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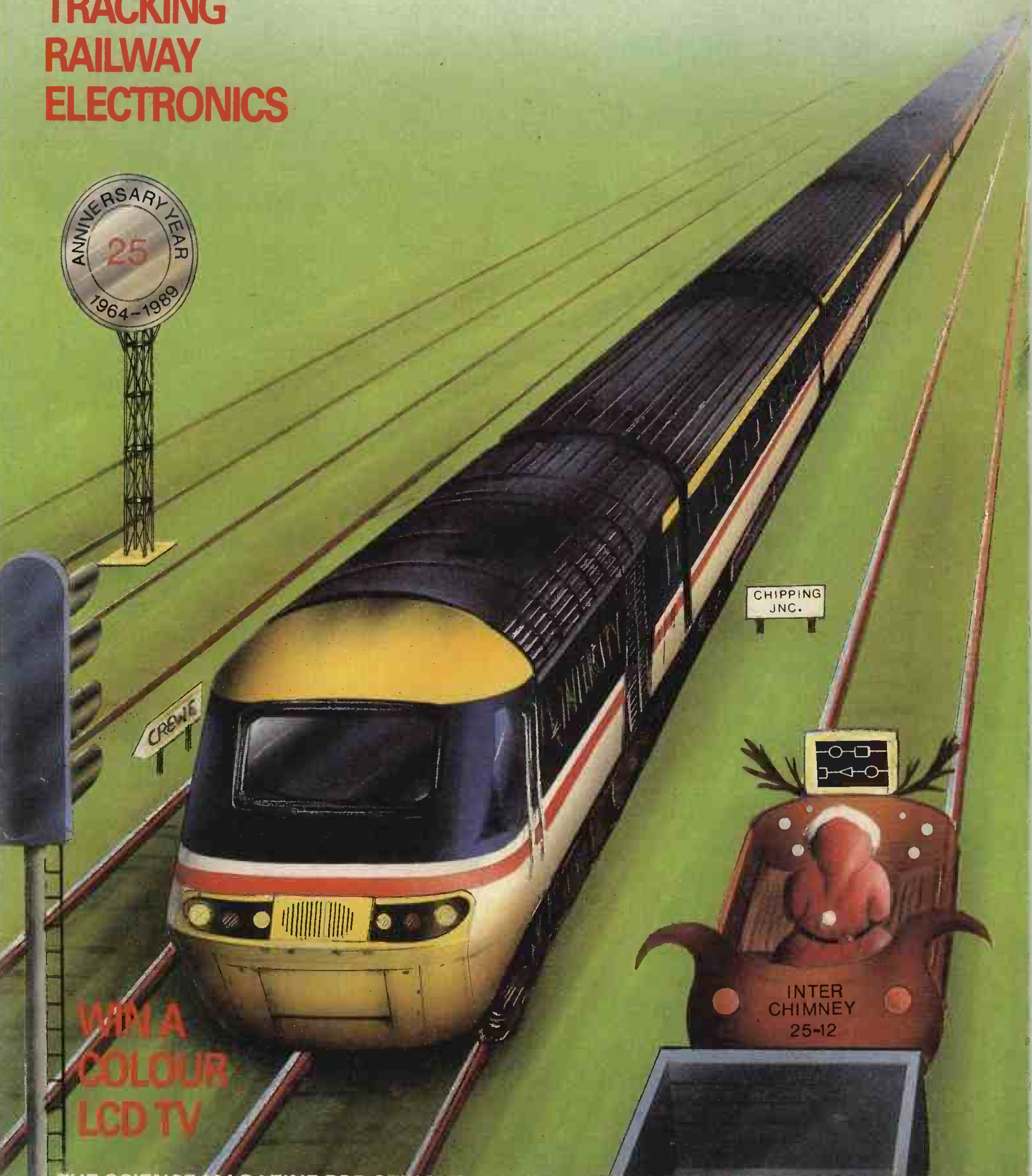

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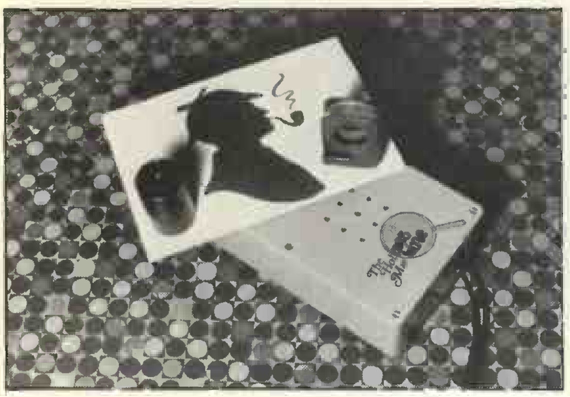
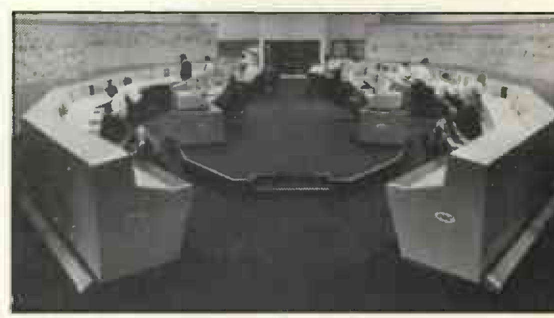
PRACTICAL ELECTRONICS
PE VOL 25 NO 1 JANUARY 1989

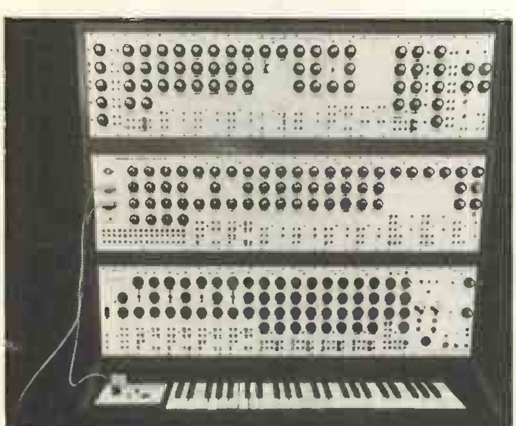
COMPETITION



CONSTRUCTIONAL PROJECTS

SPECIAL FEATURES





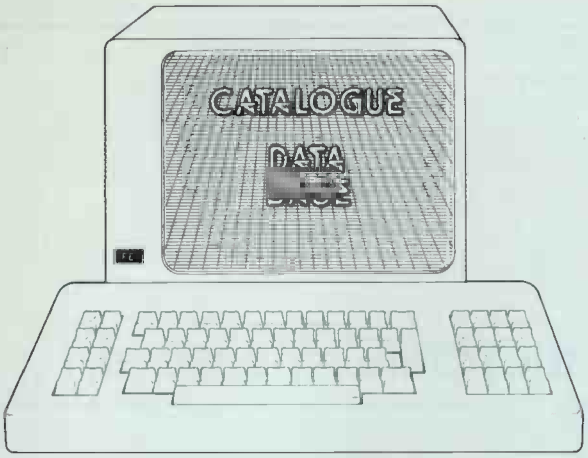
REGULAR FEATURES

NEXT MONTH . . .

TIME MARCHES ON BUT WE'RE UP TO THE MARK PREPARING – ☆ AN ASTROLOGICAL CLOCK ☆ ANOTHER IN THE TIME AND MEASUREMENT SERIES ☆ A SPECIAL FEATURE ON HIGH DEFINITION TELEVISION ☆ AND OF COURSE THERE'LL BE LOTS MORE, INCLUDING OUR REGULAR MINUTELY RESEARCHED TOPICAL NEWS, VIEWS AND FEATURES ☆

WATCH-OUT FOR OUR FEBRUARY 1989 ISSUE IT'S ON SALE FROM FRIDAY JANUARY 6TH AND IS SECOND TO NONE!

THE SCIENCE MAGAZINE FOR SERIOUS ELECTRONICS ENTHUSIASTS



We have recently received the following literature:

CPVE – A Link Between School and Work is the title of a leaflet issued by the Joint Board for Pre-Vocational Education. The leaflet is a simple guide and introduction to CPVE and will be **of interest to students, parents and employers.** Copies of the leaflet and other publicity material are available on request from The Sales Section, **City and Guilds of London Institute,** 76 Portland Place, London, W1N 4AA. 01-580 3050.

Maplin's 1989 catalogue is bigger and better than ever, and they've printed over 200,000 copies! It contains over 500 new products and has hundreds of price reductions in its 550 pages. As an introduction to the new range of Maplin cassette tapes, every buyer of the catalogue can send for **two free C60 ferric tapes** or one C60 chrome tape. The catalogue costs £1.95 and is available from any Maplin store, or from W.H. Smith. Maplin have also introduced a **new professional supplies trade catalogue. Maplin Electronics,** PO Box 3, Rayleigh, Essex, SS6 8LR. Tel: 0702 554161.

Eccentric are a company who will be of great interest to any electronics constructor who needs to interface mechanical assemblies to electronic control circuits – **they stock Meccano parts!** For some years your Ed has mourned the apparent demise of Meccano, but has learned that it's alive and well, and being comprehensively imported by Eccentric (who **stock secondhand parts as well**). I am sure they will be delighted to send you their catalogue and price list. **Eccentric,** Park Lane (off Park Street), Madeley, Telford, Shrops, TF7 5HE. 0952 583345.

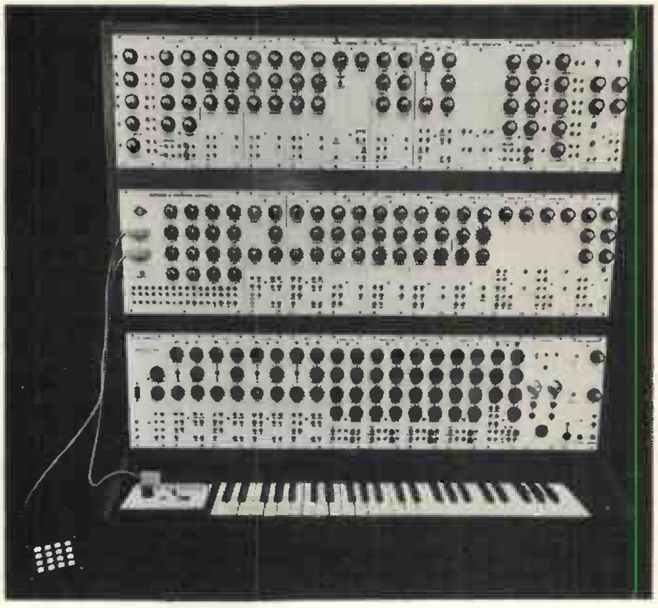
Cirkit is a company consisting of three major divisions – consumer, educational and industrial, each division having its own team of **experienced staff offering sales and customer service.** Their new catalogue, priced at £1.30, will therefore be of considerable interest to any constructor in need of a **broad range of electronic components,** from the conventional to the less-easy to find. The catalogue also contains **valuable discount vouchers,** and information on an interesting competition with several prizes. **Circuit Distribution Ltd,** Park Lane, Broxbourne, Herts, EN10 7NQ. 0992 441306.

L.J. Technical Systems have a short-form catalogue covering many **training systems, applications and courses.** Though many of the services are aimed at professionals, dedicated amateur enthusiasts could also benefit from finding out more about this company **L.J. Technical Systems Ltd,** Francis Way, Bowthorpe Industrial Estate, Norwich, NR5 9JA. 0603 748001.

Integrated Measurement Systems brochure will be of interest to PC users. It covers a **good variety of hardware and software** that enables a PC to be linked to the outside world for numerous **test, measurement and control applications** in lab, industrial and engineering environments. **Integrated Measurement Systems Ltd,** 306 Solent Business Centre, Millbrook Road West, Southampton, Hants, SO1 0HW. 0703 771143.

ADVERTISERS – HAVE YOUR CATALOGUE FREELY PUBLICISED HERE!

WHAT'S NEW



Synthesiser Kits

For some time now there has been a noticeable shortage of synthesiser diy kits on the market. Perhaps mistakenly you Ed had concluded that the sophistication of low cost ready made synthesisers had deterred kit suppliers from competing in this field.

Digisound have now announced their determination to put paid to this theory by introducing a new range of modular synthesiser kits. Tim Higham of Digisound informs me that their synthesisers are already used by a number of bands, including Wavestar who have just used on on their latest album 'Moonstar'.

Many other music-orientated kits are available from Digisound and their range will be further increased in the near future by the addition of more keyboard and sound sampler kits. Drop Tim Higham a line and ask for a free copy of the glossy catalogue – he's at: Digisound, 16 Lauriston Road, Wimbledon, London, SW19 4TQ. Tel: 01-946 0467.

Kit form audio

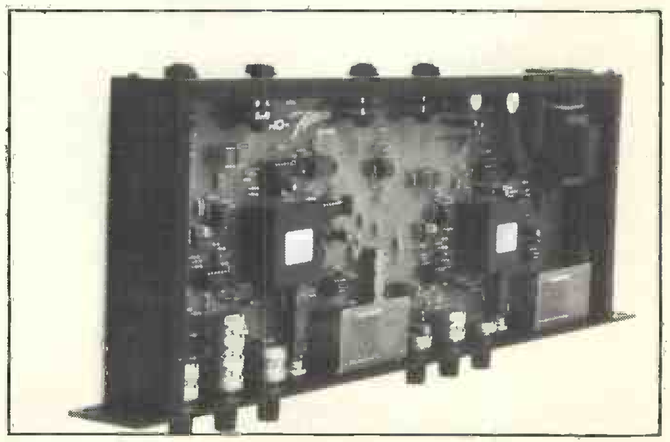
Dramatic cost savings are possible by buying TIME MACHINE'S new range of fully Professional audio processors in easy-to-build kit form.

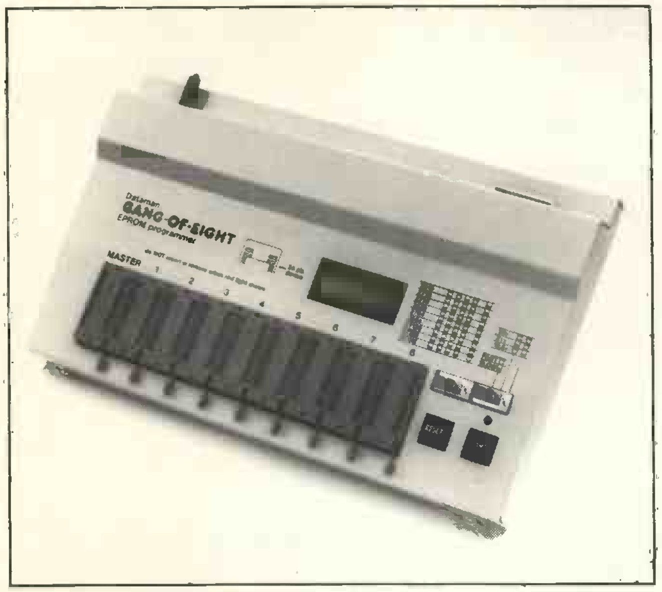
Housed in standard 19 inch cases 1U high by 6 inches deep these units have tasteful modern styling and logical control layout. The General format is that of two independent channels which can be linked for stereo operation by means of a switch.

The range includes: the Activator (a sophisticated enhancer), a dual noise gate/fade/panner, a compressor/expander with adaptive radio, and the silencer single ended noise reduction system.

Kits retail for around £130 +VAT. Fully built and tested units are also available, with user manuals, at £199 +VAT. These prices include UK carriage.

CONTACT: TIME MACHINE, Abbotsford, Deer Park Avenue, Teignmouth, Devon, TQ14 9LJ. Tel: 06267 2353.





Gang of Eight

Dataman is relaunching its production eprom programmer, the Gang-of-Eight. The latest version comes as standard in a robust steel case with bi-directional RS232 serial interface facilitating programming via PC. G8 will handle 2516, 2532 and 2564 eproms, as well as all 27 series from 2716 to 27512.

Setting is by use of dil switches. All settings are marked on the metal case for device type, programming speed and voltage selection.

When programming, G8 checks that the slave devices have been erased and upon completion checks the match with the master. The lcd display confirms the stage of programming but to avoid visual minotoring G8 also provides audible feedback.

CONTACT: Dataman, Lombard House, Cornwall, Road, Dorchester, Dorset, DT1 1RX. Tel: 0305 68066.

Radical Rigging

Concerned amateur radio users can now purchase a radically new 2m fm transceiver. The AMR1000 is a quality British made rig and is a development of the RT6500vhf radio telephone, which after only one year has become the best selling vhf set in the marine market.

The rig is available in two forms. The AMR1000 is a simple to operate fully channelised set able to function on both 12.5kHz and 25kHz channel spacing. The AMR1000S has all the features of the AMR1000 but has additional features including full scanning and programming functions. Both sets feature a well laid out control panel with clear display.

A full range of power supplies, antennas and mounting accessories that allow the transceiver to be used at home or as a mobile are available.

Prices start at aroung £247 for the AMR1000 and £299 for the AMR1000S.

CONTACT: Navico Ltd, Star Lane, Margate, Kent, CT9 4NP. Tel: 0843 290290.

COUNTDOWN

If you are organising any event to do with electronics, big or small, drop us a line – we shall be glad to include it here.

Please note: Some events listed here may be trade or restriced category only. Also, we cannot guarantee information accuracy, so check details with the organisers before setting out.

Dec 11. Satro Annual Computer and Technology Show. Music Hall, Aberdeen. 0224 273161. Satro, the Science and Technology Regional Organisation is a non-profit making organisation dedicated to supporting and enhancing science and technology education. Profits from the show will be devoted to developing computer and electronics clubs. **We hope it will be well supported.**

Dec. 20. IEEIE Computers for Engineers, Lecture SSEB, 75 Waterloo Street, Glasgow. 01-836 3357.

Jan. 12. IEEIE Communication in British Rail, Lecture. The Gonville Hotel, Cambridge. 01-836 3357.

Jan. 16. IEEIE Energy And Power Professional Group Lecture. CHP – Where are we now? IEE Faraday Room, Savoy Place, London. 01-836 3357.

Feb 7-9. Smartex – the surface mounting technology exhibition. Wembley Exhibition Hall. 01-302 8585.

Apr 5-6. Laboratory Science and Technology Show, Kelsey Kerridge, Cambridge. 0799 26699.

Apr 25-27. British Electronics Week. Olympia. 0799 26699.

Jul 10-13. EWEC '89. European wind energy conference and exhibition. Scottish Conference and Exhibition Centre, Glasgow. No reference tel. known.

Scots Technology Show

SATRO North Scotland and SATLINC (Science and Technology Links in the Community) are holding their third Computer and Technology show at the Music Hall on Sunday 11th December from 11am to 5pm.

SATLINC is an organisation for the mutual support of technology clubs, and all profits from the Show go to help the clubs.

At the show are displays of the uses of computers and technology in education, commercial stand display books, computers and software. Above all the many amateur clubs show some of the exciting things that can be done with electronics, computers and technology in general.

There will also be a preview of SATROSPHERE, the permanent Interactive Science and Technology Exhibition due to open shortly in Aberdeen.

In short, there are entertainments for the whole family including competitions and games for the children.

Northern readers who want to know about local science and technology clubs will find that Steve Delaney, 50 Stewart Crescent, Northfield Avenue, Aberdeen, AB2 5SR, probably has interesting information to offer.

For further information on SATRO, contact Dr. Lesley Glasser, University of Aberdeen, Marischal College, Broad Street, Aberdeen, AB9 1AS. Tel: 0224 273161.

bookmark

Your Ed looks at some of the new books recently received.

Chambers Science and Technology Dictionary. Chambers-Cambridge University Press. £16.95. ISBN 1-85296-1. An excellent dictionary that claims to be the most comprehensive single-volume work of its kind. With over a thousand pages and 45000 entries the main areas covered include chemistry, engineering, botany, zoo-logy, medical science and physics. Extensive treatment is also given to architecture, behavioural science, computing, geology, nuclear engineering, astronomy, building, electronics, mathematics and printing. The coverage of electronics seems pretty thorough, though I spotted the omission of a few terms which I checked at random, eg transputer and foldback, but I was gratified to see that a lot of unexpected terms were included. Definitely a book to have prominently on a bookshelf.

Designing DC Power Supplies. G.C. Loveday. Benchmarks. £6.95. ISBN 1-871047-01-3. It's good to find another book which covers the much underrated subject of power supplies. This book tackles the problem of designing regulated dc supplies, covering target specifications, test strategies, design procedures and methods. Several design tasks are set, all with solutions given at the end of the book. Although 130 pages does not allow for full coverage of this important field, the discussions and examples given should give most readers a good working knowledge of many practical techniques.

LSI Interfacing. Mike James. Heinemann-Newnes. £12.95. ISBN 0-434-90889-4. Mike James is well known to us at PE as for some time he edited our sister magazine Program Now. With his additional experience as an electronics lecturer he is well qualified to be the author of this guide to the use of standard lsi interface chips. In it he examines the general principles of data transfers and connecting interface devices to microprocessor buses. He covers a range of devices by presenting block diagrams, pinouts and their software aspects, together with a discussion of programming methods. The data will be useful to programmers, designers and students.

Digital Audio and Compact Disc Technology. Sony Service Centre (Europe). Heinemann-Newnes, £20.00. ISBN 0-434-91868-7. Decidedly a book for which the market has been waiting. Sony is one of the forerunners in the fields of dat and cd, and is the co-inventor of the compact disc digital audio system. With this pedigree the publishers can justifiably claim that this is the definitive book on cd technology. The contents include the principles of digital signal processing, sampling, quantisation, a-d conversion, codes and error correction, optoelectronics, servo circuits, signal processing, digital audio recording systems, pcm, Video 8, R-Dat, S-Dat and Dash. This book should find wide appeal amongst audio engineers, students and hifi enthusiasts.

Electronics Build and Learn. R.A. Penfold. PC Publishing. £5.95. ISBN 1-870775-15-5. The established principle of "learn by doing" is emphasised by this authoritative book. Combining theory and practice, the book begins with full constructional details of a circuit demonstrator unit that is used in subsequent chapters to introduce common electronic components. Well illustrated with practical tests and experiments the book develops the basic theme and shows how useful circuits such as oscillators, multivibrators and logic functions can be built up. This book is available though the PE book service and I recommend it to any electronics novice.

The Homebuilt Dynamo. Alfred T. Forbes. Todd-Forbes Publishing £42 including air mail post. ISBN 0-9597749-0-4. What a delight this book will be to any dedicated lover of anything to do with diy, ingenuity, and devotion to the completion of a job once started. It is the complete pictorial history of how Alfred Forbes built a dynamo to power his house in New Zealand. In 1969 he had decided to Live the Simple Life, buying a plot of land miles from anywhere, building his own house, and then finding the Electric Power People practically needed an arm and leg to bring power in. Alfred decided to build his own power plant, assuming there would be a book on the subject. There wasn't! Undeterred, he still went ahead, making practically everything with the aid of ordinary home workshop tools, and systematically photographing every stage of the work. The dynamo was ceremonially put into active service in 1984 and is capable of being used from 12V to 36V with a top rated output of 1000 watts – 28 amps and 36V at 740 rpm. Alfred stresses that this book is not just 'another diy book' but a careful diary with photographs, detailed working drawings and text that should enable anyone with an ordinary home workshop to produce the dynamo using the materials, tools and techniques described. It is a beautifully produced glossy book of nearly 200 A4 pages, and though not cheap will delight and assist anyone who loves a diy challenge. Definately a book to put on your list of wanted Christmas presents.

The Illustrated Dictionary of Electronics – Fourth Edition. R.P. Turner and S. Gibilisco. Tab Books. £18.75. ISBN 0-8306-2900-9. Tab Books have excelled themselves with this book. It has well over 600 pages containing more than 27000 terms used in electronics and more illustrations than I would care to count. There are ample cross-references and numerous data tables have been included. Although random checks reveal that not all terms known to me have been covered, it is, nonetheless, the most comprehensive electronics dictionary I have come across and will prove invaluable to anyone interested in electronics.

Electronic Circuit Design – Art and Practice. T.H. O'Dell Cambridge University Press. £9.95. ISBN 0-521-35858-2. The author says that this book has grown out of the experience he gained while involved in lab courses in electronic circuit design for final year undergraduates. In writing the book, though, he has taken a wider view by aiming it at any reader who has access to a simple electronics laboratory. He recognises that theoretical knowledge is essential, but that electronic circuit design can only be learnt by doing. An understanding of mathematics is preferable for a full appreciation of this informative book.

Experiments in Artificial Neural Networks. Ed Reitman. Tab Books. £13.20. ISBN 0-8306-9337-8. Ah! thinks I, picking up this book in anticipation of giving my brain an extra interactive expansion port. But no, I find hi-tech is still not high enough to improve my memory by means of a chip or two. Still, I'm interested by this book which describes simple neural networking systems that can store and retrieve information in a fashion similar to that used by the brain. It is basically an introduction to computer modelling and hardware experiments in this fascinating field of artificial intelligence. There are three projects, and a good variety of illustrative programs. The latter have been written for IBM clones, using MS-DOS and GWBASIC. It looks as though there is food for thought in this book.

Benchmark Book Company, 59 Waylands, Swanley, Kent, BR8 8TN. Tel: 0322 64042.

Cambridge University Press, The Edinburgh Building, Shaftesbury Road, Cambridge, CB2 2RU. 0223 312393.

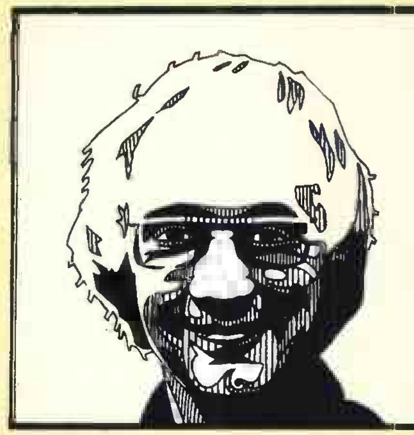
Heinemann Professional Publishing, 22 Bedford Square, London, WC1B 3HH. Tel: 01-637 3311.
PC Publishing, 22 Clifton Road, London, N3 2AR.

Tab Books are imported from the USA by John Wiley and Sons Ltd, Baffins Lane, Chichester, W. Sussex, PO19 1UD. 0243 779777.

Todd-Forbes Publishing, PO Box 3919, Auckland, New Zealand.

CORDLESS PHONES

BY BARRY FOX
Winner of the UK Technology Press Award



STUCK IN THE DOOR

Just when you thought the penny had dropped about 'standards', four different manufacturers are still looking for ways to reconcile their products

Cordless telephones, as currently on sale for £100 or less, come in two parts: a mains-powered base station which plugs into the owner's home telephone line and a battery-operated handset which communicates with the base stations by two-way radio link. Transmitter power is limited to 10mW, which reduces communication distance to 50 metres in a building or at best 1 kilometre outside. The radio link carries speech as an analogue signal, which makes it prone to interferences and insecure. Passing cars with cellphones can eavesdrop the cordless link line. Anyone with a matching receiver can eavesdrop on someone else's conversation and sometimes even make calls on their base station and thus at their expense.

The second generation cordless telephone, or CT2, is an all-digital system, with speech transmitted as code. This gives better sound quality and much greater security. The dti has allocated a 4MHz slice of the uhf radio spectrum between 864MHz and 868MHz. This can accommodate 40 channels, each 100kHz wide.

Unlike conventional cordless phones, which use two separate radio channels for each half of a conversation, CT2 makes do with a single channel. The digits representing each half of the conversation are chopped up into small packets which alternately pass down the radio channel in opposite directions and are reconstructed at each end of the link for apparently continuous analogue speech. This technique, called "ping-pong", allows the 40 channels to carry 40 conversations.

Because the speech is digitally coded, the data stream can carry hidden extra codes which identify each user. This will make it possible for owners of CT2 handsets to use them not just at home with their own base stations, but with public base stations provided by entrepreneurs in busy streets, shops, railway stations and airports. These base stations will connect calls from handsets to the BT or Mercury network and later bill users on their own home phone accounts.

In the spirit of free competition the dti set a flexible standard operating standard (MPT 1334) in April 1987. This specifies only the frequencies to be used and leaves individual manufacturers free to devise their own solutions to the tricky problem of squeezing two ping pong channels of speech into one 100 kHz radio channel.

At least four rival consortia have risen to the challenge and developed different coding systems, which are all incompatible with each other.

Shaye Communications at Winchester, grew out of a laboratory set up by Sir Clive Sinclair. In August last year Nokia Mobira of Finland paid £2.5 million for a 25% share of Shaye. The rest is owned by Fred Olsen, his Timex group and Sinclair Research. Shaye owns patents dating back to 1985 on CT2 technology which cleverly conserves battery power by setting transmission strength of the handset to the rock bottom limit needed for successful communication. Shaye plans to start selling mass-produced handsets before the end of the year. Bill Jeffrey of Shaye describes CT2 as "a tremendous opportunity, equivalent to home computers or video".

Rival company Libera, now owned by Ferranti, has been working on CT2 since 1986 and also plans to start selling systems this year. Libera has already built working prototypes of both handsets and public base stations. Libera has for two years been pressing the dti for an air interface standard which defines the signal coding, so that any handset will match any base station. The company has had enquiries from abroad, but European countries, like France and West Germany, with monopoly control of the telephone system, will not buy any technology unless it confirms to an approved European standard.

...with public base stations provided by entrepreneurs in busy streets, shops ...

BT came late into CT2, placing a £6M contract with STC in July 1987, to develop a third system. GEC and Plessey are working on a fourth system, believed to be for use with Mercury. They are especially interested because the same technology can be used to provide buildings with cordless telephone switchboards.

British Telecom plans to install 5000 public base stations of phonepoints round the country but is waiting for the government to approve its involvement. Reluctantly BT acknowledges that it will have to install two, three or even four different base station systems at each location if all handset systems are offered for sale.

Recognising the absurdity of the current situation, which kills everyone's chance of selling their technology abroad, the rival manufacturers are now trying desperately to hammer out a solution that does not kill them all. Three months ago the DTI set a deadline of July for agreement. It passed.

Paul Hermer, commercial director for the Libera project at Ferranti notes ruefully: "Things are best for those who have done the least development work. For them it will be relatively cheap to change. Those who have taken the biggest risks, and done the most development, will have to foot the biggest bill for making changes".

Changing technical specification will most seriously affect Ferranti – Libera and Shaye, because they have already designed microchips for mass production. GEC, Plessey, BT and STC are still at an earlier stage of development. Shaye and Ferranti will look for compensation if they sacrifice their lead to help the rival companies compete for what BT describes as "the glittering prize" of sales to Europe.

Continued on page 17

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Paul Doherty.

SILVER JUBILEE YEAR
PE
25
1964–1989

HIGH-HO SILVER!

There is a feeling of time-warp around the office as we go to press with this issue.

The cover date is January 1989, yet, as is customary, it is published around three weeks before Christmas. This gives you masses of time to build some of the projects – the Christmas Flashers should make a good place to start. Or how about emulating Sherlock Holmes in a little bit of shadow play? The original idea may be nearly a century old, but villains still abound.

We are just as conscious of another time-warp factor, and it's of special significance to PE. You've probably noticed the '25 Years' motif we proudly display on this page and on the front cover. It's not just part of the cartoon – it's there because it means it – '89 is the twenty-fifth year since PE was first published.

Around 25 years ago a certain Fred Bennett and his colleagues were busy plotting to revolutionise the hobbyist electronics world. They had in mind a magazine that would show how electronics could interest a much wider readership than existed for the prevailing periodicals. These had titles mostly containing the words 'wireless' or 'radio' – words which largely described their contents. Fred and Co believed that a magazine with a broader electronics outlook would encourage more people to participate in a technology that could do far more than handle radio signals.

With Fred as it's founding editor, PE was destined to take the bookstalls by storm, starting with the November 1964 issue. Since then the electronics world has witnessed many changes and PE has played a vital role in keeping an international readership well informed about them.

PE continues to play the same role, and with the sophistication of modern technology there is enormous scope for people of all ages to become part of the hi-tech scene, and to learn how to understand it.

In making plans to celebrate our Silver Jubilee with the November 1989 issue, we are constantly reminded of the part PE has played for a quarter of a century. We are confident that we shall guide you into the even-more revolutionary electronics world of the twenty-first century.

Before then, though, we shall indulge in a little nostalgia by looking back at some of the key events of our first 25 years. Many of you, like myself, have been reading PE since Issue One, others have more recently discovered PE and the addictive nature of electronics. How about joining in with the nostalgia? No doubt you have reminiscences related to PE and the project or feature articles presented over the years. If you have, drop me a line or two, and the most interesting tales will find themselves on the Letter's page. I shall also be pleased to know of any early PE projects you still have.

In the meantime, and to celebrate a more immediate festivity, we all wish you Season's Greetings, and the best of luck in our LCD TV Competition.

THE EDITOR

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STAR NL10 (Serial Interface) .... £279 (a)
STAR Power Type .... £229 (a)

BROTHER HR20 .... £329 (a)

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Dotprint Plus NLQ Rom for Epson versions for FX, RX, MX and GLP (BBC only) .... £28 (d)

PLOTTERS
Hitachi 672 .... £459 (a)
Graphics Workstation (A3 Plotter) .... £599 (a)
Plotmate A4SM .... £450 (a)

PRINTER ACCESSORIES

We hold a wide range of printer attachments (sheet feeders, tractor feeds etc) in stock. Serial, parallel, IEEE and other interfaces also available. Ribbons available for all above plotters. Pens with a variety of tips and colours also available. Please phone for details and prices.
Plain Fanfold Paper with extra fine perforation (Clean Edge):
2000 sheets 9.5" × 11" £13(b) 2000 sheets 14.5" × 11" £18.50(b)
Labels per 1000s: Single Row 3" × 1 7/16" £5.25(d) Triple Row 2-7/16" × 1 7/16" £5.00(d)

MODEMS

All modems carry a full BT approval

MIRACLE TECHNOLOGY WS Range

WS4000 V21/23 (Hayes Compatible, Intelligent, Auto Dial/Auto Answer) .... £149 (b)
WS3000 V21/23 Professional As WS4000 and with BELL standards and battery back up for memory .... £245 (b)
WS3000 V22 Professional As WS300 V21/23 but with 1200 baud full duplex .... £450 (a)
WS3000 V22 bis Professional As V22 and 2400 baud full duplex .... £595 (a)
WS3022 V22 Professional As WS3000 but with only 1200/1200 .... £350 (a)
WS3024 V22 Professional As WS3000 but with only 2400/2400 .... £450 (b)
WS2000 V21/V23 Manual Modem .... £95 (b)
DATA Cable for WS series/PC or XT .... £10 (d)
DATATALK Comms Package
* If purchased with any of the above modems * .... *£70 (c)
PACE Nightingale Modem V21/V23 Manual .... £75 (b)
(Offer limited to current stocks)

RT256 3 PORT SWITCHOVER SERIAL INTERFACE
3 input/1 output or 1 input/3 output manual channel selection Input/output baud rates, independently selectable 7 bit/8 bit, odd/even/none parity. Hardware or software handshake 256K buffer, mains powered .... £375 (b)

PB BUFFER
Internal buffer for most Epson printers. Easy to install, Inst. supplied.
PB128 128K .... £99 (c)

SOFTY II

This low cost intelligent eprom programmer can program 2716, 2516, 2532, 2732, and with an adaptor, 2564 and 2764. Displays 512 byte page on TV – has a serial and parallel I/O routines. Can be used as an emulator, cassette interface.
Softy II .... £195.00 (b)
Adaptor for 2764/2564 .... £25.00

PLEASE TELEPHONE FOR CURRENT PRICES

DISC DRIVES

5.25" Single Drives 40/50 switchable:
TS400 400K/640K .... £114 (b)
PS400 400K/640K with integral mains power supply .... £129 (b)
5.25" Dual Drives 40/80 switchable:
TD800 800K/1280K .... £199 (a)
PD800 800K/1280K with integral mains power supply .... £229 (a)
PD800P 800K/1280K with integral mains power supply and monitor stand .... £249 (a)
3.5" 80T DS Drives:
TS351 Single 400K/640K .... £99 (b)
PS351 Single 400K/640K with integral mains power supply .... £119 (b)
TD352 Dual 800K/1280K .... £170 (b)
PD352 Dual 800K/1280K with integral mains power supply .... £187 (b)
PD853 Combo Dual 5.25"/3.5" drive with p.s.u. .... £229 (a)

3M FLOPPY DISCS

Industry Standard floppy discs with a lifetime guarantee. Discs in packs of 10

5¼" Discs				3½ Discs	
40 T SS DD	£10.00 (d)	40 T DS DD	£12.00 (d)	80 T SS DD	£20.00 (d)
80 T SS DD	£14.50 (d)	80 T DS DD	£15.50 (d)	80 T DS DD	£25.00 (d)

FLOPPICLENE DRIVEHEAD CLEANING KIT

FLOPPICLENE Disc Head Cleaning Kit with 28 disposable cleaning discs ensures continued optimum performance of the drives. 5¼" £12.50 (d) 3½" £14.00 (d)

DRIVE ACCESSORIES

Single Disc Cable £6 (d) — Dual Disc Cable £8.50 (d)
10 Disc Library Case £1.80 (d) — 30 × 5½" Disc Storage Box £6 (c)
50 × 5½" Disc Lockable Box £9.00 (c) — 100 × 5½" Disc Lockable Box £13 (c)

MONITORS

RGB 14"
1431 Std Res .... £179 (a)
1451 Med Res .... £225 (a)
1441 Hi Res .... £365 (a)

MICROVITEC 14" RGB/PAL/Audio
1431AP Std Res .... £199 (a)
1451AP Std Res .... £259 (a)
All above monitors available in plastic or metal case.

TAXAN SUPERVISION II
12" – Hi Res with amber/green options.
IBM compatible .... £279 (a)
Taxan Supervision III .... £319 (a)

MITSUBISHI
XC1404 14" Med Res RGB, IBM & BBC compatible .... £219 (a)

MONOCHROME
TAXAN 12" HI-RES
KX1201G green screen .... £90 (a)
KX1203A amber screen .... £95 (a)

PHILIPS 12" HI-RES
BM7502 green screen .... £75 (a)
BM7522 amber screen .... £79 (a)
8501 RGB Std Res .... £139 (a)

ACCESSORIES
Microvitec Swivel Base .... £20 (c)
Taxan Mono Swivel Base with clock .... £22 (c)
Philips Swivel Base .... £14 (c)
BBC RGB Cable .... £5 (d)
Microvitec .... £3.50 (d)
Taxan £5 (d) .... Monochrome £3.50 (d)
Touchtec – 501 .... £239 (b)

UVERASERS

UV1T Eraser with built-in timer and mains indicator. Built-in safety interlock to avoid accidental exposure to the harmful UV rays.
It can handle up to 5 eproms at a time with an average erasing time of about 20 mins £59 + £2 p&p.
UV1 as above but without the timer £47 + £2 p&p.
For Industrial Users, we offer UV140 & UV141 erasers with handling capacity of 14 eproms UV141 has a built in timer. Both offer full built in safety features UV140 £69, UV141 £85, p&p £2.50.

EXT SERIAL/PARALLEL CONVERTERS

Mains powered converters
Serial to Parallel .... £48 (c)
Parallel to Serial .... £48 (c)
Bidirectional Converter .... £105 (b)

Serial Test Cable

Serial Cable switchable at both ends allowing pin options to be re-routed or linked at either end – making it possible to produce almost any cable configuration on site.
Available as M/M or M/F £24.75 (d)

Serial Mini Patch Box

Allows an easy method to reconfigure pin functions without rewiring the cable assay. Jumpers can be used and reused. £22 (d)

Serial Mini Test

Monitors RS232C and CCITT V24 Transmissions, indicating status with dual colour LEDs on 7 most significant lines. Connects in Line. £22.50 (d)

CONNECTOR SYSTEMS

I.D. CONNECTORS

(Speedblock Type)

No of ways	Header Plug	Receptacle	Edge Conn
10	90p	85p	120p
20	145p	125p	195p
26	175p	150p	240p
34	200p	160p	320p
40	220p	190p	340p
50	235p	200p	390p

EDGE CONNECTORS

	0 1	0 156
2 × 6-way (commodore)	–	300p
2 × 10-way	150p	–
2 × 12 way (vic 20)	–	350p
2 × 18-way	–	140p
2 × 23 way (ZX81)	175p	220p
2 × 25 way	225p	220p
2 × 28-way (Spectrum)	200p	–
2 × 36 way	250p	–
1 × 43 way	260p	–
2 × 22 way	190p	–
2 × 43-way	395p	–
1 × 77 way	400p	500p
2 × 50 way(S 100conn)	600p	–

AMPHENOL CONNECTORS

36 way plug Centronics (solder 500p (IDC) 475p
36 way skt Centronics (solder) 550p (IDC) 500p
24 way plug IEEE (solder) 475p (IDC) 475p
24 way skt IEEE (solder) 500p (IDC) 500p
PCB Mtg Skt Ang Pin
24 way 700p 36 way 750p

RIBBON CABLE

(grey/metre)

10-way	40p	34-way	160p
16-way	60p	40-way	180p
20-way	85p	50-way	200p
26-way	120p	64-way	280p

D CONNECTORS

No of Ways

	9	15	25	37
MALE:				
Ang Pins	120	180	230	350
Solder	60	85	125	170
IDC	175	275	325	–
FEMALE:				
St Pin	100	140	210	380
Ang Pins	160	210	275	440
Solder	90	130	195	290
IDC	195	325	375	–
St Hood	90	95	100	120
Screw Lock	130	150	175	–

EURO CONNECTORS

DIN 41612	Plug	Skt
2 × 32 way St Pin	230p	275p
2 × 32 way Ang Pin	275p	320p
3 × 32 way St Pin	260p	300p
3 × 32 way Ang Pin	375p	400p
IDC Skt A + B	400p	
IDC Skt A + C	400p	

For 2 × 32 way please specify spacing (A + B, A + C).

GENDER CHANGERS

25 way D type

Male to Male £10
Male to Female £10
Female to Female £10

DIL HEADERS

	Solder	IDC
14 pin	40p	100p
16 pin	50p	110p
18 pin	60p	–
20 pin	75p	–
24 pin	100p	150p
28 pin	160p	200p
40 pin	200p	225p

RS 232 JUMPERS

(25 way D)

24" Single end Male £5.00
24" Single end Female £5.25
24" Female Female £10.00
24" Male Male £9.50
24" Male Female £9.50

ATTENTION

All prices in this double page advertisement are subject to change without notice.
ALL PRICES EXCLUDE VAT
Please add carriage 50p unless indicated as follows:
(a) £8 (b) £2.50 (c) £1.50 (d) £1.00

TEXTOOL ZIF

SOCKETS 24-pin £7.50
28-pin £9.10 40-pin £12.10

MISC CONNS

21 pin Scart Connector 200p
8 pin Video Connector 200p

DIL SWITCHES

4-way 90p 6-way 105p
8-way 120p 10-way 150p

TECHNOLINE VIEWDATA SYSTEM. TEL: 01-450 9764

Using 'Prestel' type protocols. For information and orders – 24 hour service, 7 days a week

74 SERIES

7400	0.30
7401	0.30
7402	0.30
7403	0.30
7404	0.36
7405	0.30
7406	0.40
7407	0.40
7408	0.30
7409	0.30
7410	0.30
7411	0.30
7412	0.30
7413	0.50
7414	0.70
7416	0.36
7417	0.40
7420	0.30
7421	0.60
7422	0.36
7423	0.36
7425	0.40
7426	0.40
7427	0.32
7428	0.43
7430	0.30
7432	0.36
7433	0.30
7437	0.30
7438	0.40
7439	0.40
7440	0.40
7441	0.90
7442A	0.70
7443A	1.00
7444	1.10
7445	0.70
7446A	1.00
7447A	1.00
7448	1.00
7450	0.36
7451	0.35
7453	0.38
7454	0.38
7460	0.55
7470	0.50
7472	0.45
7473	0.45
7474	0.50
7475	0.60
7476	0.45
7480	0.65
7481	1.80
7483A	1.05
7484A	1.25
7485	1.10
7486	0.42
7489	2.10
7490A	0.55
7491	0.70
7492A	0.70
7493A	0.55
7494	1.10
7495A	0.60
7496	0.80
7497	2.90
74100	1.90
74107	0.50
74109	0.75
74110	0.75
74111	0.55
74116	1.70
74118	1.10
74119	1.70
74120	1.00
74121	0.55
74122	0.70
74123	0.80
74125	0.65
74126	0.55
74128	0.65
74132	0.75
74136	0.70
74141	0.90
74142	2.50
74143	1.30
74144	2.70
74145	1.10
74147	1.70
74148	1.40
74150	1.75
74151A	0.70
74153	0.80
74154	1.40
74155	0.80
74156	0.90
74159	2.25
74160	1.10
74161	0.80
74162	1.10
74163	1.10
74164	1.20
74165	1.10
74166	1.40
74167	4.00
74170	2.00
74172	4.20
74173	1.40
74174	1.10
74175	1.05
74176	1.00
74178	1.50
74179	1.50
74180	1.00
74181	2.40
74182	1.40
74184	1.80
74185A	1.80
74190	1.30
74191	1.30
74192	1.10
74193	1.15
74194	1.10
74195	0.80
74196	1.30
74197	1.10
74198	2.20
74199	2.20
74221	1.10
74251	1.00
74259	1.50
74265	0.88
74273	2.00
74276	1.40
74278	1.70
74279	0.90
74283	1.05
74742	3.20
74290	0.90
74293	0.90
74298	1.80
74351	2.00
74365A	0.80
74366A	0.80
74367A	0.80
74376	1.60
74390	1.10
74393	1.20
74490	1.40

74LS SERIES

74LS00	0.24
74LS01	0.24
74LS02	0.24
74LS03	0.24
74LS04	0.24
74LS05	0.24
74LS08	0.24
74LS09	0.24
74LS10	0.24
74LS11	0.24
74LS13	0.34
74LS14	0.50
74LS15	0.24
74LS20	0.24
74LS21	0.24
74LS22	0.24
74LS24	0.50
74LS26	0.26
74LS27	0.24
74LS28	0.24
74LS30	0.24
74LS32	0.24
74LS33	0.24
74LS37	0.24
74LS38	0.24
74LS40	0.24
74LS42	0.50
74LS43	1.50
74LS48	0.90
74LS49	1.00
74LS51	0.24
74LS54	0.24
74LS55	0.24
74LS73A	0.30
74LS74A	0.35
74LS75	0.45
74LS76A	0.36
74LS78	0.42
74LS83A	0.70
74LS85	0.75
74LS86	0.35
74LS90	0.48
74LS92	0.35
74LS93	0.54
74LS95B	0.75
74LS96	0.90
74LS107	0.40
74LS109	0.40
74LS112	0.45
74LS113	0.45
74LS114	0.45
74LS122	0.70
74LS123	0.80
74LS125	0.50
74LS126	0.50
74LS132	0.65
74LS133	0.55
74LS136	0.45
74LS138	0.45
74LS139	0.55
74LS145	0.95
74LS147	1.75
74LS148	1.10
74LS151	0.65
74LS152	2.00
74LS153	0.65
74LS154	1.60
74LS155	0.65
74LS156	0.65
74LS157	0.50
74LS158	0.50
74LS160A	0.65
74LS161A	0.75
74LS162A	0.75
74LS163A	0.75
74LS164	0.75
74LS165A	1.10
74LS166	1.50
74LS168	1.30
74LS169	1.30
74LS170	1.40
74LS173A	1.00
74LS174	0.75
74LS175	0.75
74LS181	2.00
74LS183	1.90
74LS190	0.75
74LS191	0.75
74LS192	0.80
74LS194A	0.75
74LS195A	0.75
74LS196	0.80
74LS197	0.80
74LS221	0.90
74LS240	0.80
74LS241	0.80
74LS242	0.90
74LS243	0.90
74LS244	0.70
74LS245	0.90
74LS247	1.10
74LS248	1.10
74LS249	1.10
74LS251	0.75
74LS253	0.75
74LS256	0.90
74LS2457A	0.70
74LS258A	0.70
74LS259	1.20
74LS260	0.75
74LS266	0.60
74LS273	1.25
74LS279	0.70
74LS280	1.90
74LS283	0.80
74LS290	0.80
74LS292	14.00
74LS293	0.80
74LS295	1.40
74LS297	14.00
74LS298	1.00
74LS299	2.20
74LS321	3.70
74LS322A	3.90
74LS323	3.00
74LS324	3.20
74LS348	2.00
74LS352	1.20
74LS353	1.20
74LS356	2.10
74LS363	1.80
74LS364	1.80
74LS365	0.50
74LS366	0.50
74LS367	0.52
74LS368	0.50
74LS373	0.70
74LS374	0.70
74LS375	0.75
74LS377	1.30
74LS378	0.95
74LS379	1.30
74LS381	4.50
74LS385	3.25
74LS390	0.60
74LS393	1.00
74LS395A	1.00
74LS399	1.40
74LS445	1.80
74LS465	1.20
74LS467	1.20
74LS490	1.50
74LS540	1.00
74LS541	1.00
74LS608	7.00
74LS610	25.00
74LS612	25.00
74LS624	3.50
74LS626	2.25
74LS628	2.25
74LS629	1.25
74LS640	2.00
74LS640-1	3.00
74LS641	1.50
74LS642	2.50
74LS642-1	3.00
74LS643	2.50
74LS643-1	3.00
74LS644	3.50
74LS645	2.00
74LS645-1	4.00
74LS668	0.90
74LS669	0.90
74LS670	1.70
74LS682	2.50
74LS683	3.00
74LS684	3.50
74LS687	3.50
74LS688	3.50
74LS783	18.00

74S SERIES

74S00	0.50
74S02	0.50
74S04	0.50
74S05	0.50
74S08	0.50
74S10	0.50
74S11	0.75
74S20	0.50
74S22	0.50
74S30	0.50
74S32	0.60
74S37	0.60
74S38	0.60
74S40	0.50
74S51	0.60
74S64	0.45
74S74	0.70
74S85	5.50
74S86	1.00
74S112	0.90
74S113	1.20
74S114	1.20
74S124	3.00
74S132	1.00
74S133	0.60
74S138	1.80
74S139	1.80
74S140	1.00
74S151	1.50
74S153	1.50
74S157	2.00
74S158	2.00
74S163	3.00
74S169	5.50
74S174	3.00
74S175	3.20
74S188	1.80
74S189	1.80
74S194	3.00
74S195	3.00
74S196	3.50
74S200	4.50
74S201	3.20
74S225	5.20
74S240	4.00
74S241	4.00
74S244	4.00
74S251	2.50
74S257	2.50
74S258	2.50
74S260	1.00
74S261	3.00
74S283	2.70
74S287	2.25
74S288	2.00
74S289	2.25
74S299	4.50
74S373	4.00
74S374	4.00
74S387	2.25

Special offer to PE readers only – 10% off on all TTLS and CMOS

74ALS SERIES

74ALS00	0.45
74ALS02	0.45
74ALS04	0.50
74ALS08	0.50
74ALS10	0.45
74ALS20	0.45
74ALS32	0.45
74ALS74	0.70
74ALS138	1.50
74ALS139	1.50
74ALS244	4.00
74ALS245	4.75
74ALS573	2.60
74ALS574	4.50
74ALS580	2.60

4000 SERIES

4000	0.20
4001	0.24
4002	0.25
4006	0.70
4007	0.25
4008	0.60
4009	0.45
4010	0.60
4011	0.24
4012	0.25
4013	0.36
4014	0.60
4015	0.70
4016	0.36
4017	0.55
4018	0.60
4019	0.60
4020	0.80
4021	0.80
4022	0.70
4023	0.30
4024	0.48
4025	0.24
4026	0.90
4027	0.40
4028	0.60
4029	0.75
4030	0.35
4031	1.25
4032	1.00
4033	1.25
4034	2.50
4034	2.50
4035	0.70
4036	2.50
4037	1.10
4038	1.00
4040	0.60
4041	0.55
4042	0.50
4043	0.60
4044	0.60
4045	1.00
4046	0.60
4047	0.60
4048	0.55
4049	0.36
4050	0.35
4051	0.65
4052	0.60
4053	0.60
4054	0.80
4055	0.80
4056	0.85
4060	0.70
4063	0.85
4066	0.40
4067	2.30
4068	0.25
4069	0.24
4070	0.24
4071	0.24
4072	0.24
4073	0.24
4075	0.24
4076	0.65
4077	0.25
4078	0.25
4081	0.24
4082	0.25
4085	0.60
4086	0.75
4089	1.20
4093	0.35
4094	0.90
4095	0.95
4096	0.90
4097	2.70
4098	0.75
4099	0.99
4501	0.36
4502	0.55
4503	0.36
4504	0.95
4505	3.60
4506	0.90
4507	0.35
4508	1.20
4510	0.55
4511	0.55
4512	0.55
4513	1.50
4514	1.10
4515	1.10
4516	0.55
4517	2.20
4518	0.48
4519	0.32
4520	0.60
4521	1.15
4522	0.80
4526	0.70
4527	0.80
4528	0.65
4529	1.00
4531	0.75
4532	0.65
4534	3.80
4536	2.50
4538	0.75
4539	0.75
4541	0.90
4543	0.70
4551	1.00
4553	2.40
4555	0.36
4556	0.50
4557	2.40
4560	1.40
4566	1.40
4568	2.40
4569	1.70
4572	0.45
4583	0.90
4584	0.48
4585	0.60
4724	1.50
14411	7.50
14412	7.50
14416	3.00
14419	2.60
14490	4.20
14495	4.50
145000	8.50
14599	2.00
22100	3.50
22101	7.00
22102	7.00
40014	0.48
40085	1.20
40097	0.36
40098	0.40
40100	1.50
40101	1.25
40102	1.30
40103	2.00
40104	1.20
40105	1.50
40106	0.48
40107	0.55
40108	3.20
40109	0.80
40110	2.25
40114	2.25
40107	2.80
40163	1.00
40173	1.20
40174	1.00
40175	1.00
40192	1.00
40193	1.00
40194	1.00
40244	1.50
40245	1.50
40257	1.80
40373	1.80
40374	1.80
80C95	0.75
80C97	0.75
80C98	0.75

LINEAR ICs

ADC0808	11.90
AM7910DC	12.00
AN103	2.00
AN1-5050	1.00
AY-3-1350	5.00
AY-3-8910	4.90
AY-3-8912	5.00
CA3019A	1.00
CA3020	3.50
CA3028A	1.10
CA3046	0.70
CA3059	3.25
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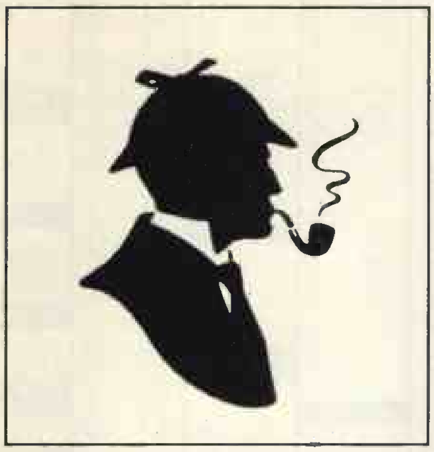


THE HOLMES MACHINE

By Owen Bishop

THE SHADOW FAMILY STAYS IN

Watson at Holmes? And why do Shadows move where no footfall is heard? Elementary, my dear reader. Those silent shapes are propelled by flip-flops. Read on ...

The germ of the idea for this project comes from Sir Arthur Conan Doyle's story. The adventures of the Empty House. The house in question was Camden House situated in Baker Street, London, exactly opposite to Sherlock Holme's room at No. 221B Holmes and Dr Watson had entered the empty house at night and were in a room facing on to the street. Watson takes up the story:

'I crept forward and looked across at the familiar window. As my eye fell upon it, I gave a gasp and a cry of amazement. The blind was down and a strong light was burning in the room. The shadow of a man who was seated within was thrown in hard, black outline upon the luminous screen of the window. There was no mistaking the poise of the head, the squareness of the shoulders, the sharpness of the features. It was a perfect reproduction of Holmes. So amazed was I that I threw out my hand to make sure that the man himself was standing behind me. He was quivering with silent laughter.'

Holmes then explained that the shadow is cast by a specially-made wax bust of himself. It is intended as a decoy to lure Colonel Moran – Holme's arch-enemy since the death of the infamous Professor Moriarty – into a carefully laid trap. Later, Watson continues:

'I was about to make some remark to him, when I raised my eye to the lighted window, and again experienced almost as great a surprise as before. I clutched Holme's arm, and pointed upward.'

' "The shadow has moved!" ' I cried.

'It was indeed no longer the profile, but the back, which was turned towards us.

'Three years had certainly not smoothed the asperities of his temper or his impatience with a less active intelligence than his own.

' "Of course it has moved," said he. "Am I such a farcial bungler, Watson, that I should erect an obvious dummy, and expect that some of the sharpest men in Europe would be deceived by it? We have been in this room two hours, and Mrs Hudson (Home's housekeeper) has made some change in that figure eight times, or once in every quarter of an hour." '

The lure worked. Colonel Moran too entered the empty house, with the intention of killing Holmes as he sat (so Morgan believed) by his window, using a ingeniously made and extremely powerful air rifle. Holmes and Watson surprised and overpowered the Colonel who was later arrested and brought to trial on several charges.

PROJECTION

This project is designed to throw moving shadows on the curtains of a room at night. Its aim is to give an observer the impression that the room is occupied. An intending intruder, believing that there is someone at home, will decide to try elesewhere.

In recent years there have been many devices marketed to turn room lighting on and off during the hours of darkness. One of the problems with these is that any type of regular switching is bound to be recognised as such by the intending intruder. It fails to act as a deterrent. Some of these devices can be programmed to switch the lights on and off frequently during the evening, with fairly irregular timings. The idea is that the frequent switching on and off of the lights is a sign that someone is there, doing the switching. Yet, in the typical household, the living room lights go on at dusk and stay on until bedtime. The effect is far from realistic.

Holmes was right (as always!). There must be signs of activity within. Moving shadows are required. Holmes did not have the benefit of mos technology to help him, but his housekeeper did the job reasonably well.

SHADOW SHOW

This project goes several stages beyond the Holmes subterfuge. The shadows actually move and in an apparently random way. There are periods of active movement with intervals of no movement. All of the following are determined randomly:

* the length of the active periods
* the length of the intervals between movement
* the speed of movement
* the amount of movement
* the direction of movement, which may sometimes change during a movement

The shadows are cast by a suitable object or objects placed on a platform. The platform is rotated from time to time by a stepper motor. As the platform rotates, the shadows move across the curtains.

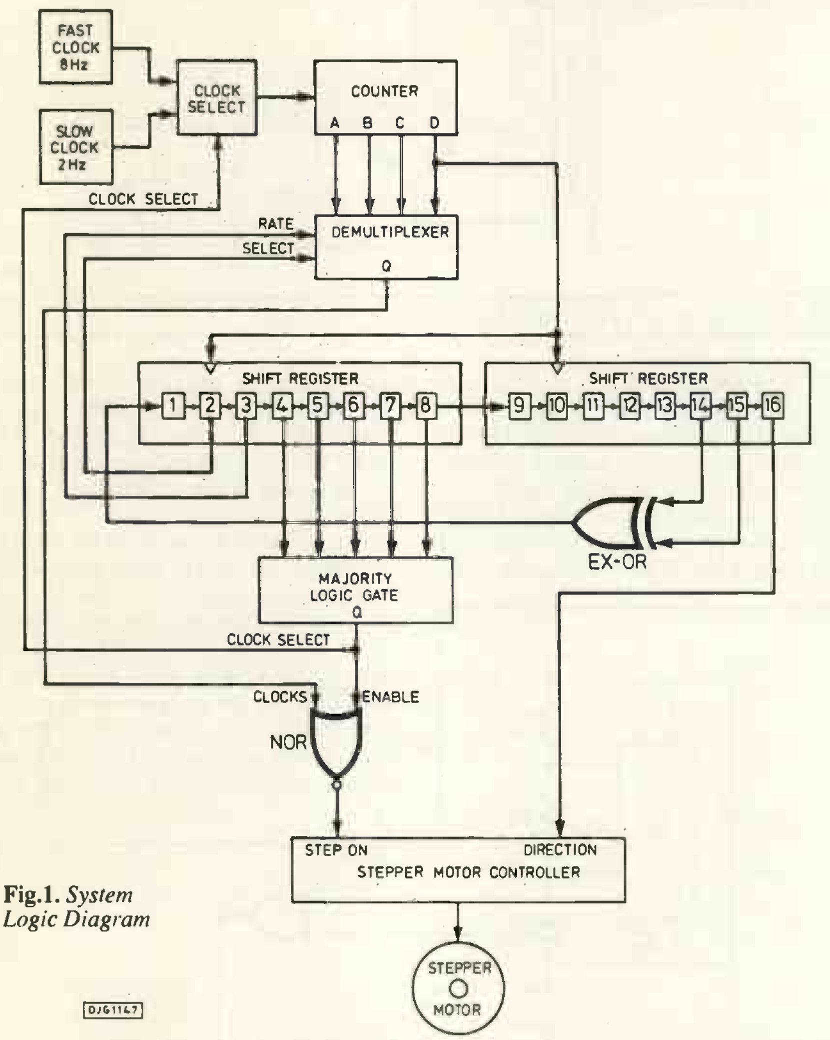


Fig.1. *System Logic Diagram*

RANDOM NUMBERS

Although Holmes did not instruct his housekeeper to change the position of the bust at irregularly spaced times, it is likely that she would have done so in practice. Busy with her other duties, she would spare the time to move the bust at roughly but not precisely regular intervals. Too much precision would have given the game away to the intelligent observer. Electronic circuits are inherently regular in operation. We must find some way of introducing a little randomness. Then the observer will be fooled into believing that there is a real live human in the room, not just a Holmes Machine.

The system (Fig. 1) is based on a random number generator built from a shift register. An interesting thing happens if we take the data from certain flip-flops in a shift register, perform the exclusive-OR operation on them, and feed the result back to the first flip-flop. In this circuit we use a 15-bit register and ex-OR the data from the 14th and 15th flip-flops. The 16th flip-flop, though it is present because the ics just happen to have eight flip-flops each, is not required for this operation.

Provided that one or more of the flip-flops contains '1' to begin with, we get a sequence of bits that repeats itself only after 32767 shifts. Fig. 2 shows 25 consecutive stages of the sequence. This was listed using a computer program to simulate the register. Although the sequence can be predicted (you can do it easily on paper if you do not have access to a computer), the practical effect is the same as if you took a coin and threw it 32767 times. Throwing a coin would give a truly random result, with roughly equal numbers of head and tails. The sequence obtained with the shift register is not truly random because it repeats itself eventually. But it is near enough to random to suit our purpose. It is pseudo-random. Incidentally, shift-registers are used in a similar way to generate the 'white noise' in sound-effects ics.

1	1	1	0	0	0	1	0	1	0	0	0	0	0	1
1	1	1	1	0	0	0	1	0	1	0	0	0	0	0
0	1	1	1	1	0	0	0	1	0	1	0	0	0	0
0	0	1	1	1	1	0	0	0	1	0	1	0	0	0
0	0	0	1	1	1	1	0	0	0	1	0	1	0	0
0	0	0	0	1	1	1	1	0	0	0	1	0	1	0
1	0	0	0	0	1	1	1	1	0	0	0	1	0	1
1	1	0	0	0	0	1	1	1	1	0	0	0	1	0
1	1	1	0	0	0	0	1	1	1	1	0	0	0	1
1	1	1	1	0	0	0	0	1	1	1	1	0	0	0
0	1	1	1	1	0	0	0	0	1	1	1	1	0	0
0	0	1	1	1	1	0	0	0	0	1	1	1	1	0
1	0	0	1	1	1	1	0	0	0	0	1	1	1	1
0	1	0	0	1	1	1	1	0	0	0	0	1	1	1
0	0	1	0	0	1	1	1	1	0	0	0	0	1	1
0	0	0	1	0	0	1	1	1	1	0	0	0	0	1
1	0	0	0	1	0	0	1	1	1	1	0	0	0	0
0	1	0	0	0	1	0	0	1	1	1	1	0	0	0
0	0	1	0	0	0	1	0	0	1	1	1	1	0	0
0	0	0	1	0	0	0	1	0	0	1	1	1	1	0
1	0	0	0	1	0	0	0	1	0	0	1	1	1	1
0	1	0	0	0	1	0	0	0	1	0	0	1	1	1
0	0	1	0	0	0	1	0	0	0	1	0	0	1	1
0	0	0	1	0	0	0	1	0	0	0	1	0	0	1
1	0	0	0	1	0	0	0	1	0	0	0	1	0	0

Fig.2. *25 Consecutive Stepping Stages*

USING RANDOMNESS

When the system is running, a pseudo-random sequence of binary digits is shifted along the register. We make use of the randomness to obtain the random movement of the shadows. There is little chance of an observer detecting any pattern in the activity. The sequence is so long that it takes several days of continuous running before it repeats.

To see how this is done, we return to Fig. 1, starting at the top left-hand corner. The two clocks are designated 'Fast' and 'Slow'. The fast clock determines how active the shadows are when they move. By setting the rate of this clock you can make it seem that the occupant of the room is a brisk, alert person, or rather more ponderous in their movements. The slow clock determines the average length of time between periods of movement. The apparent occupant can be made hyperactive or slothful.

The 'clock select' sub-circuit is used to determine which of the clocks is driving the circuit. A logic low on the 'clock select' line selects the fast clock during active periods. A high level selects the slow clock between active periods.

The selected clock pulses are fed to a counter, with four outputs running a half (A), a quarter (B), an eighth (C) and a sixteenth (D) of the selected clock rate. The slowest rate (D) is used to shift the register. Since the fast clock runs about four times quicker than the slow clock, the register is shifted about four times as quickly during active periods.

The counter outputs go to a demultiplexer, the function of which is to select one of the counter outputs for stepping on the motor. Output A gives the fastest movement while output D gives the slowest. The rate selected depends on the state of the 'rate select' inputs. These inputs are taken from flip-flops 2 and 3 of the register, but they could be taken from any pair of flip-flops – and not necessarily adjacent ones. The rates selected are A, B, C or D when the flip-flop contents are 00, 01, 10 or 11, respectively. As the sequence of digits is shifted along the register, an irregular sequence of 00s, 01s, 10s, and 11s appears on the rate select lines, selecting speed of movement apparently at random.

The output from flip-flop 16 (again, we could have chosen any flip-flop to provide the digit) decides whether the motor is to rotate clockwise or anti-clockwise.

MAJORITY LOGIC GATE

We find it hard to suppress a note of triumph when writing about this part of the circuit. Years and years ago we read about the majority logic gate. It sounded much more interesting and impressive than the boring old NANDs and NORs. Here is democracy in electronic form! The majority vote wins. There are five inputs and, if three (any three) or more are high, then the output is high. Or, by using the W input, you can make it work the other way round. So we bought a 4530 ic, which contains two such gates. After experimenting with it and finding that it worked as specified, we consigned to our stock. In over a decade we have never found a use for it – until now! In this circuit, its output goes low when any three of flip-flops 4 to 8 hold logic '1'. This triggers the beginning of an active phase. The output of the majority logic gate is used to select the fast clock and to enable the NOR gate. Pulses from the clock then pass through to the stepper motor control ic.

The design uses flip-flop 4 to 8 to control the majority logic gate, but any five flip-flops, not necessarily adjacent, could be used. With the present arrangement, which uses consecutive flip-flops, once flip-flops 4, 5 and 6 are high, there will be at least three high outputs for the next two shifts. If more '1's are shifted into these flip-flops the gate output will be high for even more shifts. This gives a good chance of the motion continuing during several shifts, perhaps at different speeds and possibly with changes in direction. The result is periods of varied activity with relatively large breaks in between. By using other arrangements, for example flip-flops 1, 4, 7, 10, 13, you will obtain shorter but more frequent periods of activity. This is another way in which you can control the 'personality' of the Holmes Machine. It is mainly a matter of experimentation to obtain the effect that you think is right.

The 4530 ic contains two majority logic gates but, so far, we have found a use for only one of the gates. Now comes the ironic part. We need a NOR gate and it seems a waste to use a whole 4-gate ic to supply a single NOR gate. There is a majority logic gate to spare and, with a little ingenuity (Fig. 3), it can be used as a boring old NOR gate. So, if anyone else has an unemployed 4530 in their junk-box, here is a way of using it, at last!

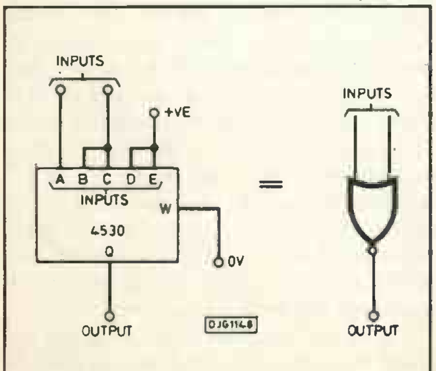


Fig.3. *Majority Logic Gate*

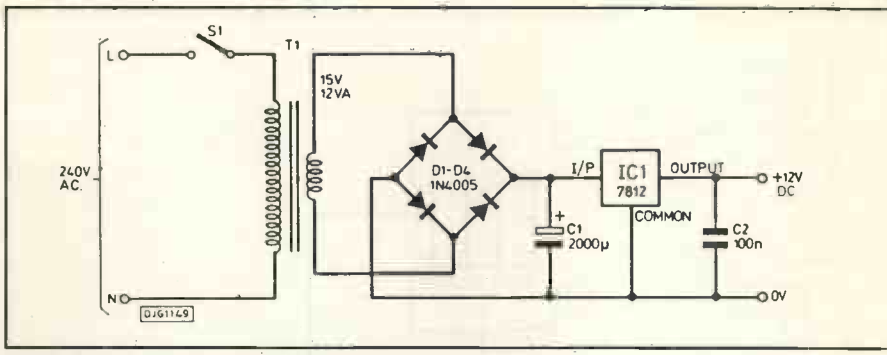


Fig.4. *Power supply circuit (Board 1)*

CIRCUIT DETAILS

Board 1 holds the power supply, a conventional 12V regulated dc circuit (Fig. 4). If a metal case is used, it should be connected to the earth line of the mains supply.

Board 2 is split into two halves. Circuit 2A (Fig. 5a) consists of the clocks and clock select logic. The clocks are straightforward astables, based on the 555 timer ic. The logic is provided by NOR gates in a single 4001 ic. There is a 'clock select' input, which causes the selected clock signal to appear at pin 11 when the input is high.

Fig. 5b shows the circuit of the other half of Board 2, the stepper motor control. This uses a special controller ic, the SAA1027. The 'step on' input goes to the counter terminal (C) of the ic. A high-going pulse steps on the counter of the ic, causing the outputs Q1 to Q4 to cycle through counts from 0000 to 1111. The motor steps on at each change of count. The direction of rotation is controlled by the input to the

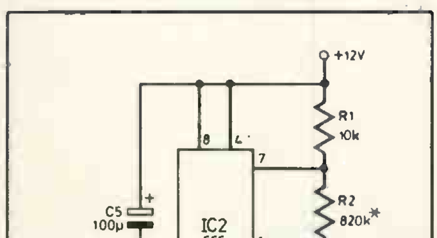
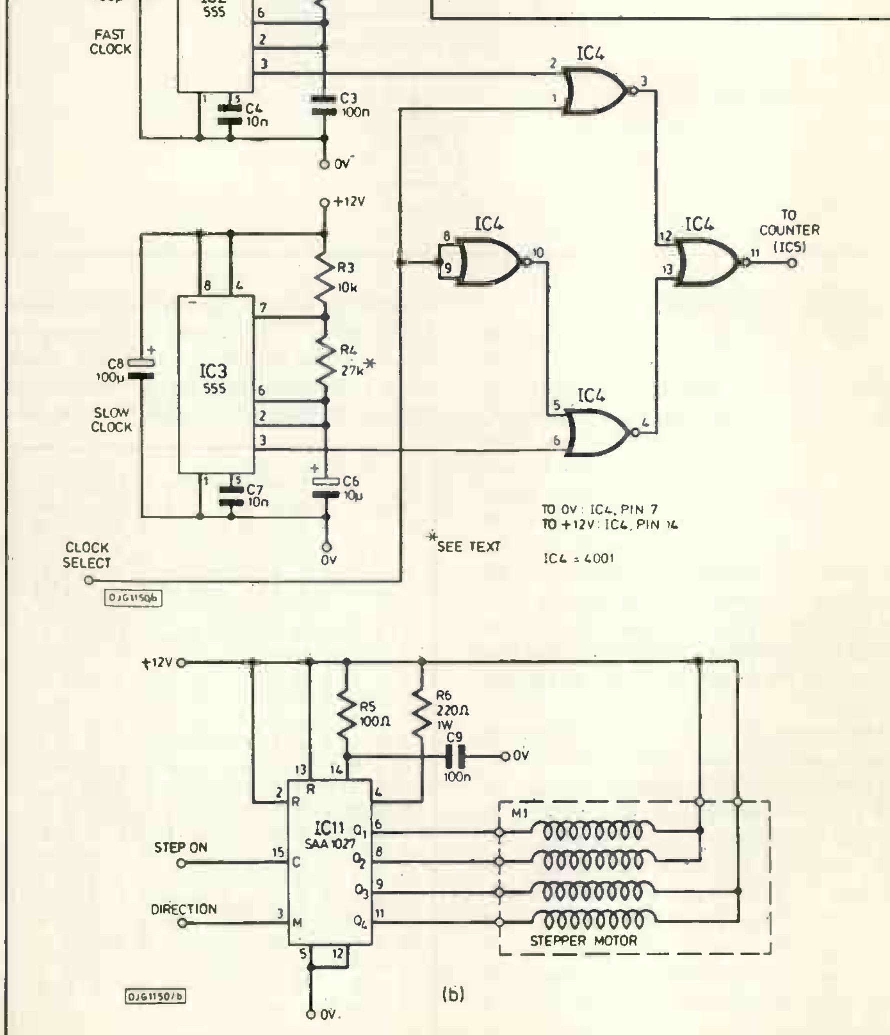



Fig.5. *Board 2 (a) clocks, (b) stepper motor control*

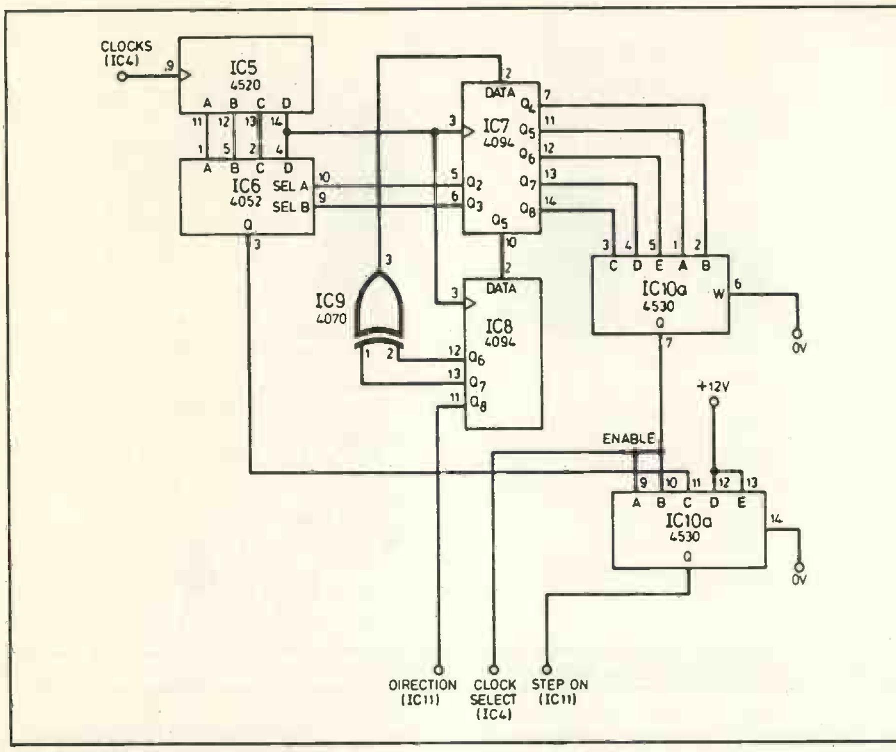


Fig.6. *Board 3: Control logic*

mode terminal (M) of the ic. The reset terminal (R) is not used, being connected to +12V.

Board 3 (Fig. 6) holds the Holmes logic. The 4520 ic has two 4-bit counters, of which only one is used. Its outputs go to the 4052 (beware the similarity in the ic numbers!) 4-line-to-1-line demultiplexer, or 1-of-4 switch. This ic can also switch analogue signals but here we are using it simply for selecting logic levels. The -5V pin (pin 7) is therfore connected to the 0V line. The 16-bit shift register is made from two 4094 ics cascaded in series. They are clocked simultaneously by pulses from the D output of the counter. These are serial-in-parallel-out registers with serial outputs. The Q5 serial output (slow-speed serial output) of the first register is used to feed the data from flip-flop 8 to the first flip-flop of the second register.

Connections from the flip-flop outputs to the majority logic gate, the select input of the demultiplexer and the direction control are shown in Fig. 6 as they were is the prototype. However, many other configurations are possible, as explained above. The only essential is the connections to the ex-OR gate must come from Q6 and Q7 of IC8, as shown.

The 4530 majority logic gate ic (IC10) contains two identical gates. Each gate produces a logical high when any three or more inputs are high. The output from each gate goes to an exclusive-NOR gate on the chip. The other input of this gate is via terminal W. Thus, if W is held low as in this circuit, the output from the majority gate is inverted. Output low when three or more inputs are high.

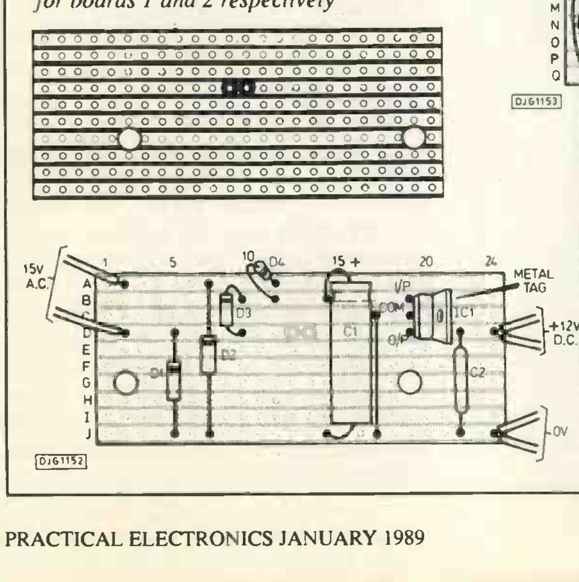
CONSTRUCTION

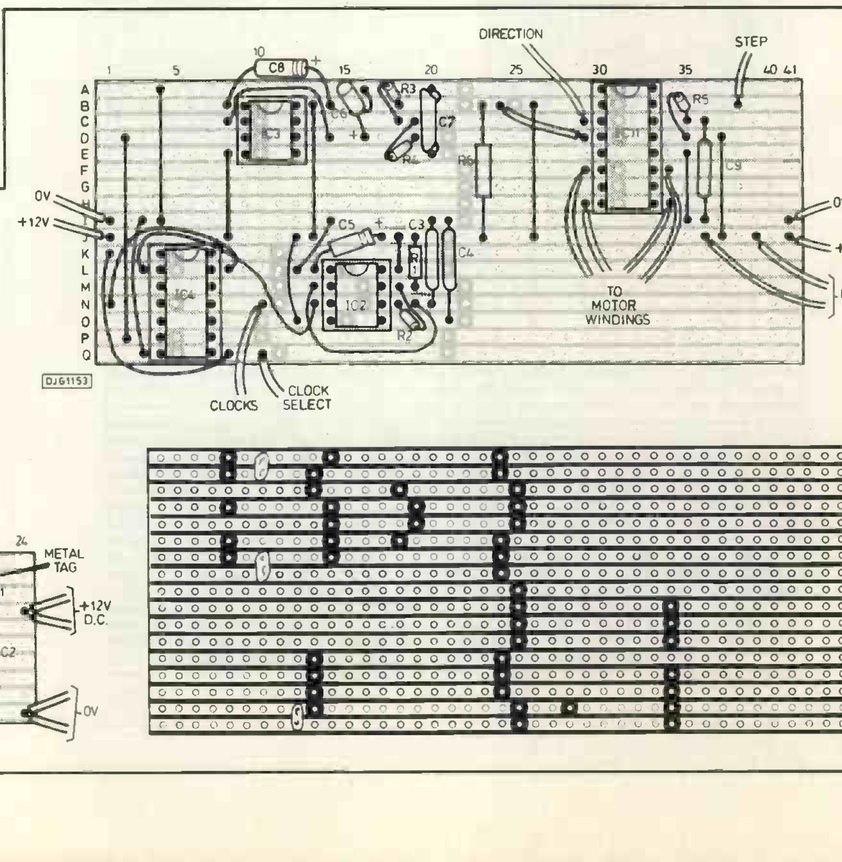
The main point to remember is to take the usual anti-static precautions when handling the cmos ics (IC3-IC10 inclusive). Do not insert these ics into their sockets until a sub-circuit is built ready for testing. Remove them and place them on conductive foam while building the next sub-circuit. Wear clothing of natural fibres, not sythetics. Touch an earthed metal surface frequently while working and touch sharp-pointed tools such as forceps, pliers and screwdrivers against this surface every time before the tool is used.

Build the power supply first. The prototype has its main switch incorporated in the mains lead, but a toggle switch can be mounted on the case if preferred. The transformer is bolted into one corner of the case. Board 1 (Fig. 7) holds the remainder of the power supply components and is mounted on two short bolts beside the transformer. A heat sink is required on the regulator ic. It is advisable to bore ventilation holes in the case and lid. Take care with exposed mains wiring when testing the power supply circuit. As soon as it is working properly, run supply leads from Board 1 out through one of the holes in the case. Then screw the lid firmly down to eliminate risk from contacting the mains side of the power supply circuit.

Next build and test the clocks (Fig. 8). Timings are not critical. Indeed you may decide to vary the clock speeds to obtain a given effect. Increasing R2 from 820k to, say, 1M or 1M2 gives a slower movement.

Fig.7. *(Below),* **Fig.8.** *(Right)*
Component layouts and track views for boards 1 and 2 respectively





Reducing it to, say, 560k or 680k increases movement rate – but would the occupant really move around that fast? Similarly, the value of R4 determines the length of time intervals between periods of activity. Ther greater the value of R4, the longer the times. The NOR gate ic (IC4) completes this section of Board 1. When ready, monitor the output (use an led, a logic probe, a voltmeter or an oscilloscope) from IC4 pin 11 as the clock select input is connected to 0V or +12V. A low input selects the fast clock. It is convenient for later testing if the clock select input pin is wired temporarily to 0V at this stage. Leave the other section of this board until later.

On Board 3 (Fig. 9), begin with the counter ic (IC5) and check its outputs. Then add the demultiplexer (IC6). Monitor its Q output while connecting the A and B select inputs to 0V or +12V:

Select input		Output same as from
B	A	IC5, output
0V	0V	A
0V	12V	B
12V	0V	C
12V	12V	D

Build the shift register next (IC7, IC8). Do not connect it to ICs 6, 9 or 10 yet. Connect the data input (IC7 pin 2) temporarily to 0V. Quickly the flip-flops all fill with '0's. Monitor pins 4-7 and 11-14 in both ics to ascertain this. Then connect pin 2 temporarily to +12V. The flip-flops quickly fill with '1's. Now add the ex-OR gate (IC9) and complete the feedback connection to the register. You should always be able to find at least one flip-flop with a high output. It could happen by chance that all flip-flops assume the '0' state when the circuit is switched on, but this is unlikely and has never yet happened in the prototype. If you do get 'all zeros', switch off and then on again.

Connect the register to ICs 6 and 10 and wire up the rest of IC10. The three outputs from this sub-circuit may now be tested. The 'direction' output alternates irregularly between '0' and '1'. The 'clock select' output alternates similarly. The 'step on' output alternates continuously but at varying rates, depending on which rate is being selected by the demultiplexer.

Finally make up the stepper motor control circuit. This has its own supply leads form the power supply unit to reduce the risk of transients affecting the shift register.

Interconnect the boards for final testing. This is the point at which the 'clock select' line on Board 2 is connected to the 'clock select' pin on Board 3 instead of the 0V line. The leads of the stepper motor are usually colour-coded, and the coding should be set out on the leaflet accompanying the motor.

Switch on the power. From now on, you may have to wait for several minutes while the circuit is in its inactive phases. A paper pointer fixed with 'Blutack' to the spindle of the stepper motor helps to show what the motor is doing. When power is switched on, the motor should soon (or after several seconds) begin to rotate. It may rotate one step (7.5°) or several steeps. It may rotate clockwise or anit-clockwise. Then there is a pause during which nothing seems to be happening. Be patient! Sooner or late, perhaps after a minute or more, the motor resumes activity again.

If all seems to be in order, mount the motor on the lid of the case so that its spindle projects up through the lid. Place the boards in their slots and screw down the lid of the case.

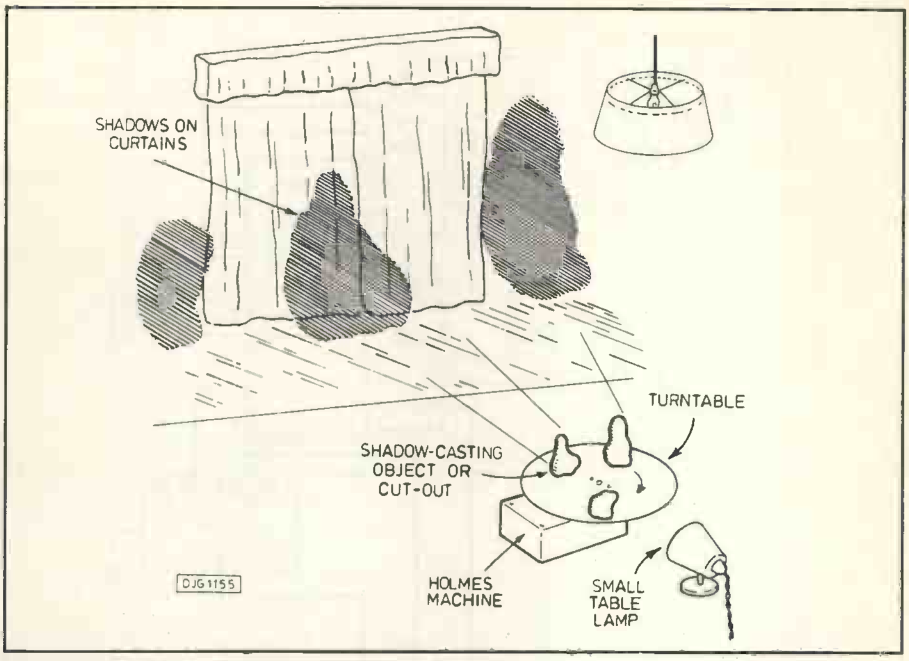


Fig.10. *The Holmes Machine in action!*

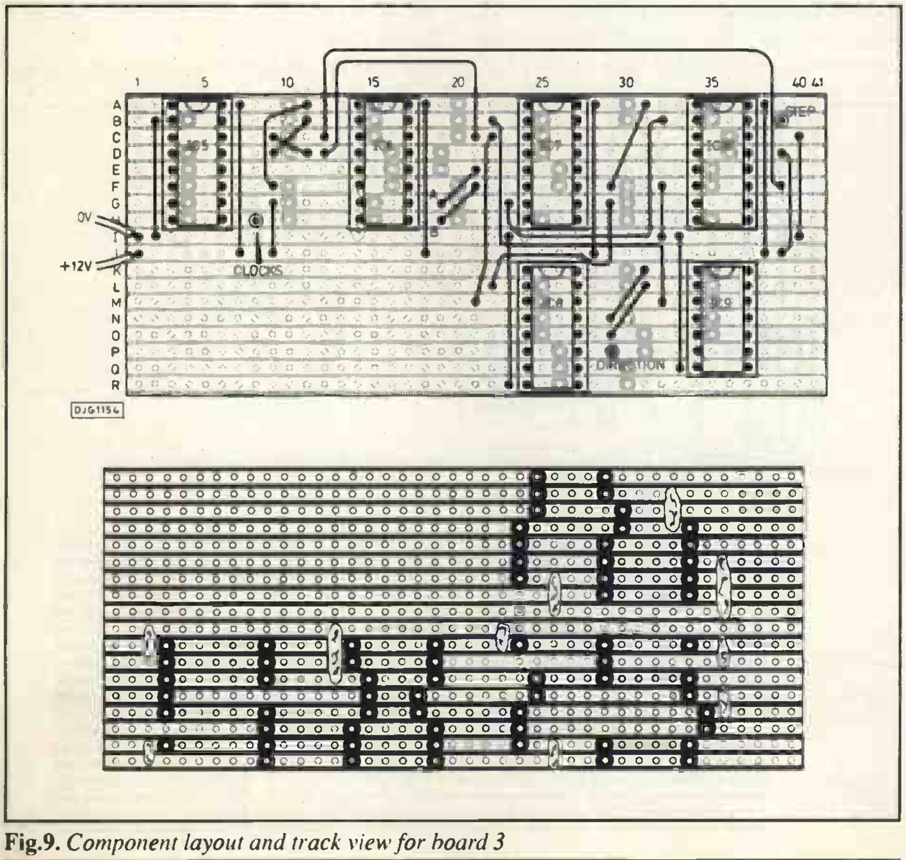


Fig.9. *Component layout and track view for board 3*

TURNTABLE

There are various ways of making the turntable that carries the shadow-producing objects (Fig. 10). In the prototype, an old Meccano bush wheel was used for mounting. You could use a block of hard rubber (eg a bottle stopper such as that available from a home-brew store), with a hole drilled to be a tight fit on the spindle. The platform can be glued to that. That platform, which can be square, rectangular or circular (or completely irregular in shape) is made of any available material – plywood, hardboard, or metal. We used a spare piece of Formica laminate.

COMPONENTS

RESISTORS

R1,R3	10k (2 off)
R2	820k (but see text)
R4	27k (but see text)
R5	100
R6	220, 1W

All 0.25W carbon or 0.6W metal film, 5% unless otherwise specified

CAPACITORS

C1	200µ electronic 16V or 25V
C2,C3	100π polyester (2 off)
C4,C7	10π polyester (2 off)
C5,C8	100µ electrolytic 16V or 25V (2 off)
C6	10µ electrolytic 16V or 25V

SEMICONDUCTORS

D1-D4	1N4005 rectifier diodes, 1A (4 off)

INTEGRATED CIRCUITS

IC1	7812 12V regulator
IC2,IC3	555 timer (2 off)
IC4	4001 quadruple 2-input NOR gates
IC5	4520 dual 4-bit binary counter
IC6	4052 dual 1-of-4 analogue switch
IC7,IC8	4094 8-bit shift register (2 off)
IC9	4070 quadruple exclusive-OR gate
IC10	4530 dual majority logic gate
IC11	SAA1027 stepper motor driver

MISCELLANEOUS

T1 transformer 15V, 12VA
M1 stepper motor, 12V, bi-directional, 4-phase, 7.5° step angle
S1 SPST mains switch
8-pin dil sockets (2 off), 14-pin dil sockets (2 off), 16-pin dil sockets (6 off).
Stripboard 10 strips by 10 holes (eg Vero 14354, 63mm x 25mm); 17 strips by 41 holes and 18 strips by 41 holes (cut from Vero 10347, 36 strips by 50 holes, 127mm x 95mm) – may be more or less than 41 holes if case dimensions different.
1mm terminal pins (24 off), abs box 190mm x 110mm x 60mm, nuts and bolts for mounting boards, fixing feet, grommet, plastic feet (4 off), materials for turntable and shadow-casters.

PLATFORM

There is one point to consider when deciding which material to use for the platform. The action of a stepper motor is somewhat 'springy'. In moderation, this produces a natural non-mechanical action. In excess, it can produce a rather unnatural effect – the would-be intruder might think that you have a roomful of kangaroos. This effect can easily be damped down by making the platform sufficiently massive. Make it of thick wood or of metal sheeting. Alternatively, place a small objet of mass about 1kg on it.

The most suitable diameter for the platform depends partly on the geometry of your room. A large platform will produce a greater movement of the shadows, allowing them to pass off the curtains and apparently out of the room.

The platform carries models or cut-outs to cast the shaddows. It might be appropriate to have cutouts showing a man playing the violin, holding up a test-tube, or smoking a pipe. However this is carrying the illusion too far. Avoid trying to emulate a Javanese shadow-puppet show and go for much more subtle designs. The outlines of the models or cutouts need not resemble humans closely. We found that a small pepper-grinder produced most acceptable shadows. The objects or cutouts can be fringed with semi-transparent paper or plastic sheet, to blur the outlines.

MODIFICATION

An interesting modification is to use a platform surfaced in rough-textured Formica. The objects slide about slightly as the platform rotates. The platform needs an edge about 1cm high to prevent them falling off. This adds even more randomness to the motion.

The source of light should be a small table-lamp, preferably with an adjustable mounting, an opaque shade and a reflector bulb. Place this so that the shadow or shadows are cast on the drawn curtains. If you have several models or cut-outs on the turntable, arrange it so that they do not all cast shadows on the window area at any one time. The shadows should be active but confusing to the observer. Therefore have other room lighting on at the same time, so that the shadows are diluted and made more obscure. If you are out and the room lighting and the shadow-casting are switched off automatically at bed-time, the Holmes Machine's busy evening is brought to a realistic conclusion.

GLOSSARY

SHIFT REGISTERS

A shift register is a series of flip-flops, each of which holds one bit of binary data (0 or 1). This circuit uses a 16-bit register, Its registers might hold the data:

1100101011100010

The shift register receives pulses from a clock circuit. At each clock pulse, the data is shifted on from one flip-flop to the flip-flop next door. In the example, a single shift would give:

X110010101110001

The X indicates that the data shifted into the first flip-flop depends upon what was present at the serial input of the register when the shift occurred. The data that was in the last flip-flop has been shifted out, and lost.

EXCLUSIVE-OR

This is the 'same or different' logical operation, performed upon two inputs.

The result is low if the inputs are the same, and high if they are different. It is the logical equivalent of 'One OR the other, but not both'. *This is the truth table:*

Inputs		Output
B	A	Z
0	0	0
0	1	1
1	0	1
1	1	0

PE

ELEMENTARY

Had Holmes been living in our era, I am sure he would have added to the deception by also ensuring that the tv was turned on, allowing its screen flicker to fall on the window blind as well.

Ed

LEADING EDGE

Continued from page 8

Everyone, including the DTI, is now in a no-win situation. Letting market forces decide the winner between several incompatible systems will sour the public perception of CT2. Delaying the launch of CT2 by the year or so it will take manufacturers to re-design and re-tool to a common standard will give rival firms in foreign countries, including the Far East, valuable time to catch up and compete. The DTI may thus set an official standard but enforce it only after different systems have been sold for an interim period of several years. If this happens BT will hold back on the sale of its own handsets.

I spoke with Sir Clive Sinclair about CT2. He acknowledges that at least two competing systems (Shaye and Ferranti – Libera) will be launched later this year, and later joined or replaced by a standard derived from these competing technologies – and thus incompatible with at least one of them. But he is still optimistic.

"There are two ways to set a standard, either have a committee, or let the public choose the system that works best. Often the latter is best, but in the case of CT2 a committee will make the decision quickly to help Britain sell into Europe. But I don't see the muddle over standards as making any big difference. I don't think it will hold things back. Public base stations on 'phonepoints' will have to be multi-standard, that will cost more, and be a damn nuisance, but I don't see it as a big problem".

Out of curiosity I took the opportunity of asking Sir Clive Sinclair the big question. When he first filed patents on CT2 did he think about public base stations?

"No", admits Sir Clive "I have to be honest. I wasn't thinking about that. In fact I don't know who came out with the idea. I wish it had been mine, but it wasn't.".

PE

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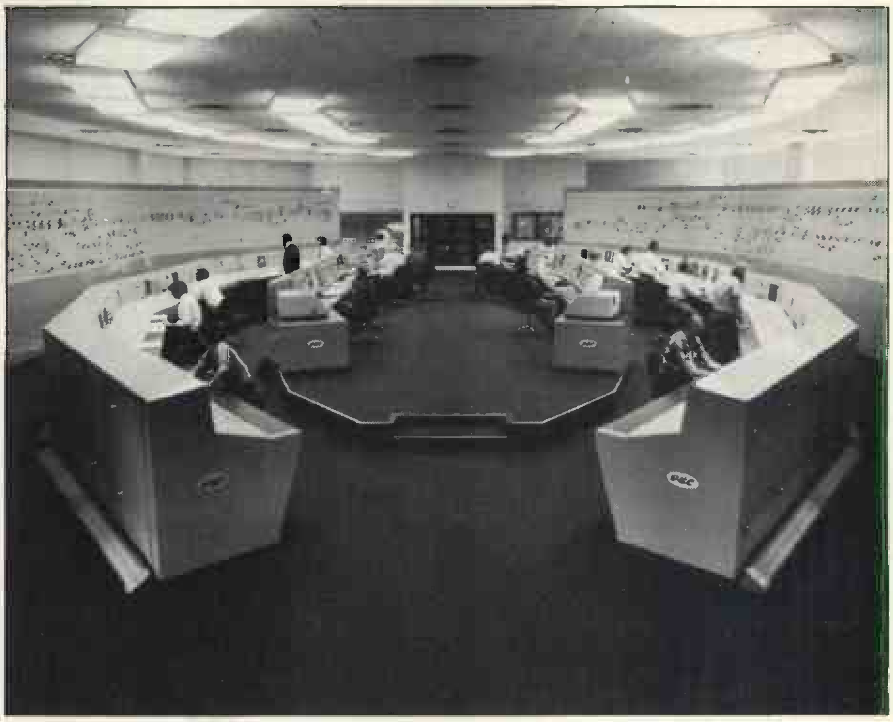
However, with the volume of rail traffic on a modern railway today, whether it be freight or passenger traffic or both, it is evident that the electronic and computerised scene is here to stay, because without it the efficiency of the railway would be very, very poor.

This article is the first of a series of three which will look at the inroads that have been made into the railroads of today by modern electronics. During the course of the articles we shall identify those systems used in railway signalling and they look at electronics in the rest of the railway scene.



The Victoria signalling control centre and train describer for British Rail Southern Region

RAILWAY SIGNALLING

Railway signalling has come a long way in the 160 years or more since the first passenger carrying train in the world was permitted to run, in the United Kingdom.

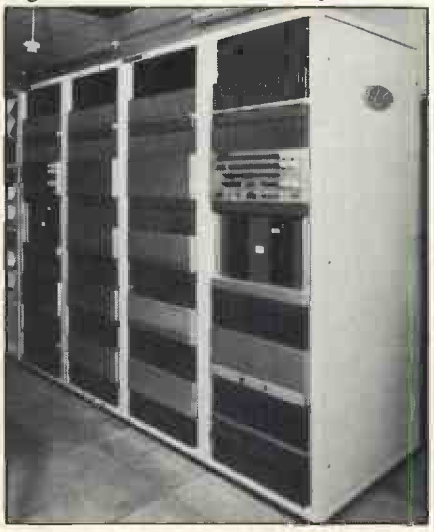
The first attempt to control the safe passage of trains was made with the use of "railway policemen" who displayed flags (red for "stop" and green for "all clear") to the drivers of trains in order to permit access through the advance track section and on to the next policeman. (In Britain these policemen, who were the forerunners of today's signalmen, gained the nickname "Bobbies" after the then Commissioner of the London Metropolitan Police, Sir Robert Peel. This name has stuck and, even today, Britain's signalmen, even those in modern sophisticated signalling control centres, are still nicknamed "Bobbies"!)

Since those early days signalling has progressed quite a lot, from the introduction of mechanical semaphore signalling through to colour light signalling and now to "cab signalling" or even to completely automatic driverless trains which are controlled by electronic signalling. At the same time, it is ironic to note that in some places the most modern systems in use can be found only a few miles away from the signalling of yesteryear.

VITALITY

Signalling systems fall into two categories. "Vital" systems, by definition, are used to control the safety side of the signalling system. "Non-vital", or "Less-vital", systems are those systems which, under failure conditions, will not affect the safe running of railway traffic in any way, even though the failure in itself may probably cause some disruption to services.

It is in this latter category, that of the "non-vital" systems, where the first use of electronics was to be found. One of the first devices to be developed for signalling use was the Train Describer, or "TD", not a signalling device in itself but, rather, an aid to the signalman. Used as an intended replacement of the old system of train recording whereby signalmen would record the train's number as the train passed a certain fixed point on the track, say a starting signal. It was also used as a replacement



Train describer cubicles at Victoria signalling centre

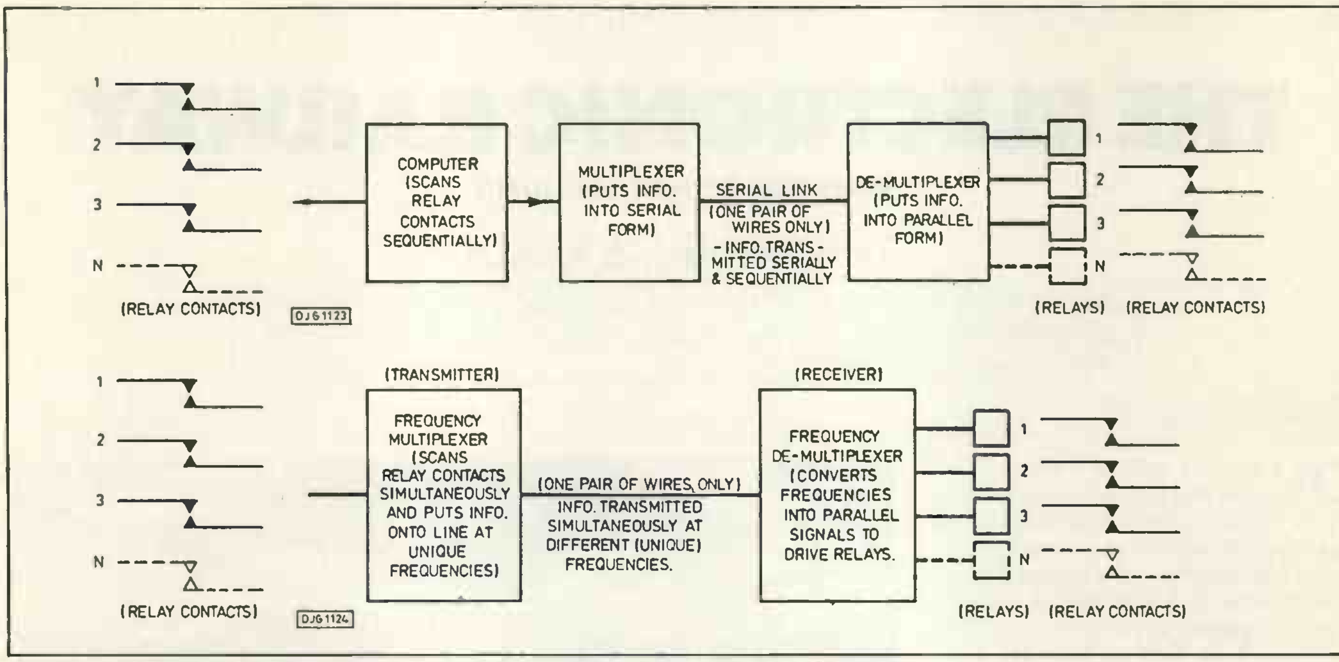


Fig.1 *Remote control system. (Top) Time division multiplex, (Bottom) frequency division multiplex*

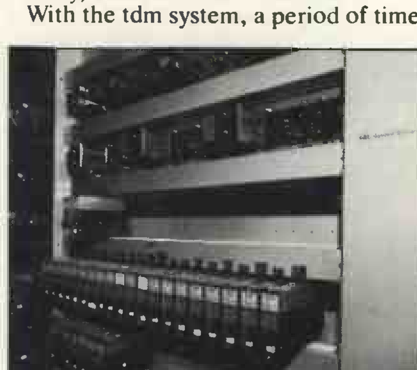
for the "bell code" system in which a signalman would "describe" a train's type to a signalbox in advance, eg, fully braked freight or express passenger. The train describer allows a signalman to identify by train number the position and type of any particular train which is either within his control area or approaching it. Used in conjunction with track circuit indications on his control panel or, on an ultra-modern installation, his visual display unit, the train describer automatically steps on the identification of a train as it progresses through a signalling section or on to the next signalling control centre.

REMOTE CONTROL

Another early use for the computer in the signalling field was in the introduction of the remote control system. Where a signalling control centre controls a signalling interlock several miles away, there has to be some way of operating the relays which in turn control the signals and points at the interlocking. In the past the practice was to provide direct wire connections using multicore signalling cables. With the ever-increasing costs of copper cabling, though new methods had to be found to perform the required task. Hence the development of the time division multiplex (tom) remote control system. TOM involves the sequential scanning by a computer of a number of relay contacts (representing the signalling output functions) at the control centre. The information thus obtained is then sequentially transmitted over just one pair of wires to a second computer at a remote, or "field", interlocking and here the information is decoded to operate the required functions. There is, therefore, a vast saving in copper cabling between the control centre (or "office", as it is known) and the remote location. Hence there is a saving in overall costs, even though a transmitter/receiver computer system has been used. Because the system is used as an aid to the control of vital signalling equipment, rather than controlling them directly, it is said to be "non-vital".

With the tdm system, a period of time is divided up by a number of functions being transmitted sequentially from one end of the system to the other. There is another system in use whereby a number of functions are transmitted/received over two wires, at unique frequencies for each function. With this system, known as fom, or frequency division multiplex, either "vital" or "non-vital" information can be distributed, depending upon the design of the system used. This system is invaluable where information may not necessarily need to be transmitted all the way along the total control system. For example, a road/rail level crossing may need to be controlled somewhere between the "office" and "field" locations.

Type RM (TDM) remote control equipment at Victoria signalling centre



Type RR Reed (FDM) remote control equipment at Waverley signalling centre

INTERLOCKING

What of the interlockings themselves? Indeed, what is an interlocking? This is the location where the logical cross-checking is carried out to ensure that no signal route becomes free to be operated until all opposing signal routes are first normalised and until all points are set in their correct positions for the safe passage of trains. Also, any other equipment or functions, such as groundframes, level crossings, etc, must be correctly set/normalised as required.

In the past the interlocking was carried out mechanically using rods, locks and tappets within a signalbox leverframe. Lately, the mechanical mechanisms have been replaced by relay interlockings whereby electrical circuits have provided the (vital) checking as required. However, now we have witnessed the first of the computerised interlockings. Called "solid state interlockings", or ssi, there may be two or three computers which, through their predetermined programs, check their own and their partners' operation. This ensures and maintains the integrity of

Geographical route relay interlocking at Waverley signalling centre

Solid state interlocking (SSI) trackside signal module

SSI cubicles and technicians terminals at Inverness signalling centre

the safety which would previously have been allowed with the relay interlockings. At a fraction of the cost of a relay interlocking, the ssi is the latest innovation to hit the signalling industry, with savings in times of installation as well as the cost involved in carrying out such installations. In addition, the buildings used to contain the equipment are much smaller than the conventional "relay rooms" of the past.

TRAIN DETECTION

Mention was made earlier of the "track circuit". This forms the very basis for any signalling system and is the means of detecting the presence of a train on a railway line. In essence, the track circuit is an insulated pair of rails which have a power supply at one end of the rails and a detection device, say a relay, at the other end of the rails. Without a train present on the track the detector is in the "track clear of trains" state. If, the detector is a relay, this will be in its energised state, where the power supply is feeding the relay's energisation coil.

Once a train enters the area of the track circuit the power supply is effectively removed from the circuit and the detector goes to the "train present" state. Again, if the relay is being used, this will de-energise. Thus an effective means of train detection is available. In the past, and even now, the track circuit has been little more than a basic electrical circuit. These days, sophisticated arrangements are also often in use where a transmitter at one end of a section of track (which may not necessarily be insulated from the next section) operates a receiver at the other end of that section. The transmission frequency chosen is unique for a particular section, thus preventing false operation from adjacent track circuits. The presence of a train is detected by the receiver not receiving the transmitted "message" due to the train's wheels interrupting the circuit.

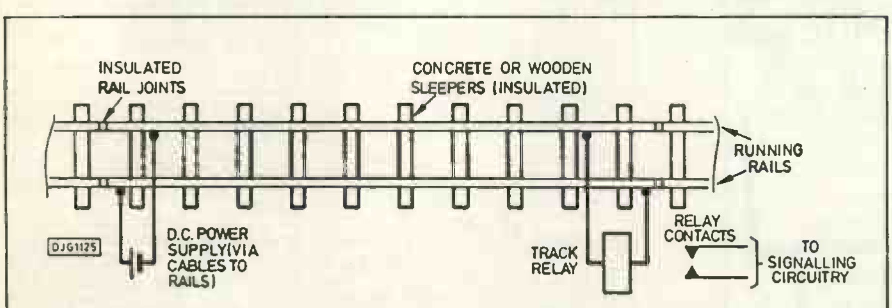


Fig.2 *Direct current track circuit*

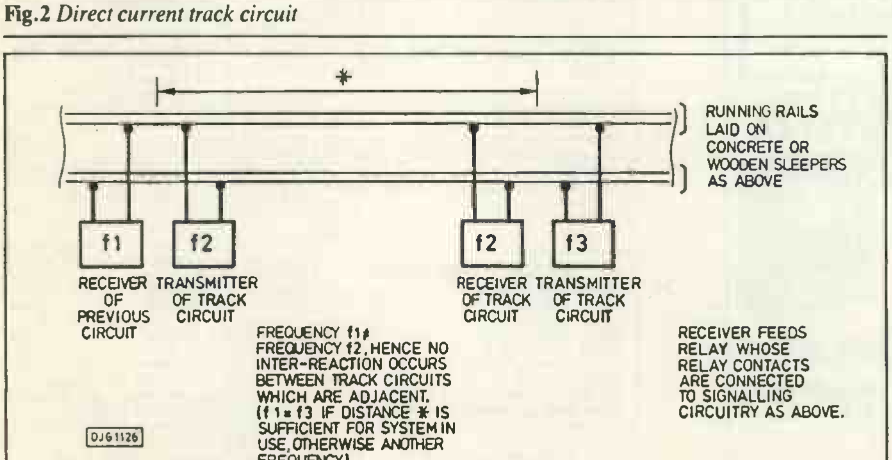


Fig.3 *Jointless track circuit*

EXTREME TEMPERATURES

In some colder countries the railways have many problems due to the freezing up of point switches. This can involve delays to traffic while rail staff work to unfreeze them by applying either heat or de-freezing chemicals.

A better answer is to use automatic point heaters. In this method electronic sensors detect when the ambient temperature drops to a critical level. Automatic circuits are then operated which ignite a propane gas jet aimed at the point switches, thus melting the ice or snow.

At the opposite end of the temperature scale, heat can cause quite a lot of problems also. If a train's axle box overheats, say through the leaking out of lubricants, rolling stock can catch fire, sometimes with disastrous results. Some railways use "hot axle box detectors" which are electronic devices installed near the rails. These detect when an axle box of a vehicle is significantly higher in temperature than other axle boxes within the same train, working on the principle that not all the axle boxes will be running hot at any one time. The detector then transmits a message to a control centre or signalbox and records the details of the train concerned and even the exact vehicle and axle involved, so allowing the train to be stopped and inspected.

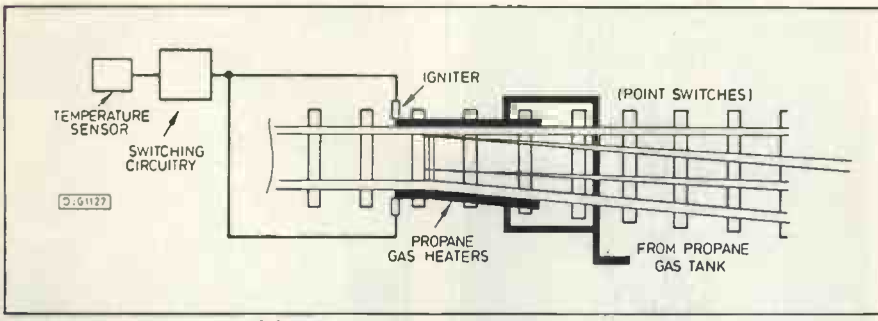


Fig.4 *Automatic point switch heaters*

WAGON SORTING

Staying on the subject of detection devices, consider the freight yard. In some countries "hump yards" are used in which a shunting train has its "consist" of wagons uncoupled in such a way as will allow their correct separation into the required sidings. The information of the wagon "cuts" or portions is entered manually into a computer, along with details of their required destination sidings. A shunting locomotive then propels the entire train up and over a hump in the track at a constant low speed. As each cut of wagons goes over the hump, gravity allows them to run down the slope towards the receiving sidings. Special air-operated retarders slow down the rolling wagons if necessary. Point switches are operated to the correct positions for the route to the desired sidings for that cut of wagons.

There are several detectors involved in the process. Each wagon, or cut of wagons, is dynamically weighed while rolling down the slope and acceleration is detected. This enables the correct "rollability" factor to be computed, and hence the correct air pressure on the retarders. As a parallel example, an egg can be held by very little pressure. However, apply too much pressure and the egg is crushed. Likewise, if too much pressure is applied to retard a wagon, then the wagon can literally be squeezed off the track. The whole process is computer-controlled to make the procedure as efficient as possible.

To be concluded next month

PE

The photographs in the Electronic Railway article have been kindly supplied by GEC-General Signalling Ltd.

X-TRA BYTE SIZED

Integrated circuit manufacture currently depends on the use of visible light and optical techniques to literally print the circuit on the chip. With the call for smaller and faster chips, optical techniques are becoming increasingly incapable of the fine resolution required to minimise component size.

Researchers are currently turning to investigating X-rays as the possible successor to light rays for the next generation of devices. Having a very short wavelength, X-rays can create extremely sharp edges when projected through the printing masks. The penetrating power of X-rays presents problems, though, and the researchers, notably at IBM, are having to create special mask materials. There is the additional problem of focussing the X-rays, which unlike light, cannot be diverted by lenses. Consequently, the masks have to be cut to the precise sub-miniature size by an electron beam. Using an electron accelerator storage ring to boost the X-ray power available, IBM has found that line-definitions can be obtained that could enable 64 million megabyte chips to be reliably manufactured.

The research will eventually extend beyond X-rays when the maximum expected 256Mbyte chip is achieved, the limit to which X-ray techniques are likely to go. Ed.

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6A 100V BRIDGE .... 2/£1
8A 200V BRIDGE .... 2/**£1.35**
10A 200V BRIDGE **£1.50**
25A 200V BRIDGE **£2** .... 10/£18
25A 400V BRIDGE **£2.50** .... 10/£22

SCRS
2P4M EQUIV CI06D .... 3/£1 100/£20
MCR72-6 10A 600V SCR **£1**
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NEC TRIAC AC08F 8A 600V TO220 .... 5/£2 100/£30
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SLOTTED OPTO-SWITCH OPCOA OPB815 .... **£1.30**
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10R 20R 100R 200R 250R 500R 2K 2K2 2K5 5K 10K 22K 47K 50K 100K 200K 500K 2M2 .... **50p each**

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6 pin 15/**£1** 8 pin 12/**£1** 14/16 pin 10/**£1** 18/20 pin 7/**£1**, 22/24/28 pin 4/**£1** 40 pin **30p**

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100n ax short leads .... 100/£3
100n ax long leads .... 100/£6
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Access

No. 1 LIST BAKERS DOZEN PACKS

All packs are £1 each, if you order 12 then you are entitled to another free. Please state which one you want. Note the figure on the extreme left of the pack ref number and the next figure is the quantity of items in the pack, finally a short description.

BD1	5	13A junction boxes for adding extra points to your ring main circuit.
BD2	5	13A spurs provide a fused outlet to a ring main where devices such as a clock must not be switched off.
BD7	4	In flex switches with neon on/off lights, saves leaving things switched on.
BD9	2	6V 1A mains transformers upright mounting with fixed clamps.
BD11	1	6½in speaker cabinet ideal for extensions, takes our speaker. Ref BD137.
BD13	12	30 watt reed switches, it's surprising what you can make with these – burglar alarms, secret switches, relay, etc., etc.
BD22	2	25 watt loud speaker two unit cross-overs.
BD29	1	B.O.A.C. stereo unit is wonderful value.
BD30	2	Nicad constant current chargers adapt to charge almost any nicad battery.
BD32	2	Humidity switches, as the air becomes damper the membrane stretches and operates a microswitch.
BD34	48	2 meter length of connecting wire all colour coded.
BD42	5	13A rocker switch three tags so on/off, or change over with centre off.
BD45	1	24hr time switch, ex-Electricity Board, automatically adjust for lengthening and shortening day original cost £40 each.
BD49	10	Neon valves, with series resistor, these make good night lights.
BD56	1	Mini uniselector, one use is for an electric jigsaw puzzle, we give circuit diagram for this. One pulse into motor, moves switch through one pole.
BD59	2	Flat solenoids – you could make your multi-tester read AC amps with this.
BD67	1	Suck or blow operated pressure switch, or it can be operated by any low pressure variation such as water level in water tanks.
BD91	2	Mains operated motors with gearbox. Final speed 16 rpm, 2 watt rated.
BD103A	1	6V 750mA power supply, nicely cased with mains input and 6V output leads.
BD120	2	Stripper boards, each contains a 400V 2A bridge rectifier and 14 other diodes and rectifiers as well as dozens of condensers, etc.
BD122	10m	Twins screened flex with white pvc cover.
BD126	10	Very fine drills for pcb boards etc. Normal cost about 80p each.
BD132	2	Plastic boxes approx 3in cube with square hole through top so ideal for interrupted beam switch.
BD134	10	Motors for model aeroplanes, spin to start so needs no switch.
BD139	6	Microphone inserts – magnetic 400 ohm also act as speakers.
BD148	4	Reed relay kits, you get 16 reed switches and 4 coil sets with notes on making c/o relays and other gadgets.
BD149	6	Safety cover for 13A sockets – prevent those inquisitive little fingers getting nasty shocks.
BD180	6	Neon indicators in panel mounting holders with lens.
BD193	6	5 amp 3 pin flush mounting sockets make a low cost disco panel.
BD196	1	in flex simmerstat – keeps your soldering iron etc. always at the ready.
BD199	1	Mains solenoid, very powerful, has 1in pull or could push if modified.
BD201	8	Keyboard switches – made for computers but have many other applications.
BD210	4	Transistors type 2N30455, probably the most useful power transistor.
BD211	1	Electric clock, mains operated, put this in a box and you need never be late.
BD221	5	12V alarms, make a noise about as loud as a car horn. Slightly soiled but OK.
BD242	2	6in ×4in speakers, 4 ohm made from Radiomobile so very good quality.
BD246	2	Tacho generators, generate one volt per 100 revs.
BD252	1	Panostat, controls output of boiling ring from simmer up boil.
BD259	50	Leads with push-onb ¼in tags – a must for hook-ups – mains connections etc.
BD263	2	Oblong push switches for bell or chimes, these can mains up to 5 amps so could be foot switch if fitted into pattress.
BD268	1	Mini 1 watt amp for record player. Will also change speed of record player motor.
BD275	1	Guitar mic – clip-on type suits most amps.
BD283	3	Mild steel boxes approx 3in × 3in × 1in deep – standard electrical.
BD293	50	Mixed silicon diodes.
BD296	3	Car plugs with lead, fit into lighter socket.
BD305	1	Tubular dynamic mic with optional table rest.

Most other packs still available and you can choose any as your free one.

VERY POWERFUL 12 VOLT MOTORS – ⅓ HORSEPOWER Made to drive the Sinclair C5 electric car but equally adaptable to power a go-cart, a mower, a rail car, model railway, etc. B rand new. Price £15.00 plus £2.00 postage. Our ref 15P8.

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There is a total of over 400 packs in our Baker's dozen range and you become entitled to a free gift with each dozen packs.

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ATARI 65XE COMPUTER

At 64k this is most powerful and suitable for home and business. Brand new, complete with PSU, TV lead, owner's manual and six games. Can be yours for only £45 plus £3 insured delivery.

DATA RECORDERS ACORN for Acorn Electron, etc., reference number ALF03, with TV lead, manual and PSU. Brand new. Price £10 plus £1.50 post. Order ref 10P44. ATARI XC12 for all their home computers. With leads and handbook. Brand new. Price £10 plus £2 post. Order ref 10P53.

JOYSTICK FOR ATARI OR COMMODORE for all Atari and Commodore 64 and Vic20. New. Price £5. Order ref 5P126.

EXTRA SPECIAL OFFER We will supply the Atari 65XE, data recorder XC12, joystick and six games for £57.50 plus £4 insured delivery.

SUB-MIN TOGGLE SWITCH Body size 8mm x 4mm x 7mm SBDT with chrome dolly fixing nuts. 4 for £1. Order Ref. BD649.

EX GPO MULTI-RANGE TEST METER 12/C1 Complete in real leather case with carrying handle – this is a 20,000 OPU Instrument, with 19 ranges including AC and DC volts – dc current 5mA to 1A 3ohms ranges up to 20meg – the low ohms range is particularly useful, you will be able to read right down to one ohm and below. Not new but are in first class condition-tested and guaranteed. Price is £7.00. Order ref 7P5.

Re-CHARGEABLE NICADS 'D' SIZE
These are tagged for easy joining together but tags, being spot welded, are easy to remove. Virtually unused, tested and guaranteed. £2.00 ref 2P141 or 6 wired together for £10.00 ref 10P47.

RECORD PLAYER DECK BSR, 12 volt operated, belt driven with an 11in turntable, stereo cartridge. It will play 7in-10in or 12in individually at either 45rpm or 33rpm. Fitted speed selector and pick-up cueing lever. Price £12 plus £3 postage. Order ref 12P4.

2.5kw TANGENTIAL BLOW HEATER has an approximate width of 8in (plus motor), elements made up of two 1 2kw sections so with switch available you can have 2.5kw, 1.2kw or cold blow. Over-heat cutout eliminates fire risk should fan stop or air flow be impeded. Fan blades are metal. Price £5 plus £2.50 post. Our ref 5P62. Switch 50p.

ALBA TWIN CASSETTE RECORDER AND PLAYER WITH STEREO RADIO This is a mains/battery portable made to sell, we understand, at about £50 but the ones we have are line rejects. They are brand new still in the manufacturers' boxes but have a slight defect associated with the cassette section. The radio and amplifier section, both mono and stereo, is perfectly OK. If you are handy at mending things then this should be for you. Price £20 or two for £38 plus £3 insured post, either package. Our ref 20P7 or 2 x 20 P7

LASER TUBE

Made by Phillips Electrical. New and unused. This is helium-neon and has a typical power rating of 1.6mW. It emits random polarised light and is completely safe provided you do not look directly into the beam when eye damage could result. Do not use in the presence of children unless a diverging lens if fitted. DON'T MISS THIS SPECIAL BARGAIN! Price £29.95 plus £3 insured delivery.

POWER SUPPLY FOR PHILIPS LASER is now available in kit form. Price £13 plus £2 postage or made-up ready-to-use at £18 plus £2.50 postage. Our ref 13P1 for the kit and 18P1 for the made-up version.

PAPST AXIAL FAN-MANUFACTURERS REF NO. TYP4560N.
This is mains operated. 15 watt rating and in a metal frame with metal blades so OK in high temperatures. Body size approx. 4¾" square × 1⅜" thick. £6.00 each, plus £1.00 postage. Our ref 6P6.

VERY POWERFUL MAGNETS Although only less than 1" long and not much thicker than a pencil these are very difficult to pull apart. Could be used to operate embedded reed switches, etc. Price 50p each, 2 for £1.00. Ref BD642.

ORGAN MASTER

is a three octave musical keyboard. It is beautifully made, has gold plated contacts and is complete with ribbon cable and edge connector. Brand new, only £15 plus £3 postage. Order ref 15P15.

MUSIC FROM YOUR SPECTRUM 128 We offer the Organ Master three octave keyboard, complete with leads and the Interface which plugs into your 128. You can then compose, play, record, store, etc., your own music. Price £28 plus £3 special packing and postage. Order ref 28P2.

20A DOUBLE POLE RELAY WITH 12V COIL complete with mounting brackets made by the Japanese Omron Company. Price £2 each. Our Ref. 2P173A.

TORROIDAL MAINS TRANSFORMER with twin outputs, 6.3V 2A and 12V 600mA, so ideal for FDD power supply. Price £5. Our Ref. 5P122.

DOUBLE MICRO CASSETTE DECK made by the Japanese ABS company. This takes two micro cassettes and is complete with motors, solenoids to select the deck to use and record and playback heads. Price £10. Our Ref. 10P49.

QUICK FIX MAINS CONNECTOR A must for your workshop. Saves putting on plugs as you just push the wires under the spring clips. Automatically off when lid is up. Price £7.50. Our Ref. 7P5/1.

BT HANDSET with curly lead terminating with flat BT plug. Colour cream. Price £5. Our Ref. 5P123.

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POPULAR ITEMS

Some of the many items described in our current list which will you receive if you request it

3½in FDD CHINON 80 track 500k. Shugart compatible interface. Standard connections. Interchangeable with most other 3½in and 5¼in drives. Brand new £28.50 plus £3 insured post.

CASE NOW AVAILABLE FOR THE CHINON F353 This is the 80 track, single sided one which we have been selling at £28.50. The case is sheet metal, finish in hammer-beige with ample ventilation and rubber feet. Overall size 4¼in x 7in x 1½in approx. Designed to take the ribbon cable and 3 core power lead. Price £8. Our ref 8P21.

3in FDD HITACHI HFO3X3XA Shugart compatible interface 500k on 3in disc. Recommended for many Amstrads but interchangeable with most drives. £29.50 plus £3 insured post.

FDD CASE AND POWER SUPPLY KIT for the 3in or 3½in. £11.00. Ref 11P2 for the Chinon, 11P3 for the Hitachi.

9in MONITOR made for ICL, uses Phillips black and white tube. Brand new and complete but uncased. £18.00 plus £5.00 post.

ACORN COMPUTER DATA RECORDER REF ALF03 Made for the Electron or BBC computers but suitable for most others. Complete with mains adaptor, leads and handbook. £10.00. Ref 10P44

POWERFUL IONISER Uses mains transformer. Generates approx. 10 times more ions than the normal diode/cap ladder circuits. Complete kit £11.50 plus £3.00 post.

FREE POWER! Can be yours if you use our solar cells – sturdily made modules with new system bubble magnifiers to concentrate the light and so eliminate the need for actual sunshine – they work just as well in bright light. Voltage input is .45 – you join in series to get desired voltage – and in parallel for more amps. Module C gives 400mA. Price £2, Our ref. 2P199 Module D gives 700mA. Price £3, Our ref. 3P42.

SOLAR POWERED NI-CAD CHARGER 4 Ni-Cad batteries AA (HP7) charged in eight hours or two in only 4 hours. It is a complete, boxed ready to use unit. Price £8. Our ref. 8P3.

90V 20A TRANSFORMER 'C' Core construction so quite easy to adapt for other outputs – tapped mains input. Only £25 but very heavy so please add £5 if not collecting. Order Ref. 25P4.

SWITCH AC LOADS WITH YOUR COMPUTER This is easy and reliable if you use our solid state relay. This has no moving parts, has high input resistance and acts as a noise barrier and provides 4kW isolation between logic terminals. The turn-on voltage is not critical, anything between 3 and 30V, internal resistance is about 1K ohm. AC loads up to 10A can be switched. Price is £2 each. Ref. 2P183.

METAL PROJECT BOX Ideal size for battery charger, power supply etc.; sprayed grey, size 8in x 4¼in x 4in high, ends are louvred for ventilation other sides are flat and undrilled. Order Ref. 2P191. Price £1.

BIG SMOOTHING CAPACITOR. Sprague powerlytic 39,000uF at 50V. £3. Our ref. 3P41.

4-CORE FLEX CABLE. Cores separately insulated and grey PVC covered overall. Each copper core size 7/0.2mm. Ideal for long telephone runs or similar applications even at mains voltage. 20 metres £2. Our ref. 2P196 or 100 metres coil £8. Order ref. 8P19.

6-CORE FLEX CABLE. Description same as the 4-core above. Price 15 metres for £2. Our ref. 2P197 or 100 metres £9. Order ref. 9P1.

TWIN GANG TUNING CAPACITOR. Each section is .0005uF with trimmers and good length ¼in spindle. Old but unused and in very good condition. £1 each. Our ref. BD630.

13A PLUGS Good British make complete with fuse, parcel of 5 for £2. Order ref. 2P185.

13A ADAPTERS Takes 2 13A plus, packet of 3 for £2. Order ref. 2P187.

28V -0- 20V Mains transformers 2½ amp (100 watt) loading, tapped primary. 200-245 upright mountings £4. Order ref. 4P24.

BURGLAR ALARM BELL – 8" gong OK for outside use if protected from rain. 12V battery operated. Price £8. Ref. 8P2.

24 HOUR TIME SWITCH – 16A changeover contacts, up to 6 on/offs per day. Nicely cased, intended for wall mounting. Price £8. Ref. 8P6.

CAPACITOR BARGAIN – axial ended, 4700μF at 25V. Jap made, normally 50p each, you get 4 for £1. Our ref. 613.

PIEZO ELECTRIC FAN – An unusual fan, more like the one used by Madame Butterfly than the conventional type; it does not rotate. The air movement is caused by two vibrating arms. It is American made, mains operated, very economical and causes no interference, so is ideal for computer and instrument cooling. Price is only £1 each. Ref. BD598.

SPRING LOADED TEST PRODS – Heavy duty, made by the famous Bulgin company, very good quality. Price 4 for £1. Ref. BD597.

ASTEC P.S.U. – Switch mode type. Input set for +230V. Output 3.5 amps at +5V, 1.5 amps at +12V, and 3 amps at +5V. Should be Ok for floppy disc drives. Regular price £30. Our price only £10. Ref. 10T34. Brand new and unused.

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⅛TH HORSEPOWER 12 VOLT MOTOR Made by Smiths, the body length of this is approximately 3in, the diameter 3in and the spindle 5/16th of an inch diameter. It has a centre flange for fixing or can be fixed from the end by means of 2 nuts. A very powerful little motor which revs at 3,000 rpm. We have a large quantity of them so if you have any projects in mind then you could rely on supplies for at least two years. Price £6. Our ref 6P1, discount for quantities of 10 or more.

CHRISTMAS FLASHERS

by Chris Bowes

RUDOLPH THE RED LED REINDEER!

The Three Wise Men had to make do with one star, but you can have as many as there are leds in your junk box! And rotating angels, flashing Rudolphs, flickering puddings and random candles! Strike a light!

We are all used to the twinkling of the lights on the Christmas tree during the festive season but wouldn't it be nice to add a little more sparkle to other decorations? The circuits described in this article do just that. You can choose between angels with rotating halos, Rudolph with a flashing nose, pulsating stars, candles which flicker or a random circuit to liven up your decorative plum puddings, holly bunches or miniature Christmas trees. In fact the extent of what you can do is limited only by your ingenuity.

The circuits are designed so that you have a choice of outputs. You can use standard leds, high current-high intensity leds or even les or mes bulbs. This makes the circuits suitable for use in the home or in a big hall.

RUDOLPH'S NOSE

This is the simplest of the circuits and is suitable for flashing off and on any single dc load. It may be used to make Rudoplh's nose flash or to control a number of leds such as you might arrange into a large star or a small mock Christmas tree. The circuit for this project is shown in Fig. 1 and is basically a simple 555 timer astable circuit, the frequency and duration of which is governed by the values of VR1, R1, R2 and C1. The frequency of operation of the circuit is adjusted by setting VR1 and the component values given in the circuit diagram have therefore have been chosen to give a fairly wide range of speeds. C2 is required to set the control voltage at pin 5 to the correct voltage when the bipolar version of the 555 timer is used. If you use the cmos version of the ic you may omit this component, although no harm is done by leaving it in the circuit if, for instance, you should need to change IC1 at any time.

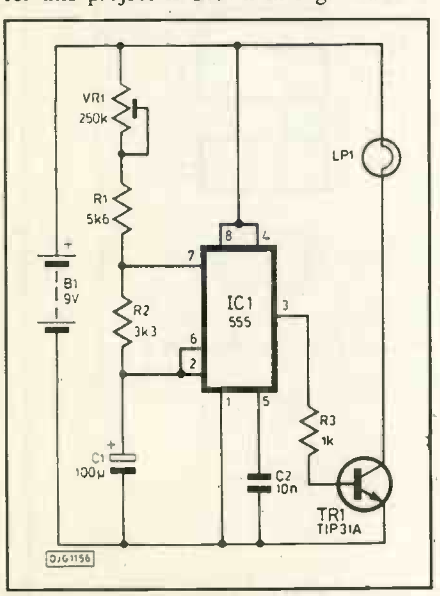


Fig.1. *Rudolph's nose circuit*

RUDOLPH'S NOSE

RESISTORS	
R1	5k6
R2	3k3
R3	1k
All 1/4 watt 5%	
POTENTIOMETER	
VR1	250k min horiz preset
CAPACITORS	
C1	100uF 10V electrolytic
C2	10n polyester
SEMICONDUCTORS	
TR1	TIP31A
IC1	555 timer bipolar or cmos type
MISCELLANEOUS	
LP1	6V mes bulb
B1	9 volt battery (PP9 or similar) and connector

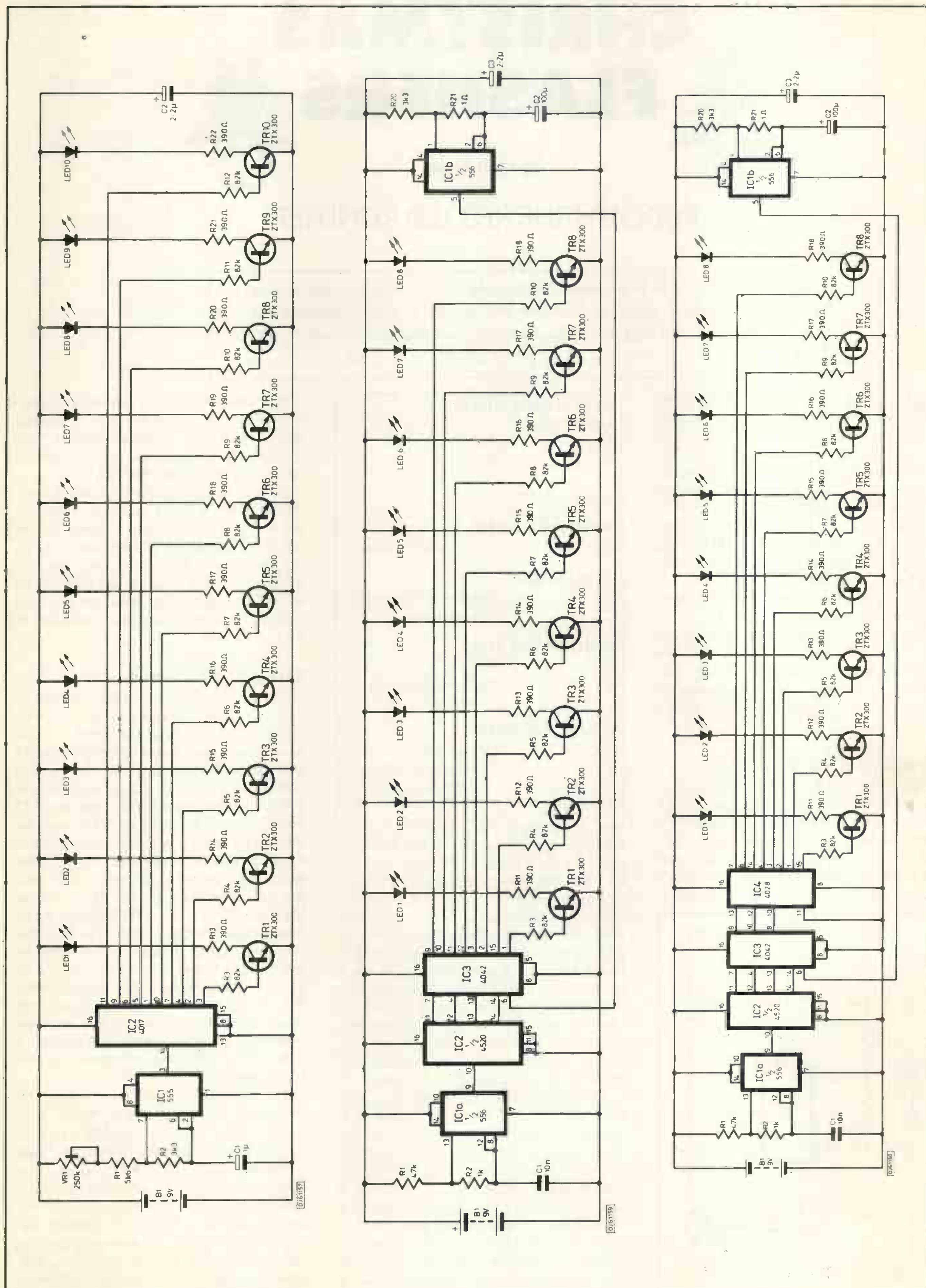
The output from the 555 timer is only really sufficient to drive a very small load, such as a single led. For most applications this will not be sufficient, so a driver transistor (TR1) and bias resistor (R3) have been included in the circuit. To allow a substantial load (up to 1A) to be driven a TIP31A power transistor has been selected. In this circuit R3 acts as a current limiter to prevent the current flowing through the base/emitter junction of TR1 rising above a safe level. When the voltage at the output (pin 3) or IC1 rises to V_{SS} a current flows through both R3 and the base/emitter junction of TR1. This causes TR1 to conduct and a current is therefore made to flow through the load and the collector/emitter circuit, thus energising the load.

If your application only requires the circuit to drive a single led output then the driver transistor and bias resistor can be omitted. The circuit is modified by reducing the value of R3 to 380 ohms and connecting the led in place of TR1. The anode of the led replaces the base, and the led's cathode replaces the emitter connections of TR1 on the pcb.

THE ANGEL'S HALO

The Angels Halo and Pulsating Star circuits are both basically simple ten way chaser circuits, with different output sequences. The diagram for the Angel's Halo circuit is shown in Fig. 2. This project is the standard ten way chaser, consisting of a 4017 counter, clocked by a standard 555 astable timer. As with Rudolph's nose, the timing pulses are generated by IC1 which is a 555 cmos timer configured in the astable mode. Here again the frequency of the output pulses is governed by the values of VR1, R1, R2 and C1. VR1 has been deliberately made a large value so as to make the circuit adjustable through a wide range of speeds, although in practice the effect is at its best when the circuit is running fairly fast, so C1 has been made a fairly small value. Note that this circuit, and all of the following projects, *must* be constructed with a cmos 555 timer, the bipolar version is not suitable.

The clock output from pin 3 of IC1 is connected to the CP_0 input of the 4017 counter IC2. The CP_1 and MR inputs of IC2 are kept at the logic 0 state, by being connected to 0 volts, which causes the counter to advance at every clock pulse output from IC1. This causes each of the outputs O_0 to O_9 of IC1 to be raised to the logic 1 state in turn. These outputs are then connected to the base of the appropriate driver transistors (TR1-10), via a bias resistor (R3-10). The transistor driver circuit operated in the same manner as is described



Left to Right: **Fig.2.** *Angel's halo chase.* **Fig.3.** *Candle flicker;* **Fig.4.** *Random pudding.*

ANGELS HALO

RESISTORS

R1	5k6
R2	3k3
R3-R12	82k
R13-R22	390 ohms
All 1/4 watt 5%	

POTENTIOMETER

VR1	250 min horiz preset

CAPACITORS

C1	1uF 10V pcb electrolytic
C2	2.2uF 16V tantalum

SEMICONDUCTORS

LED1-LED10	high brightness leds, yellow
TR1-TR10	ZTX 300
IC1	555 cmos timer
IC2	4017 counter

MISCELLANEOUS

B1	9 volt battery and connector

11 way ribbon cable to connect pcbs

Components lists refer to the versions illustrated in the main circuit diagrams (Fig. 1 to 5). Refer to Figs. 6, 7 and 7a for other versions of circuits.

CANDLE FLICKER

RESISTORS

R1	47k
R2	1k
R3-10	82k
R11-19	390 ohms
R20	3k3
R21	1 ohm
All 1/4 watt 5%	

CAPACITORS

C1	10nF polyester
C2	100uF 10V pcb electrolytic
C3	2.2uF 16V tantalum

SEMICONDUCTORS

LED1-LED8	high brightness led, yellow
TR1-TR8	ZTX300
IC1	556 dual cmos timer
IC2	4520 dual binary counter
IC3	4042 quad latch

MISCELLANEOUS

B1	9 volt battery & Connector

RANDOM PUDDING

RESISTORS

R1	47k
R2	1k
R3-R10	82k
R11-R19	390 ohms
R20	3k3
R21	1 ohm
All 1/4 watt 5%	

CAPACITORS

C1	10nF polyester
C2	100uF 10V pcb electrolytic
C3	2.2uF 16V tantalum

SEMICONDUCTORS

LED1-LED8	high brightness led (Colour to suit application)
TR1-TR8	ZTX300
IC1	556 dual cmos timer
IC2	4520 dual binary counter
IC3	4042 quad latch
IC4	4028 1-of-10 decoder

MISCELLANEOUS

B1	9 volt battery and connector

above, energising the leds 1 to 10 in turn. The series resistors (R11-19) are included in the circuit to lower the voltage present across the led to the correct voltage for the devices specified and restrict the current flowing through them to the specified, safe level.

FLICKERING CANDLE

The next two projects are based on random circuits which use the technique of loading the output from a fast running clock into a latch and displaying the output.

The candle flicker uses the circuit shown in Fig. 3. IC1a is half of a 556 dual cmos timer which is configured in the astable mode, to provide a high speed clock output. The frequency is, as for the previous circuits, determined by the values of R1, R2 and C1. In this application the values of these components are not critical, although they should be of the same order of magnitude as those specified. The pulses generated by the high speed clock circuit are fed into the CP_1 input of IC2, which is half of a 4520, 4-bit binary counter. The CP_0 and MR inputs of this counter are held at 0 volts and the circuit thus counts up, in binary, at high speed, forcing the outputs O_0 to O_3 to the logic 1 state in a binary sequence, which gives 16 possible output combinations. These outputs are connected to the inputs I_0 to I_3 of IC3, which is a 4042 quad latch, in a random fashion. (In fact the order in which the inputs and outputs are connected to this IC has been chosen so as to make the design of the pcb as easy as possible.) The E_1 input of the 4042 is connected to the output of IC1b, which is the other half of the 556 dual cmos timer. This is also configured in the astable mode but the component values have been chosen so as to give an output which oscillates between the logic 0 and logic 1 states at a rate which is considerably slower than that of the high speed clock.

The E_0 input of IC3 is connected to 0 volts, making it permanently in the Logic 0 state. When both E_0 and E_1 of IC3 are at the same logic state the latch is opened and the state of the outputs O_0 and O_3 follow those of the corresponding inputs. When the two enable inputs are at different states then the outputs O_0 to O_3 remain at the state which existed when the two enable inputs were last both in the same logic state. Thus when the output from IC1b is at logic 0 the contents of the latch are changed to reflect the state of the outputs of IC2. The 4042 is also provided with inverting outputs O_0 to O_3 which are always at the opposite logic state to the corresponding normal output. Thus, with the circuit as designed, there will always be four outputs in the energised state and four outputs in the off state. Because the two clocks are running at different rates the outputs are made to flicker in a random fashion. If the output devices (leds or les bulbs) are positioned as a four in two decorative candles a realistic flicker effect is obtained. This circuit can also be used with any of the decorative ideas given for the Random Pudding circuit.

RANDOM PUDDING

This circuit is a variation of the circuit used for the Flickering Candle, and is intended for use in decorative Christmas puddings (with the leds being the plums), holly bunches (with led berries) or miniature illuminated Christmas trees with random flashing lights. Alternatively a number of these circuits could be used to give a twinkling star effect as a background for a Christmas Crib or flying Rudolph.

The circuit diagram for this project is given in Fig. 4. The circuit is identical in operation to that of the Flickering Candle except that only one output is energised at a time. This difference between the two circuits is achieved by the inclusion of a 4028, 1 of 10 decoder (IC4). The outputs from the latch (IC3) are taken, again in an order which makes the design of the pcb easy, to three of the inputs (I_0 to I_2) of IC4. Input I_3 of IC4 is permanently held at the logic 0 state by virtue of being connected permanently to 0 volts. In this arrangement only one of the outputs, I_0 to I_7 of IC4 will be at the logic 1 state at any moment in time. The output so energised is determined by the value of the binary number present at the inputs I_0 to I_2 of IC4. As input I_3 is at the Logic 0 state this value can never exceed 0111 (decimal 7). The driver circuitry connected to the outputs of IC4 is identical to that for the previous circuit.

PULSATING STAR

The circuit for this project is shown in Fig. 5. As with the other projects the first part of the circuit is a cmos 555 timer, configured as an astable. The clock output from IC1 is used to advance the 4017 counter as described above. In this application we require a different type of output sequence with which to control our output drivers to that required for the Angel's Halo. To achieve this the outputs O_0 to O_9 of the counter are connected to the six output driver

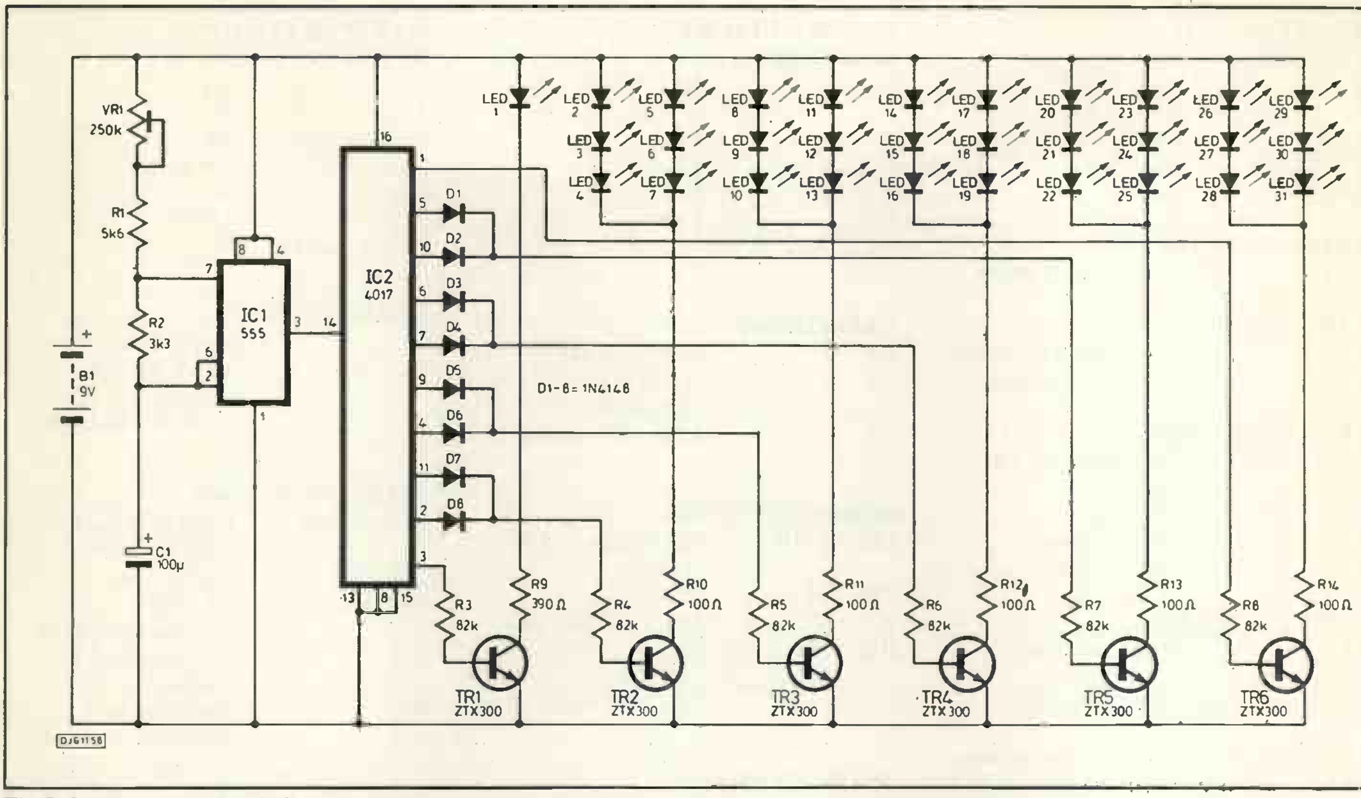


Fig.5. *Pulsating star circuit diagram*

circuits, via D1 to D8, so as to cause the six outputs to be energised in the order:-

O_1, O_2, O_3, O_4, O_5, O_6, O_5, O_4, O_3, O_2, O_1, O_2 and so on, with the sequence repeating ad infinitum.

This gives a backwards and forwards sweeping effect to the outputs, which are fed, through the respective dropping resistors, to the base of the transistors TR1 to TR6, which operate as described above. In this project the leds (or other output indicators) *must* be driven via transistor current amplifiers since the load would otherwise exceed the recommended maximum current which may be drawn from the outputs of the 4017. The component values given in the circuit diagram are those required for high brightness leds. If your application requires normal leds with a current of 10mA the component values should be altered so that R3=68k, R4-R8=82k, R9=330 ohms and R10-R14=150 ohms.

The leds (both types) or bulbs are arranged as shown in Fig. 12 to form a series of spokes centered on LED1 and are driven in such a way that they produce a pattern which pulses in and out of LED1 which acts as a central point.

PULSATING STAR

RESISTORS	
R1	5k6
R2	3k3
R3-R8	82k
R9	390 ohms
R10-R14	100 ohms
POTENTIOMETERS	
VR1	250k min horiz preset
CAPACITORS	
C1	100uF 10V pcb electrolytic
C2	2.2uF 16V tantalum
SEMICONDUCTORS	
LED1-LED31	high brightness leds – yellow
D1-D8	1N4148
TR1-TR6	ZTX300
IC1	555 cmos Timer
IC2	4017 Counter
MISCELLANEOUS	
B1	9 volt battery & connector
7-way ribbon cable to link pcbs	

ALTERNATIVE OUTPUTS

The outputs shown in all of the circuits given above (except for Rudolph's Nose) are designed to accommodate high brightness leds with currents too great for them to be directly driven from the outputs of the cmos ics specified. (Cmos devices are limited to 100 mW power dissipation per output or a total dissipation of 500 mW per ic.) It is therefore necessary to use the simple transistor driver circuits shown when the circuits are used to drive more than four standard leds (drawing a maximum current of 10 mA each). It is however possible to use devices other than high brightness leds for the outputs of the circuits shown above providing that a few modifications are made.

LOW POWER LEDS

If, for your application, you only need to drive a single led, with a maximum current of 10 mA from each output, with no more than five leds on at any one time then the leds can be driven directly from the outputs of the cmos ics without the need for a driver transistor. Modification of the circuit is a simple matter since it is only necessary to change the transistor bias resistor (typically

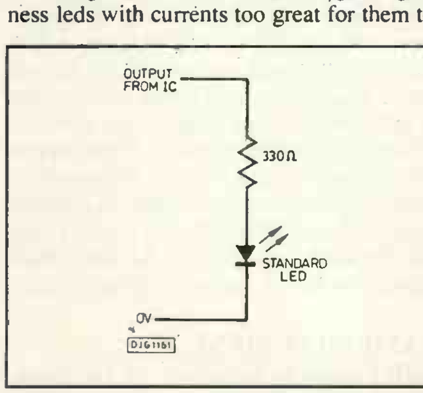
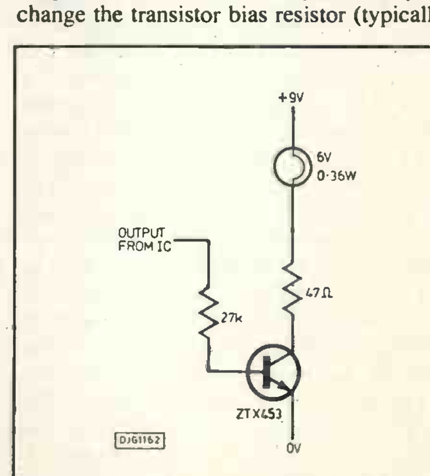


Fig.6. *(above) direct drive circuit for standard leds.*

Fig.7. *(right) transistor driver circuit for 6V bulbs*



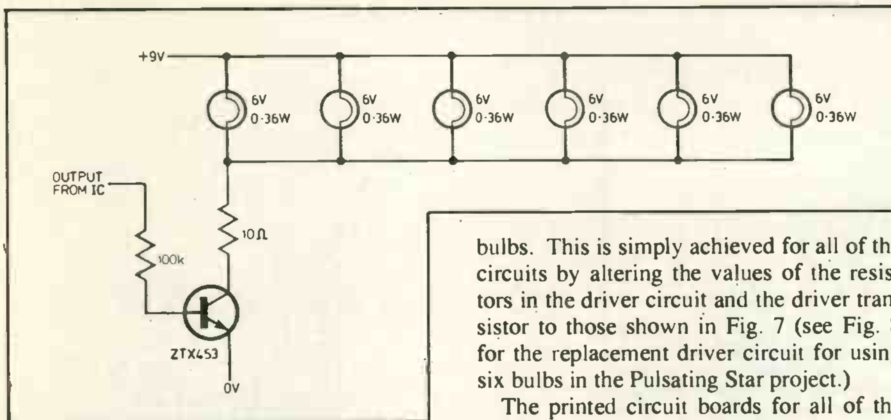


Fig.8. *Transistor driver circuit for 6V bulbs replacing leds in pulsating star circuit*

82k) to the 330 ohm led current limiting series resistor and connect the led in place of the base and emitter connections of the ZTX300, as shown in Fig. 6. This modification may be used for all of the circuits given *except for the Pulsating Star Circuit.* (If low power leds are used in this project then the component values should be altered to those given in the circuit details for the Pulsating Star.)

MES OR LES BULBS

For a brighter display, perhaps in a larger room, such as a school or church hall you might wish to replace the leds with small-bulbs. This is simply achieved for all of the circuits by altering the values of the resistors in the driver circuit and the driver transistor to those shown in Fig. 7 (see Fig. 8 for the replacement driver circuit for using six bulbs in the Pulsating Star project.)

The printed circuit boards for all of the projects have been designed to accommodate both of the above variations.

GREATER LOADS

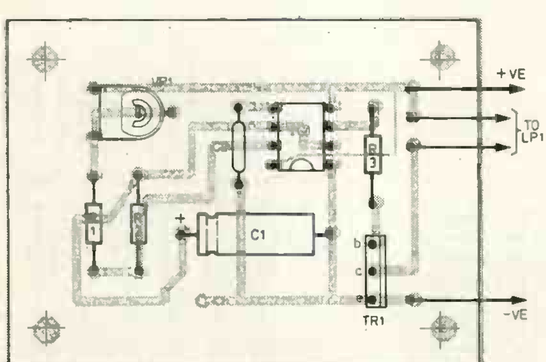
If you want to get really adventurous an even greater dc load could be driven by replacing the ZTX300 transistor with an output circuit such as that shown for Rudolph's nose, but the pcb design will also have to be altered. Indeed it is perfectly feasible to use a relay with mains contacts, switching mains voltage bulbs, in place of each of the output leds/bulbs in each of these circuits, but by then you are getting into the High Street Illumination league.

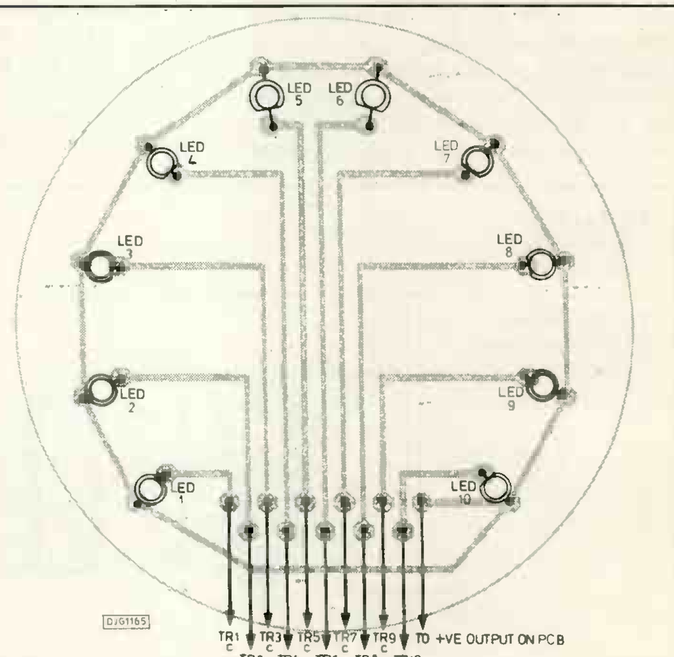
CONSTRUCTION

The control circuits for all of the projects are built on the appropriate printed circuit boards, for which the foil patterns and the component layouts are shown in Figs. 9 to 15. It is anticipated that the leds or other output devices will be placed in holes drilled in appropriately shaped pieces of plastic or wood cut to shape, but foil patterns are also given for display pcbs for the Angel's Halo and Pulsating Star projects.

The foil patterns should be transferred to suitable boards which are then etched and drilled in the usual way. The components can then be inserted into the board and soldered in place. Although this process can be carried out in any convenient order, you will find that it is easier to perform this task if the components are inserted in ascending order of size. All the components of a particular size should be soldered into position before going onto a larger size of components. Care should be taken to ensure that polarity sensitive components are inserted into the board the correct way round.

The ics are best accommodated in sockets





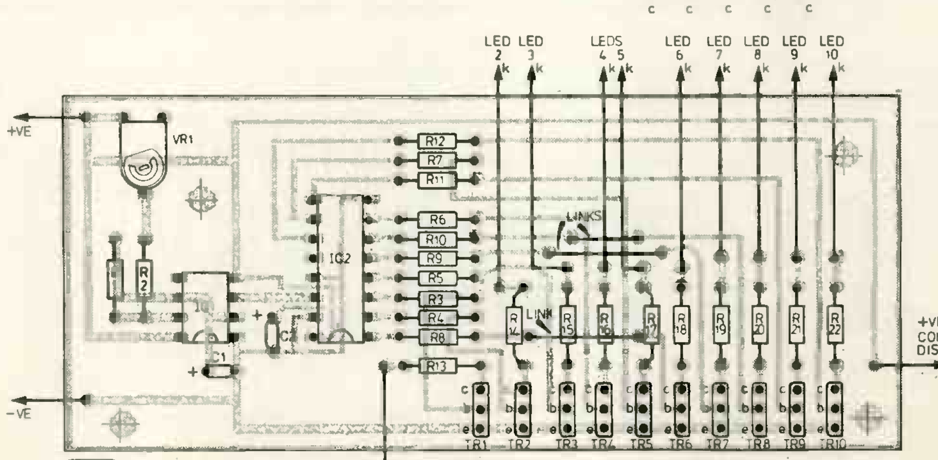
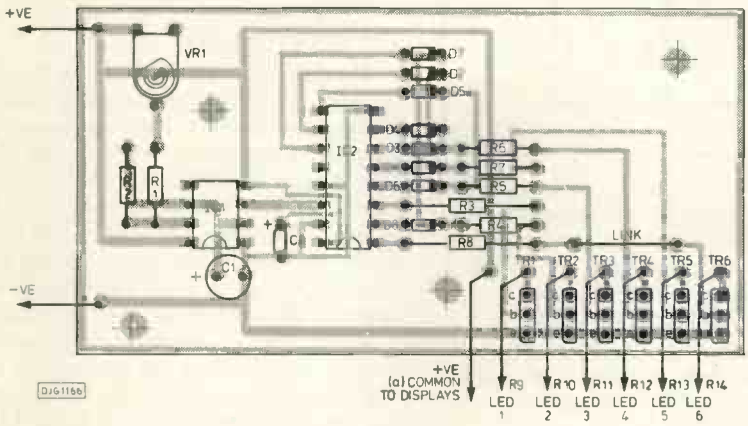


Fig.9. *(above) Rubolph's nose PCB layout*

Fig.10. *(right) Angel's halo control PCB layout*

Fig.11. *(Top right) Angel's halo display PCB*



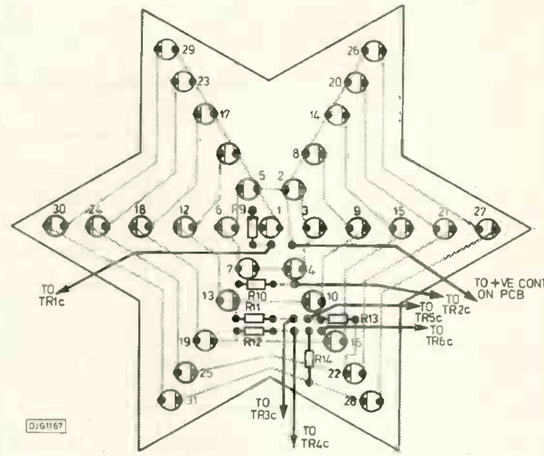


Fig.12. *(above) pulsating star control PCB layout*
Fig.13. *(right) pulsating star display PCB*

which are soldered in place along with the other components. The ics should be inserted as the last task before testing out the unit.

WIRING UP

Most of the pcbs have been designed in such a way that it is possible to mount the leds or bulbs directly on them for testing the circuit but this will not produce an effective display (except in the case of the two special display boards). It is anticipated that constructors will wish to place the output indicators in an appropriate place on the decoration and to connect them to the appropriate points on the pcbs with wires. The boards are best not wired up until all the components, except for the ics, have been inserted and soldered. The ends of these wires must be prepared by tinning before soldering into place. On/off switches have not been included in the designs since it was felt that it would be easy enough to simply connect and disconnect the battery, but if a switch is required it is a simple enough matter to include one in series between the battery positive connection and the pcb.

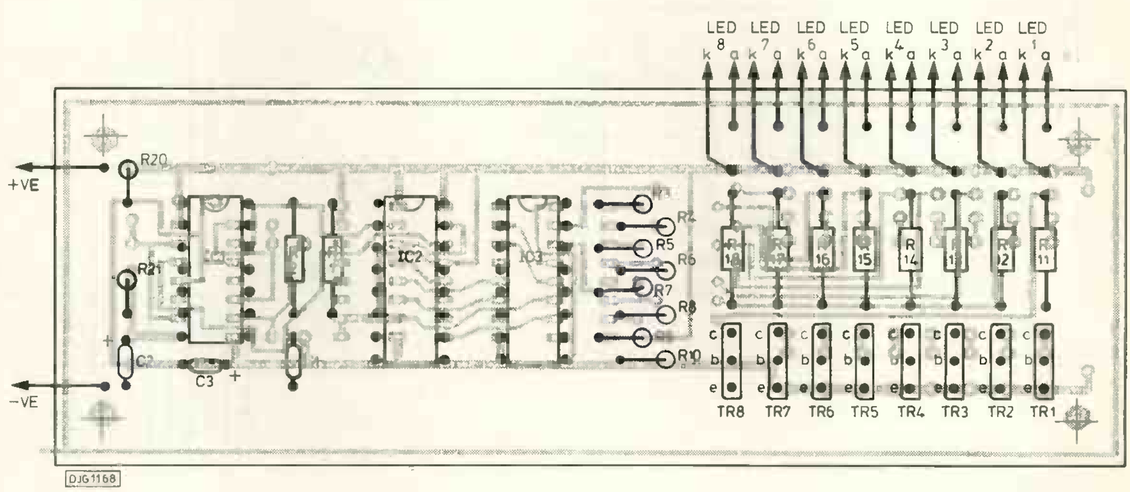
TESTING

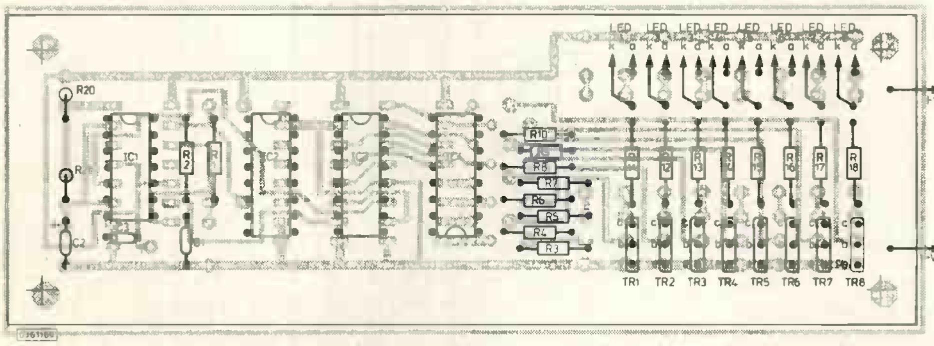
Once all the connections have been made the boards should be carefully checked before inserting the ics and testing the unit. The ics should then be inserted into the correct sockets, taking care to ensure that they are the correct way round.

The circuit can then be tested by connecting the battery and ensuring that the circuit works as described. **PE**

Fig.14 *(right) Candle flicker PCB layout*

Fig.15. *(below) Random pudding PCB layout*





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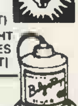

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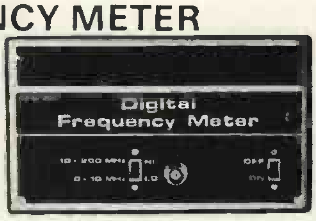

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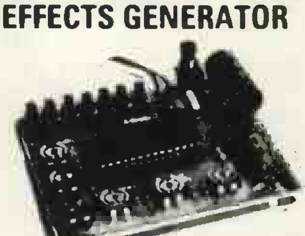

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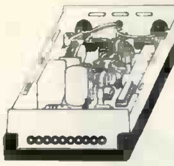
POWER CONDITIONER

FEATURED IN ETI
JANUARY 1988



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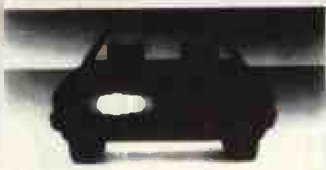
PARTS SET £28.50 + VAT

Some parts are available separately. Please send SAE for lists, or SAE + £1 for lists, circuit, construction details and further information (free with parts set)



KNIGHT RAIDER

FEATURED IN ETI JULY 1987

The ultimate in lighting effects for your Lamborghini, Maserati BMW (or any other car, for that matter). Picture this: eight powerful lights in line along the front and eight along the rear. You flick a switch on the dashboard control box and a point of light moves lazily from left to right leaving a comet's tail behind it. Flip the switch again and the point of light becomes a bar, bouncing backwards and forwards along the row. Press again and try one of the other six patterns . . . An LED display on the control box let's you see what the main lights are doing

The Knight Raider can be fitted to any car (it makes an excellent fog light!) or with low powered bulbs it can turn any child's pedal car or bicycle into a spectacular TV-age toy!

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Measures Hi-Fi output power up to 100W – includes PCB, components, meters	
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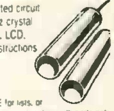
FEATURED IN ETI AUGUST 1988

There's nothing quite so encouraging as having a quantifiable result to show for your training efforts. If you are not particularly fit, your resting heart rate will be around 80 beats per minute. As your jogging, aerobics or sport strengthens your heart, the rate will drop dramatically – possibly to 60bpm or less. With the S101, you can watch your progress day by day.

Breathing is important too. How efficiently do you take up oxygen? How quickly do you recover from oxygen debt after strenuous activity? The S101 will let you know.

The approved parts set consists of case, 3 printed circuit boards, all components (including 17 ICs, quartz crystal, 75 transistors, resistors, diodes and capacitors), LCD, switches, plugs, sockets, electrodes, and full instructions for construction and use



PARTS SET £33.80 + VAT

Some parts are available separately. Please send SAE for lists, or SAE + £2 for lists, circuits, construction details and training plan (free with parts set)

THE DREAM MACHINE

FEATURED IN ETI
DECEMBER 1987

Adjust the controls to suit your mood and let the gentle relaxing sound drift over you. At first you might hear soft rain, sea surf, or the wind through distant trees. Almost hypnotic, the sound draws you irresistably into a peaceful, refreshing sleep.

For many, the thought of waking refreshed and alert from perhaps the first truly restful sleep in years is exciting enough in itself. For more adventurous souls there are strange and mysterious dream experiences waiting. Take lucid dreams, for instance. Imagine being in control of your dreams and able to change them at will to act out your wishes and fantasies. With the Dream Machine it's easy!

The approved parts set consists of PCB, all components, controls, loudspeaker, knobs, lamp, fuseholders, fuse, mains power supply, prestige case and full instructions.

PARTS SET £16.50 + VAT

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THE MISTRAL AIR IONISER

The best ioniser design yet – this one has variable ion drive, built-in ion counter and enough power to drive five multi-point emitters. For the technically minded, it has nine main drive stages, five secondary drives, and a four section booster to give an output capability of almost fifteen billion (1.47×10^{13}) ions every minute, or 2.45×10^{11} ions per second. With extra emitters this can be increased still further!

PARTS SET £24.80 + VAT

The parts set includes case, printed circuit boards, 126 top grade components, all controls, lamps, hardware, a multi-point phospher-bronze emitter and full instructions.

Some parts are available separately – please send SAE for lists, or SAE + £1 for lists, circuit and construction details and further information (free with parts set).

READY-BUILT MISTRAL

The Mistral Ioniser (and most of our other projects) can now be supplied built, tested and ready to go. For details, please contact *Peter Leah at P.L. Electronics, 8 Woburn Road, Eastville, Bristol BS5 6TT. Tel: 0272 522703.*

IPA BOARD CLEANER £0.98 + VAT

Essential for removing grease and flux residues from the Mistral PCB to achieve peak performance. Applicator brush supplied.

INTERNAL EMITTER £2.69 + VAT

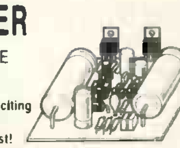
Can be used in place of the P-B external emitter, or both can be used together for the highest ion output. Parts set includes PCB, ion emitters, components and instructions.

ION DISPERSION METER £16.40 + VAT

A hand-held test meter to check ion levels in your room and output of any ioniser. Parts set available January 1989 onwards.

ARMSTRONG 75W AMPLIFIER

FEATURED IN PE
JULY 1988



A.J. Armstrong's exciting new audio amplifier module is here at last!

Delivering a cool 75W (conservatively rated – you'll get nearer 100W), this MOSFET design embodies the finest minimalist design techniques, resulting in a clean, uncluttered circuit in which every component makes a precisely defined contribution to the overall sound.

You can read all about it in the July issue of PE, but why bother with words when your ears will tell you so much more?

Parts set includes top grade PCB and all components.

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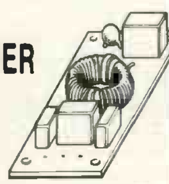
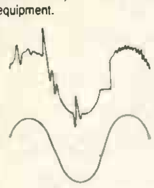
Please send SAE + £1 for data and circuits (free with parts set) including diagrams for matching pre-amp and power supply. This amplifier will not be available from your usual audio supplier – we produce the only designer approved parts set

MAINS CONDITIONER

FEATURED IN ETI
SEPTEMBER 1986



Cleans up mains pollution easily and effectively. You'll hardly believe the difference in your Hi-Fi, TV, Video, and all other sensitive equipment.

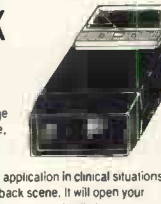


PARTS SET £4.90 + VAT

RUGGED PLASTIC CASE £1.65 + VAT

BIO-FEEDBACK

FEATURED IN ETI
DECEMBER 1986



Bio-feedback comes of age with this highly responsive, self-balancing skin response monitor! The powerful circuit has found application in clinical situations as well as on the bio-feedback scene. It will open your eyes to what GSR techniques are really all about.

The complete parts set includes case, PCB, all components, leads, electrodes, conductive gel, and full instructions.

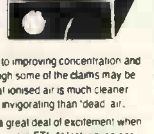
PARTS SET £13.95 + VAT

BIO-FEEDBACK BOOK £3.95 (no VAT)

Please note: the book, by Stern and Ray, is an authorised guide to the potential of bio-feedback techniques. It is not a hobby book, and will only be of interest to intelligent adults.

POWERFUL AIR IONISER

FEATURED IN ETI
JULY 1986



Ions have been described as 'vitamins of the air' by the health magazines, and have been credited with everything from curing hay fever and asthma to improving concentration and putting an end to insomnia. Although some of the claims may be exaggerated, there is no doubt that ionised air is much cleaner and purer, and seems much more invigorating than 'dead' air.

The DIRECT ION ioniser caused a great deal of excitement when it appeared as a constructional project in ETI. At last, an ioniser that was comparable with (better than?) commercial products, was reliable, good to build . . . and fun! Apart from the serious applications, some of the suggested experiments were outrageous!

We can supply a matched set of parts, fully approved by the designer, to build this unique project. The set includes a roller tinned printed circuit board, 66 components, case, mains lead, and even the parts for the tester. According to one customer, the set costs 'about a third of the price of the individual components'. What more can we say?

Instructions are included

PARTS SET WITH BLACK CASE £11.50 + VAT

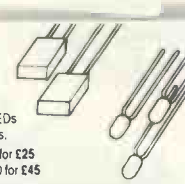
PARTS SET WITH WHITE CASE £11.80 + VAT

LM2917 EXPERIMENTER SET

Consists of LM2917 IC, special printed circuit board and detailed instructions with data and circuits for eight different projects to build. Can be used to experiment with the circuits in the 'Next Great Little IC' feature (ETI, December 1986).

LM2917 EXPERIMENTER SET £5.80 + VAT

LEDs



Green rectangular LEDs for bar-graph displays.

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BRAINWAVE MONITOR

FEATURED IN ETI AUGUST 1987

The most antonishing project ever to have appeared in an electronics magazine. Similar in principle to a medical EEG machine, this project allows you to hear the characteristic rhythms of your own mind! The alpha, beta and theta forms can be selected for study and the three articles give masses of information on their interpretation and powers.

In conjunction with Dr. Lewis's Alpha Plan, the monitor can be used to overcome shyness, to help you feel confident in stressful situations, and to train yourself to excel at things you're 'no good at'.

Our approved parts set contains case, two PCBs, screening can for bio-amplifier, all components (including three PMI precision amplifiers), leads, brass electrodes and full instructions

PARTS SET £36.90 + VAT ALPHA PLAN BOOK £2.50

SILVER SOLUTION (for plating electrodes) **£3.60 + VAT**

Parts set available separately. We also have a range of accessories, professional electrodes, books, etc. Please send SAE for lists, or SAE + £2 for lists, construction details and further information (free with parts set).

DIGITAL ELECTRONICS

By Owen Bishop

PART 5 – INTERFACING

This month we explain the meaning of 'interfacing' in digital electronics – the difference between digital and analogue, and between logic-to-logic and real-world. As usual, there are investigations to carry out and modules to build.

One of the main themes of this series is that it is not only possible but really easy to join together lots of little black boxes to make bigger black boxes. In other words, we work with simple logic modules that can be put together in hundreds of different ways to build an enormous variety of electronic systems. The electronic systems may range in complexity from a door buzzer circuit to a computer. If we are to be able to do this we must know how modules can be joined to each other. This is what it meant by this month's topic, interfacing. We shall deal with all kinds of interfacing except one particular field – interfacing electronic circuits to microcomputers. That will form the subject of a later part of this series. The subject of interfacing has lots of minor details about it that are not really worth memorising. Read the paragraphs below to get the gist of the subject, then keep this article handy for reference when you actually have a project to design.

If we are simply interfacing one logic gate to another gate of the same series, then a length of wire will do the trick. Though even, in this clear case, there is something to think about. Electric current travels fast, but logic gates are fast too. If the wire connecting one gate to another is too long, the delay while a high or low pulse travels along the wire may be sufficient to upset the operation of the system. So an important rule is to keep connections as short as possible. Avoid having wires longer than 500mm. This also reduces possible problems due to electromagnetic effects causing spikes to be generated in the wires. Later in this article we see what to do if wires must be long, when you are transmitting data from one room to another, for example, or controlling a robot.

If any logic circuit needs more than about three ics, it seems an inescapable law that you can't find all the logic types you require in one logic series. It might be that the cmos 4000 series is just right for most of the circuit, but you are virtually forced to use one low power ttl ic because there is no equivalent 4000 ic available. How to interface the different logic series is something we all need to know about. Different series have different supply voltage ranges and often different input/output levels. The most fussy are standard ttl, LS ttl and HCT ttl. They need a regulated 5V supply so, if a circuit has any of these in it, it is usually more convenient to run all the logic at 5V. We sometimes need a pull-up resistor when joining one gate to another of a different series. Fig. 1 shows when this needs to be done. The triangles represent 'any gate' in the series. Pull-up resistors are needed because the 'high' output voltage from standard or LS ttl is not quite high enough to be recognised by HC ttl or the 4000 series. A straightforward wire connection can be used for other interfacing, such as cmos to ttl, standard ttl to HCT ttl, etc.

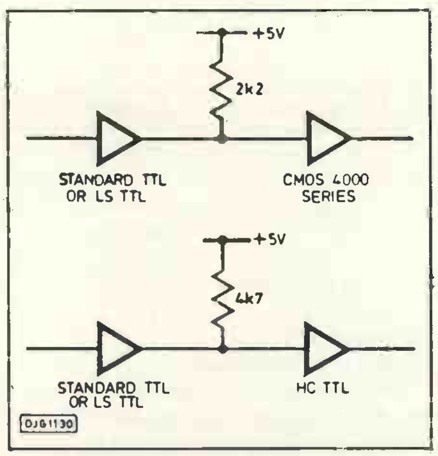


Fig.1. *Interfacing logic systems, all at 5V.*

It may sometimes be more convenient to power the ttl ics at 5V, and the cmos ics at another voltage. This could be preferable if the cmos ics are to be connected to other ics which won't work at 5V. Fig. 2 shows ways of handling this. When connecting ttl to 4000 series, the ttl ic must have an open collector output. Usually the output stage of a ttl gate has an active pull-up. This is to pull the output voltage up when the output is supposed to be 'high' (Fig. 3a). But a high output from ttl is normally only about 3.4V, which is not high enough to drive a cmos ic working at 10V. With an open-collector output (Fig. 3b) there is no pull-up circuit on the chip. The collector is left 'open' for a pull-up resistor to be connected externally. The pull-up resistor is connected to the higher voltage, such as the 10V supply voltage of the 4000 series gate (Fig. 2a). A high output from the ttl gate now produces an input voltage high enough to affect the cmos gate.

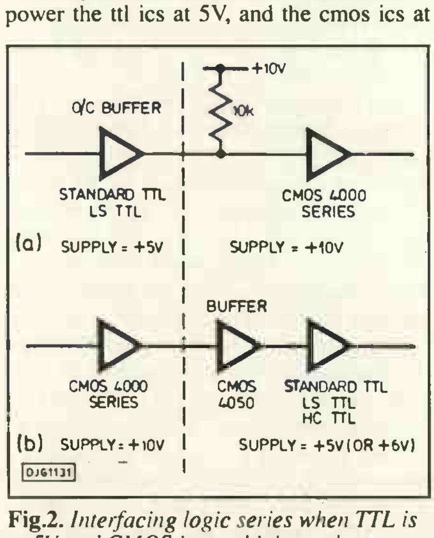


Fig.2. *Interfacing logic series when TTL is at 5V and CMOS is at a higher voltage*

The most generally used open-collector buffers are the 7406 (NOT, or inverting gates) and 7407 (TRUE or non-inverting gates). The resistor can be connected to any external voltage up to 30V. Such outputs are also useful for driving other

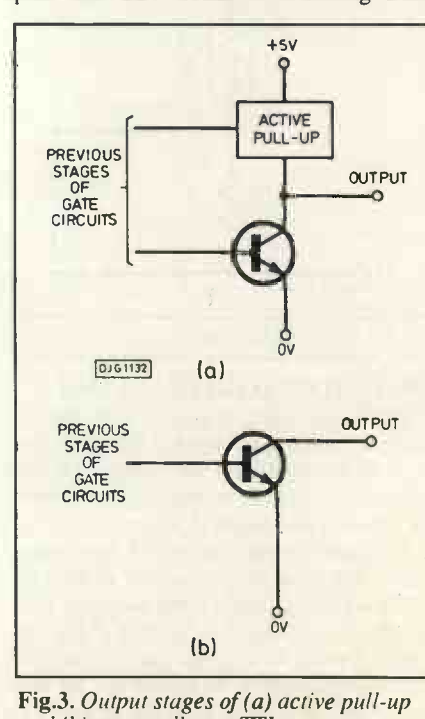


Fig.3. *Output stages of (a) active pull-up and (b) open-collector TTL*

devices, such as lamps, that work on voltages greater than 5V. There are also ttl NAND, NOR and AND gates with open-collector outputs. Gates of this type are often referred to as buffers because their main function is not to perform logic but to act as an interface between parts of a circuit that have different characteristics.

The cmos 4050 buffer in Fig. 2b is powered from the 5V supply, so it is compatible with the ttl gate that follows it. Its input stage is specially designed to accept input voltages up to 15V without suffering damage. This means that it can take its input from a cmos gate running on a 10V supply.

FANOUT

This is the number of logic inputs that can be fed from a single logic output. In most circuits this creates no problem since it is not often that we want to drive more than two or three inputs from one output. In any case, cmos inputs (4000, HC ttl, or HCT ttl) draw virtually no current and fanout is unlimited. Actually, in a 4000 series circuit, fanout is limited (to 50 gates), but this is not likely to worry you very often!

The table shows the fanout numbers for driving standard ttl and LS ttl – the only situation in which you need to think about fanout. In most cases, fanout is large enough to be no problem. An exception is the 4000 series which drives only one low power ttl gate and will not drive standard ttl. If you need to drive standard TTL from 4000 series cmos, you must use one of the cmos buffer ics (see table). There is more about buffers and tri-state outputs later. Input pins of certain ics may be connected to more than one logic input on the chip. Examples are clock, set and reset inputs of flip-flops, which may be equivalent to two ordinary inputs.

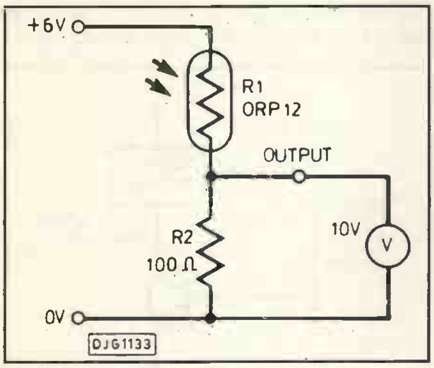


Fig.4. *Light sensitive circuit*

REAL WORLD INTERFACING

Interfacing logic to logic is fine but we need real-world interfacing if our system is to be of practical use. In other words, the system must have input and output sections. We consider real-world input first.

The most obvious real-world input interface is the press-button, switch or key, by which we tell a circuit what we want it to do. The interfacing may consist of just the button, switch or key by itself, though it may be preferable to de-bounce it. Module 4 (Oct 88) is a good example of such an interface.

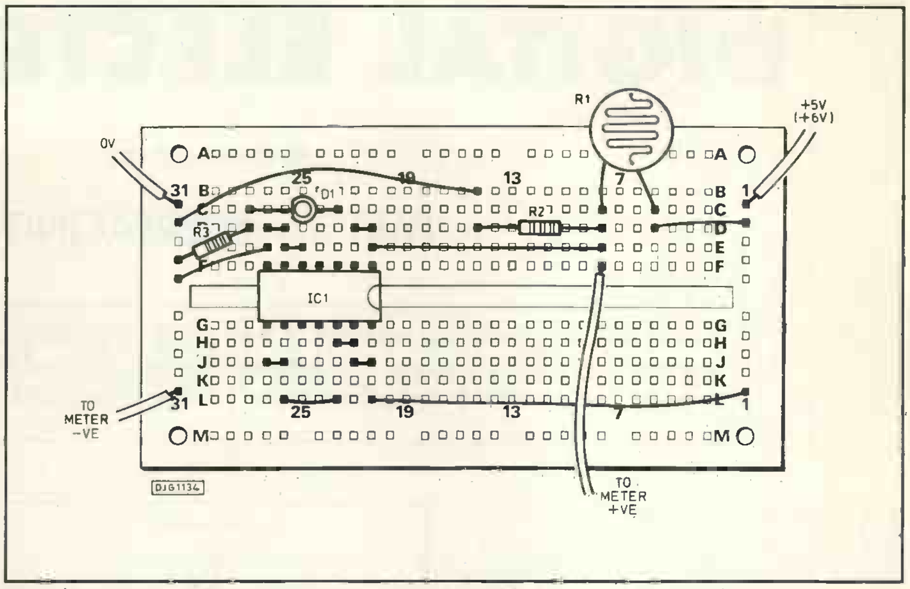


Fig.5. *Breadboard layout of circuits for Figs. 4 and 6.*

In a previous article we described a security system that operates only by day. It needs a light-sensitive input stage. There are various ways of building this sort of interface. One way is shown in Fig. 4. Let's find out how it works.

Investigation 1
Light-sensitive interface

The interface has a light sensor, consisting of a light-dependent resistor (ldr) alternatively known as a photoconductive cell (pcc). ldrs (or pccs) are made of cadmium sulphide. This is a semiconductor material, the resistance of which depends on the amount of light falling on it. Resistance is high in darkness or low light, but is much less in bright light. We make use of this fact in the light-sensitive interface.

1. Connect the circuit as shown in Fig. 5. For the present do not include the components on the lower half of the board (IC1, D1, R3), which will be added later.
2. Cover the ldr with a small box (or you hand) to keep light away from it.
3. Switch on the power. Read the meter.
4. Gradually remove the box (or your hand), do that an increasing amount of light falls on the ldr. Watch how the meter reading changes.
5. What is the meter reading when the ldr is fully exposed?
6. Gradually replace the box (or your hand). Watch how the meter reading changes.

What is happening is that the resistance of the ldr falls gradually as the ldr receives more light. The ldr (R1) and the fixed resistor (R2) act as a potential divider. As the resistance of R1 falls, the voltage at the junction between R1 and R2 rises.

This interface gives us an output voltage that varies according to the amount of light. Now we need to arrange for this to have an effect on a logic gate. Add IC1, D1 and R3 to the breadboard, to make the circuit shown in Fig. 6. The figure shows the connections if a 4011 ic is used to provide the gate. The inputs to the unused gates are connected to +5V (pins 8, 9, 12, 13) or 0V (pins 5, 6) for reliable action. If you are using ttl, the pins to be connected to 5V or 0V are 4, 5, 9, 10, 12 and 13 (as in Fig. 8).

The output level from the gate is indicated by the led (D1), but you could use a logic probe instead. Now to continue with the investigation.

7. Vary the amount of light falling on the ldr. What happens to the output? When is the output low? When is the output high?

Interfaces to design
(Comments on p. 41)

1. Design a light-sensitive interface that has a low output in the light and a high input in the dark.
2. Design a light-sensitive interface that has low input in the dark, high input in the light, and that can be adjusted to change from low to high at any given light level.

IMPROVING THE INTERFACE

The interface described above gives a good clear response if the light level is distinctly weak or distinctly strong. What happens when it is in-between? For example, if the level of light is increasing slowly as the sun rises, there are in-between light levels which are neither weak nor strong. What is the interface to do at these levels?

We can decide on a particular threshold light level and say 'If it is darker than this, it is night – the interface must have a low output. If it is as bright or brighter than this, it is day – the interface must have a high out-

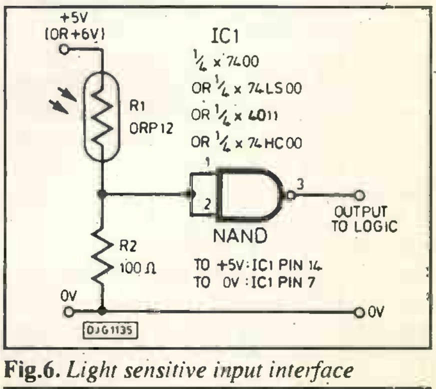


Fig.6. *Light sensitive input interface*

put.' We then design the interface to trigger at the level we have decided on. But, just after the sun has risen and day has just begun and the interface is giving a high output, a small cloud passes in front of the sun. This reduces the light level. The interface returns to its night-time state! What a short day! This could happen many times during dawn. Under such circumstances, the interface output changes many times from low to high and back again. It settles at high only when the sun is so far above the horizon that clouds can not reduce light below the threshold level.

The reverse situation occurs at sunset. Imagine a porch lamp that is to be turned on at dusk. In cloudy weather, the lamp flickers on and off for perhaps half and hour at sunset. The cure for such erratic behaviour is to use a Schmitt trigger gate, as described in part 2 (Oct 88), instead of the NAND gate of Fig. 6. In a Schmitt trigger interface designed to operate at sunrise, the gate changes state when the light level first reaches the selected level. Clouds do not normally reduce light level sufficiently to make the gate change back again. This principle is used in the interface described below. it is also used in this month's Module 7, as you can find out by building it and experimenting with it.

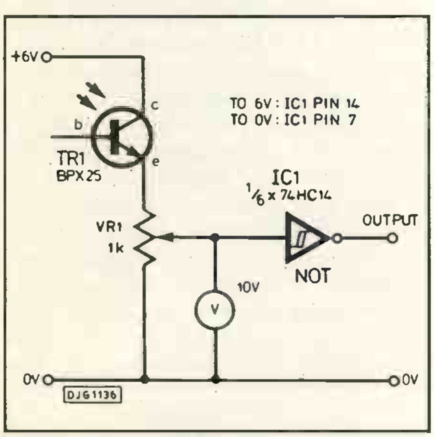


Fig. 7. *A light sensitive interface, using a photo transistor and a Schmitt trigger gate. The meter is used for investigating the action of the gate*

PHOTO-TRANSISTOR SENSOR

This is another sensor used for detecting light. In Fig. 7 it looks as though we have forgotten the base connection, but it is not necessary to supply current to the base of a phototransistor. When light shines on the transistor, charge carries are produced in its base region. The effect is the same as if a current is flowing into the base region. The brighter the light, the bigger the effect. Increasing the light has the same effect as an increased base current.

As in an ordinary transistor, increasing the base current increases the collector current. So the final effect of increasing the light is to cause an increased collector current to flow. The current flows on through VR1. The bigger the current the bigger the voltage developed across VR1. We tap this voltage at any required level by adjusting

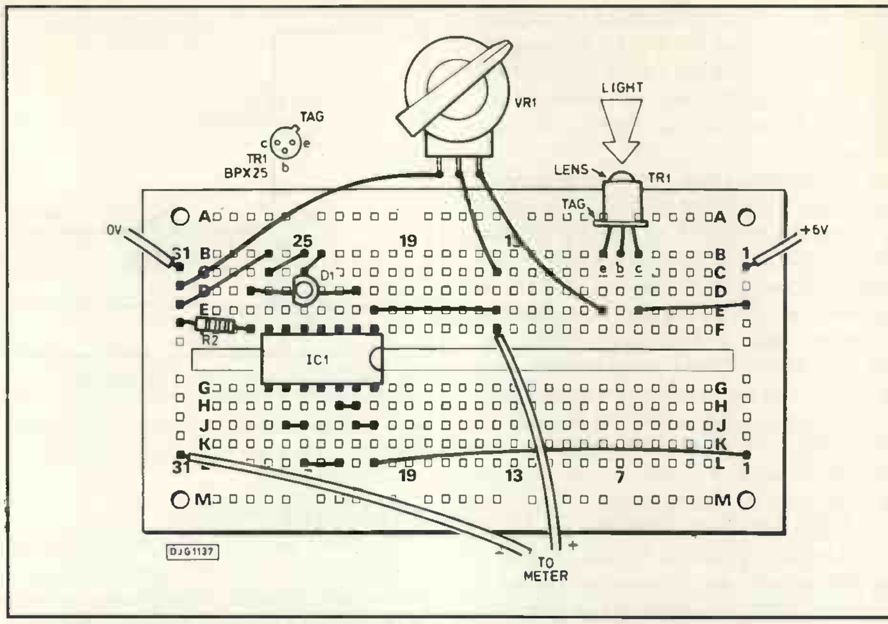


Fig.8. *Breadboard layout of the circuit in Fig. 7.*

VR1. In this interface we use a 74HC14 ic which is a cmos ttl gate with a Schmitt trigger input. The reason for preferring this type of gate input was explained in the previous section. Follow the instructions below to find out how it works.

Investigation 2
Phototransistor interface

The circuit has a variable resistor, so that it can be set to trigger at a required light level. The phototransistor is in a metal case with a small lens to direct the light on to the tiny transistor inside.

1. Arrange a bench lamp to shine on the phototransistor from a distance of about 50cm, and make sure that the lens is pointing directly at the lamp. Bend the wire leads of the phototransistor, if necessary.
2. The voltmeter measures the voltage at the wiper of VR1. This is the voltage that is being input to the gate. Turn VR1 to raise the voltage to 3V or more. If it does reach this level, check that the phototransistor is pointing at the lamp. If it is already pointing at the lamp and the voltage is not high enough, bring the lamp nearer. The led should now be off.
3. Slowly turn VR1 to reduce the voltage. Watch the led and stop turning VR1 as soon as the lamp goes on (ie, the input to the gate counts as 'low'). What is the voltage? This is the lower threshold voltage of the gate.
4. Turn VR1 slowly back again. The led does not immediately go off. Continue turning VR1 slowly until the led goes off. What is the voltage? This is the upper threshold voltage of the gate.
5. Slowly place your hand between the lamp and the phototransistor. You will see the voltage fall as the light level decreases. As the voltage reaches the lower threshold the led comes on.
6. Slowly take your hand away. Does the led go out immediately?
7. Continue moving your hand slowly away and watch the voltage increase as the amount of light reaching the phototransistor increases. This is what would happen at sunrise.
8. Stop moving your hand as soon as the upper threshold is reached and the led goes off. Now try moving your hand a little way back – this is the cloud passing over the rising sun. Does the led immediately come on again? (see p. 41).

CHOOSING LIGHT SENSORS

The ldr and the phototransistor work in different ways, but with the same effect – a change of voltage. An important difference between them is that the phototransistor responds more rapidly than the ldr to changes in light level. With a slowly changing light level, such as sunrise, the ldr is fast enough. But, if you have to detect a sudden and short-lived change such as the momentary breaking of a light-beam, an ldr may not have time to respond before the light is restored to its high level again. For applications such as these, which include detecting a racing-car passing the winning post or articles moving along a conveyor-belt, the phototransistor has the advantage. Its response time can be further reduced by

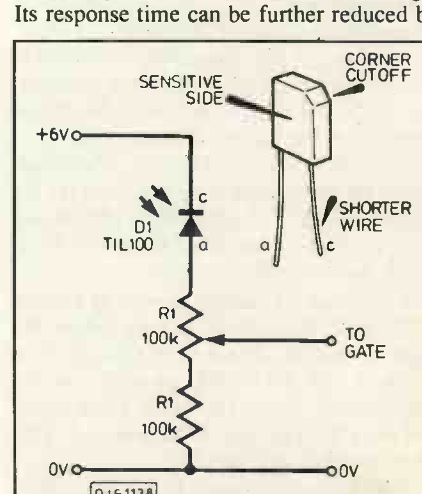


Fig.9. *Using a photo-diode. Inset: the TIL100*

connecting its base terminal to the positive supply through a resistor of high value. This provides a small steady base current which puts the transistor into readiness for sudden changes in the amount of light falling on it.

Another sensor that has several applications is the photodiode (Fig. 9). It is usually connected as shown, so that it is reverse-biased. You might think that nothing would happen, because a reverse-biased diode is supposed to prevent current from flowing. However, there is a current flowing, the leakage current. This is small but, if it goes on to flow through a high resistance, a sizeable voltage appears across the resistor. In bright light, the leakage current of the TIL100 is around 15µA. The voltage developed across the resistors is:

$V = IR = 0.000015 \times 200000 = 3V$

By choosing a suitable resistor, or using a variable resistor, we can arrange to obtain a voltage suitable for triggering a gate at a given light level. The TIL100 photodiode has a large sensitive area and is particularly sensitive to infra-red. It has many applications, including remote-control systems and intruder detection.

Investigation 3
Infra-red interface

Investigate the behaviour of the TIL100 photodiode as in Investigation 2, using a bench lamp as a source rich in infra-red radiation.

TEMPERATURE SENSOR

The most useful device for sensing changes in temperatures is the thermistor. This is made from a resistive material, the resistance of which changes markedly with change in temperature. Two kinds of thermistor are available. Those with positive temperature coefficient (ptc) have increased resistance as temperature increases. Those with negative temperature coefficient (ntc) have decreased resistance with increased temperature. The latter type is used in the next investigation.

Investigation 4
Temperature–sensitive interface

A range of ntc thermistors is available with different resistances at room temperature (25°C). The type chosen for this investigation has a resistance of about 47k.

1. Set up the circuit (Fig. 10). The breadboard layout is similar to Fig. 8, with R1 instead of TR1. Adjust VR1 until the led goes on. The voltage at the wiper of VR1 is below the lower threshold.

2. Increase the voltage slowly, by turning VR1, until the voltage is just below the upper threshold. The led remains off. Use a meter to find this position, as in Investigation 2, or experiment a few times and note the position of the knob of VR1 when the led first comes on.

3. Grip the thermistor gently with your finger, to warm it. What happens to the led?

4. Remove your fingers to let the thermistor cool. Does the led immediately come on? Does it ever come on? (p. 41).

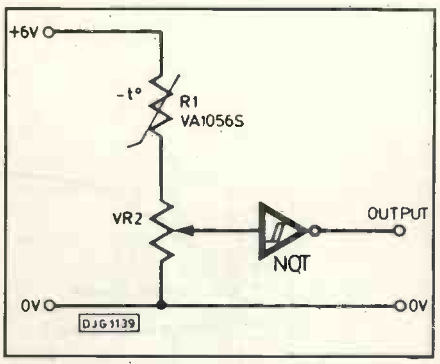


Fig.10. *Temperature sensitive interface*

ANALOGUE INPUTS

We have confined our discussion and investigations to binary inputs. For example, we have thought of light levels as being 'high' (=day) or 'low' (=night). We have thought of temperature as being 'too darned hot' (so sound the alarm) or 'not too darned hot' (keep quiet). In our light sensors, we have even gone to the trouble to use a trigger circuit to make a clear distinction between day and night. In-between states are not recognised.

In other applications we want to know exactly what the light level (or temperature) is. A digital thermometer, for example, must be able to measure temperature to the nearest degree, or even more precisely than that. 'Too hot' or 'too cold' is not good enough. For applications such as this we need to replace the binary input with an analogue input. Analogue inputs (and outputs) will be next month's topic.

OUTPUT INTERFACES

These are the interfaces that make something happen in the real world. One of the simplest of these is the humble led. We have used this frequently to indicate what is going on in the logic circuit. It does not do much except please you or annoy you, depending on what you expected it to do!

In practical applications of digital electronics we use output interfaces to drive devices such as lamps, motors, sirens, bells, solenoids, heaters – all of which are electrically-powered. Driving these devices is a matter of switching them on or off as required. Controlling the brightness of lamps or the speed of motors is usually a matter for analogue output circuits which, as stated above, will be described next month.

Fig. 11 illustrates some techniques for driving external devices from logic circuits. The simplest form of switching is to drive the device directly from the logic output (a). Only a few milliamps is available from the gate. The led indicator is our most common example of this. Using gates with open oscillator outputs, we can drive lamps and other low-current devices that operate on higher voltages (b).

If more current is required, we use a transistor switch (c). For currents up to 300mA a low-power transistor such as the ZTX300 can be used. A medium-power transistor (BD131) can carry up to 3A, while a high-power transistor (2N3055) can carry up to 15A. As well as higher currents, these transistors can power devices that operate at higher voltages (up to 25V, 45V and 60V respectively). Higher voltage and higher currents mean higher power – a heat sink may be necessary. Transistor switches can be used for a wide range of outputs interfaces, including lamps, audible warning devices, sirens, solenoids, dc motors, and amplifiers. If the load is inductive (ie, it has an electromagnetic coil in it), it is important to connect a diode across it, as shown by the dotted lines in Fig. 11c. This

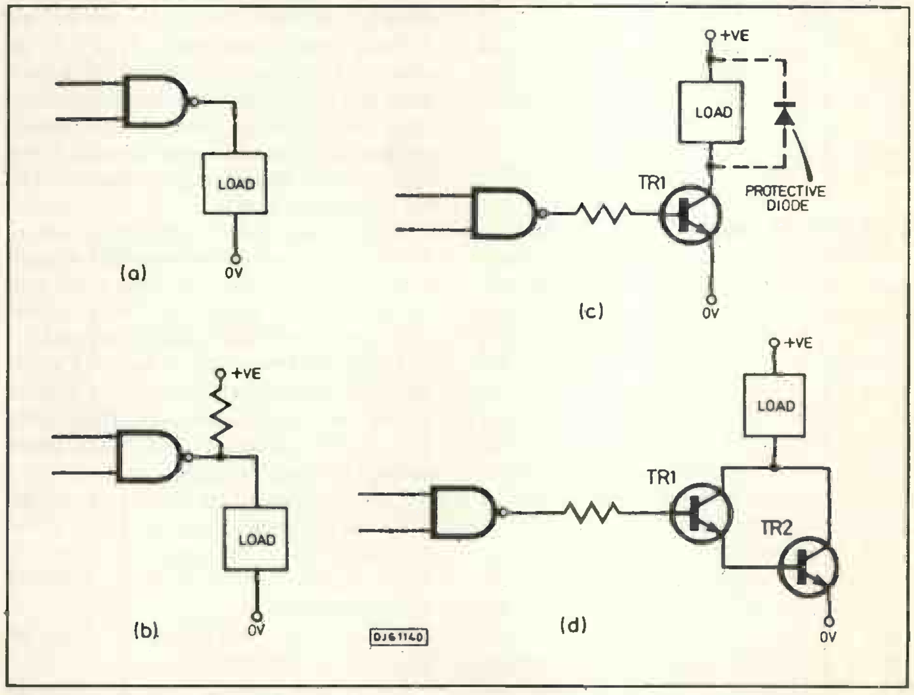


Fig.11. *Output interfaces: (a) direct logic device, (b) open-collector output, (c) transistor switch, (d) Darlington switch.*

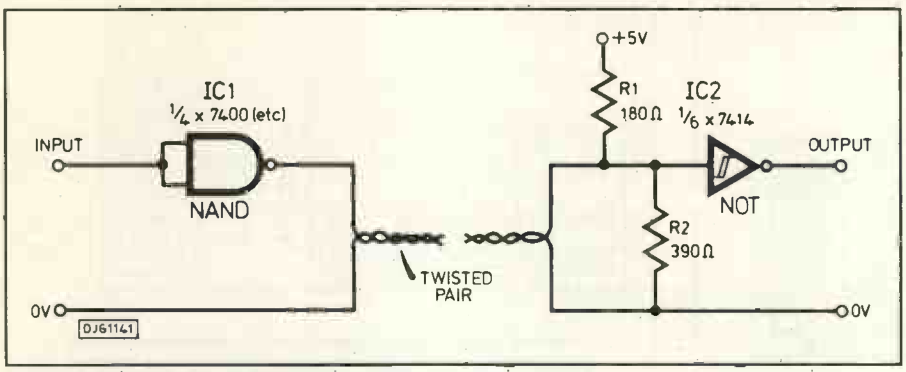


Fig.12. *Line driving with TTL*

is because of the strong back emf that the coil generates when the current in it is suddenly switched off. The back emf may be several hundred volts. It produces large currents through the transistor in the wrong direction and possibly destroys it. The protective diode conducts such currents safely away. Use it in circuits for driving electric bells, relays, motors and solenoids.

Although the transistor may be able to cope with large currents, it may be that the logic gate is unable to provide sufficient base current to switch the transistor. This is often the problem with power transistors, which usually do not have such a high current gain as the low-power transistors. The 2N3055, for example, has a current gain of only 45. If we are trying to switch a motor requiring 5A, the base current to the powe transistor must be at least 111mA. Obviously no logic gate could supply a current of this magnitude. In this case we use two transistors, connected as a Darlington Pair (Fig. 11d). TR1 can be a high-gain low-power transistor, and TR2 is a low-gain high-power transistor. The gate supplies a small base current to TR1. The collector current of TR1 is (say) 200 times larger than this, and becomes the base current of TR2. The gain of TR2 might be 50, giving an overall current gain of 10000 for the pair. Only 0.5mA is required from the gate to result in a current of 5A through the load.

Another way of switching is to use a relay. Use any of the circuits in Fig. 11, with the relay coil as the load. Apart from their being able to switch loads operating at high voltages (250V or more), an high currents (10A or more), relays are able to switch alternating current, including audio signals. This is something that the transistor switches described above can not do. Some relays can be energised directly from a ttl output, as in Fig. 11a. This type is often available in dil package like an integrated circuit, which makes it very convenient for mounting on the circuit board beside the logic ics. These low-power relays usually have lower voltage and current ratings than the larger types. If you use these, take care not to overload them as sparking may cause the contacts to weld together – and there's no way of getting inside the package to prise them apart!

The larger relays are best driven by making their coil the load of a transistor switch (Fig. 11c or 11d). This is the technique adopted for the relay of Module 8. Note the protective diode in the module. Some types of relay have a diode built in, but this type does not. With a suitable relay, you can interface to anything from a low-voltage lamp, an alarm bell, a radio set, an ac motor or an immersion heater to a ship's turbine or airport landing lights.

LINE DRIVING

If we feed the output from a logic gate into a long wire, the logic levels at the far end of the wire may be very different from those at the starting point. The gate may not succeed in driving the levels firmly high or low. Electromagnetic interference may generate voltage spikes on the line. Sudden changes of voltage may be reflected back from the far end of the wire. We can reduce the electromagnetic effect by twisting the signal wire and the 0V wire around each other. This is known as a twisted pair.

We can improve the reception of logic levels at the far end by using special buffer gates designed for line driving and line receiving. Fig. 12 shows a way of driving and receiving, using ordinary ttl gates. The driver is any standard ttl gate, such as the NAND gate illustrated. This is connected as a NOT gate, so it inverts the original logic level. Connection to the receiving ic is by way of a twisted pair of wires. At the receiving end the input of the Schmitt trigger gate is held ready to move up or down according to the signal arriving along the line. The Schmitt trigger input helps to ensure that minor changes in voltage, caused by interference, have no effect on the gate. The gate is a NOT gate, so it inverts the logic level back to the original state. This method of line driving is not as reliable as using specially-designed line driving ics but is satisfactory for many purposes.

TRI-STATE OUTPUTS

This name is a bit of a puzzler, since it sounds as if we have a new type of logic with three possible states. Could they be 'high', 'low' and 'your guess is as good as mine'? No, there are only the two usual states 'high' and 'low'. The third state is 'mind your own business'. In other words, in the third state, the output of the logic circuits inside the ic is disconnected from the output pin of the ic and you can't tell what the output is. A more technical way of saying this is that the third state is high impedance.

Gates with three-state outputs are very commonly used in computers and other microprocessor-based circuits. In these, it is necessary to transfer data from one part of the circuit to another. For example, in a computer we may need to transfer data from:

* the memory to the microprocessor,
* the microprocessor to the memory,
* the disc drive to the memory,
* the microprocessor to the printer,

and many other transfers too. We could have several sets of wires – one set for every data transfer to be made. But we usually need at least eight wires for data transfer. The interior of the computer would soon begin to look even more like a bird's nest than it does already. The solution is to have just one set of connections, the data bus, to which all the parts of the computer are connected. Fig. 13 shows a data bus (only four lines to make the drawing simpler). This has four devices attached to it – these might be the output or input stages of the memory, the microprocessor, the disc drive or the printer. Device A, B and C all have outputs connected to the bus. These are 'talkers'. They put data on to the bus. Device D has inputs connected to the bus. It is a 'listener'. It reads the data that is present on the bus.

D can receive data from A or from B or from C. The important thing is that A, B

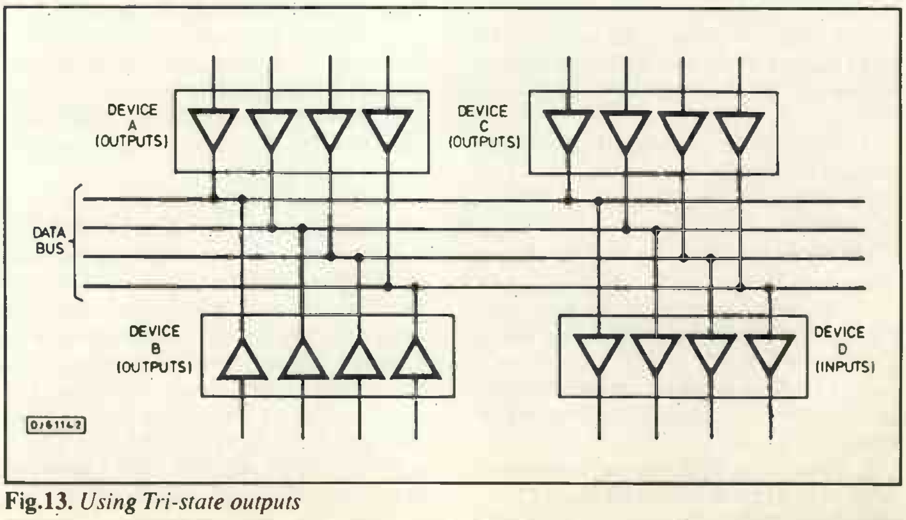
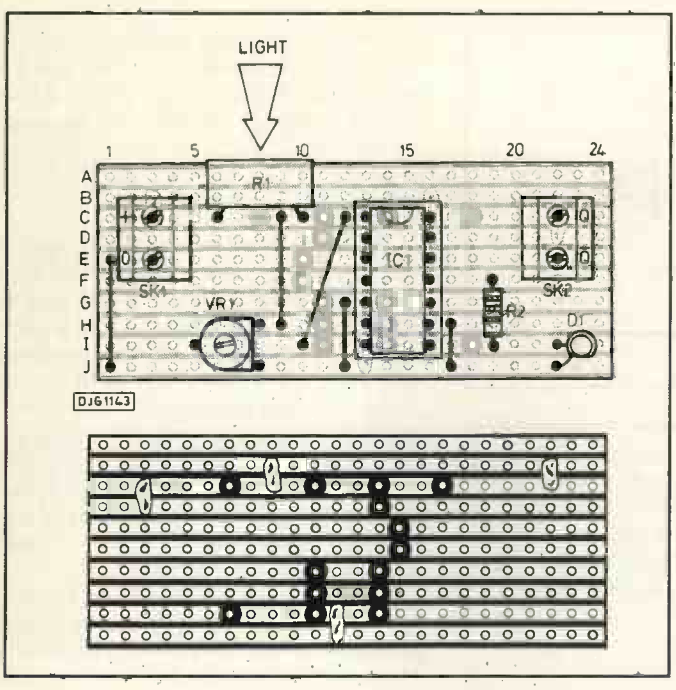


Fig.13. *Using Tri-state outputs*



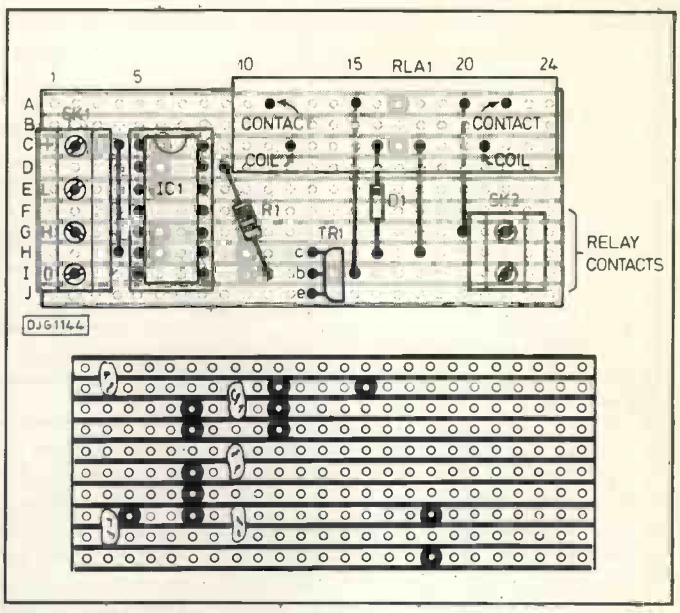


Fig.14. *(Left) Module 7: Light sensor*
Fig.15. *(Right) Module 8: Relay*

and C must not all talk at once. This is where the TRI-state outputs are used. The outputs of the gates in devices A to C are all three-state outputs. When a device is not supposed to be putting data on the bus, its outputs are switched to the high impedance, or disabled state. The logic of the computer control circuit is such that only one device is enabled to put data on the bus at any one time. D listens happily to one talker at a time, without being confused.

TEST YOURSELF

Answers on p. 41

1. Which gate-to-gate interfaces need a pull-up resistor?
2. What happens to the resistance of an ldr when the amount of light falling on it is reduced?
3. How many standard ttl gates can be driven from an HC ttl output?
4. What kinds of sensor can be used in a light-sensitive input interface? Which would you choose for the fastest response?
5. What is the difference between a ptc thermistor and an ntc thermistor? Which sort did we use in the temperature sensitive interface?
6. In Fig. 10, what is the effect on the input voltage of the gate as the temperature increases? What is the effect on the output voltage?
7. Which of the circuits of Fig. 11 would you use for interfacing to:
   (a) an electric fan driven by a 240V ac motor.
   (b) a beacon operating at 12V dc and requiring 4A.
   (c) an audible warning device on a washing machine, operating at 6V dc and taking a current of 10mA.
   (d) a small dc motor on a robot, operating at 3V, 250mA and able to be reversed by reversing the current.
8. What is the third state of a three-state output and where is it most often used?

MODULES OF THE MONTH

7. Light Sensor

This module (Fig. 14) is based on a ldr and is adjustable to trigger over a wide range of light levels. Output Q is high when the light is below the set level and is low when it is above. Output Q is the inverse of output Q. The led shows the state of output Q. The ldr faces toward the top edge of the board, but can be mounted to face in other directions. It can also be connected on an extension lead if preferred. The module takes 6mA when the led is off, and 15mA when it is on.

Parts required

R1	ORP12 light-dependent resistor (or similar type)
R2	180 ohm carbon or metal-film
VR1	1k preset resistor, miniature,
IC1	74HC14, hex Schmitt trigger inverters
D1	TIL209 or similar led

SK1, SK2 pc terminal 2-way
14-pin dil socket. Stripboard Vero 14345.

8. Relay

This module (Fig. 15) drives a relay from logical inputs. There are two inputs:

L activates the relay when it receives a low input; if this input is not being used, connect it to the positive supply (+).

H activates the relay when it receives a high input; if this input is not being used, connect it to 0V (0).

Both inputs may be used in a circuit – ie, the relay is activated if L is low OR H is high (or both). There is room on the board to substitute any small relay. The type specified is a reed relay with a normally-open switch which closes when the relay is activated. Another type in the same series has a change-over switch; substitute a 3-way terminal for SK2 if you are using this. The contacts of the specified relay are rated at 500mA, 200V dc, 10W, with a non-reactive load. This module takes 3mA when quiescent and 30mA when the relay is energised.

Parts required

R1	56k, carbon or metal film
D1	1N4148 silicon diode
TR1	ZTX300 npn transistor
IC1	74LS02 quadruple 2-input NOR
RLA1	encapsulated reed relay, form A (Electromail stock no. 348-970)
SK1	pc terminal 4-way
SK2	pc terminal 2-way

14-pin dil socket
Stripboard Vero 14345

SYSTEMS OF THE MONTH

Here are two systems that you can build using some of the modules described in previous months:

1). Traffic lights (Fig. 16)

This is powered by Module 1, a bench psu or a 6V battery. The timer is the programmable multivibrator (Module 5) set to run in astable mode at 0.5Hz. Its output drives the counter (Module 6) which runs through the following stages:

Count	Outputs D C B A	leds to be lit
0	0 0 0 0	
1	0 0 0 1	Red
2	0 0 1 0	
3	0 0 1 1	
4	0 1 0 0	
5	0 1 0 1	Red and yellow
6	0 1 1 0	
7	0 1 1 1	
8	1 0 0 0	
9	1 0 0 1	Green
10	1 0 1 0	
11	1 0 1 1	
12	1 1 0 0	
13	1 1 0 1	Yellow
14	1 1 1 0	
15	1 1 1 1	

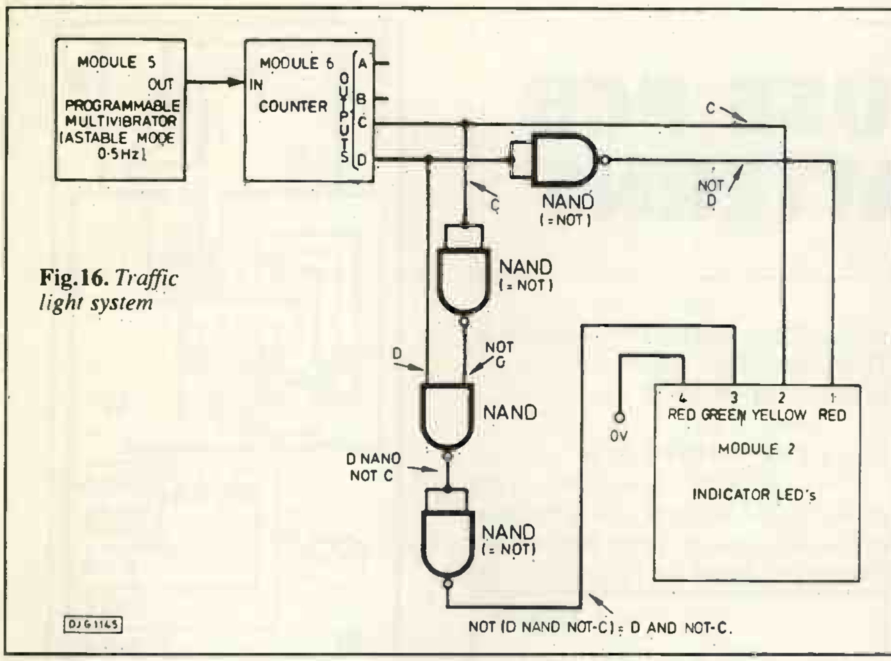


Fig.16. *Traffic light system*

To decode this output and make it switch the leds we need use only outputs D and C. This gives us the following logical statements:

Statement	Logic circuit needed
Red is on when D=0	NOT D
Yellow is on when C=1	Drive yellow direct from C
Green is on D=1 AND C=0	D AND NOT-C

Instead of using an AND gate for the green light, it is more convenient (though more confusing) to use NANDs:

D AND NOT-C = NOT (D NAND NOT-C)

The logic is wired up on a breadboard, using a single 74LS00 ic.

The same sequence of lights is obtained using the A and B outputs instead, with the clock running at one quarter of the speed.

Design problems: The lights are at a cross-road. Design the logic to operate the lights for the crossing road; i.e. 0-3 gives green, 4-7 gives yellow, 8-11 gives red, 12-15 gives red and yellow. (No answer given – try it out on the breadboard!).

2. Light-triggered alarm (Fig. 17): The alarm sounds when the light beam is broken or the alarm-button is pressed. It continues to sound until the reset button is pressed. Use a 74LS02 for the two NOR gates.

Design problem: Replace Module 8 and the bell with an oscillator based on Module 5.

FANOUT NUMBERS

Output from	Input to Standard ttl	LS ttl
Standard ttl	10	40
LS ttl	5	20
HC or HCT ttl	2	10
4000 series	0	1
Standard ttl buffers	30	60
LS ttl buffers	15	60
HC ttl buffers	4	15
4000 series buffers	2	4

BUFFERS

Series	Number	Logic
ttl open-collector	7406	NOT (inverting)
	7407	TRUE (non-inverting)
CMOS 4000	4049	NOT (inverting)
	4050	TRUE (non-inverting)
	4502	NOT (inverting)*

* with tri-state outputs

DIGITAL ELECTRONICS

Comments

Interfaces to design

1. There are two ways of setting about this. One is to interchange the ldr and resistor R2 (Fig. 6). Make R2 larger (100k is suitable) to get the gate to change state at typical light levels. The other approach is to invert the output from the gate. Feed the output to a second gate in the same ic. This too has its inputs connected to make it act as a NOT (INVERT) gate. The output from this is the inverse of the output from the first gate, which is what is required.

2. The circuit is the same as Fig. 6, except that R2 is replaced by a variable resistor of low value, for example, 1k. The gate input is taken from the wiper of this resistor. The light level at which the gate output changes depends on the setting of this variable resistor.

Investigation 2

If the supply voltage is 6V, the lower threshold of the gate is approximately 2V. The upper threshold is approximately 2.8V. At step 6 the led does not go out immediately; you have to withdraw your hand until the voltage reaches the upper threshold. At step 8 the led does not come on unless the voltage falls below the lower threshold.

Investigation 4

At step 3 the led comes on, usually within a second if you have set the voltage close below the upper threshold. The slight reduction in resistance of the thermistor produces a slight rise in voltage, sufficient to trigger the gate to change state. The led does not come on when you take your fingers away. You need to cool the thermistor, perhaps by putting ice on it, to make the led come on again. This interface is suitable for a fire alarm system, but not for a thermostat. Why?

PE

Answers to questions

1. TTL or LS ttl to 4000 series or HC ttl: ttl or LS ttl to 4000 series when the 4000 series i.c. is operating on a higher supply voltage.
2. It increases.
3. Two inputs.
4. LDR, phototransistor, photodiode. For speed, use a phototransistor or photodiode.
5. PTC = positive temperature coefficient: resistance increases with increasing temperature. ntc = negative temperature coefficient: resistance decreases with increasing temperature. The interface uses the ntc type.
6. Input voltage increases. The output voltage decreases when the input voltage equals or exceeds the upper threshold voltage of the gate.
7(a). a heavy-duty relay rated for at least 240V and 5A.
(b). a power transistor.
(c). try driving direct from the gate output: if this does not give a loud enough sound, use a low-power transistor.
(d). since current must be reversible, a relay is used. Since current and voltage are small, this can be a low-rated type, possibly driven directly from the gate output.
8. High-impedance. Used where outputs feed data to a data bus.

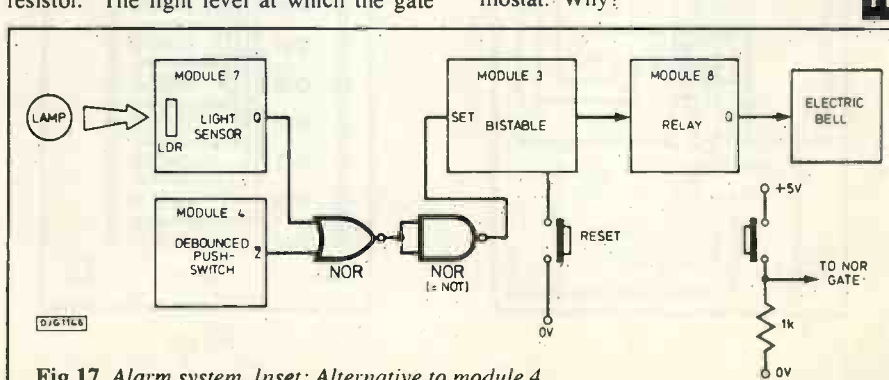
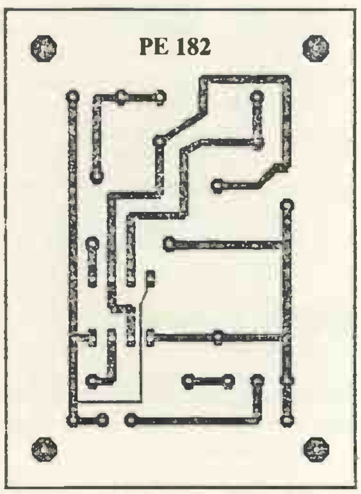


Fig.17. *Alarm system. Inset: Alternative to module 4.*

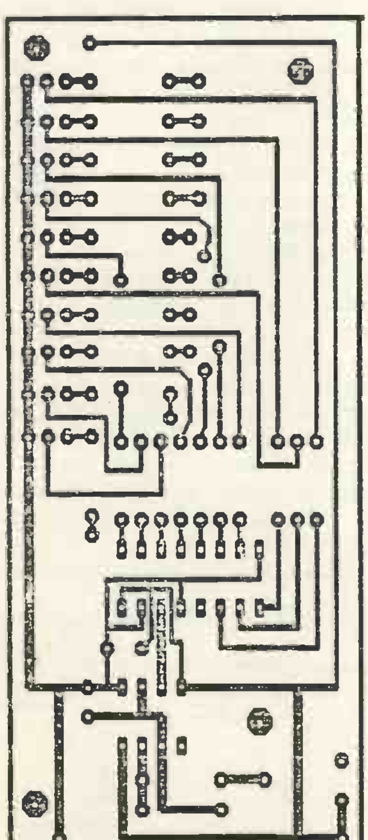
HOW TO USE PCB TRACK PATTERNS

ISODRAFT METHOD

Have a normal photocopy made, ensuring good dense black image. Spray ISOdraft Transparentiser onto copy in accordance with supplied instructions.



PE 182

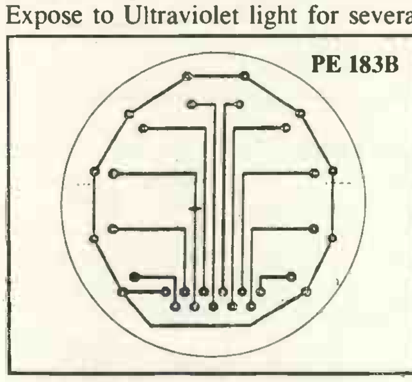


PE 183A

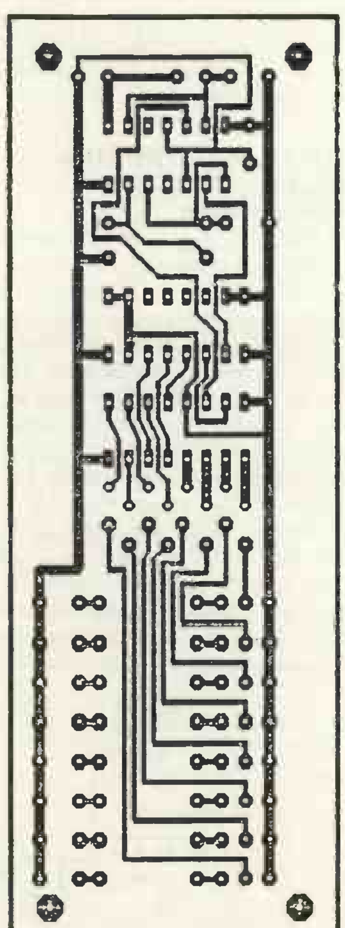
ISOdraft is available from **Cannon & Wrin,** 68 High Street, Chislehurst, Kent. Tel: 01-467 0935.

NEXT PRINT ONTO PCB

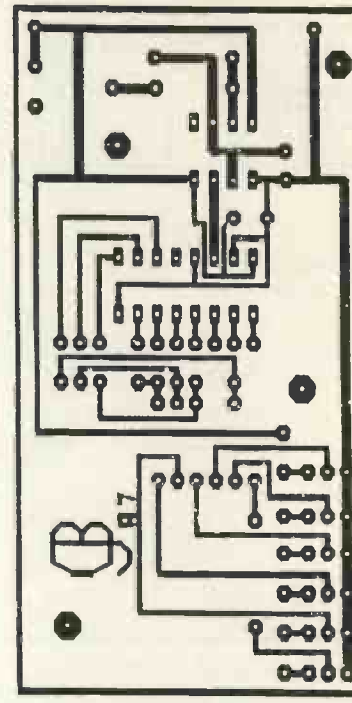
Place positive transparency onto photosensitised copper clad fibre glass, cover with glass to ensure full contact. Expose to Ultraviolet light for several



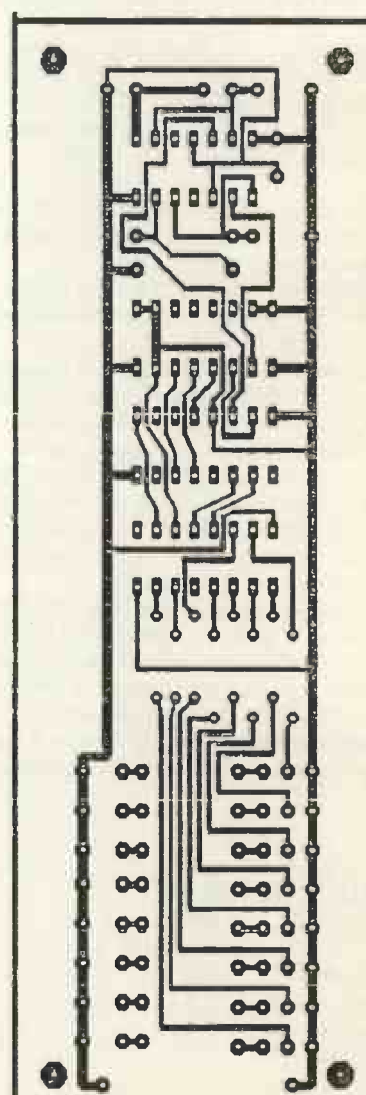
PE 183B



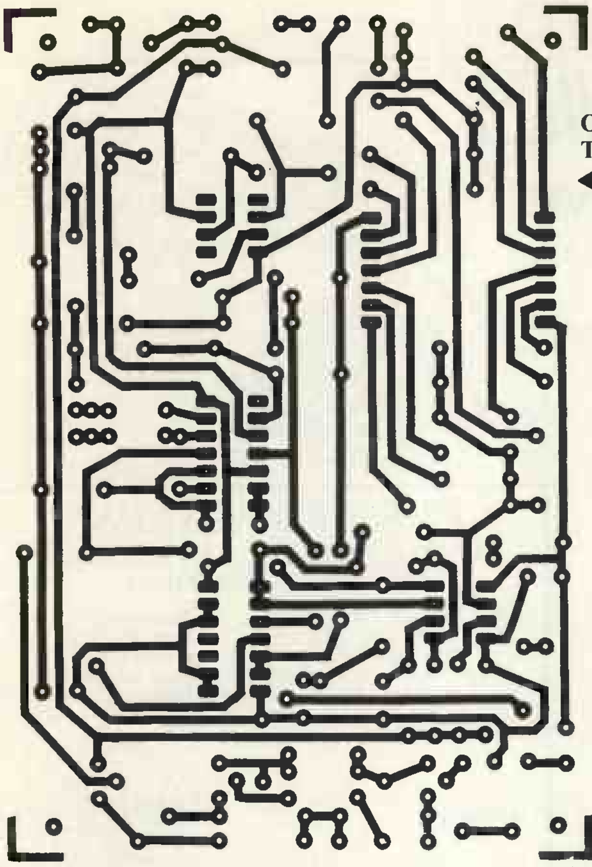
PE 184



PE 185A

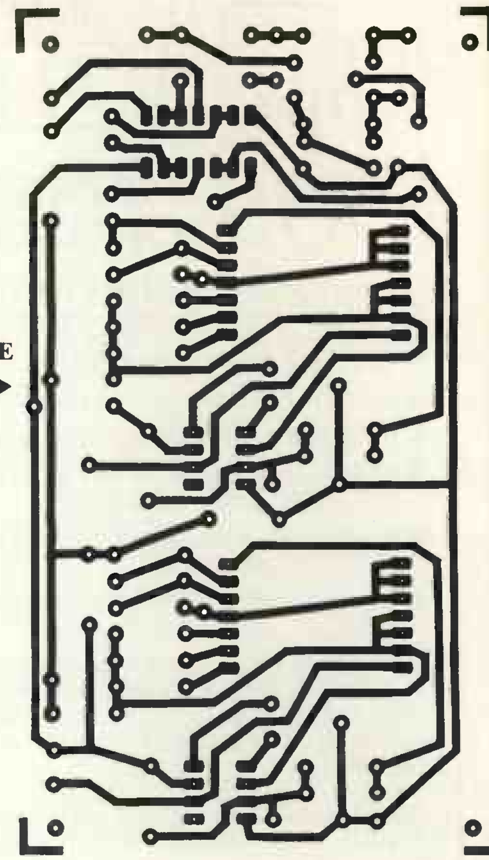


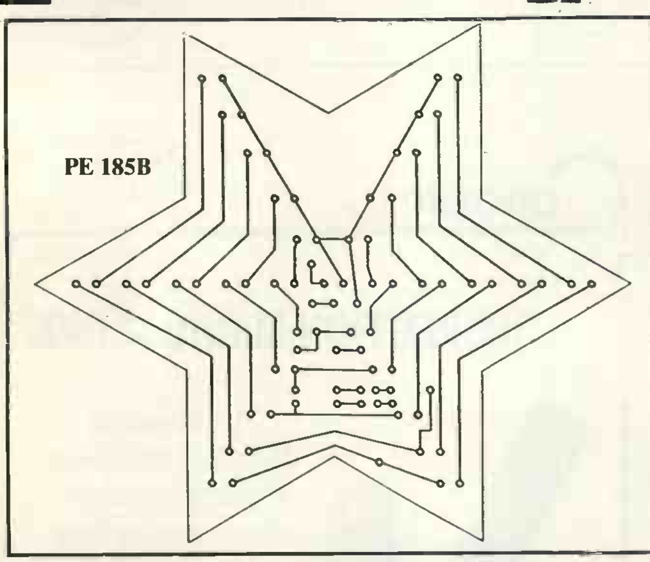
PE 186



OSCILLOSCOPE TIME BASE ◀

OSCILLOSCOPE Y-AMPS ▶





minutes (experiment to find correct time – depends on UV intensity).

Develop PCB in Sodium Hydroxide (available from chemists) until clean track image is seen, wash in warm running water. Etch in hot Ferric Chloride, frequently withdrawing PCB to allow exposure to air. Wash PCB in running water, dry, and drill holes, normally using a 1mm drill bit.

(PCB materials and chemicals are available from several sources – study advertisements.)

*** CAUTION – ENSURE THAT UV LIGHT DOES NOT SHINE INTO YOUR EYES. PROTECT HANDS WITH RUBBER GLOVES WHEN USING CHEMICALS.**

ALTERNATIVE METHOD

Buy your PCB ready made through the PE PCB SERVICE, most are usually available.

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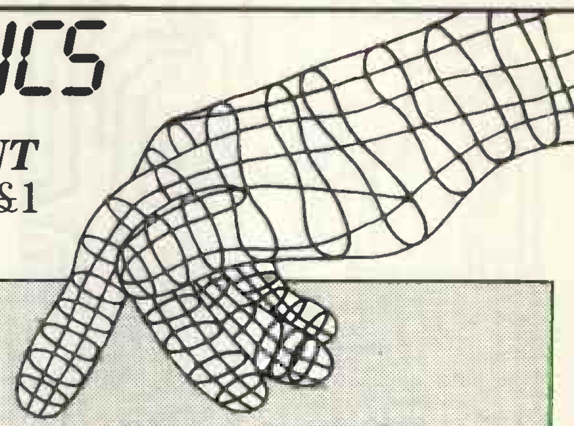

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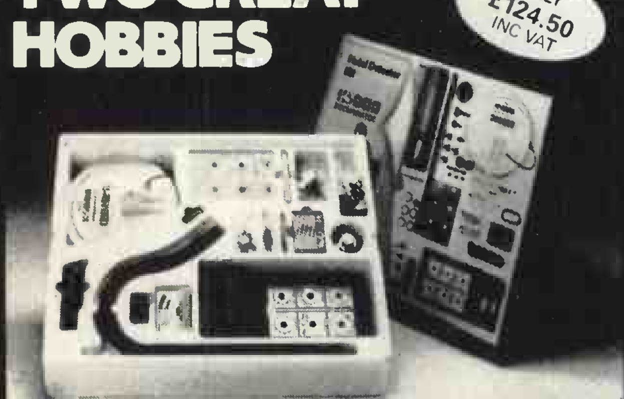

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READERS' LETTERS

LEDDING EDGE

Dear Ed,

I read with great interest Owen Bishop's Digital Electronics Pt. 1. It's very informative and starts from the very basics. The Sept.88 issue of PE is the first one that I have seen and was one of the best electronics mags on the shelf – I eagerly await more issues.

I have a couple of queries, though. In the indicator module, why use IC1, cannot logic levels from any source be coupled, via resistors, straight to the leds? Secondly, why is a 120 ohm resistor used for led current limiting? With a psu line of 5V, it appears that over 40mA will flow through the led, in excess of its capabilities.

Keith Clapson, Oxon.

The indicator board is a general purpose module, and since some logic ics cannot supply the current necessary to drive leds, a more powerful buffer is required as an interface, hence IC1, which has more than enough output power available.

Since there is a drop of about 2V across the led, the equation is not 5V/120R, but 3V/120R, which equals 25mA. A good question!

Ed.

LINK TRAINER

Dear Ed,

Well done again PE – another superb idea. I have taken PE for many years now and although I'm not a professional, I do try out a lot of your projects and am always glad when a series like Digital Electronics comes as part of my information-packed issue.

Unfortunately, I do have a moan – the Veroboard diagrams in part one were unclear. How about numbering the underside diagram, and shouldn't we use wire links instead of blobs of solder?

Apart from the minor moan, keep it up PE, you're worth every penny.

Dave Heneghan, Epsom.

Thanks, compliments and points well noted. Parts two onwards have clearer track layouts. Would other readers prefer extra links to solder blobs?

Ed.

METERING METAL

Dear Mr Becker

I am one of the very old school, from the days of swinging coil reactions and bright emitter valves; the days of fusing lead and sulphur in order to obtain crystals. I built my first receiver in 1922, including the making of coils, condensors and transformers etc.

I have just found your magazine – very interesting but a little strange to me, all those funny words!

The metal detector article in the July issue interested me so much that I have obtained the CS209 chip for it, but I have a couple of questions. Can I modify the circuit to include a meter, and if the voltage is increased to 18V will this improve the search range?

Sorry if this is elementary, but I am 77 years of age and have forgotten a lot.

Arthur Bloomer (ex G6SO), Camborne.

We are delighted to hear your interests have crossed the years. I pass you over to Robert for the answers to your questions.

Ed.

For meter indication an inexpensive tuning meter of about 200µA to 250µA full scale deflection should suffice. It should be connected from IC1 pin 4 to the positive supply rail via a 22k resistor and a 47k potentiometer connected in series. The pot is adjusted for the highest sensitivity that does not result in the meter being driven beyond full scale.

A higher supply voltage is unlikely to result in increased search range, but very careful adjustment of VR1 will optimise it.

Robert Penfold.

ULTRASONIC TAPE

Dear Ed,

Your readers may be interested to know of one or two snags we came across while building Robert Penfold's Ultrasonic Tape Measure of March 87, and of our solutions to them.

The circuit and pcb diagrams differed in that R6 and R7 were interchanged as were R8 and R9. We found the pulse width of the lfo too long, though the frequency was ok, so allowing two bursts of the 40kHz pulses and consequent resetting before an echo was received. A working solution was obtained by changing C3 to 20nF and R3 to 20M. This ensured only one burst. The counter clock frequency appeared to be twice what it should be, we changed R4 to about 560 ohms to correct this though we are concerned that this might affect its stability. We also found it necessary to widen the distance between transducers to 70mm. The Schmitt trigger signal appears noisy and we are considering a filter for this stage.

Arnold Collett, Wolverhampton Poly.

A few people have encountered difficulties with this unit but the only known error was the swapped resistors, a fact reported in Points Arising. I no longer have the prototype and cannot check on the capacitor values, although a lot of previous checking brought no further errors to light. I do not understand the point about reducing R4, which would further reduce the pulse width from the lfo rather than affecting the counter clock frequency. Anyway, if anyone has difficulties it is worthwhile making the suggested mods to the lfo values.

Robert Penfold

CALLING HEBAREK ZBADIA

Dear Sir,

I have received a letter from one of your readers, Mr Hebarek Zbadia. Unfortunately he did not tell me his address and since he sent money with his letter I would like to contact him urgently.

Could you kindly appeal to him through your pages?

C.R. Brown, 7 Mayfield Drive, Buckley, Clwyd, CH7 2PL.

It's amazing how frequently advertisers also come up against the problem of anonymity, especially when people illegibly sign their letters without using block capitals.

Ed.

STRIKING INTEREST

Dear Ed,

I was most annoyed about the recent postal strike. It happened just as PE was due, so I had to wait *two weeks* for the October issue of my favourite magazine – what inconsideration!

But it was worth the extra long wait, for, as usual, it had brilliant articles, beautiful presentation and the interesting and unusual projects make it the best magazine I have ever come across. Keep up the good work.

Benjamin Summers, Norwich.

We also ran up against postal delays of urgent material, resulting in two articles having to be postponed. However the merits of the strike may be regarded, such actions must surely prompt more people to go over to using electronic mail systems of various types.

Ed.

OMNIPOTENT

Dear Mr. Becker,

Please accept our latest catalogue which we hope you will find comprehensive enough to merit a mention in your "News and Marketplace" feature.

Our main business is in over-the-counter sales, but we are happy to say that the mail order side of our business is growing steadily as customers try us and find that we rarely send out an incomplete order.

Being a small company means that customers get a more personal service. We do try to help as best we can, not least by trying to keep in stock the goods we say we have, so avoiding disappointment.

We would also like to take this opportunity to congratulate you on the way the magazine has developed over the past few years, it really has improved tremendously.

Janice Borthwick, Omni Electronics, 174 Dalkeith Road, Edinburgh, EH16 5DX.

Your catalogue is very comprehensive, and I was pleased to include a mention of it in the October issue. I hope your business benefitted from the additional publicity.

Thank you for your kind remarks about PE, we too really try to offer people what they want – I believe people respond to the personal approach.

We are pleased to mention any advertiser's catalogue on the News pages if we are sent a copy. Whether the catalogue is one page or a thousand is immaterial if the goods are of interest to our readers. Likewise, we shall be pleased to try to publicise details of any advertiser's new product or service, especially if accompanied by a suitable photograph. The News pages are a free, but valuable, shop window of which more advertisers should take advantage.

Ed.

OUR REGULAR LOOK AT ASTRONOMY

SPACEWATCH

BY DR PATRICK MOORE CBE

SUPER SOLAR POWER

The Sun is becoming more active, which is more than can ever be said about Phobos 1, and while Discovery is back on course, we could wait a thousand years for U Scorpii to become spectacular.

Activity on the Sun is on the increase, and already there are suggestions that the next solar maximum may be at least as energetic as that of 1958-9, the most active on record. But has this anything directly to do with the weather we experience on Earth?

Measurements carried out from the Solar Maximum Mission satellite (SMM) suggest that the Sun is actually brighter when it is most active. True, the difference is not very great – about 1 part in 2500 – but it could be significant. Of course, more of the surface is covered by the relatively dark sunspots near maximum, but evidently this is more than offset by the greater brilliance of the faculæ, brilliant areas usually asspciated with active spot-groups.

It has also been suggested that longer-term fluctuations do affect our climate. During the period of the so-called Maunder Minimum, from 1645 to 1715, when spots were rate, we experienced the 'Little Ice Age' when the Thames froze for every year between 1680 and the end of the decade. In America, Thomas Crowley and Gerald North now suggest that a sustained change in solar output could affect the climate strongly enough to cause mass extinctions – and this brings us back to the dinosaurs, which I discussed last month! However, it is all very tentative, and we must await further results from SMM and other satellites.

On the debit side, there now seems no hope of regaining contact with Phobos 1, the Russian probe which was accidentally switched off by a faulty command from the ground station and which the computer did not override. This leaves us only with phobos 2, which should rendezvous with Mars next month. Luckily it was Phobos 2 which carried the "frog" which will hop over the surface of the tiny Martian satellite, so that all is not lost.

Of course the success of the Shuttle launch of October, when *Discovery* performed almost faultlessly, is encouraging in every way. Astronomers are particularly delighted, because it means that if nothing else goes wrong we may hope that the Hubble Space Telescope will be put into orbit early in 1990. This is eagerly awaited – not least because the telescope itself has not been improved by the long delay; it was never built to endure long periods on the ground. However, if it really is launched in the first part of 1990, it should perform up to expectations. We may also hope now for more definite timings of other future probes, such as CRAF (Comet Rendezvous and Asteroid Fly-by) and Cassini, the all-important mission to Saturn and its enigmatic satellite Titan.

First, however, will come the Voyager 2 pass of Neptune in August 1989. So far all is well; astronomers everywhere are keeping their fingers crossed!

SUPERNOVA NEWS

Astronomers are still hard at work analyzing the results from supernova SN 1987A, in the Large Cloud of Magellan. As we know, the progenitor star was not a red supergiant, but a blue one – which explains why the outburst was underluminous by

The Sky This Month

During December there are still several bright planets on view. Venus, in the morning sky, is of about magnitude -4, an is unmistakable even though it has started to draw in toward the Sun and will not rise until after 7am at the end of the month. It is gibbous, with a phase of over 85 per cent – rather like the shape of the Moon a few days from full – and no telescope will show anything upon its brilliant surface apart from a few vague shadings now and then.

Mars remains in the evening sky. It is still brighter than any star apart from Sirius, but its apparent diameter has dropped to only about 10 seconds of arc at the end of December as compared with 23 seconds of arc at opposition last autumn. However, observations of it are still useful. Generally, Mars develops dust-storms when near perihelion, and one such storm has been expected, but at the time when I write these words (October 4) it has not developed, so that Mars, like the Earth, is having unusual weather! The south polar cap has now become very small.

Jupiter reached opposition on 23 November, and is still excellently placed, moving on Taurus not far from the star-clusters of the Pleiades and the Hyades. It is above the horizon almost throughout the night, and this is an excellent time to look for the Galilean satellites. The remaining bright planets, Saturn and Mercury, are to all intents and purposes out of view this month.

The Moon is new of December 9, at first quarter on the 16th, full on the 23rd and last quarter on the 31st. It is at perigee (closest to the Earth) on the 16th, and apogee (greatest distance) on the 2nd and the 30th.

There is one good meteor shower this month: the Geminids, which last from the 7th to the 16th, with maximum on the 13th. This is usually rich, and this year the Moon will not interfere to any great extent – so why not try some meteor photography near the maximum of the shower? Later (17th to 25th December) we have another regular shower, the Ursids, but these are not so rich as the Geminids, and the Moon will be inconveniently obtrusive.

By now Orion rises reasonably early, and we also have the brilliant retinue, from Sirius through Procyon, the Twins (Castor and Pollux), Capella and Aldebaran. Look too for the Milky Way, which stretches in a glorious band from one horizon to the other. The W of Cassiopeia is near the zenith or overhead point which means that Ursa Majoris low down; the Square of Pegasus is descending in the west, and Vega skirts the northern horizon. In the early hours of the morning Leo, the Lion, makes its entry in the east, headed by the first-magnitude Regulus – so-called "Royal Star".

supernova standards (a blue star has less surface area than a red one). There are also some other strange facts. The celebrated "Mystery Spot", 1/20 of a second of arc away from the centre of the outburst, now seems to have disappeared, and it is best to admit that we do not have the slightest idea of what it really was. Unless it reappears, we will have great trouble in finding out.

The neutrino observations have also been under scrutiny. The 19 neutrinos recorded by the 'water detectors' at Kamiokande in Japan and under Lake Erie seem unquestionably to have come from the supernova, and indicate that the mass of a neutrino of this kind really is negligible by any standards. However, the neutrinos reported from the Mont Blanc detector a few hours earlier now seem definitely to have been spurious, and not associated with the supernova.

Meanwhile, when can we expect a new supernova in our Galaxy? We cannot tell – but we can hope. The best candidate is probably Eta Carinæ, in the far south of the sky, which is an erratic varible – in the 1830s it outshone every star in the sky apart from Sirius, though for a century now it has hovered just below the limit of naked-eye visibility. Another is U Scorpii, a recurrent nova which has flared up in 1863, 1906, 1936 and 1979. Observations now indicate that a new outburst has occurred, so that the star rose from its normal magnitude of 18 to brighter than 11 for a few days. The outburst was discovered in 1987 by the South African amateur Danie Overbeek, and there are suggestions that U Scorpii may be a potential supernova. Unfortunately its distance is not known, and estimates range between 10,000 light-years to 200,000 light-years. It is a binary, so that if it does 'go supernova' it will be of Type I, whereas SN 1987A was, of course, of Type II.

We must wait and see. Watch U Scorpii; in a thousand years or so, or even before, it may provide us with something really spectacular! PE

DUAL BEAM OSCILLOSCOPE

PART THREE BY JOHN BECKER

BE Ys TO THE EVENT

In the last part of the PE Dual Beam 'Scope project, we describe the Y-input amplifiers and the beam splitter, and describe a number of useful functions for the 'scope.

So far, in the last two issues, we have powered up the tube and have the beam sweeping nicely across the screen face. Perhaps some of you have already had the trace going vertically as well – by turning the tube on its side! This month I'll show how the vertical trace is produced without trickery, by describing the two Y-input amps and the beam splitter. Then I'll give a few hints on using a scope.

There are two input amps, which are identical to one another and have been kept to a minimum of simplicity. Fig. 25 shows one of them. Consisting of switched passive attenuation and switched active gain stages they amend the input signal levels to meet the dictates of the screen display height.

The input signal comes in via the relevant input socket and is immediately presented with a choice of routes by S8. Signals with an ac content, ie, frequency signals, are decoupled by leaving S8 open and routing them through C21. For pure dc voltages, or ac signals with little or no dc bias, S8 is closed so bypassing C21. Where frequency signals may be imposed on a high dc voltage level, the dc is removed by opening S8 to interpose C21 in the path.

Following S8 is the attenuator selection switch S6a and a chain of three potential-dividing resistors. They *nominally* attenuate the input potential to one-tenth and one-hundredth. More precise resistor values could be substituted if exact division ratios are desired.

After S6a, ac signals pass through C22, but dc voltages meet R41, on the other side of which are D11 and D12. This combination restricts the maximum voltages that can appear at this junction to approximately those of the power lines.

The working voltage of the standard polyester capacitors used in the prototype for C21 and C22 is 160Vdc. If voltages higher than this are to be probed, capacitors of a higher voltage rating should be substituted. The same also applies to C17 of the external sync input shown in part two.

Non-inverting opamp IC6 acts as a buffer and gain stage. The LM6361 suggested will handle frequencies well in excess of 3MHz. VR6 adjusts the dc output offset level. The LM6364 and LM6365 are equally suitable without circuit modification. Alternatively, a TL071 or TL081 could be substituted for IC6 (and for IC4), though they will only handle frequencies up to

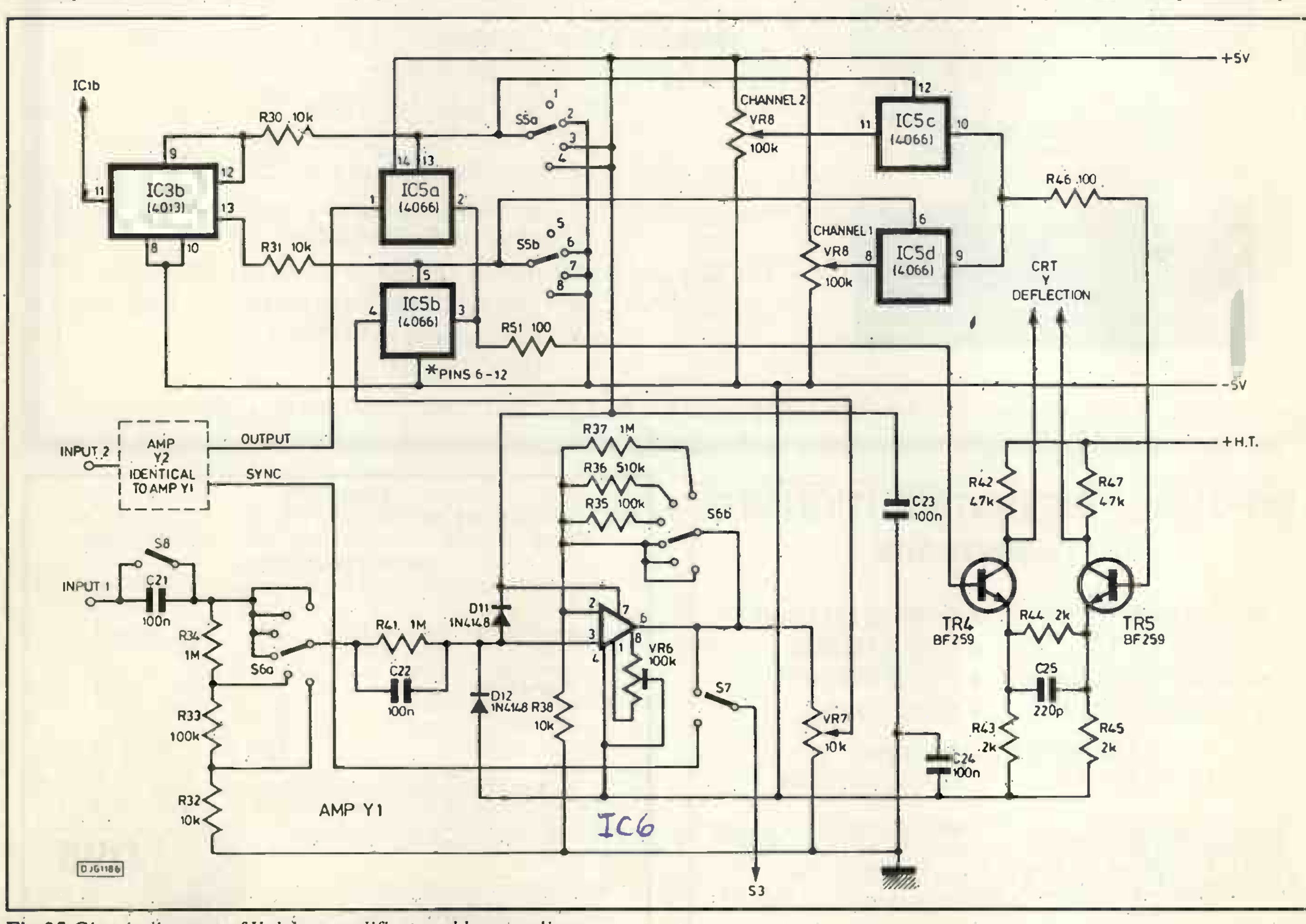


Fig.25 *Circuit diagram of Y-drive amplifiers and beam splitter*

about 150kHz and VR6 must be connected across pins 1 and 5 instead of pins 1 and 8.

With S6b in positions one to three, no gain is given and the signal attenuation is selected via S6a. With S6 in position 3, the signal passes through the opamp with neither attenuation nor amplification. In positions four to six, S6a routes an unattenuated signal, but S6b selects nominal gains of 10, 50 and 100. Different gain factors may be given by substituting other resistance values if preferred. In reality, viable use of gains of 100 and above will depend upon how carefully and neatly you connect your overall wiring since stray signals from the rest of the circuits could be picked up at high gains.

For each of the two channels the output of IC6 is brought to S7, a single internal sync signal routing switch. This allows the time base sync trigger to be selected from either channel.

Following IC6, panel pot VR7 controls the signal level sent through one of the gates of IC5a-b (more about these in a moment), after which it controls the vertical deflection drive transistor TR4. The action of TR4 and TR5 is similar to that of TR1 and TR2 of the X-trace drive, except that the offset deflection positioning is done by one of the two VR8 pots as selected by gates IC5c-d. This method enables each Y-trace to be independently positioned vertically on the screen by the respective pot.

With VR7 set for maximum level and with S6 on position 3, a 1V p-p input signal will give a vertical trace of approximately half the screen height.

BEAM SPLIT

In order to display two waveforms on the screen we simply insert an automatic changeover switch at the output of the two Y amps. We then constantly switch back and forth from one amp to the other. By applying slightly different dc biases, also routed by switched gating, to both Y signals the screen will display the two traces at different positions.

The switching between the traces needs to be synchronised so that the changeover does not occur while the trace is already moving across the screen. The output of IC1b in Fig. 20 is taken to the input of flip-flop IC3b in Fig. 25. IC3b is wired so that the twin outputs produce opposing logic levels each time a pulse is received on the input. In other words, when one output goes high, the other goes low, and vice-versa.

Each time the output of IC1b goes high at the end of the sweep period, the pulse triggers IC3b into its next state. The control pins of the four analogue gates IC5a-d, are connected to the respective flip-flop outputs. Each gate opens when the control pin goes to logic 1, and closes for logic 0. Although digitally controlled, the open gates will allow analogue signals to pass through virtually unattenuated. Each pair of gate outputs are commoned and then fed to the respective Y-axis deflection drivers TR4 and TR5.

For most X-axis sweep rates the alternate switching between the Y amps will be sufficiently fast so that the traces appear to be occurring simultaneously. At very slow sweep speeds, of course, the alternate switching will be apparent.

Incidentally, I experimented with high speed toggling between Y amps *during* slow sweeps, blanking the sweep at the moment of transition between amps. This is a method used on commercial scopes with more expensive screens and circuitry. The characteristics of the tube used in this project, though, appeared incapable of allowing clean traces to be produced with this technique.

S5 is included to provide a choice of Y display modes. In position one, the dual mode is selected. In the next two modes just one trace is displayed, either Y1 or Y2. This is done by forceably opening one gate pair by holding the control high, while holding the other gate pair closed by taking its control low. The inclusion of R30 and R31 prevent adverse loading of the outputs of IC3b.

As an idea for experimentation, it is possible to split a single beam into more than just two traces. If two octal gates, such as 4051s, were to be used, eight traces could be displayed. In this case the gate selection would be performed by replacing IC3b with a binary counter. Connecting the first three outputs to the multiplexed control inputs of the 4051s, the latter can be cycled through each of their eight individual outputs. In reality, the circular three-inch screen of this scope is probably insufficiently large for eight traces to be usefully displayed, and the pcb would need modifying, but the technique could certainly be used for a larger rectangular screen.

S5 in position four diverts amp Y2 to the X-plates in place of the sweep generator. This enables Lissajous to be drawn, as discussed later.

Y-BOARD ASSEMBLY

Fig. 26 shows the component layout for the third printed circuit board. This pcb holds both Y-amps, the beam splitter circuit, and the Y-axis drive transistors.

Note that, as with the X-board, the pcb mounting rotary switches are soldered to the *back* of the board. Again make sure that the pins are satisfactorily soldered, and that the semiconductors and electrolytic capacitors are inserted correctly.

The remaining control pots, switches and sockets are shown in Figs. 23 and 24 of part two. Make all connections except for those to the Y tags of the tube base, and the +250V supply (pins 21-23).

Observant readers may have noticed by now that not all consecutive component and

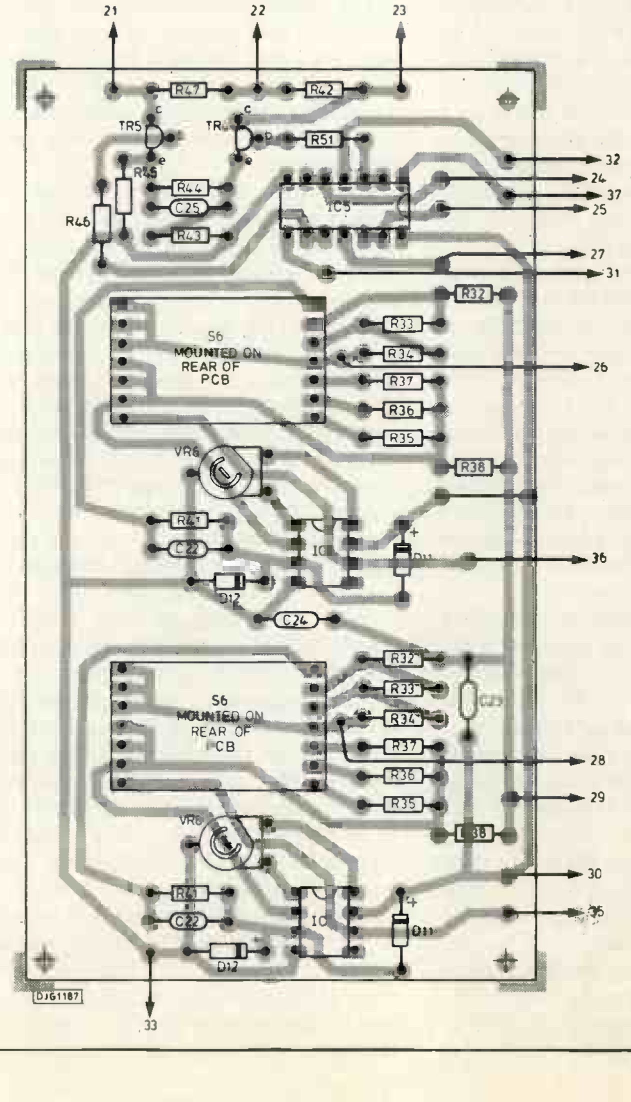


Fig.26. *Y-drive printed circuit board component layout*

connection numbers are used. True, on bench testing the prototype, it was found possible to simplify the circuit in some areas.

Y-AMP TESTING

With all ics inserted, temporarily connect the wipers of both VR8s to gates IC5a-b in place of the VR7 wipers. Monitor the junction of IC5 pins 2 and 3 on a meter, and check that with S6 in positions 2 and 3 the respective VR8 will vary the output voltage up and down. Reconnect the VR7s and VR8s to their correct points. Now monitor the junction of IC5 pins 9 and 10 and check that with S6 in positions 2 and 3 the respective VR8s vary the levels at this junction. Next set each VR8 for a slightly different voltage, switch the time base to a slow rate and check that pins 12 and 13 of IC3b toggle up and down. Again monitor IC5 pins 9 and 10, switch S5 to position 1 and observe that the gates are switching between the two VR8s.

Centre the X-trace on the screen, and switch off. Remove the two temporary Y-deflection pots referred to earlier in the article, and connect pcb pins 21-23 to their correct tube and ht points. Set VR9 for minimum resistance, switch on again and if necessary readjust VR11 so that the positive ht is at +250Vdc.

Switching between both channels, adjust the respective VR8 and check that the X-trace moves up and down the screen. With S5 on position one both traces should be seen to be independently variable.

You can now check the front end of each Y amp. First, connect each Y-amp input to 0V. Then monitor the junctions of each IC6 and VR7 in turn and carefully adjust the offset control VR6 so that a reading of 0V is present at all settings of S6.

Remove the input 0V temporary links and connect a lead between the 50Hz output and each Y amp input in turn. With S6 on position 3 and S8 open turn up VR7 until you see a vertical waveform on the screen. Set the sync switches S3 and S7 to the correct channel path and adjust the sync level pot VR5 until the trace stabilises. If necessary, select a different X-sweep rate with S1 and also adjust the variable sweep rate pot VR2. Switching the sync phase switch S4 up and down the waveform display should shift position by half a cycle.

Switching S5 to position one, the 50Hz signal should appear on one trace, while the other trace remains unmodulated. Connecting the 50Hz into the other amp will then swap the roles of each trace.

Temporarily couple the two Y amp inputs so that the 50Hz feeds both circuits simultaneously. Set both VR7s to maximum output level, switch both S6s to the same position whereby both screen traces are seen fully. Position each trace on top of each other and observe that their amplitudes are roughly equal to one another.

Finally, adjust VR3 so that the X-trace extends an inch or so to either side of the screen width, allowing latitude for VR4 to shift the trace to left and right.

FREQUENCY MEASUREMENTS

It is the rate at which the beam spot travels between two points that determines the calibration of a displayed Y-axis frequency. The number of times per second that the beam crosses the screen is irrelevent to this calculation. You can trigger the sweep just once per minute and still know that the distance between two waveform peaks represents a particular frequency.

The factor that governs the sweep rate across the screen is the rate at which the control voltage changes between two levels. If the beam takes precisely one second to cross one centimetre, during which time one complete waveform cycle is vertically displayed, the waveform frequency is 1Hz. From this observation you know that if ten full cycles are shown within that 1cm, the frequency is 10Hz. If you increase the rate at which the sweep control voltage changes by a factor of ten, so that the sweep covers 1cm in 0.1 secs, then ten full cycles appearing within 1cm will represent 100Hz, and so on up the scale.

PERSISTANT SWEEPS

Although you need the beam to cross only for a given number of cycles per centimetre, it is adventageous to repeat the sweep as frequently as possible for two reasons. First, you obviously want to observe the monitored waveform long enough to make measurements and note how the waveform may change across a period of time. Secondly, a single sweep, especially when sampling high frequencies, is usually insufficient for the eye to adequately register the detail, even though image persistance may help.

One source of persistance is due to the human eye being capable of retaining an image on the retina for several tenths of a second, even after the original image source has disappeared. Another source is the tube itself since the fluorescent screen coating will also continue to glow for a brief period after the beam has passed. Indeed, tubes are manufactured in a variety of screen materials to offer different persistance rates. Despite these factors, unless the sweep is slow, the image still needs reinforcing at a frequent rate for it to be readily observable. Hence the requirement for retriggering the beam at the earliest practical moment – it's usually so we can see the darn thing!

When switching between ramp rate ranges, ideally the rates should be matched multiples. The normal tolerances of the actual components used will inevitably results in imprecise ratio changes, though the variations can be corrected by adjustment of VR2. You could, of course, at greater expense, substitute capacitors of a more precise tolerance. You could also replace S1 by an RS Components' rotary switch kit with two 1-pole 12-way rotors and include intermediate capacitor values.

At the fastest switched ramp rate and with VR2 at minimum resistance, ten cycles of a 1MHz signal can be displayed. At the slowest setting and with VR2 at maximum resistance, the sweep takes approximately five seconds to cross the screen. The 50Hz reference generator can be used for low frequency calibration, though a signal generator with known outputs frequencies provides a better overall answer.

AMPLITUDE MEASUREMENTS

Whereas the horizontal deflection measurements represent time and frequency, vertical deflections represent voltage levels. The 50Hz generator is useful here as well. Once its output has been set to a known level, the relative screen positions of the vertical trace can be observed and adjusted by the VR6s so that amplitude is related to vertical displacement. DC voltage levels may also be monitored, when S8 is closed. First set the trace centrally on the screen, then probe the voltage source.

As I mentioned earlier, the precision of the attenuation and gain resistors will determine the uniformity between switched input

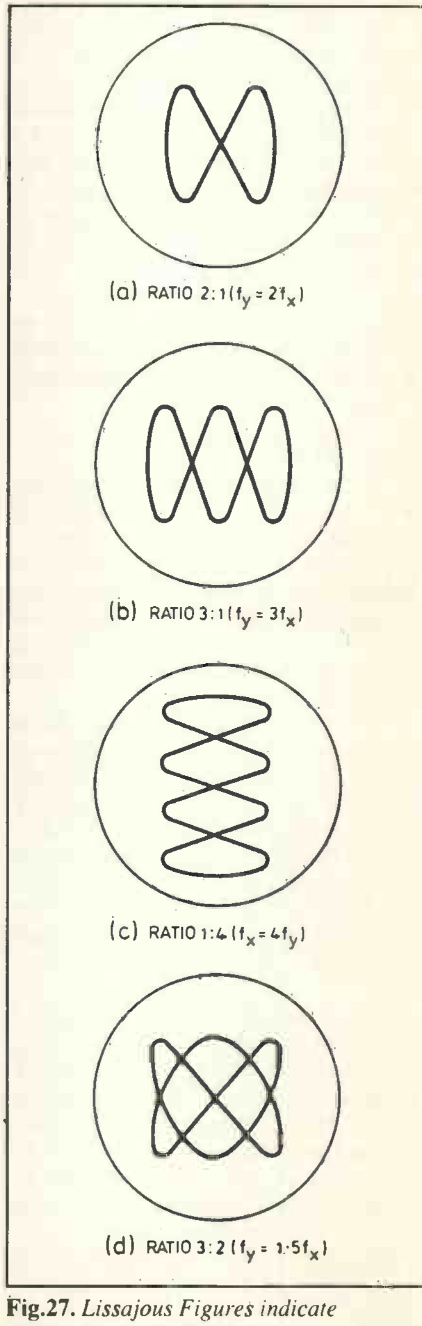


Fig.27. *Lissajous Figures indicate frequency relationships*

levels. You will also remember that the IC6 opamps have an offset correction control. Inevitably, even very small variations in the equivalent levels of the power supply will be reflected in the basic dc output level of the opamps. This will be further enhanced when gain is switched in, resulting in the deflection of the vertical trace. The precise setting of the VR6 offset controls will minimise the deflection when switching between gain ranges.

Within the bounds of the slowest sweep rate, there is no lower limit to the input frequency. The upper frequency limit of the LM6361 input opamps is well above 3MHz, though the characteristics of the tube and the simplicity of the Y-deflection drivers impose a lower top frequency limit. The observed signal amplitude decreases with frequency, with a usable maximum of about 2MHz, but beyond that the vertical signal trace becomes too small. When frequencies rise above about 500kHz, squarewaves will also increasingly be reshaped to triangle waves, as the frequency gets closer to the drive transistors' gain limits.

DUAL BEAM MONITORING

One big advantage of seeing two traces on the screen is that comparisons between signals can be made. There are many ways in which the facility may be used, of which I'll quote only a few, plus some general hints on scope use.

With one probe connected to the input of an amplifier the other probe can be used to follow the signal through the amp at various points. Comparisons of amplitude, phase shifting and shape changing are just some of the qualities for which you can look.

MATCHING OSCILLATORS

Two oscillators can have their fundamental or harmonic frequencies precisely matched by taking a probe to each and synchronising the sweep trace to one of them. By adjusting one of the oscillators, the relevent peak counts can first be corrected. Then when the rates are fairly closely matched it will be seen that the second trace moves in relation to the other. A forward movement indicates that it's running faster than the primary oscillator, and vice-versa. Carefully adjusting the rate in the correct direction, the relative movement will cease when both oscillators are running at precisely matched frequencies. The matching of crystal controlled oscillators for clocks is one obvious use.

If you were trying to match frequencies by moving a single probe from one oscillator to the other, you could never achieve this same degree of precision since you would be trying to see mere fractions of horizontal displacement between separate observations. However, you *can* use just one probe to achieve matching precision if you connect the external sync input to the primary oscillator, and then observe the second oscillator on the screen. Obviously, this method also applies to single beam scopes. With a dual beam scope, the same technique allows two oscillators to be observed relative to a third.

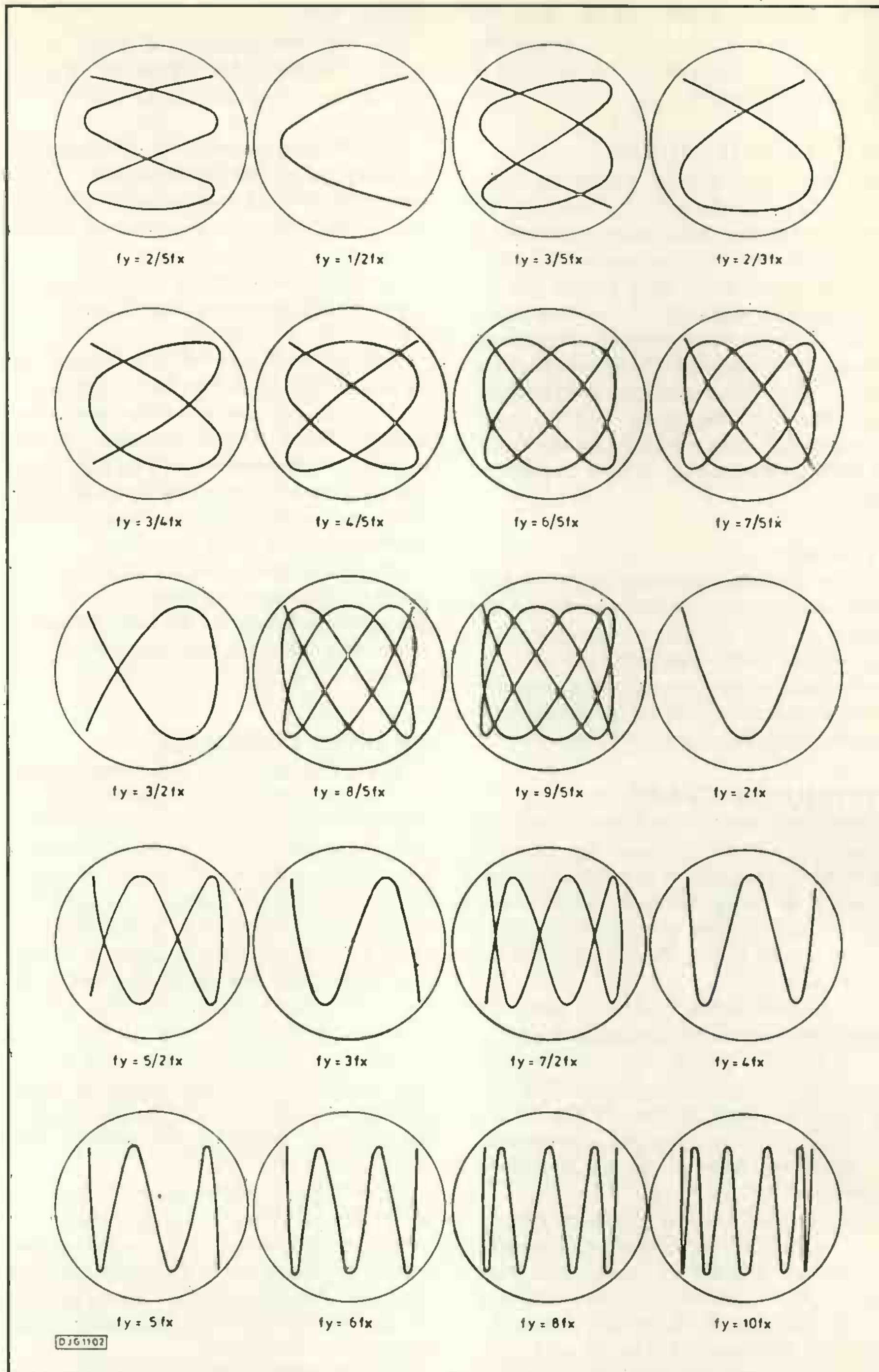


Fig.28. *Lissajous figures used for calibrating a sine-wave generator*

MONITORING DELAYS

Monitoring reverb or echo delay units is another ideal dual-beam function. By syncing one trace to the input, the other can monitor the delayed output and the screened distance between the original and delayed events measured, from which the delay time can be established.

Delays or displacements between logic signals can also be monitored, syncing on one and observing both. Switching to the opposing sync phase trigger is also beneficial in cases like this, effectively advancing or retarding the sync point by half a cycle.

Additionally, by opening the 'bright-line' switch S2, the situation occuring immediately after an infrequent event can be monitored. In this mode, the trace is synchronised to the infrequent event signal. In its absence the trace will remain untriggered and the screen stay dark. On receipt of the sync trigger the trace will start across and the signal from the second probe will be seen.

COMPARISON MARKER

Two probes can also be used in another fashion, to monitor comparative signal levels. One probe is used as the investigator, and the other as a marker. The amplitude of one signal is first monitored and the marker is moved vertically to a particular reference point on the trace. The investigative probe is then moved to another signal source and the level here compared with the marked one. Further comparisons can be made at other strategic points.

CURRENT MEASURING

Current flow can be monitored using either one or two probes. By measuring the screen deflection both before and after a known value resistor, the peak difference is read and from it the peak current can be found by applying Ohm's Law. Conversly, if the current is already known, a resistance value may be equivalently calculated. Note though, that the impedance and inherent capacitance of the probe and its input amplifier will have an effect on the signal or voltage levels from a high impedance source.

TUNING

An oscilloscope of either single or dual trace variety is virtually indispensible in the tuning of filter circuits. It is so easy to observe the shape and amplitude of a filtered signal while carrying out adjustments to filter controls. Even for audio signals it beats listening for volume and distortion.

LISSAJOUS FIGURES

Practically every book I've ever seen on scopes talks about Lissajous figures. I've included the facility on this scope, though in fact I've rarely found the need to use them. Perhaps experienced readers may care to tell me how important they find the figures to be...

A Lissajous figure is created when two signals are individually applied to the X and Y deflection plates, and necessitates bypassing the time base generator. In this way patterns, such as those in Fig. 27 are displayed and from them phase or frequency differences between the signals can be established.

The classical use of a Lissajous figure is for frequency determination, usually, though not necessarily, using two sine waves. With a known frequency sinewave fed to one pair of deflection plates, the unknown sinewave is fed to the other pair. A series of loops is seen on the screen, and providing their ratios are within about ten-to-one, the nature of the pattern will be determined by the frequency relationship. If the frequency ratios are precisely related harmonics, eg, 2:1, 3:1, 1:4, 3:2 as in Fig. 27, the pattern will be stationary. Any shift away from the harmonic will result in the apparent rotation of the figure – moving pictures, folks!

The full interpretation of these figures can be complex and is beyond the scope of this article. Nonetheless, I'll give a few examples.

The frequency ratio can be found by counting the number of times that the pattern touches imaginary or real horizontal and vertical lines. In Fig. 27a, two peaks touch the X line, and one touches the Y line, the ratio is therefore 2:1. By similar reasoning, the pattern in Fig. 27d represents 3:2.

A further selection of ratio patterns is shown in Fig. 28, and as you can see, you don't necessarily need to have complete patterns displayed to find the ratio. If you examine the first display of Fig. 28 there is one loop on the X base, and two and a half loops on the Y side, converting to whole numbers the ratio is 2:5.

The figures don't always make such neat patterns and phase relationships will alter the pattern produced by the same frequency ratio. Fig. 29 shows three possible shapes for each of the ratios 2:1 and 3:2.

PHASING LISSAJOUS

The phase relationship between signals can be established by interpretation of the patterns produced for given ratios. Take a simple example of two sinewaves of identical frequency, produced perhaps by monitoring the input and output of an amplifier. If there is no phase shift a diagonal line from 225° to 45° will be seen, as in Fig. 30a. If the phase has changed by 180°. ie, it has been inverted, the line will then be seen between 315° and 135°, Fig. 30b. Intermediate phase shifts will result in figures ranging from the diagonal lines, through ellipses to circles, the latter occuring when one signal lags the other by 90°, or preceeds it by 270°.

Knowledge of precise phase changes will be largely academic to most people, so I won't go into detail about analysing the curves, but simply refer those interested to Fig. 31. Measurements of this type also require that the deflection amplitudes of the two signals are identical.

Ignoring mathematics, you can have a bit of fun (and probably impress a neighbour with your cleverness) with Lissajous figures by adjusting frequency inputs and waveforms to produce endlessly revolving patterns of different complexities. The figures are easier to control, and measure, when the frequencies are in the low audio range – higher rates are less easy to manage.

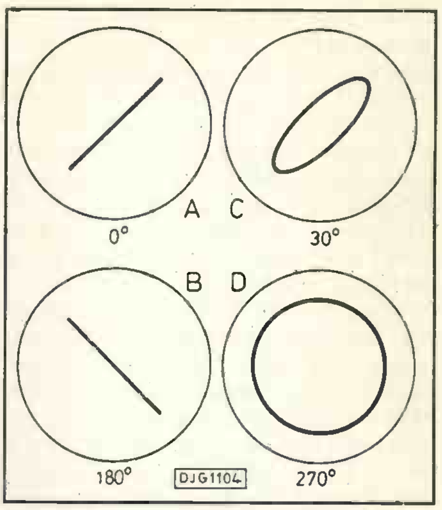


Fig.30. *Portraying phase relationships*

SHAPING LISSAJOUS

Although the Lissajous technique can be used for waveforms of any shape, those with fast leading or trailing edges, such as sawteeth and squarewaves, tend to be difficult candidates. As a hint, though, you can sometimes make the pattern more observable for frequency matching by turning the brilliance fully up and defocussing, so spreading the beam more widely on the screen. Turning out the room lights can also help to make fast transients more visible in this and other scope modes!

To put this scope into Lissajous mode, switch S5 to position four. This opens the analogue gate to amp Y1 only, and routes Y2 to VR3. Signals from the Y1 amp will continue to control the vertical trace, whereas Y2 will now control the horizontal trace. It will usually be preferable to switch S2 open and turn down the sync control.

Lissajous figures are also discussed by Ian Hickman in the *Oscilloscopes* book I referred to in part one. Another book, mentioned in Bookmark recently, also looks at them – *Meters and Scopes (How to Use Test Equipment)*, by Robert J. Traister, published by Tab Books, ISBN 0-8306-2826-6.

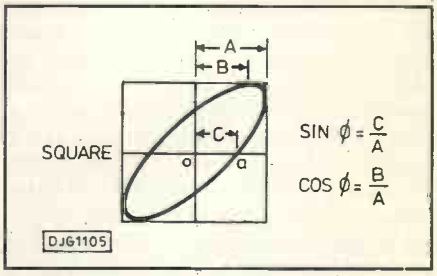


Fig.31. *Measuring phase difference*

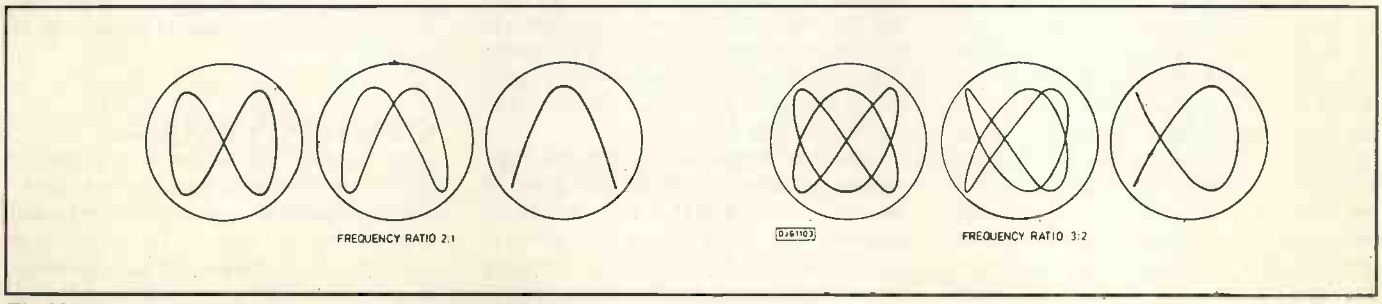


Fig.29. *Variations in Lissajous patterns for the same frequency ratio*

COMPONENTS OSCILLOSCOPE Y-AMPS

RESISTORS

R30-R32,R38	10k (6 off)
R33,R35	100k (4 off)
R34,R37,R41	1M (6 off)
R36	510k (2 off)
R42,R47	47k (2 off)
R43-R45	2k (3 off)
R46,R51	100 (2 off)

All 1/4 watt 5%

CAPACITORS

C21-C24	100n polyester (6 off)
C25	220p polystyrene

POTENTIOMETERS

VR6	100k skeleton (2 off)
VR7	10k mono rotary (2 off)
VR8	100k mono rotary (2 off)

SEMICONDUCTORS

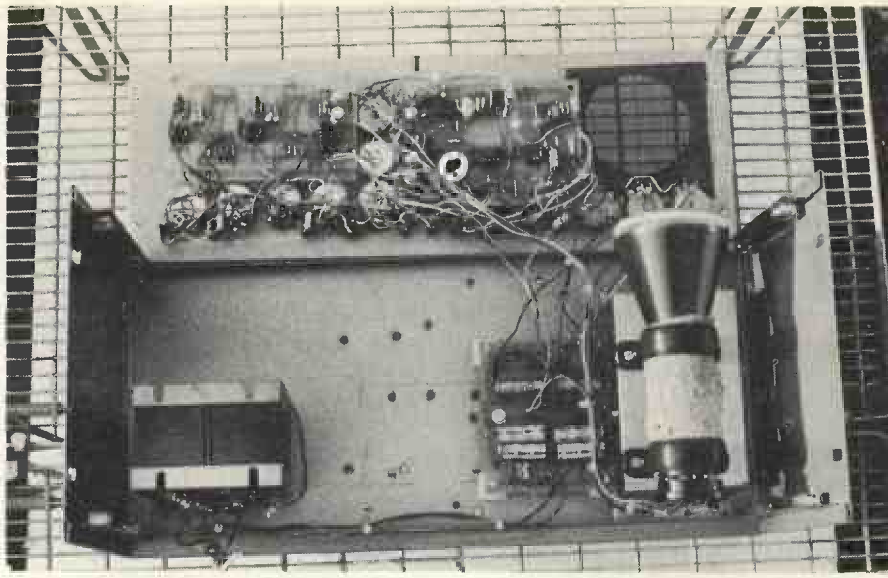
D11,D12	1N4148 (4 off)
TR4,TR5	BF259 (2 off)
IC5	4066
IC6	LM6361 (2 off)

SWITCHES

S5	3p4w rotary
S6	2p6w pcb mounting
S7,S8	min spdt (3 off)

MISCELLANEOUS

Knobs (9 off), Phonosonics PCB290B, 8-pin ic socket (2 off), 14-pin ic socket, 3.5mm jack sockets (2 off)



SYNCING FEELINGS

It may seem that it is always desirable for a non-Lissajous waveform to be synchronised with the time base. This is true in many instances, for frequency assessment and shape comparison, for example. In other cases it's more convenient if the trace is just a fast blur.

Suppose you are examining a high frequency signal, but wish to periodically compare its amplitude with that of a much lower frequency. When you need to look at the lower frequency the present high rate of the X sweep may be too fast for any of the slow waveform to be seen. You could switch down the time base rate accordingly, or simple turn the sync control fully down. Both waveforms will then be seen as a blur and amplitude differences readily compared. Even for measurements of individual waveforms this method can sometimes be easier than trying to see exactly where the waveform peak occurs.

Another use of non-sync viewing is when monitoring the swing of a very low frequency, of only fractions of a Hertz for example. Switch to a high time base rate, take off sync and the low frequency will be represented by a continuous line sweeping and down the screen. This is an easier technique than switching to a synchronised low sweep rate when you will alternately be waiting for the start of the trace and then observing a solitary dot moving on the screen.

As an aside, when I was a film editor it was acceptable grammar for the verb 'to synchronise' to be extended to forms such as 'sunk-up', 'unsunk' and 'sank'. I've even heard 'sunk-up', though 'sinked-up' was more common.

Neither sync nor optimum time base setting are needed for simple signal tracing, or dc level checking. In these instances seeing a vertical displacement of any sort is often enough to give answers about whether a signal is present or not, and as to whether a line is positive, negative or neutral.

SWEEPING UP THE TRACES

A scope is a vital piece of test gear for any electronics hobbiest, and in my own workshop it is used far more regularly than an ordinary meter. May you find as much benefit and pleasure from building and using this scope as I did when I built my first one. Once you've used a scope, however simple, you'll reap the rewards from an enlightened view of how electronics works. So get the tube and beam yourself a board...

PE

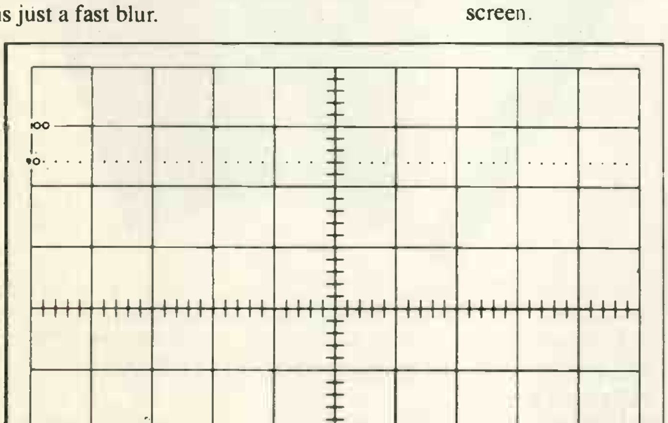
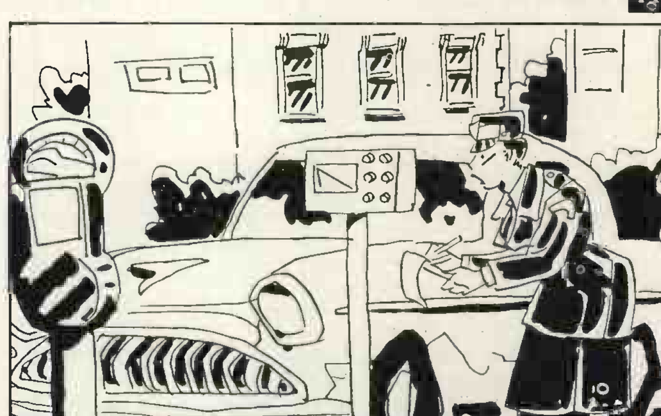


Fig.32. *Typical oscilloscope screen graticule, which can be enlargement photocopied onto clear film, then mounted in front of scope tube*



Your Ed believes scopes can often be used in place of meters – but will they meet the ticket for our meter-maids?

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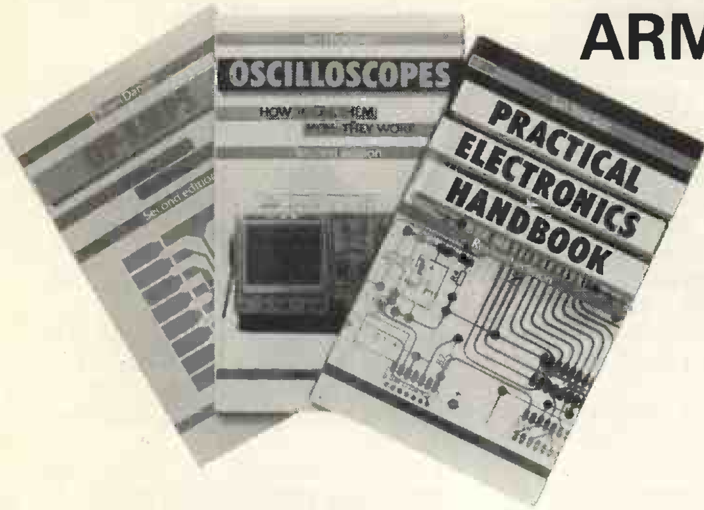

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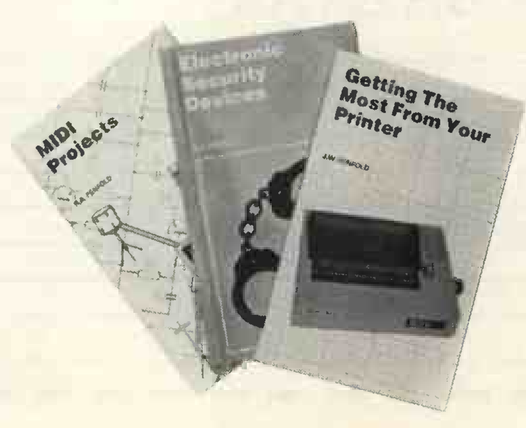

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THE ELECTRONIC PERSUADER

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The media can't control what you think, but it does control what you think about. . . when it comes down to it, what is the difference?

Do you ever wonder if television viewing is influencing your life in any way? On the face of it the electronics industry seems to have produced a very powerful machine for changing our brain connections through the visual and auditory nerve pathways. Certainly it's the programme material that is responsible for arousing our emotions and thoughts. But the effectiveness with which this software does its job must depend a great deal on the current level of hardware technology.

This whole question is brought to mind by the prospect of increasing deregulation in UK broadcasting. A government White Paper due out at the time of writing will propose that the IBA should be abolished and all commercial television (terrestrial broadcasting, cable and satellite) be controlled by a new tv authority. Many broadcasting professionals fear this will mean lower programme standards, less real choice for viewers and a reduction in quality public service programming.

Clearly, television commercials do persuade people to go out and buy the goods or services advertised. Whether the portrayal of violence on tv influences people to a similar extent to go out and commit violent acts is a matter for continuing debate. Probably a lot depends on the life experience of the individual viewer. For example, having become a rather cynical person, I make a point of never buying anything that is advertised on tv. But I have to admit that this selective, negative reaction is in itself an acknowledgement of the power of persuasion being applied.

A strong characteristic of domestic tv is its ability to exclude reality. To start with, consider how this works through the physical facts of the television set operating in the home. The images on the screen are produced by means of transmitted light from glowing phosphor sources, whereas we normally see most things in the world be reflected light. Sound is usually present most of the time, even though the real world often has to be interpreted in comparative silence.

The pictures are viewed in the humdrum surroundings of household objects and events. A furious bit of drama could be working itself out on the screen immediately next to a plate of sandwiches or a sleeping cat. On this screen the people and objects are miniatures, and the convergence feedback of our binocular vision tells us that the images are not the same as the originals seen at a distance. Overall the effect is something like a brightly lit toy theatre.

Within these physical limitations the deliberately selective processes of the broadcaster are operating. There is an old adage that newspapers can't tell you what to think but they do control what you think *about*. Selection and exclusion on television begin with the overall policy of the broadcaster. This is implemented first in programme planning and then in the structure and content of individual programmes. In political discussions, for example, the agenda is set in advance. Any controversy is held within previously determined limits, which can be enforced later by editing the video recording.

But it's in the 'language' and conventions of the visual presentation that we see exclusion and selection most immediately. First the sequence of shots is selected. Then each shot is structured by a variety of artifices – by choice duration, framing, lighting, the angle and distance from which it's taken, and so on. The precise meaning or mood which the viewer is expected to attach to the resulting images is fixed by the use of sound. Speech and music are very specific in their effects.

One result of this concentration of selective processes is a distancing or alienation of the viewer from normal experience. Jonathan Miller describes it well in a book on the one-time media guru, Marshall McLuhan. The images which television presents, he says, are "curiously dissociated from all other senses. The viewer sits watching them all in the drab comfort of his own home, cut off from the pain, heat and smell of what is actually going on. Even the sound is artificial. ..... All these effects serve to distance the viewer from the scenes which he is watching, and eventually he falls into the unconscious belief that the events which happen on tv are going on in some unbelievably remote theatre of human activity. The alienating effect is magnified by the fact that the tv screen reduces all images to the same visual quality. Atrocity and entertainment alternate with one another on the same rectangle of bulging glass. Comedy and politics merge into one continuous ribbon of transmission."

Perhaps what Miller describes is the result of the most powerful selective process of all – in the mind of the viewer. If we seem to go into a kind of trance when watching tv it is because we have involuntarily agreed to suspend judgement on the reality of what is appearing on the screen. We have colluded with the tv producer in allowing ourselves to be transported by his art, shutting out our normal, hard-headed, sceptical sleves.

In this irrational state of suspended belief the contrived images and sounds become more 'real' to us than the real world. Temporarily we can be persuaded of anything. This metal state, and how to produce it, is well understood by television playwrights, propagandists and makers of commercials. The influence of the medium lies in the unperceived surrender of our minds.

One effect of continually excluding reality is to artificially raise the expectations of some people – particularly the deprived or unhappy – of what life should be like. Goodies are dangled in front of them. In the case of individuals who enjoy or need vigorous or violent action, certain tv programmes raise their levels of expectation of excitement from life. They have become addicted to their own adrenalin. When this excitement is not produced by the normal routine of living they go out and create it. This could be one contributory factor to the increasing violence in our society.

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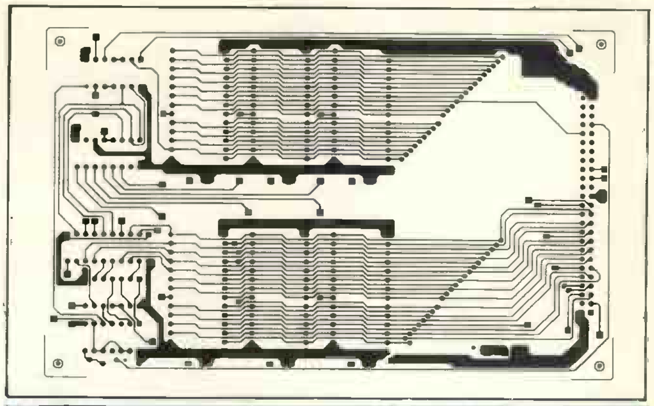

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HOW TO ENTER

Ed's quoted ten definitions for terms and names in regular electronic use, he's also given eight of the answers in a different order. Decide which answer goes with which definition and write it in the box. Two definitions are without quoted answers so into the relevant box just enter a name or term which you think is most appropriate.

The names of those with all the correct answers will be put into Ed's ex-Christmas hat on January 31st 1989 and the first three names drawn out will each win one of the three lcd tvs. The next three names drawn out will each win twelve month's free subscription to PE.

The winners will be announced in the April 1989 issue of PE, on sale from March 5th.

THE EDITOR'S DECISION IS FINAL!

Send the entry form to: ***Practical Electronics TV Competition, Intra House, 193 Uxbridge Road, London W12 9RA***

EIGHT OF THE ANSWERS:

Battery, capacitance, chip, Farad, Henry, impedance, microprocessor, resistance.

LCD TV ENTRY FORM

TEN DEFINITIONS:

- The property exhibited by two conductors separated by a dielectric, whereby an electric charge becomes stored between the conductors.
- A multicell device which generates dc electricity by means of electro-chemical action and having a current supplying capability usually expressed in amp-hours.
- One or more elements that contain the control unit and logic functions suitable for use as the central processing unit of a microcomputer or dedicated automatic control system.
- The absolute SI unit of electrostatic capacitance, defined as that which, when charged by a potential difference of one volt, carries a charge of one coulomb.
- The absolute SI unit of self and mutual inductance of a closed circuit in which one volt is produced by a current changing uniformly at one amp per second.
- A small slab, wafer, or die of dielectric or semiconductor material on which a subminiature component or circuit is formed.
- In electrical and acoustical fields the real part of the impedance characterised by the dissipation of energy as opposed to its storage.
- The total opposition offered by a circuit or device to the flow of alternating current, the symbol for which is Z, and having the ohm as its unit.
- The science magazine for serious electronics and computer enthusiasts celebrating its silver jubilee in 1989.
- A leading British organisation committed to innovation, design, technology and reliability in audio, hifi, tv and video.

NOT PART OF THE COMPETITION, BUT PLEASE TELL ME:

Have you access to a computer, if so what type?________________

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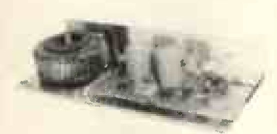

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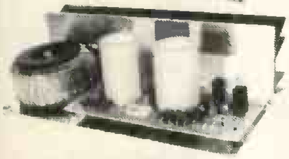

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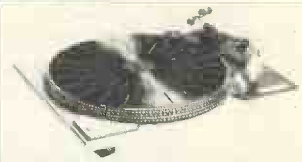

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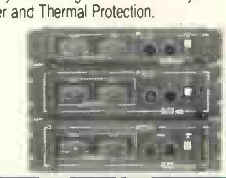

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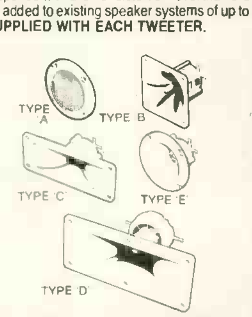

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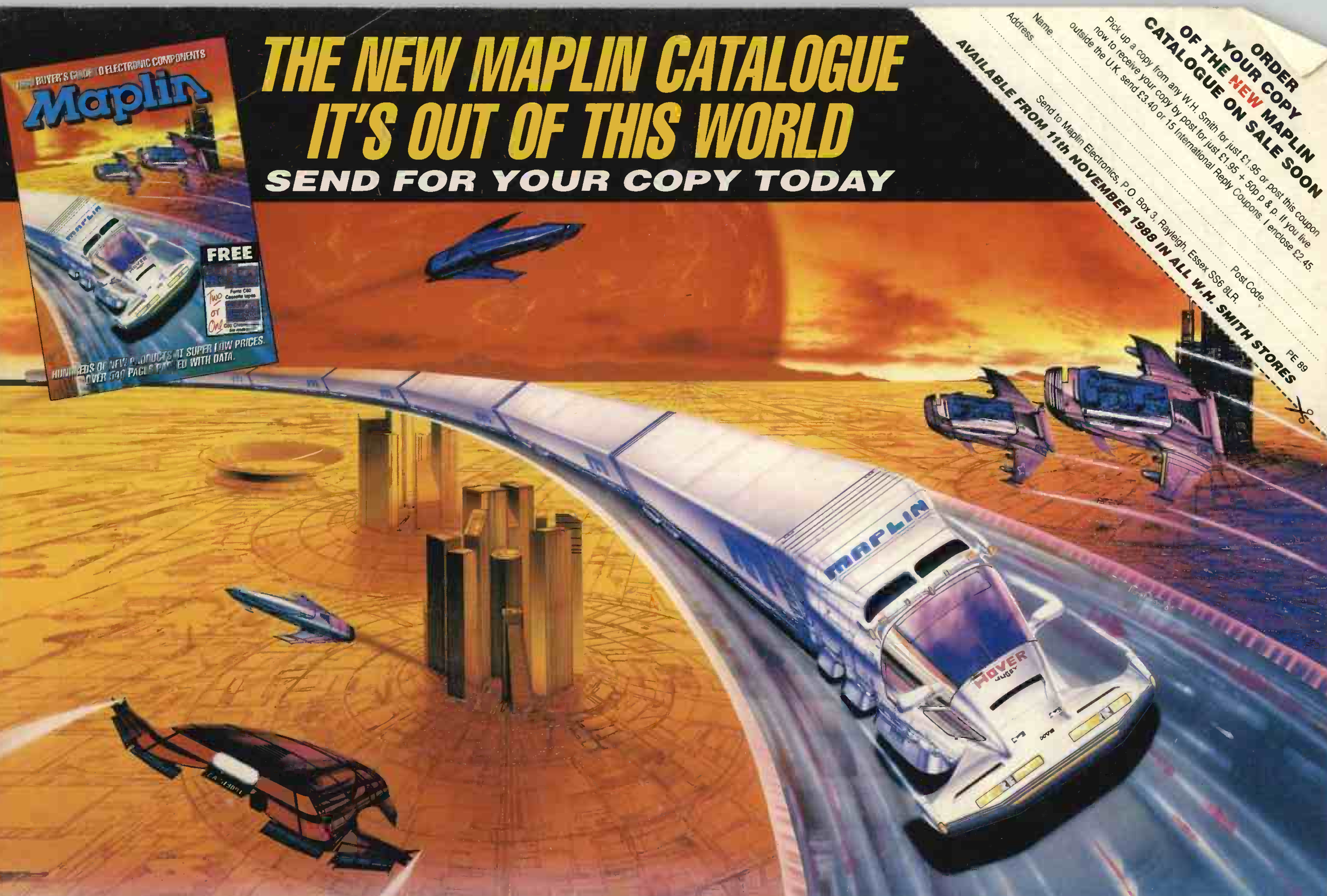
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