whereas a CRO almost certainly will be to hand – hence the justification for the method described.

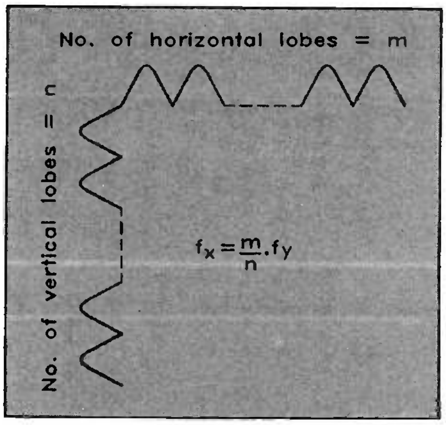


Figure 6. Using the Lissajous figure to determine an unknown frequency.

The Circular Timebase

This is a special case of the Lissajous figure and is obtained when the two driving signals are 90° out of phase. It was shown, in Figure 1(b), how it is produced, but what is the use of it? The answer is that it can be 'modulated' with a signal of higher frequency to produce a recognisable pattern when these two frequencies have (again) an integral relationship. This is often used for fairly high frequency ratios, e.g. 10:1 or greater. The basic circuit for generating a circular timebase is shown in Figure 7.

To obtain a true circle with equal X and Y gains, the voltage V_C and V_R must be the same. For this to be true, the reactance of the capacitor C must equal the value of the active portion of the variable resistor R. In practice, the latter is adjusted until a circular trace is seen. For the values given in Figure 7, frequencies in the range 100 to 2000Hz should be found to work.

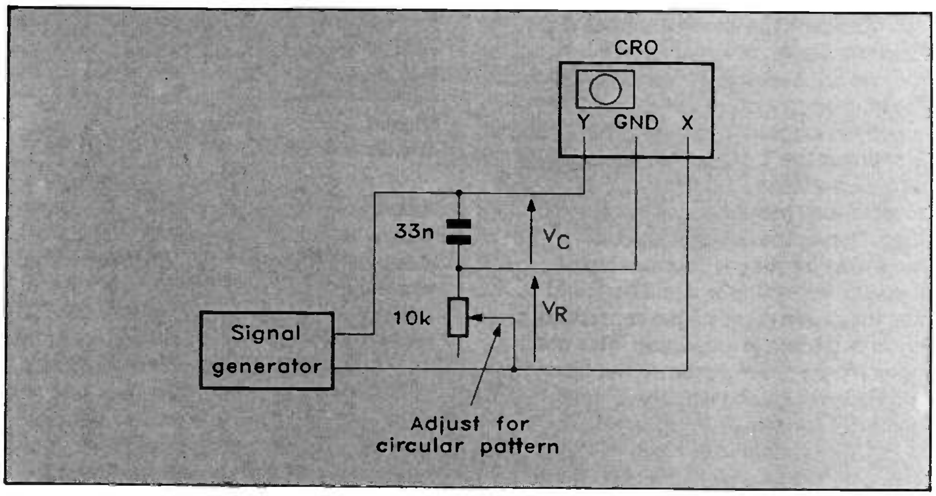


Figure 7. Circuit for generating a circular timebase.

The Modulated Ring Pattern

To make some practical use of the set-up of Figure 7 it must be modified to include the higher, unknown frequency mentioned earlier. The way that this is done is shown in Figure 8(a), while the 'gearwheel' pattern produced appears in Figure 8(b). The display will be stationary when there is an exact integral relationship between the two frequencies. Counting the number of 'teeth' gives this integer and hence, by multiplication, the value of the unknown frequency is obtained.

Unknown frequency
= known frequency × number of 'teeth'.

A variation on this method is obtained by using the unknown frequency to drive the Z input of the CRO (Figure 9(a)). This is usually found on the back of the CRO, and gives access to the grid of the tube, allowing the brightness to be controlled. When a sinusoidal signal is applied to this input, the brightness increases on the positive half-cycles and reduces on the negative half-cycles. It works best if the manual brightness control on the front panel of the CRO is used to reduce the brightness as low as possible without the display actually disappearing. The variations in brightness on the two half-cycles is then particularly evident, the display becoming noticeably brighter on positive half-cycles and disappearing completely on the negative half-cycles. The display consists of a segmented circle as shown in Figure 9(b). It is used as for the modulated ring pattern but substitute segments for teeth.

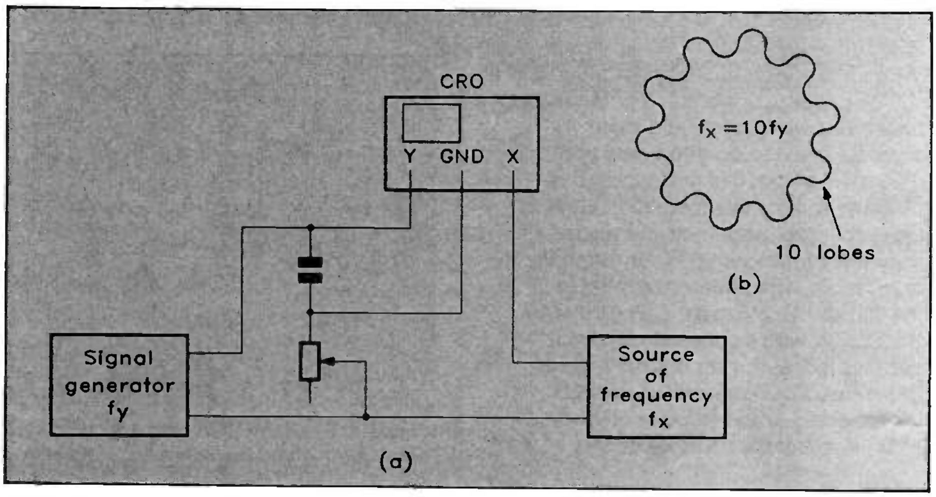


Figure 8. (a), circular timebase used to produce a 'modulated ring' pattern; (b), display obtained when $f_x = 10f_y$.

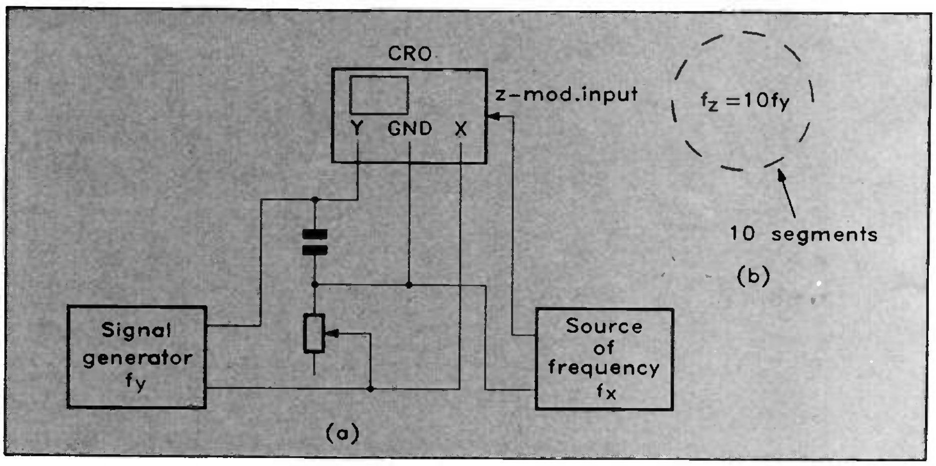


Figure 9. (a), circular timebase used to produce a 'broken ring' pattern; (b), display obtained when $f_x = 10f_y$.

Observation and Measurement of an A.M. Wave

The amplitude-modulated radio wave is one in which the carrier amplitude varies in accordance with the modulating signal waveform. There is an upper limit to the degree of modulation that can be impressed upon the carrier, this being expressed by the 'depth of modulation'. The theoretical limit is 100%, which is obtained when the modulated wave swings between zero and twice the unmodulated amplitude. The calculation for modulation depth is easily carried out, as shown in Figure 10, if the waveform is displayed on the CRO just like any other signal waveform. This may require the use of a RF probe to achieve it but, when displayed, the amplitudes A and B shown allow the calculation to be made. There is no need to invoke voltage measurement, the use of the calibrated Y axis on the graticule being sufficient.

For example, if height A is found to be 6cm and height B is 4cm, then the depth of modulation is given by:

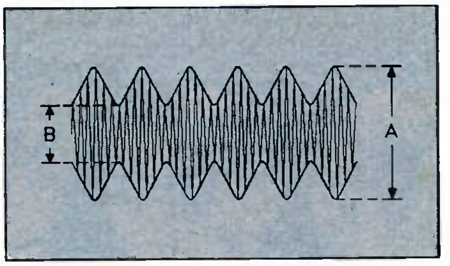


Figure 10. Measuring depth of modulation of an AM wave, using a conventional type of display.

Depth of modulation
$= (A - B)/(A + B) \times 100\%$,
$= (6 - 4)/(6 + 4) \times 100\%$,
$= 20\%$.

Distortion of the a.m. wave and effects such as over-modulation can also be observed in this way. However, there is an alternative method, similar to the use of Lissajous figures, in which the a.m. signal is applied to the Y input and the modulating signal alone is used as the X drive. This produces the type of display seen in Figure 11(a), (b) and (c).

Figure 11(a) shows a normal, undistorted a.m. wave for which the heights A and B have the same meaning as previously. Thus, depth of modulation can be determined by using these dimensions and the fact that there is no significant amount of distortion present is deduced from the linearity of the slope.

Figure 11(b) shows the type of display that might result if there is some distortion in the modulating waveform. The evidence is the non-linear slope.

Figure 11(c) shows the effect of over-modulating the wave.

The method does, of course, assume that the modulating signal is available as a separate entity. This is likely to be true whether we are considering either transmitters or receivers. In the case of a transmitter an audio-frequency signal generator could be used to provide the modulation input while in the case of a receiver, this could be fed from a modulated RF generator, in which the modulation signal is usually separately available as a matter of course.

That concludes this short series on the use of the CRO, which it is hoped that readers will have found both useful and interesting.

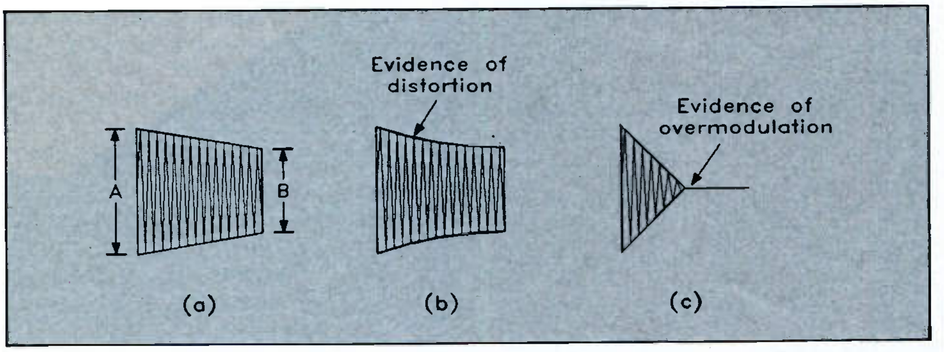


Figure 11. Measuring and observing modulation of an AM wave when (a), modulation is correct; (b), modulating waveform is distorted; (c), wave is over-modulated.

Fax Developments continued from page 26.

distribution to up to 99 local or remote fax systems. The fax plus terminal interface allows any other fax machine to function as a remote terminal printer.

This method of mail distribution is also more secure for sending confidential information. Documents are created on-screen and downloaded to the fax, but by utilising its private mailbox facility, the fax machine will not release a hard copy of the document until it receives authorisation. Thus only one hard copy is produced, and privacy is guaranteed.

It is also possible to have an enhanced version of the product which allows up to five images as well as text to be transmitted, for example a corporate logo and up to four different signatures could be stored in the PC's memory by using the fax as a scanner. These can then be used to 'top and tail' external correspondence by calling up the appropriate codes, and so giving faxed messages the look of a business letter.

The dual network interface enables fax machines to utilise the most cost effective transmission routes through accessing a range of high-speed fixed cost data lines, as well as PSTN lines. Compatibility is allowed with digital networks, enabling Group III machines to transmit at speeds normally only associated with Group IV models.

The fax system's DNI is plug compatible with statistical multiplexers, switching multiplexers, T1 multiplexers, X.25 PADs and digital PBXs. It also enables companies to add value to their private data networks by making use of spare line capacity for internal fax comms, saving money on transmission costs.

In some organisations, fax documents can contain sensitive, confidential material and the possibility of fax 'wire tapping' becomes a concern. Encryption devices 'scramble' the transmission so it is impossible for an unauthorised person to intercept a document. Through an RS232 hardware board and special software, it is possible for units to interface with most commercially available encryption devices.

When sending a document via a fax with the encryption modem attached, the information is scrambled and transmitted, then 'decoded' and printed at the remote location, so reducing the risk of any unauthorised third party gaining access to that information.

MERCURY RELEASES CABLE AND WIRELESS SUREFAX

Mercury Communications has released Cable and Wireless Surefax in the UK, which is part of Cable and Wireless' globally managed service to provide multinational organisations with a more cost-effective means of sending a fax. Already in operation in the US, Hong Kong, the Phillipines and Italy, Surefax uses existing equipment – customers continue to send faxes in the normal way, but will find that documents are always sent first time.

A company sending an average of 6,000 faxes a week is said to be spending over £100,000 a year to pay staff to watch paper go through a machine. Surefax can broadcast to hundreds of fax machines simultaneously, will automatically reconnect if there is disruption on the line and can defer faxes to take advantage of off-peak rates and time zone differences. It is said to be the only globally managed fax service in the world which does *not* force users to change the way they send faxes.

As well as saving staff time, the UK Surefax service costs on average 13% less than sending an international fax via BT, when compared to BT's basic PSTN charges. As there is no charge for disconnects or retries, companies can expect to make further savings in transmission and people costs. Research has also shown that, for multinationals, 30% of their fax traffic comes from international faxes, which account for 80% of their fax bill.

Mercury has already signed (as of October, 1991) 22 blue chip companies onto the Surefax service, including one of the UK's largest High Street banks. Mercury's Surefax switch is probably the largest single fax exchange in the world.

100W PRO-AMP

by Joe Fuller

F E A T U R E S

★ Standard 19in. 2U Rack Mounted Case ★ 100W RMS Power Output ★ Balanced Line Input ★ Loudspeaker Protection ★ Switch-on Mute ★ Thermal Protection

A P P L I C A T I O N S

★ Instrument Amplification ★ Stage Foldback ★ Small Venue P.A. ★ Studio Monitor Amplifier

Specifications of Prototype

Input Impedance:	100kΩ
Rated Load Impedance:	4 to 8Ω
Maximum Power Output:	
4Ω	105W RMS
8Ω	90W RMS
THD @ 75W (1kHz):	0·02%
Signal to Noise Ratio:	85dB
Input Sensitivity for Rated Output:	
4Ω	−13·65dBm/160mV RMS
8Ω	−11dBm/215mV RMS
Maximum Input Level:	+8dBm/1·9V RMS
Frequency Response:	10Hz to 40kHz −1dB
Supply Voltage:	240V AC 50Hz
Power Consumption:	
Quiescent	17W
At Rated Output	194W(4Ω) 130W(8Ω)
Dimensions:	483 × 88 × 370mm (W.H.D.)

Over the years 'Electronics' has published a number of very popular designs for high quality audio projects. Each of these have been 'building blocks' to form part of a complete system or unit. However, details on how to put together a complete amplifier based around such projects, although often requested, have not been published previously.

The particular projects used in this amplifier are Dave Goodman's (recently revamped) 150W MOSFET Amplifier, and Alan Williamson's High Quality Power Supply. To complement the power side of the amplifier, an equally good input stage is required; Gavin Cheeseman's SSM2016 Differential Preamplifier is ideal in this application. No high quality amplifier is complete without protection circuits, and in this case the Amplifier and Temperature Monitor projects, both designed by Alan Williamson, are an ideal choice.

However, to form a complete amplifier, each project needs to be 'tailored' a little; to give the required performance and allow the projects to interconnect. Construction of the amplifier also requires numerous items of hardware. Additionally, careful layout and wiring are prerequisites to ensure that the amplifier is safe, electrically stable and free from hum and noise.

The 100W Pro-Amp is not intended as a 'domestic' amplifier, but instead as an amplifier for use on-stage, in the recording studio or other similar 'professional' applications. As such, the Pro-Amp is comparable, in terms of price, performance and features, to many commercial amplifiers.

Features and Facilities

The Pro-Amp includes many features to make it as versatile and easy to use as possible, these include:

The amplifier is housed in a strong and attractive 19in. 2U rack mounted case for longevity and ease of integration with other professional equipment.

A Balanced line input is provided on both ¼in. jack and 3-pin XLR sockets; the input stage is very low noise and offers excellent rejection of interference when driven from a balanced source. The input stage is AC coupled and has an impedance of 100kΩ. The balanced input is compatible with unbalanced signal sources to ensure compatibility with a wide range of equipment.

To guard against switch-on and switch-off transients, power amplifier faults and other such 'nasties' that can damage expensive loudspeakers, an amplifier monitor is included. If a fault has occurred and has been cleared, the monitor circuit can be reset by means of a front panel switch.

Thermal protection is also provided to protect the amplifier from excessive temperature rise.

LEDs are provided to indicate the status of the amplifier (switch-on time-out, amplifier OK, amplifier shutdown, and thermal shutdown) and presence of the power amplifier supply rails.

The loudspeaker output is available on both a ¼in. jack socket and a 3-pin XLR plug. The amplifier output is DC coupled and can drive loads down to 4Ω.

To minimise susceptibility to mains borne interference, the 240V AC 50Hz mains supply is connected via a 3-pin filtered mains inlet.

Rear panel fuseholders are provided for the mains input and amplifier supply fuses.

Adjustment of input sensitivity is provided by a front panel level control.

Module Construction

The kit of parts contains the five kits that comprise the amplifier, plus the additional parts required. Construction begins with the individual kits.

150W MOSFET Amp

Construct the amplifier as described in the instructions that accompany the kit; no modifications are required.

HQPSU

Construct the HQPSU as described in the instructions that accompany the kit; however, the following changes are required:

Fit a wire link in place of D9 and do not fit PL1; the unregulated 17V output is not required.

Fit a wire link on the underside of the PCB between the negative lead of C3 and the positive lead of C12; this 'commons' both signal and power 0V lines.

SSM2016 Preamplifier

Construct the SSM2016 Preamplifier as described in the instructions that accompany the kit; however, the following changes are required:

R1 and R2, fit 100kΩ 0·6W metal film resistors instead of 10kΩ; this increases the input impedance to 100kΩ.

R3, fit 10kΩ 0·6W metal film resistor instead of 470Ω; this decreases gain to around 3·5 times.

Fit PCB pins P1, P2, P3, P7 and P8; do not fit the remainder of the PCB pins.

Construct the AC Coupling Module as shown in Figure 1. Cut the stripboard to size (7 holes by 5 strips) and make two track cuts as shown. Fit the four PCB pins; note that the PCB pin that will be situated *between* the capacitors should be fitted from the *component* side of the stripboard, this is to facilitate connection to the preamplifier PCB. Fit the two 1μF polylayer capacitors. Do not trim the component leads nearest the edge of the stripboard; this is to facilitate connection to the Preamplifier PCB.

Locate the PCB pin and capacitor leads of the AC Coupling Module through holes P4, P5 and P6 of the Preamplifier PCB and solder.

Amplifier Monitor

Construct the Amplifier Monitor as described in the instructions that accompany the kit; however, the following changes are required:

Referring to Figure 2, lay the Temperature Monitor PCB over the Amplifier Monitor PCB (RL101 area – see Photo 1) so that the corner mounting holes align. Mark the Amplifier Monitor PCB through the Temperature Monitor PCB mounting hole adjacent to TH1 connector legend. Drill a 3·5mm diameter hole through the Amplifier Monitor PCB, at the position

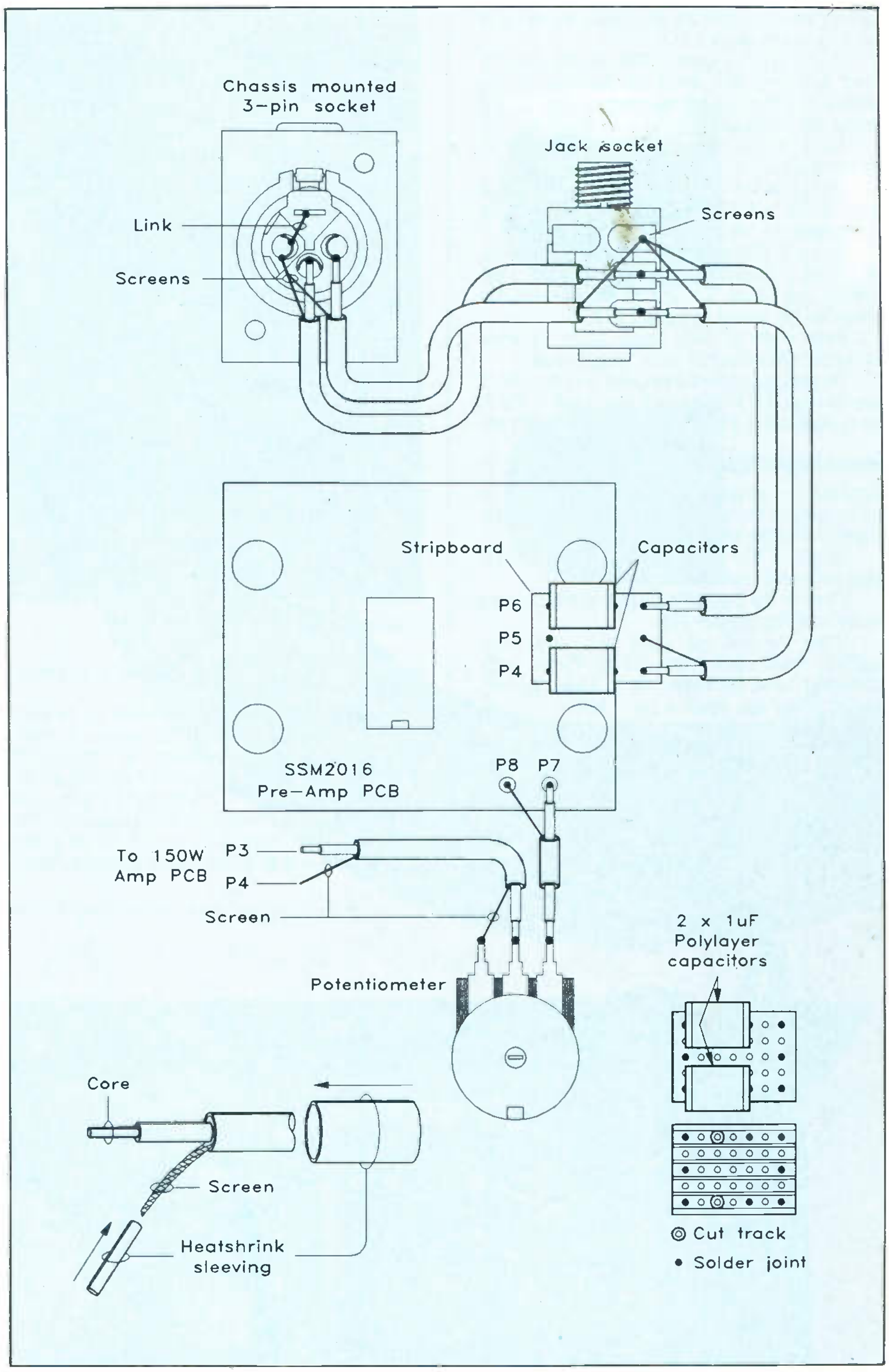


Figure 1. SSM2016 Preamplifier AC input module construction; input XLR and jack socket wiring and potentiometer wiring.

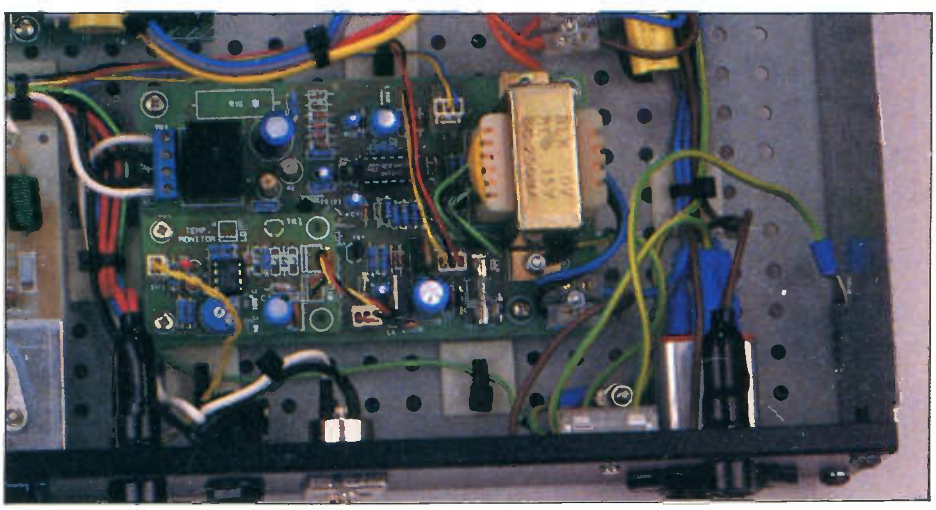


Photo 1. Close-up of Amplifier Monitor and piggybacked Temperature Monitor PCBs.

marked. This is to facilitate 'piggyback' mounting of the Temperature Monitor PCB.

If you have an Issue 1 PCB, modify the PCB (track cuts and wire links) as described in the addendum leaflet. Issue 2 or higher PCBs do not require this modification.

Do not fit TB2, R15 or R16; these components are not required.

Do not fit any components with a '10' prefix (e.g., R101, C101, D101, TR101, etc.); these components are not required.

Do not fit PCB pins in the positions marked 0V, I/P, −12V (adjacent to RG1), instead fit a 3-pin Minicon plug (from Temperature Monitor kit); the orientation tab should be nearest D19.

Bend leads of TR1 before fitting to allow Temperature Monitor PCB to be 'piggybacked'.

Depending on how the amplifier is to be used, it may be necessary to change C1 from 10μF to 33μF, this is explained in the instructions supplied with kit.

Temperature Monitor

Construct the Temperature Monitor as described in the instructions that accompany the kit; however, the following changes are required:

Do not fit R7, R8, R9, D3, TR1 or TB3/LD1; these components are not required.

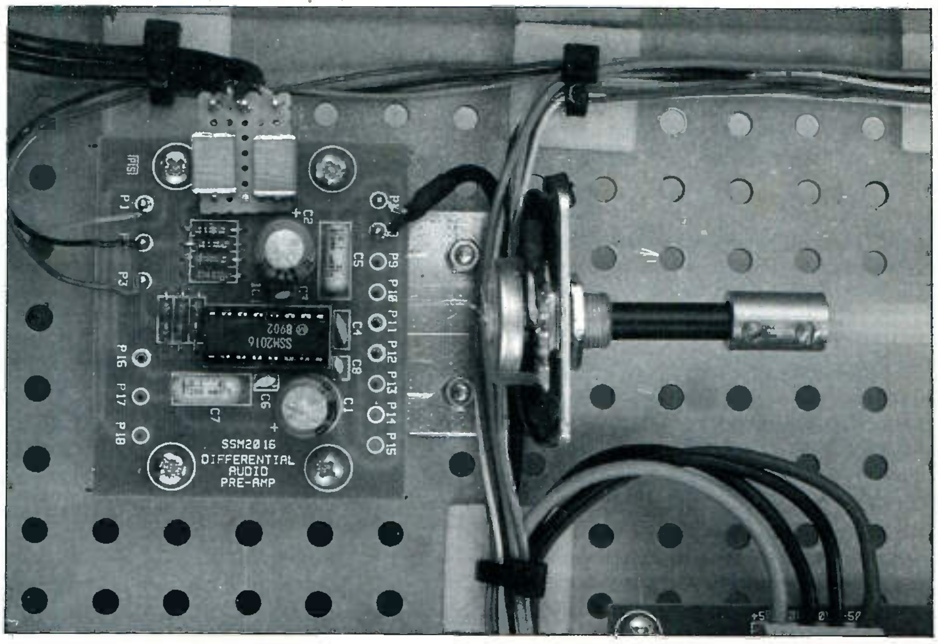
Do not fit the 3-pin Minicon plug as it is required for the Amplifier Monitor PCB.

Using the thin red, black and yellow wire supplied, make up a short (50 to 75mm long) connecting cable terminating in a 3-way Minicon housing at one end, black = pin 1, yellow = pin 2, red = pin 3. Connect the free end to the temperature monitor PCB as shown in Figure 2.

Case Drilling

The following instructions for case drilling make basic assumptions on marking out and drilling panels, for a more detailed description of how to drill cases, the reader is referred to 'Finishing Off' Part 1, published in Issue 53 of 'Electronics'.

Various modules and components are secured to the bottom of the case; the matrix of holes provides a convenient reference for location of mounting holes. Since all of the holes required do not line up with the matrix, it is a matter of aligning one hole and drilling the remainder where necessary. The 'reference holes' have been chosen to allow the remaining holes to be drilled clear of the matrix holes. The additional holes can be easily marked by aligning the module with the reference hole and using a fine-tipped marker pen, mark the inside of the case through the remaining holes. Prior to drilling the holes, use a centre-punch to prevent the drill skidding. Wear appropriate safety equipment (goggles, etc.) to prevent injury from flying metal swarf. Place a block of wood under the area being drilled to prevent case deformation (and damage to the kitchen table!). After drilling the holes, use the marker pen to



Close-up of the potentiometer assembly.

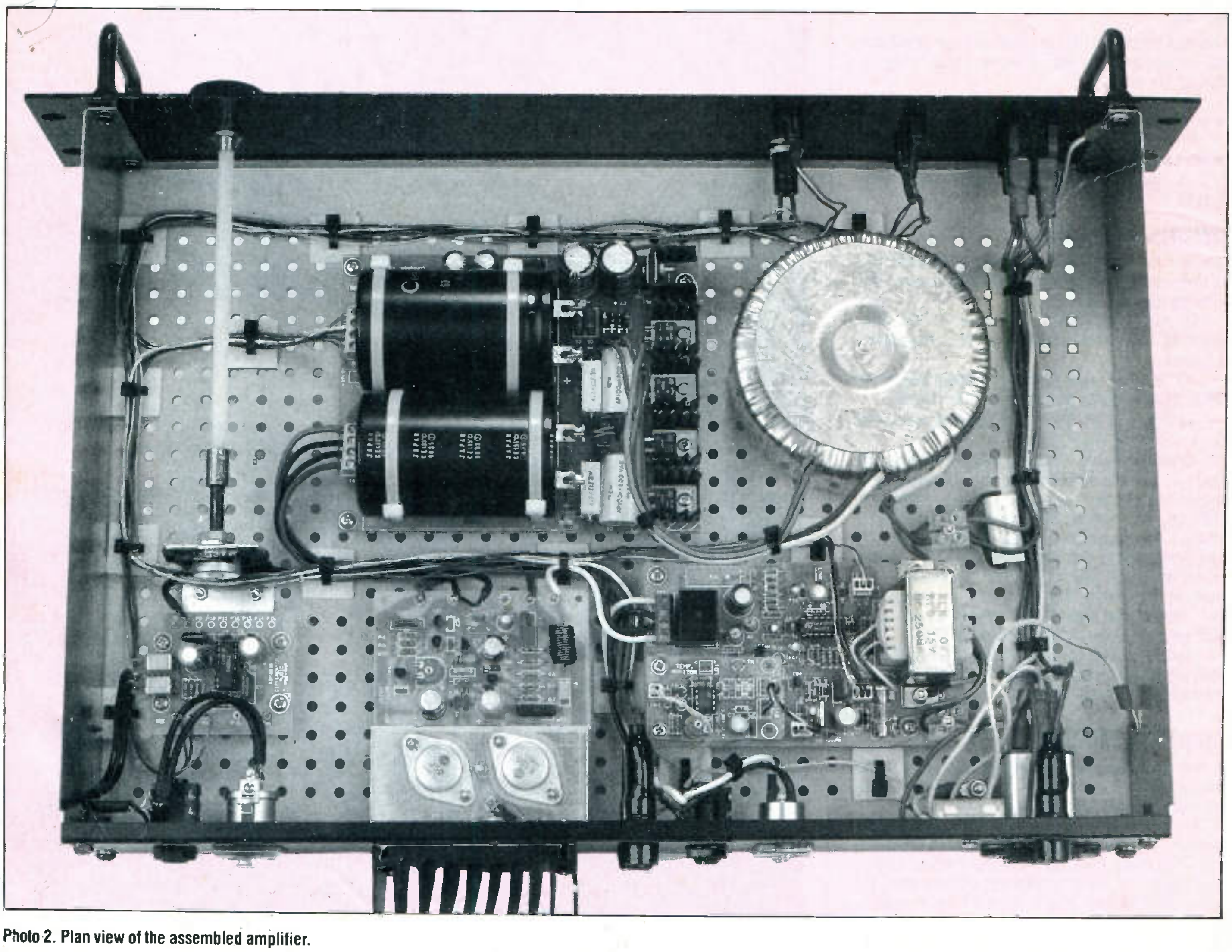


Photo 2. Plan view of the assembled amplifier.

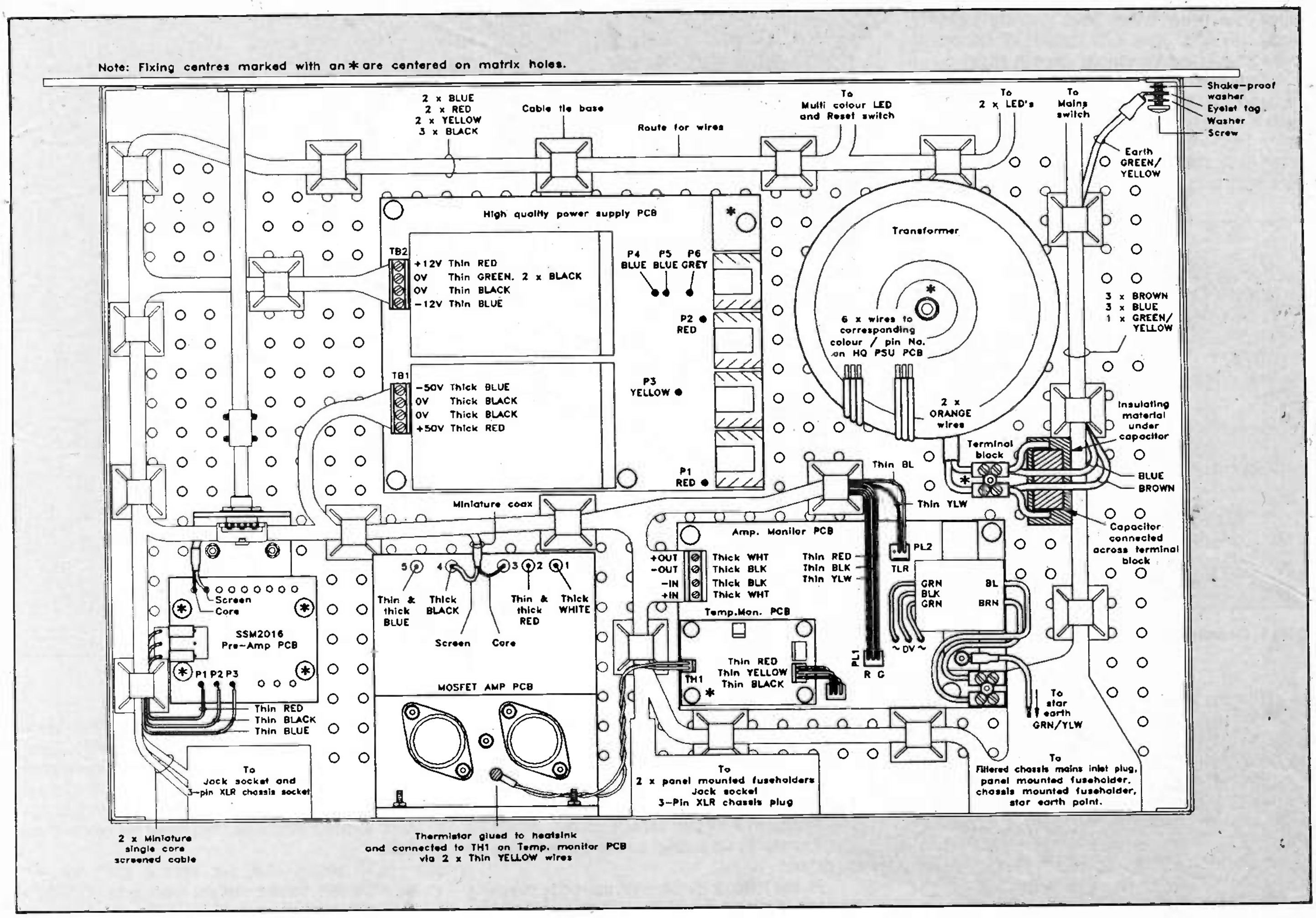


Figure 2. Overall amplifier wiring and assembly diagram.

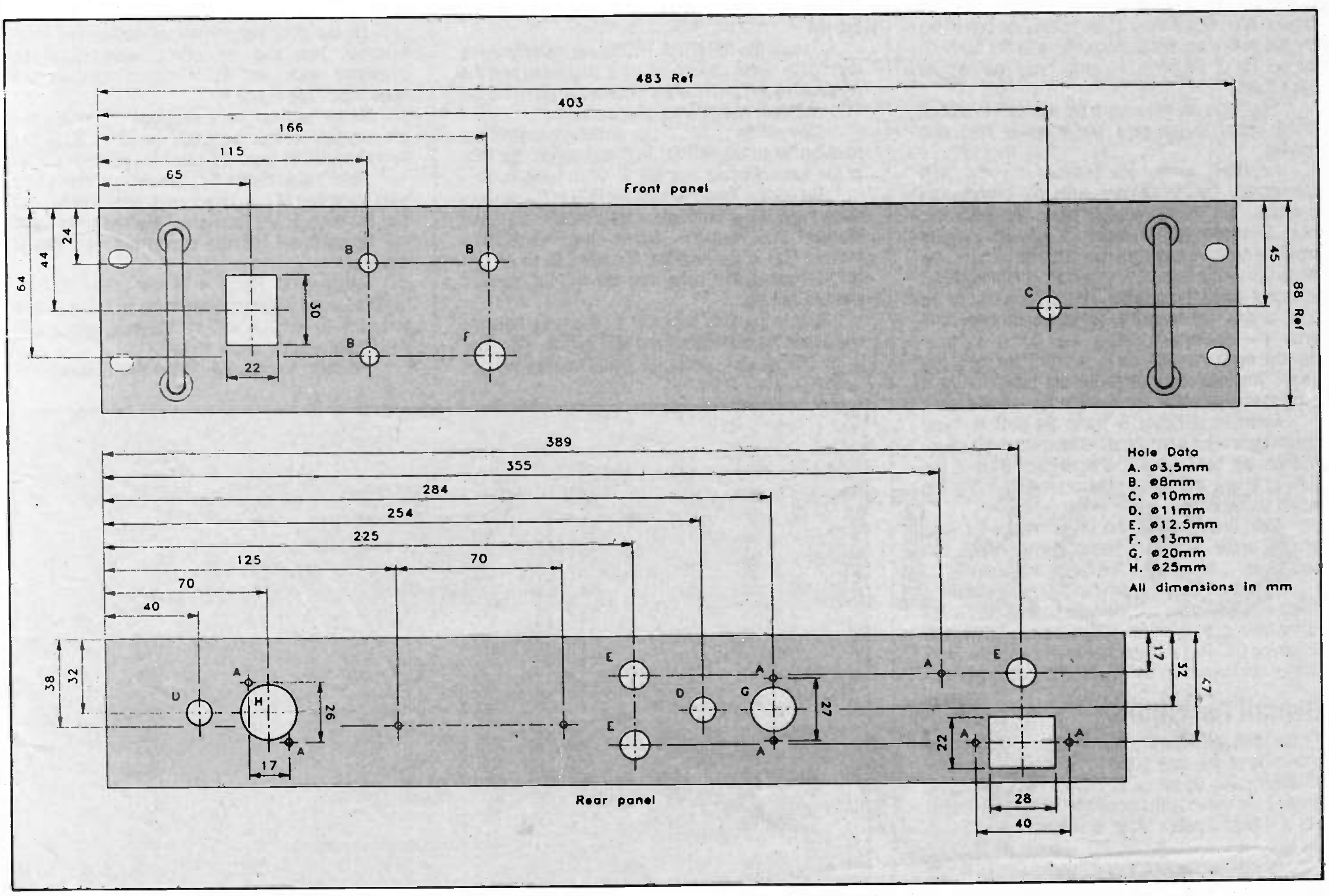


Figure 3. Front panel (3a) and rear panel (3b) drilling details.

'circle' the newly drilled holes and the reference holes; this is to allow easy location of the correct holes when fitting the various items in place!

Referring to Table 1 and Figure 2, locate modules and components and drill holes as required. References to holes are given as co-ordinates relative to the front-left hole in the case bottom that is the origin (0,0), the X axis runs left to right and the Y axis runs front to back.

	X	Y
Toroidal Transformer *	8	5
Terminal Block	5	11
Earthing Bolt	4	20
Amplifier Monitor **	15	18
HQPSU **	14	2
SSM2016 Preamplifier ***	28	15
	32	15
	28	17
	32	17
Potentiometer Bracket	29	13
	31	13

* Drill out hole to 5mm dia.
** Dia. of additional holes: 3·5mm
*** Holes do not line up exactly, but are close enough for practical purposes.

Table 1. Co-ordinates of reference holes.

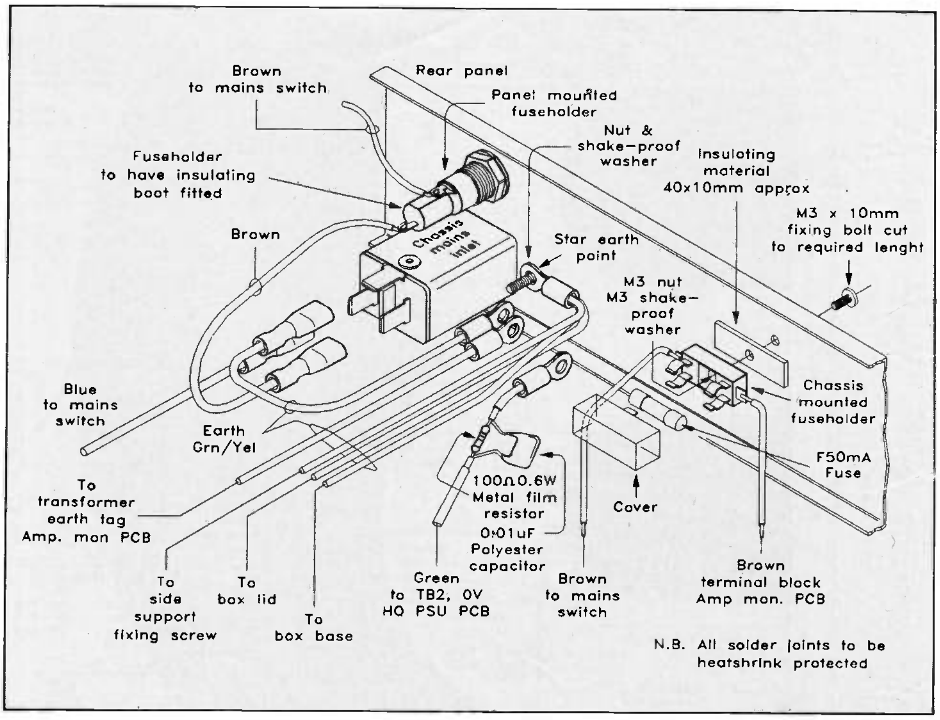


Figure 4. Rear panel mains wiring.

Referring to Figures 3a and 3b mark out and drill the front and rear panels. It is advisable to cover the panels with masking tape as this will assist marking out the panels and protect them from scratches.

The rectangular holes for the mains inlet socket and the rocker switch can be cut out by drilling a series of holes just inside the marked out line. The holes can the be joined up using a needle file or a coping saw fitted with a 'metal' blade. Finally the hole can be filed out to size with a flat file, frequently check the hole size by offering-up the socket/switch to ensure a good fit.

The large circular holes required for the XLR connectors are best cut out using a set of chassis cutters. After first drilling a hole to take the bolt of the chassis cutter, assemble the cutter with the blade on the outside of the panel, so as to avoid marking the paint finish.

Two holes are required in the heatsink to allow it to be bolted to the case and amplifier mounting bracket.

Insulating plates are required for the XLR connectors, the fuseholder and the suppression capacitor. The XLR insulating plates are fabricated from fibreglass PCB material as follows; allowing *plenty* of surrounding material, cut a large hole, the same size as the respective rear panel mounting hole, to accept the XLR connector. Fit the connector in the hole, copper side nearest to the connector body, and mark the connector outline and fixing centres. Remove the connector, cut to size and drill the fixing holes. The insulating plates for the fuseholder and suppression capacitor are show in Figures 2 and 4.

Referring to Figure 5, make the potentiometer mounting bracket from the sheet aluminium supplied. To form the bend, place the aluminium plate in the jaws of a vice and apply pressure evenly along the length of the plate.

After drilling all of the holes, check for, and remove where necessary, metal burrs – these can cause cuts to fingers and insulation on cables!

The exact way in which the panel-mounted switches, connectors and indicators are labelled is left to the individual to decide. The reader is referred to 'Finishing Off' Part 4, published in this issue of 'Electronics' for details on various labelling techniques.

Overall Assembly

Fit the four self-adhesive feet in the corners of the underside of the case bottom. Fit the eighteen self-adhesive cable tie bases as shown in Figure 2 and Photo 2. At the required positions, secure the twelve M3 × 14mm spacers (used to support the PCBs) to the case bottom with twelve M3 × 6mm panel bolts.

To secure the two-way terminal block, fit the M2·5 × 20mm bolt through the case bottom with a M2·5 washer on either side, slide on an M3 × ¼in. spacer and secure thus far with an M2·5 nut. Place the terminal block over the bolt and secure with a second M2·5 nut.

Secure the potentiometer mounting bracket with two M3 × 10mm panel bolts and two M3 nuts, place a M3 shakeproof washer under each nut. Attach the potentiometer to the bracket so that the terminals are uppermost.

Fit the toroidal transformer using the mounting hardware supplied; locate the bolt through the case bottom, place the transformer over the bolt with rubber washers above and below the transformer, add the metal top-plate and washer, and secure with the nut.

Secure the SSM2016 PCB to the spacers using four M3 × 6mm panel bolts, it is suggested that the previously fitted spacers are loosened while fitting the PCB and then re-tightened afterwards.

Connect the six secondary wires from the toroidal transformer to the HQPSU PCB and secure the PCB to the spacers using four M3 × 6mm panel bolts.

Secure the Amplifier Monitor PCB to the spacers using three M3 × 6mm panel bolts (not Temperature Monitor PCB corner). Secure the Temperature Monitor PCB to the Amplifier Monitor PCB using two M3 × 10mm panel bolts, two M3 × ¼in. spacers and one M3 nut.

Attach the side supports to the case bottom, and attach the front panel and rear panels. Note that to maintain earth continuity, additional shakeproof washers must be added. Assembly of the front panel is shown in Figure 6; eight M4 shakeproof washers are required, do not fit the eyelet tag and plain washer at this stage. Similarly eight M4 shakeproof washers are required for the rear panel; additionally four M4 plain washers should be fitted under the heads of the bolts.

To ensure that the control shaft for the potentiometer rotates easily; a brass bush is fitted on the front panel. However, the nylon extension rod supplied is fractionally too large to rotate freely in the bush; the bush should therefore be drilled out to 6·5mm dia. before fitting.

Fit the front panel mounted rocker and reset switches; note that the rocker switch should be orientated such that its 'mains in' contacts are uppermost, see Figure 7.

Fit the three rear panel-mounted fuseholders and the two jack sockets. Note that the stereo input jack socket should be located nearest the SSM2016 PCB.

Referring to Figure 8 fit the chassis mains inlet plug using two M3 × 15mm countersunk bolts, and two M3 nuts, fit M3 shakeproof washers under each nut. Do not fit the M3 plain washer and eyelet tags at this stage.

Referring to Figure 4 fit the 20mm chassis fuseholder and insulating plate using an M3 × 10mm bolt (cut to length) and an M3 nut, with a M3 shakeproof washer under the nut.

Referring to Figure 9, fit the two XLR connec-

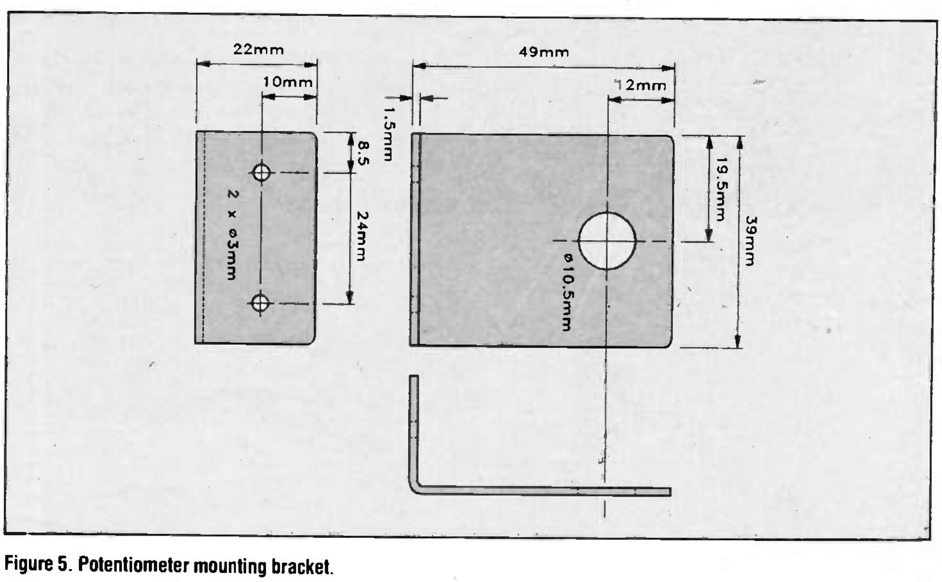


Figure 5. Potentiometer mounting bracket.

tors and insulating plates; the XLR plug should be located nearest the two panel-mounted fuseholders. Note that the XLR plug requires M3 hardware and the XLR socket requires M2·5 hardware.

Using two M3 × 20mm panel bolts and two M3 nuts, secure the heatsink and MOSFET Amplifier PCB to the rear panel, fit M3 shakeproof washers under the M3 nuts. Note that both mating faces of the heatsink and the amplifier mounting bracket should be liberally covered in heat transfer compound before assembly.

Interwiring

To ensure safe, reliable, hum-free operation, the wiring instructions given should be carefully followed. Figure 2 shows the overall layout of the wiring path. Use cable ties to hold the cables neatly in position.

Mains

Referring to Figures 4 and 7, use thick (32/0·2) brown (Live) and blue (Neutral) wire to connect the chassis mains inlet plug to the rocker switch. The Live wire is connected via the panel mounted fuseholder. The connections to the inlet plug and switch are by means of ¼in. 'Lucar' connector receptacles. A purpose designed crimp tool is available for these connectors. The live wire from the inlet plug must connect to the end terminal of the fuseholder. The connections to the fuseholder must be covered by an insulating boot.

Referring to Figures 2 and 7, use pairs of thick brown and blue wire to connect the rocker switch to the toroidal transformer mains terminal block and the Amplifier Monitor mains terminal block. Connect the live wire to the Amplifier Monitor Terminal block via the chassis mounted fuseholder. A 0·1μF interference suppression capacitor is fitted across the Live and Neutral terminals of the toroidal transformer terminal block. The wires of the capacitor must be covered with heat-shrink sleeving. Glue the capacitor insulating plate (copper side down) in place with quick setting epoxy resin. Connect the two mains wires from the toroidal transformer to the vacant end of the terminal block.

Referring to Figures 4 and 8, use thick green/yellow (Earth) wire to connect the inlet plug to the star mains earth point. Similarly, using individual green/yellow wires, connect the front panel (Figure 6), case lid, case bottom and Amplifier Monitor transformer case (Figure 2) to the star mains earth point. The connections to the case lid and bottom should be secured with an M4 × 6mm panel bolt and M4 nut; an M4 shakeproof washer should be placed under the eyelet tag and the nut. Using thin (7/0·2) green wire, connect the star mains earth point, via a 100Ω 0·6W resistor in parallel with a 0·01μF polyester capacitor, to TB2 0V (adjacent to +12V).

Power Supply Wiring

Referring to Figure 2:

Use thick black wire to connect HQPSU TB1 0V (adjacent to +50V) to MOSFET Amplifier P4.

Use thick black wire to connect HQPSU TB1 0V (adjacent to −50V) to Amplifier Monitor TB1 −IN.

Use thick red wire to connect HQPSU TB1 +50V to MOSFET Amplifier P2 via 'upper' panel mounted fuseholder. Note that the end connection to the fuseholder must be from HQPSU TB1 +50V and that the fuseholder must be covered by an insulating boot.

Use thick blue wire to connect HQPSU TB1 −50V to MOSFET Amplifier Pin 5 via 'lower' panel mounted fuseholder. Note that the end connection to the fuseholder must be from HQPSU TB1 −50V and that the fuseholder must be covered by an insulating boot.

Use thin black wire to connect HQPSU TB2 0V (adjacent to −12V) to SSM2016 P2.

Use thin red wire to connect HQPSU TB2 +12V to SSM2016 P1.

Use thin blue wire to connect HQPSU TB2 −12V to SSM2016 P3.

Front Panel Wiring

Referring to Figures 2 and 7:

Use thin black wire to connect 'upper' green LED cathode to HQPSU TB2 0V (adjacent to +12V).

Use thin red wire to connect 'upper' green LED anode to MOSFET Amplifier P2 via a 24kΩ 0·6W metal film resistor.

Use thin black wire to connect 'lower' green LED anode to HQPSU TB2 0V (adjacent to +12V).

Use thin blue wire to connect 'lower' green LED cathode to MOSFET Amplifier P5 via a 24kΩ 0·6W metal film resistor.

Use thin red wire to connect tri-colour LED 'green' anode to Amplifier Monitor PL1 P1.

Use thin yellow wire to connect tri-colour LED common cathode to Amplifier Monitor PL1 P2.

Use thin black wire to connect tri-colour LED 'red' anode to Amplifier Monitor PL1 P3.

Use thin yellow wire to connect reset switch to Amplifier Monitor PL2 P2.

Use thin blue wire to connect reset switch to Amplifier Monitor PL2 P3.

Signal Wiring

Referring to Figures 1 and 2 prepare the screened cables as shown. Connect the XLR and stereo jack

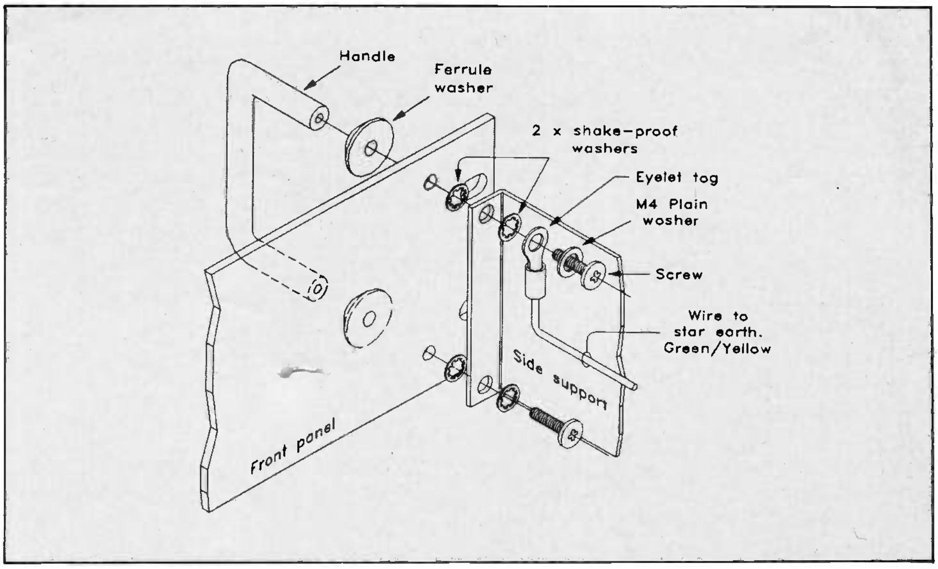


Figure 6. Front panel assembly and earth connection.

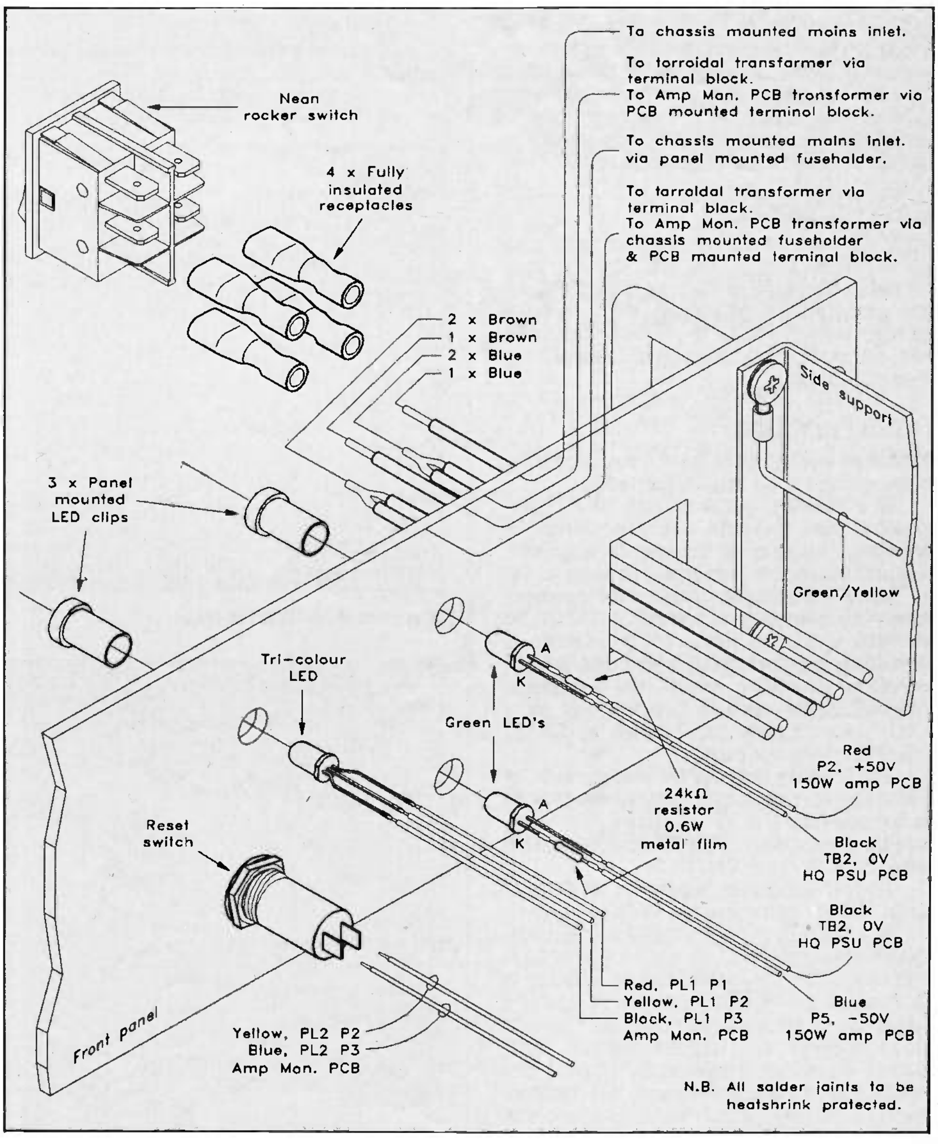


Figure 7. Rocker switch, LED and reset switch assembly and wiring.

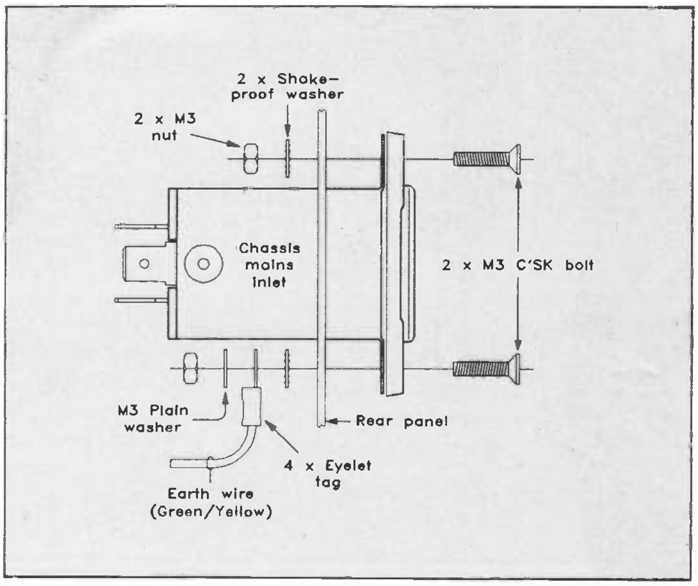


Figure 8. Chassis mains inlet plug assembly and earth connection.

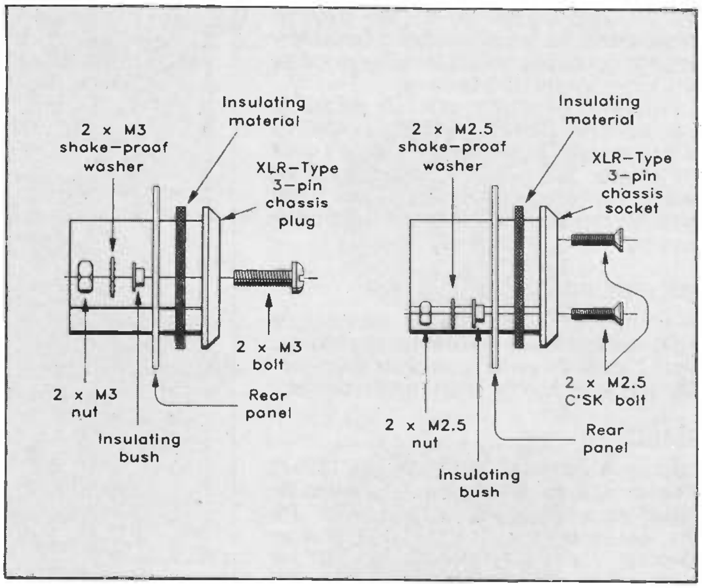


Figure 9. XLR connector assembly.

sockets to the SSM2016 PCB. Connect the potentiometer to the SSM2016 PCB and MOSFET Amplifier PCB. It is important that the cable screens are connect as shown.

Output Wiring

Referring to Figures 2 and 10, use thick black and white wire to connect the XLR plug and mono jack socket to Amplifier Monitor TB1 −OUT and +OUT.

Thermistor Wiring

Referring to Figure 2, use thin yellow wire to connect the heatsink thermistor to Temperature Monitor TH1. Cover the connections to the thermistor with heat-shrink sleeving, coat one face of the thermistor with heat transfer compound and glue the thermistor to the heatsink using quick set epoxy resin.

Shaft Extension

Locate the nylon rod through the front panel bush and secure the knob to the rod. Slide the knob towards the front panel so that there is approximately 1mm gap between it and the panel. Mark the nylon rod where it meets with the end of the potentiometer shaft, cut the shaft and connect the assembly with the brass shaft coupling.

Testing and Use

Recheck all stage of construction before proceeding as any mistakes could be potentially lethal.

Fit a 13A plug, with a 3A fuse, on the euro-connector lead, the earth wire *must always* be connected. Because of the design of the amplifier, it is unlikely that an earth hum loop will develop in use.

Using a multimeter, measure the resistance between the case metalwork and HQPSU TB2 0V, the resistance should be 100Ω, if the resistance is substantially less than this, it is likely that the XLR connectors are making contact with the chassis metalwork. If the resistance is substantially above 100Ω, check the connections between HQPSU TB2 0V and the mains star earth.

The following tests involve procedures to be carried out with the case top removed and 240V AC mains connected. It is imperative that every possible precaution is taken to prevent electric shock. 240V AC mains CAN KILL!

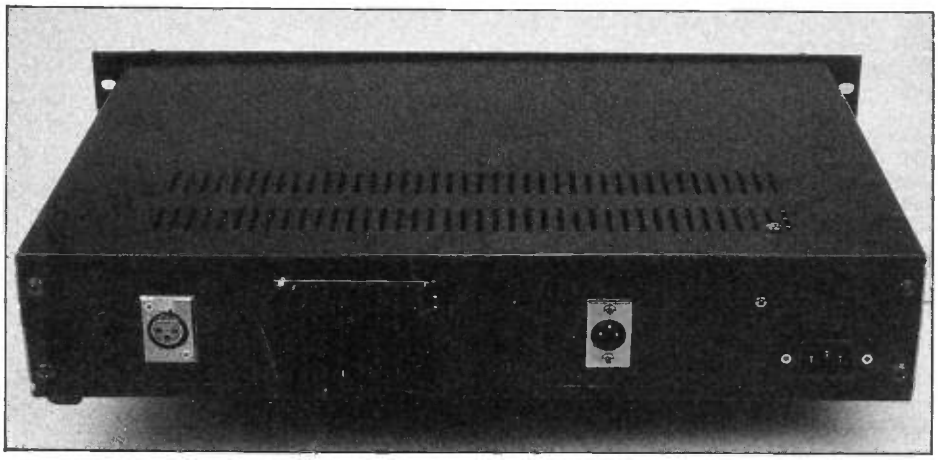
DO NOT connect the amplifier to the 240V AC mains until the instructions say to do so.

Fit a T2A fuse in the panel mounted fuseholder above the mains inlet plug, do not fit any other fuses at this stage. With the amplifier's mains switch set to ON, measure the resistance between the Live and Neutral pins of the mains inlet plug, the resistance should be greater than 10Ω and less than 100Ω. Measure the resistance between the Earth pin and various parts of the case metalwork, the resistance should be less than 100mΩ. Measure the resistance between the Live and Earth pins, and the Neutral and Earth pins, in either case the reading should be infinity. If a 'Megger' type test meter is available repeat the last test, the resistance should not be less than 2MΩ at 500V.

Connect the amplifier to the 240V AC mains and set the ON/OFF switch to ON. The neon indicator should light. Using a multimeter, set to a suitable DC voltage range, measure the voltages on HQPSU TB1 and TB2 with respect to 0V (not the case). TB1 +50V should read between +50 to +55V, TB1 −50V should read between −50 to −55V. TB2 +12V should read between +11·5 to +12·5V, TB2 −12V should read between −11·5 to −12·5V.

Disconnect the mains supply, allow the reservoir capacitors time to discharge and fit two F500mA fuses in the panel mounted fuseholders adjacent to the amplifier heatsink, ensure that the input level control is set fully anticlockwise. Disconnect the thick red wire from HQPSU TB1 +50V and connect a multimeter, set to a suitable DC current range, in series with the +50V supply. Reconnect the mains supply and adjust RV1 for a reading of 100mA (±20mA). The two green LEDs on the front panel should be lit.

Disconnect the mains supply, allow the reservoir capacitors time to discharge, disconnect the meter, reconnect the thick red wire and fit two T3·15A fuses in place of the F500mA fuses. Fit a T100mA fuse in the chassis mounted fuseholder adjacent to the mains panel mounted fuseholder, and a T250mA fuse in the fuse clips on the Amplifier Monitor PCB.



Rear panel of the 100W Pro-Amp.

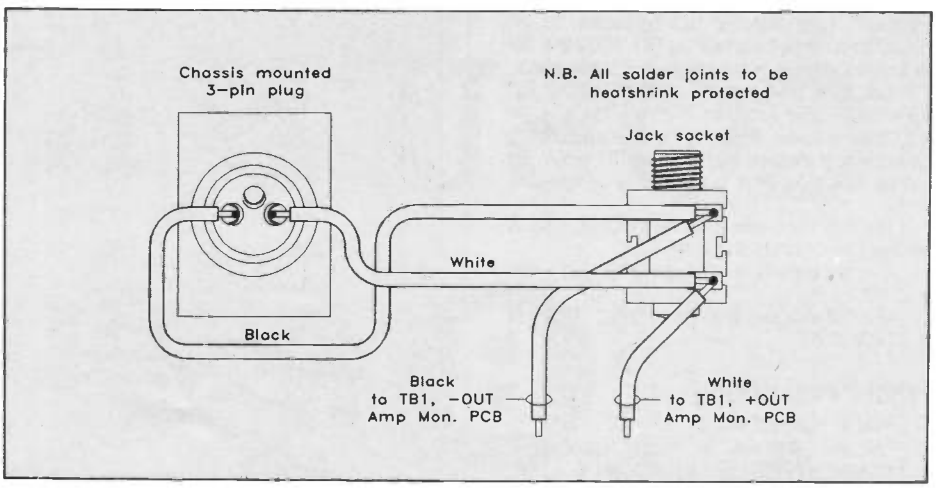


Figure 10. Output XLR plug and jack socket wiring.

Reconnect the mains supply; the tricolour LED should illuminate red. After a period of around 10 seconds, the LED should change to green and a click should be heard as the relay operates.

Connect a multimeter, set to a suitable voltage range, across the output of the amplifier, it is likely that there will be a small DC voltage present (around ±20 to ±50mV); if the voltage is 0·5V or more, it is likely that there is a fault with the MOSFET Amplifier.

Disconnect the mains supply and allow the reservoir capacitors to discharge. Set the preset on the Temperature Monitor PCB to minimum. Disconnect the thick white wire from Amplifier Monitor TB1 +IN and insulate it so that it cannot come into contact with any surrounding metalwork or circuitry. Reconnect the mains supply; after the Amplifier Monitor has timed out, briefly connect TB1 +IN to HQPSU TB2 +12V, the relay should immediately drop out and the multicolour LED should be flashing red. Press and hold the reset switch for a couple of seconds, the relay should drop in again and the LED should return to green. Repeat the above, except this time briefly connect TB1 +IN to HQPSU TB2 −12V, the relay and LED should behave as before.

Carefully heat the thermistor area of MOSFET Amplifier bracket with a hair-dryer. The relay should drop out fairly quickly, and the LED will flash alternately red and green, indicating excessive temperature rise. Allow the MOSFET Amplifier bracket to cool, at some point the LED will change to flashing red only. Pressing the reset switch will reset the Amplifier Monitor as before.

Disconnect the mains supply and allow the reservoir capacitors to discharge, set the Temperature Monitor preset to maximum and reconnect the thick white wire. Secure the case lid, do not forget to connect the earth wire to the lid.

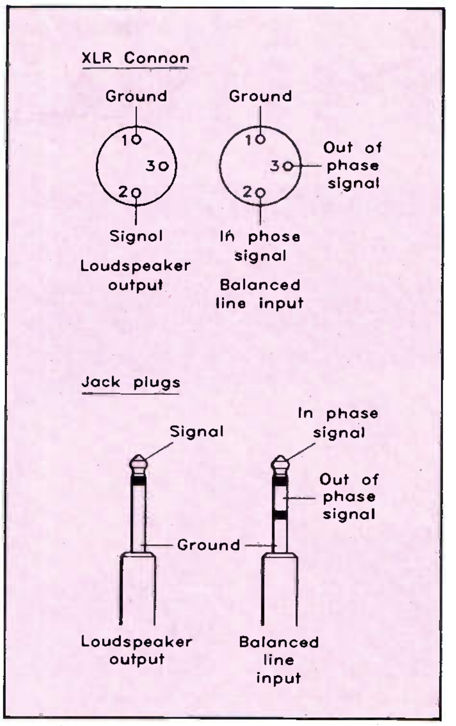


Figure 11. XLR plug/socket and jack socket connections.

Referring to Figure 11, connect an audio source and suitably rated loudspeaker to the amplifier. The XLR and stereo jack sockets are the signal input; note that only one signal source should be connected. The XLR plug and the mono jack socket are the loudspeaker output.

Balanced signal sources should be connected with the in-phase signal connected to XLR pin 2 or jack plug 'tip', the out-of-phase signal connected to XLR pin 3 or jack plug 'ring', the screen should connect to XLR pin 1 or jack plug 'sleeve'. Unbalanced signal sources should be connected with the signal connected to XLR pin2 or jack plug 'tip', and the screen connected to both XLR pins 3 and 1 or jack plug ring and sleeve (alternatively use a mono jack plug).

Loudspeakers should be connected with the positive to XLR pin 2 or jack plug 'tip', and negative to XLR pin 1 plug 'sleeve'.

Ensure the front panel level control is set fully anti-clockwise and reconnect the mains supply. When the status LED changes to green, rotate the level control clockwise – your ears should be rewarded by a clear, undistorted facsimile of the source material.

In use, the level control should be used to set the maximum required output level (i.e. during the soundcheck); thereafter use the output level control on whatever is driving the amplifier to adjust the volume level.

Look after the finished amplifier and it should provide many years of reliable service.

100W PRO-AMP PARTS LIST

RESISTORS: All 0·6W Metal Film (unless specified).		
100Ω	1	(M100R)
24kΩ	2	(M24K)
100kΩ	2	(M100K)
4k7 Linear Potentiometer	1	(FW01B)
CAPACITORS		
1µF Poly Layer	2	(WW53H)
10nF Polyester	1	(BX70M)
SEMICONDUCTORS		
LED Green 5mm 2mA	2	(UK49D)
KITS		
MOSFET Amplifier Kit	1	(LP56L)
Amplifier Monitor Kit	1	(LP32K)
SSM2016 Differential Preamplifier Kit	1	(LP44X)
High Quality Power Supply Kit	1	(LP15R)
Temperature Monitor Kit	1	(LP71N)
MISCELLANEOUS		
Rack Mounted Case 2U 19in.	1	(XM68Y)
Large Square Rubber Feet	1 Pkt	(FD75S)
Small Cable Tie Bases	18	(FE01B)
Cable Ties 140mm	22	(BF92A)
Panel Fuseholder 20mm	3	(RX96E)
Fuseholder Insulating Boot	3	(FT35Q)
Chassis Fuseholder with Cover 20mm	1	(KU29G)
Heatsink Type 2E	1	(HQ70M)
XLR Chassis Socket 3-pin	1	(BW90X)
XLR Chassis Plug 3-pin	1	(BW92A)
Mono Chassis Jack Socket ¼in.	1	(HF90X)
Stereo Chassis Jack Socket ¼in.	1	(HF92A)
Filtered Mains Inlet	1	(FT36P)
Moulded EuroConnector Lead	1	(BW99H)
DPST Red Neon Rocker Switch	1	(YR70M)
Square Push-to-Make Switch	1	(FF98G)
Concave LED Clip 5mm	3	(UK15R)
Black Knob Type AC13C	1	(JH48C)
Nylon Extension Rod	1	(RX38R)
Spindle Coupler	1	(RX29D)
Brass Bush	1	(RX31J)
Threaded Spacer M3	2 Pkts	(FG38R)
Spacer M3 × ¼in.	1 Pkt	(FG33L)
Isobolt M3 × 6mm	3 Pkts	(JY21X)
Countersunk Bolt M3 × 10mm	1 Pkt	(LR57M)
Isobolt M3 × 20mm	1 Pkt	(JY25C)
Countersunk Bolt M2·5 × 10mm	1 Pkt	(JC68Y)
Isobolt M2·5 × 20mm	1 Pkt	(JY32K)
Isobolt M3 × 10mm	1 Pkt	(JY22Y)
Isobolt M4 × 6mm	1 Pkt	(JY13P)
Steel Nut M4	1 Pkt	(JD60Q)
Steel Nut M3	1 Pkt	(JD61R)
Steel Nut M2·5	1 Pkt	(JD62S)
Isoshake Washer M4	2 Pkts	(BF43W)
Isoshake Washer M3	1 Pkts	(BF44X)
Isoshake Washer M2·5	1 Pkt	(BF45Y)
Plain Washer M4	1 Pkt	(JD75S)
Plain Washer M2·5	1 Pkt	(JD77J)
Fully Insulated Blade Receptacle ¼in.	1 Pkt	(JH82D)
Insulated Eyelet Tag 4·3mm	1 Pkt	(JH71N)
Heat Transfer Compound	1 Srnge	(HQ00A)
Short TO66 Insulator	1 Pkt	(JR78K)
Small Stripboard 10 strips × 39 holes	1	(JP46A)
Small Single Sided Fibreglass Board	1	(FA60Q)
Aluminium Sheet 18 SWG	1	(LH12N)
Heatshrink Sleeving CP64	1m	(BF90X)
Heatshrink Sleeving CP48	1m	(BF89W)
Fuse 20mm F500mA	2	(WR02C)
Fuse 20mm T2A	1	(WR20W)
Fuse 20mm T3·15A	2	(RA11M)
Power Connection Wire (32/0·2) Black	4m	(XR32K)
Power Connection Wire (32/0·2) Blue	4m	(XR33L)
Power Connection Wire (32/0·2) Brown	2m	(XR34M)
Power Connection Wire (32/0·2) Red	2m	(XR36P)
Power Connection Wire (32/0·2) Green/Yellow	2m	(XR38R)
Hook-Up Wire (7/0·2) Black	1 Pkt	(BL00A)
Hook-Up Wire (7/0·2) Blue	1 Pkt	(BL01B)
Hook-Up Wire (7/0·2) Green	1 Pkt	(BL03D)
Hook-Up Wire (7/0·2) Red	1 Pkt	(BL07H)
Hook-Up Wire (7/0·2) Yellow	1 Pkt	(BL10L)
Double Bubble Sachet	1	(FL45Y)
Instruction Leaflet	1	(XT74R)
Constructors' Guide	1	(XH79L)
OPTIONAL		
Chassis Punch Set	If Req	(YK27E)
Crimp Tool	If Req	(FY31J)
XLR Line Plug 3-pin	As Req	(BW89W)
XLR Line Socket 3-pin	As Req	(BW91Y)
Mono Screened Jack Plug ¼in.	As Req	(HF87U)
Stereo Screened Jack Plug ¼in.	As Req	(HF89W)

The Maplin 'Get-You-Working' Service is available for this project, see Constructors' Guide or current Maplin Catalogue for details.
The above items (excluding Optional) are available as a kit, which offers a saving over buying the parts separately.
Order As LT11M (100W Pro-Amp Kit) Price £159.95. H
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.

FINISHING OFF

PART FOUR
by David Smith

In the final part of this series, we are going to take a look at the various painting techniques that you could employ to improve the appearance of your project(s). In addition, we will contrast how the 3M 'Dynamark' labelling system compares with other artwork products that are available to the amateur constructor.

Let us start from the beginning and assume you have a metal case in which to build your project, and that this case is either the wrong colour, or indeed has no colour at all (due to the fact that it is still bare aluminium). So, the first thing you have to do now is paint it – WRONG! Initially, you need to drill, or cut out, all of the necessary holes required. Painting it first would simply be a waste of time, because however careful you try to handle the case, there is every chance of marking it, either from a drill bit (accidentally scratching the surface), or from a vice having a similar affect. So get the 'rough stuff' out of the way first.

Assuming that some time has elapsed, and your case is sitting in front of you with all holes neatly drilled and the stressful metal work duly executed, it is worth remembering that before you start any painting, the case will need to be cleaned thoroughly. Fresh paint should never be applied to any smooth surface, because it needs a 'key' on which to grip properly, otherwise flaking could result. To provide this 'key', you must rub down the surface of the metalwork (whether it has previously been painted or not), by using a fine grade of 'wet or dry' emery paper – as shown in Photo 1. This action causes microscopically fine grooves to be produced in the metal, so that any fresh paint has a rough surface (and hence a larger more effective surface area) on which to adhere. When rubbing down, carefully include all the fiddly bits as well as the easy bits (such as large flat surfaces) – but don't be tempted to cheat. It can be a boring job, but it's well worth it in the end. Ask any professional painter how he achieves such a superb finish with his paint-work, and he will tell you that 'it's all in the preparation'.

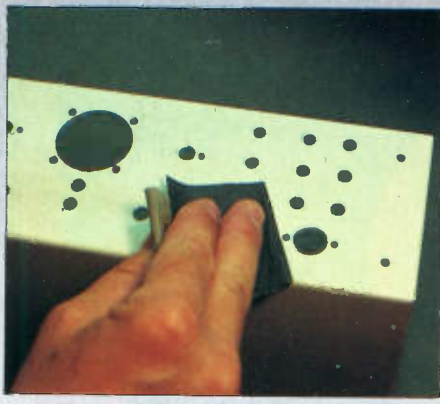


Photo 1. Preparing a case for painting; rubbing the surface with fine emery paper provides a 'key' for the paint to adhere.

The box may now look clean to the naked eye. However, a closer inspection would probably expose a collection of greasy fingerprints, along with tiny pieces of metal swarf. Cleaning is no problem and can easily be accomplished by using a small amount of isopropyl alcohol. This is available from all good chemists, and a 500ml bottle would be a most useful addition to the workshop. Not only is it effective for the job we have in mind here, but it can also be used for cleaning tape recorder heads, in addition to many other jobs. Soak a small amount onto a lint-free piece of cloth (or a clean handkerchief!), and rub it firmly over the surfaces of your box, as shown in Photo 2; it will dry almost immediately. Your project is now ready for painting. If it's a very small box that you're going to paint, you could get away with using a small fine haired brush and a tiny tin of paint, both of which can be obtained from your local model shop. These paints come in an extensive variety of colours (as can be seen from Photo 3) and offer either a gloss or matt finish. In addition, because they are normally used for painting metal or plastic models, such paints are ideally suited to your needs. I say this because there are certain types of paint on the market which are most unsuitable for plastic surfaces, causing them to go soft after being applied. So, stay safe by checking the label on the can before purchasing.

Photo 2. After rubbing down the paintwork, any remaining dust and grease can be removed using some isopropyl alcohol. This can be obtained, in small quantities, from your local chemist.

Make sure that the brush that you are going to use is of good quality, and check to see if there are any loose hairs that could come adrift (more likely on poorer quality brushes), because these could remain on the surface of the box after the paint has dried. In addition, try to work in a dust and insect-free environment. Dust can create a rough-looking finish on the paints surface, and insects seem to have a 'kamikaze' mentality, which impels them to 'attack' your box just as the final coat is being applied!

Photo 3. A small cross-section of the vast range of paints available from model shops.

Remember that painting any large areas with a brush will result in the job being very time-consuming, and that the difficult act of preventing brush marks from showing up may demand a great deal of dexterity on your part. You may consequently choose to spray the box instead, and if this should be the case, then the following techniques should be applied.

Spraying

Unlike the paint flowing off a brush, the paint that leaves the nozzle of a spray-can is far harder to control, and therefore more likely to get into places that are not intended to be sprayed. It is vitally important, therefore, that adequate preparation be made beforehand. Firstly, make sure that the area in which you choose to spray your project has good lighting, adequate ventilation and is free from any draughts that are likely to blow the paint spray in the wrong direction. Next, cover any holes in the case that are likely to let paint through, with masking tape. This should be stuck to the side of the box that isn't going to be sprayed, as shown in Figure 1. Of course, if you are spraying the enclosure, both inside and out, in one colour only, then the latter is not necessary.

If you intend spraying the inside of the 'BENCHMASTER' project, then you will need to scrape back, to the bare metal, the area that is to receive the heatsinks of the amplifier. Having done that, cover both heatsink areas with strips of masking tape to prevent any paint from encroaching.

Follow the instructions on the spray-can carefully. Thoroughly mix the paint by shaking the can for the suggested time. One or two minutes can feel like an eternity, as you listen to the little ball bearing rattling around inside the spray can, but it is worth the effort of making sure that the paint is mixed properly. It is most important to check the mixing time.

Begin spraying by using smooth, even movements across the work-piece. Be careful not to pause at the edges for too long when reversing the spray's direction, or you might apply more than the necessary amount of paint. This happens because one tends to slow down when coming to an edge, on account of having to change direction. You could of course spray straight off the end of the work-piece and into fresh air before changing direction, giving a more even coverage. Although using slightly more paint using this technique, one benefits from a smoother finish. Do not spray your box by applying just one single coat; one thickly applied layer is liable to run. It is far better to give it three or more thin coats. Some car manufacturers use this technique when spraying cars – and often apply 20 coats or more.

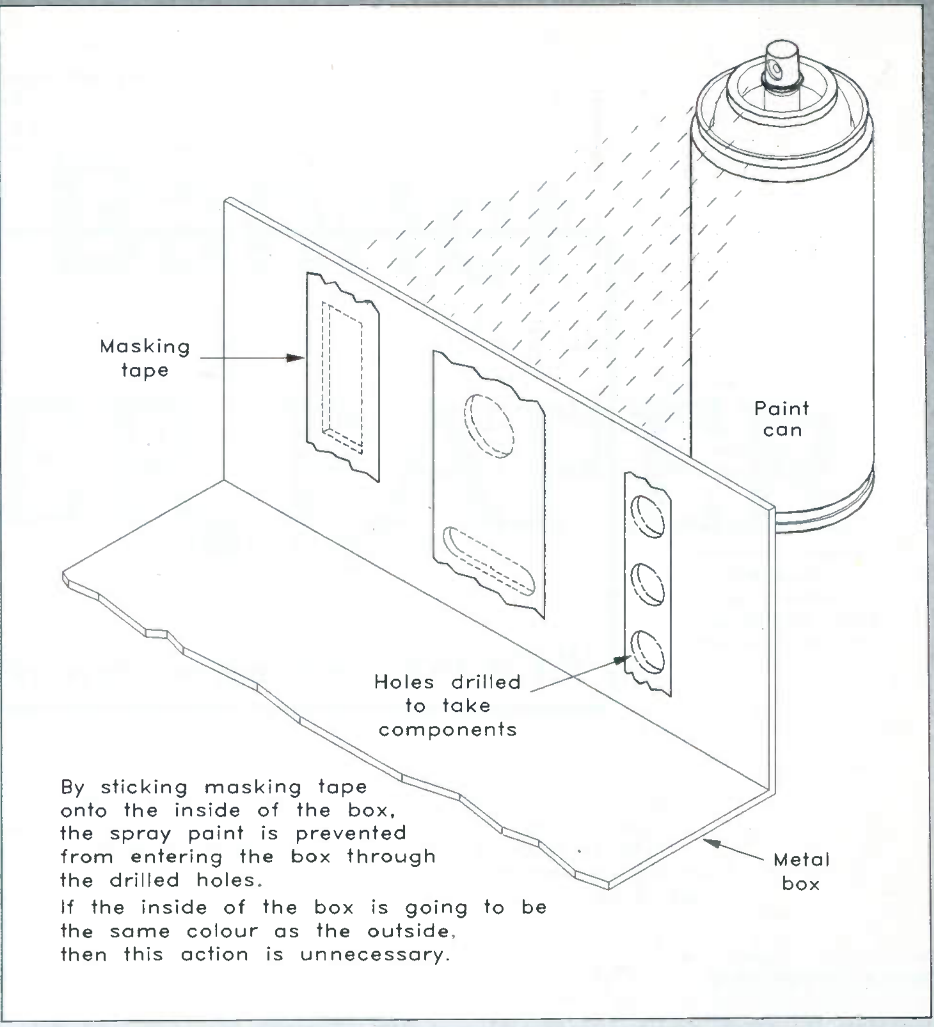


Figure 1. How to prevent spraying the inside of your case.

Fablon

If painting by hand or spraying a case does not appeal to you, then another method of quickly changing the colour of your case is to use a self-adhesive PVC-based decorative covering called 'Fablon'. Manufactured in the U.K. by The House of MayFair, Fablon is available widely throughout the country in model shops. The inside of the 'BENCHMASTER' project was covered with white Fablon. This was achieved by simply measuring and cutting the correct amount off the roll. On the rear of the backing paper is a grid of straight lines to assist in cutting. Peeling off the backing paper, the Fablon was then pushed up inside the case, and pressed firmly into place, whilst making sure that no air bubbles remained underneath. Upon negotiation of a corner, a slit was made and the two corners were made to overlap (similar techniques are used when hanging wallpaper around corners).

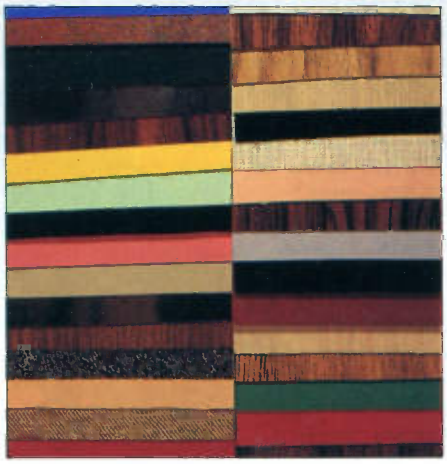


Photo 4. A selection of Fablon coverings; a wide variety of colours and textures are available.

This material is good at hiding overlaps, as it lies quite flat. Be careful if you overlap 'wood grain' effect Fablon, as the direction of the grain will show quite positively what you have been trying to do! Once the Fablon has been affixed, a sharp modelling knife can be used to trim away any surplus waste from around the edges of the case, and from any holes that are required to accept components.

Finally, cut away two pieces of Fablon from the area of the case where the amplifiers' heatsinks have to be located, as well as a small piece from underneath the earthing tag (situated under one of the fixing bolts that hold the mains socket in position). In addition, make sure that any paint is removed from these areas. This is very important, since any specks of paint or Fablon hindering the electrical conductivity of the earthing wire could prove fatal.

As you can see from Photo 4, there is a large variety of textures and colours available. These include an extensive range of wood grain effects, red, green and brown baize-type materials and numerous colours; some matt, some gloss. Most types are available from your local hardware or DIY shop, and are cut off a metre-wide roll to the length you require. Covering the outside of your project is just as simple, although I wouldn't advise using it where graphic transfer letters are to be situated. This is because when applied, Fablon does have a very slight tendency to shrink, and any graphic transfers that are placed upon it may move slightly, thereby spoiling the appearance of the case.

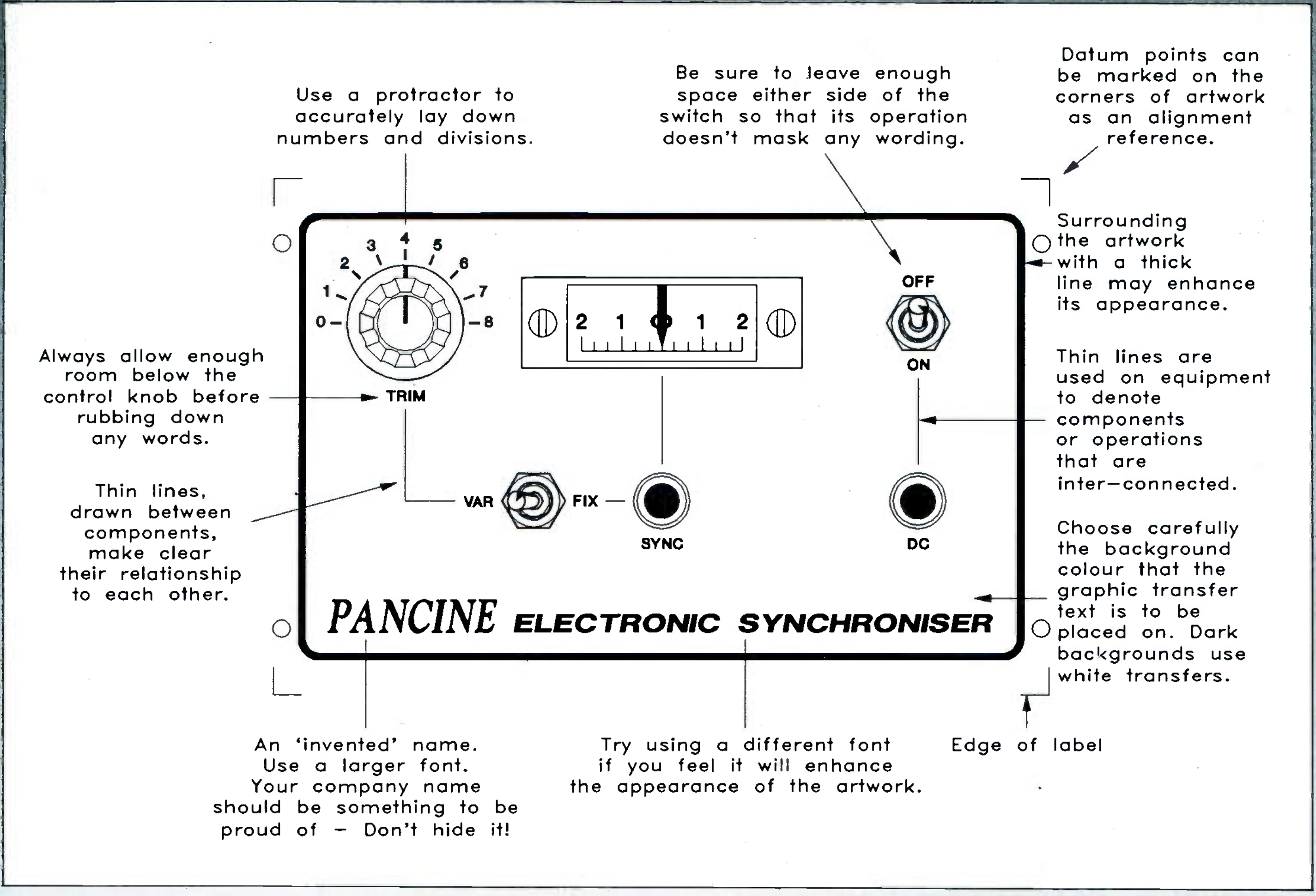


Figure 2. Artwork ideas.

However, it is hard-wearing and can be cleaned quite easily using a mild detergent or isopropyl alcohol.

Labelling

Whether your case has been painted or covered with Fablon, you are now ready to progress to the next stage of preparation, which is to label the various functions of your project, along with your logo or trademark perhaps. There are various ways in which this can be achieved, and Figure 2 may offer a few ideas. However, before we take a closer look at the actual physical techniques employed in labelling, let's study the psychological aspects of such artwork.

Trademarks and logos are used for identifying a product with a certain manufacturer. If a product is good, people will stay loyal to the manufacturer for years to come. Although you probably have no intention of going into the large manufacturing business, placing some sort of logo or name on the front of the project suggests that it has indeed been manufactured by a company, and thereby gives it a kind of professional status, even if people have never heard of the name.

Study the logos and names of products that are already on the market. Not only will this give you ideas, but it will also reduce the chance of calling your device by a name that's a Registered Trademark already in use. Manufacturers have already employed popular electronic words such as ELECTRO, VOX, ...MATIC, RADIO, DIGITAL etc., and the job of finding a new way to combine all these 'electro-words' has become increasingly difficult. Nevertheless, there are some combinations yet to be used, but you do have to think hard before finding one!

The name 'BENCHMASTER', which I gave to the project described in this series of articles, was conceived by making a long list of names relating to how the project functioned and where it was going to be used. The list contained names such as amplifier, power, volts, supply, preamp, bench, workshop, home, etc., and coupled with a few other relevant lists, I mixed together the various names. The final result was the name 'BENCHMASTER'. However, when using this technique, do try to avoid obvious and pretentious names such as 'POWER-O-MATIC' or 'ELECTRO-POWER'.

Once you've given your project a name, give it a model number. Again, stay away from the obvious, like 'Model No. 1'. Manufacturers nowadays seem to go for four-figure numbers with plenty of zeros. If you think about it, they don't have to, as they could quite easily call one of their products, 'Model No. 341' – but it doesn't sound quite as exciting as a KZX 7000L, does it? So be a little adventurous, using three or four numbers, and include one or more zeros. If you feel like it, throw in a couple of letters for good measure. By the way, good strong letters to use within model numbers are Q,P,Z,X,K and L plus the lower case letter i, which should always be placed at the end of any combination of letters or numbers. Try checking around the shops to see the formats of model number that manufacturers have given to their products, and you will see trade psychology working at its optimum.

Finally, give your 'product' a serial number. You may only be building one project and may therefore see no reason why it should have one, but it does look more professional – which is after all, the image we are striving for. Again, steer clear of the number 0001. Use the date (mixed up) if you have to, or literally think of a number off the top of your head!

An important label for mains-driven equipment is that which warns the user not to tamper with the inside of the equipment whilst it is still connected to the mains. Maplin stock such a label, with the warning printed in black on a yellow background (Order Code WH48C). Having a self-adhesive backing, it can be stuck in a prominent position. The usual place is at the rear of the case somewhere, but remember, it only needs to be read if an attempt is made to open the case, so stick it where it will be seen easily, next to some fastening screws, perhaps? – but not on the front panel.

So, assuming you now have a

name, model and serial number, you can begin the process of embossing them onto your box along with all the other relevant details regarding the projects function(s). There are various ways to achieve this, but first we'll start by taking a look at what NOT to use! Remember, we're after a professional look to our project and the following types of labelling are definitely out:

(a) Using a felt tip pen to write onto the box.
(b) Any form of handwriting, however neat.
(c) Typing the words onto paper or sticky labels, cutting them to size and fixing them onto the project.
(d) Use of those sticky peel-off labels which have been pre-printed with words such as 'input', 'output', 'bass', 'treble', 'volume' and so on.

All of the above, although useful in their own right, are of no use to us if we are to create a smart-looking product.

Graphic Transfers

Maplin offer a range of very high quality rub-down letters, numbers and symbols. The sheets containing letters are available in 2·5mm and 4·2mm heights. Both sheets contain lower and upper case letters, as well as punctuation marks and numerals. Alternatively, you can obtain sheets with only numerals printed onto them, or sheets which

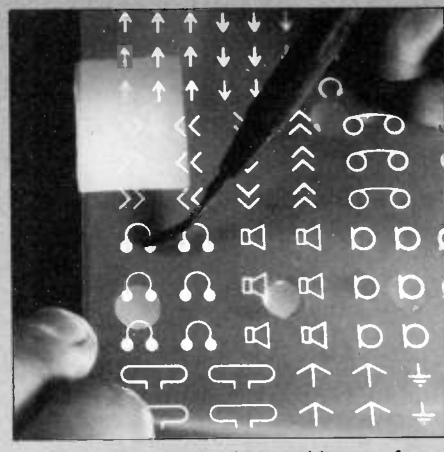


Photo 5. Applying Maplin graphic transfers to the front of the 'Benchmaster'. Although the correct tool is shown being used, perfectly acceptable results can be obtained by using only an ordinary pencil to rub down the letters.

contain various electronic symbols of the type used on electronic equipment. All types are available in both white and black.

The sheets are quite simple to use, although it is better to practice on paper first with a few letters and numbers to get the feel of them, but bear in mind that each letter and number can only be used once. Firstly, draw a straight pencil line on paper, and then place the graphic transfer sheet onto the paper, carefully positioning each required letter just above the guideline. Use a soft pencil to rub down each letter (see Photo 5). Be careful not to accidentally press on any other part of the sheet, as this may cause unwanted letters to be transferred onto the paper. To prevent this from happening, you can utilise the paper backing which comes with every graphic transfer sheet. Place it between the paper and the lettering sheet, thus using it as a protective film. Situate it slightly lower than the line of graphic lettering that you are about to work with. You can usually tell when each letter has been rubbed down properly, as the colour of the letter changes from black to a dull grey as it leaves the sheet and gets transferred onto the paper. Afterwards, make sure each transferred letter is free of air bubbles by pressing it gently but firmly onto the paper.

To centralise words, count the number of letters and divide by two. For instance, if you need a six-letter word to be rubbed down, then there would be three letters either side of a central guideline. On the other hand, if there are seven letters in your chosen word, then obviously there will be three either side of a centrally positioned letter. There are pitfalls though, as you can see in Figure 3. This is because letters such as A, V and W all have lines which sit at an angle. If you were to leave the same amount of space between these as you did with all the other letters, then they would appear incorrectly spaced. Strange but true. There are quite a few optical illusions regarding the placement of letters and it can be quite

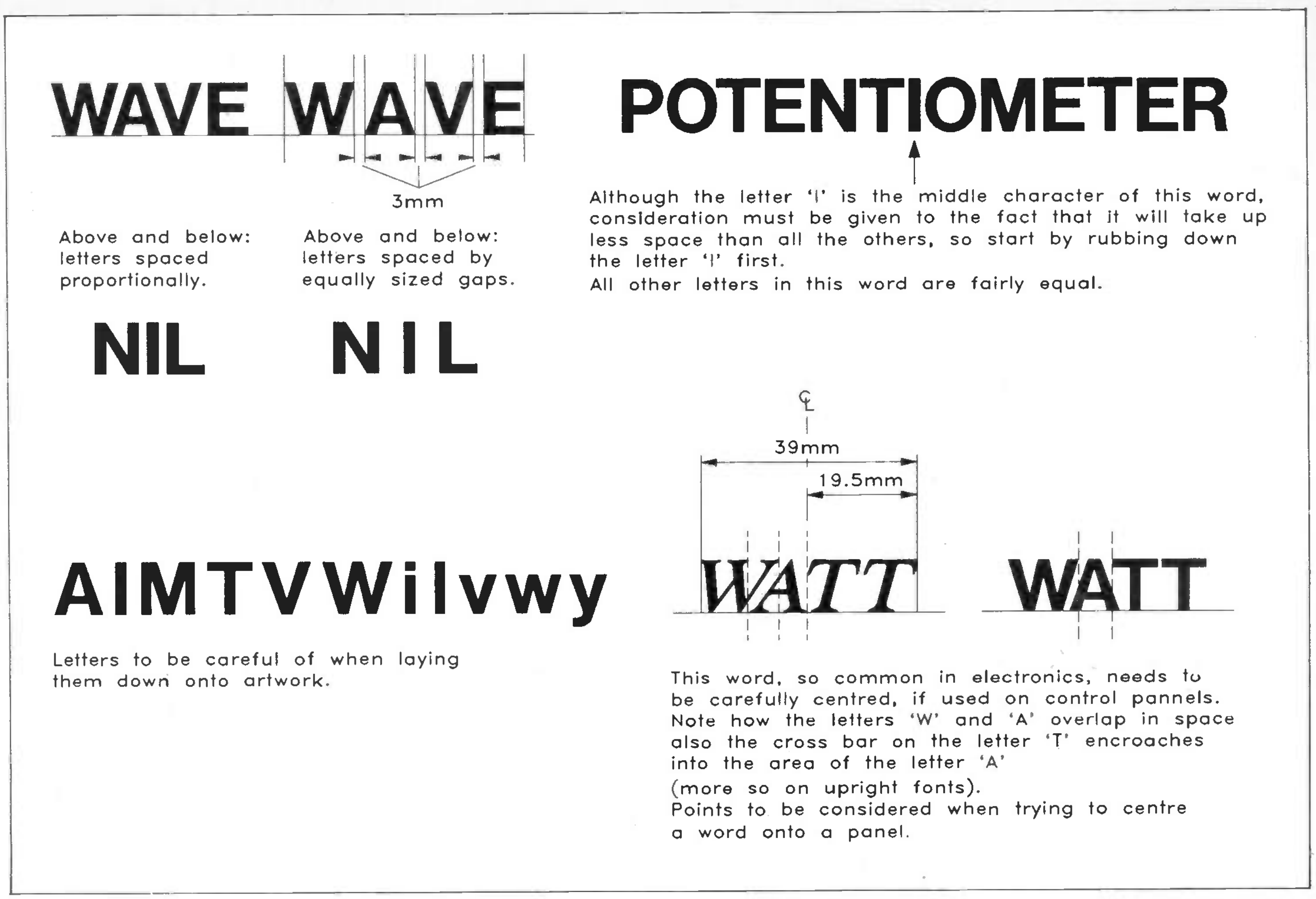


Figure 3. These examples stress the importance of correct spacing between the letters.

hard to get it right, and so lots of practice will be required.

The method employed when correctly spacing letters is also used by the publishing industry in general, and is called 'proportional spacing' – and it makes the printed word look more pleasing to the eye. If you have a word processor, it may have such a feature. Figure 3 shows various examples of how/how not to use the letters of the alphabet using this technique.

The relative height of each successive letter is another important aspect to consider when producing professional-looking artwork. Most of the letters will be easy to place, as they have straightedged cross or down members, which can be carefully aligned on a suitable guideline. On the other hand, letters like O, Q, S and C are a little more difficult to rub down accurately. This is mainly because of their curving characteristics, but partly due to the fact that sitting one of the above letters on a guideline doesn't always make it look right. In some cases, a letter may have to be placed slightly lower or higher than the position where it would be normally. You may also find that the letter O should appear higher than other letters to counteract this optical effect.

Once the letters have been soundly rubbed down, any guidelines (which should have been drawn lightly in soft pencil) can be rubbed out. Be careful not to rub off any lettering when doing this. Only practice and experience will tell you how hard to press, as it is impossible to explain in words the pressure needed.

Finally, the transferred graphics can be protected from damage by carefully painting over them with a matt varnish (see Photo 6). This should protect them from most of the knocks that are encountered on ones workbench. However, a more robust (albeit more expensive) type of labelling system is one produced by 3M.

3M 'Dynamark' Photolabel System

The 'Dynamark' photolabel system, manufactured by the 3M company, offers a simple yet flexible method of producing your own labels and artwork to fix onto a project. The 3M system consists of an extensive range of coloured sheets of labelling material, either metal or plastic. When exposed to ultra-violet light and developed, Dynamark becomes transparent or allows a background colour to be revealed. By inserting a transparent acetate sheet containing the artwork between the UV light source and the labelling material, one is able to transfer the contents of the artwork onto the labelling material, which will subsequently reveal itself when developed. It is a process not unlike

Photo 6. Unless properly protected, graphic transfers can easily be rubbed off. A good idea is to apply some varnish (matt or gloss); when dry, this will form an almost invisible protection against any wear and tear inflicted on the letters.

that used to produce printed circuit boards and photographic prints. The set-up required is shown in Figure 4.

Once the coloured sheet has been developed, it can be cut to size if necessary, and stuck onto your project using its integral adhesive backing. Further protection of the artwork can then be achieved by either placing a sheet of protective film over it, or by spraying it with either a matt or a gloss protective substance.

Referring to Photos 7a to j, we will progress through and study the various stages of production that are required to achieve the finished result.

First, you will need to draw your design on paper (or graph paper if you prefer) so that you can explore all the various options open to you regarding lettering, line placement, symbols and so on. Once you are satisfied with your layout, you need to transfer the design, using Maplin graphic transfers, onto a piece of transparent tri-acetate sheet (available from art shops and large stationers). Place the tri-acetate sheet on top of your artwork. Remember, discrepancies of only 1mm can mar the final appearance, so it is wise to fasten the tri- acetate sheet onto the paper with adhesive tape to prevent movement.

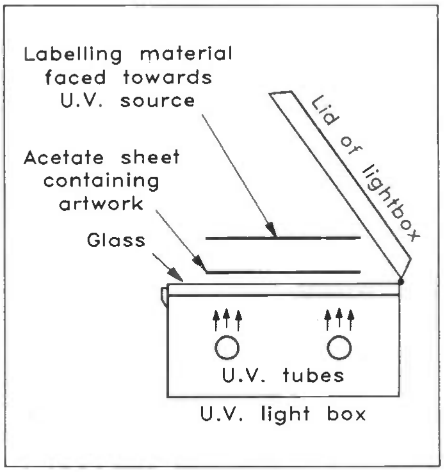


Figure 4. Exposing 3M Dynamark labelling material to UV light, prior to development.

Next, you will need to mark your tri-acetate sheet with 'datum-points'. These marks, which will not appear on your finished label, are necessary in case your artwork should be moved accidentally whilst being marked out. Should this happen, the datum points can be employed to accurately re-locate the exact position of the tri-acetate sheet once more. Placement of datum points is up to you, but they are usually marked at each corner of the label or, for example, superimposed over four corner-fixing screws where they will not be seen. However, if you have to place them in such a position where they would remain visible on the finished label, then remember to remove them from the tri-acetate sheet before the UV exposure stage, otherwise they will be transferred to your final artwork. Removal of any datum points or mistakes can be accomplished quite easily using – yes, you've guessed it – isopropyl alcohol!

Using your chosen Maplin graphic transfer sheet of lettering, identify the centre position of any holes that are required using some sort of mark. 'Rapidograph' techni-

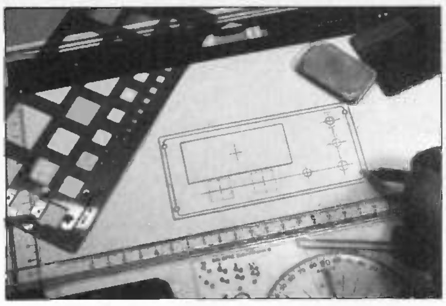


Photo 7a. Drawing the artwork in pencil first, allows for any changes to be made.

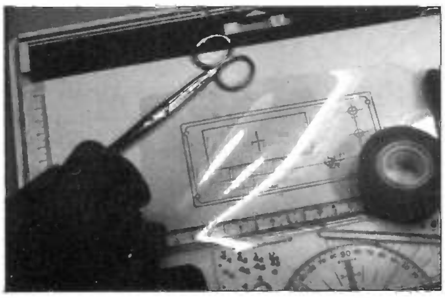


Photo 7b. A piece of tri-acetate sheet is placed carefully over the pencil drawing, before attaching the two firmly together with adhesive tape.

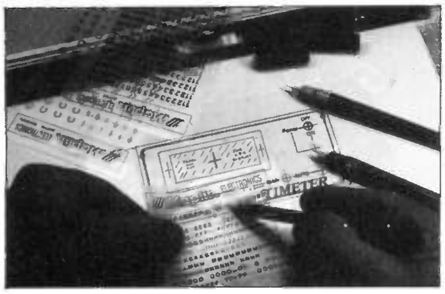


Photo 7c. Maplin graphic transfers are used to apply any necessary lettering or artwork to the tri-acetate sheet. Datum points are marked at each corner of the sheet, in case of accidental movement.

Photo 7d. Placing the artwork onto a piece of 3M labelling material. Make the label slightly larger than the artwork; it can be trimmed to size afterwards. To prevent movement, the two should be fastened together with adhesive tape.

Photo 7e. Having completed any required test exposure(s), place the artwork and label onto the glass of the UV exposure unit, with the label's emulsion towards the light source, and expose for the required period of time. Observe all the safety precautions relating to the use of UV light.

cal drawing pens, made by Rotring, are an ideal method of marking the tri-acetate sheet. They come in a variety of nib sizes and, when used with Rotring black drawing ink, allow any number of marks, lines (or whatever) to be placed onto the sheet. Alternatively, a 'full stop', from the graphic transfer sheet, would do as a centre-hole marker.

Rub down any necessary lettering, paying careful attention to the distance required above (or below) any place where a rotary control has to be fitted. I say this because it can prove deceptive when calculating just how far away from the centre of the hole any lettering has to be. Take into consideration the size of the control knob, then add some distance above or below it, so that the actual writing can be read with ease.

Be meticulously clean when working with the tri-acetate sheet. Ideally, wear a pair of white cotton gloves to save marking it with greasy fingerprints. Remember that any speck of dust or imperfection stopping the UV light reaching the labelling material will be faithfully reproduced on your label!

Once you are happy with the artwork, the next step is to expose it to an ultra-violet light source. Some of you may already be in possession of an UV light box, which you use to produce your own PCBs. However, if you don't have such a box, then using an ultra-violet sunlamp will be just as effective. Observe all the safety precautions when using a sunlamp – and remember to wear goggles. Don't stand in front of the lamp waiting for the label to be exposed. Move well away, ideally to another room. Some experimentation regarding exposure times will have to be executed beforehand on an off-cut of your chosen material. 3M supply an exposure test strip so that you can calculate the correct UV exposure time for your labelling material. By placing the test strip over a small sample strip of plastic or metal labelling material, and then exposing it to UV light for 5 minutes, you can ascertain from the test results whether or not to change the exposure time. For instance, if you are using plastic label material, the test sample (once developed) should only show numbers 1 and 2, after which the strip should remain clear. For metal labels, numbers 1 to 3 should be visible. If your test sample shows more numbers than are required, then you have over-exposed it to the UV light source. However, if your sample has fewer numbers than required, then it has been under-exposed. Repeat the test until correct, and make a note of the corresponding time.

Having ascertained the correct

Photo 7f. Having exposed the label, place it in a plastic dish and pour a small amount of 3M developer over its surface.
Wear protective rubber gloves and eye goggles during this operation.

Photo 7g. Using an ML4 pad, begin development by using light figure-of-8 movements to remove most of the background coating.

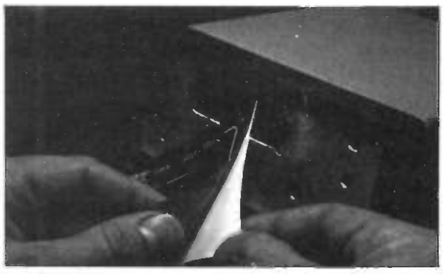


Photo 7h. After rinsing the label under running water, dry and remove the paper backing. Carefully place the label onto the metalwork of your case.

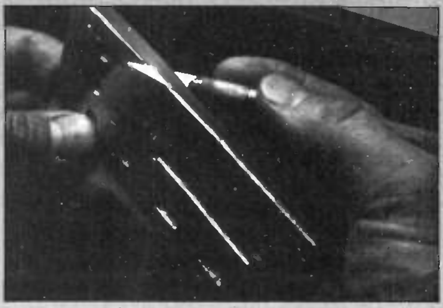


Photo 7i. With the label fixed firmly in place, trim off all excess material from around the edges.

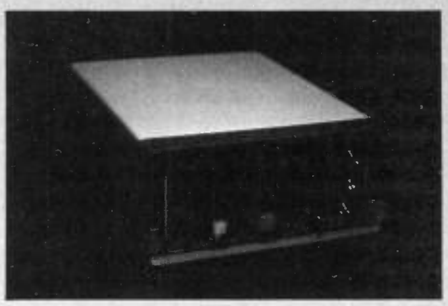


Photo 7j. The finished label, with components fitted, adorning the front of an electronic stopwatch project.

exposure time (which is usually around 5 minutes), put both the tri-acetate sheet containing the artwork and the Dynamark material into the lightbox, with the artwork closest to the UV light source (see Figure 4). Exposure times will vary depending on the colour and type of material that you have chosen to use. It is not necessary to use a darkroom when handling the photosensitive material, but don't handle it for more than 5 minutes in bright light. Keep it in the dark until required, and work in subdued or yellow lighting if at all possible. If you are using an ordinary type of UV sunlamp (i.e. the type used for tanning the body), then you will have to place the labelling material and artwork under a sheet of glass, in order to keep them in close proximity to each other. Again, observe the safety precautions mentioned earlier regarding the sunlamp.

Once the exposure is complete, and the material has been removed from the light box, development can begin. For this, you will need a bottle of 3M's 8500 photosensitive developer and some ML4 pads. At this point in time, suitable precautions must be taken before using the developer. Eye protection is recommended, as is the wearing of protective gloves – and use the developer in a well-ventilated area. Pour a small amount of developer onto the exposed material, and spread it immediately over the surface of the label by using one of the ML4 pads. After a few seconds, the image of your artwork should start to appear. Continue to rub the ML4 pad over the label's surface, using gentle but firm strokes. After a little while, reverse the pad or turn it inside out whilst adding a little more developer.

After between 30 seconds and a minute, your label will be fully developed.

After a final rinse under running water to wash away any remains of the developer, the label is ready for sticking onto your project. Make sure you align it correctly into its final position before pressing it down, as you won't get a second chance. Once it is stuck to the surface of your box, it's there for life! Trying to remove the label will only cause it to distort or crack.

You can now cut out all of the holes where the components are to be fitted, using a sharp DIY knife. Simply push the blade through the label and into the hole behind, rotating the knife around the edge of each hole.

For extra protection, labels can be sprayed with 3M 3900 (gloss) or 3930 (matt) spray. Alternatively, protective film 8019 (matt) or 7931 (gloss) can be placed over the label. All that remains is to carefully fit the components into their respective holes.

It may appear at first sight that the 3M labelling system process is very involved and somewhat fiddly. However, I can assure you that after the artwork has been prepared, the action of making the actual label takes no more than 10 minutes. You then have a remarkably accurate reproduction of your artwork, commensurate with a label of great durability and quality.

Being Different

There may come a time when the ranges of enclosures offered in electronic component catalogues fail to meet your requirements. They may be of the wrong shape or size for your needs, or may have panels in all of the wrong places. It could be that you don't want your enclosure ending up looking like all the others on the market. What can be done about this? Well, a visit to the local model shop could well reap rewards. There you will find all sorts of bits and pieces which could help you with the construction or remodelling of an enclosure. A typical selection is shown in Photo 8. They usually have various kinds of metals on offer, which are sold in sheet form, or as tubing or rods. Then there are several types of wood, all offered in different shapes and sizes. Do not forget plastic model kits either, or those shelves loaded down with add-on goodies, all of which are capable of enhancing your project. I'm not saying that your multimeter project will look better with a plastic Chieftain Tank bolted to the side of it; what I'm advocating is the deployment, on your project, of small items of a shape that would be hard to reproduce at home or obtain readily from elsewhere. If you think along the lines of changing an ordinary household room by adding beading and other DIY decorative

Photo 8. Model shops contain a wide variety of unusually-shaped objects, along with the more commonly stocked items (such as paint, metal sheeting and brass rods). Model shops are well worth a visit when looking for unusual items to enhance the appearance of your project.

Photo 9. Front view of the completed 'BENCHMASTER 104'. The reasons for giving this project such a name are discussed in the text.

trimmings, then you will know what I'm getting at. It's impossible to go into details here, as what should be done depends on your circumstances, your project and your imagination. Suffice to say, be frugal with your changes and you will have created a project that will be sufficiently different from all the rest!

Conclusion

If you've been building the 'BENCHMASTER' project over the last few months. Hopefully, you will have taken great care during the construction and artwork stages before reaching completion. You should now be in possession of a very useful piece of equipment, capable of offering a stereo preamp with switchable microphone or RIAA inputs, a 15W per channel stereo power amp, and a twin 1·2 to 30V variable power supply. The finished prototype is shown in Figure 9.

One of the rewards of building equipment at home is that, once a project has been finished, you can stand back proudly from it and say to yourself... "I did that – and it's unique, because *I* decided on its final appearance".

Nevertheless, the degree of uniqueness and professionalism that it appears to have depends upon whether you have grasped the qualities that do indeed cause one piece of equipment to stand out above the rest. Identify those qualities and you are well on the way to producing equipment that looks superb, taking on that professional appearance so sought after by many constructors.

Acknowledgments

Acknowledgments are due to Kemps Model Shop, Wymondham, for granting permission to take Photos 3 and 8 on their premises.

Stray Signals

by Point Contact

Occasionally PC thinks that despite having a piercing analytical mind (at least when it comes to technical matters), he must be a little slow on the uptake. Sets of initials are no problem; you won't catch me out with RISC, ASIC, CAD/CAM, SPARC, DSP etc. Even in other fields, such as medicine (a topic not without interest for PC, who's sister is a doctor), I know for example what ACTH is, and what PKU stands for. From time to time new words suddenly appear though – about 20 years ago everybody started talking about 'commuters' without ever saying what they were, and years later the Iron Lady dredged up the word 'renege' from the depths of the Longer Oxford English Dictionary. Fortunately in these cases the meaning soon became evident from the context, but this is not always the case. Currently PC is puzzled by a medical mystery – I know about bacteria and viruses and microbes and germs, but can't find out what 'freshens' are. Still, it's comforting to know that whatever sort of nasties they are, the particular brand of lavatory cleaner that Mrs PC uses kills germs and *them*.

Returning to matters electronic, where PC feels more at home, it was announced some little time ago that research physicists at the Dallas Laboratories of Texas Instruments have made a transistor operating on quantum effect principles, a world first. Its dimensions are 100 times smaller, and carrier transit speeds are more than 1000 times faster than bipolar transistors. Although strictly a laboratory development at present, future development holds out the hope of chips with 100 times more functionality, size for size, than present day ICs, whilst consuming far less power. Truly, the future holds the promise of supercomputer performance in a lap-top portable. What a contrast to the level of functionality available in the days of valves, a mere four decades ago.

Talking of valves reminds me of the days when the schoolboy PC earned a little extra pocket money by repairing radios. Customers came to me by recommendation, as my charges were lower than those of radio shops. A common fault was bad distortion of the sound, and this could be due to a number of causes. One of the commonest was grid current in the output valve. One could sometimes diagnose this at a glance, from a blue glow in the region of the anode, but this was not an entirely reliable indication as some valves, notably the EL36, frequently had a little blue glow without noticeably, affecting the performance. Where grid current was the cause of the distortion, PC offered the customer a choice of alternatives: fit a new output valve at the cost of £1.00 (list price 15 shillings (75p), though what I paid for them on the surplus market was another matter), or my patent fix for five bob (25p) which would probably last for years (but no guarantee). Most customers gratefully opted for the latter course, which involved dropping the grid leak resistor from the usual 470k to 33k – if the resultant audio sounded too thin then one also increased the size of the coupling capacitor from the anode of the preceding double diode triode. It didn't cure the grid current problem, but it did greatly reduce the voltage drop which this caused across the grid leak, restoring the bias conditions to what they should be. About that time, PC was inordinately proud of a valve voltmeter, with a 10 megohm input impedance, which he had built; what a contrast to the 10k/volt of the usual multimeter. On boasting about it to Charlie, the local friendly radio dealer, PC was promptly shot down in flames. I had proudly announced that my new valve voltmeter was so sensitive that it could measure the volt drop across the grid leak of an output valve, so unmistakably indicating the presence of grid current. Charles said *he* used his multimeter, which I knew was only 10k/volt. "Nonsense" I said, "it's not nearly sensitive enough," but Charlie insisted. On challenging him to prove it, he simply said he watched his meter while measuring the anode voltage, and shorted the grid leak: if the anode voltage changed there was grid current. It had never occurred to me that one could use the output valve as its own valve voltmeter!

Yours sincerely,

Point Contact

Ideal for beginners – No soldering required.

All You Need to Build Your Own

FUNTRONICS

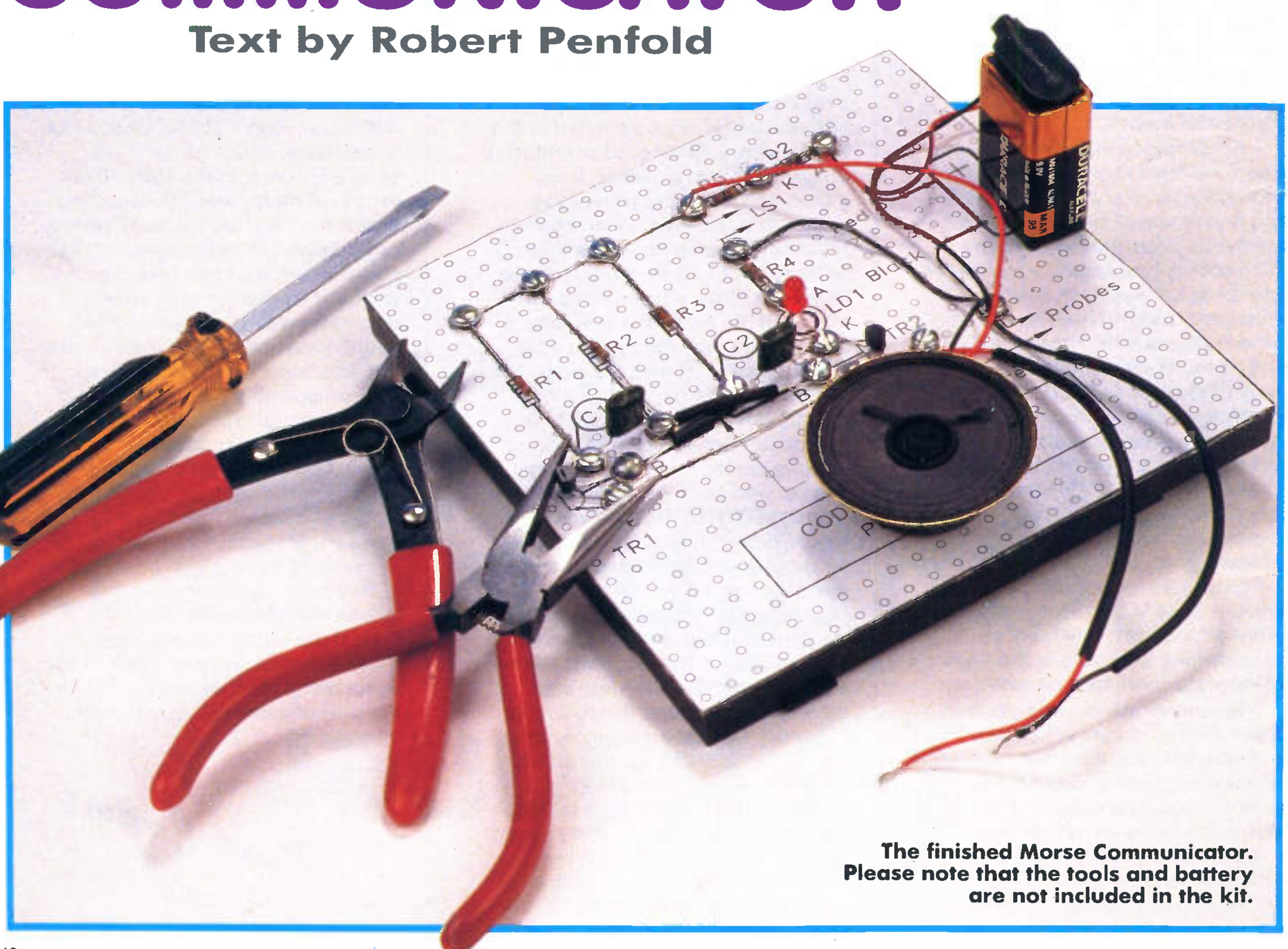
PROJECT No 9

MORSE CODE COMMUNICATOR

Text by Robert Penfold

It is an interesting fact that if conditions are so bad that other forms of communications won't work, Morse Code transmissions will often get through. It was the first form of radio communication, and it was used for communications via wires in the pre-radio era. In these days of space satellites you can still hear radio amateurs talking to each other around the world in Morse Code, just for the pleasure of it. Due to its ability to reach the areas that other forms of communication cannot, it is still used for commercial, maritime, and military communications.

This project will help you to learn Morse Code and communicate with others using this special 'language'. It must be stressed that the unit featured here simply produces an audio tone and lights an LED when the 'key' is depressed. It is not any form of radio transmitter; you have to pass the RAE (Radio Amateurs' Examination) and obtain a Class 'A' amateur radio licence before you can do that! Alternatively, you could study for your Novice Licence; contact the Radio Society of Great Britain



The finished Morse Communicator. Please note that the tools and battery are not included in the kit.

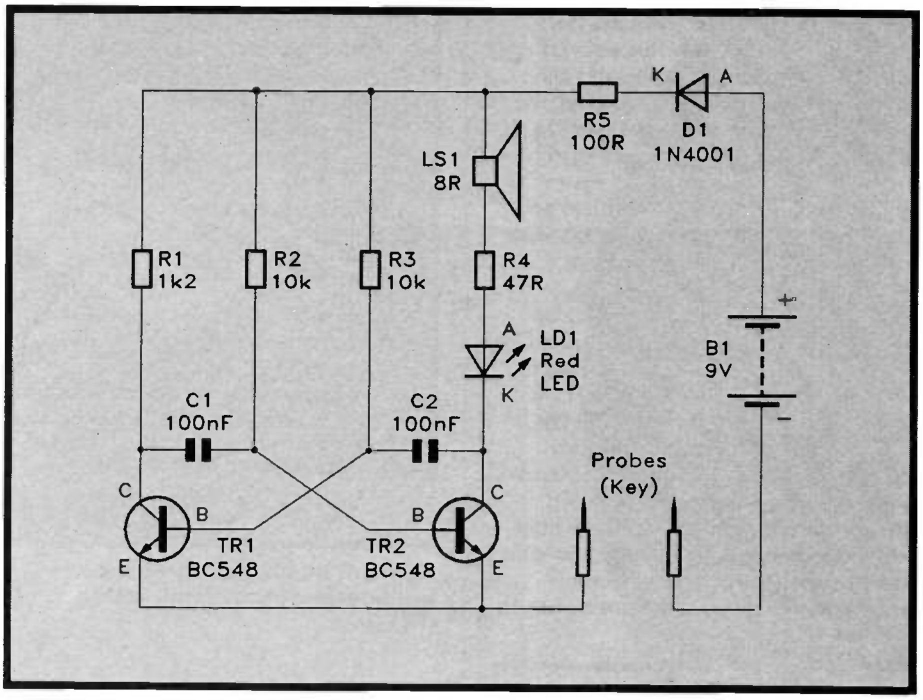


Figure 1. The Morse Communicator circuit diagram.

(RSGB) for further details. Amateur radio is a fascinating hobby; it gives you the chance to talk to people all over the world and make new friends, while acquiring useful technical knowledge. There may even be a radio amateur's society near you if you wish to find out more; the RSGB will put you in touch with your local club if you are not sure that one exists! However, until such time as you join the airwaves as a licensed amateur, the Morse Communicator can be used to communicate over short distances if a twin cable is used between the receiving and transmitting units.

How it Works

Refer to Figure 1 for the circuit diagram of the Morse Code Communicator. The circuit does not really need much explanation, being very similar to some of the previous 'Funtronics' circuits. It is basically just another astable multivibrator circuit, the operation of which is described in Funtronics project No. 5 (The Flasher, detailed in the April 1992 issue of 'Electronics', Order Code XA52G).

This one operates at a frequency of several hundred pulses per second (Hertz), and the output of one transistor (TR2) is used to drive LED indicator LD1 and the loudspeaker, LS1. The LED will flash at a rate of several hundred times per second but, as we have seen before, it will appear to light continuously. Although it is only receiving brief pulses of electricity, the average current flowing through LD1 is quite high, and so it will light up quite brightly. The loudspeaker converts the pulses of electricity into soundwaves, and you hear the rapid succession of clicks produced as a audio tone.

R5 and D1 are the protection components, as fitted to all 'Funtronics' projects. If you should manage to make a mistake, such as getting the battery connected the wrong way round, R5 and D1 will protect the components in the circuit. A pair of prods connect, or disconnect, the battery from the circuit, turning it 'on', or 'off', thereby acting as a simple Morse key.

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 of the sleeving supplied in the kit should be used 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

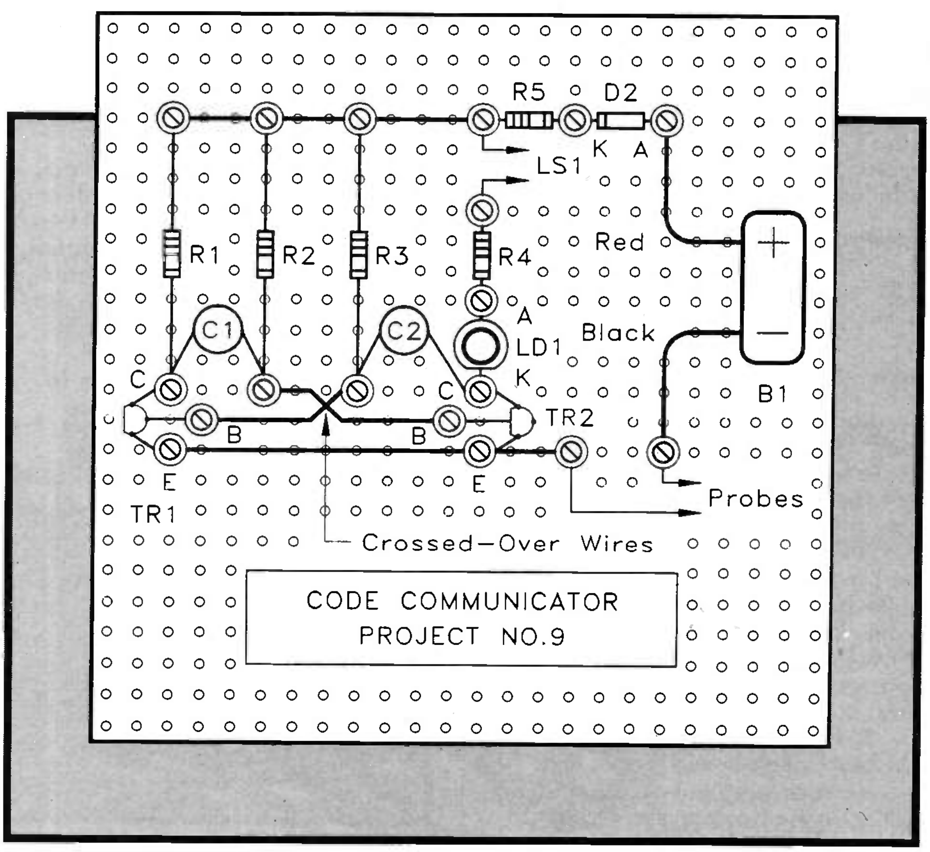


Figure 2. The component guide-sheet for the Morse Communicator.

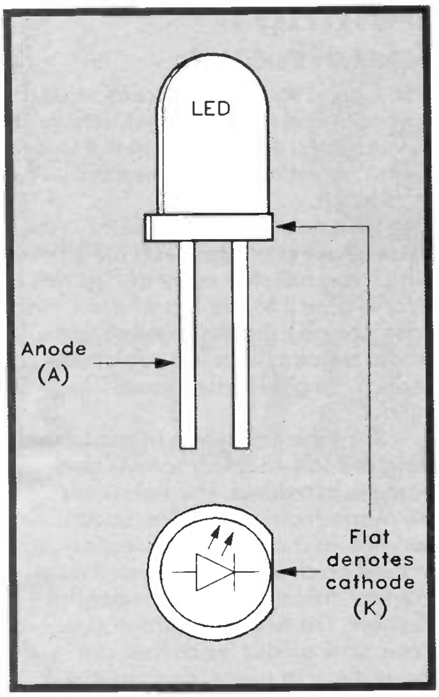


Figure 3. LED symbol and connections (LD1,2).

components' wires so that they are just long enough to loop around the 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 R1,2,3,4 and 5. 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. For each resistor, the colours (and value) are as follows:

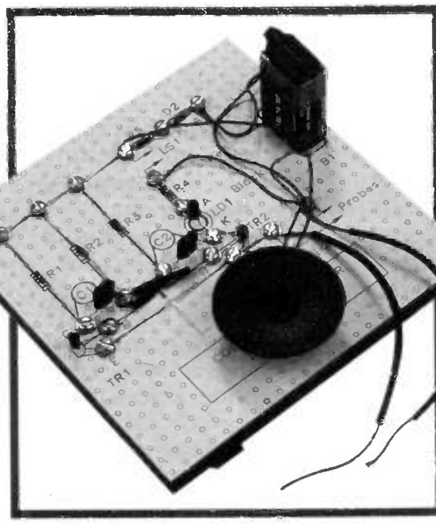
Resistor	**Band Colours**	**Value**
R1	brown, red, red	1200Ω*
R2,3	brown, black, orange	10k
R4	violet, yellow, black	47Ω
R5	brown, black, brown	100Ω

*(also written as 1K2)

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 LED, LD1, which is a 'blob' of clear red plastic with two wires coming out of one end. It is fitted in the position shown on the guide-sheet, and *must* be connected the right way round – or it will not light up. One side of the LED is flattened (the lead on this side of the LED is known as the cathode (K), while the lead on the other, rounded, side is called the anode (A)). The LED, circuit symbol and connections are shown in Figure 3. Make sure that the LED is fitted so that the 'flattened' side lines up with the drawing of the component printed on the guide-sheet.

c) The next component to be fitted is D1, which is a small tube-like component having a lead at each end of its black body. Like LD1, it must be connected the right way round (in other words, D1 is a 'polarised' component). 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. D1, its circuit symbol and connections, are shown



in Figure 4. The diode should be fitted so that the band lines up with the band on the drawing of the diode on the guide-sheet.

d) C1 and C2, the capacitors, look like little green 'blobs' with two wires coming from the base. As with most capacitors (with the exception of electrolytic and tantalum bead types) it does not matter which way round they are connected. Each should have its value of 0·1 μF included amongst its markings. In most cases this will be shown as 104 (10 with 4 '0's at the end, meaning 100,000 picofarads,

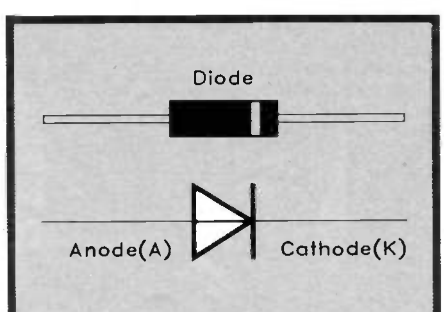


Figure 4. Diode symbol and connections (D1).

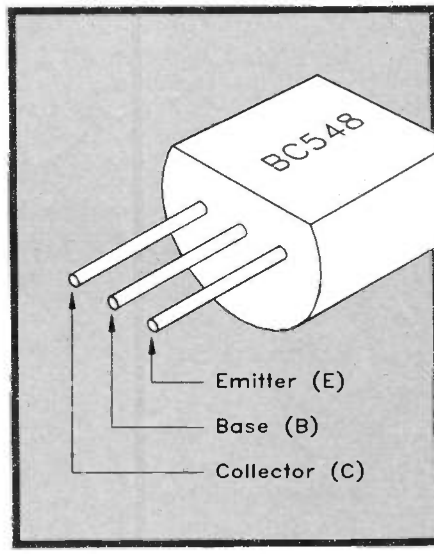


Figure 5. BC548 transistor circuit symbols and lead identification (TR1,2).

which represents the same value.)

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 number, which in each case is 'BC548'. 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 5 shows which lead is which, making this task easy.

f) The loudspeaker (LS1) is the largest (and heaviest) component supplied in the kit (except for the board, of course), and 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

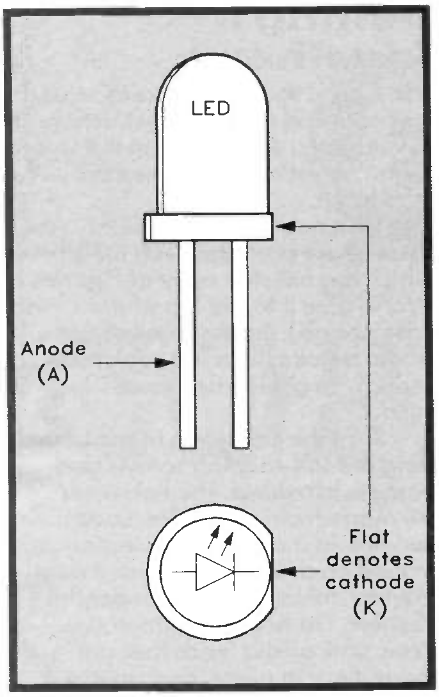


Figure 3. LED symbol and connections (LD1,2).

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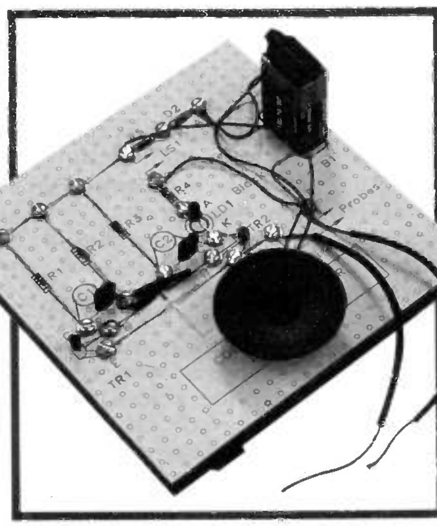

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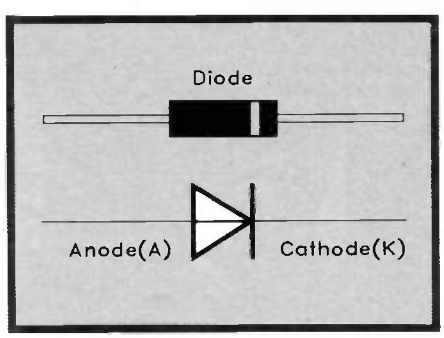

Figure 4. Diode symbol and connections (D1).

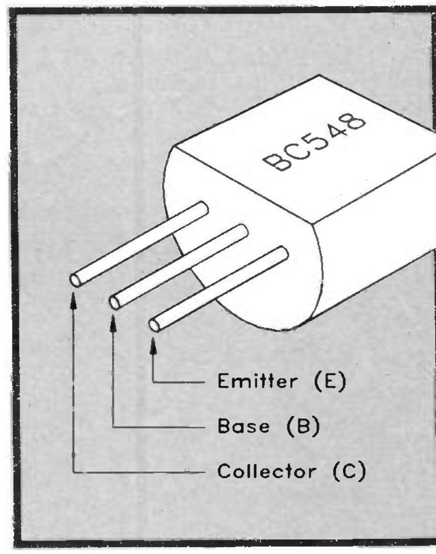

Figure 5. BC548 transistor circuit symbols and lead identification (TR1,2).

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 number, which in each case is 'BC548'. 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 5 shows which lead is which, making this task easy.

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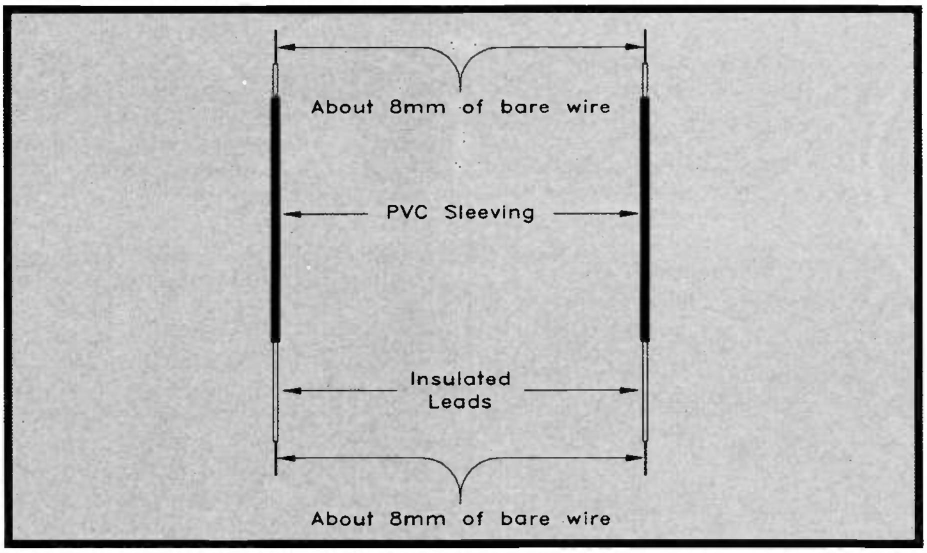


Figure 6. Preparing the probes.

A	di dah	·–	Y	dah di dah dah	–·––
B	dah di di dit	–···	Z	dah dah di dit	––··
C	dah di dah dit	–·–·	.	di dah di dah di dah	·–·–·–
D	dah di dit	–··	?	di di dah dah di dit	··––··
E	dit	·	Error	di di di di di di di dit	········
F	di di dah dit	··–·	1	di dah dah dah dah	·––––
G	dah dah dit	––·	2	di di dah dah dah	··–––
H	di di di dit	····	3	di di di dah dah	···––
I	di dit	··	4	di di di di dah	····–
J	di dah dah dah	·–––	5	di di di di dit	·····
K	dah di dah	–·–	6	dah di di di dit	–····
L	di dah di dit	·–··	7	dah dah di di dit	––···
M	dah dah	––	8	dah dah dah di dit	–––··
N	dah dit	–·	9	dah dah dah dah dit	––––·
O	dah dah dah	–––	0	dah dah dah dah dah	–––––
P	di dah dah dit	·––·			
Q	dah dah di dah	––·–			
R	di dah dit	·–·		Try to decode this message:-	
S	di di dit	···		dah di dah dit di dah dah dit	
T	dah	–		di dah dah dit dah di dah dah	
U	di di dah	··–		dah dah dah dah dit dit di dah dit	
V	di di di dah	···–		dit dah di dah dit dit di dit	
W	di dah dah	·––		di di di dah dit dah dah dit	
X	dah di di dah	–··–		di di dah dah di dit	

Table 1. The International Morse Code.

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 two pieces of insulated multi-strand wire (coloured red and black) and two pieces of hollow insulated sleeving (also coloured red and black). The probes should be made up as shown in Figure 6, use wire strippers to remove the insulation where shown. Again, the bare ends of the leads should be twisted together to prevent the wires from splaying apart. Slide the red sleeving over the red wire and the black sleeve over the black wire. Connect the two wires to the screws on the board marked 'Probes' – the red wire should go to the screw nearest the emitter of TR2 (shown on the board by the letter 'E'). The free ends of the two wires are touched together to act as a Morse key.

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 guide-sheet. The 9V PP3 type battery should be connected to the battery connector, it will only fit properly one way round.

Testing and Use

To test the unit, simply connect the battery and then touch the bare ends of the prods together a few times. The unit should produce a Morse-like 'beep' and the LED should light up, while the prods are touching. If the unit does not work, disconnect the battery at once and recheck the wiring. In particular, make sure that LD1, D1, TR1, and TR2 are connected correctly.

When learning Morse Code, it is essential to think in terms of sounds, rather than dots and dashes. Most people find the task easier if dots and dashes are thought of as 'dit' and 'dah' sounds respectively, see Table 1. With perfectly sent Morse, a 'dah' is the same length as three 'dits'. The space between characters is also three 'dits' long, and the space between words is equal to seven 'dits'. There is no way of getting all this spot-on – you just have to 'guess-timate' it as accurately as you can. The main thing is to get a steady rhythm so that your Morse Code is consistent. It should then be easily read.

You will probably find it much easier to learn the characters a few at a time rather than trying to learn the whole lot at once. You can practice sending Morse code using your Code Communicator, and you can practice receiving Morse with the aid of a helper, a cassette recorder, or a short-wave radio. To communicate using the unit you must connect the loudspeaker to the board via a twin cable (that can be many metres long if necessary), so that the loudspeaker can be installed at the receiving end of the system. For two-way communications, two Code Communicators are required (one unit for each direction).

Availability

The Funtronics Morse Communicator is available from Maplin Electronics, through our chain of regional stores, or by mail order, **Order Code LT07H Price £3.95.**

Next Month

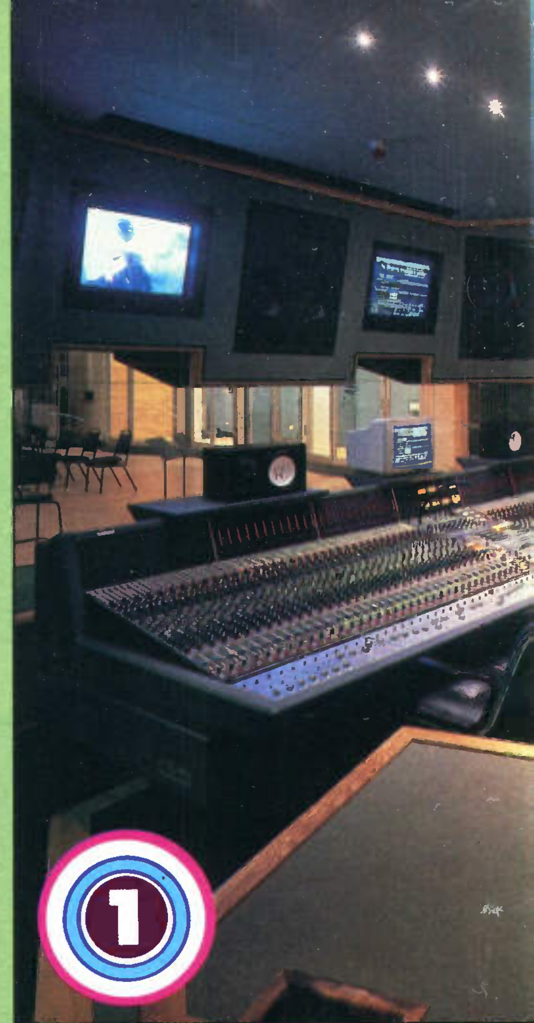
The last Funtronics kit in the series will be a 'Music Maker' – something well worth keeping your ears open for!

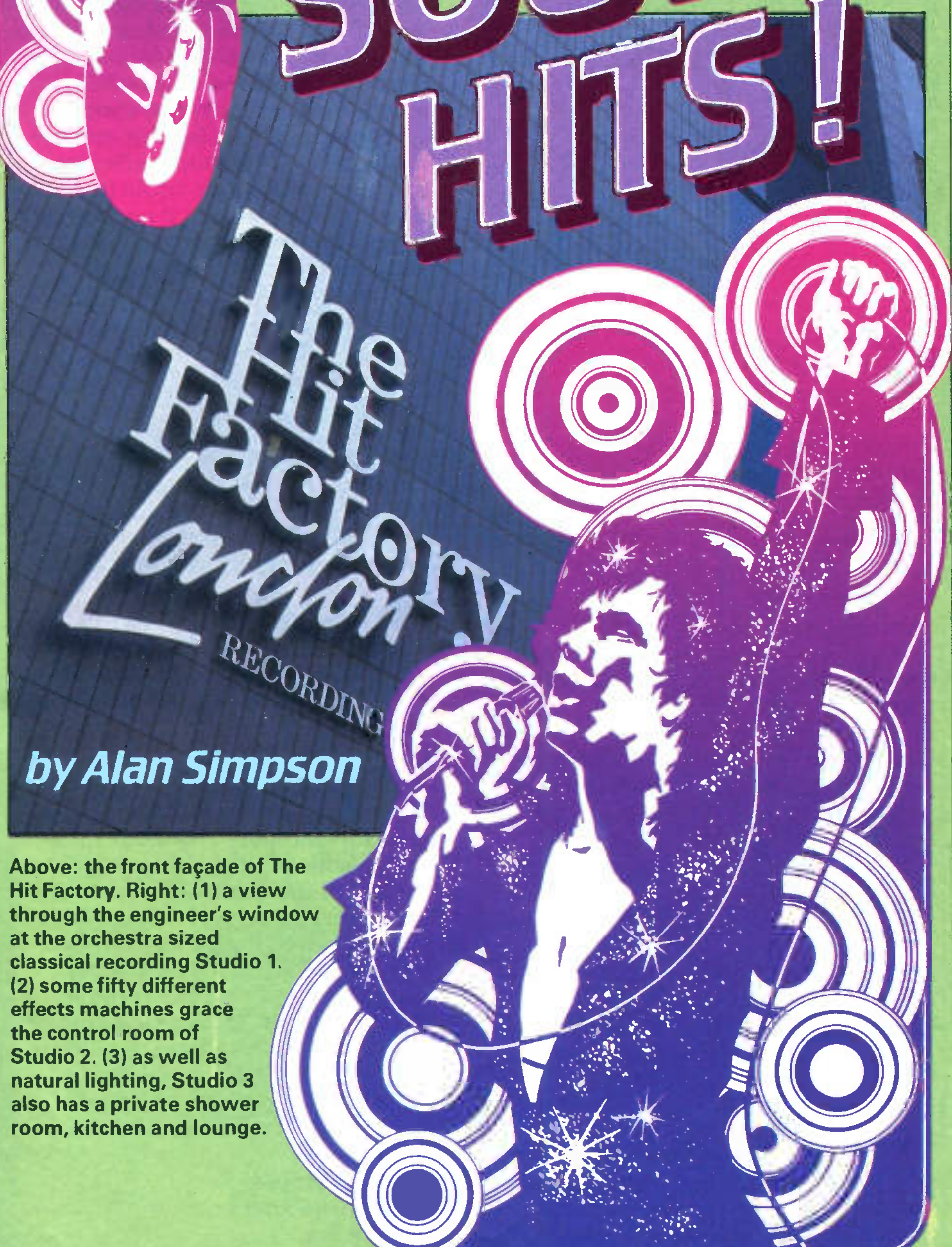
The RSGB

So you are interested in becoming a radio amateur? The main organisation in the UK to contact for information on this broad subject is the Radio Society of Great Britain (RSGB), an organisation founded in 1913. Apart from defending the interests of amateur radio in the UK, the RSGB runs many useful services for its members, as well as publishing the acclaimed 'Radio Communication' and 'DIY Radio' magazines. The address is:
RSGB,
Lambda House,
Cranborne Road,
Potters Bar,
Herts. EN6 3JE.

This month Out and About visits what is claimed to be the UK's most up-to-date record production studio. The Hit Factory may not be able to guarantee you a 'Gold Disc', but the studio does offer substantially more promise (and fortune) than busking under the arches.

MASTERING SOUND HITS!





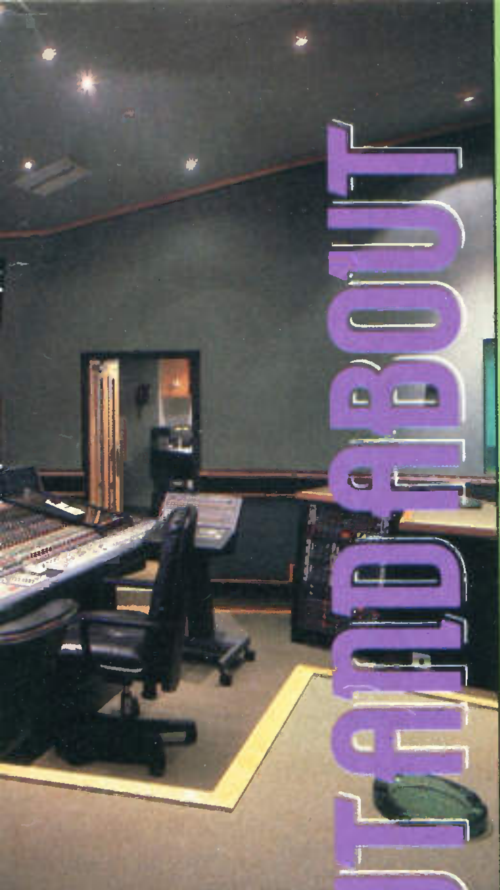
by Alan Simpson

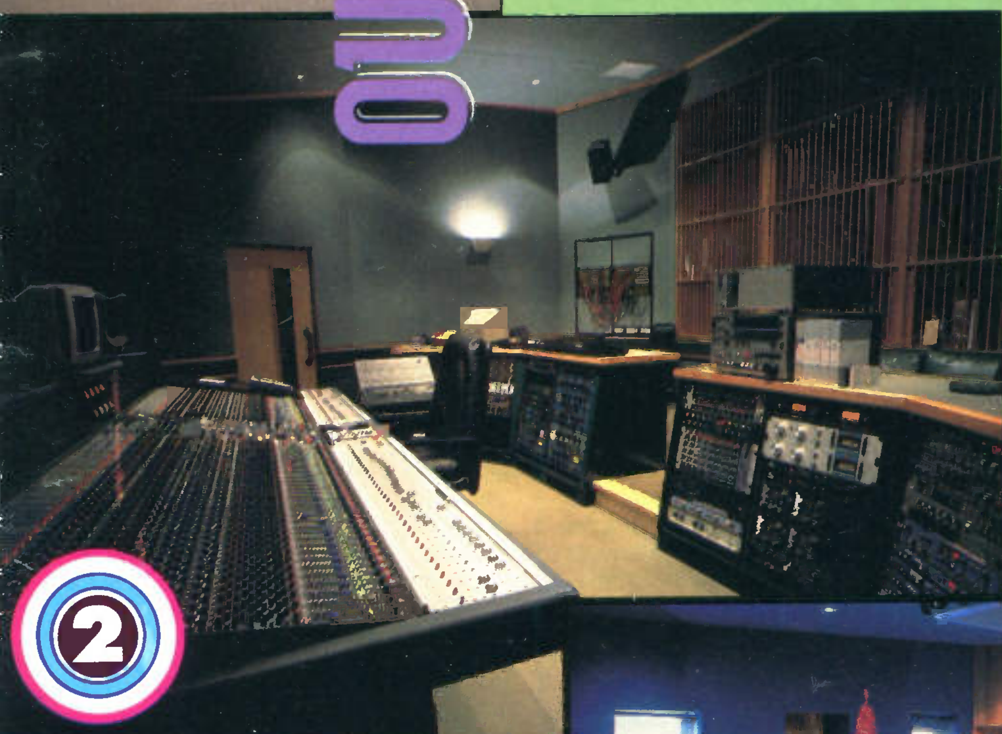
Above: the front façade of The Hit Factory. Right: (1) a view through the engineer's window at the orchestra sized classical recording Studio 1. (2) some fifty different effects machines grace the control room of Studio 2. (3) as well as natural lighting, Studio 3 also has a private shower room, kitchen and lounge.

What do The Rolling Stones, Alison Moyet, Bros, Shakin' Stevens and The London Symphony Orchestra have in common? Well, apart from all being household names, they all use The London Hit Factory recording studios. So what do you need to gain access to one of Europe's most up-to-date studios – apart from money, that is? Certainly the studio facilities are not for the 'hoping to hit the big time' dedicated amateur musician. If you hanker after recording a flute and oboe hit Xmas record, but don't happen to have the resources to buy even a second-hand metronome, you had best stick to your garage studio conversion. The average production and marketing spend needed to produce a hit record album, says Ray Davidson, The Hit Factory Studio Director, is over £¼ million.

For a start, to hire a studio equipped with 24 or 48 track analogue tape-recorders for 'rock work' would cost something getting on for £1,500 for a period of 12 hours. But extras soon mount up. 48 track digital equipment would cost a further £500 per day, and then there are such extras as a 3rd synchroniser, use of edit facilities, Dolby, and working to pictures. And there are more costs to come. If you want to hire the expert skills of in-house producers, engineers, mixers and editors, The Hit Factory will be happy to oblige.

OUT AND ABOUT





Charts Matter

Pop groups have to be exceptional to make it, says Ray Davidson. At the first stage, potential record companies need to be 'turned-on' by a first-class demo tape. Then they need a first-class recording product if they are to make it to the top. *'Artificial' sound is out.* Most studios, says Ray, prefer to create a genuine sound. At the same time, live gigs are essential. But it is a far less essential factor to produce a supporting video. "It is the record which gets you into the hit parade."

Budding groups must also regard their pop career as being a long-term haul, rather than a short-lived blow-out. If any proof is needed, then Dire Straits (now more familiarly known as Di Straits after their number one fan Princess Di) as a group is a wonderful example. Under their genteel leader Mark Knopfler, the group have achieved sales in excess of 20 million copies of their 'Brothers In Arms' album. Okay, so sales were helped by Philips bundling in copies of the CD with their early compact disc players. But even so, their latest album 'On Every Street', backed by a massive worldwide tour, looks like repeating the successful formula. The group are acknowledged leaders in using the resources of modern recording studios to the full.

Dire Straits would certainly have their high tech talents stretched if they made use of The Hit Factory Studios, one of the very select number of such studios to be located in London's West End. Equipment suppliers include Lexicon, Yamaha, Sony, Fairchild, Mitsubishi, Studer, Lynx, and Aiwa. Studio equipment includes Steinway and Fazioli Concert Grand pianos, and facilities include Dolby surround sound.

In fact, The Hit Factory does not need to advertise. "It is all done through personal contact", confirms Bernadette Kelly, studio booking manager. "Our professional staff of 33 include three production engineers, four assistants and three general assistants covering both rock and classical recording." Several of the main recording studios, which were revamped in 1990, have a lounge, shower room, kitchenette, and TV room where it is possible to relax between takes, or while the engineering teams are working on the session. Not surprisingly, the studio, which is open 24 hours a day, seven days a week, is busy most of the time. The Hit Factory can also act as a film studio with an ability to synchronise Dolby surround sound onto film.

A Pressing Need

While the Beatles recorded their strings of hits on 4 or 8 tracks, mainly in monophonic and often in one play-through sitting, today's recording standards are on a somewhat higher plane. The record buying public now expect a high quality product, one embracing analogue, digital, and Dolby stereo technologies. Vinyl, says Ray Davidson, has to be mastered onto a lacquer. To make cassettes, the material has to be transferred onto a DAT or digital mnemonic, while CDs have to be mastered on mnemonic or digital tape. CDs are the future – at least until the next high wave of technology arrives from Japan.

Record industry authority Kay Khan, who is responsible for the international Encore Record label, believes that The Hit Factory is one of the best European recording studios

A tape recorder and a half – 48 digital tracks on the Sony PCM 3348 in Studio 2.

and therefore attracts the cream of the world's musical talent. "Recording is very definitely one activity area where reputation counts." But Kay warns that the studio facilities are not for novices. "The rates are too high. But if you have the funds, then you can do no better than leave it to the experts."

Sound Advice

"Every recording session is different," says Ray Davidson. "The producer will have his own ideas as to the sound required, and will work closely with the engineers to achieve perfection. Each instrument or voice has a highly selective individual mike linking into a separate track. Having made several tracks, the producer balances or mixes the sound, sometimes in conjunction with the artists. At this stage, it could be necessary to do a re-vocal, which then goes through the re-mixing process. The finished product then goes to the record company, artists and producer who review the tracks and give it, hopefully, the thumbs up sign."

If all parties are happy, then it returns to the studio to be mastered. "Mastering is very much a high tech art," says Ray.

"Our specialist equipment can create that perfect sound by tweaking a few vocals here and there. Once the Master has been produced (plus a back-up copy held at the studio), it is sent to the record manufacturing company, probably in Aylesbury for cassettes, Austria for CDs and Holland for Vinyl. The library cases are most often made in Wales where Sony has several factories."

Just about the only thing lacking for The Hit Factory is a zebra crossing outside the studios. However, in all other respects, the Hit Factory can be guaranteed to continue producing a seemingly non-stop flow of top twenty hits. Love them or loath them, you can be assured they have been made in the world's finest recording environment.

You too can sample the delights of The Hit Factory Studios. The top prize in this months contest is a visit for two to The Hit Factory studios in London, and a personally conducted tour by Ray Davidson, the studio director. Who knows, you could find yourself rubbing shoulders with such recording stars as Bros, Paul Young, Rick Astley or even The Rolling Stones! Sony are also kindly donating no less than three copies of the new Rolling Stones CD, 'Flash Point'. To win, just answer the questions below correctly, and the first four all-correct entries drawn out of our editor's aged, moth-eaten hat, will be hearing from us.

The rules are simple. Just zap your entry on a postcard (or back of an envelope) to 'Sound Hits Competition', The Editor, Electronics – The Maplin Magazine, P.O. Box 3, Rayleigh, Essex, SS6 8LR. Take note that the contest closes on 31st August 1992.

Please also note that employees of Maplin Electronics and family members of same are not eligible to enter. In addition multiple entries will be disqualified.

SOUND HITS! COMPETITION

1. 'Top of The Pops' can be seen where?
a) On Sky TV
b) On BBC TV
c) At the local lemonade factory

2. Where is the Royal Albert Hall located:
a) South Kensington, London
b) Alberta, Canada
c) The Royal Docks, East London

3. Spot the 'top twenty' odd one out:
a) Randy Crawford
b) Madonna
c) The Phantom Tadpole
d) Linda Ronstadt

4. Who heads The Rolling Stones?
a) Samantha Fox
b) Gilbert & Sullivan
c) Andrew Lloyd Webber
d) Mick Jagger

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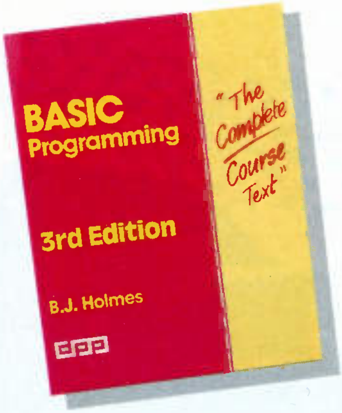
NEW BOOKS



BASIC Programming

Third Edition

by B.J. Holmes

The aim of this book is to present to the reader the many facets of the BASIC language, in the context of a college-based course on computer programming. The book has already proved to be very popular with those students studying for computer examinations, where BASIC is the preferred language.

In addition, the home-computer enthusiast who wishes to progress beyond the 'game-playing' stage will also find this text invaluable in understanding how to program a computer.

BASIC is an acronym for 'Beginner's All-purpose Symbolic Instruction Code', and was developed at Dartmouth College, USA, as a means for teaching students a simple language for programming a computer. The language can be used to solve problems covering a wide range of applications on many different types of digital computer.

In recent years many small and inexpensive microcomputers have become available that use BASIC, so the language is readily available and, because it has been designed for ease of use, program development can be achieved in minimum time with the minimum effort. BASIC is a 'high level' language meaning it consists of statements written using English words and mathematical notation.

However, the compatibility of the language between different machines has suffered. It has therefore evolved into many different 'dialects', having a common core of statements resembling the 1960s original, with extra make and model specific features added to support such things as structured programming, file processing, graphics and sound. This book however has *not* been written for any one dialect, but deliberately for use with any computer that uses BASIC. However, the dialect differences between Microsoft BASIC as used on the IBM PC and compatibles and the BBC/Electron BASIC are included by way of illustration.

The majority of BASIC programming books tend to concentrate on BASIC coding and pay little attention to the design of programs prior to coding. Such books encourage the composition of programs at the keyboard, which generally leads to poorly designed programs that often contain errors and become very difficult to maintain. Throughout this book the emphasis is on structured program design from proper planning. Contains many programming examples. Well recommended.
1990. 287 pages. 245 x 190mm, illustrated.

Order As WZ27E (BASIC Programming) £7.95 NV

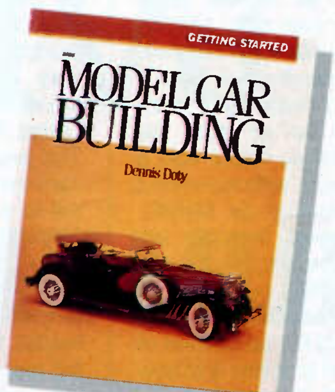
Getting Started in Model Car Building

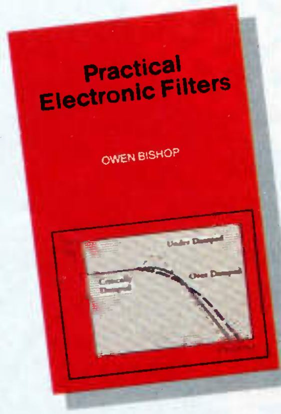
by Dennis Doty

While this book has nothing to do with electronics directly, it would however, be very useful for anyone interested in building radio controlled models for example. While concentrating on static model cars, the chapters constitute a complete guide to the materials and tools you will need, descriptions of various painting methods, and details on realistic finishing applications for both plastic and metal components, and includes hints and tips from an author having many years experience behind him, enabling you to produce authentically detailed models.

The book also includes a brief history of car modelling, tracing models from the introduction of 1/16 scale wooden models in the '40s to large-scale models popular in the '70s. The way in which injection and vacuum moulded plastic parts revolutionised the business in the '50s is also covered. The production of a model kit is followed, from the initial proposal stage to actual assembly and testing in the manufacturer's shop. For this alone the book should interest anyone who enjoys plastic kit model building as an insight into the production processes. Some addresses are also given but be aware that the book is American.
1989. 128 pages. 233 x 188mm, illustrated.

Order As WZ24B (Model Cars) £8.95 NV





Practical Electronic Filters

by Owen Bishop

Filters play a vital part in almost all electronic circuits, yet many people believe that they are difficult to understand. This is probably because so many of the books on this topic are extremely mathematical. By contrast, this book deals with the subject in a non- mathematical way. It reviews the main types of filter, explaining in simple terms how each type works and how it is used.

The book also presents a dozen filter-based, practical projects with applications in and around the home or in the constructor's workshop. These include a number of audio projects such as a rhythm sequencer and a multi-voiced electronic organ. Project descriptions include circuit diagrams, explanations of their operation, and detailed instructions for building them. A number of the projects are suited to the beginner, while some will be of interest to the more advanced constructor.

Concluding the book is a practical step-by-step guide to designing simple filters for a wide range of purposes, with circuit diagrams and worked examples.

The author is well-known as a contributor to the popular electronic magazines and is the author of over 50 other books mainly on electronics.
1991. 104 pages. 178 x 111mm, illustrated.

Order As WZ22Y (Pract Elec Filters) £4.95 NV

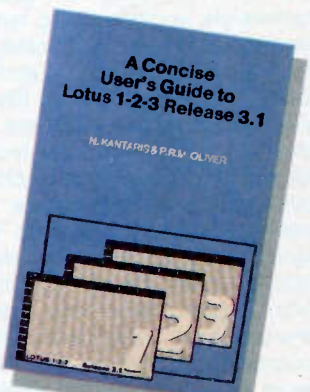
A Concise User's Guide to Lotus 1-2-3 Release 3.1

by N. Kantaris and P. R. M. Oliver

Lotus 1-2-3 is a powerful and versatile software package which, over the last few years, has proved its usefulness, not only in the business world but also for scientists and engineers. The program's power lies in its ability to emulate everything that can be done by the use of pencil, paper and a calculator. Thus, it is an 'electronic spreadsheet' or 'spreadsheet', a name which is also used to describe it and other similar products. Its power is derived from the power of the computer it is running in, and the flexibility and accuracy with which it can deal with the solutions of the various applications it is programmed to manage. These can vary from budgeting and forecasting to the solution of complex scientific and engineering problems.

Early versions of 2.0 2.01 and 2.2 run on IBM XTs and compatibles (having 8086 or 8088 processors). This book deals with versions 3.0 and 3.1, requiring a slightly more powerful 80286/80386 equipped AT or PS/2.

If you are a PC user and want to upgrade to Lotus 1-2-3 Release 3.1, then this book will teach you how to do just that in the shortest and most effective way. It was written with the existing spreadsheet user in mind, and has been designed so that you don't have to start at the beginning and go right through to the end. The more experienced user can start at any section as these were designed to be self-contained.



You will find out how to generate and manipulate 3-dimensional worksheets and link files together; how to generate and add graphs to a worksheet, edit, preview and print worksheets; how to use the WYSIWYG add-in to produce top quality displays; how to set up a database management system, sort and search a database, use the find, extract and modify commands; how to create macros and custom menus, use macro keywords and debug a macro.

The book lists all the Lotus 1-2-3 3.1 indicators, functions and macro commands so that it is self-contained and can be used as a reference long after you become an expert in the use of the program.
1991. 112 pages. 198 x 130 pages, illustrated.

Order As WZ43W (Users Guide Lotus 3.1) £3.95 NV

Radio Controlled Model Cars

by Trevor Tennant

Introducing the Basics

The hobby of 1/10th scale model buggy off-road racing has now been a worldwide activity for close on ten years. As with most things, the Japanese are responsible for the popularity that the sport has attained.

A Brief History Lesson

A few words on the history of model racing may prove interesting. Before the last war, in spite of suitable small lightweight engines being rare and very expensive, there was some activity in both the United Kingdom and the United States. The engines were lifted from the pioneer model aircraft of the time, while the cars themselves were crude devices designed to go around in circles, being anchored to a central pole by a steel cable. The early cars with their spark ignition engines were not very fast, with 60mph being the top speed. After the war, engine power rose markedly with the magic ton being the aim of all serious competitors. Here in the UK, speeds were kept down by the absence of the top-performing American engines. This was a direct result of the draconian import restrictions of the time.

Gradually, as the top racers obtained the relevant engines, speeds began to rise. After only a few years speeds, and more ominously costs, rose so much that only the person with considerable means could compete, and the sport died out in the UK. However, on the continent, cable car racing still has followers – and speeds are now 300mph plus!! During the war, the Americans took some cable cars, removed the cable attachments, fitted some guides under the cars (which engaged on a vertical guide rail), and built some fearsome tracks, with banked corners angled over 75°. This must have been a frightening spectacle with up to six cars, each weighing over eight pounds, travelling at over 80mph.

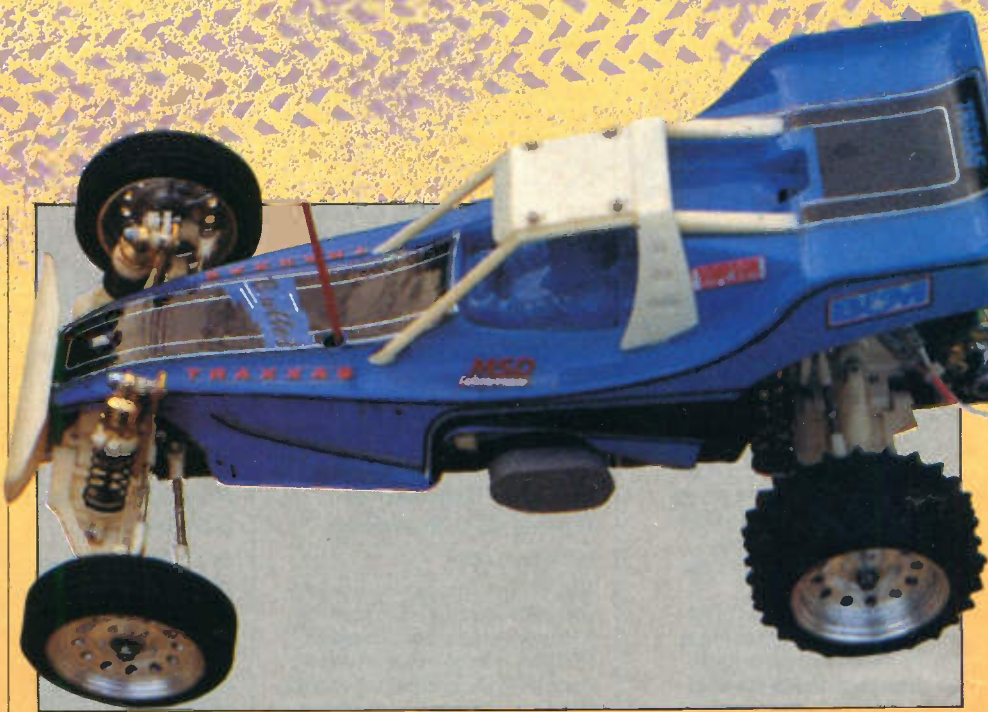


Photo 1. The Bullet fitted with batteries – and ready for its first racing challenge!

In the UK, a group of model engineers, inspired by reports of the Americans' track-racing exploits, decided to build their own versions. These were suitable for use indoors, and used small British diesel engines. The first club was the Raildromers of North London, and the circuit and cars of its members attracted much attention. The sport had a keen following, with many firms supplying enthusiasts with all of the parts required to make their own cars. MRRC, a renowned company based in Bournemouth, could supply everything to build a competitive car at very reasonable cost. The circuits cropped up all over the world; indeed even Disney World had a superb fully scenic circuit, with wonderful scale replica cars supplied by MRRC. The sport was followed through the 1950s and to my knowledge was still practised in the late 1960s by the North London Society of Model Engineers. What is quite interesting is that several of the more famous model engines first saw the light of competition in model cars – both cable and rail racing types. Notable engines were the Oliver Tiger, ETA and Super Tigre of Italy. A couple of world-famous American 10cc engines, the McCoy 60 and Dooling 61, were all originally cable car engines.

The tracks took up a lot of room, and many halls would not tolerate the noise and smell that the smoky engines would produce. The sport prospered for some years but because the speed could not be controlled once the cars were under way, it still wasn't that realistic. The electric rail and slot cars, which became very popular first in the mid-1950s, pointed the way, since they proved that a cheap form of racing could be popular. The problem for the purist was that the cars could not be properly steered with rail or slot – the answer had to be radio control. Up until 1962, most affordable radio control systems worked on the 'Bang Bang' principle i.e. the movement of the control surfaces of an aeroplane model, for instance, was from neutral to full movement either way, depending on the command selected. The early systems really were hopeless for serious car

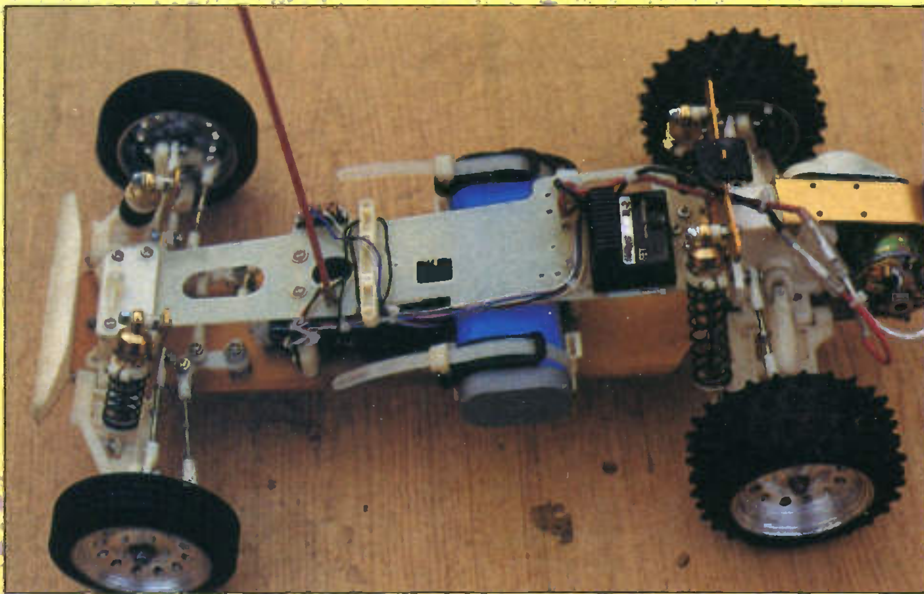


Photo 2. The Bullet with body removed. Note tidy wiring – nothing to flap around and get caught.

racing – they were not precise enough and, more importantly, not fast enough.

At the 1962 World Radio Control Aerobatics Championship, fully proportional control was seen to work for the first time. Compared with the reed-activated system, it was a revelation – and the other methods were made obsolete overnight. What prevented cars taking off at that time was a two-fold problem. Firstly, the cost; a typical set cost over three hundred pounds (a respectable annual wage then!). Secondly, it was doubtful whether the servos (which operate the steering and engine controls) would take the hammering dished out by a car hitting things. During the latter part of the 1960s, several attempts were made to promote radio control racing, but the cost still was too high. Several efforts were made to reduce the expense (for example, combining the steering and throttle control – the Jerribee system), but these did not appeal outside the USA.

Early in 1970, Dicky Laidlaw Dickson promoted the first radio control race meeting in the UK at a school in Berkhamstead – and the fuse was lit. Development of the cars was slow at first in this country, and it was the visit of Ted Longshaw to the USA Nationals in 1972 that allowed him to see how things were developing there. Armed with new-found knowledge and specialist parts, the sport in the UK caught up and, with the advent of PB suspension cars, surpassed the Americans in technology. The main drawbacks with engine-powered cars were that they were noisy, smelly and dirty things to operate. They also required purpose-built tracks to allow them to perform at their best. Engines can also cause difficulties in inexperienced hands. Something simpler that could be run anywhere was required. In the States, desert racing was producing full-sized cars that were purpose-built to race at high speeds over extremely rough terrain. These single-seater cars were to be the inspiration behind the evolution of the electric motor-driven 1/10th scale off-road racer. As soon as fast-chargeable Ni-Cd batteries came on the market at sensible prices, the idea really took off. The first practical machine was the Japanese Tamiya Roughrider, which was a worldwide success.

Shortly afterwards Kyosho, another Far Eastern firm, simplified the idea and launched the Scorpion, which was also very successful. When Tamiya brought out their first four-wheel drive race car, the Hotshot, the market was really on the move. Up until then, the Americans had not bothered making a car, but in 1985 Associated released the classic RC10 two-wheel drive car which changed the thinking of designers overnight. Simple, light, and with excellent suspension the RC10 was the car to beat for some time. Kyosho, meanwhile, released the four-wheel drive Optima which was another worldwide success. Meanwhile in England, Schumacher and PB Racing were designing their challengers for 1986. The PB car was out first, and was very successful – until the Schumacher Cat was introduced. Schumacher continued the development of their unique ideas with great success right up to the present day.

For further information on the history of model car racing, please refer to the April to May 1990 issue of 'Electronics' (Maplin Order Code XA37S, price £1.20).

For some years now, the Maplin range of radio controlled car equipment has consisted of some simple basic cars. Where this years selection differs from those of the past is that several of the current offerings are viable club racing machines.

The cars which we will be dealing with are all designed by the American company Traxxas. Based at Dallas in Texas, this company is fast gaining a worldwide reputation as a provider of great value high-performance racing cars. At the 1992 Earls Court Toy Fair, I was able to talk at great length to Jim Jenkins, the owner of the TRAXXAS concern. I found his attitudes and outlook a refreshing change; Jim is extremely keen to provide equipment which allows the average racer to compete at the highest levels. A pre-production model of his latest car was the sensation of the 1991 World Championships held at Detroit, USA. He has recently signed up one of the world's finest racers, Rick Venho, to further influence the development of Traxxas cars. Maplin are importing a selection from the wide range of existing cars.

The Jet Cat is very basic 'no-frills' car which will appeal to the younger element. Already assembled, the Jet Cat is a very strong car which will take all the bashing that a young uncaring driver can dole out. Not intended to be an all-out racer, it is none the less a good car. I raced one some years ago and it performed well, but was beaten by later-made cars.

Up the performance scale, we have the Radicator and TRX-10 Bullet cars. Both cars are serious state-of-the-art club racing machines. The Radicator is an American Regional Champion in the standard two-wheel drive class. The Bullet is a slightly more expensive version of the Radicator, with several of its components made from T6 grade

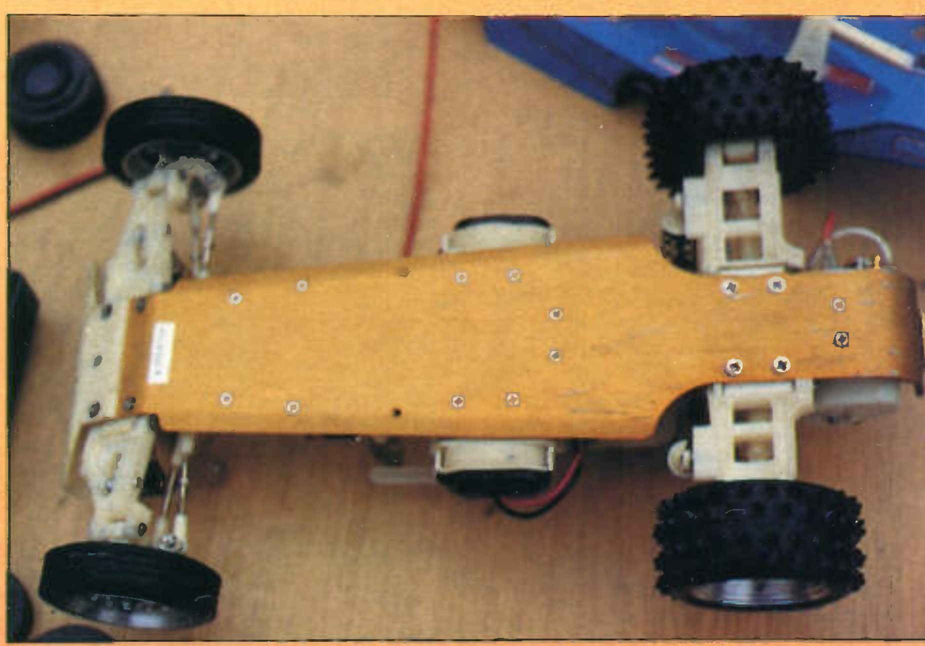


Photo 3. The underside of the Bullet – note that there are no protrusions, all screws being countersunk. The alloy chassis is very tough, and is very unlikely to be damaged in a crash.

firmly onto the flat of the motor shaft – a touch of thread cement will be in order here. When the motor is screwed into the car, make certain that the pinion meshes inline with the gearbox gear. Allow for the end float on the armature shaft by pulling the shaft outwards, checking that the grub screw on the pinion does not hit the driven gear. Motor fitting information is shown in Figure 1. The mesh must be such that there is no possibility of the gear slipping, but not so tight that the motors will overheat. A good tip is to place a piece of polythene bag in between the pinion and the driven gear. The motor retaining screws should be tightened firmly – in racing, a collision with another car could cause the motor to move with dire consequences!

Fitting the Radio Gear

Take the radio out of the box, and check that the crystals in the transmitter and receiver are labelled with the same colour. Charge the eight AA Ni-Cds and fit them in the receptacle at the back of the transmitter. Make certain that the cells are orientated correctly – and don't mix Ni-Cd batteries with normal ones. Switch on the transmitter; the meter pointer should show full power reading. If it does not, check again the polarity of cells. Take one of the 7·2V battery packs and give it approximately five minutes of charge time. You only require a small amount of energy in the battery pack to check that the radio gear is working. Making sure that the switch on the receiver harness is off, connect the plug, which is wired to the switch via the thin black and red leads, into the receiver at the BATT position. Connect one of the servos to channel 1 – this will be the steering servo. Mark this servo so that you can identify it later. The other servo is connected to the remaining position; the plug of the battery pack should be placed in its socket. WARNING! Do not force the battery connector – it should fit correctly one way only. If you are using second-hand equipment, it may be that some different non-standard plugs are fitted to the equipment. Nethertheless, the implication of reversed supply leads for non-protected servos (or indeed other electronic equipment) is severe damage, the cause of which will be immediately obvious to any service technician! Screw the aerial into the socket at the top of the transmitter case and tighten fully. Switch the transmitter on, making sure that the two small trimming controls are centrally located. Switch the receiver on and give the sticks on the transmitter a 'wiggle' – each servo should work in turn when the relevant stick is moved. It will be noted that the servos should move in a precise manner, in response to the relevant stick movement.

Beware of trying this check under fluorescent lights, as these can cause some strange interference effects.

Turn off the receiver first; this will fix the position of the servo output shafts in the central position, in relation to the transmitter's signal output. Turn off the transmitter, and disconnect all the plugs from the battery and receiver. Instructions on how to fit the radio system in the car are given in the supplied manual. Note that since the car was designed, the speed controller has been changed for a far better item – refer to the separate sheet (supplied with the manual) for details. It is recommended that at this stage in the learning curve, you refrain from using an electronic speed controller.

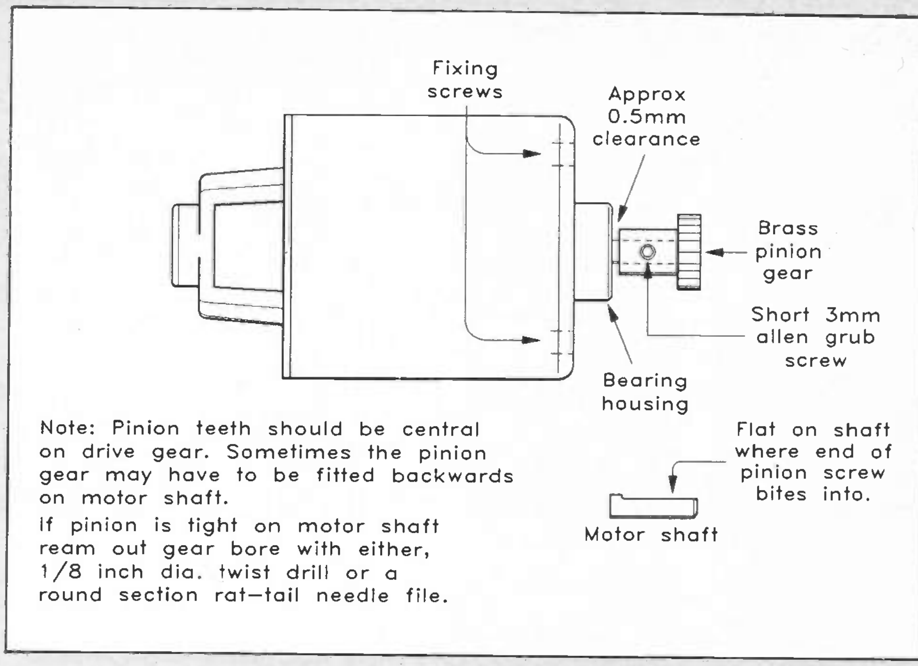


Figure 1. Fitting the pinion gear to the motor.

Improving the Steering

The steering arrangement can be slightly altered to give more lock, which will prove useful in tight corners. I found that when running the car, the alloy uprights, upon which the nylon steering bellcranks rotate, can bind on full lock. Check yours for any sign of stiffness. I removed the posts and carefully eased some material off the alloy with 400 grade wet or dry sandpaper, until the total movement was completely free. Afterwards, the posts and bellcrank were lubricated with silicone grease. The steering motion must be perfect, or the car will be very difficult to drive.

If the steering or throttle control operates with the opposite effect, the servo-reversing switches on the bottom of the transmitter should be changed over.

When the steering stick is in the neutral position, the car must travel in a straight line. The way to check this is by placing the finished car on a flat surface and driving it away from you – its path should not deviate from a straight line. Correct any deviation with the transmitter trim lever.

If you cannot solve the problem with the trim lever, place the lever in its central position. Next, remove the steering servo 'saver' (a spring-loaded shock absorbing device which protects the steering servo from the effects any sudden force

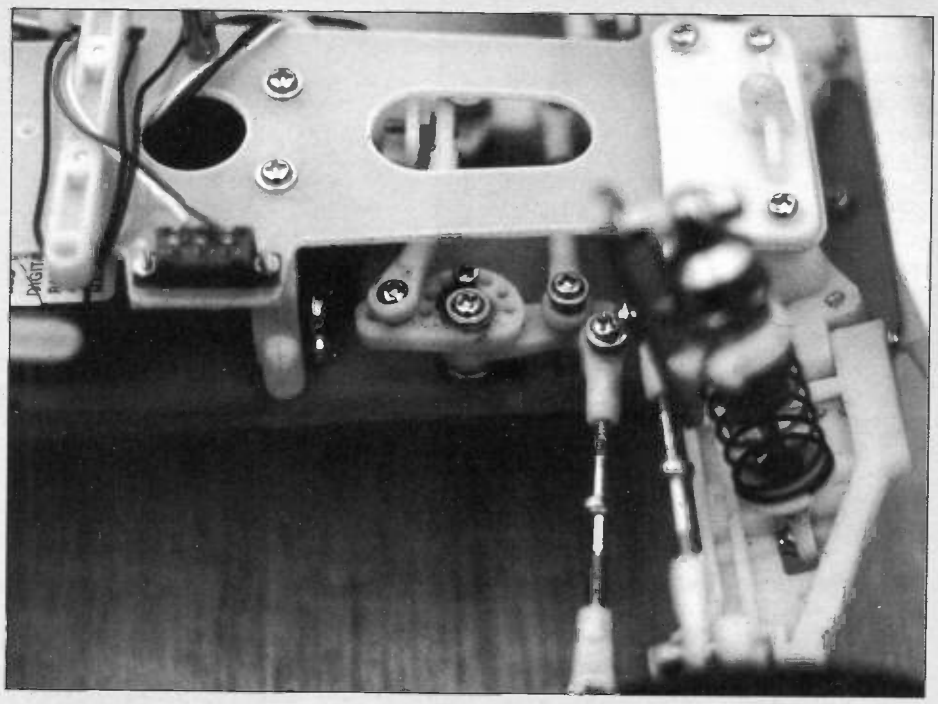


Photo 6. Steering arrangement. The pivot posts, in the centre of the picture, should allow the bellcrank to swivel freely. The link next to the steering servo is moved into the hole nearer the centre of the bellcrank, to provide more steering lock.

exerted on the wheels) from the splined shaft of the servo, and move it around one spline in the opposite direction to that of the steering error, to compensate for it.

This last point is critical – the car must run straight when the stick is central. Note that for straight running, the car should be stable i.e. not needing any input to keep a straight course. This is a common fault with newcomers. Figure 2 shows how the front steering should be set up.

It also helps if you have a slight amount of 'toe in' on the front wheels, as this will improve the straight-line stability (see Photo 5). Toe in is where the front edge of the front tyres are closer together than the rear of them. The difference should be in the order of 2 to 3mm.

Life Preserver

The receiver's aerial wire should be neatly stowed so that only approximately 12mm protrudes outside the top of the aerial tube. While mentioning receivers, it will be a good idea to obtain some extra pairs of different band crystals because you might qualify for a final, and need to change frequency. Note that you must never swap the crystals round – fitting a receive crystal in a transmitter allows it to work on an illegal frequency, so do not do it! In addition, you must ensure that the gear is kept dry during wet weather. The simple solution is to put the car away when it rains!

However, if you have paid your money to race at a meeting, some work will have to done to preserve the equipment. Smearing petroleum jelly around all the joints of the servos' cases, along with fillets round the output shaft and lead grommet, will normally work. This treatment is shown in Figure 3. The receiver can be inserted in a normal rubber balloon, with the wires exiting the neck. Speed controllers should be lightly wrapped in cling film in the case of mechanical units. Electronic speed controllers should be wrapped loosely in cling film to allow some air flow, while preventing direct water contact. Never spray receivers, servos or speed controllers with WD40-type oils. Many manufacturers will not honour their warranties if such oil sprays are used. Motors should be covered with one of the rubber boots available to prevent water and debris from entering the open brushgear end. Keeping the transmitter dry is easy – all you need is a transmitter-sized polythene bag, with a hole punched in it for the aerial to pass through. In addition, a bag will help prevent the hands getting too cold during those typical British winters! As soon as you arrive home after a wet meeting, remove the radio gear from the car, take off all the temporary protection and leave it near a radiator to dry out. Failure to do this last step will almost certainly result in damage to the equipment through corrosion. However, please note that some radiators tend to get hotter than others – and prolonged exposure to these may cause the plastic components of your prized equipment to distort or melt!

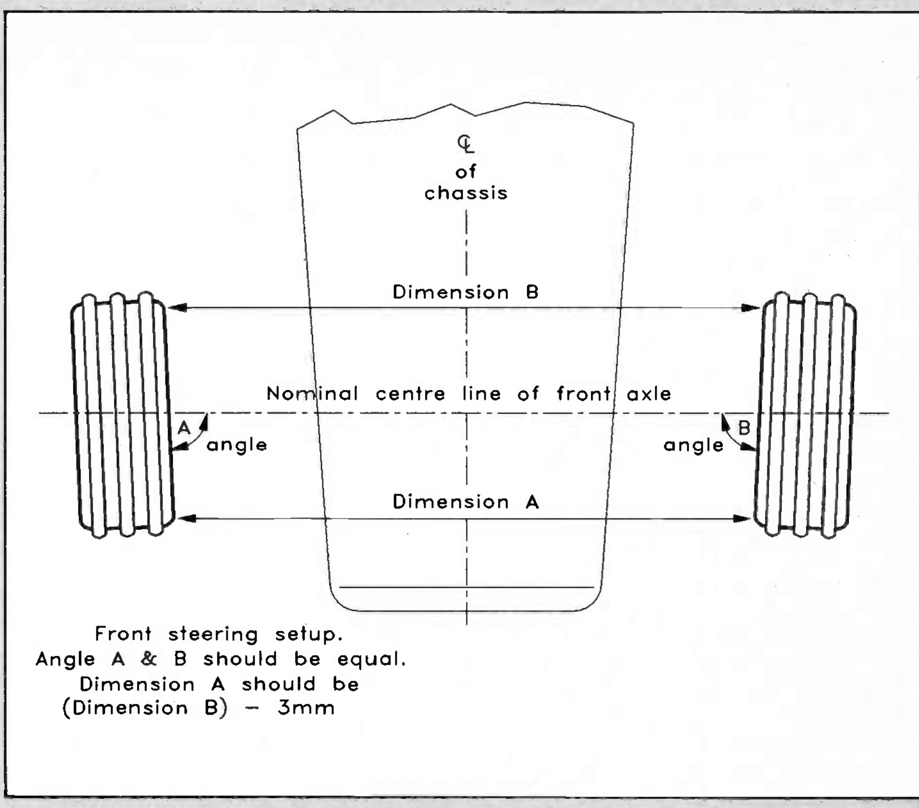


Figure 2. Front steering set-up.

Body Painting

The body shell supplied is a clear polycarbonate moulding. It will require painting on the *inside* with suitable paints. The choice of paint is not a simple selection. Car spray paints and model plastic enamels are not suitable; they are too brittle. The most common paint available will be the purpose-made product on sale in Model Shops. Pactra, Parma and Tamiya are popular, the Tamiya (being water soluble) is very simple and clean to use. Spraying the paint is the best method – these paints do not brush on well. Before spraying, throughly wash the body in hot water with some washing-up liquid mixed in; this will remove any grease present. Spray the paint on thinly for best effect. Choice of colour is important; a bright bold colour will show up better. Take care when spraying; the area that you choose

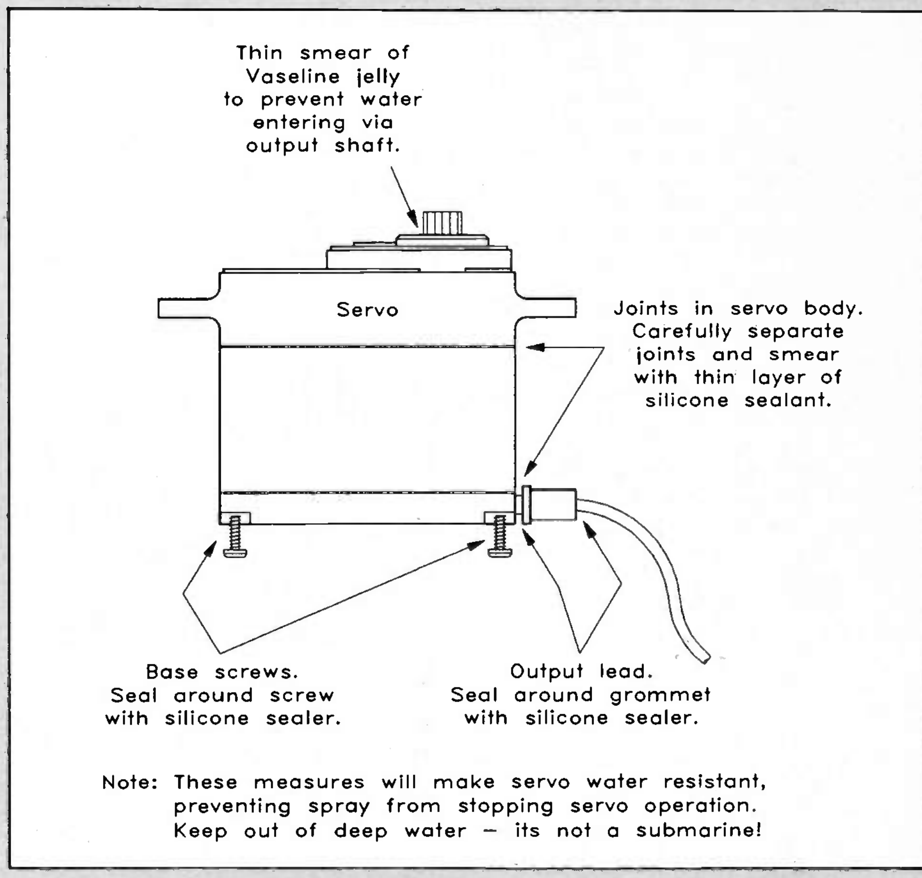


Figure 3. Waterproof treatment of Maplin servos.

should be warm, free from dust and well-ventilated. To help the supplied 'go-faster' stickers to be positioned correctly, spray a thin coating of water (with a trace of washing-up liquid) on the body; this will allow the stickers to slide into position.

Charging the Batteries

There is a veritable minefield of information on this subject – ask any ten experts how they charge their Ni-Cds and you will receive ten different answers! May I suggest that for your first meetings you keep to a simple formula so that there is little chance of damaging your precious batteries. I intend to cover batteries and charging techniques in greater detail in Part 2. For now, the Maplin unit listed will do nicely – at this point in time, a fancy charger will not help your driving.

Another important point is that the 12V 'source' battery, if used, must be in A1 condition if it is to have the power to charge your race batteries properly. I am aware that the Maplin charger has a cigar-lighter plug, but the track may be some way from your parked road car.

I suggest that two racing packs are purchased – while one is cooling after a race, the other can be recharged. If finances permit, the ideal situation would be to have as many packs as the number of races that you expect to compete in at a meeting. However, two will suffice to start with. All Ni-Cds will benefit from being run in; I make up a simple rig consisting of a car headlight bulb, which is wired so that both filaments will be lit when it is connected to a suitable battery. This device, shown in Figure 4, will be used, during the cycling process of battery preparation, to discharge the cells.

To use, charge one pack of cells until the red light on the charger goes out. With the aid of a stopwatch, measure the time it takes for the bulb to go dim – but not out. Allowing the bulb to go out completely could eventually damage the batteries, if they are left in a discharged condition for prolonged periods. Make a note of the time, let the cells cool down over a short period and repeat the process four times. A progressive improvement in duration should be noted. When satisfied, keep the cells in a discharged state – fully charged cells are potentially dangerous if not handled carefully. They should be kept away from anything that could short-circuit the output terminals together, as high currents could flow (due to the cells' low internal resistance) – a potential fire hazard. Look after them by not dropping them or allowing them to get wet (the cells' casings will rust very quickly otherwise). After any wet race meetings, dry the cells near a radiator.

Driving Tips

When it is time to give the car a run, be warned, don't test it in your own home or a confined space. Model shops all over the country make a lot of money supplying spare parts for cars broken in collisions with chairs and table legs. A raw novice will find a fully charged car an uncontrollable beast in a tight space.

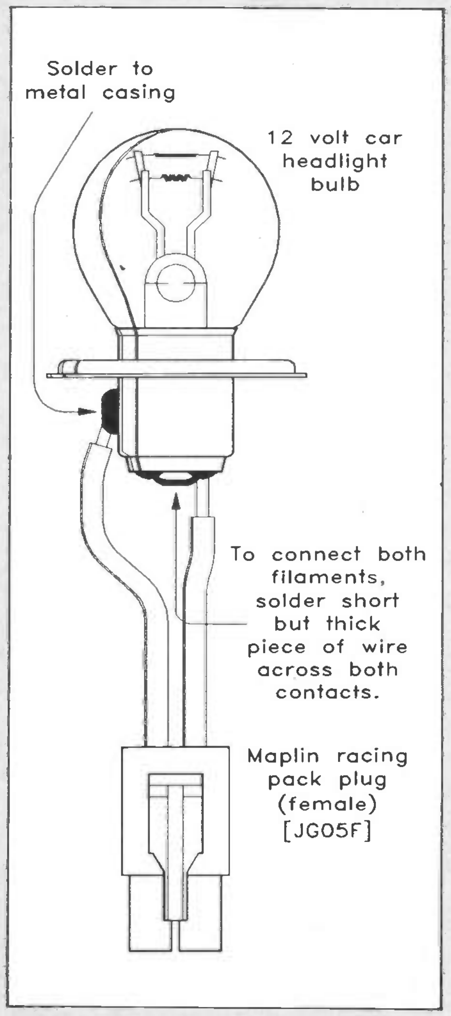


Figure 4. Battery discharger, used for 'pre-race hardening'.

A better idea is to find a suitable recreational area or parking lot – preferably one free of full-size cars! Yours will not be the first car to be accidentally run over by a road vehicle! In addition, please ensure that there are no people (particularly children) about. A radio controlled car running at full-speed could do significant damage to an unwary person's ankles.

Make up a simple rectangular-shaped course using plastic soft drinks bottles as markers. A good size, of course, would be ten metres by three metres (see Figure 5). It's a good idea to stand back a few paces from your practice circuit. Standing on a stout box is another useful tip. It will prepare you for driving your car from the raised rostrum as used by most clubs.

It will be better if the ground is dry for your first attempt at racing practice; studded tyres will not grip well on wet tarmac.

Turn the transmitter on, followed by the car. Check that the steering is centralised, and that the car is stationary with both sticks central. Carefully move the speed control stick in the selected forward direction, keeping the steering stick central. As the car approaches the first marker, centralise the speed stick and move the steering stick in the desired direction. The car should turn the corner smoothly when the car has turned the corner – centralise the steering and apply the speed control again. By spending time circulating your circuit smoothly in both directions, you will be better prepared for your foray on a purpose-made track.

Visit your local club circuit and see if they will allow you to have some practice before your first race meeting. It is better to learn the way around when there is no-one else on the track to distract you. Try to run your car carefully so that you can circulate without hitting the barriers. Getting round cleanly is what you are looking for. Keep practising until you begin to have a feel for the track. A useful tip, if you have problems with some parts of the track, is to take a walk around the track looking carefully at the areas where you are having trouble. It may be a small dip or bump that is upsetting your car. Try a different line though the troublesome parts. When satisfied that you can get round satisfactorily, and that the car will last the five minutes, the time has come for you to have your first race.

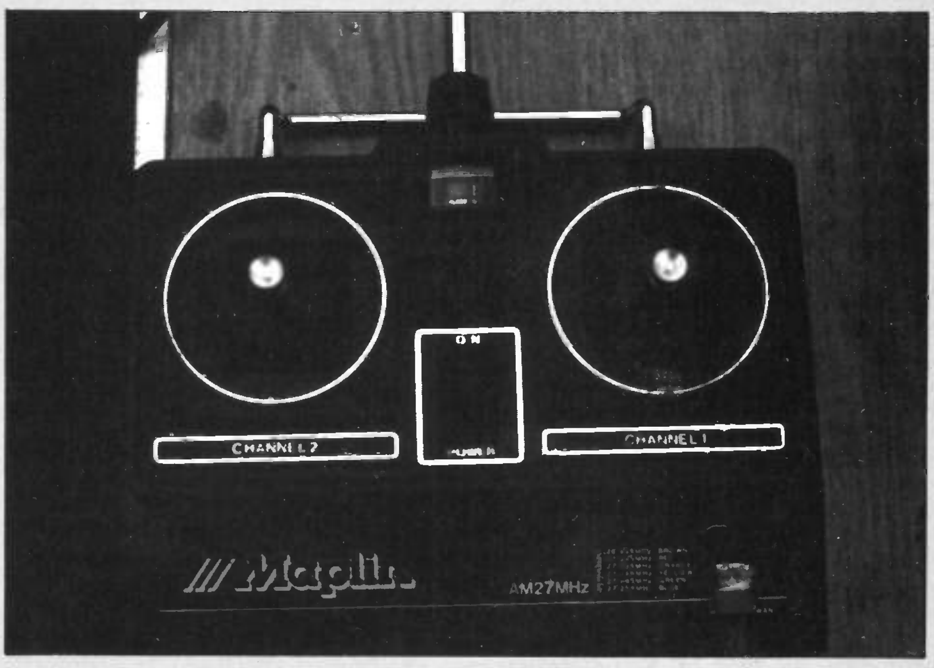


Photo 7. Maplin transmitter. The small recess in the lower right-hand corner is the crystal port. The left-hand stick is used for speed control; whereas the right-hand stick is for steering.

Your First Race Meeting

Arrive in plenty of time before the start time of the first race. Sometimes, the club may use extra removable obstacles which are only seen on race days. When the circuit is complete, and while the first battery pack is being charged, walk the course. Watch for any areas that may be wet or cut-up, and any dips or bumps. Mount the driving rostrum, stand in the place marked for the frequency you intend to use. Mentally follow the line of the circuit so that you are clear in your mind how the circuit will flow. Five minutes spent learning the line will be a great help when your first race is due. Some time before the racing starts you will be asked to book in. The organiser will need to know your name and race class (two-wheel-drive in the case of the Bullet). In addition, clubs sometimes grade the motors used, in which case you will be in the 'standard' class. You will also be asked your frequency number or 'colour' (the 27MHz radio-control band is split into six solid 'colours', which range from brown to blue – see Table 1). You can also obtain the 'split' frequency crystals, which allow you to run with another six cars which use the 27MHz band. The colours for these are shown in Table 2.

To count your laps, most clubs use a visual method where each car carries its frequency number in two prominent places. More and more clubs are introducing automatic lap-counting systems where a small transducer is temporarily fitted to the car. Every time the car passes the aerial loop it will register a lap. Make certain that (a) you fit the correct colour transducer for your heat and (b) you actually fit a transducer to your car. Several well-known racers have forgotten to do this, and have lost some good race results! After the race, return your transducer to race control.

It's a good idea to take some practice laps just before the racing starts. Before you turn your radio on, check that no-one is using the same frequency as yourself. Most clubs use a peg-board system to show, at a glance, which frequencies are in use. This simple arrangement is where the colour of each frequency is represented by a peg of that colour. You are not allowed to turn your radio on unless you have the correct colour peg – it is just plain bad manners to turn your radio on when someone else is on the same frequency. When everyone has been booked in and the races have been arranged, the meeting director will call a driver's briefing which you must attend. You will be told all the details that you need to know. Note most clubs will expect you to do your share of marshalling the other races. What normally happens is that after your race, you will be asked to marshal the next race. Failure to marshal will result in you losing your best time – or worse – depending on the clubs rules.

It will be a strange feeling, standing on the driving rostrum for the first time with your car lined up with (possibly) seven others. Try to put your car on the back of the grid; this will allow the others to keep away from you at the first corner. When the signal to start is given, leave the line slowly and make your way round the track, keeping to your own speed and ignoring the others. Try to keep calm, take your time, and after three races you should really be getting into the swing of things!

From now on, it is a question of getting your act together regarding racing techniques. Only make changes to the car if you are having trouble lasting the five minutes. A slightly smaller motor pinion of 10 teeth may be required if the track is very is very muddy or if the grip of the tyres is very high.

If the weather is as per normal for the UK, the car will occasionally get really dirty. Most of this dirt can be removed with an insecticide spraying kit. Fill the bottle with soapy water and, after each race, clean the mess off the wheels, tyres, suspension and bodyshell. Keep the water well away from the radio gear. A side-shoe cleaning brush is a useful tool for cleaning sticky mud from in between the spikes and ribs of the tyres.

As experience is gained, the first tune-up option for the car could be a full set of ballraces instead of the bushes fitted as standard. An electronic speed controller could be considered – the Traxxas XL-1 (Order Code ZF33L, Price £34.95) would be a sensible choice. This item will fit directly into the car. Electronic speed controllers are more efficient than mechanical units (no servos to eat away at the battery's reserves), leaving more of the finite battery energy to propel the car. Follow the set-up instructions exactly, or expensive damage could happen. The recommended speed controller is a reversable unit – wait until you have a great deal of driving experience before considering using a forward-only unit. On very tight narrow tracks the lack of reverse can be a big drawback, the car requiring the attention of corner marshals too often for comfort!

In the near future, I will cover the Sledgehammer monster truck, the Blue Eagle truck stadium racer, and the XL-2/XL-3 speed controllers. In addition, there will be some additional information regarding charging techniques. For information on the full range of Maplin radio-controlled models and accessories, please refer to the relevant section in the current Maplin Catalogue.

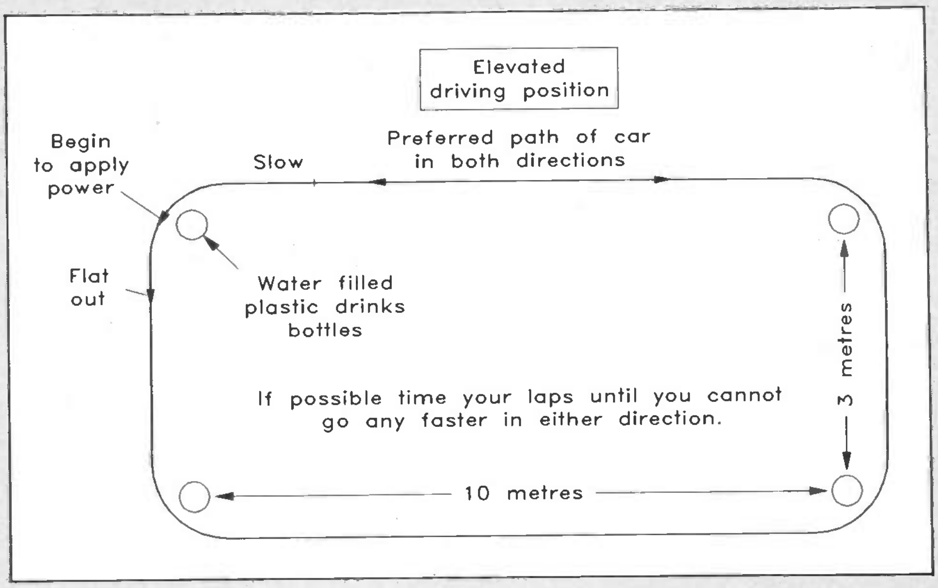


Figure 5. Practice course.

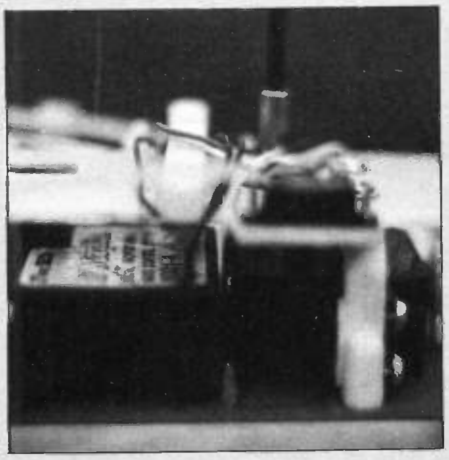


Photo 8. The Bullet, showing steering servo and receiver protected by upper chassis bracing.

Table 1. 27 MHz Frequency Colours (solid)

Channel No.	Frequency	Colour
1.	26·995	Brown
2.	27·045	Red
3.	27·095	Orange
4.	27·145	Yellow
5.	27·195	Green
6.	27·255	Blue

Table 2. Split Frequency Colours

Channel No.	Frequency	Colour
7.	26·975	Grey/brown
8.	27·025	Red/brown
9.	27·075	Red/orange
10.	27·125	Orange/yellow
11.	27·175	Yellow/green
12.	27·225	Green/blue

Join the British Radio Cars Association

The BRCA is the governing body responsible for the administration of model car racing in the United Kingdom. For full details, contact the Membership Secretary, 16 St Giles Close, Hove Edge, Brighouse HD6 2RX.

CIRCUIT MAKER

Circuit Maker is a forum for readers' circuits, ideas and tips. The circuits and information presented here must be considered as a basis for your own experimentation, no warranty is given for suitability in particular applications, reliability or circuit operation. Maplin cannot support, in any way, the information presented here. However, where possible, we will endeavour to check that information presented, is correct and that circuits will function as stated. If you would like your ideas to be considered for inclusion in Circuit Maker, please mark your submission 'Circuit Maker' and send it to: The Editor, 'Electronics – The Maplin Magazine', P.O. Box 3, Rayleigh, Essex, SS6 8LR.

Chirping Cricket by P.W. Fry

The concept of light activated 'annoyances' is not new. However, that does not mean that there is any less fun to be had from making and using them. The design presented here is based on the 4093 CMOS quad Schmitt trigger NAND IC, and is based on the fact that it is possible to produce a square wave generator from a single NAND gate. Using CMOS gives a very low battery drain, in fact most of the 75 or so microamps of current taken in daylight operation is drawn by the 150kΩ bias resistor, R1, feeding the light dependent resistor.

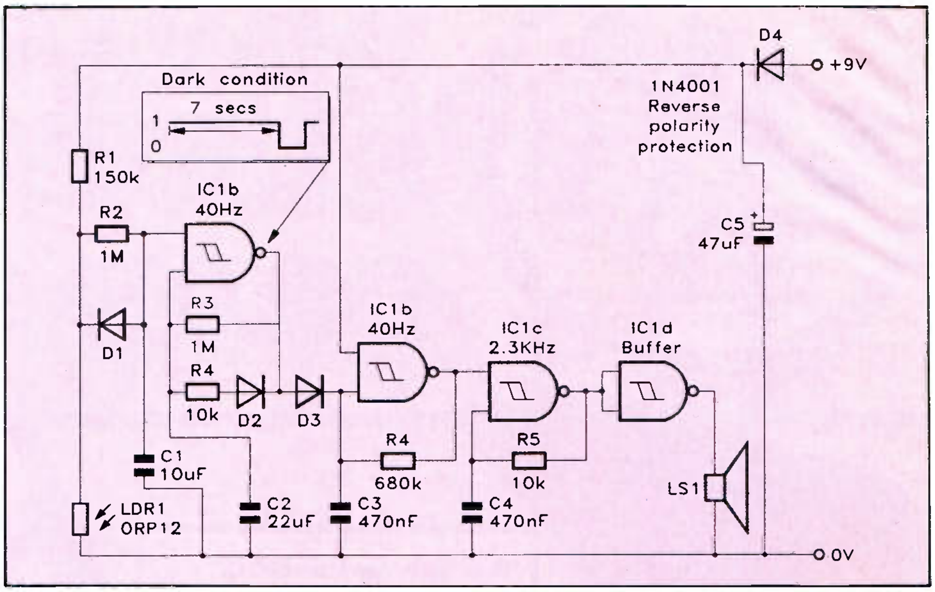


Figure 1. Circuit diagram of the 'Chirping Cricket'.

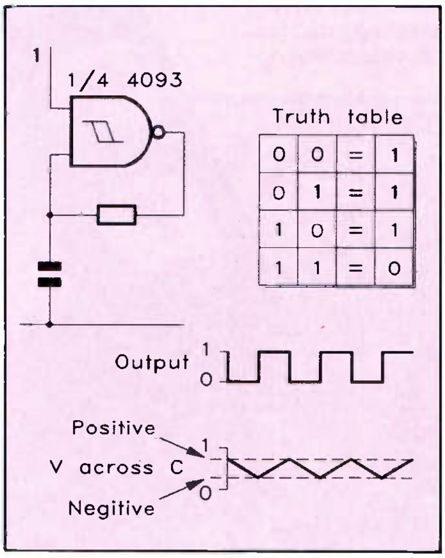
Circuit Description

Figure 1 shows the circuit diagram of the 'Chirping Cricket'. With light falling on the Light Dependent Resistor (LDR1), its resistance is low, typically a few hundred ohms. This holds the voltage on C1 down and prevents the oscillator (IC1a) running. When there is very low light level, the resistance of the LDR rises to several hundred kΩ. This then allows C1 to slowly charge via R2, and at the upper trigger threshold the oscillator is enabled and will then produce a short 'chirp enable' pulse every few seconds. D2 and resistor R4 provide the unequal mark-to-space ratio. If the light level rises, then the chirp is immediately disabled via D1.

IC1c oscillates at approximately 2·5kHz, but is, however, turned on and off at a frequency of 40Hz by IC1b. This produces the cricket-like chirp. However, in order to turn off both gates IC1b and IC1c during the silenced periods, it is necessary to hold both inputs to IC1b at logic 1, and this is achieved by diode D3. IC1d is simply an output buffer.

Schmitt Oscillators

Figure 2 shows the operation of a single Schmitt NAND gate oscillator, of which three are used in the Chirping Cricket. At turn on, there will be zero volts across the capacitor, and supply volts on the second input. From the truth table it can be seen that, with logic 1 on one input and logic 0 on the other, the gate output will be logic 1. This logic 1 will start to charge the capacitor through the resistor, the rate of which being dependent on the value on the resistor capacitor. After a period of time the capacitor voltage will reach the logic 1 upper trigger point. Again from the truth table it can be seen that, with two logic 1s, the gate output will fall to logic 0. The capacitor will now start to discharge, however, because this is a Schmitt trigger device, the gate will not declare the capacitor to be at logic 0 until its voltage has fallen to the lower trigger level. Therefore, after the timed period, the capacitor reaches the lower threshold and the whole cycle begins again. The logic diagram in Figure 2 shows the sequence. The oscillator can be stopped by setting a 0 on the 'spare' input (not connected to C1) and from the truth table it can be seen that, with a logic 0 on either input, the output will always be logic 1. This is called gating the oscillator and is a feature used throughout the Chirping Cricket.



0	0	=	1
0	1	=	1
1	0	=	1
1	1	=	0

Figure 2. Operation of a Schmitt NAND gate oscillator.

Construction and Testing

The Chirping Cricket is easily constructed on a small piece of stripboard. Always try to use an IC socket, and before inserting IC1 and powering-up the circuit, do double-check all your connections and solder joints. Since IC1 is a CMOS type, observe the normal static precautions when handling. Go through the built circuit again and double-check connections against the diagram. Stripboard is wonderful stuff to work with for quickly producing a working board, but mistakes are easy to make. Connect the battery (9V PP3 type) and, if possible, observe the current drawn. In light, this should be approximately 75μA. Covering the LDR1 with black tape to simulate darkness should cause the supply current to initially fall to just a few microamps and then, slowly, begin to rise to approximately 200μA, at which point a chirp should be emitted. If not, check the tape or try the device in the dark as it can be quite difficult to seal all the light from the LDR using tape alone. All being well, a short chirp should sound every few seconds, stopping instantly a light is put on. Once reset by exposure to light and then returned to darkness there will be a delay of approximately 15 seconds before chirping resumes. The Cricket should be able to operate for months on one good quality battery.

PARTS LIST

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

R1	150k	1	(M150K)
R2,3	1M	2	(M1M)
R4	680k	1	(M680K)
R5	10k	1	(M10K)
LDR1	LDR ORP12	1	(HB10L)

CAPACITORS

C1	10μF 16V Minelect	1	(YY34M)
C2	22μF 16V Minelect	1	(YY36P)
C3,4	470nF Polyester	2	(BX80B)
C5	47μF 25V PC Elect	1	(FF08J)

SEMICONDUCTORS

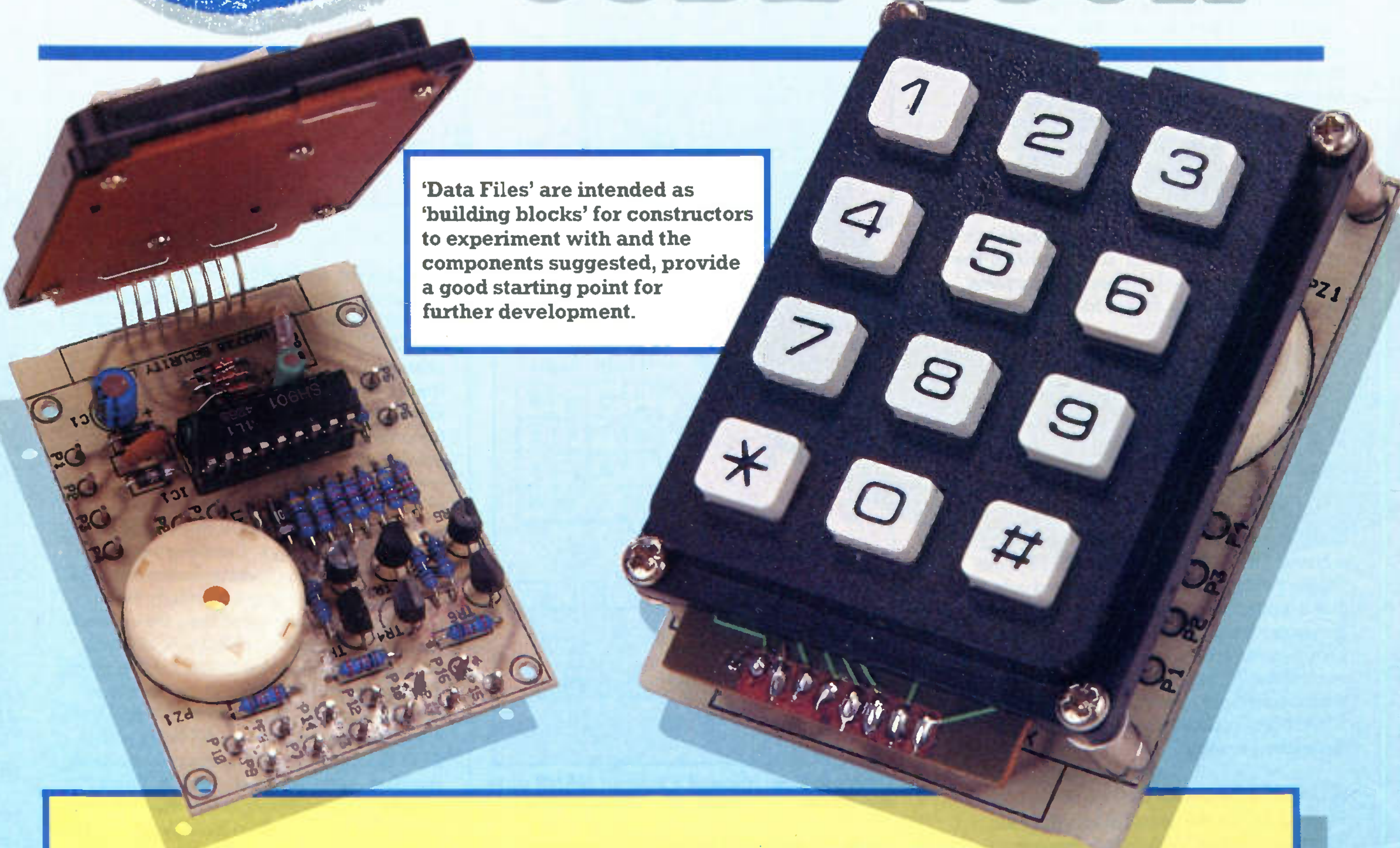
IC1	4093BE	1	(QW53H)
D1-3	1N4148	3	(QL80B)
D4	1N4001	1	(QL73Q)

MISCELLANEOUS

LS1	Min Piezo Sounder	1	(FM59P)
	Strip Board 1039	1	(JP46A)

DATA FILE

UA3730 ELECTRONIC CODE-LOCK



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

FEATURES

★ LOW POWER CONSUMPTION ★ KEY-PAD ENTRY
★ 3 DIFFERENT OUTPUTS ★ 10^{12} UNIQUE CODES
★ PROGRAMMABLE UP TO 12 DIGITS

APPLICATIONS ★ Security Systems ★ Electronic Locks

The UA3730 is a single chip electronic code-lock IC utilising CMOS technology. The IC can handle passcodes of up to 12 digits, allowing the use of up to 1 million million unique codes. If an incorrect code is entered three times or more, an output is activated allowing a burglar alarm to be triggered. The code may be changed as many times as required by the user providing additional security. Figure 1 shows the IC pin-out, and Table 1 lists typical electrical characteristics for the device. Also please note that the UA3730 may also be correctly supplied and marked as SH901.
Figure 2 shows a typical application circuit for the IC. The IC requires a battery

Parameter	Conditions	Min.	Typ.	Max.
Power Supply Voltage:		3V	5V	6V
Operating Current:	Operating Freq. = 400kHz	1mA		4mA
Stand-by Current:			5μA	30μA
Operating Frequency:		260kHz	400kHz	645kHz
Output Current (OUT1-3):				15mA
Storage Temperature:		−55°C		125°C
Operating Temperature:		−30°C		70°C

Table 1. Typical electrical characteristics.

back-up to prevent the code from being lost if the main power supply fails. When the device is initially powered up, the code is automatically set to 0. If IC pin 13 is connected to 0V, the IC is set to the program mode. A new code may then be set as follows: key in the new code (up to 12 digits) followed by 'M' (∗). The code has then been changed to that entered. After the new code has been set, pin 13 should

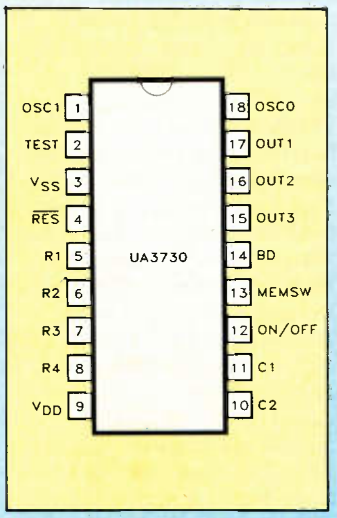


Figure 1. IC pinout.

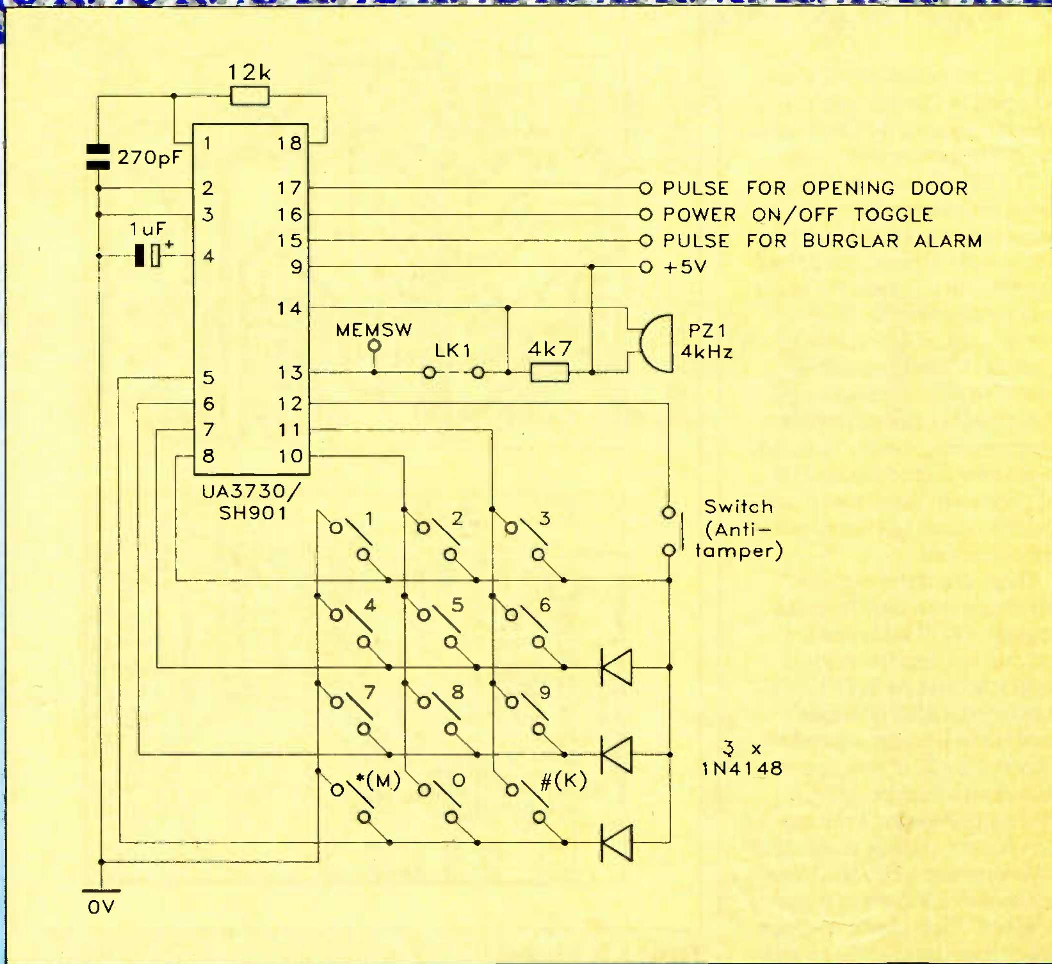


Figure 2. Typical application circuit.

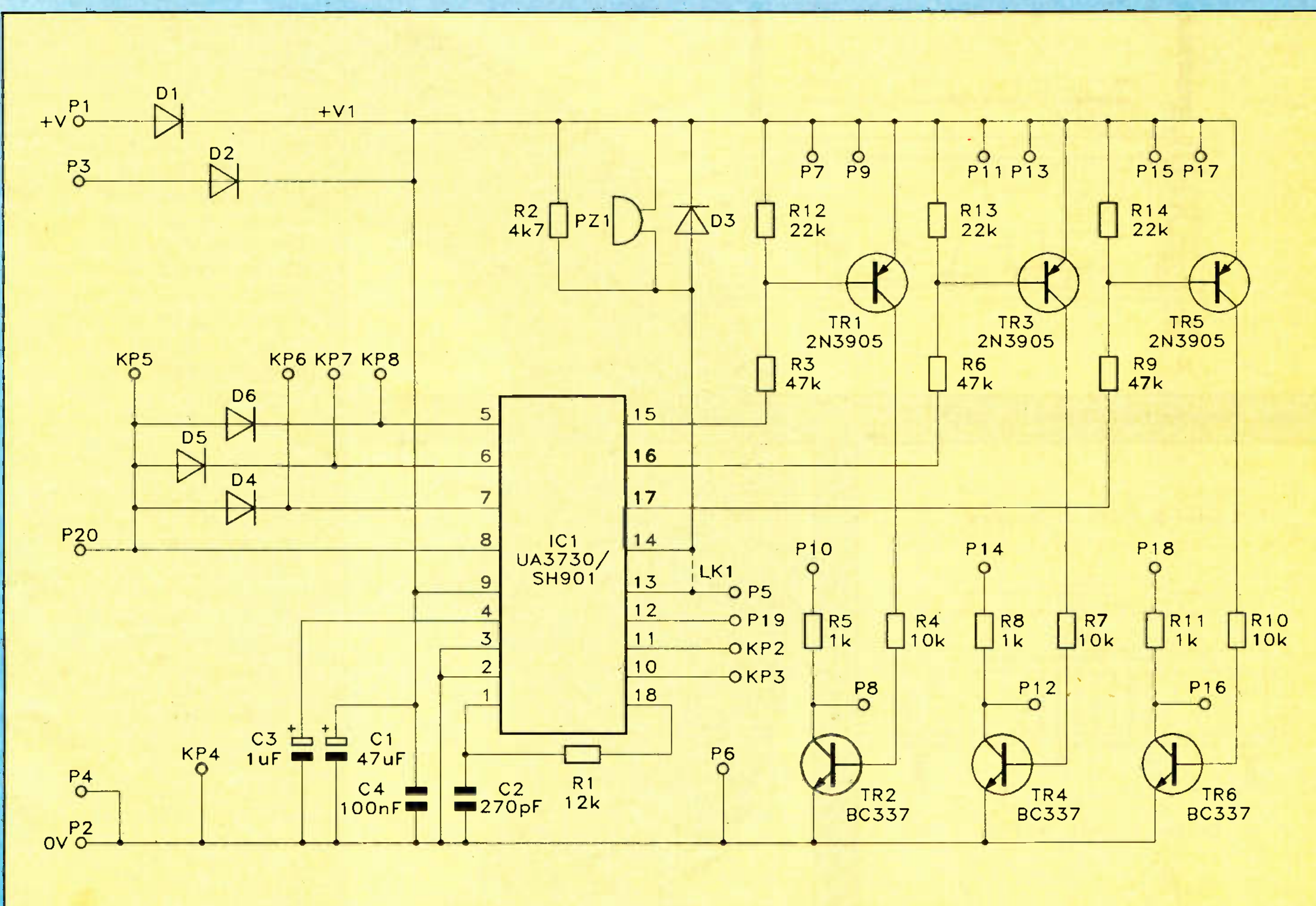


Figure 3. Circuit diagram.

be disconnected from 0V and returned to the 'floating' state, preventing unauthorised users keying in further new codes.

The circuit may also be set to the programming mode using the keypad, if pin 13 and pin 14 of the IC are linked together. In this case the code may be changed as follows: key in the current code (which is set to '0' when the unit is powered up) followed by 'M'. The circuit is now set to the programming mode. Then key in the new code followed by 'M'. The new code is then set and the circuit returns to the previous state.

There are three outputs which are activated from the keypad. OUT1 activates for 2 seconds when the correct code followed by 'K' (#) is entered. OUT2 changes state when the correct code followed by 'K' is entered providing a toggle action. OUT3 activates for 1 minute if an incorrect code is entered three times or more, and this output may be used to trigger an alarm. All outputs are open drain types and require a pull-up resistor. IC pins 12 and 8 may also be used to trigger an alarm condition, and may be connected to a mechanical microswitch to provide additional anti-tamper protection.

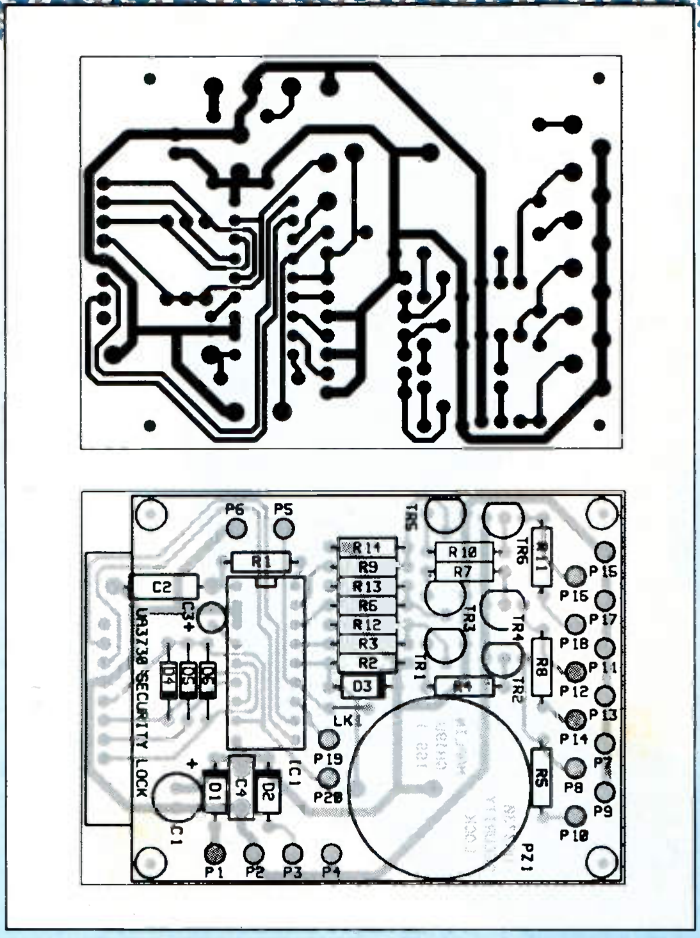


Figure 4. PCB legend.

Kit Available

A kit of parts is available, including a fibreglass PCB with a screen printed legend, for a basic application circuit using the UA3730. A simple numeric keypad is also supplied in the kit. Figure 3 shows the circuit diagram of the module, and Figure 4 shows the PCB legend. The PCB is designed to mount onto the rear of the keypad and be wired directly to the terminals. Figure 5 shows how to mount the PCB onto the keypad using M3 spacers and washers and M2·5 nuts and bolts. The keypad is connected to the PCB using 24 SWG tinned copper wire as shown in Figure 6. Other input and output connections to the module are made via double sided PCB pins, and may be taken from either side of the PCB. The pins are fitted such that the thin end of the pin is inserted into the PCB from the track side. A different keypad may be wired onto the PCB in place of the keypad supplied as long as the matrix is correct. The required matrix is shown in Figure 7. A piezo sounder is included in the design as an aid to the user. The length of the output from the sounder indicates whether or not the input has been accepted, as shown in Table 2. LEDs may also be connected to indicate output status.

The module requires a regulated 4V to 6·5V power supply that is capable of supplying at least 20mA. The power supply should be well decoupled to prevent the introduction of noise onto the supply rail, as this could produce unpredictable results. If the power supply is also used to drive an output load connected to the module, then the total current consumption of the load must also be added to the power supply capacity; for example, if the total load current is 30mA, then the power supply must be capable of supplying at least 50mA (20mA for the module and LEDs + 30mA total load current). Figure 8 shows a simple 5V regulator

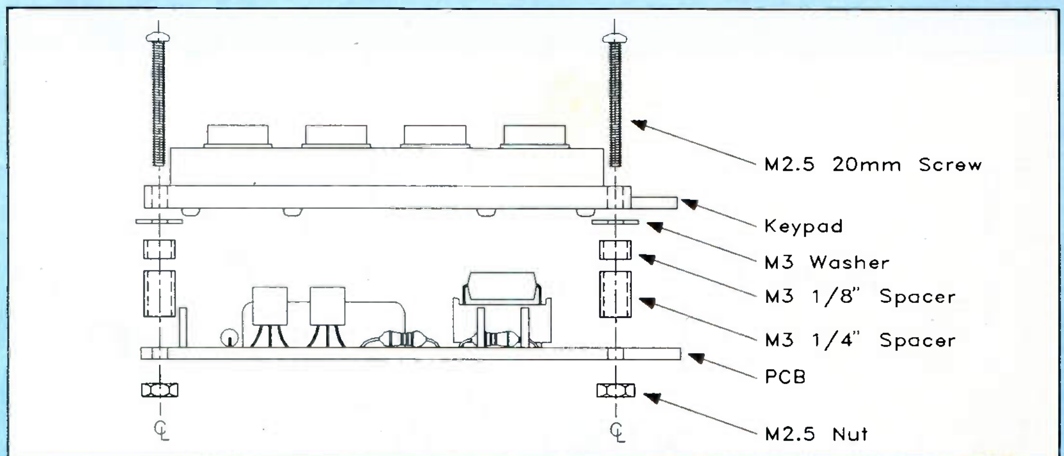


Figure 5. Mounting the PCB onto the keypad.

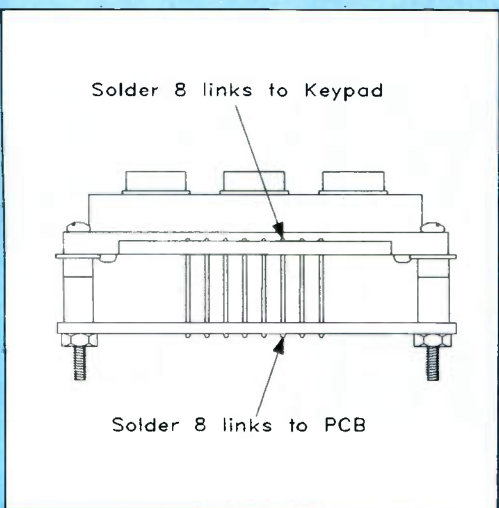


Figure 6. Linking the keypad to the PCB.

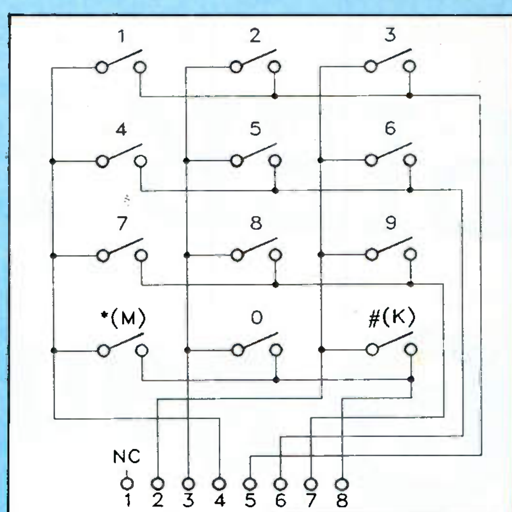


Figure 7. Keypad matrix.

circuit suitable to power just the module and LEDs (any output loads should be connected to a separate supply).

Setting the User Code

There are two methods of setting a user code as detailed above. Link LK1 may either be fitted or omitted depending on the chosen method of setting the code. The options are as follows:

1. LK1 NOT Fitted

To set the new code, link P5 to P6 and enter the new code (up to 12 digits) followed by the '∗' symbol on the keypad. The new code is then set and the circuit will no longer respond to any previous codes. After the new code is set, the link between P5 and P6 should then be removed.

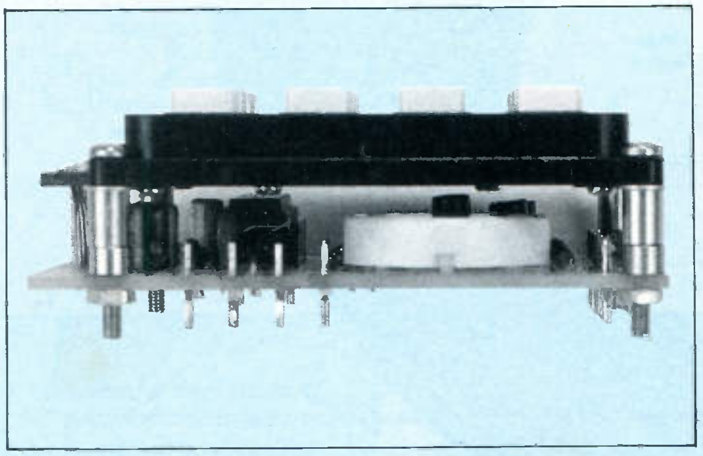
2. LK1 Fitted

To set the new code, key in the current code ('0' when the circuit is initially powered up) followed by the '∗' symbol; the circuit is now in the program mode. Enter the new code (up to 12 digits) followed by '∗'. The new code is then set and the circuit will no longer respond to any previous codes. This procedure must be followed each time a new code is set. If LK1 is fitted P5 and P6 must NOT be linked at any time.

The '∗' button on the keypad is only used when a new code is being set. For normal use, the code is entered to activate and deactivate the outputs to open and close doors, switch lights on and off, etc. To operate the outputs, key in the code (which you have previously set using the procedure above) followed by the '#' symbol on the keypad.

Condition	Number of Pulses from Sounder	Outputs P16 OUT1	P12 OUT2	P8 OUT3
Input Correct Code:	1	Active for 2s	Toggle	–
1st and 2nd Wrong Inputs:	2	–	–	–
3rd Wrong Input; Tamper (on/off) Input:	Groups of 3 Pulses for 1 Minute	–	–	–
P19 connected to P20:	Active for 1 Minute	–	–	–

Table 2. Output conditions.



Side view of the keypad/PCB.

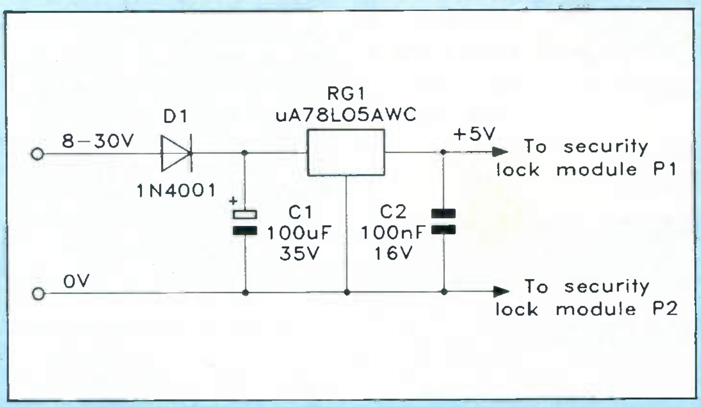


Figure 8. Simple regulator circuit.

Battery Back-up

If the user wishes to retain the code when the power supply is removed, then a back-up battery supply must be provided. Facility for the connection of a back-up battery is provided by P3 (battery +) and P4 (0V). The voltage of the main supply should be kept at least 0·5V above the back-up battery voltage to prevent the battery being drained in normal use. The battery voltage should be between 3·7 and 6V. Typically, with a main supply voltage of between 5V and 6V, a back-up 4 to 4·5V battery pack could be used. The quiescent current of the circuit in stand-by mode is typically in the order of a few hundred nA and so the drain on even a low capacity back-up battery is very little when the circuit is in the quiescent state.

Alarm Condition

If an incorrect code is entered more than twice then the circuit latches into an alarm condition and the sounder pulses for 1 minute or until the correct code is entered.

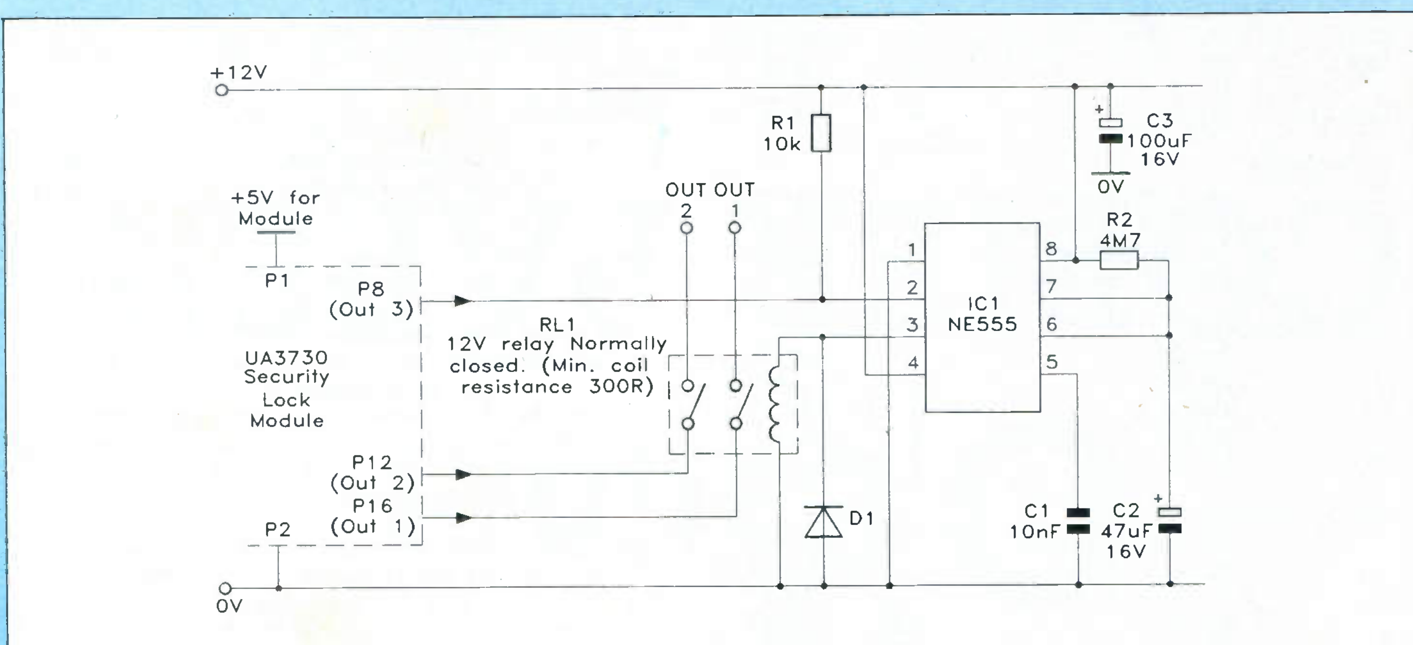


Figure 9. Typical example of a simple 'lockout' circuit.

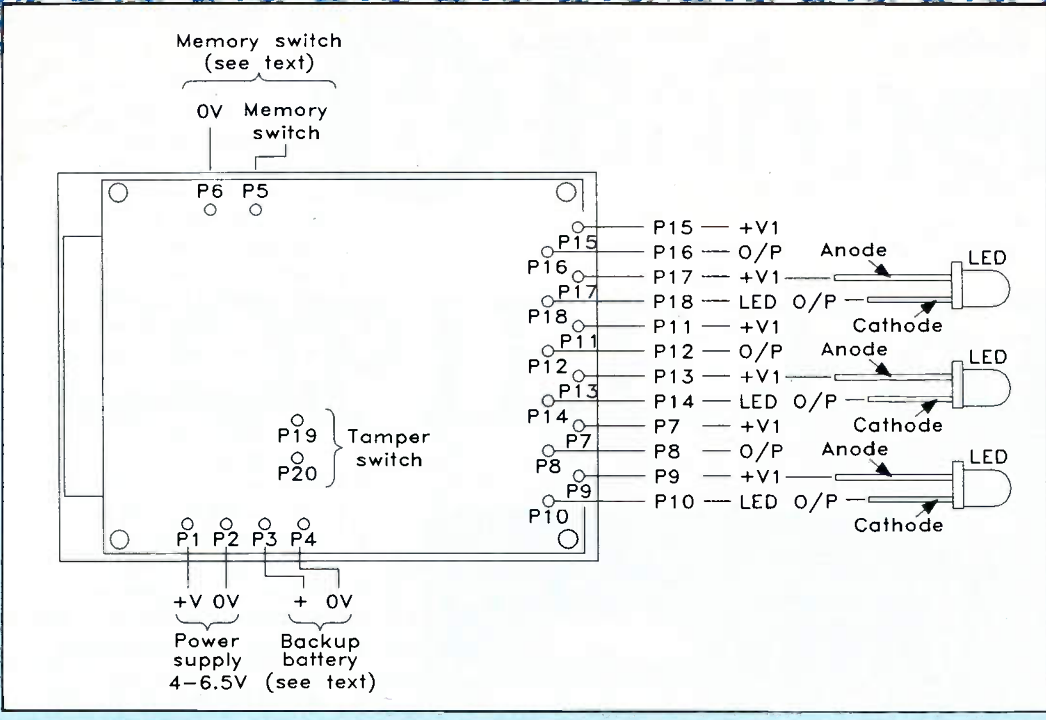


Figure 10. Wiring diagram.

Parameter	**Condition**	**Typical**
Power Supply Voltage:		4V to 6·5V
Back-up Battery Voltage:	< Supply Voltage −0·5V	3·7V to 6V
Power Supply Current:	Stand-by	220nA at 5V
	Operating (Without LEDs)	310μA at 5V
	Operating (LEDs Active)	17mA at 5V
PCB Size:		51mm × 71mm
Outputs:	Open Collector Type	
Output Sink Current:	Absolute Maximum	40mA

Table 3. Specification of Prototype.

An alarm condition can also be created by connecting P19 to P20 using a mechanical switch; a microswitch may be connected to this input to provide a degree of anti-tamper protection. It should be noted that this input may be used to activate the alarm output (OUT3) independently of the previous state of the circuit. In addition to triggering an alarm, the alarm output may also be used to trigger additional circuitry, providing a 'lockout' function. This means access is denied for a set period after the alarm output has been triggered, even if the correct code is subsequently entered and the keypad disabled. Figure 9 shows an idea for a simple 'lockout' circuit, featuring a lockout time of around 5 minutes.

Outputs are provided for 3 LED indicators to show the state of the outputs OUT1 to OUT3. In some cases, the user may not wish to fit the LEDs as they do add to the current drain. If a visual indication is not required, then it is quite acceptable to omit the LEDs.

The three outputs from the module are of the open collector type and the load is connected between the appropriate output pin (P8, P12 or P16) and either a +V1 pin on the PCB (P7, P11 or P15) or another suitable +V supply (15V maximum). The load current should not be allowed to exceed 40mA at any time, as irreparable damage could occur. Finally, Table 3 shows the specification of the prototype UA3730 Security Lock module.

Figure 10 shows the wiring diagram for the module, showing how to connect the LEDs, back-up battery, etc.

ELECTRONIC CODE-LOCK PARTS LIST

RESISTORS: All 0·6W 1% Metal Film

R1	12k	1	(M12K)
R2	4k7	1	(M4K7)
R3,6,9	47k	3	(M47K)
R4,7,10	10k	3	(M10K)
R5,8,11	1k	3	(M1K)
R12,13,14	22k	3	(M22K)

CAPACITORS

C1	47μF 16V Minelect	1	(YY37S)
C2	270pF 1% Polystyrene	1	(BX50E)
C3	1μF 63V Minelect	1	(YY31J)
C4	100nF 16V Minidisc	1	(YR75S)

SEMICONDUCTORS

IC1	UA3730	1	(UM98G)
D1-3	1N4001	3	(QL73Q)
D4-6	1N4148	3	(QL80B)
TR1,3,5	2N3905	3	(QR41U)
TR2,4,6	BC337	3	(QB68Y)

MISCELLANEOUS

DIL Socket 18-pin	1	(HQ76H)
Numeric Keypad	1	(JM09K)
PCB Piezo Sounder	1	(JH24B)
Pin 2144	1 Pkt	(FL23A)
Steel Screw M2·5 × 20mm	1 Pkt	(JY32K)
Steel Nut M2·5	1 Pkt	(JD62S)
Spacer M3 × ⅛ in.	1 Pkt	(FG32K)
Spacer M3 × ¼ in.	1 Pkt	(FG33L)
Steel Washer M3	1 Pkt	(JD76H)
TC Wire 24swg 0·56mm	1 Reel	(BL15R)
PCB	1	(GH18U)
Instruction Leaflet	1	(XT75S)
Constructors' Guide	1	(XH79L)

OPTIONAL (Not in Kit)

LED Red 5mm 2mA	1	(UK48C)
LED Green 5mm 2mA	1	(UK49D)
LED Yellow 5mm 2mA	1	(UK50E)

The Maplin 'Get-You-Working' Service is not available for this project.

The above items (excluding Optional) are available as a kit which offers a saving over buying the parts separately.

Order As LP92A (UA3730 Data File) Price £9.95.

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 item (which is included in the kit) is also available separately, but is not shown in the 1992 Maplin Catalogue.

(UA3730 PCB) **Order As GH18U Price £2.45.**

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

Computer Interference

Dear Sir,
Not long after moving house just recently I began to experience intermittent malfunctions with my home computer. These machine errors happened two or three times a day; I put it down to mechanical damage whilst moving.
Not having much knowledge of computer electronics, I called for the services of a professional computer engineer. After explaining the symptoms to him, he gave the PC a thorough check, then he informed me no fault could be found, but suggested that, as the problem was intermittent and the PC was somewhat old, it could be susceptible to noise, not conducted but radiated from some external source, in other words Radio Frequency Interference (RFI). This sometimes occurs in certain environments, and when asked how this could be rectified, he said it was not viable to work on a computer of that age and to invest in a new one.
Do older machines suffer from RFI? Have you or any other readers experienced these problems in computer or microprocessor controlled equipment? What are the potential sources of RFI and how do you overcome them? Are there any good books on the subject, I have searched several good bookshops but to no avail. 'Please help'.
J. Conners, Cambridge

Yes, ticklish problem. First off, it's interesting to note that the problems only appears to occur at the new location. Presumably if you could take your PC back to the old house it would work OK. Sounds like my old Commodore which is sometimes required to operate in close proximity to a thermostat controlled 1kW radiator. Occasionally the drives hang up, trying to interpret the mains noise as command data. Several things to consider: mains filter and transient suppressor, isolation transformer, possible mains supply or PSU faults, radiated noise from a monitor (having as it does EHT like a TV), mains spikes from other appliances. Does your PC have a plastic case or a steel case? Steel offers better screening. In the event that there is something nearby behaving like a powerful radio transmitter (and it isn't yours), try contacting the Radio Regulatory Department or the Radio Investigation Service. These sort of RFI problems are the very thing that the European Community directive on Electromagnetic Compatibility intend to prevent!

S·T·A·R L·E·T·T·E·R

This issue, Hugh Bright from Sussex, receives the Star Letter Award of a £5 Maplin Gift Token for his letter about our reply to the Star Letter in issue 54!

Confusing

Dear Sir,
Peter Milburn's letter in the June issue regarding fusing is timely in making the point of 'horses for courses' when ensuring that fuse protection is correctly rated for the current flowing in the circuit.
Sadly however, your reply seems to perpetuate the erroneous principle that a fuse's sole purpose is to protect the device it feeds. Although it is true that a blown fuse prevents more damage occurring in the device, its main function is to protect the conductor back to the supply on the next fuse in the circuit. The IEE Regulations are quite clear on this principle.
Once this principle is accepted then it is easy to appreciate that any fuse or current breaking device must be seen to be part of the overall circuit back to the supply, and each part of the circuit must be adequate for the current that the fed device requires.

You are absolutely right, of course. But hold on one moment! It was quite clearly pointed out in the reply that the function of the mains plug fuse is to protect the cable and that protection of the appliance from further damage is a secondary benefit. The IEE wiring regulations cover the selection, installation, testing and maintenance of wiring systems, and as such are a prerequisite for anyone involved in such work (have you got your copy of the 16th edition yet?). However, the regulations have to 'hand over' to other standards when talking about domestic electrical and electronic appliances. For instance BS415, which covers such items as TVs, VCRs, A V and Hi-Fi equipment, deals with many other important safety issues which are way outside the scope of the wiring regulations. Internal fuses, over and above that required to limit overload, are often included to prevent one failure 'snowballing' into numerous others; such good engineering practice will by definition protect cabling, circuit board tracks, etc. From a safety point of view only, this additional protection may not afford more protection; but it certainly makes repair easier – ask any TV engineer! It is these differences that often differentiate between the world of electrics and electronics.
Ultimately, however, any protection device has the primary function of protecting human life – any other benefit is 'secondary' to this objective!
Trivial fact – did you know that the origin of today's fuse is from steam Locomotive design? If the water level in the boiler fell too low, the top of the copper firebox would be exposed and melt, with dire consequences. Hence, if this occurred, lead plugs in the firebox roof were designed to melt first, directing steam onto the fire and putting it out. Yep, these plugs were called 'fuses'.

Igniting Stuff!

Dear Sir,
I recently purchased a copy of Electronics – The Maplin Magazine and I was interested in the article on an electronic ignition system for cars, unfortunately it was Part 2 and I obviously also need Part 1 to build the kit. Would it be possible to obtain a copy of Part 1 either in article form or last month's magazine.
D. Ginn, Welling, Kent

Mike Holmes replies:
A copy of the magazine is on its way to you. The amplifier described in Part 2 does not actually exist as a Maplin kit, but remains a circuit. it was built on stripboard and installed in the extruded alloy case as shown in the photographs in Part 2. Maplin cannot accept any responsibility for any such amplifier built and fitted to any vehicle. Exhaustive bench testing, as described in Part 2, is vital before any thought is given to installing it in a vehicle, to guarantee 100% reliability and safety.
The dual-circuit prototype (Photo 2, Part 2) has successfully operated on my V-twin motorcycle for about 18 months or more, in intimate proximity to a hot engine (under the tank between both cylinders), and without the complete weather protection as can be afforded by a car bonnet.

Seagulls and Satellite Sounds

Dear Sir,
I recently ordered and received a kit of parts for the EnviroSynth, and a few hours later had it working perfectly. However, and this is in no way a criticism, there is something missing – NO seagulls! Will it be possible in the near future to print an add-on design for this kit to incorporate seagull sounds?
Incidentally I have found the best way to position a dish on a satellite without recourse to my non-existent signal meter is to place a thick towel over the dish to cut the signal down and then fine aim the dish. (Now that's what I call technical!)
I. Dempster, Birmingham

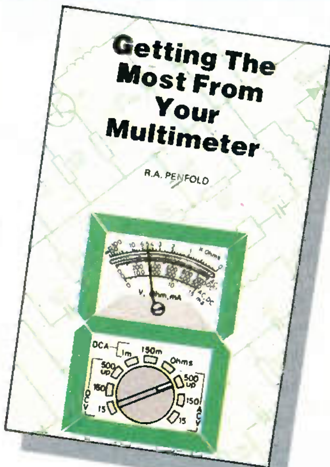
With respect to your query, your letter has been passed on to the designer of the EnviroSynth – seagulls would be nice, wouldn't they! – but to sound realistic, the electronics involved are likely to be rather complex. We like your novel way of attenuating microwaves – as science fiction writer Douglas Adams likes to tell us, a towel is a very useful piece of kit...!

These are our top twenty best selling books based on mail order and shop sales during May '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.
(WP94C) Cat. P80.
Previous Position: 1
Price £2.95



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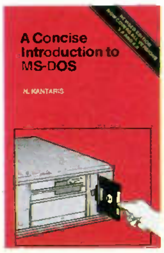


A Concise Introduction to MS-DOS, by N. Kantaris. *(WS94C) Cat. P101.* Previous Position: 3. **Price £2.95.**

3

IC555 Projects, by E. A. Parr *(LY04E) Cat. P85.* Previous Position: 2. **Price £2.95.**

16

More Advanced Power Supply Projects, by R. A. Penfold. *(WP92A) Cat. P77.* Previous Position: 14. **Price £2.95.**

17

Servicing TV and Video Equipment, by Eugene Trundle. *(WS76H) Cat. P96.* Previous Position: 16. **Price £25.00.**

4

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

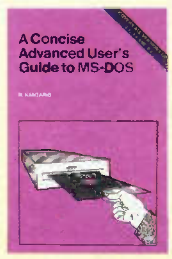
7
NO CHANGE

International Transistor Equivalents Guide, by Adrian Michaels. *(WG30H) Cat. P76.* Previous Position: 7. **Price £3.95.**

10
NO CHANGE

Electronic Security Devices, by R. A. Penfold. *(RL43W) Cat. P84.* Previous Position: 10. **Price £2.50.**

13
NO CHANGE

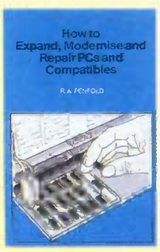


A Concise Advanced User's Guide to MS-DOS, by N. Kantaris. *(WS44X) Cat. P102.* Previous Position: 13. **Price £2.95.**

18
RE-ENTRY

Mastering Electronics, by John Watson. *(WM60Q) Cat. P74.* Previous Position: Re-Entry. **Price £5.99.**

5

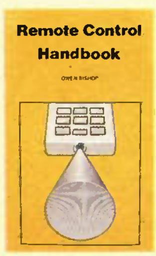


How to Expand, Modify and Repair PC's and Compatibles, by R. A. Penfold. *(WS95D) Cat. P104.* Previous Position: 4. **Price £4.95.**

8
NO CHANGE

How to Use Oscilloscopes and Other Test Equipment, by R. A. Penfold. *(WS65V) Cat. P80.* Previous Position: 8. **Price £3.50.**

11
NO CHANGE

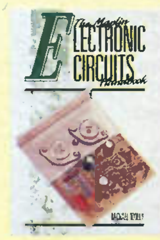


Remote Control Handbook, by Owen Bishop. *(WS23A) Cat. P83.* Previous Position: 11. **Price £3.95.**

14

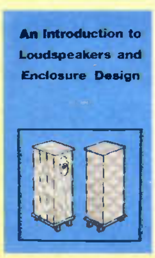
Electronic Music Projects, by R. A. Penfold, *(XW40T) Cat. P89.* Previous Position: 19. **Price £2.50.**

19



The Maplin Electronic Circuits Handbook, by Michael Tooley. *(WT02C) Cat. P82.* Previous Position: 15. **Price £12.95.**

6
NO CHANGE

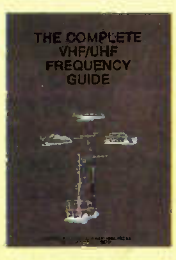


An Introduction to Loudspeakers and Enclosure Design, by V. Capel. *(WS31J) Cat. P87.* Previous Position: 6. **Price £2.95.**

9
NO CHANGE

Loudspeaker Enclosure Design and Construction. *(WM82D) Cat. P88.* Previous Position: 9. **Price £9.95.**

12

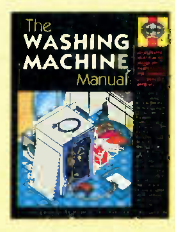


The Complete VHF/UHF Frequency Guide, by B. Laver. *(WT70M) Cat. P93.* Previous Position: 17. **Price £5.95.**

15

How to Use Op Amps, by E. A. Parr. *(WA29G) Cat. P79.* Previous Position: 12. **Price £2.95.**

20



The Washing Machine Manual, by Graham Dixon. *(WS98G) Cat. P96.* Previous Position: 18. **Price £11.95.**