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No. 91

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ELECTRONICS

The Maplin Magazine

Britain's Best Selling Electronics Magazine

JULY 1995 • £2.10

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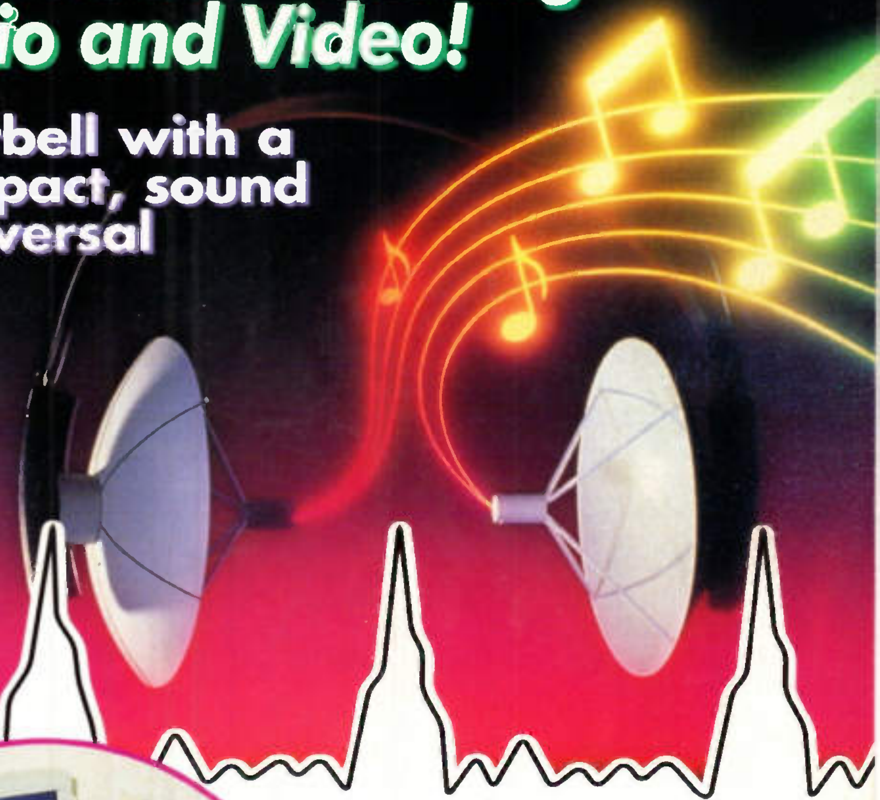

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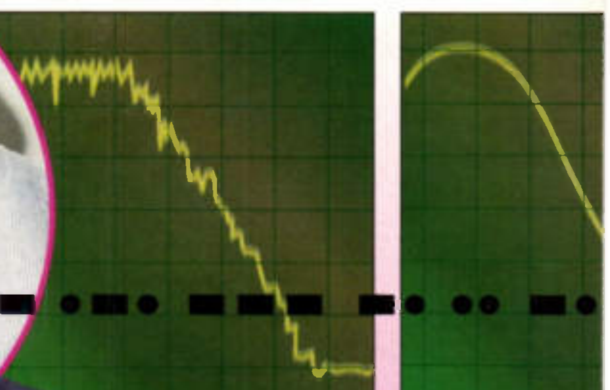

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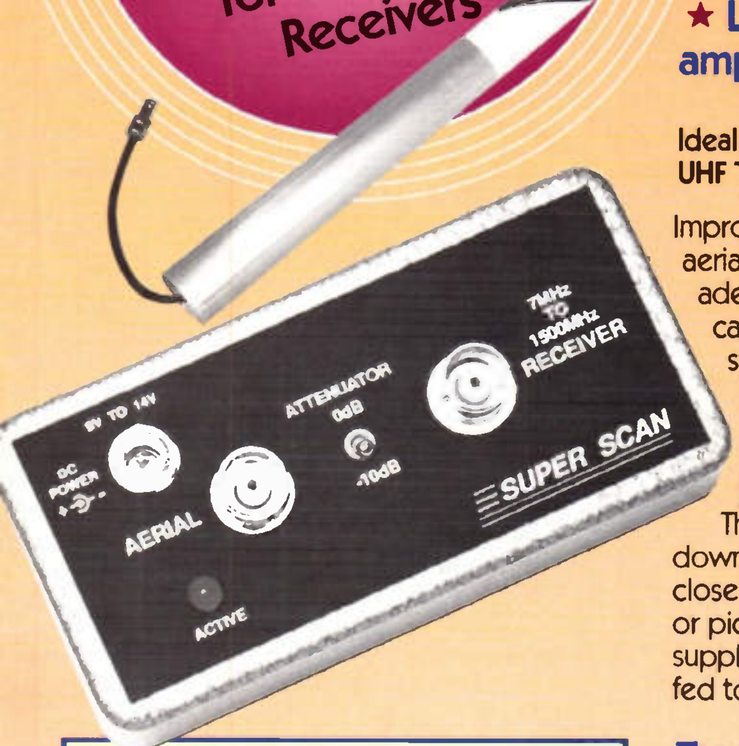

AVAILABLE– READY BUILT AND TESTED, OR AS A KIT FOR YOU TO BUILD!

LEAFLETS AVAILABLE – XV54J (assembled), price 25p *NV* or XV32K (kit), price 99p *NV*.

★ Indoor or outdoor use ★ Power supply through down lead ★ No tuning required ★ Low power consumption ★ Masthead signal amplifier ★ High gain ★ Wideband antenna

Ideal for HF/VHF/UHF Amateur radio bands, FM broadcast band, UHF TV band, CB, PMR bands, VHF Marine band, VHF Taxi band, etc.

Improve your scanner's reception with this active, broadband aerial. The aerial supplied with most scanners is perfectly adequate for local reception, but a significant improvement can be made in the reception of long distance (DX) and weak stations by using a fixed, active aerial like the Super Scan.

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Specification

Power supply:	+9V to +14V DC
Supply current:	22mA @ 12V
Frequency range:	7MHz to 1500MHz
Gain:	19dB max.
Impedance:	50Ω
Antenna length:	1·24m

The ready-built and tested Super Scan includes:

- Super Scan antenna
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- Instruction leaflet (XV54J)*

Order Code 90061, **Assembled Super Scan, £79.99** C

C Add carriage £2.80

BUILD IT YOURSELF AND SAVE £££s

PROJECT RATING 4

LEAFLET AVAILABLE – (XV32K) **price 99p** *NV*

The Super Scan is also available as a kit which includes all the parts necessary to construct the basic aerial and preamplifier.

General items such as those marked* above are not included, allowing the aerial to be custom constructed to suit the exact requirements of your particular scanner: for instance, your scanner may use a variety of connectors or have a built-in antenna power supply. The 1¼in. plastic waste pipe for the housing is readily available from DIY suppliers.

Comprehensive assembly details (also available separately, Order Code XV32K, price 99p *NV*) and a Constructor's Guide are included with the kit.

The project rating for the Super Scan is 4: Advanced. A fairly high level of skill is required in construction, however, the only test gear required is a multimeter, and no setting-up is required.

See the full range of over 350 project kits in the 1995 Maplin Catalogue: only £3.45 from your local Maplin Electronics store or branches of W H SMITH; or by mail order direct from Maplin Electronics (Order Code CA12N) for £3.95 inc. p&p. Call the Credit Card Hotline on **(01702) 554161** to order kits or a copy of the catalogue, or call **(01702) 552911** for details of your local store.

Maplin Electronics operates a policy of continuous improvement, and we reserve the right to change specifications quoted on this advert without notice.

Order Code 90062, **Super Scan Kit, £29.99**

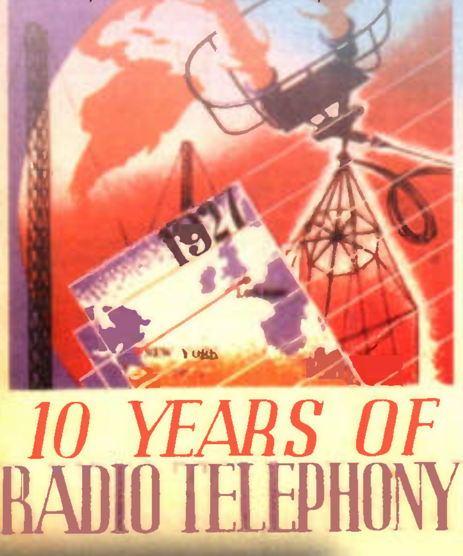
All prices include VAT, except those marked *NV* which are zero rated, and may change after 31st August 1995. All items subject to availability. E&OE.

JULY 1995
VOL 14. No. 91

IN THIS ISSUE...

PROJECTS *FOR YOU TO BUILD!*

FEATURES *ESSENTIAL READING!*



REGULARS *NOT TO BE MISSED!*

ABOUT THIS ISSUE . . .

Hello and welcome to this month's issue of *Electronics*! An important news flash hereby follows! This is to announce a replacement for the Subscribers' 5% Discount Card Scheme, for Subscribers who are unaware of this change, which took effect from April. However, before you start protesting, please read on! To take its place, there will be a selection of superb Special Offers, advertised within the pages of this, and future issues, and giving discounts, for example, a huge saving of £57 (over 47% !!!) on a 300W Car Amplifier – being a Subscriber will enable you to take advantage of these astonishing bargains! If you would like to become a subscriber and take advantage of future special offers and benefits of subscribing, turn to page 46 of this issue to find out more, or Tel: (01702) 554161. Note: if ordering by Mail Order, normal handling charges apply, but if purchasing from one of our retail outlets, you will not have to pay the carriage charges.

This month, there is a varied crop of five interesting projects for you to build, which consist of the Universal Stereo Preamp, designed to complement the Correction Preamp detailed in the previous issue, and in Circuit Maker, there is a highly useful Battery Saver circuit, to provide automatic power-down of equipment that has accidentally been left on. The CMOS Electronic CW Keyer which is used in conjunction with a paddle key, is a modern version of the mechanical 'bug key', and allows Morse operators to send a given number of dots/dashes with just one side swipe of the key, reducing the not inconsiderable effort required for lengthy transmissions. Then, there is the long-awaited (!) Interactive Doorbell, an entertaining project based on a digital speech recording IC, which can replay messages or sound effects to callers at your door, doubtless, much to their amusement and satisfaction, not to mention yours! Finally, the Mains Power Conditioner is a highly-effective filter, for smoothing out the noise and spikes from the mains supply, to prevent it causing damage or spurious effects to any sensitive equipment you may possess.

Features this month, include Colour Printing, by Frank Booty, giving the low-down on developments taking place in this widely expanding illustrative medium, Compact Disk Interactive (CD-i), from Martin Pipe, telling all you wanted to know about this exciting facet of multi-media technology, whilst Fuses, by Stephen Waddington, looks at the other end of the device complexity spectrum, showing which fuse to choose and why, for any given application, out of the large choice available. Douglas Clarkson's History of Defibrillation, describes the development of the Defibrillator, the now-familiar electronic shock machine, as seen in every good(?) medical drama shown on TV nowadays. Concluding this absorbing line-up, is Setting Up a Radio Shack, from Ian Poole, and also the second part of Sailing Ship to Satellite by Lenore Symons. All this, plus our usual regular, nourishing dose of essential and informative reading matter. So, until next month, from everyone here at *Electronics*, here's wishing you a highly enjoyable read!

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IN NEXT ISSUE . . .

In the August issue of *Electronics*, there are more terrific projects planned, in the shape of the Call Code Switch, which allows you to switch on/off, appliances at different locations, for example, at home – by means of putting a call through to a telephone nearby the Call Code Switch, of a specific pattern of 'phone rings (which only the user will know). This would allow you to switch on the lights, TV, kettle, etc., from anywhere – even from the other side of the world! Then, there is the Western Sound Generator, which can provide a selection of six realistic Country'n'Western sound effects, comprising rifle/gun/cannon shots, horses galloping/whinnying, and a bugle fanfare! The Multi-Strobe is one for all the ravers amongst you, which is designed to flash a Xenon flash-tube, in a choice of 100 beguiling patterns – just the ticket for parties, discos, or as an attention-grabber, for advertising. The SW Regenerative Receiver is a relatively simple, but highly effective, shortwave radio, aimed at beginners to the world of global radio coverage – so, now's the time to brush up on your international language skills!

An all-new line-up of features planned for this issue, consists of Flash EPROMs, by Ian Poole, which analyses this high-speed memory, which could soon take the place of floppy disks in computers. Low Energy Personal Computers, by Frank Booty, discusses the design initiatives behind the new generation of 'Green PCs' – ways of cutting back on the energy-guzzling excesses of PCs as we currently know them. Douglas Clarkson's UV Radiation informs us of the various forms of UV light spectra, and applications for this type of radiation in electronics and computing. Meanwhile, Yesterday's Electricity, by Stephen Waddington, looks back in time, to tell the fascinating story of the pioneers of electrical and electronic developments and inventions, many of which came about quite by accident!

Heading your way soon, are the continuing parts of Coupled Cavity Speakers, by David Purton, and John Woodgate's investigation into Noise. Forthcoming new series, include Practical Guide to Modern Digital ICs, by Ray Marston, which describes the operation, characteristics and applications for the various sub-families of logic ICs available today, whilst Music Synthesis, by Richard Wentk, tracks the path of the development that led to the design and use of synthesizers in modern music. And talking of paths, make sure you regularly beat one down to your local newsagent, so that you don't miss *Electronics* each month!

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Project Ratings

Projects presented in this issue are rated on a 1 to 5 for ease or difficulty of construction to help you decide whether it is within your construction capabilities before you undertake the project. The ratings are as follows:

1. Simple to build and understand and suitable for absolute beginners. Basic of tools required (e.g., soldering iron, side cutters, pliers, wire strippers and screwdriver). Test gear not required and no setting-up needed.
2. Easy to build, but not suitable for absolute beginners. Some test gear (e.g., multimeter) may be required, and may also need setting-up or testing.
3. Average. Some skill in construction or more extensive setting-up required.
4. Advanced. Fairly high level of skill in construction, specialised test gear or setting-up may be required.
5. Complex. High level of skill in construction, specialised test gear may be required. Construction may involve complex wiring. Recommended for skilled constructors only.

Ordering Information

Kits, components and products stocked by Maplin can be easily obtained in a number of ways:

Visit your local Maplin store, where you will find a wide range of electronic products.

If you do not know where your nearest store is, Tel: (01702) 552911. To avoid disappointment when intending to purchase products from a Maplin store, customers are advised to check availability before travelling any distance.

Write your order on the form printed in this issue and send it to Maplin Electronics, P.O. Box 3, Rayleigh, Essex, SS6 8LR. Payment can be made using Cheque, Postal Order, or Credit Card.

Telephone your order, call the Maplin Electronics Credit Card Hotline on (01702) 554161.

If you have a personal computer equipped with a MODEM, dial up Maplin's 24-hour on-line database and ordering service, CashTel. CashTel supports 300-, 1200- and 2400-baud MODEMs using CCITT tones. The format is 8 data bits, 1 stop bit, no parity, full duplex with Xon/Xoff handshaking. All existing customers with a Maplin customer number can access the system by simply dialling (01702) 552941. If you do not have a customer number Tel: (01702) 552911 and we will happily issue you with one. Payment can be made by credit card.

If you have a tone dial (DTMF) telephone or a pocket tone dialler, you can access our computer system and place orders directly onto the Maplin computer 24 hours a day by simply dialling (01702) 556751. You will need a Maplin customer number and a personal identification number (PIN) to access the system. If you do not have a customer number or a PIN number Tel: (01702) 552911 and we will happily issue you with one.

Overseas customers can place orders through Maplin Export, P.O Box 3, Rayleigh, Essex, SS6 8LR, England. Tel: +44 1702 554155 Ext. 326 or 351; Fax: +44 1702 553935.

Full details of all of the methods of ordering from Maplin can be found in the current Maplin Catalogue.

Subscriptions

Full details of how to subscribe may be found on the Subscription Coupon in this issue. UK Subscription Rate: £21.96/12 months, £10.98/6 months.

Prices

Prices of products and services available from Maplin, shown in this issue, include VAT at 17·5% (except items marked NV which are rated at 0%) and are valid between 2nd June and 31st August 1995 errors and omissions excluded. Prices shown do not include mail order postage and handling charges, which are levied at the current rates indicated on the Order Coupon in this issue.

Technical Enquiries

If you have a technical enquiry relating to Maplin projects, components and products featured in *Electronics*, the Customer Technical Services Department may be able to help. You can obtain help in several ways; over the phone, Tel: (01702) 556001 between 9.00am and 5.30pm Monday to Friday, except public holidays; by sending a facsimile, Fax: (01702) 553935; or by writing to: Customer Technical Services, Maplin Electronics plc., P.O. Box 3, Rayleigh, Essex, SS6 8LR. Don't forget to include a stamped self-addressed envelope if you want a written reply! Customer Technical Services are unable to answer enquiries relating to third-party products or components which are not stocked by Maplin.

'Get You Working' Service

If you get completely stuck with your project and you are unable to get it working, take advantage of the Maplin 'Get You Working' Service. This service is available for all Maplin kits and projects with the exception of: 'Data Files'; projects not built on Maplin ready etched PCBs; projects built with the majority of components not supplied by Maplin; Circuit Maker ideas; Mini Circuits or other similar 'building block' and 'application' circuits. To take advantage of the service, return the complete kit to: Returns Department, Maplin Electronics plc., P.O. Box 3, Rayleigh, Essex, SS6 8LR. Enclose a cheque or Postal Order based on the price of the kit as shown in the table below (minimum £17). If the fault is due to any error on our part, the project will be repaired free of charge. If the fault is due to any error on your part, you will be charged the standard servicing cost plus parts.

Kit Retail Price	Standard Servicing Cost
up to £24.99	£17.00
£25.00 to £39.99	£24.00
£40.00 to £59.99	£30.00
£60.00 to £79.99	£40.00
£80.00 to £99.99	£50.00
£100.00 to £149.99	£60.00
Over £150.00	£60.00 minimum

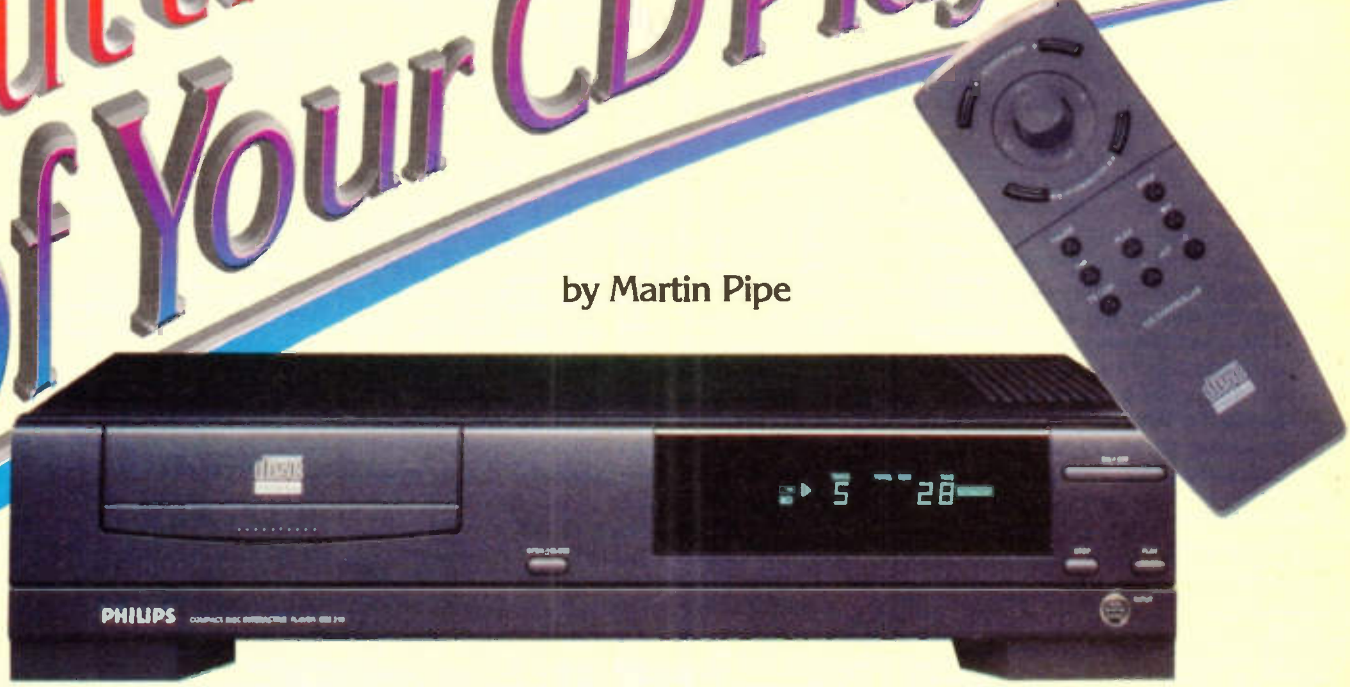
Readers Letters

We very much regret that the editorial team are unable to answer technical queries of any kind, however, we are very pleased to receive your comments about *Electronics* and suggestions for projects, features, series, etc. Due to the sheer volume of letters received, we are unfortunately unable to reply to every letter, however, every letter is read – your time and opinion is greatly appreciated. Letters of particular interest and significance may be published at the Editors discretion. Any correspondence not intended for publication must be clearly marked as such.

Write to: The Editor, *Electronics – The Maplin Magazine*, P.O. Box 3, Rayleigh, Essex, SS6 8LR, or send an e-mail to AYV@maplin.demon.co.uk

Putting You in Control of Your CD Player

by Martin Pipe



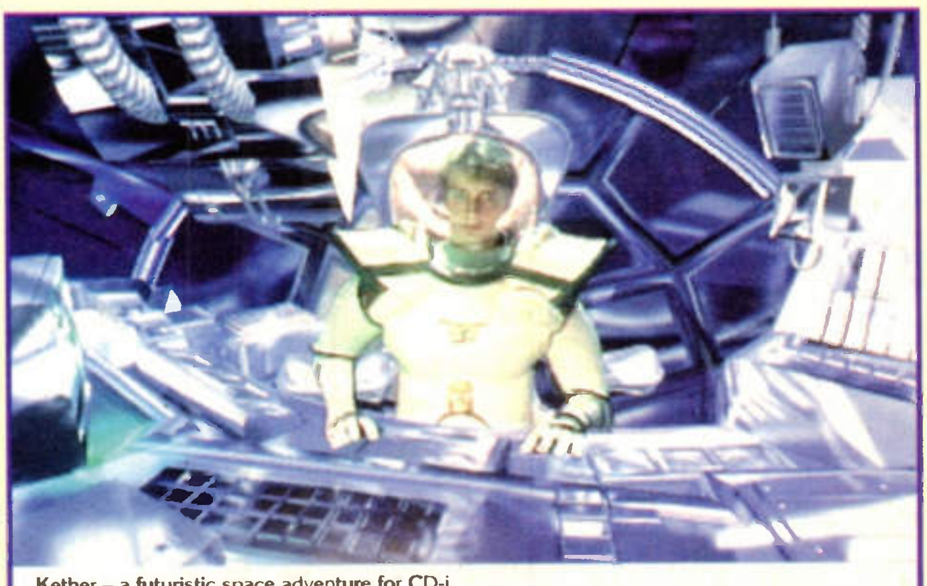
In March 1983, CD was launched on an unsuspecting Britain, with claims of 'no more snap, crackle and pop' and 'perfect sound forever'. The medium was indeed far more robust than the then-dominant LP record – does anybody remember the hole-drilling demonstrations and the famous *Tomorrow's World* 'smear test'? Although 'real' audiophiles sneered at the new medium, the manufacturers predicted that within 10 years CD would have virtually replaced vinyl. Unlike most predictions, this one proved surprisingly accurate.

COMPACT Disc was developed in the late 1970s by Philips and Sony, both consumer electronics giants on their respective continents. One of the reasons for the success of CD was the fact that licenses were sold to all major manufacturers, and a wide range of players became available – there was no competitive medium around at the time. Ironically Sony and Philips are now competing head on with their respective digital audio recording systems – MiniDisc and Digital Compact Cassette.

Apart from containing music, the vast data capacity (approximately 650 megabytes) is proving useful in other areas. Launched by Philips and Sony in 1985, CD-ROM started replacing large quantities of paper in libraries and research institutes in the late 1980s. It has since spread like wildfire to the consumer market with 'multimedia PCs' – basically a flashy name for a regular Mac or PC retro-fitted with a CD-ROM drive (and sound-card, in the case of the PC).

Nevertheless, the capacity of CD gives exciting possibilities for computer users – for example, the inclusion of megabyte-hungry sound-bites and real-time video sequences into software. With appropriate software, you can even use your £1,000+ PC as a £100 audio CD player! CD-ROM has given us some fascinating, well-presented and user-friendly programs (typically graphics-heavy games and 'infotainment'), useful business tools – and some textbook examples of pretty sloppy programming, which makes poor use of the near-gigabyte available!

Kodak's Photo-CD, first announced in September 1990, is another standard that makes good use of the CD format. Take your negatives or undeveloped film to a Kodak-approved chemist, and say that you want them on a CD, rather than the regular set of



Kether – a futuristic space adventure for CD-i.

CD-i joystick.

Phillips' current CDI 210 player.

prints. Buy yourself a Photo-CD compatible player, and then watch them on your TV screen. Features of the system include random access viewing, zooming and panning.

Each Photo-CD disc will hold up to 99 colour shots, but it is rather restrictive – you cannot, after all, lug around a bulky array of equipment to show your mates holiday snaps down the pub. Photo-CD has, however, found a niche market in photo libraries for electronic publishing. Interestingly, Kodak is now selling a portable Photo-CD player (also compatible with audio CDs) – presumably to try and gain support with the general public.

Multimedia CD

In 1991, Commodore launched the £600 CD-TV, which married a CD player to an Amiga computer. It flopped spectacularly, because it was marketed poorly – potential customers were not sure whether CD-TV was a computer or a games machine. Other companies, targeting their wares at a specific audience (such as Sega and its heavily advertised Mega CD) have had rather more success with CD-based systems.

Into the arena have come two more CD-based 'multimedia' home entertainment systems. A number of significant companies, such as Panasonic, Electronic Arts and AT&T, have thrown their weight behind the recently-launched 3DO system. Philips gave CD-i, or Compact Disc Interactive, a US launch in October 1991, and followed this a few months later in Europe and the UK, with much fanfare.

The Japanese have kept quiet about their involvement in CD-i, and one can be forgiven for believing that it is totally a Philips innovation. Sony and Matsushita (Panasonic, Technics) co-developed the system and the Japanese CD-i consortium also includes Kyocera, JVC, Sanyo, Yamaha and Pioneer, who are all developing players. In fact, the Japanese consortium has over 200 members, involved in both hardware and software. Sanyo's CDX1 prototype resembles a lap-top computer, with a 4in. colour LCD display, while Matsushita designed a more conventional player.

These prototypes were demonstrated in 1992 – interestingly, there has, of yet, been no UK launch of either. This is perhaps understandable in the case of Matsushita, which has recently launched its 3DO Multi-player. Sony, meanwhile, has made noises about launching CD-i as a business-orientated product – rather like its currently-available Data Discman. Philips, out of interest, is releasing a similar machine with a colour LCD screen. Business applications of CD-i will be discussed later.

On the European front, those supporting CD-i include TV companies, software houses, hardware companies and publishers. These include Central Television, Maxwell Communications, Elsevier, Carlton Communications and Pearson.

A major Taiwanese manufacturer will shortly be producing domestic CD-i players, while US company Interactive Media is producing cards (Media-Desktop) for CD-ROM-equipped PCs and Macs which give them full compatibility with CD-i discs. Philips hopes that other manufacturers will follow, making it a 'world standard' – but the company realises that good quality software will help to achieve this goal. Most of the CD-i press releases issued by Philips' PR company relate to the software being produced, rather than hardware. When audio CDs were first introduced, there was no direct competition. Over ten years later, the situation is clearly different for the many types of computer-based system that use the medium as a data storage. As we will find out, though, the CD-i standard has some interesting tricks up its sleeve which, it is hoped, will make consumers choose the system over the others. The large, but largely unannounced, third-party support will help.

What can CD-i do?

CD-i is, according to Philips, the multimedia version of the compact disc. CD-i discs store a mix of video, text, graphics, animation and sound, which is all under control of the user – hence the 'interactive' part of the name. In

Group shot of joystick and selected software.

Rear view of CDI 210 player.

Opening screen shots of various titles.

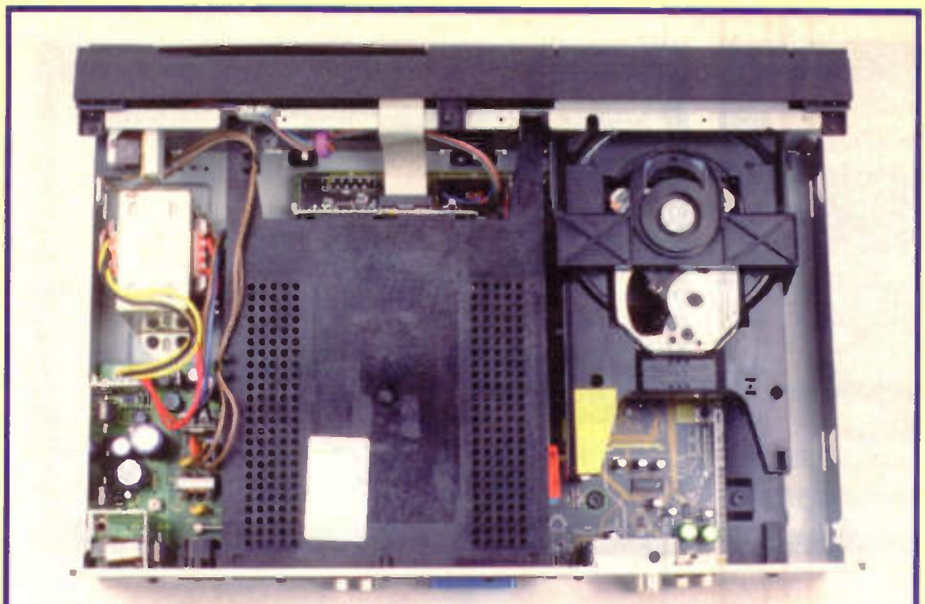
the UK, the system first went on sale in April 1992, accompanied by 32 software titles including children's games, interactive encyclopedias and music discs.

CD-i is, as you would expect, fully compatible with regular audio CDs – but then so are all the other CD-based systems mentioned earlier. The box even looks like a regular audio CD player, albeit with fewer buttons on the front panel. The main difference is that the unit plugs not only into your Hi-Fi system, but your TV set as well. The supplied remote control looks unlike any supplied with a CD player, its most distinctive feature being a joystick.

The basic CD-i player, currently the CDI 210 (a pretty similar machine to its predecessor, the CDI 205, which launched CD-i in Europe) will, in addition to audio and interactive CDs, work with Kodak's previously-mentioned Photo CD. This will help to improve consumer take-up of that standard. Unlike other systems, CD-i is not tied to a national TV standard – in common with audio CDs, a disc bought in one part of the world can be played in another.

But the real jewel in the crown is Video-CD, the first consumer product in the world to use MPEG-1 digital video. To play Video CDs, a FMV (full-motion video) cartridge needs to be inserted into a slot at the rear of the CD-i player. A few months ago, Philips offered the CD-i player and FMV cartridge together at a special price. Future machines will incorporate the MPEG decoder as standard.

It is important not to get the fully digital



Interior view of CD-i player.

Video-CD mixed up with CD Video (CDV), which was launched in 1987. CD Video is the current high-quality 12in. laserdisc system, popular with home cinema buffs, in which the picture is stored on the disc in analogue form, in the same way as the original LaserVision system. The sound, meanwhile, is stored digitally as per regular audio CDs. 12in. CDVs yield up to an hour of sound and vision on each side – you have to turn the disc over in the middle of a film unless you have one of the new 'double-sided' players which does it for you. Originally, there were also single-sided 8in. and 5in. versions, which never quite took off. With a 5in. 'clip' CD (the same medium, remember as Video-CD) playing times were limited to 6 minutes of video/audio, and a further 20 minutes of audio only. The bigger 8in. ('EP') discs provided a maximum of 20 minutes of audio only. The bigger 8in. ('EP') discs provided a maximum of 20 minutes of vision and sound, which was still to short for most purposes. The only practical use for the medium was just an expensive way of buying a CD single, with a pop promo thrown in for good measure. Philips even launched a midi-sized player, the CDV-185, which would play the 5in. CDVs, in addition to regular CDs. Not surprising, these were destined to be yet another icon of the yuppie era.

An unusual application of the CD-i/FMV system is a CD karaoke system, jointly developed by Philips and JVC. The system is compatible with regular FMV-equipped CD-i players, and existing CD-Graphics based karaoke machines which have been MPEG-upgraded. CD-i karaoke offers multi-lingual capabilities, and the software can be produced at low cost. Existing titles will be ported over to the new format, building up a large library of karaoke titles.

CD-i is the first system compatible with Video-CD, which is being heralded as a landmark event in consumer electronics. Up to 74 minutes of video and audio can be stored on each disc – inconceivable when the original audio CD format was developed in the late 1970s!

CD Standards

At this point, it would be wise to look at the various CD standards around. Audio CDs, which conform to a standard known as Red Book, deliver around 2 million bits per second, of which 1·4 million are used for storing the audio information. The rest are used for error correction, player control and text. The latter is rarely implemented or supported, except in karaoke machines.

CD-ROMs, now referred to as Mode 1 discs, provide more error correction to protect the data, and so can only deliver 1·2 million bits of data every second. Multimedia CD-ROMs appear to be slow, since sound and pictures are written on different parts of the disc and the laser pick-up has to do a lot of travelling! This explains why double-speed CD-ROM drives are becoming popular to speed up access times.

This was rather a bodge, and so Mode 2 discs were introduced. These interleave small portions of the sound and pictures, which are separated from the bit-stream by the decoder, providing both simultaneously. There are two variants of the Mode 2 standard. Multimedia CD-ROMs are usually used for non-critical leisure and educational applications. These usually conform to the Form 2 variant, which provides less error correction. CD-i is, in fact, a Mode 2 Form 2 system. The XA format, another conformant, has been designed to work across different platforms. XA discs include Photo CD and Video-CD. Business applications are catered for by Mode 2 Form 1 discs, which use very reliable error correction at the expense of capacity.

Video CD

Video CD, an XA Mode 2 Form 2 format, uses MPEG-1 digital full-motion video, which was discussed in an article in the December (Issue 84) of *Electronics*. Video-CD gives full on-screen indexing of the disc (like 'chapters' on a laser-disc) which gives users the opportunity to select any section of a movie, or song on a music disc, easily and very quickly. The full interactivity of CD-i is missing, however, because the control codes have been left out for reasons of disc space. The Video CD standard, known as White Book, was laid down by Philips, Sony, Panasonic and JVC in mid-1993. A number of manufacturers are developing, or are marketing White Book-compatible equipment. These include MPEG video boards for multimedia PCs, 3DO add-ons, etc.

The first Video-CDs were launched by Philips before White Book was finalised, presumably to gain a foothold in the market, and these do not conform to the White Book standard. These discs will, as a result, not play on anything other than a FMV-equipped CD-i player. Philips have had to contend with other Video-CD gremlins. When watching a movie on a CD-i player with an early FMV cartridge, there was geometric distortion of the picture. Everyone appeared tall and thin! Without informing customers who had already bought a FMV cartridge, Philips quietly brought out a newer version which worked at a slightly different clock rate to counter the problem. If you experience any problems, contact the Philips hotline on (0181) 665 6350).

Video-CD players will be launched by Samsung in the spring of 1995, for around £350. With the cost of the Philips CD-i player and FMV cartridge currently at £500 (and falling), it can be argued that this is too expen-

Disassembled CDI 210 player.

sive – CD-i gives you more facilities for only £150 extra. The difference will be even less when CD-i players incorporating the MPEG circuitry are available.

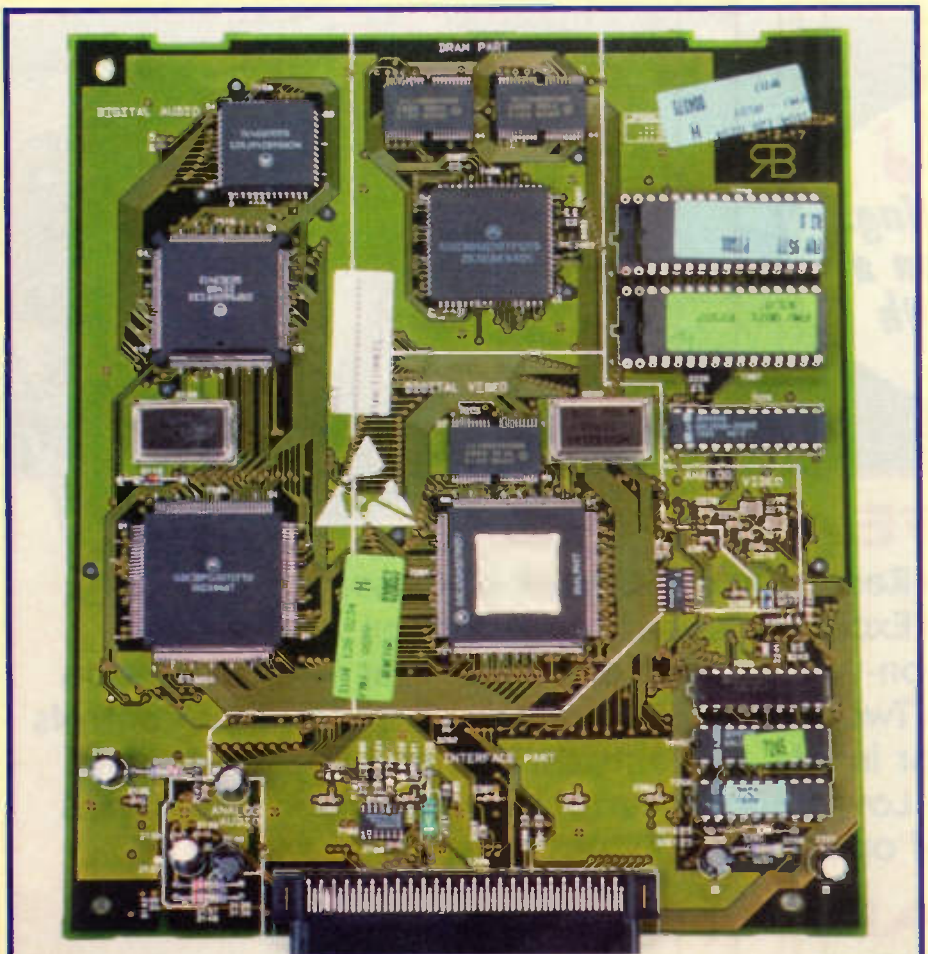
The implications of Video-CD are enormous, particularly for the video rental industry. No more customer complaints about annoying drop-outs from much-played tapes, and no more chewed tapes to be replaced. Indeed the system will offer the same robustness of audio CDs. They are also considerably cheaper to produce in bulk than video cassettes (which have to be duplicated in real-time) and are easier to store.

Current Video CD titles available include *Top Gun, Patriot Games, Star Trek VI, Sliver, Indecent Proposal, A Fish Called Wanda, Wayne's World, Patriot Games* and *The Krays*. The price of Video CD movies is typically £18. Deals have been signed with Paramount Pictures, Orion, MGM/UA and PolyGram to release over 180 titles, and many more are set to follow. Music titles include Pink Floyd's *Delicate Sound of Thunder* concert, and Bryan Adams' *Waking Up The Neighbours*.

With a Philips-supplied CD-i player and FMV cartridge, the *Patriot Games* double CD gave good results, with little vision artifacts noticeable, indicating a good MPEG mastering stage (some of the earlier discs were somewhat poorer in this respect). The picture quality, which is obviously not as good as that from 12in. analogue laser-discs, had roughly the same resolution as VHS tape (260 lines), but had none of the dropouts or graininess. The digital soundtrack also held the Dolby Surround information intact. The only inconvenience is that you have to change the disc halfway through a movie – but users of analogue laser-discs have to do that anyway!

Scene from *Voyeur*.

Nimbus is working on a £150 add-on which sits between your audio CD player's digital output and your TV. Sadly this system (also known as Video-CD), which will yield 79 minutes of video and sound, is incompatible with Video-CD. Since Sony and Matsushita have huge stakes in film and music companies, they are unlikely to provide software for the system – a major blow for getting the system established. Big business strikes again! In addition, Philips say that as many as 70% of suitably-equipped audio players will mute their digital outputs, because they are likely to be confused by the XA flag. Presumably, modifications could be made to by-pass the mute switch.


Interior view of FMV cartridge.

CD-i Software

Since it was launched in 1991, a wide range of CD-i software has been made available. Educational software, arcade games and music titles feature most prominently. The *Comptons Multimedia Encyclopedia* was one of the most impressive, giving easy access to information on an incredible variety of information, albeit seen from an US perspective. The disc is often bundled with the player, and could well be a valid excuse to buy one. Interested in the history of art, the Second World War or how a CD player works? It's all here! There are a few minutes of 'base case' video snippets available (you do not require a FMV cartridge for this!), countless digitised photographs, and hypertext links so that you can access information on topics related to the one currently being scrutinised.

The encyclopedia is very well laid-out, and there is an excellent on-line tutorial to introduce you to the system. The only problems noted were that some of the photographs did not display correctly, and disc access could be painfully slow. What's more, the system inexplicably crashed on one occasion. Bearing in mind that the disc was one of the first available, Comptons did an extremely good job. Other educational software includes pre-school titles for kids, an 'art gallery on a disc', and an impressive photography tutorial from Time-Life. Another package, Two Can Publishing's *Shipwreck*, introduces electricity to over-eights in an imaginative way. There is even a CD-i version of the *Joy of Sex*, but Philips' PR company saw fit not to include anything in the box. Presumably it had excited another reviewer so much that (s)he forgot to take it out of the player! On the subject of adult entertainment, a *Playboy Relaxation Disc* is available. The mind boggles!

Thanks to the capacity of CD, some advanced games have been made available on CD-i, including conversions of arcade games. Thanks to a licensing deal with Nintendo, a subsidiary of Philips (Fantasy Factory) produced an original (and surpris-

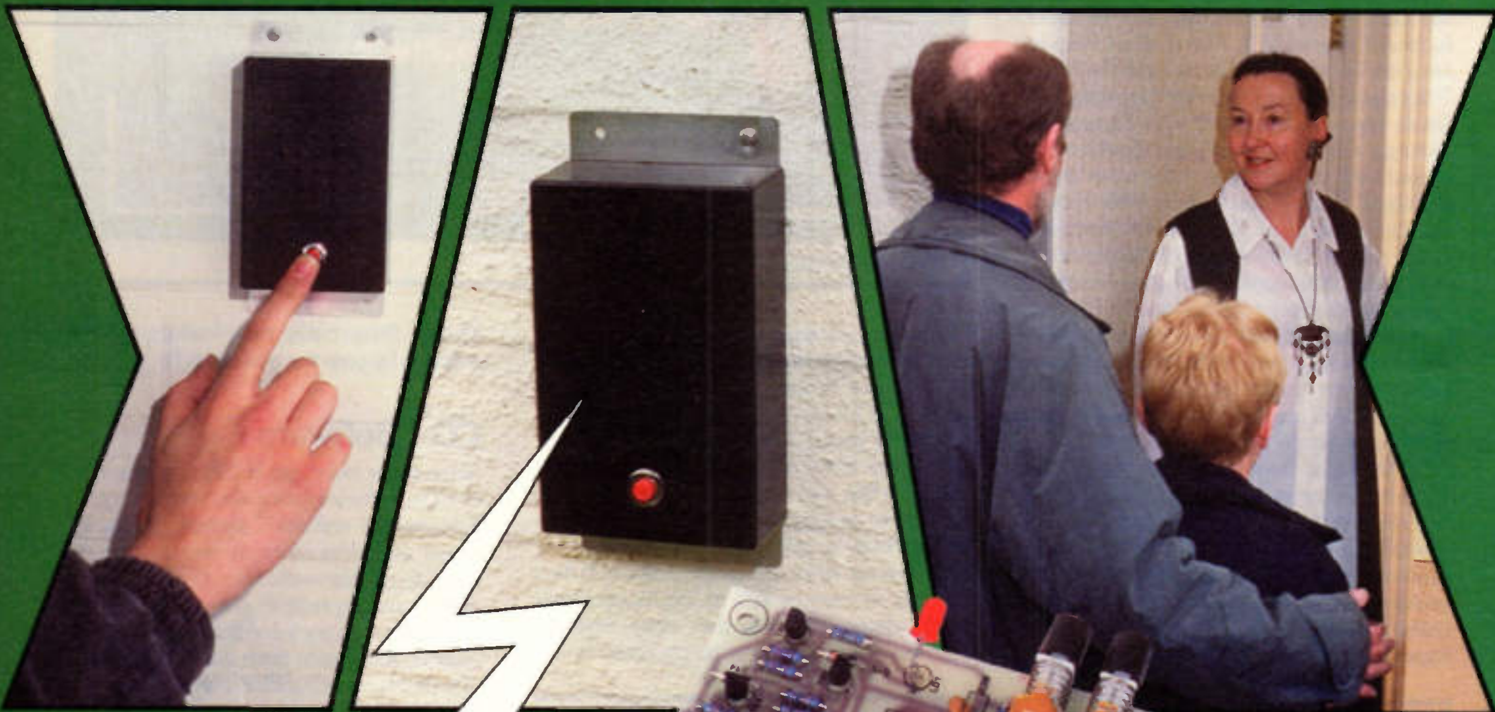
Continued on page 21.

INTERACTIVE DOORBELL

Design by Nigel Skeels
Text by Maurice Hunt and Nigel Skeels

3 PROJECT RATING

KIT AVAILABLE (90023) Price £39.99 A1



DING DONG

"Sorry to keep you waiting. Please can you hang on a moment, I will be with you directly"

Here is a doorbell with a difference – not only will it give a rather fetching 'ding-dong' chime, it can also relay any message you wish to the caller! It does not have to be a worded message; you could instead choose to regale your visitors with a few seconds of music, or sound effects. For example, have the soundtrack of a ferocious dog barking – when you are away on holiday! The provision of mode selection allows you to ring the changes (gratuitous pun intended), by choosing to have either the bell on its own, bell followed by message, or blissful 'do not disturb' total silence mode.

FEATURES

* Record and playback of messages * Excellent sound reproduction * 16 second non-volatile memory * Ten year voice retention * Two-tone chime sound * Independent controls for inside and outside bell and speech volume * Low standby current consumption * 3 modes of operation * Extension speaker facility

APPLICATIONS

* Novelty or serious use * Homes, shops, offices, hotels, etc.

Specification

Power supply:	8·4V DC (Ni-Cd PP3)/8V AC (Bell Transformer)
Supply current (standby):	7·15μA DC or 3·2mA AC
Supply current (activated, maximum):	203mA DC or 250mA AC
PCB dimensions:	103 × 163mm
Case dimensions (unit):	197 × 110 × 56mm
Case dimensions (bell box):	80 × 171·5 × 42mm
Visual indicators:	LED 'Recording' indicator
Recording time:	15·9 seconds

Circuit Description

The circuit, the block and circuit diagrams of which are given in Figures 1 and 2, respectively, consists of five main sections, these being the speech record/playback circuit, the doorbell chime circuit, the triggering circuit, the output amplifier and the power supply.

The speech recording and playback circuit operates using an ISD ISD1016AP integrated circuit, IC5, the block diagram of which is shown in Figure 3. This chip has already

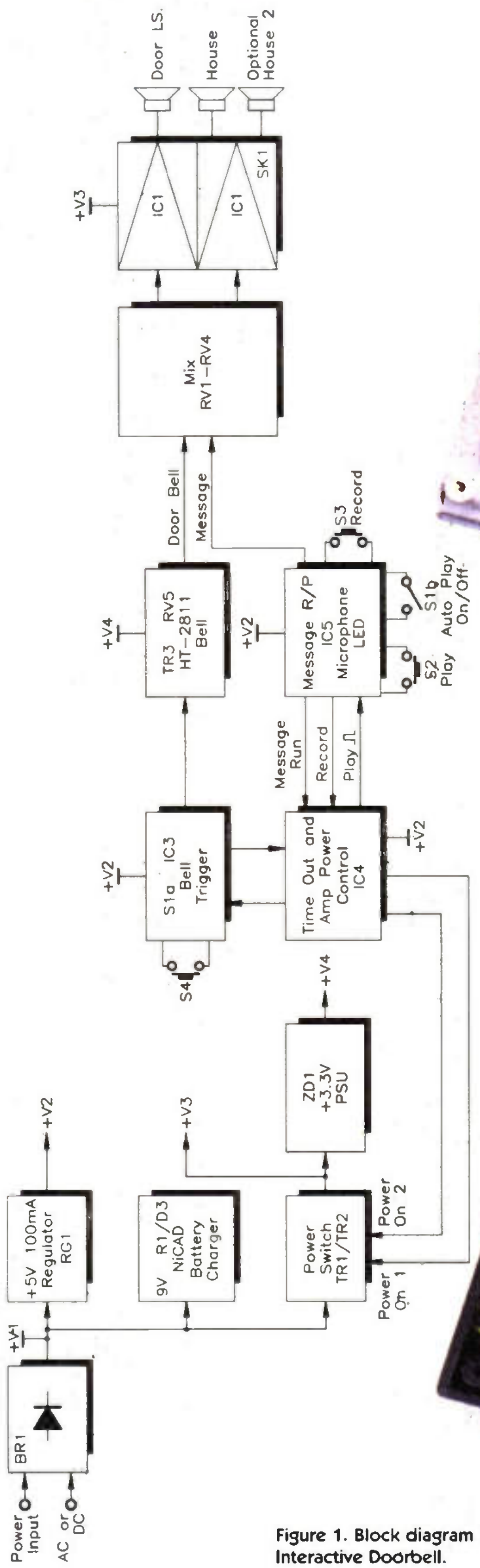
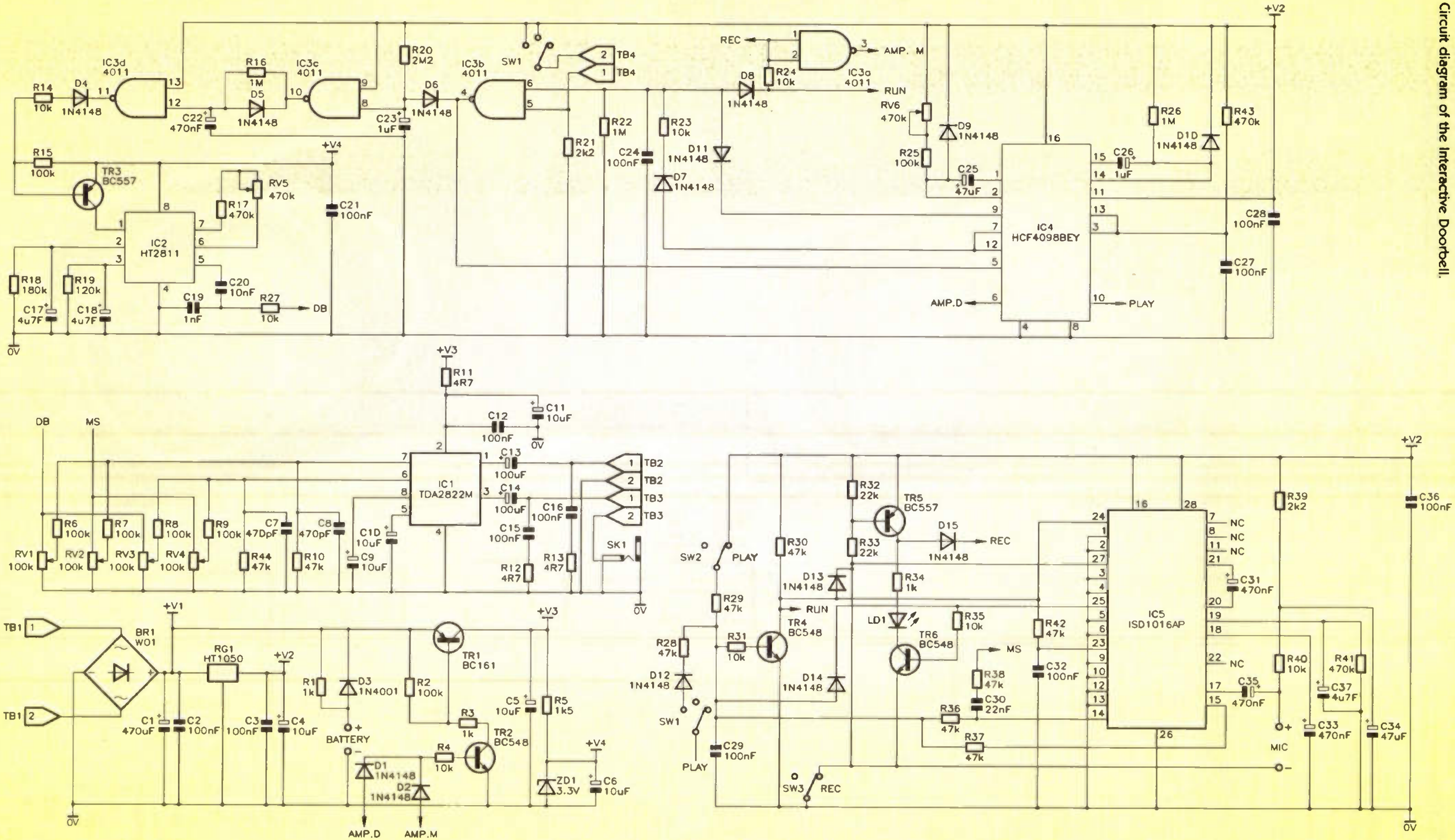


Figure 1. Block diagram of the Interactive Doorbell.

Internal view of the indoor unit.

Internal view of the outside unit.

Figure 2. Circuit diagram of the Interactive Doorbell.



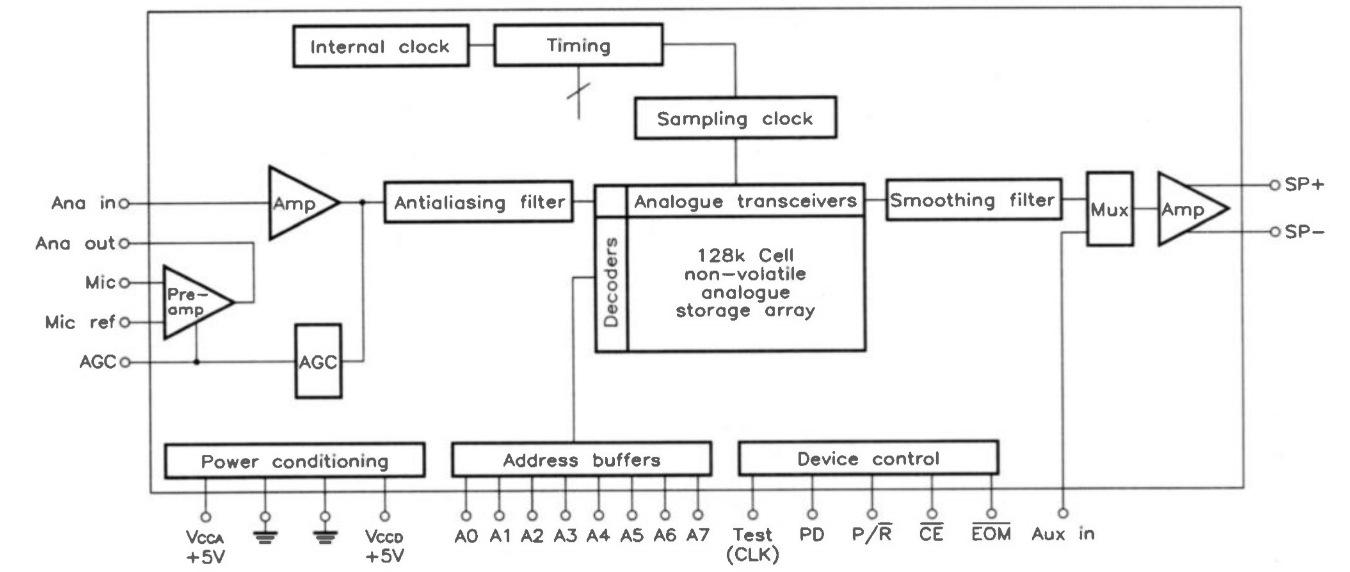


Figure 3. Block diagram of the ISD1016AP Voice Record/Playback IC.

been used to good effect in previous projects, such as the Velleman Electronic Record/Playback Module (VF43W), described in *Electronics* Issue 85, and the Electronic Memo Pad (LT79L) featured in Issue 87 (albeit using a surface-mount version). This is a single-chip voice record/playback device, which provides 16 seconds of recording time stored in a non-volatile array of analogue cells, doing away with the need for digital memory; it is claimed that the 128K analogue cells are equivalent to 1M-byte of digital storage. Another advantage of this revolutionary method is that it eliminates the need for complex digital conversion, compression or voice synthesis techniques which often compromise the resultant voice quality.

The door chime circuit uses a Holtek chip, IC2, which is an HT-2811, a dedicated doorbell sound generator device, featuring a very low standby current of around 1μA, which is extremely useful when using battery operation. The pinout of this device is shown in Figure 4.

Although the speech IC contains an audio amplifier, this is not used, since, with an output power of 50mW into a 16Ω impedance, it is not powerful enough to give an acceptable doorbell volume when used to feed the two speakers required (one inside, one outside). Instead, an external stereo amplifier is used. This is based upon IC1, a TDA2822M 1W power amplifier, each channel being used to drive a loudspeaker (with the identical signal, i.e., it is not in stereo!), and allowing provision of an extension speaker, if required.

Further power saving is incorporated by means of IC4, providing an amplifier switch-off delay, the time period being set by RV6, which also determines the delay between the bell and replay of the message. Preset potentiometers RV1 to RV4 are the volume controls for the individual setting of inside/outside speaker, and bell/message levels, whilst RV5 adjusts the speed of the oscillator, which determines the pitch of the bell sound.

The circuitry is powered via a 5V regulator, RG1, a Holtek HT-1050, which is chosen for its low power consumption, of just 9μA.

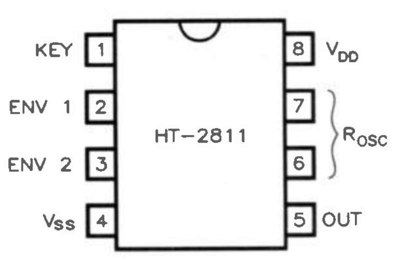


Figure 4. Pinout of the HT-2811 Doorbell IC.

A bridge rectifier, BR1, is included, so that the power supply may be of either 8V AC, or 15V DC. Although the recorded message will be retained in memory in the event of a power failure, the design includes a Ni-Cd PP3 cell, which provides a back-up, so that the doorbell and message will remain working during a power cut. The battery is kept charged at all other times by built-in trickle-charging circuitry.

Indeed, the interactive doorbell could feasibly be run from large capacity batteries as opposed to a mains PSU if desired, since overall power consumption is very low in standby mode, although you would get some very odd-sounding messages being emanated when the battery eventually runs low!

Connections between the main board and the power supply, internal and external loudspeakers and bell push are made via terminal blocks TB1 to TB4, respectively.

PCB Construction

Following the circuit diagram, PCB legend and track, illustrated by Figures 2, 5a and 5b respectively, will assist in the building-up of the PCB, and in the understanding of the following description.

Generally, the board is built in order of ascending component size, from smallest to largest. Leave the ICs in their protective packaging until the remainder of the board is completed, before plugging them into their sockets, taking cautions against stray static charges – in particular with the main voice chip, which is quite expensive to replace. It is important that **the wire links should be fitted prior to anything else**, since some are positioned beneath the IC sockets, and hence will become inaccessible.

Next, fit the Veropins, resistors, diodes and Zener diode, observing correct diode polarity, followed by the preset potentiometers. The bridge rectifier, BR1, should then be fitted, succeeded by the IC sockets, observing that they have alignment notches which should ideally be appropriately orientated, although as long as the ICs themselves are put in the correct way round, it is not a crucial point.

Follow this by fitting the capacitors, observing correct polarity with electrolytic ones, then the transistors and voltage regulator RG1.

Prior to fitting switches S2 and S3, they must be converted from locking to non-locking (momentary) action, and this is achieved by replacing the wire retainer clip on each switch with the special nylon retainer (supplied with the switch), as per Figure 6. Note that when the wire retainer is removed, the plunger will be forced out under spring pressure, so ensure that it is held in firmly as the clip is taken out, or else the plunger will be launched across the room – or into an eye! Then install switch S1, and the terminal blocks TB1 to TB3. Finally, solder the electret microphone and LED onto the Veropin connections, as per the diagram shown in Figure 7.

Case Preparation

Internal box

Refer to Figure 8a, which provides the drilling details for the inside-mounted casing. It is necessary to screw the two halves of the case together prior to drilling, since some of the holes in the case sides are on the joining edge axis. However, the end-plate may be drilled separately, if it makes life easier, which depends on what sort of clamps/vice(s) you have(!) Remove any resulting burrs using a small file or scalpel, to tidy up the edges.

Having drilled the holes in accordance with the diagram, mount the PCB in the dark grey section of the box, remembering that

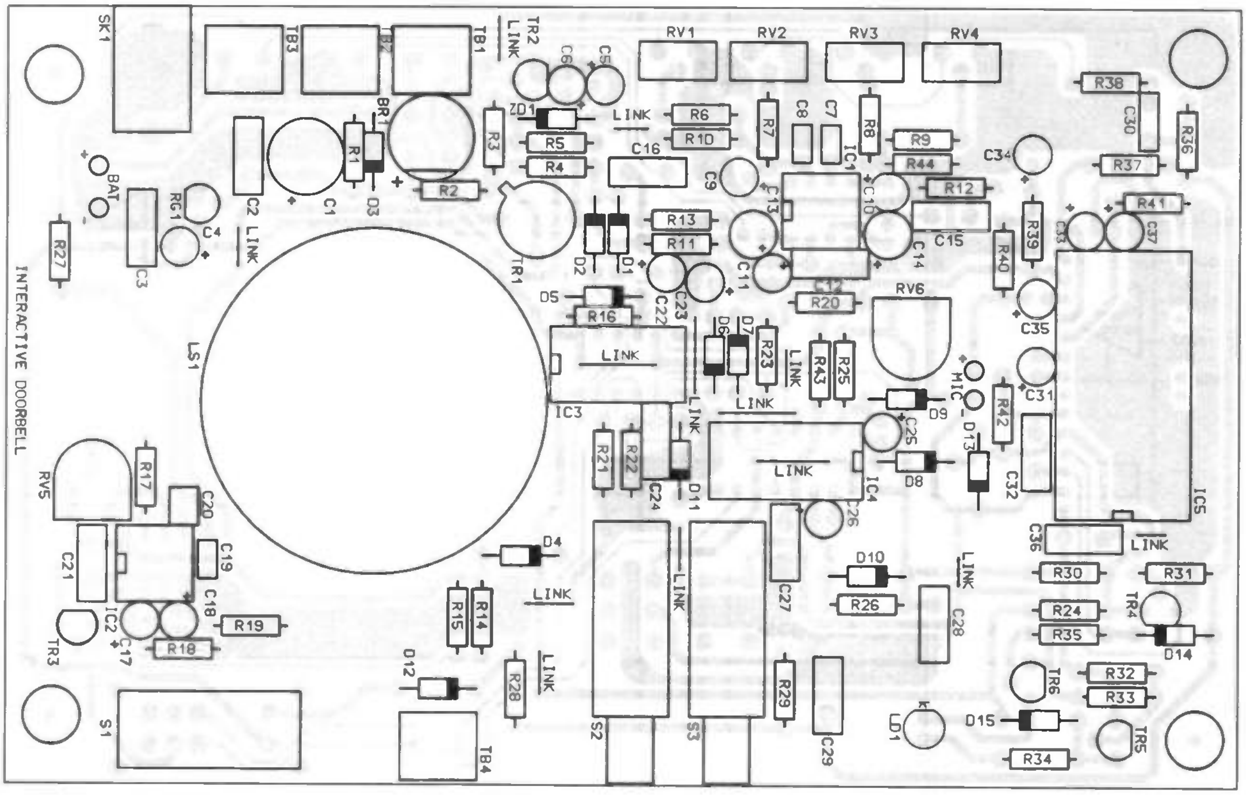
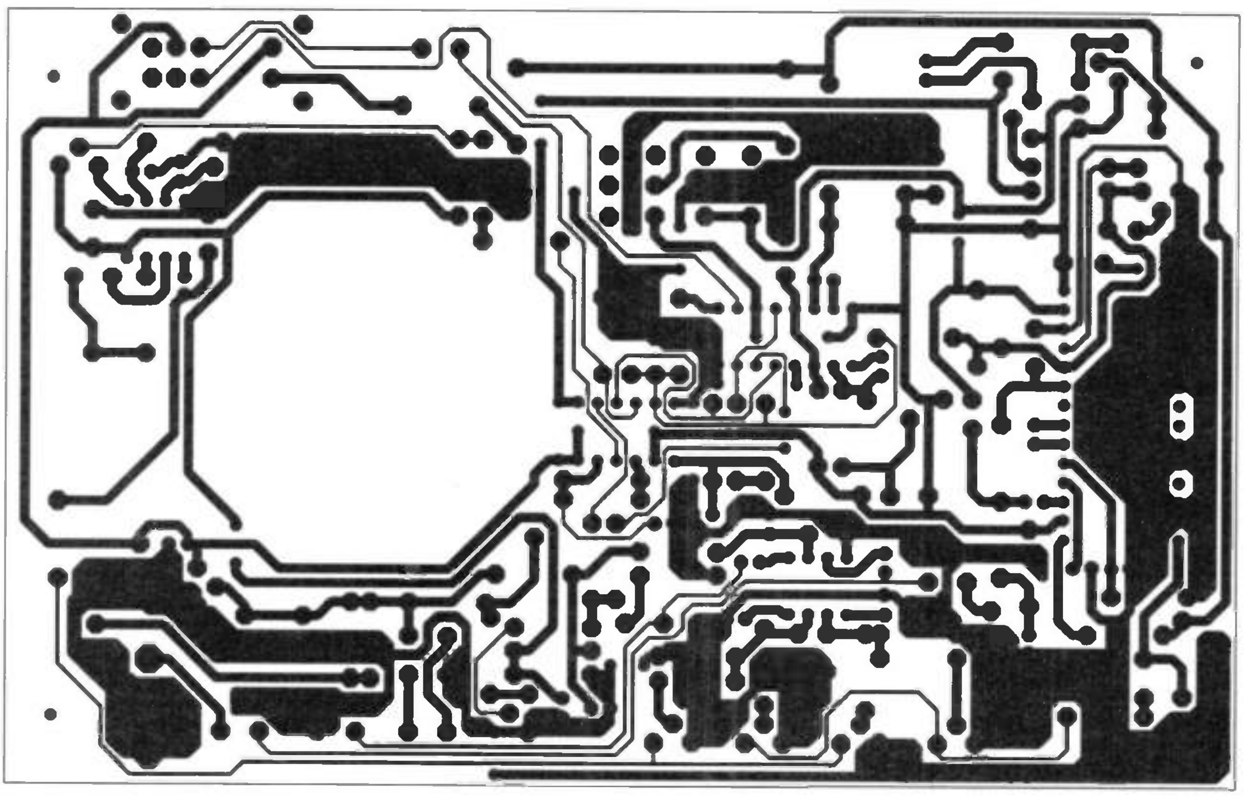


Figure 5a. Interactive Doorbell PCB legend.



5b. Interactive Doorbell PCB track.

the fixing posts at each end of the box are spaced at different distances. Once the PCB has been secured, the speaker may be mounted into the light grey part of the box. This is attached via the posts that are spaced closer together. Note that only one end of the speaker's mounting flange is secured by means of short screws into the two posts, the opposite side of the speaker rests on the plastic pegs moulded into the box.

External box

Refer to Figure 8b for the drilling details for the outdoor-mounted box. Only the front face of the box is drilled, to accept the doorbell push switch (unless you are using the existing one), and to allow the speaker's sound out, whilst maximising its water-resisting ability, to cater for exterior mounting. Take care to ensure accurate, symmetrical drilling of the holes, and remove any burrs with a file or scalpel, as this will enhance the aesthetic appeal of the finished unit.

After the connections have been made to the speaker and bell push, the speaker is mounted into the box, so that it is in alignment with the set of holes that have been drilled for it. The speaker is held in place by means of the piece of matrix board supplied, which is screwed down onto the

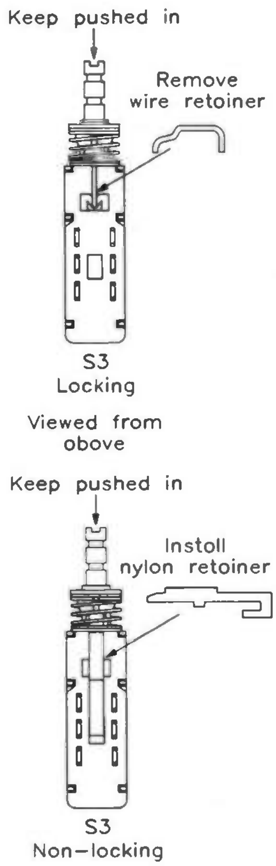


Figure 6. Preparing switches S2 and S3 for momentary action.

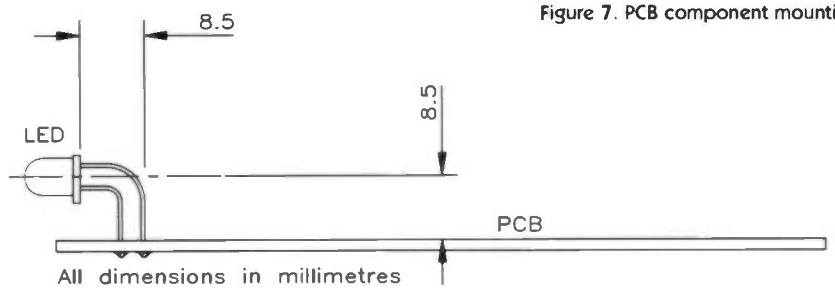
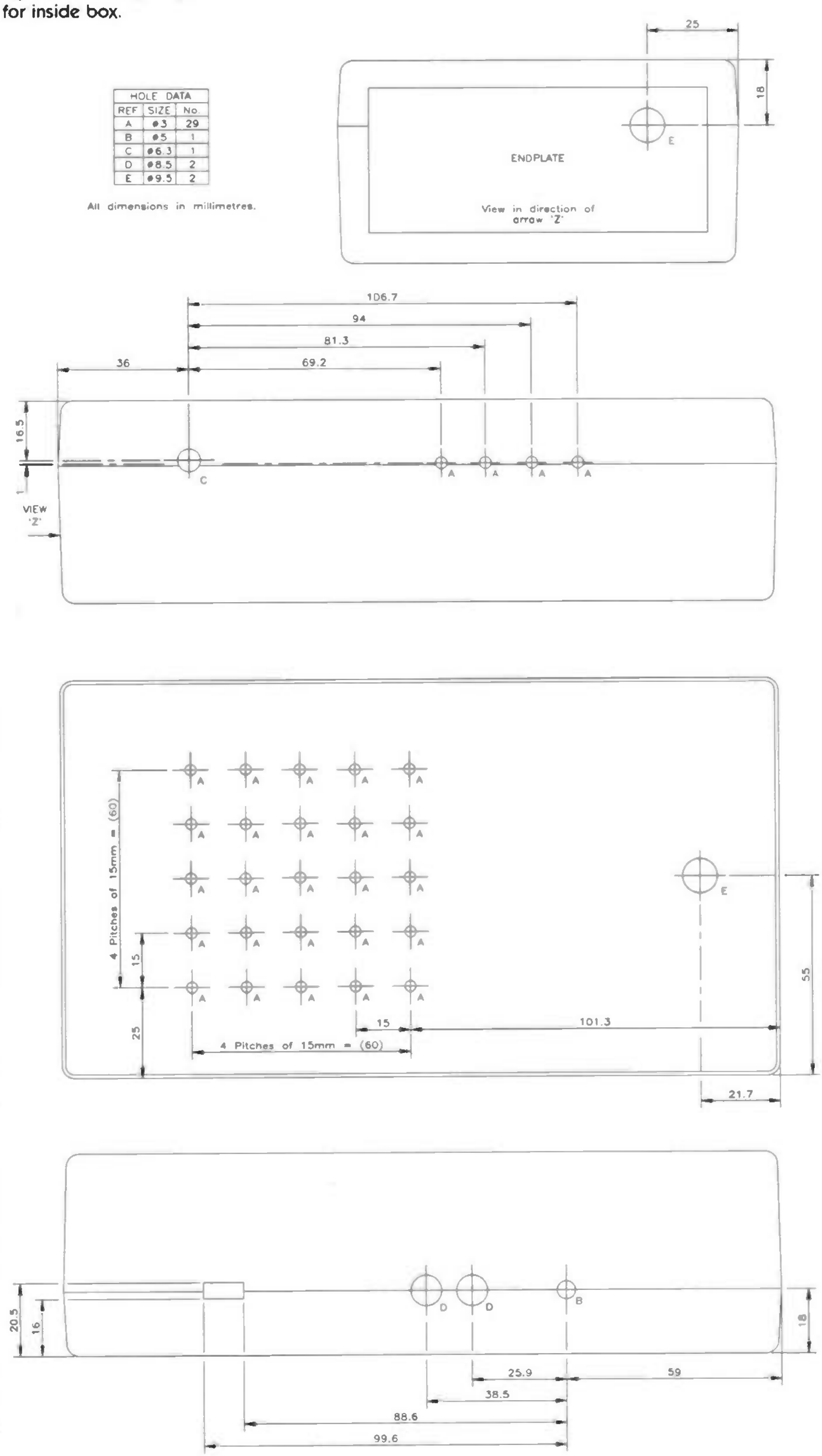


Figure 7. PCB component mounting.

Figure 8a. Drilling diagram for inside box.



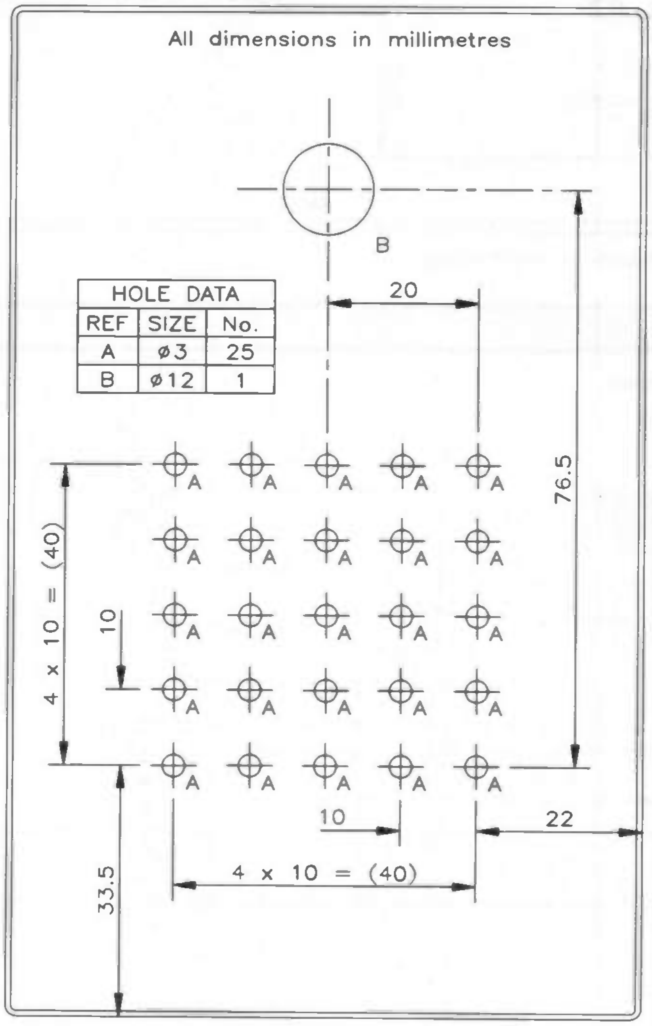
internal pillars in the box – the speaker height is the same as that of the pillars. However, if the speaker remains loose, packing foam can be used between the speaker magnet and matrix board to secure it. The metal base can then be fitted on the box. The protruding 'ears' of the base can be used for attaching the unit to a flat surface outside, such as a wall or the door.

When the box construction is complete, the side panel labels, depicted in Figure 9, can be applied to the interior case, taking care to apply each label to the correct side of the box, and the correct way up! Figure 10 shows the exploded view of the final assembly for the interior unit; assembly of the external unit, containing just the speaker and bell push, is self-explanatory.

Installation

The system can be installed in many different ways, depending on how much of the original doorbell wiring you want to make use of, if any. Figures 11 and 12, showing wiring connections to the main board, and overall installation diagram, respectively, will be of help here. Four-core burglar alarm cable (XR89W) is best for the job, i.e., two wires for the bell push switch and two for the speaker. Note that the wire may exit from the external box anywhere you choose, but a suggested idea is to have the wire exiting from the metal base, and going through the wall/door that the box will be mounted on, thus avoiding the possibility of the wire being cut by malicious types.

The choice of bell push is yours, and again, you may want to use the original, or the alternative is to house the button in the



8b. Drilling diagram for outside box.

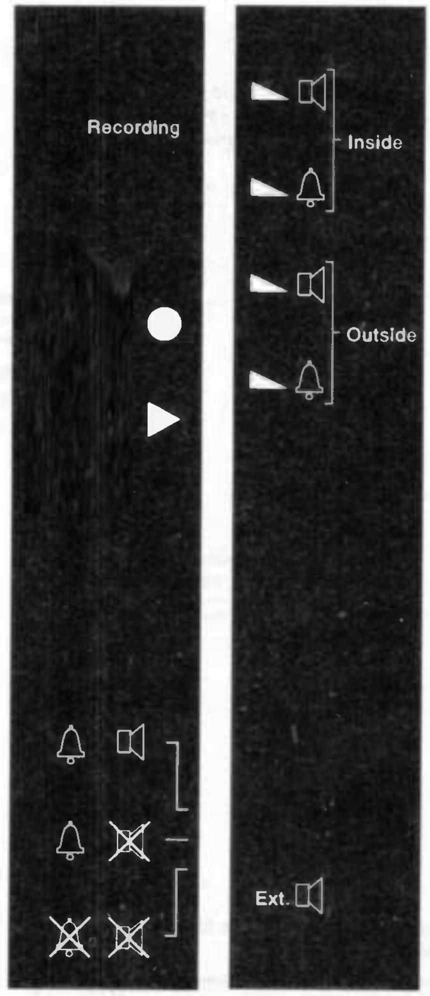


Figure 9. Interactive Doorbell side panel labels.

same box as the outside speaker. A suitable box for this is (YU47B) which has external lugs that enable the box to be attached to a surface. A stronger box, such as diecast box DCM5007 (LH72P) may be needed to protect the speaker and the bell push if it is more likely to be abused. If possible, mount the box in a sheltered position, so that it is protected from the elements. If there is the possibility of it getting wet, it is advisable to use a silicone sealant (available from DIY outlets), to seal the box against its base. Note that the external speaker is of the Mylar cone type, which is weather- and splashproof from the front.

An ideal doorbell button would be the bell push switch (FS17T) or the splashproof push switch (RD20W) if you need extra water proofing capabilities. If the bell push was to be separate then the FS17T would be ideal for the job. The internal box needs to be mounted at a location that is low enough for easy access, to enable the message to be changed, whilst being high enough to be out of reach of meddling children or destructive pets!

Note: If your doorbell push incorporates a backlight, this may be run from the same power supply as that used for the circuitry, by wiring it in parallel to the supply connections at the terminal block, TB1. Check beforehand that the backlight bulb is correctly rated for the voltage applied.

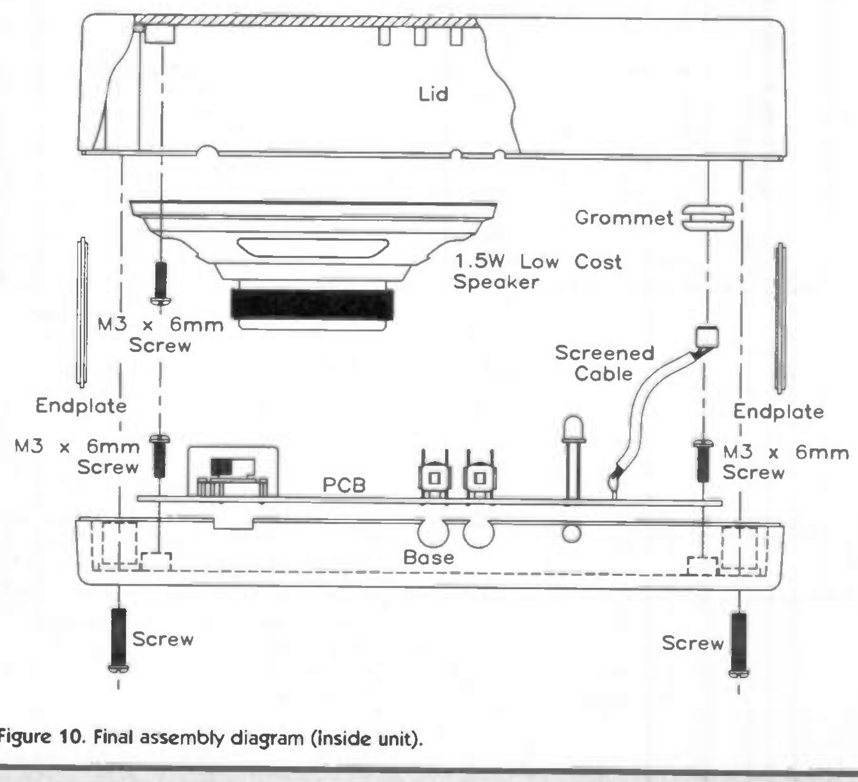


Figure 10. Final assembly diagram (inside unit).

Testing

Make the usual checks prior to applying power for the first time, ensuring that the components are correctly placed, that polarity-conscious parts are properly orientated, and that there are no solder bridges between PCB tracks, or 'dry' joints.

It is highly advised that the circuitry be confirmed working correctly before

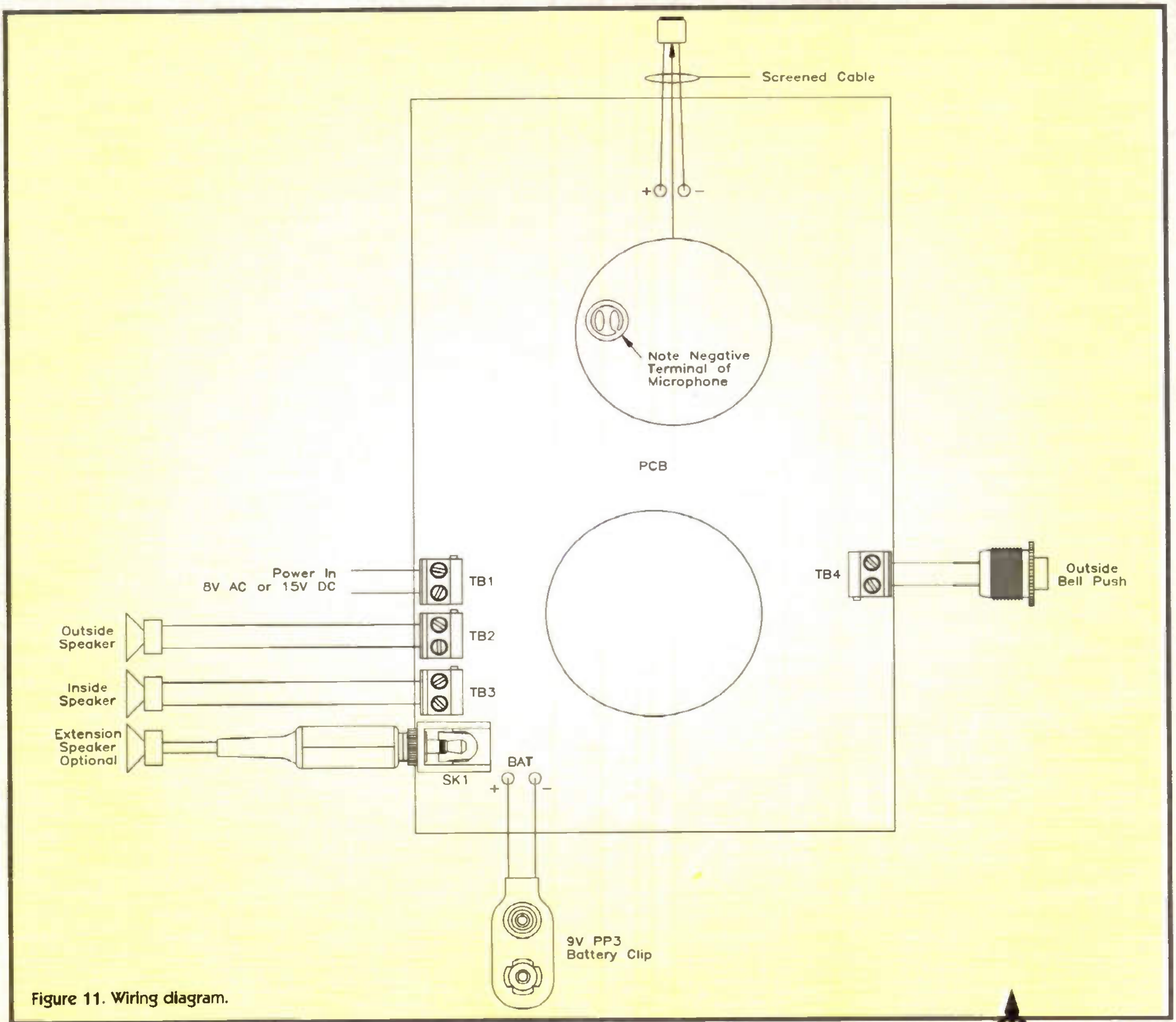


Figure 11. Wiring diagram.

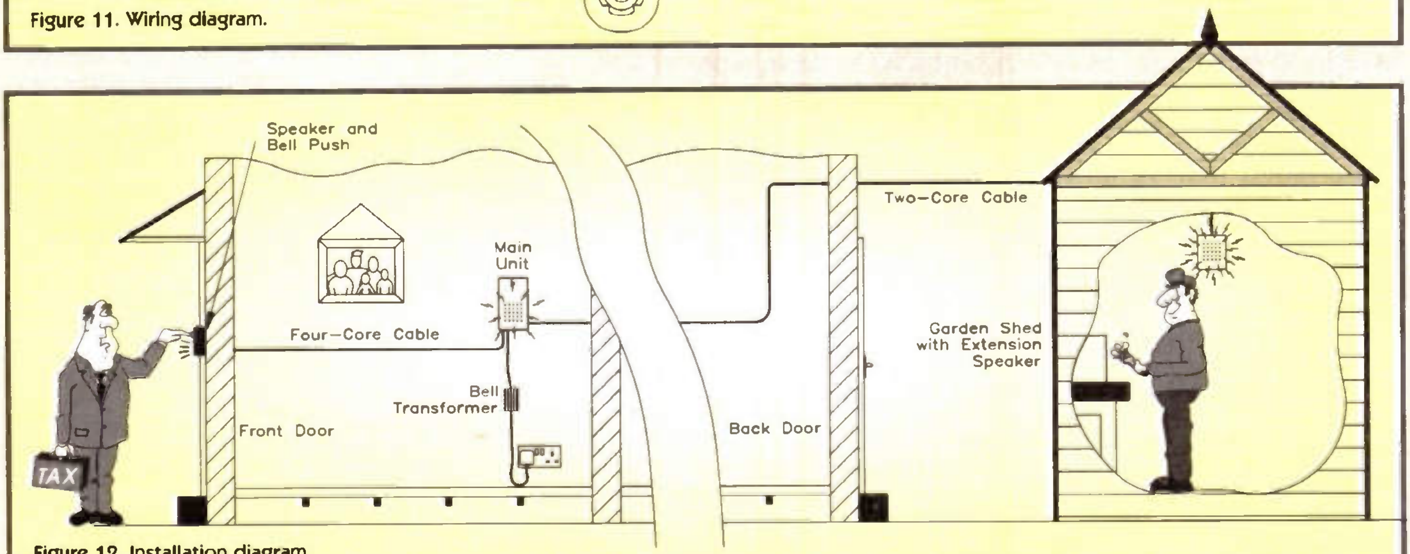


Figure 12. Installation diagram.

installation into the box, and obviously before weather-sealing the external box (with silicone sealant) and mounting it all on the wall!

Using the Interactive Doorbell

The use of this project is extremely simple. To record a message, press and hold the record button S3 until either you have finished, or the 15·9 seconds have elapsed, this being verified by the red 'record' LED extinguishing. To check that the recording is OK, the 'play' button is pressed, and with a bit of luck and the wind in the right direction, out will come the message that you have just recorded.

Now that the message has been recorded, the system can be tested properly, in the following manner. First, make sure that the mode switch S1 is in the "BELL AND MESSAGE" position, then, try ringing the doorbell. You should now hear two pairs of two-tone chimes, followed by the message that you had recorded. Now switch S1 to the "BELL ONLY" position and ring the doorbell again, and this time the bell should sound, but not the message. The final test is to put the bell into the "DO NOT DISTURB" mode, and as the name suggests, neither the bell nor the message should sound. The idea of this mode is that people leave you n peace, of course, this does not guarantee that they will not start indignantly rapping on your door.

The main thing that you definately have

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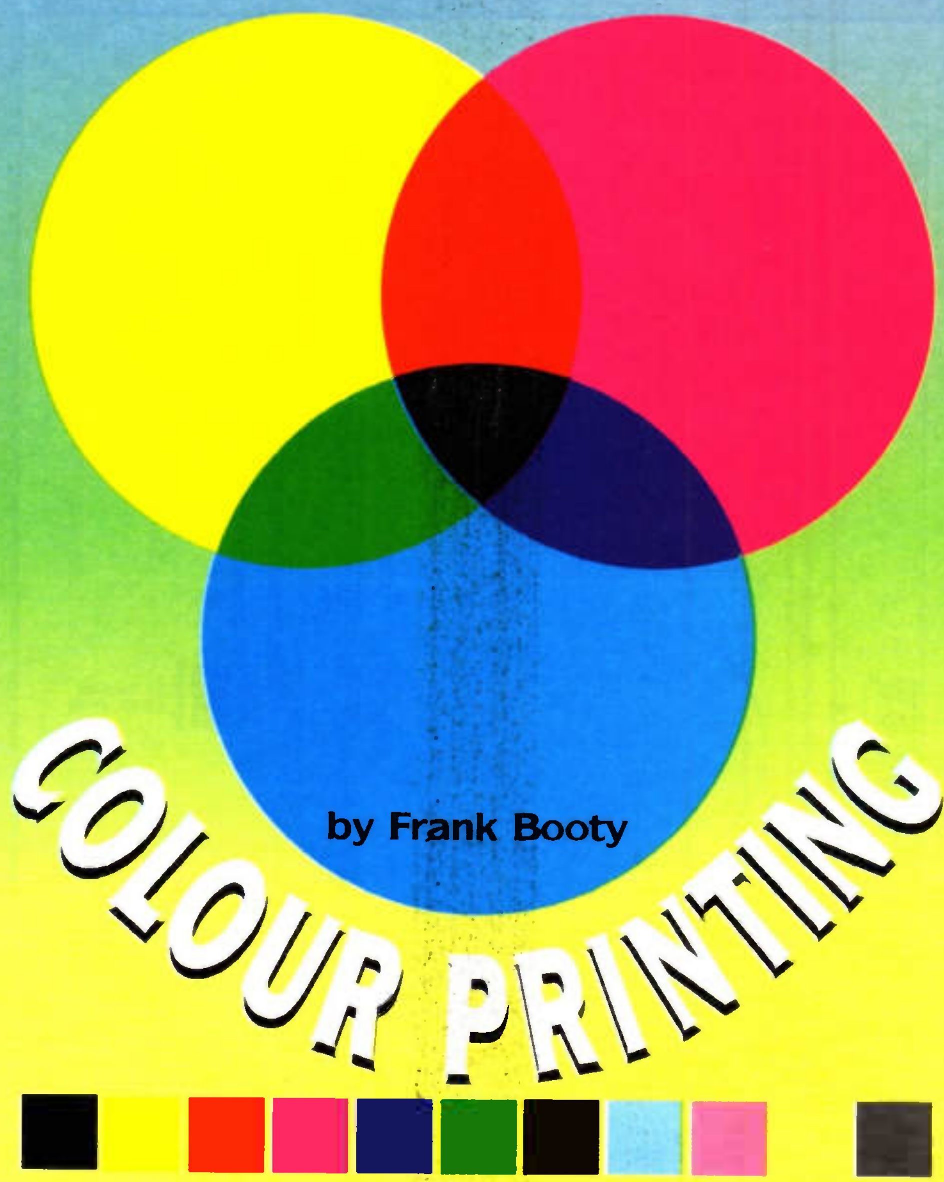


COLOUR PRINTING

by Frank Booty

Colour is an essential process in conveying meaning from graphic images, it is not just cosmetic. Compared to paragraphs of text, tables or numbers, well chosen colour graphics make key points easier to identify and remember. As more and more software packages make use of colour, so the opportunity to print out in colour grows. All the major printer manufacturers now offer colour printers in their product range. However, several quite different types of printing technologies are used to produce output. This article attempts to explain how colour works, and what printer technologies are available – each technology is reviewed and the advantages and disadvantages of each discussed. Applications for which each technology is best suited are also evaluated.

TODAY, communication is more complex than ever. There is an abundance of information and ways are constantly sought to improve the efficiency of communication. There is no doubt that graphics aid communication, a fact that has been known since primitive humans first drew on cave walls, or made intricate designs on bronze artifacts, prepared religious icons and produced sophisticated hieroglyphics. Today, graphics are everywhere, ranging from corporate logos to road signs.

Whenever light interacts with our visual system, we experience colour – like radio waves, microwaves and X-rays, the light we perceive as colour is a form of electromagnetic radiation. Light waves themselves are not coloured, but when they are processed by the human visual system, they evoke the sensation of colour. Colours are seen because their wavelengths fall into the narrow band of frequencies that the human visual system responds to, i.e. the spectrum from red through to violet.

White light, such as sunlight, is generally a mixture of all the visible frequencies of light. A prism can be used to separate the light into components. Most objects do not glow and give off their own colour – their colour depends on the fact that they absorb some wavelengths and reflect others. When a person talks about how colours look to them, they generally speak in terms of four attributes: hue, saturation, lightness and brightness.

Hue is the most basic component of colour. It is the attribute that answers the question 'what colour is it?' Green, blue and red are examples of hues. Saturation answers the question 'how coloured is it?' Pink and red have the same hue, for example, but pink is less saturated. Lightness refers to how much white, grey or black is part of the colour. Brightness is a function of intensity, and is a measure of how bright or dark an object appears depending on the amount of light illuminating the object.

Printer Colours

With the exception of pen plotters, computer graphics printers are raster devices that produce images via patterns of tiny dots. Printers work with three colours of dots: cyan (or blue-green), magenta and yellow. These colours are called the subtractive primaries: primaries because all other colours can be derived by combining them, and subtractive because a printer's inks, dyes, and pigments act as filters that subtract or absorb certain wavelengths and reflect others. Mixing equal amounts of cyan, magenta and yellow subtracts all the visible wavelengths and creates black.

The printer can overlay two primaries and so produce red, green and blue. It can overlay all three primaries to give black. Many printers include a separate black so they can produce a very dense black. Consequently, the printer's subtractive colour system is known as CMY or CMYK (the 'K' is for black). Beyond these few colours, the printer works with patterns of dots. To print an intermediate colour such as purple, the printer lays down a pattern of primary dots – in this case, magenta and cyan. For less saturated hues, the printer dithers, or mixes white by leaving some dots or areas unprinted – for example, white space plus magenta for light pink.

Screen colours

A workstation, PC or terminal generates colour quite differently from a printer. The display uses the additive primaries of red, green and blue. They are called additive because adding equal amounts of red, green and blue together gives white, and this colour system is known as RGB. Another difference between printers and displays is that paper reflects light, whereas a CRT display emits light. The surface of the display comprises thousands of tiny phosphor dots. For each pixel on the screen (addressable dot), there are three phosphor dots: red, green and blue. To display a red image, the system turns on the red phosphors that make up the image's outline and interior with an electron gun. To produce intermediate hues, the system turns on two or three phosphors in a group of three.

Another distinction is that the display can vary the hues. If the electron gun has four levels, the system has a palette of 64 colours. With high end (expensive) displays and workstations, very fine steps of the electron gun make possible subtle colour distinctions at each pixel, and allow thousands of colours to be displayed. The difference in the methods of creating screen and printed colours is the basis of the problems of screen to output colour matching, since what is seen displayed is not always what is obtained when printed.

Paper and Inks

High quality colour output is not just a matter of the printer technology, but is also related to the type of inks and paper used. For bright colours, inks need to adhere to the surface of the paper or overhead transparency. To enable quick drying and provide colour permanence with ink jet printers, a portion of the ink needs to sink into the paper. If too much ink soaks in, the colours look dull. If too little sinks in, the droplets can spread and bleed into one another making the colour fuzzy. For laser, dye sublimation and thermal wax printers, the finish of the paper must be smooth enough for all the ink to adhere to it. Drying is not an issue, but by using special office or printer paper rather than general paper, the problems of ink adhesion and soaking are reduced. For colour printers, there are three categories of media: general office paper, special office paper and special printer paper, and transparencies.

Many colour printers are marketed under the claim that there is the capability to print on plain paper. However, exactly what is plain paper? There is, in effect, no one answer, because plain paper has varying qualities depending on grade, weight, finish and colour. Many people will define plain paper as general office paper, for example, company letterheads or photocopy paper. Depending on the application for colour printing, there may be a requirement to print on plain paper. For example, a user may want to print on preprinted company stationery for business reports (i.e. special office paper), or a designer may want to produce mock ups.

With the exception of phase change, today's colour printers need special office, or special printer, paper to give best results. While plain paper printing is possible, colour quality is sacrificed. Special printer paper for office correspondence and business reports is usually unacceptable due to its finish and light weight. Using plain paper for colour printing affects colour quality as shown in Table 1.

A Look at the Technologies

Dot Matrix

These are low-cost devices that essentially put a colour ribbon on an ordinary monochrome dot matrix printer. Small wires or hammers in the printhead transfer ink from an inked ribbon onto the paper. Best applications are considered to be business documents using simple colour. But they are noisy, slow and colours become duller as the ribbons age.

Pen Plotters

With best applications in 2D CAD and large format line drawings, plotters use computer-controlled motors to guide up to eight separate pens. In a flat bed plotter, the pen moves back and forward over a sheet of paper or other material. Other types of plotter move the pen in one direction and the paper in another. Limitations include time (up to 30 minutes a copy), eight colours maximum, difficulty with solid fills and limited fonts. But they are reliable, and print on large format and plain paper.

Liquid Ink-Jet

Known for their bright, highly saturated colours, liquid ink-jet printers propel fine droplets of ink toward the surface of the paper. But special printer paper is mandatory. While plain paper printing is possible, colours lose their brightness as inks soak into the paper or smear. These printers fall into two categories, continuous flow, and drop on demand. In continuous flow printing, the print head continuously directs ink droplets toward the paper. Ink is deflected onto a waste tray unless a particular ink spot is required on the page. This technique gives superb colour but at the expense of high running costs. Ink whether needed on the page or not is continuously pumped from the print head for the duration of the print. Drop-on-demand (bubble jet and piezo) ink-jet propels ink toward the paper only when a drop is required on the page. A pulse mechanism is used to propel the ink droplets from the print head.

Bubble jet uses heat to vaporise a portion of the ink and drive the remainder toward the paper. As the liquid ink heats, some of it vaporises, forming a bubble which expands, forcing ink out of the nozzle. At this point, the heater is switched off, the bubble shrinks, and more ink flows into the print head from the reservoir. In piezo-based systems a charge is applied to a piezo-ceramic diaphragm, which compresses and fires ink out of the jets.

Plain paper is a problem with all types of liquid ink printers, because the ink soaks into the paper and mixes with the ink from adjacent pixels. This destroys the brightness and definition of colours. Also, the image may not be dry when printed (particularly on transparency or special paper), which can cause smudging or a delay before use. Some ink jets use built-in heaters to reduce drying times and improve quality. Special paper is needed for high quality work. When a water-based ink jet is used, the water can dry out of the ink, leaving some residue which obstructs the print head. The head must then be either cleaned using a purging system, or discarded. Best applications (continuous flow) are prepress proofing, high quality, low-volume printing, (drop-on-demand) overhead transparencies and low- to medium-quality office printing. Large colour palettes are advantages, while print times can be six minutes per print.

Thermal Wax Transfer

The basic process works by heating coloured wax panels, and fusing it to specially formulated paper or overhead projection foils. A thermal transfer roll is segmented into consecutive, page sized sheets of wax pigments. These panels are complete sheets of each

Liquid Ink-Jet	Special office quality paper recommended Wicking (ink soaks in and edges become blurred) due to its wetness Crinkling, if heater system used As more porous paper is used, so the colours lose their saturation and brilliance Smearing of ink if a very smooth, low porosity paper is used.
Thermal Wax	Not usable with true plain paper, special office quality paper required. Lower grade papers will cause poor ink adhesion, and give poor quality output.
Colour Laser	Special office paper recommended. Lower grade papers will cause some loss of colour brilliance.
Phase Change Ink-Jet	Gives consistently good results on broadest range of plain paper (will print on fabric).
Dye Sublimation	Unable to use any paper, other than special printer paper/transparency.
Dot Matrix	The most established monochrome office printer, but it offers little for users of colour.

Table 1. How using plain paper affects the colour quality.

primary colour – cyan, magenta and yellow (plus black where required). Thousands of individually controlled elements in the thermal head are heated to between 70°C to 80°C, to melt pinpoint spots of colour onto the paper.

The paper makes three or four passes under the head; one for each primary colour, plus an optional pass for a separate true black. Additional colours are created using dithering techniques. As thermal wax usually needs special paper for high quality output, best applications are overhead transparency presentations, spreadsheet publishing, graphic arts and technical data analysis. Limitations include speed (2 pages per minute), higher purchase and running costs than ink jet generally, and in some cases registration.

Dye Sublimation

A cousin of thermal wax printing, dye sublimation is a colour printing technique at the high end. Print elements are heated up to near 400°C. Instead of the colour being layered on the surface of the paper, as with thermal wax, in dye sublimation the colour is impregnated in the paper itself. The special composition of the wax means that by varying the amount of heat applied to different points on the printhead, the amount of colour transferred to the paper can be controlled. This varies the intensity of the colour, thus giving continuous tone printing. For example, to create a certain shade of colour for a single pixel, it is possible to lay down 19% cyan, 65% magenta and 34% yellow.

Heating the ink causes it to change from a solid state to gas, missing out the liquid stage. This process is called sublimation, hence the name. The various colours are mixed in the gas which means that 16·7 million hues can be produced for each individual pixel. The gas then interacts with chemicals in the paper, developing the final image. Dye sublimation produces very high quality output, particularly when printing continuous tone or photographic images, and uses special, synthetic paper to achieve such high quality results. They are, however, slower than thermal wax printers, and the cost of their consumables is higher. Best applications are graphic arts, 3D imaging systems, multimedia hard copy, satellite imaging, high end visualisation and medical imaging. Its limitations include cost, special paper, slow speed of 3 minutes per page and large image files, implying a long download time.

Phase-Change Ink-Jet

So called because it uses inks that change phase from solid to liquid and back to a solid state when melted and jetted onto paper, this technology produces very good results. Special colour sticks (one for each primary) are loaded into the print head. Heaters in the print head melt each wax stick at 90°C into individual reservoirs and hold the inks at this temperature.

To produce a picture, the printer pumps small quantities of the inks out of the reservoirs and heats them still further. Using a specially-designed print head mechanism, the printer makes a single pass over the paper, which is held securely on a drum. An electronic pulse mechanism propels tiny droplets of liquid ink, as required, towards the paper.

As the droplets of ink contact the paper, they freeze so quickly that most of the ink remains on the surface, even on absorbent material. The freezing process locks the droplet onto the print surface, giving excellent adhesion and helping to produce brilliant colour, on any paper. Because the phase change inks solidify quickly, raw phase change output can have a bumpy feel to it. So, as a final step, some printers use a fusion process that smooths the surface of the image.

Phase change technology has an advantage over liquid ink jet technology, in that the inks are not absorbed into the paper, making it possible to print onto virtually any medium while maintaining the brilliant colours. Best applications are graphic arts, brochure mock ups, 3D CAD and visualisation, and plain paper business documents. Its limitation is a slow page throughput of two minutes per page.

Colour Laser

Colour laser (or electrophotographic) printing employs principles similar to those used in office photocopying machines and in electrostatic or toner-

Colour Printing Technology →	Liquid Ink-Jet, continuous flow	Liquid Ink-Jet, drop on demand	Thermal Wax	Phase Change	Dye Sublimation	Pen Plotter	Colour Laser
Best Applications ↓							
Business reports (paper)	–	*	*	**	–	–	**
Business presentations (O.H.P.s)	–	*	**	*	**	–	–
Pre-press proofing	**	*	*	**	**	–	**
Graphic arts	–	*	*	**	**	–	**
3D visualisation	–	*	*	*	**	–	–
2D CAD	–	*	–	*	–	**	–
Visual data analysis	–	–	**	**	**	–	–
Medical imaging	–	–	*	*	**	–	–
High quality, high volume printing	–	–	–	–	–	–	–
High quality, medium volume printing	–	–	–	–	–	–	–
High quality, low-volume printing	**	–	*	*	**	–	*

Key: – Not recommended; * Good; ** Excellent

Table 2. Choosing a printer technology.

based printing. In the typical colour laser process, a static charge is applied to a photoreceptive drum or belt (a photoreceptive surface is one that is conductive when light hits it).

A laser beam exposes the areas not to be printed, leaving charged the areas that will be printed. A dry toner that sticks to the charged areas of the drum is applied, and the image on the drum is then transferred electrostatically to the paper. This is repeated four times: one for each primary colour and once for black. Finally the image is fused with heat, pressure or both. Hitherto, this process has been reserved for the expensive high end of the market. Now colour desktop products are beginning to emerge with speeds up to three pages per minute. A list of Printer Technologies and the best applications are shown in Table 2.

The Market

Research undertaken by Gartner Group, Dataquest and BIS has shown that colour printers are forecast to rise from 17% to 36% of total market installs by 1997. This reinforces the pervasive industry view that colour applications are increasingly moving away from traditional niche applications and into the mainstream. Hitherto, colour in the office has been limited to low volume colour desktop printers, which in some cases proved expensive and inflexible. According to BIS market research figures, there are expected to be massive jumps in colour inkjet sales and comparatively modest jumps in sales in the colour laser and dye sublimation sectors. Decreases are expected in thermal wax, serial matrix and pen plotter sectors. These trends are summarised in Table 3, and Figure 1.

The office market is changing with standalone PCs and printers moving to networked PCs and shared printers, proprietary systems and environments moving to open systems, centralisation to right-sized operations and the separate data centre, office and print room experiencing blurring of boundaries. With 1·7 million Novell NetWare users, 150,000 local area networks (LANs), and the average number of users per LAN increasing, the networked office is coming, and there are now more mixed environments. According to Rank Xerox, 46% of printers will be networked by 1996. It is still the case that 95% of all information is communicated by documentation.

Certain criteria needs to be considered in selecting the right colour printing technology (including such items as network connections for workgroups and Ethernet and token ring links): the purchase price, running costs (including the consumables), colour quality levels, plain paper printing capability, printer volume capacity and PostScript support.

Narrow format:	1992	1993	1997	1998
Mono Inkjet	–	2,780·00	–	1,927·00
Option Colour	–	435·00	–	3,114·00
Colour Inkjet	–	672·00	–	2,805·00
Colour Laser A4	–	0·46	–	42·30
Colour Laser A3	–	0·01	–	1·50
Thermal Wax A4	–	24·90	–	18·00
Thermal Wax A3	–	2·45	–	1·85
Dye Sublimation A4	–	2·60	–	13·10
Dye Sublimation A3	–	1·10	–	3·70
Serial Matrix	–	316·00	–	94·00
Pen Plotters	–	17·90	–	9·70
Wide format:				
Colour Inkjet	–	8·70	–	32·80
Mono Inkjet	–	10·50	–	19·50
LED Plotters	–	0·73	–	1·40
Pen Plotters	–	23·80	–	2·50
Direct Thermal	–	2·10	–	0·70
Mono Electrostatic	–	0·47	–	0·01
Colour Electrostatic	–	0·71	–	0·19
Colour copiers:				
Digital Electrophotographic	10·40	11·50	21·10	–
Analogue Electrophotographic	2·00	2·10	1·60	–
Inkjet	13·50	10·50	4·50	–

Table 3. Printer installations, in thousands of units. (Reproduced, courtesy of Gartner Group/Dataquest/BIS.)

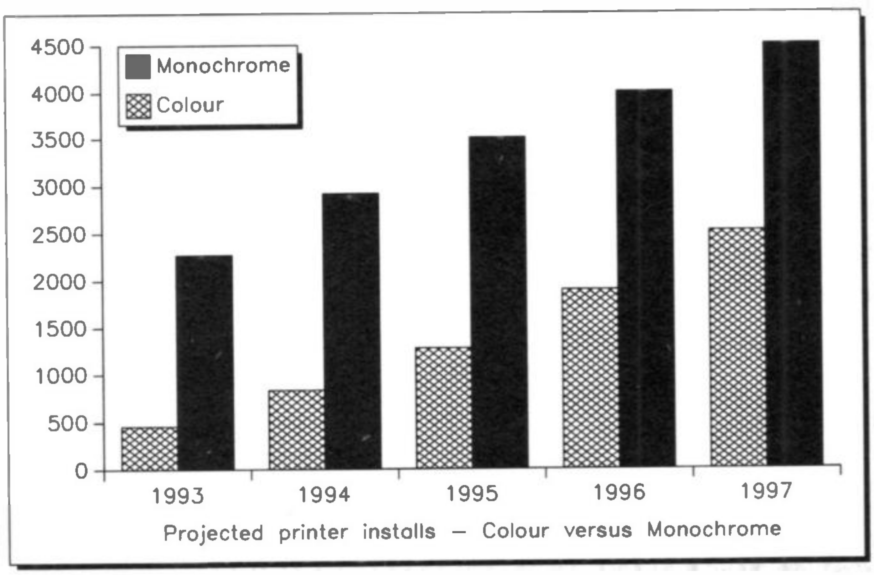


Figure 1. Bargraph showing increasing market share of colour printers, whilst monochrome installations continue to increase.

Products

According to market researcher Romtec, the colour ink jet market share is Hewlett Packard (HP) 76·5%, Canon 20·4%, Lexmark 1·3%, Apple 0·9%, Integral 0·7% and Tektronix 0·2%. Top of HP's range is the DeskJet 1200C unit with an MIO slot in the back for JetDirect cards to give multiprotocol support, supporting its role as a departmental colour printer. There is also the 1200CPS PostScript version, and the PaintJet XL300, which additionally offers A3 printing.

The Canon BJC-600 colour printer similarly, costs about £550, prints on normal paper or overhead transparencies, and has 360dpi resolution.

Tektronix has introduced its seven model Phaser range for workgroup colour printing solutions. Three use thermal transfer, two dye sublimation and two phase-change ink jet technology. All offer parallel, RS-232 serial and AppleTalk network connections, and switch automatically when needed, with optional Ethernet on Novell NetWare, EtherTalk and TCP/IP. There are also software packages for additional network functionality. There is a graphical user interface for printing and control of printer features for users of Sun and Silicon Graphics UNIX workstations, and others to provide VMS connectivity for Tektronix PostScript printers.

To get an idea of cost, the base price of a phaser 220i (2ppm, 600dpi for A4 thermal or premium laser paper and transparency) is £5,395, to which must be added £630 for Ethernet interface and £270 for TCP/IP. The 480 dye sublimation top-of-the-range unit, which prints photorealistic output on A4, A3, tabloid extra size paper and A4 transparencies, costs £12,995, plus the interfaces. The costs of consumables have to be borne in mind. A three colour roll (342 copies) for the 200 series costs £125, while a four colour roll for A4 media only (210 copies) for the 480 costs £690. Dataproducts upgraded its Jolt PS solid-ink PostScript colour printer last Autumn, which features its virtual printer technology network printing architecture, VPT2. There is support for Novell IPX, TCP/IP, DEC LAT and Apple EtherTalk protocols simultaneously.

Desktop colour lasers are an emotive point. HP – king in the land of mono desktops – will not say if or when it is to produce a colour machine. Meanwhile, QMS has produced the industry's first desktop colour laser printer, the QMS 1000, which retails for £8,895. With a recommended duty cycle of 5,000 prints per month, the QMS 1000 features Crown technology which was developed to solve problems in shared printing environments. Print speed is 2ppm in colour and 8ppm in mono. QMS has further released the Magicolor 600 × 600dpi desktop laser which outputs at 2ppm colour, 4ppm spot colour and 8ppm mono. The full range of networking protocols is supported under the Crown system, and the cost is £9,995.

Rank Xerox has also recently released its 4900 colour desktop colour laser which retails at £8,895. Operating at 3ppm colour and 12ppm in mono, the 4900 offers direct connectivity to LocalTalk, Centronics parallel, RS232C serial, Ethernet and token ring. Monthly print volumes are up to 15,000 pages. Xerox's patented quad dot technology is claimed to reduce coarse dots and banding typically found on lower dpi colour printers. The resolution is up to 1,200 × 300dpi.

QMS also markets a range of thermal wax transfer machines, the ColorScript 210 and 230 network colour printers. While sales of thermal wax transfer machines are predicted to decline in the period to 1998, the professional component of the market is expected to grow, from 12,000 units installed during 1993 to 18,000 units in 1998. At the high end of the laser field, names like Rank Xerox, Kodak and EFI supply machines costing upwards of £33,000, with outputs of 8ppm colour and 30 to 36ppm mono.

Conclusion

Colour is mandatory in conveying meaning from graphic images, and is not just cosmetic. Communicating in colour is becoming a necessity for today's users, whatever their line of business. Combined with the growth in networking, colour is set to assume a key role in businesses. But it is not there yet, unless you are willing to spend a lot of money. The good news is that colour printing devices will become ever more reliable, cost-effective and affordable, as time marches on. E ingly playable!) animated game called *Hotel Mario*, in which you control the famous Mario in his quest to rescue a princess, who is held prisoner in one of seven hotels.

More CD-i games software is making use of the FMV cartridge. *Dragon's Lair* is a 'dungeons and dragons' type fantasy adventure, with glossy cartoon-quality animation, in which you (surprise, surprise) have to rescue a princess. I would have liked to ascertain the originality of the game, but I could not get it to work! According to the blurb on the box, an optional touchpad controller was 'recommended'. Based on my experience, I would say that this was 'essential' – I certainly had no luck with the standard infra-red joystick!

Ever fancied being Frank Bruno or Chris Eubank? Another FMV game is *Caesar's World of Boxing*, in which you are put into the ring at the Caesar's Palace in Las Vegas. Apart from the fight, you have to deal with managers, trainers, the media and even groupies! Although game play is somewhat limited, the disc makes incredible use of video sequences, and indicates what the alliance of Video CD and FMV has in store.

Interactive movies, where you control the outcome, are also available on CD-i/FMV. *Voyeur*, billed as a CD-i thriller for adults, stars Grace Zabriskie (Twin Peaks) and Robert Culp (I-Spy). The software allows viewers to peek into the windows of the palatial home of Reed Hawke, US presidential candidate, and investigate the often-salacious private affairs taking place behind closed doors. Viewers interact by deciding which room to zoom into and by collecting evidence that will put the evil Hawke behind bars.

There are also some interesting oddities around for CD-i. A typical example is the FMV-compatible *The Worlds Of . . .*, which introduces you to five Rhythm King bands, The Sultans of Ping, Ugly, CNN, C and HWXI. You can remix a record by one group, chase the members of another around the subways of Tokyo, and even electrocute one hapless fellow if you think that he is lying. Oh yes, and you can watch eight promo videos and access various trivia about the bands responsible, the video's director, the record label that made it possible, who put the kettle on during the editing stage . . . As an example of CD-i's potential, *The Worlds Of . . .* is excellent, well-presented with oodles of nineties gloss – but was a little too gimmicky to stomach.

Industrial Applications of CD-i

The interactivity and low cost of CD-i makes it ideal for tutorials and introducing procedures to employees. It can also be used as a user-friendly way of gaining access to large amounts of information, such as technical standards and statute books. CD-i thus has potential as a catalogue or reference aid. Software development tools are now available that will allow larger companies to develop their own applications. Added to this, the costs of CD-writing equipment are steadily falling.

Since CD-i is an integrated system (apart from the controller and TV), CD-i does not require an expensive multimedia PC to operate, and will be ideal for situations where the flexibility of a PC is not required. A leading High Street bank is using a functionally similar system, introduced a few years ago and based around analogue laser-discs, to train staff.

For example, a massive product launch taking place all over Europe by white goods manufacturer Philips Whirlpool is using a CD-i produced at the Epic Interactive Media Company studios in Brighton. The first disc, a sales training programme on microwave ovens, will be produced in a total of 15 different languages. As well as interactive training on the use of three Whirlpool microwaves, the disc includes a brief history and general information on the company so it can double up as a sales presentation aid. The disc even features the recent Whirlpool TV advert.

Another training course, *Credit Where Credit's Due*, looks at the selection of candidates for vocational qualifications. It features interactive video 'case studies'. A disc which was produced by Niam Interactive Media, a Dutch company, for Agfa-Gevaert, received the Authorware award for 'Best Interactive Multimedia Application of the Year' in 1992. This application provides information on a medical imaging system.

Other applications of CD-i include public information terminals in libraries and railway stations, and point-of-sale information points in large shops. Catalogue showrooms would be an ideal contender here. The low cost (shielded CD-i player and TV set) makes this attractive, as does the robustness of the system.

Interactive TV

In a joint venture, GTE ImagiTrek (a major developer of CD-i applications) and Philips Interactive Media are currently developing a form of interactive television. The system would permit the interaction of TV programmes with material presented on CD. The combination of broadcast material with interactive software utilises, not surprisingly, the CD-i system. Viewers will be able to use their CD-i system to retrieve information or images related to the programme on screen. This results in a on-demand and viewer-specific service, benefiting customers and broadcasters alike.

An example of where the system would be useful is the avid cricket fan who, with the appropriate disc in his player, would be able to access details of the batsman currently on screen. The problem with this form of interactive television is obvious – it depends on frequent CD issues to ensure that the information remains up to date. What would happen in the cricket example if a new team manager is selected with quite different tactics, or the top batsman decides to retire to the sun early?

CD-i Technology and Hardware

The CD-i technical specification, agreed between Sony and Philips, is known as the Green Book, and was finalised in 1988. The minimum machine, without the FMV cartridge, is referred to as the 'base case' system.

With CD-i, all of the information is digitised, whether it is video (still or full-motion video, animation, visual effects), audio (music, narration, sound effects) or data (text or graphics). This makes it possible to interleave all kinds of information, giving great flexibility. CD-i has the ability to adapt the amount of storage capacity to the application.

Delta – YUV:	Digital component video. Used for natural still pictures (e.g., Photo CD) and some moving video. 16 million colours available.
RGB 555:	Used for user-manipulated graphics. Every pixel is encoded with 5 bits per colour, making 32,768 colour variations possible.
CLUT:	Colour Look-Up Table encoding. Several modes possible, maximum of 256 colours. Used for simple graphics.
Run-length:	Used for cartoon animation. 128 colours available.
MPEG-1:	Used to provide full-motion video. Effects, including cut, dissolve, granulation and wipes are also available.

Table 1. Video encoding methods.

PCM digital audio:	Over one hour of Red Book (regular CD) Hi-Fi stereo audio.
Level A:	Over two hours of high-quality and noise-free stereo audio.
Level B:	Only consumes 25% of disc space that would be required using Red Book encoding. Quality similar to that of good FM stereo broadcast.
Level C:	Speech and background audio. Only consumes 12·5% of disc space that would be required using Red Book encoding. This allows 8 stereo channels (9·6 hours) or 16 mono channels to be put onto the disc. Ideal for multilingual applications. AM sound quality.

Table 2. Audio quality levels.

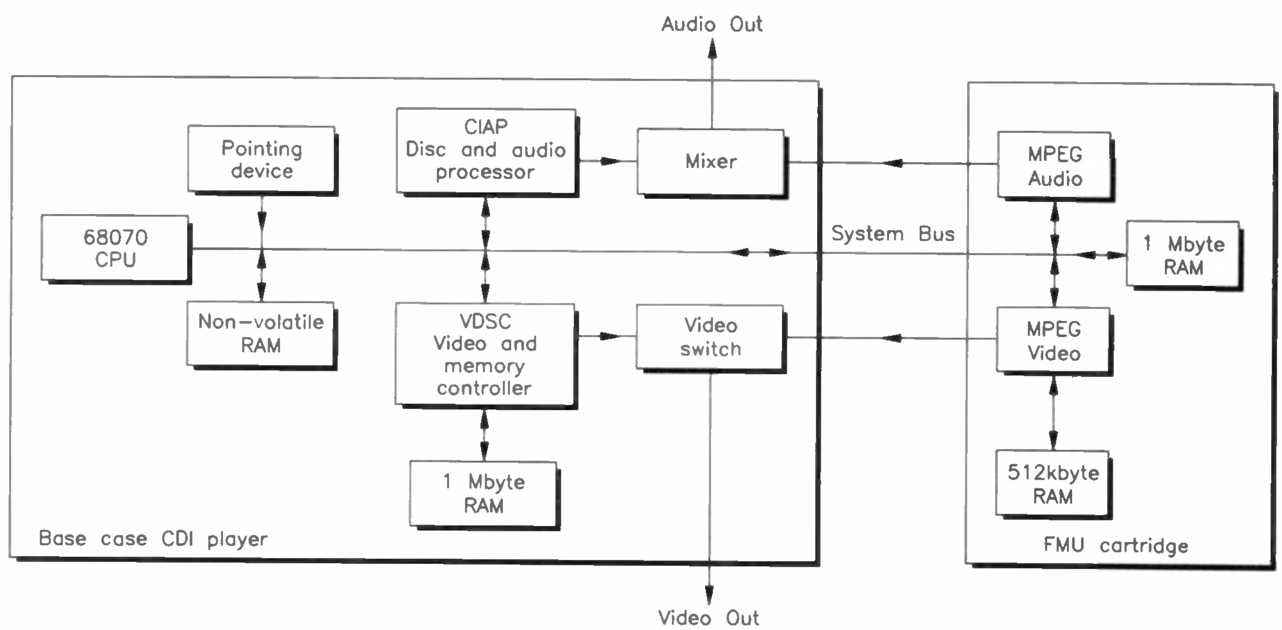


Figure 1. Simplified block diagram of modern CD-i player (courtesy David Penna, Philips Research Laboratories).

The CD-i transfer rate, is typically 170K-bit/s, explaining the slow access times that are experienced when changing from one photograph to another. A buffer memory, into which is placed the next likely pieces of information to be accessed, would help here. But this adds to the cost – quite significantly, so bearing in mind the profiteering going on at the moment in the memory industry, perhaps double-speed CD-i drives might be the answer.

There are five different encoding methods for video, and four quality levels for audio, as shown in Tables 1 and 2. Text, meanwhile, is held as either characters or as bit-mapped pictures. You can get full-motion (12·5 frames per second) video with the base-case CD-i player, as evidenced on the Compton disc, but it is confined to a maximum of 13% of the screen area, to save disc space and to limit the restrictions of a fairly slow CD data transfer rate. This increases to 50% using special encoding techniques, which also allow twice as many still pictures to be held on a disc.

Since CD-i is a multimedia system, it caters for the simultaneous presentation of, for example, sound and pictures. The software designer decides on the combination of sound/picture quality and screen area that makes best use of the disc. Typical combinations include CD audio with text overlays on a background image (karaoke), high-quality full-screen stills with a speech-quality commentary ('slide show'), or a part-screen, television-quality video sequence with background music (video clips).

Like the Commodore CD-TV machine, the CD-i standard is based around a variant of the Motorola 68000 microprocessor. The first CD-i chipset was announced by Philips and Motorola in 1989. At its heart is the MC68340, a dedicated CD-i CPU, which is concerned with overall control of the player. The 32-bit chip can handle data transfer rates as high as 33M-bit/s, by virtue of a twin DMA provision. This works with a MC68HC0518 intelligent peripheral controller, which handles data to and from the various displays, and the infra-red joystick. Another chip is used to interface the microprocessor to the disc drive.

Decoding the CD-i video data stream is a MC44466 VSD (video signal decoder), which can simultaneously handle two video channels (normal and high-resolution) and the interleaving of four video planes. Its output is a digital RGB signal which is converted into analogue form by a MC44200 DAC. The audio side is handled by a separate signal processor and DAC.

For a description of the Motorola FMV silicon, please refer to the MPEG article in the December (Issue 84) copy of *Electronics*. C-Cube are also producing ICs suitable for decoding the MPEG data stream.

There is a trend towards miniaturisation, which will reduce power consumption and costs. This is much in evidence in the latest Philips players (not yet available in the UK) which are much smaller than their predecessors. The target is to get most of the CD-i specific circuitry onto a single chip, which could incorporate as many as two million transistors, by 1996.

To indicate how miniaturising is progressing, Figure 1 is a simplified block diagram of a second-generation CD-i player. Disc control, video and audio processing is now handled, in the main, by two chips – the CIAP disc and audio processor, and the VDSC video and memory controller. The processor has also been upgraded to a Motorola 68070 device.

The base case player has 1Mb of RAM, which is organised as two banks of 512Kb, nearly all of which is available for video, audio, text and data. An 8Kb non-volatile memory is available to both applications and operating system. The CD-i operating system, held in ROM, is known as CD-RTOS, a specially-adapted version of Microware's OS-9.

Video data consists of both pixel data and video control data, and is accessed independently from each bank of RAM, the two display paths being combined to provide an analogue RGB output. This is fed into a PAL encoder chip, and thence to a UHF modulator, to give compatibility with all UK TV sets.

I/O provision on the base case machine is, audio and video apart, limited to the infra-red remote pointing device (in this case, a joystick) and the FMV slot. A socket on the rear of the machine accepts RC5 data of the type used with the remote control. The base case player can apparently be extended to include a full alphanumeric keyboard, MIDI, floppy and hard drives, comms ports, maths co-processors and extra RAM. Presumably most of this is implemented in the machines used by software developers.

It would have been nice of Philips to include a SCSI interface, so that the CD-i player could be used as a CD-ROM drive with Apple Macs and PCs. Since CD-ROM is taking off, Philips are denying themselves customers who already use a computer. What's more, such a system would be a real boon in electronic publishing, as Photo-CD images could be loaded in directly.

Crystal Ball

At the Chicago CES show last summer, Philips launched a CD-i player with built in FMV capability. Retailing for $500, the CDI 550 is bundled with Comptons Multimedia Encyclopedia and Space Ace. It has a quarter of the size as the first CD-i machine and costs considerably less, presumably down to a reduction of the chipset. The $300 CDI 450, which has the same specification as the 550 *sans* FMV, is also available. This retails for the same amount as many less-capable machines which will play games only. Philips also plans a 21in. TV set with a built-in FMV-equipped CD-i player.

With the acceptance of Video-CD, and high-quality software that takes advantage of the system, CD-i may have a good chance in the competitive consumer sector. A good sign for CD-i's future will be when other consumer manufacturers start producing hardware. I would personally like to see Philips introduce a SCSI interface option to the base case player, so that CD-i players will double as CD-ROM players for multimedia PCs and Macs. The CD-i player would then surely be an excellent multi-purpose CD workhorse, enabling it to penetrate the maximum number of different markets. E

INTERACTIVE DOORBELL – *Continued from page 15.*

to remember when recording your message, is not to disclose too much information as to where you are going or how long you will be, as it may be an unsavoury character that is ringing on your doorbell!
Note: (a) If the bell push is held in, the bell then the message are repeatedly played, in order; (b) If the bell push is pressed several times in quick succession, the bell then message are still played in order, once only.

Setting-up procedure

Having got the interactive doorbell up and running, and with a message recorded, you can proceed to 'fine-tune' the system to your requirements, in terms of the volume of the bell and message both inside the house and out. This is achieved by altering the settings of presets RV1 to RV4, via the access holes in the box.

Additionally, the delay between the last sound of the bell and commencement of the message can be set, by adjusting RV6.

INTERACTIVE DOORBELL PARTS LIST

RESISTORS: All 0·6W 1% Metal Film			
R1,3,34	1k	3	(M1K)
R2,6,7,8,9,15,25	100k	7	(M100K)
R4,14,23,24,27,31,35,40	10k	8	(M10K)
R5	1k5	1	(M1K5)
R10,28,29,30,36,37,38,42,44	47k	9	(M47K)
R11,12,13	4Ω7	3	(M4R7)
R16,22,26	1M	3	(M1M)
R17,41,43	470k	3	(M470K)
R18	180k	1	(M180K)
R19	120k	1	(M120K)
R20	2M2	1	(M2M2)
R21,39	2k2	2	(M2K2)
R32,33	22k	2	(M22K)
RV1-4	100k Vertical Preset Potentiometer	4	(UH19V)
RV5,6	470k Horizontal Preset Potentiometer	2	(UH08J)
CAPACITORS			
C1	470µF 35V Electrolytic Radial	1	(FF16S)
C2,3,12,15,16,21,24,27,28,29,32,36	100nF 16V Ceramic Disc	12	(YR75S)
C4,5,6,9,10,11	10µF 50V Electrolytic Radial	6	(FF04E)
C7,8	470pF Metallised Ceramic Disc	2	(WX64U)
C13,14	100µF 25V Electrolytic Radial	2	(FF11M)
C17,18,37	4µ7F 63V Electrolytic Radial	3	(FF03D)
C19	1nF Metallised Ceramic Disc	1	(WX68Y)
C20	10nF 50V Ceramic Disc	1	(BX00A)
C22,31,33,35	470nF 100V Electrolytic Radial	4	(FF00A)
C23,26	1µF 100V Electrolytic Radial	2	(FF01B)
C25,34	47µF 25V Electrolytic Radial	2	(FF08J)
C30	22nF Ceramic Disc	1	(WX78K)
SEMICONDUCTORS			
D1,2,4-15	1N4148	14	(QL80B)
D3	1N4001	1	(QL73Q)
ZD1	BZY88C 3V3 Zener	1	(QH02C)
LD1	5mm LED (Red)	1	(WL27E)
BR1	W01 Bridge Rectifier	1	(QL38R)
RG1	HT1050	1	(BH68Y)
TR1	BC161	1	(QB49D)
TR2,4,6	BC548	3	(QB73Q)
TR3,5	BC557	2	(QQ16S)
IC1	TDA2822M	1	(UJ38R)
IC2	HT2811	1	(BH69A)
IC3	HCF4011BEY	1	(QX05F)
IC4	HCF4098BEY	1	(QX29G)
IC5	ISD1016AP	1	(KU63T)
MISCELLANEOUS			
S1	2-Pole 3-Position Right-angled Slide Switch	1	(FV02C)
S2,3	2-pole Latchswitch	2	(FH67X)
	Omni-directional Ultra Miniature Microphone	1	(QY62S)
LS1	1·5W Low-cost Speaker	1	(YT25C)
	3in. Square Mylar Speaker	1	(YN01B)
TB1-4	2-Way PCB Terminal Block 300 Series 5mm	4	(JY92A)
	PP3 Clip	1	(HF28F)
SK1	3·5mm PCB Jack Socket	1	(FK02C)
	Single-ended PCB Pin 1mm (0·04in.)	1 Pkt	(FL24B)
	8-pin DIL Socket	2	(BL17T)
	14-pin DIL Socket	1	(BL18U)
	16-pin DIL Socket	1	(BL19V)
	28-pin DIL Socket	1	(BL21X)
	Front Panel Label	1	(90025)
	PCB	1	(90024)
	Instruction Leaflet	1	(XV33L)
	Constructors' Guide	1	(XH79L)
OPTIONAL (Not in Kit)			
	PP3 120mAh Ni-Cd	1	(AG33L)
	Plastic Project Box Type D-014 (Black)	1	(ZB03D)
	Box with Base and Matrix Board Type TB-16	1	(YU47B)
	PP3 Battery Holder	1	(XX33L)
	4-Wire Burglar Alarm Cable	1	(XR89W)
	Bell Push	1	(FS17T)
	Splashproof Switch	1	(RD20W)
	Bell Transformer	1	(FL37S)

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 90023 (Interactive Doorbell) Price £39.99 A1
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 1995 Maplin Catalogue
Interactive Doorbell PCB **Order As 90024 Price £6.69**
Interactive Doorbell Front Panel Label **Order As 90025 Price £2.29**

DIARY DATES

Every possible effort has been made to ensure that the information presented here is correct prior to publication. To avoid disappointment due to late changes or amendments please contact event organisations to confirm details.

6 June. Using Thermionic Valves, Sunbury & District Radio Amateurs, Wells Hall Old School, Great Cornard. Tel: (01787) 313212.

14 to 15 June. Government Computing & Information Management, Royal Horticultural Halls, London. Tel: (0171) 587 1551.

17 June. 100 Years of Radio by Jon Weller, Crystal Palace & District Radio Club, London SE19. Tel: (0181) 699 5732.

20 to 22 June. Multimedia Interactive Information Forum, Business Design Centre, London. Tel: (0171) 359 3535.

27 to 29 June. Networks Exhibition, NEC, Birmingham. Tel: (0181) 742 2828.

28 June. 'The Man who was Q', Lincoln Short Wave Club, Lincoln. Tel: (01427) 788 356.

1 to 2 July. VHF Field Day Contest Weekend, Crystal Palace & District Radio Club, London SE19. Tel: (0181) 699 5732.

4 July. Operating QRP. Sunbury & District Radio Amateurs, Wells Hall Old School, Great Cornard. Tel: (01787) 313212.

10 July. Summer Social, Stratford-upon-Avon and District Radio Society, Stratford-upon-Avon. Tel: (01789) 740073.

24 July. Construction Competition, Stratford-upon-Avon and District Radio Society, Stratford-upon-Avon. Tel: (01789) 740073.

20 August. Evening on Air, Crystal Palace & District Radio Club, London SE19. Tel: (0181) 699 5732.

27 August. East Coast Amateur Radio and Computer Rally, Clacton Leisure Centre. Tel: (01473) 272002.

2 September. Wight Wireless Rally, Arreton Manor Wireless Museum, Newport, IOW. Tel: (01983) 567665.

2 to 3 September. HF SSB Field Contest Weekend, Crystal Palace & District Radio Club, London SE19. Tel: (0181) 699 5732.

Please send details of events for inclusion in 'Diary Dates' to: The News Editor, *Electronics – The Maplin Magazine*, P.O. Box 3, Rayleigh, Essex SS6 8LR.

MAINS POWER CONDITIONER

Design by Alan Williamson
Text by Alan Williamson and Maurice Hunt

The Mains Power Conditioner described in this article, is designed to reduce the level of noise, in the form of transient spikes (sudden; momentary rises in voltage level) and RF interference that exists on the mains supply, and which can upset the operation of sensitive mains-powered equipment, such as computers, TVs, Hi-Fis, test gear and communications devices.

2 PROJECT RATING

FEATURES

- ★ High-grade filtering of interference
- ★ Does not require separate PSU
- ★ Up to 1·44kW continuous load rating
- ★ Direct, in-line connection to equipment
- ★ Excellent value
- ★ Compact, self-contained unit

APPLICATIONS

Reduction of noise level (transient spikes) and RF interference

Above: Assembled PCB in lower half of case, with the neon mains indicator disconnected.

KIT AVAILABLE (90019)
Price £32.99 A1

THERE is evidence to suggest that there are unscrupulous individuals who intentionally corrupt the mains waveform, with the aim of inducing noise onto the earth line to destroy any data that may be passed down the mains supply! It offers superb value in comparison to commercial units, which generally retail at near the £100 mark and upwards.

The unit provides a high degree of filtering of the domestic mains supply, and it is also just as effective at preventing noise pollution from equipment, such as triac circuits, electric power tools, motorised equipment, etc., from being injected back onto the mains supply. The maximum continuous load that can be sustained by the conditioner is 6A (1·44kW at 240V), making it suitable for most low-to medium-power applications to be found in the workplace and home.

Circuit Description

Figure 1 depicts the block diagram of the Mains Power Conditioner, and the circuit diagram is shown in Figure 2. The circuit is very simple, comprising as it does of two potted filter blocks, a handful of extra decoupling capacitors and a triplet of Voltage Dependent Resistors (VDRs), which limit any incoming transient spikes to 250V.

SK1 and SK2 are Euro connectors, for mains input and output, respectively. The unit is protected from overloading by the T6·3A time-delay fuse (safety first),

Important Safety Note:
It is important to note that mains voltage is potentially lethal. Full details of mains wiring connections are shown in this article, and every possible precaution must be taken to avoid the risk of electric shock during maintenance and use of the final unit, which should never be operated with the box lid removed. Safe construction of the unit is entirely dependent on the skill of the constructor, and adherence to the instructions given in this article. If you are in any doubt as to the correct way to proceed, consult a suitably qualified engineer.

and a neon indicator is employed to provide a reminder that mains is being supplied.

Three transient suppressors (TS1 to TS3) are used to give adequate protection from high current spikes. The devices quench the transient voltage increase, by absorbing the spike and partially self-destructing. Therefore, to maintain peak performance, TS1 to TS3 should be replaced on a periodic basis (between 1 and 3 years, depending on how noisy the mains supply is).

Capacitors C1 and C2 syphon off a small amount of AC current from the live line, drawing some of the mains noise along with it (plus the noise produced by the neon indicator and its built-in resistor) to the neutral line. This effectively reduces the amount of noise the filter blocks have to reject.

The filter blocks themselves, contain a 1mH bifilar wound choke, which cancels any induced noise present on the live and neutral lines simultaneously, without running into saturation. The filter blocks also contain three capacitors in a Delta configuration, linking the live to neutral line via a 100nF capacitor, the live to earth line via a 2n2F capacitor, and neutral to earth line, also via a 2n2F capacitor. The capacitors C3 to C5 add extra decoupling after the filter blocks; note that FB2 is intentionally fitted 'backwards'.

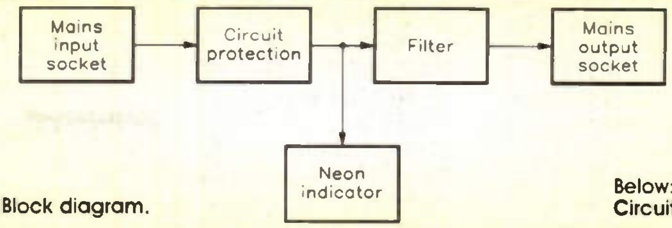
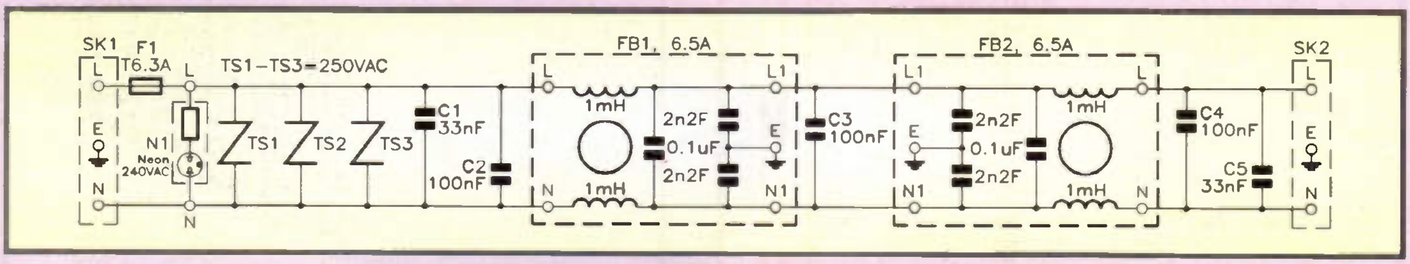


Figure 1. Block diagram.

Below: Figure 2. Circuit diagram.



Construction

Construction of the PCB is quite straightforward, and Figure 3, showing the PCB legend and track, will be helpful when carrying out this procedure. The mains outlet Euro socket must have its spare earth tag removed, as indicated by Figure 4. Also, trim off part of each of the two Lucar connector cable lugs, as shown in Figure 5, before fitting them to the PCB. Use a high-power soldering iron (50W is recommended) to heat the connectors, since they act as effective heatsinks! If you only have access to a low-power soldering iron, an alternative is to increase its bit temperature, by carefully placing its tip in the flame from a gas stove or blowlamp, but do not overdo it, or else damage to the iron may result. A helpful tip (pun not intended), is to use a large soldering iron tip, as it will 'hold' more heat. Fill the solder tag cable well with solder to add strength. Mount the rest of the components, working from the centre of the PCB outwards. Figure 6 depicts an exploded view of the connectors and neon lamp.

Figure 7 shows the box drilling details for the end plates. Prior to drilling, note the top/bottom and inside/outside

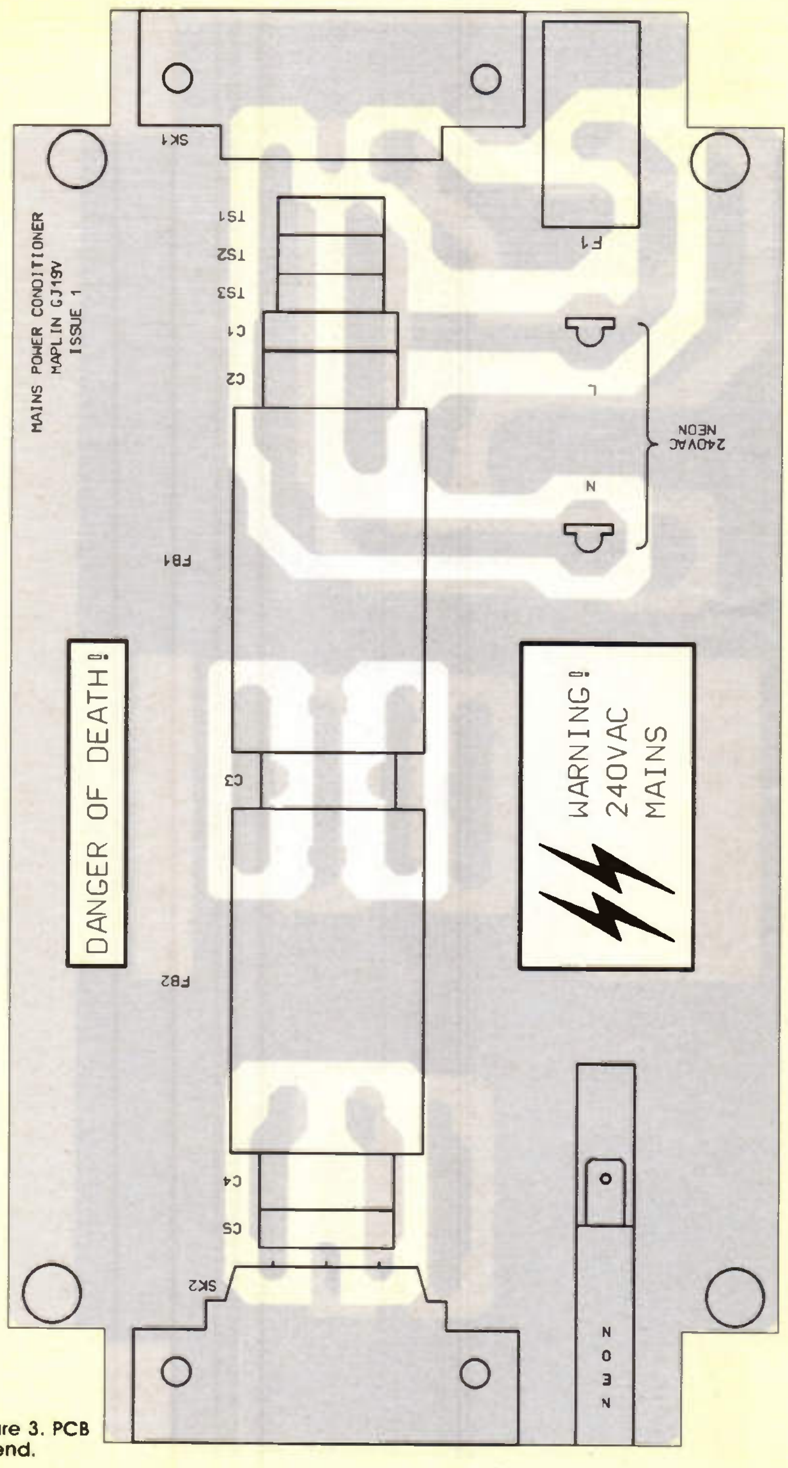


Figure 3. PCB legend.

Specification

Operating voltage:	240V AC domestic mains supply
Maximum continuous load:	6A @ 240V AC
Maximum continuous power:	1·44kW @ 240V AC
Visual indicators:	Neon 'mains on' lamp
Overcurrent protection:	T6·3A Time-delay fuse, in addition to 7A/10A mains plug fuse
Insulation classification:	Class I, earth-to-equipment, plastic casing
PCB dimensions:	189 × 101mm
Case dimensions:	197 × 110 × 56mm

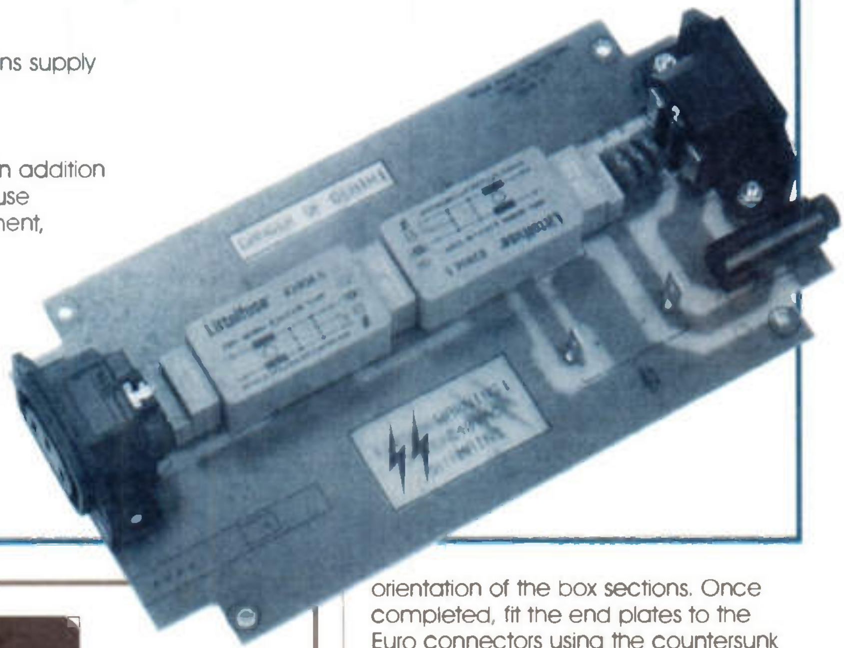


Photo 1. Assembled PCB, with neon lamp and cable disconnected from the Lucar terminals.

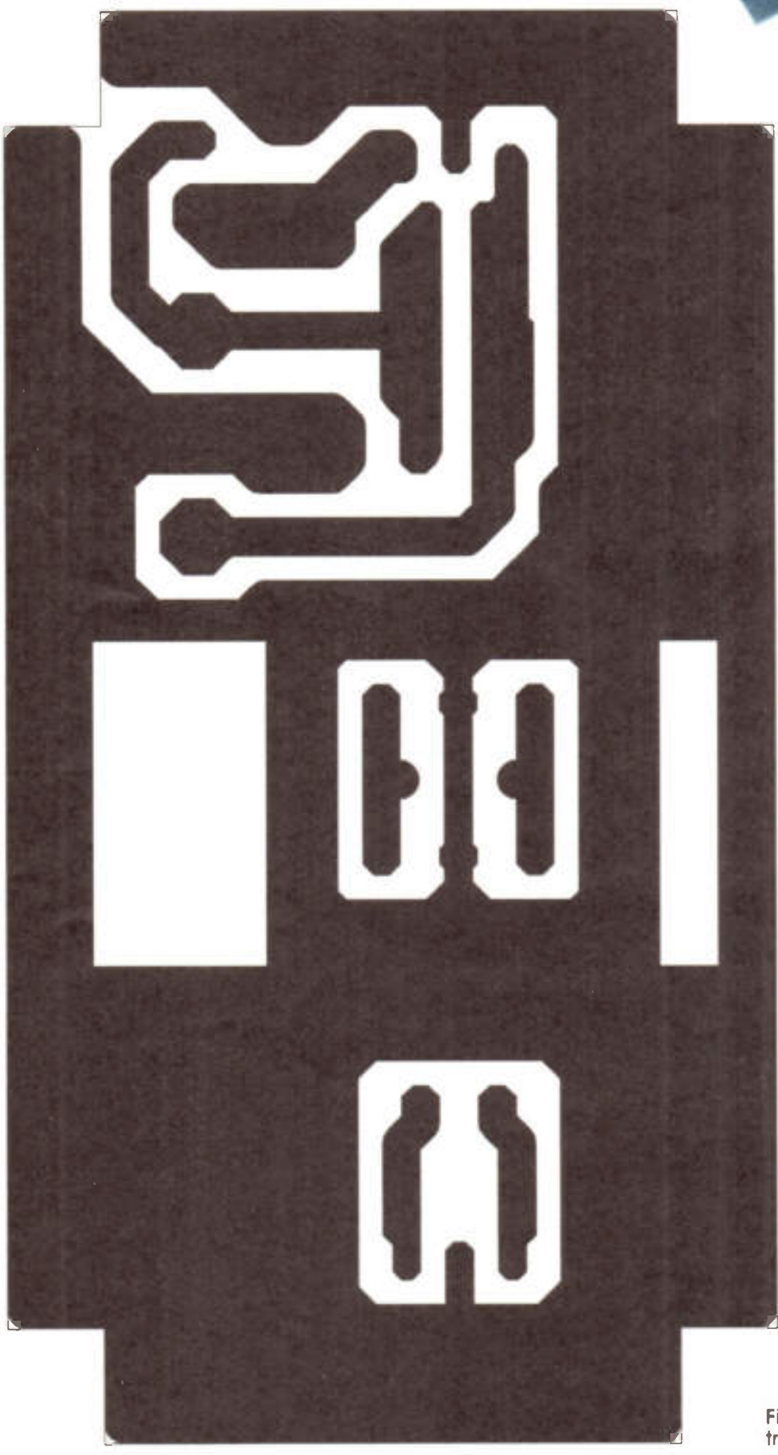


Figure 3. PCB track.

orientation of the box sections. Once completed, fit the end plates to the Euro connectors using the countersunk M3 screws and hardware. Note also, that the inlet connector requires a different-shaped cut-out in the case to that of the outlet connector. Fit the Lucar connectors to the length of mains cable, remembering to slide the insulating sleeves onto the cable beforehand (very frustrating if you happen to forget!), then fit the cable assembly to the neon and PCB terminals.

Next, fit the whole assembly into the enclosure base and fix in place. Note, it will only fit in one way round. Then, attach the label (shown in Figure 8) to the enclosure cover, and fit the cover to the enclosure base. Finally, fit the rubber feet to the base of the case, and last of all, fit the fuse into the fuseholder. Figure 9 shows an exploded view of the unit, which clarifies the assembly layout.

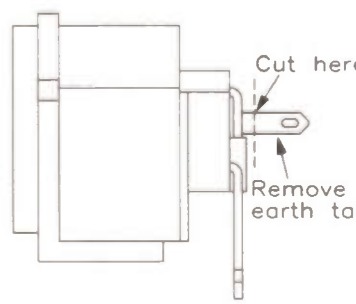


Figure 4. Modification of the Euro socket (removal of the earth tag).

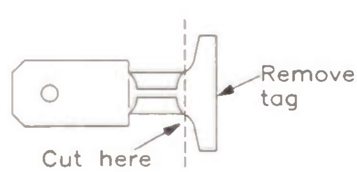


Figure 5. Modification of the Lucar connectors for PCB mounting.

Figure 6. Expanded view of connectors and neon lamp.

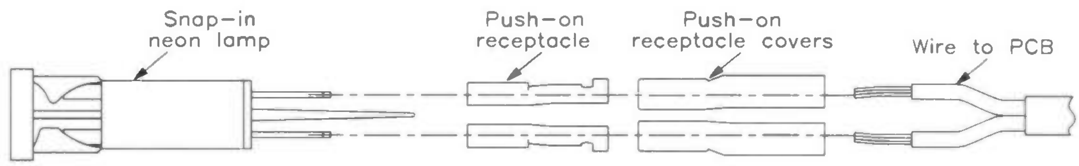


Figure 7. Box drilling details.

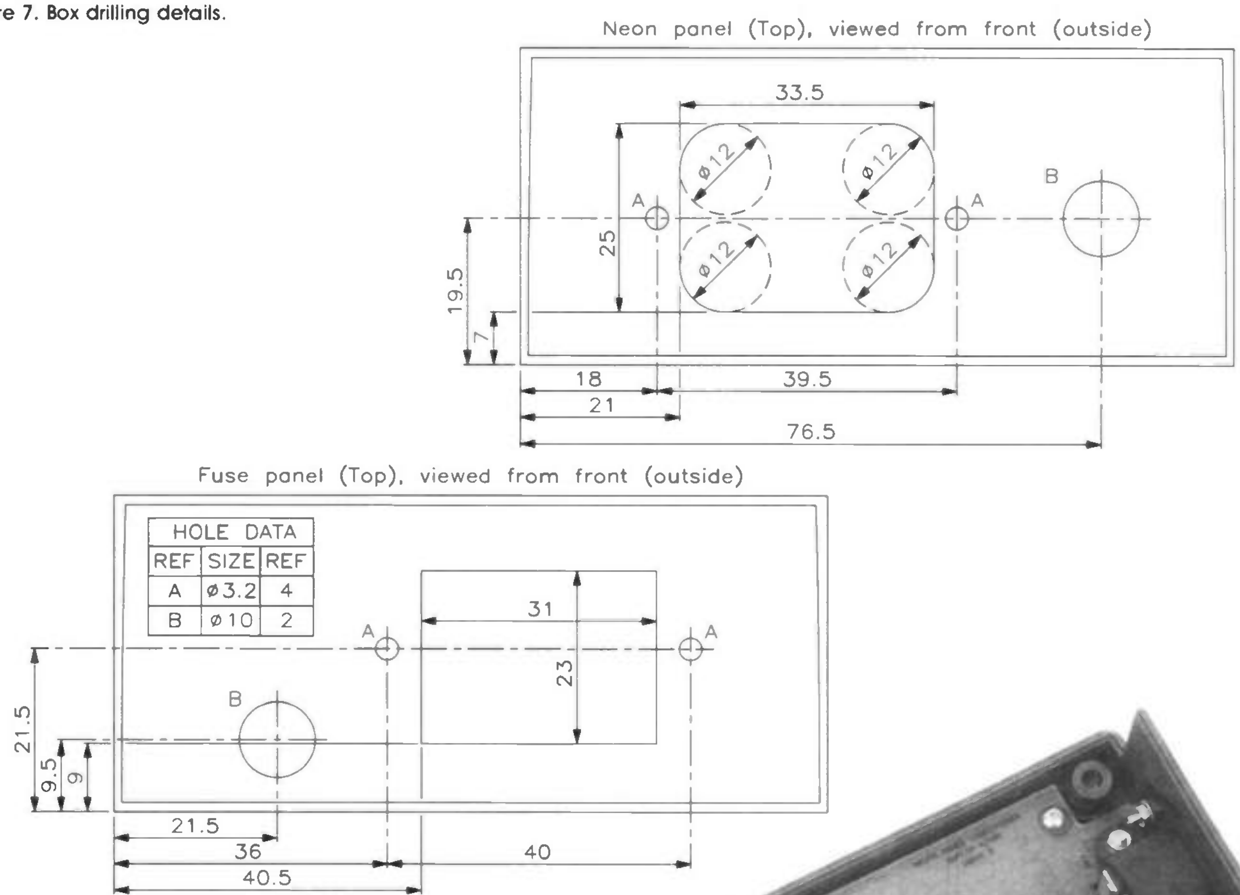


Figure 8. Top cover label. (Shown at 50% of actual size.)

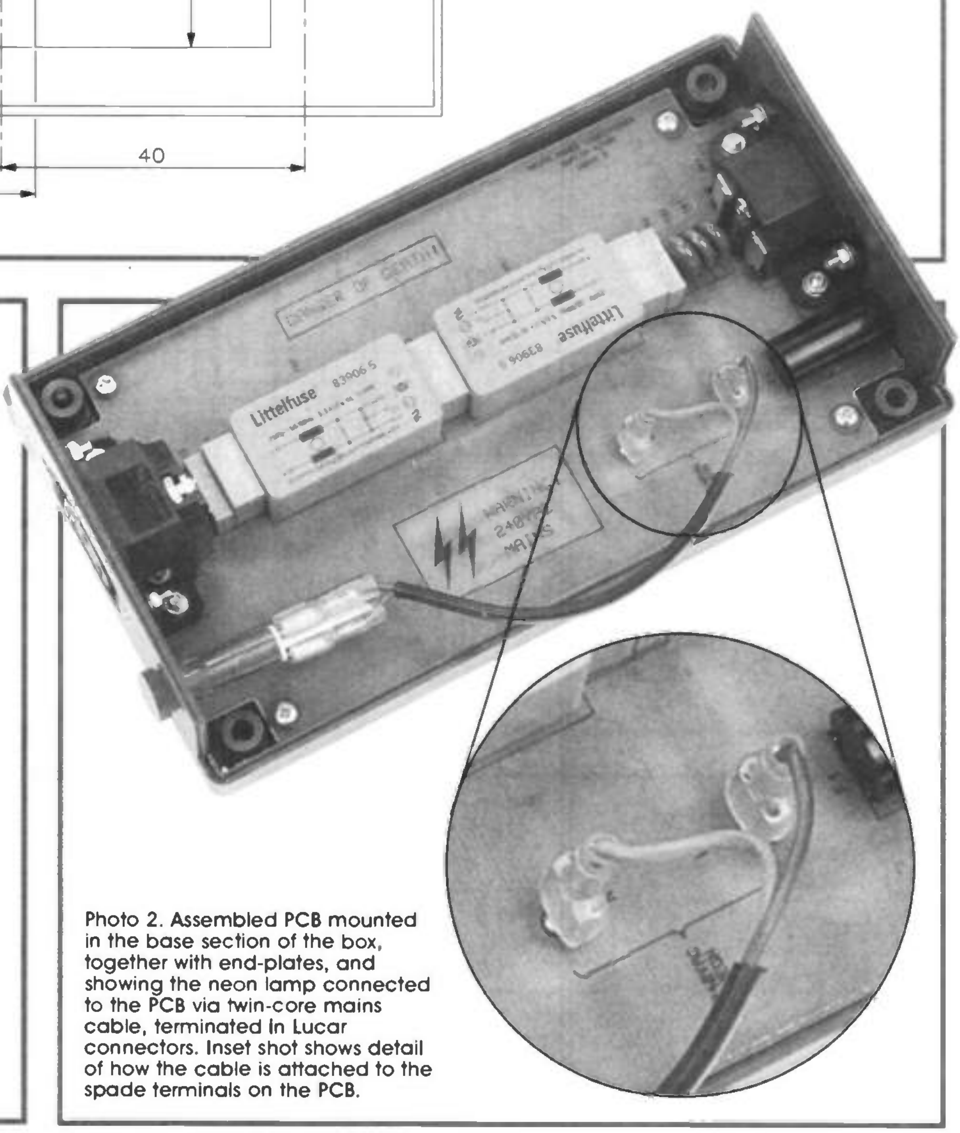


Photo 2. Assembled PCB mounted in the base section of the box, together with end-plates, and showing the neon lamp connected to the PCB via twin-core mains cable, terminated in Lucar connectors. Inset shot shows detail of how the cable is attached to the spade terminals on the PCB.

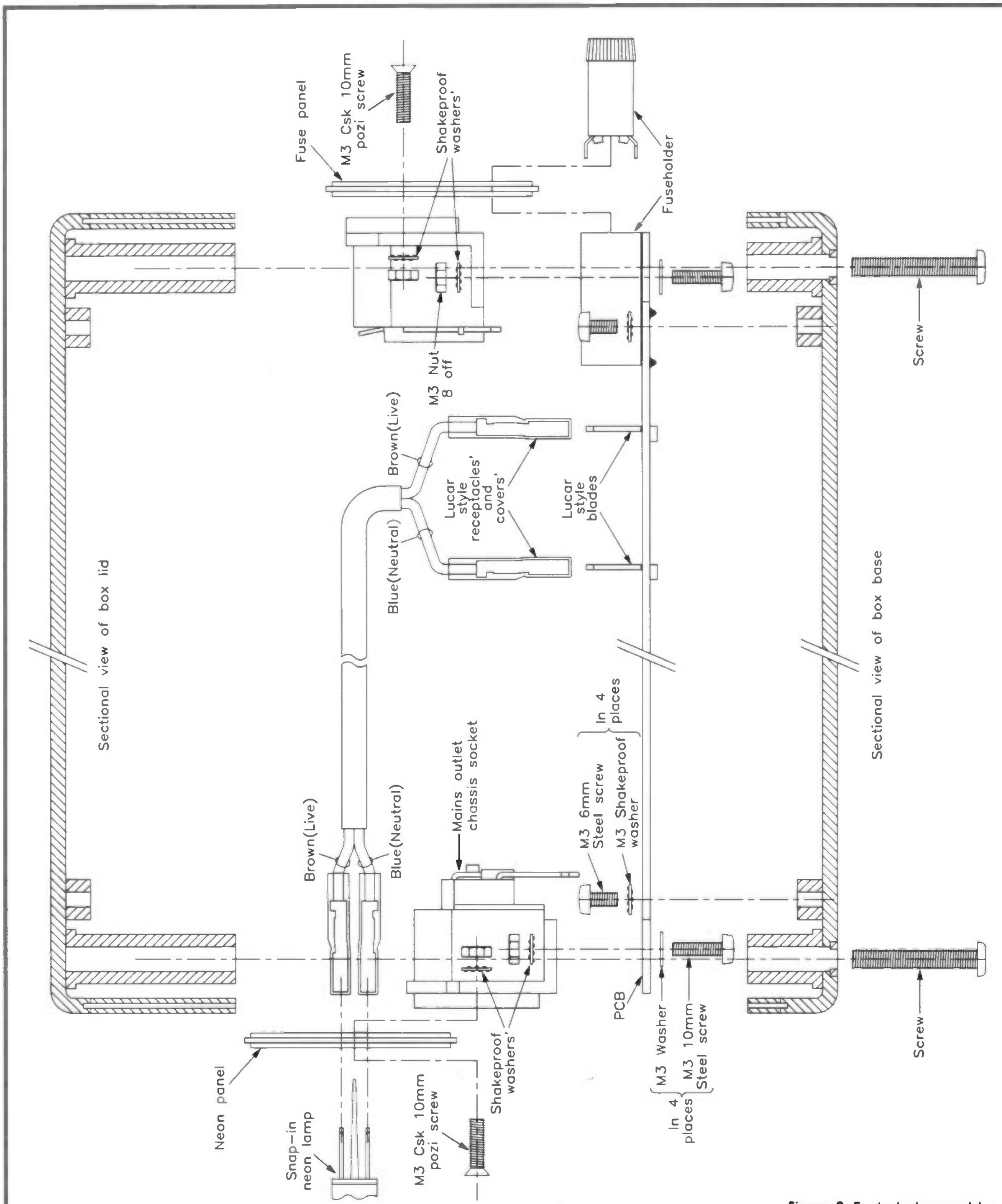


Figure 9. Exploded assembly.

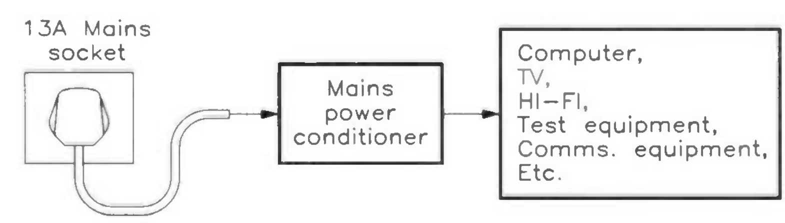


Figure 10. Typical application wiring diagram.

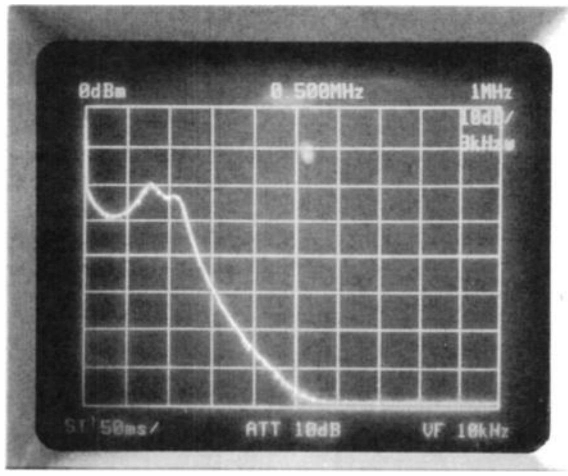
Testing and Use

Carefully check your assembly work, ensuring that all components are correctly placed, and that solder joints are good (although you would have to be trying very hard indeed to suffer the problem of solder bridges on the PCB, as the gap between tracks is generous). **IMPORTANT: ANY INSPECTION OF THE CIRCUIT SHOULD BE CARRIED OUT WITH THE MAINS SUPPLY DISCONNECTED. NOTE, IT IS STILL POSSIBLE TO RECEIVE A SHOCK FROM CHARGED CAPACITORS.**

Ensure that the lid is fitted to the box before connecting the unit to the mains, to avoid the risk of shock. **Remember, MAINS VOLTAGE CAN KILL.** Do not use this unit in environments where there is the possibility of it getting damp, such as bathrooms or kitchens, and never use the unit outdoors; the casing specified is not waterproof.

To test the Power conditioner, connect it in line to a piece of equipment, as shown in Figure 10. Leads will need to be made up, terminating in Euro connectors as appropriate, to suit those at the inlet and outlet on the unit. Use a 7A fuse (DK19V) or 10A fuse (DK20W) in the mains plug that is fitted to one end of the inlet lead. A ready-made Euro socket-to-13A-plug lead is available separately, Stock Code MK41U, but this will need to have its 5A fitted fuse replaced by a 7A or 10A one. Note, should either fuse blow, the neon indicator will extinguish. You should, after a reasonable period of time, detect an improvement in the operation of previously noise-affected equipment, when used in conjunction with the Mains Power Conditioner. Photo 4, a shot of a spectrum analyser display, shows the level of RF attenuation provided by the unit, whilst Photo 5 is of an oscilloscope trace, displaying the 'before and after' waveforms of the mains input to the conditioner, and the corresponding, cleaned-up mains output.

Photo 3. RF attenuation graph (spectrum analyser).



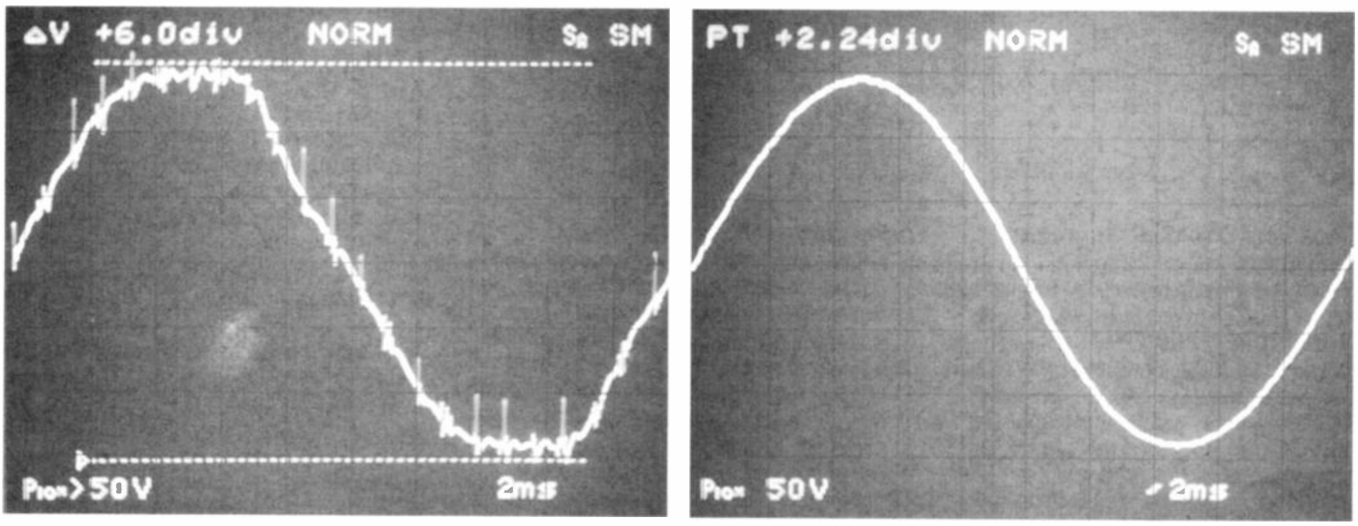


Photo 4. Oscilloscope traces of 'before and after' waveforms.

MAINS POWER CONDITIONER PARTS LIST

CAPACITORS

C1,5	33nF Interference Suppression	2	(FT34M)
C2,3,4	100nF Interference Suppression	3	(JR34M)

MISCELLANEOUS

SK1	PCB Mounting Euro Plug	1	(FE15R)
SK2	PCB Mounting Euro Socket	1	(BE23A)
N1	Red Snap-in Neon Lamp	1	(MK78K)
TS1,2,3	250VAC Transient Suppressor	3	(HW13P)
FB1,2	6·5A PCB Mounting Mains Inlet Filter	2	(RC61R)
F1	T6·3A Time-Delay Fuse	1	(RA13P)
	20mm PCB Mounting Fuseholder	1	(DK75S)
	Push-on Lucar Receptacle	1 Pkt	(HF10L)
	Push-on Receptacle Covers	1 Pkt	(FE65V)
	Push-on Lucar Blade	1 Pkt	(HF11M)
	M3 Steel Nut	1 Pkt	(JD61R)
	M3 Steel Washer	1 Pkt	(JD76H)
	M3 Metric Shakeproof Washer	1 Pkt	(BF44X)
	M3 × 10mm Steel Screw	1 Pkt	(JY22Y)
	M3 × 10mm Pozidrive Screw	1 Pkt	(LR57M)
	M3 × 6mm Steel Screw	1 Pkt	(JY21X)
	Stick-on Rubber Feet, Square	1 Pkt	(FD75S)
	2-core 3A Mains Cable (Black)	1m	(XR47B)
	Plastic Project Box, Type D-014	1	(ZB03D)
	Box Cover Label	1	(90021)
	PCB	1	(90020)
	Instruction Leaflet	1	(XV28F)
	Constructors' Guide	1	(XH79L)

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 seperately.

Order As 90019 (Mains Power Conditioner) Price £32.99 A1

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 1995 Maplin Catalogue.

PCB **Order As 90020 Price £5.99**

Box Cover Label **Order As 90021 Price £2.29**

Stray Signals

by Point Contact

Technical Chit-Chat from Here and There

First, three items from the USA. One concerns a new invention, a golf ball-sized light bulb that produces dazzlingly bright white light. The bulb contains sulphur combined with an inert gas excited by microwaves, and is coupled to a tube which, from the scant details in the report, sounds fluorescent-tube-shaped, presumably to avoid a point source too bright for comfort. Apparently, the US Department of Energy said one of these devices could produce as much light as hundreds of high-intensity mercury vapour lamps! A little 'American specmanship' there, surely.

Another snippet from across the Atlantic, concerns the failure of a recent wire-fraud indictment against a college student, for software copyright violations. He ran a bulletin board which distributed illegally copied software, placed there by various unidentified persons and downloaded again by many others. The legal arguments were abstruse, but in a nutshell, as the student did not make any profit from the venture, nor could it be established who placed any given pirated software there in the first place, the case against him was thrown out.

Next, news of a conference in Dallas, Texas, sponsored by two Associations, of Health Industry Manufacturers, and of the Cellular Telecoms Industry, concerning emc problems. Some fifty such problems were reported in a recent one year period, with some patients reportedly having died due to the resultant equipment failures. There are no Federal standards for medical equipment immunity, and some equipment has been found to fail due to irradiation by RF fields as weak as 0·1V/m! Maybe the same sort of thing is already happening in our NHS hospitals, a frightening thought.

And from India

Where there is lots of sunshine, solar cells are big business. The Indian Ministry of Non-conventional Energy Sources reports that there is in the country, a total installed capacity of no less than 500kW for street lighting, 700kW for domestic lighting, 640kW for water pumping systems, 520kW for village power plants, and other sundry applications. The important thing is that this energy is replacing energy that would otherwise be generated by burning non-renewable fuel, or by installing more nuclear power, so it is very environmentally friendly. Pity it won't work in our climate, though.

And Talking of the UK . . .

It was announced on 24th January, that the London-based satellite communications organisation Inmarsat, had succeeded in raising about £900 million from 38 telephone companies worldwide, to launch a global satellite system for hand-held phones – to be up and running before the end of the Century (Beam me up, Scotty!) And, reading one of the freebie electronics newspapers recently, I saw a snippet about another advance on the road to the *universal* op amp, that paragon of all virtues, with no input offset voltage, zero bias current, a bandwidth from DC to daylight, and rail-to-rail output swing and common mode input range. This particular contender boasted the rail-to-rail bit, and at 150µV, the input offset voltage is certainly on the low side. But at 10nA, the input bias current is a good deal larger than many other devices, while the lack of any claims in the report on slew-rate or bandwidth leaves PC with the suspicion that the figures are not so hot. Still, I must get a data sheet, all the same. (As you may have guessed, although the freebie paper in which this report appeared is British, the device itself is not.)

Recycling

Recycling is all the rage nowadays – one might be forgiven for thinking that it is a new idea. But, old hands at electronics (or radio, or even – in the case of really old hands – wireless) will recall that they always practised it. Want a coil for your crystal set? Take the cardboard tube from the middle of an exhausted toilet roll, bake in a hot oven (at Sunday lunchtime, after the lady of the house has finished with it for the day) to drive out any moisture, and – while still hot – paint liberally with Shellac. Add another coat or two when dry, and then wind your coil. Exhausted dry batteries could be coaxed into a little more life, by warming gently in front of the fireplace, or even recharging; cells in those days were built in a solid zinc pot, which besides forming the negative pole, doubled as the cell's container. Almost anything could come in handy; in a copy of one of the popular radio magazines of yesteryear which PC was browsing through recently, there was a design for a tiny portable set (big, by modern standards!), which used the caps from discarded toothpaste tubes as the control knobs. PC remembers that article when it first appeared – ouch!

Tailpiece, re All Those Lovely Profits

In a long and chequered career, PC has been many things, including at one time, Technical Director of a smallish but well-known, close-knit company, which designed, manufactured and sold RF passive components and a range of communications test equipment. The Managing Director, who was also the majority shareholder, was a colourful, larger-than-life character, despite his diminutive stature. During PC's time with the company, trading conditions were consistently difficult, as much so as now, if not worse. So, the accounts commonly made less than cheerful reading, with the bottom line usually reporting "Shareholders' funds overdrawn". The MD had a neat way of summing up the company's business: to other businessmen in the electronics field, met at exhibitions etc., things were always going just fine. But, privately, he would summarise the state of play succinctly, as follows: "Of the money our customers pay us, you can reckon one third goes on materials, one third is labour, one third overheads, and all the rest is profit!"

Yours sincerely,

Point Contact

The opinions expressed by the author are not necessarily those of the publisher or the editor.

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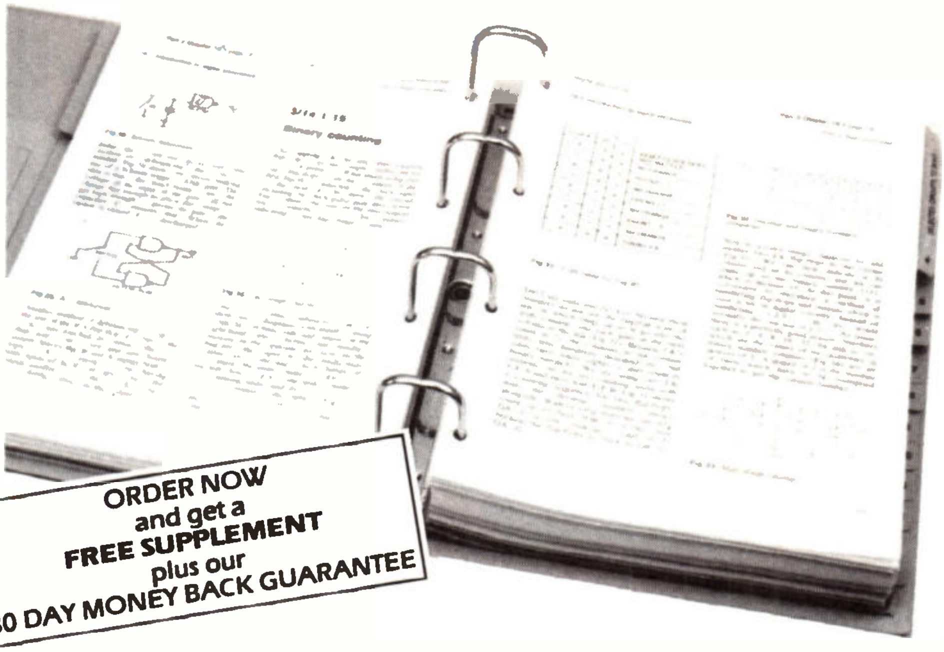

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by Douglas Clarkson

THE DEVELOPMENT OF THE DEFIBRILLATOR

The defibrillator is perhaps one of the most high profile items of medical equipment which the public catches sight of, particularly in emotive medical dramas or re-enactments of the dedicated work of the emergency medical services.

It is easy, however, to lose sight of the fact that the defibrillator has only recently become widely available in its present form. This is partly due to the late realisation that patients' lives could be usefully saved – and not just in hospitals – by the wide availability of suitable equipment within the community.

A Shocking Start!

One of the earliest sources of electricity known to man is the electric eel. There are some records of such creatures having been used by the Romans in a curative fashion – perhaps believing that with a short, sharp shock the patient could be cured of anything. Shocks of at least 1,000V could be attained in this way. There is no record, however, of their use for cardiac defibrillation.

The first recorded use of electricity to revive a patient in the UK is noted in 1774. The patient, a young child called Sophia Greenhill, had fallen out of a stair window, and showed no sign of life as could be determined by surgeons at the Middlesex Hospital or a local apothecary. A certain Mr Squires, however, tried the application of electric shocks to various parts of the body. It was found that a faint pulse was started after some shocks were applied to the thorax. Soon after the child started to breathe with difficulty and slowly recovered – even though the first shock had been given some 20 minutes after the initial incident.

It is reported, in 1775, that Abilgard succeeded in resuscitating a chicken using an AC signal after having caused ventricular fibrillation (VF) previously by means of AC current. The creature apparently made such a good recovery that it escaped its captors by flying off!

Within the limits of the available technology, efforts were made to develop equipment as electrical resuscitators, evidenced by the equipment of Dr Kite, shown in Figure 1, which dates from 1788. The basic component of such a device is the Leyden Jar.

Arrested Development

Developments continued in the next century as evidenced, in 1824, by Richard Reece's 'reanimation chair', depicted in Figure 2. This item of equipment allowed electric shocks to be given between an oesophageal electrode and exterior parts of the body – typically over the heart. While these developments were largely based on fortuitous experimentation, more basic work was undertaken towards the end of the 19th century. Work by the Swiss

Above: A typical semi-automatic defibrillator in service in an emergency situation. The unit weighs only 8kg and can analyse ECG signals within 10 seconds to provide guidance as regards detection of VF.

physiologists Prevost and Batelli was to anticipate in many ways the work that would be later taken in optimising defibrillation techniques. In animal studies it was noted that DC defibrillation was better than AC defibrillation, that excessive energy dissipation had deleterious effects, and that larger electrodes were more effective than smaller electrodes. There is perhaps the suspicion that the emotive writings of Mary Shelley in *Frankenstein*, published in 1818, was partly prompted by reports of work of this nature.

Initial Clinical Trials

Even though it had been anticipated for some time that the defibrillator could be an important item of life saving equipment, it was only in 1947 that the first successful defibrillation during thoracotomy (open chest surgery) of man was reported by Beck. This prompted development of the external defibrillator and P. M. Zoll in 1956 reported the use of such equipment as being mains powered. There may, however, be unrecorded gaps in clinical information between the earliest experiments with defibrillation and the mid-1950s.

Around this time there was a development of the concept of external chest compression in order to maintain a level of blood flow to the brain until defibrillation was attempted. The concept of hearts 'too good to die' – those rendered inoperative by ventricular fibrillation, was introduced by Beck in 1960. With the beginning of successful use of external defibrillation, it became increasingly understood that patients could make an excellent recovery provided that the electrical resuscitation could be applied in a timely manner.

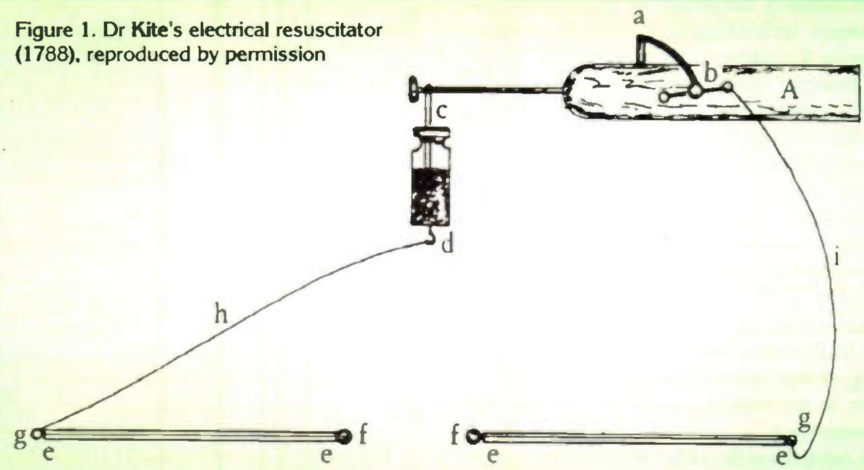
In the 1990s it is easy to lack appreciation of the considerable advances which have been made in the much wider availability of clinical defibrillation. It was Professor Pantridge and his colleagues in Belfast who saw that most fatalities caused by heart failure were taking place in the community and not the coronary care ward of a teaching hospital. This led to the development of a rapid response vehicle service which transported a clinical team with a defibrillator to the site of the arrest. Initially mains equipment was used and problems arose with different types of plug points within domestic houses. When mains inverters became available that could be operated from 12V car batteries, their considerable weight of around 100lb resulted in these power sources being fondly referred to as 'hernia packs' by those who had to move them!

Once the clinical need for more mobile, more lightweight equipment was evident, this led to the relatively rapid development of defibrillator technology. It is only in the 1990s, however, that emergency vehicles in the UK have all been equipped with defibrillation equipment. If the initial process of successful defibrillation was a mystery to the experimenters, perhaps it is more of a mystery now to determine why such widespread availability of defibrillators was not achieved sooner.

Basic Defibrillator Design

The key elements of the defibrillator are indicated in Figure 3. All modern equipment is designed for mains/battery operation. Both nickel cadmium and lead-acid batteries are extensively used. A typical modern unit will charge to maximum energy of 360J in less than 10 seconds, and hold enough charge for at least 25 shocks at maximum energy.

Figure 1. Dr Kite's electrical resuscitator (1788), reproduced by permission



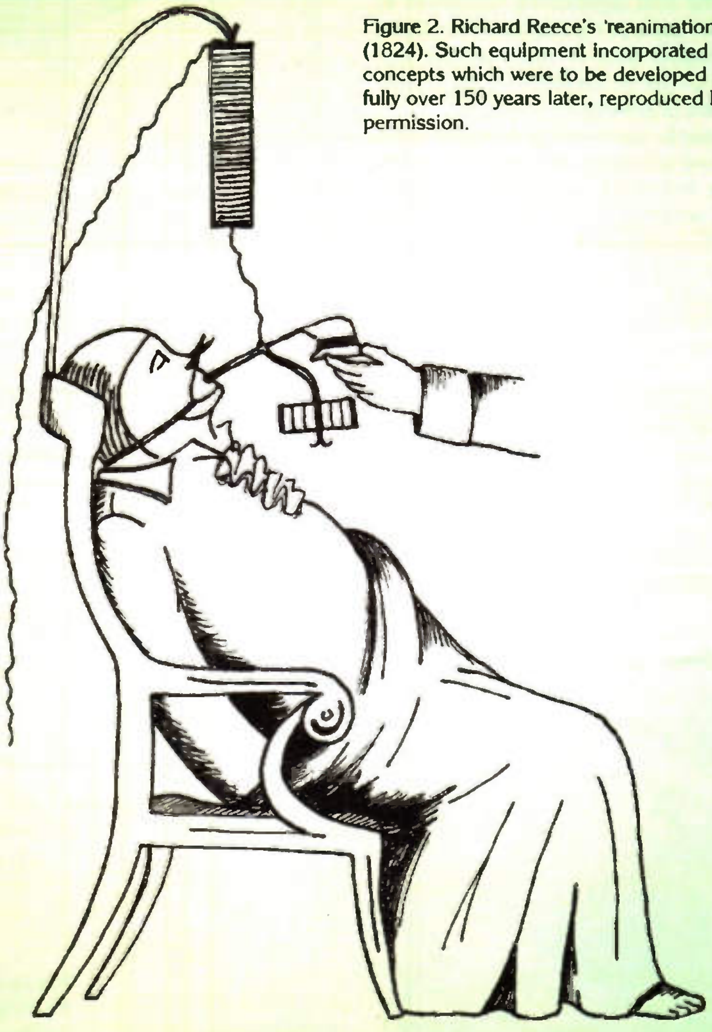


Figure 2. Richard Reece's 'reanimation chair' (1824). Such equipment incorporated several concepts which were to be developed more fully over 150 years later, reproduced by permission.

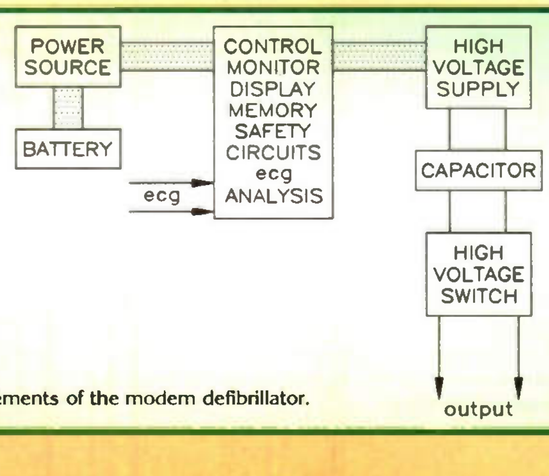


Figure 3. Key elements of the modern defibrillator.

All modern defibrillators employ microprocessor technology to control the various complex functions of the equipment. There are, however, many older units still in service which utilise traditional digital and analogue circuits, whereas the modern unit uses the microprocessor to monitor all aspects of device function. Initially, defibrillators were designed as two stage units – a monitor to display ECG waveform and a defibrillator to deliver the high voltage shocks. Since the display of the ECG is such an integral part of the equipment almost all units are now provided with ECG monitors built-in. Also, the monitoring of the patient after successful defibrillation is an important element of patient management.

As equipment is made for increasing portability, increased use is being made of flat screen technology such as liquid crystal and plasma types. This has, however, tended to increase the cost significantly compared to models with cathode ray displays. Also, liquid crystal screens tend to lack visibility and are more prone to damage in the hostile environment of emergency medicine.

Considerable work was undertaken in the development of more compact high voltage capacitors. In order to store 400J at a maximum DC potential of 5kV, a capacitance of value 32°F is required (using the formula $E=\frac{1}{2}CV^2$). The first Polyvinyldene Fluoride (PVDF) capacitor was developed in Belfast in 1969, and allowed a considerable reduction in the overall weight of the defibrillator equipment.

Further work is being undertaken in using materials with even higher dielectric constants and which can tolerate high electric field values. Whilst standard materials such as mylar have a dielectric value of around 4, materials such as Kurela are being developed with dielectric constants as high as 12. Another main component of the defibrillator is the high voltage switch, these units typically incorporating an inert gas atmosphere to prevent arcing. One requirement of such work is to produce ultra-reliable components – there being little benefit in producing devices which have a superior specification at the cost of durability, since medical equipment tends to be in service for long periods before it is replaced, a typical active life of ten years being expected.

A fundamental benchmark of the design process is that defibrillators should be user friendly. In the heightened emotional atmosphere associated with use of such equipment, it is most important that equipment is easy to use. Thus a 'good' defibrillator is required not only to have an optimum set of functional and performance characteristics, but also to be simple to operate. At the design stage of the instrument, it is important to have the layout of controls and paddles defined by the end user and not by an electronics engineer with little appreciation of the needs of emergency medicine.

A multiple configuration defibrillator unit – non-automatic or manual type typically used in acute hospital environment where clinical staff are on hand to determine VF.

An automatic implantable Cardioverter system – the implant device and the programmer/monitor unit. Such units are now able to be programmed to cater for needs of specific patients and offer a broad range of detection/correction modes.

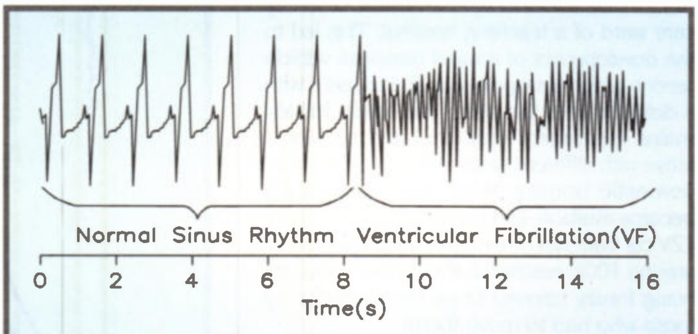


Figure 4a. Translation from normal sinus rhythm to ventricular fibrillation (VR).

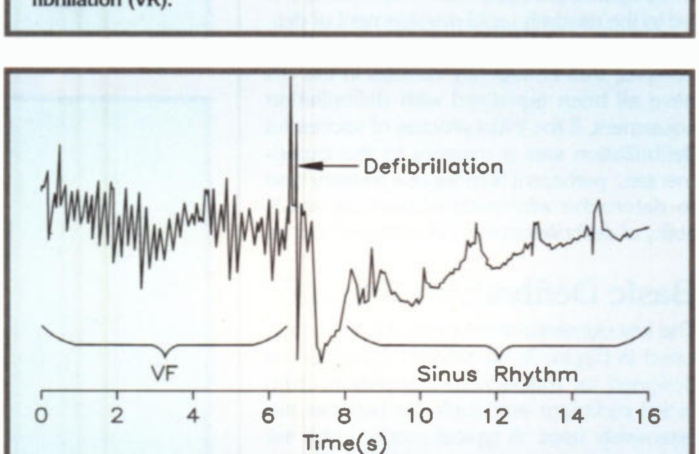


Figure 4b. Successful defibrillation: VF to sinus rhythm.

Electrocardiograph (ECG) Trace Diagnosis

It must be stressed that appropriate expertise must be available in order to provide appropriate defibrillation. There are a range of heart rhythms which are not VF, and where damage to the heart could take place if defibrillation was undertaken. This is why the early response teams had a clinical cardiologist as a key member of the team. It is only recently, however, that emergency ambulance personnel have been trained to both identify VF and apply defibrillation shocks at the site of patient collapse. In hospitals, the role of nursing staff is in many places being extended to include 'hands on' defibrillation. Figures 4a and 4b show respectively the transition from normal sinus rhythm to ventricular fibrillation and the transition from VF to normal sinus rhythm being achieved by a single defibrillation pulse.

During the defibrillation process, it is important to place the paddles of the defibrillator over the correct area of the chest, the optimum paddle placement being indicated by Figure 5. Usually by convention, the Apex paddle is charged positive with respect to the Sternum one, although there is little clinical evidence to suggest that this produces better results than would be achieved by using the opposite polarity.

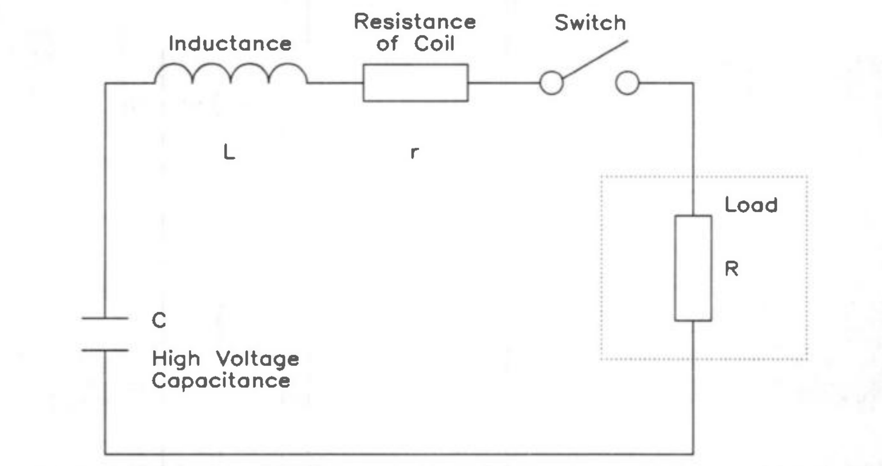


Figure 6. Equivalent discharge circuit of the defibrillator.

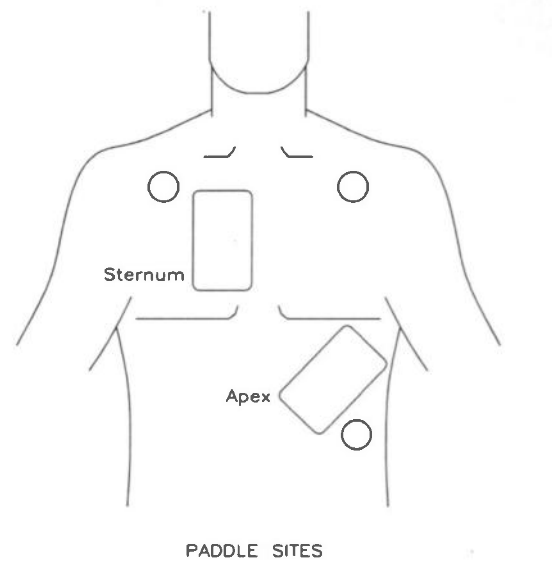


Figure 5. Paddle placement for optimum defibrillation. Normally the Apex is at a positive voltage relative to the Sternum.

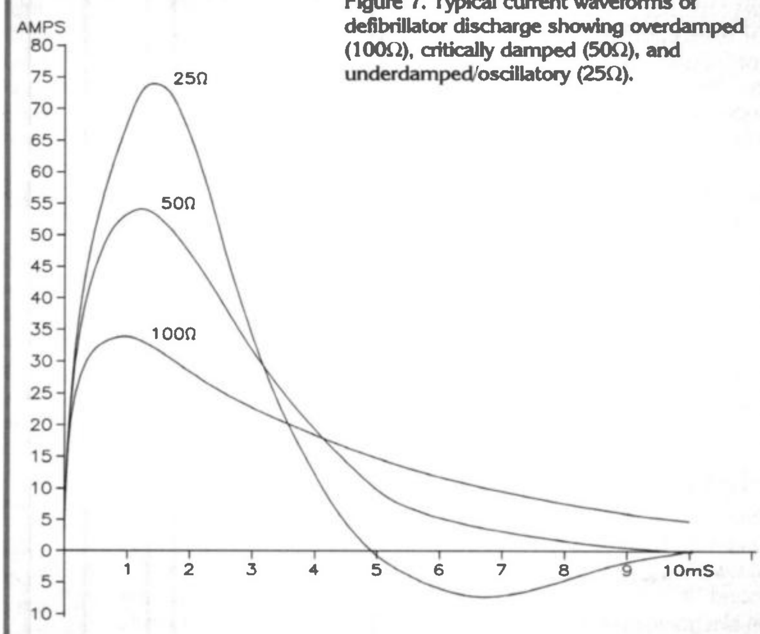


Figure 7. Typical current waveforms of defibrillator discharge showing overdamped (100Ω), critically damped (50Ω), and underdamped/oscillatory (25Ω).

It was usual at one time to use round metal electrodes with electrode jelly smeared on them, but it is now increasingly common to use disposable electrode pads that are fixed onto the skin so that the metal surfaces of the electrodes have an even contact. Also, with the electrode jelly, there was always the risk of current passing over the skin of the patient rather than across the thorax area. Also, if the jelly was not applied uniformly over the metal electrodes, then burns could be produced in areas of high current density. One of the unwelcome surprises of defibrillation can occur where Transdermal GTN nitropatches used for the treatment of Angina may explode on delivery of the shock current!

The advent of the newer automatic and semi-automatic defibrillators has led to the increased use of self-adhesive pad electrodes which allow both monitoring of ECG and application of the defibrillation energy. The use of such pads facilitates the procedure for defibrillating a patient in a rapidly moving emergency vehicle, whereas previously the vehicle would have to slow down or even stop to ensure the safety of emergency personnel.

Equivalent Circuit Design

The equivalent discharge circuit of a typical defibrillator is given by Figure 6, with the waveform of a typical defibrillator discharge cycle being shown in Figure 7 as a function of the load impedance. Referring to this graph, the 100Ω load corresponds to the overdamped transient of a standard LCR circuit, the 50Ω load to the critically damped waveform, and the 25Ω load to the oscillatory decay waveform.

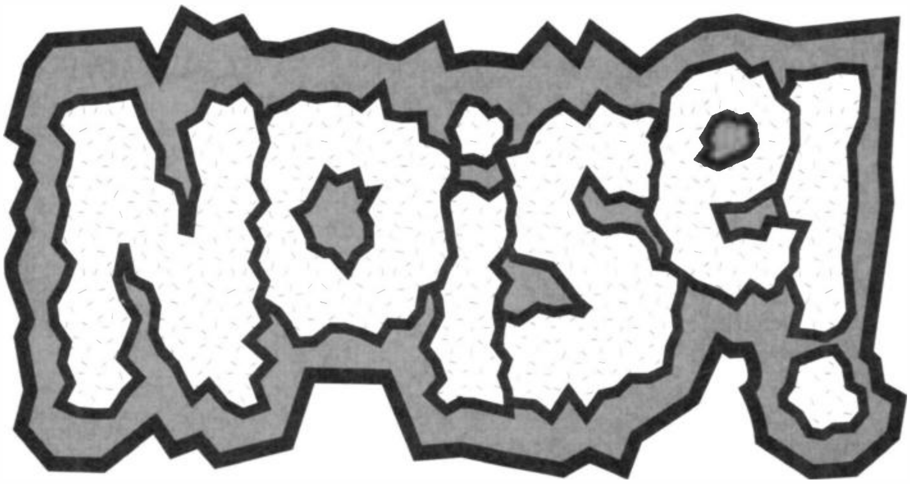
Defibrillation causes a large transient current to flow within the heart region for around 10ms. Whilst for purposes of equipment modelling the trans-thoracic impedance is set at 50Ω, it has been shown to vary between 40 and 170Ω. This implies that while energy values are set for a 'standard' patient, in practice a range of peak currents will be delivered depending on the value of the trans-thoracic impedance, represented in Figure 7 by the different loads. It has been shown that the trans-thoracic impedance rises in those patients who have suffered a heart attack, which can be largely attributed to the increased impedance of blood which has stopped flowing. This will tend to reduce the peak discharge current flowing (refer to Figure 7).

Defibrillation Guidelines

It is certainly dangerous to administer adult energy doses to children, hence separate ranges and paddles are used. While the starting energy for adult defibrillation is set to 200J, the equivalent value of child defibrillation is 2J per kg body weight, thus an infant of 20kg would have an initial energy level setting of 40J. The revised European Resuscitation Council recommended sequence for terminating ventricular fibrillation or pulseless ventricular tachycardia (abnormally rapid heart rate) in adults is outlined below.

(a) DC shock of 200J
(b) DC shock of 200J, if no response with (a)
(c) DC shock of 360J, if no response with (b)

Continued on page 72.



What is it, and Why?

PART ONE

by J. M. Woodgate B.Sc.(Eng.), C.Eng., M.I.E.E., M.A.E.S., F.Inst.S.C.E.

The subject of noise is one of the most confusing and troublesome in electronics. Circuits which seem similar, turn out to have widely different noise characteristics, for example, we often read conflicting statements about the effects of high and low resistor values on noise. When we come to noise measurements, the situation becomes even worse. Why does bandwidth matter? What exactly is 'A-weighting'? Find out the answers to these questions and more, by following this four-part series, each month, examining the theory and consequences of noise.

Physics

First of all, what is noise? Originally, and in the dictionary, it is defined as being 'unwanted sound'. It first came to light, as an electronic phenomenon, in telephone technology. While 'noise' due to bad contacts, and the picking-up of external interference (such as from sparking in electric tramways and railways) occurred from the earliest days, we are going to concentrate on internally generated noise in circuits. The observation of this effect may date from as early as the introduction of the triode valve (tube) in radio receivers around 1910, because an oscillating receiver (which the better ones were only too prone to do) could produce noise in the headphones. Serious theoretical study almost certainly dates from the introduction of valve (tube) amplifiers in telephone circuits, which occurred more than seventy years ago. Much of the theoretical work on the physics of electronic noise was done at the end of the 1920s, by H. Nyquist, who also made major contributions to feedback amplifier design methods and who originated the sampling theorem, which is one of the fundamental rules of information theory, and digital signal technology in particular.

Electronic Noise

Electronic noise is due to random motion of the elementary current carriers, normally electrons. In a wire carrying current, electrons travel (albeit not very quickly; less than 1mm/s unless the wire is running hot) along the wire towards the positive end, but since a current of 1A represents $6{\cdot}25 \times 10^{18}$ electrons per second flowing past any given point, it is not surprising that they keep bumping into each other, and the atoms of the material of the wire. This means that they do not arrive at any point at a precisely uniform rate. This is analogous of a road full of cars, all trying to travel at 60mph, but subject to random minor collisions; clearly, some will progress faster than others. If we could put an ammeter with an enormous scale length into the circuit, so that we could see the movement of the needle even due to one electron passing, we would see that it was constantly vibrating, as either more or fewer electrons than average passed through it. If we connected a very sensitive pair of headphones across it, we would hear the corresponding acoustic noise as a hissing sound, rather like compressed air escaping from a tyre valve. Because of this, it seems reasonable to call the electrical effect 'noise' as well.

If the atoms in the material vibrate faster, they naturally cause more collisions with the electrons. Since the rate of vibration of atoms in a material is shown on the macroscopic scale (as opposed to the 'microscopic' scale of the atoms themselves) as its temperature, we should not be surprised to find that the sort of noise we are discussing is called 'thermal noise'. Notice that we made no assumptions about what the material of the wire was, so our analysis is completely general. Thermal noise is an all-pervading effect, and can only be reduced by reducing the temperature T of the material, which is why some very sensitive types of circuit are cooled with liquid nitrogen (not to produce superconductivity).

How Much Noise?

Any electrical conductor has some resistance (We have to leave out superconductors in this simplified analysis). Inevitably, it also has some stray capacitance across it, which, combined with the resistance, forms a first-order, low-pass filter. This filter defines a frequency bandwidth B, characteristic of the particular conductor, and roughly equal to the corner frequency of the filter. This frequency is also called the 'half-power frequency', because the output power is half the input power, and thus the attenuation of the filter is 3dB. We shall see more about this approximation later.

The *noise power*, W, produced by the effects of the electron collisions on the atomic scale is given by Nyquist's equation:

$$W = 4kTB$$

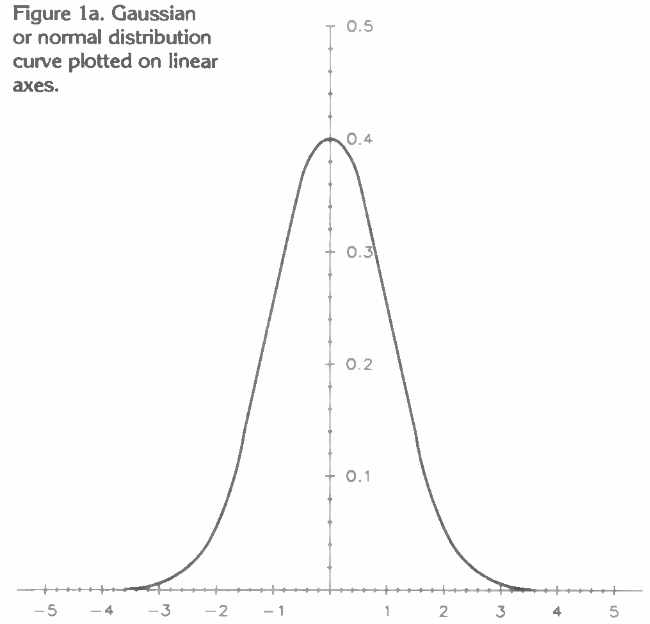
The constant k is called Boltzmann's constant, and has the extremely small value of $1{\cdot}38 \times 10^{-23}$ JK^{-1} (joules per kelvin). It represents the factor that has to be introduced to fit the units which mankind has adopted to measure power, temperature and bandwidth (or, indirectly, the fundamental units of length, mass and time). In the equation, T is the *absolute temperature* in kelvin, i.e., relative to –273°C. Degrees are not used with the kelvin scale. Notice that the noise power depends only on the temperature and the bandwidth, and not on the resistance R of the conductor. This appears when we find the voltage V, or current I, which this noise power produces:

$$V = \sqrt{WR} = \sqrt{4kTBR}$$

$$I = \sqrt{W/R} = \sqrt{4kTB/R}$$

We can see that the thermal

Figure 1a. Gaussian or normal distribution curve plotted on linear axes.



noise voltage produced at 300K (27°C) by a 3kΩ resistor in a bandwidth of 20kHz is 1μV, and the noise current through the short-circuited resistor is 332pA. These values are worth remembering if one is doing much work on noise, since scaling can be used to find other values, provided you remember the square root. For example, the thermal noise voltage of a 300kΩ resistor is 10μV in a 20kHz bandwidth, and thus, 7μV in a 10kHz bandwidth.

'Low-noise' resistors exist because some types, notably the old carbon composition type, are not 'low-noise', i.e., they produce significantly more noise than the Nyquist equation predicts, and this excess noise depends on the voltage applied to the resistor and the current through it. For the vast majority of applications these days, there is no need to use carbon composition resistors, and virtually all the other types produce very little more noise than theory predicts.

Statistics

The introduction of the National Lottery has drawn public attention to the statistical analysis of random events, and all sorts of pseudo-scientific rubbish has been published as a result. It seems strange that any predictions at all can be made about truly random events, by definition of 'random', but in fact, this is possible if the number of random events is large enough. This is usually put down to the 'Law of Averages', a natural law which is well-known in pubs but, alas, is unknown to professional statisticians!

It is traditional to begin this subject, by considering the tossing of a 'fair' coin, i.e., one which is completely symmetrical, so that there is no effect due to unbalance while it is in flight. To be sure that our number of random events is large enough for the statistical analysis to work quite accurately, we need to toss it at least ten thousand times. This is a large number in this context, but minute compared with the number of electron arrival events in almost all electronic experiments.

It would be surprising if, in our ten thousand events, we found exactly five thousand 'heads'. We would naturally expect some variation around this number if we repeated the ten thousand tossings many times. The statistical theory of this experiment was studied by Jacob Bernouilli, among others. It deals with discrete objects, such as coins or dice, so that fractional values do not occur. However, in many natural processes, either there are no discrete objects at all, or they are so numerous (like electrons) that for all practical purposes, we can consider the results as a function of a continuous variable. The mathematician and physicist, Karl Gauss, studied this subject, and came up with an equation that describes the statistical variation to be expected in this case. It is rather a complicated equation in its general form, but much simpler when normalized. Regular readers will recognise this term from the series on filters. It is a scaling process that sets all variable values, that can be so set without producing errors, to 1. In this case, there is a previous step, which is to subtract the expected or average value of the results, from each individual result. This is equivalent to setting the average value to zero, or, in electronic terms, ignoring the DC component of the signal. When we do this, Gauss' equation becomes:

$$y = \frac{1}{\sqrt{2\pi}} e^{-\frac{1}{2}x^2}$$

which can also be written:

$$y = \frac{1}{\sqrt{2\pi}} exp\left(-\frac{x^2}{2}\right)$$

Where y is the *probability* of obtaining the value x, and e is the base of natural logarithms, equal to 2·718. . . . Recalling that the average value of the results corresponds to x being zero, we can calculate the corresponding value of y quite easily, if we remember that any number to the power zero is equal to 1. It turns out to be very nearly 0·4, so that the odds against getting exactly 5,000 heads in 10,000 tosses of a fair coin are 6:4. The graphs of y against x are shown in Figures 1a and 1b, and this is known as the *Gaussian* or *normal* probability distribution curve. It is called 'normal' because it applies to many (but, by no means all) types of natural event.

When we are doing practical measurements of things that we cannot count, i.e., excluding coins, balls and similar discrete objects, we can never measure the results with infinite accuracy. For example, if we use a digital meter with a 3-digit display, and we get a result of, say, 376, all we can say is that the actual result is between 375·5 and 376·5. In fact, we are putting the result into a 'bin', one unit wide, centred on 376. If we repeat the measurements, there is bound to be some statistical variation in the results, so we can expect to be able to plot the complete set of results as a distribution curve. Unless we have a very large number of results, it is unlikely to resemble the normal curve. The y value of each bin represents how many results fell into that bin, which can be described as the *probability density* of the results in the range 375·5 to 376·5. Like all other branches of knowledge, statistics has its own technical terms, and we have to learn them in order to understand the subject.

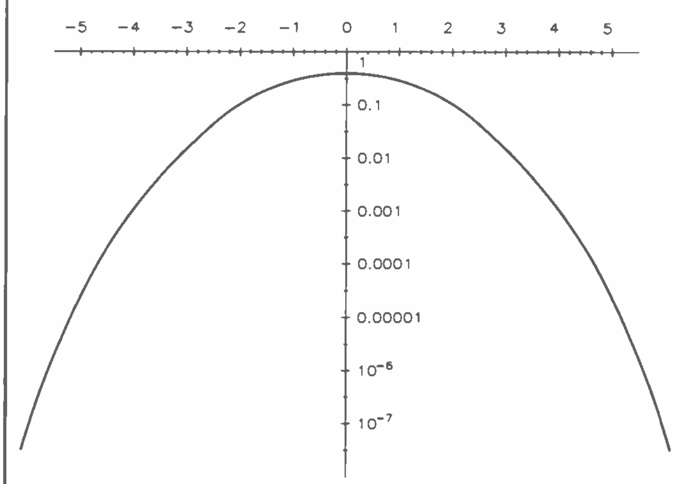


Figure 1b. Normal distribution curve plotted with logarithmic y-axis, to show the end values more clearly.

Standard Deviation

When we looked at the normalized Gauss equation, we neglected the 'DC component'. So, what is left can represent an AC signal, in fact, a noise signal. It has many interesting properties, for example, however large x becomes, y never quite falls to zero, so theoretically, the signal has an infinite peak value. However, the probability of x being larger than 3 is less than 1 in 300, and of being larger than 5 is less than 1·5 in a million. The average value is, of course, zero, because we arranged it that way. The other value we like to know about an AC signal, is its rms value. Since the peak value is infinite, it might be thought that the rms value would be infinite too, but we have to take into account that very large values are very rare. We can calculate the rms value, remembering that it is the (square) Root of the Mean value of the Squares of the individual x values. The y function is then a *weighting function*, which accounts for the probability, or *frequency*, of that value of x appearing in the results. Notice that statisticians use the term *frequency* to mean something different from its meaning in electronics. The calculation goes as follows, and involves some mathematics which is not too difficult, but tends to be reserved for the later years of study:

$$m = \int_{-\infty}^{\infty} x^2 y dx$$

$$= \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{\infty} x^2 exp\left(-\frac{x^2}{2}\right) dx$$

$$= \sqrt{\frac{2}{\pi}} \int_{0}^{\infty} x^2 exp\left(-\frac{x^2}{2}\right) dx$$

$$= \sqrt{\frac{2}{\pi}} \int_{0}^{\infty} 2u\ exp(-u) \frac{du}{\sqrt{2u}}$$

Where: $u = \frac{x^2}{2}$

$$= \frac{2}{\sqrt{\pi}} \int_{0}^{\infty} u^{\frac{1}{2}} exp(-u) du$$

$$= \frac{2}{\sqrt{\pi}} \int \Gamma\left(\frac{3}{2}\right)$$

$$= \frac{1}{\sqrt{\pi}} \Gamma\left(\frac{1}{2}\right)$$

$$= 1$$

Where m is the mean square value, rather than the root-mean-square, because keeping the square root all the way through the integration would make the equations look unnecessarily complicated. $\Gamma(n)$ is the 'gamma function', defined by the integral equation in the previous line. For whole numbers,

$\Gamma(n) = (n-1)!$ (factorial of $(n-1)$)

However, for fractions, the integral equation has to be used, usually together with the reduction formula used in the last-but-one step in the evaluation of m above:

$\Gamma(n) = n\Gamma(n-1)$

The evaluation of the final integral is a standard result, like 2 + 3 = 5. There is a proof, which includes a remarkable bit of mathematical chicanery, and it can be found in the Annex. Still, the end result is simple enough, and is actually not an accident. The normalization process involves scaling what the statisticians call the *standard deviation* to be equal to 1, and it turns out that what they call the standard deviation, is what we call the rms value! Although we have not proved it, this still applies if there is a DC component (or non-zero mean value, in statistician-speak).

This major effort produces some useful results. We saw above that x is greater than 3 only 0·3% of the time. In other words, the peaks of the noise signal exceed three times the rms value only 0·3% of the time. Further useful calculations, show that the rms value itself, is exceeded for nearly 32% of the time, and twice the rms value is exceeded for just over 4·5% of the time. This tells us how much 'headroom' (extra signal-handling capacity) we need in any circuit handling noise signals. For example, if we require to handle a noise signal of 1V rms, our circuit must be able to handle 4V Pk-to-Pk if we can accept clipping for 4·5% of the time, or 6V Pk-to-Pk if we can only accept it for 0·3% of the time. The latter is usually regarded as being the minimum acceptable for electronic voltmeters (but is not always achieved!). 10V Pk-to-Pk (corresponding to $x = 5$) is required in the same circumstances for precision measurements, because some noise signals do not have the normal probability distribution – they are non-Gaussian noise signals.

Colours

Thermal noise contains all frequencies (at least up to the bandwidth limit, B), at substantially equal amplitudes. By analogy with white light, which contains all colours (or wavelengths) equally, it is therefore called 'white noise'. Recalling the 'bin' concept, we can say that there is equal energy in each frequency 'bin', in particular, equal energy per unit bandwidth (of 1Hz, of course). For audio purposes, we have to take into account that our ears do not work like that. We appreciate musical pitch, the subjective analogue of frequency, on a logarithmic scale, divided into octaves, which represent frequency ratios of 2:1. To get equal energy in each octave, we have to reduce the energy (or power, it is the same in effect) in white noise inversely proportional to frequency, i.e., at 3dB per octave. This can only be done approximately, but a quite accurate example was given in the series on filters. Noise treated in this way is called *pink noise*, not red noise, because the low-frequency energy is only partially dominant. True red noise has the *voltage* falling, inversely proportional to the frequency. Blue noise has the voltage rising in proportion to frequency, and is, for example, produced by an FM receiver with no de-emphasis, no muting and no signal input.

The outcome of all this analysis is that, to be precise, thermal noise is 'Gaussian white noise'. There is one more qualification to consider, and that is bandwidth.

Bandwidth Again

We saw that the noise voltage produced by any conductor of resistance R, was limited by the effect of the inevitable capacitance, C, in parallel with it. The equivalent circuit is shown in Figure 2, where E_n is the thermal noise voltage, and V_n is the voltage across the accessible terminals of the conductor. We can calculate V_n as follows:

$E_n^2 = 4kTBR = 4kTBR$ in unit bandwidth

$$V_n^2 = \frac{E^2}{(2\pi fC)^2} \cdot \frac{R}{\frac{1}{(2\pi fC)^2} + R^2}$$

$$= \frac{4kTR^2}{1 + (2\pi fCR)^2}$$

So, that over all frequencies:

$$V_n^2 = 4kT \int_0^\infty \frac{R^2 df}{1 + (2\pi fCR)^2}$$

$$= 2\frac{kT}{\pi C}\left[\arctan(2\pi fCR)\right]_0^\infty$$

$$= 2\frac{kT}{\pi C} \cdot \frac{\pi}{2} = \frac{kT}{C}$$

$$\therefore V_n = \sqrt{\frac{kT}{C}}$$

This is a remarkably simple result, which has several practical consequences. Note that the resistance and bandwidth have completely disappeared from the equation, and that the noise voltage is inversely proportional to the square root of the capacitance. This means that noise is a particular problem in low-capacitance devices and their amplifier circuits, such as electret and capacitor microphones, and video camera tubes. For example, a circuit with a 5pF parallel capacitance, produces a noise voltage of 32·9μV at 300K. We can find the bandwidth in which this noise is generated, by combining the above result with Nyquist's equation:

$$\frac{kT}{C} = 4kTBR$$

$$B = \frac{1}{4CR}$$

$$f_{-3db} = \frac{1}{2\mu CR}$$

$$\text{So } B = \frac{\pi}{2} f_{-3db}$$

So, our previous rough answer, that the *noise bandwidth, B*, is equal to the 3dB bandwidth, turns out to be about 63% of the true answer. However, since the noise voltage is proportional to the square root of the bandwidth, the rough answer gives a noise voltage which is very nearly 80% of the correct answer, and this is not too bad. For higher-order filters, with steeper attenuation rates, the noise bandwidth is closer to the 3dB bandwidth.

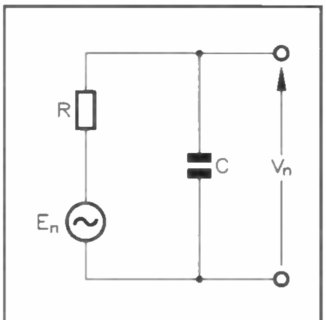


Figure 2. Equivalent circuit of a resistor (or any conductor) for noise analysis.

If the resistance of the circuit is low, the bandwidth in which this noise voltage is generated is very large, so the actual noise output may well be limited by the bandwidth of the amplifier or whatever else is connected to the circuit. Table 1 illustrates this for a circuit with 5pF capacitance.

Resistance (Ω)	Bandwidth (Hz)
1	50G
10	5G
100	500M
1k	50M
10k	5M
100k	500k
1M	50k
10M	5k

Table 1. How bandwidth relates to the resistance of a circuit.

Well off the end of Table 1, is the situation in a miniature electret microphone. The transducer itself may well have a capacitance of only 5pF, and the input resistance of the built-in FET source follower is typically 1GΩ. So, the same 32·9μV noise voltage appears in a bandwidth of only 50Hz! It is not easy to check this, because of the acoustic noise picked up by the microphone. Also, the noise of the FET itself rises at low frequencies, an effect I plan to discuss in Part 2.

Noise in Tuned Circuits

Readers of my series on filters will perhaps recall that the frequency response of a single-tuned circuit is related to that of a first-order, low-pass filter, the response of which is shown in Figure 3, by a transformation of the frequency variable. This means that the noise voltage generated by a single-tuned circuit is given by the same, simple expression as for the RC circuit. We need to study one more important 'primitive' circuit, and then, with a clear head, we can investigate the noise performance of any passive circuit.

The LR Series Circuit

This circuit fairly represents several types of transducer, such as the moving-coil microphone, the magnetic tape head, and the magnetic pick-up for analogue discs. All these have low output power, so that thermal noise significantly limits the available dynamic range at the low end. The circuit is, of course, another form of first-order, low-pass filter, so that there is an inherent bandwidth limitation. The –3dB corner frequency, f, is given by:

$$f = \frac{R}{2\pi L}$$

However, this only applies to the *current* output if the LR circuit is fed into a very low impedance load. This does happen: the magnetic field strength meter described in my series on audio-frequency induction-loop systems uses this technique, to compensate for the rising response with frequency inherent in magnetic induction. In this case, the noise current can be found from the Nyquist equation, and the noise bandwidth is $R/4L$.

Normally, we feed the LR circuit into a resistive load that is at least comparable in value with

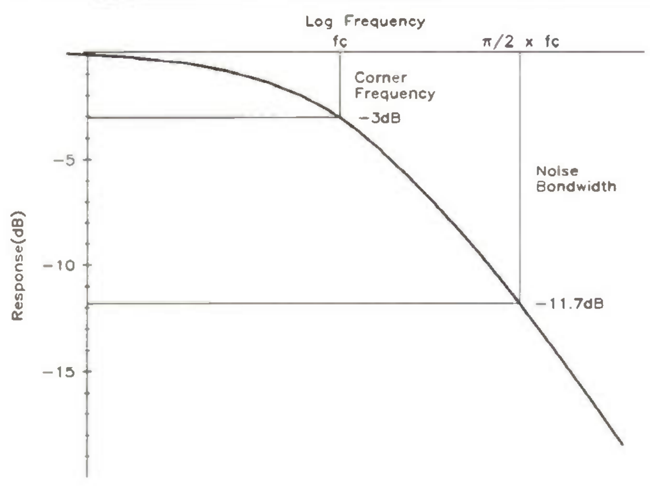


Figure 3. Frequency response of an RC circuit (or any 1st order, low-pass filter), showing the corner frequency and the noise bandwidth.

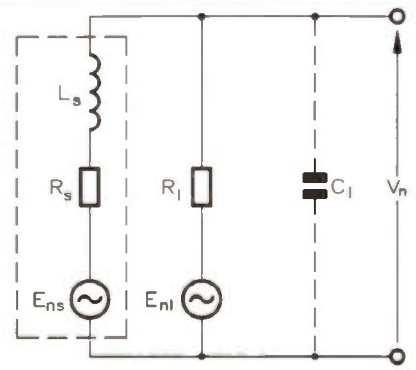


Figure 4. Equivalent circuit of any inductor or inductive transducer with an external load, for noise analysis.

R_s and may be much higher. This is shown in Figure 4. There will inevitably be some stray or deliberate capacitance in parallel with the load resistance. We could treat this as a single-tuned circuit, but the *Q* is usually very low indeed, so this approach is not too helpful. If the load resistance is very high and the capacitance very small, which we could achieve by a direct connection to a FET or FET op amp, there is virtually no current through L_s, and the noise voltage is simply that due to R_s, according to Nyquist's equation. However, this is unusual, and it is much more likely that R_l is comparable in value with the impedance of L_s at the high end of the operating frequency range. This makes matters rather less simple, and we have to calculate the noise voltage appearing across R_l, neglecting C_l for the moment. This also means that we have to leave out the noise contribution of R_l, because without C_l, there is no bandwidth limitation on it. In a very small bandwidth *df*, the noise voltage dV_n is given by:

$$(dV_n)^2 = \frac{4kTR_sR_l^2df}{R_l^2+R_s^2=4\pi^2f^2L_s^2}$$

So the total noise voltage is given by:

$$V_n^2 = \frac{4kTR_sR_l^2}{R_l^2+R_s^2}\int_0^\infty\left[\frac{df}{1+\frac{4\pi^2f^2L_s^2}{R_l^2+R_s^2}}\right]$$

This looks much worse than it really is – after some algebra, it turns into the standard form:

$$V_n^2 = \frac{4kTR_sR_l^2}{2\pi L_s\sqrt{R_l^2+R_s^2}}\int_0^\infty\frac{dF}{1+F^2}$$

Where:

$$F = \frac{2\pi fL_s}{\sqrt{R_l^2+R_s^2}}$$

so that:

$$V_n^2 = \frac{4kTR_sR_l^2}{2\pi L_s\sqrt{R_l^2+R_s^2}}\left[\arctan F\right]_0^\infty$$

The definite integral evaluates to $\frac{\pi}{2}$, so:

$$V_n^2 = \frac{kTR_s}{L_s}\cdot\frac{R_l^2}{\sqrt{R_l^2+R_s^2}}$$

and the bandwidth, B, is given by:

$$B = \frac{V_n^2}{kTR_s} = \frac{R_s}{4L_s}\cdot\frac{R_l^2}{\sqrt{R_l^2+R_s^2}}$$

We will have to hold over to Part 2, the case where C_l is significant, as it is if there is a screened lead from the transducer to the amplifier. Meanwhile, it is worth noting that R_l and R_s form an attenuator that reduces both the signal voltage and the noise voltage by the same amount, so the signal-to-noise ratio at the output of the transducer is not affected. BUT, the reduction in signal level makes the noise of the amplifier that much higher in relation, so the signal-to-noise ratio at the amplifier *output* is reduced. So, there is a good reason for making R_l much higher than R_s, but we have not taken into account the noise contribution of R_l itself, which requires C_l also to be included.

Adding Noises

If two noise sources are entirely independent of each other, their noise powers add, so their voltages or currents add 'rms-wise', i.e. the result is the square root of the sum of the squares of the separate voltages or currents. Such independent sources are termed *uncorrelated*.

Annex: Evaluation of $\Gamma(^1/_2)$

By definition,

$$\Gamma(n) = \int_0^\infty x^{n-1}e^{-x}dx$$

Put $x = t^2$

$$\Gamma(n) = \int_0^\infty t^{2n-2}e^{-t^2}.2tdt$$

$$= 2\int_0^\infty t^{2n-1}e^{-t^2}dt$$

$$\therefore \Gamma\left(\frac{1}{2}\right) = 2\int_0^\infty e^{-t^2}dt$$

Now comes the clever bit. If we call the integral I, we can write:

$$I = \int_0^\infty e^{-x^2}dx$$

There is nothing special about *x*, so:

$$I = \int_0^\infty e^{-y^2}dy$$

$$I^2 = \int_0^\infty\int_0^\infty e^{-(x^2+y^2)}dxdy$$

over the positive quadrant of the x–y plane.

Changing to polar co-ordinates:

$$I^2 = \int_0^{\frac{\pi}{2}}\int_0^\infty e^{-r^2}rdrd\theta$$

$$= \int_0^{\frac{\pi}{2}}\left[-\frac{1}{2}e^{-r^2}\right]_0^\infty d\theta$$

$$= \int_0^{\frac{\pi}{2}}\frac{d\theta}{2} = \frac{\pi}{4}$$

$$\therefore I = \frac{\sqrt{\pi}}{2} \text{ and } \Gamma\left(\frac{1}{2}\right) = \sqrt{\pi}$$

E

Next Time

In Part 2, we will look at noise in active devices, valves (tubes) as well as transistors, Part 3 will deal with noise in circuits, and in Part 4, I hope to deal with measurements and experiments.

What's On?

Preserving Yesterday for Tomorrow

The Story of Television is the title of a new exhibition, organised by the Museum of Communication Foundation. Presented at the Almond Valley Heritage Centre, Livingstone, the exhibition includes live exhibits such as television cameras and receivers, together with archive television footage played through vintage television receivers.

The foundation has suffered rocky times since it was established two years ago by Harry Matthews, a collector of vintage television, radio and telecommunications equipment. Matthews gave over his collection to the foundation in January last year. Shortly afterwards, the group was requested to vacate its permanent premises at the Bo'ness Heritage Centre.

Scottish Power came to the rescue, providing storage space at its Bandeath and Bonnybridge depots. But the lack of permanent display space has meant that the Foundation has had to seek out temporary exhibitionopportunities.

Almond Valley Heritage Centre is one such opportunity, which follows hot on the heels of a two week appearance at the Edinburgh Science Festival.

While exhibitions are a key element of the work of the Museum of Communication Foundation, volunteers work hard behind the scenes cataloguing and restoring pieces for future displays.

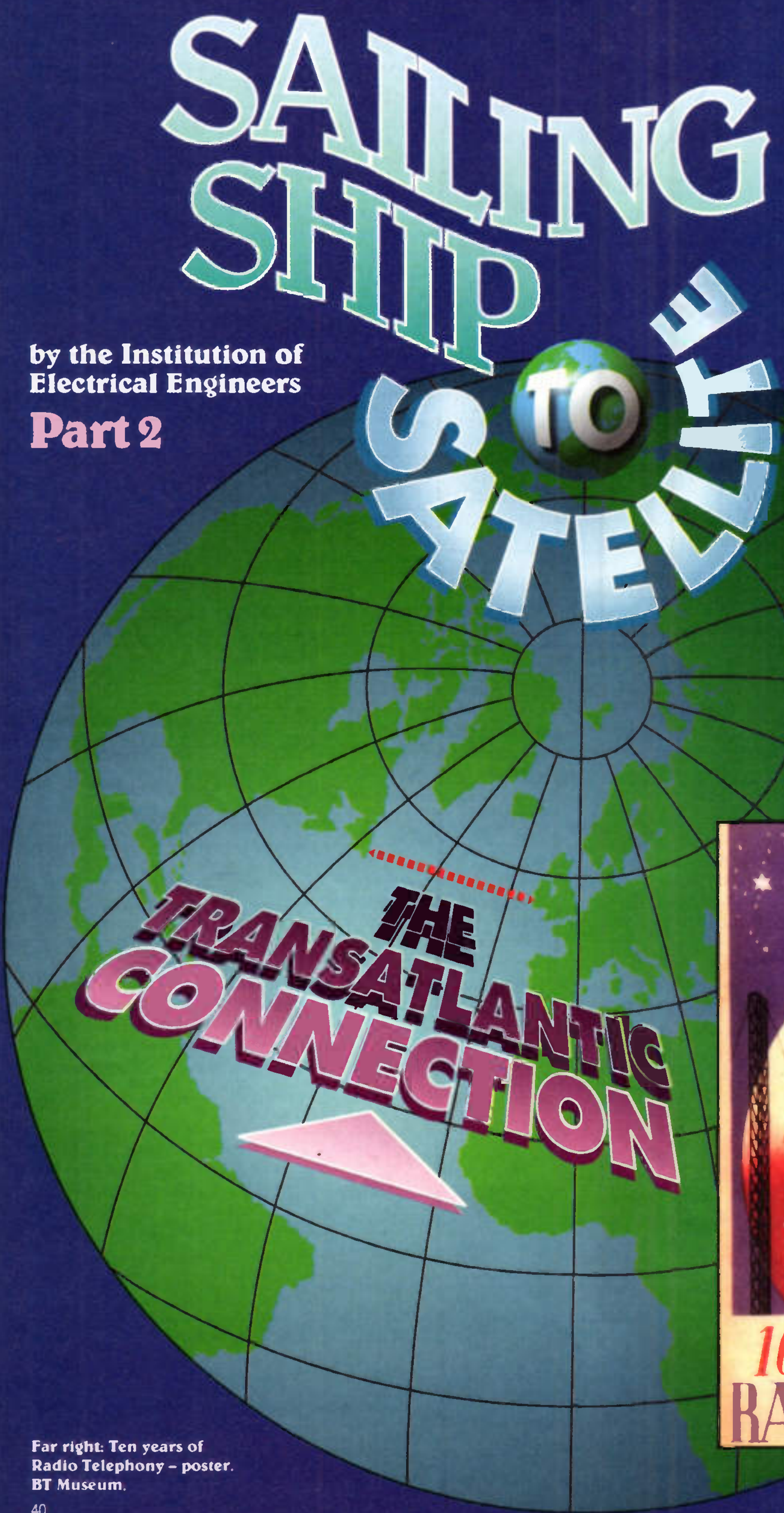
According to David Pack, chairman of the Foundation, "It is essential that we continue to recruit new members, and retain those we already have". Membership costs £10 annually. Members are encouraged to take on active roles within the foundation – this can vary from staffing exhibitions to contributing material to the Foundation newsletter.

The Story of Television is open daily, and runs until October 1995.

Contact: Museum of Communication Foundation, Tel: (01506) 823 424.

Until the mid-1920s the few long-distance radio-telegraphy links used long waves (up to 10,000m or even more), working at high power levels, and with huge and expensive antenna systems. Marconi believed that similar results could be achieved with much shorter waves, of the order of 10m.

SAILING SHIP TO SATELLITE



by the Institution of Electrical Engineers

Part 2

The Transatlantic Connection

In 1924 C. S. Franklin of the Marconi Company developed the 'beam' system of directional antennae, and by 1926 it was in use for telegraphy between Britain and Canada. This system posed a serious threat to the cable services, and in 1928 the British interests in international cables and radio merged into a single company, Cables and Wireless, now Cable and Wireless.

Early Radio Telephonic and Picture Transmissions

The transmission of speech by radio telephony, however, was being developed by the Marconi Company for the British Post Office and by RCA in the US. Long-wave transmitters at Rugby, England and at Rocky Point, and receivers at Wroughton, England and Houlton, Maine were demonstrated in 1926 and brought into public use in 1927. They provided a two-way telephone channel on long waves, which needed so much bandwidth that there was no prospect of providing a second one if the traffic needed it. Short wave radio telephony was, however, introduced in June 1928 between London and New York, and provided 15 more channels by 1956.

One other innovation of the 1920s is worth more than a footnote. The Marconi Company in conjunction with the Radio Corporation of America began a transatlantic photoradio service. In December 1924 the Caernarvon station participated in the first experimental wireless transmission of still pictures between England and the USA. The picture to be transmitted was mounted on a rotating cylinder which was traversed by a beam of light, and the modulation of the reflected light was converted to electrical signals for transmission. At the receiving end a similar cylinder was rotated in synchronism. Even at best it produced a poor quality repro-

Far right: Ten years of Radio Telephony – poster. BT Museum.

duction, but it was a promising start, and in 1926 the system was used commercially between the Marconi Company, Radio House, London, and New York. Although the process was too slow for newspaper use, a wide range of material was copied across the Atlantic, including wills, cheques, specimen signatures, and even images of the latest Paris fashions. On 3 November 1929 the Marconi-Wright facsimile apparatus, based on super high-speed Morse telegraphy, was demonstrated. Documents and photographs of all types could be transmitted across the Atlantic in an average time of three minutes. The service was eagerly taken up by the newspapers and by 1934 Cable and Wireless had extended the service to Australia.

The Transatlantic Telephone

On 25 September 1956 an entirely new medium of transatlantic telephone communications was inaugurated. For the first time an undersea cable allowed voice communication by telephone between London and New York, and London and Montreal. Designed to link the US and Canada with the UK and thence other European countries, the transatlantic telephone cable, later christened TAT 1, took just three years to complete. A co-operative effort of three nations, the system was jointly owned and developed by the American Telephone and Telegraph Company and its subsidiary, the Eastern Telephone and Telegraph Company (operating in Canada), the British Post Office, and the Canadian Overseas Telecommunications Corporation. The project was undertaken by the British Post Office Engineering Department, the Long Lines Department of the American Telephone and Telegraph Company, Bell Telephone Laboratories and the Canadian Overseas Telecommunications Corporation. On both sides of the Atlantic the engineers of these companies worked as a team with the single objective of constructing the best possible system. Their achievement owes much to the research and practical work by the American Telephone and Telegraph Company and the British Post Office during the previous thirty years in submarine cable and repeater development.

> *Hullo, New York!*
>
> British Post Office, 1956.

Technology Helps Cable Development

As we have seen, the first commercial voice links across the Atlantic were inaugurated in 1927 with a single radio telephone circuit. It was very expensive. In 1928 the basic rate for calls from London to New York was reduced to £9.00 for the first three minutes and in the mid-1930s to £6.00. Moreover, the system was subject to atmospheric disturbance and fading, and at best had a limited number of frequencies available for circuits. At the time people discussed the desirability of a telephone cable across the Atlantic, but there were too many technical difficulties. The chief problem was the need to divide the cable into sections, linked by repeaters along its length, to boost the signal over the vast distances across the Atlantic. Moreover, the repeaters would have to be sufficiently rugged and reliable, to work beneath two miles of ocean for decades, because it would be very difficult indeed to adjust or repair them once they had been laid. In the 1930s, the appropriate technology to overcome these problems was only experimental, and in the decade of the Great Depression little progress was made.

However, during the 1940s, the necessary equipment was gradually developed. The crucial elements necessary for successful transatlantic telephony by cable included the development of coaxial cables with polythene insulation. Polythene (polymerised ethylene) had greatly superior electrical insulating qualities. It was a British invention made in the laboratories of ICI, and production began just as the Second World War broke out. Two other essential technological developments were improved carrier frequency equipment and broad-band submerged repeaters.

US research on repeaters culminated in the provision of two cables with repeaters – between Havana, Cuba, and Key West, Florida. British research focused on the medium depths in which cables were laid around the coast and across to the European mainland. In 1943, the first submerged repeater (suitable for depths to 200 fathoms) was laid in the Irish Sea between Anglesey in Wales and the Isle of Man. Other coaxial cables with submerged repeaters followed later to link the UK with Germany, Belgium, Denmark and Norway.

Telephone Cable Links

On 1 December 1953, the Postmaster General announced that a contract had been signed to construct and maintain a telephone cable system to link the USA and Canada to Britain. The first difficulty encountered was in the selection of a route for the two cables across the Atlantic (one for each direction of transmission) as the shortest routes were already occupied by telegraph cables. A new route to the north was found, and sites to land the cable were chosen in Newfoundland and Scotland. Initially, the system consisted of two submarine cable links extending from the Scottish coast near Oban to the Canadian-US border near St. John, New Brunswick via Newfoundland and Nova Scotia.

The main Atlantic crossing consisted of two cables, one for each direction, designed by the Bell Laboratories, whose previous experience was with deep ocean telegraph cables. Each cable had 51 one-way flexible repeaters installed at 37-mile intervals along the cable. The British Post Office designed the cable for the shallow waters of the 300 mile Cabot Strait. The Post Office Research Station had developed a novel system of two-way repeaters spaced about 20 miles apart, thus allowing transmission in both directions over a single cable. Because of the shallow depth, steel-protected armoured cable was necessary to prevent damage from ships' anchors, and trawler gear. Most of the cable was made at a factory specially constructed for the purpose by Submarine Cables at Erith, Kent.

Taking cable aboard near Greenwich. BT Museum.

From Sydney Mines, Nova Scotia, to Portland, Maine – a line-of-sight microwave link completed the system. The countries operating the system each provided the necessary connection from the ends of the cable system to the operating terminals in London, White Plains (New York), and Montreal – and then to the continents beyond. The role as inter-continental link was the main priority in setting the basic objectives of the system.

It was important to Britain that as much as possible of her share of the project should be supplied in kind rather than imported from elsewhere. As Dr Arnold Lynch, then a research engineer at the British Post Office research station at Dollis Hill, noted,

'We hoped that British polyethylene (poly-

Taking cable ashore. BT Museum.

thene) would be used, but it was acceptable only if it were exactly like the American polyethylene which the repeaters were designed to work with – alike, in particular, in the extent to which it would be compressed by the water pressure at the sea-bed.

In July 1954 the only measurements available were of small discs of British polythene, and cables made from American material. The results appeared to be different; but when I discussed them with a Bell Labs. physicist we were able to develop the theory of what was occurring and show that the apparent differences were the differences between the discs and cables, not between the American and British materials. In the event, nine-tenths of the cable was made in Britain, using British polyethylene, so Britain was saved from having to buy American material with dollars that it did not have."

Except for the shore ends, the whole of the transatlantic cable was laid by the British cable ship *Monarch* (commissioned in 1946) the only cable ship afloat capable of carrying 1,500 nautical miles of cable to be laid in one piece along the deepest stretch of the route across the Atlantic. *Monarch's* cable machinery had to be adapted for the revolutionary TAT 1 cable. The size of the cable engine drums was altered to avoid damaging the long flexible repeaters as they were paid out. Each repeater with its tapering tail cables was some 70 feet (21m) long. Manufactured by Western Electric, they were designed to be only slightly larger in circumference than the cable itself to allow them to pass along the laying gear while *Monarch* was still travelling, albeit at a reduced speed. For laying rigid repeaters she had to stop each time.

At the end of June 1955 *Monarch* began laying the first 200 miles of shore end cable from Clarenville, Newfoundland, leaving the end marked by a buoy. Then she returned to Britain to pick up more cable, and laid 1,500 miles of cable across the Atlantic to Rockall Bank in the north Atlantic. After picking up yet more cable, she then laid the last 500 miles toward Oban, where she spliced it to the shore end already in place. On 26 September 1955 the first of the two Atlantic cables was complete.

The project recommenced in Spring 1956 with a similar programme, once the Atlantic weather had improved. TAT 1 was completed on 14 August, three months ahead of schedule.

The new service was inaugurated in London at 4.00p.m. on 25 September 1956, when the Postmaster General received the call from the Chairman of AT&T in New York. In the first 24 hours of public service there were 588 London/New York calls and 119 between London and Canada. It was the beginning of a substantial increase in traffic. During its first year of service TAT 1, with its 36 telephone circuits, carried twice as many calls as the radio telephone circuits had in the previous year.

The first transatlantic cables, in 1956, were regarded as a major technological achievement on which to base future research and improvements. They were also a remarkable testament to the co-operation of the engineers and businessmen of the three countries involved.

Telephone traffic expanded rapidly once the new technology was in place, and three years later TAT 2 was laid between Newfoundland and France, and in 1961 CANTAT 1 provided 60 circuits between the UK and Canada. This system employed a revolutionary lightweight cable with two-wire rigid repeaters, and became the world standard for deep-water cables. With each cable the capacity increased tremendously. TAT 5 provided an 845-circuit system between the USA and Spain, and in 1976 TAT 6 increased capacity to 4,000 circuits, while in 1988 TAT 8 – the first optical fibre cable – vastly increased capacity and efficiency.

TAT 9 brought into service in March 1992, has 15,000 circuits providing capacity for 80,000 telephone calls, and for routing television transmissions, TAT 9 gives a standard performance comparable to that of communication satellites – and it is their development which we shall consider next.

> ***An artificial satellite at the correct distance from the earth would make one revolution every 24 hours . . . Three repeater stations 120 degrees apart in the correct orbit could give television and microwave coverage to the entire planet.***
>
> **Arthur C. Clarke, 1945.**

Satellites

Arthur C. Clarke's vision was remarkable. In 1945 no object had been placed in orbit. His article in the British journal *Wireless World* described what are now called geosynchronous satellites, that is satellites placed in orbits about 22,000 miles above the earth's surface so that their orbital period would exactly match the daily rotation of the earth on its axis. He gave the basic requirements for the satellite's height and orbit and calculated the rocket velocity required to place the satellite into orbit. But several technological innovations and developments would have to occur before Clarke's concept could become reality.

Space Communication

The realisation of satellite communication was a by-product of the East-West arms race. The launch of the first man-made satellite into orbit by the USSR on 4 October 1957 spurred the United States into an accelerated programme for the development of rockets and space vehicles. The United States launched its first satellite, Explorer 1, on 1 January 1958. The space programme presented almost endless technological problems that challenged the resources of all engineering disciplines. In practical terms the research and engineering sponsored by the US Department of Defense, and the predecessor of the National Aeronautics and Space Administration (NASA), formed on 1 October 1958, were essential for the launching of satellites.

At the same time forward-looking individuals in the communications industry recognised the potential of satellites for communications. Among these was John R. Pierce of the Bell Telephone Laboratories (BTL) of the American Telephone and Telegraph Company (AT&T) who was at the forefront of many fields of research in telecommunications science, including antennas and travelling wave tubes. In 1954, without knowledge of Clarke's paper, he spoke to an Institute of Radio Engineers group in Princeton, New Jersey, about the possibilities of satellite communication. He envisaged unmanned satellites with simple electronic equipment aboard (active satellites) or satellites which would be passive reflectors with no electronic equipment at all. In 1958, after the launch of the first military satellites, Pierce and his colleague at BTL, Rudolph Kompfner, saw a picture of a large inflated sphere that NASA proposed to place above the earth to measure the density of the upper atmosphere. They realised that the sphere was exactly what was needed for passive satellite communications. Their proposal was accepted as the basis for a joint experiment by NASA, Jet Propulsion Laboratory (JPL), and BTL. BTL developed and paid for the equipment it provided. The project was named Echo.

Much of the technology necessary for this project and for early active satellites had already been developed. Kompfner invented a primitive travelling-wave tube in Birmingham, England, during the war, which Pierce modified later. Transistors, invented in 1947 by J. Bardeen, W. H. Brattain and W. Shockley of BTL had been sufficiently improved in reliability and performance to be substituted for vacuum tubes for most of the functions necessary in satellites, requiring less power to operate and with greater reliability. Solar cells promised a light and reliable source of electric power. The maser, invented by C. H. Townes (also of BTL) in 1954, was later modified to form a sensitive microwave receiver to be used in conjunction with large-diameter dish antennas to receive and amplify the weak satellite signals.

The passive satellite Echo successfully measured atmospheric density and demonstrated the potentials of satellite communication. Moreover, it aroused public interest and at AT&T headquarters 'imagination caught fire'. The vision of John Pierce and his colleagues at BTL, of active satellites, became company policy at AT&T. Financing and staff were set up quickly for a major project. The project occupied 450 people and, at its peak, occupied more people than any other project in the history of BTL up to that time. The satellite was named Telstar – an inspired choice of name which caught the public imagination on both sides of the Atlantic.

Telstar – The First Active Communications Satellite

Leroy C. Tillotson, with Rudolph Kompfner, was instrumental in the Telstar project. On 24 August 1959 he wrote a memorandum for internal circulation at BTL in which he proposed a satellite with specifications very similar to those which were actually used on Telstar when it became operational. The primary object of Telstar was to prove that good quality long distance telephone, telegraph, facsimile and television transmission could be achieved by satellite. Its secondary aim was to continue the development of satellite technology that began with Pierce's Echo project.

Telstar Satellite in laboratory. BT Museum.

In 1960 work began on the project at BTL, but not until 27 July 1961 did NASA agree to supply AT&T with a booster rocket to launch the satellite into space. European Post Office organisations were very keen to participate, and both Britain and France agreed to co-operate. On 14 February 1961 a memorandum of understanding was signed by the British Post Office and NASA confirming an intention to develop the medium. By the spring of 1962 a British Post Office team, under the direction of John Bray, Head of Post Office Space Systems Branch, and F. J. D. Taylor, Head of the Radio Experimental Branch at Dollis Hill, was formed to develop and build a ground station for tests with Telstar and another US communications satellite, Relay. They sought a site as far west as possible to facilitate transatlantic communication and as far away as possible from existing terrestrial microwave networks to avoid interference in the shared frequency bands.

These considerations led them to the Lizard Peninsula in Cornwall where they found a site at Goonhilly. Meanwhile, the US built its tracking station at Andover, Maine, and France built one at Pleumeur Bodou in Brittany. The latter stations incorporated immense horn antenna systems some 3,600 square feet (350 square metres) in area. Two buildings housed the transmitting, receiving and control equipment for the Telstar and Relay satellite projects. But Bray and Taylor realised that with the 'more limited financial and other resources available to the Post Office', a simpler and cheaper version would have to be developed for the UK ground station.

With the aid of Tom Husband, who had designed an aerial for use at microwave frequencies for Sir Bernard Lovell's 250-foot (76 metres) radio telescope at Jodrell Bank, Bray and Taylor found a solution. They designed and constructed an 85-foot (26 metres) diameter steerable aerial sturdy enough to withstand the gales of the Lizard Peninsula. Two other components crucial to the success of the station were obtained. The Mullard Research Laboratories designed and constructed a low-noise 'maser' microwave amplifier to cope with the very weak signals received from the satellites, and the Services Electronic Research Laboratory at Baldock modified and manufactured their S-band (3GHz) travelling wave tube for the high frequencies used. With these innovations and much teamwork by many people over long hours the Goonhilly satellite ground station was completed in time for the first tests with Telstar 1 in July 1962. Its entire cost was a fraction of the cost of its rivals at Andover and Pleumeur Bodou, and it out-performed them as well. Indeed, it became a model for many ground stations that were built later as part of the Intelsat world-wide satellite network.

Live Transatlantic Satellite Transmissions

At 08.35GMT (Greenwich Mean Time) on 10 July 1962, NASA launched the Telstar satellite from Cape Canaveral, Florida. A demonstration television broadcast from the USA to Britain and France via the satellite was planned for that evening (the first live telecast from America to Europe) but the transmitted signals were very weak and the BBC's imperturbable commentator, Raymond Baxter had the unenviable task of explaining the fuzzy images to a nationwide television audience. What had happened was that, owing to a last minute misunderstanding, Post Office engineers had reversed the direction of polarization of the Goonhilly aerial which was thus only able to pick up very weak signals. The reversal was corrected during the day of 11 July and excellent television images were received at Goonhilly from Andover during the evening. Later that night, television transmissions were made from Goonhilly showing scenes from the control room, with commentary from Raymond Baxter and Ian Trethowan of the Independent Television Authority (ITA), and these were broadcast live throughout the United States.

In Washington, DC, where the Senate was debating the regulation of satellite communications, there was vast interest in the broadcast of the first Telstar images received at Andover. In Britain, on the night of 11 July the BBC transmission of these signals excited public enthusiasm. A popular song was written called 'Telstar', which was performed by The Tornados, a well-known pop group of the time.

There were severe limitations to Telstar's use as a transatlantic communications and broadcast medium. Because of its low, elliptical orbit which it completed in about three hours, the satellite was seldom visible from both sides of the Atlantic for as long as 30 minutes during each orbit. Moreover, complex tracking equipment was necessary to follow its progress. But Telstar's importance was that it demonstrated conclusively that although transatlantic transmissions were intermittent, two-way transatlantic satellite communication was technically feasible for television and for multi-channel frequency division multiplex (FDM) telephone transmission. On 23 November 1963, when news came of the assassination of President Kennedy, Goonhilly was hurriedly activated and within three hours of the event, television pictures of the tragedy were broadcast all over the world.

The next great step was the launch of geosynchronous satellites. In 1964 eleven nations signed agreements to set up the International Telecommunications Satellite Consortium, INTELSAT. Intelsat 1, the first communications satellite to operate in a geostationary orbit, was launched on 6 April 1965. From August 1965 it provided a commercial transatlantic communications service, with the principal earth stations in Europe taking turns to act as the European space terminal. Intelsat 2, providing greater power and wider bandwidth, succeeded Intelsat 1 and gave unbroken multiple access to all earth stations in the Atlantic region. Indeed, in 1994, 126 countries belong to Intelsat, and the Intelsat series of 19 satellites provides virtual global coverage with a capacity of tens of thousands telephone circuits and several television channels.

Today, cables and satellites are competing to provide communications across the Atlantic to carry speech, television, and computer data. The demand seems to grow as fast as new services can be introduced. For the route we have described – London to the USA and Canada – it is possible that fibre-optic cables will be the preferred method for the next few years, but new inventions come so fast that any prophecy is difficult.

British Post Office poster showing the giant aerial at Goonhilly, Cornwall. BT Museum.

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TECHNOLOGY WATCH!

with Keith Brindley

While Rupert Murdoch bounds like a kangaroo (well, he *is* an Aussie after all) to the front of the race to develop and have digital television services on-air and operational, it might have seemed to a casual observer that the follow-up technologies have not been giving much thought to what their next move should be. Nothing, though, could be further from the truth. Videocassette recorders which, let's face it, rely totally on the availability of television as an entertainment medium for their existence, now face the prospect of digitalisation too.

The leading manufacturers of videocassette recorders based on the worldwide VHS standard have already got together to develop a digital variant (known as D-VHS) in which the digital television signal data is stored in its originally compressed and encrypted form, direct from the digital decoder. On playback, the data is then rerouted to, and decoded by, the decoder for your very own eyes on screen. D-VHS videocassette recorders are backwards-compatible in that they can play existing non-digital cassettes.

Between 3·5 hours of high-definition, and 49 hours of long-play, low-definition video can be recorded on each D-VHS cassette by the system. Coupled with the move to digitalisation, these new videocassette recorders will also be able to store some 44 gigabytes of data in an archive-style tape backup system for use with personal computers.

One of the points about videocassette recorder use in the past has always been that playback quality has never been as good as video disk systems' quality. D-VHS could change all that.

On the other hand, while undoubtedly of better quality, video disk systems currently haven't got the ability to record. This has always relegated such an entertainment medium to low down the consumer's wish list. Pioneer, however, recently announced a recordable video CD. The disk is based on the Toshiba variant, and can record up to just over 2 hours of full-motion video.

Maybe the VCR's time as the premier entertainment system after the television is limited.

Meanwhile on the personal computer front, writable CD-ROMs look set to appear on a computer desktop near you shortly. Panasonic has developed a low-cost (well, lower than existing devices anyway) CD-ROM drive which can be used to write to special recordable CD-ROM. While they won't be available, until at the earliest, the end of the year, it's a sign of the times that they have been developed. Everyone knew it was a question of time, and it seems the time is now.

Prices (initially) will be over twice the price of existing quad-speed CD-ROM drives, but as manufacturing steps up, it's likely that they'll end up only 20 to 40% more expensive than ordinary drives.

That will be the Daewoo

As if a brand new marketing strategy to sell cars directly to us motorists was not enough, South Korean manufacturer Daewoo has developed a brand new type of display known as an *actuated mirror array* (AMA) device which the company is touting to be the next thing for laptops computers and TVs. With an investment totalling well over £100 million, this is obviously going to be worth a look. I'll report back as soon as I get some further information.

The Paperless Desktop – at Last?

Every now and again I like to have a look at a product which I think has the potential to reshape technology at close hand. The product here is a clever combination of scanning hardware and optical character recognition software, enabling users to get graphical or typed information rapidly into the computer.

Visioneer's PaperPort is a neat product, which you can place between your computer's keyboard and CPU. When you want to use it you simply place the paper to be copied into the access slot: whereupon the PaperPort turns itself on, pulls the paper through, scans it and displays the paper on screen, in a single operation. From there, using the PaperPort software, you can choose one of several options:

- **Fax** – if you have a fax modem or server, PaperPort can pass the image through to your fax software for transmission.
- **OCR** – built-in OCR software can be used to recognise typed characters, changing the image to editable text files for your word processor. Alternatively, if you already have a preferred OCR package you can use it to do the conversion.
- **Annotation** – you can mark-up documents on-screen with highlight, sticky notes, arrows, text and free hand tools.
- **File** – store and retrieve documents via the in-built filing system software.

It has to be said that there is nothing unique in any *one* of PowerPort's features. Everything's been around individually for years on the computer desktop, but to put all this in a compact and relatively low-priced single unit is simply a *brilliant* concept.

PowerPort is available now for PC and Mac platforms and a networkable version should be available shortly. It is distributed in the UK by:

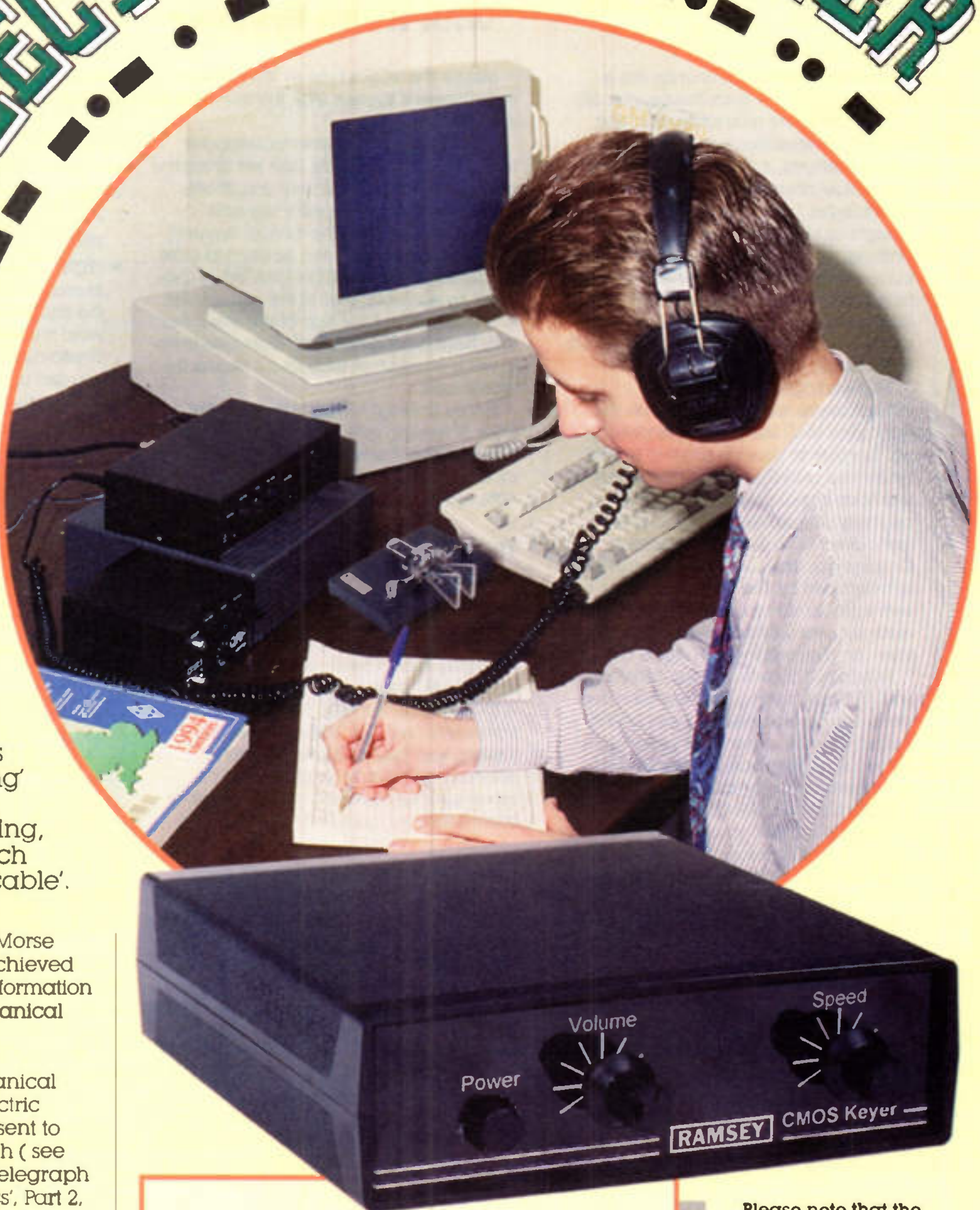
Computers Unlimited (0181 200 8282). Price: £369.

The opinions expressed by the author are not necessarily those of the publisher or the editor.

Text by Robin Hall G4DVJ

KIT AVAILABLE (90018) Price £26.95

CMOS ELECTRONIC CW KEYER



Telegraphy has been around long before the days of radio, when it was the main mode for the transmission of messages along telegraph wires. Even today, the words 'telegraph signalling' also synonomous with train signalling, and phrases such as sending a cable'.

LONG before the advent of Morse Code, signalling was achieved by pulling levers and information conveyed by cables to mechanical semaphore signals.

Later with the advent of electromagnetism the mechanical cables were replaced by electric cables, and the results were sent to an electromagnetic telegraph (see the Cooke and Wheatstone Telegraph in 'A Brief History of Electronics', Part 2, Issue 87 page 43).

With the introduction of a form of 'on off' keying code known as Morse Code by Samuel Morse in 1844 'telegraphy' began to evolve. In 1851 International Morse Code was devised into a form that we are more familiar with today. The origin of the terms such as 73 and 88 are shrouded in mystery from those early days. When wireless was invented, International Morse Code became the ideal method to send messages by 'on off' keying of a transmitted carrier wave (CW), and became known as Wireless Telegraphy (W/T).

FEATURES

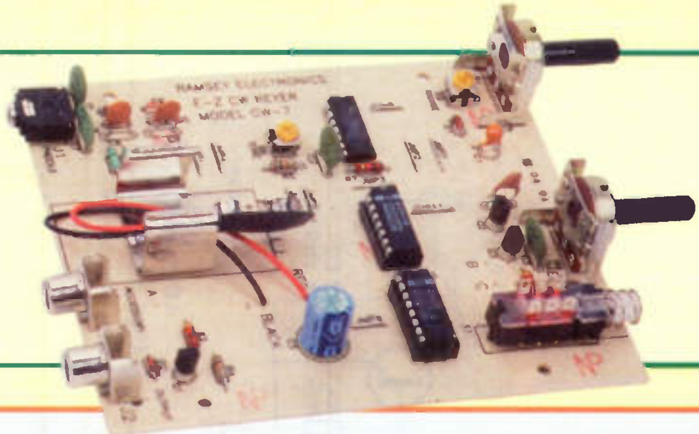
- Easy to build
- Adjustable speed
- Adjustable volume
- 9V operation

Please note that the case shown above is not included in the kit and must be purchased separately.

2 PROJECT RATING

Specification

DC power supply source:	+9V PP3 battery
Supply current minimum to maximum:	20 to 125mA
Rated loudspeaker impedance:	8Ω
Audio output power:	200mW
PCB size:	120 x 102mm



Today there are other forms of telegraphic codes such as those used by the Russians and the Japanese.

The traditional method of sending Morse Code using a straight key can be rather tiring, especially as the movement is up and down. From time immemorial, other methods of keying have been tried. The most popular alternative method using some form of 'bug key'. This had a sideways keying movement and the original mechanical 'bug key' had a series of weights and springs introduced to produce mechanical dots. All the operator had to do was to make the dashes, and then select the right amount of dots. The problem was that the energy stored in the spring which provided the dots ebbed away, this did not present a problem as the maximum number of dots required technically was 8, and the movement could be repeated. The CMOS Keyer ('Elbug') presented here, electronically produces an infinite number of dots and dashes, depending on how long the battery lasts out.

A	· –	M	– –	Y	– · – –
B	– · · ·	N	– ·	Z	– – · ·
C	– · – ·	O	– – –	1	· – – – –
D	– · ·	P	· – – ·	2	· · – – –
E	·	Q	– – · –	3	· · · – –
F	· · – ·	R	· – ·	4	· · · · –
G	– – ·	S	· · ·	5	· · · · ·
H	· · · ·	T	–	6	– · · · ·
I	· ·	U	· · –	7	– – · · ·
J	· – – –	V	· · · –	8	– – – · ·
K	– · –	W	· – –	9	– – – – ·
L	· – · ·	X	– · · –	0	– – – – –

Punctuation

Full Stop	· – · – · –	Equals sign (=)	– · · · –
Comma	– – · · – –	Stroke (/)	– · · – ·
Question Mark (?)	· · – – · ·	Mistake	· · · · · · · ·

Procedural Characters

For procedural characters made up of two letters, they are sent as a single letter with no break between them.

Start of Work (CT)	– · – · –
Wait (AS)	· – · · ·
End of Work (VA)	· · · – · –
End of Message (AR)	· – · – ·
Invitation to Transmit (K)	– · –
Invitation to a Particular Station to Transmit (KN)	– · – – ·

The Morse Code.

Circuit Description

As an aid to understanding the circuit, a block diagram of the CMOS CW Keyer is shown in Figure 1 and the circuit diagram in Figure 2. U1,CMOS type 4001, is a quad 2-input NOR gate device. U2, CMOS type 4093, is a quad 2-input NAND Schmitt trigger device. U3, CMOS type 4027, is a dual J-K Master-slave flip-flop device.

Two of U2's NAND gates are configured as a latch to accomplish self-completing dits and dahs as soon as either side of the paddle device is touched.

A third NAND gate functions with R1, R2 and timing capacitor C2 as the dot clock, an adjustable 18 to 100Hz clock oscillator. R1 is the front panel CW speed control. Trimmer R2 is an internal 'speed range' adjustment.

U3's J-K flip-flops (divide-by-1 dit, divide-by-2 space, divide-by-3 dah), generate correct standard CW timing.

Two of U1's NOR gates drive Q1, the output switching transistor, which keys low-voltage solid-state transmitters or a relay. These gates also control the fourth U2 NAND gate as a sidetone oscillator, whose pitch is adjusted by R6. Q2 and Q3 amplify the sidetone for speaker operation. R8 gives front panel control of sidetone audio volume.

Hints and Tips

There are a number of suggestions that could enhance the use of the CMOS CW Keyer, preferably before completion. Using IC sockets is generally good practice, but not essential. Two sockets have been prefitted by Ramsey Electronics. If the remaining one were to be used, it would require one 16-pin DIL IC socket.

The audio output is directly

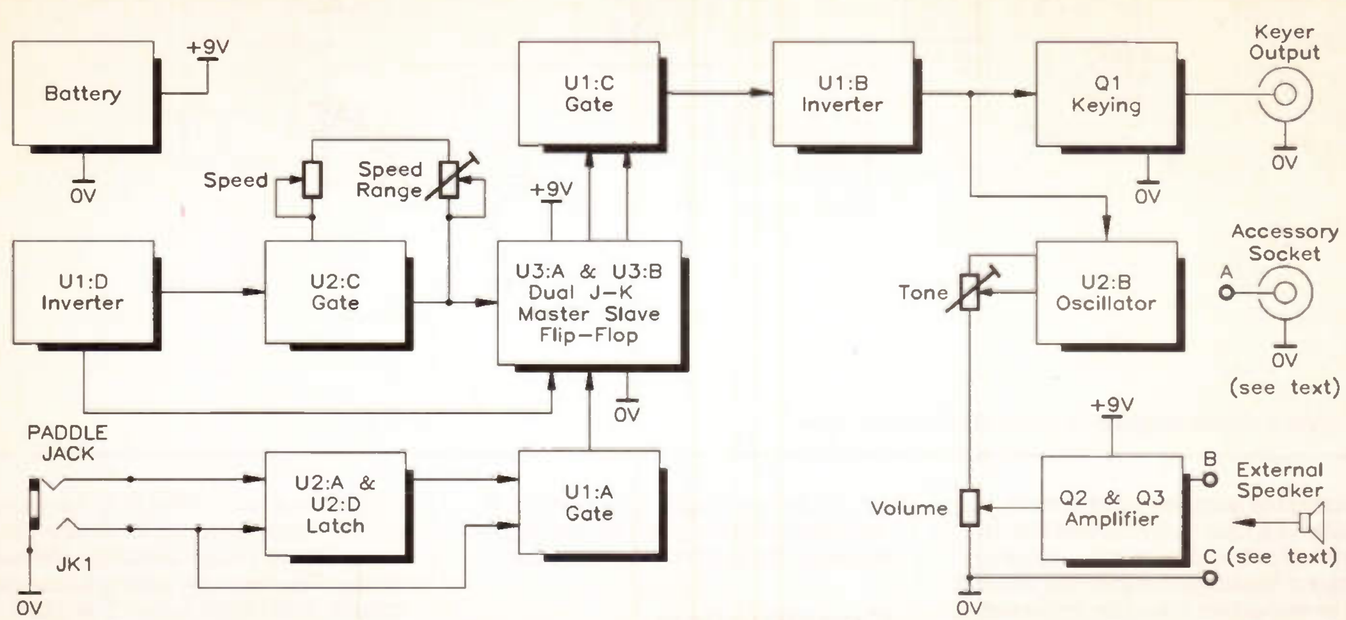


Figure 1. Block diagram of the CMOS Electronic Keyer.

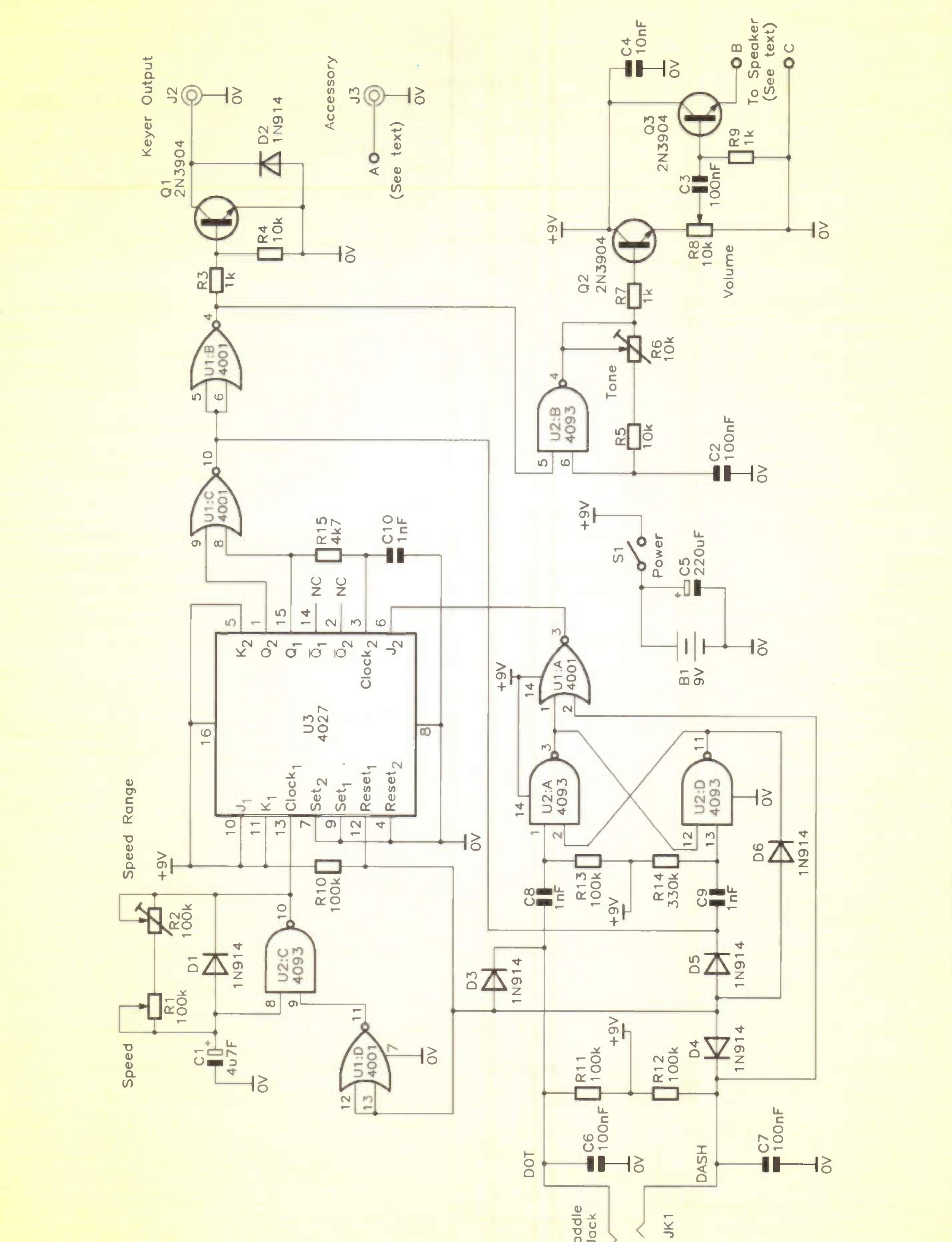


Figure 2. Circuit diagram of the CMOS Electronic Keyer.

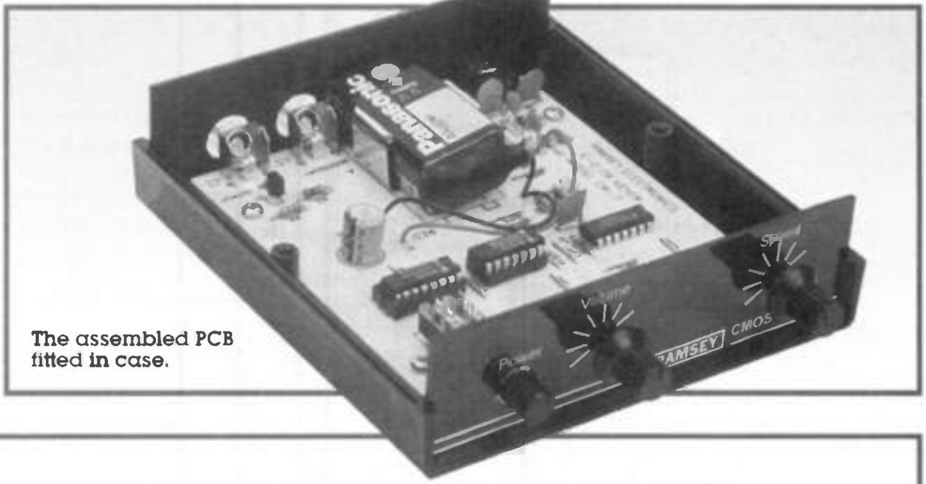
obtainable from the board, from positions B and C, for connection to an 8Ω loudspeaker. If one wanted to make a modification then an internal 8Ω loudspeaker could be mounted in the box, but holes would have to be made in the lid for the sound. Another suggestion is to wire position A from the Accessory Socket J3 to position B, and feed the audio out via the phono socket to an external loudspeaker.

Construction

The CW-7 kit includes all the components required to build the CMOS Electronic Keyer PCB. It is good practice to sort out, and identify the components before soldering them in place. This way one gets to know the values, and check to see if any are missing before soldering them in position. Figure 3, which shows the PCB legend will assist PCB assembly.

It is best to start-off by fitting and soldering the *larger* components first, such as switches, sockets and potentiometers. Note this is contrary to our normal recommendation and is based on Ramsey's recommended assembly sequence and check list.

There are very good instructions supplied with the kit, and they show a logical path to follow. If you are new to project building, refer to the Constructors' Guide (order separately as XH79L) for helpful practical advice on how to solder, component identification and the like.



The assembled PCB fitted in case.

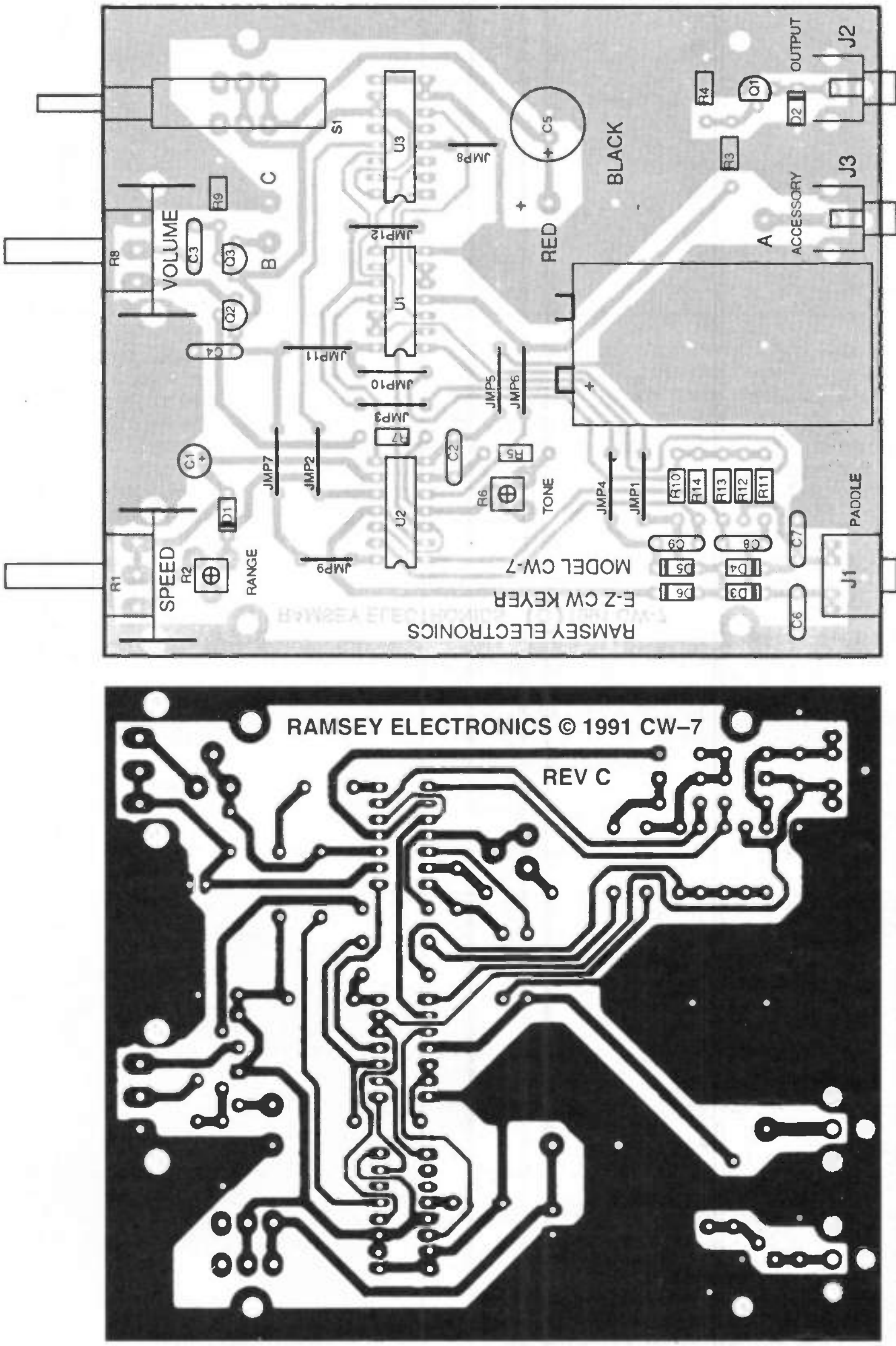


Figure 3. PCB legend and track.

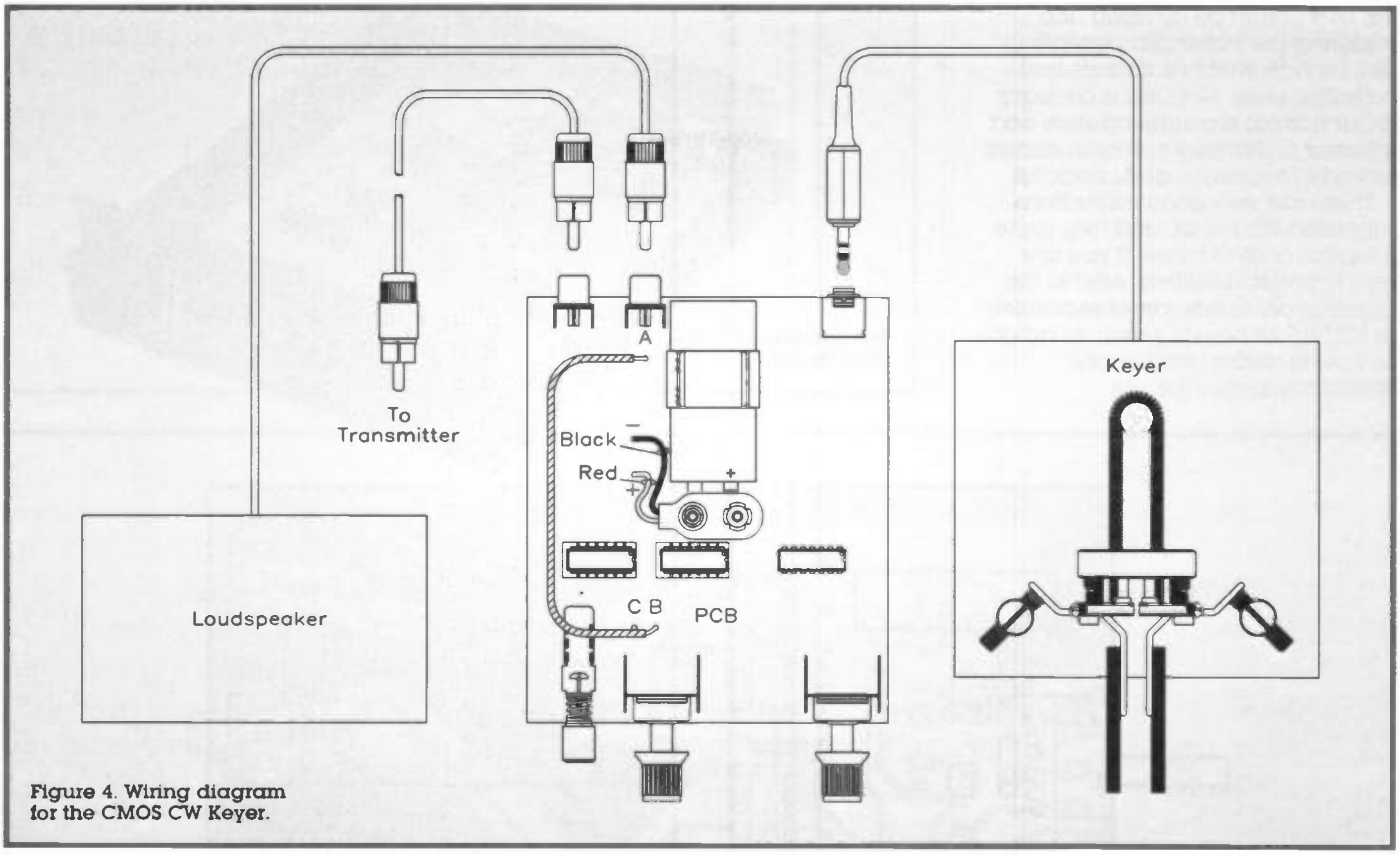


Figure 4. Wiring diagram for the CMOS CW Keyer.

To finish off, there is an optional case available for the kit (RU91Y), which includes knob, feet and fixing screws, and is quite easy to fit. There are a number of boxes from the Maplin Catalogue that could be made equally suitable as a case with some drilling.

Optional extras not included in the kit are: an 8Ω loudspeaker (RU73Q), a suitable paddle type key, and a 9V PP3 type battery (JY60Q).

Setting Up and Operation

Setting up the CMOS CW Keyer is fairly straightforward, and can be achieved with the minimum of test equipment. After making sure that the components are in their correct positions, and that there are no shorts or whiskers of solder on the board, connect a suitable paddle type keyer to the input and an 8Ω loudspeaker (not supplied) to the audio socket, and finally a PP3 type 9V battery to the power connector, see Figure 4. To use, switch on and then press the paddle key, a series of dots and dashes will be heard. To use the CMOS Keyer with a transmitter, a suitable radio licence, such as the Class A Amateur Radio licence or Novice Radio licence is required.

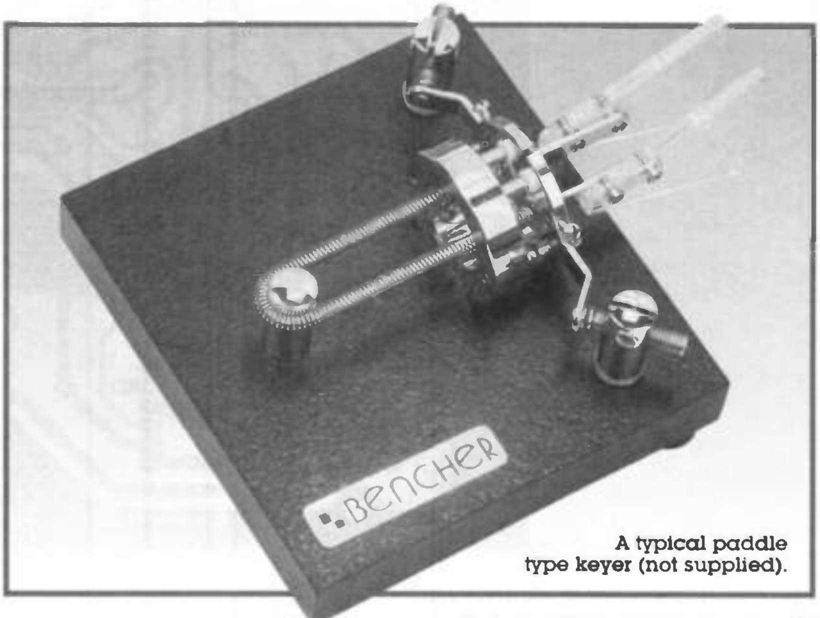
Further Reading

There are of course many books available on radio and Morse Code in particular. Other books on all aspects of the hobby such as: how to become a radio amateur or novice, how to pass the Morse Test, and building suitable equipment. Here are just some of the books that could be useful for the enthusiast:

The Secret of Learning Morse Code, by Mark Francis, (WT72P).
The Morse Code for Radio Amateurs, by George Benbow, G3HB, (WT36P).
An Introduction to Amateur Radio, by I. D. Poole, (WS50E).
Setting Up An Amateur Radio Station, by I. D. Poole, (WT74R).
Amateur Radio for Beginners – How to Discover the Hobby, by Victor Brand, G3JNB, (WT69A).

Some articles which appeared in recent issues of *Electronics* were 'Amateur Radio Novice Licence' by Ian Poole Issue 66, 'Amateur Radio on the HF Bands' Issue 75, which covered many aspects of amateur radio communications, including commonly used abbreviations, Q-Codes, and the International Morse Code. Finally in Issue 87, 'The History of Electronics Part 2', also by Ian Poole

The kit as supplied.



A typical paddle type keyer (not supplied).

covered the early use of Telegraphy and the role of Samuel Morse and the acceptance of his code.

Contacts

There are many clubs and societies for the radio enthusiast, ranging from the broad field of amateur radio to the more dedicated clubs devoted to one type of mode. Local radio clubs and the Radio Society of Great Britain (RSGB) will be pleased to give details on any Morse classes in your particular area as many amateur radio clubs hold special Morse Code classes for beginners, and there are established CW training transmissions on the amateur bands.

Acknowledgment

Thanks to Waters & Stanton Electronics of Hockley for supplying the CMOS Electronic Keyer.

CMOS ELECTRONIC KEYER PARTS LIST

RESISTORS: All 5% Metal Film (Unless specified)		
R3,7,9	1k	3
R4,5	10k	2
R10-13	100k	4
R14	330k	1
R2,6	100k PCB Mounting Preset	2
R8	10k PCB Mounting Potentiometer	1
R1	100k PCB Mounting Potentiometer	1
CAPACITORS		
C8,9	1nF Ceramic Disc	2
C4	10nF Ceramic Disc	1
C1	4μ7F Electrolytic	1
C5	100μF Electrolytic	1*

* This value may be changed, i.e. 100μF to 470μF

SEMICONDUCTORS		
Q1-3	2N3904 NPN Transistor	3
U1	4001 CMOS	1
U2	4093 CMOS	1
U3	4027 CMOS	1
D1-D6	1N4148 or 1N914 Signal Diode	6
MISCELLANEOUS		
S1	PCB Mounting Latchswitch DPDT	1
J1	PCB Mounting Stereo 2·5mm Jack Socket	1
J2,3	PCB Mounting Phono Socket	2
	PCB	1
	PP3 Battery Clip Connector	1
	PP3 Battery Mount	1

OPTIONAL (Not in Kit)		
CW-7 Plastic Case (Includes Knobs, feet and Screws)	1	(RU91Y)
Phono Plug	2	(HQ54J)
Paddle Keyer	1	
SP-140 Mobile Speaker 8Ω	1	(RU73Q)
8Ω Magnetic Earpiece	1	(LB23A)
9V PP3 Battery	1	(JY60Q)
16-pin DIL IC Socket	1	(BL19V)
Constructors' Guide	1	(XH79L)

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 90018 (CMOS Electronic Keyer) Price £26.95

Please Note: Some parts, which are specific to this project (e.g., PCB), are not available separately.

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Edinburgh 126 Dalry Road, Dalry.
Forest Hill 107-113 Stanstead Road.
Glasgow 264-266 Great Western Road.
Hammersmith 120-122 King Street.
Ilford 302-304 Green Lane.
Leeds Carpet World Building, 3 Regent Street.
Leicester Office World Building, Burton Street.
Liverpool Edge Lane, Fairfield.
Manchester 8 Oxford Road.
Middlesbrough Unit 1, The Forbes Building, 309-321 Linthorpe Road.
Milton Keynes Unit 2, Office World Building, Snowdon Drive, Winterhill.
Newcastle-upon-Tyne Unit 4, Allison Court, (The Metro Centre) Gateshead.
Northampton 139 St. James Road.
Nottingham 86-88 Lower Parliament Street.
Portsmouth 98-100 Kingston Road.
Preston Unit 1, Corporation Street.
Reading 129-131 Oxford Road.
Sheffield 413 Langsett Road, Hillsborough.
Slough 216-218 Farnham Road.
Southampton 46-48 Bevois Valley Road.
Southend-on-Sea 282-284 London Road.
Stockport 259-261 Wellington Road South.
Stoke-on-Trent 39-45 London Road.

Ring 01702 552911 for further details.

A readers' forum for your views and comments. If you would like to contribute, please address your replies to: ***The Editor, Electronics – The Maplin Magazine P.O. Box 3, Rayleigh, Essex SS6 8LR, or send an e-mail to: AYV@maplin.demon.co.uk***

AIR YOUR VIEWS

Resurfacing . . .

Dear Editor,
I have just received the May 1995 issue of *Electronics*. In the readers letters section, a reader commented on surface mount components. I haven't tried to use them yet, because they look fiddly, and have some questions regarding them:

1. Are the specifications in the same language as for transistors (say), i.e., H_{fe}, max/min voltage, etc., or do we have to learn yet another new language?
2. Equivalence – can you get BC109s in surface mount, or are they completely different?
3. What special precautions are needed to protect against static, or overheating during soldering?
4. Can we get logic gates in SMT?

A few more articles on this subject would be greatly appreciated.
M. J. Williams, Birmingham.

It is inevitably the case, that constructing projects in surface mount devices will be more fiddly than it would with conventional components, due to their considerably reduced dimensions. However, with practice, one rapidly adapts to the techniques required, and indeed, some aspects of working with the new technology are easier, such as when soldering in ICs, a line of solder 'paste' can be run along the PCB terminal pads prior to holding the IC in position, soldering then being accomplished by stroking the soldering iron along the row of IC pins – the paste then flows over the metal connecting areas only, quicker than soldering individual pins of conventional ICs. The major advantages are the extremely compact layouts that can be achieved, and less susceptibility to RF interference. The specifications of semiconductor SMDs are generally the same as for their conventional equivalents, e.g., SO2369A (SMD) and conventional 2N2369 transistors have exactly the same characteristics, to name but one example, so equivalence is high. Antistatic precautions are much the same as for normal devices, but soldering should be done as rapidly as possible to avoid overheating, since the SMD terminals are that much shorter – with ICs, the paste mentioned above can be used to enable speedier soldering. All the usual logic gates are available in SMT, with pinouts usually the same as conventional logic ICs. SMD components are available from MPS, but note that passive components are only available in relatively large, strip quantities, although ICs are available separately. Look out for forthcoming SMT articles and projects in future issues of Electronics!

S·T·A·R L·E·T·T·E·R

In this issue, Paul Tuff, from Newcastle-upon-Tyne, wins the Star Letter Award of a Maplin £5 Gift Token, for his retrospective observations and comments on PIC microcontrollers.

Dear Editor,
Isn't it amazing how much electronics has advanced in the last few years. I was looking through some old issues of *Electronics* the other day, and some of the adverts looked really antiquated. It is also interesting to see how the number of microprocessor-controlled circuits has increased in modern-day magazines. The favourite at the moment seems to be the 'PIC' microcontroller. I do agree that this device simplifies circuits immensely, however, I do not like the fact that to program this device, you need over £90 of equipment (and that's excluding the cost of the computer!), when the cost of the components in this programming device only amount to around £20. This effectively increases the price of any circuit containing a PIC device threefold. Would it not be a good idea to produce a simple PIC programmer which costs less than £20 to produce, I'm sure it's not too hard, and no other electronics magazine has done this, so why don't you?

It is truly remarkable, the advances that take place in the world of electronics in such a short space of time, but then, that's what makes this subject so exciting! As you say, some of the adverts of several years back, do look sometimes, hilariously old hat, when viewed from a modern perspective, and makes many a once yawn-inspiring advert into a positive rib-tickler! Everyone and their dog seems to be jumping onto the PIC-based project bandwagon, and some of their programmers seem to expect a king's ransom to reveal their few lines of PIC code, to enable the project to be brought to life. However, the software and small amount of hardware that one needs to get started in developing your own PIC programs, costs around the same as the hardware needed to program EPROMs (EPROM programmer and eraser units), yet the PIC microcontrollers are far more versatile programmable devices, so as the saying goes, it's 'horses for courses'. A sub-£20 PIC programmer (if it were possible to produce it at that price) would indeed be a boon to constructors, but if it was that easy, it would undoubtedly have been done by now.

Tiptronic

Dear Sir,
Here are some tips, which your readers may find useful. (a) The audio level of piezo sounders can be usefully increased, by cutting the spout off a plastic funnel at a point so that the diameter of the hole matches that of the sounder, and fixing it with adhesive, thus forming a horn.
(b) When soldering small items, such as a tag or terminal that needs to be held with pliers, sometimes this is difficult, as the pliers act as a heat shunt, taking heat from the joint, with the risk of a dry joint being formed, most likely when using a low-power soldering iron. Use a piece of thin card between the jaws and component, to form a heat barrier. (c) When removing small screws from an item to be repaired, putting them in a tray may keep them together, but if it is knocked, they can still jump out or be spilled. Put some strips of double-sided adhesive tape in the bottom, so the screws stick to it when dropped in, thus reducing the risk of them getting lost.
M. Perry, Kidderminster, Worcester.

Thank you for sharing this wisdom, which will doubtless be useful to all the constructors out there. However, novice constructors please note, get the owner's permission before hacking their funnel apart, and get a responsible adult to do any dangerous cutting for you! Judging by the state of the trays around here, double-sided adhesive tape isn't necessary, such is the depth of unclassifiable sticky gunge deposited on them over the years. Here's one we prepared earlier. . . .

Optional Extras

Dear Sir,
Congratulations on your wonderful catalogue and magazine. You seem to have got the catalogue just right now, but I have found one fault in your magazine. In the parts list, you mention optional items. I tend to get the things from this list which I do not already have, which can prove expensive. Most of the time, the things are very useful, like boxes and knobs, but some of the items are not at all necessary. I would like you to include a price and use for the optional items. I would also like to mention an amendment to your reuseable fuse kit. I expect a lot of people will have had trouble fitting the circuit into the optional box – it does not fit, because an electrolytic capacitor seems to be too tall. I recommend that the thick translucent plastic washers from the terminal posts are put the wrong way up, and one nut is tightened into the hole by gripping the plastic washer with pliers (thus gripping the nut) and twisting, then put a metal washer on that, followed by the circuit board, and then another nut. The case lid may bend slightly when it has been screwed in, but PVC tape covers gaps nicely, and the unit works perfectly.
Tim Kerby, Fife, Scotland.

Thank you for your comments and suggestions. The parts in the optional list are just that – optional, so that people can choose just the items they need, separate of the kit itself, or none at all if they wish. Admittedly, these optional bits can add up to a substantial part of the cost of the project (particularly the casing), but it is generally a worthwhile expense, to achieve a professional looking finish to the completed article, which will then add to the satisfaction gained from building and using it. The use of most of these optional parts is mostly self-explanatory, or doesn't take much imagination to work out a use for it! Your problem with the electrolytic capacitor being too tall may have resulted in an alteration in the manufacturer's specification for this part (or the box), which they reserve the right to change without notice, unfortunately. An alternative solution may be to mount this (radial) device on its side on the PCB (there is just enough room to allow this), but taking care to avoid its leads being shorted out on the nut of an adjacent terminal post.

Your Starter for One . . .

Dear Editor,
Some years ago, I bought some fluorescent lamp starter switches called Pulsestarter, made by Arlen Electrical PLC. These starters are electronic rather than mechanical, and delay the striking voltage on the lamp until the cathodes have properly heated. They are so good, that I have never had a lamp failure when using these starters, and the lamp ends do not blacken. I would like to buy more of these switches, but they are no longer available. I have to assume that the company has gone out of business. Do you, or any of your readers, know the circuit of these switches? Could Maplin market a kit to build them?
G. A. Boyce, Lancing, West Sussex.

Most fluorescent starter units (cylindrical plastic, bayonet fitting type) that I have come across (and taken apart to see what was inside!), consist simply of two components – a form of neon lamp (or spark gap?), in parallel with a large disc ceramic capacitor (at least, that is what these components appear to be). I have never heard of a mechanical version like you mentioned, i.e., all starter units, to my knowledge, are 'electronic'. Unfortunately, it would probably be uneconomic to produce these starters in kit form, as they are generally inexpensive to purchase ready-made, and the market for kit versions would, therefore, be extremely small. Perhaps a reader 'in the know', or electrician/electrical supplier, could disclose a source of the Arlen units.

NEWS Report

TI and IMEC Collaborate on Process Research

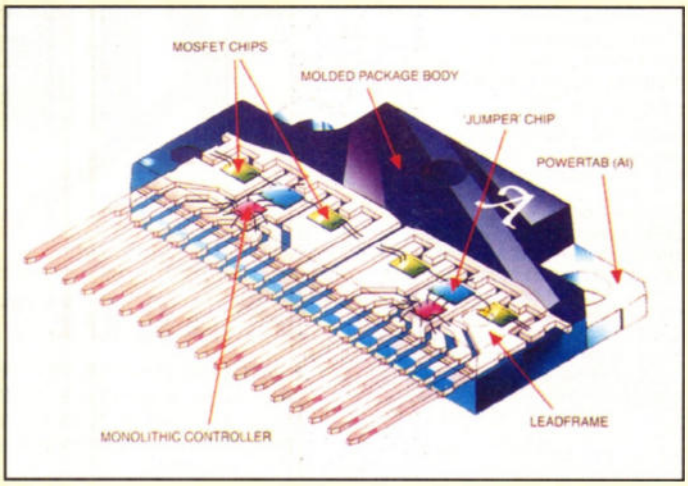
Texas Instruments and IMEC, an independent research and development organisation based in Leuven, Belgium, are collaborating on research for an advanced lithography process, that will help enable migration from megabit-class semiconductor chips to the next-generation, gigabit-class chips. The extensive memory storage available on a gigabit memory chip – the equivalent of the average size of today's PC hard-disk drives – will enhance future digital applications, such as HDTV, video on demand and desktop video conferencing, and will be one of the key enablers of applications using the information society.

Contact: Texas Instruments, Tel: (01234) 223 511.

In-Car Refreshment for Tired Batteries

Laptop computers are superb for individuals who wish to work on the move. However, regular use, remote from a power socket, can cost dearly in spare batteries. Car travellers can now cut down on new battery consumption, by using a product which enables portable devices to be recharged from the car engine. Called Pocket-AC, the product plugs into the cigarette lighter and converts the battery voltage into mains-type power, suitable for direct connection to a laptop computer. Pocket-AC costs £85 plus VAT, and includes a safety overload cut-out, which activates if the power demanded is more than the available 150W.

Contact: Radix Technologies, Tel: (0171) 731 8199.



Stepper Motor Control

High-power stepper motor control is enabled by a new range of pulse-width modulated (PWM) devices from Allegro Microsystems. The new devices utilise four NMOS FETs for the high current, high voltage driver outputs. These feature low on-resistance, improved body diodes and very fast switching, for minimal power dissipation.

Contact: Allegro Systems, Tel: (01932) 253 355.

Quad-Speed around £200 Mark

Sales of quad-speed CD-ROM drives are expected to account for half the CD-ROM drives sold during the next quarter, according to supplier Teac. The company claims that quad-speed drives account for 5% of the 3,500 drives sold last December. These claims can perhaps be justified by the recent fall in the prices of quad-speed units. When they were first announced some 18 months ago, the price tag was around £800. Now prices from manufacturers such as NEC, are levelling out at around the £200 mark. Industry pundits claim it will not be too long before quad-speed replaces double-speed as the standard in pre-assembled multimedia machines.

Contact: Teac, Tel: (01923) 819 630.

Making the Invisible Visible

3M Electrical Specialities claim that up to 90% of manufacturers have no, or little, idea how much electro-static discharge (ESD) is costing them in failed components. According to Nick Mendham, European Marketing Manager for 3M Electrical Specialties, "Independent Research Indicates that ESD is responsible for over 25% of board and device failures". But now, 3M have found a way of enabling plant manufacturers to collect data from their process, to enable them to establish the frequency and extent to which static events are occurring. The detection method is based upon a 1in.^{2} electrostatic sensor module, designed to monitor static events as they occur at all stages of production on ungrounded objects, such as PCBs, parts trays or small assemblies. The sensor measures the difference between voltages transmitted to its backplate and its small conductive internal antenna. The antenna is then capacitively coupled to earth-ground. During an ESD event, a brief difference in potential exists between the backplate and antenna, triggering the sensor, and activating an amplifying latch circuit.

Contact: 3M Electrical Specialities, Tel: (01344) 858758.

Fast State Machine for Critical Applications

If speed is a critical issue in Programmable Logic Designs, Philips Semiconductors have designed a device that offers the fastest setup and clock-to-output speeds available. The 5ns ABT22V10A5 is intended for critical high-speed registers, or state machine applications. According to Mark Aaldreing, Philips Semiconductors' programmable logic marketing and applications manager, "When designers are looking for the ultimate in performance, they tend to rely on the traditional SPLD architectures, especially when the application is a state machine. Therefore, when selecting a device, the setup, hold and clock-to-output specifications are critical. The ABT22V10A5 has a setup time of 2ns, a register hold time of 0ns, and a clock-to-output of 4ns. These specifications are the best in the industry."

Contact: Philips Semiconductors, Tel: (+31) 40 72 20 91.

Young Radio Amateur of the Year, 1995

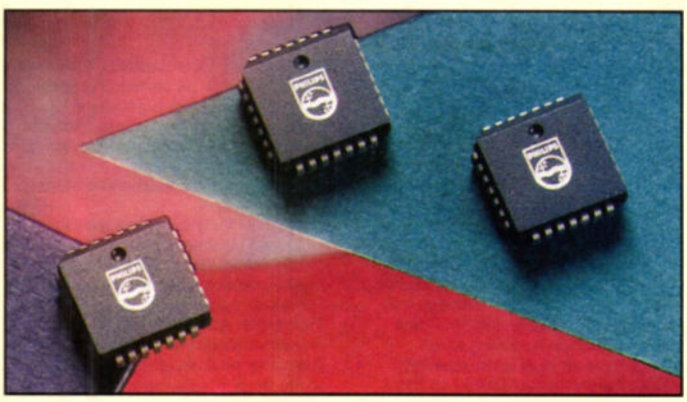
The hunt is on for the Young Radio Amateur of the Year. Nominations are being sought for individuals under the age of 18 who have shown promise in radio construction, operating, community service, and encouraging others for school projects. Once again, the radio communications industry is stumping up cash prizes and radio equipment for the winner and runner-up. Further details and entry forms may be obtained from Marcia Brimsom at Radio Society of Great Britain (RSGB) headquarters. Nominations close on 31 July, 1995.

Contact: RSGB, Tel: (01707) 659015.

Music up by 16%

Figures released last month, by the International Federation of the Phonographic Industry (IFPI), show that record sales around the world, grew by 16·5% in 1994. This takes the total value of worldwide sales to US$35·5 billion. The most significant development is the continuing rise in popularity of CD, particularly in developing markets, where audio cassettes have previously monopolised sales. Unit sales of CDs rose by 25%, cassette sales grew by 2·6%, while vinyl fell by 53·1%.

Contact: International Federation of the Phonographic Industry, Tel: (0171) 434 3521.



Video over Radio Capability

Still pictures could be sent over cellphones on the move, with new technology from Racal Radio. The new technology gives rise to a range of possible applications. Continuous observation of dead ground, unmanned incursion screens and access control requirements can also be fulfilled by the technology. Potential para-military, covert and civil users include surveillance teams and border, or area, security services. The video over radio technique relies on a pair of encoding algorithms developed by Racal Radio with Cambridge Neurodynamics. The image compression used, known as modified fast lapped transform, does not give the hard-edged, blocky artifacts of other compression techniques, such as JPEG or MPEG. With the ability to connect to existing digital radios, function over wire telephone lines or cellular phone, the colour system compresses the image and transmits it over narrow radio channels, with little loss to normal voice on radio ranges. This capability effectively quadruples the range achievable by wide-band TV image transmissions. The range can be further increased by the addition of rebroadcast or repeater stations.

Contact: Radio Racal, Tel: (01734) 669969.

Recyclable Circuit Boards

Four European companies have struck a deal to jointly promote a recyclable printed circuit board. IBM Germany, DuPont, Sorep and Alcatel SEL have signed a joint agreement to promote the wider use of low-temperature cofired ceramic (LTCC) technology in Europe. LTCC was originally developed for military mock-ups. The costs of LTCCs per square inch is typically two or three times that of conventional boards, but, according to DuPont, far higher densities can be achieved. Using via diameters down to 100μm and track widths of 200μm, more components can be fitted into a smaller space. Telecommunications and automotives are seen as the largest potential markets outside the diminishing European defence industry. The telecommunications industry has used LTCC for at least 10 years, in areas where high frequencies demanded special dielectric materials. The fact that LTCCs can be recycled and the metals recovered, should make this technology attractive to mobile phone manufacturers who wish to adopt eco-friendly materials as a selling point.

Car Anti-Theft Deterrent

A new device from National Semiconductor (NSC) decodes encrypted signals for remote keyless entry applications. Unlike the majority of keyless entry products which send a fixed code signal, NSC's devices generate a non-reversible rolling code signal. This means that the NSC device generates a new random signal every time it is activated, making it literally impossible to break the code. NSC's challenge in developing the device, named the HiSeC Rolling Code Generator, was to create a scheme with near-infinite possibilities, that required very little memory. The success of this engineering effort can be seen in the device's ability to randomly generate a code from 281·5 trillion possibilities. The HiSeC Rolling Generator supports either an infra-red or radio frequency transmitter, and can be clocked with either an RC clock or crystal oscillator. The device operates over a voltage range of 2·2 to 6·5V, and offers a low stand-by mode current consumption (typically <1μA), allowing a 5-year battery life.

Contact: National Semiconductor, Tel: (+49) 81 41 35 1269.

SPARC Technology SuperSPARC-II Processor

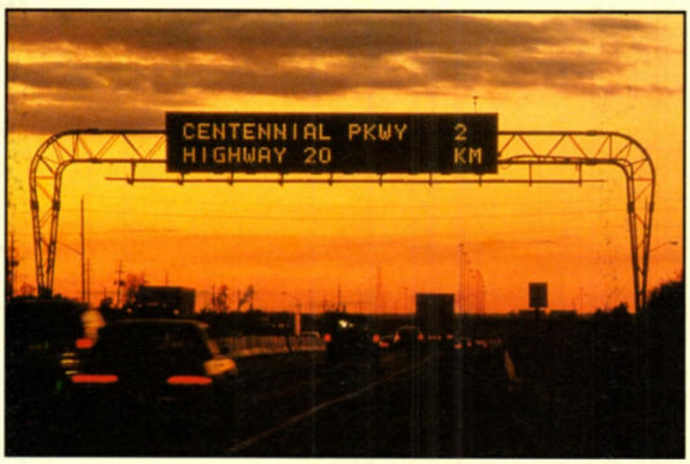
Sun Microsystems' SPARC Technology Business has announced sample silicon availability of its 90MHz SuperSPARC-II microprocessor. The new processor allows SPARC Technology Business customers to deliver higher-performance systems with minimal research and development costs, and provides the large installed base of end-users with up to a 45% performance upgrade. Performance for the 90MHz SuperSPARC-II is rated at 148SPECint and 143SPECfp. The 3·1 million transistor SuperSPARC-II is module-compatible with existing hardware, and requires no application or operating systems changes. It is binary-compatible with over 9,400 software solutions developed for the SPARC platform. The SuperSPARC-II family was designed for plug-compatibility with MBus and XBus SuperSPARC systems, to enable quick and easy performance upgrades for users.

Contact: Sun Microsystems, Tel: (01276) 451 440.

New Books from RSGB

Two new operating aids have been published by the RSGB. The RSGB Prefix Guide continues the work of the late Geoff Watts. It is the definitive guide to identifying those tricky callsigns often used by special event and contest stations, not to mention new countries which pop up from time to time. The RSGB Prefix Guide is available from RSGB Sales, price £4.75. The VHF Contesting Handbook, compiled by the RSGB VHF Contests Committee, includes sections on choosing a site, equipment, antennas and recent rules changes. The VHF Contesting Handbook will appeal to contesters of all levels of ability and experience, and is now available, priced £4.00.

Contact: RSGB, Tel: (01707) 659015.



High Visibility

Visibility of road signs at night is the concern of FP Displays. The company has been developing a range of roadside display products based on shuttered Fibre Optic Switches (FOS), which provide high visibility at night, without the need for external illumination. FP Displays now intend to construct road signs using the FOS technology. Each light point consists of an optical fibre bundle, terminated by a lens, which is opened and closed by the use of a shutter device. The bundles accept light from quartz halogen lamps. It is estimated that the lamp life of displays utilising this technology should be in excess of 10,000 hours, since FP Displays' special photocell dimmer system runs the lamps at lower power than conventional systems.

Contact: FP Displays, Tel: (01272) 251125.

Trafficmaster Serves up Localised Data

Trafficmaster, the UK traffic technology specialist, is to introduce a transmitting function to its latest traffic information system, which will allow more detailed local data about the traffic in the receiving vehicle's area. To date, the infra-red sensor units that measure traffic speed on motorways, have not been transmitting to cars directly. Instead, they relay the information back to the traffic information centre, which then transmits the processed information via a paging network to the in-car units. The new functionality is expected to come online later this year, and will interface directly with units currently in use.

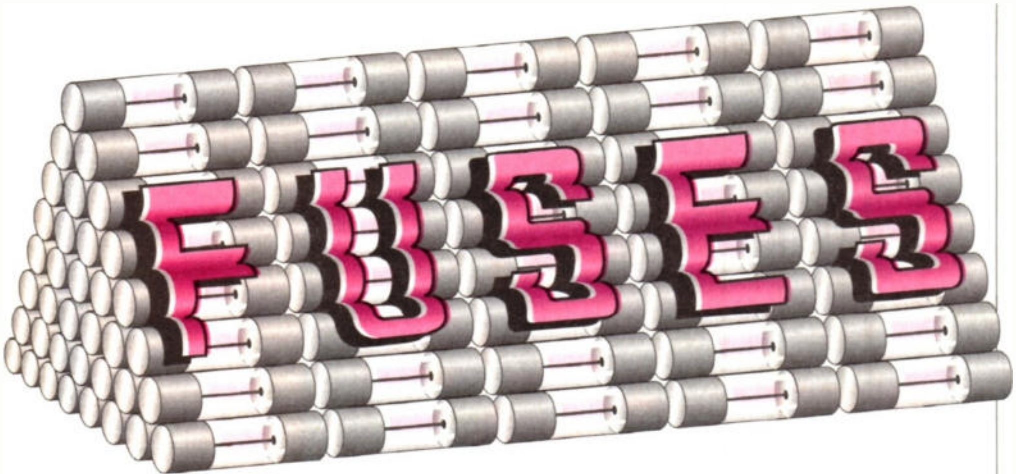
PhoneDay – Take Two

You must be aware by now, that all UK geographic trunk codes changed on Sunday, 16th April. Additionally, the codes for several major cities, including Leeds and Bristol, changed as they moved from 6- to 7-digit working. These changes should allow for the future growth in UK telecommunications. But, there are rumours that some other cities may also be allocated new codes – Reading, in Berkshire, being a notable example. There are proposals for a second PhoneDay sometime in 1997, to make way for further network expansion. Considering the immense cost that UK businesses have had to face reprogramming existing telephone systems and updating databases with software tools, a second PhoneDay is likely to be greeted with absolute horror.

Advanced Networking Client Technology

Novell is extending its client technology, by providing 32-bit networking clients that are tightly integrated with new 32-bit desktop operating environments, giving customers greater network integration with the desktop of their choice and improved access to NetWare services. Novell's 32-bit clients will support all 32-bit desktops, including Windows NT, Windows 95, OS/2 Warp and Macintosh. The next release of Novell client technology will be the NetWare Client for Windows NT, expected to be available in the UK this quarter.

Contact: Novell UK, Tel: (01344) 724460.



by Stephen Waddington
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Selecting a fuse to protect electronic circuitry is not nearly as easy as you might expect. The variety of types and classifications available are enough to baffle anybody. ConFUSEd? Don't be! In this article, Stephen Waddington wades through the theory and provides some commonsense advice on selecting a fuse for a particular application.

HERE follows a basic definition of an electrical fuse: A fuse is a piece of hardware designed to protect a circuit from overcurrent damage. It is generally constructed from a thin piece of wire, usually fixed inside a glass or ceramic tube. The wire is usually connected by blobs of solder to metallic holders, or caps, at either end of the tube, as illustrated in Figure 1.

The Fuse Charter

The fundamental requirements of overcurrent devices are to prevent injury to humans and livestock, or damage to property from excessive temperature rise or mechanical forces which are caused by excessive current flow. In the case of earth leakage and earth fault currents, the overcurrent device must also prevent the risk of electric shock.

All electronic circuits, and electrical ones for that matter, should be fused to prevent damage that might result from excess current flow. In this sense, fuses have numerous purposes including the following:

- To protect a battery or power supply from overload or, in an extreme situation, a short circuit, should an electronic circuit fail.
- To protect components within an electronic circuit from increased current flow.

If subjected to power levels beyond design values, components may fail or suffer long-term degradation.

- To limit the probability of violent failure.

If incorporated into a circuit correctly, fuses operate because the fuse element is the weakest link in a circuit. Overcurrent will melt this link, cutting power to the circuit.

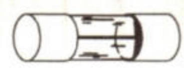

Figure 1. Schematic of a typical barrel fuse.

If a circuit is not fused and a fault occurs, the weakest link will suffer; this may be an expensive power transistor or integrated circuit. Alternatively, the most susceptible parts of a circuit may include devices such as electrolytic capacitors, or wire-wound resistors in the power supply, both of which could fail with dramatic results if subjected to excess current.

- To indicate the location of a fault.

A blown fuse clearly isolates a faulty circuit within an electronic system.

The placement of a fuse in a circuit is almost as important as selecting the correct fuse for a particular application. In this sense, fuses should be positioned as close as practically possible to the voltage source. Figure 2 illustrates the correct – and by contrast incorrect – placement of a fuse in a number of circuits. Notice that the fuse is always placed before the switch, and as close to the power supply as physically possible. This ensures that as much of the circuit as possible is protected, while similarly ensuring the power supply is protected from overloading by potential faults in the connected circuit.

A fuse must always be placed in the supply conductor(s) at the highest potential with respect to the reference conductor (usually earth). In the case of the UK domestic mains supply, the fuse must be placed in the Live conductor because the Neutral conductor is earth referenced (see Figure 3). If a transformer is used to supply AC, and it has a centre tap which is earthed or at 0V potential, then fuses should be included in both supply lines derived from each end of the transformer, as shown in Figure 4. In the case of a DC supply, the fuse must be included in either the positive (relative to 0V or earth), or the negative (relative to 0V or earth) rail as applicable (see Figure 5). The fuse should never be placed in the 0V/Earth rail. Equipment with split/multiple supplies should have a fuse in each power rail (except for the 0V/Earth rail), as shown in Figure 6.

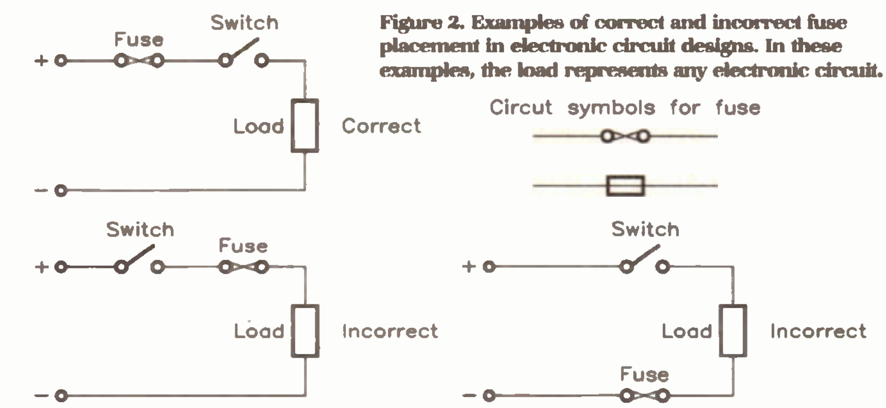

Figure 2. Examples of correct and incorrect fuse placement in electronic circuit designs. In these examples, the load represents any electronic circuit.

Figure 3. Fuse placement in the UK domestic mains supply.

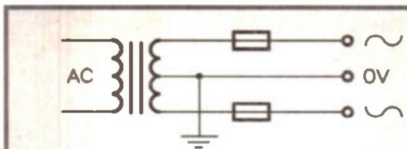

Figure 4. Fuse placement with a 0V centre-tapped AC transformer supply.

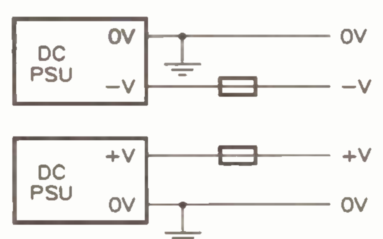

Figure 5. Fuse placement with a DC power supply.

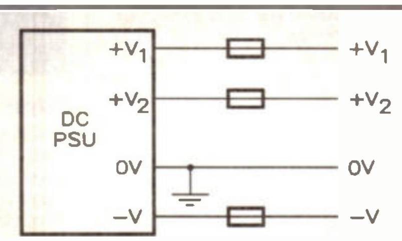

Figure 6. Fuse placement with multiple DC power supplies.

Selection

Fuse selection can be bewildering. A brief glance through the Maplin Catalogue reveals at least five or six different types. Fortunately, there are international, or at least European, guidelines, from which we can seek assistance.

In Europe, the standard relating to fuses for electronic equipment and circuitry, is IEC publication 127. This specifies that equipment should be protected by 20mm length × 5mm diameter (20 × 5) barrel devices, as shown in Figure 7. Ironically, this is where confusion can begin. Similar fuse standards in the USA and Canada (UL198G and CSA22-2 No. 59, respectively) specify 1·25in. by 0·25in. fuses, the characteristics of which are completely different from their smaller counterparts.

That said, 1·25 × 0·25in. fuses used to be common in the UK, characterised by their resistor-like colour coding. These days, they are almost redundant, sold only as replacement devices, or for use in imported equipment. Modern equipment requiring protection is designed around the more compact 20 × 5mm device.

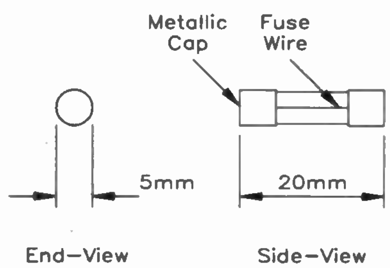

Figure 7. 20 × 5mm barrel fuse.

Rated Current

The most important definition is that of *rated current*. This indicates how much current a fuse will sustain without fault or failure. A fuse will rarely fracture at the value indicated on the barrel. Instead, it can take a maintained current of up to 200% of the rated current before the fuse blows. Consequently, it is important to select a device with an appropriate current rating to ensure effective overcurrent protection.

For example, if the circuit current rises by 10% above the fuse rating, it may take four hours or more for the fuse to fail, dependent on the type. If the current is 50% above the rated value, it may take 20 to 30 minutes to fail, and if the current exceeds twice that of the fuse rating, it can only take up to 15 seconds to fail. This allows fuses to tolerate surge currents which typically occur when a piece of equipment is switched on.

Response Time

This leads us to another important definition: *fuse response time*. Fuses are grouped into five major current-time classifications. At one end of the scale, semiconductor circuits require protection that will react very quickly on fault conditions. These are described as super quick-acting fuses, coded *FF*. At ten times the rated current these will blow in a millisecond or less and, for twice the rated current, the blowing time will be 50ms or less.

Photo 1. Quick-blow fuse (classes *FF* & *F*).

Photo 2. Time-delay fuse (class *T*).

Progressing up the scale, the next group comprises quick-acting class *F* fuses (see Photo 1), used for general-purpose protection where current surges are unlikely to be encountered. These have a slower blowing characteristic, some 10ms for ten times the rated current, and just over 100ms for double the rated current.

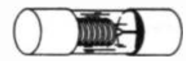

Figure 8. Helical spring time delay fuse, common to classes *T* and *TT*.

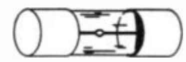

Figure 9. Solder blob fuse, common to classes *M* and *T*.

Class *FF* and *F* fuses are the only ones that have any chance of protecting semiconductor equipment. In both cases, the element is made of a pure drawn metal, as shown in Figure 1. This is typically silver, giving a quick reaction to both sustained overloads and short duration surges.

Medium time delay fuses, coded *M*, will withstand small current overloads that might, for example, be caused by charging

	Fuse Type	
	20mm Quick-blow	**20mm Time-delay**
Rupture Time (at 2 × rated current)	2 minutes maximum, but 1 second typically.	Up to 3A rating: 5s minimum. Over 3A rating: 12s minimum.
Rupture Capacity	35A or 20 × rated current – whichever is greater.	35A or 20 × rated current – whichever is greater.

Table 1. Comparison of 20mm Quick-blow and 20mm Time-delay fuses stocked by Maplin.

Rating	Stock Code		
	20mm Quick-blow Fuse	**20mm Time-delay Fuse**	**1in. Domestic Mains Fuse**
50mA	WR93B	UJ90X	–
63mA	UJ73Q	UJ91Y	–
80mA	UJ74R	RA04E	–
100mA	WR00A	UJ92A	–
125mA	UJ75S	UJ93B	–
160mA	WR94C	RA05F	–
200mA	UJ76H	UJ94C	–
250mA	WR01B	RA06G	–
315mA	RA01B	RA07H	–
400mA	UJ77J	UJ95D	–
500mA	WR02C	WR18U	–
630mA	RA02C	RA08J	–
800mA	RA03D	RA09K	–
1·0A	WR03D	WR19V	–
1·25A	UJ78K	UJ96E	–
1·6A	WR04E	RA10L	–
2·0A	WR05F	WR20W	HQ31J
2·5A	UJ79L	UJ97F	–
3·0A	–	–	HQ32K
3·15A	WR06G	RA11M	–
4·0A	UJ80B	–	–
5·0A	WR07H	RA12N	HQ33L
6·3A	UJ81C	RA13P	–
10A	UJ82D	UJ98G	DK20W
13A	–	–	HQ34M

Table 2. The range of 20mm Quick-blow and 20mm Time-delay fuses stocked by Maplin.

capacitors. These fuses will blow after about 20 seconds on a twofold overload. The longer time taken for the smaller overload allows for current surges that are not particularly large, but are of quite long duration.

Time delay fuses, denoted as class *T*, will blow in 100ms for a tenfold overload, and about 20 seconds for a twofold overload. Finally, super time-lag, class *TT* fuses will permit 150ms at a tenfold overload, and 100 seconds at a twofold overload.

The original form of time delay fuse construction, common to classes *T* and *TT*, is shown in Figure 8 and Photo 2. It employs a helical spring held in tension between two pieces of low melting point wire, commonly tin. Under short circuit conditions, the wire ruptures like a conventional fuse, releasing the spring.

Another form of delay fuse is the solder blob type, used for classes *M* and *T*. Here, a bead of solder bridges the end of two link wires, as shown in Figure 9. Excess current causes the solder bead to melt, breaking the circuit after a given period.

Characteristic curves for the fuses described above are outlined in Figure 10. This clearly illustrates the distinction between the various classes. In most cases, only *T* and *F* fuses will be commonly encountered; see Table 1 for typical *T* and *F* fuse characteristics, and Table 2 for the range currently available from Maplin.

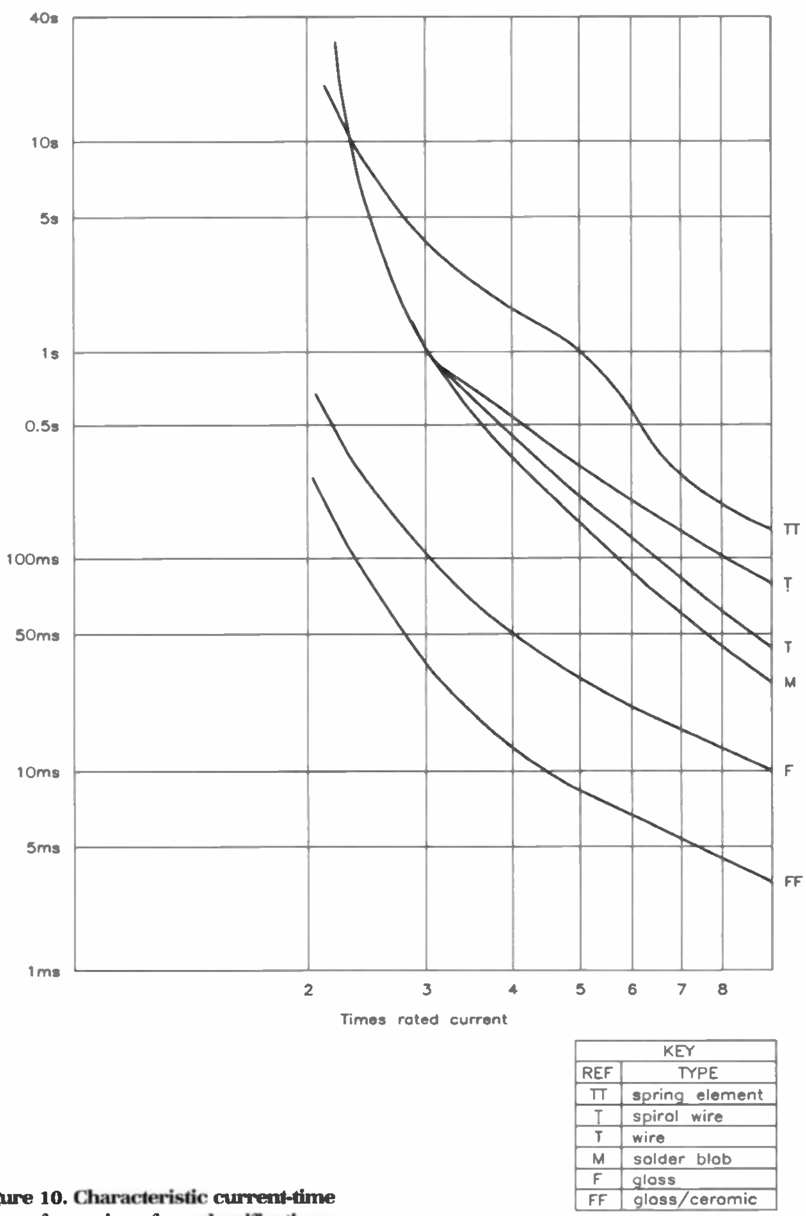

Figure 10. Characteristic current-time curves for various fuse classifications.

Electronic Fuses

An article on fuses would be incomplete without at least a passing reference to electronic fuses, as illustrated in Figure 11 and Photo 3. Similar in operating characteristic to time delay (class *T*) fuses, electronic fuses are solid-state, and can be simply soldered into a circuit. While this has value, the chief benefit of electronic fuses is that they will automatically reset. Under overload conditions, an electronic fuse will latch into a high impedance state, returning to normal as soon as the fault condition is removed.

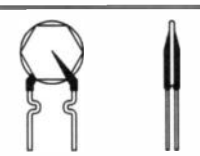

Figure 11. Electronic solid-state fuse.

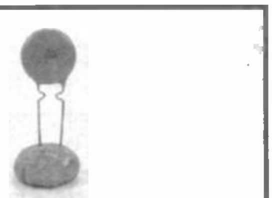

Photo 3. Electronic fuse.

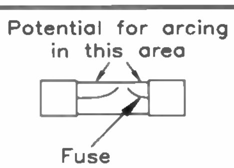

Figure 12. Fuse fracture, leaving potential for arcing.

Voltage

Let's throw in another problem. During and after a fuse has ruptured, the melted wire remains, usually resting on the edge of the barrel as illustrated in Figure 12. If the voltage at either side of the fuse terminals is sufficient after the fuse has blown, an arcing effect can occur. In severe cases, this can result in current flow in the circuit.

Consequently, all fuses carry a *maximum voltage rating*. Above this value, the fuse cannot be reliably used, as an arcing effect is prone to occur once the fuse has blown. Devices for electronic applications are typically rated in values of 50V, 100V, 250V and 500V. Devices with a high rating can happily be used in circuits with a lower voltage, but never the other way round. For example, to protect a 110V circuit, use a 250V or 500V device, but not 50V or 100V.

Interrupt Test Rating

The *interrupt test rating* or *short circuit rating* of a fuse is another definition which is not well-known. A fuse rated at 500mA will never have to bear a current of 100A or more in normal operation, but its behaviour at such currents is critical. If a circuit fails, current flow can be indiscriminate. The fuse may well melt, seemingly protecting the circuit, but if the current rises sufficiently, conduction may occur in the metal vapour from the fuse wire.

To counteract this problem, some manufacturers replace the air in the fuse barrel with an inert gas, or sand. This prevents current flow once the fuse has blown. Either way, approval testing for fuses is carried out at very high currents and voltages, and the limits of both figures are usually quoted by manufacturers.

Temperature Sensitivity

The specification of most fuses is defined over an ambient temperature range of 20 to 25°C, though this may vary from manufacturer to manufacturer. In particular applications, where there is likely to be a current surge on switch-on (such as circuits using inductive loads) the current rating of the fuse should be increased by 25% at 25°C to avoid nuisance blowing. For example, a 10A fuse should not be operated at a circuit current of more than 7·5A at 25°C.

If circuits are to be operated in higher temperatures, such as inside a car or a heating system, further increases of the current rating may be necessary. The slower blowing fuses, such as classes *T* and *TT* in particular, which depend on some form of heatsinking to delay blowing, need to be derated when used at high ambient temperatures. Figure 13 illustrates typical derating factors, varying from 0% at 20°C, to 60% at 100°C. These values could be extrapolated further, although standard fuses prove unreliable at higher ambient temperatures.

Resistance

Fuses act like resistors. While devices with high ratings will have negligible resistance, this is not true for the lesser-rated types, which may typically have values of 5 to 50Ω. The phenomenon gets worse with time. While a new fuse may have minimal resistance, longer service counterparts can develop resistance over time. This is because the wire within the fuse is typically very fragile and, in service, current surges will misalign molecules within the wire, resulting in increased resistance.

Fuse resistance, particularly over time, is rarely quoted by manufacturers or suppliers because it can be so variable. For this reason alone, it is important that it is not overlooked, and tolerance margins up to 100Ω should be built into circuit designs, particularly power supplies, to prevent unreliable operation.

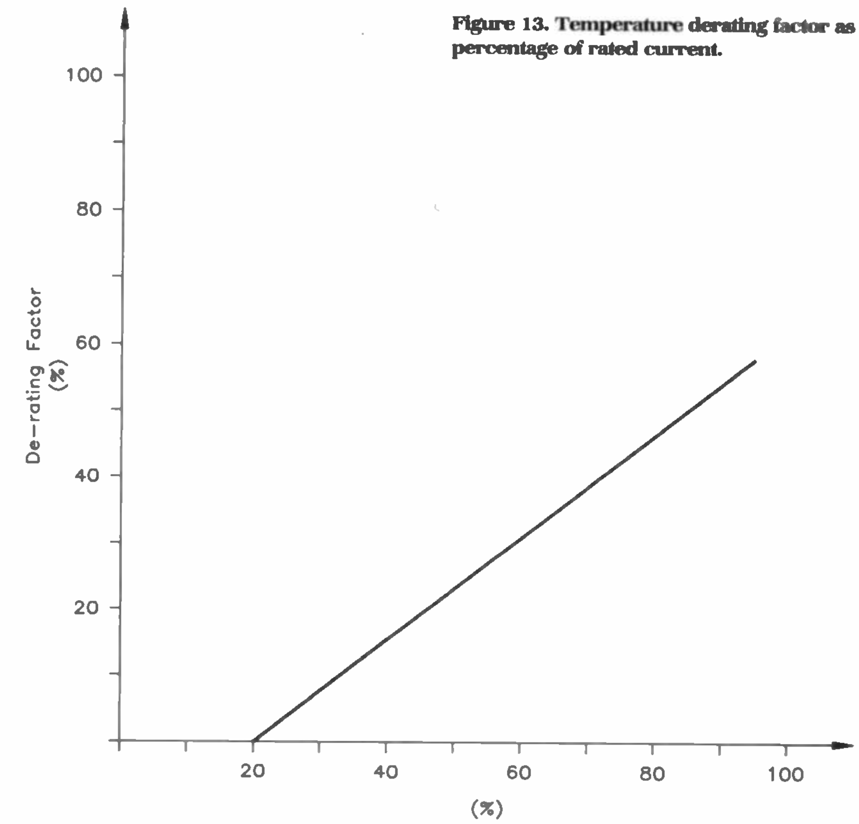

Figure 13. Temperature derating factor as a percentage of rated current.

The Domestic Fused Plug

The 13A fused domestic plug was developed to free designers from the limitations (and expense) of having to place each 15A socket on a radial circuit; it led to the development of the 30A ring and multisocket radial circuits.

The purpose of the fuse in the plug is NOT, as commonly thought, to protect an item of equipment, but to provide short circuit protection for the flexible mains cord of an item; overcurrent protection for an electrical appliance should be included within the item itself. Since a fuse can take a maintained current of up to 200% of its rated value before blowing, the flexible cord must be able to withstand up to 26A in the case of a 13A fused plug. The IEE state that British Standard 20A fuses/circuit breakers provide adequate short circuit protection for flexible cords having a cross sectional area of 0·75mm² or more, and this is now the smallest size generally specified for use with domestic equipment; a minimum of 0·5mm² cord should be used for 13A outlets on a 30A ring circuit. A plug fitted with a 3A fuse will provide protection for a flexible cord with a minimum cross sectional area of 0·22mm².

The length of the flexible cord is another important factor to be considered. The longer the cord, the higher the resistance and, hence, the lower the fault current, which means that the fuse will take longer to blow. The IEE recommend that the maximum length of cord used will limit the duration of the fault current to 5 seconds (see Table 3). According to the IEE wiring regulations, PVC-insulated cords of the appropriate cross sectional area should not be longer than 10m. Rubber-insulated cords are preferred for (13A fused) 'extension leads' and, for lengths greater than 10m, they should have a minimum cross sectional area of 0·75mm².

Thermal Fuses

Not quite as popular as current devices, thermal fuses (see Photo 4) are used to protect equipment from excess temperature. They are used extensively in consumer products such as sandwich toasters, water

	Cross Section of Conductor	
	0·5mm²	1·0mm²
Maximum length of cord (30A m.c.b.)	≈14m	≈40m
Maximum length of cord (32A fuse)	≈20m	≈60m

Table 3. Maximum lengths of cord on 32A fuse protected and 30A circuit-breaker protected ring circuits for a 5-second fault current.

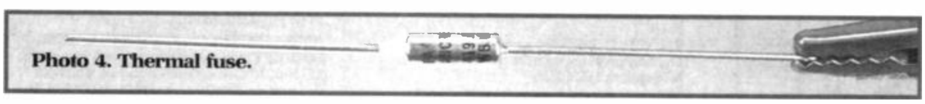

Photo 4. Thermal fuse.

Rating:	240V @ 15A maximum
Rupture Current:	40A Resistive 20A Inductive
Open Circuit Breakdown Voltage:	1200V AC
Opening Threshold Temperature Tolerance:	+0°C -4°C

Table 4. Characteristics of thermal fuses stocked by Maplin.

Temperature Rating °C	Stock Code
72	RA61R*
91	RA14Q
110	RA64U*
128	RA15R
152	RA17T
167	RA18U
184	RA19V
192	RA20W
228	RA22Y
240	RA23A

* Indicates that these fuses have been especially formulated for use in audio and test equipment.

Table 5. The range of thermal fuses stocked by Maplin.

heaters, hair curlers and toasters to prevent fire, should excessive temperature rise occur.

Thermal fuses normally provide a low impedance path for electric current, but they go open circuit if their temperature threshold is exceeded. Although both current and temperature ratings are quoted (see Tables 4 and 5), the current is the limiting factor beyond which the device cannot carry out its primary thermal function. Once the fuse blows, it cannot be reset, and must be replaced.

Commonly available in ratings from 91 to 240°C, thermal fuses come in a variety of shapes and sizes. The most common is the 4 × 12mm bullet design as shown in Figure 14. Note that, in spite of their packaging and appearance, they are not semiconductor devices, and are not polarised.

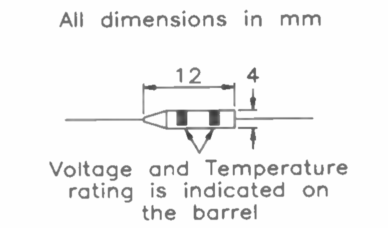

Figure 14. Thermal fuse.

Choosing a Fuse

Selecting a fuse for a particular application is always a compromise. On the one hand it is important to maintain high safety standards, but nuisance blowing must also be prevented.

When selecting fuses for a particular application, follow these four general rules and you will not go far wrong:

- Select a current rating around 125% of the circuit's full load consumption.
- Use an *FF* device where semiconductor devices are being protected.
- Use the most appropriate type of delay fuse where inrush or transient currents are expected. The period and, consequently, amplitude of transient currents can be calculated using RC or RL time constant equations (Reference: *Introductory Circuit Analysis*, Robert Boylestad).
- Determine the maximum short circuit current, open circuit voltage, and choose a fuse to suit. In general, use a high-voltage fuse where the prospective fault voltage and current is high.

When a Fuse Blows

Unexplained fuse failure is one of the most frustrating faults known to an electronics technician. A possible cause (that I have discovered on a couple of occasions) is a faulty fuseholder with high contact resistance. This gives rise to additional resistance, an increased voltage drop, and consequently, higher current drain, leading ultimately to indiscriminate failure.

Medium-term failure, often for no apparent reason, can be caused by metal fatigue in the element. In this case, the fault becomes apparent, prior to complete failure, by the circuit cutting out intermittently, especially on switch-on, due to expansion and contraction of the element. Fitting a fuse with a longer delay, but same current rating, will overcome this problem.

Much can be gleaned by carrying out an autopsy on a blown fuse. If the glass body is broken or cracked, the fuse has probably passed more than 50A which, in a mains context, means there is a short circuit, possibly within a faulty capacitor or rectifier. If the glass tube is blackened or sprayed with metallic particles, the fuse has blown violently. This usually means a current limiting resistor has gone short circuit, leaving the fuse to take the full short circuit current.

A soft blown fuse will have suffered metal fatigue or moderate overload. Remember that moderate increases in ambient and self-generated heat can both cause a fuse to blow prematurely. E

Safety First

The importance of fitting the correct type of fuse in an electronic circuit cannot be emphasised enough. Equally, when replacing fuses in existing circuits, it is critical that the correct value is used, appropriate to the correct relationship between fuse and cable rating, both within equipment and mains leads.

Fire and electrocution in electrical and electronic equipment has been greatly reduced in recent years by the application of BS, BEAB and DTI regulations, and the vigilance of inspecting bodies. This effort could so easily be destroyed by the use of a different type of fuse, or one of a higher rating, to that originally specified. Be warned, and be careful. If in any doubt about selecting a fuse for use in mains or other high power applications, seek the guidance of a qualified electrician; do not make guesses ('educated' or otherwise) of the fuse protection needed.

Further Information

For further information on fuses, consult BS1362 for 13A plug fuses, and IEC 127 for 20mm fuses. Readers may also like to refer back to 'Mains Safety in Hobby Projects – Part 2', Issue 83 (November 1994), which also dealt with fuses.

If you wish to find out more about safety, rules and regulations, you may find the following books helpful:

IEE Wiring Regulations for Electrical Installations (16th Edition) (WZ90X), IEE, 1991. Price £34.00 *NV*

On Site Guide to the 16th Edition Wiring Regulations (WZ97F), IEE, 1992. Price £10.00 *NV*

IEE Wiring Regulations Guidance Notes: Number 1 – Selection and Erection (WZ98G), IEE, 1992. Price £12.00 *NV*

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THE LINCOLN SHORT WAVE CLUB meets every Wednesday night at the City Engineers' Club, Waterside South, Lincoln at 8pm. All welcome. For further details contact Pam, (G4STO) (Secretary) Tel: (01427) 788356.

THE (WIGAN) DOUGLAS VALLEY AMATEUR RADIO SOCIETY still meets on the first and third Thursdays of each month from 8.00pm. The Hesketh Arms, Shevington Moor, Shevington. Wigan. For further details contact D. Snape, G4GWG, QTHR, Tel: (01942) 211397.

SCIENCE AT YOUR FINGERTIPS, for 'hands-on' science experiences and experiments, *Science at Your Fingertips Science Review*, Membership £1. For further details, please contact Daniel and Caroline Gee, The S.A.Y.F., 37 South Road, Watchet, Somerset TA23 0HG.

SEEMUG (SOUTH EAST ESSEX MAC USER GROUP). meet in Southend, every second Monday of each month. For details Tel: Michael Foy (01702) 468062, or e-mail to mac@mikefoy.demon.co.uk.

SOUTHEND & DISTRICT RADIO SOCIETY meets at the Druid Venture Scout Centre, Southend, Essex every Thursday at 8pm. For further details, contact: P.O. Box 88, Rayleigh, Essex SS6 8NZ.

WINCHESTER AMATEUR RADIO CLUB meets on the third Friday of each month. For full programme contact: G4AXO Tel: (01962) 860807.

MODEL RAILWAY ENTHUSIAST? How about joining 'MERG', the Model Electronic Railway Group. For more details contact Paul King, 25 Fir Tree Way, Hassocks, West Sussex BN6 8BU.

AARS (ABERDEEN AMATEUR RADIO SOCIETY) meets on Friday evenings in the RC Hall 70 Cairngorm Crescent, Kincorth. For further details contact Martin GM0JCN (Secretary). Tel:(01569) 731177.

CRYSTAL PALACE & DISTRICT RADIO CLUB. Meets on the third Saturday of each month at All Saints Church Parish Rooms, Beulah Hill, London SE19. Details from Wilf Taylor, G3DSC, Tel: (0181) 699 5732 or Bob Burns G3OOU Tel: (01737) 552170.

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

Setting up a RADIO SHACK

For a habitual short wave listener or licensed radio amateur, it is important to have somewhere set aside for radio equipment. Traditionally, radio amateurs have called their rooms the 'shack', and often this describes them very well. But whatever state they are in, a shack of some description is a great asset for any radio enthusiast, and this article provides useful guidelines for anyone wishing to establish a new shack, or improve upon an existing one.

by Ian Poole, G3YWX

Choice of Location

The choice of where to put the shack can be a daunting one. Whether it is the first one to be made when starting out on the hobby or the twentieth when moving house, the shack has to meet many requirements. It must be somewhere that the wife will not moan about the mess, and where the children won't electrocute themselves or be able to wreck the equipment. Unfortunately, the shack is not normally at the top of the list of priorities for space within the house. Even so, it must be somewhere that the radio equipment can be operated safely, and the hobby enjoyed.

This may be a tall order, but many people have managed to construct very good shacks which are sometimes in the most unlikely places. Some shacks are fitted into odd corners, whilst others are neatly laid out with plenty of space. Each shack has its own story, and something can be learnt from every design. When setting out on planning one's own shack it is amazing what can be learnt from the experiences of others. Just looking at their designs can give a number of ideas which can be incorporated into one's own. Having recently moved house, I thought I would cast my mind back over some of the shacks I have had and others that I have visited to recall some of the good ideas which have been used and try to incorporate them in my own.

Spare Room

Of all the shacks I have seen, those people who are lucky enough to have a spare room in the house must be the most fortunate, since generally there is plenty of space, it is warm, and close to hand, so it is possible to 'pop' in and out for five minutes or so at a time. The rig can be kept on two metres listening for the telltale signs of sporadic E, or the DX bands can be monitored from time to time to see if that rare DXpedition has materialised. Also, if it is at the back of the house, the feeder runs to the aerials in the back garden can be made fairly short.

I can remember one person who, a few years ago, had a shack in the back bedroom of his bungalow. A very large AR88 valve receiver with an equally sizeable Heathkit DX100U AM/CW transmitter occupied the centre place on the table, there was plenty of room for other odds and ends around the shack, and even ample space for visitors to have chairs. A final luxury was a cupboard to house all the components, spares and other essential bits which go with every ham radio station. In fact my only complaint, about this station, was that I have never had the space to set up a shack like it!

Garden Sheds

As most people are relegated to lesser places than spare rooms, it is necessary to think of ingenious ways to make an elegant shack out of somewhere not quite as nice. One shack I can remember was set up in a garden shed. Before work started, it was full of all the usual gardening bits and pieces. There were old lawn mowers, fertilizer, seeds, forks, spades and everything else you can think of, together with a liberal amount of garden dirt. First of all, the old garden junk and rubbish was cleared out, the outside was repaired to prevent any leaks occurring which might damage the equipment, the inside of the shed was lined with hardboard and a nice new table was fitted. All the electrical wiring was installed at the same time, so that it could be run behind the table and under the hardboard.

Once all the woodwork had been done, it was painted and a carpet was laid. A heater was also installed to make operating comfortable in the winter, and finally all the equipment was installed – once finished, the shack looked very inviting. It was somewhere out of the way from the family and the calls to attend to every little job going (although I remember there was an intercom to say when lunch was ready). This shack was very successful – a lot of DX was worked from it, and it was ideal for antenna experimentation. Being in the back garden, it was easy to run feeders of all sorts from the aerial directly into the shack – through an open door if necessary for trials.

The main disadvantage of a shack like this must be security. As it was not in the home it would have been comparatively easy to break into. However, a first project could be to install a suitable burglar alarm system such as those stocked by Maplin, to help safeguard the equipment (Note there may be a possibility of radio-controlled 'wireless' type alarms causing interference with amateur radio equipment).

Care also has to be taken when installing the mains supply. Firstly the earth wire must be intact to prevent the possibility of equipment becoming live, and secondly, the wiring must be of the correct power rating for the job. As it is likely that the run to the shed will be relatively long, there is a possibility of voltage drops. In many cases this might not be a great problem, but if a large linear amplifier is used then the lights might start to dim when it is switched on.

Picturesque external view of a shed-based shack.

Example of a suitable alarm system to protect a shed or garage, this being the 'Versatile Multi-purpose Intruder Alarm' (AP97F, Price £19.99).

An example of a loft-based shack.

Garages

The idea of using a garage for a shack never inspires me. I have heard too many people saying over the air that their shack is in the garage, and that it is cold and draughty or is being overtaken by car parts or other junk from the garage. However, this is probably a rather negative point of view. Often a garage can have plenty of space which is a necessity for most people when they get into amateur radio. In addition to this, there is the improved security over a wooden garden shed because it is easier to properly safeguard a garage. Even so, it would not really be my choice for a shack.

Lofty Ideas

One area of the home which is often reasonably accessible is the loft. It does tend to be the place where all the suitcases, toys which the children have outgrown, and all sorts of other junk is stored. But if this can be sorted out and some space made, then it does become a possibility.

I did have a loft shack at one time. One of my major concerns was that the floor would not be strong enough. So to help overcome this, the table with the equipment was placed over one of the supporting walls, and some flooring chipboard was laid down to spread the load. In addition to this, some wiring had to be put in for the lighting and for powering the equipment, and a loft ladder had to be installed. Fortunately, these ladders are quite cheap and are easy to fit, storing neatly out of the way when they are not in use. Finally, the roof was lined with some hardboard. This prevented some of the dust getting in, and it also gave some added insulation, this being necessary because the loft was very prone to extremes of temperature. In winter it was very cold, often preventing CW operation after a short while up there, and in summer it became so hot on sunny days that it was definitely a case of going up there in swimming trunks! Fortunately this was not the case all of the time, particularly during the spring time and autumn when the temperature was usually fine.

Put the Ham in the Cupboard

It is not always possible to have some form of room for the shack. Flats and maisonettes pose problems as they may not have a loft, garden shed (or a garden), and there may not be a spare room. One idea which can be brought into play in these instances, is to use a cupboard. In fact, when I lived in a flat, there was a reasonably large 'walk-in' style cupboard, which I jumped at the chance of using, as it seemed ideal. A table was soon built into it, and there was just enough room to store a fold-away chair in it with the door closed. In addition to this, plenty of shelves were put up to act as storage space for books and components. Space was obviously at a premium, and a certain number of items had to be sorted out and stored elsewhere or auctioned at the local radio club junk sale. Despite this drawback, it was quite an efficient little shack. It served its purposes well, and it had the great advantage that when it was not in use, it could be shut up and kept out of the way, and could be made to look tidy simply by shutting the door.

It did have a number of disadvantages. The space factor has already been mentioned. Mains had to be laid on as well, and there was a difficulty in getting the feeders from the shack to the outside world without running them all through the flat. Nonetheless, it worked quite well and I have seen a number of other people who have also succeeded in making very neat little shacks out of convenient cupboards, both large and small (the cupboards, that is!).

Emulating Jack Horner

It is not always possible to set aside a room, loft, shed or a cupboard, and sometimes a table or desk in the corner of a room has to suffice. Whilst this obviously has its drawbacks, I have seen a number of stations set up like this. Fortunately, today's rigs are quite compact when compared to the giants of a number of years back, receivers like the AR88 and transmitters which are rack mounted now being a thing of the past. This means that with some careful planning, a neat and effective station can be set up without it having to dominate the whole room.

A small table with a shelf or two can house a complete station without too much difficulty. After all, a small transceiver together with a microphone, a key, an aerial tuner unit (ATU) and a few other odds and ends, is all that is really needed to work stations all over the world. A VHF or UHF station may need even less. So it is not the end of the world if there is not much room available!

In fact, one station which I had for a while was situated in a small chest of drawers. The top provided space for the log book when the station was in use, and the rig was mounted behind one of the fronts of the drawers which folded down instead of pulling out. It was not the place for project construction, but it certainly kept the rig out of sight when it was not in use, and operating the rig was quite easy.


Compact modern amateur radio equipment may be sited on a small desk with space to spare for upkeep of the log, etc. Note striplight below the shelf.

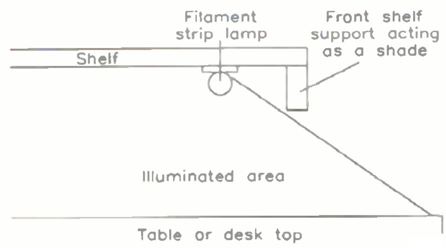


Figure 1. Use of a strip light to illuminate the work surface.

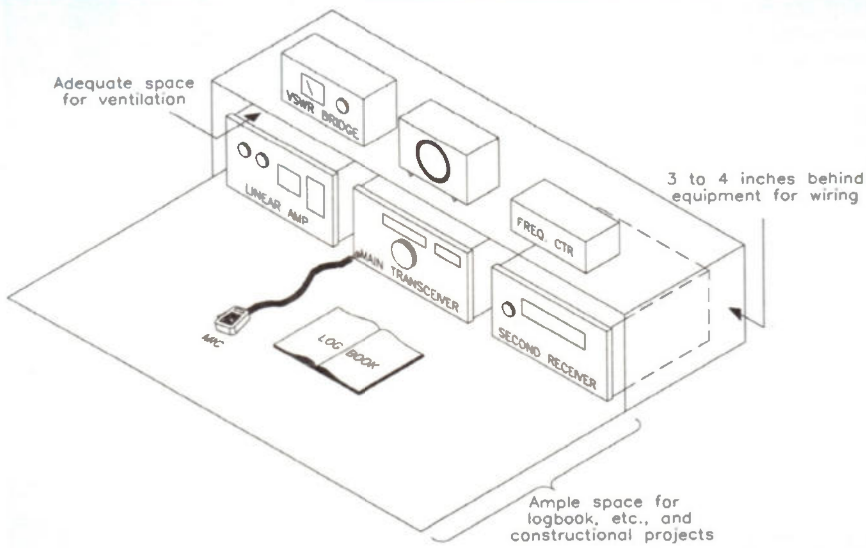


Figure 2. A possible layout for an amateur radio station.

Other Considerations

When setting up a shack, the amount of table space is always very important. All too often, people house the equipment quite satisfactorily but forget to allow sufficient room in front of the rig for keeping the log, general construction, or even a morse key. The number of times I have seen people perching something on an odd corner must be too many to count. To my mind it makes the station much more difficult to operate, and it will reduce the enjoyment of using the shack.

Ideally, there should be a minimum of about eighteen inches of space in front of the rig. Even this can easily be clogged up with all sorts of junk, but at least it is there in the first place. Also when planning out the work space, sufficient space should be allowed behind the rig for electrical wiring and coaxial cables. It should be borne in mind that three or four inches will be needed because the coax has a limited bend radius and connectors are surprisingly long.

Shelves are a useful addition to any shack. If they are placed above the rig, they can then be used as space for many of the smaller items of equipment like VSWR meters, ATUs and the like. However, when planning the shelves, sufficient space should be allowed around the main equipment for ventilation. If there is only a receiver then this is not much of a problem, but if there is a transmitter, transceiver or at worst a linear amplifier, then this factor must be considered, to avoid problems of overheating, or even fire risk.

Lighting

Lighting is an important feature in any shack. Lights in the centre of the room are not ideal because you always cast a shadow over where you are working. There are a number of ways to overcome this, other than making yourself transparent! A small incandescent strip lamp can be mounted under a shelf above the work surface. In this way the light will come from in front of you. It is even possible to use the front support of the shelf as a blind to prevent any direct light shining into your eyes. However, when doing this, be careful to obey the instructions of the light manufacturer, and not place the light too near any of the supports.

Anglepoise lamps are also very good, because they can be positioned to give the maximum amount of light where it is needed. This is very important when constructional projects are likely to be undertaken, especially with today's components becoming ever smaller.

Mains Wiring

When building the shack, a little thought should be given to the mains wiring. A typical station will have a great variety of pieces of equipment, many of which will require mains power. To supply all of them in a neat fashion, multi-way mains power distribution blocks can be used (e.g., Maplin Stock Code ZF55K). In this way, the use of a multitude of two and three-way adaptors can be avoided.

A further item worth including in the shack is an earth leakage circuit breaker (ELCB), now often referred to as a Residual Current Device (RCD) or a Residual Current Circuit Breaker (RCCB). RCDs trip out when a current difference above a certain value (normally 30mA) is detected between live and neutral. Such a difference will occur if a fault develops in a piece of equipment and current flows from live to earth – perhaps even *through* the person using the equipment. The RCD is able to disconnect the supply in a very short space of time, and thus is likely to prevent a fatal electric shock from being received. RCDs are available as a 'plug in' unit – ideal for use with portable equipment for use in a variety of locations – and as permanently fitted units, for inclusion in the mains distribution system in the home. If you are going to the effort of building a custom shack, the additional cost of having a permanently-installed RCD is well worthwhile, as it can be used to protect the whole house and not just the shack! Note however, that *these devices do not prevent shocks entirely*, and the utmost care must therefore be exercised when using the mains, even if an RCD is installed. If in doubt about any aspect of tackling the mains wiring for the shack, it is always highly advisable to consult a capable electrician for suitable guidance.

Equipment Layout

To allow the station to be operated efficiently, and easily, the actual layout of the equipment is important. It probably goes without saying that the main receiver or transceiver should take the centre position. Ideally the tuning knob should be a couple of inches above the table top, enabling you to rest your arm on the table whilst tuning up and down the band.

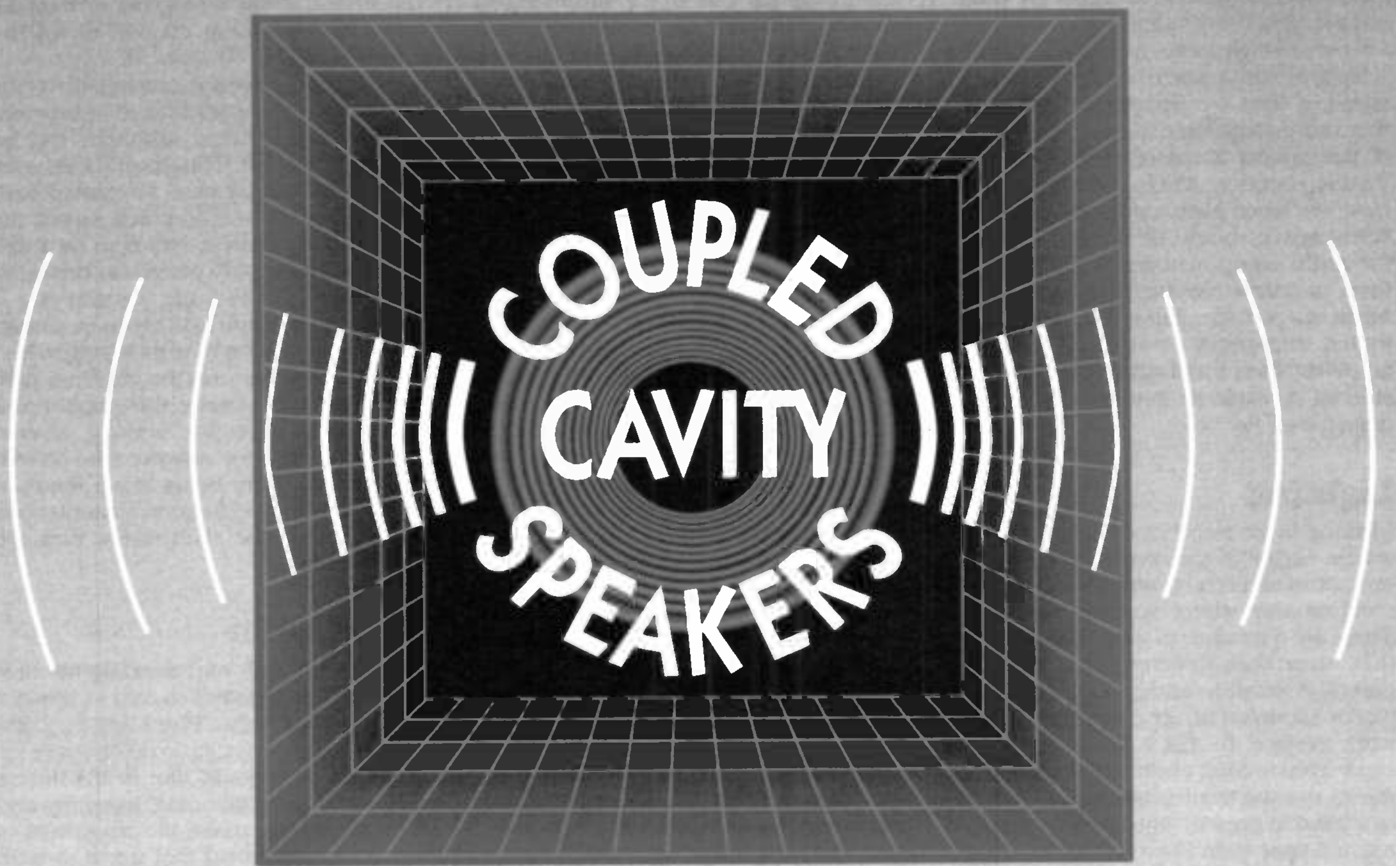
If there is a second receiver or transceiver, this can be positioned to the right of the first. A linear amplifier can be placed to the left. This means that your right hand can be used for tuning both sets without having to reach across the table top. If a morse key is to be used, this can be suitably placed on the right-hand side of the table. Conversely, a microphone which is likely to be placed in the left hand can have its wiring routed so that it appears on the left-hand side of the table. Obviously, this applies to a right-handed operator, and the reverse would be true for anyone who is left-handed. Ancillary items like a speaker, VSWR bridge, and frequency counter can be placed on the shelf where they are clearly visible.

Conclusion

Planning a shack and deciding the best place for it to go is not as easy as it might seem at first sight. There are very few people who can devote as much space (or time!) as they would like to the hobby. However, a little planning, ingenuity and forethought can make the enjoyment of using the equipment that much greater. It can make the best of what is available, and bring extra rewards when operating the equipment or experimenting. Go ahead, get yourself shacked up and enjoy the experience!

Further Reading

Setting Up An Amateur Radio Station, I. D. Poole (author of this article), (WT74R) Price £3.95 NV.
Electric Wiring: Domestic, A. J. Coker & W. Turner, (WS82D) Price £12.95 NV.
Wiring and Lighting, Albert Jackson & David Day, (WT56L) Price £6.99 NV.
Wire It, Robert Henley, (WT55K) Price £1.99 NV.



PART 2: CONSTRUCTION DETAILS

by David Purton

In Part 1, last month, we looked at both the theory and benefits of a band-pass, or coupled cavity sub-woofer. The major benefit of a sub-woofer that filters above and below a determined frequency, is in enabling the designer to eliminate large value inductors used in a bass crossover, which adversely and dramatically affect the damping factor of the power amplifier. This is illustrated by the response plots shown in Figures 1 to 3.

ADDITIONALLY, the cone of the drive unit in a coupled cavity sub-woofer is loaded, both back and front, by a contained volume of air. This symmetrical loading substantially reduces harmonic distortion. Correctly designed and built, this type of bass loading endows those bottom octaves with a speed and definition rarely available in any other type of design. This article will enable the DIY enthusiast to build just such a pair of loudspeakers.

Choosing the Right Design

Illustrated in Figures 1 to 3, are response plots for three designs, A, B and C respectively, based around the Maplin 10in. driver loudspeaker (XG46A). Designs A and B require two drive units for a stereo pair of sub-woofers (one in each!), and design C (which we will come back to later) requires four drive units for a stereo pair.

The different responses should enable you to match to your chosen satellite speakers. If your present speakers are 15 to 30 litres in volume, response A should be considered, and for small sealed cabinets, response B. Truthfully, this can only be a guide, as exact matching in phase and amplitude can only be achieved by means of computer simulation and prediction, or by actual measurement.

For the purist, if you have the amplitude and impedance plot of your current system, or know the drive unit's make and model number, and the internal volume of your cabinets, then design facilities as offered by the Obsession Loudspeaker Design Company, in association with Wilmslow Audio, may be of benefit. This service costs £50 (at the time of writing), but will ensure an exactly matched and dedicated sub-woofer. See details at the end of this article. Do not be too alarmed though: the frequencies being dealt with are very low, and, given the potential to place the sub-woofers anywhere in the room, experimentation will establish the best position for them to suit the listeners' particular tastes.

The response plots are actually predicted for $2 \times \pi$ space loading, but actually the same rules of physics apply. In other words, you will get more bass if you load them close to corners or flat walls, and less bass the further you move them into the room. Close proximity to flat radiating surfaces gives a greater probability of producing a more even bass reproduction, but there are no hard and fast rules on this one! The ability to 'tune' the system in this way is probably one of the major benefits of separate sub-woofers, enabling the small satellite speaker to remain in free space, to maximise their ability to image well.

All the response plots are referred to 8Ω impedance units, however, efficiency will vary. All the designs are BP3 type (back cavity tuned to front cavity, as described in the previous part of the series). This design offers benefits such as substantial reduction of cone movement at the tuning frequency. However, because of the number of impedance tuning spikes within a relatively small frequency range, the amplifier will often see an average of higher than 8Ω impedance (or 16Ω in the case of design C). This will effectively reduce the power to the sub-woofer, relative to the satellites. If your satellites are of a nominal 8Ω impedance, and have an efficiency of between 86 and 88dB, then given different room sizes and sub-woofer positioning, designs A or B will offer a very good performance.

If you own a vinyl or CD test disc (e.g., AY00A £16.99), or a pink noise generator, and a sound level meter (set to response C), you will be able to experiment to your heart's content, or at least until, by altering the speaker placements, you achieve an accurate balance! You will also be able to test your own sub-woofers, by placing the microphone of the sound meter at the mouth of the exit port. Using the one-third octave pink noise signals on the test disc, you will be able to establish the turnover frequencies, bandwidth and response.

What is so Special about Design 'C'?

Design 'C' differs from the others, in that it uses two 10in. drive units mounted face-to-face, one on each side of the baffle, and driven out of phase, which results in both

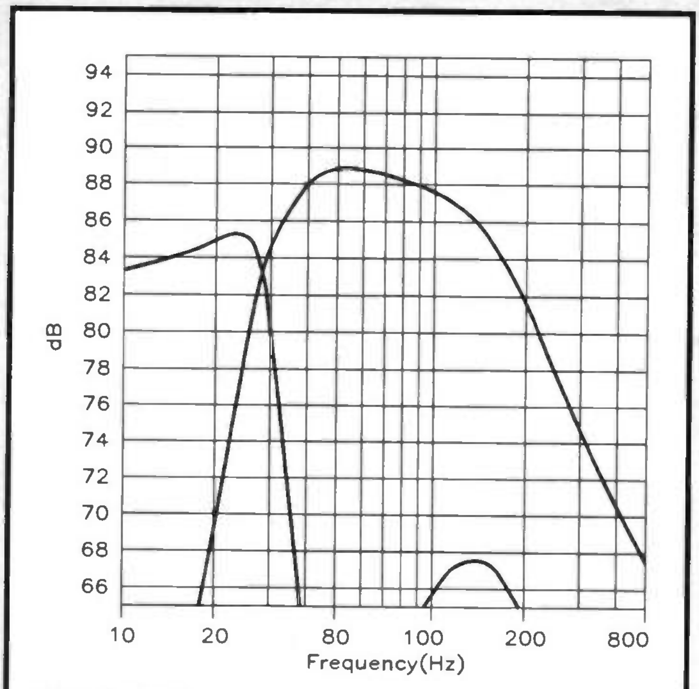


Figure 1. Design 'A' response.

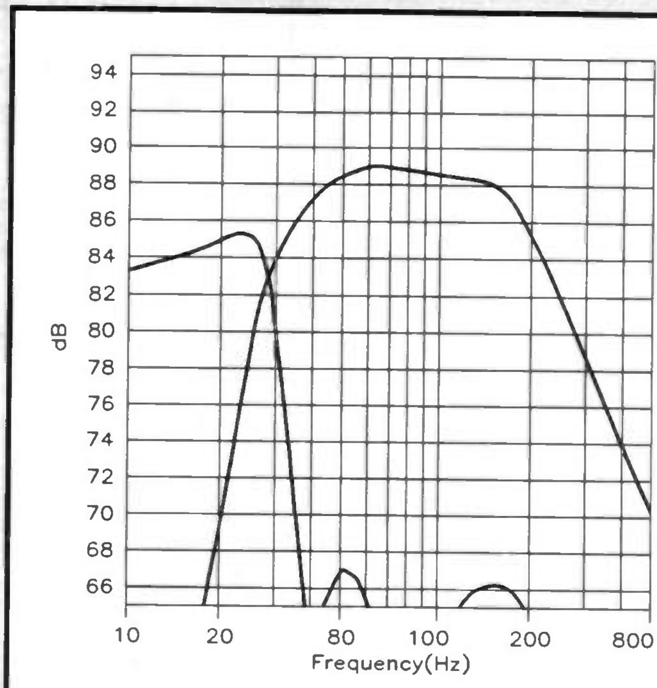


Figure 2. Design 'B' response.

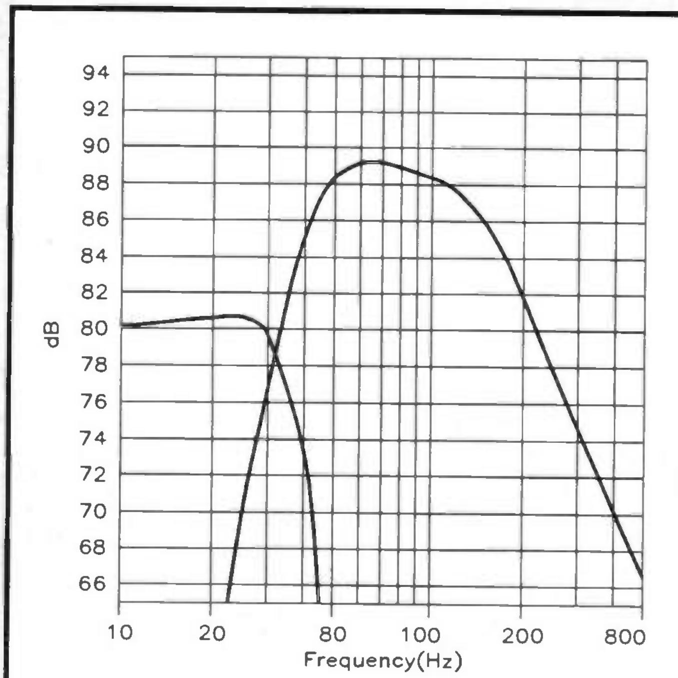


Figure 3. Design 'C' response.

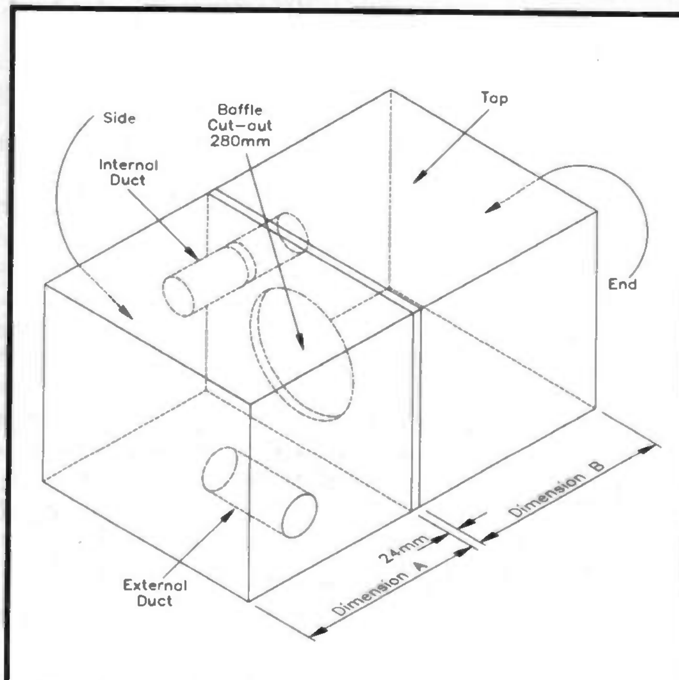


Figure 4. 'X-ray' view, showing internal layout of all three designs.

cones moving in the same direction. This form of loading has major benefits: the power handling is increased to 200W, and because the drivers are in 'compound' configuration, the cabinet volume can be reduced (down to 32 litres in total!). Driver distortion is also further reduced with this style of loading.

A series connection of the drivers will result in an impedance of nominally 16Ω, and a parallel connection, 4Ω. The series connection is recommended if the sub-woofer is driven in parallel with the satellites, and the parallel connection is recommended if you choose to drive your sub-woofers with a separate amplifier. If you choose to go to the expense of a separate bass amplifier (maybe one of the excellent Maplin Kits!), you will be able to precisely match your chosen bass unit by varying the amplifier gain. If you are thinking high-end, a powerful transistor amplifier for the bass units, and a valve for the satellites might bring you close to nirvana! Superb results can still be obtained with the standard, in parallel connection, and one good power amplifier, so do not be put off. . . .

Building a Pair of Coupled Cavity Speakers

Having decided which response or design is best suited to your normal listening loudspeakers, Table 1 provides you with cabinet volume details and tuning pipe lengths. The -3dB points and reference efficiency are also stated.

Figure 4 represents any of the designs mentioned. The baffle dimensions stay the same for all three designs, so just the length dimensions are varied, to produce the required cabinet volumes, as per Table 2. You may choose to make the box any shape you like, and as long as you can accurately measure the volumes of the two cabinets, you can be as inventive as you like. However, remember you have to be able fit the ports in – so do not come running to me if they will not fit within your beautiful pyramid-shaped enclosure!

Table 3 provides the sheet cutting information you require, and is based on 24mm thick Medium-density fine (MDF) panels. A superbly accurate cutting service is offered by my local DIY store. The 24mm thickness is achieved by bonding pairs of 12mm panels together before final assembly. The design is relatively straightforward, and DIY fanatics may choose their own method of fixing the panels, depending on your woodwork skills. The internal volumes are quite critical though. I have built in an over-sizing of approximately half to one litre on the dimensions, to allow for wadding and magnet assemblies.

Design	V1 (L)	V2 (L)	D1 (mm)	D2 (mm)	L1 (mm)	L2 (mm)	–3dB (Hz)	Efficiency (W/m)	A1	Poles (Hz)	Power (W)
A	35	26	75	75	182	56	30/120	88	BP3	40/68	100
B	35	18	75	75	182	54	35/180	88	BP3	40/82	100
C	16	16	75	75	272	75	40/150	88	BP3	50/80	200

Where: V1 = Volume of back cavity
V2 = Volume of front cavity
D1 = Volume of internal port
D2 = Diameter of external port
L1 = Length of internal port
L2 = Length of external port

Table 1. Cabinet volume details and tuning pipe lengths.

Design	Dimension A (mm)	Dimension B (mm)
A	250	335
B	172	335
C	160	160

The internal baffle is 300 × 350mm in all cases, and the baffle cut-out for the driver is 280mm. If you change these dimensions, you will need to recalculate dimensions A and B. All dimensions allow for a 24mm thick baffle, dimensions A and B being for each side of the baffle. Account has been made for the volume taken by magnet assemblies and internal wadding or felt damping.

Table 2. Cabinet length dimensions.

Design	Baffles/ends (12 of)	Top/bottom (8 of)	Sides (8 of)
A	350 × 300	657 × 350	657 × 348
B	350 × 300	579 × 350	579 × 348
C	350 × 300	392 × 350	392 × 348

These measurements (in mm) assume you are constructing your sub-woofer from two thicknesses of 12mm MDF, bonded together to give 24mm thick panels. Remember! You are making a stereo pair, and therefore, two cabinets must be fabricated.

Table 3. Sheet cutting information.

Next month, Part 3 will cover the building and testing of design 'B'. A step-by-step approach will be taken, and illustrated with photographs. The designer is also making enquiries with cabinet makers, to establish if the design may be produced as a 'flat-pack' kit – more on this next time. If, however you are impatient to start, the following is offered as a general guide.

- Cut all the apertures before assembly.
- Mount drivers and internal duct before assembly.
- 'Half round' the exit of the 'outside' port if you have the equipment. MDF shapes quite easily, even with sand paper.
- Ensure the cavities are well sealed from each other.
- Make sure one panel is removable, and that you can still get to the driver.
- Use damping felt on the larger surfaces.
- Line the cabinets with 50mm of 'Rockwool' or similar. If you are going to measure your design, you may alter the amount of damping to suit.
- Keep the exit port at right angles to the driver. If you are getting midrange slush, or high-frequencies emitted from the port, you may use a 3 to 5mH choke to filter it out. Only low DC resistance ferrites please, and make it a big one! (e.g., Falcon Acoustics).
- Finally, and MOST IMPORTANT: MDF is unpleasant stuff, so ALWAYS WEAR A DUST MASK WHEN CUTTING OR SANDING IT.

Look out for the final construction article in the next issue.

@Internet

One of the backbones of the Internet is the ability to send (upload) and receive (download) computer files to and from a distant computer server. There are various ways to do this, but by far the most common is FTP. This acronym stands for *file transfer protocol*, which gives a clue as to what is happening when you do it. As you might expect, each computer in the transfer operation has to follow a strict protocol to ensure files are transferred correctly.

The software you run on your computer can be one of a range of programs. These are generally shareware or freeware, and can often be picked up on magazine cover disks or from friends already on the Net. Nowadays, some World Wide Web browsers have some form of FTP transfer capability too, so you don't strictly need a separate FTP program. Once connected you can even download other programs (or latest versions of your own FTP program or web browser) from various FTP sites around the world.

Operation of all these FTP programs is very similar. You logon to a site giving your user name. For most sites you can use the name *anonymous* which gives you access to the server's free information. (Note that most servers will have other information which you can not get to unless you have the proper access user name and identity.) From there you have access to directories and files in a similar style as Window's File Manager or as the Macintosh Finder in *view by name* mode.

There are a couple of points about FTP, though, which all users should be aware of. First, this information is free to users, but paid for by the providers of the FTP server – usually universities around the world. So treat it respectfully. Each time an external user access the server and downloads huge files from it, the server slows up a bit to do the job. Which means other users (maybe students or researchers) whose work depends on it, may take longer to process their jobs.

Second, with this in mind, try to use the FTP server out of normal hours. If a server situated in the States is your choice, use it only in the early hours of the UK; when most people Stateside are asleep. That way, local users who rely on the server during their daytime have a better chance of finding the server running as fast as they would like, and *you* have faster access too (when all the local users are not using it).

Third, many FTP sites are *mirrored* around the world – that is, other servers are set up which directly copy the information from the first server. If you use a mirrored site in your home country, FTP downloading is cheaper for the site, faster for you, and better for the whole Internet.

Add-ons get Netted!

As little as twelve months ago, e-mail users were innovators. Now if you haven't got an e-mail address, you might as well communicate using carrier pigeon. This month PC Card specialist Portable Add-ons jumps aboard the bandwagon, having decided it does not want to get left behind.

For the end-user, this means you can find out more about a product in which you are interested, together with details of your nearest authorised reseller.

To say Portable Add-ons is only just catching up is perhaps a tad unfair. In fact for the past two years, the company has been running the PAranOid bulletin board (BBS), which is available by dialling (01483) 295 720.

With PAranOid, software updates such as enhanced drivers – can be downloaded. There is also an on-line conference, and a newsletter. All speeds up to v.34 are supported, and the format is 8 data bits, no parity, and one stop bit (8-n-1).

It is hoped that an FTP site will follow soon, so that PAranOid's software library can be accessed from the user's nearest Internet point of presence. In addition, Portable Add-ons is looking into the possibility of establishing its own WWW page.

Contact: Portable Add-ons, Tel: (01483) 440 777.

TI Goes Online With WWW Site

Texas Instruments has launched its home page on the Worldwide Web. Internet users can now access a wealth of information about the company, its business units, products, services, management structure, history, current stock and financial data, and product and distributor listings.

Contact: **http://www.ti.com**

Online Olympics

The Atlanta Olympic Games Committee is setting up a WWW server in conjunction with IBM for the 1996 Olympic Games. This means that individuals the world over will be able to access official information about the 1996 Olympic Games from the home page.

This new server will provide a wealth of constantly updated facts, figures, photos, videos and audio content providing all the latest news and information, including details of how to book tickets for the games.

Contact: **http:/www.atlanta.olympic.org**

Private Eye

Satirical magazine *Private Eye* has widened its Internet access. The magazines editorial has been contactable by e-mail for the past six months, at **strobe@cix.compulink.co.uk**. And CIX users have been able to discuss items from the magazine such as Colemanballs, Letters and Pseuds on a newsboard, with dedicated topics for each section of the magazine. But now Lord Gnome has a WWW page.

Contact: **http://www.intervid.co.uk/intervid/eye/gateway.html**

Calling All Internet Users

US Robotics claim that few individuals understand the practical benefits of the Internet to business and home users. Fear not, the company intends to put the record straight.

US Robotics is calling for anyone with an interesting Internet story to submit it to them for inclusion in a booklet to be published in the Summer.

According to Marketing Manager Lucy Brown, "There are plenty of guide books to the Internet, but they all seem to concentrate on how rather than why? We are trying to tell ordinary people what a great resource the world has just discovered."

The applications can be either commercial or recreational. Contact US Robotics with your ideas. But if you want to reach them by e-mail, you'll have problems. Far from practising what it preaches, the company has yet to publish Internet contact details. Sounds like US Robotics has yet to realise the value e-mail.

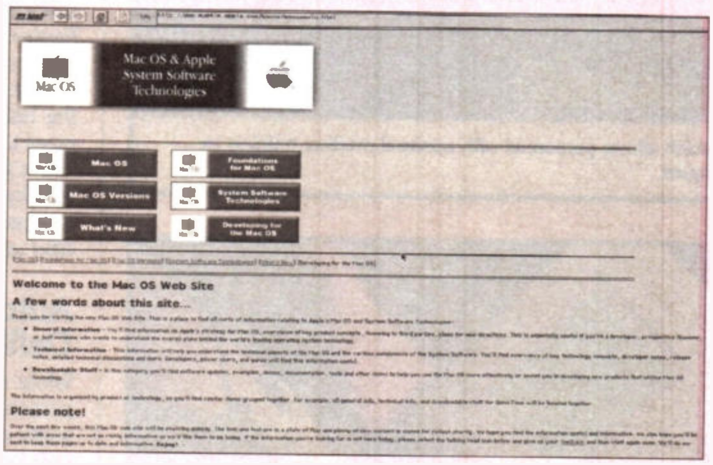
Contact: US Robotics, Tel: (01734) 288 200.

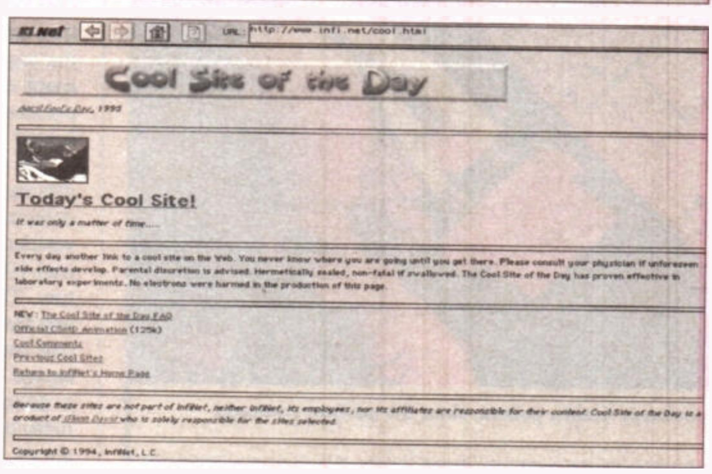
Virtual Shopping

Online service provider CompuServe has signed up eight high street retailers for the UK's first virtual shopping centre. Live from 27 April, shopping chains such as Our Price, PC World, Dixons, W H SMITH, Interflora and Past Times are taking part.

CompuServe aims to have 25 shops online before the end of the year. The server will be free to all 100,000 UK CompuServe members.

Contact: CompuServe, Tel: (01734) 391064.





Site Survey – *the month's destinations*

Two offerings this month. The first is a look at Apple's new site set up specifically to cover developments of the MacOS – the operating system which currently runs the Apple Macintosh range of computers. For those not aware, Apple has only recently begun to licence the MacOS to other computer vendors, which should make a great deal of difference to how many computers around the world run it. Previously Apple has always guarded the MacOS like the Crown Jewels, never letting any other computer manufacturer have it. This, of course, meant that you had to buy an Apple computer to run it. Now, though, a growing number of other manufacturers (Radius, Power Computer, Daystar, Pioneer, Bandai (yes the Mighty Morphin' Bandai) and others) are starting to build computers (or computer-based games machine, in the form of Bandai's new device codenamed Pippin) which run the MacOS. Some of these other machines should be available by the time this issue is on the streets. Apple intends to grow its market share of computers world-wide accordingly.

The MacOS home page is at: **http://www.austin.apple.com/macos/macos main.html**

Finally, a quick look at the Cool Site of the Day, found at: **http://www.infi.net/cool.html** where every day an interesting site is shown for your very own self-gratification. Worth a look if only to find out what someone else deems as *cool*. Although it is a little late (press dates for the magazine did not allow us to show the site in an earlier issue) here is the site which was listed on 1 April this year. Needless to say, clicking on the *Today's Cool Site!* hyperlink brought any such puzzled observers back to the same site. Glad to see someone on the Internet's got a sense of humour.

 – Continued from page 35.

Where the collapsed patient with these conditions is administered to within four minutes, then the success rate for this first stage of defibrillation is remarkably high – of the order of 90%. With increasing delay, however, the chances of successful defibrillation steadily diminishes. The major initiative now with defibrillation techniques is training and speed of response. (Is time to first defibrillation in hospitals specified in the Patient's Charter?)

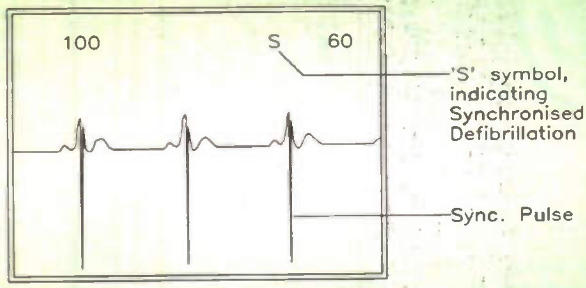


Figure 8. Correct synchronisation for synchronised defibrillation relative to the R wave of the ECG.

Synchronised Defibrillation

When the heart adopts an abnormal rhythm such as atrial fibrillation or ventricular tachycardia and drug treatment is unsuccessful in restoring a normal heart rhythm, then the procedure of synchronised defibrillation can be utilised as a corrective stimulus. The patient is usually under general anaesthetic during synchronised defibrillation, and so would be unaware of the procedure being undertaken. It is important, nevertheless, that the application of energy to the exterior chest wall is synchronised to the ECG as per Figure 8. Usually the energy is delivered some 25ms after the top of the QRS complex, a specific 'fingerprint' section of the ECG trace. This implies that defibrillators used for this procedure must be of the 'synchronised' type and have the ability to monitor the ECG waveform and deliver the energy pulse at the correct time relative to the QRS complex.

There is, however, increased interest in reducing the level of energy required to achieve synchronised defibrillation. Using the method of Transoesophageal defibrillation, current is applied between the oesophagus and the external chest. Since the heart muscle is being targeted more effectively, lower values of delivered energy can be used for the benefit of the patient.

Automated advisory defibrillator, which allows personnel with minimal medical training to apply effective resuscitation techniques.


Advisory defibrillator in use on an obviously healthy patient, since the advisory message displayed is "No Shock Advised"!

Transtelephonic Defibrillation – Remote Resuscitation

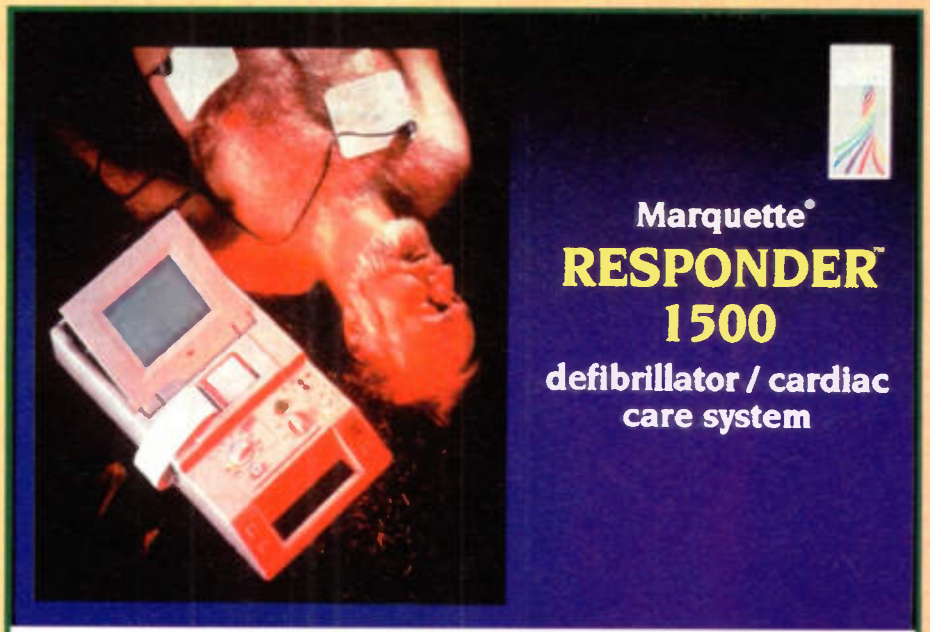
In the resuscitation of the collapsed patient, response time to administration of the first shock is of vital importance. A team of cardiologists at the Royal Victoria Hospital, Belfast, in association with the Northern Ireland Bio Engineering Centre, have developed a transtelephonic system which allows direct connection of an ECG monitor/defibrillator attached to a patient remote from the hospital. Once the electrodes have been attached to the patient's chest in order to capture an ECG signal and possibly administer defibrillation shocks, the ECG can be monitored and the defibrillation process controlled by a cardiologist at the base hospital. Dual tone, multi-frequency (DTMF) signals are employed in order to minimise the risk of accidental discharge. With the widespread development of the cellular network all the technology is in place to make transtelephonic defibrillation a viable possibility. A specific product could be developed to cater for this, with the operating company having a central response desk to offer user support.

Automatic External Defibrillation

While nursing staff emergency ambulance personnel can be trained to recognise VF, some element of signal recognition has been built into recent models of defibrillators so that they can, with a good measure of accuracy (in the region of 95%), identify VF. Such equipment is designed for use where non-clinical personnel are on hand to attend to the collapsed patient.

The development of cost-effective microprocessors and software algorithms for the detection of abnormal heart rhythms such as ventricular fibrillation led to the initial use in the mid-1980s of 'automatic' external defibrillators. The basic concept of such equipment was that they could be used by staff with minimal training for the resuscitation of the collapsed patient. The excellent feature of such a device was that it potentially reduced the delay before the administration of the first DC shock. One problem, however, with such equipment was that it was possible to detect false positives, i.e., mistake specific heart rhythms as VF and also false negatives, i.e., fail to recognise true instances of VF.

Part of the problem is that during the Cardiac Pulmonary Resuscitation (CPR) mode, the patient's chest is compressed extensively and the mechanical disturbance is added 'noise' to the potential recognition of the ECG. Usually an automatic or semi-automatic machine will require about 8 to 10 seconds of trace to analyse before it reports its 'pronouncement' on the ECG. There is currently considerable debate about the relative effectiveness of such equipment. Such debate, however, requires detailed studies of the relative effectiveness of the 'automated' or 'manual' types of equipment. In trials of equipment, however, it is difficult to assess and make allowances for the training of staff. Even excellent equipment in the wrong hands will yield inferior results.



Defibrillator/cardiac care system with the Apex and Sternum paddles placed correctly on the patient, as per Figure 5.

Implantable Cardioverter Defibrillators

It was following the sudden death of a close colleague in 1969 from ventricular tachycardia, that a certain Dr Michel Mirowski set about developing an implantable device for correction of abnormal heart rhythms. At first the medical establishment was distinctly hostile and funds for development were hard to come by. Developments in circuit technology, however, made it possible in 1975 to produce a device which was implanted in a dog. In the USA, the use of all medical equipment and drugs is rigidly controlled by the Federal Drugs Administration. After approval of the device was granted for use in humans, the first implant took place in 1980. Since then, and especially in the USA, the implantable Cardioverter Defibrillator has become big business, and by 1991 one manufacturer alone had implanted some 25,000 devices. With units costing between £15,000 and £20,000, however, the use of such devices by the NHS is severely limited, yet methods of implantation have been considerably simplified by the utilisation of veins for insertion of active leads into the body.

Recent Developments

Work undertaken under the direction of Professor J. McC. Anderson is seeking to model the behaviour of cardiac cells under various modes of excitation other than the conventional single anterior – anterior pulse. Cardiac cells can be considered as having individual identity as well as contributing to a summed electrical activity.

Models and preliminary experimental evidence combine to indicate that it may be more effective to apply a series of appropriately timed 'mini-shocks' of around 30J rather than a single large shock. Moreover, the total energy delivered with the series of mini-shocks would typically be less than the large single shock value. There is also the possibility of measuring the electrical characteristics of the cardiac system during this process in order to optimise timing of such mini-shocks. Such developments could further miniaturise defibrillation equipment.

Summary

Modern technology has made available highly advanced defibrillator units as key items of equipment for the treatment of cardiac arrest. The emphasis now is on adequately training a broad range of staff in their use, and generally making the public more aware of proper responses in coping with such medical emergencies. It does seem remarkable, however, that up until the 1960s remarkably little work had been done since the days of Richard Reece's reanimation chair – close to the time of the Battle of Waterloo – to develop the appropriate technology.

Further Reading

The Update on Defibrillator Technology and Practice, Supplement September 1994, Greycoat Publishing, 1 Harley Street, London W1N 1DA.

Important Warning

The intention of this article is to provide information about defibrillation equipment for *interest* only. Under no circumstances should readers attempt to build or use defibrillation equipment or conduct any experiments described.

This article is not intended to provide guidance to medical personnel – such guidance should be sought from appropriate authoritative medical sources. Improper use of defibrillation equipment may prove fatal. In case of emergency, apply recognised First Aid procedures and request attendance of the appropriate emergency services.

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.

BATTERY SAVER

Design by Peter Fry
Text by Peter Fry and Maurice Hunt

Build this project, and save yourself a packet, by reducing your bill for replacement batteries. Good for the environment too, in the long run!

Described here is a simple-to-build project, designed to be used as a universal power-down module, for fitting into most battery-powered equipment, where there is a possibility of the device being accidentally left on, causing reduced battery life. This is not only a nuisance, but a waste of energy, and with escalating battery prices, gets to be quite costly.

This circuit provides automatic shut-down of the appliance after a widely-adjustable preset period, and will be particularly useful for test equipment, powered toys, and other devices which are used in situations where your thoughts may be elsewhere, forgetting all about the time and what you have left switched on!

The power-down circuitry itself features minimal current consumption, and barely places any extra load on the battery, particularly in the 'off' state, when current drain is just a couple of microamps, yet, it can switch loads of up to around 300mA. The circuit will operate over a wide supply voltage range, making it extremely versatile. No external modifications are required to incorporate the circuit into a piece of apparatus, unless you require the power down inhibit (permanently 'on'), or quick reset option, in which case, an extra switch will be needed. With careful choice of switch and its siting, however, this can be made to be very unobtrusive. In fact, I have fitted one of these circuits to the Maplin flickering candle, providing added realism (candle 'burns out', or gets 'blown' out!), in addition to saving batteries.

Circuit Description and Operation

Following the circuit diagram of Figure 1 will assist in understanding of the following description. The circuit is basically a timer, giving a 'monostable' output response, in that the output goes high for a set period, prior to it dropping 'low' again, and remaining at this level until reset (either by switching power off and on again, or by pressing the (optional) quick reset button).

The timer is based on IC1, an HCF4541BEY, programmable timer IC, which contains an oscillator and programmable divider. The oscillator frequency is determined by the RC network on pins 1, 2, and 3, the frequency being adjustable between 1kHz and 100kHz, in accordance with the formula:

$$f = \frac{1}{2{\cdot}3\ R1\ C1}$$

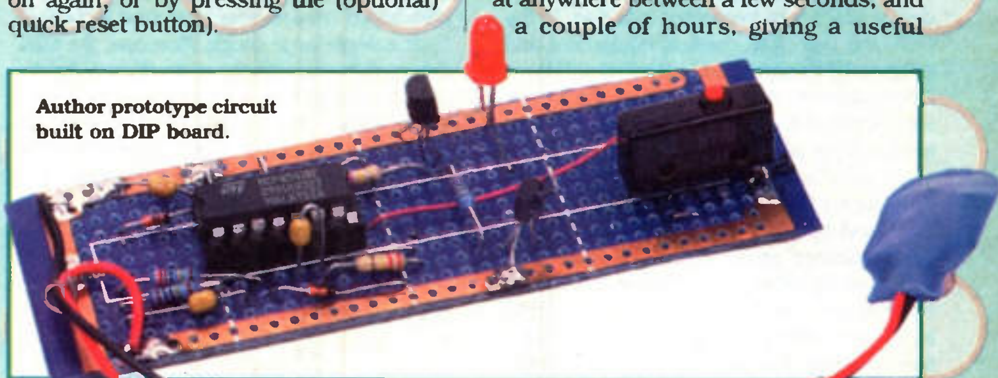
Where:
R1 = 5kΩ to 1MΩ,
R2 = 2 × R1,
C1 = 100pF to 100nF.

Table 1. A code set up on inputs A and B (pins 12 and 13, respectively), determines the division ratio of the counter stage as follows:

A	B	Count
0	0	8,192
0	1	1,024
1	0	256
1	1	65,536

Table 1. Divider set up codes.

By choosing suitable values of R1 and C1, and selecting the appropriate division ratio, the timed period may be set at anywhere between a few seconds, and a couple of hours, giving a useful range for almost any type of battery operated equipment imaginable!



Author prototype circuit built on DIP board.

Specification

Supply voltage range:	+5V to +18V DC
Current consumption (off):	2·6μA (with 9V supply and components suggested)
Maximum output switching current:	300mA

This chip, whilst being excellent for timing, has one very annoying feature, in that the oscillator does not shut down at the end of the timed period, resulting in the IC continuing to draw from 50μA to 1mA, depending on the RC network chosen. To get around this foible, D2 is used, to pull pin 3 low at the end of the timed period. This is, however, a compromise, since the current drawn is then equal to V/(3 x R1), approximately 2·6μA, assuming V=9V, and R1=1MΩ. It can be seen from the equation, that the higher the value of R1, then the lower is the current consumption. In theory, the consumption could be reduced below even this figure, but this would entail using components of values beyond the specified limits, with unpredictable effects on circuit operation, hence this is not advised.

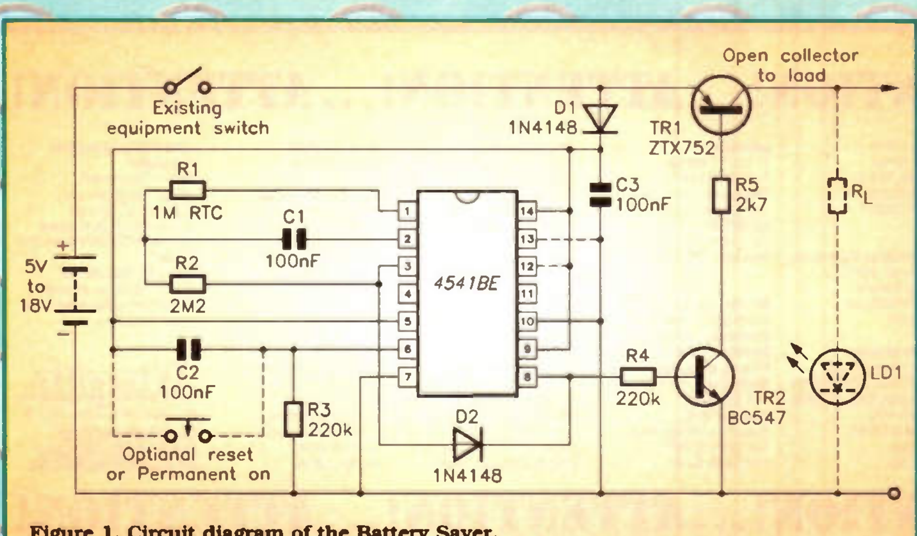


Figure 1. Circuit diagram of the Battery Saver.

The switch-on signal is taken from pin 8, the Q output of the divider, and passes to TR2, which in turn, controls TR1. TR1 acts as the output switch, and is in open-collector configuration to allow connection to the device under control. A ZTX752 is chosen for TR1, this being capable of driving 300mA with the 2k7 base resistor. The design trade-off here is in minimising base drive whilst maintaining TR1 in saturation, to allow maximum power transfer. Darlington pair set ups were avoided, as the object was to minimise the switch voltage drop. A transistor of lower specification, along with a higher base resistor could be used as the output switch, if the maximum allowable drive current were to be reduced.

Reverse polarity protection is provided by D1, preventing damage to IC1. TR1 will start to conduct at –8V (Reverse V_{be}), putting approximately 1V of reverse polarity on 9V equipment, but if the VF of a diode wired (in series) into the supply is acceptable for the application, then full protection could be offered. A Schottky diode could be used if the application demands a diode of low V_F.

The circuit is normally activated via the existing equipment on/off switch, but additionally, an optional extra switch can be included, which is connected across C2. This may be used to provide either a 'permanent on' option, or a reset facility, whereby the timing period will be restarted on closing then opening of the contacts. For the permanent on function, a latching push switch (e.g., FH41U), or slide switch (e.g., FF77J) is required, which may also be used as a reset by turning the switch on, then off. For a reset-only facility, a momentary action push switch (e.g., JM01B) is needed. Obviously, the casing of the equipment that the circuit is to be installed in will have to be modified to take the chosen type of switch, so it will generally be best to opt for the smallest switch possible that will do the job.

Note that the output goes high (timed period begins) the moment that power is first applied to the circuit, and that the power supply voltage may be between 5V and 18V (absolute maximum!), but that the current consumption will increase in proportion to supply voltage. If the optional LED indicator (LD1) is required, use a load resistor, RL, in series with it, of a value appropriate to the supply voltage being used. The value can be calculated from the formula:

$$R_L = \frac{(V_S - V_F)}{I_F}\ \Omega$$

Where:
R_L = Series resistance (Ω),
V_S = Applied voltage,
V_F = Forward voltage of LED,
I_F = Forward current (A).

BATTERY SAVER PARTS LIST

RESISTORS: All 0·6W 1% Metal Film			
R1	1M	1	(M1M)
R2	2M2	1	(M2M)
R3,4	220k	2	(M220K)
R5	2k7	1	(M2K7)
CAPACITORS			
C1,2,3	100nF Monolithic Ceramic	3	(RA49D)
SEMICONDUCTORS			
D1,2	1N4148	2	(QL80B)
TR1	ZTX752	1	(UH52G)
TR2	BC547	1	(QQ14Q)
IC1	HCF4541BEY	1	(QQ47B)
MISCELLANEOUS			
	14-pin DIL IC Socket	1	(BL18U)
	Veroboard or PCB	As Req.	(see text)
OPTIONAL			
LD1	Red LED	1	(WL27E)
	R_L	As Req.	(see text)
	Switch	As Req.	(see text)

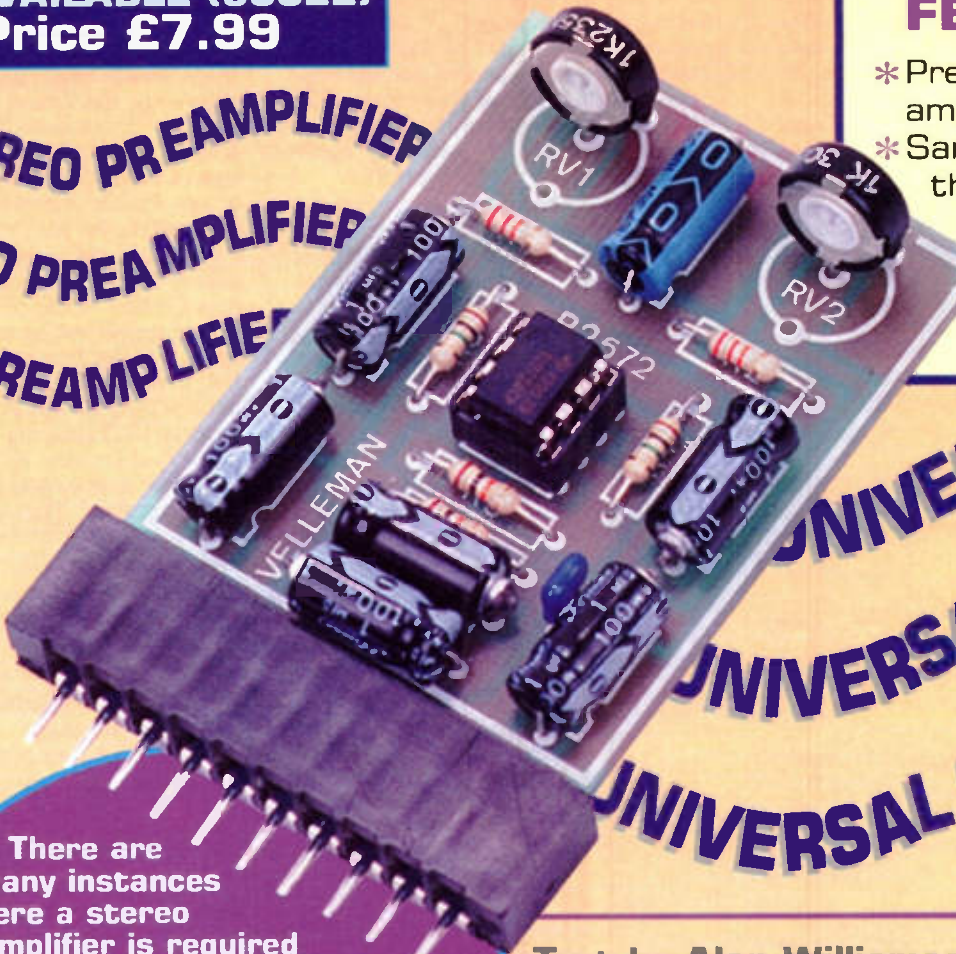
The Maplin 'Get-You-Working' Service is not available for this project.
The above items are not available as a kit.

Construction

There are no specific guidelines for the construction of this circuit, but its simplicity ensures ease of building, onto Veroboard, or a PCB if you wish. Generally, the aim will be to make the circuit as compact as possible, to enable easy fitment into the piece of equipment it will control. Remember to set the required 'on' time period, by means of the links to pins 12 and 13 of IC1 and/or by altering the values of R1,C1 and R2 as appropriate. Make the usual checks for correct connections, component polarity (diodes and transistors), and solder joints, before applying power to the circuit for the first time.

KIT AVAILABLE (90022)
Price £7.99

UNIVERSAL STEREO PREAMPLIFIER



2 PROJECT RATING

FEATURES

- Presettable output amplitude
- Same pinout as the Stereo RIAA Correction Preamplifier
- Standard connections

There are many instances where a stereo preamplifier is required for use with a system, but is not available. Normally this shows up when the level of signals coming into the amplifier system are either too much or too little. The Universal Stereo Preamplifier has been designed with this in mind, and can be used with most amplifier systems. Alternatively it can be used in conjunction with other modules, available in the range to make a complete stereo preamplifier system.

Text by Alan Williamson and Robin Hall

Specification

Power supply:	10 to 30V DC regulated
Supply current:	typical 5mA
Amplification:	40dB
Output impedance:	1kΩ
Frequency response:	40Hz to 30kHz (–3dB)
Input signal:	50mV

Circuit Description

As an aid to understanding the circuit a block diagram for the Universal Stereo Preamplifier is shown in Figure 1, and the circuit diagram in Figure 2.

Common components serving both amplifiers, are the resistors R1 and R2 which form a half supply voltage reference for the non-inverting inputs of the op amp IC1, and capacitor C1, used for decoupling the reference voltage to the power supply ground (pin 5 of the edge connector). The capacitor C4 decouples the supply rail at high-frequency.

The components making up the two amplifiers are identical; to save confusion, only the top half of the preamplifier circuit will be described.

The preamplifier is inverting, and has a fixed gain of 100 (or 40dB); the gain being determined by the value of the (1MΩ) feedback resistor divided by the value of the (10kΩ) input resistor. The input impedance is also set by the value of the input resistor.

The low-frequency cut off point of the amplifier is determined by a combination of the value of the input coupling capacitor and the value of the input resistor; in this case –3dB at 16Hz using the $1/2\pi R.C$ formula. The output signal is then AC coupled to the attenuation potentiometer to remove the DC offset (to prevent crackle). The output signal amplitude is controlled by adjustment of the potentiometer. The signal is again AC coupled from the potentiometer wiper (to prevent DC being fed into the potentiometer) before finally exiting the circuit.

Customising the Circuit

If the amplifier is to have a different fixed gain, it is preferable to set the gain more accurately by altering the ratio values of the input and feedback resistors.

In order to lower the gain, reduce the feedback resistor value.

To increase the gain, reduce the value of the input resistor. However, this will also reduce the low-frequency response of the amplifier, and so the value of the input coupling capacitor will have to be increased to compensate.

If the next amplification stage is AC coupled, it is not desirable to have two capacitors in series, one of the capacitors must be linked out. Which one will be determined by the difference of the DC offset between the circuits. If the offsets are identical, and you do not fancy the idea of DC coupling, link out the preset and wiper output coupling capacitor on the Universal Preamplifier board, and then fit the capacitor with the input signal feeding into the plus (+) terminal.

Construction

The construction process is fairly straightforward; with all the components mounted on the legend side. Begin with the smallest components first, working up in size to the largest. Be careful to correctly orientate the polarised devices, i.e. electrolytic capacitors and the IC. Fit the 8-pin DIL socket, making sure that the notch on the socket matches the legend on the PCB. The last stage of construction should be to insert the IC into its socket, again making sure that the orientation of the notch is correct.

Thoroughly check your work for misplaced components, solder whiskers or bridges, and dry joints. Finally, clean all the flux off the PCB using a suitable solvent.

Wiring Up

The wiring to the numbered pinout connections (1 to 10, see Figure 3 and Table 1) on the edge PCB connector is identical to the wiring of the K2573 RIAA Correction Preamplifier (90014).

Note, screened cable should be used for the signal interconnections. The screen of the cable should be terminated at one end only, to prevent hum arising from earth loops when using a common power supply.

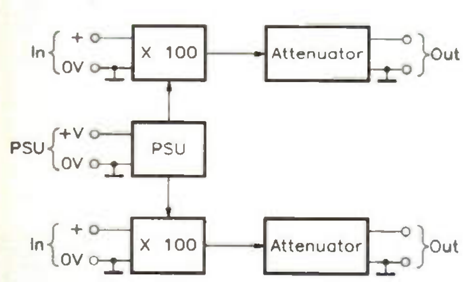


Figure 1. Block diagram of the Universal Stereo Preamplifier.

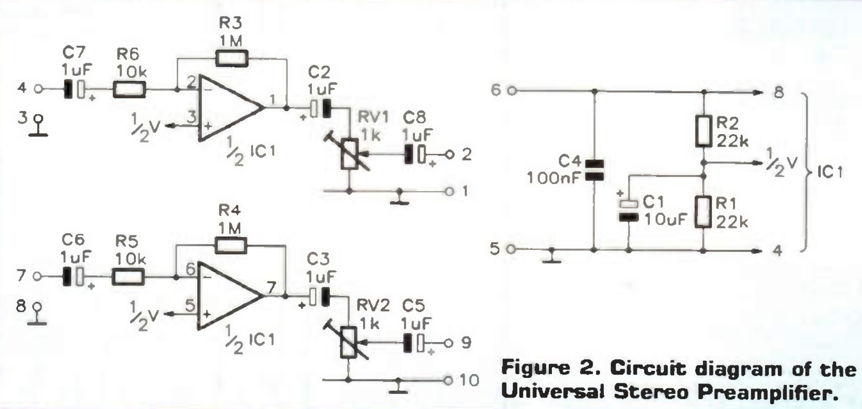


Figure 2. Circuit diagram of the Universal Stereo Preamplifier.

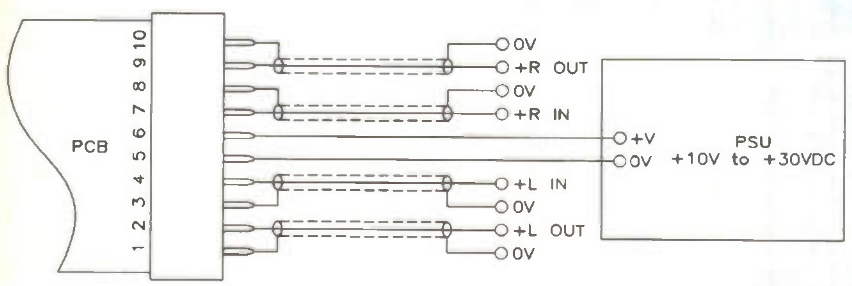


Figure 3. Wiring diagram, also showing the edge connector pinout.

1.	Out left screen (0V).	6.	+V (power supply) (+V).
2.	Out left (+L OUT).	7.	In right (+R IN).
3.	In left screen (0V).	8.	In right screen (0V).
4.	In left (+L IN).	9.	Out right (+R OUT).
5.	Ground (power supply) (0V).	10.	Out right screen (0V).

Table 1. Wiring connections.

PSU Requirements

A low current PSU with an output voltage between 10 to 30V DC is suitable for the Universal Stereo Preamplifier. However, the PSU MUST be well regulated and free from noise for trouble free operation. Keep the module well away from transformers, mains cable, and televisions etc., this is in order to prevent hum pick-up.

Using the Preamplifier

Figure 4 (see overleaf) shows a block diagram of a preamplifier system incorporating a number of Universal Stereo Preamplifiers and other modules e.g. the K2573 Stereo RIAA Correction Preamplifier.

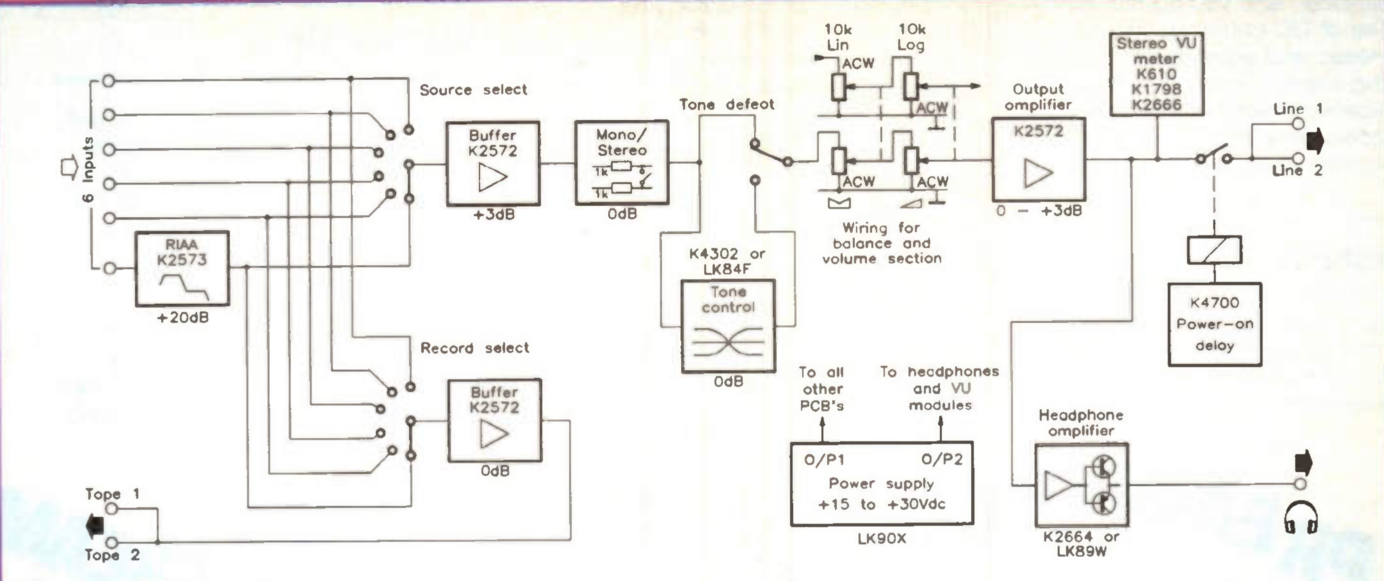


Figure 4. Suggested block diagram of a complete preamplifier system. Inset: Wiring diagram for a balance and volume section.

UNIVERSAL STEREO PREAMPLIFIER PARTS LIST

RESISTORS: All 1/3W 5%

R1,R2	22k	2
R3,R4	1M	2
R5,R6	10k	2
RV1,RV2	1k Potentiometer	2

CAPACITORS

C1	10μF 35V Electrolytic	1
C2,C3,C5,C6,C7,C8	1μF Electrolytic	6
C4	100nF	1

SEMICONDUCTOR

IC1	TL072ACP	1

MISCELLANEOUS

8-pin IC Socket	1
10-pin Edge Connector	1
PCB	1

The Maplin 'Get-You-Working' Service is available for this project, see Constructors' Guide or current Maplin Catalogue for details.
The above items are available in kit form only.
Order As 90022 (Universal Stereo Preamplifier) Price £7.99
Please Note: Some parts, which are specific to this project (e.g., PCB), are not available separately.

These descriptions are necessarily short. Please ensure that you know exactly what the kit is and what it comprises before ordering, by checking the appropriate issue of *Electronics* referred to in the list.
The referenced back-numbers of *Electronics* can be obtained, subject to availability, at £2.10 per copy.
Carriage Codes – Add; A: £1.55, B: £2.20, C: £2.80, D: £3.30, E: £3.90, F: £4.45, G: £5.35, H: £6.00.

DID YOU MISS THESE PROJECTS?

The Maplin 'Get-You-Working' Service is available on all of these projects unless otherwise indicated.

To order Project Kits or back-numbers of *Electronics*, 'phone Credit Card Sales on (01702) 554161. Alternatively, send off the Order Coupon in this issue or visit your local Maplin store.

Maplin: The Positive Force In Electronics

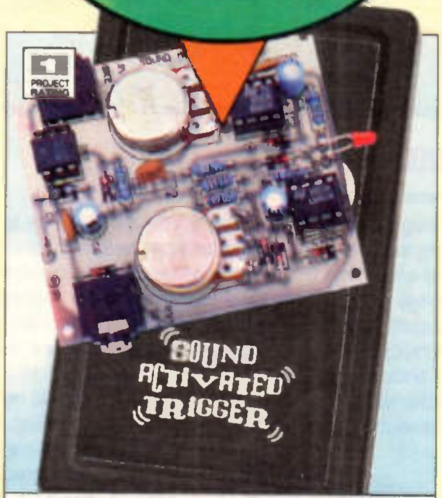
All items subject to availability. Prices include VAT.

MICRON III RADIO CONTROLLED CLOCK

The right time all the time! Used in conjunction with the Rugby Clock Receiver (LP70M), this radio-controlled timepiece receives ultra-precise date and time data from the MSF transmitter in Rugby which it shows on a bank of 12 seven-segment displays. Other features include automatic Leap Year and British Summertime correction.
Order as: LT03D (Micron III), **£47.99** B1. Details in *Electronics* No. 88, April 1995 (XA88V); LP70M (Rugby Clock Receiver), **£22.99**. Details in *Electronics* No. 47, November 1991 (XA47B).

FOX WIRELESS ALARM UPGRADE

Upgrade your Fox Wireless Burglar Alarm to use the Maplin XP03D, fully tamper-proof, External Bell Box with battery back-up. The kit contains all the necessary connectors, and details of the simple wiring modifications. Please note that the Maplin 'Get-You-Working' Service is not available for this project.
Order as: LU09K, **£1.49**. Details in *Electronics* No. 89, May 1995 (XA89W). XP03D Assembled Polycarbonate Bell Box (not included), **£42.99** C5.



SOUND ACTIVATED FLASH TRIGGER

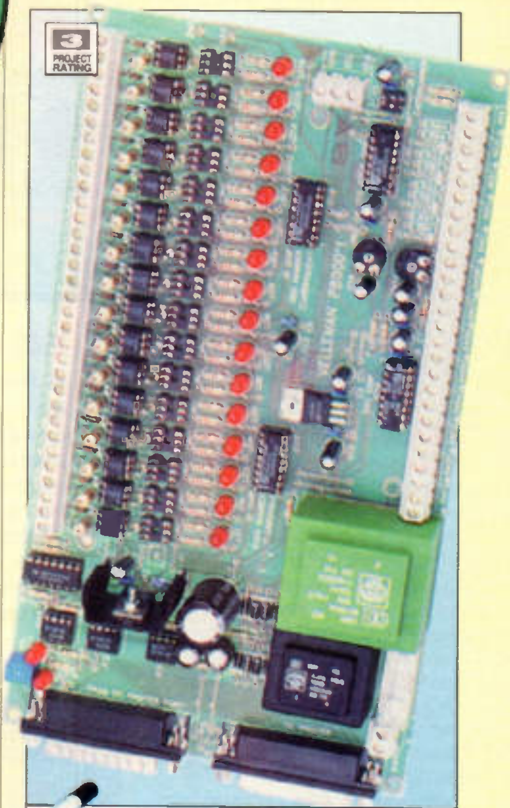
Produce exciting pictures of darts bursting balloons, bullets passing through light bulbs etc., with this inexpensive flash trigger. The sound of mum's best bone china hitting the floor triggers the unit which operates your flash-gun in time to photograph the bits whilst still in mid-air.
Order as: LT86T, **£14.99**. Details in *Electronics* No. 88, April 1995 (XA88V).

SUPER SCAN HF/VHF ACTIVE AERIAL

Improve your scanner's reception with this active, broadband aerial. The aerial supplied with most scanners is perfectly adequate for local reception, but a significant improvement can be made in the reception of long distance (DX) and weaker stations by using a fixed, active aerial like the Super Scan. (Plastic aerial housing and PSU box not included in kit.)
Order as: LT27E, **£29.99**. Details in *Electronics* No. 89, May 1995 (XA89W)

VOICE VANDAL

Create your own distortion effects and 'alien' voices with this entertaining audio project. Both music and voices can be 'vandalised' by pitch changing, clipping and echo effects. Ideal for plays, amateur dramatics or just for fun. Dad's Max Bygraves collection will never sound the same again! (Case not included in kit.)
Order as: LT82D, **£29.99**. Details in *Electronics* No. 89, May 1995 (XA89W).



COMPUTER INTERFACE BOARD

Unleash your computer's power by allowing it to communicate with the outside world. This fully optoisolated interface is suitable for IBM compatibles and simply connects to the printer port, while still allowing the printer to be used. Features include: sixteen inputs/outputs; eight 6-bit analogue outputs; one 8-bit precision analogue output and four 8-bit analogue inputs.
Order as: VF54J, **£84.99**. Details in *Electronics* No. 88, April 1995 (XA88V).

RS232 SERIAL LINE TESTER

Troubleshoot RS232 equipment quickly and conveniently with this battery powered, hand-held tester. The tester produces a short RS232 message and is ideal for checking terminals, printers, and other serial equipment, as well as their interconnecting data cables.
Order as: LT83E, **£32.99** A1. Details in *Electronics* No. 89, May 1995 (XA89W).

All of the books featured on this page are available from Maplin Regional Stores and by Maplin Mail Order. To find your nearest Maplin Regional Store Tel: (01702) 552911 or to order call the Credit Card Hotline on Tel: (01702) 554161

Automobile Electrical & Electronic Systems

by Tony Tranter

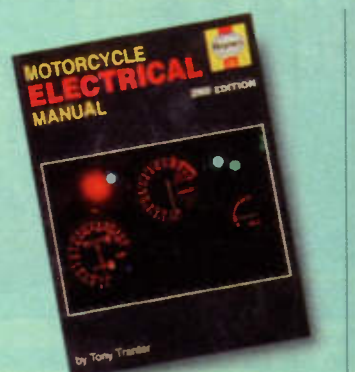
Use the information contained within the pages of this comprehensive guide to automobile electrical and electronic systems, and save yourself a small fortune on garage repair bills when the electrical bugs begin to bite! The initial chapter details all the electrical theory you need to know, so that even relative beginners to vehicle maintenance will be able to comprehend the technical details and practices that follow. The manual covers every component and sub-section of vehicle wiring systems, fitted to both older and modem vehicles. To this end, the book describes the engine's ignition and combustion operations, including electronic control units (engine management), fuel injection installations, batteries and charging, dashboard instruments and control switchgear, lighting, diagnostics and testing, airbags and other safety devices such as ABS brakes and traction control, and other up-to-date developments. A very interesting book for anyone with an interest in automotive electronics, or for motorists wishing to maintain their vehicle to a well-informed standard.

264

1993. 280×212mm. ***Order As 90007 (Automobile Elect Sys) £12.95 NV*** A2

Motorcycle Electrical Manual (2nd Edition)

by Tony Tranter



Keep your motorcycle's electrical system in optimum condition, to give instant starting in all weathers, along with maximum engine efficiency, and to keep its instruments accurate and all lamps shining brightly, as the manufacturers intended! To have everything operating as it should is highly important on today's congested roads, as an essential, but often overlooked, part of the machine's (and your!) safety. This comprehensive manual explains how the electrical systems work, quick and certain troubleshooting, and how to fix electrical gremlins rapidly and effectively when faults develop, so that your motorbike retains a reliable temperament, enhancing your pleasure of this mode of transport. And you do not need to have prior experience in vehicle electrics, for this book begins with a description of the basic principles, before launching into the deep-end world of magnetos, electronic ignition, ABS brakes, traction control and three-phase alternators! These parts, and all others of a motorcycle's electrical system, are catered for by this manual, together with sections on wiring, tools, testing and theft deterrents.

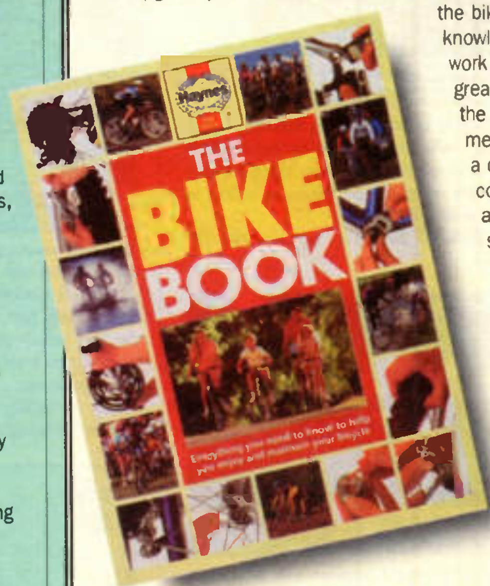
204

1993. 270×210mm. ***Order As 90006 (Motorcycle Elect Man) £12.99 NV***

THE BIKE BOOK

by John Stevenson

With the resurgence of interest in the bicycle, primarily due to the cycling boom of the eighties, which continues unabated into the nineties, the emergence of the mountain bike (MTB), increased media coverage of cycle racing, and as the ultimate in environmentally-friendly transport, there is an increased demand for manuals explaining the best techniques to use for choosing, buying, riding and maintaining cycles. This book aims to cover every facet of all things biking, and you will quickly recoup the cover price as you learn how to repair and upgrade your machine without having to resort to taking it to the bikeshop. Having the knowledge to competently work on your cycle is a great boon, particularly if the machine suffers a mechanical malady during a cycle trip into the countryside, miles from anywhere! This book shows you how, and offers many useful tips to the novice and experienced cyclist alike.



1994. 269×210mm. ***Order As 90004 (The Bike Book) £10.99 NV*** A1

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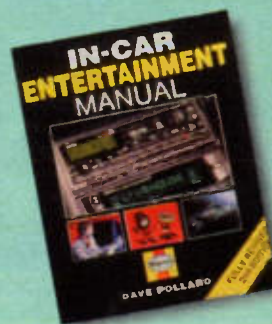

In-Car Entertainment Manual
Fully Revised 2nd Edition

by Dave Pollard

You would be surprised at how much time is spent in the vehicle by the average motorist – it adds up to a significant part of one's lifetime, and to stop and ponder this whilst stuck in yet another interminable traffic jam is not a recommended way of combating the stress of such a situation. However, In-Car Entertainment (ICE) is a sure -fire way to relieve such frustrations, which is why many people are now installing sophisticated stereo systems in their vehicles, with a sound quality that matches, or even exceeds, their home Hi-Fi equipment. This book shows every step of the way, of how to go about creating your own, customised ICE system, that may even make those traffic queues enjoyable, or at least, bearable! There are sections describing how to make your choice of equipment, effective installation techniques, dealing with interference, uprating the system, fitting in-car telephones, and a security section on how to protect your investment, with plenty of photographs to support the informative text.

192

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