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and everything

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Your Spectrum as a development tool

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TV aerial booster project

FREQUENCY METER

Budget project for the
workshop

NEWS, REVIEWS, CIRCUIT IDEAS AND MORE

AUDIO • CO. G • MUSIC • DOMESTIC



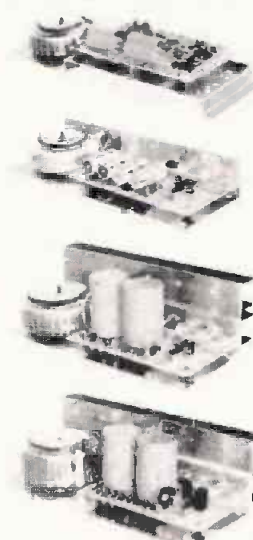
OMP POWER AMPLIFIER MODULES

PRICES INCLUDE V A T * PROMPT DELIVERIES * FRIENDLY SERVICE * LARGE S A E 28p STAMP FOR CURRENT LIST

OMP POWER AMPLIFIER MODULES

Now enjoy a world-wide reputation for quality, reliability and performance at a realistic price. Four models available to suit the needs of the professional and hobby market i.e. Industry, Leisure, Instrumental and Hi-Fi etc. When comparing prices, NOTE all models include Toroidal power supply, Integral heat sink, Glass fibre PCB, and Drive circuits to power compatible Vu meters. Open and short circuit protect.

Supplied ready built and tested.



OMP100 Mk II Bi-Polar Output power 110 watts R M S into 4 ohms, Frequency Response 15Hz - 30KHz -3dB, T.H.D. 0.01%, S.N.R. -118dB, Sens for Max output 500mV at 10K, Size 355 x 115 x 65mm
PRICE £33.99 - £3.00 P&P

OMP MF100 Mos-Fet Output power 110 watts R M S into 4 ohms, Frequency Response 1Hz - 100KHz -3dB, Damping Factor 80, Slew Rate 45V/uS, T.H.D. Typical 0.002%, Input Sensitivity 500mV, S.N.R. -125dB, Size 300 x 123 x 60mm
PRICE £39.99 + £3.00 P&P

OMP/MF200 Mos-Fet Output power 200 watts R M S into 4 ohms, Frequency Response 1Hz - 100KHz -3dB, Damping Factor 250, Slew Rate 50V/uS, T.H.D. Typical 0.001%, Input Sensitivity 500mV, S.N.R. -130dB, Size 300 x 150 x 100mm
PRICE £62.99 + £3.50 P&P

OMP/MF300 Mos-Fet Output power 300 watts R M S into 4 ohms, Frequency Response 1Hz - 100KHz -3dB, Damping Factor 350, Slew Rate 60V/uS, T.H.D. Typical 0.0008%, Input Sensitivity 500mV, S.N.R. -130dB, Size 330 x 147 x 102mm
PRICE £79.99 - £4.50 P&P

NOTE: Mos Fets are supplied as standard (100KHz bandwidth & Input Sensitivity 500mV) If required P.A. version (50KHz bandwidth & Input Sensitivity 775mV) Order - Standard or P.A.



Vu METER Compatible with our four amplifiers detailed above. A very accurate visual display employing 11 L.F.D. diodes (7 green, 4 red) plus an additional on/off indicator. Sophisticated logic control circuits for very fast rise and decay times. Tough moulded plastic case with tinted acrylic front. Size 84 x 27 x 45mm
PRICE £8.50 - 50p P&P

LOUDSPEAKERS 5" to 15" up to 400 WATTS R M S
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POWER RANGE
8" 50 WATT R M S Hi-Fi/Disco
20 oz magnet 1" ally voice coil Ground ally wiring esculchtein Res Freq 40Hz Freq Resp to 6KHz Sens 92dB PRICE £10.99 Available with track ferrite £11.99 P&P £1.50 ea
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50 oz magnet 2" ally voice coil Ground ally wiring esculchtein Die cast chassis White cone Res Freq 50Hz
25Hz Freq Resp to 4KHz Sens 95dB PRICE £28.50 - £3.00 P&P ea

McKENZIE
12" 85 WATT R.M.S. C1285GP Lead guitar/keyboard/Disco
2" ally voice coil Ally centre dome Res Freq 45Hz Freq Resp to 6.5KHz Sens 96dB PRICE £29.99 + £3.00 P&P ea
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Res. Freq. 45Hz Freq. Resp. to 14KHz PRICE £31.49 - £3.00 P&P ea
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3" ally voice coil Die-cast chassis Res. Freq. 40Hz Freq. Resp. to 4KHz PRICE £57.87 + £4.00 P&P ea
10" 60 WATT R.M.S. 1060GP Gen. Purpose Lead Guitar/Keyboard/Mid. P.A.
2" voice coil Res. Freq. 75Hz Freq. Resp. to 7.5KHz Sens 99dB PRICE £19.99 + £2.00 P&P
10" 200 WATT R.M.S. C10200GP Guitar, Keyboard, Disco
2" voice coil Res. Freq. 45Hz Freq. Resp. to 7KHz Sens 101dB PRICE £44.76 + £3.00 P&P
15" 200 WATT R.M.S. C15200 High Power Bass
Res Freq 40Hz Freq Resp to 5KHz Sens 101dB PRICE £62.41 + £4.00 P&P
15" 400 WATT R.M.S. C15400 High Power Bass
Res. Freq. 40Hz. Freq. Resp. to 4KHz Sens 102dB PRICE £89.52 + £4.00 P&P

WEM
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1" voice coil Res Freq 52Hz Freq Resp to 5KHz Sens 89dB PRICE £22.00 + £1.50 P&P ea
8" 150 WATT R.M.S. Multiple Array Disco etc.
1" voice coil Res Freq 48Hz Freq Resp to 5KHz Sens 92dB PRICE £32.00 + £1.50 P&P ea
10" 300 WATT R.M.S. Disco/Sound re-enforcement etc.
1" voice coil Res Freq 35Hz Freq Resp to 4KHz Sens 92dB PRICE £36.00 + £2.00 P&P ea
12" 300 WATT R.M.S. Disco/Sound re-enforcement etc.
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1" voice coil Res Freq 56Hz Freq Resp to 20KHz Sens 89dB PRICE £10.99 + £1.50 P&P ea
8" 60 WATT R.M.S. Hi-Fi/Multiple Array Disco etc.
1 1/2" voice coil Res Freq 38Hz Freq Resp to 20KHz Sens 89dB PRICE £12.99 + £1.50 P&P ea
10" 60 WATT R.M.S. Hi-Fi/Disco etc.
1 1/2" voice coil Res Freq 35Hz Freq Resp to 15KHz Sens 89dB PRICE £16.49 + £2.00 P&P

PANTEC HOBBY KITS. Proven designs including glass fibre printed circuit board and high quality components complete with instructions.

FM MICROTRANSMITTER (BUG) 90/105MHz with very sensitive microphone Range 100/300 metres. 57 x 46 x 14mm (9 volt) Price: £8.62 + 75p P&P.
3 WATT FM TRANSMITTER 3 WATT 85/115MHz varicap controlled professional performance. Range up to 3 miles 35 x 84 x 12mm (12 volt) Price: £14.49 + 75p P&P.
SINGLE CHANNEL RADIO CONTROLLED TRANSMITTER/RECEIVER 27MHz. Range up to 500 metres. Double coded modulation. Receiver output operates relay with 2amp/240 volt contacts. Ideal for many applications. Receiver 90 x 70 x 22mm (9/12 volt) Price: £17.82 Transmitter 80 x 50 x 15mm (9/12 volt) Price: £11.29 P&P + 75p each. S.A.E. for complete list



BURGLAR ALARM

Better to be 'Alarmed' than terrified
Thandar's famous 'Minder' Burglar Alarm System. Superior microwave principle. Supplied as three units complete with interconnection cable. FULLY GUARANTEED.

IDEAL for Work-shops, Factories, Offices, Home, etc. Supplied ready built



Control Unit - Houses microwave radar unit, range up to 15 metres adjustable by sensitivity control. Three position key operated fascia switch - off - test - armed. 30 second exit and entry delay.
Indoor alarm - Electronic swept freq siren 104dB output
Outdoor Alarm - Electronic swept freq siren 96dB output. Housed in a tamper proof heavy duty metal case.
Both the control unit and outdoor alarm contain rechargeable batteries which provide full protection during mains failure. Power requirement 200/260V AC 50/60Hz. Expandable with door sensors, panic buttons etc. Complete with instructions.

SAVE £138.00 Usual Price £228.85
BKE'S PRICE £89.99 + £4.00 P&P
Why buy a collection of self assembly boards

OMP LINNET LOUDSPEAKERS

The very best in quality and value. Made specially to suit today's need for compactness with high sound output levels. Finished in hard wearing black vinyl with protective corners, grille and carry handle. All models B ohms Full range 45Hz - 20KHz Size 20" 15" x 12" Watts R M S per cabinet Sensitivity 1W 1mtr dB



OMP 12-100 Watts 100dB. Price £149.99 per pair.
OMP 12-200 Watts 102dB. Price £199.99 per pair.
Delivery Securicor £8.00 per pair

OMP 19" STEREO RACK AMPS



Professional 19" cased Mos-Fet stereo amps. Used the World over in clubs, pubs, discos etc. With twin Vu meters, twin toroidal power supplies, XLR connections. MF600 Fan cooled. Three models (Ratings R M S into 4 ohms) Input Sensitivity 775mV
MF200 (100 - 100)W. £169.00 Securicor
MF400 (200 - 200)W. £228.85 Delivery
MF600 (300 - 300)W. £322.00 £10.00

1 K-WATT SLIDE DIMMER

- Control loads up to 1Kw
- Compact Size 4 1/2" x 1" x 2 1/2"
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- Full wave control using 8 amp triac
- Conforms to BS800
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PRICE £13.99 - 75p P&P

BSR P295 ELECTRONIC TURNTABLE

Electronic speed control 45 & 33 rpm. Plus Minus variable pitch control. Belt driven. Aluminium platter with slip mat. Cue lever. Anti-skate lever. Adjustable counter balance. Manual arm. Standard cartridge fixings. Supplied complete with cut out template. D.C. Operation 9.14V D.C. 65mA
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ADC 04 mag. cartridge for above Price £4.99 ea P&P 50p

PIEZO ELECTRIC TWEETERS - MOTOROLA

Join the Piezo revolution. The low dynamic mass (no voice coil) of a Piezo tweeter produces an improved transient response with a lower distortion level than ordinary dynamic tweeters. As a crossover is not required these units can be added to existing speaker systems of up to 100 watts (more if 2 put in series). FREE EXPLANATORY LEAFLETS SUPPLIED WITH EACH TWEETER.

TYPE 'A' (KSN2036A) 3" round with protective mesh. Ideal for bookshelf and medium sized hi-fi speakers. Price £4.90 each - 40p P&P
TYPE 'B' (KSN1005A) 3" Super horn for general purpose speakers. Case and P&P systems etc. Price £5.99 each - 40p P&P
TYPE 'C' (KSN6016) 3" with decorative horn. For hi-fi systems and audio systems. Price £6.99 each - 40p P&P
TYPE 'D' (KSN1025A) 3" F and D horn. For hi-fi systems. Price £6.99 each - 40p P&P
TYPE 'E' (KSN1026A) 3" horn tweeter with level control. Suitable for hi-fi systems. Price £8.99 each - 40p P&P
LEVEL CONTROL - This unit is used to control the level of the tweeter. It is connected to the tweeter via a 10k potentiometer. Price £3.99 each - 40p P&P

STEREO DISCO MIXER

STEREO DISCO MIXER with 2 Stereo R graphic equalisers and 10 LED Vu Meters. Many outstanding features. 5 Inputs with individual volume controls. Useful components. 3 Transistors. 3 WATT 4 ohm and 16 ohm outputs. 3 WATT 4 ohm and 16 ohm outputs. 3 WATT 4 ohm and 16 ohm outputs. 3 WATT 4 ohm and 16 ohm outputs. Price £7.24 25p

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PINEAPPLE SOFTWARE

Programs for the BBC model 'B', B+, Master and Master Compact with disc drive

DIAGRAM II - now also available for ARCHIMEDES

Diagram II is a completely new version of Pineapple's popular 'Diagram' drawing software. The new version has a whole host of additional features which make it into the most powerful and yet quick to use drawing program available for the BBC micro. The new features mean that 'Diagram II' can now be used for all types of drawings, not just circuit diagrams. Scale drawings are possible and the facilities for producing circles and rubber banded lines together with the pixel drawing routines make any type of drawing possible. This advert has been produced completely using Diagram II.

Summary of Diagram II features:-

1. Works on all model BBC computers and makes use of Shadow memory if poss.
2. Rapid line drawing routines with automatic joins for circuit diagrams.
3. Rubber band line and circle drawing modes.
4. Makes use of the Acorn GXR rom to produce ellipses, arcs, sectors, chords and flood filling.
5. Pixel drawing mode allows very fine detail to be added.
6. Defined areas of screen may be moved, copied, deleted or saved to disc.
7. On-screen cursor position indication allows scale drawings to be made.
8. Keyboard keys may be defined to print User Defined Characters allowing new character sets to be used.
9. Wordprocessor files may be loaded and formatted into defined areas.
10. Up to 655 UDC's if shadow memory available, 381 without shadow.
11. Compatible with Marconi Trackerball and most makes of 'mouse'.
12. All 'Diagram Utilities' are included.
13. Completely 'scalable' print routines allow any area of the diagram to be printed either horizontally or through 360deg. in scales that may be varied in 1% steps allowing up to 16 mode 0 screens to be printed on an A4 sheet (still with readable text).
14. Smooth scrolling over the whole area of the diagram.

Diagram II consists of a set of disc files and a 16k Eprom. The disc is formatted 40k side0 and 80k side2. Please state if this is unsuitable for your system, or if you require a 3.5" Compact disc

DIAGRAM II - £55.00 + vat P & P free

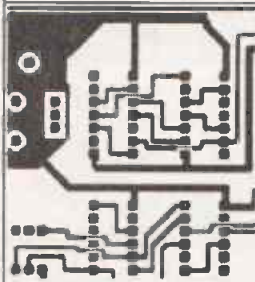
MARCONI TRACKERBALL

For Model 'B' and B+ (with Icon Artmaster)	60.00	+ vat
For Master 128 (with Pointer Rom)	60.00	+ vat
Bare Trackerball (no software)	49.00	+ vat
Pointer Rom (available separately)	12.50	+ vat
Trackerball to mouse adapters	9.00	+ vat
Postage and Packing on Trackerballs	1.75	

PCB

Pineapple's now famous PCB drafting aid produces complex double sided PCB's very rapidly using any model BBC micro and any FX compatible dot-matrix printer. The program is supplied on Eprom and uses a mode 1 screen to display the two sides of the board in red and blue either separately or superimposed. Component layout screens are also produced for a silk screen mask. The print routines allow a separate printout of each side of the board in an expanded definition high contrast 1:1 or 2:1 scale. The print time is typically about 5 mins. for a 1:1 print of a 7" x 5" board. This program has too many superb features to adequately describe here, so please write or 'phone for more details and sample printouts.

£85.00 + vat Plotter driver to suit most plotters £35.00 +vat



PCB AUTO-ROUTING

See review in this issue!

This brand new addition to the PCB program greatly increases the power of the software and speeds the design of PCB's even more. A list of up to 198 connections may be entered in the form of a 'rats nest' and then the computer does the rest! You may specify which side of the board you wish a track to be on or you may leave the choice to the computer, and you may also say whether tracks should be allowed to pass between I.C. pins. The program is in the form of a second Eprom and full features are available on a standard model 'B'. Please write or 'phone for full details.

COMPLETE AUTOROUTE PACKAGE £185.00 + VAT
(Including manual Eprom)

ADFS Utilities Rom

ADU is an invaluable utility for all ADFS users. It adds over 22 new commands to the ADFS filing system as well as providing an extensive Menu facility with over 35 sub commands covering areas such as repeated disc connection, saving and loading Rom images, auto booting of files and many more. Copying of DFS discs onto ADFS discs can be made in one pass with automatic creation of the required directories on the ADFS disc. All functions are fully compatible with Winchester drives including BACKUP which allows backing up of Winchesters onto multiple floppies. New commands are as follows:- ADU, *BACKUP, *CATALL, *CHANGE, *DFSADFS, *DIRALL, *DIRCOPY, *DIRDESTROY, *DIRREN+E, *DISCEDIT, *DRIVE, *FILEFIND, *FORMAT, *KILLADU, *LOCK, *MENU, *PURGE, *PURBK, *UNLOCK, *VERIFY, *VFORMAT, *WIPE

PRICE £29.00 + vat

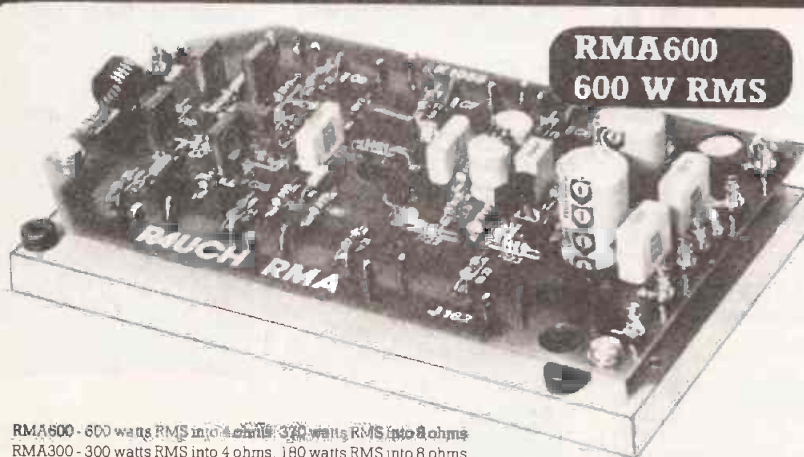
MITEYSPICE - Powerful A.C. & D.C. circuit analyser package - £119.00 +vat with Graphics output. Send for more details

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Access

PROFESSIONAL GRADE AMPLIFIER MODULES



RMA600
600 W RMS

RMA600 - 600 watts RMS into 4 ohms, 300 watts RMS into 8 ohms
RMA300 - 300 watts RMS into 4 ohms, 150 watts RMS into 8 ohms
RMA150 - 150 watts RMS into 4 ohms, 75 watts RMS into 8 ohms

Available for the first time, **MosFet** power amplifier modules derived from internationally acclaimed **RAUCH** Pro-Audio technology.

The **RMA** series of amplifier modules offer outstanding power handling capability and combine a 'Class A' driver stage with MosFet output devices to give Audiophile performance.

All of the **RMA** modules have been over designed for long term reliability, and are constructed on a glass-fibre solder resisted board with component legging. The power Mosfets are mounted under the PCB and bolted to a substantial 9mm thick aluminum mounting plate. This forms a compact and very robust package which can be easily mounted to the heatsink.

RAUCH
precision

RAUCH PRECISION ENG LTD
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BLACKHILL IND EST
SNITTERFIELD
STRATFORD ON AVON
WARKS CV37 0PT

GENERAL SPECIFICATION FOR ALL MODULES

Frequency response 20Hz - 20kHz, +0dB - -0.2dB
T.H.D. 0.01% @ 1kHz max, typically 0.003%
S.N.R. -110 db A weighted
Slew Rate 100v/uS
Input Sensitivity 0.775v RMS, 0dB
Dimensions 137 x 76 x 42mm
Weight 0.375Kg max

Note: the above specifications only apply when the modules are used with the correct power supply and heatsink, which we can supply, see listing below

PRICES excluding VAT and carriage

RMA600 Amp Module	£74.00 built	£65.00 kit
RMA300 Amp Module	£49.00 built	£41.00 kit
RMA150 Amp Module	£37.00 built	£30.00 kit
Toroidal transformer 800 VA 60-0-60v for RMA600	£36.00	
Toroidal transformer 500 VA 60-0-60v for RMA300	£26.00	
Toroidal transformer 200 VA 60-0-60v for RMA150	£17.00	
10,000 uf 100vW PSU capacitors with clamps	£11.80	
600v 35 amp bridge rectifiers	£ 2.90	
Heatsink 300 x 80 x 40mm 0.45 oC/W	£12.00	
24v DC fan 120mm (Papst)	£21.90	
24v DC fan 90mm (Papst)	£20.80	
Thermal switch, re-setting	£ 2.80	
DC protection card	£10.40 built	£ 8.50 kit

CARRIAGE £2.20 FOR ALL ORDERS, CHEQUE OR POSTAL ORDERS ONLY. S.A.E FOR FURTHER DETAILS, TRADE ENQUIRIES WELCOME!

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September

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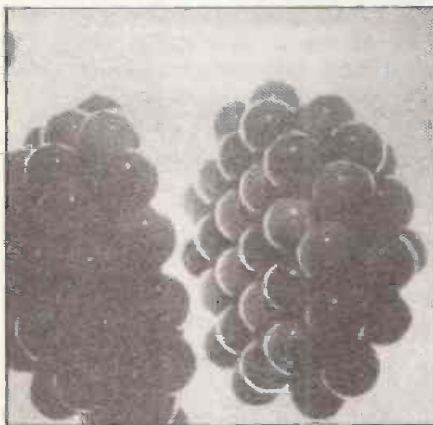
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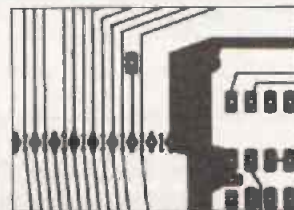
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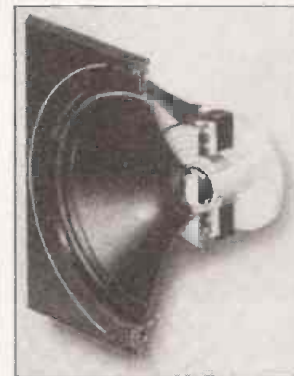


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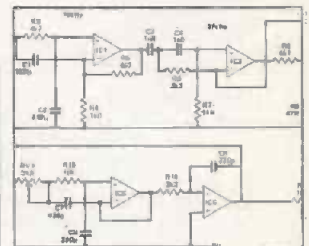


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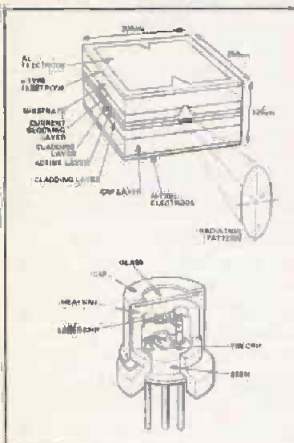
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Steve Malone goes deeper into theory than ever before with a complete explanation of the Universe along with instructions for building your own!

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Paul Chappell continues the *Circuit Theory* look at op-amps with an in-depth investigation of offset voltages



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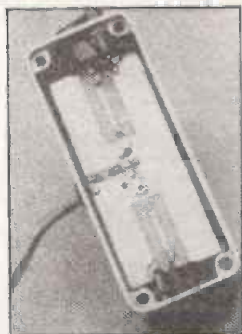
Brought To Light

Mike Barwise has found a cheap laser diode for experimentation or blinding the neighbour's cat and he is devoting this month's *Chip In* to handling this versatile device

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Speaking For Yourself

Malcolm Walmsley has emerged from the garage with sawn fingers, hammered thumbs and a pair of Maplin loudspeaker kits



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Keith Brindley takes to the road with a simple-to-build *1st Class* project to give you better TV pictures in your caravan or tent

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Frequency Meter

Low cost is the watchword for this useful item of workshop equipment from Mark Thewliss



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Graeme Durant, fresh from his exploits with the ETI Spectrum second processor has turned his humble home computer into a fully-fledged development tool

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Model Railway Circuits

Robert Penfold enters a second (or third?) childhood with a collection of *Tech Tips* for the model train fanatic



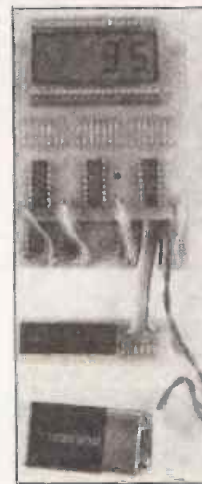
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No Holds Barred

More silly puns to announce the results of the July ETI bar code competition



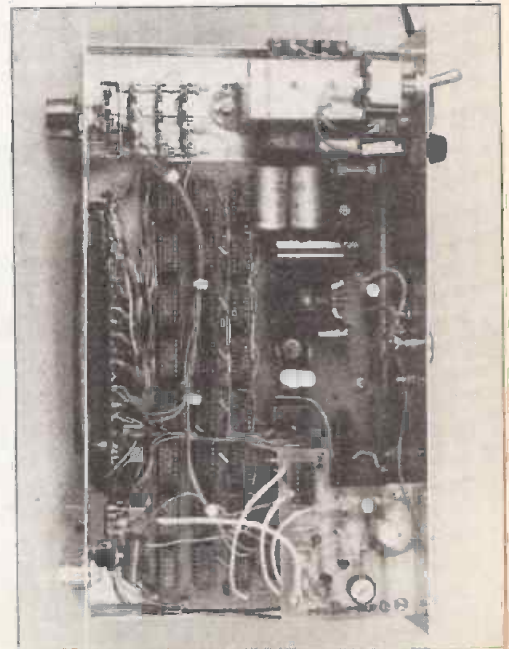
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Snooker balls, cue and bridge in the cover photo courtesy Lillywhites of Piccadilly Circus, London.

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NEWS

END OF INDI RECORDINGS

At last Indonesia has agreed to halt or at least curb music piracy of European recordings. Until May such flagrant disregard of copyright has been legal in Indonesia and vast numbers of unofficial copies have found their way into Europe, perhaps the most notorious example being the 'official' Live Aid cassettes in 1985.

The International Federation of Phonogram and Videogram Producers has been lobbying for action ever since pirating was sent underground in Singapore and Hong Kong and many copying operations moved to new bases in Indonesia. It is expected that the next shift will be on to the Philippines, although hopefully it will be some time before operations will grow to reach their present strength.

Indonesia's agreement to clamp down comes after an official investigation by the European Community, instigated primarily by the IFPPV.

IMPROVING ON PERFECTION



The 'perfect' sound of compact discs can be significantly improved, claims Arcam, the British hi-fi manufacturer based in Cambridge.

Arcam has launched a 'black box' digital audio interface that takes the delicate signal-converting stages of CD operation away from the host CD-player where RFI leaks from noisy drive mechanisms and processors can dull just the musical accuracy that the CD fraternity swears by.

The unit is based around one custom ASIC developed in conjunction with Newmarket Microsystems. The ASIC takes over the processing

tasks generally performed by some 25 standard CMOS chips — 1000 gates in all.

The launch has taken the hi-fi community somewhat by surprise — not least the Japanese electronics giants, whose earlier attempts to solve the problems resulted in add-ons that were prohibitively expensive for the consumer market.

The Black Box Digital Audio Interface will retain around £250.

Contact A&R Cambridge (Arcam), Pembroke Avenue, Waterbeach, Cambridge CB5 9PB Tel: (0223) 861550.

NICAM STEREO UPDATE

The slow stroll towards NICAM 728 stereo television continues with both the BBC and IBA moving for a national stereo network in the early years of the next decade.

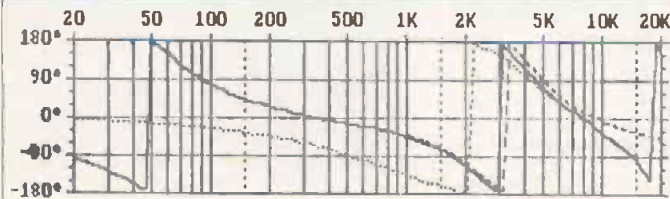
Although the BBC has officially shelved NICAM indefinitely with a review in 1991, recent directives to the Director of Engineering show that transmitters will continue to be updated to handle NICAM as routine maintenance takes place. This would produce a complete network by the end of the decade.

The feeling within the BBC is that a service of sorts may well be underway by then, in the same way that stereo radio was broadcasting nationally for two hours a day without being described as an official service.

The IBA is testing next year and should have a stereo service on both channels in London, Yorkshire and possibly Somerset in Autumn 1989, with a national service the following year.

Meanwhile you can tune your Nicam VCR to Wogan, Top of the Pops and various BBC outside broadcasts, all of which are regularly transmitted in stereo to the Home Counties.

SPEAKER DESIGN



ACAD package for loudspeaker optimisation has been produced by an Australian software house. CALSOD from Audiosoft uses curve fitting to develop minimum phase transfer functions for impedance and sound pressure response.

The program will handle a cross-over network of 60 components (passive only) and CALSOD

optimises the summed acoustic output of the multiway speaker system to get — or approximate — a desired response.

The mail order price to England is \$330Aus — about £150.

For full details write to Audiosoft, 128 Oriol Road, West Heidelberg 3081, Melbourne, Australia.

SOLAR FLAIR

The summer sun should be beating down on tanned ETI readers this month and TK Electronics has introduced some giant size solar cells to make the most of the hot house temperatures.

The panels are 12ins square, deposited on glass. Each panel can produce 200mA at 12V in bright sunlight — though TK is honest enough to estimate that most British summer days (dull and overcast) will

deliver about 60mA at 11.5V, still useful for trickle charging a car battery, or NiCds to run equipment after dark.

The panels cost £14.50 + VAT and there is a £1.75 postage charge to cover the careful packing of these delicate items.

Contact TK Electronics, 13 Boston Road, Ealing, London W7 3SJ. Tel: 01-567 8910.

SOCCER FANS SHOWN CARD



In an attempt to banish hooliganism from the terraces, Reading Football Club is issuing its supporters with PROM cards.

The scheme is being sponsored by British Rail South East, and pre-empts the Government's insistence that all League division grounds must introduce identity systems for the 1989 season. The cards use the Cardkey system from Datacard of Hampshire.

Club members pass their cards through a Cardkey reader on entry to the ground and any banned supporters will be refused entry and set off a security alarm.

The credit card format of data retention is becoming increasingly popular. Datacard now produces more than 70 million plastic cards a year.

Hakuto of Waltham Cross is now producing EEPROM cards as well as

SRAM, PROM, EPROM and OTP masked ROM formatted cards.

The latest 64kB 'smart cards' produced by Bull CP8 of France are finding applications throughout Europe and beyond.

The University of Rome has just issued 165000 cards to all students and staff for administrative tasks from enrolment to library registration.

In Australia, the Westpac Banking Corporation is using the Bull cards for its top business clients, providing a simple card-reader that interfaces with the client's PC, enabling them to conduct financial transactions by phone. Multiple access codes reduce the risk of fraud and other Australian banks are expected to follow suit.

For further information contact Datacard, New Lane, Havant PO9 2NR or Bull CP8, rue Eugene Henaff, BP45, 78193 Trappes Cedex, France. Tel: 33 1/30696050.

CURRIE MAKES MOVES

Controversy has arisen over a recent article in the quarterly newsletter of *Electronics and Computing for Peace* describing the shipping of obsolete medical electronics to hospitals in Nicaragua. The equipment was contravening the UK's Health and Safety laws and was due to be scrapped until it was saved in cooperation with the Nicaragua Health Fund for use in the third world. Safety regulations in South America are less stringent than our own and medical equipment is in short supply.

Enter Edwina Currie, brandishing a copy of ECP's newsletter and ordering an investigation by the NHS auditors. The NHS employees responsible suffered quite some embarrassment and distress for what would seem on the whole to have been a charitable act.

ECP has now sent an open letter to Mrs Currie asking that she decide whether electronic equipment that becomes available in future should be allowed to be used in third world countries, or whether it should be scrapped as NHS property.

For full information contact ECP on 01-341 2509.

FREEBIES

If you're short of things to read on the beach this month, dip into the ETI guide to freebie literature.

An interesting guide to making and commissioning videos is available from Documentary Video Associates, explaining in a compact 24-page booklet what video could do for you (and why DVA should do it). It normally costs £2.95, but mention ETI and you'll get it for free. Write to DVA, 16 Fernhill Road, Farnborough, Hants GU14 9RX.

British Telecom International has published a new guide to international data communications, covering mainly Datel and IPSS and aimed primarily at PC users. Not only is the handbook free, those awfully nice BT people have opened a Freephone line to order it on. Telephone (0800) 400435.

West Hyde has produced a summer leaflet covering various racks, boxes and bits (phone (0908) 640695) and JA Crew has issued a supplement to its 1988 hardware catalogue, available on (0908) 583252.

Hitachi has a 16-page brochure describing its ZTAT (Zero Turn Around Time) microcomputers. Write to Hitachi, 21 Upton Road, Watford, Herts WD1 7TB.

And lastly, for those in search of second-hand (but guaranteed) test gear, Instrumex has an 8 page list of available stuff. Telephone (0753) 44878.

SM TOOLS



Surface mounting electronics tools form the latest range of hardware from CK, the toolmakers.

Pliers and cutters are all box jointed with good solid grips, and the tweezers (nine varieties in all) are manufactured from anti-magnetic acid resistant steel.

For details of the full range contact CK, Pwllheli, Gwynedd LL53 5LH. Tel: (0758) 612254.

COPY KITTEN

A neat little portable plain paper photocopier has just hit the streets courtesy of Panasonic. The FN-P300 weighs just 6kg and can copy A4 or smaller using digital scanning (similar to fax scanning) and thermal printing. The front section of the unit is the A4 plate and the unit scans stationary pages rather than feeding sheets, which enables books and magazines to be copied — a feature often unable on other personal machines.

The FN-P300 is also cheaper than competition — it retails at £449 + VAT.

Information from Panasonic Office Automation, 300-318 Bath Road, Slough, Berkshire. Tel: (0753) 34522.

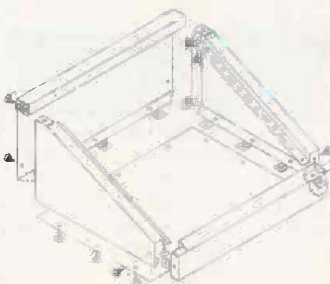
ON THE RACK

Nineteen inch rack mounting units are the specialisation of Rackz of Bristol.

Rackz produces a wide range of units (and the cabinets to slot them into), all constructed from 0.9mm PVC pre-coated steel with aluminium front panels. Enclosures are supplied in flatpack kit form with assembly instructions.

The latest range includes a sloped desk mixer (order code M6U) retailing at £29.

For details of the complete range contact Rackz, PO Box 1402, Mangotsfield, Bristol BS17 3RY. Tel: (0749) 840102.



PLANT GROWTH

Westcode, the Hawker Siddeley subsidiary, is helping put some marrow back into the backbone of the UK semiconductor industry by opening a new £8 million manufacturing plant in Chippenham, Wiltshire.

Westcode is using the plant to produce power semiconductor products to the highest standards for use within the UK and for export to Europe, North America and into the difficult marketplace of Japan.

The plant is one of the most sophisticated in Europe complete with ultra-clean facilities for producing uncontaminated silicon wafers. Electron beam evaporation, photolithographic and diffusion technologies are all catered for, with many production materials being specially processed in Westcode's new facilities.

For more information contact Westcode Semiconductors, Langley Road, Chippenham, Wiltshire SN15 1JL. Tel: (0249) 654141.

COURSES

The London Electronics College is now taking applicants for four new BTEC National Certificate courses starting in the autumn.

The four subjects are Software Engineering, Electronic Equipment Servicing, Computing Technology and Information Technology, and are designed to be especially useful to those wishing to retrain or update their knowledge of the latest technology.

The courses are full-time and take a year to complete. Prices can be obtained from the college — the courses do qualify for ATS grant aid and employer sponsorship might be worth seeking.

For prices and full information contact The London Electronics Centre, Penywern Road, London SW5 9SU. Tel: 01-373 8721.

REPLY FROM BT

Which?

STILL OUT
OF ORDER?

British Telecom has responded to the widely reported *Which?* magazine survey that concluded BT's performance since privatisation has been "a big disappointment"

BT is still a virtual monopoly in most areas and has little incentive to perform efficiently. The report recommends Government action to produce tougher legislation or effective competition.

British Telecom admits that through most of last year, many services were not up to its own targets. But the *Which?* survey is six months out of date, it points out, and was largely based on information gathered after last year's storms wrecked a third of the country's overland infrastructure.

Many of the services suggested by *Which?* such as itemised billing and compensation are already on the way. The OfTel agreement announced on July 7th brings a much wider range of services under price control. BT will now operate a price freeze until August 1989 followed by a 4-year OfTel price cap of 4.5% below increases in the RPI.

RND KITS

The Random Number Display from last month is now available in kit form from GP Electronic Services in Durham.

The complete kit includes all parts except the case and window filter and costs £24.98 including VAT and p&p. The case of the prototype was constructed from hardboard and a red plastic A4 wallet makes a good window filter for the 86 LED display.

GP is also supplying the PCB for the project at £9.98. It is not available from the ETI PCB Service as we started last month (orders sent there will be forwarded to GP).

Contact GP Electronic Services, 87 Willowtree Avenue, Durham DH1 1DZ.

READ/WRITE

WORDS OF WARNING

Recently a request for help arrived via the offices of ETI. A reader had tried everything he could think of to get a circuit of mine published in ETI *Tech Tips* to work and he was completely stymied. Some of his problems and the solutions to them serve as an example as to how to get the best from *Tech Tips*, and indeed from *Blueprint*.

The circuit was of a digital thermometer, published in the car special issue of ETI January 1987. Lack of space prevents me from reprinting the circuit but it used an ICL7107 DVM chip to measure the voltage output from an LM335 temperature sensor IC. A 'zero' voltage of 2.73V was applied to the negative differential input of the DVM so that the sensor output voltage at 0°C (2.73V) registers as 0 on the display.

The power supply to the DVM was from the car electrical system via a 5V regulator and the negative supply required to bias various portions of the chip was generated by a charge pump circuit clocked from the DVM clock signal. A CMOS buffer (4049 or 4050) was used to drive the charge pump.

The first problem noted was that the reference voltage could not be set to the specified 1V, measuring between ground and one end of the reference. The original *Tech Tip* did not specify where to measure the reference voltage but the 7107 has Ref Hi and Ref Lo terminals and the intention was that the reference voltage should be measured between the two terminals.

The instructions were brief, which is the nature of *Tech Tips* and the correspondent did not draw the obvious conclusion from the presence of two reference pins. With a *Tech Tip*, the reader is expected to notice and deduce things which would be explained in more detail in a proper project.

The second problem was that there was no negative power supply. The first cause of this problem was that there was a pin numbering error and the power supply pin of the 4049 was

labelled 16 rather than 1. Such small but crucial errors are always a danger when a diagram is transformed from a rough designer's sketch to a finished drawing. The original may have a small error which may be particularly hard to spot. Even if the original is correct, mistakes can occur at the redrawing stage. Such errors are hopefully rare, but unfortunately inevitable where humans are employed.

When the power to the 4049 was connected correctly, there was still not enough negative supply voltage. The likely possibilities are a misconnected component in the charge pump circuit or too much load on the output (a damaged decoupling capacitor or a fault in the DVM chip).

The third fault was that the display was fluctuating at some setting of the presets, and apparently incrementing in steps of more than one at other settings. Almost certainly the reason for this is that the reference voltage is set so low that very small changes on the input cause several digits' change on the display. For example, warming the temperature sensor gently could heat it up much faster than 1 least significant digit per measurement cycle. It is also unlikely that the display will show anything really sensible until the power supply voltages are correct. The lack of a proper negative supply could cause puzzling faults.

We can learn several things from all this. First of all, if something does not work and the power supplies are not correct, it is fruitless to try to correct any other apparent errors.

The difference between a project and a *Tech Tip* is that the project has been tested in detail and the *Tech Tip* might not have been. In the case of a project it may be realistic to build it as shown in the magazine and expect it to work without problem (if there are no construction errors). A *Tech Tip*, however, should be treated as a guide rather than a tested recipe.

Andrew Armstrong
Leighton Buzzard, Bedfordshire

HOT BREATH

Congratulations on the excellent heart and respiration rate monitor recently (and finally!) completed in the August issue of ETI.

This really is a remarkable device and a serious rival to many commercial units I have considered buying in the past (but much, much cheaper!)

In fact, it is mainly the heart rate section I am interested in (for medical experiments) and I must say that I have never before come across a commercial unit which combines the compactness, low cost and accuracy of your design. Thank you!

George Lawson
Maidstone, Kent

VENERABLE SAGE

After reading the news story in ETI June issue I bought a pair of the Sage Supermos modules and power supply components from Sage Audio.

I'm glad I did! I have heard many esoteric amplifiers in hi-fi shops costing up to £5000. Some of these are very good so I thought it would be interesting to compare the Sage amps with a friend's Kreil. I may have been hearing things but I couldn't believe my ears! The Supermos sound was effortless and much more relaxing to listen to.

After several months of comparisons my friend has finally swallowed his pride and built a Sage amp.

So, full marks to Sage Audio for an excellent product and friendly service, and to ETI my favourite high street mag. More hi-fi and sound articles please and less computer and printer projects.

L. Atkinson
Carlton, West Yorkshire



We have a pair of Sage Supermos modules here at ETI for review and so far it must be said that they live up to all that Sage claims for them. A full review of these modules will appear in ETI shortly.

Meanwhile, readers may like to refer back to the review of Sage Audio's Superamp bipolar amp modules in the May 1987 issue of ETI.

We shall be carrying further hi-fi projects in ETI in the near future but we can't promise to cut out all the computer and printer stuff too!

DISH OF THE DAY

A bit of bad timing, I fear. Why should I want a £1300 satellite television system courtesy of Pace and Vivor (your June/July competition) when I shall soon be able to have a complete system for £200 from Amstrad to watch Rupert Murdoch's new channels? If anything is going to kill off satellite TV (not that it requires much in the way of a death blow) it is the new satellite TV!

Who is going to watch Sky and Superchannel when all the new BSB channels appear. I bet all those who have already spent £1300-odd on an STV system are really kicking themselves now.

Alan Wilson
Neasden, London

Whoa! Not so fast. Don't dismiss satellite TV that easily. First, the Amstrad system will not be able to pick up signals from any other satellite except Astra (unless it is set up to point at another satellite, in which case it won't pick up Astra). Good STV systems (such as the prize in ETI's Reach For The Sky competition) have polar mounts and actuators so they can be pointed at any satellite between the horizons (local scenery permitting). Amstrad is promising an add-on to allow this with the £200 system but it is not known yet when this will appear or how much it will cost.

With a full large, steerable dish you are able to pick up many more channels from many more satellites and easily fit decoders or format changers to suit whatever you wish to watch.

Satellite TV is far from dead. There are now several hundred thousand STV receivers in the UK. Many millions more viewers will take to the skies when Amstrad's system comes along but this won't make redundant the dishes already out there. People didn't stop buying Rolls Royces when the Model T Ford was launched!

By the way, the existing Sky channel is one of Murdoch's.

CHOCOLATE BARS

Well you can't say I didn't try. Into Sainsbury's I boldly strode, hiding my July ETI among my basket of sickly chocolate cake and cured pork and as the girl on the till weighed up my mangoes I ran the ETI cover over their bar code machine.

Not a blip. Nothing. Just odd looks from the queue behind me.

Now come on ETI, did it mean anything? How am I supposed to work out how to read this — the cover was no simple 'wide or narrow' bar code like the ones for the project inside. What was the secret message? (This Saturday I try Sateways.)

(This Saturday I try Sateways.)
Nigel Griffiths
Peterborough, Cambridgeshire
How dare you, Sir! Of course there

was a meaning to the July cover (there's a deep philosophical meaning to all our covers — this month the meaning is that all matter is in fact made of bright plastic balls and that the Universe is finite and surrounded by six pockets!)

The code is much more complicated than the Bar Code Lock system.

It is in fact the EAN 13 figure system (as used on your chocolate cake and cured pork) and all is revealed in the competition results elsewhere in this issue!

Unfortunately the readers in Sainsbury's simply can't fit a code of these staggering proportions into their field of vision.

INSIGHT

Consumers in Britain accept new products and technology faster than anywhere else in Europe, concludes an extensive survey into the UK consumer electronics market.

The report shows the UK VCR market to be particularly buoyant. Last year the 'household penetration' of videos passed 50% and this year an estimated 2¼ million machines will be sold. Just under half of these are people replacing old recorders, primarily machines that were rented but many are converting to VHS from the now mortally wounded Beta format.

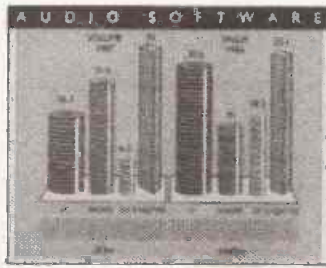
The most popular feature on new VHS machines last year was undoubtedly the twin-speed facility for long play of cassettes — and while hi-fi sound is becoming increasingly common, this is thanks more to the manufacturers than the consumers, who are unlikely to demand audio improvement until NICAM stereo TV is officially introduced.

The television market is also steadily rising, though ETI readers will surely be appalled to discover that the public rates the appearance of a TV as almost twice as important as the features it possesses. Price, reasonably enough, was more important than either. More than 4 million sets were shifted last year, with FST storming the large screen market.

TV rental has been declining in recent years, slowly levelling off at about 24% of the total large screen market. The current re-explanation of hire purchase as 'option three — rental with ownership after 3 years', may cause further decline.

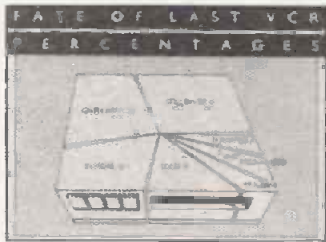
In the UK audio market, the continuing success story is of course compact disc. With prices still falling and disc catalogues blooming, the CD player is rapidly becoming an essential component of any music system. Although often criticised by hi-fi purists, the sound quality is a recognisable improvement over the mediocre turntables offered in comparable component and stack systems and UK consumers have taken the affluent image of the CD player to their hearts and their hi-fis.

The only declining area of CD is the personal player, and hardware manufacturers are planning to boost this market by pushing the 3-inch CD



over the next six months. In-car CD is still overcoming technical hiccups but is expected to take off over the next 12 months unless DAT can get its nose under the bonnet first.

Despite the CD onslaught, radio cassettes and to a lesser extent good old vinyl discs are still holding the vast majority of music sales — taking 65% of the market value last year.



The report holds nothing but optimism for the future. The video market will be boosted by the appearance of S-VHS in the autumn — particularly in the camcorder market although a summer lull in sales is likely until the new format cameras reach the market. CD-video should be briefly noted — although the success of CD-audio will certainly assist its introduction, it must be remembered that video discs have flumped once in the UK already.

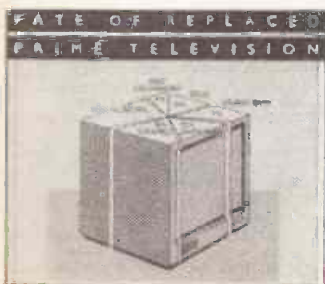
In the audio market the appearance of DAT is predicted to have only a small impact on CD sales if it manages to take off as a consumer product at all.

The report's greatest optimism is for the TV market, with satellite broadcasting producing a possible extra million units a year market by the mid-90s.

If the recently announced Murdoch-Sugar collaboration achieves its target, the market may be bigger still. They plan to get an Astra targeted system on the marketplace under £250 by broadcasting in PAL format, thus removing the expense of D-MAC conversion decoders.

That could be the lever that finally gets STV rolling as a mass market success.

The report *The UK Consumer Electronics Market* was prepared by Ferguson, Cambridge House, 270 Great Cambridge Road, Enfield, Middlesex EN1 1ND. Tel: 01-363 5353.



Advertisement

PCB Manufacturers — Which to choose?

With scores of PCB manufacturers falling over themselves to make your conventional boards, it can be very difficult to choose the right one.

You could however, choose a PCB manufacturer with more to offer. Such as, assembly, panel printing, final build and design.

Slee Electro Products can provide you with these services and will still offer you competitive prices on your PCB's.

"We're hot on quality and delivery too. And being a member of the Printed Circuit Association, means we have to try harder."

Slee Electro Products, Tel: 0226 200717, Fax: 0226 731817, Unit 4, Grange Lane Industrial Estate, Carrwood Road, Barnsley, South Yorkshire S71 5AS, England.

PROFESSIONAL SURVEILLANCE EQUIPMENT KITS

- **MTX** Micro-miniature VHF transmitter. The smallest kit on the market measuring market measuring an incredible 17mm x 17mm including on-board mic. Super sensitive. Fully tuneable over FM band. 9V operation with range up to 1000m. £10.95
- **VT500** High power version of the MTX with on-board PA stage providing 250mW of RF. Measures just 20mm x 40mm, power requirements 9-15V. Excellent sensitivity and stability. Fully tuneable over FM band. Ranges over 3000m can be expected. £12.95
- **VOX75** Voice-activated transmitter. Variable sensitivity trigger level switches transmitter on when sounds are detected. Stays on for time delay variable between 1-20 sec. Fully tuneable output covers all FM band. Very sensitive and low standby current through CMOS circuitry. 9V operation, range up to 1000m. Measures 30mm x 40mm. £15.95
- **CTX900** Sub-carrier scrambled transmitter. Audio is double modulated providing very secure transmissions. Any unauthorised listener will not be able to demodulate signal without DSX900 Decoder unit. Variable modulation on-board. Fully tuneable output covering FM band. 9V operation, range up to 1000m. Measures 30mm x 40mm. £18.95
- **DSX900** Decoder unit for CTX900. Connects to earphone output of receiver to descramble signal from CTX900. Monitor using small speaker or headphones. Variable decode frequency on-board for best resolution. 9-12V operation. Measures 36mm x 50mm. £17.95
- **TLX700** Micro size telephone transmitter. Connects onto line at any point and requires no batteries. Clearly transmits both sides of conversations on both incoming and outgoing calls. Undetectable by phone users. Fully tuneable output covering FM band. Range up to 1000m. Measures just 20mm x 20mm. £9.95
- **ATR2** Micro size telephone recording unit. Connects onto line at any point and connects into ANY normal cassette recorder, standard or micro having MIC and REM sockets. Requires no batteries. Switches recorder on silently when phone is used for incoming or outgoing calls, switches off when phone replaced. Clearly records both sides of conversations. Undetectable by phone users. Measures 10mm x 35mm. £10.95
- **XML900RF** Bug Detector/Locator. Wide band input circuitry detects presence of RF field and triggers flashing LED and piezo bleeper. Variable sensitivity enables source of transmission to be pinpointed to within 6 inches. Max sensitivity will detect MTX or similar transmitter at around 15-20 feet. 9V operation. Measures 55mm x 55mm. £21.95

All kits come fully documented with concise assembly and setting-up instructions high quality fibreglass PCB and all components necessary to complete the module. All prices are inclusive but please add £1.50 to cover P&P. Orders over £50.00 post free. Please state requirements clearly and enclose cheque or PO to cover.

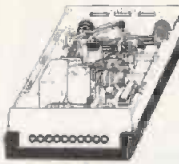
Phone orders on ACCESS or AMEX accepted. Tel: 0827 714476.
NOTE: It is illegal to operate a transmitter in the UK without a licence.
Send 9x4 S.A.E. for full catalogue of these and other surveillance kits.

SUMA DESIGNS, THE WORKSHOPS, 95 MAIN ROAD, BAKTERLEY, Nr. ATHERSTONE, WARMS CV9 2LE. TEL: 0827 714476

POWER CONDITIONER

FEATURED IN ETI
JANUARY 1988

The ultimate mains purifier. Intended mainly for lowering the noise floor and improving the analytical qualities of top-flight audio equipment.



The massive filter section contains thirteen capacitors and two current balanced inductors, together with a bank of six VDRs to remove every last trace of impulsive and RF interference. A ten LED logarithmic display gives a second by second indication of the amount of interference removed. Our approved parts set consists of case, PCB, all components (including high permeability toroidal cores, ICs, transistors, class X and Y suppression capacitors, VDRs, etc.) and full instructions.

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 lets you see what the main lights are doing.

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

The parts set consists of box, PCB and components for control PCB and components for sequence board, and full instructions.

Lamps not included.
PARTS SET £19.90 + VAT

RAINY DAY PROJECTS



All can be built in an afternoon!

JUMPIN' JACK FLASH (ETI March 1988)

Spectacular rock stage and disco lighting effect

£6.90 + VAT

CREDIT CARD CASINO (ETI March 1987)

The wicked pocket gambling machine

£5.90 + VAT

MAINS CONTROLLER (ETI January 1987)

Isolated logic to mains interface

£6.20 + VAT

MATCHBOX AMPLIFIERS (ETI April 1986)

Listen: 50W of Hi-Fi power from an amp small enough to fit in a matchbox!

£6.50 + VAT

Matchbox Amplifier (20W)

£8.90 + VAT

Matchbox Bridge Amplifier IC with data and circuits

£3.90 + VAT

TACHO/DWELL METER (ETI January 1987)

Turn your Metro into a Porsche!

£16.40 + VAT

HI-FI POWER METER (ETI May 1987)

Measures Hi-Fi output power up to 100W

£3.90 + VAT

Measures Hi-Fi output power up to 100W - includes PCB components meters

£7.20 + VAT

Mono power meter

£3.90 + VAT

Stereo power meter

£7.20 + VAT



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 18 6555 timer crystals, 75 resistors, 10 capacitors, 10 LEDs, 1000 Ohm potentiometer, LCD switches, 500 Ohm potentiometer, 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, circuit construction details and further information (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 irresistibly 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!

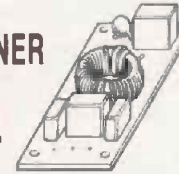
The approved parts set consists of PCB, all components, controls, loudspeaker, knobs, lamp, fuseholders, fuse, mains power supply, prestige case and full instructions.

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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 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?

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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).

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, undistorted 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?

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BIO-FEEDBACK

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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.

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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.

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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).

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BRAINWAVE MONITOR



FEATURED IN ETI
AUGUST 1987

The most ambitious project ever to have appeared in any 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 not good at.

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Next Month
in



ELECTRONICS
TODAY INTERNATIONAL

Next month ETI is more than usually educational. To coincide with the start of the new academic year, the October issue is a careers and educational special. If you are about to look for an electronics course to take on after A-levels, you'll want to read the ETI low down on the types of course (diplomas, and degrees) available to the school leaver. If you are about to get your degree or HND we have information on the jobs available — the companies and who they are looking for.

For those ETI readers already far beyond all this and now teaching others, we reveal how electronics teaching is changing with the new GCSE curriculum and what the teachers really want.

Projects are not forgotten in the October issue. For the beginners we have a deafening bicycle siren to frighten the neighbours, a sophisticated peak programme meter for your hi-fi or recording studio and a super-powerful fully variable air ioniser. Plus, there's news, reviews, and lots, lots more in the high-octane October issue.

**Don't be an ocker, get the October ETI
— out Sept 2nd**

The articles mentioned here are in preparation but circumstances may prevent publication

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IT'S A SMALL WORLD

Stephen Malone
accepts no
responsibility for any
universe created using
the forces described in
this look at state-of-
the-quark physics

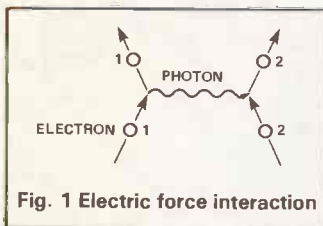
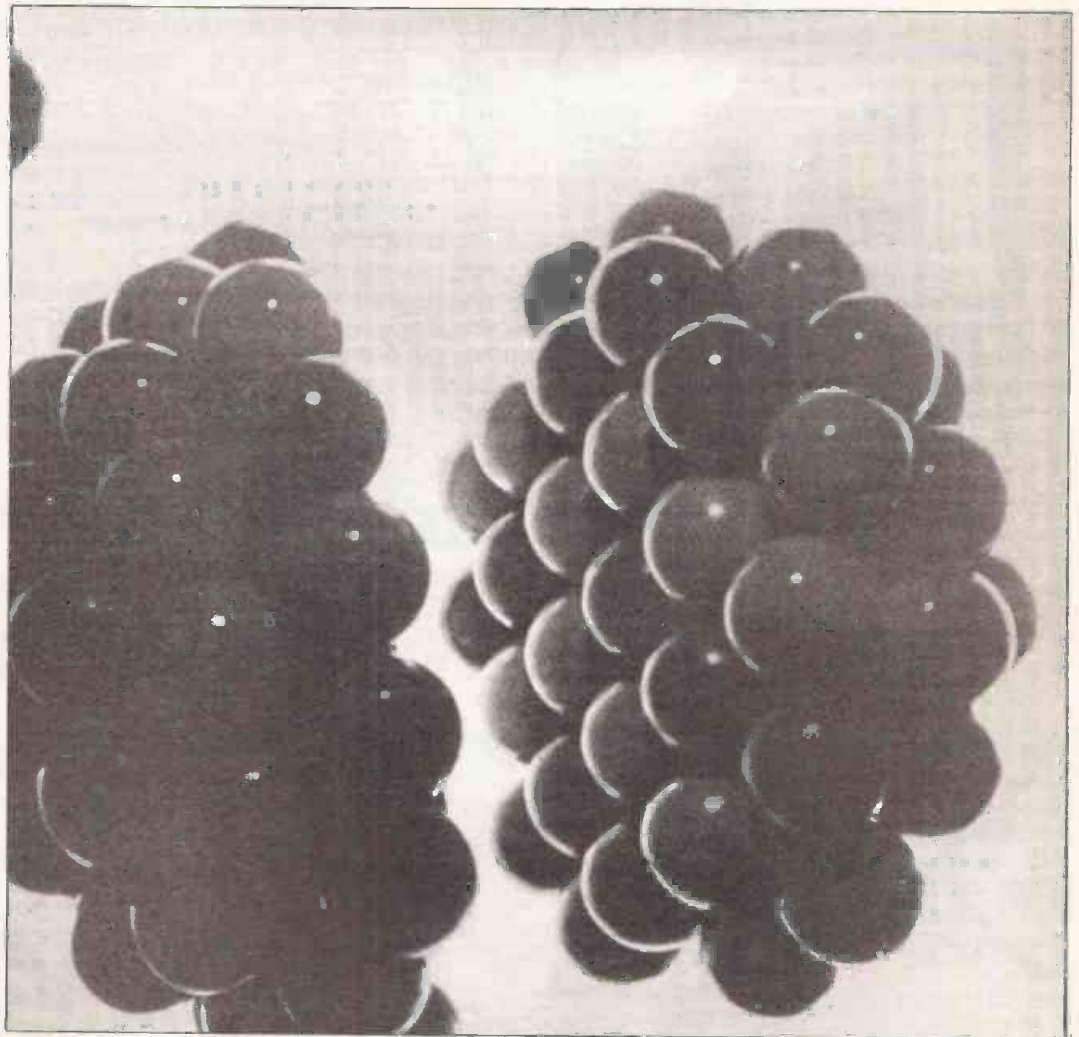


Fig. 1 Electric force interaction

PARTICLE PHYSICS

Does matter exist? We really should be told. For decades scientists have been 'discovering' particles that are getting smaller and smaller and smaller. Some people are now wondering if there is actually anything there at all.

For most of this century following the confirmation of the nuclear model of the atom, scientists have been engaged in a search for *the* fundamental forces and *the* fundamental particles of nature.

It was all getting along fine until Heisenberg hit them with electrons being waves and particles at the same time. And although they took that on board, as they peered deeper things seemed to dissolve in the uncertainties of Quantum Theory.

So what is really there among the fuzz of quantised energy and empty space? What holds it all together? Why does it hurt when you walk into a wall? Well since you ask . . .

Force-carrying Particles and Sub-atomic Structure

First the electric force. The tricky thing about electromagnetic interaction is that it involves action

at a distance — you waggle an electron over here and it affects that one over there. But the reaction is not instantaneous, the force travels at the speed of light (even thinking in the abstract doesn't mean you can violate the Theory of Relativity!).

But what is the force? What travels at the speed of light?

Well, the force-carrying particle is a photon (or indeed a wave-packet of electromagnetic energy, but if you don't know what that is, forget it). See Fig. 1.

Richard Feynman won himself a Nobel prize for coming up with these nifty little diagrams — they're actually very useful for doing the maths as well as looking pretty. In practice the two electrons would swap many photons back and forth in the course of the encounter, but the simpler diagram is easier to understand.

Okay, but where do the photons come from? (I was afraid you might ask that.)

Heisenberg's Uncertainty Principle

This is generally expressed in terms of momentum and position, $\delta P_x \delta x \geq h$ — the more exactly we know the position of our particle, the less exactly we know

its momentum and vice versa (well, it stands to reason really — we can only measure the momentum by letting it move — so where is it? Somewhere between here and there. And if we fix it to an exact spot at an exact moment in time, how can we measure its momentum?).

However we can equally validly express it as $\delta E \cdot \delta t \geq h$ (you can do the dimensional analysis yourself), and energy and time are what we are concerned with here.

In any given very short period of time, there is a very large uncertainty in the amount of energy present, and as Einstein said $E = mc^2$. So, with a flick of the wrist, nothing up my sleeve guy, honest, we have our photon.

It doesn't last long of course, it's not allowed to — but the electron keeps at it, flashing on and off as it moves along (about 1:137 on:off, don't ask me why). And when it meets another one, a quick barrage of imaginary energy and away they go.

The scientists had lots of fun arguing about whether these particles of light were real or not — they are by definition impossible to detect or measure — and in the end plumped for calling them 'virtual particles'. But virtual or not they can change the world around them — much as you could get a million pounds out of the Autobank on Friday night, buy a cut-price Van Gogh in America and sell it in Japan (but only for a million again, don't forget the conservation of energy) and then get the money back in the bank first thing Monday. You've changed the world by moving a Van Gogh across the world and a million pounds in the other direction, without your bank balance changing at all!

Of course there's more fun to be had with this. Virtual energy can exist even in empty space because of the impossibility of measuring its lack of energy instantaneously (nice sentence, though of course it's really the 3K microwave background that we're failing to measure accurately instantaneously).

This energy can create short lived pairs of particles and anti-particles as in Fig. 2. These are always in pairs — can't go round changing the total amount of matter in the universe with virtual energy now can we! Empty space could be thought of as seething with short-lived particles — electrons and anti-electrons, protons and anti-protons (shorter lived because heavier) and so on.

So, what about our little photon. Well the photon passing between the two electrons could be thought of as consisting of an electron and an anti-electron (Fig. 3). This is perhaps more figurative than literal — most photons would not be energetic enough to actually materialise a pair of particles — but the electric charges cancel out and the combination works just like a photon.

So why don't they annihilate each other? Well, you could say they do — and the product of the annihilation is our friendly photon. But it is a useful convention, emphasising that the force carrier exists at the very interface of the universe and anti-universe, and since the creation of a matter/anti-matter pair need not alter the net contents of the universe they are very useful for carrying a force whenever the need arises.

Mesonic Handshakes

The *strong nuclear force* is around 100 times stronger than the photon-carried electric force and is carried by mesons. This force holds nuclei together as in Fig. 4 (okay so it's an attractive force, but this is the convention in these diagrams).

Why does it operate on so short a range? Well mesons are heavy, it takes a lot of energy to make one,

they don't last long and don't go very far — but protons flash with mesons the way electrons flash with photons.

That's all about the Strong Force for a while, but if you hang in there we'll come round to these mesons again.

Confused yet? No? Okay then, here goes nothing! Ever wondered how a star manages to burn hydrogen to make helium — four protons giving two protons and two neutrons? Something is changing protons into neutrons. You can go on like this as far as iron. To get your heavy elements first explode your star — the resulting neutrons tack on to existing nuclei, some of them become protons — hey presto, a heavier element. Something is changing neutrons into protons.

The Weak Force

This is a tricky one. It's not a force in the sense of an attraction or repulsion, but we're swapping 'force'

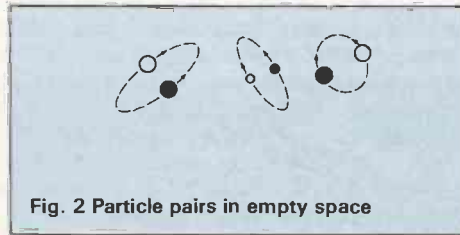


Fig. 2 Particle pairs in empty space

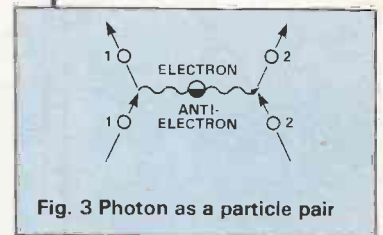


Fig. 3 Photon as a particle pair

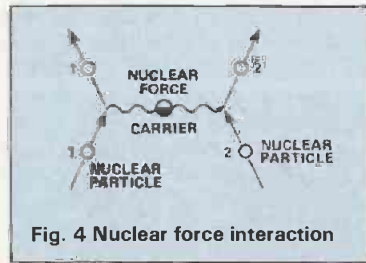


Fig. 4 Nuclear force interaction

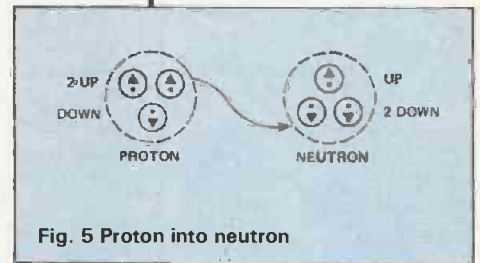


Fig. 5 Proton into neutron

carrying particles around and by a roundabout route it links with the electric force — the first glimmerings of unification.

Changing protons into neutrons involves us with quarks. There'll be more later, but for now we just need two — the up quark and the down quark. Protons are made of two up quarks and one down quark, neutrons of one up and two down. So for proton into neutron we have the change shown in Fig. 5, or more exactly Fig. 6.

But what's actually happening here? How does the up quark become a down quark? Brace yourself — here come some more pairs of imaginary particles.

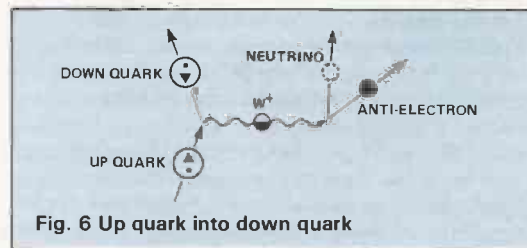


Fig. 6 Up quark into down quark

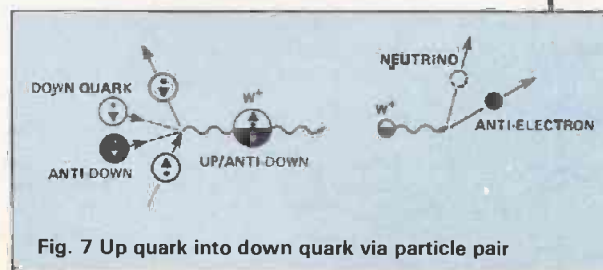


Fig. 7 Up quark into down quark via particle pair

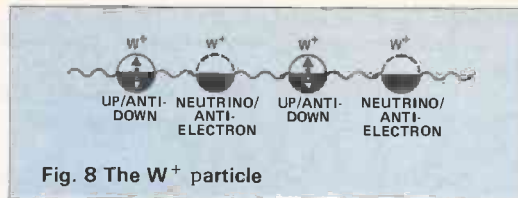


Fig. 8 The W^+ particle

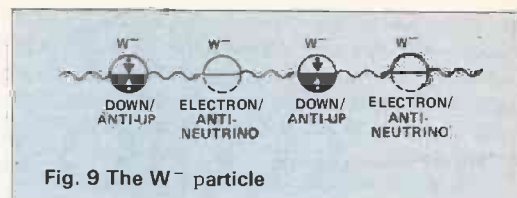


Fig. 9 The W^- particle

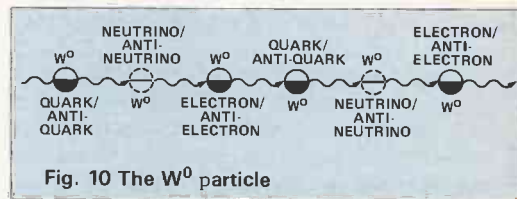


Fig. 10 The W^0 particle

Remembering our uncertainty about the matter/energy present at any time, we can look at it as in Fig. 7. The up quark is replaced by the down, leaving us with an up/anti-down pair which is the force carrying particle, the W^+ boson (you could look at the electric force the same way, but it's a rather trivial case as the substitution of an electron for an electron goes largely unnoticed).

On the right of fig. 7 we have our W^+ boson breaking down into a neutrino and an anti-electron — it could be thought of as being made of a neutrino/anti-electron pair.

Actually it's an elusive swine our W^+ boson, fond of disguises, never know what it's going to be from one moment to the next (Fig. 8).

The opposite process — neutron into proton (or down quark into up quark) gives us the W^- boson (Fig. 9). The + and - denote real unit charge (as you'll see if you balance both sides of the proton \leftrightarrow neutron equation — down quarks have $-1/3$ charge, up quarks $2/3$ charge if that helps).

But there are other interactions where no change of charge is involved, such as interactions between neutrinos and quarks where the neutrino remains unchanged. This brings us to the W^0 boson in Fig. 10. Among the repertoire of our W^0 boson we find an electron/anti-electron pair — say hello to the electric force! But how do the W particles vary their constitution? Well, remember we are dealing with particle/anti-particle pairs. It is not so much that an up/anti-down pair is the same as a neutrino/anti-electron pair but rather that the difference between the pairs of particles is the same in each case.

So is the electric force carried by W^0 bosons then? And if not, what's the difference? Well, the W^0 particles are very short range, very heavy, it takes a lot of energy to make one. They could indeed be considered as freak cases of the electric force — if only one force - carrying photon in a thousand behaved this way, it would account for all the weak force interactions that take place.

This is the first breakthrough in the direction of the legendary Unified Field Theory (nowadays it's the Grand Unified Theory and they seem to be pretty much there except for the elusive graviton). Of course it wasn't worked out with pretty pictures, they were really very deep in some hairy mathematics — but it's so much easier to talk about some generalised 'gauge theory' than to get into gauge transformations of wave equations which is what the theorists were up to their eyes in.

Gauge theory? Well, that's what helped them tie up the loose ends in the maths. The possibility of multiple exchanges of force carrying particles kept giving uncomfortable answers with apparently infinite forces, but Gerald 't Hooft (I only introduce him because of that name!) came up with the gauge transformation as a mathematically valid way of providing limits to the equations and it all hung together.

The main implication for the heavy, short range force carriers is that they feel the force themselves (Fig. 11). Two particles approaching each other both send out force carrying particles. These meet in the middle and feel each other's effects which modifies their behaviour.

More Quarks

Although all the matter we meet from day to day is made up of protons/neutrons/electrons in more exotic environments (ranging from cosmic ray interactions at the surface of the atmosphere to the heart of exploding stars) peculiar variants on the proton and neutron are to be found. These consist of variations on the three quark (up/down) structure of the proton using any three of the six available quarks in Fig. 12. The meson family of particles is made of any pair of quark/anti-quarks.

Perming any three from six gives us a large family of proton related particles, the more so when we take quark spin into account. With mesons it's fairly straightforward (Fig. 13), for the proton relatives slightly more complicated (Fig. 14).

So looking at just the up-down-strange combinations we have the tree for the 'souped-up' particles shown in Fig. 15. Throw in charm as well and we've got a pyramid of combinations with ccc at the apex — I won't even think about trying to represent the picture with the truth and beauty quarks thrown in, but you get the idea.

So far, so good. But then the scientists began wondering quite what was sticking the quarks together in these combinations and came up with the gluons . . . and quantum chromodynamics.

The Colour Force

So why are we only allowed certain quark combinations: three quarks for protons, or quark/anti-quark in a force carrier? Why not a pair of ordinary quarks, or four quarks together? And why no lone quarks?

This is where the colour theory comes in. It proposes a new quality of matter (roughly comparable with electric charge) called 'colour'. Of course the quarks aren't really coloured in the macroscopic sense, but the analogy proves useful.

All observable particles must be 'white', but the whiteness can be produced by mixing colours in various ways (Fig. 16). The proton family are made up of one red quark, one green and one blue (anti-protons of one turquoise, one mauve, one yellow). The mesons combine a coloured quark with the appropriately anti-coloured anti-quark.

The assignment of a colour to a quark has no connection with what type of quark it is. Any quark can be red, green or blue — in fact the operation of the colour force requires that each quark in the proton is forever changing its colour (though the combination must remain white).

The force carrying particles for the colour force are our gluons. Because they are never seen outside the proton they can be non-white (the colour doesn't have to be matched by its anti-colour), and we have a variety of coloured gluons.

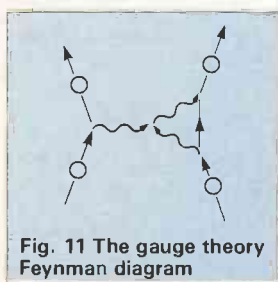
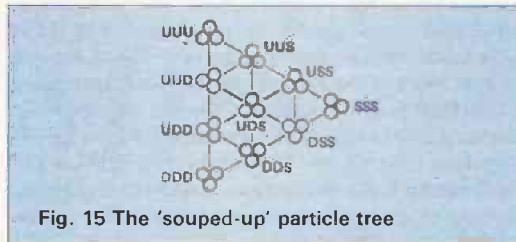
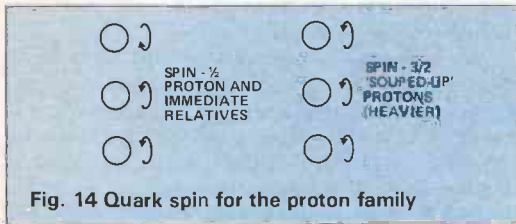
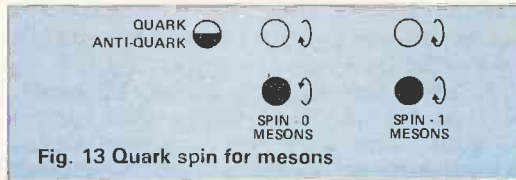
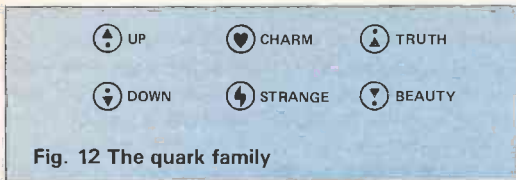


Fig. 11 The gauge theory Feynman diagram

PARTICLE PHYSICS



red-mauve green-turquoise blue-turquoise
red-yellow green-yellow blue-mauve

In addition there are the red-turquoise, green-mauve and blue-yellow which, though you and I might think make three white gluons, in fact for 'subtle reasons of group theory' mix together to make two 'off-white' combinations. Well that's what the theorists insist — giving us the family of eight gluons, shown in Fig. 17.

The force carrying gluons shuttle about between the three quarks of a proton changing their colours. The operation of six 'charges', (three colours and three anti-colours), compared with just two (+ and -) for the electric force means that the colour force is very strong indeed. But the force is essentially the same kind as the other cosmic forces and we can still draw our pretty Feynman diagram (Fig. 18). Or, remembering that coloured gluons would themselves feel the colour force, we can fit it into the gauge theory and have this diagram (Fig. 19).

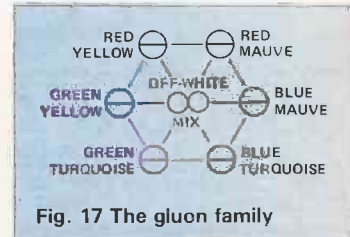
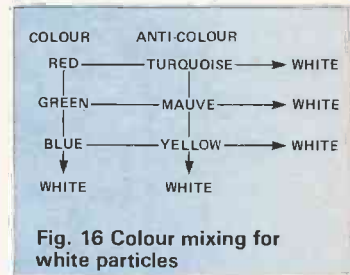
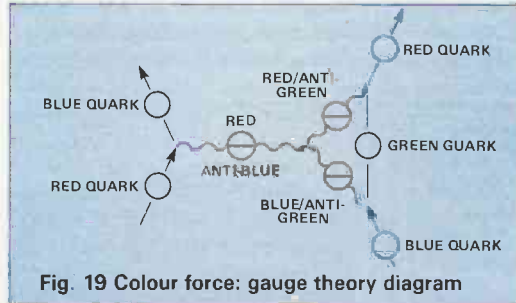
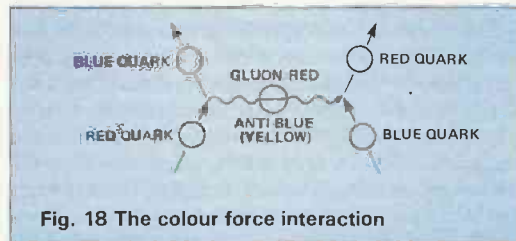
One of the peculiarities of the colour force is that the force is fairly weak at short ranges, but as the quarks move further apart they feel a stronger and stronger force binding them within the proton. One way of looking at this phenomenon is to consider the network of interactions over a larger distance as forming 'strings' between the quarks (Fig. 20). The strings are conceived of as white, each gluon cancelling the colours of its neighbours (on the very small scale, at the 'centre' of the proton, you would still have red, green and blue colours exposed and interacting).

If you tried to pull a quark out of a proton, you could only move it by making the string longer, putting in enough energy to create another gluon. This amount of energy doesn't decrease the further away you get, so the force remains as strong.

But can you break the string by pulling hard enough? Wouldn't this give you a lone quark? Well, no — because that would be like asking for a piece of string with only one end, or a single pole magnet. Snapping the string simply exposes new quarks at the broken ends (Fig. 21). The exposed end of the string running back to the rest of the proton has the same colour as the original quark, so the proton remains unchanged. All you have managed to do with your input of energy is to create a new particle — a perfectly ordinary particle, a quark/anti-quark pair of opposite colours — an ordinary 'white' meson, the strong force carrier. And this is where the strong force and the colour force tie together.

The relation of the colour force to the strong force is similar to that of the electric force to the Van der Waal's force between molecules in liquids. A normal molecule is electrically neutral — a normal particle of nuclear matter is colour neutral (white). The Van der Waal's force arises through electric resonance between

electrons in neighbouring molecules even though they are tethered within the molecule by electric force. Similarly, even though quarks are tethered within nuclear particles by the colour force they can exchange relatively feeble 'vibrations' in the form of white force-carrying particles (Unified Field Theory? Who mentioned the Unified Field Theory?).

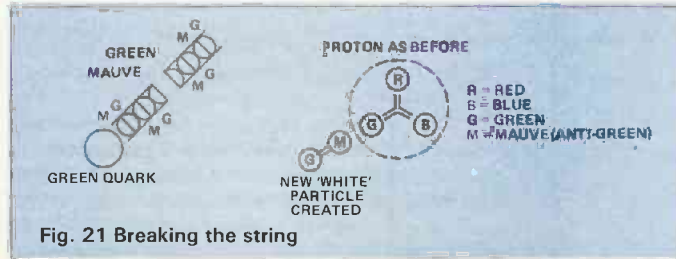
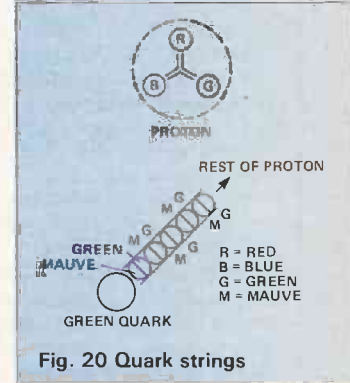


And There's More

What? More — you want more? No, I'm afraid that's it. Those are your fundamental forces (ok, ok, so I've left out gravity, but they haven't quite sorted that out yet) and your fundamental particles — the quark family and the electron/neutrino family. Gluons don't have to be more fundamental than quarks — quarks aren't made of gluons. As we have seen gluons are very much akin to mesons and in one sense we could say gluons are made of quarks.)

But what is this with these multiple fundamental particles? Couldn't there be one thing from which all these others are built? Well, yes there is — it's called energy.

Everything's made of energy. One type of energy distribution makes up quarks, with minor variations



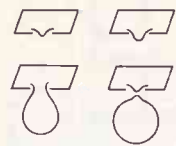


Fig. 22 Creating a child universe

PARTICLE PHYSICS

giving us the different types. Add the requisite ones together and you get a net energy distribution that behaves just like a proton — well it is one.

Electrons are energy (even gravitons are energy). We know that everything is Unified, it's all made of energy — what we're after is a mathematical description that will predict and explain the universe.

So if it's all just energy, why do we see objects as solid? Well, we're seeing photons reflected by these large scale organisations of energy. What are we feeling? We feel the average of incalculable numbers of interactions at the atomic level — we feel what that electric pulse travelling to the brain tells us to feel. And why does it hurt when we walk into a wall? For the same reason that a Maglev train stays hovering above the rails — energy in the right configuration can be pretty damn solid when it wants.

Okay, so there you have the basis of modern nuclear theory — but they sorted most of that out ten years ago. What's new? Superstring theory, that's what.

This starts with the idea of supersymmetry — the proposal that every force carrying particle (gluon, graviton and so on) must have a partner in the material world (gluino, gravitino). Or that every particle in the 'world' has a corresponding particle on the 'world'/anti-world interface where force carriers exist (and then a further corresponding particle in the anti-world, such as electron-selectron-positron).

And strings? Well, here comes another mathematical conceit. All attempts to include gravity in the above theories kept bringing in awkward infinities again. This all comes about because the physicists, when they're not treating them as waves, treat their particles as mathematical points. If on the other hand you look on them as strings, little one-dimensional lines, things start to look friendly again.

Not only does the problem with infinities vanish, but gravity doesn't need to be added to the theory — it's already there. Gravity — specifically a graviton with zero mass and spin 2 — is a necessary part of any workable string theory of the particle world. Now they've just got to find the elusive little particles.

That's your lot. I shall pause only to add an interesting cosmological rider on the quantum fluctuations due to $\delta E \cdot \delta t \geq \hbar$.

In general relativity, gravity and mass have opposite energies — we label mass as positive energy and gravity as negative energy. It is possible that the gravity of the universe exactly cancels out its mass so that the overall energy of the universe is arbitrarily close to zero. If so, then the universe could be conceived of as nothing more than a quantum fluctuation with E very very small and t very very large. Fun, hey — and there's more.

Want to make a universe? All you need is the energy of a large hydrogen bomb. Confine the energy in a matchbox to squeeze a small portion of our universe into a mini black hole. Conditions within match those early in the birth of the universe where quantum fluctuations could create a small bubble of space time. At these energies and densities the bubble would be forced out of our universe and a new 'child universe' is born in another space and time (Fig. 22).

Of course if we did create such a mini black hole it would explode within about 10^{-13} of a second. Not very long for a universe to evolve, you might think. But that is only the time-scale as viewed from our universe. The child universe is completely separate from our space time. Inside it the whole cycle of inflation, steady expansion, formation of galaxies and the evolution of life could run its course while we were still opening the matchbox to see if it had worked.



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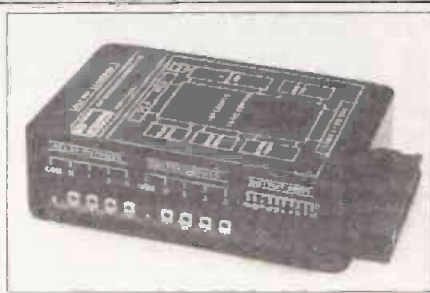
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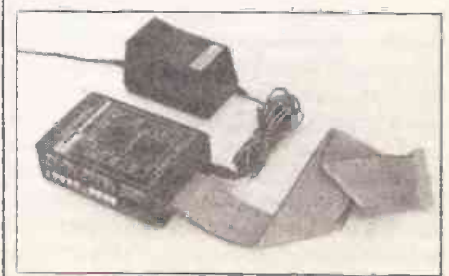
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- eight channel multiplexed analogue to digital converter
- precision 2.5V reference
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- 15-way expansion bus

All sections of the interface are memory mapped in the 1MHz expansion map for maximum ease of use and compatibility with existing peripherals.

The expansion bus provides all the data and address/control signals for the addition of further DCP modules or home-built devices. All the information required for using additional devices is included.



OP-AMPS

Having successfully minimised the effect of an op-amp's bias current on circuits last month, I'll now risk upsetting you by saying that unfortunately this is not the end of the story. Another cause of DC errors is the input offset voltage.

In all articles so far, I have assumed that if the two input terminals of the op-amp are at the same voltage, the output will be at 0V. This is not the case and the reason can easily be seen by inspecting the input circuits of the 741 op-amp (Fig.1). Unless the four

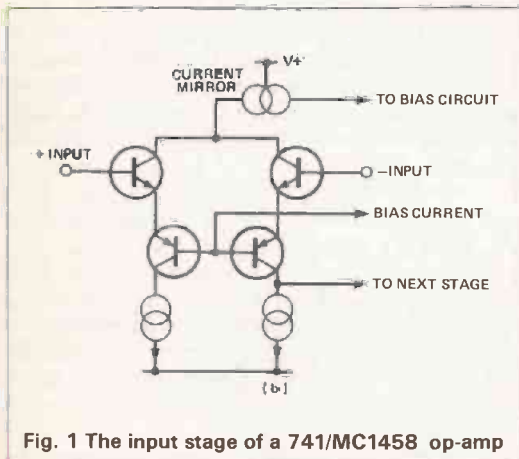


Fig. 1 The input stage of a 741/MC1458 op-amp

input transistors are exactly matched, the voltage needed to cause a given current in the collector will not be the same for both pairs. Because of this imbalance, the output of the op-amp will be at 0V when a small difference in voltage exists between the two input terminals. This voltage is known as the input offset voltage, and may be around 10mV for a low cost bipolar op-amp.

Taking the same four circuits as last month (Fig. 2), let's see what effect this has on their operation, assuming once again that the gain of each op-amp is large enough for any variation in the input voltages to be neglected. In Fig. 2a, all that will happen is that the output will settle at -10mV (we'll assume that the offset has the +input 10mV higher than the -input).

Ah . . . but of course what I should say is that all things being equal it would settle at -10mV. Last month we discovered that all things are not equal — there is already a +100mV offset due to the bias current. In this case, the output will actually settle at +90mV, so the input offset has actually resulted in a slight improvement! On the other hand, the specified 10mV voltage offset could actually be in either direction so the two might add up to give +110mV.

However, it's clear that in this circuit the output offset due to bias current outweighs that due to input voltage offset.

Adding the extra resistor in series with the + terminal will bring the bias current induced offset down to the same order of magnitude as the voltage induced offset, and you could reasonably expect the output voltage to lie somewhere between -20mV and +20mV. Zero if you're very lucky!

Figure 2b we have already found to be a dud from bias current considerations, so seeing what additional effect the input offset voltage will have is purely academic. As it turns out, the component of the output voltage necessary to maintain the -input 10mV below the +input is -10V (-10mV x the

With bias currents safely under his belt, Paul Chappell confronts the hazards of offset voltages in the op-amp world

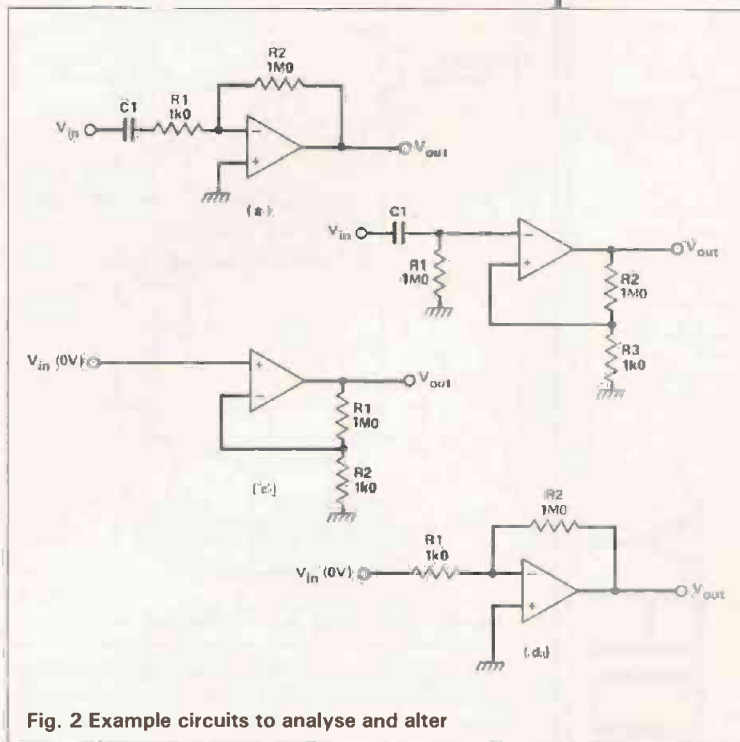


Fig. 2 Example circuits to analyse and alter

circuit gain of 1000), which means that the output is now only straining to reach 90V instead of 100V. Perhaps it won't quite dent the positive supply rail as much as before.

In Fig. 2c we have the DC coupled version of the series feedback circuit which was not too bad from a bias induced offset point of view. On the other hand, the output will still amplify up the -10mV on the -terminal to give -10V at the output. Not too good

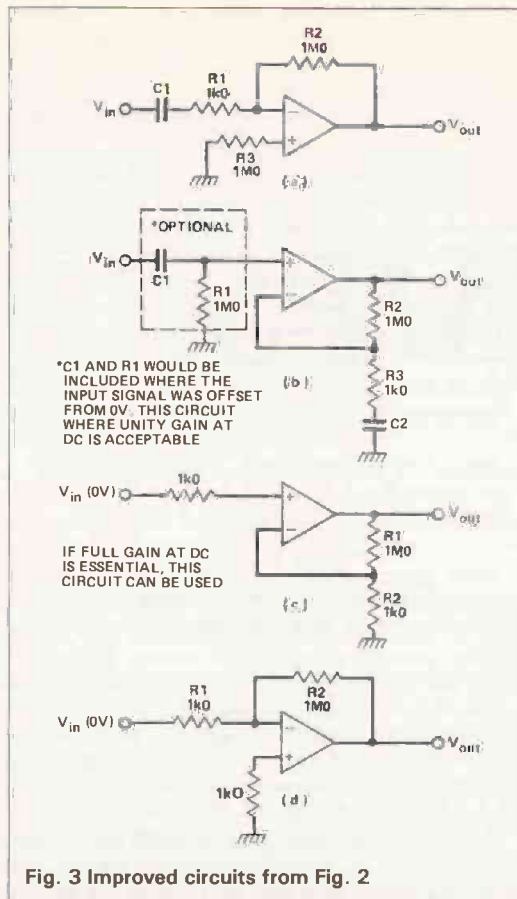


Fig. 3 Improved circuits from Fig. 2

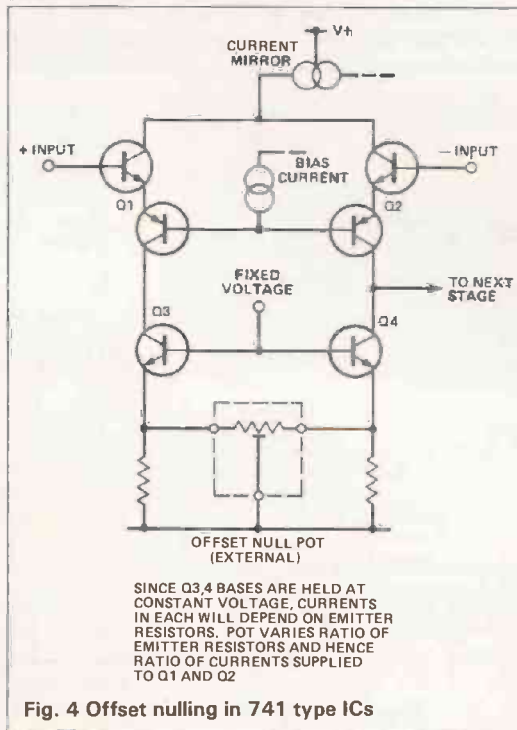


Fig. 4 Offset nulling in 741 type ICs

Figure 2d is no better. Yet again the input offset will be amplified to give $-10V$ at the output. It begins to seem as if the only practical op-amp circuit is Fig. 2a.

Thankfully, this is not the case. There is no simple 'fix' to remove the effects of input offset voltage, but it certainly needn't be as high as the story so far might suggest. Ignoring 2b, which was a non-starter anyway, it's clear that the large output offsets of Figs 2c and 2d are due to the fact that the circuits amplify at DC and magnify the input offset voltage by the circuit gain. The fact that Fig. 2a is 1000 times better suggests one solution: reduce the gain to unity at DC.

In Fig. 2d this is achieved by a capacitor in series with $R1$, to give Fig. 2a. In Fig. 2c the capacitor goes in series with $R2$ to give the kosher version of Fig. 2b (Fig. 3b).

That's all very well for AC amplifiers, but often an op-amp circuit is used in conjunction with, say, temperature or pressure transducers, or other applications where very slow moving signals are involved. Even if you could get hold of a large enough capacitor for the purpose, the settling time of the circuit might be hours, or even days! Let's face it, sometimes there's no alternative to DC coupling.

If the output offset is too large to be tolerable by a factor of ten or so, one way to reduce it is to apply offset trim. Many single op-amps have terminals for just this purpose: a preset pot is connected between the two terminals with its slider to one or other of the supply rails (depending on the type of IC). The effect is to vary the current ratio in the two input transistor collectors, to counteract the imbalance of their base circuits. Figure 4 shows how this works for the 741 type ICs.

Trimming

The offset can be trimmed to zero by this means, so it would be the ideal solution if not for the fact that the input offset voltage will vary with time and temperature. If you reckon on much more than a factor of 20 improvement over the IC in its 'raw' state, you may be unduly optimistic. Unless of course you are willing to keep adjusting the null pot every time the drift makes itself felt.

The essential entry in the specifications table is the offset voltage drift — for general purpose op-amps it will be given in terms of so many μV per $^{\circ}C$. For op-amps intended specifically for DC amplification, you'll probably get some indication of the long term drift with time too.

Another possibility is to arrange your own offset null. In the circuit of 2d, for instance, instead of taking the +input to ground, take it to the slider of a pot which will vary the voltage between $\pm 10mV$. Then adjust until the output is at 0V. An even better idea with dual or quad op-amp packages is to assume that the temperature drift of two ICs in the same package will be similar, and incorporate another op-amp in the nulling circuit in the hope that they will track. This can often give very good results.

An obvious solution is to apply money to the problem. Buy a better op-amp! Some very good devices can now be had for quite reasonable cost. The OP77, for instance, has a maximum input offset voltage of $60\mu V$, a long term offset stability of around $400nV$ per month and a maximum temperature drift of $0.6\mu V$ per $^{\circ}C$ (all this for the GP version). These features and many more very respectable performance figures in an IC which costs less than £2!

The ultimate solution for circuits where even the slightest offset is intolerable is to use one of the many types of chopper, stabilised or auto-zeroing amplifiers. The principle of the true chopper amplifier is illustrated in Fig. 5. The chopper FET switches the input to the AC amplifier continuously between the voltages at the + and - input terminals.

The amplifier is AC coupled at both the input and output, so its own voltage offsets have no bearing on the signal. The result is an amplified square wave, the amplitude of which depends on the difference in voltage between the two input terminals, but not at all on their common mode voltage.

After amplification, a synchronous demodulator restores the waveform to a DC level, which is then buffered and appears at the output. The only place

CIRCUIT THEORY

where significant DC errors can be introduced is in the output buffer, and as we've already seen it is gain that causes the problems. A unity gain buffer can be made to behave itself very well indeed.

The kind of performance possible with amplifiers of this kind is exemplified by the Analog Devices 261, with a maximum input offset of 25 μ V, a drift with temperature of 0.3 μ V/ $^{\circ}$ C and with time of 0.5 μ V per month.

Even better performance is achieved with the auto-zero or 'capacitor nulling' breed of amplifiers. Details of operation vary from device to device but all have the common feature that the input offset voltage is somehow transferred to a capacitor on one phase of the clock, then the voltage on the capacitor is added to the input signal in such a way as to cancel the offset on the other clock phase. It usually involves some fairly complicated switching — often there will be two separate amplifiers which are zeroed and used alternately, so that one or the other is always able to amplify the input signal.

Figure 6a shows the bare bones of the process (or one way of doing it, anyway) and Fig. 6b shows a practical version as used in the ICL7605/6. The principle is that in the nulling phase, the op-amp's offset is transferred to the capacitor. Let's say the offset voltage is 10mV, with the - terminal positive with respect to the + terminal. The circuit will stabilise with the output at +10mV, and a voltage of 10mV across the capacitor.

In the amplify phase, the capacitor holds the internal amplifier's + terminal 10mV below the voltage at the + input of the complete amplifier. If the two input terminals were now at the same voltage, the output of the amplifier would indeed be 0V because the two terminals of the internal amplifier are held 10mV apart by the voltage on the capacitor.

The practical version of the circuit is nothing more than the basic circuit doubled, with each internal amplifier being zeroed while the other handles the signal. The switching takes place at 160Hz or 256Hz (nominal) depending on the voltage applied to the 'division ratio' pin, which alters the internal clock divider.

The performance of the ICL7605/6 is maximum input offset voltage $\pm 5\mu$ V, temperature drift 0.2 μ V/ $^{\circ}$ C and long term offset stability 0.5 μ V per year.

These days the trend is for the performance of non-switching op-amps to catch up with and even to overtake that of the chopper or commutating types. The prices of high performance amps of any variety are still high, so it pays to look carefully at the design problem you're faced with to see whether more careful circuit design can relax the specification of the ICs needed.

ETI's breathing rate monitor circuit is a case in point. The detection of slowly changing temperatures is an 'obvious' case for DC coupling, yet by resisting the temptation it was possible to use a very ordinary op-amp and still to achieve excellent performance. There's no substitute for careful thought!

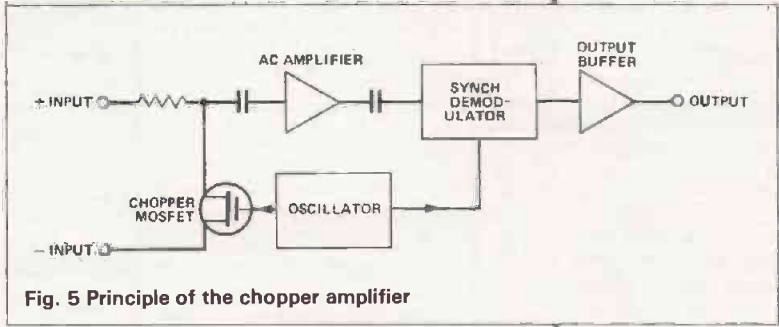


Fig. 5 Principle of the chopper amplifier

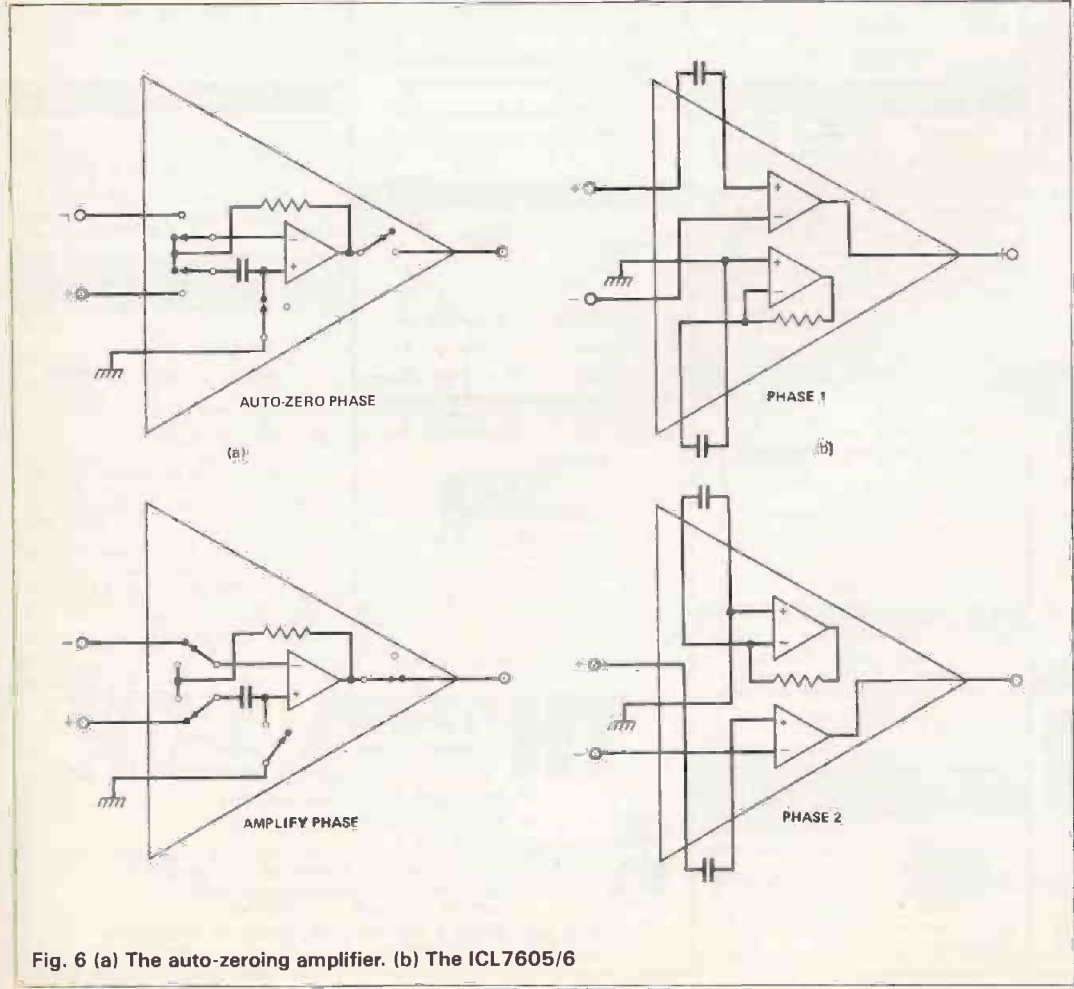


Fig. 6 (a) The auto-zeroing amplifier. (b) The ICL7605/6

Last month the cure for the circuit in Fig. 2d was giv3n as a 1MO resistor is series with the +terminal. The value should have been 1kO.



BROUGHT TO LIGHT

CHIP IN

I thought last month that I had finished my brief introduction to opto-electronics. However, as we went to press I found a source of laser diodes at £16 (yes — sixteen quid!). This caused me to postpone my revue of electronic sensors in favour of some basic practical information on how to set up an experimental laser using one of these diodes

Figure 1 reproduces the standard laser safety level for non-visible output lasers. The top line means what it says! Although the dispersion angle of semiconductor lasers is quite wide (minimum 8°) there is a lot of power available in addition to the small percentage of visible light. It may not look very bright, but your eyes can be damaged permanently by the invisible infra-red (IR) emission. With this diode 30cm is the absolute minimum safe viewing distance and even this is not advisable.

Figure 2 illustrates the recommended safe procedure for viewing the output from your diode. The safety glasses are *not* sunglasses. They are special *green* (usually) glasses designed to filter out the IR. The fluorescent screen emits visible light when exposed to IR so you can see an image through the glasses. I suggest that you have a chat with either your Sharp distributor or with Kodak Professional Sales in London before going ahead.

Please note that the above is *no joke* if you want to keep your sight undamaged. It is, however, unnecessary to assume the gormless facial expression illustrated in Fig. 2! This takes a lot of practice and contributes very little to either safety or experimental results!

Diode safety

Having looked at personal safety, we now come to diode safety. Even at £16 to £35, you don't want to blow up too many diodes! The bees knees of laser diode handling stations is shown in Fig. 3. Once again, the facial expression is irrelevant and I think this system shown is extreme over-kill. Where I work nobody uses humidifiers or ionisers and very few use floor mats or wrist straps. The conductive bench mat is definitely essential, as is the grounded soldering iron tip but that is about all that is needed provided you are careful and intelligent about the static problem.

Obviously, you should not wear a nylon shirt and stroke the cat for half an hour before soldering your laser diode on a polypropylene carpet but it is not

necessary to use a conductive neck tie attached to the ceiling unless you are really desperate.

The aim is to prevent static discharge with spike potentials in excess of about 20V (yes twenty). This is surprisingly simple. All you have to do is ensure you are resting your bare arms on the same conductive surface the diode is on at all times while you are touching it, and before you touch it if you have lost contact with it.

Here again, another warning: It is extremely dangerous to make a conductive mat out of metal or other good conductor. If your soldering iron should short out, you could kill yourself even if there is a resistor to ground proper in the lead. A conductive mat should always have an inherent resistance of 5k to 100k per linear centimetre in addition to a series resistor of 1MΩ at 2W rating as near as possible to the earthing point.

The best system I have found is to use a 13A mains plug with the live and neutral pins entirely removed and to put the 1MΩ resistor inside the plug body. A substantial yellow wire (1.5mm sq/15A rating) is soldered to the resistor, the cord gripped using a nylon tie (not insulating tape as this deteriorates with age and slips) and terminated in a standard crocodile clip which attaches to the edge of the mat. To strictly conform with safety regulations, the plug body should be painted bright yellow!

Commercial conductive mats are expensive but a cheap and adequate compromise is to use a conductive bag. These can frequently be begged from electronics component shops and even a slightly damaged one will do. Slit it open and unfold it, and you have a reasonable anti-static mat, albeit not very durable.

Test it with a DMM to make sure it is conductive as specified above, as many (mainly transparent or pink) bags are static passivated (they don't generate static) but not really conductive. The bag that works would normally be black. Another alternative for the more intensive experimenter is to purchase an offcut of proper matting. These can usually be obtained quite cheaply from firms that make special mats for industry. I got a 6×2ft conductive polyethelene mat from Conductive Products as an offcut for about £15. It is a really durable material about 2mm thick, with a textured surface. The piece was not quite square but I tried it up with no more than a craft knife and straight edge

Mike Barwise
enthusies over a cheap
laser diode but finds
using it isn't that easy

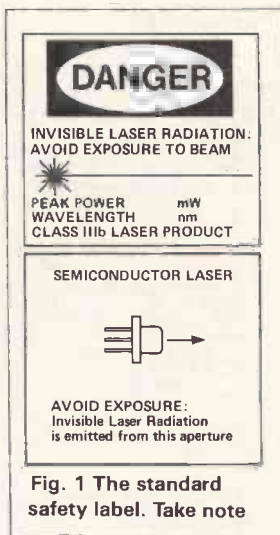


Fig. 1 The standard safety label. Take note



Fig. 2 Safety precautions

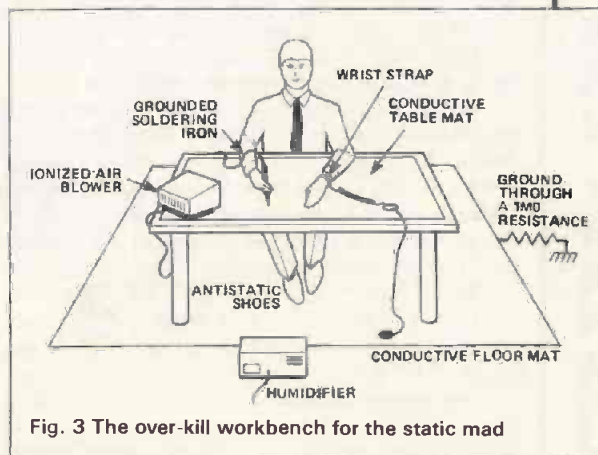


Fig. 3 The over-kill workbench for the static mad

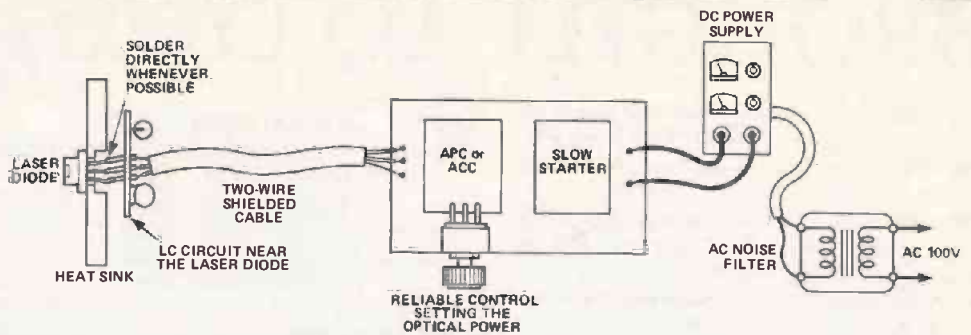


Fig. 4 Circuit board precautions

The Diode In Service

Laser diode protection does not stop as soon as you have soldered it in place. For the diode to survive it must be protected throughout its life from static and surge currents. Figure 4 shows the Sharp recommended layout for this. Note that an LC filter is assembled as close as possible to the diode. A typical filter is shown in Fig. 5. An ACC is an auto current control and an APC is an auto power control. More on these in a moment.

The final notes on handling concern setting up the drive current to avoid overload and physical handling of the package.

As to power measurement, it is totally wrong and very dangerous to the diode to set up the power by measurement of input current only. The input current versus optical power and the lasing threshold vary dramatically device to device and over temperature for any given diode, so this is the best way to blow one up in less than a nanosecond.

Optical power meters are generally very expensive, but a good compromise is shown in Fig. 6. A large area photodiode (Sharp recommends the SPD102) is used with a load resistor and mV meter (DVM set to 200mV range or lower). Using the SPD102 with a 10R resistor, the output is 5mV per mW of optical power. With this detector, 200mV out should not be exceeded, as it goes non-linear above this.

Needless to say, this test should be done in the dark. A small metal or plastic box containing the detector diode can have a hole in it through which the laser diode can be inserted.

Note that these laser diodes have internal reference diodes which are used for active power control in conjunction with a controller IC. To avoid light getting reflected back off the detector onto the reference diode (which would temporarily reduce the laser output power — resulting in overdrive) the detector should be tilted at an angle of about 15°.

It is important the whole output of the laser diode falls on the active area of the detector. If in doubt, always place the two closer together rather than further apart, and do a little Pythagoras theorem on the basis of the dispersion angles given in the laser diode data before designing your little box.

When mounting your laser diode, remember it is a precision mechanical structure. The glass window can be cracked by stress, so mount by the flange only, as shown in Fig. 7. Also remember that contamination on the window will cause severe output degradation due to diffraction effects (a fingerprint will act as a crude meaningless hologram). Never touch the window but after you have, clean it with ethanol or Isopropyl Alcohol, not India Pale Ale! Although it is generally recommended that these devices are assembled in a clean room, it is not strictly necessary.

Precautions should be taken to avoid lumps of goop and pieces of fluff landing on the window during assembly and while in service but this is reasonably

easy to ensure in the average electronics environment. Be extra careful if your bench is in your bedroom. If so, it is probably worth putting an open kettle of boiling water on the bench about 10 minutes before you start work to lay the dust.

The Diode — At Last!

Figure 8 shows the construction of a typical Sharp laser diode. The black rectangular blob in the middle of the active layer is one end of the resonant cavity I mentioned last month. It has a partial mirror at each end to reflect part of the light and is of a critical length which is an exact multiple of the wavelength of the primary emitted light. Figure 9 is a section of the laser diode package showing the relative positions of the laser and reference chips.

The general term 'coherence' used last month actually encompasses two different attributes of laser light: *temporal* and *spatial* coherence.

Temporal coherence (Fig. 10b) is a measure of the spectral bandwidth of 'purity' of the emitted light. A perfect laser from this point of view might emit light at a wavelength of, say, 783nm, and no other

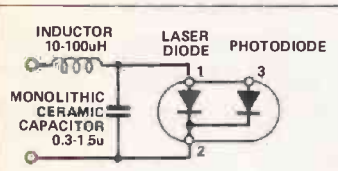


Fig. 5 The LC circuit

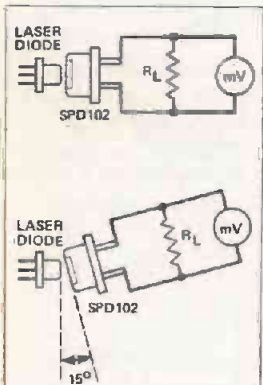


Fig. 6 Optical power measurement

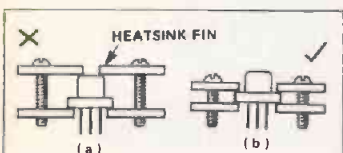


Fig. 7 Incorrect and correct diode clamping

CHIP IN

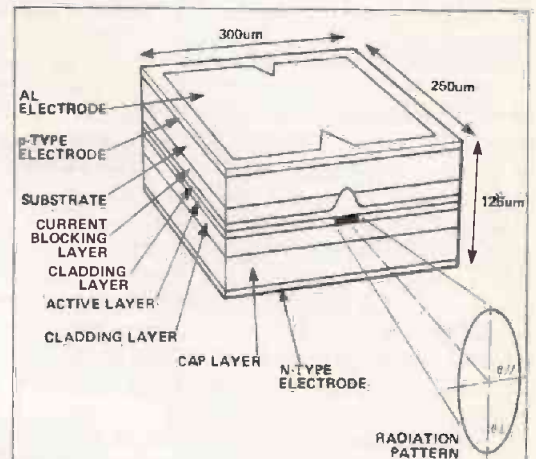


Fig. 8 The Sharp laser diode structure

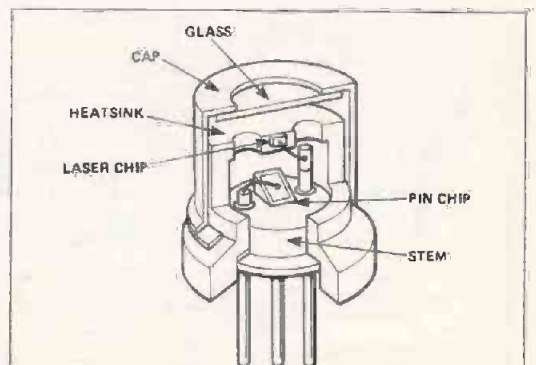


Fig. 9 Internal structure of the diode

CHIP IN

wavelength. This is practically impossible. There is always some spread. As will be seen later, the spread is very dependent on the proportion of maximum power at which the diode is being driven, anyway. The 'coherence length' is the distance from the diode over which the emitted light remains in phase *along any one axis*. The coherence length of these cheap laser diodes is very short — about 2mm. In fact, by the time the light was emerged from the package window, it can be considered temporally incoherent. This is designed-in on purpose. These diodes are produced for use in CD players, where excessive temporal coherence leads to increased noise.

Spatial coherence (Fig. 10d) is a measure of how perfectly the optical wavefronts conform to segments of concentric circles centred on the emission point of the diode. The better the spatial coherence, the smaller the area of the focussed spot through a collimating lens. The spatial coherence of a CD player diode has to be good: a small spot of light is needed at the surface of the disc. Similarly, if you are to launch the light efficiently into an optical fibre (core diameters from 2 micron to 50 micron) you need a high degree of spatial coherence.

Any lens used to focus the light from the laser to a small spot is a collimating lens. Normally a microscope objective of about $\times 10$ focal length is used. In this case, the diode finishes up about 2-4cm from the threaded (back) end of the objective and the focussed light is insertable into a fibre about the same distance from the other end.

Warning!! Collimated laser light is extremely dangerous. The spot is very small so the relative intensity is dangerously high. Never look directly at the output of your collimating lens along the optical axis.

To set this type of system up, you need some kind of rigid adjustable support for the laser diode, the collimating lens and the fibre or other device the light is aimed at. Professional aligners are costly but so long as you have lots of patience you can use fairly crude equipment if it is rigid.

Magnetic bases with clamp-on arms are available for mounting engineers' dial gauges. These will do quite well with care. A steel baseplate about $\frac{1}{4}$ in thick is then an adequate 'optical bench'. A good size for use with magnetic bases would be about 3in wide by a foot or so long, screwed down to large enough piece of wood to ensure the system is completely stable. When aligning the system, the same detector mentioned above can be used and the different bits are manipulated until a maximum output reading is obtained. I know this sounds very rule of thumb but it is: just move things around until it comes out right!

The laser diode must be mounted on a substantial heatsink (not less than $6^\circ\text{C}/\text{Watt}$).

Driver Chips And Control

Sharp makes a couple of driver chips which greatly simplify the bringing up of laser diodes with internal references. If you should get a laser diode without an internal reference, then the driver circuit given last month will serve but it will be necessary to add an active cooler/heater.

All the low cost Sharp diodes have an internal reference. This is not more than a photodiode positioned to receive a constant proportion of the light emitted by the laser.

The driver chip circuits are shown in Fig. 11. They are both about £4. Figure 11a shows a simple driver with a TTL compatible control input and Fig. 11b is a slightly more complex circuit which allows the use of a thermistor attached to the laser diode heatsink

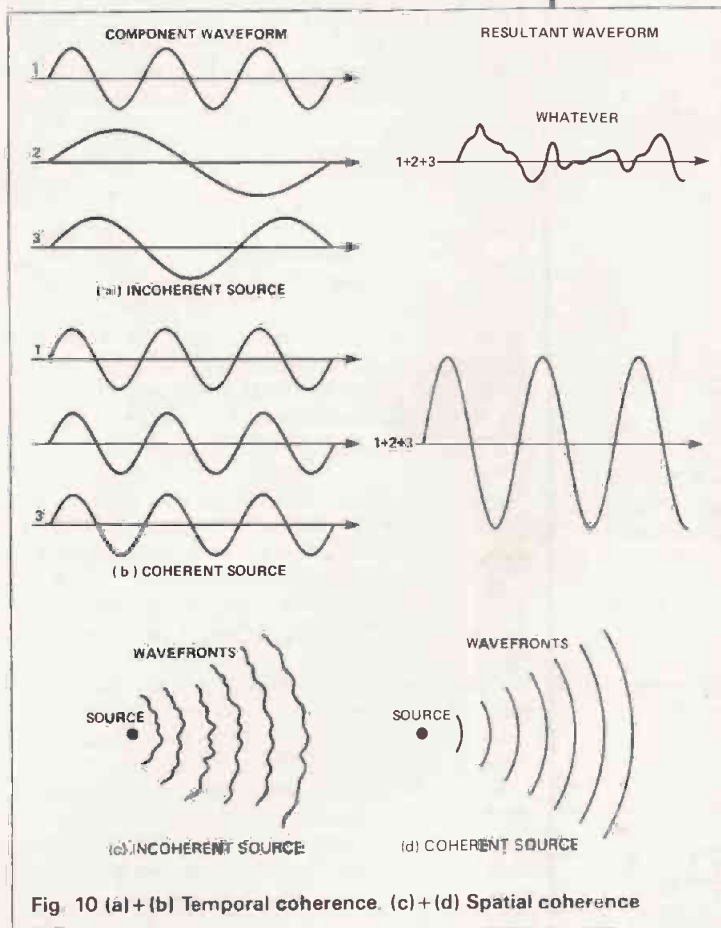


Fig. 10 (a) + (b) Temporal coherence. (c) + (d) Spatial coherence

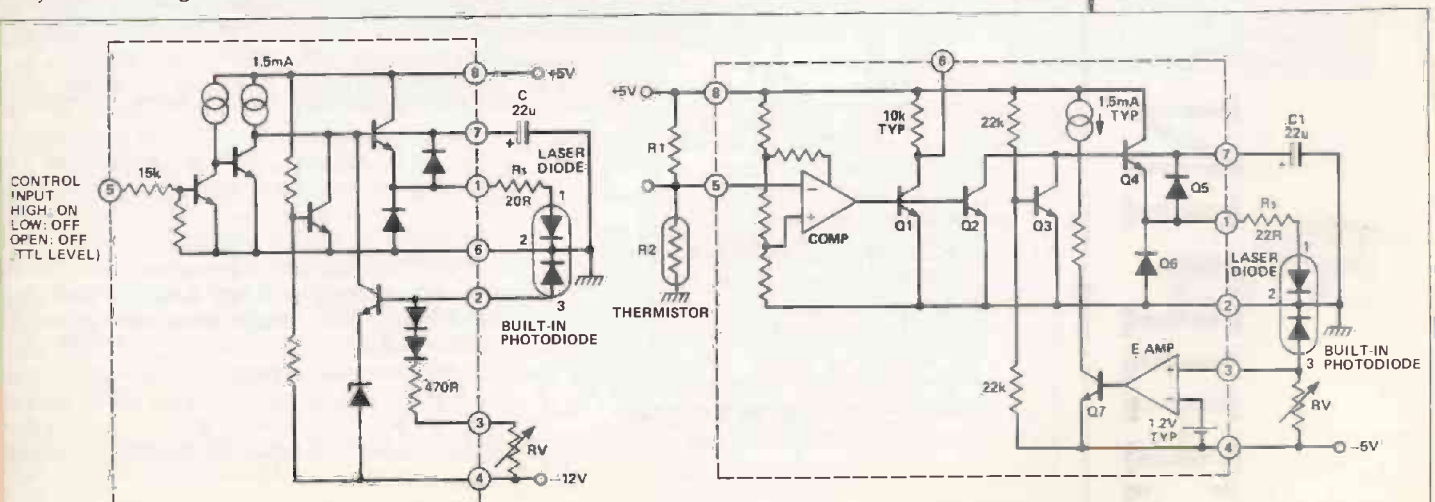


Fig. 11 Driver circuits

to shut it down if it overheats. There is not great advantage in using the circuit in 11a. Both circuits include slow start to eliminate switch-on spikes and both can be driven from TTL.

It is important to realise that the terms ON and OFF do not mean what you normally think. The laser is not extinguished when 'off' as, while you can modulate it within its lasing region at high speed, it is quite sluggish to turn on if you take it below lasing threshold and back.

The LC filter (Fig. 5) should always be incorporated when using these driver circuits, and their power should be supplied from a well regulated source. The TTL control input should be debounced.

Sharp LT022MC

Now let us look at the specific laser diode I am enthusing about: the Sharp LT022MC. This cost £16 + VAT at the last count. Some of its more important characteristics are illustrated in Fig. 12.

Figure 12a shows the dependence of forward current and voltage over temperature (which does not show much variation) and Fig. 12b shows the optical output power versus input current over temperature (which varies a lot). The transition between near-horizontal and near-vertical in this graph is the *lasing threshold current*. As you can see, it changes a lot with temperature, so it is important to keep the diode temperature as constant as possible. In the absence of active cooling/heating, use a large heatsink and don't keep it switched on for too long. As can be seen from the graph (12b) the threshold current at 50°C is about 62mA, which would overdrive the diode destructively at 0°C.

Figure 12c is a clearer indication of threshold current change with temperature.

Temperature change will also alter the wavelength of the emitted light (Fig. 12d) due to changes in the length of the resonant cavity. This should not be a problem for most applications, as the diode is not suitable for interferometry anyway (which is mainly where critical control of wavelength is required) due to its short coherence length.

What is more of a potential problem is the change in bandwidth with optical power output (Fig. 12e). As can be seen, the harder you drive the diode, the purer the output spectrum. However, it is most unwise to drive the diode at more than about 50 per cent power in such lash-ups as we are discussing, to avoid frequent replacement due to blow-ups.

Coupling To Fibre

The main use of our laser diode will probably be the insertion of high intensity light into optical fibres. The most usable types of fibre will be large diameter plastic (1mm approx), 200 micron plastic coated silica (PCS) and possibly 50/125 silica (50 micron core, 125 micron cladding). The interference patterns described last month are quite easy to obtain and with a good 'launch' (optical insertion) it should be possible to throw a detectable pattern over a distance of some 4-6 inches. Sorry folks but the 'across the room' laser light show is not really on. Remember, also, that most of the power output is *invisible* with these lasers.

This is the knotty point. Optical sensing using coherent light is a pretty complex business. There are many alternatives and many modes of operation. There just isn't the space to go into them in detail. The main thing is: get experimenting. You might just discover something important in this still experimental field. Above all, though: do it safely.

The laser diodes, information about safety glasses, viewing screens and detector diodes are available from Access Pacific, Bury St Edmunds. Tel: (0284) 69661.

Plastic Optical fibres are available from Electromail; silica fibres from York VSOP, School Lane, Chandlers Ford SO5 3PG or: Optal Fibre, Second Avenue, Deeside Industrial Park, Deeside, Clwyd CH5 2NX.

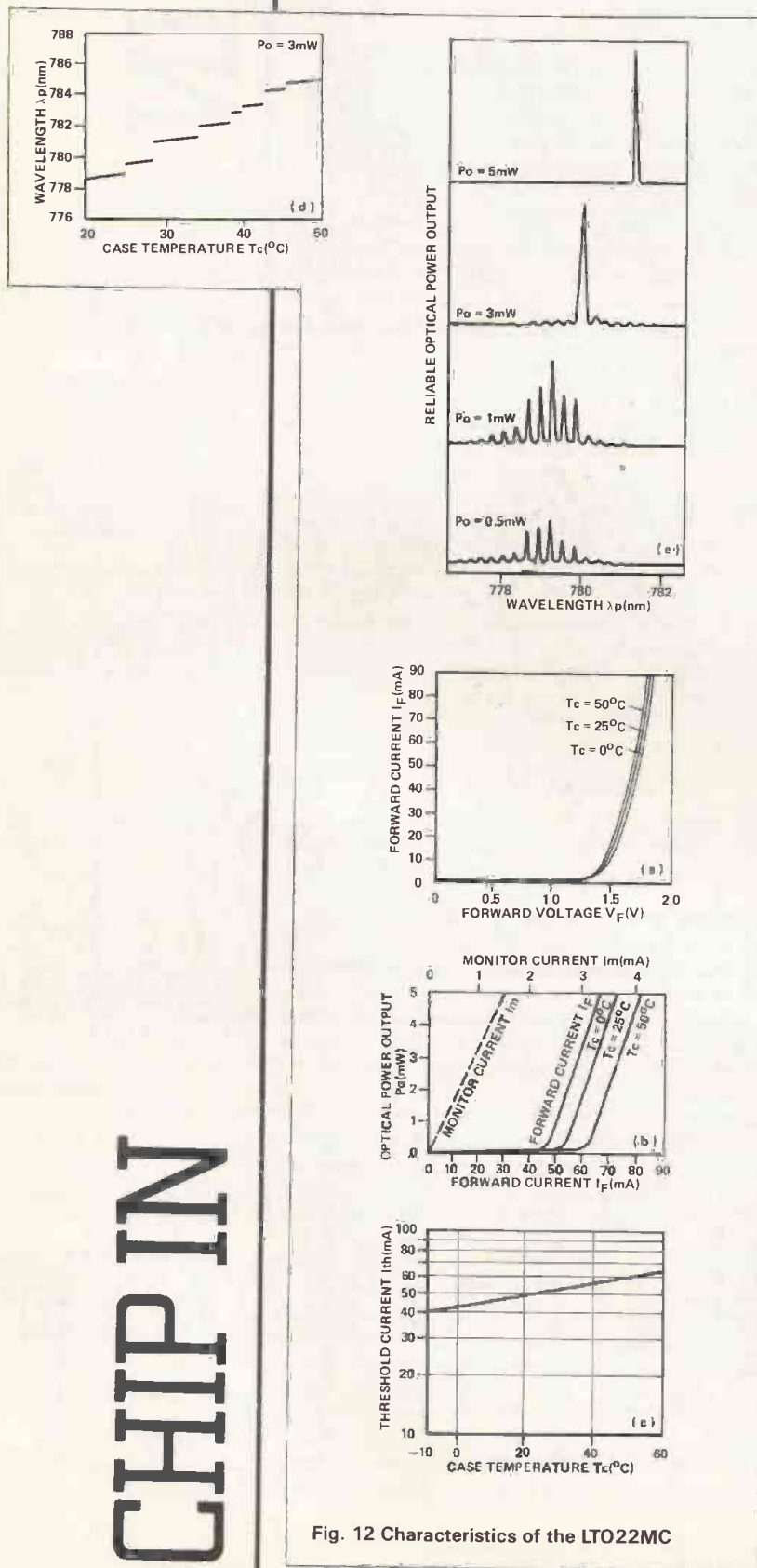
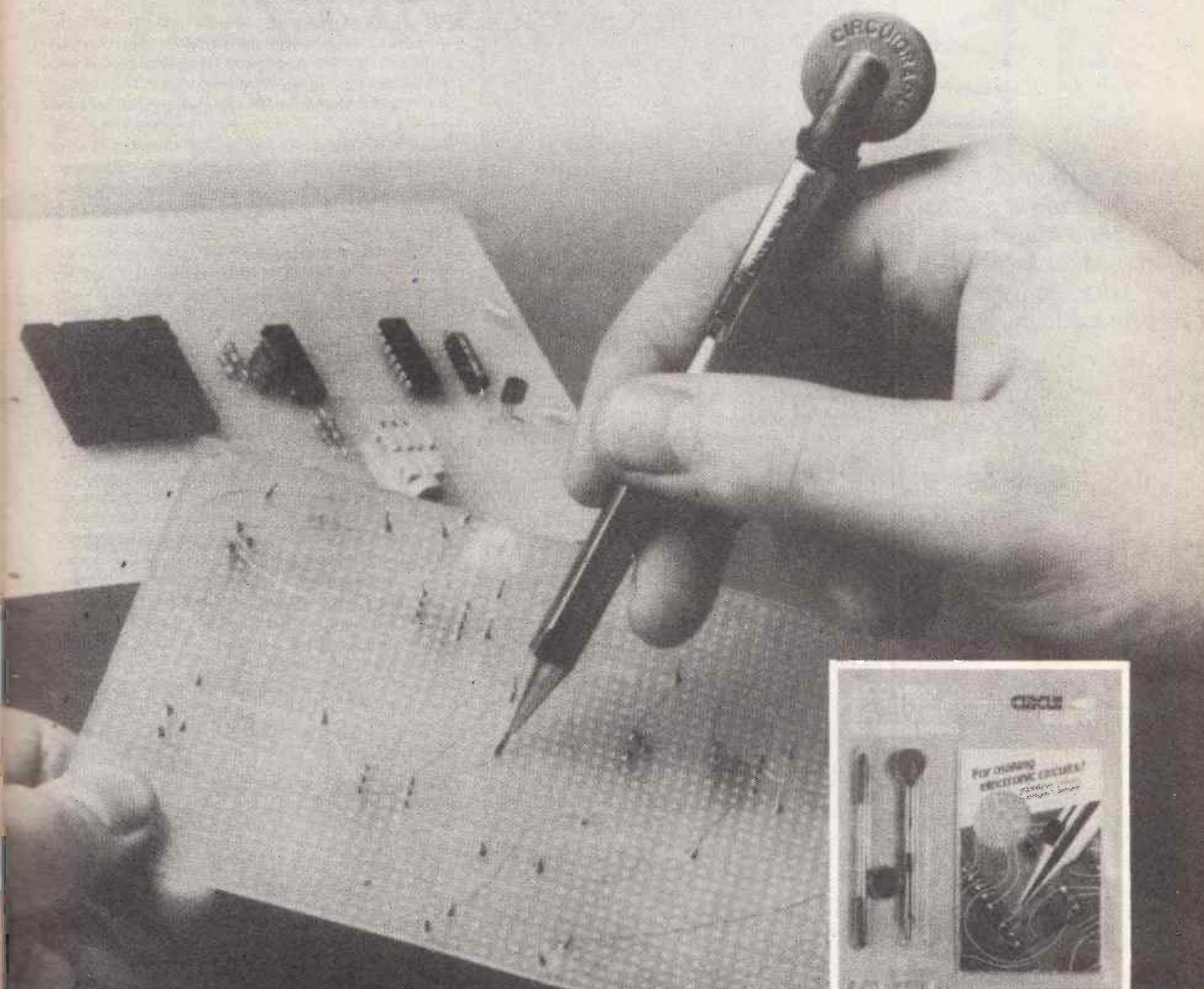


Fig. 12 Characteristics of the LTO22MC

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SPEAKING FOR YOURSELF

Malcolm Walmsley tries his hand at putting together a Maplin loudspeaker kit. While that's drying, here's one he made earlier

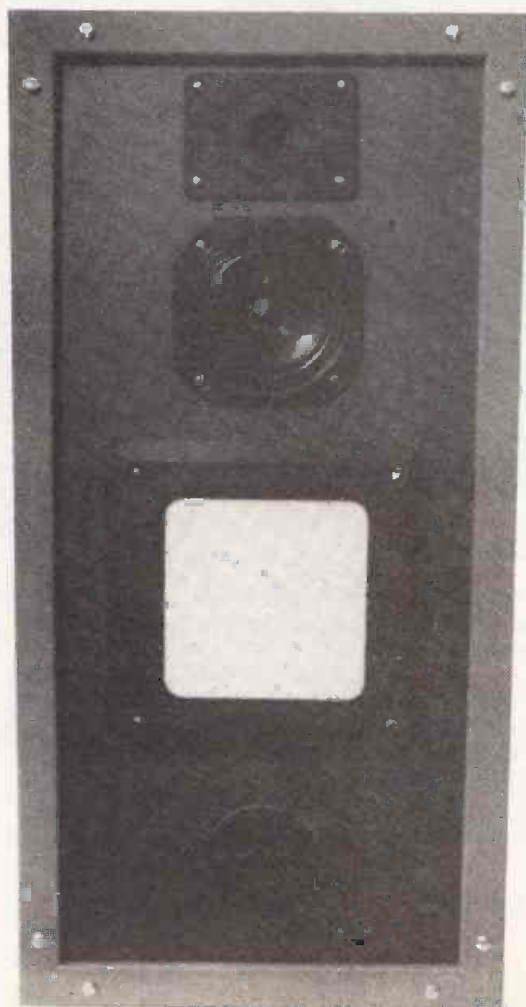
REVIEW

There was a time when loudspeaker kits were almost as common as their ready-made cousins. I've still got a pair of Wharfedale Dentons and a couple of Kefs made up from kits bought more years ago than I'd care to remember in 'normal' hi-fi shops in Tottenham Court Road.

Nowadays it seems speaker kits are only to be found in obscure electronics dealers and through obscure mail order firms.

This is a great shame. There is nothing mystical or even difficult about making loudspeaker cabinets. Designing good ones is tricky, it's true, but putting together a few pieces of wood cut to someone else's design is (relatively) child's play. However, the savings over letting the nice man at the Korean factory do it are considerable.

The most difficult bit is making them look as good as the commercial equivalents. Even that is less difficult than it used to be, now that commercial speakers seem to be universally designed to look unattractive.



It's all to the good then, that Maplin has done its bit to straighten the record with a couple of speaker kits ideal for the home constructor like me with a bodge-it attitude to DIY and very little skill.

The two kits are broadly similar and offer a 2-way 23 litre enclosure and a 3-way 40 litre enclosure. At £29.95 and £35.95 per speaker, respectively, these are well into the large savings category.

Both designs are rated at 50W and are based (if you'll excuse the pun) on a bass reflex system using Maplin's own bass driver unit with a flat square honeycomb foam diaphragm. This is supplied complete with a front baffle edging trim piece to both look and sound good.

The 2-way system has a single mid-range/tweeter unit on top of that whereas the 3-way system uses a miniature dome tweeter and a mid-range unit as well.

The 3-way enclosure is the subject of this review but many of the comments apply equally to the smaller system. Neither enclosure is on the tiny side — 40 litres is a lot of space to take out of your living room. This design is 20 × 10 × 16in in size.

The tweeters are standard enough but the mid-range unit is quite unusual. This is a *ferro-fluid* cooled driver (in other words it has some magnetic fluid filling the cavity around the voice coil) and is enclosed in its own sealed metal infinite baffle. This means it can be simply inserted in a cabinet and forgotten about.

The kit is not a complete MFI-type flat pack assemble-in-half-an-hour job. For a start, it does not include most of the woodwork. This kit comprises the three drive units, the crossover, a tuning duct for the reflex port, some connecting wire, damping wadding, screws and the front baffle.

The front baffle is the blessing. This is supplied cut to size (and square — nearly impossible to perform in my workshop!) and pre-cut and drilled for the drive units. It is made of fibre board (expensive but easy to work) and finished with a black textured vinyl coating.

All that is required of the constructor is the other five sides of the box to be cut from 3/4in chipboard and knocked together as per the clear instructions.

The chipboard to complete the cabinet should cost you about £5. Your local DIY warehouse will help out there. It is essential that you use the high density stuff. This not only works better but tends to be smoother surfaced too, so it looks better in the end.

I must say that I cheated. The instructions clearly tell you to put the box together with **hardwood** battens in the inside corners. I just glued the chipboard directly. It worked, it's strong and it was much easier!

Once the two sides, top and bottom are firmly attached to the front baffle I prettied it up! The drive units themselves are clearly designed to look good without a grill cloth and so they got none from me. Instead, I covered the cabinet top, bottom and sides with Maplin's black vinyl cabinet cloth and the front edge of the chipboard sides (not a pretty sight) with a frame made from hardwood moulding (with lovely

mitred corners — that took ages) to fit flush around the sides.

For reasons of domestic decor the front frame was painted green. (OK, so you think it's horrible but I rather like it and you've got to see it in situ to really appreciate this masterpiece of design).

The drive units are then simply screwed into position with the nice pan head bolts provided. The crossover is screwed to one inside wall and wired up, the tuning duct (a bit of plastic drainpipe to you) is glued into the right hole in the baffle, the wadding distributed around the walls, the back stuck into position and away we go.

A minor quibble is that there is no back panel connection provided. Of course everyone disagrees over which type (push connectors, screw terminals, sockets, and so on) are the most hi-fi or the most convenient so I suppose leaving the choice up to the constructor is sensible enough. I would really like to have used those levered cable grips in a sunken panel as my existing speakers (which these are going to augment) use that system. However, Maplin doesn't do those (although Tandy does!) so I plumped for screw terminals as these are the cheapest alternative.

Now came the acid test. What did my creations actually sound like?

Well I tested them next to my favourite Wharfedale Mach 3's — 2-way reflex speakers, highly efficient in the Wharfedale tradition. Many purists scoff at Wharfedales in general and the Mach range in particular but I must confess I love the sound of these. I like the extended bass response of the reflex system (despite the large size this usually entails) and the crispness and clarity (some would say colouration) of efficient speakers driven fairly hard.

Okay, so that's why some years ago I coughed

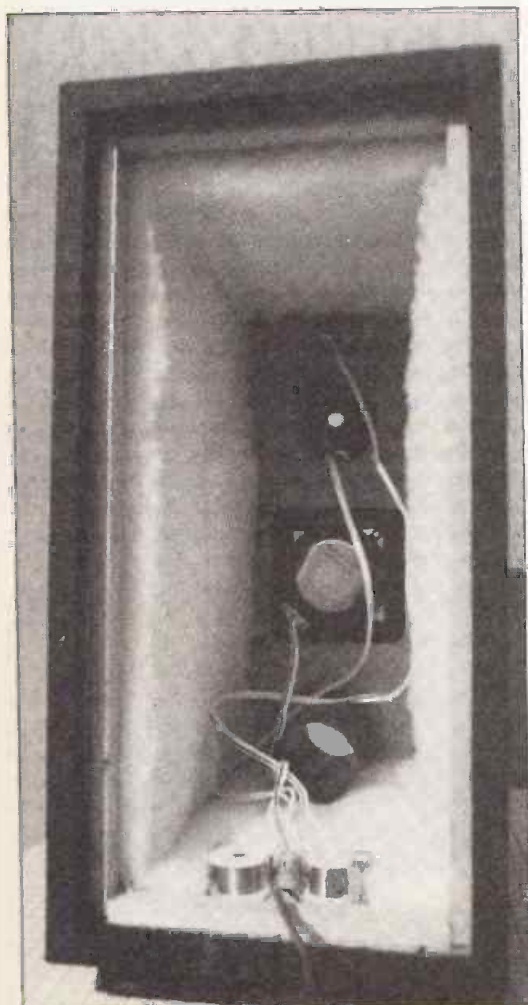


up £160-odd for the Mach 3's — what about the Maplin effort? Well, I was very pleasantly impressed. The kits are overall larger than the Wharfedales and the bass response stretched correspondingly lower. I found the low regions a little boomy, even after moving the cabinets away from the floor and walls, so this was no great advantage.

The treble was excellent, I always have the totally superfluous crossover treble control on the Mach 3's cranked up full but even then the Maplin kits gave a fuller treble without any hint of tinniness or wispieness.

The midrange is a little too subtle for my liking. It doesn't have the real punch that I like. However, this is a very personal view and it's unlikely to detract from most listeners' enjoyment.

Indeed, the whole business of choosing speakers is a personal one. It is a shame you cannot go to a Maplin shop and listen to these kits made up before you decide. However, I would venture to say that to compliment a reasonable hi-fi, for a price (see the panel) which should if not appeal at least not horrify most, the Maplin kits provide both a chance to let off some creative steam and produce some excellent speakers at the end of your hard work.



REVIEW

Maplin 40L loudspeaker LM20W £35.95

The bits are separately:

Bass driver (YN24B)	£14.95
Mid-range driver (YP13P)	£7.95
Treble driver (FD95D)	£3.95
Crossover (WF03D)	£5.95
Front baffle (XJ06J)	£2.95
3m Wadding (RY06G)	£3.00
Reflex port tuning tube	£0.50
Cable	£1.00
Screws, nuts and bolts	£1.00

Total £41.25

Hardware: (approximate cost)

Chipboard	£5.00
Hardwood	£2.00
Cabinet cloth	£5.50
Wood glue	£1.00
Screws and nails	£2.00
Cabinet feet	£0.50
Paint	£3.00

Grand Total
for single complete speaker from kit **£54.95**



TRAVELLER'S AERIAL AMP

Keen caravanner Keith Brindley finds poor television pictures a bind. With this project he's guaranteed a good picture wherever he parks his van

1st CLASS

Campers and caravanners alike will know the difficulties in picking up a strong enough signal to ensure good television reception when touring around the country. The main problem is, of course, that the typical touring aerial you use hasn't the same sort of gain which permanent aerials have. Permanent aerials can have gains up to 20dB, depending on size and the number of elements. Touring aerials, if you're lucky, give around 4dB.

What's more, your aerial at home is sitting at rooftop level — your touring aerial is at best stuck on the top of a caravan, at worst a tiny set top job, inside the van or tent.

Aerial pre-amplifiers are available but most are mains-powered — fine for home use but not so fine for touring where your only source of power is often a car or caravan 12V battery. Those which allow low-voltage operation have limited gain anyway — no more than about 10dB usually — so pictures can often be still marred if you happen to have pitched for the night in a location with poor signal reception.

The aerial amp featured here on the other hand gives a remarkable 23dB gain so, even with a limited touring aerial and situation, you should be watching acceptable television pictures when you're on holiday in next to no time.

The main component in the project is a thick-film hybrid IC, Mullard's OM335. It features an extremely wide bandwidth (wide enough that you can use it for amplifying VHF radio broadcasts, too) and wide operating voltage (around 9-28V). These make the IC ideal for the purpose here, although it can also be used to advantage as a masthead, set-back, or MATV preamplifier in the home or laboratory.

Construction

Construction couldn't be simpler. With the grand total of three — yes only three — components mounted on the circuit board, the project ideally qualifies for 1st Class category. Nevertheless, a number of points need to be made and certain precautions must be taken to ensure the project works.

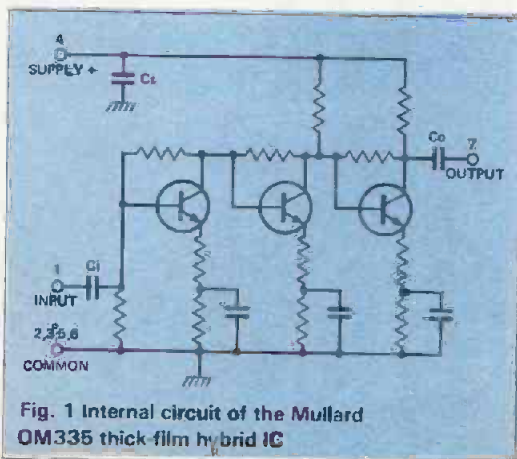


Fig. 1 Internal circuit of the Mullard OM335 thick film hybrid IC

HOW IT WORKS

Figure 1 shows the internal circuit of the OM335. It is a complete wideband preamplifier, formed by three DC coupled transistor amplifying stages. The circuit really is wideband, amplifying with almost identical gain all signal frequencies between 40MHz and 860MHz. Gain still occurs outside these limits and the IC will make a respectable 10MHz to 1.4GHz preamplifier, albeit with a none too-flat frequency response. For example, with a power supply of 24V, gain at 10MHz is 22.5dB, while gain at 1.4GHz is 13.2dB. Mid-band gain at this supply voltage is around 26dB.

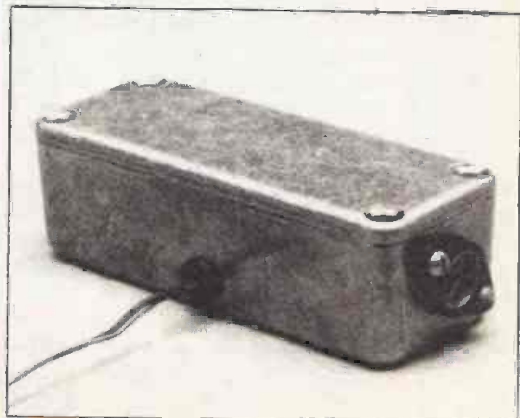
Input and output to and from the IC are AC coupled via capacitors C_1 and C_3 , while supply decoupling is performed by capacitor C_2 . Figure 1 shows the overall circuit which features an extra supply decoupling capacitor and a diode to ensure no damage can be done if the power supply is accidentally reversed.

Note that the IC is formed by thick-film techniques which means the individual components you see in the diagram are real components, built into the circuit, one by one, at manufacture.

The IC's characteristic input and output impedances are both 75 Ω in common with UK VHF and UHF practice and this means it is vital to match these impedances to steer clear of mismatch problems. This could be done by soldering standard 75 Ω coaxial cable direct to input and output pins of the IC but this makes construction a bit tricky, not to mention messy.

Instead, the circuit board designed for the project has tracks which themselves have characteristic impedances of 75 Ω too. For standard 1.6mm thick epoxy glass board, an impedance of 75 Ω corresponds to a track dimension of 1.5mm width with an earthed layer either side and underneath of the track. Using such a board with input and output connection track dimensions like this, it is then an easy job to mount the IC onto the PCB, then make coaxial cable connections direct to the board.

You must remember that a high-gain amplifier working at the sort of frequencies which televisions receive (450-900MHz) can often be subject to oscillation if adequate screening and mounting techniques are not followed. This is the reason why the project can *only* be built using a PCB — a double-sided PCB at that — and *not* on Veroboard. The ins and outs are explained more deeply in the *How It Works* section.



PARTS LIST

CAPACITORS	
C1	100n ceramic
SEMICONDUCTORS	
IC1	OM335
D1	1N4001
MISCELLANEOUS	
Aluminium alloy diecast box (89x35x30mm). Two coaxial aerial sockets. PCB. Grommet. PCB pins. Nuts and bolts.	

BUYLINES

All parts should be easily obtained. The OM335 IC is available from Electromail on (0536) 201234. The PCB is available from the ETI PCB service.

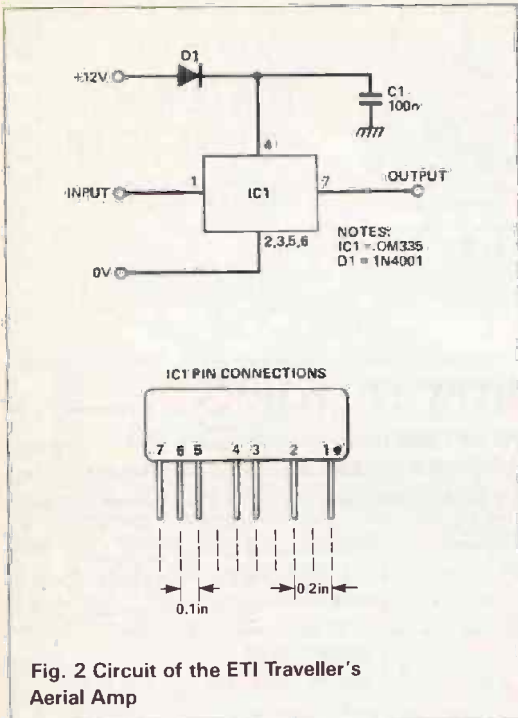


Fig. 2 Circuit of the ETI Traveller's Aerial Amp

Start with the case. In our prototype, an aluminum alloy diecast box was used. This not only gives a suitably tough enclosure for portable use but also allows total electrical screening of the internal circuit. The PCB (see Fig. 3) was designed for use with this case so it makes sense for you to use an identical one but anything larger will also do.

First, drill the case for the two co-axial aerial sockets and power input lead. The aerial socket fixing holes must be drilled at about 45° angles to allow the bolts to pass through the case without touching the threaded supports inside the case at each corner. Fit a grommet into the power input hole.

Next, file the PCB (without any components, at this stage) to fit the case, between the two inside edges of the two aerial sockets. The board must be a fairly good fit, because it is to be held in position between the two sockets simply by soldering the sockets' terminals to the board.

Now solder the components into the board. Be extremely careful with the amplifier IC. It's not particularly fragile but it can be damaged by excessive heat. Solder it in one pin at a time, letting the IC cool in between. Pins should be soldered on both sides of the board (component side and underneath) so you'll need a fine-tipped soldering iron to avoid touching the IC when soldering on the component side.

Mount and solder the other two components (ensuring the diode is the correct way round) and solder in two PCB pins, to which the earth terminals of the two aerial sockets can be soldered. Solder in power connections. About an inch from the board, tie a knot in them to prevent them from being pulled out and feed them through the grommet. Now, insert the PCB between the aerial socket terminals (the components should be on the underside).

Solder the aerial socket terminals to the PCB at each end. Finally, earth the case to the PCB with a short connection from one of the socket mounting nuts and bolts to the board. For your own reference, mark the case so that input and output sockets cannot be confused.

No setting up is required, simply connect a power supply of 9-28V and plug in your aerial and television leads.

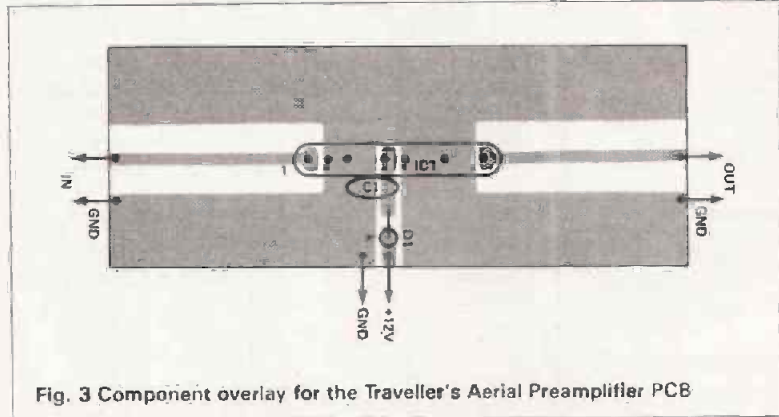
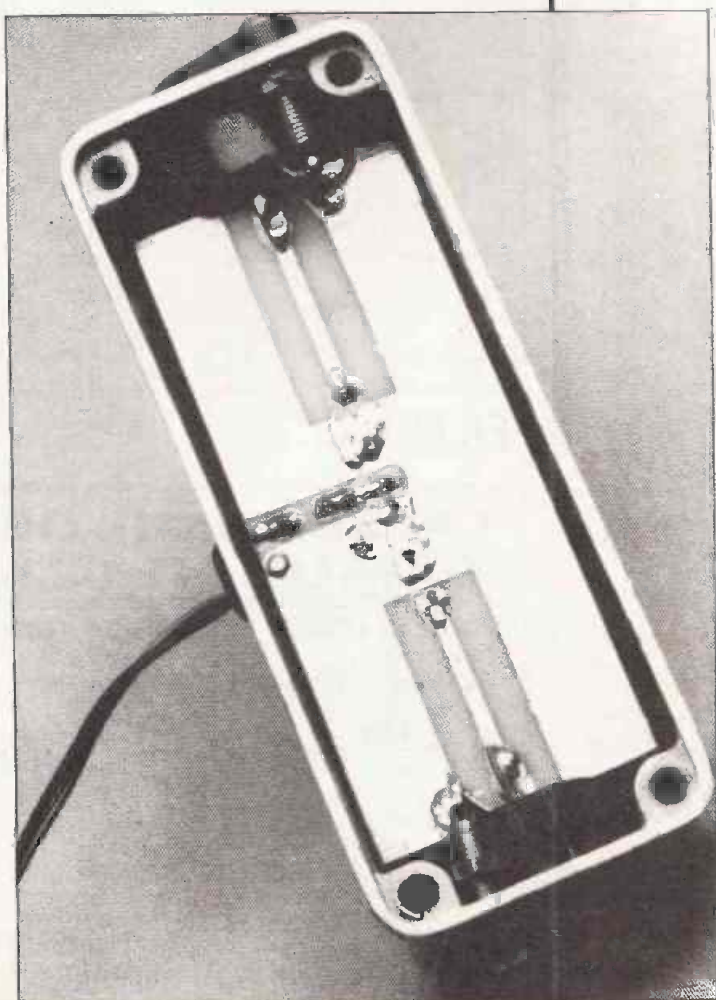


Fig. 3 Component overlay for the Traveller's Aerial Preamp PCB

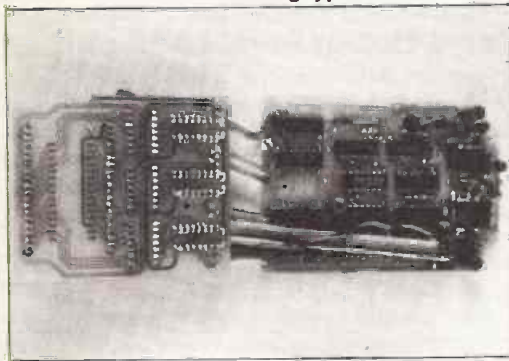


RECURRING DREAM

PROJECT

Those of you who have followed this project from the start may have noticed something missing from last month's construction article. Remember the lucid dream stimulator? It hasn't been overlooked.

Lucid dreams are those strange experiences that happen to many people from time to time, when they are able to take control of their own dreams. Psychologists with a particular interest in dreams are not content to wait until the lucid variety occur of their own accord and have devised a way to turn ordinary dreams into the more exciting type.



Lucid dream stimulation relies on the fact that if a sleeping person is disturbed during an ordinary dream, it will often turn into a lucid one. The stimulator must therefore be able to detect the onset of dreaming and then when the time is right apply the necessary disturbance, usually in the form of a very mild electric shock.

Detecting a dream sounds as if we need a mind reading circuit, but it's really much simpler than that. Dreams occur during a particular phase of sleep known as REM (rapid eye movement) sleep. The physical changes that occur in your body when you enter this phase of sleep include a change in your brainwave patterns, rapid movements of your eyes and . . . a speeding up of your breathing rate. You begin to see how it all comes together?

This month I'll be giving you, amongst other things, a circuit which will transform your breathing rate monitor into a lucid dream stimulator. Before I get onto that, there's some work to be done. The breathing rate signals inside the monitor will have to come out, so there's a socket to be fitted before you do anything else.

The Interface Socket

The signals you need are all available at the edge of the main PCB, and are the very same ones that drive the display board. In Fig. 3a of last month's article they are labelled J,K,H,L (G is not required), N,P,M,R and T,V,S,W. A ground reference is also needed — this can be taken from the unused pad just above the Y connection on the display board.

The most suitable type of socket to use, taking into account the number of connections and the space available for it in the case, is a 15-way D socket. The twelve signals and ground (battery -) can be wired

to the pins in any order, so I won't draw a diagram. As long as you know which is which and can identify the signals at the other end, that's all that matters.

Since the display board and the socket both need the signals, the new cable between the main board and socket can be soldered to the rear of the main PCB. Otherwise, PCB pins can be soldered into the J,K...W holes and both cables can be taken to the pins. Yet another alternative is to connect both the main PCB and the display PCB to the socket. There's no difference electrically, so do whichever looks neatest or easiest.

Space inside the case is very limited, so it's a good idea to check the socket position very carefully before making the cut-out. It fits on the top of the case, just above the battery compartment and below the display PCB. A suitable hole can be made by marking out a rectangle of a size suitable for the socket, drilling holes

Paul Chappell adds on to his breath/heart rate monitor to produce the elusive Lucid Dream Machine and other goodies

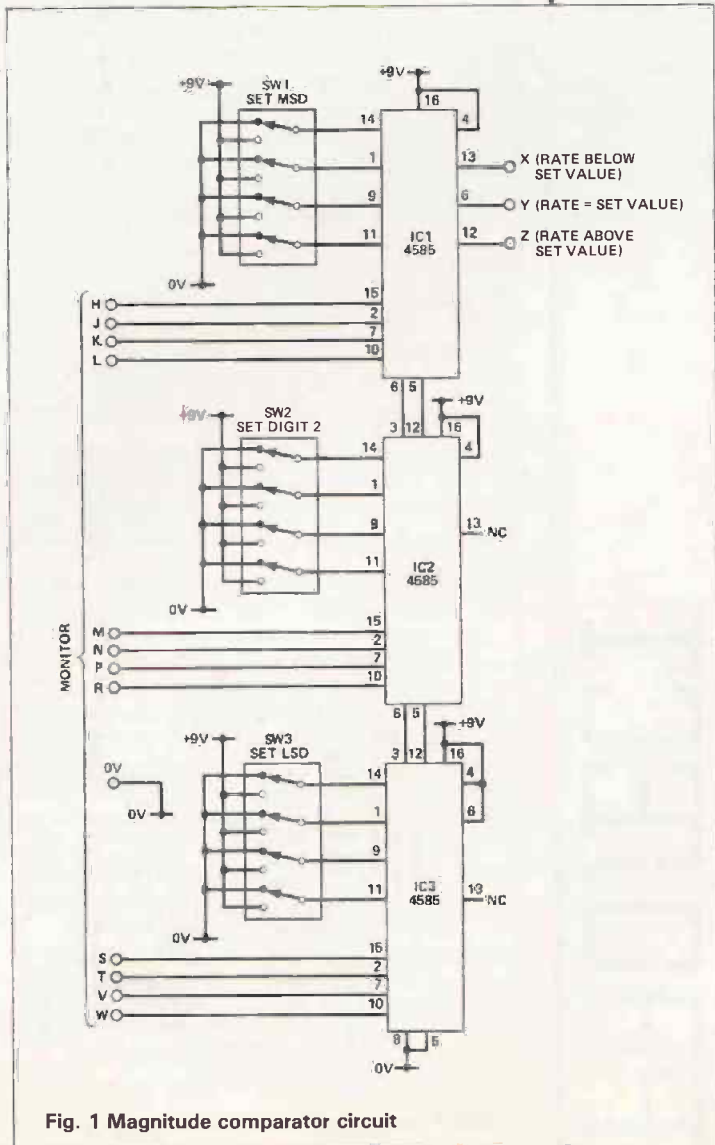


Fig. 1 Magnitude comparator circuit

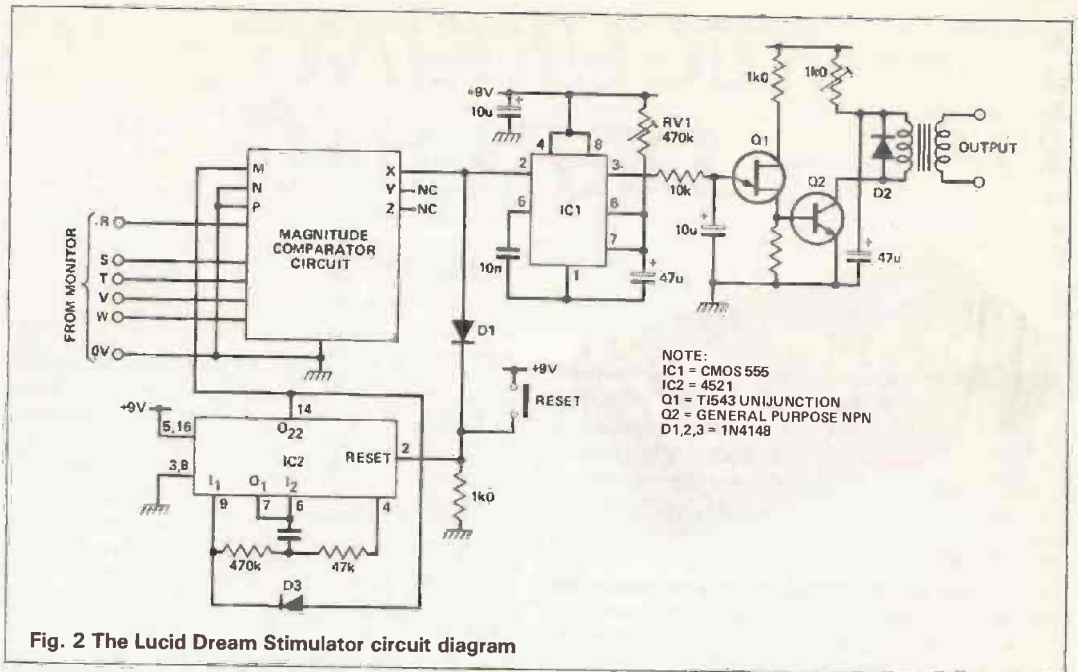


Fig. 2 The Lucid Dream Stimulator circuit diagram

around the inside, then removing the surplus plastic with a modelling knife. The flange of the socket will cover any rough edges.

Magnitude Detector

All the add-ons I'm going to suggest for your monitor involve detecting whether the reading is above or below a certain value, so the magnitude comparator of Fig. 1 is common to all. I have shown the 'fully upgraded' version with DIL switches to select any value whatsoever as a set point but the circuit can be simplified considerably as I'll explain at the appropriate time.

The circuit needs little explanation. It simply uses three 4585 magnitude comparator ICs cascaded in the usual way to compare the breathing or heart rate from the monitor with the reference value selected by the DIL switches. As long as the monitor shows a rate less than the selected value, output X will be high. If the monitor rate equals the set rate, output Y will go high, and Z shows that the monitor rate has exceeded the value set by the switches.

Values are selected in BCD, so each switch can be set to a value from 0000 to 1001. Rotary BCD switches would be more suitable than DIL sp/o switches if the values are to be changed frequently.

Lucid Dream Stimulator

The circuit of the stimulator is shown in Fig. 2. It is almost the same as the stimulator suggested in May as an add-on for the Brainwave Monitor — and why not? If a circuit works well, there's no point in changing it.

For the magnitude comparator you could use the entire circuit of Fig. 1, but you can save an IC and DIL switch by missing out IC1 and taking the X, Y, Z outputs from pins 13, 6 and 12 respectively of IC2. Having selected a suitable trigger point you can also hardwire the switch inputs to IC2 and 3, saving two more switches.

The top three switch sections of SW2 are set (or wired) to 1, 0, 0. The bottom switch and all of SW3 are used to set a breathing rate above which the circuit will trigger. Set it a little below your normal resting breathing rate.

The 4521 is used as a timer to allow about half an hour for you to fall asleep. During this time the comparator will be looking for a breathing rate of above 80 per minute (since pin 14 of IC2 is high) and, unless there's something very odd about your breathing, it won't happen. After the half hour period, O₂₂ of the 4521 goes high and the comparator now looks at whether your breathing rate is above that set

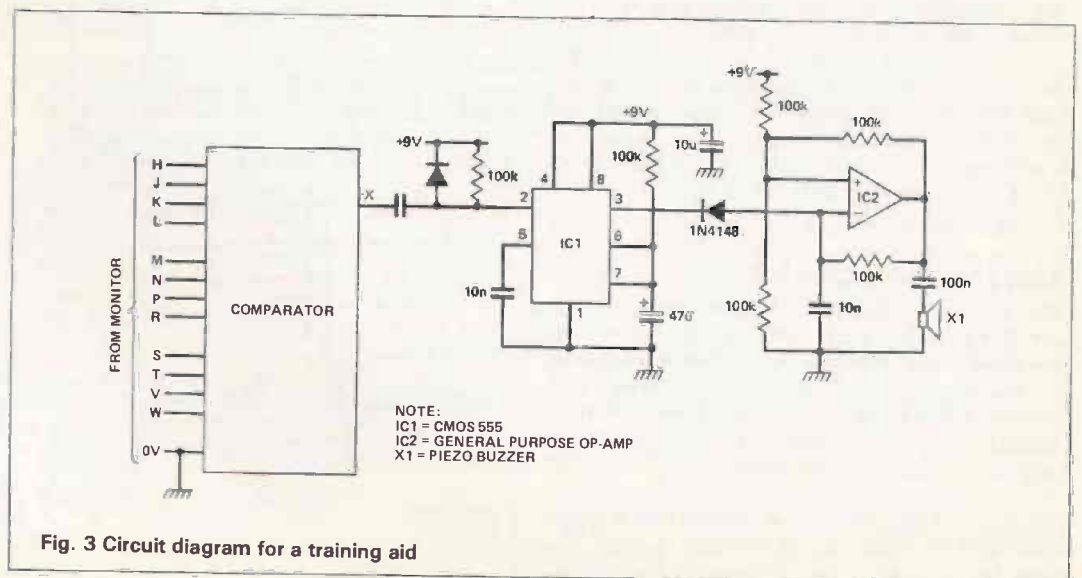
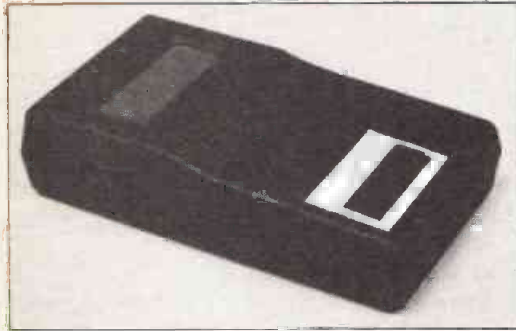


Fig. 3 Circuit diagram for a training aid

by the switches. The circuit is armed!

When your breathing rate speeds up as you enter REM sleep and begin to dream, the comparator will detect this and trigger the 555 IC, which fires the shocker. This is set to give you a little tingle — just enough to disturb your sleep, but not enough to wake you up. At the same time as the circuit fires, it resets



the counter for another half-hour delay to be ready for your next dream.

The shocker electrodes are connected to the output of Fig. 2 and taped to one arm or leg. Two 1p pieces will do — if you can afford it! Needless to say, the circuit must be run from a battery and *not from the mains*.

Training Aid

Last month I suggested a training program which involved raising your heart rate to 100 beats per minute with occasional peaks of 140. It could be that when you're jogging along you'd prefer to look where you're going rather than keep your eye on the heart monitor. Your training won't do you much good if you end up running into a lamp post.

Reaching a level of 100 beats per minute is easy — unless you're very fit already you can assume that a gentle jog will give at least this rate. For extra bursts of exertion however, it could be useful to know when you've hit the 140 target without having to look at the monitor. Figure 3 shows a little circuit which bleeps briefly as you hit the right level. The comparator switches are of course set or wired to 140.

Baby Alarm

The chances of a new born infant dying for no apparent reason are alarmingly high. Much higher than I would have guessed if I didn't know better. If there is no previous history of 'cot death' occurring in your family, the statistics give your child about 1 chance in 500 of dying inexplicably. If there have already been cot deaths, the chances of another are much worse — about 1 in 125.

Already there are gadgets available which detect a child's breathing rate and sound an alarm if it should stop. The ETI monitor was not designed for this purpose but could certainly be used in this way. The circuit is trivial and is shown in Fig. 4.

The units used for this in hospitals are called Apnoea monitors and are based around a pneumatic sensor capsule. This is connected to a plastic cone lined with foam rubber, which is taped to the baby's tummy. Respiration is monitored down a plastic tube connected to the cone, and the sensor supplies signals to the main unit. Unfortunately I haven't yet discovered exactly what form these signals take, and some adjustment to the input stage of my circuit may be needed if such a system is to be used reliably and safely.

The commercial devices apparently sound the alarm after a breathing interruption of 30 seconds. Since the ETI monitor would take rather longer than

this to register zero, the switches should be set to a rate of about half your infant's breathing rate. You can check on the delay time by simply removing the sensor leads and waiting for the alarm to sound.

As long as the breathing sensor is properly arranged, the monitor can't do any harm and may actually save your child's life, so it's got to be worth investigating.

Biofeedback

I can't let this project go by without mentioning biofeedback. The reason I have not raised the topic before is that although conscious control of your heart rate is easy to achieve, there's not really much point in doing it! However, there are a few snippets of information that may amuse, enlighten or bore you, and I'd like to take this opportunity to share them with you all, brothers and sisters.

The most bizarre experiment I have come across is the one conducted by Dr. Miller of Rockefeller University when he took it into his head to teach rats to beat their hearts slower or faster. The idea is wacky enough in itself but the good doctor went one stage

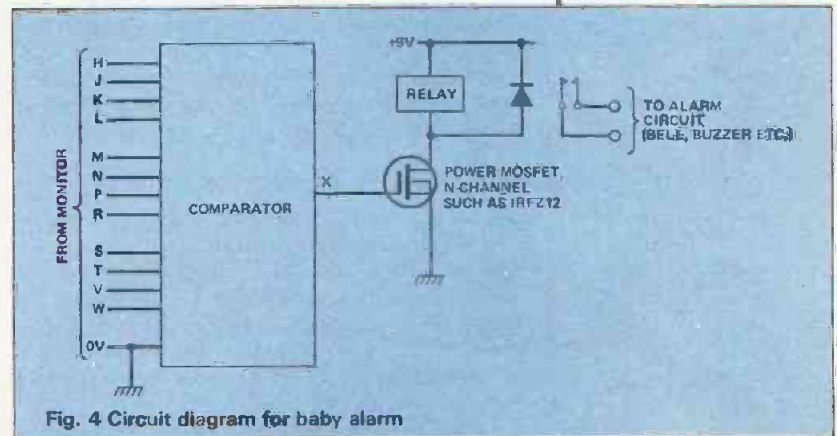


Fig. 4 Circuit diagram for baby alarm

further. Just so that the rats couldn't cheat by having a crafty jog around the cage or a peek at Playrat magazine, they were injected with curare. This drug has the effect of knocking out the skeletal muscles, so the poor old rats couldn't do a thing for themselves — they couldn't even breathe.

To keep the rats in working order for the duration of the experiment, Miller attached them to little rodent respirators (I'm not making this up!) and rewarded the proper responses with jolts of electrical ecstasy to the pleasure centres of their brains.

The outcome was that the rats could indeed control their heart rates, Miller's students all got their PhDs, Dr. Miller eventually received a mention in ETI, and the rats were disposed of by the caretaker.

Humans, without the curare and respirators, can usually learn without difficulty to increase or decrease their heart rates quite significantly — around 20 beats per minute on either side of the resting rate is easily achievable. Being able to do this has clinical applications in the treatment of cardiac arrhythmias, but this really does require the guidance of a doctor and the aid of sophisticated heart monitoring equipment. The only point in doing it at home is just to see whether you can!

The increased awareness of your own heart could be beneficial if you were ever unlucky enough to suffer with some kind of heart trouble — you might well notice the signs and be able to have treatment earlier.

A veritable myriad of applications then, and no doubt readers will conceive more than a few more. Good luck, and sweet dreams!



FREQUENCY METER

Mark Thewliss introduces a low cost frequency meter

Frequency meters are rather expensive things to buy. I don't need one every day of my life and can think of much better things to blow a hundred quid on. So I decided to do something about it. This meter uses cheap 74LS ICs and works out to about £3 for each digit of the display and maybe £20 for the rest of the circuit.

The design is flexible enough to be expanded gradually or built as the full 8-digit version from the start. If you're looking for something to check frequencies into the gigahertz range then I'm afraid this design ain't the one for you as the response is limited by the TTL circuitry to 40-45MHz, which is fine by me.



If Mr Leong of Harlow is reading (hello Mr Leong), he may recognise a large chunk of the gating logic. This appeared as an ETI Tech Tip some years back and I've used it here since it worked best in pre-prototyping trials.

You can choose between using LEDs and incandescent displays — incandescents are probably a better bet if you can get them, as they do not need current limiting resistors and have a long life expectancy (50000 hours). Because of this option on the display there is no PCB to mount the digits, this would be an added expense in any case.

The prototype used stripboard to mount the incandescents with wires connecting to the main PCB. The wires were colour coded corresponding to the segment connected and I really would recommend this as the only way to avoid total confusion with 56 wires flying around. This way it isn't as daunting as it seems.

Construction

To keep costs down the main PCB (Figs. 2 and 3) has been made single sided. This means there are more links on the upper side of the board than is usual. Begin by fitting all links (*insulated* where there is a chance of shorting) not forgetting that some lie under IC sockets. The short links under the 74LS75 ICs may be fitted on the track side if

HOW IT WORKS

The circuit diagram is shown in Fig. 1. IC2a is configured as a 1MHz clock oscillator and drives buffer stage IC2f. This clock signal is fed to the combination of IC3 and IC4 which together divide the clock by 10,000.

A reset pulse is output from IC4 back into IC3 to continuously enable this part of the circuit. A pulse is also output from IC3 pin 2 which clocks the three divide-by-ten ICs 5, 6 and 7. The four outputs at .01secs, .1s, 1s and 10s intervals are selected by SW2 and then applied to the gating logic.

IC8a is a 'D' type flip-flop configured to divide by two. The output enables IC9a which is a monostable dependant on the time constant of the 2µ2/680k combination on its output side.

There is a further monostable between IC2 pin 6 and 5 which generate the main counter reset pulse. Q5 is a buffer stage to the LED on the front panel which indicates when the gate is open.

IC8b is an overflow indicator driver which is operated by a pulse from the MSD 74LS90. When this occurs, the LED is lit and the gate IC9b is disabled thus halting the count. The input into the pre-amp stage is by way of a BNC socket on the front panel feeding a switched attenuation stage via C1. Diodes D1 and D2 together with the combination of 180k/220p also protect Q1 from damage from high-voltage spikes.

Q1 and Q2 are connected as a high gain wideband amplifier. The output from the first pair of transistors is then fed to the darlington pair Q3 and Q4. The amplified signal is output from the emitter of Q4. The 1k preset pot in the drain lead of Q1 sets the stage gain of the FET and thus the rest of the pre-amp.

IC1 is an XOR gate which, if fed from either +5V or 0V changes the polarity of the square wave signal on its opposite input.

The main counter input is fed from IC1 pin 3.

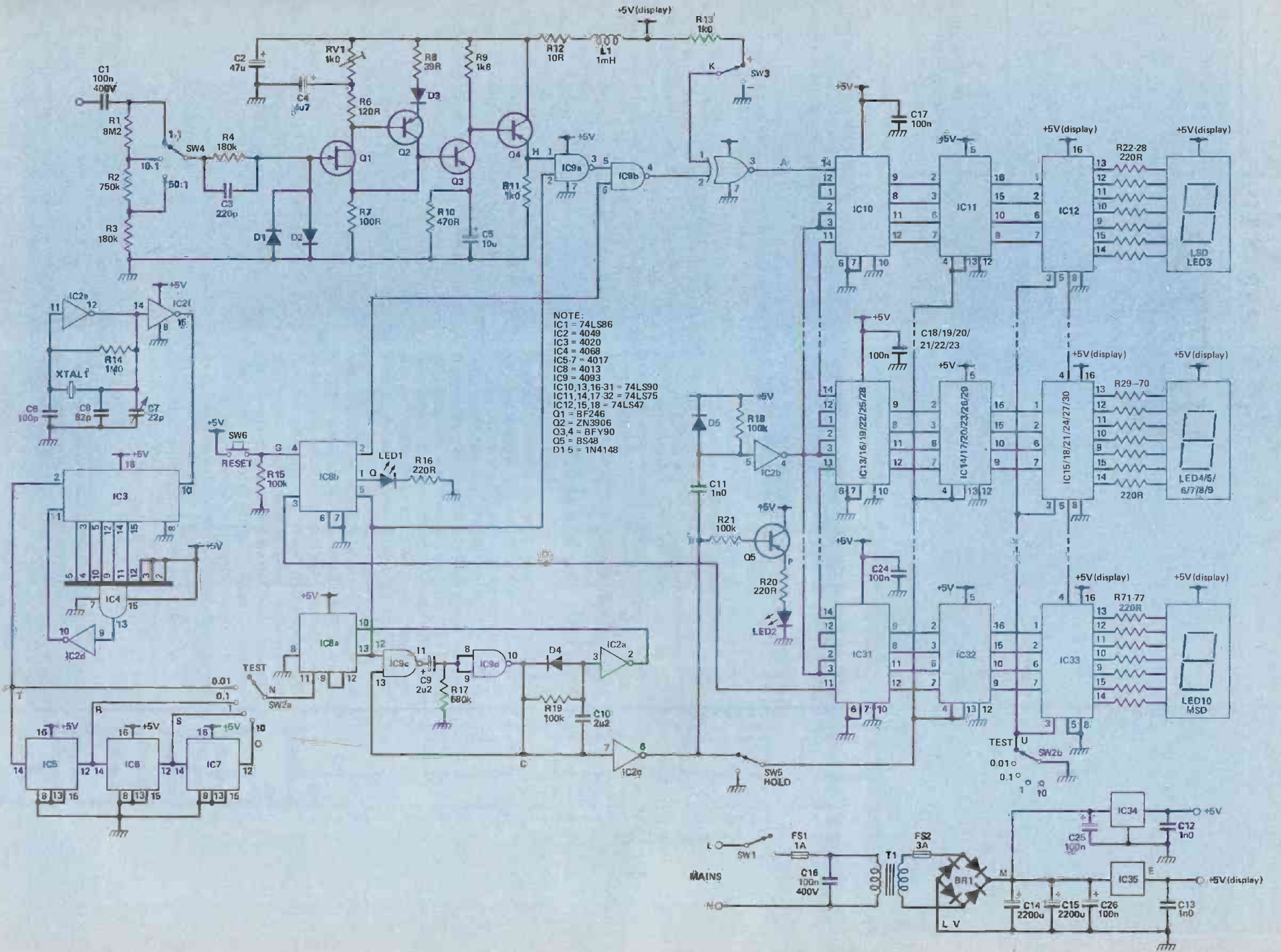
Each stage has three ICs — one to convert pulses into BCD, one latch to either pass the information or not, and a third IC to drive the display. The third IC (74LS47) has 'lamp test' and leading zero blanking facilities and both these are used. Note that the current limiting resistors R22-77 are only needed for LED displays.

Each stage in the counter is identical and accepts pulses on the input pin of each 74LS90, giving output pulses to the next stage in the series on pin 11. Thus the LSD counts units, the next tens, the next hundreds and so on.

The power supply is standard. Note that there are two regulators fitted, this is to obviate any overload situation which might arise. The larger rated 78H05 device is mounted on the case of the instrument, necessitating a metal case. The rectifier is protected by a fuse as is the mains input to the instrument. All the circuitry with the exception of the pre-amp is on one PCB thus simplifying construction.

PROJECT

Fig. 1 Circuit diagram for the frequency meter



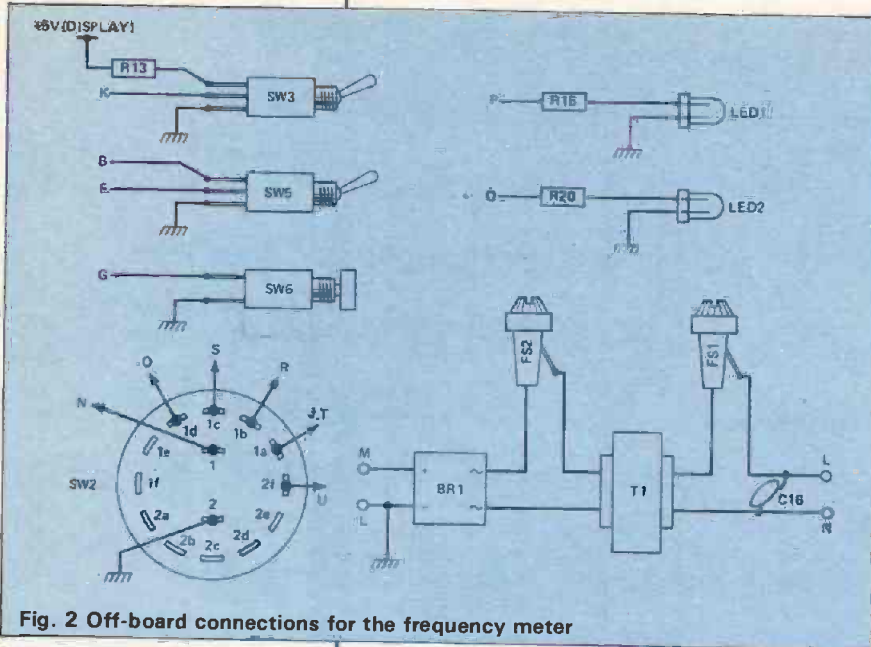


Fig. 2 Off-board connections for the frequency meter

desired. Next fit throughboard pins at the appropriate places for off-board connections.

IC sockets are fitted next, then diodes, resistors and capacitors (noting polarity where appropriate), gradually building the height of components on the board. Last of the capacitors should be the pair of 2200 μ in the power supply and don't forget the transistor Q5 between IC7 & 8. The two 220R resistors for the LEDs are mounted on the display board.

At this point the main board should be finished by checking with a multi-meter for short circuits between power rails and between IC pins (except where these are supposed to be).

Don't Fit The ICs Until I Say So

For the display board (stripboard) you'll have to fly solo I'm afraid, since this all depends on the type of display you decide to use and anyway pin-outs differ from device to device. Whatever you use you should prewire the display now and check very carefully with a trusty multimeter as a single short circuit here can cause some pretty obscure faults. And write down the colour code you use (I used the resistor codes — black for segment a, brown for b, red for c and so on — so that in five years I'll still be able to understand).

If you are using LED displays you will need either SIL resistor packs or individual 180R or 220R resistors to the front edge of the main board. Two types of SIL packs are suitable, one with seven resistors and a cheaper one with eight. The cheaper one is just as good here, so remove the extra legs (pins 8, 9) and fit as for the other type.

If you are using incandescent displays then ignore the above paragraph and proceed from here.

Wire each display segment to the main board, the colours of which should run from right to left in this order (assuming the aforementioned colour scheme) — green (f), blue (g), black (a), brown (b),

BUYLINES

All components should be available from the normal suppliers except perhaps Q1, available from STC on (0279) 626777. The PCB is of course available from the ETI PCB Service on 0442 41221.

PARTS LIST

RESISTORS (All $\frac{1}{4}$ W 5% unless specified)

R1	8M2
R2	750k
R3, R4	180k
R6	120R
R7	100R
R8	39R
R9	1k8
R10	470R
R11, R13	1k
R12	10R
R14	1M
R15, R18, R19, R21	100k
R16, R20	220R
R17	680k
R22-77	180R or 220R
RV1	1k min preset

CAPACITORS

C1, C16	100n 400V polyester
C2	47 μ 35V tantalum
C3	220p min polyester
C4	4u7 35V polyester
C5	10uf 35V
C6	100p silver mica 5%
C7	22p min trimmer
C8	82p silver mica 5%
C9	2u2 35V tantalum
C10	2n2 min ceramic
C11	1n0 min ceramic
C12, C13	1n0 min disc
C14, C15	2200u 25V axial electrolytic
C17-C24	100n min disc

SEMICONDUCTORS

IC1	74LS86
IC2	4049
IC3	4020
IC4	4068
IC5-7	4017
IC8	4013
IC9	4093
IC10, 13, 16-31	74LS90
IC11, 14, 17-32	74LS75
IC12, 15, 18-33	74LS47
IC34	78H05
IC35	7805
Q1	BF246 or 2SK40 FET
Q2	2N3906
Q3, 4	BFY90
Q5	BC548
D1-5	1N4148
LED1, 2	hi-brightness LED
LED3-10	incandescent or LED digit displays

MISCELLANEOUS

BR1	6A bridge rectifier
FS1	1A fuse
FS2	3A fuse
L1	1mH wire ended choke
SW1	SP mains toggle
SW2	5-way, 2-pole
SW3, 5	1-pole C/O
SW4	3-way, 1-pole
SW6, 7	press-to-make
T1	9V 2.5A secondary
XTAL1	1MHz crystal
Case, IC sockets, Nuts and bolts.	

PROJECT

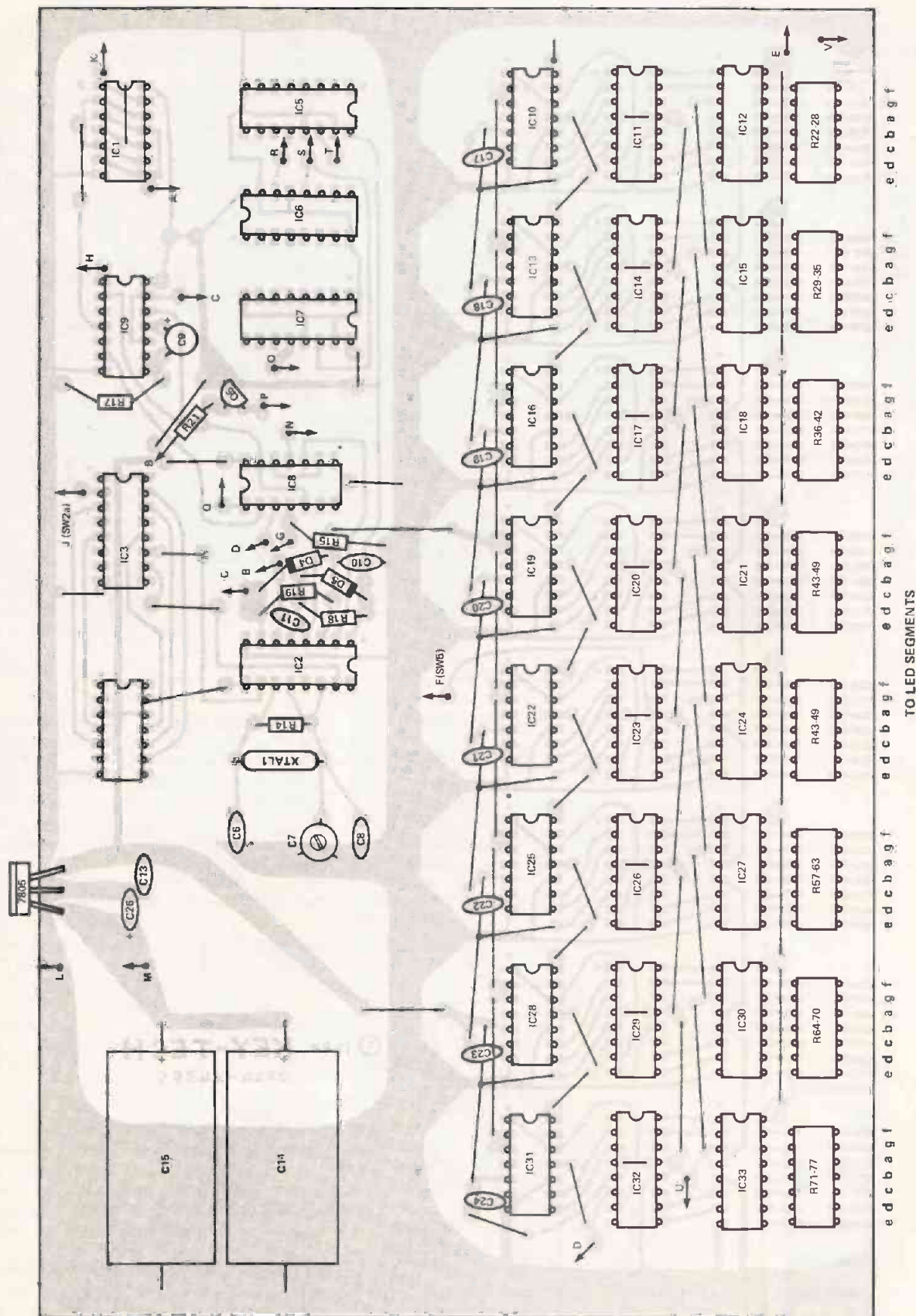
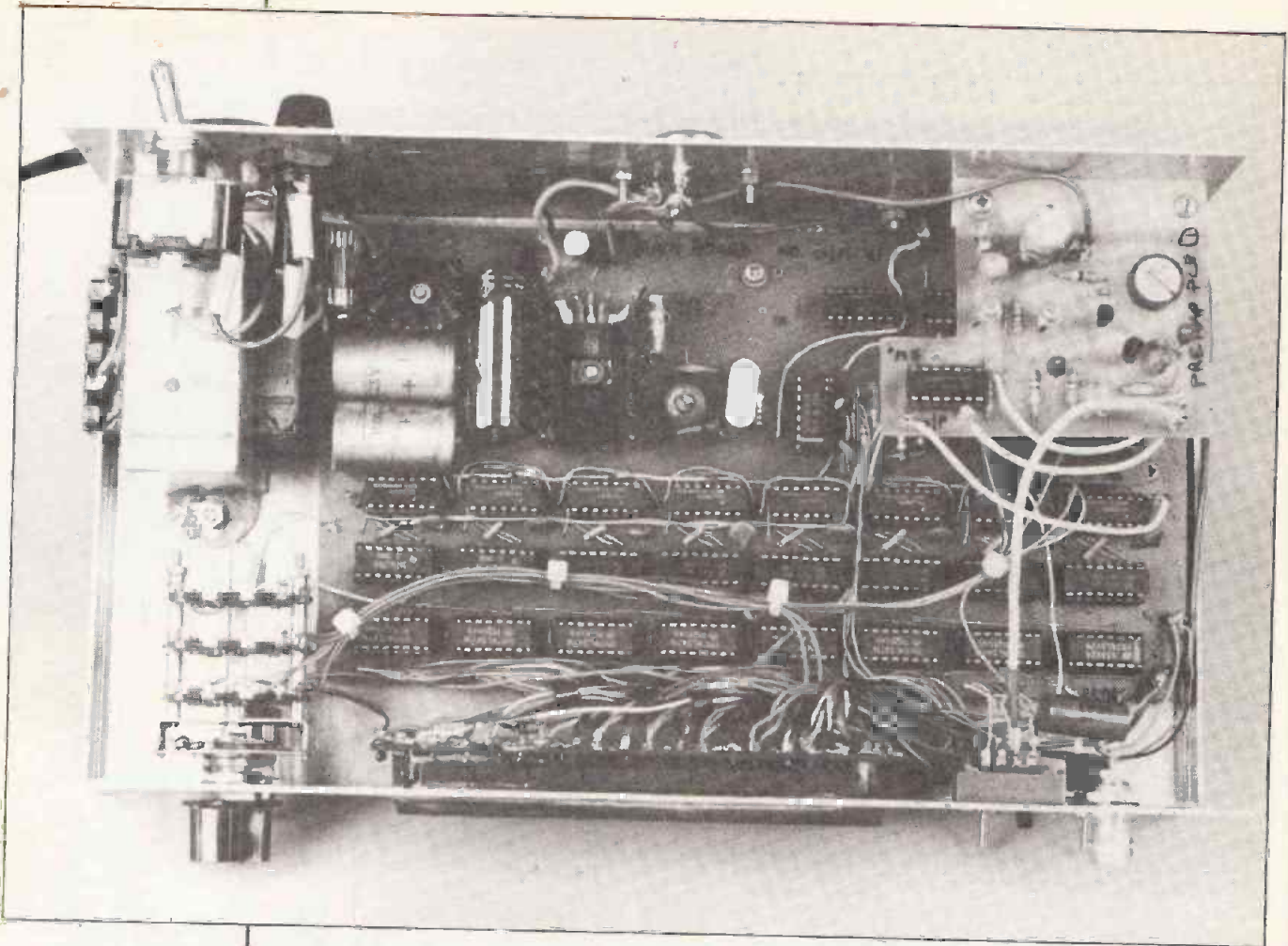


Fig. 3 Component overlay for the main board



red (c), orange (d), yellow (e). This applies to all displays.

Assemble the pre-amp PCB (Fig. 4) using the same order of construction as for the main board (there is only one link to fit). The only point to note here is that Q1 pads have been provided for either BF246 or 2SK40 FETs — the overlay shows a BF246 as this is the more common device.

The case depends on the transformer you use. The prototype used the transformer from a ZX81 which is fairly small for a 2.5V secondary (which is what you need). With this, everything fits neatly into the recommended case, but otherwise a larger case is recommended. Mark and drill the front and rear panels to suit the switches and displays you are using.

PROJECT

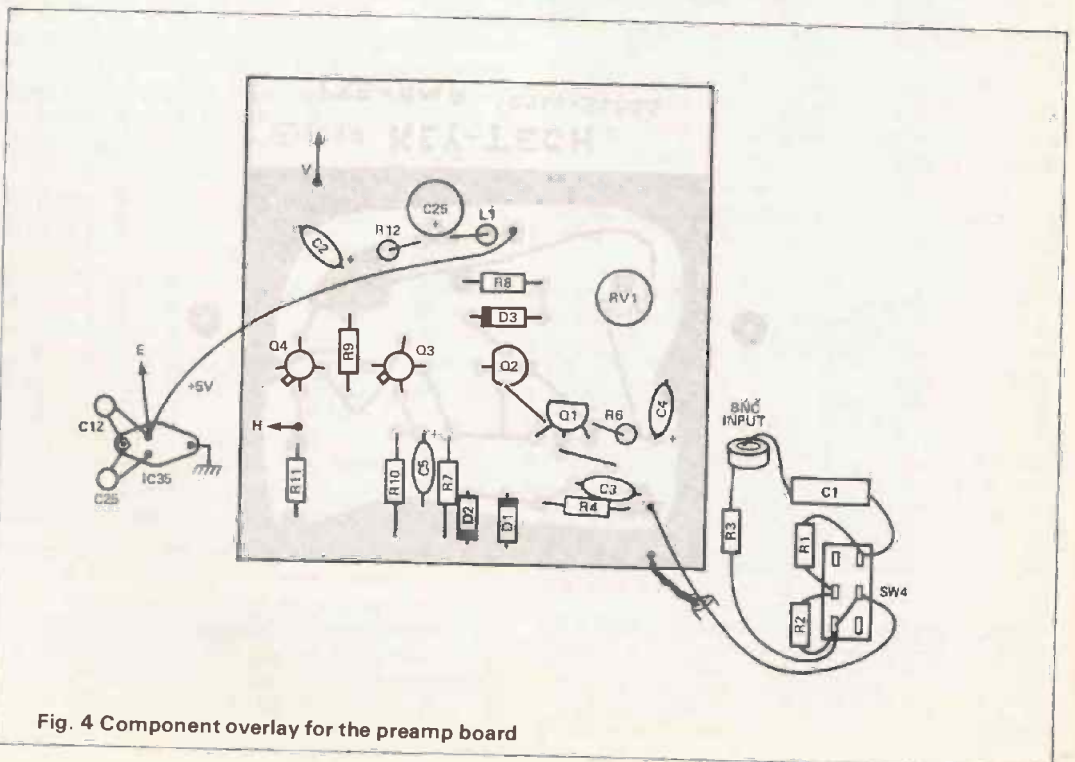


Fig. 4 Component overlay for the preamp board

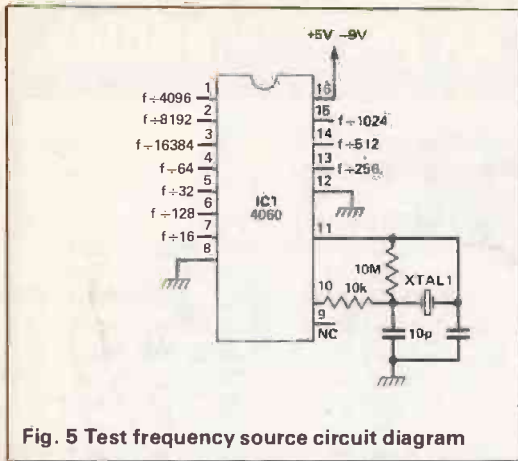


Fig. 5 Test frequency source circuit diagram

Testing

At this point it will be necessary to loosely wire everything together for testing purposes. Do not fit the main board into the case just yet.

Assuming you haven't got a bench power supply capable of giving 2.5A then proceed as follows. Mount the mains transformer, input fuse and mains switch in position being careful to cover exposed terminals with sleeving. Also mount the 78H05 regulator IC34 on the rear panel allowing enough room for the pre-amp and the 7805 regulator IC35 as well. Temporarily fit a heatsink to the 7805 regulator and mount it on the main board.

Ignoring the pre-amp for the time being, make connections between the 78H05 and the through board pin at the front of the main board. Temporarily link the case with the ground plane on the PCB and make the following tests.

Insert FS1 and apply power to the unit. There should be AC voltage on the secondary of the mains transformer. This can lie anywhere between 8V and 12V but should not be much lower than the lower figure or the regulators may not work properly.

Test for DC at the 2200 μ capacitors C14, 15, the figure here will be somewhat higher, in the range of 10-15V DC. If it isn't, switch off before something catches fire and check, check and check again on your construction.

If all is well to this point, then you should have -5v on all the IC sockets (you didn't fit the ICs did you?) at the relative pins. If not, check for missing links, broken tracks or pins not soldered.

Remove FS3 and in its place fit a milliammeter, turn off the power and fit the logic ICs one at a time noting the current consumption as you go.

It should gradually increase from virtually zero to a couple of hundred milliamps, if there is a sudden change, power down quickly and investigate the cause.

If you have connected the two LEDs on the front panel one or the other may be lit. If the overflow is lit check it goes out when you apply +5V to IC8 pin 4.

If you make temporary links in place of SW2 the gate LED should light in response to where you make the link — if you connect IC6 pin 12 to IC8 pin 11 the LED should be lit for 1 second and extinguished for 1 second.

If these tests are good to this point, transfer the milliammeter to the output lead of the 78H05, after first checking to see if there is +5V on its output.

Power down and insert the 3 ICs for the LSD

of the counter. As before note the current reading as you go and power down on anything which looks like a fault. Clear it and proceed to the next stage.

As each digit is checked the current should rise by some 60 to 80mA although individual ICs may consume more than others. If after inserting all the counter ICs you have not had any major disasters to this point, then grounding pin 3 on the 74LS47 ICs should light all segments. In this condition the 78H05 regulator will be supplying about 2.4A if all is well.

Remove the temporary heatsink from the 7805, drill the PCB for mounting and fit sticky stand-offs through these holes. Simply press the PCB into the bottom of the case et voila. The display board is mounted in the same way (you did allow for the extra length of course) and the remainder of the controls may now be fitted and wired up.

High brightness LEDs are recommended for the two panel mounted devices and if the overflow LED does not appear to be bright enough then an extra transistor Q5 may be included as a buffer.

Before the displays are finally mounted it is advisable to stick some contrasting material behind the aperture (in the case of LEDs this will obviously be red, but if incandescents are used then they can be any pretty colour you fancy).

Final Assembly

With the main PCB in the case, mount the pre-amp PCB on a bracket at the rear. The 7805 should also be mounted at this time.

Connect the attenuation switch on the front panel to the pre-amp board with a short length of screened cable. At this point the preset resistor on the pre-amp should be set up. To do this, monitor the voltage at the emitter end of R11. There should be approximately 1.5V at this point relative to ground — adjust the preset and re-adjust this later for optimum performance.

At this point it is the time to adjust the master oscillator using if possible a frequency standard. However if you cannot gain access to the above proceed as follows: construct on stripboard the oscillator in Fig. 5. Depending on the frequency of the crystal used you should be able to read something close to the stated frequency.

A word here about crystals — have a chat with your local TV repair shop, they will probably be happy to part with a 4.4433619 device for a few pence (these are the ones used in all colour TVs but don't whatever you do go poking around in your TV).

Having built your test signal source apply power to it and inject the output into the BNC socket, noting that it is better to start with the attenuation switch in the 50:1 position to begin with. Trim the master oscillator on the counter by adjusting C7. If it won't quite make it to the stated frequency try altering the values of C6, C7 and C8.

All that remains to be done now is to box up the unit leaving it running for an hour or so and giving the trimmer C7 a final tweak.

In use, you may find that when investigating square waveforms that the counter refuses to count properly. Use of SW3 will enable you to choose the best edge to count on. A final word about performance — the pre-amp should be good for the worst case transformer in the design which is Q2 whose f_r is quoted at 150Mhz.

In the counter itself the upper frequency limit is imposed by the TTL itself, this being 40-45Mhz.

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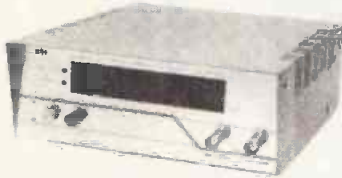


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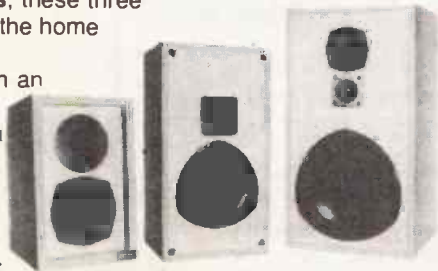
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SPECTRUM EPROM EMULATOR

PROJECT

It is a fact of life that when it comes to designing and debugging microprocessor based circuits, your old single beam valve oscilloscope and trusty Avo won't get you very far! Microprocessors are tricky beasts to get going at the best of times and specialised development and support tools are really aimed at the professional engineer in industry, where the elevated price tag is of secondary importance.

One extremely valuable piece of microprocessor development equipment is an in-circuit emulator. This usually takes the form of a big box of tricks and a 'pod' on the end of an umbilical cable, which plugs into your target circuit in place of the microprocessor chip. From then on, the emulator pretends to be the processor, and if desired the memory too, simulating all the functions in real-time.

The emulator provides facilities to start and stop the processor, examine and change register values, and perhaps most importantly, examine and change the memory contents. Such systems provide an amazingly powerful development tool, cost many thousands of pounds and no, we're not going to build one!

A few steps down in complexity from the in-circuit emulator but no less valuable, is the so-called EPROM emulator. Once again this provides a 'pod' at the end of a cable which plugs into the target board, this time in the place of the EPROM containing the operating software.

As far as the target board is concerned, the EPROM emulator is the EPROM — a block of read-only store. However, the emulator is in fact RAM and data can be put into it during code development, from some external source such as a home computer.

This means that changes to code can be made in seconds, without going through the hassle of erasing and programming EPROMs each time you discover a tiny bug in your software. It also means that short test routines can be quickly employed to test and debug new hardware, again saving time with EPROMs.

Such EPROM emulators have appeared in ETI before, so what is so special about this one? The major difference is in the method used to download the code into the emulator. Usually, having been compiled/assembled, the code is moved from the development computer into the emulator via a serial link. This requires a program to be running in the home computer to transmit the data, and some hardware in the emulator to receive the data and write it into the appropriate RAM locations. In this design all that is unnecessary.

A Full Spectrum

This emulator has been designed for use with our old friend the ZX Spectrum and simply plugs onto the expansion port at the back. The emulator RAM maps

itself into the Spectrum memory as an 8K location block starting at address 49152.

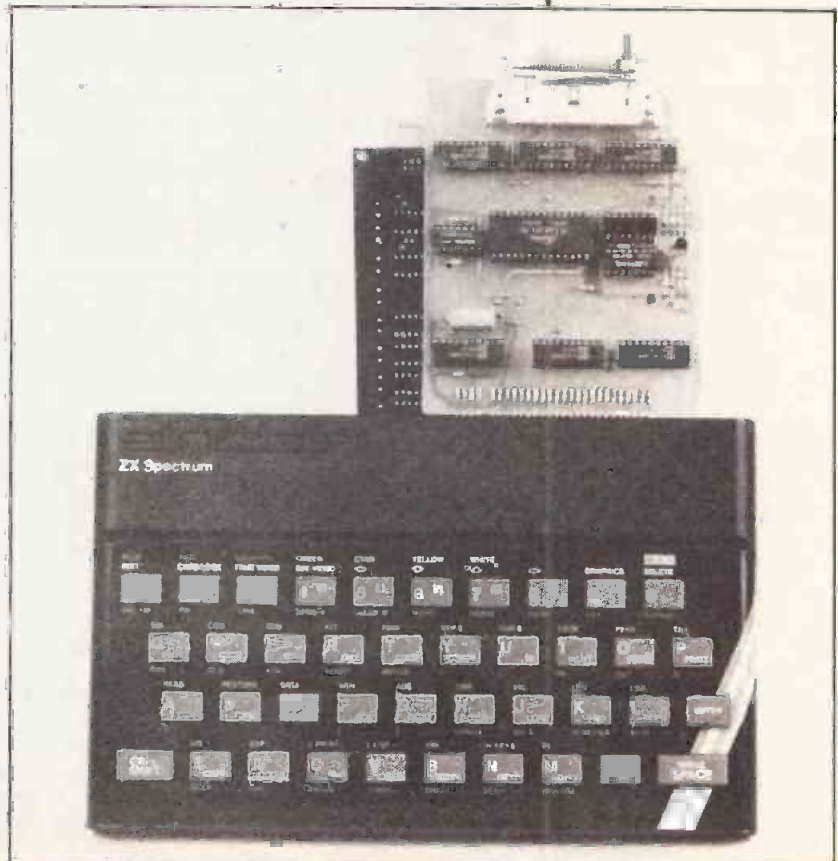
The idea is that the Spectrum sees the emulator RAM as its own memory so that downloading data is handled automatically. However, the Spectrum's memory map is full of its own RAM already.

In order to overcome this, the emulator RAM is configured as 'Write-Only' memory (WOM!?) as far as the Spectrum is concerned. This means that if the Spectrum writes to these locations, the data is put into both its own RAM and that of the emulator. If the Spectrum reads from these locations, it sees only its own RAM contents. Thus the emulator will not affect in any way the operation of the Spectrum, yet manages to receive download data at the same time.

In this way we simply use the Spectrum BASIC 'Poke' command to put suitable data into the emulator. However, even more amazing is the possibility of assembling code into this area of memory. The mere act of assembling source code on the Spectrum writes executable code into memory, and in this case into the emulator RAM at the same time.

With an ordinary serially loaded EPROM emulator, getting executable code into the emulator RAM is a lengthy process. First, it is necessary to load the assembler into the computer, then load the source

Graeme Durant's Spectrum bears more than a passing resemblance to a development system's EPROM



HOW IT WORKS

The block diagram for the system is shown in Fig. 1. The eprom emulator basically consists of a block of static RAM, its address and data lines being switchable between one of two external ports.

The port shown on the left is connected to the Spectrum address and data busses via the Spectrum's expansion slot. This port is write-only, and allows the EPROM data to be downloaded into the emulator from the Spectrum.

The port shown on the right goes to the target system via a cable and EPROM look-alike pod. This port is read-only, and emulates the effect of an EPROM.

The switching of the RAM between these two ports is handled by some simple control logic — basically by the state of the power supply to the target board as sensed by the EPROM-pod power pin. If the target board is turned off, the emulator is switched to its download mode. EPROM emulation starts as soon as power is sensed on the target board.

The emulator board itself is always powered from the Spectrum, via the 5V supply connection on the expansion slot.

The circuit diagram (Fig. 2) demonstrates operation in more detail. The heart of the emulator is IC4, an 8K x 8bit CMOS static RAM chip. The switching of data and address lines to IC4 is achieved by means of the tri-stateable 8-bit buffers IC1, 2, 3, 8, 9 and 10.

Looking first at the write-only port from the Spectrum, the incoming data and address signals arrive on the emulator board via edge connector SK1, and are buffered by IC1 and IC2, 3 respectively onto the data and address lines of IC4.

The 8K locations present in the emulator are mapped into the Spectrum's memory space by IC5b and c so that they start at 49152 (dec). IC6b detects a memory write access by the Spectrum to one of these locations.

The write strobe to IC4 is derived from the output of IC6b and can be disabled in emulation mode by IC5a.

Looking now at the read-only port to the target system, the outgoing data and the incoming address signals leave or enter the card via connector SK2, and are buffered by IC8 and IC9, or 10 respectively from or onto the data and address lines of IC4.

This time there are only thirteen address bits coming from the pod, so these all go to the RAM without decoding — any decoding will already have taken place on the target board.

The most significant address bit from the target system (A12) has a high value pull-up resistor R5 connected to it. This is there to ensure that this line doesn't pick up noise whilst the board is emulating the smaller 4K EPROM (2732) with this address line floating unconnected. This does mean however that whilst emulating the 2732, data should be placed in the top half of the 8K RAM, starting at Spectrum address 53248 (dec).

It is worth noting too that the RAM address and data lines are not connected to the two external ports in the same order as defined by the manufacturer's data sheet. This dramatically simplifies the PCB

layout, and has no effect on operation providing that a data line from a port goes to a data line on the RAM, and an address line from a port goes to an address line on the RAM.

Each unique address combination will access a different RAM location capable of storing data; it does not matter where exactly this occurs on the chip! Naturally, the data and address lines on the two ports must match so that data put into a certain address from the Spectrum end will be found at the same location at the emulation port.

As mentioned previously, the operating mode of the card is determined by the state of the power supply on the target board. This is detectable on the pod by the voltage on the 'EPROM' power pin, and is handled by Q1 and its associated biasing resistors. When the target supply exceeds about 3.5V Q1 turns on (the transition voltage being set by R8 and R9). The state of Q1 is converted into TTL levels by schmitt inverter IC7a. An LED driven via IC7b indicates when the emulation mode is in operation.

The circuit diagram shows this voltage sensing taking place on pin 28 of the 2764 pod. A second connection, via diode D1, comes from pin 26. This is for 2732 emulation, when the EPROM supply pin does not coincide with that of the larger device, and pin 28 is unused (diode D1 is present to protect the target system from a possible fault condition, if in the case of 8K device emulation, pin 26 of the EPROM socket is not open circuit as the 2764 pinout assumes).

Imagine first that the target board power is off, and the emulator board is thus in the download mode. Q1 will be switched off, and so the output of IC7a will be low. The output of IC7c is always the complement of the output of IC7a, so will be high.

The low output of IC7a will directly enable buffers IC1, 2, 3 so that the Spectrum data and address signals will reach the emulator RAM. At the same time, the high output of IC7c will allow IC5a to pass write strobes from the Spectrum to the RAM, so that the download information can be written into IC4. The high output of IC7c also disables the address buffers (via IC6a,c) from the emulation port IC9, 10, and disables the data output drivers in IC4 and the data buffer to the emulation port IC8.

After the download is complete, the target system power can be applied. Q1 turns on, sending the output of IC7a high and the output of IC7c low. IC7a disables the three Spectrum port buffers IC1, 2, 3, thus effectively decoupling the emulator from all the Spectrum's influence.

Similarly, IC7c enables the emulation port address buffer so that IC4 receives the required EPROM address signals from the target board.

Any further write strobes from the Spectrum are stopped by the low signal on pin 1 of IC5a, so now the RAM is held in its read mode constantly. The logic is carefully arranged so that as long as the Spectrum is not trying to write data to the RAM at the time, changing mode from download to emulation or back can never cause an erroneous write pulse to be sent to the RAM, which might otherwise

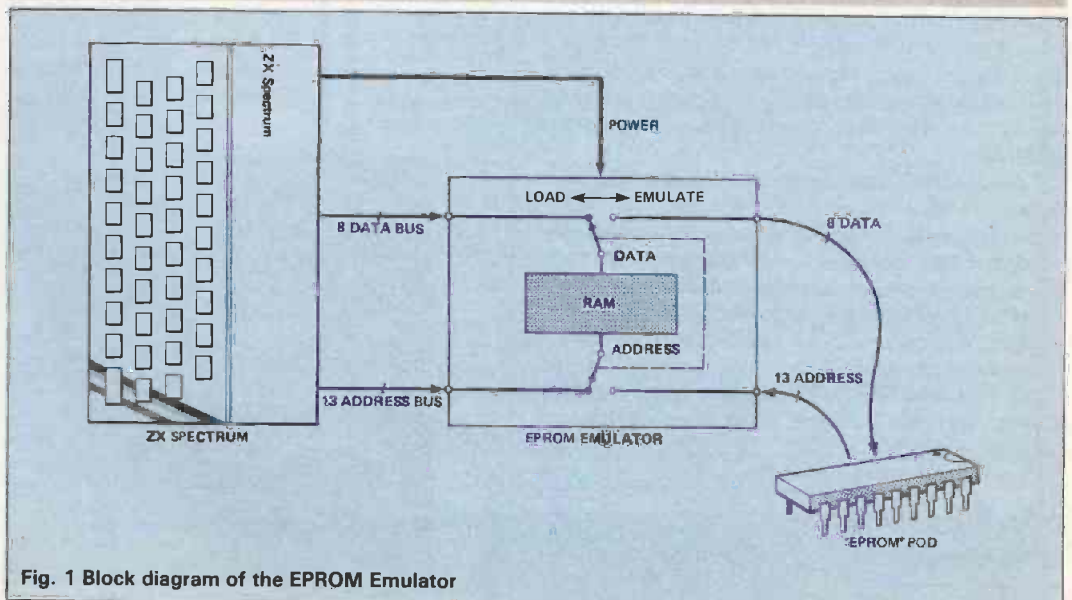


Fig. 1 Block diagram of the EPROM Emulator

PROJECT

PROJECT

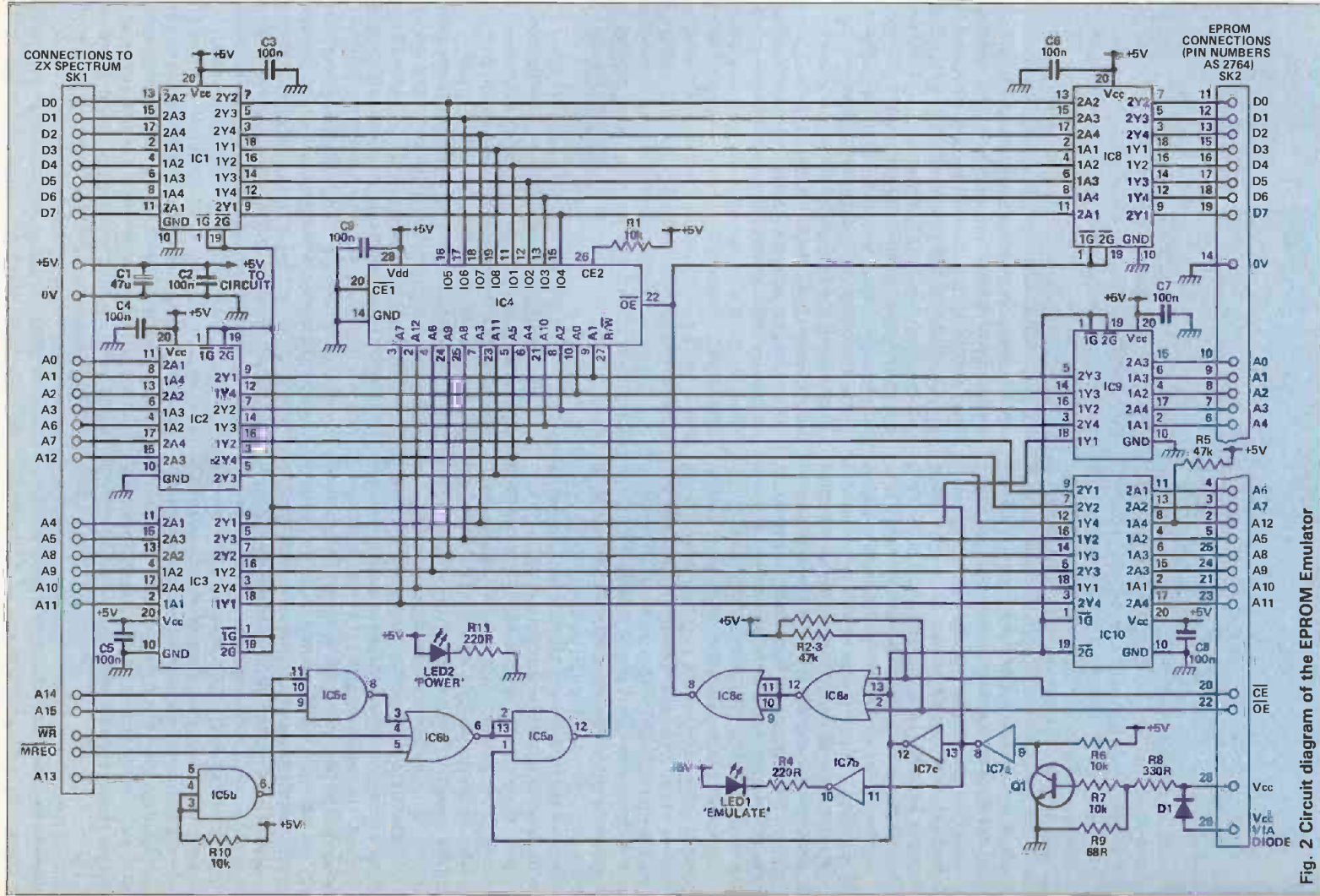


Fig. 2 Circuit diagram of the EPROM Emulator

corrupt its contents.

When the target board decided to access our 'EPROM', it pulls the CE and OE pins on the pod low after supplying a suitable address. This condition is detected by IC6a and c, and (assuming the emulation mode is in operation) the data output drivers (IC4) and emulation data bus buffer (IC8) will be enabled. The accessed data can then get from the RAM to the target board.

The timing specification for access is shown in the table on the right. The resistors R2 and R3 on the CE and OE lines of the pod reduce the sensitivity of these signals to noise pickup when the target system is unpowered.

Finally, decoupling capacitors are distributed liberally about the board to ensure that the supply to the emulator is noise free. A large value capacitor, C1, is also included near to the power connectors

from the Spectrum. This helps to avoid supply droopouts if the Emulator is accidentally knocked, and also prevents problems due to the fact that the power supply is connected remotely.

	MINIMUM	MAXIMUM
Address access time	-	186ns
CE to output valid	-	118ns
OE to output valid	-	118ns
CE to output High-Z	-	55ns
OE to output High-Z	-	55ns
Output data hold time	20ns	-

These timings make the emulated device equivalent to a 250-300ns part

code. Once assembled, the object code must be saved, then the serial link download program must be loaded into the computer, after which the object code must be re-loaded in order to transmit it to the emulator. If a small change is required in the code, this whole process must be repeated. If you are working with floppy disks or worse still audio cassettes, all this loading and saving is painfully slow and very tiresome:

With the design described here, once the assembler has been loaded into the Spectrum, it can stay there, as can the source code. Code can be assembled into the emulator, the source code can be tweaked and then immediately re-assembled into the emulator for another try — all in seconds!

This design is capable of emulating the two industry standard EPROMs most commonly used by the hobbyist — the 2732 and the 2764 (4K × 8 and 8K × 8 respectively) and has an emulation access time equivalent to that of a 250-300ns device.

Thus it is perfectly suited for use with 4MHz Z80A based target systems (such as ETI Spectrum Co-processor CPU card), and indeed any application requiring such a medium speed EPROM.

Construction

Construction of the EPROM Emulator should not prove to be difficult, particularly if the recommended PCB (Fig. 3) is used. This is a double-sided board and requires a number of interconnections to be made between the two layers. (The board is not a through-hole plated PCB due to the excessive costs involved.) Use tinned copper wire pushed through the appropriate hole in the board and soldered in on both sides.

Many of the required through connections are made via the IC pins themselves, each time a copper track is connected to an IC pin on the component side of the PCB. In these cases (48 in all) the ICs must be soldered in on both the top and underside of the board.

This is straightforward if you plan to put the ICs directly into the board but can create problems if you decide to put the ICs into DIL sockets. Sockets must be employed which provide access for soldering to the

topside of the PCB. This really means DIL sockets of the 'turned-pin' variety, designed in such a way that the base of the pin is visible on the component side of the PCB.

To fit these sockets, solder into place as normal from the underside of the board. Then solder in on the component side of the board but not directly with a soldering iron (it would be very difficult to avoid melting the plastic socket frames). The pins should be heated in turn from the underside of the board whilst dabbing fine solder onto the topside of the pin, until solder flows to form a good joint.

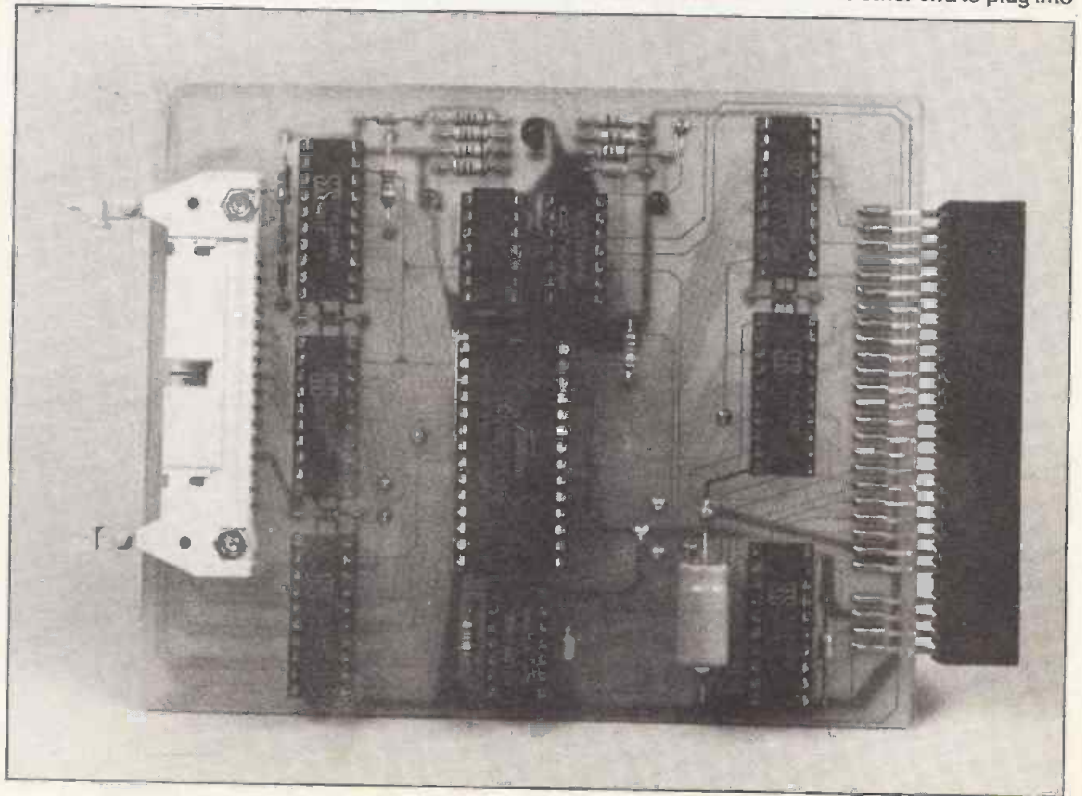
Once the through connections and the IC sockets (if used) are in place, the rest of the components can be inserted. No particular order is necessary, but it is always wise to put the semiconductors in last of all. Remember to put the LEDs, Q1, D1 and C1 in the right way round!

All that remains now is to fit the two connectors SK1 and SK2. SK1 is the edge connector for the Spectrum port and must be fitted so that one row of its pins are soldered to the topside of the PCB, and the other row to the underside.

The two rows of pins will probably need to be squashed together a bit, before fitting the connector to the board. The pins do not go through holes in the PCB, they lay flat against its surface and are soldered down by flowing solder onto the copper pad associated with each pin. Squashing the pins together can be achieved either using pliers or more easily, using a small vice. SK1 should then be slid onto the edge of the PCB and soldered into position.

The other connector SK2 sits at the other end of the PCB and provides the EPROM emulation connections. The pinout used is shown in Fig. 4. This connector should be simply inserted and soldered into place. For extra reliability, it is recommended that M2.5 nuts and bolts are used through the PCB to fix the socket in position.

This completes the construction of the PCB itself, but now we must look briefly at the cable assemblies which connect the target system to the emulator. Basically, these consist of a length of ribbon cable with an IDC header socket at one end to plug into SK2, and an IDC DIL header at the other end to plug into



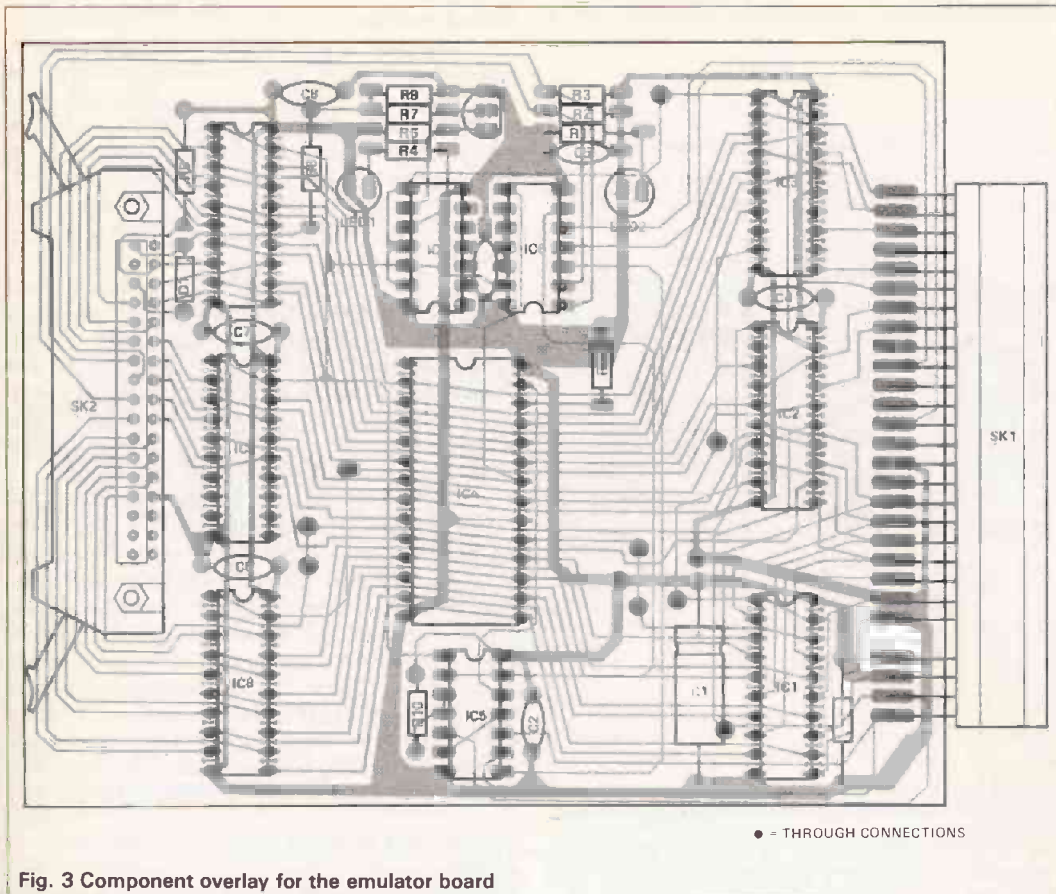


Fig. 3 Component overlay for the emulator board

the target system EPROM socket.

A different cable assembly is used depending on which size EPROM is being emulated, so you may need to make up two types.

Figure 5 shows the pinouts of the two types of EPROM we are seeking to emulate. The 2732 is in a 24-pin package, whilst the 2764 is in a 28-pin package. The pinouts are so designed that if you put the smaller device in the larger device's outline, matching up the ground pins, the rest of the signals correspond perfectly.

Obviously, the 2732 does not need as many signal connections as the 2764 but if the emulator provides all the connections for the larger device then the smaller device simply uses a subset of these signals. So, it is possible to make the required emulation connections to either device by only changing the size of DIL pod on the end of the cable assembly — no further signal switching is required.

Figure 5 also shows the construction of the two cable assemblies. Care must be taken to ensure that the DIL plug and the IDC header socket are fitted exactly as shown, particularly the latter which has a number of unused socket positions.

The length of ribbon cable used should not be much more than about 200mm, since the signals travelling up and down it are ordinary TTL levels, and are at quite high speeds. Any longer and the emulation could become unreliable. If it were necessary to have a much longer cable, then high-speed twisted pair line drivers would have to be used, but this is really beyond the scope of this simple project.

To actually fit the connectors to the cable, you should ideally use one of the special presses designed for IDC work. Not everybody has one of these (!) but with a little care it is quite possible to use a small vice to do the same job.

First the IDC connector should be loosely assembled so that it sandwiches the end of the ribbon cable. Then the two halves should be carefully

squashed together in the vice, to make a permanent connection to the cable. Before the permanent connection is made, you must be absolutely sure that the ribbon cable is correctly positioned in the connector, because it is not easy to go back after the connector has been assembled.

It is worth then plugging it into the emulator and testing the connections from the PCB to the DIL pod with a continuity tester to make sure that correct and reliable links have been formed. Once this has been done, we are ready to test the Emulator itself.

Testing

Before plugging the board into the back of your beloved Spectrum, it is wise to check that there are not potentially damaging short circuits between the emulator's power and ground lines, using a multimeter on the ohms range. If there are, make sure that the shorts are found and eliminated before moving on.

Then take the plunge and push the emulator onto the expansion port of your Spectrum. Apply the power. The power indicator, LED2, should light up and LED1 (the emulation LED) should be off.

BUYLINES

There are no special parts needed to build the emulator, and your usual supplier should stock most of the components required.

The miniature axial ceramic capacitors used in this project are available from Verospeed as order code 92-50952H. Verospeed can be contacted at Stansted Road, Boyatt Wood, Eastleigh, Hants SO5 4ZY. Tel: (0703) 644555.

Suitable DIL sockets for soldering on the topside of the PCB should be commonly available, but try the turned pin range from Maplin if uncertain. Maplin can also supply the Spectrum edge connector if required, order code FG23A.

The PCB is available from the ETI PCB service.

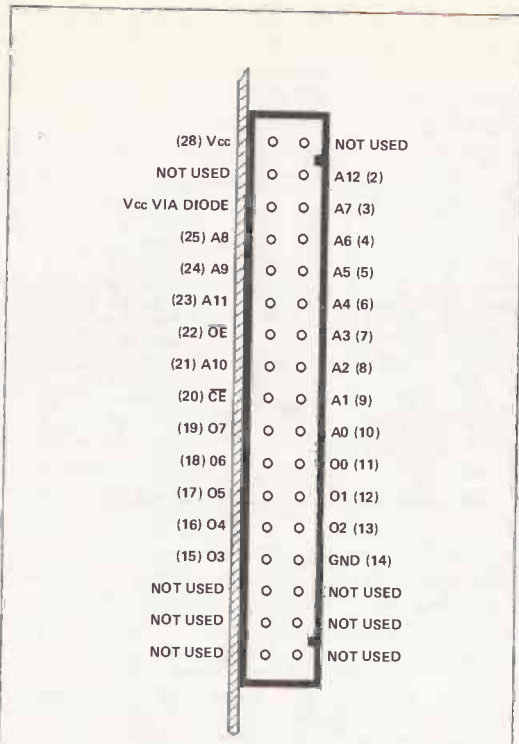


Fig. 4 IDC header plug pinout (viewed from pins)

If all is well, fit one of the emulator cable assemblies so that you can get at the 'EPROM' pin connections. Using a piece of wire or a croc clip, connect the Vcc pin on the EPROM pod (pin 28 for 2764, pin 24 for 2732) to +5V somewhere on the emulator card to simulate the power being applied to the target system. This should switch the emulator into emulation mode — LED1 should illuminate.

If the circuit has responded so far, the rest of the emulator can be tested (remove the test wire on the Vcc pin). Using Spectrum BASIC, poke a data value of 85 (dec) into the top location of the emulator (Spectrum address 57343). In binary, this data value has alternate one and zeros, and is thus great for

finding stuck bits.

Next, put the emulator into emulation mode by reconnecting the Vcc wire. The data just loaded into the RAM can be looked for at the pod by pulling the 'EPROM' CE and OE lines low using further wires. At this point it becomes convenient to plug the pod into a solderless breadboard or similar to make the necessary connections. If you do not have such a thing plug the pod into an IC socket and solder test wires to the pins.

Since unconnected TTL input lines float at the logical high level, leaving the emulation address inputs open circuit on the pod will address the highest location in the RAM; this is where we put our test data previously. So, using a voltmeter or a scope, it should be possible to look at the data bits coming out of the emulator pod one by one, checking that they are correct.

If all is well, try loading a value of 170 (dec) into the same location (this value in binary is the same as the last but with the ones and zeros swapped) and check for the correct bits on the pod data pins. If you are using a plug-in breadboard to test the emulator, it is quite easy to check a few more addresses besides the top location — simply pull down some of the address pins on the pod to 0V, having poked suitable test data into the RAM. This is certainly worth trying.

After all this static testing the real proof that the emulator is working must be to try it in a real target system, after loading real executable code into it.

Use

Using the emulator in a real target system is very simple, so long as a few basic rules are obeyed. With the target system unpowered, and the emulator connected to both the Spectrum and the target board, code should be assembled/compiled into the appropriate area of Spectrum RAM.

For 2732 emulation, the starting address in the Spectrum should be 53248 (dec). For 2764 emulation, the starting address in the Spectrum should be 49152 (dec).

One vital thing to remember is that these starting addresses are equivalent to address zero in the

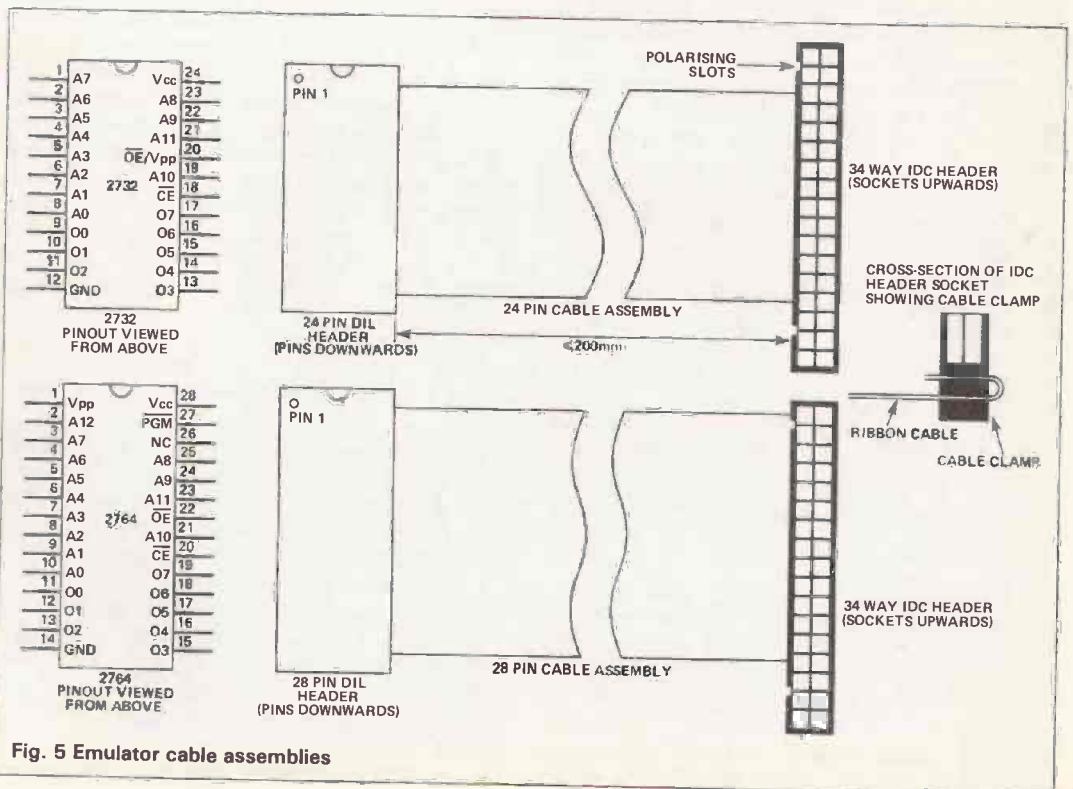


Fig. 5 Emulator cable assemblies



'EPROM' — the whole 'EPROM' contents are offset in the Spectrum memory by an amount equal to these starting addresses.

If your assembler allows you to assemble object code into a different area of memory to the runtime locations, then you are lucky. Simply write the source code from the target system's point of view starting at address zero, and then assemble it into the Spectrum memory starting at the addresses listed above.

PARTS LIST

RESISTORS (all 1/4W 5%)

R1, 6, 7, 10	10k
R2, 3, 5	47k
R4, 11	220R
R8	330R
R9	68R

CAPACITORS

C1	47 μ 10V axial electrolytic
C2-9	100n miniature axial ceramic

SEMICONDUCTORS

IC1-3, 8-10	74LS244
IC4	6264 — 150ns 8k x 8 CMOS sRAM
IC5	74LS10
IC6	74LS27
IC7	74LS14
IC1, 2, 3	BC548
LED1	Green LED 3mm diam
LED2	Red LED 3mm diam
DI	1N4148

MISCELLANEOUS

SC1	Edge-connector for Spectrum (28 way double-sided)
ES2	34 way PC mounting right-angled IDC header plug
IL	sockets (see text). Cable assembly to EPROM pod (see text). PCB
TP	Red copper wire for through connections. M2.5 nuts and bolts for ES2.

Unfortunately, the majority of software development tools for the Spectrum cannot handle such complicated concepts (!), being much less powerful than proper professional development software (though of course much cheaper!).

The only problem this does create concerns the assembler generated addresses in the executable code. Obviously, you must assemble the code into the Spectrum starting from the addresses listed above. As far as the target system is concerned, all the absolute addresses generated by the assembler in the resulting object code will have an inbuilt offset equal to that starting address. If you are able to make your code relocatable by using only relative addressing, then there is absolutely no problem. However, if you are forced to use absolute addresses in your program, then it will be necessary to correct them by hand, subtracting the Spectrum start address before download.

This whole problem could have been overcome during the hardware design, by mapping the emulator into the area of Spectrum memory starting at zero instead of where it is. Unfortunately, most assemblers for the Spectrum will not allow assembly into that part of the memory map, since that is where the Spectrum operating system EPROM sits. Despite the problem with offsets, the actual method used at least guarantees that the assembler will work!

Once the code has been assembled, the power can be applied to the target system and (assuming that the program is correct) it should spring to life. Further downloads can then be achieved by simply repeating the above process again.

One interesting possibility worth noting concerns EPROM programmers. Once the final working version of your software is available, having developed and tested it using your EPROM emulator, it is possible to use the emulator as the source of the data for an EPROM programmer. After downloading the code into the emulator, the pod can be plugged into the programmer, and the data read out, just as if you were copying a real EPROM. This provides an easy means for the transferral of code from the Spectrum to the programmer, without using messy serial links and the like.

Just one extra reason for building this simple but effective development tool!



MODEL RAILWAY CIRCUITS

Robert Penfold adds ballast to your layout with a selection of circuits to keep you on the right track

Digital Train Controller

This is a pulse type train controller that is primarily intended for computer control. Although the range of available speeds is rather limited (stop, full speed, and two intermediate) the transition from one speed to the next has been made very gradual to avoid any unrealistic jumps in speed. The circuit can easily be modified to provide a greater range of speeds if desired.

The unit provides a variable average output voltage by varying the mark-space ratio of the output signal. Provided a suitable output frequency is used, this type of signal is suitable for driving DC electric motors. In fact it gives very good results, fine speed regulation and immunity from stalling at slow speeds.

This circuit uses a standard pulse width modulator with IC1 to provide the triangular clock signal, and IC2 operating as the voltage comparator. The clock frequency is just over 200Hz, which seems to give good results with any small DC electric motor.

With the voltage at the non-inverting input (pin 2) of IC2 halfway between the peak to peak voltages of the clock signal, the output signal is a square wave having a perfect 1:1 mark-space ratio. Taking this input voltage higher results in it being exceeded by the clock signal for a smaller percentage of the time, and the high output period becomes longer than the low output time. Reducing the input potential has the opposite effect. This gives the desired result, with an average output voltage that is proportional to the control voltage.

Q1 and Q2 form a complementary emitter follower output stage that enables the unit to handle

output currents of up to a couple of amps. Q2 is not strictly necessary but with D1 it helps to suppress voltages generated by the motor when Q1 is switched off. As Q1 operates in a switching mode it only requires a small bolt-on heatsink. Q2 does not require a heatsink at all.

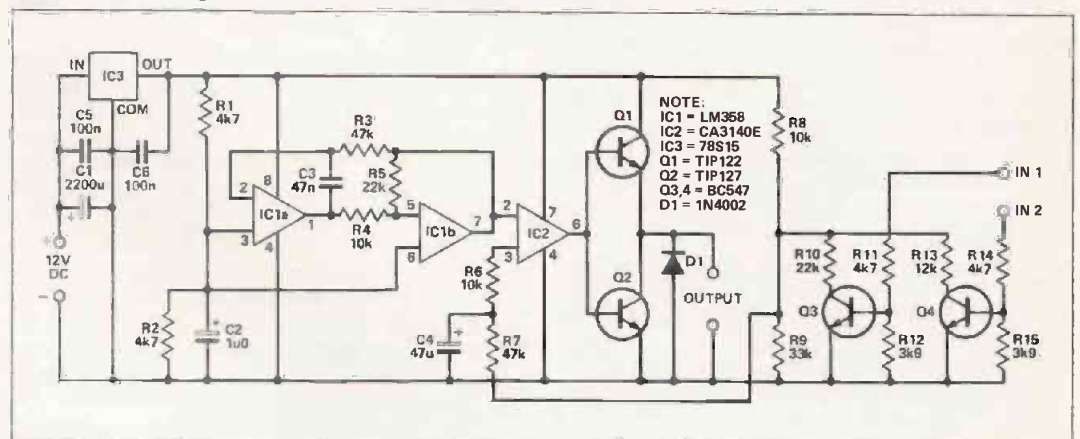
For straightforward manual control a potentiometer circuit to drive pin 3 of IC2 is all that is required. For computer or digital control a DAC is needed, and a very simple and inexpensive 2-bit circuit can be used.

The state of the signals at inputs 1 and 2 alter the resistive network determining the signal fed into IC2, and therefore the speed of the train. With both inputs at 0, Q3 and Q4 are off so that R8 and R9 provide a high enough control voltage to keep the controller output continuously high.

Applying a logic 1 signal to input 1 or input 2 shunts either R10 or R13 across R9, giving a lower control voltage and a lower average output voltage. As R10 and R13 have different values, the two logic inputs provide different speeds. Taking both inputs to logic 1 produces a very low average output voltage, and the train halts.

More transistor drivers and shunt resistors can be added to give a greater range of speeds. The transition time between speeds is proportional to the value of C4 and is easily changed.

A reasonably smooth and stable 15V supply, with current limiting to protect the unit against the inevitable short circuits on the output, is provided by a simple smoothing and regulator circuit fed from the 'raw' 12V DC output of a train controller. Direction control can be provided manually via a DPDT switch, or under computer control via a relay and driver circuit.



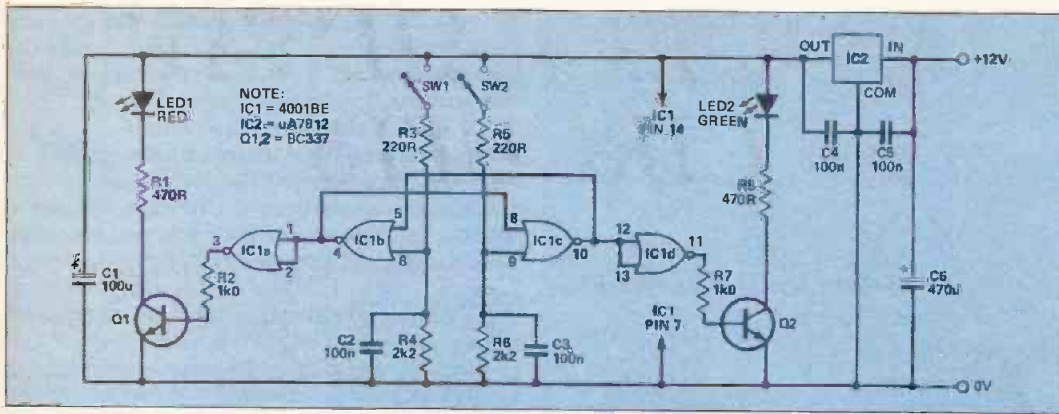
Two-colour Signal

This two-colour red/green signal is automatically operated by the train via sensors on the track. There are several ways of sensing the train as it passes but the two most simple and reliable methods are to use micro or reed switches.

I prefer reed switches positioned just under the track, activated by a magnet mounted just above track level on one of the pieces of rolling stock. Sometimes

the DC motors used in locomotives will activate the reed switches but in most cases a small bar magnet must be added to each train by the constructor. Note that the reed switches are activated when parallel to a bar magnet and not when one pole of a magnet is applied to them. Switches should be mounted lengthwise along the centre of the track, with the magnet mounted lengthwise along the middle of the floor of a piece of rolling stock. The distance between them probably needs to be about 10 millimetres or less — this should be possible without continual

TECH
TIPS



derailment.

The purpose of the sensors is to set the signal to red as it is passed by a train and then to reset it to green when the train has progressed to some point further along the track. The circuit is basically just a S-R flip-flop built around IC1b and IC1c. The other two gates of IC1 are wired as inverters and used as buffers at the outputs of the flip-flop.

SW1 is the reed switch near the signal and when this is activated it sends the output of IC1a high. This switches on Q1 and the red signal LED1. SW2 is further along the track, and returns the output of IC1a to the low state. It also sends IC1d high activating LED2, the green signal.

Problems with spurious triggering due to switch bounce or stray electrical noise in the connecting cables are counteracted by R4, C2 and R6, C3. If manual override is required, add push-button switches in parallel with SW1 and SW2.

It should be possible to control a ready-made signal, but LED types will probably incorporate current limiting resistors and R1 and R8 will then be unnecessary. The unit should also be able to control sub-miniature 12V filament bulbs in the same way, but the bulb current should not exceed about 200 mA.

A 9 or 12V battery is the easiest source of supply. IC2 and C4 to C6 are only needed if the unit is fed with the raw 12V DC output of a train controller.

Two-tone Horn

This sound effects unit is designed to simulate the sound of a two-tone horn, as used on many diesel and electric locomotives. This is the type of horn that goes up about a fifth in pitch (about 50% higher in frequency) after the initial tone. The basic sound is not just a simple tone, and is actually a quite complex signal.

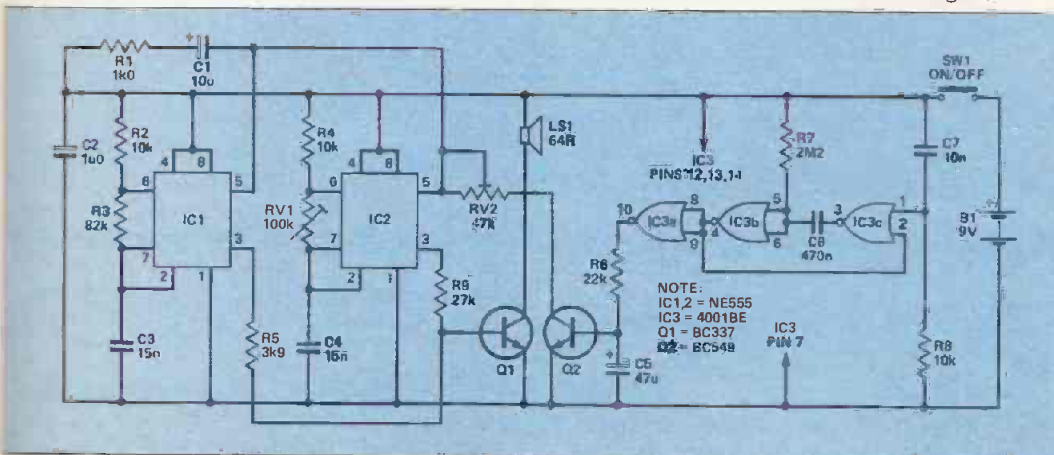
Accurately simulating an intricate sound of this type is far from easy but results here are about as good as you are likely to obtain from a simple circuit and a loudspeaker of about 65mm in diameter! Unless you are a steam only fanatic, it should certainly add a bit more realism to your model railway layout.

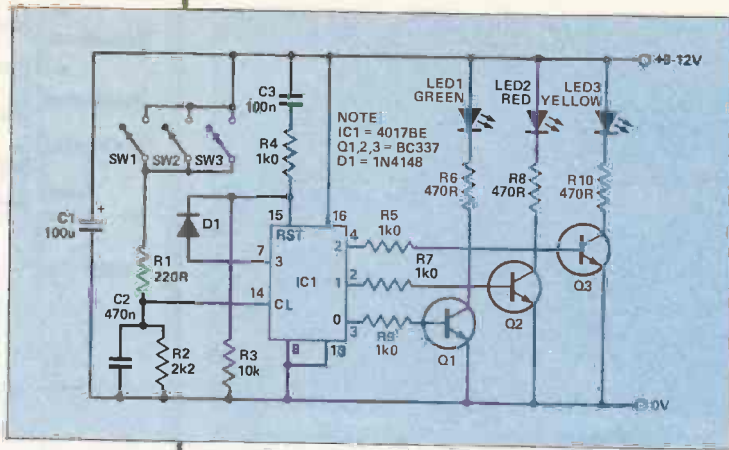
The basic audio signal is generated by a 555 timer (IC1) used in the standard astable circuit. It drives a miniature high impedance loudspeaker via common emitter amplifier Q2. LS1 must have an impedance of 64R to 80R and must not be a low impedance type. The oscillator's operating frequency works out at approximately 550Hz but we are using frequency modulation applied via pin 5 of the device and it does not always operate at this frequency.

The horn starts fractionally flat, and moves up to the normal operating pitch over a period of around 200ms, regulated by C1 charging up through R1.

Pin 5 of IC1 must be pulled lower in voltage in order to raise the output frequency and give the two-tone effect. This is provided automatically just under a second after switch-on by IC3, a quad 2 input NOR gate which has three of its gates connected to operate as a monostable with an output pulse duration of around 800ms. This is triggered at switch-on by C7 and R8 but, as it provides a negative output pulse, Q2 is initially switched off. It is turned on when the output pulse ends and it then pulls pin 5 of IC1 lower in voltage by an amount that is controlled using RV2. In practice RV2 is adjusted 'by ear' to give the correct second tone from the unit. C5 gives a smoother transition to the higher pitch for a slightly improved effect.

The second 555 oscillator is used to enrich the sound and its output is mixed with the main tone signal at a much lower level, frequency modulated in exactly the same way as the main tone generator. It is probably best to initially leave one terminal of R9 unconnected so that RV2 can be adjusted with only the main oscillator driving the loudspeaker. With R9 connected, RV1 can be adjusted for the best effect. This will probably be with the second oscillator just slightly off-tune from the main one, or perhaps with the second oscillator set about a fifth higher.





Three-colour Signal

This signal is similar to the two-colour type but controls a three-colour (green, amber and red) signal and requires an additional track sensor.

The signal changes from green to red as the train passes the sensor next to the signal. The sensor further along the track sets the signal to amber, and a third sensor still further along the track brings it back to green again. Like the two-colour signal, the sensors can be micro or reed switches.

The circuit is based on a CMOS 4017BE. This can provide a standard divide by ten action, but it has ten more outputs (0 to 9), each of which go to logic 1 for one clock cycle, in sequence.

C3 provides a reset pulse at switch-on, taking output 0 high driving Q1 into conduction and turning on the green signal LED1. The track sensors (SW1 to SW3) provide a positive pulse to the clock of IC1 each time the train is detected. R1 and C2 provide switch debouncing and help avoid problems with electrical noise.

Note that with this circuit it does not matter which track switch is used in which position on the line — the circuit merely requires a clock pulse each time. A switch to permit manual setting of the signal might be useful since, if the train does not pass the signal's switch first, the lights will be out of sequence. A push button switch in parallel with SW1, 2 and 3 can be used to sequence the circuit through to the desired colour.

The final clock pulse of each sequence takes output 3 high but this is coupled to the reset input of IC1 by way of D1 and it takes the circuit back to the beginning of the sequence.

If the signal is a home-made type, a yellow LED will suffice for LED3 or an orange type might be considered better. (Orange LEDs certainly seem to be generally much brighter than the yellow variety).

The circuit can be powered from a 9 or 12V battery or from the 12V DC output of a train controller using the smoothing regulator circuit from the two-colour signal circuit.

Cycling Three-colour Signal

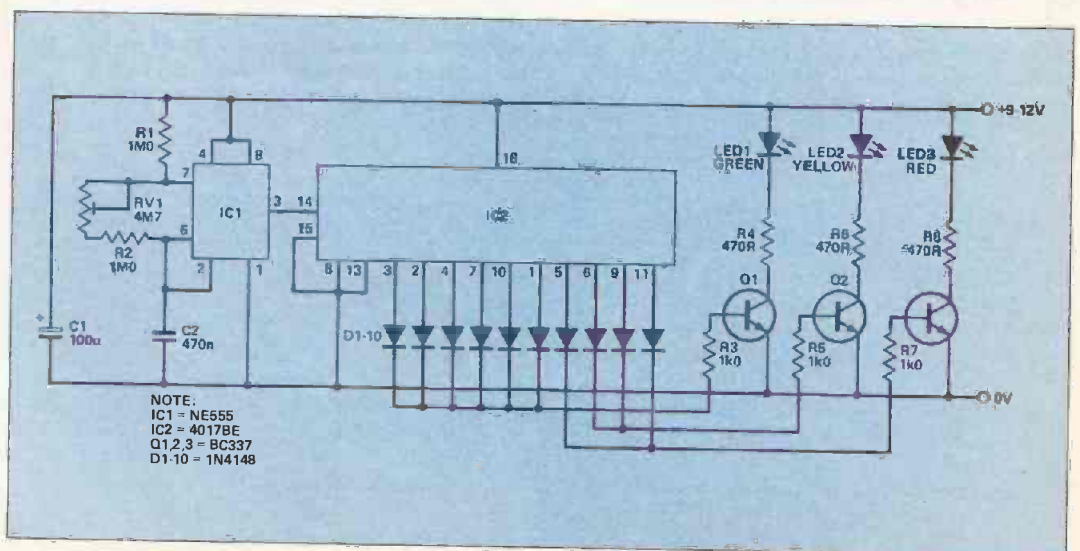
Similar to the three-colour signal, this circuit cycles continuously under the control of a built-in clock oscillator, and it does not use track sensors at all. It is not so much a matter of the train activating the signal as the operator having to control the train so that it obeys the signal. The colour sequence of the signal is slightly different, with a green — amber — red — amber — green sequence. In order to avoid a lot of inactivity (and boredom) the signal has the colours weighted in favour of green.

Again this circuit is based on a 4017BE one-of-ten decoder (IC2). In this case though, all ten outputs of the device are utilised. Outputs 0 through to 5 drive

the green LED1, outputs 6 and 9 drive the amber LED2, and outputs 7 and 8 control the red LED3. This gives the required colour sequence with heavy weighting in favour of a green signal. Rewiring diodes can alter the weighting or colour sequence if desired.

A low frequency clock signal is required, and this is provided by a standard 555 astable circuit. RV1 enables the clock frequency to be adjusted from a little over 1Hz to under 0.25Hz. This equates to a complete cycle time of between about 10 and 40 seconds but a longer cycle time can be achieved by making C2 higher in value. Note that C2 must be a high quality (low leakage) type due to the high timing resistance values used in the circuit. Any plastic foil type should be suitable but electrolytics are not recommended.

The notes on power sources for the two and three colour signals apply equally to this design. RV1 may have to be a large preset, as sub-miniature types in this value (4M7) can be difficult to obtain.



TECH TIPS

Points Controller

Some model railway points are purely mechanical but electric points are now a standard accessory. These are mostly very basic and are really just a manual point with the addition of a couple of solenoid mechanisms giving the option of manual operation or electric remote control using a form of changeover switch plus a 12V DC supply.

The points have three terminals, one of which is a common terminal wired to one supply rail. The other terminals are wired to the other supply rail via the changeover switch which selects the desired solenoid. By alternating this switch the points can be repeatedly set and reset.

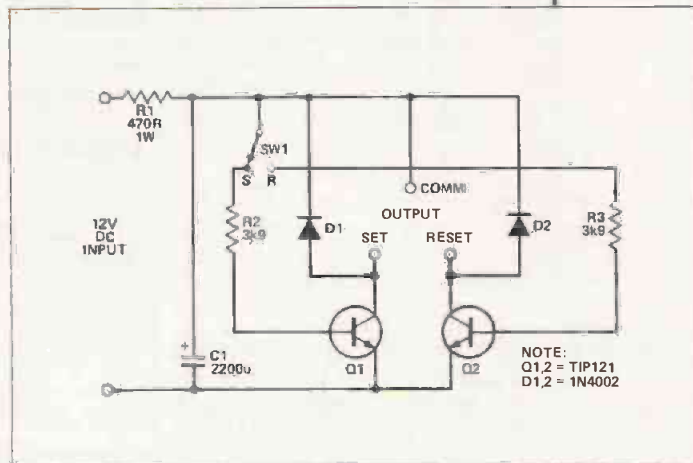
The changeover switch is slightly non-standard in that it is spring-loaded to a central off position, so that ordinarily it does not supply power to either solenoid. This is an important point, as the solenoid currents are quite high. Applying power for more than a second or two risks burning the solenoid out. These points are not always totally reliable in operation and the addition of a simple capacitive discharge circuit improves this and totally removes the risk of applying excessive power to the solenoids in an attempt to force operation.

In this points controller circuit the input supply is fed to a high value capacitor C1 by way of current limiting resistor R1. R1 keeps the current at no more than about 25mA, which should be well short of the current needed to cause over-heating. It is also well short of the current need to drive the point from one setting to the other! This does not matter though, because C1 will charge to virtually the full input supply voltage, and can supply a large enough burst of current to reliably operate the points. The extremely

low source impedance of a capacitor means that the large pulse of current normally removes any tendency for the points to stick.

The solenoids can simply be driven from across C1 by way of the changeover switch. However, things can be refined a bit further, as in this circuit. The switch selects one of two Darlington power devices (Q1 or Q2) which control the solenoids. R2 and R3 limit the base currents and result in the switch only handling very small currents. This eliminates any problems with contact sparking reducing the operating life of the switch. A miniature toggle type which is spring-loaded to a central off position is perfectly suitable for SW1.

D1 and D2 protect Q1 and Q2 against any high reverse voltage spikes generated across the solenoids as they are switched off. Q1 and Q2 do not require heatsinks. Also note that it takes a second or so for C1 to recharge after the unit has been used and that the controller cannot function until C1 has almost fully recharged.



TECH TIPS

NO HOLDS BARRED

The Bar code competition in the July issue attracted a large number of entries. We never knew so many readers were fluent in check-out-ese and baked-bean-ian. The lucky winner was Jim McCarthy of Wokingham who correctly decoded the bars and guessed the secret message held therein. A year's free subscription to ETI goes to Mr McCarthy. The explanation of the bar code is given below.

The bars were encoded in the standard EAN 13-digit code as used on baked bean cans in the supermarket. This is in two sections with six figures in each section and a barrier code (101 or bar-gap-bar) between them and at each end. The pattern of figures in the first section gives an additional figure at the beginning of the code. The last figure is a checksum.



4 5 5 4 4 9 6 5 7 4 6 9 0

The code (excluding the checksum) is a series of hex figures which turn out to be the ASCII codes for ETIeti. Now you know!

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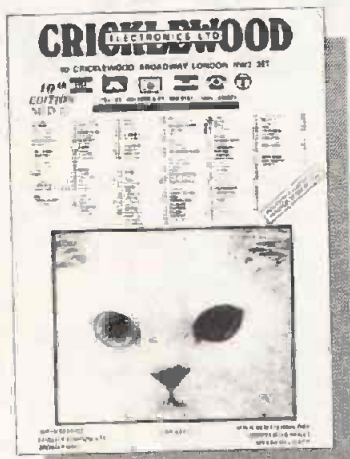
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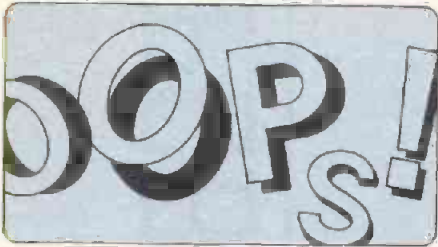
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E8504-5	CCD Delay	F	E8706-2	MIDI Keyboard CPU	U
E8505-5	Stereo Simulator	F	E8706-3	MIDI Keyboard Front Panel	O
E8506-1	Audio Mixer Main	J	E8706-4	Flame Simulator	G
E8506-2	Audio Mixer PSU	F	E8707-1	MIDI Keyboard PSU	H
E8506-3	Audio Mixer RIAA	D	E8707-2	Telephone Alarm	J
E8506-4	Audio Mixer Tone Control	D	E8707-3	Nuclear Strategy Simulator	J
E8506-5	EPROM Prog MKII	O	E8708-1	Remindalite	F
E8507-1	Noise Gate	H	E8708-2	Rear Wiper Alarm	G
E8508-1	RCL Bridge	N	E8708-3	Rev Counter	F
E8508-2	EX42/BBC Interface	E	E8708-4	Car Alarm	F
E8508-3	EPROM Emulator	L	E8708-5	Knight Raider	J
E8509-1	Spectrum EPROM card	F	E8709-1	Boiler Controller	G
E8509-2	Direct Injection Box	E	E8709-2	Amstrad Sampler (2 bds)	P
E8510-9	Sunrise Light Brightener	K	E8709-3	Portable PA	G
E8511-1	MTE Waveform Generator	H	E8709-4	EEG Monitor (2 bds)	L
E8511-2	Millifaradometer	H	E8710-1	Concept CPU board	N
E8511-3	Cymbal Synth	J	E8710-2	Concept Power board	K
E8511-5	Chorus Effect	H	E8710-3	Concept display board	G
E8511-7	Enlarger Exposure Meter	F	E8710-4	Hyper-Fuzz	F
E8511-8	Switching Regulator	E	E8710-5	Big Digits digit board	N
E8511-9	Second Line of Defence	M	E8710-6	Big Digits minute board	F
E8512-1	Specdrum Connector	F	E8710-7	Big Digits battery board	G
E8512-2	MTE Pulse Generator	H	E8711-1	Quiz Controller	E
E8512-3	Specdrum	L	E8711-2	256K Printer Buffer	N
E8601-2	Walkmate	L	E8712-1	Heating Management System	O
E8601-3	MTE Counter-timer	M	E8712-2	SWR Meter	H
E8602-1	Digibaro	O	E8712-3	Dream Machine (free PCB)	D
E8603-2	Programmable Logic Evaluation Board	H	E8801-2	Passive IR Alarm	H
E8603-3	Sound Sampler Analogue Board	R	E8801-3	Deluxe Mains Conditioner	G
E8604-1	JLLH PA PSU	H	E8801-4	RGB Dissolve	L
E8604-2	Matchbox Amplifier	C	E8802-1	Electric Fencer	E
E8604-3	Matchbox Amp Bridging Version	C	E8802-2	Telephone Intercom	L
E8604-4	MTE Analogue/Digital Probe	M	E8802-3	Transistor Tester (2 bds)	L
E8605-1	Microlight Intercom	E	E8802-4	Spectrum Co-processor CPU	N
E8605-2	Baud Rate Converter	M	E8803-1	Co-processor RAM board	N
E8605-3	Baud Rate Converter PSU Board	C	E8803-2	Beeb-Scope (3 bds)	O
E8605-4	Portable PA	H	E8803-3	Jumping Jack Flash	E
E8606-1	MIDI-CV Converter Board	H	E8804-1	Spectrum Co-processor Interface Board	N
E8606-2	MIDI-CV Converter PSU	D	E8804-2	Combo-lock	E
E8606-3	Troglograph	F	E8804-3	Kitchen Timer	E
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E8607-3	BBC Motor Controller	F	E8806-1	Universal digital panel meter	L
E8608-1	Digital Panel Meter	G	E8806-2	Universal bar graph panel meter	K
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E8609-4	Upgradeable amp, Output board (mono)	F	E8807-1	Bar Code Lock (2 bds)	N
E8610-1	Audio Analyser Filter Board	L	E8807-2	Analogue Computer Power Board	L
E8610-2	Audio Analyser Display Driver	K	E8807-3	Bell Boy	F
E8610-3	Audio Analyser Display	H	E8807-4	Logic Probe	C
E8610-4	Audio Analyser Power Supply	F	E8807-5	Updated FM stereo decoder	J
E8611-1	Audio Switcher (2 bds)	H	E8807-6	Breath Rate display board	F
E8611-2	PLL Frequency meter (4 bds)	Q	E8808-1	Breath rate main board	H
E8611-3	Upgradeable Amp PSU	J	E8808-2	Breath rate switch board	C
E8611-4	Call meter, main board	O	E8808-3	Telephone recorder	D
E8611-5	Call meter, interface board	N	E8808-4	Analogue computer main board (2 bds)	M
E8612-1	Bongo Box	J	E8808-5	Random number display	O
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E8701-3	Flanger	H			
E8701-4	Audio Selector main board	M			
E8701-5	Audio Selector PSU	H			
E8701-6	Tacho-Dwell	F			
E8702-1	Ratometer main board	K			
E8702-2	Ratometer ranging board	F			
E8702-3	Photo Process Controller (3 bds)	O			
E8702-4	LEDline display board (2 off)	K			
E8702-5	LEDline PSU and controller (2 bds)	G			
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E8703-2	Geiger Counter	L			
E8703-3	Credit Card Casino	E			
E8704-1	BBC micro MIDI interface	L			
E8704-2	ETIFaker patch box	H			
E8704-3	24Hr Sundial	E			
E8705-3	MIDI Keyboard keyswitch boards (3 bds)	W			
E8705-4	Batlite	C			





Printer Buffer (November 1987)

The listed software for the EPROM has three errors. The byte at 039A should be 20, at 039B 14 and at 0492 30 (all hex). Connections to 21c and 22c in the circuit diagram disagree with Table 1. The table is correct. C3-28 are 100n as listed in the parts list and not 10n as in Fig. 2. C1 is orientated with the positive terminal to the right.

Dream Machine (December 1987)

The transistors used in this project are ST1702. BC108s can be substituted.

Heating Management System

(December 1987)

A 4116 is not a suitable alternative to the 6116 specified. A 4016 RAM chip will suffice. In Fig. 1 the junction of R1/D5 should connect to D1-4/C1 and not cross. The zener diodes above the temperature sensor ICs (IC16-19) should be deleted. C4 should be 220n and not 220μ. C7-10 should be 10μ. Q2-7 should be 2N3904 and not BC3904.

RGB Auto-Dissolve (January 1988)

In Fig. 5 there are marked two D6's. The right hand one should be D5 (they are both 1N148's anyway). In the text the reference to zener diode D5 should read ZD1.

Power Conditioner (January 1988)

There is confusion between the values of R7 and R8 in the Parts List and Fig. 1. These should be: R7-27k, R8-10k and not as given in the Parts List. In addition, ZD1 is incorrectly orientated in Fig. 3. The positive terminal should be at the southern end.

Passive Infra-Red Alarm

(January 1988)

Fig. 2(a) shows the base of Q1 connected to ground and to R14. It should be connected only to R14.

Transistor Tester (February 1988)

The foil pattern for the main board was printed reversed left-right on the foil pages.

Spectrum Co-processor (March 1988)

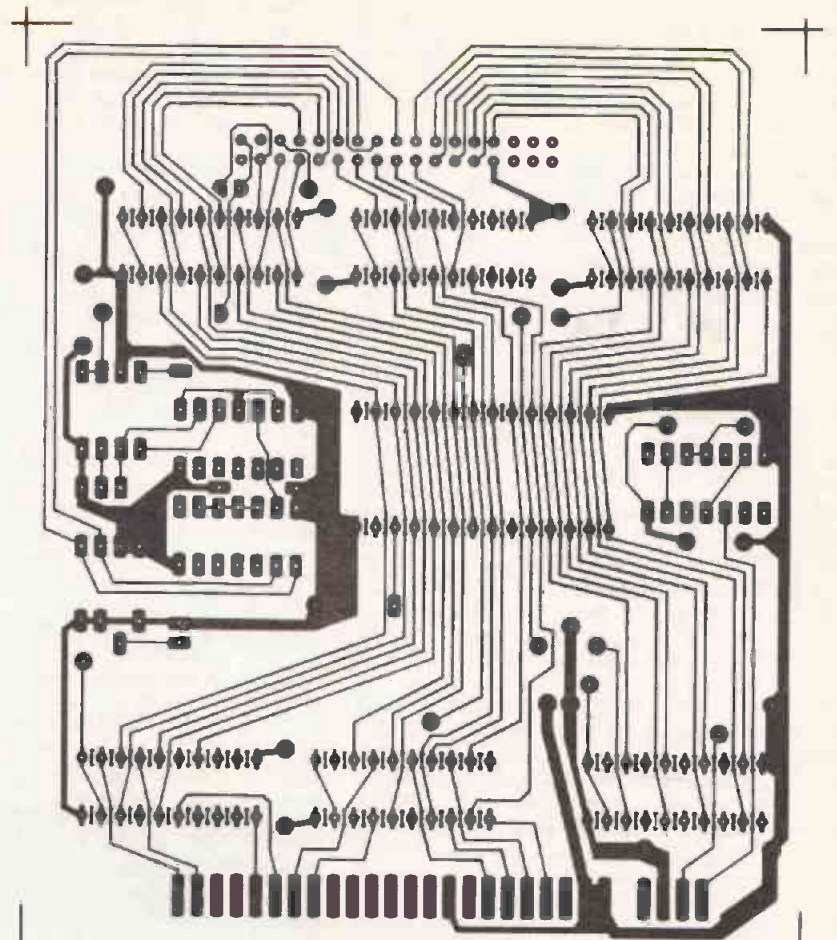
Mogul Electronics, given in the Buylines as suppliers of the RAM chips, have moved to: Unit 11, Vestry Estate, Sevenoaks TN14 5EU. Tel: (0732) 741841.

Dynamic Noise Reduction (May 1988)

The LM1894 is no longer available from the sources listed but it can be obtained from the author. Please address orders to Manu Mehra, 88 Gleneagle Road, Streatham, London SW16 6AF.

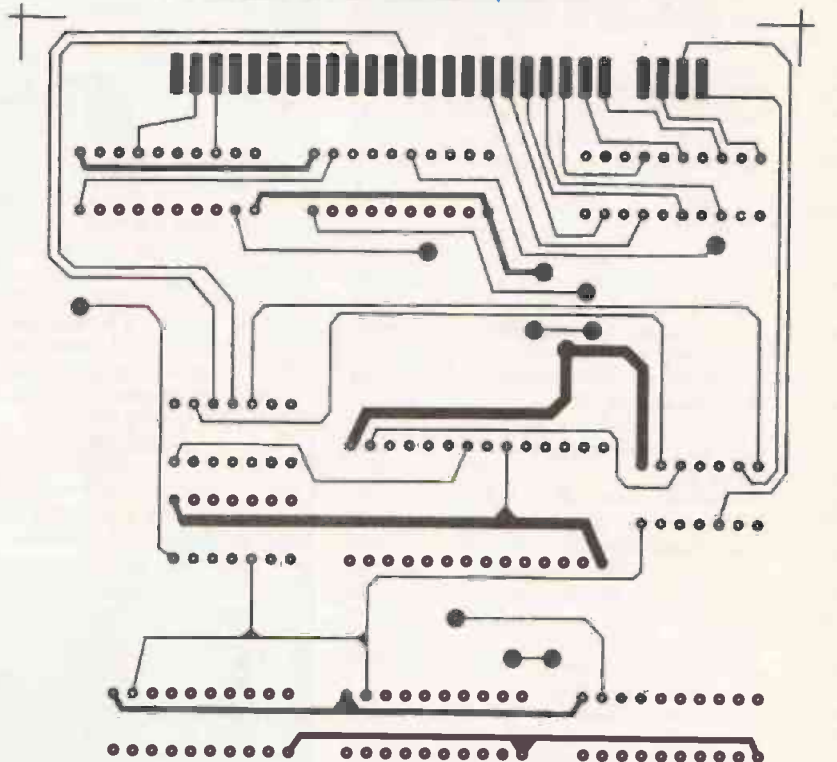
QL Output Port (Tech Tips May 1988)

Several problems with the diagram for this one. A5 should read AS — that is, address strobe. Pine 22 and 24 should be connected to +5V and the junction of the (only) resistor and diode connected to VPA on the QL.

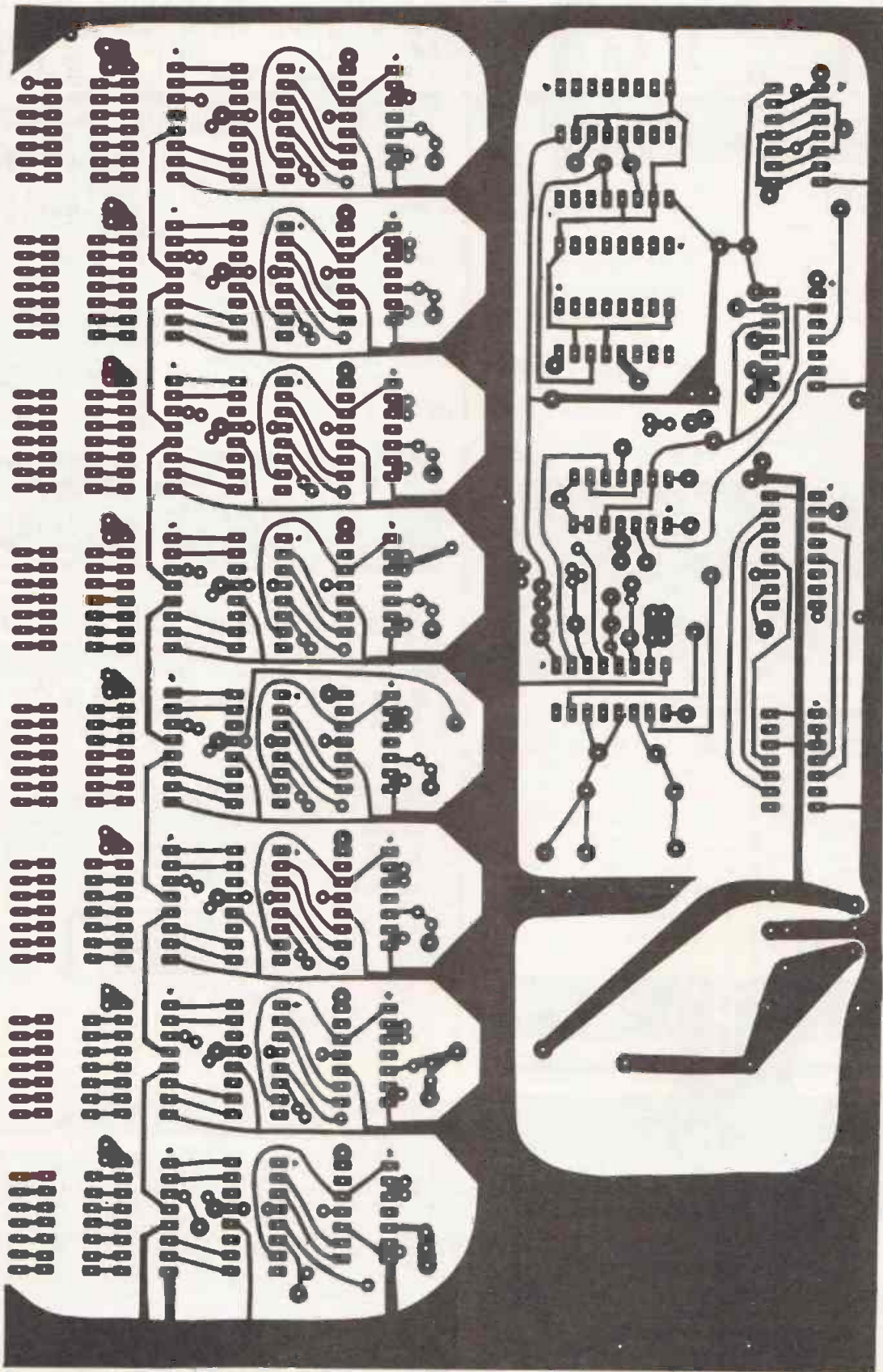


The Spectrum EPROM emulator solder side foil

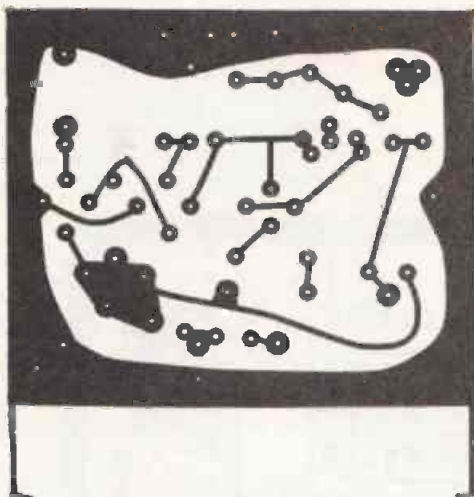
The Spectrum EPROM emulator topside foil



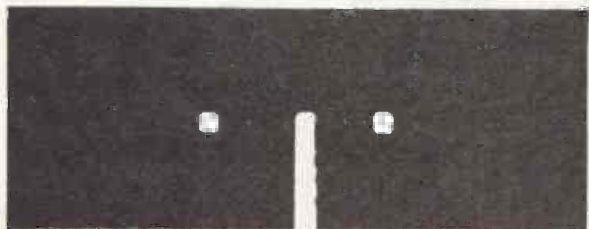
PCB Foil Patterns



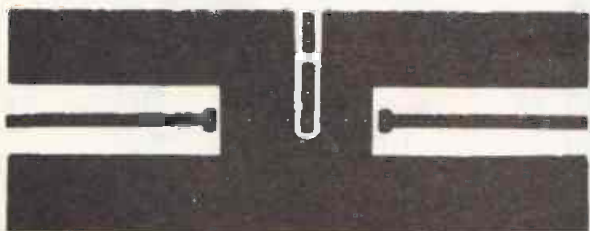
The frequency meter main board foil pattern



The frequency meter pre-amp board foil



The aerial amp screening topside foil



The aerial amp solderside foil

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OPEN CHANNEL



Within a couple of years or so (well, three to be precise) drivers in London should have access to an automatic route guidance system, which is fitted into the car's dashboard.

The *Autoguide* system will provide drivers with voice synthesised instructions regarding route at each junction, allowing drivers to miss busy spots and traffic hold-ups. In theory, the system will save hours of drivers' time at the wheel.

A network of infra-red beacons linked to a central computer system will communicate with passing cars fitted with *Autoguide* and relevant information will be passed to the driver. The central computer system is to be frequently updated with traffic information including accidents, hold-ups and roadworks.

Having spend many an hour fit to burst behind the wheel of my trusty rustbucket, I can appreciate the potential of such a product but I still have reservations. The system is planned with beacons only on main routes in the capital and if one route is blocked chances are the adjacent ones will probably be busy too (particularly if most other drivers receive the same instructions) so it may be of only minor efficiency.

Only the first drivers who chance to come upon a hold-up will benefit from the instructions to change route. After a few minutes the alternative route will be taking twice the traffic it normally does and so will be blocked itself.

It may be that the system would need to re-route drivers along routes normally unused (sidestreets) as well as alternative main routes to ensure congestion doesn't occur. But I suppose residents in those sidestreets might object to my suggestion.

High-tech Cops 'n' Robbers

The Police computer system is to be upgraded by 1990 with a new network. This will allow national access to an index of records incorporating photographs of convicted people, criminal records and so on. It looks as though the network will allow access to the Swansea computer which holds and vehicle licensing data, too.

High-tech Phone

British Airways aims to commence customer trials of satellite-linked public telephone calls from transatlantic Jumbo jets by the end of the year. Initial non-customer trials have been successful, routed via British Telecom's Goonhilly earth station in Cornwall.

Eurocrypt - Tomb With a View?

Agreement about an international

standard for encryption of European direct broadcast satellite (DBS) television services has been reached — after much argument. The standard covers scrambling of the transmitted picture and conditional access of the signal by individual television receivers.

The agreement means that hardware manufacturers can now press ahead to develop receivers complete with chip sets for the European market, instead of purely national ones. The exception to this appears to be British Satellite Broadcasting (BSB) and its foreseen transmission standard D-MAC. All other countries will be using D2-MAC. Careful design, however, should ensure either transmission standard can function with the Eurocrypt conditional access system.

Meanwhile, BSB has been concentrating on placements of chip and module orders, in an effort to ensure they are available when manufacturers start to put together design plans for receivers. It has been reported that four million D-MAC transmission standard chips have been ordered from ITT subsidiary Intermetall (ITT already make the European-preferred D-MAC chips). An order has also been placed with General Instruments, to supply conditional access modules.

Instead of going for a brand new chip design, BSB has accepted that the General Instruments modules are to use existing technology. However, it doesn't appear to be clear whether the BSB-chosen conditional access system follows the Eurocrypt standard. If not, does it really matter? What seems to be important is that BSB is pulling its finger out nice and early, to ensure receiver manufacturers will have the goodies when they need them.

This is an important move by BSB (itself merely a programming and organisational body) and does prove a high level of commitment by them to ensure that British DBS television services are going to work, right from day one, and right on schedule.

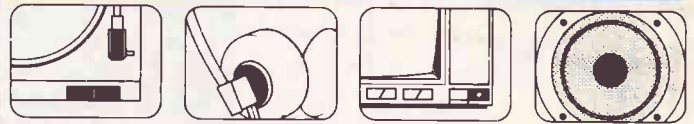
BT/Mercury Can Work Together!

British Telecom and Mercury are starting work with France Telecom to lay the first fibre optic cable across the Channel. The cable will start full-time operations next year. France Telecom is to own 50% of the cable, British Telecom and Mercury have 25% each. The deal marks the first international link by Mercury.

Linking Brighton to Dieppe, the cable will be the longest multi-fibre connection without signal repeaters.

Keith Brindley

PLAYBACK



Loudspeaker designers have a problem. The engineers use a controlled environment (anechoic chamber) in which to perform measurements but this is hardly representative of the average consumer's living room.

It may only be some months after a product's launch that a manufacturer can accurately gauge the broad compatibility (or otherwise) of a new loudspeaker.

Those innovative people at KEF are fully aware of this problem, having come unstuck themselves in days gone past. However they have recently announced a new drive unit technology under the banner of Uni-Q — an attempt to address the inherent difficulties of controlled speaker directivity.

Directivity (both horizontal and vertical) is the key element here for it is the off-axis response of the loudspeaker that determines how favourably the system will interface with a given environment.

There is little point having a smooth on-axis response if sharp discontinuities appear as soon as you listen slightly off-axis. Furthermore, any ragged off-axis signals that are reflected from neighbouring boundaries will mix and colour the perceived on-axis response.

Recent evidence suggests that vertical reflections from floor and ceiling tend to result in the most damning subjective colourations rather than the equivalent horizontal reflections occurring off nearby walls.

This may well be due to the relative ear/dispersion symmetry — the brain judging quality through dissimilarities between signals arriving at the ears.

As such it is the horizontal dispersion that influences the perception of stereo space and whether these reflections detract from absolute accuracy or not, any extra spatial effects are usually quite pleasing.

Anyway, though KEF have no control over the type of listening room used they have decided to at least minimise any unpleasant interactions by manipulating the off-axis characteristics of the speaker itself.

The Uni-Q driver adopts a co-axial construction but one that enjoys a truly coincident source. This has been achieved by placing a soft-dome high frequency unit in the throat of the main low frequency driver. KEF have therefore achieved a single physical coincidence of the drivers — close to the ideal point source. This technique also avoids the uneven path lengths, subsequent time delays and crossover anomalies suffered by other two-way loudspeakers.

Tannoy's dual-concentric driver has been used for many years now but its



method of construction differs in several important respects. Here the treble unit is mounted behind the main driver and fires through several phase-compensating tubes machined out of the central pole piece. This is terminated in a concentric HF horn whose flare is continued by the exponential curve of the LF cone itself.

Tannoy then employs a 'phase coherent' crossover network to align the acoustic centres at one point on the axis. However, an electrical delay is only appropriate for on-axis correction. It is certainly no substitute for pure physical alignment.

KEF has achieved this goal by recourse to a new magnet material that offers up to 10 times the energy product of conventional ferrite, this being machined into a motor assembly small enough to sit right inside the voice coil of the bass driver!

Composed of neodymium, iron and boron this very expensive alloy magnet is sourced from Sumitomo in Japan. The Delco Remy division of General Motors have a similar material on their books known as Magnequench. It is apparently slightly cheaper but offers a lower total energy product.

A standard ferrite magnet is employed for the bass motor assembly while the cone is formed from BCC polypropylene, its curvature providing the optimum loading for the inset tweeter.

So in short, KEF have succeeded in manufacturing the first coincident co-axial drive unit that offers a matched directivity throughout the crossover region and a carefully controlled directivity off-axis.

Four new loudspeaker models (£159-£599) incorporate the fruits of this Uni-Q technology — the C35, C55, C75 and C95 but the results of any listening tests will have to wait until a future issue. Oh yes, KEF will be catering for the DIYer's amongst you, the Uni-Q driver is seemingly ideal for home constructor projects.

Paul Miller

BLUEPRINT



This column is a service to readers to provide electronic designs to order. Many a project never gets further than the drawing board because of difficulties with one small part. If you are stuck for a circuit or a technique, let the ETI expert help you out. Send your requirements, with as much detail as possible, to ETI Blueprint, 1 Golden Square, W1R 3AB.



This month's Blueprint request comes from S.A. Bowen of the Birmingham and Black Country Bat Group

Bats emit ultrasonic sounds between 35kHz and 80kHz and we in the Birmingham & Black Country Bat Group would like to build our own detector to convert these frequencies into the audible range. There are detectors on the market but they cost around £150 which is beyond our price range.

There are three obvious methods to tackle your problem and they have different disadvantages. The most obvious is to record the sounds on a reel-to-reel tape recorder at a high speed and replay at a slower speed.

This will decrease the frequency of the tones in proportion to the reduction in speed of tape. The duration of the tones is also increased, of course, and you can't listen until you have rewound the tape. In addition, most tape recorders cannot be modified to handle such high frequencies.

The second possible method is similar in concept. The sounds from the bats would be picked up by a microphone, buffered and fed into a bucket brigade delay line at high speed. When the delay line is full the signals would be read out at (say) 0.1 times the read-in speed. Thus 10ms of sound would be stretched to 100ms at 0.1 times the frequency.

The big disadvantage here is that the bats are only being monitored for 10% of the time. However, the technique is suitable for moderate frequency changes, for example to correct the sound of speech on a tape recorder played too fast. I may provide a project along these lines next year.

The third possible approach would be to heterodyne the frequencies down so that some of the range would be audible. This has two obvious disadvantages. First of all, the bandwidth of sounds used by bats is 45kHz, while the human ear is capable of hearing an absolute maximum of 20kHz. Secondly, harmonic information is lost in the conversion.

For example, if a 35kHz tone has a harmonic at 70kHz, the 2:1 relationship will be lost if the frequencies are reduced so that the 35kHz becomes 1kHz and the 70kHz becomes an inaudible 36kHz. This technique would, however, give immediate and continuous monitoring of the bats.

Fig. 1 shows a possible system to achieve the required frequency shift. This circuit produces sum and difference frequencies of the oscillator and the bat sounds but only the difference frequency is audible. A frequency of 45kHz would be converted to approximately 10kHz and 55kHz to approximately 20kHz, so the higher range of frequencies would be inaudible. However, if the higher range is needed then the low pass filter frequency and the oscillator frequency could be raised as appropriate — perhaps two switched frequencies would be useful.

Fig. 2 shows a possible circuit to do the job. I would emphasise that this circuit has not been prototyped and may require some alterations when tested, but it should be workable in principle — the only piece of circuitry not similar to something I have tested is the multiplier. That is designed to conform to the information in the data

book but what the data book tells is sometimes not the whole story.

In addition it is very easy to overlook a small point at the initial design stage, so some experimentation with access to an oscillator covering 35-80kHz and an oscilloscope may be necessary.

This circuit is far from the only way to implement the heterodyne system illustrated in Fig. 1 but it has the advantage that most parts of the circuit are conventional and should work with minimum difficulty. The low pass filter on the input could perhaps have been omitted because signals above 80kHz are unlikely to be present. An input buffer was needed so a filter has been included to minimise the chance of unwanted frequencies causing intermodulation.

The input stage is also configured to provide gain, the level of which is set by R4 and R5. The values chosen should work but if less gain is needed, the value of R4 can be increased. The gain shown in the circuit is the maximum which is sensible with the IC chosen over the frequency range. If higher gain is needed then two resistors should be added to the circuit of IC2 (the high pass filter) to provide gain in this stage as well.

It is necessary to provide enough signal to IC3 to give a good signal to noise ratio, without overloading the input of the multiplier. The gain needed can be determined by experiment and will depend on the microphone chosen.

The multiplier uses the 3080 operational transconductance amplifier. This device provides an output current (rather than a voltage) proportional to the differential input voltage multiplied by the bias current fed into pin 5. This is not exactly what is required because zero output must

occur at half scale bias current. To achieve this result, the input signal from the microphone is fed to the inverting input of the multiplier and a non-inverted signal is fed forward via R10 to cancel the inverted output signal at approximately half scale bias current.

The output stage is simply a current summing stage with frequency roll-off to remove ultrasonic frequencies.

The sine wave oscillator which provides the signal to multiply by the input signal is of a conventional design, using an integrator (which provides a 90° phase lag) and a lowpass filter (which provides a 90° phase lag at the corner frequency, given by the formula $1/(2 \times \pi \times \sqrt{R17 \times R18 \times C7 \times C8})$). The component values in the integrator are chosen to give enough voltage gain at the operating frequency to provide about ±4V peak output. The amplitude of oscillation is stabilised by D1 and D2 but the distortion products generated by these diodes are filtered out by the filter and the integrator, so the output is a clean sine wave.

The microphone must be able to respond to frequencies up to at least 50kHz to give a useful response and not all types will manage this. I can only suggest experimentation as a means of finding a suitable type but probably an electret microphone would be more likely to work.

No audio amplifier design is shown because audio amplifiers for small circuits are commonly available. One suitable amplifier would be the Matchbox amplifier as published in the April 1986 ETI (photocopies from the ETI Photocopy Service folks).

Adjustment

First of all, RV1 should be adjusted to null out any offsets. The left hand end of RV2 (marked X) should be temporarily connected to 0V and RV1 set to provide 0V on the output of IC4.

To adjust RV2, connect a signal generator providing about 40kHz to the input of the circuit and adjust RV2 (still connected to 0V) for no output from IC4. It is best to use an oscilloscope for this although an AC voltmeter may be usable. If a signal generator is not available, the output signal from the oscillator could be used. The signal level is much too large to feed to the input directly, so it must be potted down via a 10k potentiometer.

When RV2 has been adjusted, reconnect it to IC6, and the circuit is ready for field trials. When there are bats to listen to, RV3 should be set to adjust the oscillator frequency to reduce the frequency of the bats by the correct amount. The unit should now be working.

Andrew Armstrong

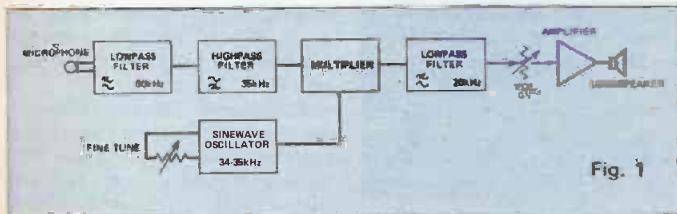


Fig. 1

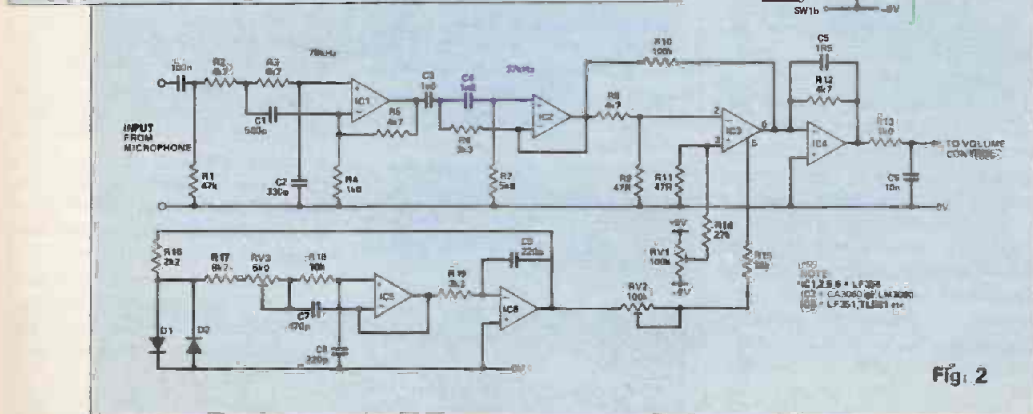
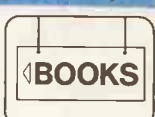
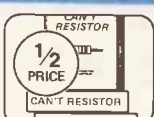
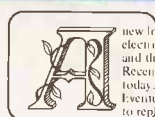
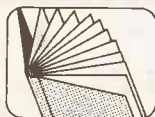


Fig. 2

BOOK LOOK



The world of satellite television rears its head again this month with three new books on the scene. Interest here for both the newcomer to the subject and for STV die-hards.

Satellite and Cable TV Scrambling and Descrambling by Brent Gale and Frank Baylin. £19. Vincent Technical Books, 24 River Gardens, Purley RG8 8BX.

A tricky subject this one. Even the (American) authors note in the acknowledgements that all the other contributors wished to remain anonymous! However, it is debatable whether it is illegal to descramble STV signals not intended for your reception and it is certainly not illegal to read about it!

This is an excellent book with just one (major) downfall — it is very American. This not only means it is written in that wearing style apparently loved on the other side of the pond but more importantly that few of the scrambling systems talked about have relevance in Europe.

Nevertheless the book gives a good background to the whole subject and should be considered a useful read if you are contemplating building your own decoder (shame!)

The first third of the book is devoted to the principles of television reception and display. Although this naturally concentrates on the American NTSC system, much mention is made of PAL (and SECAM for that matter) and so it provides a good framework of reference.

The rest of the book is devoted to the principles and practices of encryption. The discussion of techniques used is quite fascinating. After reading 70 pages of the trials and tribulations of broadcasting and receiving a TV picture, to see all the methods used to louse up the process is almost amusing.

This section is really useful. Not only are the technicalities of it all discussed in quite some detail (suf-



ficient for a competent TV engineer to go about designing a decoder) but example screen pictures are given for many of the scrambling methods. This means that when you're presented with a moving mess on your TV screen you can have an intelligent stab at guessing the scrambling system being used.

Unfortunately, the rest of the book (around half) is devoted to discussions of the innumerable commercial scrambling and descrambling units available in the US. Much information is given, including numerous photos of the boxes concerned and inter-connection details.

However, little of this is of any use to the European would-be viewer (although the various versions of MAC are well covered). Unless you are intending to try your hand at satellite TV DX-ing and grab some US TV, this is all largely wasted.

It is interesting to see how the theory of the earlier chapters has been put into practise by the manufacturers but otherwise there's not a lot here for us limeys.

You are unlikely to find this book in your local library (although you could always try to persuade them to get it in for you) so the limited use that a read of it will give you is only available for the rather steep price of £19.

The Hidden Signals on Satellite TV by Thomas Harrington and Bob Cooper. £20. Vincent Technical Books, 24 River Gardens, Purley RG8 8BX.

This is another one aimed at an American audience. It is about two years old and is now available in this country through STV specialists Vincent Technical Books. This one came as something of an eye-opener for me. I had no idea there was quite so much going on up there.

Everyone knows about the satellite TV transmissions (that's what you get a dish for in the first place). The same satellites can also carry non-video material such as radio, teletype data, telephone channels, teletext and who knows what else.

Many US satellites do indeed carry such information and this book goes into quite some detail of the technical methods of transmission of the data and the commercial (or otherwise) contents of these 'hidden' signals.

Much of the information in this book is by way of experimental data — a write-up of what the authors have found in many years of searching the frequency spectrum and investigating the signals they've found.

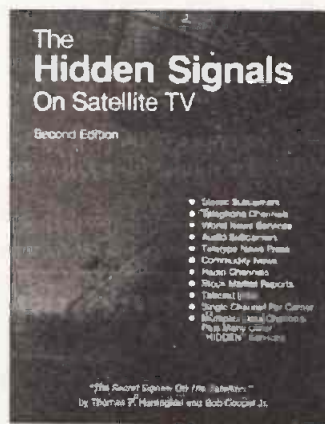
Of course the authors haven't been looking at the same satellites as you and I have available above the

horizon. This means all their findings are next to useless for UK readers — or are they? Many of the techniques used for encoding the carrier signal with non-video data are used as much in this neck of the woods as in the US. Indeed, some services mentioned — such as Reuters' news-view service — are international ones and can of course be received over here.

The big problem is that this book is entirely (well, except for a few brief paragraphs at the end) concerned with the C-band satellites which make up the majority of transmissions in the US. These are at a frequency of 3.7-4.2GHz as opposed to the 11.7-12.7GHz 'Ku-band' satellites which broadcast all the TV signals in this country and in Europe generally.

There are many C-band satellites above our skies too but you'll need a second LNB and probably a second dish to pick them up.

I am sure there are a good many hidden transmissions coming from the European Ku-band satellites too (teletext is standard on the Sky and Super-channel stations and a satellite radio channel has recently started, broadcasting on a secondary audio frequency from one of the main STV satellites) but these are a different kettle of fish and this book does little to encourage the weary newcomer to venture off his receiver's pretuned settings.



An Introduction To Satellite Television by F. A. Wilson. £5.95. Bernard Babani Publishing, The Grampians, Shepards Bush Road, London W6 7NF.

At last the Babani stable is getting into satellite television with this eminently understandable and all-encompassing guide to the subject.

Infact, it's even a little over-encompassing. An awful lot seems to be standard chapters regurgitated with no real thought as to their relevance to STV enthusiasts. Do we really need sections on scientific notation or SI



units? Are the internal technicalities of rocket motors or even amplifiers that relevant?

Where the book does concentrate on the subject in hand it does a good job. The prose is pleasantly readable and despite the vast number of mathematical equations and formulae, it remains for the most part unforboding and positively encouraging for the newcomer.

Considering this is a Babani book, not enough emphasis is put on the DIY aspects of STV. It quite correctly points out that building an STV receiver is beyond all but the most dedicated (and knowledgeable) electronics enthusiast. However, only scant duty is paid to installation — an area where most ETI readers, for example, can easily not only save a bob or two but often perform a better job than many so-called professionals.

Nevertheless, like most Babani offerings, this volume does offer a solid grounding in the subject. Refreshingly it approaches the maths of it all neither skirting around the subject nor attempting the 'baffle 'em with science' approach.

Little is said about the material on offer or scheduled to grace our screens in the future. Although the preface points out that in a restaurant 'it is hardly necessary to understand the chemistry of cooking to enjoy the food', this whole book makes a meal out of the theory with few programming appetisers.

For a basic reference work, as a clear tutor through the labyrinth of dish efficiencies, free space path loss and the like, this one is cheap and readable.

Martin Tame

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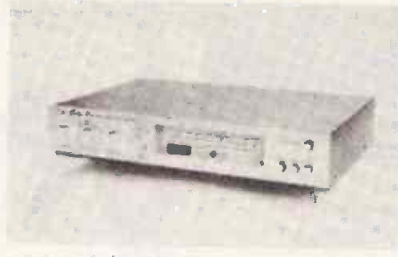
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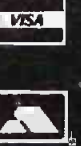
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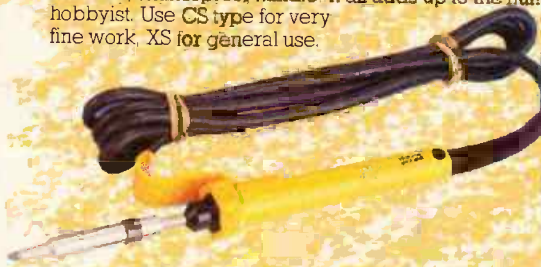
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