MAY 1993

# EVERYDAY WITH PRACTICAL ELECTRONICS

INCORPORATING ELECTRONICS MONTHLY

FULLY S.O.R. £1.80

## GUITAR PREAMP & DISTORTION UNIT

## LINEAR CLOCK
An Unusual Executive Toy

## JOINING THINGS TOGETHER
John Linsley Hood explains how to mix and match audio circuits

## UNIVERSAL ALARM MODULE

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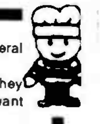
THE No. 1 INDEPENDENT MAGAZINE for ELECTRONICS, TECHNOLOGY and COMPUTER PROJECTS



**MICROWAVE CONTROL PANEL.** Mains operated, with touch switches. Complete with 4 digit display, digital clock, and 2 relay outputs one for power and one for pulsed power (programmable). Ideal for all sorts of precision timer applications etc. **Now only £4.00 ref 4P151.** Good experimenters board.

**FIBRE OPTIC CABLE.** Stranded optical fibres sheathed in black PVC. Five metre length £7.00 ref 7P29R or £2 a metre.

**12V SOLAR CELL.** 200mA output ideal for trickle charging etc. 300 mm square. Our price £15.00 ref 15P42R. Gives up to 15v.

**PASSIVE INFRA-RED MOTION SENSOR.** Complete with daylight sensor, adjustable lights on timer (8 secs -15 mins), 50' range with a 90 deg coverage. Manual overide facility. Complete with wallbrackets, bulb holders etc. Brand new and guaranteed. **Now only £19.00 ref 19P29**

Pack of two PAR38 bulbs for above unit £12.00 ref 12P43R

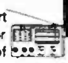
**VIDEO SENDER UNIT** Transmit both audio and video signals from either a video camera, video recorder or computer to any standard TV set within a 100' range! (tune TV to a spare channel). 12v DC op. £15.00 ref 15P39R Suitable mains adaptor £5.00 ref 5P191R. Turn your camcorder into a cordless camera!

**FM TRANSMITTER** Housed in a standard working 13A adapter (bug is mains driven). £26.00 ref 26P2R. Good range.

**MINATURE RADIO TRANSCEIVERS** A pair of walkie talkies with a range of up to 2 kilometres. Units measure 22x52x155mm. Complete with cases and earpieces. £30.00 ref 30P12R

**FM CORDLESS MICROPHONE.** Small hand held unit with a 500' range! 2 transmit power levels. Reqs PP3 battery. Tuneable to any FM receiver. Our price £15 ref 15P42AR.

**12 BAND COMMUNICATIONS RECEIVER.** 9 short bands, FM, AM and LW DX/local switch, tuning 'eye' mains or battery. Complete with shoulder strap and mains lead. £19 ref 19P14R. Ideal for listening all over the world.



**CAR STEREO AND FM RADIO.** Low cost stereo system giving 5 watts per channel. Signal to noise ratio better than 45db, wow and flutter less than .35%. Neg earth. **£19.00ref 19P30**

**LOW COST WALKIE TALKIES.** Pair of battery operated units with a range of about 200'. Our price £8.00 a pair ref 8P50R. Ideal for garden use or as an educational toy.

**7 CHANNEL GRAPHIC EQUALIZER** plus a 60 watt power amp! 20-21KHZ 4-8R 12-14v DC negative earth. Cased. £25 ref 25P14R.

**NICAD BATTERIES.** Brand new top quality. 4 x AA's £4.00 ref 4P44R. 2 x C's £4.00 ref 4P73R, 4 x D's £9.00 ref 9P12R, 1 x PP3 £6.00 ref 6P35R Pack of 10 AAA,s £4.00 ref 4P92R.

**TOWERS INTERNATIONAL TRANSISTOR SELECTOR GUIDE.** The ultimate equivalents book. New ed. £20.00 ref 20P32R.

**GEIGER COUNTER KIT.** Complete with tube, PCB and all components to build a battery operated geiger counter. £39.00 ref 39P1R

**FM BUG KIT.** New design with PCB embedded coil. Transmits to any FM radio. 9v battery req'd. £5.00 ref 5P158R. 35mm square.

**FM BUG** Built and tested superior 9v operation £14.00 ref 14P3R

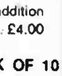
**COMPOSITE VIDEO KITS.** These convert composite video into separate H sync, V sync and video. 12v DC. £8.00 ref 8P39R.

**SINCLAIR C5 MOTORS** 12v 29A (full load) 3300 rpm 6"x4" 1/4" O/P shaft. New. £20.00 ref 20P22R. Limited stocks.

As above but with fitted 4 to 1 inline reduction box (800rpm) and toothed nylon belt drive cog £40.00 ref 40P8R. 800 rpm.

**ELECTRONIC SPEED CONTROL KIT** for C5 motor. PCB and all components to build a speed controller (0-95% of speed). Uses pulse width modulation. £17.00 ref 17P3R. Potentiometer control.

**SOLAR POWERED NICAD CHARGER.** Charges 4 AA nicads in 8 hours. Brand new and cased £6.00 ref 6P3R. 2xC cell model £6.00.



**ACORN DATA RECORDER ALF503** Made for BBC computer but suitable for others. Includes mains adapter, leads and book. £15.00 ref 15P43R

**VIDEO TAPES.** Three hour superior quality tapes made under licence from the famous JVC company. Pack of 10 tapes **New low price £15.00 ref J15P4**

**PHILIPS LASER. 2MW HELIUM NEON LASER TUBE. BRAND NEW FULL SPEC £40.00 REF 40P10R. MAINS POWER SUPPLY KIT £20.00 REF 20P33R READY BUILT AND TESTED LASER IN ONE CASE £75.00 REF 75P4R.**

**12 TO 220V INVERTER KIT** As supplied it will handle up to about 15w at 220v but with a larger transformer it will handle 80 watts. Basic kit £12.00 ref 12P17R. Larger transformer £12.00 ref 12P41R.

**25 WATT STEREO AMPLIFIER IC.** STK043. With the addition of a handful of components you can build a 25 watt amplifier. £4.00 ref 4P69R (Circuit dia included).

**BARGAIN NICADS AAA SIZE 200MAH 1.2V PACK OF 10 £4.00 REF 4P92R, PACK OF 100 £30.00 REF 30P16R**

**FRESNEL MAGNIFYING LENS** 83 x 52mm £1.00 ref BD827R.

**12V 19A TRANSFORMER** Ex equipment £20 but OK.

**POWER SUPPLIES** Made for the Spectrum plus 3 give +5 @ 2A, +12 @700mA & -12 @ 50mA. £8 ref Q8P3

**UNIVERSAL BATTERY CHARGER.** Takes AA's, C's, D's and PP3 nicads. Holds up to 5 batteries at once. New and cased, mains operated. £6.00 ref 6P36R.

**IN CAR POWER SUPPLY.** Plugs into cigar socket and gives 3,4,5,6,7.5,9, and 12v outputs at 800mA. Complete with universal spider plug. £5.00 ref 5P167R.

**QUICK CUPPA?** 12v immersion heater with lead and cigar lighter plug £3.00 ref 3P92R. Ideal for tea on the move!

**LED PACK** .50 red, 50 green, 50 yellow all 5mm £8.00 ref 8P52

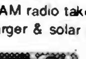
**IBM PRINTER LEAD.** (D25 to centronics plug) 2 metre parallel. £5.00 ref 5P186R. 3 metre version £6.00 ref 6P50.

**COPPER CLAD STRIP BOARD** 17" x 4" of .1" pitch "vero" board. £4.00 a sheet ref 4P62R or 2 sheets for £7.00 ref 7P22R.

**STRIP BOARD CUTTING TOOL** £2.00 ref 2P352R.

**WINDUP SOLAR POWERED RADIO!** FM/AM radio takes rechargeable batteries. Complete with hand charger & solar panel 14P200R. Set of 2 AA nicads £2 ref L2P9

**PC STYLE POWER SUPPLY** Made by AZTEC 110v or 240v Input +5 @ 15A,+12 @ 5A,-12 @ .5A,-5 @ .3A. Fully cased with fan, on/off switch, IEC inlet and standard PC flyleads. £15.00 ref F15P4



**TELEPHONE HANDSETS** 10 brand new handsets with mic and speaker only £3.00 for 10 ref 3P146R

**BENCH POWER SUPPLIES** Superbly made fully cased (metal) giving 12v at 2A plus a 6V supply. Fused and short circuit protected. For sale at less than the cost of the case! Our price is £4.00 ref 4P103R

**SPEAKER WIRE** Brown twin core 100 feet for £2.00 REF 2P79R

**720K 3 1/2" DISC DRIVE FOR £9** Brand new units made by JVC complete with tech info just £9.00!! they have a metal tab instead of a button and you may want to fit an led. Combined power and data cable easily modified to IBM standard. ref L9P2.

**MONO VGA MONITORS £59** Standard IBM compatible monitor made by Amstrad. Ex display Our price just £59. Ref 59P4RB.

**CAR BATTERY CHARGER** Brand new units complete with panel meter and leads. 6 or 12v output £7.00 ref J7P2.

**CUSTOMER RETURNED SPECTRUM +2**

Complete but sold as seen so may need attention £25.00 ref J25P1

**CUSTOMER RETURNED SPECTRUM +3**

Complete but sold as seen so may need attention £25.00 ref J25P2

**AMSTRAD 1640DD BASE UNITS**

**BRAND NEW AND CASED**

**TWO BUILT IN 5 1/4" DRIVES**

**MOTHER BOARD WITH 640K MEMORY**

**KEYBOARD, MOUSE & MANUAL**

**OUR PRICE JUST**

**£79!!!!**

**SCART TO D TYPE LEADS**

Standard Scart on one end, Hi density D type (standard VGA connector) on the other. Pack of ten leads only £7.00 ref 7P2R

**OZONE FRIENDLY LATEX**

250ml bottle of liquid rubber sets in 2 hours. Ideal for mounting PCB's fixing wires etc. £2.00 each ref 2P379R

**VIEWDATA SYSTEMS**

Brand new units made by TANDATA complete with 1200/75 built in modem infra red remote controlled qwerty keyboard BT appproved Prestel compatible, Centronics printer port RGB colour and composite output (works with ordinary television) complete with power supply and fully cased. Our price is only £20.00 ref 20P1R

**COMMODORE 64 COMPENDIUM** Pack consisting of a Commodore 64 computer, power supply, data recorder and software. All for £69 ref Q69P1.

**PPC MODEM CARDS** Made for the Amstrad PPC1640/1512 range these are plug in modules that operate at 2400 baud. No data. £15 ref Q15P5.

**AMSTRAD LQ3500 PRINTER ASSEMBLIES** Entire mechanical assemblies including print head, platen, cables, stepper motors etc etc. infact everything bar the electronics and case! Our price just £10 ref Q10P3.

**AMSTRAD DMP4000 PRINTER ASSEMBLIES** Entire printer assemblies including print head, platen, cables, stepper motors etc. Everything bar the electronics and case. Our price just £20 ref Q20P2.

**TOROIDAL TRANSFORMER** 146VA with tappings at 8v, 10v and 32v will give 50v at 3A or 32 at 4A etc. Centre tapped primary. £9 ref Q9P2. Fixing kit is £2 ref Q2P1.

**AERIAL BRACKETS** Wall plate 7.5" sq complete with rawl bolts, 10" stand off brackets with standard tube clamps. Will take up to 2" mast. Substantial bracket (would take body weight). £7 ref Q7P1.

**TV SOUND RECEIVERS** Popular units that with the addition of a speaker act as a tv sound receiver. Ideal as a stand alone unit or for connecting into HI FI!. £12 ref Q12P4

**2,000 COMPONENTS FOR £3** Yes thats right! just send us £3 and you can have 1,000 resistors plus 1,000 capacitors! Our choice of value. Order ref Q3P1.

**ETRI FANS** Mains, 11 watt 80mm diameter. £6. Ref Q6P3.

**LIGHTGUNS** Originally made for the Spectrum+2 but may have other uses (good stripper). £2 Ref Q2P3

**GX4000 GAMES CONSOLES** Complete with motor racing game, psu and joystick. £15 ref Q15P3. Extra 4 games £12 ref Q12P2

**VCR RABBIT SYSTEM** Lets you control your VCR from a second set using the VCR remote control. Retail £99 ours £39!!!

**CAMERAS** Customer returned units. 3 for £10 ref L10P2.

**STEAM ENGINE** Standard Mamod 1332 engine complete with boiler piston etc £30 ref 30P200

**HANDHELD TONE DIALLERS**

Small units that are designed to hold over the mouth piece of a telephone to send MF dialling tones. Ideal for the remote control of answer machines. £5.00 ref 5P209R

**AMAZING TALKING COINBOX!**

Fully programmable talking, lockable coinbox BT approved, retail price is £79 ours is just £29! ref J29P2.

**ANSWER PHONES £15** Customer returned units with 2 faults one we tell you how to fix the other you do your self! £18 ref J18P2 or 4 for £60 ref J60P3 BT approved (retail price £79.95!! each)

**COMMODORE 64 MICRODRIVE SYSTEM**

Complete cased brand new drives with cartridge and software 10 times faster than tape machines works with any Commodore 64 setup. The orginal price for these was £49.00 but we can offer them to you at only £25.00! Ref 25P1R

# BULL ELECTRICAL

**250 PORTLAND ROAD HOVE SUSSEX**

**BN3 5QT TELEPHONE 0273 203500**

**MAIL ORDER TERMS: CASH PO OR CHEQUE WITH ORDER PLUS £3.00 POST PLUS VAT.**

**PLEASE ALLOW 7 - 10 DAYS FOR DELIVERY**

**FAX 0273 323077**

**SOME OF OUR PRODUCTS MAY BE UNLICENSABLE IN THE UK**

**90 WATT MAINS MOTORS** Ex equipment but ok. Good general pupose unit £9.00 ref F9P1

**HI FI SPEAKER BARGAIN** Originally made for TV sets they consist of a 4" 10 watt 4R speaker and a 2" 140R tweeter. If you want two of each plus 2 crossovers for £5.00 ref F5P2.

**EMERGENCY LIGHTING SYSTEM**

Fully cased complete with 2 adjustable flood lights. All you need is a standard 6v lead acid battery. Our price is just £10 ref J10P29

**AMSTRAD 464 COMPUTERS** Customer returned units complete with a monitor for just £35! These units are faulty non returnable.

**WOLSEY DMAC DECODERS**

Made for installation in hotels etc as the main sat receiver no data but fully cased quality unit. £20 ref K20P1. Suitable psu £8 ref K8P3.

**REMOTE CONTROLS**

Brand new infra red CONTROLS originally made for controlling WOLSEY satellite receivers. £2 ea ref K2P1 or 20 for £19 ref K19P1.

**DOS PACKS** Complete set of PC discs with DOS 3.2, basic, gemdesktop & gem paint. No manuals, 5 1/4" discs. £10 ref K10P2

**CORDLESS TIE CLIP MICROPHONE**

transmits between 88-108MHZ FM 5.2cm x 2cm, uses LR44 watch battery. Complete with wire aenal & battery. £16 ref K16P1.

**CHASSIS MOUNT TRANSFORMERS**

240v primary, 12v secondary 20VA £2 ref K2P2

240v primary, 16v secondary 10A (split winding). £10 ref L10P1

**100 RED LED PACK (5MM) £5 REF K5P2**

**12V STEPPER MOTOR** Ideal for models etc. 3" dia. £2 ref J2P14

**CAPACITOR BARGAIN PACK** 100 CERAMICS **£2 REF J2P2.**

**SPECTRUM JOYSTICKS TWO FOR £5 REF J5P2.**

**AMSTRAD PC CASE, POWER SUPPLY AND 720k FLOPPY DRIVE ALL THIS FOR £30 REFQ30P15**

**USEFUL POWER SUPPLIES.** 18v 900mA dc output (regulated) fully cased with mains cable and DC out cable. £6 ref K6P1.

**UNCASED PC POWER SUPPLIES.** Standard PC psu without case, fan etc. Good for spare or low cost PC! £4 ref L4P6.

**RADAR DETECTORS. Detects X and K bands (ie speed traps). Not legal in the UK so only available if you intend to 'export'it. £59 ref J59P1.**

**100 WATT MOSFET PAIR.** Same spec as 2Sk343 and 2SJ413 (8A,140v, 100w) 1 N channel and 1 P channel. £3 a pair ref J3P9.

**LOW COST CAPS.** 1,000 capacitors £3 (33uf,25v) ref J3P10.

**VELCRO.** 1 metre length 20mm wide, blue. £2 ref J2P16.

**JUG KETTLE ELEMENTS.** Good general purpose heating element just £3 ea ref £3P8 or 5 for £10 ref J10P3.

**VERY BIG MOTOR.** 200v induction 1.1kw 1410 rpm 10"x7" GEC 1" keyed shaft. Brand new. £95 ref J95P1.

**BIG MOTOR.** 220-240v 1425rpm 2.8A 5/8th" keyed shaft GEC 6.5" x 8" complete with mounting plate. £38 ref J38P1.

**SMALL MOTOR.** Electrolux 160 watt 3,000 rpm, 220-240v 5/8" shaft precision built £18 ref J18P1.

**EPROMS 27C64 PACK OF 10 £7 REF M7P1. 27C256 PK OF 10 £9 REF M9P1. 27C512 PK OF 10 £10 REF M10P1.**

**MODEMS FOR £1.25?** These modems are suitable for stripping only hence they are only 4 for £5 ref J5P3.

**SOLAR POWERED WOODEN MODELS.** Complete with solar panel, motor and full instructions. £9 ref J9P2. 3 diff £20 ref J20P3.

**SOUND OPERATED LIGHT.** Clap your hands and light comes on. Turns after preset delay. (4 AA's req'd). £2 ref J2P3.

**FERGUSON SRB1 REMOTE CONTROLS.** Brand new units ideal for a spare or have two remotes! £4 each.

**5 1/4" 360K DISC DRIVE** Made for AMSTRAD 1640/1512 machines. White front. Our price just £9 ref Q9P1.

## PC CORNER

**PC CASES** Desktop case +psu £51.60 ref BPCC1, Deluxe slimline case +psu £60.00 ref BPCC2, Minitower case +psu £51.60 ref BPCC3, Deluxe midi case +psu £90.00 ref BPCC4.

**MONITORS** Mitac 14" SVGA .39DP £174 ref BPCM02, Mitac 14" SVGA .28DP £202 ref BPCM01.

**MEMORY** 256K Simm 70ns £8.40 ref BPCMI1, 1MB Simm 70ns £26.40 ref BPCMI2, 4MB Simm 70ns £96 ref BPCMI3

**MICE** 2 button serial mouse with 3.5" s/ware. £8.40 ref BPCMI6, 3button serial mouse with 3.5" s/ware £9.60 ref BPCMI7.

**KEYBOARDS** 102 AT UK standard keyboard £18.60 ref BPCMI4, Deluxe keyboard 102 AT UK £26.40 ref BPCMI5.

**SOFTWARE** MS DOS V5 OEM version £39.60 ref BPCMI8, MS WINDOWS V3.1 OEM version. £42 ref BPCMI9.

**MOTHERBOARDS** 286-16 Headland chipset £46.80 ref BPCMB1, 386SX-33 Acer chipset £82.80 ref BPCMB2, 386SX-40 UMC with 64K cache £110 ref BPCMB3, 486SX-25 UMC with 64k cache £191 ref BPCMB4, 486DX-33 UMC with 256k cache £378 ref BPCMB5, 486DX-66 UMC with 256k cache £515 ref BPCMB6.

**FLOPPY DRIVES** 1.44mb 3.5" drive £32.34 ref BPCDD05, 1.2MB 5.25" drive £38.40. 3.5" mounting kit £5 ref BPCDD07.

**HARD DRIVES** 42MB IDE 17ms £99 ref BPCDD01, 89MB IDE 16ms ref BPCDD02, 130MB IDE 15ms £215 ref BPCDD03, 213MB IDE 14ms £298 ref BPCDD04.

**VIDEO CARDS** 256k C&T 8 bit SVGA card £19.20 ref BPCVC01, 512k Trident 9000 16 bit SVGA card £31.20 ref BPCVC02, 1MB Trident 8900 16 bit SVGA card £45 ref BPCVC03, 1MB Cirrus AVGA3 16.7M colours £48 ref BPCVC04, 1MB Tseng multimedia £82.80 ref BPCVC05.

**ADD ON CARDS** Multi I/O card 2 serial, 1 parralel, 1 game, 2 floppy, 2 IDE hard drives. £11 ref BPCAOC01, ADLIB sound card with speakers £37 ref BPCAOC02, Orchid sound card with speakers £63 ref BPCAOC03.

**EXAMPLES OF COMPLETE SYSTEMS**

**386SX-33 SYSTEM**

386SX-33 board at £82.80, case £51.60, 2MB ram £52.80, 42MB drive £99, 512SVGA card £31.20, 3.5" FDD £32.34, multi I/O card £11 SVGA colour monitor £174, 102 k/board, £25 build fee if required. Total £579.34

**486DX-33 SYSTEM**

486Dx-33 board £378, case £51.60, 2MB ram £52.80, 89MB drive £166, 512 SVGA card £31.20, 3.5" FDD £32.34, multi I/o card £11, SVGA monitor £174, 102 k/board £18.60, £25 build fee if required. Total £939.84.

**ALL PC PARTS AND SYSTEMS ARE GUARANTEED FOR 1 YEAR PARTS AND LABOUR.**

**1993 CATALOGUE AVAILABLE WITH ALL ORDERS IF REQUESTED OTHERWISE A4 SAE FOR FREE COPY.**

**IN SUSSEX? CALL IN AND SEE US!**

VOL. 22 No. 5 MAY 1993

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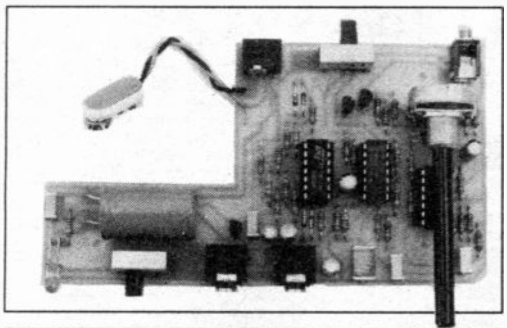
# ELECTRONICS

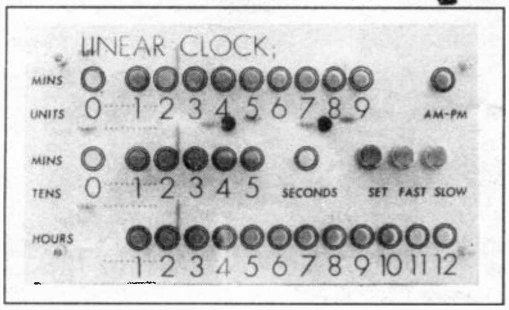
INCORPORATING ELECTRONICS MONTHLY

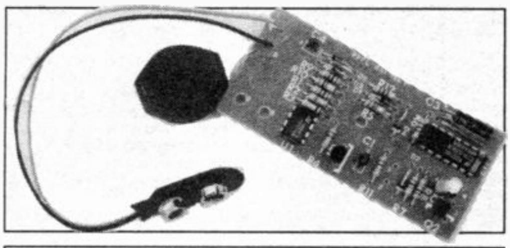
**The No. 1 Independent Magazine for Electronics, Technology and Computer Projects**

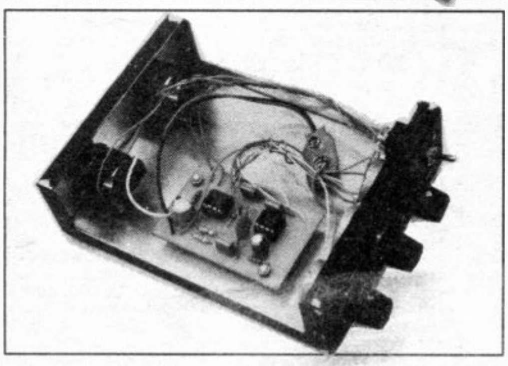
ISSN 0262 3617

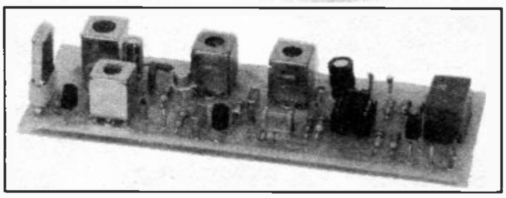
PROJECTS ... THEORY ... NEWS ...
COMMENT ... POPULAR FEATURES ...











*Our June '93 issue will be published on Friday, 7 May 1993. See page 315 for details.*

## *Projects*



## *Series*



## *Features*

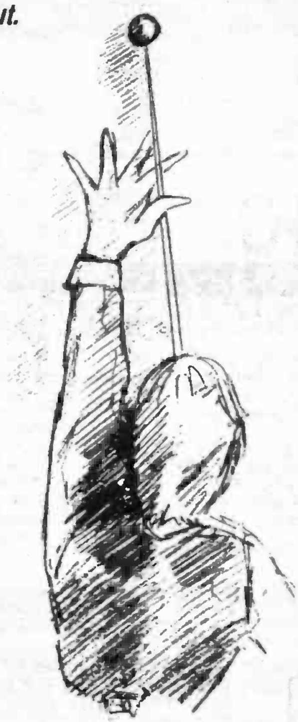
# NEXT MONTH

## FUZZY LOGIC EXPLAINED

*Fuzzy Logic is quickly establishing itself as the top growth technology of the nineties. The reason for which is very simple; user-friendliness is reaching new levels of simplicity and the order of the day is to optimise human interface where at all possible – hence the new generations of pen-based computing and voice recognition products. Fuzzy addresses many such applications perfectly as it resembles human decision making with an ability to generate precise solutions from uncertain or approximate information. We take a look at what Fuzzy is all about.*

## SNOOKER SCOREBOARD

*This high tech scoreboard replaces the traditional wooden sliding pointers, with a set of L.E.D.'s arranged to look as much like the traditional scoreboard as possible. The score is entered by a set of colour coded push-buttons corresponding to the different coloured balls. The single display is switched between the two players and the score is always added to the selected player. At the end of the game the reset button is pushed and the score board resets, after first testing the lamps and sounding the buzzer, ready for the next game.*



## IMMERSION HEATER CONTROLLER

*Automatic control for your water heater. This timer was designed in response to a request for an easy-to-use immersion heater controller for an elderly person. It would be equally useful, however, for anyone needing hot water at a preset time each day. By switching on the immersion heater early in the morning, it is possible to take advantage of the Economy-7 system (if one is installed) and make considerable savings using off-peak electricity. Some details of Economy-7 are also given.*

## QUIZ MONITOR

*This Quiz Monitor can provide precedence switching, as used in TV quiz games, for up to eight contestants. Each contestant has a key-pad which includes a pushbutton and a visual l.e.d. indicator. The question master's control panel is equipped with an on/off switch, a reset pushbutton, a seven-segment l.e.d. display, indicating the number of the contestant that pressed first, and an "appealing" audible output tone that differentiates between contestants. The entire system is battery operated.*

**EVERYDAY WITH PRACTICAL ELECTRONICS**

**JUNE ISSUE ON SALE FRIDAY 7th MAY**

R T V C

# ★★ GRAND CLEARANCE SALE ★★

## EVERYTHING MUST GO

All new and unused hardware, semiconductors, loudspeakers, cable, wire, capacitors, resistors, tweeters, screws, i.c.s and much, much more.

## BULK BUY ORDERS ONLY

Orders in bulk and appointments to view on Sundays only, please phone for details of your requirements.

Telephone:–
Warehousing: **081 992 8430**
Retail Shop: **071 723 8432**
Fax: **071 723 3467**

Retail Shop at 376 Edgware Road, London W2 1EB
Warehouse only at 21 High Street, London W3 6NG

| No. | Qty. per pack | |
|---|---|---|
| MO21 | 1 | 60W Hifi tweeter made for *Jamo UK* size 90mm sq. £1 |
| MO22 | 2 | 30 watt 8 ohm Hifi chassis speakers. *Made for Hitachi UK* midi systems, size 125mm sq. with large 70mm magnet **£9.00 + £2.00 p&p** |
| MO23 | 2 | Pod Car Speakers. Moulded in black plastic with 15 watt 10cm *Goodmans* unit fitted **£3.95 pair + £2.50 p&p** |
| MO23A | 1pr | 40 watt Car Speakers made for Roadstar of Switzerland. Fitted with dual polypropylene cone and foam rubber surround. Big 70mm magent for good base response. Supplied with grills fixing screws and cable. Size 13cm, weight 1.5Kg **£11.70 pair + £3.65 p&p or TWO pairs for £25.00 UK post paid** |
| MO24 | 2 | Audax JBL 40-100watt dome tweeters. High performance 10mm Ferrofluid cooled horn loaded unit for load distortion and high output. Supplied with 1st order crossover, spec. 40 watts at 3kHz, 100 watt at 8kHz; size 51mm x 51mm x 16.5mm. Ideal for car use **£7.50 + £1 p&p** |
| MO25 | 2 | 33000µF 10V d.c. can type computer grade quality electrolytic *UK made* £1 |
| MO25A | 1 | 47µF 385V d.c. can type electrolytic. Size 350mm x 250mm. *UK made by Phillips* £1.75 |
| MO26 | 2 | 680µF 100V d.c. can type electrolytic size 45mm x 25mm £1 |
| MO27 | 3 | 2200µF 25V d.c. can type electrolytic size 45mm x 25mm £1 |
| MO28A | 1 | 2200µF 40V d.c. can type electrolytic capacitor made by Seimans, size 48mm x 30mm £1 |
| MO29 | 1 | 33000µF 16V 27A can type electrolytic size 113mm x 50mm £1 |
| MO30 | 20 | Assorted Variable trimmers £1 |
| MO31 | 4 | Tuning capacitors 2-gang dielectric type £1 |
| MO32 | 2 | 10k + 10k wirewound precision potentiometer £1 |
| MO33 | 8 | Rotary potentiometers £1 |
| MO34 | 5 | 100k multiturn Varicap type tuning potentiometer with knob size 45mm x 5mm £1 |
| MO35 | 200 | Carbon resistors £1 |
| MO36 | 2 | Large VU meters. *Japan Made* £1 |
| MO37 | 1 | Large Tuning meter 125µA-0-125µA size 55mm x 47mm £1.75 |
| MO38 | 1 | Dual VU meter 280µA f.s.d., size 80mm x 42mm x 15mm £1.50 |
| MO39 | 5 | Coaxial Aerial Plugs, all metal type £1 |
| MO40 | 6 | Fuseholders, chassis mounting for 20mm size fuses £1 |
| MO41 | 4 | Fuseholders, in-line type for 20mm size fuses £1 |
| MO42 | 20 | 5 Pin Din 180°chassis mount sockets £1 |
| MO43 | 6 | Double phono sockets £1 |
| MO44 | 5 | 6.35mm (¼") Stereo Jack sockets £1 |
| MO45 | 4 | 6.35 (¼") Mono Jack Plugs £1 |
| MO46 | 12 | Coax Sockets chassis mount £1 |
| MO47 | 2 | Case handles plated U-shape, size 97mm x 50mm £1 |
| MO48 | 30 | Mixed control knobs £1 |
| MO49 | 1 | Cassette tape transport mechanism, belt-drive, top loading, six piano key operation with knobs, stereo record/replay erase heads, heavy fly-wheel **£5.50 + £2.65 p&p** |
| MO50 | 1 | Hifi stereo pre-amp. module. Input for CD Tuner record player with diagram. *Made by Mullard* £1 |
| MO51 | 2 | AM/FM tuner head modules'. *Made by Mullard* £1 |
| MO52 | 3 | AM I.F. modules'. *Made by Mullard* £1 |
| MO53 | 1 | FM stereo decoder module with diagram. *Made by Mullard* £1 |
| MO54 | 3 | UHF Varicap tuned tuner heads unboxed, untested but complete. *Made by Mullard* £1 |

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| MO55 | 1 | 25V d.c. 150mA Mains adaptor in neat plastic box, size 80mm x 55mm x 47mm £1 |
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| MO57A | 1 | SRBP Copper Clad Printed Circuit Board. Size 410mm x 360mm x2mm **£3.65 + 75 p&p** |
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|---|---|---|
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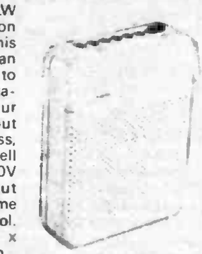
| MO86 | 1 | AM, FM, LW Ross Pushbutton Radio. With this neat unit you can easily tune in to five pre-set stations of your choice without fiddling or fuss, runs off six C-cell batteries or 240V mains. Output 400mW, volume and tone control. Size 230mm x 150mm x 65mm  **£9.95 each + £2.95 p&p** |
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**35MM BALLRACE,** complete with spindle, but this can be removed. 4 for £1, Order Ref. 912.
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**STANDARD CASSETTE MOTOR** for 9V recorder players. This is brushless and has internal electronics to facilitate speed change and reverse. £1.50 each, Order Ref. 1.5P14.
**MINI CASSETTE MOTOR** but will operate from 1V upwards as it is so well made. Speed, of course, increases with voltage and is speed regulated at 9V. £1, Order Ref. 540.
**STOP THOSE PEAKS** as they come through the mains, they can damage your equipment. 2A unit is a combination of cores and caps gives complete protection. £2, Order Ref. 2P315.
**SOLAR KIT BARGAIN.** A recent lucky purchase enables us to offer 2 solar models at approximately half price. The Aeroplane kit comprises all the parts to make a model aeroplane, solar cell and solar motor to drive its propellor. The kit was £7.50 but can be yours for only £3.75, Order Ref. 3.75P1. The second one is the Vintage Gramophone. Again, all the parts to make the model, the solar cell which drives the module which plays the tune. Again, the kit was £7.50, now only £3.75, Order Ref. 3.75P2.
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**LCD CLOCK MODULE** 1·5V battery-operated, fits nicely into our 50p project box, Order Ref. 876. Only £2, Order Ref. 2P307.
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are only described in our newsletter. Many appear in our current issue. If you order something this month you will receive this and the next issue posted to you.

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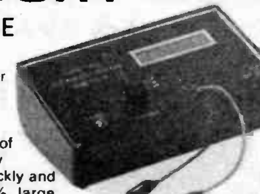

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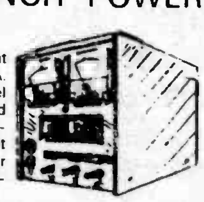

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KIT 769.................................................. £56.82

## DIGITAL CAPACITANCE METER
Provides clear readings of capacitance values from a few pF up to thousands of µF. Ideal for beginners. It allows obscurely marked components to be identified quickly and easily. Quartz controlled accuracy of 1%, and large clear 5 digit display. Kit is now supplied with a punched and printed front panel, case, all components and top quality printed circuit board. New low price.

KIT 493.................................................. £34.95

## BAT DETECTOR
An excellent circuit which reduces ultrasound frequencies between 20 and 100 kHz to the normal (human) audible range. Operating rather like a radio receiver the circuit allows the listner to tune-in to the ultrasonic frequencies of interest. Listening to Bats is fascinating, and it is possible to identify various different types using this project. Other uses have been found in industry for vibration monitoring etc.

KIT 814.................................................. £21.44

## QUICK CAPACITANCE TESTER
A low cost hand-held audio/visual unit which can identify short, open and working capacitors quickly and with a minimum of fuss. Also gives indication of leakage current . An ideal kit for beginners, built on a single printed circuit board which has large copper areas used as test pads. Only a minimum of wiring is needed. 2 l.e.d.s and a piezo transducer provide the output indication.

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KIT 444.......................... £22.37

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KIT 842.......................... £22.56

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KIT 560.......................... £22.41

## LIGHT RIDER 9-12V CHASER LIGHTS
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KIT 559.......................... £15.58

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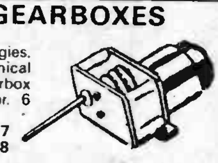

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**EVERYDAY WITH PRACTICAL ELECTRONICS**

INCORPORATING ELECTRONICS MONTHLY

**VOL. 22 No. 5** **MAY '93**

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## GETTING IT TOGETHER

The name of John Linsley Hood has been synonymous with high quality audio design for many years. EPE readers will no doubt have seen kits for his designs advertised regularly in our pages. We are, therefore, pleased to present the first article from John to be published in this magazine.

*Joining Things Together* deals with the problems many readers face when trying to join various circuit designs together to form a "hybrid" that meets their requirements. As we know tens of thousands of readers study a multitude of electronic projects each month, a few of them build those projects but many more "pinch" bits of circuitry to put together designs of their own making. This, of course, is the very stuff of electronics as a hobby. It is what makes it interesting to many readers, and what leads to a fuller understanding of the subject and gradual development of design skills.

We hope John's article will encourage more readers to "have a go" and develop their own personalised circuitry.

## ENGINEERING OR ALCHEMY

Looking a few months ahead we will also be publishing a short series of articles from the same author entitled *Audio Amplifier Design – Engineering or Alchemy?* In this series John considers the two opposing views on audio design; the engineers, some of whom believe that all competently designed amplifiers will sound the same; and the "subjectivists", who believe even the nature of the wire used in the amplifier will change the sound of the system.

Finding himself caught in the middle, John discusses some of the design aspects the engineer must now consider and looks at how much effect various types of component have on the reproduction of an audio signal. The series is highly informative and looks, in a balanced way, at the opposing opinions, what lies behind them and how they can be justified.

All the articles are fascinating and informative – we hope you enjoy them, in due course, as much as we have.

### SUBSCRIPTIONS

Annual subscriptions for delivery direct to any address in the UK: £20. Overseas: £26 (£43.50 airmail). Cheques or bank drafts (**in £ sterling only**) payable to Everyday with Practical Electronics and sent to EPE Subscriptions Dept., 6 Church Street, Wimborne, Dorset BH21 1JH. Tel: 0202 881749. **Subscriptions start with the next available issue.** We accept Access (MasterCard) or Visa payments, minimum credit card order £5.


### BACK ISSUES

Certain back issues of EVERYDAY ELECTRONICS, PRACTICAL ELECTRONICS and EVERYDAY with PRACTICAL ELECTRONICS (from Nov '92 onwards) are available price £2.00 (£2.50 overseas surface mail) inclusive of postage and packing per copy – **£ sterling only please**. Visa and Access (MasterCard) accepted, minimum credit card order £5. Enquiries with remittance, made payable to Everyday with Practical Electronics, should be sent to Post Sales Department, Everyday with Practical Electronics, 6 Church Street, Wimborne, Dorset BH21 1JH Tel: 0202 881749. In the event of non-availability one article can be photostatted for the same price. *Normally sent within seven days but please allow 28 days for delivery.* **We have sold out of Jan, Feb, Mar, Apr, May, June, Oct, & Dec 88, Mar & May 89, Mar 90 & Sept 91 Everyday Electronics, and can only supply back issues from Jan 92 to Oct 92 (excluding Mar 92) of Practical Electronics. Feb 93 Everyday with Practical Electronics is also unavailable.**

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We advise readers to check that all parts are still available before commencing any project in a back-dated issue.

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### TRANSMITTERS/BUGS/TELEPHONE EQUIPMENT

We would like to advise readers that certain items of radio transmitting and telephone equipment which may be advertised in our pages cannot be legally used in the UK. Readers should check the law before using any transmitting or telephone equipment as a fine, confiscation of equipment and/or imprisonment can result from illegal use. The laws vary from country to country; overseas readers should check local laws.

# ELECTRIC GUITAR PREAMP AND DISTORTION UNIT

## JOHN CHATWIN

*A versatile preamplifier that can make you loud and clear or send you wild with distortion.*

DISTORTION units have been around for a long time, ever since Jimi Hendrix started to use a "big muff" back in the sixties. It is the most common guitar effect and can give even the cheapest guitars much more power and sustain.

Units usually come in two forms, "overdrive" and "fuzz". Though basically the same they sound subtly different. Overdrive has a raunchy feel with lots of guts, much loved by hard rock and heavy metal players, while Fuzz is smoother and more round sounding.

Many of the early seventies groups such as T-Rex used this type of sound and it is gaining popularity again today. The unit described here combines the best of both types of distortion and can also be used as a clean signal booster to give more power and clarity to other electric instruments.

### CIRCUIT DESCRIPTION

The Guitar Preamp and Distortion Unit is based around two op. amps, see Fig. 1. IC1 is a low noise TL071 which is connected so that it amplifies the guitar signal fed in through the jack socket SK1. The gain for this stage is adjusted by rotary potentiometer VR1 and ranges from unity to around +26dB. From here the undistorted signal is taken to IC2 which is a general purpose 741 op. amp.

Diodes D1 and D2 connected across the feedback resistor R6 and "Distortion" control VR2 act as limiters that clip the signal into a square wave, giving the characteristic fuzzy sound. VR2 controls the depth of the effect. Capacitor C4 is used to remove high frequency interference that can be a problem at high gain levels.

Both i.c.s share a voltage divider formed by resistors R2 and R3 which keeps the non-inverting (pin 3) inputs at a mid point, that is half the supply voltage. Capacitors C2 and C6 help to smooth things along.

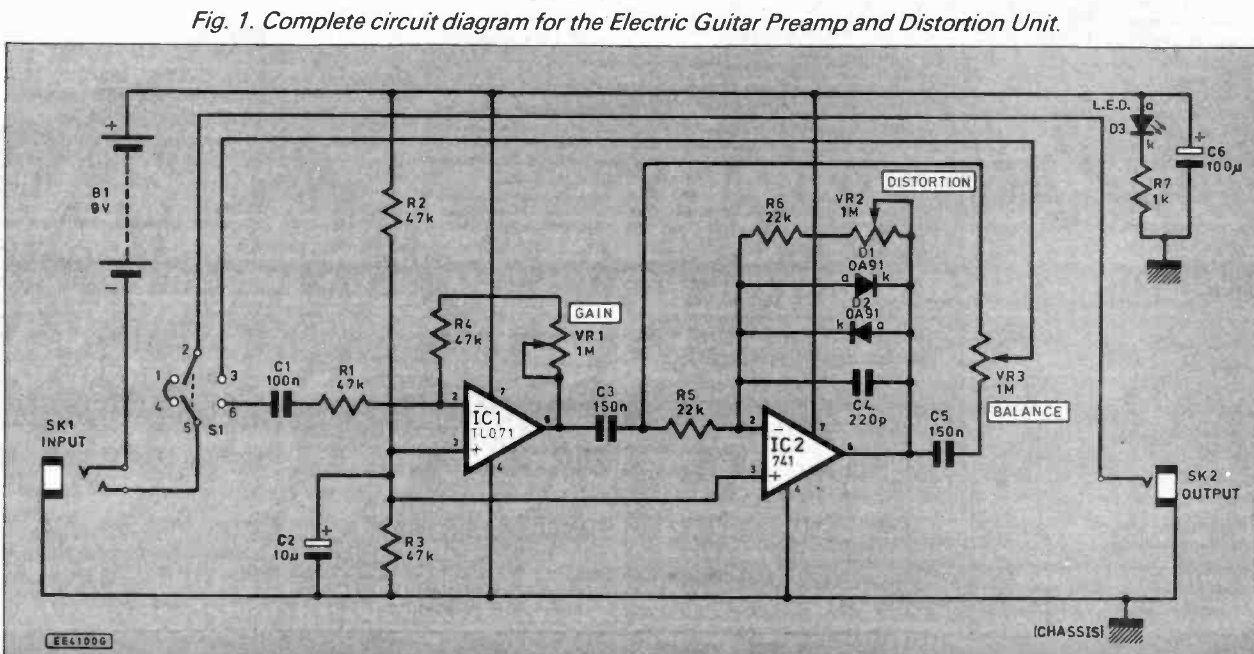
### OUTPUT

The outputs from the "clean" and "dirty" sections of the circuit are fed into potentiometer VR3 which acts as a Balance control. At one end of its travel all the output comes from IC1, giving a distortion free, low noise signal boost. As the control is turned the other way this fades out and the output of IC2 is brought in until the output from the unit is a distorted signal only.

The preamp can be switched in and out using the d.p.d.t. toggle switch S1 which disconnects the unit's input and output, and connects SK1 to SK2. This method of bypass is better than just turning the power on and off as it avoids thumps and other noise that occurs when this is done.

Overall power on/off is achieved when a normal Mono guitar lead is plugged into socket SK1. The shaft of the leads jack plug shorts across the first two terminals of the socket and connects the negative supply line to the battery.

*Fig. 1. Complete circuit diagram for the Electric Guitar Preamp and Distortion Unit.*



## CONSTRUCTION

The printed circuit board (p.c.b.) component layout and full size underside copper foil master pattern is shown in Fig. 2. This board is available from the *EPE PCB Service*, code 829.

Construction of the unit is very straight forward and should present no real problems. All components fit onto the p.c.b. apart from the rotary potentiometers, sockets and bypass switch S1. These should be wired-up once in position, if possible, to keep wire runs as short as is practical.

Components should be soldered in carefully as the p.c.b. is quite small and it would be easy to make unwanted solder bridges between the copper tracks. Be particularly careful to ensure that the polarity conscious components, electrolytic capacitors, diodes and i.c.s, are mounted on the board the correct way round.

For the prototype unit a small aluminium case was used, of the type found in many of the component catalogues. It measured approximately 133mm x 102mm x 38mm, dimensions are not important as long as the p.c.b., jack sockets, "pots" and battery can all be mounted inside the case.

It is most important that the case be metal. The circuit operates at high gains and will leap at the chance of picking up stray interference from lighting, mains cables etc.

## TESTING

Before you plug in and blow the room away with a wild solo, it's important to check everything one more time. A little bit of care now can save hours of fiddling about later on.

When you are totally satisfied that everything is the right way round and all the wires go to the right places, connect a PP3 battery and plug a jack plug into the input socket. If the l.e.d. D3 lights, at least this is connected up OK, you might as well try the unit out with a guitar.

Start with *all* the controls on the unit and your guitar amplifier turned right down in case you have problems with feedback, then, starting with the bypass switch, make sure that you can hear a normal guitar signal with the unit bypassed. Turn the unit on and raise the gain control. This should enable you to get a large boost in volume without any distortion.

Turning the Balance control VR3 fully clockwise should bring in a distorted signal at the same level as the clean one. By using the distortion control you should be able to vary the depth of the fuzz effect from a slight clipping to a totally over the top screaming sustain.

If everything is working OK you can put away your soldering iron and get back to the serious business of playing along to your Led Zeplin albums. □

## COMPONENTS

See SHOP TALK Page

**Resistors**

| | |
|---|---|
| R1, R2, R3, R4 | 47k (4 off) |
| R5, R6 | 22k (2 off) |
| R7 | 1k |

All 0·25W 5% carbon film

**Potentiometers**

| | |
|---|---|
| VR1, VR2 | 1M rotary carbon, Log (2 off) |
| VR3 | 1M rotary carbon, Lin. |

**Capacitor**

| | |
|---|---|
| C1 | 100n min. polyester layer |
| C2 | 10µ radial elect., 16V |
| C3, C5 | 150n min. polyester layer (2 off) |
| C4 | 220p ceramic |
| C6 | 100µ radial elect., 16V |

**Semiconductors**

| | |
|---|---|
| D1, D2 | OA91 germanium diode (2 off) |
| D3 | 5mm red l.e.d. |
| IC1 | TL071 low noise op. amp. |
| IC2 | 741 op. amp. |

**Miscellaneous**

| | |
|---|---|
| S1 | Miniature d.p.d.t. toggle switch |
| SK1 | ¼ inch stereo jack socket |
| SK2 | ¼ inch mono jack socket |
| B1 | 9V battery (PP3), with snap-on clips |

Aluminium case, size 133mm x 102mm x 38mm approx; printed circuit board available from the *EPE PCB Service*, code 829; 8-pin d.i.l. socket (2 off); multistrand connecting wire; solder etc.

Approx cost guidance only **£12**

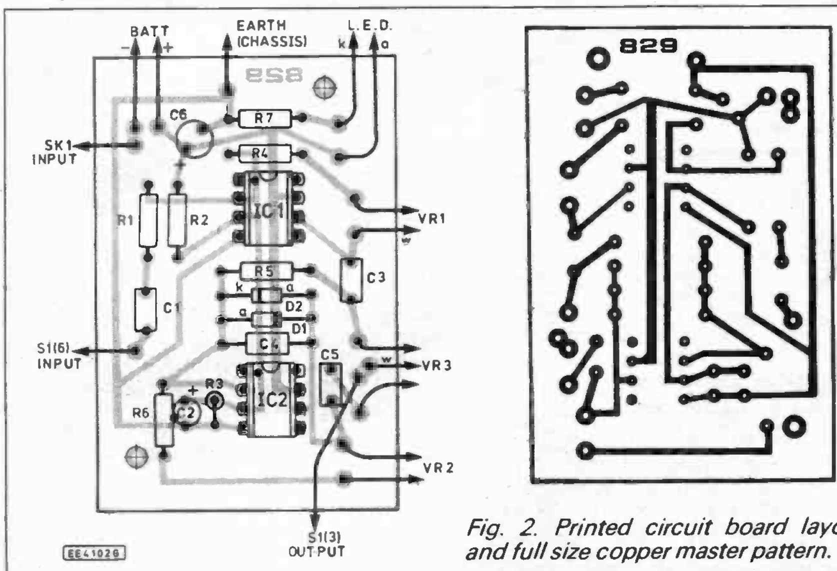
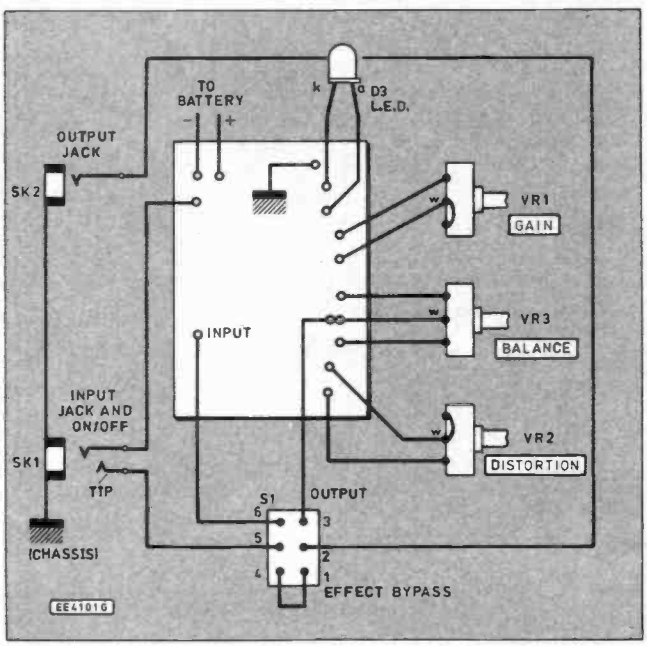
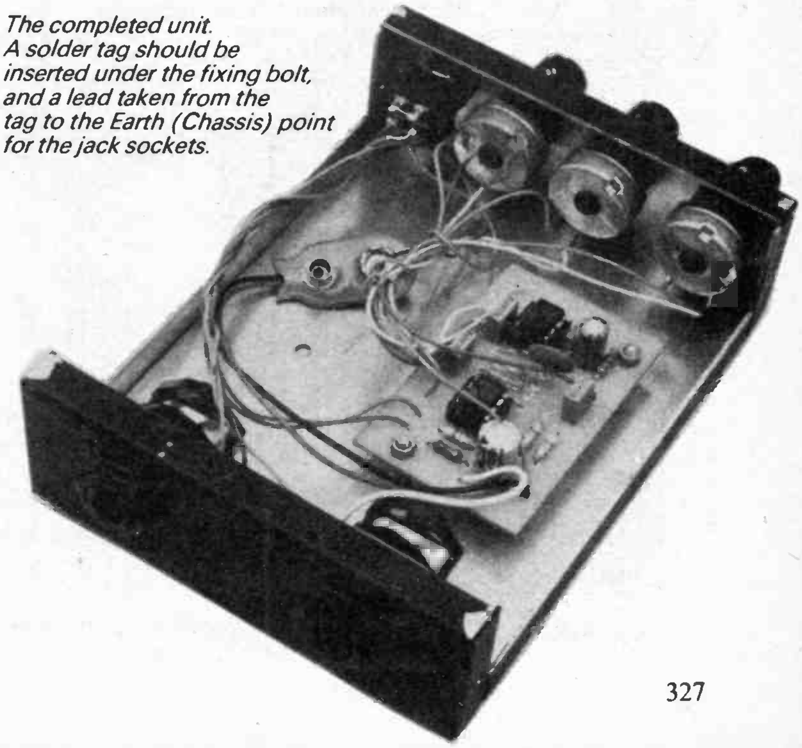



*Fig. 2. Printed circuit board layout and full size copper master pattern.*

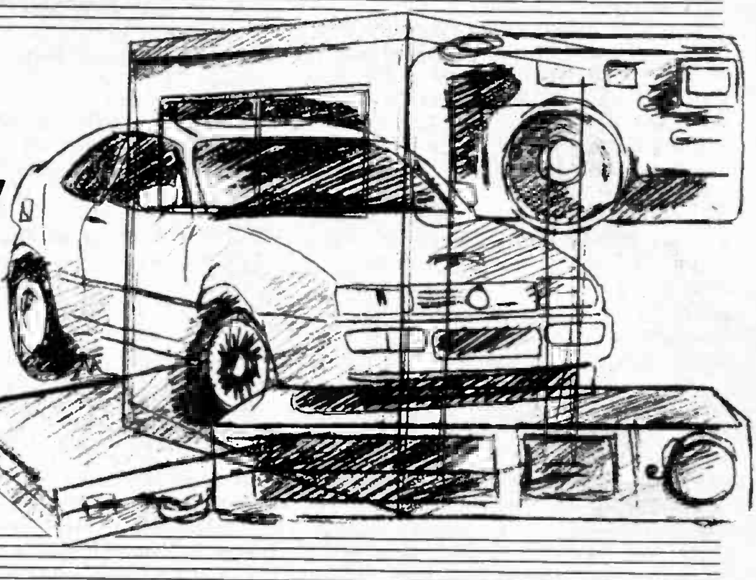
*Fig. 3. Interwiring from p.c.b. to case mounted components.*




*The completed unit. A solder tag should be inserted under the fixing bolt, and a lead taken from the tag to the Earth (Chassis) point for the jack sockets.*



Constructional Project



# UNIVERSAL ALARM MODULE

PAUL KERMAN

*A basic module that provides vibration sensed alarm timing, together with "entry" and "exit" delays.*

THIS versatile alarm circuit can be used for virtually any application where vibration will trigger it off. Due to its small size and very low quiescent battery consumption it is ideal for use with personal items where its use could prevent the items being carried away. It is also suitable for use in cars, on bicycles, motorcycles, or to protect video recorders, etc.

## BASIS OF OPERATION

The circuit has to produce three time delays as follows: one to allow for the setting of the alarm (and leaving the car, or item) – arming phase; another to allow time to deactivate the alarm (when entering the vehicle) – disarming phase, and a third to prevent the alarm from ringing too long in the event of it being triggered – alarm phase.

The circuit has been designed to keep power consumption to the barest minimum hence the use of CMOS devices and very high resistances throughtout. It should be noted that both IC1 and IC2 are static sensitive devices and should be handled accordingly.

The time delays are achieved by an arrangement of capacitors and resistors and a number of Schmitt triggers. In fact the entire circuit consists of essentially five Schmitt triggers.

## CIRCUIT

When the switch S1 (Fig. 1) is closed the inputs to the NAND gate IC2c are taken low causing its output to swing high. The use of such a method of powering the op.amp means that even if S1 contacts are relatively high resistance the alarm will trigger, also it uses the remaining i.c. gate. This powers up the op.amp IC1 and increases the potential of node *A* to approximately the supply voltage. The inputs of the NAND gate IC2b are taken high by this action and as a consequence the output then goes low, this is, in turn, inverted by the NAND gate IC2a.

At point *B* current from the output of IC2a divides into two; one portion flowing through D4, R11 and WD1. The purpose of this is to generate the faint bleep emitted from the alarm during the arming phase. The remaining portion of the current flows through R12 and the base emitter junction of TR1, this inhibits any current flowing into the non-inverting input of the op.amp IC1 by providing a current path to ground via TR1. This prevents the Schmitt trigger formed by IC1 and R4 from triggering – again during the arming phase.

## ARMING PHASE

During the arming phase the output from the op.amp IC1 must be low and this

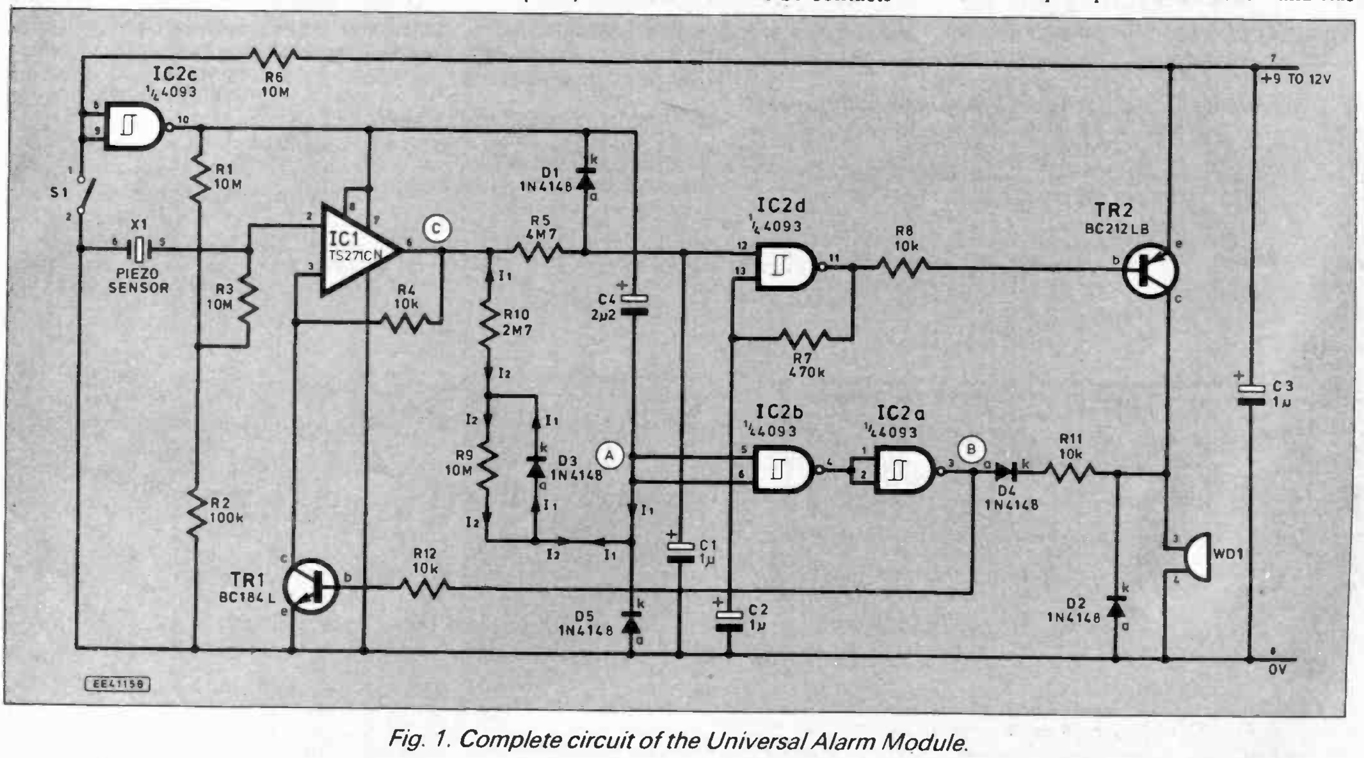



*Fig. 1. Complete circuit of the Universal Alarm Module.*

will provide a path for the current $I_1$ to flow to ground via D3 and R10. As C4 charges so the potential of node *A* falls, when this voltage drops to approximately 4V IC2b triggers switching off the bleeper and TR1 – the alarm is now armed.

Should any vibration that causes a deflection of the sensor X1 occur a voltage will be produced. If this voltage is over a threshold value set by R1, R2 and R3 (approximately 1/100th of the supply voltage) the Schmitt trigger formed by IC1 and R4 will trigger.

In the event of the threshold voltage being attained the output of the op.amp goes high as does node *C*. At *C* current from the op-amp will divide into two. One current path is through R5 to charge C1. The other is via R10 and R9 (since D3 is reverse biased and is non-conducting) to discharge C4.

Considering the path through R5 first: as the voltage across C1 rises the voltage applied to one of the inputs to the NAND gate IC2d rises to the threshold value of the Schmitt trigger on that input. This starts the astable multivibrator, formed with C2, R7 and the gate itself, oscillating at approximately 1Hz.

## DISARMING PHASE

The period of time required to charge C1 is the disarming phase; if the alarm is not turned off before the voltage across C1 reaches the threshold value then the bleeper WD1 will start to sound. The above oscillator drives the base of TR2 so that the current supplied to the sounder is chopped up into a series of pulses each approximately 0·5 second in duration.

The other portion of the current ($I_2$) from the output of IC1 as stated discharges C4 (fairly slowly as it has to flow through a total resistance of 12·7 megohms). When the voltage at node *A* reaches the trigger point of the Schmitt gate IC2b node *B* goes high turning on TR1, thus resetting the Schmitt trigger formed from IC1. The period of time required to discharge C4 is the alarm phase.

The diodes D5 and D1 protect the inputs of their associated gates. D2 guards against any back e.m.f. or flyback voltage produced by WD1.

## CONSTRUCTION

The alarm is built on a small p.c.b. which is available from the *EPE PCB Service* order code EPE9070. As mentioned above the i.c.s are both static sensitive and should be left in their protective packaging until the board is completed. It is a good idea to use sockets for mounting these i.c.s.

Commence construction by fitting the resistors, diodes and capacitors first, observing the polarity of the last two where marked.

Note that IC1 is a performance programmable op-amp, i.e. its a.c. performance can be selected by the bias select pin (pin 8). This can be left floating for medium performance, connected to 0V for high performance, or connected to $V_{DD}$ for low performance. The setting of this pin also affects the current drawn by the TS271 i.c.

On the original circuit board pins 7 and 8 of the op.amp were bridged with solder to reduce current consumption (low performance). For further information refer to the Texas Instruments LinMOS Design Manual.

If an unmounted piezo element is used as the sensor this should be carefully and quickly soldered to avoid damaging it, it is *not* a polarised component. Check carefully that all wiring is complete and correct before inserting the i.c.s.

## COMPONENTS

**Resistors**

| | | |
|---|---|---|
| R1, R3, R6, R9 | 10M (4 off) | |
| R2 | 100k | |
| R4, R8, R11, R12 | 10k (4 off) | |
| R5 | 4M7 | See |
| R7 | 470k | SHOP |
| R10 | 2M7 | TALK |

**Capacitors**

| | |
|---|---|
| C1 | 1µ tantalum 35V |
| C2, C3 | 1µ radial elect. 50V (2 off) |
| C4 | 2µ2 tantalum 35V |

**Semiconductors**

| | |
|---|---|
| D1 to D5 | 1N4148 (5 off) |
| TR1 | BC184L *npn* silicon |
| TR2 | BC212LB *pnp* silicon |
| IC1 | TS271CN op.amp |
| IC2 | 4093 quad 2-input NAND Schmitt |

**Miscellaneous**

| | |
|---|---|
| X1 | piezo element (see text) |
| S1 | s.p.s.t. toggle switch, key operated switch or changeover reed switch – see text |
| WD1 | Audible warning device with built-in drive circuit (max current 200mA) |

Battery connector; printed circuit board, available from the *EPE PCB Service*, order code 9070.

Approx cost guidance only **£8**

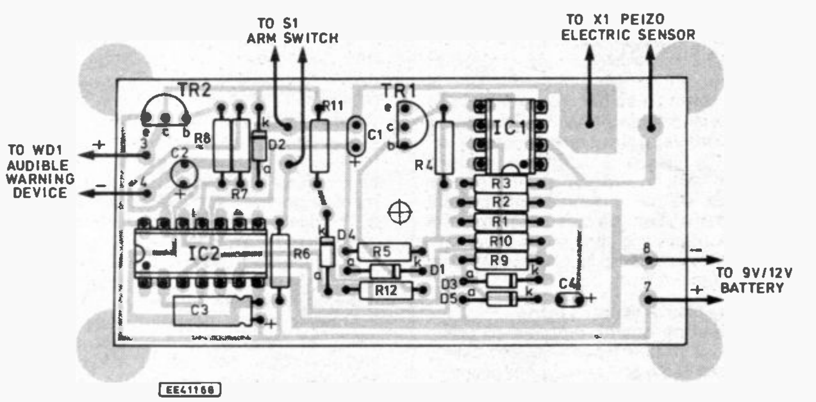
## TESTING

Connect up the sensor and the beeper ensuring the polarity of the beeper is correct. Connect up to a 12V power supply and operate the arming switch. At this point the beeper should beep softly for about 10 seconds or so, after this time the alarm is armed and should sound a couple of seconds after a disturbance has triggered it. The alarm sounds for approximately 60 seconds. To switch off the alarm either disconnect the power supply or turn off the arming switch.

## IN USE

The Universal Alarm Module can be used to give protection to virtually anything where vibration will set off the alarm. If an unmounted piezo sensor is used this could be glued to glass or over a 12mm hole drilled in the alarm case. In this way movement of the case will set it off – the sensitivity of the unit when used like this can be increased by glueing a small fishing weight to the centre of the piezo disc.

The alarm unit can thus be completely



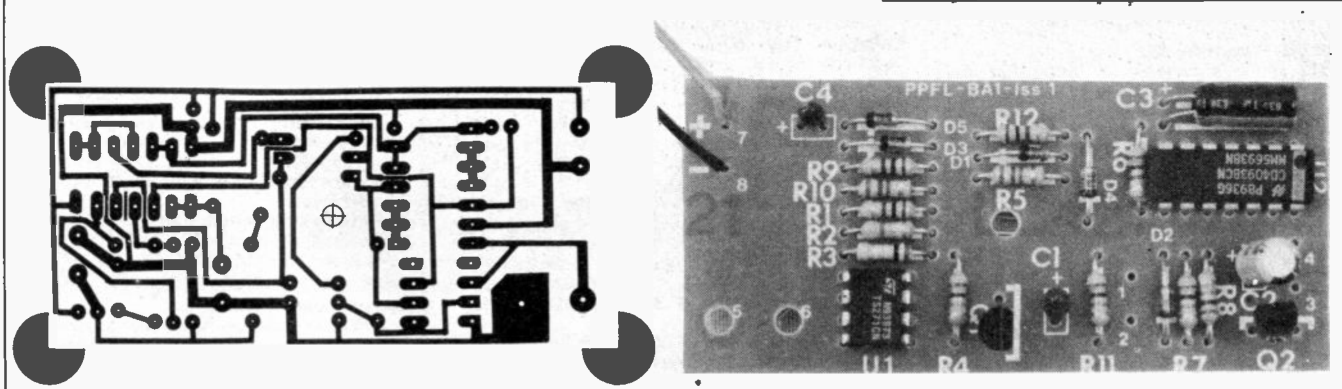



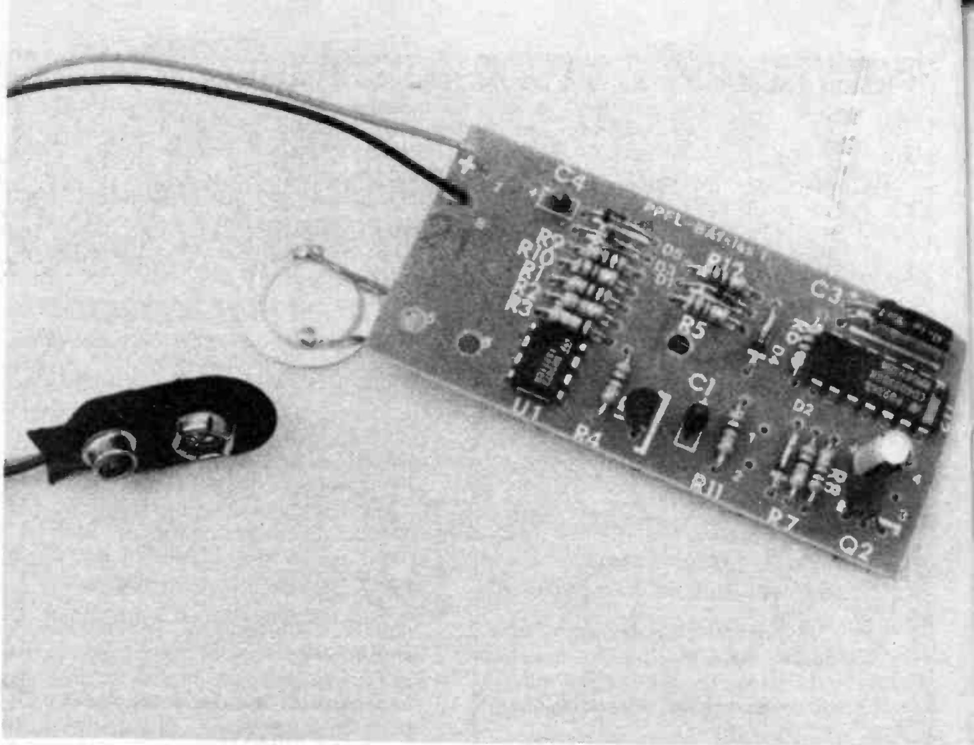

*Fig. 2. PCB layout and wiring of the module.*

self-contained in a small plastic case and may use a key-operated switch or an internal normally closed (changeover) reed switch with a magnet to switch it off. In this way the unit can be placed on, or stuck to, almost any item that requires protection.

In a car the arming switch could again be a key-operated type mounted inside the car or simply a hidden or disguised toggle-switch. The unit can also provide protection to a bicycle or motorcycle in the same way.

If you are using the module as a video alarm open up an old video cassette, remove the tape and spools, and fit the module inside the cassette case. A suitable power supply here would be an alkaline PP3 battery. The best way of arming the unit is to use a changeover reed switch glued to the inside of the lid, the normally closed contacts are connected to the arming wires. Keeping a magnet on top of the alarm when not in use will deactivate it and removing the magnet prior to inserting the alarm into the video recorder will arm it.

If the unit is required to sound a high power alarm or siren (taking more than 200mA), then WD1 can be replaced by a 12V 200 ohm (or greater) relay and the contacts used to switch the alarm. □




# SHOP TALK

## with David Barrington

**Universal Alarm Module**

The TS271CN i.c. used in the *Universal Alarm Module* is a special i.c. and, as far as we are aware, only available from one source. The i.c. is a "performance programmable" op.amp, which basically means its a.c. performance can be selected by the bias pin (8). This can be left floating for medium; connected to 0V for high; or connected to $V_{dd}$ for low performance.

The TS271CN is included in a very good "value-for-money" kit (XK222) being offered by **Greenweld Electronic Components** (☎ *0703 236363*). Costing only £4.95, the kit contains everything (including a component screen printed p.c.b.) to build the project, except the "arming" switch which is left to individual choice. For those wishing to purchase a set of parts, excluding the circuit board, switch and piezo sensor, this will work out at £3.95. Add £1 for post and packing for either of these kits.

The cost of parts shown in our components list is based on an individual item costing. So you can see that the Greenweld kit offers a good saving. No case has been specified for the module but they will supply a suitable one for an extra £1.50. Greenweld will also be sending a free copy of their catalogue with each order received.

The small printed circuit board is available from the *EPE PCB Service*, code 9070.

**Mini Lab (Teach-In '93)**

This month's subject for our *Mini Lab (Teach-In '93)* experimenter's "test bed" is the *Display Module*. This circuit contains three identical BCD-to-decimal, seven-segment decoder/driver i.c.s type 74HCT4511. This should be available from most of our semiconductor advertisers.

It is most important that 0·5 inch common cathode displays be used in this circuit. Nearly all the popular types sold by advertisers should fit the board, but check before purchase.

The dual-in-line resistor module contains an eight resistor network and is the RS package, code 140-603. Be careful, some other types have different pinouts from the one specified. It is the "8-individual" type which is required.

A selection of kits for the Mini Lab, including the Display Module, has been specially prepared by **Magenta Electronics** (☎ *0283 65435*). These include the single Eurobreadboard which replaces the two original Veroblocs (discontinued).

The large Mini Lab printed circuit board is available from the *EPE PCB Service*, code MINI LAB (see page 387).

**Guitar Preamp/Distortion Unit**

We do not expect any component buying problems to arise when shopping for parts for the *Guitar Preamp/Distortion Unit*.

It is important that a Metal case is used in this project and it must be "earthed". This is achieved by inserting a solder tag under one of the fixing bolts and taking a lead from the tag to the earth (Chassis) point on the board.

Note that the stereo jack socket is used to switch the battery supply, so make sure the two sockets do not get mixed up and are mounted correctly. Also, be sure to specify the two "Log" law potentiometers when ordering.

The printed circuit board is obtainable from the *EPE PCB Service*, code 829.

**Mind Machine MkII – Magic Lights**

Most of the components required to complete the *Mind Machine MkII – Magic Lights* unit are standard items and should not prove to troublesome to find locally. However, all parts for this project, including switches and sockets, are intended to fit directly on the circuit board and will have to be selected carefully.

The following items were all purchased from **Maplin** (☎ *0702 554161*): Hyperbright (3·5cd) l.e.d.s, code UK20W; p.c.b. slide switches, code FV01B; p.c.b. stereo sockets, code JM23A; 2·5mm p.c.b. socket, code FK01B; 2·1mm d.c. power socket, code RK37s. The plastic case is the Vero part number 202-21040F and was purchased from the same source (code LL08J).

The micropower 5V positive voltage regulator, type LP2950CZ, was chosen in preference to one of the more popular 78L05 series for its ability to operate at a lower current and voltage. At present it only appears in the **Electromail** (☎ *0536 204555*) listing, code 648-567.

Note that the control VR1 must be a "log-law" component and must be ordered as such. The printed circuit board is available from the *EPE PCB Service*, code 827 (see page 387).

**Superhet Radio Control Receiver**

Some of the items called up for the *Superhet Radio Control Receiver* are "specials" and may prove difficult to find locally. This applies particularly to the r.f. MOSFET transistor type MFE207. It seems to be only listed by **Cirkit** (☎ *0992 44411*) and carries the stock code of 60-04201.

Cirkit are the main stockists for Toko coils and can supply all the transformer coils for this project. They are also stocked by **Maplin**. When ordering make sure you write down each type number very clearly as there is quite a range to choose from.

The relay used in this circuit is the 12V, 400 ohm coil, ultra miniature p.c.b. mounting relay, with 2A (resistive) 1A (a.c. inductive) s.p.d.t. contacts. This relay was purchased from Maplin, code YX94C (Ult-Mn Relay 12V SPDT). Other relays, with identical electrical characteristics, may be used provided they fit on the p.c.b. They can, or course, be hard-wired to the board.

The CA3140E op.amp should be used in this circuit, most other op.amps (such as the µA741C, LF351N, etc.) will not work properly here. The printed circuit board is available from the *EPE PCB Service*, code 828.

**Linear Clock**

The only item that looks as though it could cause some headaches when shopping around for components for the *Linear Clock*, is the 32·768kHz crystal. This crystal is usually found under the timekeeping sections in catalogues and is normally used in digital watches. If any readers do experience local supply difficulties, it is currently listed by Maplin, code UJ02C.

Quite a few of our advertisers carry special offers on "Mains/12V d.c. regulated adapters" and a suitable one should not be to hard to find. You could try contacting Marco, Greenweld, Cricklewood, Bull Electrical to name just a few. The one used by the author is the Maplin mains adaptor, code YZ21X.

The two fairly large printed circuit boards are available from the *EPE PCB Service*, codes 830 (Timing) and 831 (Display).

**PLEASE TAKE NOTE**

**Universal Data Logger (March '93)**

The 11MHz crystal specified for last month's Universal Data Logger should have been a 11·05920MHz type. We understand that the circuit will not function with the 11MHz crystal.

The only supply source we have been able to locate for the correct 11·05920MHz crystal is **Viewcom** (☎ *081 471 9338*). This is listed under their HC49/U4H range.

**Spatial Sound (March '93)**

Some constructors have been experiencing some distortion being produced by IC2 in the Spatial Sound project,. The remedy for this is to place a 100 kilohm resistor to "ground" after capacitor C3. Since IC2 is a.c. coupled, via C3, and has no biasing, adding the resistor stops it "floating".

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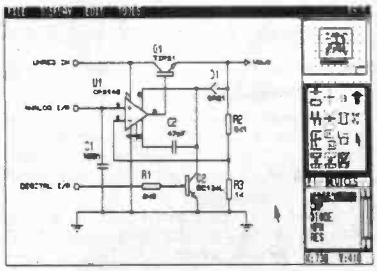

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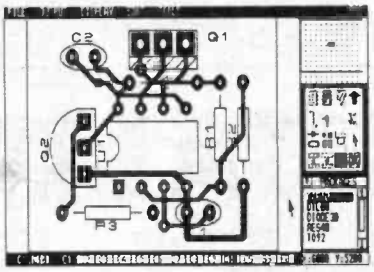

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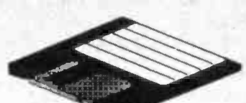

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# Innovations

**A roundup of the latest Everyday News from the world of electronics**

## TELEPRESENCE

HEADSETS of the type seen in futuristic adventure movies are being developed by BT. In fact they already have a working prototype at their Martlesham Heath labs and expect commercial systems to be available during 1995. The "telepresence" system uses advanced voice, data and visual communication to enable people to operate with the benefit of an expert looking over their shoulder – who is really not there at all.

By mounting a miniature TV camera – or cameras, for stereoscopic vision – on a remote headset, an almost exact feeling of presence can be given to someone many miles away. He or she sees exactly what the person wearing the headset sees, whatever the angle.

BT's work on this remarkable technology is the most advanced in the world, embodied in what it calls the Camnet telepresence system.

"We still have a great deal of work to do, but the basic elements are all there and working," says BT's Keith Cameron.

"We now need to concentrate on getting the weight down and packaging components and circuitry into something that is practical and comfortable for someone to carry on their head for long periods."

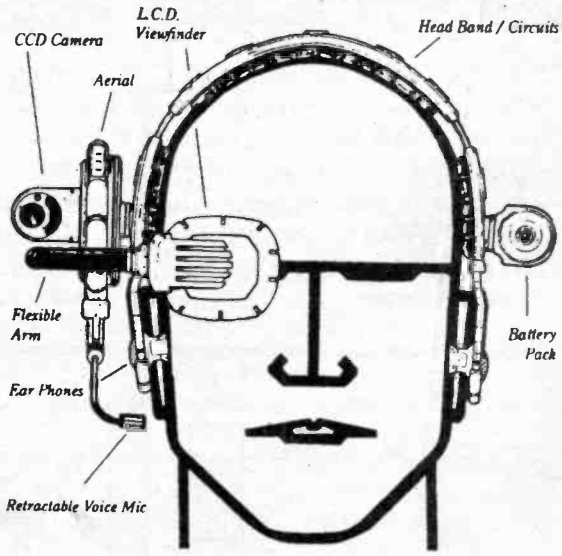
Telepresence could soon revolutionise news gathering. With Camnet, one lone reporter would become his own sound recordist and cameraman – with all the equipment he needs sitting on his head.

For the service engineer, Camnet could become one of the fundamental tools of the trade, putting an expert at his shoulder whenever he has a problem diagnosing or correcting a fault.

It could also help in aircraft checks following an accident. A rapid visual inspection could be made under the eye of remote experts, shortening the time the airline would have to ground its aircraft.

It could even become a key weapon in the fight against crime, with equipment miniaturised as a tiny assembly in the policeman's badge.

And in medicine, telepresence could be used to "teleport" GPs, surgeons and consultants to rural practices and operating theatres, as well as to give urgently needed expert help to paramedics trying to save the lives of road accident victims.




*Headset for the future*

## 50's REVIVAL

Now those of us that are "over 21" can indulge in a little nostalgia – at a price. Roberts Radio have launched The Revival, a three band – l.w./s.w./f.m. – radio with modern performance and technology but styled in the image of the 50's. Roberts say that "the cabinet of the Revival is an authentic replica of the R200 which became a must for style connoisseurs and celebrities in the 50's and 60's. It has all the stylish charm of the original, built in the same mahogany and leathercloth finish as before. However the Revival at £99.99 is packed with all the latest components and technology to combine the distinctive Roberts quality with a contemporary performance. F.M. sound is now available in this lightweight portable radio that is sure to prove as much an essential fashion accessory for the famous and stylish, as the R200 did in its heyday."

## Electronic Newspaper

A joing venture between the RNIB, *The Guardian*, Aptech Ltd and Intelligent Research Ltd, has resulted in the launch of an electronic newspaper for the blind under the joint venture company Electronic Text Network Associates (ETNA) Ltd.

The launch of the electronic newspaper means that visually impaired people in the UK will be able to access the full text of the days Guardian by six a.m. – before some people receive their printed version.

The evening before publication, *The Guardian* pages are processed to remove photographs, graphics, and tables which are diffucult to convey with synthesised speech. The pages are then compressed and coded for transmission using an encryption technique which ensures that only ETNA users can receive and decode files.

The Electronic Newspaper reader plugs a TV aerial into the ETNA decoder board fitted to his/her personal computer. Overnight *The Guardian* files are received via teletext transmissions and stored on the computer's hard disk. When required, they are decompressed and processed ready for reading. *The Guardian* can be read using a speech synthesiser, braille display or large character display. Teletext and TV sound are available at any time.

The newspaper reading software allows the user to find and read articles and teletext pages with a series of simple menus. The majority of operations can be completed by using a handful of keystrokes, making the system suitable for people who have never used a computer before.

Cost of the basic system (for those that already have a suitable PC) is £560, including £160 for a years subscription. The cost of a speech synthesiser adds at least £350 to this price.

## MINI IRON

A new range of miniature soldering irons have been introduced by Cooper Tools, manufacturers of Weller equipment. The Weller Mini Series 2000 is a range of seven different irons rated at 12, 15, and 20 watts, prices start at around £13 including VAT.

## More Phones

Up to 1,100 BT payphones will be installed in post offices nationwide under a new multi-million pound contract with Post Office Counters.

The programme of installation is expected to take about a year to complete, with the first being installed shortly. Most of the payphones are BT's new Payphone 490 model, designed to accept coins and credit card payments. The contract also includes 60 Cardphones which take BT Phonecards and commercial credit cards.

# "Gogglevox" may be developed to help partially sighted

**by Hazel Cavendish**

A HAMPSHIRE man who developed the world's first television set mounted in a pair of goggles may further develop his invention to restore a degree of vision to the near-blind who retain some vestige of sight.

William Johnson, whose "Gogglevox" was launched on the international market in January (see Jan '93 *Innovations*), was made aware of the perils experienced by partially sighted pedestrians when he saw two people narrowly avoid an accident with a car in Lymington High Street. As he walked back to his home in the town it suddenly occurred to him that his recent invention could be adapted to bring sight to those officially classed as "legally blind".

While negotiations proceed with both the United States and Japan to produce the Gogglevox under licence, Johnson has had time to put his inventive genius into solving this problem.

"Although it is still early days in this development, I can say now that we may be able to do something to help people with eyesight problems. Living in a town where so many are elderly and retired, I have long felt sympathy for those who lead their daily lives with the ever-present handicap of minimal eyesight.

"Using the same 'Microsharp' technology that was employed in producing Gogglevox, you could have something on the lines of a miniaturised TV camera which would feed its picture into the l.c.d. screen placed in front of each eye. The scene would be magnified to the virtual size it was in reality, and because it would be close to the eye they would see it more clearly.

"I also foresee the development of a device rather like a pencil, containing a miniaturised camera, which could be plugged into the system for reading purposes, magnifying the words and making reading possible for the partially sighted. Although all this is in its infancy, I am excited by the prospect of helping people with tragically reduced eye-sight."

Johnson took seven years to produce the Gogglevox with the assistance of a team of scientists from Loughborough University, under the leadership of Professor Nicholas Phillips. He gives full credit to his "team of geniuses" whose physics enabled him to smooth out the screen pixels and produce a near-faultless picture offered by the miniature goggles set, using a patented paper-thin transparent film of "Microsharp" material.

It has aroused enormous interest worldwide, being widely publicised in scientific journals in the United States and Japan, and negotiations to produce it are well forward. To Johnson's continuing regret, no firm in Britain has showed interest in acquiring and marketing his original invention, but it remains to be seen whether the British medical world will be quicker when his latest idea reaches the market place.

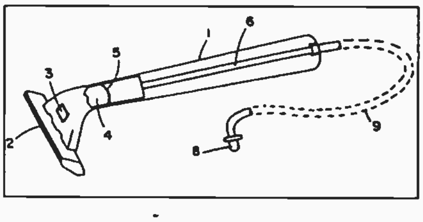
# THE THINGS PEOPLE PATENT!

The following abstracts are taken from recent UK patent applications in the general electrical/electronics area. British Patent Specifications can be ordered from The Patent Office, Sales Branch, Unit 6, Nine Mile Point, Cwmfelinfach, Cross Keys, Newport, Gwent, NP1 7HZ.

## Microwave space and water heating system

In UK patent 2248681 Alan Keith Baker, Paul David Neale Cain and David Alan Combes describe a microwave heating system. It includes a heat generator and means for circulating fluid through a generator in order to abstract heat for transfer to space to be heated.

The generator comprises a microwave source and a microwave absorber. A transfer device comprising a tortuous passageway through which heat transfer fluid is passed, the passageway includes a number of surfaces which absorb the microwave energy and reflect the energy into the heat transfer fluid. The heat transfer fluid may be water, and may contain sodium chloride to increase its absorbency of microwave energy. The heat transfer fluid may be piped to a radiator system and to a hot water cylinder.




## Razor with hair detection means

In UK patent 2249515 Keter Plastic Ltd describe a razor having an integral hair detector. It comprises a razor assembly (2) mounted on a handle (1) for brushing against the surface of a person's face and vibrating in response to contact with hairs. A pickup (3) is coupled to the handle and responds to the vibrations, generating a corresponding signal.

Electronic or acoustic audio frequency amplifying means (5) are provided within the handle (1) for amplifying the signal from the pickup (3) and producing an audio frequency output. In use, the person shaving hears the amplified vibrations either directly via a loudspeaker or via an earpiece (8) so as to obtain feedback relating to the surface quality of the shave.

## Warning triangle

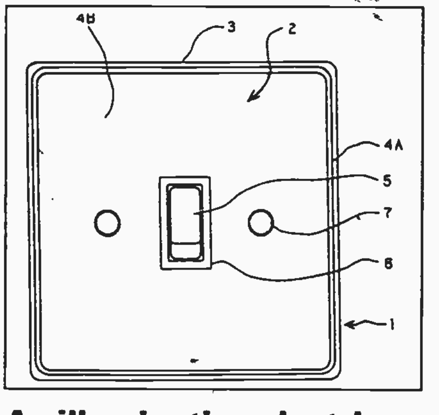
In UK patent 2254094 John West Holes describes a collapsible warning triangle. The support for this is in the form of a box which is adapted to enclose the triangle when it is collapsed. The warning triangle comprise three reflective, linear elements and a light source arranged to project light to make the triangle more visible. The light source includes one or more electric lamps connected via an electric socket to an electric power source.

## Detecting cable faults

In UK patent 2249841 Radiodetection Ltd describe a method of detecting faults in a buried cable that comprises an inner core and conductive armouring. This is done in three stages. First, a fault is detected by measuring the resistance of the conductive armouring and comparing this with the expected resistance. of the armouring. This method makes use of an alternating signal having a frequency less than 1kHz. Resistance of the cable is then measured using equipment connected to the ground via three ground spikes.

By first measuring the resistance between each pair of ground spikes the resistance of one ground spike can be determined and this resistance can then be eliminated from the measurement of cable resistance. By repeating this operation at a remote point in the cable using further measuring equipment connected to the ground via further ground spikes, the location and resistance value of a fault in the cable can be determined.

Data may be transmitted between the measuring equipment at a frequency less than 1kHz via the armouring. The use of a low frequency reduces capacitative effects.




## An illuminating electric light switch

In UK patent 2251060 Andreas Charalambous Georgiou describes an electric light switch (1). It comprises a housing (2) for mouting on the wall of a room and serves to control a remote primary source of illumination that gives a high level of illumination required for normal activity within the room.

The switch housing (2) incorporates a secondary source of illumination (3) providing a lower level of light. The switch (1) includes a contact (5) for selecting either the primary or the secondary source as the source of illumination within the room.

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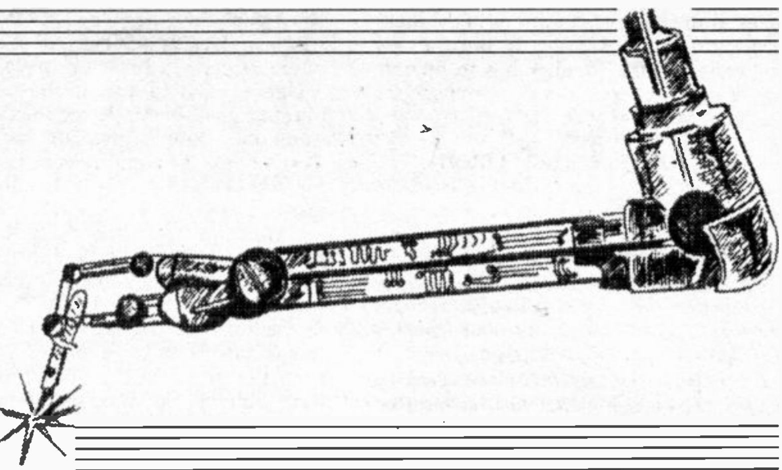
# CIRCUIT SURGERY




## MIKE TOOLEY B.A.


***Welcome to* Circuit Surgery*, our regular clinic which deals with readers' problems. In this month's* Surgery *we shall be returning to a regular favourite with readers, power supply design. We also provide some hints for estimating the ratings of power transformers and details of a simple aerial booster which can be used with most types of radio receiver. For good measure we also briefly revisit the bargraph ammeter described in February's* Circuit Surgery.**

## More power supply hints

Prompted by *Circuit Surgery*, several readers have sent in hints and tips for erstwhile power supply designers. Judging by the amount of mail received, this is obviously still a subject which interests many readers!

***Phil Morris*** from Gloucester is a regular experimenter. Phil writes:

*"I have come to the conclusion that the L200 regulator can meet virtually any need for a low-voltage regulated d.c. supply up to about 1A. Unlike fixed voltage regulators like the popular 7805 and 7812, this handy chip can easily be configured for any voltage or current by means of two simple pre-set adjustments."*

Phil has supplied the circuit diagram shown in Fig. 1. The L200 voltage/current regulator should be mounted on a suitable heatsink and an input voltage of between 17V and 22V should be quite adequate for output voltages in the range 9V to 15V.

***Mr F. Yeates*** writes from the Isle of Wight with two useful suggestions:

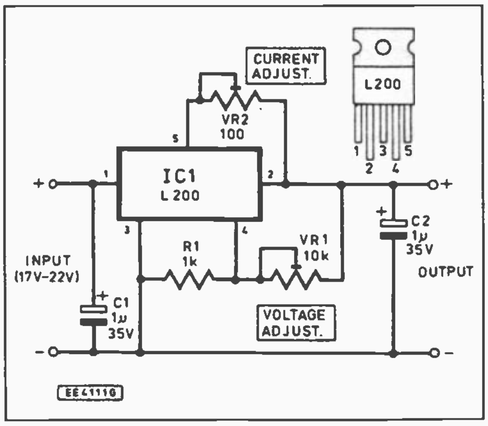
*"With reference to your article on regulator protection, I came across the enclosed circuit (Fig. 2) many years ago. Apparently, a voltage regulator which has its voltage increased by diodes loses its protection if it experiences a short circuit on its output.*

*To prevent this, and to stop the common voltage being reverse biased by more than 0·2V, a* germanium *diode (D3) is connected as shown. I have used this circuit but not tested it to destruction."*

Mr Yeates also offers a very useful hint for those who need an accurate split-supply (or a half-supply rail) at a few tens of milliamps. The circuit, Fig. 3, is based on the ubiquitous LM380 in which pins 3, 4, 5, 10, 11 and 12 are all connected to the negative rail using as much spare copper as possible in order to act as a heat shunt.

The output voltage from pin 8 of the LM380 will be half that of the input voltage. If this point is then used as a 0V rail the +ve and −ve rails will be at +6V and −6V respectively.

*Fig. 1. Circuit diagram for the L200 voltage/current regulator suggested by Phil Morris.*



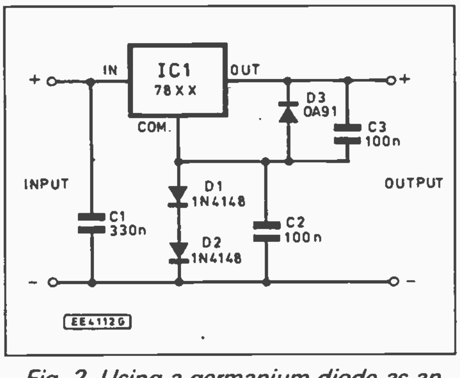




*Fig. 2. Using a germanium diode as an output "protection" device.*

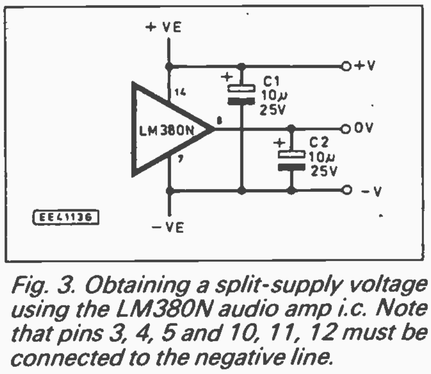



*Fig. 3. Obtaining a split-supply voltage using the LM380N audio amp i.c. Note that pins 3, 4, 5 and 10, 11, 12 must be connected to the negative line.*

Finally, ***Andrew Paul,*** a student from York, suggests that budding power supply designers should be wary of the large value electrolytic capacitors found in high-current low-voltage supplies. Andrew writes:

*"These capacitors are not charged to any great voltage but that doesn't mean that they don't contain a very large amount of charge. A short circuit across the terminals will release a very large amount of energy. Be particularly careful if you have a metal watch strap – I melted part of mine when it came into contact with a 68,000µF electrolytic!"*

## Bargraph ammeter display

***Eric Johnson*** writes from Worcester with some pertinent points regarding the LM3914-based bargraph ammeter described in February's *Surgery*. Eric writes:

*"I was interested in your L.E.D. Bargraph Ammeter in the February issue of* EPE *using the voltage dropped across the earth strap since I had built an ammeter with a meter display starting from that point. I have now built up the circuit to your design and I have the following comments:*

*1. It was necessary to change D4 to a 3V Zener and to increase resistor R7 to 1k to get sufficient drive to the LM3914.*

*2. VR1 gave far to coarse adjustment and I found it necessary to replace it with a 200 ohm potentiometer padded out with 2k2 resistors on each side.*

*3. Is it correct to describe TR1 and TR2 as a long-tailed pair since there is no common resistor "tail" in the source connections. TR2 is completely unaffected by the signal. The description misled me at first."*

The first two points noted by Mr Johnson may be extremely useful to anyone who is having problems with setting-up the ammeter circuit and, in particular, achieving a satisfactory full-scale indication.

Mr Johnson is perfectly correct on the third point – although the circuit configuration for TR1 and TR2 resembles the classic differential amplifier circuit, it should not be described as a long-tailed pair. Having searched through the recesses of my mind, I now recall that the reason for using this particular arrangement was simply to help reduce susceptibility to temperature induced variations in the input stage (the input voltage is only a few millivolts and the circuitry has to operate reliably over quite a wide temperature range).

## Testing mains transformers

***John Wyllie*** writes from the Irish Republic with an interesting query:

*"I have a large number of mains transformers with unknown secondary outputs. Voltage output is no problem but how can the maximum current be measured without causing damage? Also, by how much should this figure be reduced for continuous use?*

*I seem to develop a mental block (perhaps it's panic!) when it comes to transformers, so I would be grateful if you could find a few empty lines in your* EPE *pages to answer this."*

Thanks for bowling this one, John, but as you might expect the answer is not at all straightforward!

One method of estimating the rated secondary current for a transformer simply involves measuring the diameter of the secondary windings. Sadly, this technique can only be applied when the secondary windings are brought out to tags or when they form flying leads.

If this measurement can be performed, the following table can be used to estimate the maximum rated current:

| Wire diam. | Approx. gauge | | Fusing current | Max. rated current |
|---|---|---|---|---|
| (mm) | SWG | AWG | (A) | (A) |
| 0·2 | 35 | 32 | 5 | 0·33 |
| 0·32 | 30 | 28 | 9 | 0·9 |
| 0·56 | 24 | 23 | 17 | 2·5 |
| 0·71 | 22 | 21 | 25 | 3·5 |
| 1·25 | 18 | 16 | 45 | 12 |
| 1·6 | 16 | 14 | 70 | 22 |

Notes: 1. AWG = American Wire Gauge
2. SWG = Standard Wire Gauge (UK)
3. Maximum rated current is dependent upon permissible temperature rise. In the case of a transformer (where the wire is densely packed) the values given in the right-hand column should be de-rated by at least 50 per cent.

Even when operated within the maximum current ratings determined as above, a transformer may still fail to operate satisfactorily if it is driven beyond the onset of saturation. At this point, losses will increase rapidly and efficiency will fall.

Another rule-of-thumb technique for estimating the rating of a transformer involves comparing its size and weight with that of a known component of similar construction. For example, if a transformer has a known rating of, say 50VA, and it is slightly smaller and lighter than another (unknown) component which produces an off-load output of 12V, it would be reasonably safe to assume that the unknown transformer could happily supply a load current of up to 4A.

## Some (don't) like it hot!

Before moving on from this topic it is worth emphasising that power transformer ratings (as with all other components) are dependent on the temperature at which they operate. This point was once brought home to me when operating a very hefty home-built public address amplifier. This equipment used four high-power pentode valves in the output stage and produced an output of around 200W into a 100V line.

Due to limited funds, the mains and output transformer selected for this project were only barely adequate for the job. Despite this, the equipment ran reliably on my workbench during a lengthy "soak-test".

Unfortunately, when using the equipment for the first time (and in front of an audience of several hundred) the amplifier was subjected to a continuous ambient temperature of around 40 deg.C! When things started to go wrong, I found that both the mains and output transformers were running at excessive temperatures and, in order to keep the show running, I was forced to rapidly improvise an exceedingly risky cooling system.

Despite my efforts, both transformers later failed internally. This story very effectively demonstrated the fact that something that works well in the relatively gentle environment of the workshop may rapidly fail when subjected to "real-world" conditions.

## Aerial booster

Another reader from Ireland, ***Mark McGuinness,*** writes to ask for some assistance with the design of an aerial booster. Mark writes:

*"I have for some time been looking for a circuit for an aerial amplifier for use with a mono. radio receiver which I have at home. Could you publish a suitable design in* Circuit Surgery?"

Well, Mark, you have not given me an indication as to whether your receiver is used for VHF (f.m.) reception or for Medium/Long Wave (a.m.) reception so I will try to give you a circuit which will cover both (i.e. a "Wideband" Amplifier).

The complete circuit diagram of the Wideband Amplifier Aerial Booster is shown in Fig. 4. The single-stage unit provides ample gain over an extremely wide range (typically more than 15dB over the range 100kHz to 100MHz).

The circuit is based on a UHF transistor having a typical transition frequency of 2GHz (normal low-frequency and standard r.f. transistors will NOT operate in this circuit). The circuit will provide a reasonable match to a 75 ohm aerial source and a 75 ohm receiver input. In either case, coaxial feeder cable should be used.

The circuit operates from a low-current 9V d.c. supply (the prototype used a PP3 battery) and ideally should be laid out on a small printed circuit board with a generous copper ground (0V) plane. Matrix board can also be used provided signal leads are kept very short and several parallel-connected tracks are used to provide an effective ground connection at the input and output. Note that, whichever technique is used, ALL component leads must be kept VERY short if VHF performance is to be maintained.

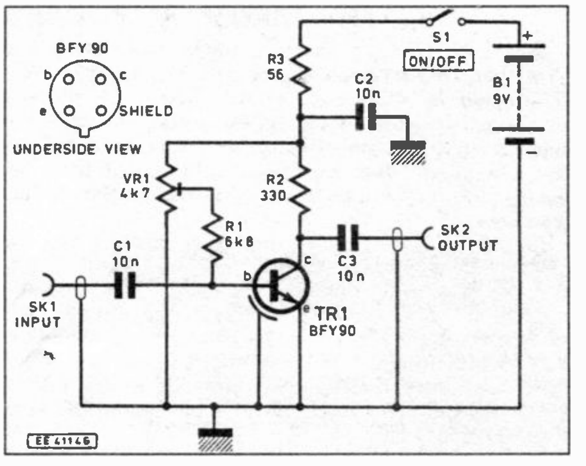
The transistor bias point is adjustable by means of preset VR1. This component should be set to the position at which maximum gain is obtained (simply adjust VR1 for a peak indication on a signal meter or bargraph tuning indicator).

One final point worth noting is that the circuit provides very considerable gain (particularly at low and medium frequencies) and this can sometimes result in overloading and cross-modulation when very strong signals are present at the input. In such cases, the setting of VR1 should be adjusted so that the gain is reduced to the point at which the symptoms disappear.

**Next Month:** In response to several requests from readers, we shall be describing means of boosting the output of a portable CD player for home and "in-car" use. In the meantime, if you have any comments or suggestions for inclusion in *Circuit Surgery*, please drop me a line at: Faculty of Technology, Brooklands College, Heath Road, Weybridge, Surrey, KT13 8TT.

Please note that I cannot undertake to reply to individual queries from readers however I will do my best to answer all questions from readers through the medium of this column.

*Fig. 4 (below). Circuit diagram for the Wideband Amplifier Aerial Booster.*

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R2 330
R3 56
All 0·25W 5% carbon film

See SHOP TALK Page

**Potentiometers**
VR1 47k miniature skeleton preset

**Capacitors**
C1, C2, C3 10n miniature ceramic

**Semiconductors**
TR1 BFY90 *npn* high frequency transistor

**Miscellaneous**
SK1, SK2 75 ohm coaxial socket (2 off)
B1 9V battery (PP3), with snap-on clips
S1 Miniature s.p.s.t. toggle or slide switch

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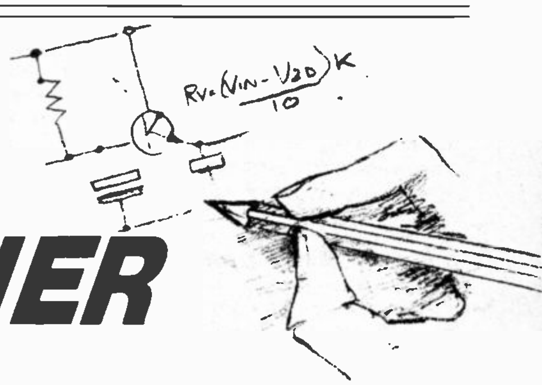
*Approx cost guidance only* **£9**




# JOINING THINGS TOGETHER

JOHN LINSLEY HOOD

**One of the problems for the newcomer is that articles in technical magazines tend to be written by experts, who fail to explain some of the simple things which can cause problems to the novice. One of the questions most often asked by readers is: "How do I join circuits, expecially audio designs, together?" Here, that renowned audiophile John Linsley Hood offers some advice.**

AN INEVITABLE problem in any kind of technical article is that the text is usually written by an expert, or at least someone with a good working knowledge of the subject, but the article is then read, and the hardware in question is put together, by enthusiasts of a rather lesser degree of expertise. This kind of situation isn't too trouble prone if the would-be constructor only wants to do what the author of the article describes.

However, in real life, the fun of electronics lies mostly in adapting ideas from various sources, and adding them together to make something different yet again. This kind of empire building may not be too difficult with logic circuitry where the d.c. power supply line for the hardware is just a low impedance +5V source, and the input and output signals are of a standard pulse height, but in analogue circuits things are much less cut and dried, and in audio circuitry, in particular, DIY activity can become a mine field.

I become aware of this problem from time to time when I get letters from readers who have seen a design of mine for, say, a tone control or filter layout, and want to put this on the input of an audio amplifier circuit from some different author; *"need to know how to do it – and would, ideally, like a ten word answer."* My heart sinks when I consider that, without knowing their exact circumstances, it might take a five page reply to cover all the possibilities – so, for all of you out there, I hope this gives a general reply.

The things which need to be sorted out, in order to do the job satisfactorily, can be divided into four groups: Supply line voltages; signal return (0V) line connections; signal output/input impedance matching; and interface d.c. and signal level voltages. Starting with the first of these catagories, the following may help to understand the problems involved in "joining things together".

## D.C. supply line voltages

It is becoming increasingly common for audio circuit designers to choose circuit layouts based on i.c. gain blocks, using devices like the LM833 or TL052 dual op.amps. which run, typically, from a pair of ±15V supply lines. It is also fairly common for the audio amp. to have a pair of split voltage supply lines, though usually in the range ±30V to ±55V. So it would seem, in principle, that all that is needed is to drop the voltage from the power amp. supply, and pinch the few milliamps needed by the filter circuit or whatever, from this.

With recent types of op.amp gain blocks, which have very good supply line ripple rejection; which can be up to 100,000:1 in terms of breakthrough from the supply line to the output signal line; a simple hook-up using a couple of Zener diodes, of the kind shown in Fig. 1a, will probably be quite adequate. As an alternative, if the input supply lines are not more than 35V, one could use a pair of "three terminal" voltage regulator i.c.s. These could be the popular 7815 and 7915 negative and positive line devices, as shown in Fig. 1b, and all ones problems would be solved. (Note, however, that these i.c.s have different pin connections, as shown in the drawing).

However, if the designer has chosen to use an input small-signal circuit based on separate transistors, capacitors and resistors – because some people believe that discrete component audio circuitry can sound a shade more "open" than comparable circuitry based on i.c.s – one must remember that such layouts may not be as good as an i.c. in terms of supply line rejection. In this case a simple Zener voltage dropper layout, like that in Fig. 1a, may not be good enough to stop "hum", audio signal residues on the power amp. supply line (which will probably be badly distorted if the output stage uses a push-pull output layout), and other unwanted supply line rubbish from breaking through into the signal channel.

This is a very tricky area for the constructor who hasn't got access to a distortion meter, since the circuit may appear to work to specification, but has, in fact, got a distortion figure about a hundred times worse than it should have had. The only safe answer, here, is to be very careful about the quality of the d.c. supply lines to such discrete component preamplifier stages.

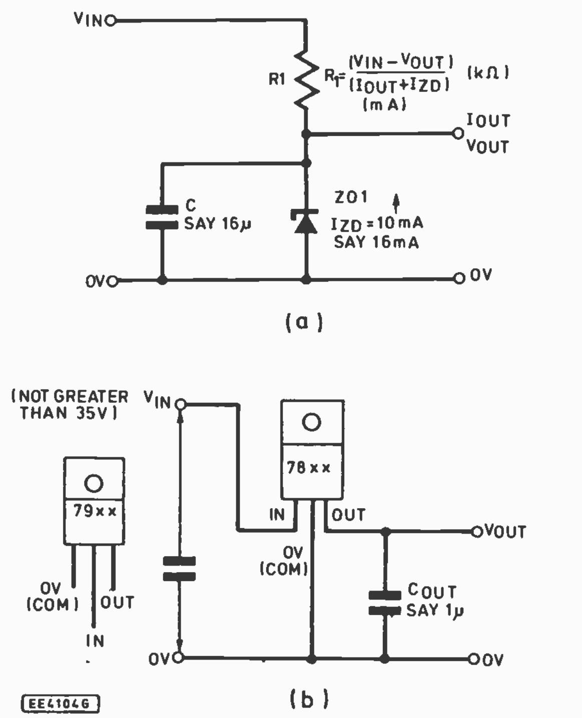



*Fig. 1(a). Simple Zener diode voltage dropper circuit diagram and (b) an i.c. regulator circuit. Note that the 78xx and 79xx series regulators have different pin connections.*

The skilled circuit designer wishing to use discrete component layouts can choose circuit arrangements which have got good rejection of supply line breakthrough, and can recognise those layouts which haven't – usually those in which the output signal circuit has a load resistor connected to one or other supply line – but, for those less certain of their design skills, the best answer is to make doubly sure of avoiding trouble by using a power supply system with a low output noise and rubbish content. Two improvements over the simple Zener/resistor circuit of Fig. 1a, are shown in Figs. 2a and Fig. 2b.

## Single-rail and dual-rail supply system

To use common supplies for input and output circuits is certainly practicable if both of them have either a single-rail or a dual-rail supply, or if the input circuit has a single-rail and the output has a dual-rail supply system. Though, in the latter case, there will almost certainly be a standing d.c. voltage on the signal output line, and some d.c. blocking capacitor must be included in the signal line.

Trying to power a dual-rail input stage from a single-rail output system is tricky, since most of the i.c. devices which will generate a negative output voltage when fed from a single positive supply line only provide a fairly small output current, and are often unsuitable for high gain audio systems because of breakthrough from their internal oscillator circuit. Dual-rail supplied circuitry can be rearranged to operate from a single supply, using the method shown in Fig. 3, but some care is needed to avoid big switch-on voltage surges.

## Signal return (0V) line interconnections

It is obvious that, if two or more units are to be connected in cascade, their "0V" signal return lines must be connected together. However, if one of these units is, say, an audio power amplifier, its own "0V" line will need to be taken, via a very *low* resistance path, to the "0V" point of the power supply.

This can lead to problems if the stages preceding the power amp. have a significant amount of gain (say five-times or more), and their inputs need to be "earthed" to the chassis. In this case, the usual answer is to insert a small resistance in the "0V" line, where the two units join, as shown in Fig. 4. Remember, though, that any input circuit supply line

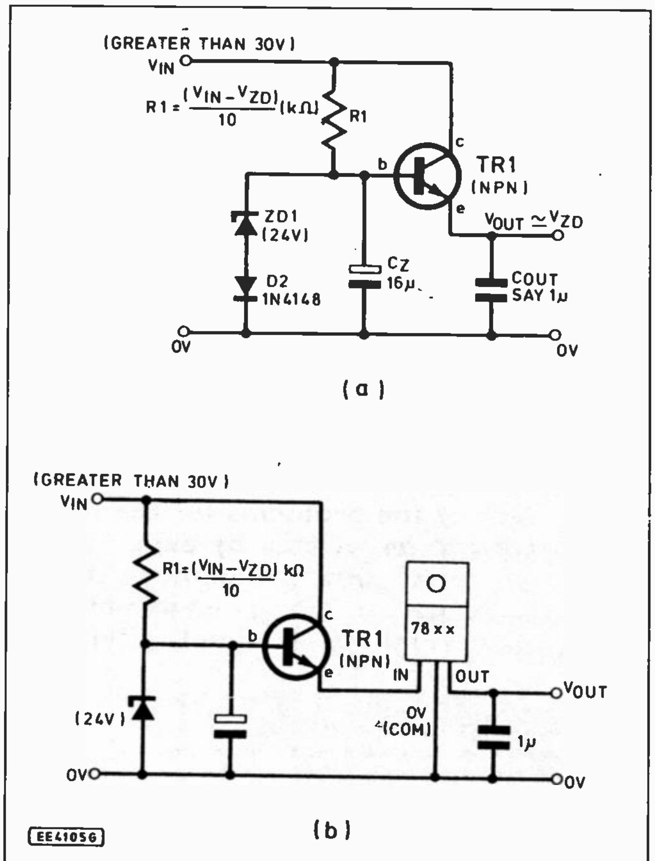



*Fig. 2(a). Transistor assisted Zener diode regulator circuit and (b) a transistor plus regulator voltage stabiliser circuit. For a –Ve supply use a pnp transistor and a –Ve (79xx) series regulator.*

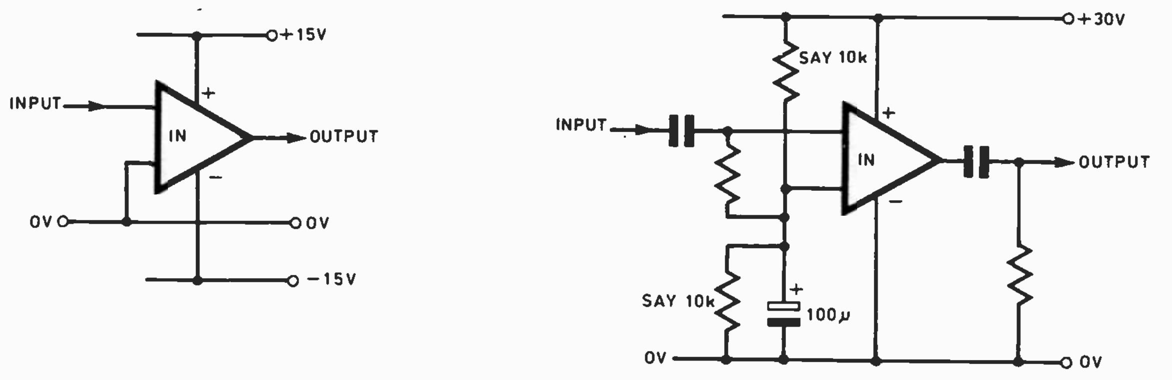



*Fig. 3. An amplifier supplied by a pair of d.c. lines can often be rearranged to operate from a single supply line.*

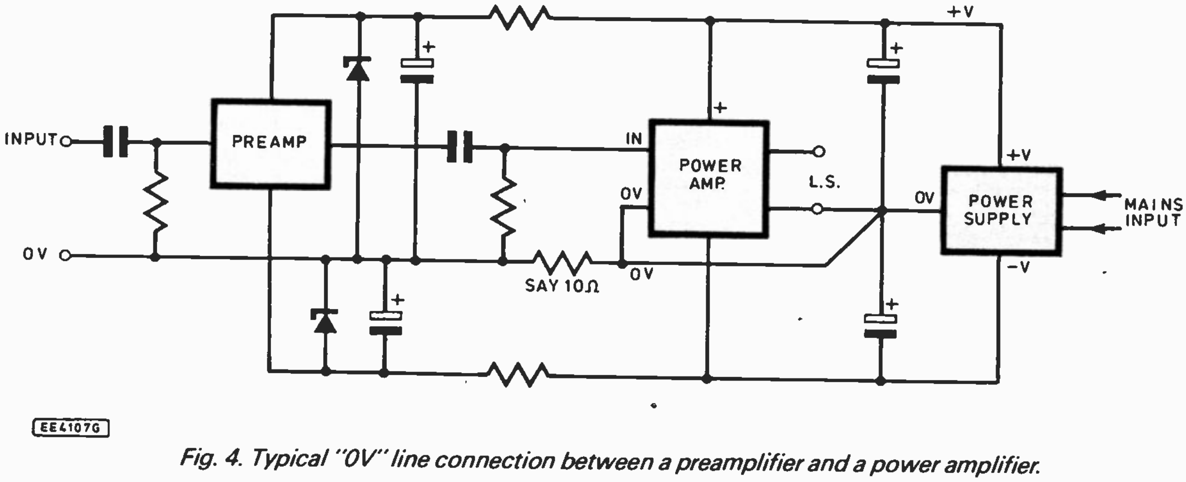



*Fig. 4. Typical "0V" line connection between a preamplifier and a power amplifier.*

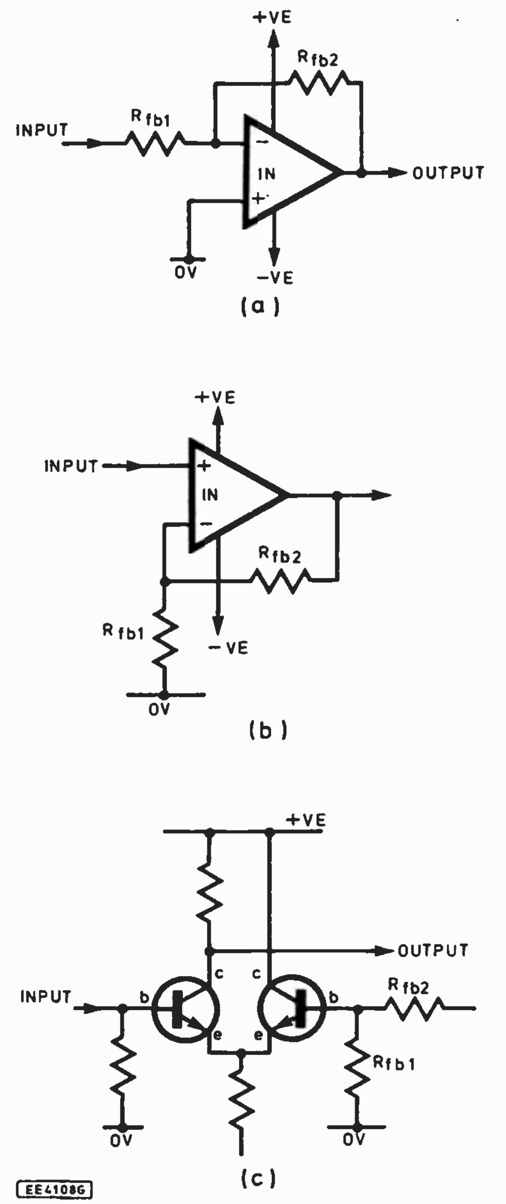



*Fig. 5. Typical stage gain determining negative feedback connections.*

decoupling capacitors must then be connected, as shown, to the input side of this "0V" line.

## Signal and d.c. output level considerations

Any audio circuit will have a maximum input signal level, beyond which it will overload, and cause signal clipping. If the designer hasn't specified what this signal level will be, it can be worked out, approximately, by taking note of the d.c. supply voltages fed to the output stage and the gain of the system. If, for example, the output stage is fed with a ±50V supply, the maximum possible peak-to-peak output voltage swing will be 100V, or $100/2\sqrt{2}$V (35.36V) r.m.s.

Being realistic, the practical output swing, on load, will probably be rather less than this – say 32V r.m.s. – and if the gain of the stage is 30×, then the maximum signal input, before overload, will be a bit over 1V r.m.s.

If the designer hasn't quoted the gain, and the amplifier circuit uses overall negative feedback, and most of them do, one can work out the gain, in the case of the circuit of Fig. 5a, by looking at the values of $R_{fb1}$ and $R_{fb2}$, from which the gain equation is $R_{fb2}/R_{fb1}$. In the circuits of Figs. 5b and 5c, which are

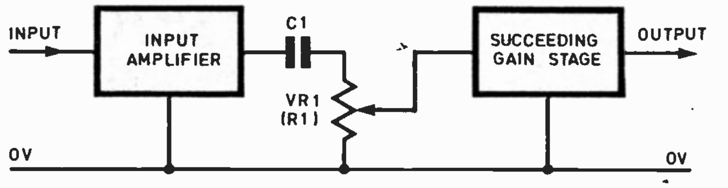



*Fig. 6. Inserting a gain control (VR1) between the input amplifier and succeeding gain stage.*

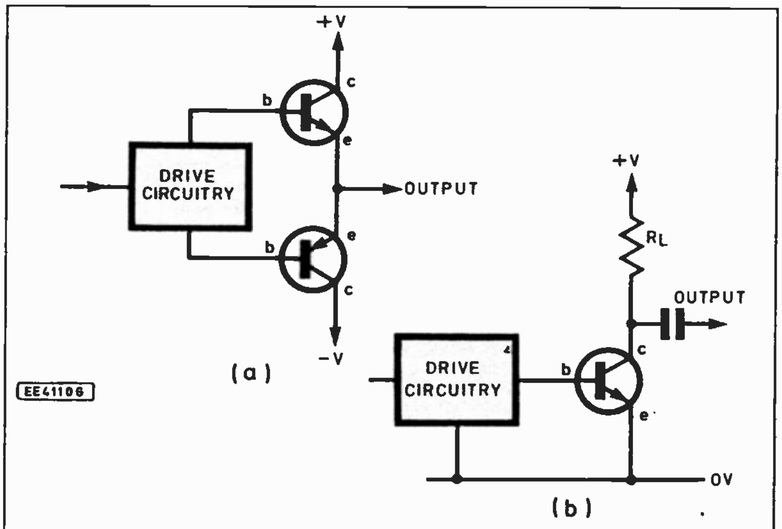



*Fig. 7(a). "Push-pull" and (b) "single-ended" output stage layout.*

the ones which are most commonly found in practice, the gain will be $(R_{fb1} + R_{fb2})/(R_{fb1})$.

If the preceding stage is likely to have an output which is larger than this, then it would be prudent to insert some kind of gain control, such as a preset potentiometer, (VR1), in the signal line, as shown in Fig. 6. The way of working out the best value to use for this "pot." is explained later.

## Interface d.c. level problems

Most electronic circuits will have an output which is composed of d.c. and a.c. voltages. If, as is nearly always the case in audio circuits, it is only the a.c. voltages which are required, and the d.c. output component is a nuisance, a d.c. blocking capacitor, such as C1 in Fig. 6, is usually inserted in the signal line.

This capacitor should be big enough in size to avoid any loss of low frequency audio signals, and the frequency at which the output voltage is reduced by 3dB, (0·707×), is given by the equation $f_o = 1/(2\pi \text{ C1 } R_{in})$, where $f_o$ is the roll-off frequency in Hz, and $R_{in}$ is the effective input resistance of the following stage. If the following stage has a fairly high input resistance, as would be the case, at l.f., with most op.amps and similar audio gain stages, one could assume, fairly safely, that the input resistance, $R_{in}$, will not be much different from R1.

It is not always sensible to choose a value for C1 which is a lot larger than would be needed to give a −3dB point at, say, 30Hz, (few loudspeaker units and almost no headphones will give a usable output below this frequency), since a needlessly large d.c. blocking "coupling" capacitor will make the switch-on "thumps" and d.c. level surges more of a nuisance. The working voltage of C1 must be, at least, equal to the value of the d.c. supply lines, even though there may be no actual d.c. voltage across it for most of the time.

The choice of value for R1, (or VR1), if the circuit designer hasn't already specified some resistance in this position, depends on the output resistance of the preceding stage and, ideally, the input resistance should always be a good bit larger than this. If the preceding stage uses a "push-pull" circuit layout, of the kind shown in Fig. 7a, then its output resistance will probably be fairly low – less than a few hundred ohms. If it is a "single-ended" layout, of the kind shown in Fig. 7b, then it is best to assume that the output resistance is the same as the value of $R_L$.

## Output to input impedance matching

In general, there is no difficulty in feeding a signal from a circuit with a low output impedance into a circuit with a high input impedance. The other way round can, however, lead to problems, due to loss of signal level, limitation of output voltage swing and possible input waveform distortion, so the interconnection of such mis-matched systems is best avoided. □

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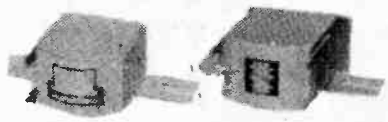

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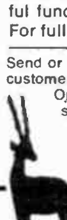

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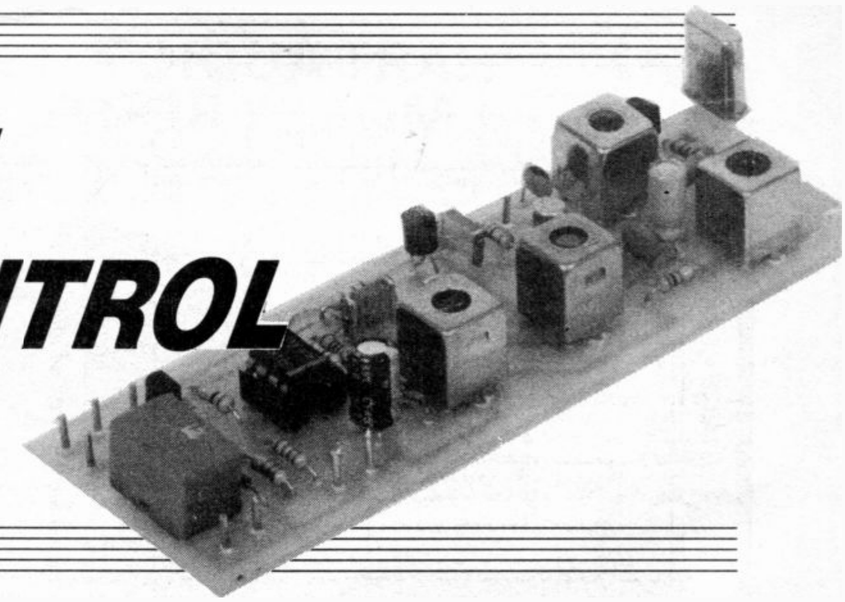
# SUPERHET RADIO CONTROL RECEIVER



ROBERT PENFOLD

*Improved operating range, up to 50 metres, and sensitivity is possible with the "superhet" receiver. No special test equipment needed for setting-up.*

A SIMPLE 27MHz radio control system was described in the February 1993 issue of *Everyday With Practical Electronics*. This system has very limited range due to the use of a rather basic receiver circuit of the t.r.f. (tuned radio frequency) variety.

The radio control receiver featured here can be used in place of the original receiver design in order to obtain a much greater range. It is a superheterodyne ("superhet") receiver which is more complex than the original design.

It is also slightly more difficult to set this receiver up properly for maximum sensitivity. However, it is still reasonably simple to build, and can be set up for optimum performance without the aid of any test equipment.

The maximum range that can be achieved depends on a number of factors, but reliable operation at up to about 50 metres is usually possible. Even if the system is only going to be used at short ranges indoors, the higher sensitivity is still an advantage.

Standing waves can produce "dead" spots where there is an inadequate signal level due to reflected signals cancelling out the direct signal. Higher sensitivity does not remove these "dead" spots, but it does render them so small as to be of no practical importance.

## SYSTEM OPERATION

No form of modulation is used at the transmitter, other than simple on/off keying of the carrier wave. The receiver must close a pair of relay contacts when the signal from the transmitter is present, and open the contacts when the signal is absent. Fig. 1 shows the block diagram for the Superhet Radio Control receiver.

A t.r.f. receiver provides all the radio frequency (r.f.) amplification at the transmission frequency, which in this case is a frequency of around 27MHz. A superhet receiver provides only a relatively small amount of gain at the transmission frequency.

Prior to detection, the incoming signal to the superhet is converted to a lower frequency, known as the intermediate frequency (i.f.). It is at the intermediate frequency that most of the radio frequency gain is obtained.

The main point of using this conversion process is that it is much easier to obtain high gain at the lower intermediate frequency. Also, good selectivity is much easier to achieve at a lower frequency.

The mixer produces sum and difference signals, and it is the latter which is required in this case. The oscillator stage operates 455kHz below the reception frequency. This obviously gives a difference between the input and oscillator frequencies of 455kHz, which is the intermediate frequency used here.

A single stage of amplification is used at the intermediate frequency. Two intermediate frequency amplifier stages are used in most superhet receivers, but for the present application a single stage seems to be better. The higher gain of two stages tends to give problems with spurious triggering.

Remember that this radio control system does not use any form of modulation, and

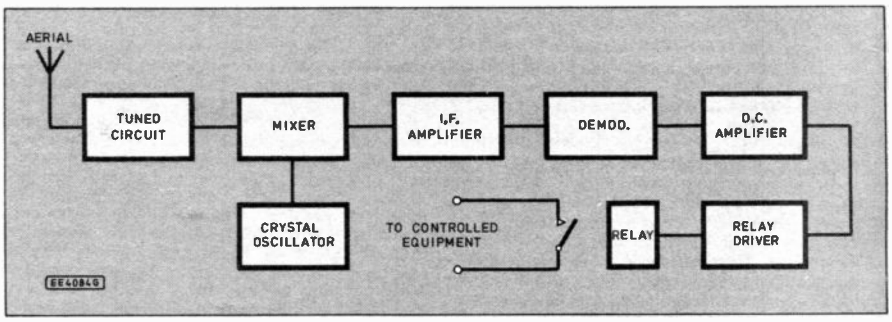



*Fig. 1. The Superhet Radio Control Receiver block diagram.*

## SELECTIVITY

The selectivity of a receiver is its ability to ignore strong signals on adjacent channels. Even though the 27MHz radio control band has a quite generous channel spacing of 50kHz, the selectivity of the t.r.f. set is wide enough for transmissions on adjacent channels to give occasional problems.

The superhet circuit has much higher sensitivity, but the selectivity is vastly better. Consequently, it is unlikely that adjacent channel interference will ever be a problem when using the superhet receiver.

The aerial signal is coupled to a tuned circuit which acts as an input filter. There is a slight problem with a superhet receiver in that it can pick up signals on a number of spurious responses. The input filter keeps the sensitivity on these responses down to an acceptable level.

The mixer and the oscillator provide the conversion to the intermediate frequency.

that any signal of adequate strength within the passband of the receiver (even just noise) will activate it. A single intermediate frequency amplifier gives adequate range for most simple radio control applications, and avoids problems with spurious operations of the receiver.

The rest of the receiver is very similar to the final stages of the t.r.f. design. A demodulator stage produces a positive d.c. output level that is roughly proportional to the strength of the received signal. This signal will usually be quite weak, but it is amplified by a d.c. amplifier to provide a more useful signal level.

The next stage is a simple relay driver circuit. Under standby conditions the output level from the d.c. amplifier is insufficient to activate this stage, but in the presence of a reasonably strong signal from the transmitter the relay will be switched on. A pair of normally open relay contacts are used to control the model, camera, etc.

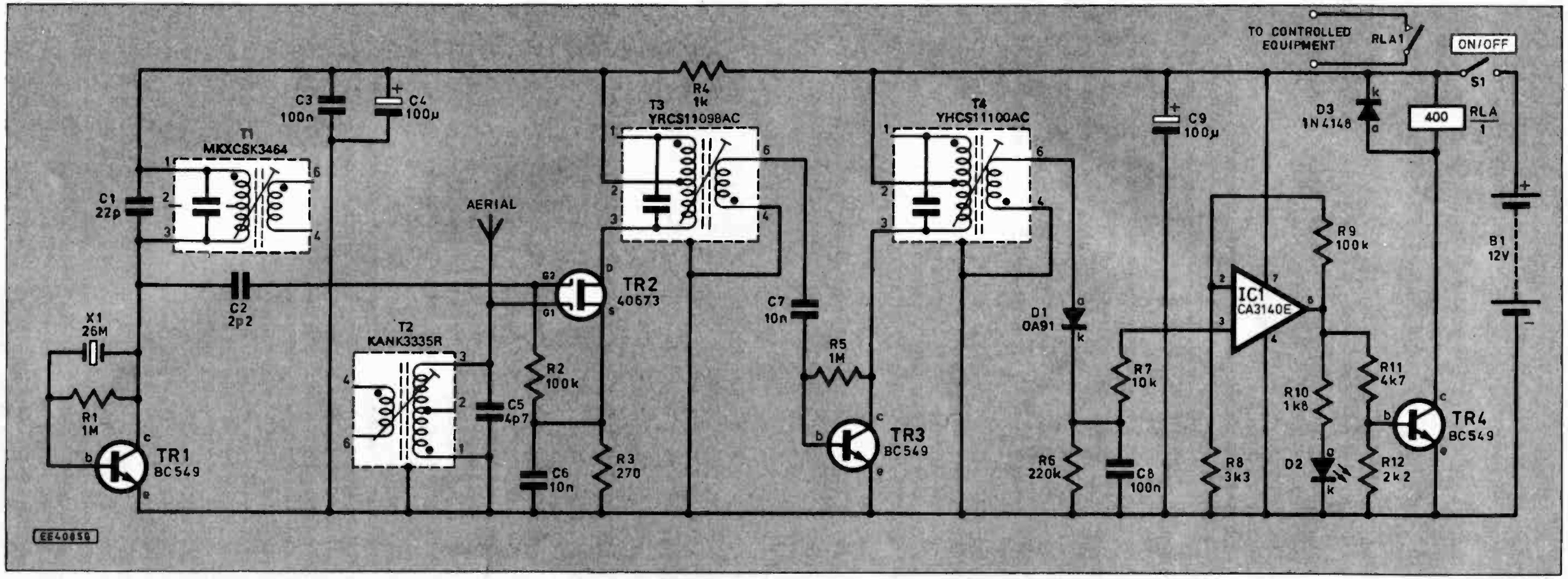



Fig. 2. Complete circuit diagram for the Superhet Radio Control Receiver. The black spots indicate the start of the transformer coil windings.

## CIRCUIT OPERATION

The full circuit diagram for the Superhet Radio Control Receiver is shown in Fig. 2. Transistor TR1 is used in the crystal oscillator stage, which is of conventional design. The oscillator transformer T1 has an integral tuning capacitor, but results seem to be better if an external capacitor (C1) is added in parallel with this. Adjustment of T1 is then far less critical, and a much "cleaner" oscillator signal is produced.

The crystal, X1, must be matched to the crystal in the receiver. Radio control crystals are normally sold in matched pairs, and it is the lower frequency crystal (26·54MHz to 26·79MHz) that is used in the receiver. The higher frequency crystal (26·995MHz to 27·215MHz) is used in the transmitter circuit.

The system might actually work if the crystals are swapped over, but the system would be illegal as it would not be operating within the authorised band. There are six channels, and this receiver will function correctly using a crystal for any of these.

The mixer stage is based on transistor TR2 which is a dual gate MOSFET. The aerial transformer T2 and capacitor C5 form the input tuned circuit, which is direct coupled to the gate 1 terminal of TR2. The input capacitance of TR2 also acts as part of the tuning capacitance, and it probably provides most of the tuning capacitance.

There is a low impedance winding on T2 which would normally be used as the aerial coupling winding. In this case the aerial will be quite short, and better results are therefore obtained if it is coupled *direct* to the tuned circuit.

Capacitor C2 couples the oscillator signal to the gate 2 terminal of TR2. The varying gate 2 voltage produces variations in gain from the gate 1 terminal to the output at TR2's drain. These gain variations give the required mixing effect, and produce the 455kHz difference signal across the primary winding of T3, the first i.f. transformer.

The output from T3's low impedance secondary winding is coupled to the base of transistor TR3 via capacitor C7. TR3 operates as a common emitter amplifier, and it provides much of the receiver's gain. The second i.f. transformer T4, provides an efficient coupling from the output of TR3 to the detector stage. The detector is a simple diode type based on D1. Due to its lower forward voltage drop a *germanium* diode is preferable in this application.

The d.c. amplifier is a non-inverting mode circuit based on operational amplifier IC1. The CA3140E i.c. used for IC1 is a type which can operate properly as a single supply d.c. amplifier. Note that most other operational amplifiers (uA741C, LF351N, etc.) will not work properly in this circuit.

Resistors R8 and R9 set the voltage gain of the amplifier at approximately 30 times. Higher gain and increased range can be obtained by making R8 lower in value.

Making R8 much lower than the specified value of 3k3 will result in noise holding the receiver in the "on" state. However, if the best possible operating range is important, it is worth experimenting with different values in order to find the optimum value for R8.

Diode D2 is a l.e.d. which acts as a very basic signal strength indicator. This is very helpful when the receiver is being set up ready for use, but it is of no great value thereafter. It is advisable to remove this component once the receiver has been aligned, as otherwise it will unnecessarily increase the drain on the battery.

Transistor TR4 is the relay driver, and this is a simple common emitter switch. D3 is the protection diode which suppresses any high voltage spikes produced across the relay coil as it is switched off.

## POWER LINES

Power is provided by eight HP7 size cells in a plastic holder. A 12V supply is used because the relay cannot be guaranteed to work reliably from a 9V supply.

However, in reality the relay (and the rest of the circuit) will almost certainly work perfectly well from a 9V supply. If possible it is best to use a 9V supply as this saves the weight and cost of two batteries.

Also, the current consumption will be reduced somewhat, which means that six batteries will actually give a longer life than eight batteries! Using a 12V supply the standby current consumption is about 10 milliamps, but the current drain is more than three times this figure when the relay is switched on.

## COMPONENTS

**Resistors**

| | |
|---|---|
| R1, R5 | 1M (2 off) |
| R2, R9 | 100k (2 off) |
| R3 | 270 |
| R4 | 1k |
| R6 | 220k |
| R7 | 10k |
| R8 | 3k3 |
| R10 | 1k8 |
| R11 | 4k7 |
| R12 | 2k2 |

All 0·25W 5% carbon film

See SHOP TALK Page

**Capacitors**

| | |
|---|---|
| C1 | 22p ceramic plate |
| C2 | 2p2 ceramic plate |
| C3 | 100n disc ceramic |
| C4, C9 | 100µ radial elect., 10V (2 off) |
| C5 | 4p7 ceramic plate |
| C6, C7 | 10n polyester (2 off) |
| C8 | 100n polyester |

**Semiconductors**

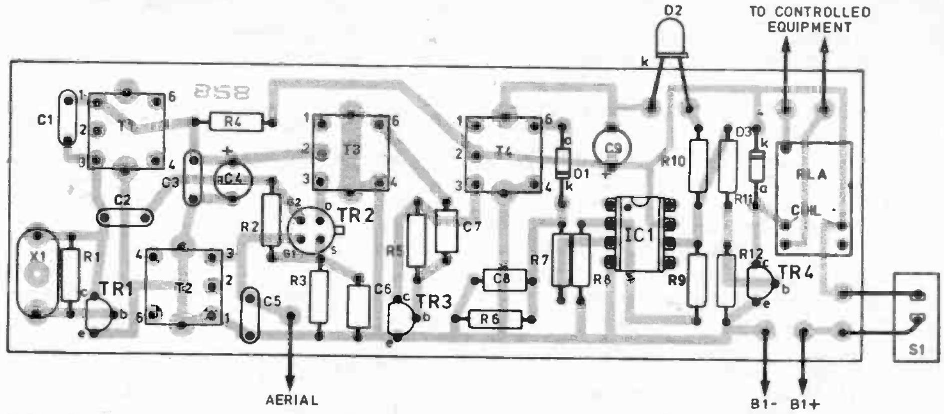
| | |
|---|---|
| D1 | OA91 germanium signal diode |
| D2 | Red l.e.d. (see text) |
| D3 | 1N4148 silicon signal diode |
| TR1, TR3, TR4 | BC549 *npn* silicon transistor (3 off) |
| TR2 | 40673 or MFE201 dual gate MOSFET |
| IC1 | CA3140E PMOS op. amp |

**Miscellaneous**

| | |
|---|---|
| T1 | Toko MKXCSK3464 |
| T2 | Toko KANK3335R |
| T3 | Toko YRCS11098AC |
| T4 | Toko YHCS11100AC |
| X1 | 26MHz HC-25U RC crystal (see text) |
| RLA | 12V, 400 ohms coil, miniature p.c.b. mounting relay, with 2A (resistive), 1A (a.c. inductive), s.p.d.t. contacts |
| S1 | s.p.s.t. miniature toggle |
| B1 | 12V battery pack (eight HP7 size cells in holder) |

Printed circuit board available from *EPE PCB Service*, code 828; plastic case (see text); aerial (see text); HC-25U printed circuit mounting crystal holder; battery connector (PP3 type); wire; solder; etc.

*Approx cost guidance only* **£22** *excluding Batts.*



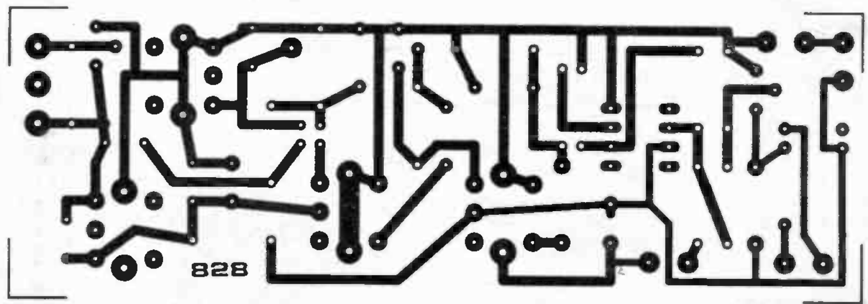
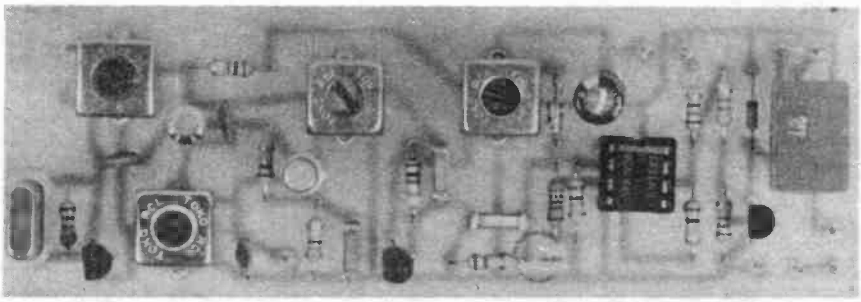




*Fig. 3. Printed circuit board component layout and full size copper foil master pattern. As the metal "can" of transformer T4 completes the battery negative line (B1 –) connection, extra care should be taken to ensure that the mounting lugs are securely soldered to the board. The completed circuit board is shown in the photograph below.*



## CONSTRUCTION

Details of the printed circuit board component layout and underside copper foil master pattern are provided in Fig.3. This board is available through the *EPE PCB Service*, code 828. Construction of the board is reasonably straightforward, but due to the use of several unusual components there are several points which are worthy of note.

Crystal X1 might have ordinary leadout wires, and if so it can be soldered direct to the board. Each soldered joint should be completed as quickly as possible to avoid internal damage to the crystal or its mounting.

It is more likely that the crystal will have pins rather than leads. A crystal of this type can be soldered direct to a printed circuit board, or mounted via solder-pins.

Fitting a printed circuit mounting HC-25U socket on the board and then plugging the crystal into this is a much neater solution. It also makes it much easier to change the crystal if you need to move the system to a different channel. However, if the receiver is likely to be subjected to a lot of vibration it is probably best to mount a pair of solder-pins on the board, and then carefully solder the crystal onto these.

The four r.f. transformers (T1 to T4) each have five pins plus two mounting lugs. All five pins and both lugs should be soldered to the board, and plenty of solder should be used when connecting the two lugs. This will securely fix the transformers to the board.

The dual gate MOSFET TR2 is a static sensitive device, but it has built-in static protection circuits which render any special handling precautions unnecessary. It should be connected using a soldering iron having an "earthed" bit though. Dual gate MOSFETs seem to be less easily obtained than they were a few years ago. Many of those that are available are of the surface-mount variety, and cannot easily be used with this printed circuit design. The 40673, MFE201, and 3N201 are all suitable for use in this design, as are any similar types which have ordinary leadout wires.

## OPERATIONAL AMPLIFIER

IC1 is also static-sensitive, and it should therefore be mounted in a holder. It should not be fitted into its holder until the receiver is finished in all other respects. Until then it should be left in its anti-static packaging, and it should be handled as little as possible when it is being fitted into the holder.

Diode D1 is a germanium type, and it is more vulnerable to heat damage than the more familiar silicon types. It is not essential to use a heatshunt when connecting this component, but each soldered joint must be completed quickly so that it does not have a chance to become excessively hot.

The board has been designed to take the specified relay, which is a very small type. From the electrical point of view, any 12V relay which has a coil resistance of about 300 ohms or more should be suitable.

There is little chance of being able to fit other relays into the available space on the board, and they would be unlikely to have the same pinout arrangement as the specified component. Therefore, it is advisable to use the specified relay unless there is genuinely a compelling reason for using an alternative type.

If it should be necessary to use an alternative relay, it will almost certainly have to be mounted off-board and then hard wired to the printed circuit board. The contacts of the specified relay are rated 2A for resistive loads, or 1A for a.c. inductive loads. The maximum voltage ratings are 24V d.c. and 120V a.c.

No attempt has been made to reduce the printed circuit board to the smallest possible size. It is still quite small though, and the capacitors must all be miniature printed circuit mounting types if they are to fit into the available space. The three polyester capacitors (C6 to C8) should have 7·5 millimetre (0·3 inch) lead spacing.

## IN CASE

If the unit is used as a camera trigger or some similar application, it must be fitted in a medium sized plastic case. When choosing the case remember that it must be large enough to accommodate the relatively large battery pack.

Probably most users will fit the receiver into a model of some kind. A case is then unnecessary, although if the unit is fitted in a model boat it might be as well to use a plastic case to shield the board from water splashes.

## AERIAL

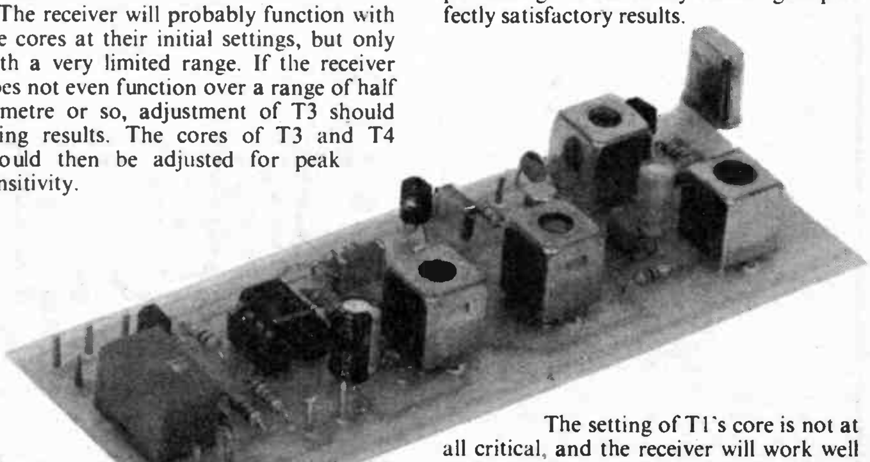
The aerial can be any telescopic type, having an extended length of about 0·6m to one metre, or any piece of wire that is about 0·6 to one metre long. Aerials about one metre long give somewhat better sensitivity than short types. The receiver will operate using an aerial of less than 0·6 metres in length, but a short aerial is almost certain to significantly reduce the maximum operating range of the system.

Note that the aerial must not be allowed to come into electrical contact with anything other than the input terminal of the receiver board. It should not be allowed to come into contact with the metal chassis of a model car for instance. Also, it is no good having the aerial within the metal bodywork of a model. The metalwork would screen the aerial from the transmitter's signal.

## ADJUSTMENT

The cores of T1 to T4 must be given suitable settings before the receiver will work properly. Only use proper trimming tools when adjusting these components. Using a small screwdriver can damage the brittle ferrites cores. The slotted cores of T1 and T2 are particularly vulnerable to damage from a wedge shaped screwdriver blade.

The receiver will probably function with the cores at their initial settings, but only with a very limited range. If the receiver does not even function over a range of half a metre or so, adjustment of T3 should bring results. The cores of T3 and T4 should then be adjusted for peak sensitivity.



In the absence of any test equipment to aid with the alignment of the receiver, the best way of going about this task is to use the transmitter as the signal source, and D2 as a tuning indicator. It is more than a little helpful to have an assistant to operate the transmitter.

With the transmitter permanently switched on, move it away from the receiver until the l.e.d. D2 is just barely glowing. Then adjust the cores of T3 and T4 for maximum brightness from D2.

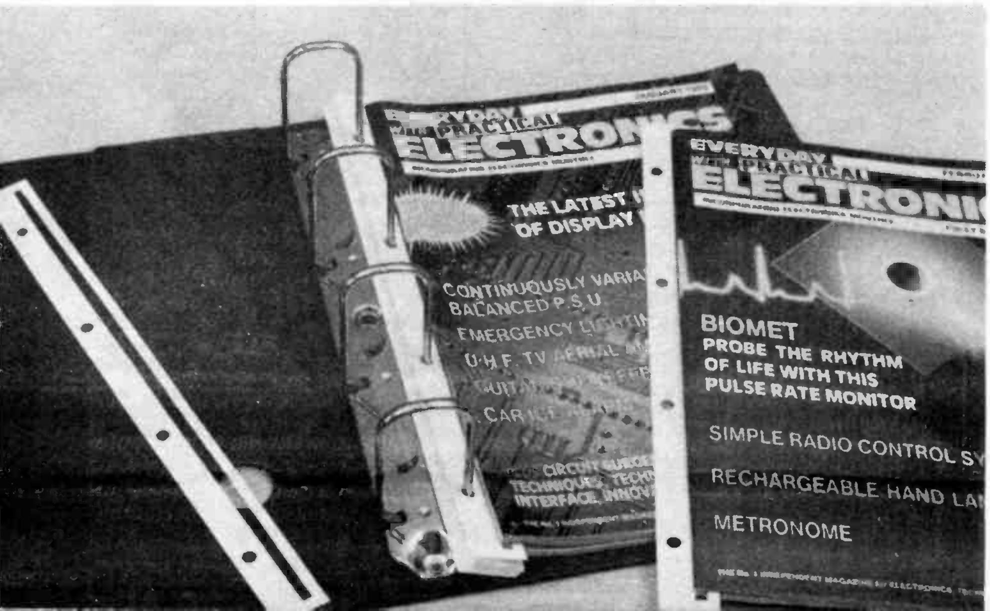
Next move the transmitter further away from the receiver until D2 is quite dim again, and then readjust the cores of T3 and T4 for optimum brightness from D2 once again. Repeat this process until no further improvement in sensitivity can be obtained.

Much the same process is used to find the optimum setting for T2's core. The bandwidth of the input filter is quite wide, especially if a fairly long aerial is used. The peak setting is much less well defined than that of T3 or T4, but any setting that provides good sensitivity should give perfectly satisfactory results.

The setting of T1's core is not at all critical, and the receiver will work well with virtually any setting. It is possible that at some settings the oscillator will fail to operate, or that it will be unreliable. If the set will not work at all, or it only operates intermittently, try unscrewing the core of T1 slightly.

You may like to try various settings for T1 in order to find one that gives optimum sensitivity, but adjustment of this component is unlikely to have much effect on results. Also, a setting that gives slightly improved sensitivity is also likely to give poor reliability. This type of oscillator normally has to be set for something less than maximum output in order to obtain reliable starting. □






# New Technology Update

*Ian Poole reports on techniques for improving Liquid Crystal Display design.*

LIQUID crystal displays are now firmly established in the electronics scene. Since they first appeared in the 1970s their use has grown very rapidly. Offering advantages of flexibility and low current consumption over the l.e.d. displays used in watches and calculators of the time, their use has spread to virtually every corner of electronics.

Now vastly more complicated displays are used in lap-top computers and many people expect that they will eventually replace the ageing cathode ray tube for use in televisions. However before this can happen a considerable amount of development still needs to be done. But in the mean time many interesting and innovative developments continue to appear, enabling liquid crystal technology to be used in even more applications.

## Liquid Crystal Basics

The way in which a liquid crystal display (l.c.d.) works is quite simple, although manufacturing them requires extremely clean conditions if they are to work correctly. Unlike many other displays including the c.r.t. and the l.e.d.., liquid crystal displays do not emit light. Instead they are seen by the light that falls on them.

Although there are two types of l.c.d., the most usual type is called a twisted nematic display. A typical display is shown in Fig. 1, and it can be seen that it contains two plates of glass. These are held apart an exact distance by a spacer around the edge. The gap which is left between the glass plates is then filled with the liquid crystal.

Layers of polarising material are placed behind the display and also in front of it. These are set so that their polarisations are at 90 degrees to one another. In addition to this there is a reflecting layer behind the back of the display. In this state the display would appear dark because any light entering the display, or reflected off the back of it would be blocked by the cross polarised films.

## Light Rotation

However the liquid crystal actually rotates the polarisation of the light. The amount of rotation depends on the thickness, and in most cases about 10μm gives the required 90 degrees rotation. This rotation means that the light will have the correct polarisation to pass through each of the cross polarised films and the display will appear light.

When a voltage is applied across the liquid crystal, it ceases to rotate the polarisation of the light. When this happens the affected area of the display turns dark.

In order to enable shapes to be displayed, transparent conductors are set down on the inside surfaces of the glass. By activating the different sets of conductors, it is possible to create a large number of shapes.

The liquid crystal is an insulator so the display consumes virtually no current making it ideal for low power applications. Unfortunately like all good ideas there are some drawbacks. The main one is that if a direct voltage is applied to the display for even a short length of time it will fail to operate. To overcome this an alternating voltage must be applied. Once this is done the display becomes trouble free.

The other main problem is that the displays are not as inherently robust as l.e.d.s for example. In view of this they have to be constructed in a very robust manner. As very few displays fail nowadays, manufacturers seem to have been very successful in achieving this.

## New Developments

Development of the l.c.d. has come a long way since the first ones were used in calculators and watches. Now they are even being used as quite large screens in lap-top computers. Here the display consists of colossal numbers of individual elements across the whole screen so that the various characters can be made up.

With this sort of display the main problem is the enormous number of pixels which are required, and the large amount of drive circuitry needed. In view of the interconnection problems, most of this circuitry is contained within the display itself.

Despite the enormous complications this causes, progress is being made very fast. In 1990 for example, one manufacturer had developed a display with a resolution of 640 × 400 pixels for a notebook computer. Now displays are available having resolutions of 1280 × 1024 pixels. To achieve this over four million transistors are required in the drive circuitry to drive the 1.3 million pixels.

In order to place all the required transistors onto the substrate, thin film transistor technology is often used. However this is not easy because of the complexity of putting down this number of transistors onto the substrate with all the associated interconnecting tracks.

One of the major problems encountered is the low yields which can be obtained when the displays are in production. It is not uncommon for yields as low as 10 per cent to be achieved initially. Naturally this has to increase if the product is to become economically viable and eventually most products of this nature will be able to achieve 80 to 90 per cent when they are established.

To achieve this high yield is not at all easy. Usually one of the keys is found in improving the cleanliness as it has been found that the cause of more than 50 per cent of defects is dust particles. This stresses the importance which must be placed in ensuring that the whole production process is maintained to the highest standards of cleanliness.

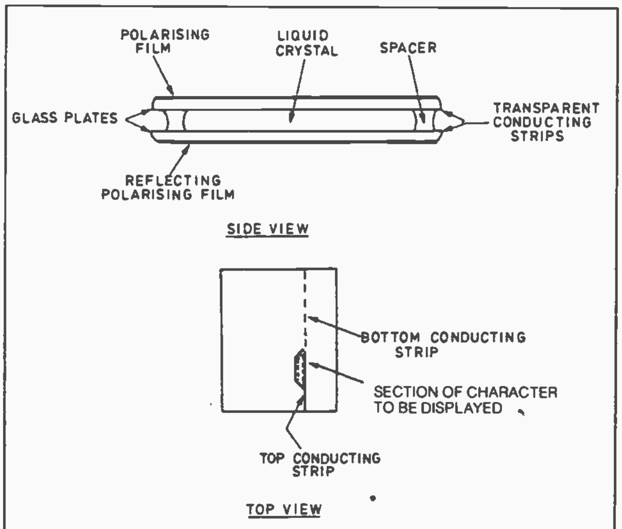



*Fig. 1. The construction of a typical liquid crystal display.*

## Image Retention

A new type of l.c.d. which can retain its image has recently been developed. This new type of display does not need a glass substrate unlike those currently in use.

Instead of the more normal mode of operation this display uses a change in the amount of reflection from the back surface. By doing this the costly glass substrates are no longer needed and much cheaper plastic ones can be used instead.

The new display has been produced by adding a polymer into the liquid crystal. This introduces defects into the crystal's structure giving a greater degree of stability because the crystal structure is split into more domains. In view of this it is found that the image remains in place until the next data is written to the display. In fact data remains displayed even when the supply is removed.

## An Unusual Use

Polymers have provided the key to another development which has lead to a very useful, if rather unusual, application for liquid crystals. In this application they are used to produce an image on a film.

As reported in the *GEC Journal of Research* flexible plastic sheets have been coated with a thin layer of a specialised liquid crystal polymer. This is initialised to give an opaque texture which scatters light.

Images can then be written onto this film using a low cost semiconductor laser. Areas scanned by the laser undergo localised heating which is followed by rapid cooling. This causes a change in the optical properties of the liquid crystal so that an image can be seen.

As the liquid crystals are bound to the polymer chains, any information written onto the film remains intact. However it is possible to add further detail if required at a later date, or if necessary, the sheet can be re-initialised making it available for re-use.

Using this technique it has been possible to achieve a very high degree of resolution. Lines only 5μm wide have been successfully produced. In addition to this shades of grey can also be produced making it possible to store pictures.

This development is of particular interest for reproducing material from computers in a convenient and manageable way. As the lasers have to be controlled by computer, the production of the images from computer aided design (CAD) packages presents comparatively few problems. In fact the new technology appears to lend itself very well to use with microfiches. The originals can be produced by the computer without the use of messy toners or developers previously needed. Updates can also be made very easily because of the way in which the films can be over-written or re-used.

## The Future

Whilst liquid crystal technology will undoubtedly find uses in many new and unusual fields the main spotlight is on its use as a replacement for the c.r.t.. In some areas of development the l.c.d. is now sufficiently well advanced. Colour l.c.d.s have been produced and they can offer sufficient resolution.

However there are two areas where there are problems which still need to be solved. The first is the refresh rate. As any user of a calculator with an l.c.d. will know they respond fairly slowly. Newly developed displays can offer a refresh rate of around 15Hz, but this is still not sufficient for a television.

The other problem is the cost. Currently the cost is several times that of an equivalent c.r.t. Whilst this price difference remains there is little chance of them being used in all but the most specialised of televisions. Unfortunately prices are likely to remain high for some time. Despite this, work is still progressing very fast and possibly by the turn of the century the first full size l.c.d. televisions may be available.

# READOUT

### FACETIOUS

Dear Ed.,

I had long contemplated writing a letter to your readers column but quite inadvertently the other day I picked up the wrong end of a soldering iron and now have my hand swathed in bandages. Ever resourceful and never daunted I resorted to the use of a cassette tape recorder. If you find the large gaps of silence on this tape somewhat irritating be patient and bear with me. These interruptions are due to the main fuses constantly blowing despite my ever increasing the thickness of the fuse wires.

My letter reads –

I shall be quite disappointed if *Everyday Electronics* takes over where *Practical Electronics* left off. Prior to *Everyday Electronics* union with *Practical Electronics*, I cancelled after many years my order for the latter as it became too technical and often featured projects costing more to make than one can buy at most electronic stores at a fraction of the cost.

My old copies of EE tell me that I have been with you for over twenty years now and have gained knowledge in consequence and technical skill and ability because of it. Similar mags have come and gone and they too have left their mark notably with their "Whoops" column resulting in unworking, half completed, drawer filling projects.

My remedy was to wait several months before deciding to make these projects and before ordering these often hard to get components and to see if there were any omissions or additions, etc. Satisfied there were none, correspondence would then ensue with the mail order firms and back would come some of the answers – Out of Stock, Part Order, Awaiting New Deliveries, Substituted quite unrelated components (some far bigger than the p.c.b. itself). Unmarked i.c.s, resistors, capacitors wrong valued, polarised for non-pole, etc., etc. all great fun but at a cost.

My three recent successful projects, *Sea Shell Synthesiser* being the latest, are all working fine and I have great pleasure in watching the birds flying and perching on and around the *Pest Scarer* watched closely by my neighbour's two cats. I have now become addicted to Qwells for sea sickness too. The Dream Machine is working very well indeed but it does keep me awake at nights with its white noise and as regards the Mind Entrainment project, well I cannot concentrate very well because of its flashing l.e.d.s.

My doctor has now prescribed a short course of Valium but I think he did so out of umbridge because when he left my flat he received a shock when he touched the light dimmer switch. By the time you receive this somewhat doleful missive I shall have been evicted in all probability.

The Morse Code Practice Key has blanked out half the televisions in the area and my Electronic Barking Dog Alarm has caused the R.S.P.C.A. to take me to court for animal cruelty. My Infra-Red Remote Control project is working too well, Ha! Ha! but it's great fun in the middle of the night watching my pyjama clad neighbours running in the roadway switching off their car alarms and searching for the intruders. Could it be that I have a cold solder joint somehow?

Seriously, though, do you think that I should abandon electronics and take up another hobby – after all I am now sixty-six years old and my sight isn't as good as it was when I made my first crystal set. But before the men in white coats come to take me away I have three questions to ask –

1. What does DIN in DIN plug mean?
2. How does one find out the amperage output for a transformer connected to nothing?
3. How can I improve my memory to remember what the fourth question was.

I wasn't as bad as this – I think things began to happen when I assembled my first computer and Black Watch – Sinclair I mean, not the Scots regiment. Oh! Well! I must sign off now – someone is pushing my door bell – I hope I have connected it correctly to the mains. Ah! Yes! the fourth question was, is the green and yellow cable the live one – it is isn't it?

But before I finally sign off I must mention the successful Dog Scarer that I assembled. I made a present of this to my friendly postman last Christmas. He thanked me profusely for the gift and as he walked down my garden path I heard him muttering "I'll show them vicious dogs I'll show 'em".

We have a different postman now. Our usual chap had to retire after being bitten by two vicious dogs. I'd forgotten at the time to mention that it required a 9V battery. I must hastily sign off now. There *is* someone at the front door – I just heard them scream.

I do apologise for that interruption, the main fuses have blown again. Ah! Well! as I said I must sign off.

*Larry Rudd*
Birmingham

P.S. I don't mind what people say about me as long as they spell my name right. But, facetiousness apart, I really enjoy my monthly edition of *Everday with Practical Electronics*. I wouldn't be without it. Over and out!

*This letter arrived in the editorial office on tape – with brilliant timing and delivery – it gave us all a smile at the end of a particularly harrowing week when someone planted a fire bomb in our building, thankfully the bomb was discovered before it went off and defused by the bomb squad. So thank you Mr. Rudd for cheering us all up.*

*To answer your questions:*

*1. DIN stands for Deutsche Industrie Normal*
*2. See this month's* Circuit Surgery
*3. Try the Entrainment unit?*

*By the way, if you are still with us, the Green and Yellow is the Earth – the Brown is the live lead (just in case anyone is not sure). Let's hope your visitor survived. – Ed.*

### HAZARD

Dear Ed.,

Although I am now working in artificial intelligence (AI) research, my early professional engineering career was spent in the design, testing and commissioning of electrical installations. I have inspected every type of electrical installation, from the small domestic to industrial sites – including complex control systems and computer equipment.

I was therefore interested to read Terry Pinnell's account in the April issue's *Home Base* feature, of how he managed to save himself money by tracing a cable insulation fault himself. Despite a mix-up in the reproduced wiring diagram of Fig. 1., Terry's approach is both logical and sensible. However, I would discourage non-professionals from attempting to deal with electrical problems of this kind.

Earth leakage faults are a potential fire hazard, and there are insurance implications for the DIY electrician. Wiring insulation tests made with an ordinary multimeter are unreliable, and the electricity supply *must always* be switched off at the mains – removing the local circuit fuse cannot be relied upon.

I have detected many serious and dangerous earth leakage and similar faults in my time – even in work carried out by fully qualified electricians employed by the largest UK electrical contractors. Never take chances with domestic wiring faults!

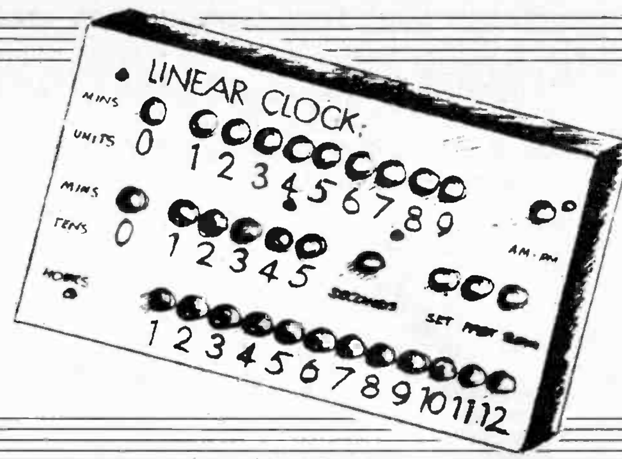
Your comments on page 252 of the same issue – concerning the fitting of 13 amp plugs on all domestic appliances by the manufacturers – are interesting. Customers-fitted 13 amp plugs have always been a source of danger, greater even than most electrical installation faults. I would expect that appliance manufacturers would be made responsible for the *initial* fitting of a correctly-rated fuse.

However, fuses and circuit breakers are installed to protect cables and flexible cords – not the domestic appliances and fittings themselves. Therefore, I expect that manufacturers may upgrade the rating of flexible cords on the larger appliances (fridges, etc.) so that a subsequently-fitted 13 amp fuse would still protect the flexible cord. However, table lamps and the like will continue to have reduced capacity flexible cords, and will still need suitably-rated fuses inserted in their 13 amp plugs.

Finally, may I as a (schoolboy) reader of the very first issue of the original *Practical Electronics* congratulate you on the excellence of your publication. EPE has revived both the spirit and interest of the original PE which, I am sorry to say, had become quite boring in its final years. And please maintain the high quality and style of your circuit diagrams. The new BS logic and component symbols might be more informative, but I still prefer "squiggly" resistors, and your older-style schematics for logic gates.

*Thomas McIndoe,* CGIA BSc MPhil DipTech FIAP CEng MIEE MBCS
Glasgow

Constructional Project




# LINEAR CLOCK


## W. D. PHILLIPS


*Now is the right time to try something different. An interesting variation on the traditional approach – Will help you develop lateral thinking!*

NO-ONE needs a linear clock ... but it *is* different! The circuit described below offers an interesting variation on traditional displays and provides an intriguing artefact without which your collection of executive playthings is incomplete.

A block diagram of the system is given in Fig. 1 and the full circuit diagram of the Linear Clock is shown in Fig. 2.

## KEEPING TIME

Circuit simplicity dictates that the timing signal should be either: (1) a 50Hz signal derived from the 240V a.c. domestic mains, or (2) a signal generated by a crystal-controlled oscillator. Although both sources are sufficiently accurate, a crystal circuit was chosen.

Safety was an important consideration in the design of the clock and it was decided to use a regulated a.c. to d.c. adaptor as the power supply. These adaptors are readily available and well-suited to providing continuous power. The mains transformer, rectifier and smoothing circuit are all safely enclosed so that there is no danger of receiving a shock from any part of the clock circuit. As a result, the 50Hz signal from the secondary of the transformer is not available.

The timekeeping circuit used is based on a 4060 CMOS integrated circuit (IC1 in Fig. 2). A crystal identical to that used in digital watches provides a frequency of $2^{15}$ = 32,768Hz.

The 4060 contains a 14-stage binary counter which divides this fundamental frequency, giving a final output at 2Hz. Outputs from many of the earlier division stages are also available. The variable capacitor VC1 allows fine-tuning of the oscillator frequency.

## TIME SETTING

In normal operation, 2Hz passes directly to the remainder of the clock but, for time setting, higher frequencies are needed. The arrangement around IC2 provides a fast setting signal at 2048Hz and a slow setting signal at 64Hz. IC2 is a 4512 data selector: this has eight *data* inputs and a single output.

The signal at the output can be made to follow the signal at any individual *data* input by means of three *select* inputs. If CBA = 000, the data at input 0 appears at the output; if CBA = 001, input 1 is selected; CBA = 010 selects input 2 and so on. As you can see, the *select* inputs are connected to 0V by 10 kilohms pull-down resistors (R3, R4, R5).

If none of the switches S1, S2, S3 are pressed, CBA = 00 and 2Hz appears at the output. Switch S1 is used as a time set Allow. Pressing S1 and S2 together makes CBA = 110 and selects the 2048Hz signal at *data* input 6. Pressing S1 and S3 together makes CBA = 101 and selects 64Hz from *data* input 5. The remaining *data* inputs are connected to 0V.

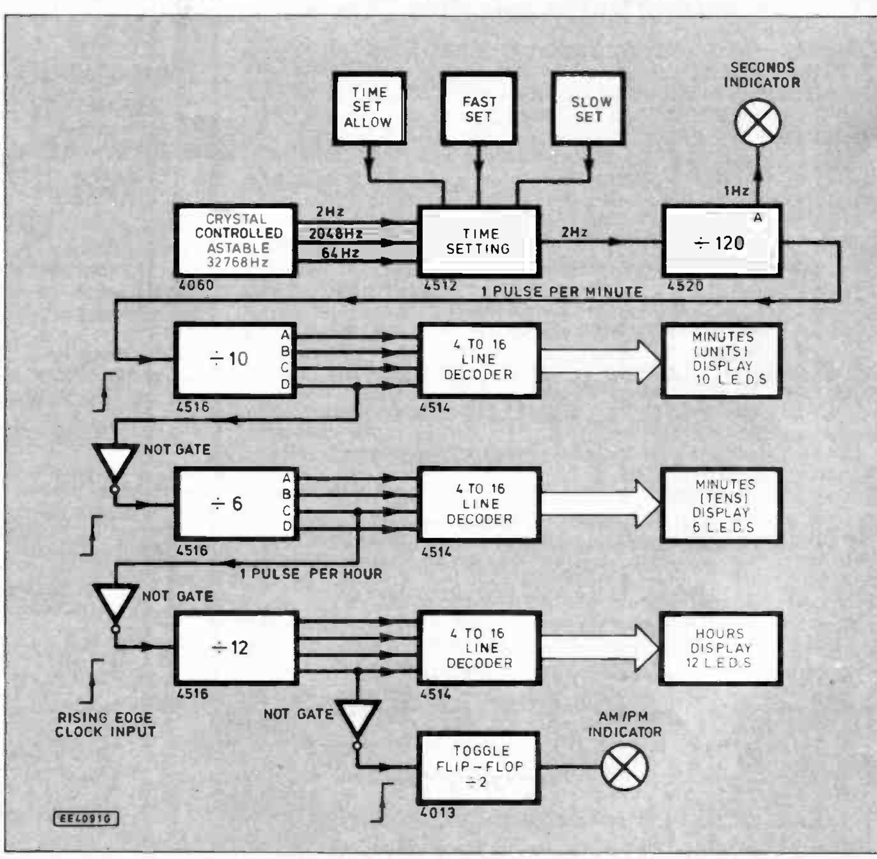
## DIVISION STAGES

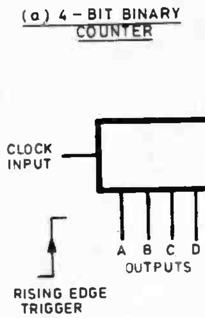
To fully appreciate the operation of the division stages of the circuit, reference should be made to Fig. 3. and Fig. 4. Fig. 3a shows a 4-bit binary counter. Fig. 3b gives the truth table for the counting sequence and Fig. 3c shows the corresponding voltage-time ($V/t$) graphs obtained at the counter outputs. Note that this particular counter changes state on the *rising edge* of the clock pulse. Output A is a square signal at half the clock frequency, output B changes at one quarter the clock frequency, output C at one eighth and output D at one sixteenth of the clock frequency.

In this circuit, the overall divide-by-sixteen action of 4-bit counters must be modified to shorten their count sequences. For example, IC3, a 4520 dual 4-bit counter, must divide its 2Hz input signal by 120 to give output pulses at the rate of one per minute. A divide-by-ten stage is followed by a divide-by-twelve.

Look again at the truth table of Fig. 3b. Outputs B and D first become "High" together at the start of the clock pulse

Fig. 1. Block schematic diagram for the Linear Clock.






(b) TRUTH TABLE

| PULSE | D | C | B | A | |
|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | |
| 1 | 0 | 0 | 0 | 1 | |
| 2 | 0 | 0 | 1 | 0 | |
| 3 | 0 | 0 | 1 | 1 | |
| 4 | 0 | 1 | 0 | 0 | |
| 5 | 0 | 1 | 0 | 1 | |
| 6 | 0 | 1 | 1 | 0 | RESET CONDITION FOR ÷ 6 COUNTER |
| 7 | 0 | 1 | 1 | 1 | |
| 8 | 1 | 0 | 0 | 0 | |
| 9 | 1 | 0 | 0 | 1 | |
| 10 | 1 | 0 | 1 | 0 | RESET CONDITION FOR ÷ 10 COUNTER |
| 11 | 1 | 0 | 1 | 1 | |
| 12 | 1 | 1 | 0 | 0 | RESET CONDITION FOR ÷ 12 COUNTER |
| 13 | 1 | 1 | 0 | 1 | |
| 14 | 1 | 1 | 1 | 0 | |
| 15 | 1 | 1 | 1 | 1 | |

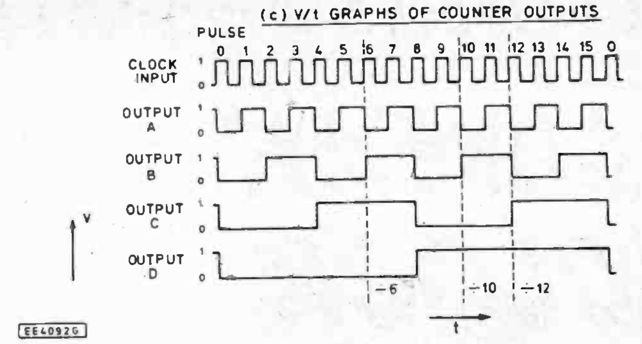
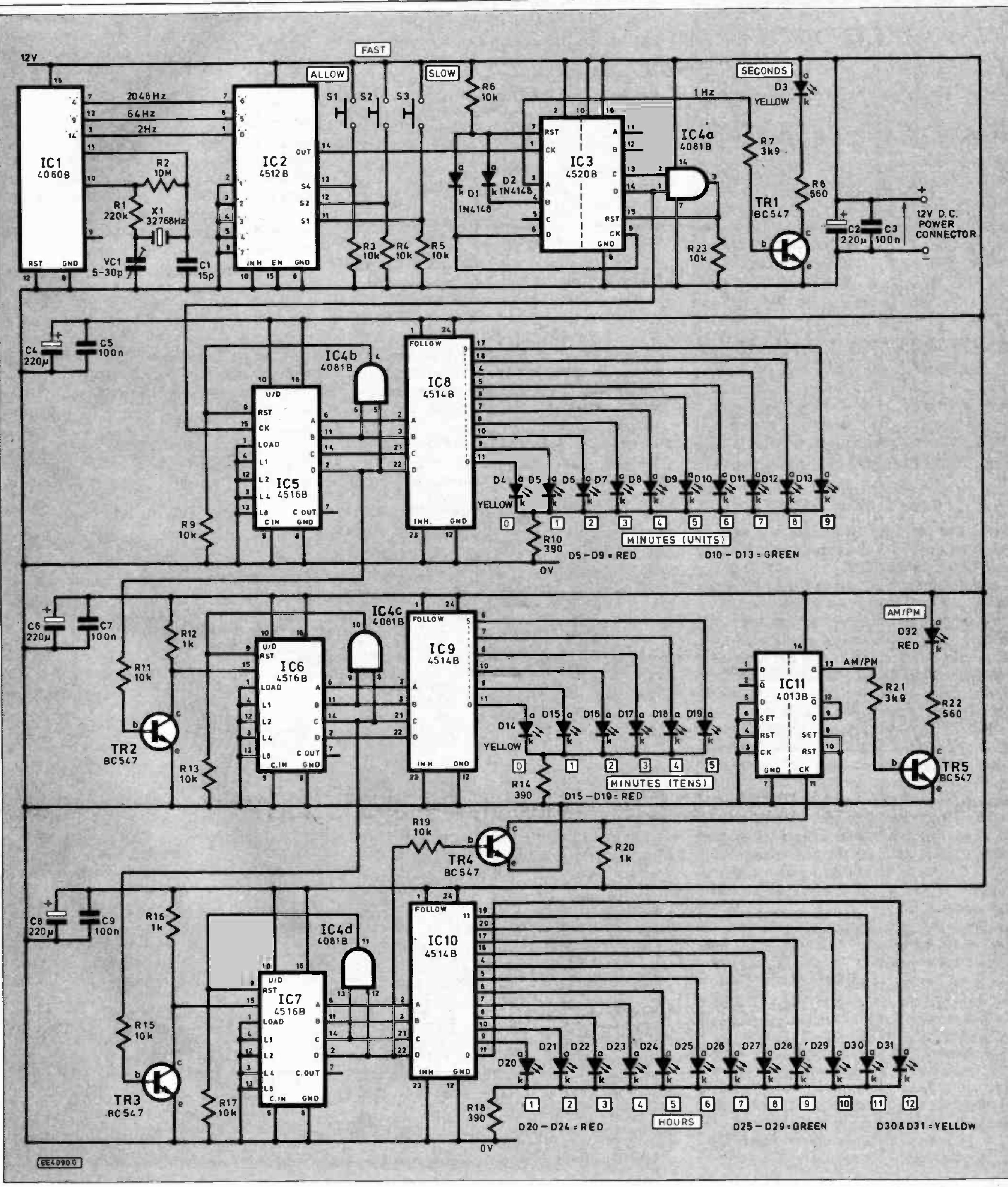



*Fig. 3. Division stages, truth table and voltage/time graphs.*

*Fig. 2 (below). Full circuit diagram for the Linear Clock.*



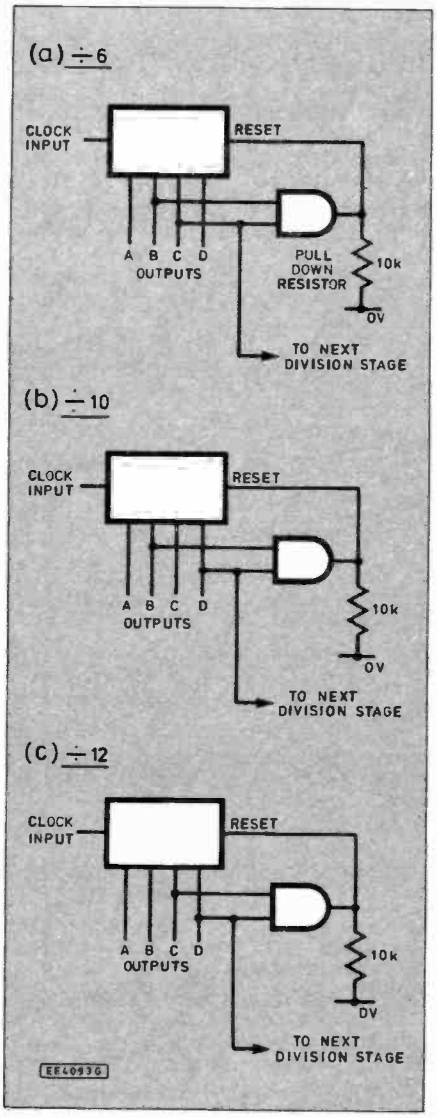



*Fig. 4. The AND gate connections for ÷ 6, ÷ 10 and ÷ 12 counters.*

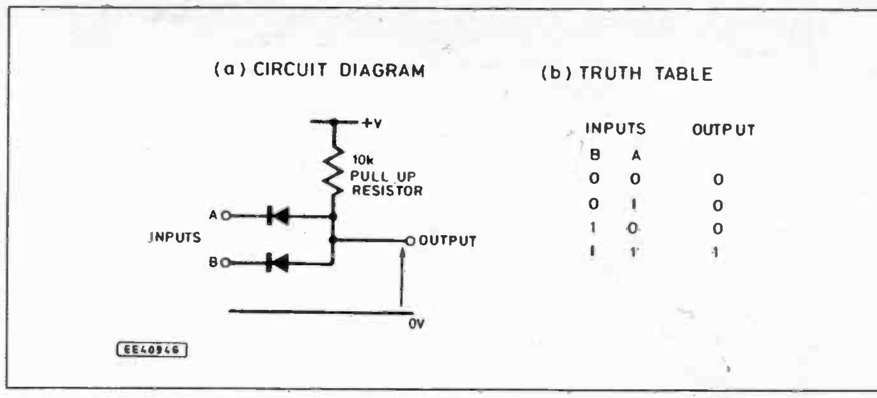
numbered 10. What is needed is a way of resetting the counter at this point, forcing DCBA to become 0000.

As shown in Fig. 4b, this is easily done by connecting B and D to the inputs of an AND gate, the output of which drives the reset pin of the counter. A divide-by-six stage can be implemented in the same way by connecting B and C to the AND gate, and a divide-by-twelve stage by connecting C and D; see Fig. 4a and Fig. 4c.

In Fig. 2, two sorts of AND gate are used. A 4081 CMOS i.c., IC4, provides four AND gates which are used individually to reset the second stage of IC3 and the three 4516 counters, IC5, IC6 and IC7, giving count sequences of the correct lengths. The first stage of the 4520 is reset by a fifth AND gate formed from diodes D1, D2 and the 10 kilohms pull-up resistor R6. Fig. 5 shows the diode/resistor AND gate circuit.

Check that you understand why the output of the gate is "High" only when both inputs are connected "High". Diode-resistor logic, sometimes called "Mickey Mouse Logic", is often useful when a single gate is needed. (How could you alter the circuit to make an OR gate?).

Because 4516 counters change state upon the rising edge of the clock pulse, simple transistor NOT gates are needed to link between IC5, IC6 and IC7. A final D-type flip-flop, IC11, is toggled by the output of IC7 and drives an l.e.d. via transistor TR5 to provide *am/pm* indication (D32).




| INPUTS B | INPUTS A | OUTPUT |
|---|---|---|
| 0 | 0 | 0 |
| 0 | 1 | 0 |
| 1 | 0 | 0 |
| 1 | 1 | 1 |

*Fig. 5. The diode/resistor AND gate circuit and truth table.*

## DISPLAYS

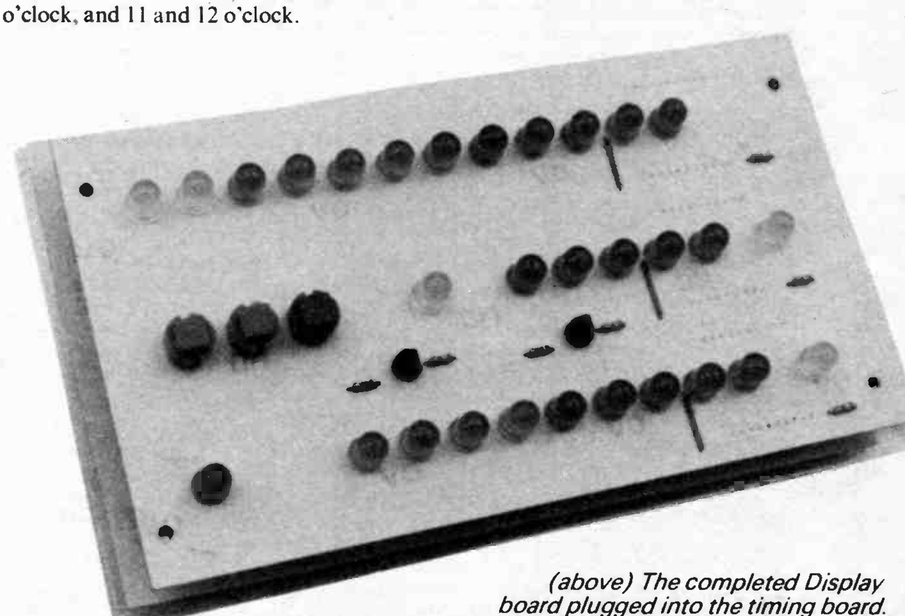
The arrangement of the display l.e.d.s can be seen from Fig. 7, which shows the topside component layout and details of the underside copper foil master pattern for the Display printed circuit board.

There are three main rows of l.e.d.s. The *Minutes (Units)* display consists of ten l.e.d.s with the "0" l.e.d. offset to the left of those for the numbers "1" to "9". The *Minutes (Tens)* display consists of six l.e.d.s similarly arranged. The hours display consists of twelve l.e.d.s with different colours for the l.e.d.s representing one o'clock to five o'clock, six o'clock to 10 o'clock, and 11 and 12 o'clock.

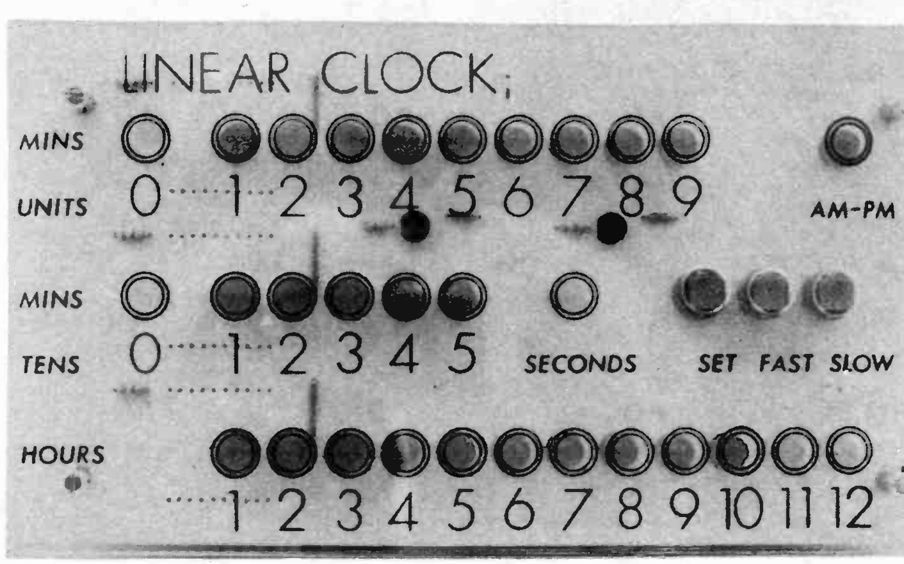
The displays are driven by IC8, IC9 and IC10. Each of these 4514 CMOS i.c.s is a 4-16 line decoder: the binary code at inputs DCBA causes the corresponding output to go "high". For example, if DCBA + 0101, output 5 goes high.

The outputs of the 4514s provide sufficient current to drive the l.e.d.s directly, and, since only one l.e.d. in each row is illuminated at a time, only one 390 ohm current-limiting resistor is needed per row.

An l.e.d. D3 flashing at 1Hz gives an indication of *seconds* and is driven via transistor TR1 from the A output from the first stage of IC3.



*(above) The completed Display board plugged into the timing board.*
*(Below) Suggested Perspex front panel layout and legends.*



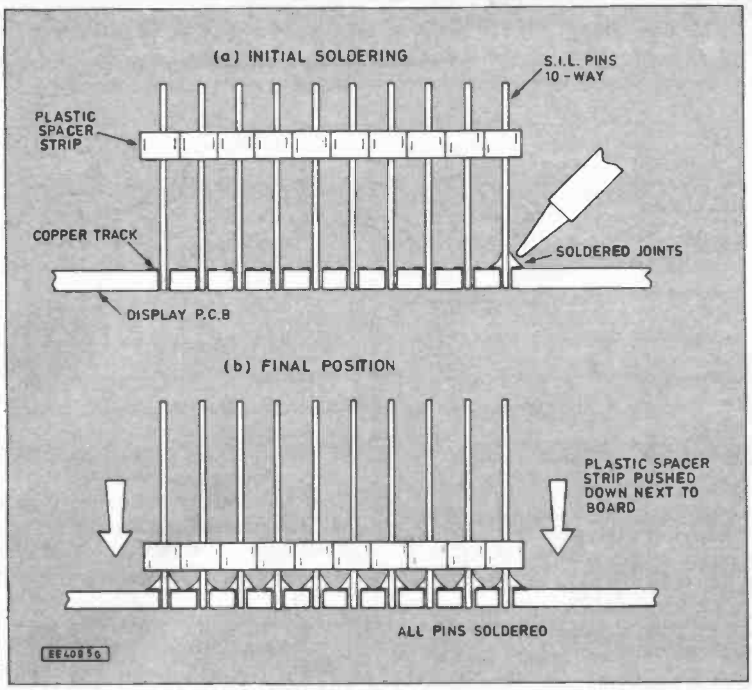



*Fig. 8. Fitting s.i.l. pins to the* **track** *side of the display board.*

## CONSTRUCTION

The component layout and underside copper foil master pattern for the main Timing printed circuit board (p.c.b.) is shown in Fig. 6. This board together with the Display board is available from the *EPE PCB Service*, codes 830 (Timing Board) and 831 (Display Board).

Start construction with the printed circuit board for the Timing board. Solder in the i.c. sockets using pins at opposite corners and check that they are flat to the board before soldering the remaining pins. Next solder in the wire links: refer to Fig. 6 to make sure that these are fitted correctly. Insulated wire must be used wherever links run parallel.

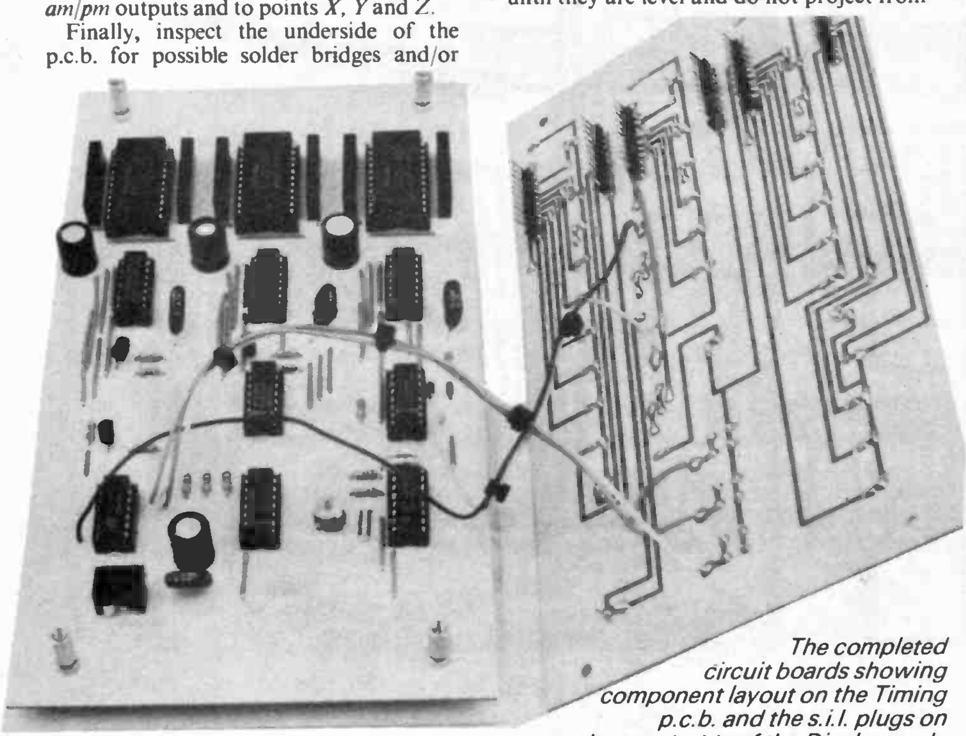
Next the resistors, capacitors and other components can be added. The s.i.l. sockets, SK1 to Sk6, should be vertical. Connect 15cm flying leads to the *1Hz* and *am/pm* outputs and to points *X*, *Y* and *Z*.

Finally, inspect the underside of the p.c.b. for possible solder bridges and/or dry joints. If all is satisfactory, the board can be put aside and attention now turned to the Display board.

Assembly of the Display p.c.b. is fairly straightforward. There are only three wire links and all the l.e.d.s face the same way, see Fig. 7. The prototype used 8mm l.e.d.s: Red was used to represent the numbers 1-5, Green for 6-10, and Yellow for 0 and 11-12. The 1Hz *seconds* indicator was Yellow and the *am/pm* indicator Red. Other arrangements of colours and sizes could be used.

Fitting the s.i.l. p.c.b. pins, PL1 to PL6, to the *underside* (trackside) of the Display p.c.b. is less difficult than it might appear. Push the *long* ends of the pins in an individual strip through from the copper trackside of the p.c.b., as illustrated in Fig. 8.

Press the pins back from the *plain* side until they are level and do not project from



*The completed circuit boards showing component layout on the Timing p.c.b. and the s.i.l. plugs on the* **track** *side of the Display p.c.b.*

## COMPONENTS

**See SHOP TALK**

### Resistors

| | |
|---|---|
| R1 | 220k |
| R2 | 10M |
| R3, R4, R5, R6 R9, R11, R13, R15, R17, R19 | 10k (10 off) |
| R7, R21 | 3k9 (2 off) |
| R8, R22 | 560 (2 off) |
| R10, R14, R18 | 390 (3 off) |
| R12, R16, R20 | 1k (3 off) |

All 0·25W 5% carbon film

### Capacitors

| | |
|---|---|
| C1 | 15p polystyrene |
| C2, C4, C6, C8 | 220µ radial elect., 25V (4 off) |
| C3, C5, C7, C9 | 100n polyester (4 off) |
| VC1 | 5p-30p variable trimmer capacitor |

### Semiconductors

| | |
|---|---|
| D1, D2 | 1N4148 signal diode (2 off) |
| D3, D4, D14, D30, D31 | 8mm yellow l.e.d. (5 off) |
| D5, D6, D7, D8, D9, D15, D16, D17, D18, D19, D20, D21, D22, D23, D24, D32 | 8mm red l.e.d. (16 off) |
| D10, D11, D12, D13, D25, D26, D27, D28, D29 | 8mm green l.e.d. (9 off) |
| TR1 to TR5 | BC547 *npn* silicon transistor (5 off) |
| IC1 | 4060B 14-stage binary counter and oscillator |
| IC2 | 4512B 8-input data selector |
| IC3 | 4520B dual 4-bit binary counter |
| IC4 | 4081B quad 2-input AND gate |
| IC5, IC6, IC7 | 4516B 4-bit binary up/down counter (3 off) |
| IC8, IC9, IC10 | 4514B 1-of-16 decoder (high output) (3 off) |
| IC11 | 4013B dual D-type flip-flop |

### Miscellaneous

| | |
|---|---|
| X1 | 32,768Hz watch crystal |
| S1 to S3 | s.p.s.t. p.c.b. mounting switch (3 off) |
| SK1 to SK6 | 10-way p.c.b. mounting s.i.l. sockets (6 off) |
| PL1 to PL6 | 10-way p.c.b. mounting s.i.l. pins (6 off) |
| PL7 | 2·5mm d.c. power connector |

Mains/12V d.c. regulated adaptor; 14-pin d.i.l. sockets (2 off); 16-pin d.i.l. sockets (6 off); 24-pin d.i.l. sockets (3 off); mounting hardware; Perspex; insulated wire links; connecting wire; solder etc. Printed circuit boards available from *EPE PCB Service*. codes 830 (Timing Board) and 831 (Display Board).

*Approx cost guidance only* **£28** *plus supply*

# LINEAR CLOCK – TIMING BOARD

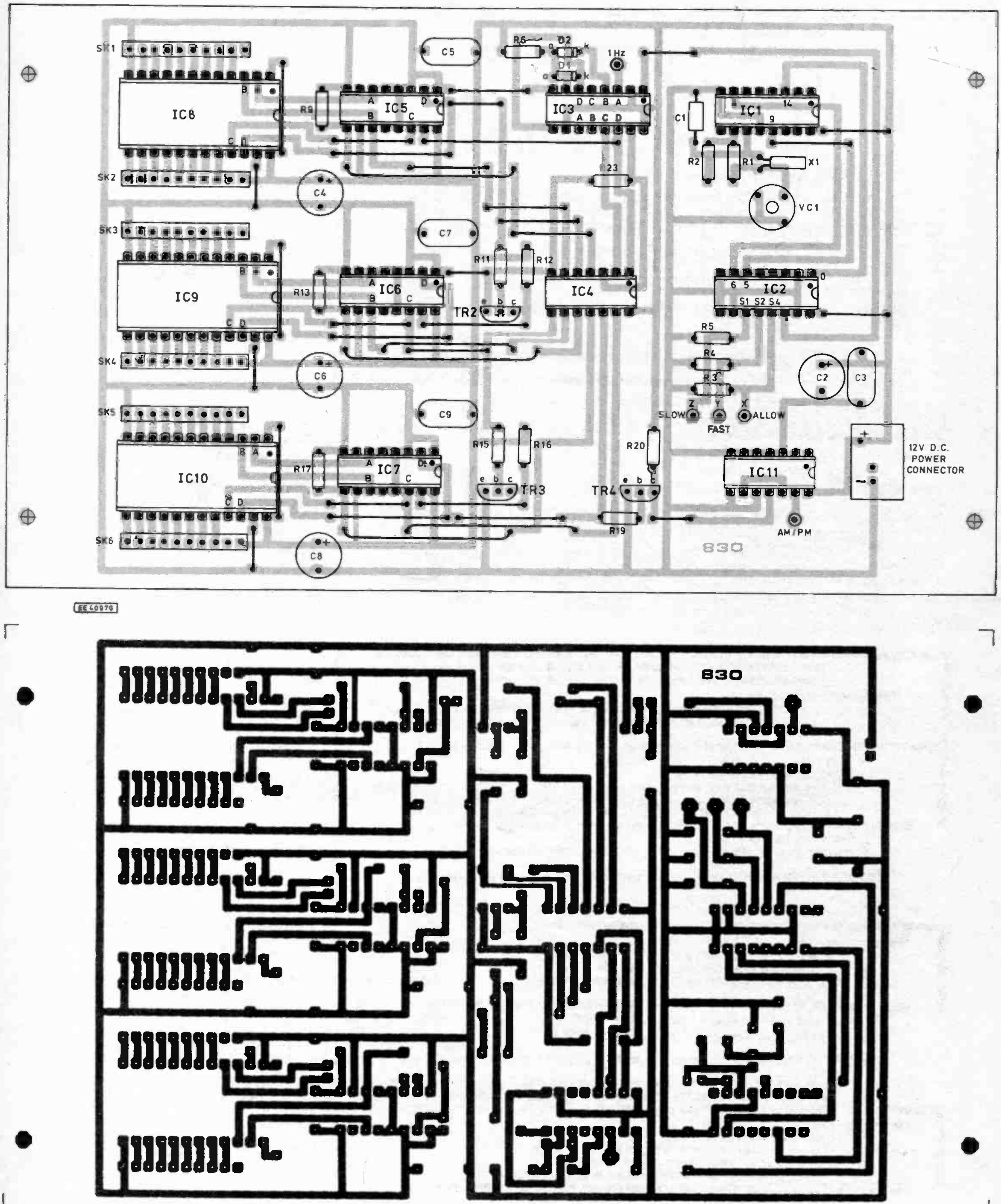



*Fig. 6. Printed circuit board component layout and full size copper master pattern for the main Timing board. All i.c.s should be mounted in d.i.l. sockets and the wire links must be made with insulated wire; double check all link connections before moving on to the discrete components.*

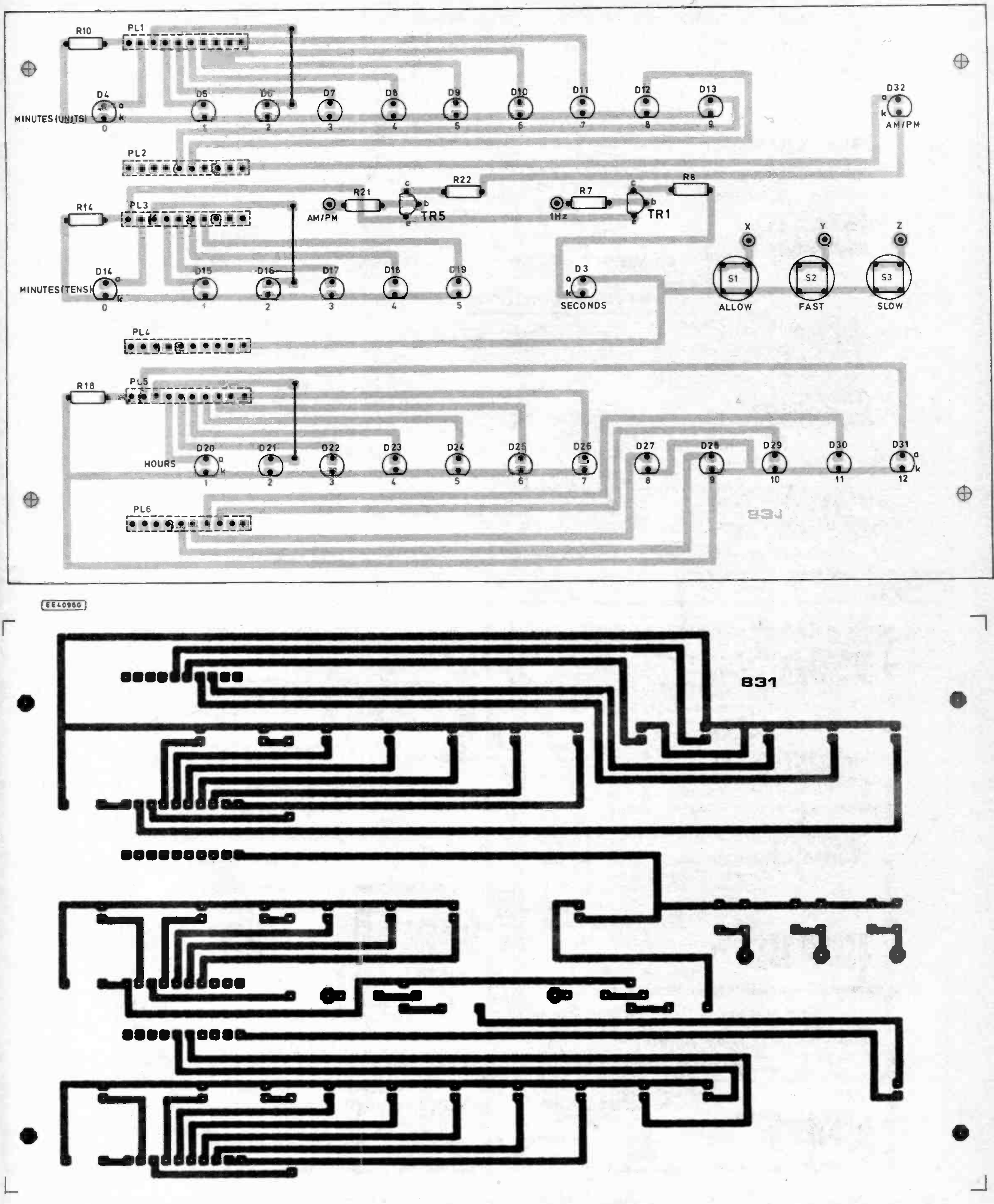
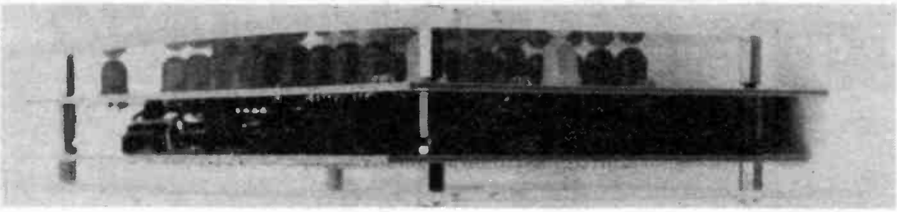
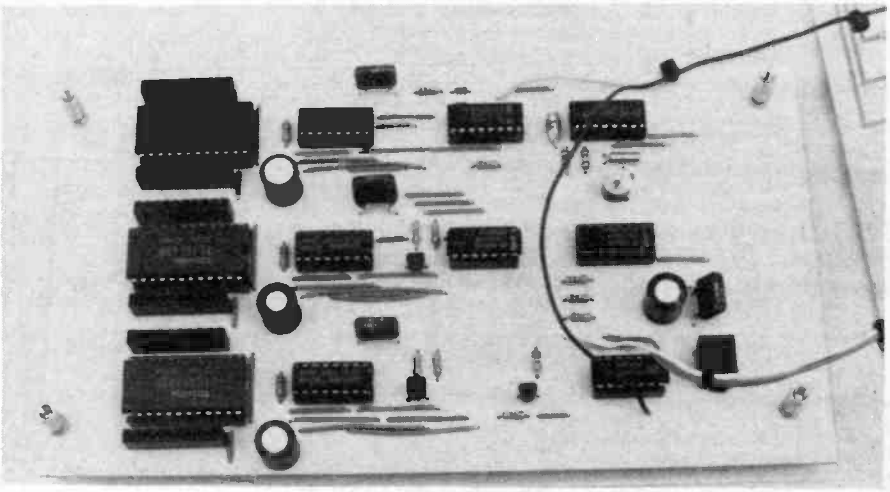



*Fig. 7. Display printed circuit board component layout and full size copper foil master pattern. Note that the 10-way s.i.l. plugs PL1 to PL6 are mounted on the copper track side of the board, see Fig. 8.*



*The "sandwich" construction of the Perspex front, Display board, main board and plain back cover board.*



*The completed main Timing board showing the s.i.l. sockets between the decoder i.c.s and four of the threaded board-spacers.*

the surface. Using a fine-tipped soldering iron, solder each pin to the copper track.

Finally, push the plastic spacer strip firmly towards the soldered joints. Check PL1 to PL6 for fit with the matching sockets on the main board but do not push them home too firmly at this stage.

## TESTING

The main Timing circuit board should be tested first. None of the i.c.s should be fitted in their sockets at this stage. After re-checking for solder bridges etc, connect the a.c./d.c. 12V adaptor and test for the presence of power supply voltages at the appropriate pins of the vacant i.c. sockets. Switch off, wait a few moments for the power supply decoupling capacitors to discharge, and then insert IC1.

An oscilloscope or logic probe can be used to monitor the 2Hz output at pin 3. If an oscilloscope is available, check the higher frequency outputs from other pins of IC1. Switch off.

Next fit IC2, IC3 and IC4 in their sockets. A 2Hz signal should be present at pin 1 of IC3 and 1Hz at pin 3. Connecting flying leads *X* and *Y*, or *X* and *Z*, to the positive end of the power supply should result in higher frequencies at the input to IC3. The final output of IC3 appears at pin 14. Fit the remaining i.c.s and follow their action with *X* and *Y* connected "High" (fast setting).

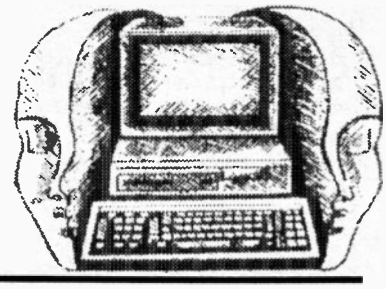
If everything is in order, disconnect the adaptor and solder the ends of the flying leads to the corresponding points on the copper track side of the Display p.c.b. The two boards can now be carefully mated together, using threaded 15mm spacers to maintain the correct distance between them. If power is re-connected the clock should be seen to function and the operation of the time-setting controls can be investigated.

## DECORATION

The Linear Clock is distinctly enigmatic and you can learn to read it accurately without further embellishment. However, you may prefer to add a Perspex panel identifying the various elements of the display.

A possible front panel design is given in the photographs. Alternatively, your own designs could be applied directly to the Display p.c.b. for a more individual appearance. □

# INTERFACE



## Robert Penfold

THE subject of do-it-yourself PCs is something that crops up from time to time in readers' letters. The two usual queries are will it save money compared to the cost of a ready made PC, and just what is involved? Like many of the queries received from readers, these are "how long is a piece of string" style questions!

For those who are not familiar with PCs it has to be pointed out that do-it-yourself PCs are put together using ready-made motherboards, display cards, etc. It is basically just a simple assembly job, and is not comparable to building a project featured in *Everyday With Practical Electronics*. It does not usually involve the use of a soldering iron at all.

### Cost Cutting

As a cost cutting exercise there is probably less to be gained from the do-it-yourself approach than you might think. It only takes a few hours to assemble a PC. You are doing very little of the work yourself, and could not reasonably expect to make massive savings. In fact the potential savings are so low that unless you shop around carefully for the parts you would almost certainly end up paying more than if you bought an equivalent PC from one of the more competitive "clone" manufacturers.

If all you require is a simple PC for use with home constructed add-ons, the best low cost solution is almost certainly to buy one of the cheap XT class PCs that still seem to be available from some of the large mail order computer suppliers. For add-on projects it is not essential to have a powerful PC, and for most purposes something as basic as an XT type PC running Microsoft GW BASIC or QBASIC will suffice.

If you also wish to run word processors, d.t.p. software, etc., then a very basic PC is not a good choice. A computer of this type is incapable of running much of the better software currently on offer, which is the reason these computers are being sold at what is often a small fraction of their original price.

### Add On

Another good way of obtaining a PC at low cost is to buy a basic system from one of the clone manufacturers, and then add the display, hard disk, etc. yourself. This often seems to give a significant saving compared to either building an equivalent system from scratch, or buying the complete system ready-made.

It has the advantage that everything in the basic system will fit together properly. Physical incompatibilities between certain components are now a major problem for the do-it-yourself PC builder. In particular, the case and power supply usually have to be bought as a matched pair, since the "standard" size PC power supplies will not fit in most modern PC cases.

Unhelpfully, some of the traditional PC connectors now seem to be less standard than they once were. Some keyboards for instance, seem to be fitted with a form of 5-way DIN plug, but not the 180 degree type usually fitted to PC keyboards.

In order to get a basic system up and running it is merely necessary to add a display card and a monitor. V.G.A. cards are so cheap these days that there is no point in bothering with one of the earlier PC display systems. Nearly all the current V.G.A. cards seem to offer some super V.G.A. modes provided they are equipped with a full complement of RAM (which is often included as standard).

If funds are limited, there are plenty of good quality monochrome (grey-scale) monitors available at surprisingly low prices. Most of the low cost colour super V.G.A. monitors provide very good quality and are very reliable.

As a point of interest, I have owned several monitors over a period of more than ten years, and as yet have never had one go wrong. Although monitors might be expected to be unreliable due to the heat generated by some of the components, and the very high voltages used, they actually seem to be about the most reliable part of a computer system!

### Identity Problems

It is useful to check that the computer is working properly by "booting-up" from a floppy disk, but in order to use the computer in earnest a hard disk drive will have to be added. The supplied hard disk controller will almost certainly be of the IDE variety. This is not really a controller at all, and it simply provides connections to the 16-bit bus of the computer. The controller is built into IDE hard disk drives.

The computer's setup program (which is in the BIOS ROM) must be used to store basic technical details of the hard disk drive in the CMOS RAM. This program is usually run by pressing the "Del" or "Esc" key during the boot-up process (an on-screen message tells you which key to press). In the original scheme of things there was a list of standard disk drive parameters, and you chose the set which matched your drive.

If your disk drive was not one of the standard types, then you chose the set of parameters that gave the highest capacity without trying to exceed the physical limitations of your drive. In practice this usually meant that about 10 to 25 per cent of the drive's capacity was lost.

Modern BIOS ROMs still have a list of 40 or more standard drive types, but they also have an option that enables the user to enter the number of heads, cylinders (tracks), and sectors per track. Within reason, this enables any drive to be used at full capacity.

An oddity of IDE drives is that they have more sectors on the long tracks towards the outside of the disk, than they do on the shorter tracks near the middle. This permits higher capacities to be obtained, but a PC BIOS can only handle a fixed number of sectors per track.

This problem is overcome by the built-in disk controller, which can make the drive appear to match any set of BIOS parameters. The only proviso is that the apparent capacity of the drive must not be higher than its real capacity. The drive manufacturer usually provides a recommended set of parameters which will give the optimum capacity, and are known to be free from any problems (some parameters might give boot-up difficulties for instance).

### Hard Boot

With the drive installed, the computer is booted-up from a floppy disk, and then the MS/DOS FDISK program is run. This is used to partition the disk, and must be run even if the entire disk will be used as drive C.

Next the MS/DOS FORMAT program is used to do the high level formatting, and to place the system files onto the disk. If all goes well it should then be possible to boot-up from the hard disk, and the computer is then ready for use.

Note that IDE hard disk drives do not require a low level format to be carried out. Low level formatting is done as part of the manufacturing process, and normal low level format programs will not work with an IDE drive anyway.

### Crossed Wires

Adding a second floppy disk drive to a PC is not difficult, but there are a few points worthy of note. Normally a twin drive computer has a cable which connects straight through to both disk drives. Jumper terminals or d.i.p. switches on the drives are used to set one drive as drive "DF0", and the other as drive "DF1".

These are drives "A" and "B" respectively in PC terminology.

Some PCs do handle the drives in this conventional manner, but most copy the original PC method, which was to have both drives set as drive "B". A twist in the drive cable (Fig.1) effectively configures one of the drives to operate as the "A" drive. The point of this is that drives can be sold ready-configured to operate as drive "A" or "B". Whichever type of cable is fitted to your PC, make sure that the additional drive is configured to operate as drive "DF1".

The Debug program provided with DOS includes a rudimentary disassembly facility, but, like the rest of Debug, it is all but unusable. It can also only be used with .COM files, and not the more complex .EXE files.

The shareware MD86 disassembler (Magic Disassembler) is an altogether superior tool. It will examine and disassemble any executable program or any series of machine instructions (like a ROM image). MD86 is designed to run on any IBM PC, XT, or AT or compatible with at least 128K of RAM memory.

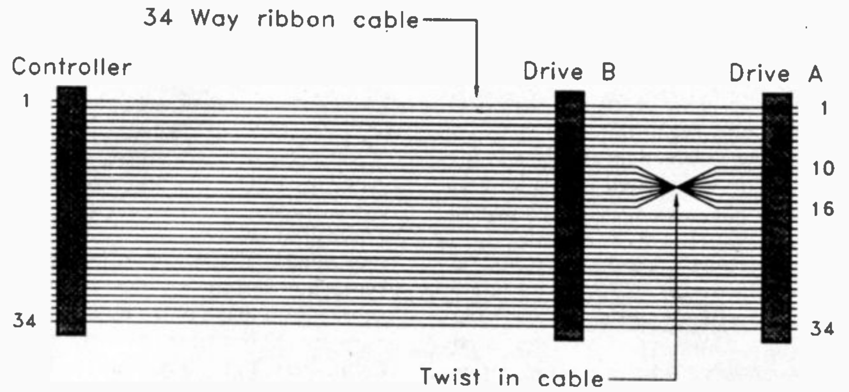



*Fig. 1. A normal PC twin disk drive cable includes a twist in the leads to points 10-16.*

## Termination Resistors

Disk drives are fitted with termination resistors. These are in d.i.l. or s.i.l. packages, and are not separate components. In a twin drive system only the drive at the end of the cable should have this resistor pack fitted.

This means that the resistor pack in an add-on second drive must be located and removed (although both drives will probably work all right if it should happen to be left in). The resistor pack will be fitted in a socket, and is easily removed.

Before an additional drive will operate properly the BIOS setup program must be run. The CMOS RAM entries can then be edited to take into account the new drive. An important point to bear in mind is that you can only use a disk drive of a type that is supported by the ROM BIOS. Because of this, some modern PCs cannot be fitted with 5·25 inch 360k drives.

Assembling and upgrading PCs is quite straightforward from the technical standpoint, and can be undertaken by practically anyone who has some experience of using PCs. Any problems are likely to be mechanical ones, and you need to take great care to ensure that the items you buy will all fit together properly.

## MD86 Disassembler

Disassembly of executable programs is something all programmers seem to try sooner or later. It can be interesting to the point of obsession, but it can also be a frustrating business. Finding the right tool is all-important.

Neither a graphics adaptor or a colour monitor is required. A hard disk is desirable but MD86 can be run on a floppy based system.

According to the Authors, MD86 was developed to produce useable source code from an executable program file. This means understandable assembly instructions and meaningful label names and comments. MD86 produces source files that are compatible with the Microsoft assembler MASM version 4·00 or later.

After MD86 has produced a source file, some changes may be needed before it can be assembled without error. This is especially likely with EXE type programs which have complex segment structures.

MD86's video display works very much like a full screen editor; allowing movement within the disassembled source file with single keys. However, though moving down through a file is straightforward, it is not always so easy to move up again, as in some cases it is difficult for the program to determine where the preceding instruction begins.

## Editing

When executed, MD86 presents the user with a full screen of information that looks very similar to the printed output from an assembler. Once you have this display, it may be edited. In particular, labels may be associated with memory addresses, just as is done when writing assembly-language programs. When the disassembler comes across these address locations again during disassembly, it uses the labels, making the listing easier to follow.

Comments may also be edited. This is all done in a manner similar to using an editor. There is a limited help facility built-in, to provide reminders of the function key assignments.

A program consists not only of instructions but also of data, such as message strings. It is sometimes possible to disassemble such areas into valid instructions, though they will make no sense as program instructions. Disassemblers can offer only limited help in identifying data areas, but MD86 does quite well here. Once identified, the data areas can be marked so that they will not interfere in the disassembly process further.

The modified file can be written to disk. The program also creates a number of data files automatically, for example to store label assignments. These make it easier to spread the task of disassembly over a number of sessions. This is likely to be necessary if you want to disassemble a large program.

Once you have a fully disassembled file, you can try passing it through an assembler to re-create the original program. After that, presumably, you can try to modify and improve it.

## Ease of Use

Of course, any job of disassembly requires programming skills, and a knowledge of assembly language programming. For this reason, it perhaps does not matter that this program (in common with all tools of this type) is not as easy to use as current business applications. There are terse commands which have to be remembered, and only the limited help mentioned. However, the documentation is adequate, not always the case with programs of this type.

It is not really practical these days to disassemble a full application. EXE files can easily exceed 250K, and this is too big for this program to handle in one bite. In any case, licenses often forbid reverse engineering of any kind. However, programs like this can be useful to disassemble small utilities, to find out how they work, and it can also be interesting to disassemble one's own programs, to find out exactly what code the compiler produces.

MD86 is an American program, and the registration fee is $17·50. It is available from the PDSL, Dept EPE, Winscombe House, Beacon Road, Crowborough, Sussex, TN6 1UL (Tel. 0892 663298). It is included on disk number 2593, and may be available from other sources under different reference numbers.

# Home Base

*Jottings of an electronics hobbyist – Terry Pinnell*

## Cause for Alarm

I've always found it difficult to understand why car manufacturers have been sluggish about including burglar alarms as standard in their new models. Although this is at last changing, with many higher priced versions offering remote-control centralised-locking combined with an alarm, why has it taken so long?

Surely price is not the issue? I know that marginal cost is proffered as a key factor when it comes to discussing the merits of nice-to-haves, and in these hard times potential buyers are highly price-conscious. But alarms could have been appearing on a mass-production scale fifteen years ago, long before this recession started. And anyway the actual cost of installing a simple alarm at the manufacturing stage (rather than the considerably more difficult task of adding one later) must be miniscule.

As I've mentioned before in this column, I proudly added an anti-theft device to my very first heap, back in 1958. That was before I knew about electronics, and it simply took the form of a secret switch in the ignition circuit. But since starting this hobby some 18 years later, I've fitted proper alarms to all my cars.

## Optimising the Design

I've tried many circuits over the years, with various combinations of the main elements: switching, exit facilities, triggering method, re-entry method and alarm signal.

My first unit was externally switched, using a heavy-duty toggle concealed behind the front bumper. This had the great advantage of simplicity and meant that the alarm could be triggered immediately on illegal entry. In retrospect I should have known better. No doubt the switch would have survived a Californian climate, but despite all my prior weather-proofing precautions it gave up the ghost after its first UK winter.

Apart from that, I never felt too comfortable with it. Although a potential car thief would hardly be expected to be watching as I switched it on furtively (I used to go through a sort of "just-checking-the-tyres" charade each time) it was not very secure. Not so good on the shirt cuffs either, especially on rainy nights after travelling down a muddy lane.

I flirted briefly with the idea of a key-switch, flush-mounted into a door just like the normal door lock, but couldn't bring myself to inflict the necessary violence on the bodywork. I suppose if I'd been prepared to strip down the door panel I could have improvised something by positioning a microswitch so that it was activated by the locking mechanism.

Come to think of it, for the last couple of decades, at a trivial extra cost, manufacturers could easily have been fitting door locks with integral electrical switching. One of my latter-day company cars, a large 1987 Ford, had such an arrangement. This was to allow the addition of a (very expensive) burglar-alarm as an optional extra, but it proved a devil of a job getting access to the appropriate two wires.

The design evolution that I am recalling here was of course well before the widespread use of remote control devices, so a miniaturised radio transmitter neatly installed in my key-fob was not an option.

A few published circuits (and some commercially available ones) have adopted the approach of activating the alarm whenever the ignition is switched off. I haven't tried this so can't do it justice, but I'm a bit uncomfortable with it, as there are certainly occasions when I switch off but don't necessarily want my alarm to become operational.

The preferred switching method I have settled on is an internal toggle or slide switch. Lots of concealment options, all of them guaranteed clean and dry, and no long runs of wire through the engine compartment.

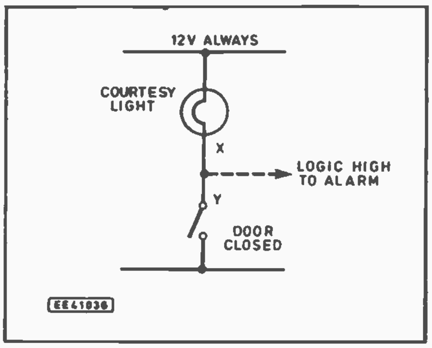



*Fig. 1. Using the courtesy light switch to trigger the alarm. When the door is open a logic low is registered by the alarm.*

Incidentally, on a practical note, it is a good idea to use a double-pole switch and route the output signal from the alarm through the second pole, en-route to the load (horn relay or siren or whatever). This will ensure you are never embarrassed in the way I was; one of my earlier alarms started unexpectedly when I was about to drive off and refused to stop until I ripped a few wires out. Needless to say, that was on a rainy night in the most densely populated spot within miles.

## Graceful Exit

One obvious disadvantage of an internal switch is that an exit delay becomes necessary, but in practice this is simple enough to implement. During this exit period of a minute or so, my alarms also generate a warning signal, in case the driver gets pre-occupied with a radio programme, or a passenger takes a while to remove luggage or something. I originally used a simple buzzer but changed at some point to a gentle gong sound in an attempt to reduce the tendency of my passengers to panic when the alert sounded. If you prefer to preserve any tranquility you've been lucky enough to find during your drive, then a visual signal such as a brightly-flashing l.e.d. would be an alternative.

Speaking of l.e.d.s, my present car's commercial alarm (a first!) flashes constantly whilst the alarm is armed, to warn-off those with dishonourable intentions, so I might incorporate this if I build another unit.

My favoured method of triggering uses the wiring to the door microswitches and courtesy light. Implementing it in practice can be a piece of cake or a real slog. It depends on the accessibility of the connection you need, namely *X* or *Y* in Fig.1. The point *X* near the courtesy light is always easily accessible, to you that is, usually by just removing the plastic light cover. But the more relevant matter is its accessibility to the alarm unit itself. Sometimes it's possible to get an extra wire across the roof (behind the lining) and thence to your alarm. But it's usually easier to concentrate on point *Y*, behind the door microswitch, or to intercept the wire on its way up to the courtesy light, and graft in a new one.

If like me you also want to protect your boot or bonnet, then you will need to install additional microswitches. On several cars I also added a bonnet light while doing so. This is another desirable extra, rarely fitted to the modern car, and has proved its worth for me on several rainy nights. It beats groping around for my torch, which will either have flat batteries or fall irretrievably into the greasy depths as soon as I try propping it in place.

To regain your rightful place behind the steering wheel without setting off the alarm yourself, you need a re-entry delay. How long you allow depends largely on how awkward it is to get to your concealed on/off switch, especially when you are carrying an armful of fragile shopping and a large umbrella (that dark stormy night scenario again, with added gales). But I have typically found that 10 seconds is adequate. I appreciate that might sound quite a long time for your would-be thief to search for the switch, but remember that he (or she, sorry) will be a trifle nervous, especially as your circuit should have started the warning sound on re-entry.

## Noisy Parker?

Turning finally to the end product of the alarm circuit, there are various ways of making the requisite loud racket. A 12V siren is a popular choice, a typical unit generating around 120dB at one metre, and consuming a modest 300 to 400mA. But you might have to pay around £15 for these, so on balance I prefer to pulse the existing car horns.

There are still a few old cars around that are powered directly from the horn-button, but most modern vehicles use a relay. So this usually means taking the output from the final stage of your alarm logic, probably an astable enabled by a monostable, first to a transistor driver which in turn then activates the horn relay and hence the horn or horns. While you are groping around getting access to these wires, you may as well go that bit further and take the same signal to your headlight or foglight relay too.

The monostable should have a period of about five minutes. I'm not sure if it's actually illegal to have the horn blasting away for the entire night until it exhausts the battery. But limiting it to a few minutes is not only considerate to those in the vicinity at the time but also minimises the chances of someone cracking under the strain and doing your motor car an injury. That would be a bit ironic after all the effort you've made to protect it.

There are alternatives to the siren or horn options. I did once toy fleetingly with the dramatic idea of a tape recording, producing a much-amplified roar for help to the outside world. Something like HELP! Someone is breaking into this car!. But, several false alarms now wincingly behind me, I am relieved that sanity prevailed.

SURVEILLANCE

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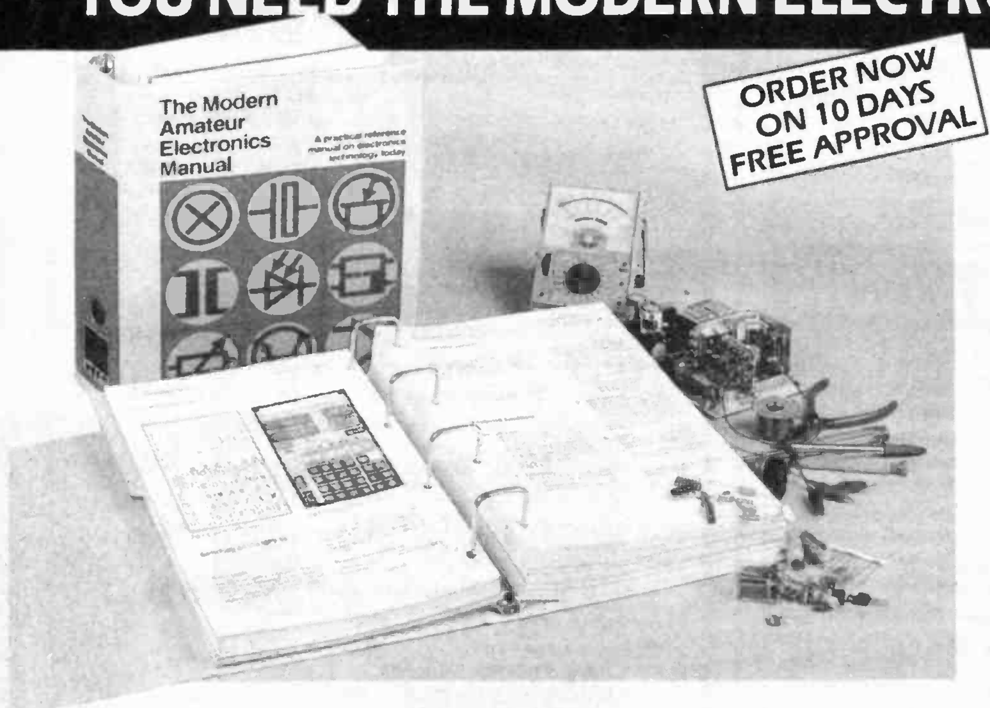


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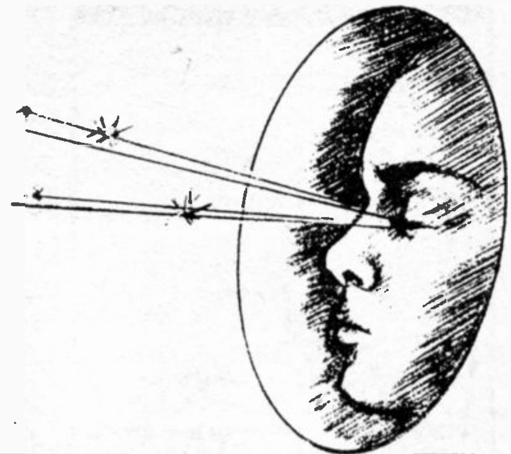
# MIND MACHINE Mk II MAGIC LIGHTS



ANDY FLIND

Part Two

*Adding synchronised light stimulation to last month's binaural relaxation signal generator. Uses the same audio cassette tape to relax the mind.*

IN LAST month's *Mind Machine Mk II* – "Binaural Signal Generator" project, it was stated that, whilst "binaural" sound alone may promote desired "brainwave" patterns, it is far more effective when accompanied by photic (light) stimulation. Most commercial "entrainment" devices rely mainly on lights for their effect, these usually being l.e.d.s fitted into glasses worn by the user.

The "Magic Lights" does this by taking the audio signals from a stereo cassette tape made with last month's signal generator and creating synchronised lights from l.e.d.-equipped goggles. It is self-powered and compact, about the size of a Walkman, so it may be slipped into a pocket and used anywhere to relieve the stresses of daily life.

## WARNING

It must be stated that there is a hazard associated with photic stimulation. Whilst sound alone is harmless, flashing lights carry a small but well-known risk of triggering epileptic seizures, which may happen to persons not previously aware of susceptibility to this.

Although this risk is small, *known epileptics should never use an entrainment device*, whilst anyone experiencing strange sounds, smells etc. with no apparent cause should stop using the device immediately and seek medical advice.

Awful Warning over; most users experience only peace, relaxation and sometimes creativity. The "Magic Lights" unit connects in parallel with the headphones of a cassette player and operates from the two sinewave signals of a "binaural" recording.

These signals are amplified into logic level squarewaves, combined in an exclusive-or gate and then filtered to extract their low-frequency difference. This controls the output stage, driving a pair of high-intensity l.e.d.s fitted into goggles worn by the user.

The combination of synchronised binaural sound and light stimulation can produce extraodinary effects, deep relaxation, inner calm, and sometimes high levels of imagery and creativity. It must be stressed that when first using the "lights", the light intensity control *MUST* be set to minimum and *gradually* increased to a comfortable level. It may also be wise to keep the eyes shut during relaxation sessions; turning the unit off or removing the goggles before opening them.

## CIRCUIT DESCRIPTION

The full circuit diagram for the Mind Machine MkII – Magic Lights is shown in Fig. 1. Two stereo sockets JK1 and JK2 are connected in parallel, with the output from the cassette player plugged into one and the headphones into the other.

The two signals are amplified by IC1a and IC1b. The voltage gain of these is initially about 33, but as the signal amplitude rises the diodes, D1/D2 and D3/D4, in their feedback paths start to conduct, reducing the gain to around unity.

The next stages, IC1c and IC1d, have positive feedback so their outputs have only two states, high and low, squaring the signals. Gates IC2a and IC2b are buffers, speeding transitions between states and giving rail-to-rail output voltage swings. The positive feedback also means that the inputs must reach a certain minimum amplitude to operate these stages, eliminating unwanted output in the absence of input signals.

These input stages provide clean logic level outputs from inputs of around ten millivolts up to a few volts. The TL064 op. amp is used because it's output swings to within about the same voltage from either supply rail, maintaining a reasonable output waveform when overdriven as with this circuit.

The gate IC2c, following IC2b, normally follows the signal, but when switch S1 is closed inverts it, inverting the final output to the l.e.d.s. This feature was added when the author discovered a pair of cheap headphones in use with this project were out of phase, but is often provided by commercial units for users to experiment with. The occasional use of opposite-phased sound and light may enhance the effects.

The signals are then combined by the EX-OR gate IC2d, producing a series of pulses of twice the audio frequency, but with varying width. If these are summed for their average value the output is found to be a triangle wave at the difference frequency between the two original input signals. Filter IC3a, a sort of third-order circuit, extracts this triangle wave in a fairly clean form across the frequency range of this project and it is then used to control the output stage.

## OUTPUT

The output stage is easier to follow if described from the final stage first. IC3d is a voltage follower driving transistors TR1 and TR2 to reproduce the voltage from VR1 across resistor R31. The resulting current through R31 also passes through the output l.e.d.s so their brightness is controlled by VR1.

## WARNING NOTICE

**Photic stimulation at Alpha frequencies can cause seizures in persons suffering from Epilepsy. For this feason such people MUST NOT try this project.**

**A user who is not a known epileptic, but when using the *Mind Machine* begins to experience an odd smell, sound or other unexplained effects, should TURN IT OFF IMMEDIATELY and seek professional medical advice.**

**Because of the above possibility the *Mind Machine* should not be used while on your own.**

**YOU MUST TREAT THIS UNIT WITH DUE RESPECT**

## COMPONENTS

### Resistors

| | |
|---|---|
| R1, R2, R3, R4, R5, R7, R9, R10, R13, R29, R30 | 10k (11 off) |
| R6, R8 | 330k (2 off) |
| R11, R12, R25 | 100k (3 off) |
| R14 | 8k2 |
| R15, R16 | 3k9 (2 off) |
| R17, R18 | 15k (2 off) |
| R19, R20 | 82k (2 off) |
| R21 | 56k |
| R22 | 33k |
| R23 | 22k |
| R24 | 1k2 |
| R26 | 47k |
| R27 | 39k |
| R28 | 4k7 |
| R31 | 10 |
| R32 | 560 |

All 0·6W 1% metal film type

See SHOP TALK Page

### Potentiometer

| | |
|---|---|
| VR1 | 10k rotary carbon, log. |

### Capacitors

| | |
|---|---|
| C1, C2 | 1μ radial elect, 100V (2 off) |
| C3, C7 | 10μ radial elect, 50V (2 off) |
| C4 | 1μ polyester layer |
| C5, C6, C9, C10 | 100n polyester layer (4 off) |
| C8 | 100μ radial elect., 10V |
| C11 | 4700μ radial lead elect., 16V |

### Semiconductors

| | |
|---|---|
| D1, D2, D3, D4, D5, D6, D7 | 1N4148 signal diode (7 off) |
| D8 | 5mm green l.e.d., low-current type |
| D9, D10 | Hyperbright (3·5cd) 5mm red l.e.d. (2 off) |
| TR1 | BC184L *npn* silicon transistor |
| TR2 | BC214L *pnp* silicon transistor |
| IC1 | TL064C quad op. amp |
| IC2 | 4070BE CMOS quad EX-OR gate |
| IC3 | LM324N quad op. amp. |
| IC4 | LP2950CZ +5V regulator, micropower type |

### Miscellaneous

| | |
|---|---|
| S1, S2 | S.P.D.T. right-angled p.c.b. mounting slide switch (2 off) |
| JK1, JK2 | 3·5mm p.c.b. mounting stereo jack socket (2 off) |
| JK3 | 2·5mm p.c.b. mounting mono jack socket |
| JK4 | 2·1mm p.c.b. mounting d.c. power socket |
| B1 | 9V battery pack, 1·5V AA cells (six off with battery holder) |

Printed circuit board available from *EPE PCB Service*, code 827; two-piece plastic case (with aluminium front and back panels), size 153mm x 84mm x 39·5mm; 2·5mm mono jack plug; 14-pin d.i.l. socket (3 off); 15mm diameter knob, or smaller; plastic cable tie for C11; solder; swimming goggles – see text.

*Approx cost guidance only* **£22** *plus batteries*

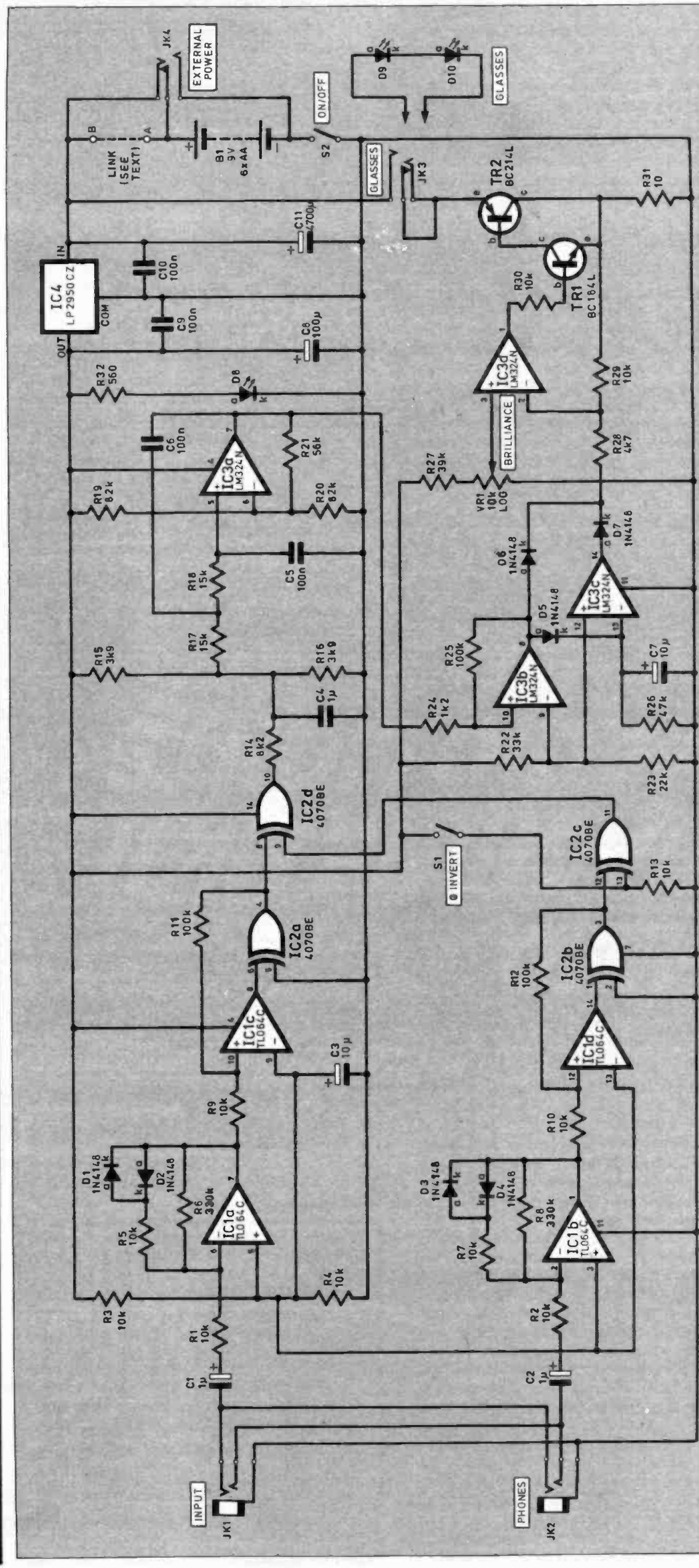



**Fig. 1. Complete circuit diagram for the Mind Machine MkII – Magic Lights Unit.**

Control VR1 is a "log-law" component since the eye, like the ear, has a logarithmic amplitude response. If the control is to appear linear, it must in fact have a log characteristic.

The latest hyperbright l.e.d.s D9 and D10, used in the glasses, each provide more light than the three used for each eye in the original *Mind Machine* project so only two are required, and these can be driven in series with a single output stage and a 9V supply.

The l.e.d.s are normally "on"; control is achieved by turning them "off" for the appropriate periods by applying a positive voltage to resistor R28. This pulls the inverting input of IC3d high so that it's output goes low and turns off the transistors.

The triangle-wave from IC3a is compared by IC3b with a reference voltage from resistors R22 and R23. Whilst it is lower than the reference voltage the output of IC3b is low, allowing the output stage to light the l.e.d.s. These are on for about 25 per cent of each cycle, this being generally accepted as the best ratio, and also allowing the l.e.d.s to be overdriven for increased brightness.

With this circuit it is possible, when the input signals stop, for the output from IC2d to remain low. This would result in the l.e.d.s being continuously "on" and, if the brilliance were turned up, might cause damage, not to mention heavy battery drain.

IC3c prevents this. Each time the output of IC3b goes high, it charges capcitor C7 through diode D5, and in normal operation the voltage across this capacitor, despite the discharge path through resistor R26, never falls low enough for the output of IC3c to go high. If the output of IC3b remains low, within about half a second the output of IC3c goes high and turns off the output.

The op. amp used for this part of the circuit, an LM324, was chosen because it's output can fall to within millivolts of the negative supply for effectively biasing diodes and transistors "off".

## POWER SUPPLY

Power is supplied by a pack of six "AA" size cells, which may be standard, alkaline or rechargeables. The output l.e.d.s are driven directly from the battery voltage, whilst the rest of the circuit is provided with five volts from regulator IC4. This is a "micropower" type, chosen because it can operate with an input only a fraction of a volt above the output, so extending battery life.

The unusually large value of decoupling capacitor C11 is intended to cope with the large low-frequency current pulses taken by the output stage. Resistor R32 and l.e.d. D8 remind the user that the unit is switched on.

## CONSTRUCTION

All the components of this project, including switches and sockets, are intended to be fitted directly onto the printed circuit board (p.c.b.), making assembly quick and simple and reducing the chance of errors. Whilst a different case could be used, with the sockets and switches panel mounted and wired to the appropriate points, the layout given does result in a very compact unit. However, the exact parts specified will have to be used if they are to fit.

The p.c.b. component layout and full size copper foil master pattern is shown in Fig. 2. This board is available from the *EPE PCB Service*, code 827.

Some of the holes on the board may need enlargement, notably those for the two switches, output and power sockets, the three for securing the unit to the case and VR1, which must be as close as possible to the board. Some of these holes, for VR1 and SK3, are better cut as slots than simply enlarged. This is easily done by gently pushing an appropriate drill bit sideways in them. This should be done and the items checked for correct fit before commencing assembly.

The link holes "A" and "B" behind socket JK4 allow for various external power and battery options. Initially this link is "made" by a track on the p.c.b. If ordinary batteries are to be used, it should be cut, so that plugging in an external supply results in battery disconnection. Alternatively, if rechargeables are fitted, it should be left intact so that a charger plugged into the socket is connected to them. The two holes allow for later changes of mind!

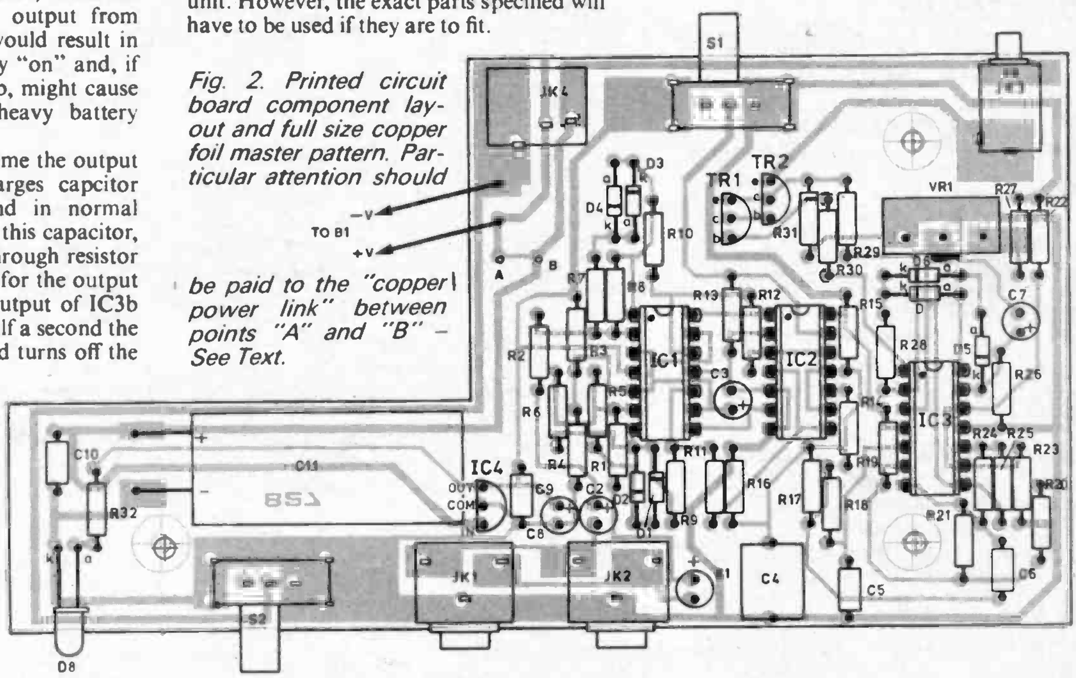
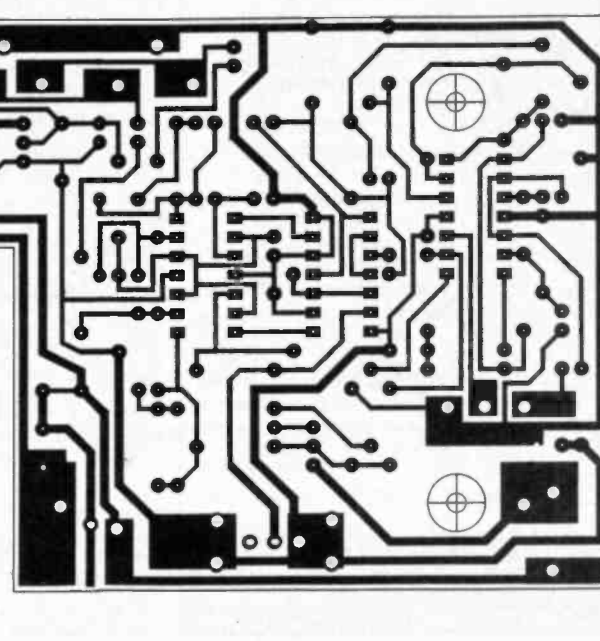
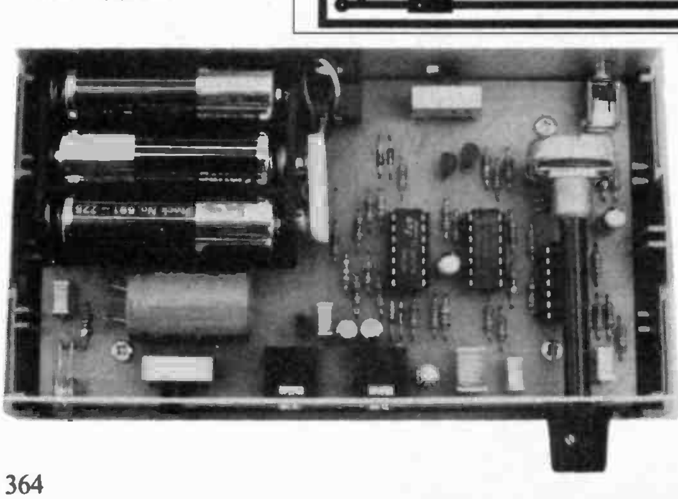



*Fig. 2. Printed circuit board component layout and full size copper foil master pattern. Particular attention should be paid to the "copper power link" between points "A" and "B" – See Text.*




*(Below) The completed unit showing the layout of components inside the case and positioning of the battery pack.*



## MOUNTING COMPONENTS

Once the supply options have been sorted out, all the components can be fitted. As usual, sockets are suggested for the three d.i.l. i.c.s, which should not be plugged in yet.

Jack sockets JK1 and JK2 have small plastic projections on their undersides, which prevent the solder pins projecting very far through the board. If it seems this will prevent good joints from being made these projections can be trimmed with a sharp knife.

Capacitor C11 should be secured to the board with double-sided sticky foam or a dollop of glue. Watch out for the polarities of the small electrolytics as C3 and C7 are the opposite way up to the others.

The leads of diode D8 are bent at right angles before soldering to the board so that it's horizontal centre is about level with that of switch S2, and it projects out about the same distance. It's cathode (k) is denoted by the flat on the body, this should be to the left, i.e. facing away from the switch.

## GLASSES

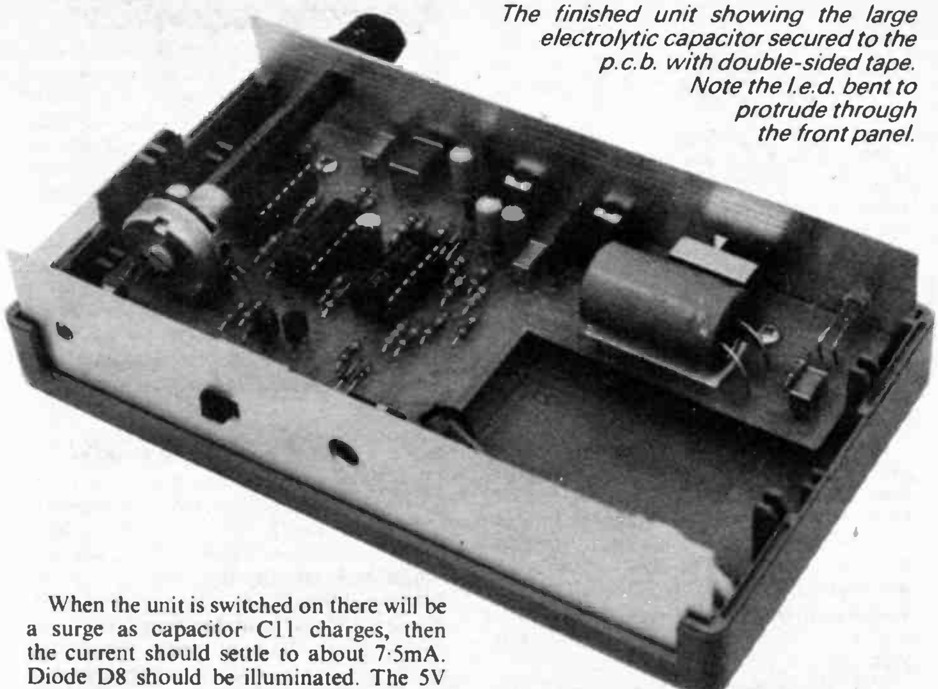
The glasses for the prototype were made from swimming goggles. The author has tried various methods of construction using safety goggles etc, but swimming goggles have been found to be the best. They are comfortable, and can position the l.e.d.s accurately.

The method of siting the l.e.d.s is to first adjust the goggles for a comfortable fit, then experiment with two small blobs of "Blu-tac" to find mounting positions for the lights where they will be exactly over the pupils. Holes are then drilled at these points for a tight press fit of the l.e.d.s which are wired as shown in Fig. 3. Any thin twin-flex may be used to connect them to the jack plug.

## TESTING

For testing, a suitable cassette recorder with a "binaural" tape should be available, with long sections of the lowest possible frequency. A special tape can be recorded for the purpose if necessary. A lead with a 3·5mm stereo plug on each end will be needed to connect the player to the unit.

The first check is to connect the player through the unit to the headphones to ensure the audio path is OK. Then power should be applied via the battery connector with a meter measuring the current drawn. At this point IC1, IC2 and IC3 should *not* be in place.



*The finished unit showing the large electrolytic capacitor secured to the p.c.b. with double-sided tape. Note the l.e.d. bent to protrude through the front panel.*

When the unit is switched on there will be a surge as capacitor C11 charges, then the current should settle to about 7·5mA. Diode D8 should be illuminated. The 5V regulator output should be checked, an easy point to find this is across pins 7 and 14 of the socket for IC2. When the unit is switched off diode D8 will take several seconds to extinguish as C11 discharges.

The TL064C op. amp IC1 should now be fitted, raising the drain by about 0·6mA. A d.c. voltage check of pins one and seven should show about 2·5V at each. If IC2 is now fitted, a check at IC1 pins 8 and 14, should be either high (about 4·5V) or low (about 0·6V), but not somewhere in between.

If the cassette player is now connected and the binaural signal supplied from it, these points should show an average d.c. level of about 2·5V, indicating that they are switching rapidly between high and low with practically equal mark-space ratios. If not, check with the headphones that a reasonable sound volume is actually being supplied to the circuit.

A check of the outputs of IC2 (pins 3, 4, 11 and 10) should similarly show an average 2·5V d.c. level, though with a low-frequency input difference pin 10 may show a visible flicker, as this is the recovered low-frequency output. This should be visible on most analogue meters.

The glasses will now be needed for further testing. IC3 should be inserted, requiring careful lifting of the shaft of VR1 as it fits beneath this. If the unit is now switched on with the glasses plugged in, VR1 set to about half-travel and a low frequency signal applied, the l.e.d.s should flash.

If they do not, the low-frequency flicker may be looked for at IC3 pin 7, centred around 2·5V, then again at pin 8, though here it should be high around three quarters of the time so the overall voltage should be a little higher. Pin 14 should be low so long as the input signal is present, and should go high when it is removed.

The total current drawn by the circuit with the input off or the glasses unplugged should be about 8·2mA to 8·3mA, although this will obviously increase when the output l.e.d.s are being driven.

## CASE DETAILS

The p.c.b. is a fairly tight fit into the case, so some modifications are needed to accommodate it. It is secured with self-tapping screws to three of the four pillars in the lower, grey half.

The remaining pillar must be removed to allow room for the battery pack. There are various ways to do this, one is to melt it off with a soldering iron, though care has to be taken to avoid this showing on the outside (and fumes)!

Two of the pillars in the top of the case need shortening too, these being above the battery and the one diagonally opposite, over the shaft of VR1. It should be noted

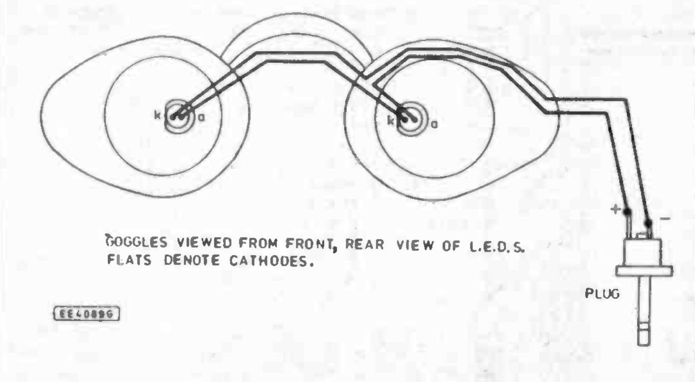
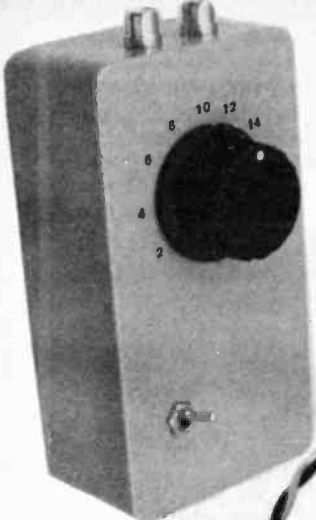
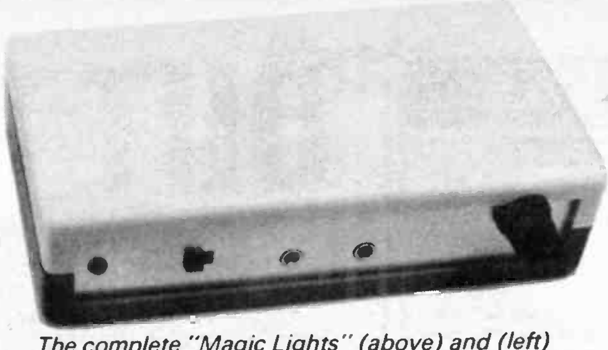


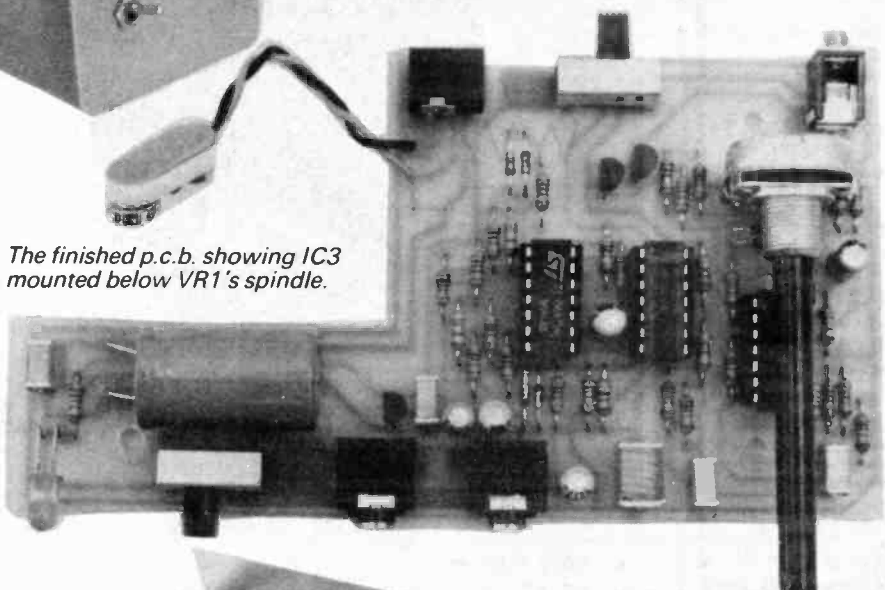

*Fig. 3. Wiring to the "hyperbright" l.e.d.s mounted in the glasses lenses.*

*The headphones and swimming goggles ready to relax the "patient".*

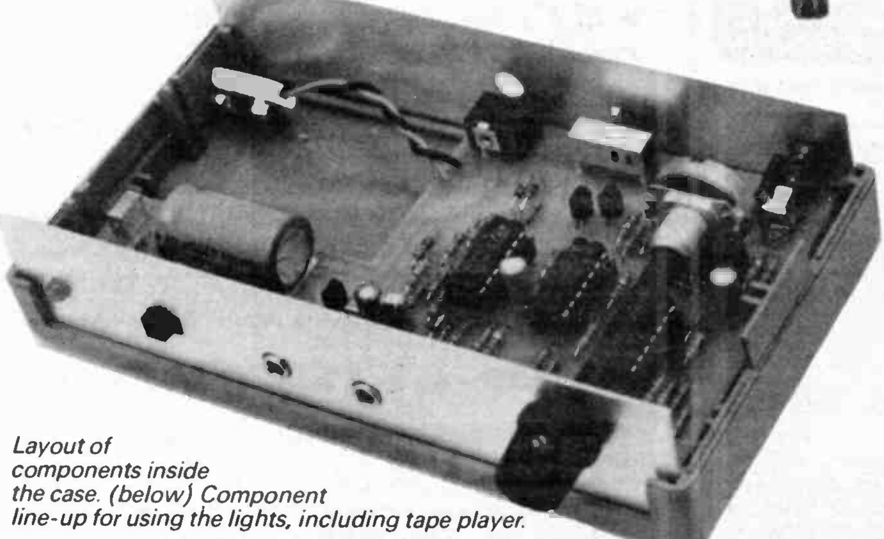




*The complete "Magic Lights" (above) and (left) the "Binaural Signal Generator" (last month) units.*



*The finished p.c.b. showing IC3 mounted below VR1's spindle.*



*Layout of components inside the case. (below) Component line-up for using the lights, including tape player.*

that the case halves only fit one way round, they are not symmetrical.

Finally, holes have to be cut in the front and rear panels for the sockets, controls and l.e.d. D8 to project through. A good way to mark these accurately is to screw the board in place, then fit a piece of card into the panel slots and use this to mark and transfer the horizontal centre lines to the actual panel.

Once the horizontal lines have been transfered, the panel can be slid into place until it rests on the components and the vertical centre lines marked. The holes can then be marked out and drilled and filed to shape. This obviously needs care and it could pay to practise on thick card first.

The control shaft of VR1 should project parallel with the p.c.b., through a hole in the panel, with sufficient length to attach the knob. The smallest knob found required a small semi-circular cutaway in the top half of the case for clearance. Sloping the shaft downwards so that it projects closer to the centre of the panel is not recommended as it just doesn't look right.

Once the panels have been cut, they can be slipped into place over the board and the assembly fitted to the case and secured with the self-tappers. A bit of foam plastic keeps the battery holder secure when the case top is snapped on, completing the project.

At this point it should be observed that the two metal panels will probably be in contact with the circuit through the metalwork of the sockets. The front will be connected to negative supply by JK1 and JK2, the rear to battery positive by the outer part of JK3 and possibly by the plug from an external power supply.

This means that the two panels should *never be* accidentally *shorted together* by contact with something metallic. However, it does make them handy points for checking the batteries! If an external supply is used, either for charging or operation, the centre of the plug should be negative and the outer positive.

## IN USE

Using the unit is simple. A suitable tape is inserted into the player and run, the headphone circuit is connected through JK1 and JK2, the glasses plugged into the socket at the rear and VR1 adjusted for comfortable brightness.

First-time users will probably see interesting patterns as the program progresses, although in the author's experience this effect wears off with repeated use. The deeply calming effect remains though, all one has to do is relax and let it work.

With these two units, the constructor has access to an entrainment tool as powerful as the original *Mind Machine*, though far simpler to construct and use. The one snag is that for best results the tapes should be individually recorded, which can be tedious.

However, there is even a way around this, although not quite as simple. A future article will describe an interface in use by the author for creating tapes with a computer. □

# Teach-In '93

with Alan Winstanley
and Keith Dye B.Eng(Tech)AMIEE

## Part 7

*Teach-In '93 continues a tradition of offering an interesting and thorough tutorial series aimed specifically at the novice or complete beginner in electronics. The series is designed to support those undertaking either GCSE Electronics or GCE Advanced Levels.*

PART SIX introduced the world of digital electronics which use logic chips as basic building blocks. These operate in terms of logic 1 or logic 0, or "high" and "low". Unlike analogue systems, digital logic is best suited to applications where clearly defined voltage levels or states are involved, rather than the continually varying signals met in analogue systems such as audio amplifiers.

### SNAP GAME

A fun application using logic gates is shown in Fig. 7.1. This "Snap" Indicator is a two-player game which clearly indicates who pressed their button first. No arguments! A pair of NAND gates are needed, which can be found in the 74LS00 chip we introduced last month. The truth table for the NAND is given below. Also see last month's issue.

*NAND GATE TRUTH TABLE*

| A | B | Q |
|---|---|---|
| 0 | 0 | 1 |
| 0 | 1 | 1 |
| 1 | 0 | 1 |
| 1 | 1 | 0 |

The truth table tells us that the gate output (Q) is only logic 0 when both inputs (A and B) are logic 1. The circuit of Fig. 7.1 uses two of the *Mini Lab* normally-closed push switches, one for each player. The circuit is symmetrical, so each gate system works the same way. Switch S1, being normally-closed, sends a logic 0 to one input of IC1a. Looking at the truth table, this means that the output must be logic 1 – it doesn't matter what state the other input is at.

This logic 1 output (roughly 5V) ensures that the l.e.d. D1 is extinguished, because there is no voltage drop across it. The same applies for D2. Also, either gate's high output is sent to the other input of the opponent's NAND gate, therefore with each NAND having a 0 and 1 input, a logic 1 output is guaranteed anyway. So both l.e.d.'s are off.

Pressing S1 opens it and allows R1 to pull up the input to a logic 1. Now both inputs of IC1 are logic 1 so the output goes to logic 0 which lights the l.e.d. to indicate the winner. Also, the output sends a logic 0 to the input of IC1b, which means that its output remains high since its inputs, previously 0 and 1 are now both logic 0. Pressing S2 has no effect on IC1b output. Hence the opponent's l.e.d. is locked out and cannot light so long as S1 is pressed. The circuit automatically resets itself as soon as Player One releases his/her switch.

We can see how a digital system like this is perfectly suited to processing digital input signals – after all, we're simply interested in the "closed" or "open" state of the two push switches, and the "win" or "lose" status of the players. An analogue system using transistors or perhaps thyristors could undoubtedly be built but a logic gate system is a perfect choice here.

It is fairly straightforward to assemble this on the *Mini Lab* breadboard using the pin-out diagram for the 74LS00 given last month. Use the +5V rail of the *Mini Lab* Power Supply to power the chip, and simply connect the logic gate pins using short lengths of solid core hook-up wire on the breadboard. Follow the pin numbers carefully using the circuit diagram as a guide, since some of the layout might become a little cramped.

The two light-emitting diodes can be fitted directly onto the breadboard and two of the *Mini Lab*'s normally-closed switches can be conveniently hooked up as usual. If it doesn't work, thoroughly check the pin-outs – and are the l.e.d.'s correctly orientated? Have fun.

### TIME DELAY

A further enhancement would be to build the circuit of Fig. 7.2(a) to form a time delay indicator. This uses a new chip for us, the 74LS14 which is a Hex Schmitt inverter. "Hex" in this case means that there are six of them in the chip. We met the Schmitt trigger when we checked out operational amplifiers. Recall that it's a circuit which converts a slowly moving voltage into a very rapid snap-action switch. In the circuit of Fig. 7.2(a), an *RC* network starts charging as soon as the pushswitch S3 is released. At this time a logic 0 is present at the input of the inverter, so its output is a logic 1.

The 74LS14 Schmitt trigger has a threshold voltage of about 1.6V and this is more consistent than a normal inverter or NOT gate, which could trigger at anything from about 0.8V upwards. When the voltage

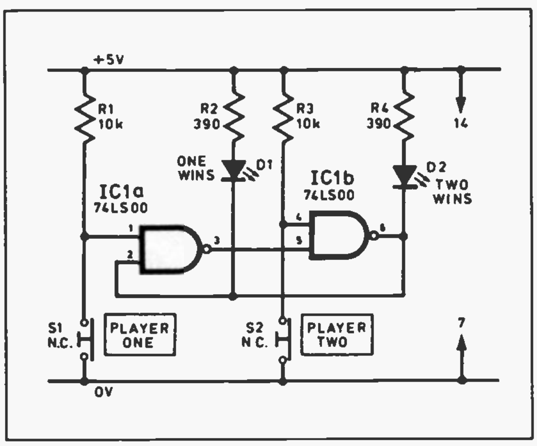



Fig. 7.1 "Snap" indicator game.

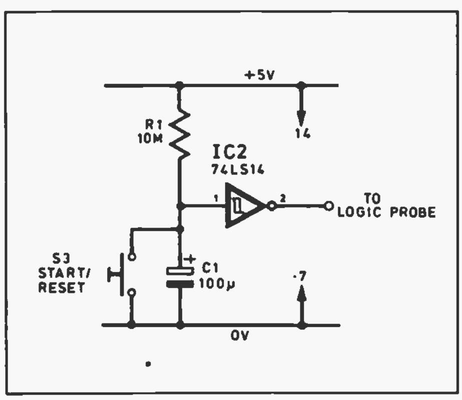



Fig. 7.2a. Time delay indicator.

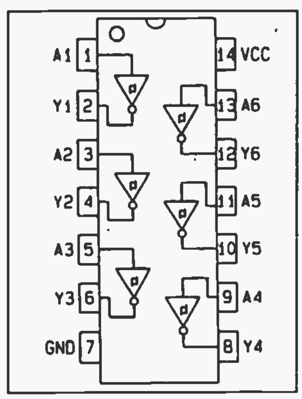



Fig. 7.2b. 74LS14 Hex Schmitt pin-out.

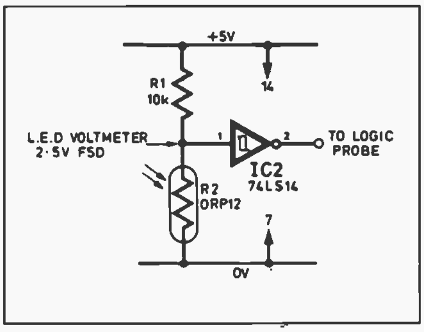



*Fig. 7.3a. Light-sensor analogue-to-digital interface.*

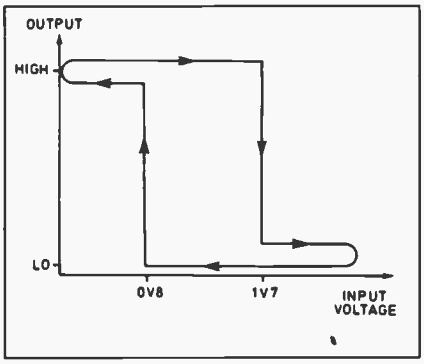



*Fig. 7.3b. Schnitt hysteresis curve.*

at the Schmitt inverter input reaches or exceeds 1.6V, this is treated by the Schmitt as a logic 1, so its output goes LOW. Obtain the appropriate chip and build this on the *Mini Lab*, next to the "Snap" Indicator assembled earlier. It's very easy and the pin-out in Fig. 7.2(b) will be useful. Hook pin 1 over to the third push switch on the p.c.b., and connect the inverter output (pin 2) to the Logic Probe.

Pressing S3 sends a logic 0 to the Schmitt inverter, so the Logic Probe changes to indicate a 1 at the Schmitt output. Release S3: nothing should happen for five or six seconds (as measured in our test) when the Logic Probe changes to indicate a LOW – in other words the input of the inverter has now gone high because its threshold voltage has been reached by the charging capacitor. Vary the capacitor value to alter the period.

This circuit can't produce very accurate delays because of the very high leakage current on the large electrolytic capacitor C1, which also has a very wide tolerance on its value. However the circuit demonstrates the action of the TTL logic version of the Schmitt Trigger. Use it as a reaction timer with your "Snap" Indicator – as soon as the logic probe changes over, the first to press their button is the winner. We'll build a more advanced digital version later on.

## TRANSDUCERS

The Schmitt trigger is also available in the form of a NAND gate (the 74LS132) – remember that a NAND gate with both its inputs wired together, forms a NOT gate or inverter – see last month. Either the 74LS14 inverter chip or the 74LS132 could be used to interface an input transducer to a digital circuit. A suitable l.d.r. like the ORP12 can be used with a Schmitt inverter to generate a logic signal from a slowly varying input.

The circuit of Fig. 7.3(a) shows how a light-sensitive digital switch could be assembled in this way. It is obviously much simpler to understand than the op-amp version shown in Part Five, though the switching threshold is predetermined up to a point by the inverter, so it's less easy to customise the design. We can determine the threshold voltage by monitoring the input level with the L.E.D. Voltmeter.

Construct this on the *Mini Lab* using one of the Schmitt inverters found in the 74LS14, or use a Schmitt NAND from the 74LS132 if you have one to hand. Using the 5V rail, connect the output to the Logic Probe, and wire the L.E.D. Voltmeter as shown (2.5V scale), to measure the voltage at the inverter's input. Cover the l.d.r. as necessary to vary the input voltage. The experiment works best in strong light and a short tube of cardboard placed over the ORP12 improves sensitivity. It should also be possible to build everything on a single Veroblock breadboard though the Euro breadboard (if fitted) allows you to spread out a bit more.

How high does the input voltage have to rise before the logic probe changes to "LOW"? (We measured 1.7V or so.) Similarly, to what voltage does the input have to fall before the input changes to "HIGH" again? (Roughly 0.8V.) The 74LS14, like all Schmitt triggers, has the property of **hysteresis**, which is the difference in the two switching thresholds. The input has to rise to 1.7V or higher, then fall back to 0.8V or lower for the inverter to switch over, so the hysteresis is typically 0.9V.

The typical characteristic curve for this l.d.r. circuit is shown in Fig. 7.3(b). It also explains why there is generally that funny sign within the Schmitt schematic symbol: it resembles the hysteresis curve.

Exactly the same principle could be used to form a temperature-sensitive switch with a thermistor to obtain a logic signal from a slowly-moving temperature dependent analogue waveform. So although logic systems prefer to function with distinct high or low levels, it is quite possible to interface analogue signals to a digital circuit using a Schmitt trigger.

## OUTPUT INTERFACE

Similarly we can interface digital logic chips to a variety of output transducers – like the light-emitting diodes of our "Snap" indicator. We explained last month that TTL logic gates aren't very good at driving loads themselves, so although a gate output may be high, it is only capable of sourcing a few milliamps. They are somewhat better at sinking current (say 8mA or so) but they need an output buffer to drive really heavy loads like a relay or a lamp.

The *Mini Lab* power transistor can be used effectively here because it's a high gain Darlington transistor which needs a base voltage of 1.4V to saturate. Fig. 7.4(a) shows how to drive a load from a gate using the Darlington. A 10k base resistor limits the base current to a reasonable value, and the Darlington will saturate when the TTL output is logic 1.

Another idea is shown in Fig. 7.4(b) which uses a potential divider across the output of a gate, and drives a normal *npn* bipolar transistor. When the output is high then the voltage at TR1 base will be about 0.7V which will turn on the transistor and its collector load. The resistor values are not too critical because the transistor gain ($h_{FE}$) varies widely between samples in any case. Using a potential divider like this is an excellent way of turning on a transistor reliably because the buffer then doesn't rely solely on the $h_{FE}$ of the transistor.

Note that whilst the TTL *gate* must be driven from the 5V power supply, it's O.K. to return the *collector load* to a higher voltage than this, with reference to 0V. In Fig. 7.4(b) the relay is powered from 6V provided by the Variable Power Supply, and the TTL gate is driven from the 5V rail as usual, so everything is happy. Use the buzzer or relay as a load for the Darlington transistor and construct the buffer of Fig. 7.4(a) on the breadboard, to drive the buzzer from either of the inverter circuits given earlier.

Substitute the Darlington for the transistor driver circuit of Fig. 7.4(b) and confirm that it works. Recall that if you use the *Mini Lab* relay, it is imperative that it is correctly orientated to take account of the back-e.m.f. diode which was incorporated in Part Two. In general terms, relay contacts could be used to control still heavier loads such as mains-operated circuits, but you must never connect any mains or high-voltage systems to the relay mounted on the *Mini Lab* p.c.b.

The load could actually be connected to an even higher voltage – providing that the load and transistor ratings are not exceeded. You could, for instance, drive a 12V load (e.g. the two 6V bulbs wired in series) simply by connecting the load to the 12V rail instead of the 5V TTL rail, thereby obtaining a higher drive voltage for your load. The 5V rail is a bit low to drive some loads, but by level-shifting it to a higher voltage, this restriction is removed. The *Mini Lab* will provide up to nearly 20V if needed, from its Variable Power Supply.

## MEMORIES

The area of combinational logic, which we introduced last month, uses logic gates to form logic systems, the outputs of which are simply dependent upon the current states of the inputs, nothing else. Changing an input may or may not change the output, depending on the system's truth table. Take a look at Fig. 7.5(a). It looks quite straightforward, and is an example of *sequential logic*. This not only looks at the current combination of the input levels, but it also takes into account their history as well.

Two NOR gates IC1a and IC1b from a

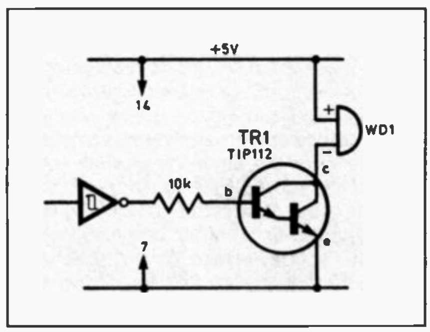



*Fig. 7.4a. Driving a load through a buffer.*

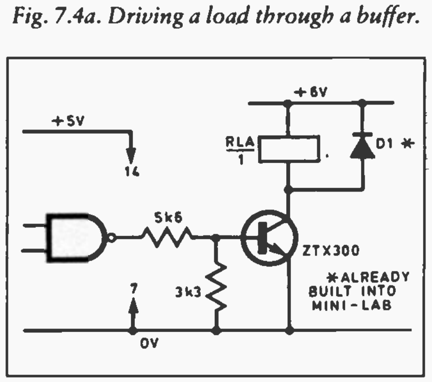



*Fig. 7.4b. Using a bipolar transistor to buffer a gate.*

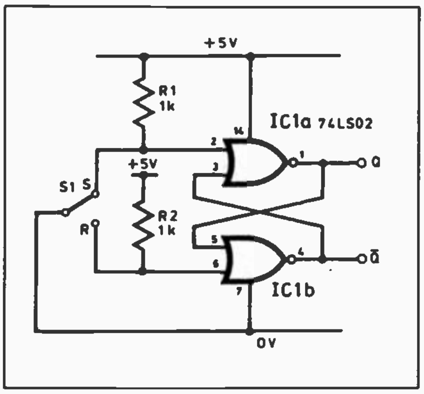



*Fig. 7.5a. Bistable of "flip-flop".*

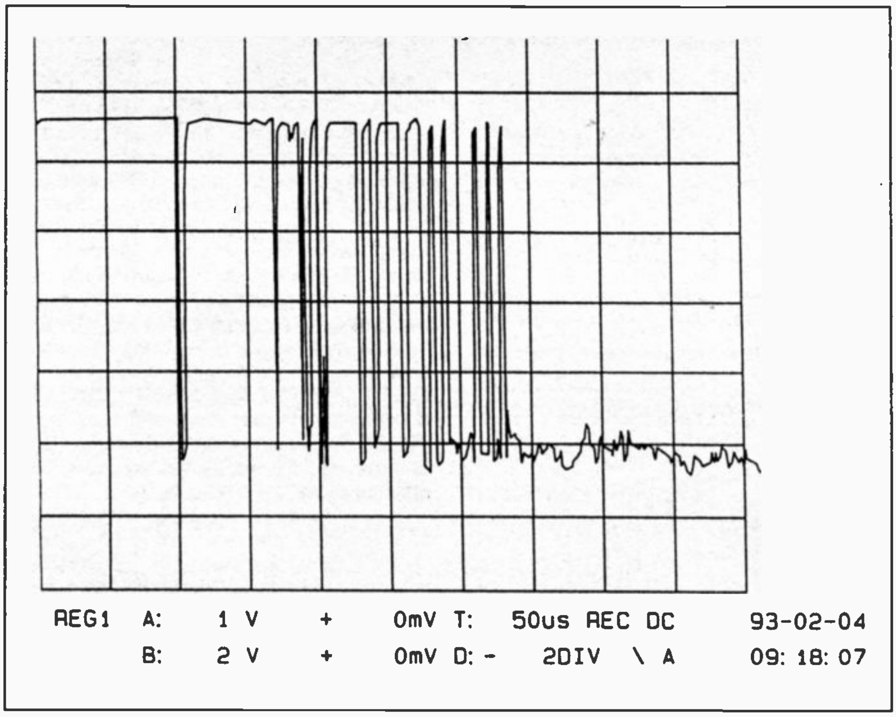



*Fig. 7.5b. Switch bounce observed on the* Mini Lab.

74LS02 are used in a symmetrical cross-coupled connection. Ignoring the switch, one of each NOR gate's inputs is pulled up with a resistor to Logic 1. From the truth table of the NOR gate (last month) we can say straight away that the output of each NOR gate must thus be a Logic 0, regardless of the state of the other input. This Logic 0 output in any case is cross-coupled to the other NOR gate's input, so each NOR gate must definitely be Logic 0, because the inputs are pulled up to logic 1 through the resistors, and logic 0 from the other gate's output. However, there's a complication.

We have added a changeover switch S1, which shunts either of the pulled-up inputs down to Logic 0. We have also labelled the two NOR outputs as Q and Q̄. Recall that the overbar means "invert". In logic it also means the "complement" or opposite. So Q̄ is always the complement or opposite of Q. Note too that we labelled the "poles" of the switch as S and R. These connect to the pull-up resistors. What effect does that switch have? Lots! Let's take it step by step.

With the switch set as shown to S, this sends a logic 0 to IC1a. Over at IC1b, its input is pulled up to logic 1 by R2, so the Q̄ output goes to logic 0 (NOR gate truth table). IC1a then has a logic 0 S input and a logic 0 from the Q̄ output, so the Q output is a logic 1. *Conclusion: in this circuit, with S at logic 0, Q output is 1 so Q̄ is logic 0.*

Changing over the switch sends a logic 0 to the R input this time. Meanwhile the S input is allowed to pull up to logic 1 so the Q output changes to a logic 0. This is also sent over to IC1b which now has a logic 0 at both inputs: Q̄ changes to a logic 1. *Conclusion: when the R input is logic 0, the Q output goes to logic 0 so Q̄ the output goes high.* Reversing the inputs once more, changes the Q and Q̄ to their previous state.

Try building this circuit using two NOR gates from a 74LS02. Preferably use a wire link to make either the S or R input low in succession. Use the logic probe on the two outputs to see what happens every time you change over input status.

This circuit clearly has two stable states – it's called a **bistable** or **"flip-flop"** and it's a fundamental element of sequential logic systems. (Recall our work with 555 timers which demonstrated the "monostable" or one shot, and the "astable" or free-running mode.) Once the flip-flop has been "set" by sending the S input low, it remembers that state until the flip-flop is reset by sending the R input low. The flip-flop acts as a **memory** in the same way that a conducting thyristor "remembers" its state until you reset it. This bistable circuit is known therefore as the set-reset or SR (or RS) flip-flop. A 74LS279 contains no less than four of these S-R bistables.

## REGISTER

Another word for a memory is a **register**. This simple flip-flop could form a register which is capable of memorising one binary digit or **BIT** (i.e. either 0 or 1) – so it would be a one-bit register. If we ignore the Q̄ output for now, the flip-flop Q output could be seen to alternate or "toggle" between 0 and 1 every time you reset or set it. The register memorises or "latches in" the current state. It's the basis of computer memory. Exercise: prove that a pair of NAND gates could form an S-R flip-flop too.

The flip-flop is especially useful in interfacing mechanical switches to logic circuits. You probably think that switches are either on or off. In reality, switch contacts are made of a springy metal and often the contacts trampoline several times before settling down to their designated position. In high speed logic circuits, this contact bounce can cause chaos: pressing a button just once can actually generate multiple erroneous signals. We managed to capture this effect using one of the *Mini Lab* push switches on our test equipment, see Fig. 7.5(b).

"Noisy" switch contacts on say a radio or hi-fi, manifest themselves with an audible crackle over the loudspeaker, every time you operate the switch. Early calculator keyboards of the mid 1970's suffered terribly from switch bounce, resulting infuriatingly in a whole string of digits being entered accidentally. (This somewhat offset the new-found novelty of writing "SHELLOIL" on your new seven segment display, held upside down!)

A good way of overcoming switch bounce is to utilise a flip-flop, placed between the switch and the logic system: the first contact bounce is enough to toggle the flip-flop which then ignores any subsequent transitions.

## CLOCK

A more versatile version of the flip-flop is shown in Fig. 7.6. This uses the same NOR gates to form a bistable as before (though NAND gates could be used instead), but extra logic has been added to the input in the form of a "gating" system made with two AND gates. There are still two input terminals S and R, but now we have added a third input called **CLOCK**. The clock signal actually forms an **Instruction** to the system to tell it to "read" the states of the Set and Reset inputs, and switch the output Q according to the truth table of the system.

As is often the case, the best way of learning about it is to observe it by constructing the system on the *Mini Lab*. The circuit diagram clearly shows the pin-outs of the various gates, noting that you will require

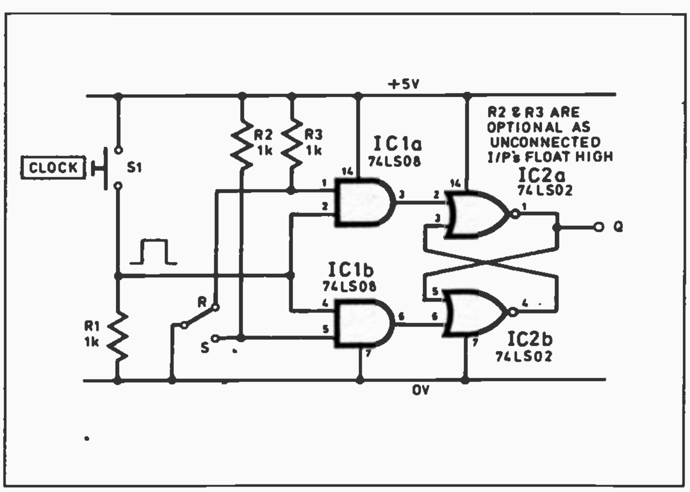



*Fig. 7.6. Clocked SR flip-flop.*

## CMOS v. TTL

Our *Teach-In* experiments have used standard TTL (transistor-transistor logic) chips to demonstrate basic logic principles. These chips use bipolar transistors and so they are thirsty for current and require a reasonable stable 5V supply.

The Digital Display module in the *Mini Lab* however makes use a CMOS BCD-Decoder Driver chip, the 74HC4511. This is a CMOS 74-series equivalent of its sister in the competing 4000 CMOS family, the CD4511.

The CMOS logic family (the 4000 series) sprang up in the late 1970's as one manufacturer's answer to 74 bipolar TTL logic. CMOS logic has some good points, particularly its very low quiescent current and zero input currents (refer to the section "F.E.T.s" in Part Five) compared with TTL, plus a more tolerant supply voltage requirement. Hence CMOS is widely used in power-sensitive applications like battery-operated projects. But like most CMOS devices, it is *static sensitive* and requires special handling precautions.

The 74HC series of CMOS devices was produced as a response by TTL makers. These are in effect CMOS versions of earlier 74-series TTL devices, so that they could compete with 4000 CMOS types. Looking through a component supplier's catalogue, you will see a bewildering array of logic chips and families. Here's a brief run-down:

**CD4000** series – the original CMOS logic chip family, still available today.

**74XX** series – the original TTL, for use in basic circuits where speed and power consumption isn't important. Now considered obsolete, but still perfectly usable for basic circuits and experiments.

**74LSXX** – the Low Power Schottky version, used in our experiments. Consumes only 20 per cent of the power that an original 74XX gate does.

**74ALSXX** – Advanced Low power Schottky has twice the speed and half the power consumption compared with 74LS.

**74CXX** – the original CMOS version of 74-series TTL logic, and broadly pin compatible. Since superseded by **74HCT** logic - High Speed CMOS versions. In our own circle, it's quite acceptable to use 74LS (bipolar) or 74HCT (CMOS pin-compatible version) families from the TTL stable, or the CMOS 4000 series as an alternative. It depends on the speed of operation and power consumption you desire.

There are some differences in the way you use the various families of logic chips. 4000 series CMOS devices are not necessarily compatible with TTL because of the different threshold voltages the families may have, so some level-shifting might be needed. Also, CMOS chips need any unused pins to be tied firmly to a supply rail and not left floating like we have with our TTL experiments. Finally of course, CMOS chips need special anti-static handling precautions.

a 74LS08 AND gate chip and a 74LS02 NOR chip. We have also used a changeover toggle switch to send either set or reset to Logic 0. (Note that a TTL input which is left unconnected or "floating" actually assumes a Logic 1, so we didn't use pull up resistors this time.)

Tip: when your toggle switch is pushed upwards (pointing at the power supply), the pins marked C and N/C (Common and Normally Closed) are the ones which are connected together. Switching the toggle over towards the loudspeaker joins the pins C and N/O (Common and Normally Open) instead. This is relevant when you need to know whether the Set or Reset terminal is the one connected to 0V at the moment.

One of the normally-open push switches is used with a pull-down resistor to generate a suitable clock signal. Pressing the switch sends the clock signal high to logic 1, otherwise it's at Logic 0. Connect the Q output (pin 1 of IC2a) to the Logic Probe. It goes without saying that pin 4 of IC2b would be the $\bar{Q}$ output of the flip-flop – the opposite of Q – so we won't monitor it here.

Check your wiring most carefully - are all the pins interconnected as required, and is the 5V power supply correctly applied? If so, switch on the 5V rail and the 12V supply for the Logic Probe. Press the push switch to apply a clock pulse: the Logic Probe may or may not change over the first time. Change the toggle switch over then apply a clock pulse: now the Q output should be seen to change states. Now pressing the clock repeatedly should make no difference.

The Q output will only change state once the S/R toggle switch is changed over. Then the clock pulse forces the bistable to change states. Clocking the circuit again makes no difference: you have to change the toggle switch again before the clock pulse will allow the Q output to change. Try to draw the truth table yourself.

Now keep the clock switch *pressed down* to apply a full-time logic 1 clock signal. Toggle the Set/Reset repeatedly. The Logic Probe will show that the Q output is now changing over in sympathy with the S/R input signal. Recall that a floating TTL input assumes Logic 1. Prove that when Reset is 0 (so Set, floating, is 1) then Q is high at logic 1. Conversely, when Reset is 1 (so Set is 0) then the Q output is low. If you're with us this far – well done!

The way in which the AND gates control the bistable is quite straightforward: the clock input and also either the Set or Reset input needs to be high before the S-R flip-flop changes state. The Set and Reset pins tell the flip-flop **what to do**, but the clock tells it **when to do it**. The clock forces the latch to *read the data* at the Set and Reset pins and change over the Q pin as required. This circuit is therefore called a **clocked Set-Reset flip-flop**.

Because of its ability to "read" data at the S/R pins, it's quite useful – more than the basic flip-flop we met initially. A drawback with this particular type is that when the clock is permanently high (the clock switch pressed down), the Q output will see right through back to the input of the circuit and switch over accordingly. Thus the circuit is also called a "transparent" latch. You proved this when you kept the clock switch pressed down whilst changing the Set/ Reset states.

## TRUTH TABLE

The truth table needs to reflect the fact that the output follows a sequence which depends on its previous state: this is different from a simple logic gate where the output simply depends on the combinations of logic levels on the inputs.

| SET | RESET | Q BEFORE CLOCK | Q AFTER CLOCK |
|---|---|---|---|
| 0 | 0 | Qn | Qn |
| 1 | 0 | Qn | 1 |
| 0 | 1 | 1 | 0 |
| 1 | 1 | 0 | ??? |

So we now have the ability to "read data" when a suitable clock signal is received. The above circuit forms the most basic of registers and is not quite as versatile as you might think: depending on the Set and Reset data, the Q output can change states whenever the clock input is high, giving that "transparent" effect.

This means that in order to use the register as a memory system, you would have to make sure that the clock signal was of an appropriate time period, otherwise you could be caught out if the Set and Reset pins changed states when the clock was at logic 1. In this way, the clock system **enables** the register whenever it is logic 1. In large-scale systems, trying to synchronise all those clocks to avoid accidental memory changes, is a headache!

A better system would actually ignore the *length* of the clock signal, and simply goes by the **edge** of the clock pulse. As soon as an edge (a change from low to high or vice versa) is received, this instructs the digital system to perform an operation. After changing states, the system ignores the length of the pulse and waits until another suitable edge signal is received at the clock terminal: then the system obediently follows its truth table.

As you have probably seen, using several TTL gate chips in order to create a register – or any other digital system – is a bit tricky, and thankfully i.c. manufacturers quickly created a whole range of logic chips which in essence contain ready-made gate systems, registers, latches and a whole lot more, you name it!

Fortunately it is quite in order to treat these chips as simple black boxes, and in our case their internal operation is irrelevant, and being realistic, there is little to gain except academic satisfaction in trying to create these chips using separate logic gates. So "black box" approach it is from now on. At this stage, you may well wish to construct this month's *Mini Lab* module – the Digital Display – so go right ahead. You will need it soon.

## D-TYPE

Introducing yet another TTL device: the 74LS74, officially described as a **Dual Positive-Edge-Triggered D-Type Flip-Flop.** "Dual" means that there are two flip-flops in one single d.i.l. package. "D" means **Data.** They are versatile in that they have *edge-sensitive* clock circuits, symbolised by the lopsided triangle in the symbol of Fig. 7.7(a).

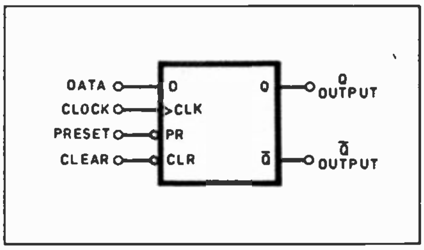



*Fig. 7.7a. "D-type" flip-flop.*

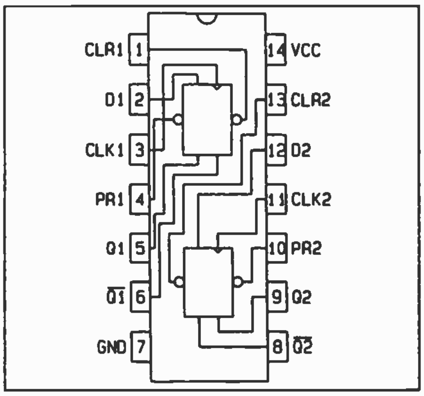



*Fig. 7.7b. 74LS74 dual D-type flip-flop pin-out.*

The **Data** (logic 0 or 1) on the "D" terminal is read by the flip-flop every time a positive-going edge signal is received at the clock terminal. The flip-flop then transfers this data over to the Q and Q̄ outputs, with Q being the same as Data. Two further inputs "Preset" (PR) and "Clear" (CLR) behave like Set and Reset pins respectively. A logic 0 on either pin will Set or Reset the outputs, regardless of the state of all the other inputs. This is signified by the "negation" circle on the PR and CLR terminals, so fix both pins at logic 1 to enable the flip-flop.

You will need two of these devices, which gives you four D-type flip-flops. Pin-outs are shown in Fig. 7.7(b). Build the circuit shown in Fig. 7.8 on your *Mini Lab* – it's easy. A push switch with pull-down resistor provides a suitable clock signal, whilst Data is provided by a changeover toggle switch. Connect the Q output to the Logic Probe, and switch on the 5V and 12V rails. (Recall the Q̄ output is the complement or opposite of Q).

With Data of 1, this appears at the Q output when the clock switch is pressed: notice how it happens immediately the switch is closed, which sends a positive edge to the clock. Nothing else happens until another positive edge is sent, when

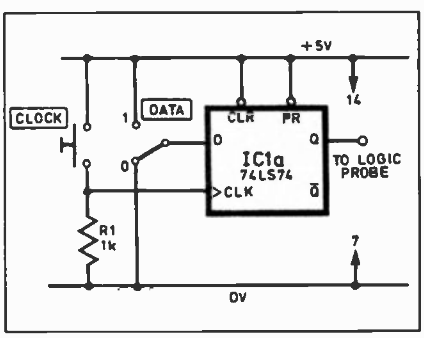



*Fig. 7.8. Demonstration of the "D-type" latch.*

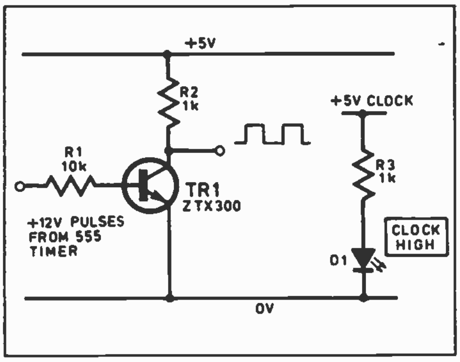



*Fig. 7.9a. 12V to 5V TTL interface, for the 555 Timer.*

the Data (either 0 or 1, whichever way the toggle switch is set) will be read and stored and sent to the Q output. More of this shortly.

## CLOCKS

Pressing a switch is one way of providing a suitable clock pulse for demonstration purposes. The problem is that switch contact bounce may cause erroneous clock signals to be transmitted – the logic is quite capable of reading these fast, false signals and acting on it. By using an oscillator circuit or square wave generator to provide continuous clock signals, we can create an electronic clock signal which doesn't cause any false signals to be generated.

The NE555 astable circuit provides a stream of pulses which can be utilised as a clock, to save you having to repeatedly press the switch. The *Mini Lab* Timer uses a 555 astable, but it is *very important* to remember that it functions from 12V, not the 5V rail used by TTL logic, and so produces 12V pulses which can't be used directly on our 5V TTL systems.

It's easy to interface the 555 to TTL Logic by using a simple level-shifting circuit, such as the simple transistor circuit of Fig. 7.9(a). This can readily be built on the breadboard, testing the output with both the L.E.D. Voltmeter and the Logic Probe to confirm that the 12V square wave from the 555 is shifted to a TTL-compatible level.

Also, remember that the 8038 Signal Generator provides a 5V square wave (pulled up to +5V), so you're spoilt for choice. The 8038 has the option of varying the mark-to-space ratio, but this has no effect with edge-triggered circuits, where only the positive-going *edge* has any effect, not the *period* of the pulse itself. In fact there are yet more ways of generating suitable clock signals. Fig. 7.9(b) shows how a single Schmitt inverter from a 74LS14, which we met earlier, can be used with an RC network to generate clean square waves, suitable for clocking. C could be anything from 0µ1 to 100µ or more, R might be up to 10k or more. Anyone with access to an oscilloscope can experiment.

Reverting to our D-type flip-flop, remove the clock push-switch and instead use the 555 via the transistor interface, to provide a stream of 5V clock pulses. Use the lowest frequency settings on the generator controls. The l.e.d. on the *Mini Lab* Timer shows when the 555 output is high, but confusingly the transistor *inverts* this to a low signal. Hence we added the l.e.d. D1 in the transistor buffer, which lights whenever the clock is high, to make it easier to monitor the clock.

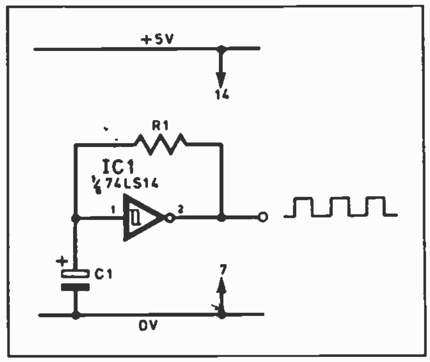



*Fig. 7.9b. Using a Schmitt inverter to generate clock pulses.*

Now the D-type flip-flop is clocked automatically by the 555 astable module and it will read the Data at the D terminal every time a clock is received. Toggle the Data setting between 0 and 1, and watch this transfer to the Q output (Logic Probe) every time a clock rising edge is received.

## AROUND AND AROUND

The circuit of Fig. 7.10 shows a D-Type flip-flop where the Q̄ output is fed back to the Data input, instead of reading data from an external source. This has an interesting effect. Construct this now on your breadboard using one half of a 74LS74, and hook up the Logic Probe to the Q̄ output, pin 6. Life becomes complicated with several l.e.d.'s to monitor, so concentrate solely on the "clock high" l.e.d. in the transistor buffer, and the "HIGH" l.e.d. (middle) in the Logic Probe. Switch on the 12V and 5V rails. Run the 555 timer at its lowest frequency.

You will notice that the "HIGH" l.e.d. will be flashing half as quickly as the "CLOCK" signal. The clock goes high which makes the Q̄ go high, then the clock goes low but nothing else happens until the clock goes high again – another positive edge is received – when the Q̄ output goes low once more. It's readily summarised in the **timing diagram** of Fig. 7.10(b).

When power is first applied, assuming the Q output is 0 so the Q̄ is 1, this means that Data is 1 too. When the first clock edge is received, Data 1 is read into the flip-flop, so now Q becomes 1 and the Q̄ and Data become 0. The Q̄ stays like this until the next positive-going clock edge is received.

## DIVIDE BY TWO / FOUR / EIGHT

This implies that the clock must now go through *the whole of its period* – the time when it is both high *and* low – before the

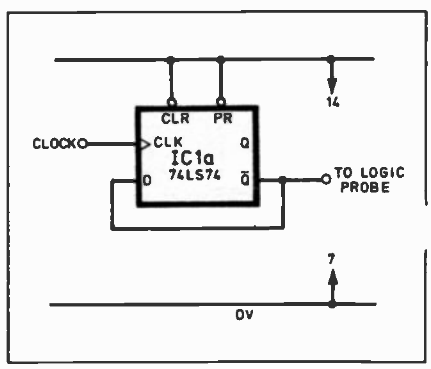



*Fig. 7.10a. Divide-by-two function using a D-type flip-flop.*

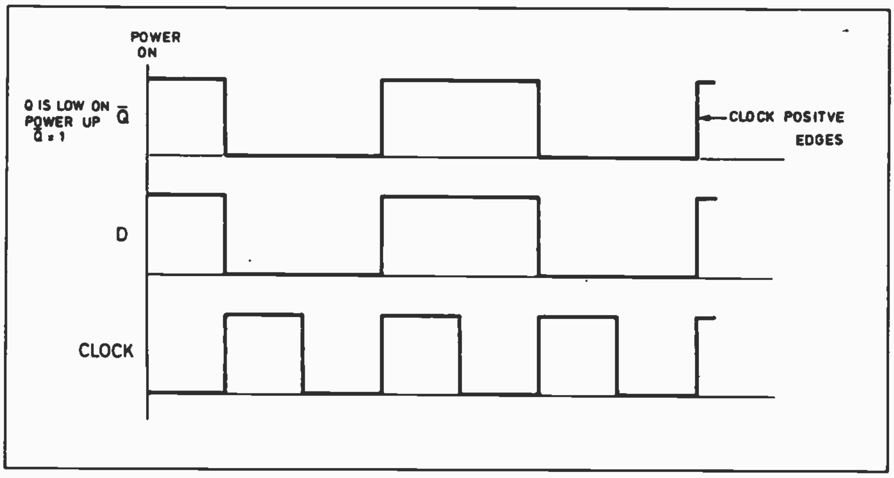



*Fig. 7.10b. Timing diagram of the divide-by-two circuit.*

next rising clock edge is received. Then the Data 0 is read and this makes the Q output go to 0 so Q̄ and Data become 1 again. Result: the outputs change over only once the clock has gone through a complete cycle. This circuit acts as a **Divide-by-Two Counter** the output of which is half the frequency of the clock signal.

It's still true that the circuit doesn't really care about time *periods* and is much more concerned with *edges*. The divided signal which is generated at the Q̄ output can itself be used as the clock to a *subsequent* divider which will divide again by two. Try to build the circuit of Fig. 7.11, which will divide your original clock signal by four. The best thing to do is to position the three light-emitting diodes (clock, Q̄1 and Q̄2 outputs) so that they are adjacent to each other anywhere on the breadboard; you will then see the counting pattern clearly. Adjust the clock frequency as required.

Now we become a little more ambitious. Insert a second 74LS74 circuit to give a ÷8 and 16 effect as outlined schematically in Fig. 7.12. Connecting the output of one flip-flop into the clock of subsequent counter produces a **ripple** counter, where the waveform is repeatedly divided down by each subsequent section. The data shuffles or "ripples" down the row of registers, here dividing by two every time. Now we take a closer look at the outputs.

Use four light-emitting diodes and connect one to each of the Q outputs (*not* the Q̄ outputs). The wiring becomes a little complicated, so use sticky labels if necessary to label the four output leads Q1 to Q4. If at all possible, try to use high-efficiency (ultra-bright) l.e.d.'s for the four indicators because these will provide a much brighter signal as the drive capabilities of the registers are poor. Normal l.e.d.'s will just about suffice though. Place them in the right order in a prominent position on your breadboard.

After turning on the 12V and 5V rails, you should see a pattern emerging on the row of light-emitting diodes, like that in the following truth table where a "1" signifies an illuminated l.e.d.

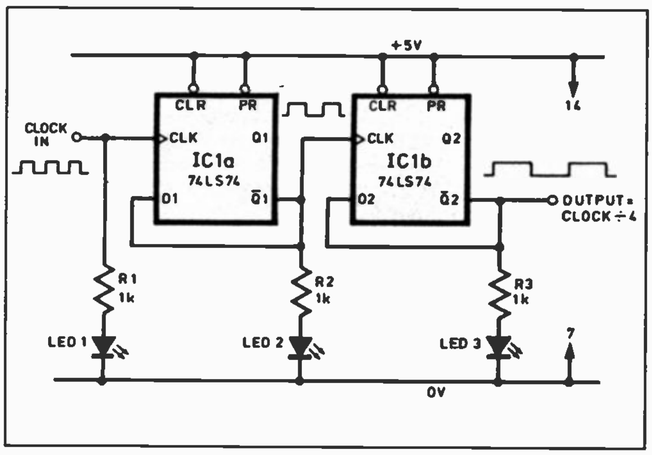



*Fig. 7.11. Divide-by-four counter.*

| Q4 BIT 4 (8's) | Q3 BIT 3 (4's) | Q2 BIT 2 (2's) | Q1 BIT 1 (1's) | DECIMAL |
|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 1 | 1 |
| 0 | 0 | 1 | 0 | 2 |
| 0 | 0 | 1 | 1 | 3 |
| 0 | 1 | 0 | 0 | 4 |
| 0 | 1 | 0 | 1 | 5 |
| 0 | 1 | 1 | 0 | 6 |
| 0 | 1 | 1 | 1 | 7 |
| 1 | 0 | 0 | 0 | 8 |
| 1 | 0 | 0 | 1 | 9 |
| 1 | 0 | 1 | 0 | 10 |
| 1 | 0 | 1 | 1 | 11 |
| 1 | 1 | 0 | 0 | 12 |
| 1 | 1 | 0 | 1 | 13 |
| 1 | 1 | 1 | 0 | 14 |
| 1 | 1 | 1 | 1 | 15 |

## FOUR BIT COUNTER

Because we are counting four binary states or digits (i.e. four "bits") we have assembled a **four-bit binary ripple counter.** We are actually counting up in *binary*, where a clock pulse represents the addition of *binary 1* to the number represented by the light-emitting diodes. Look back to last month if you need a quick reminder about Binary Notation and how a decimal number can be represented with binary digits. For instance, the four-bit number 1011 equals $8+2+1=11$ in decimal.

We've shown the *decimal equivalents* of the four-bit number, in the right-hand column of the truth table. See if you agree. Our four-bit counter starts at 0000 (which is zero in decimal) and can count up to 15 (1111 in binary) – so there are 16 possible states in all. The first bit to pop out – Q1 – is called the Least Significant Bit (LSB) so Q4 is the MSB (Most Significant Bit). Increase the clock frequency and watch the number pattern progress more quickly. Award yourself a pat on the back if you have successfully built this demonstration! You will use it again shortly.

*The next few more advanced topics require the use of the Mini Lab* Digital Display the assembly of which is described separately.

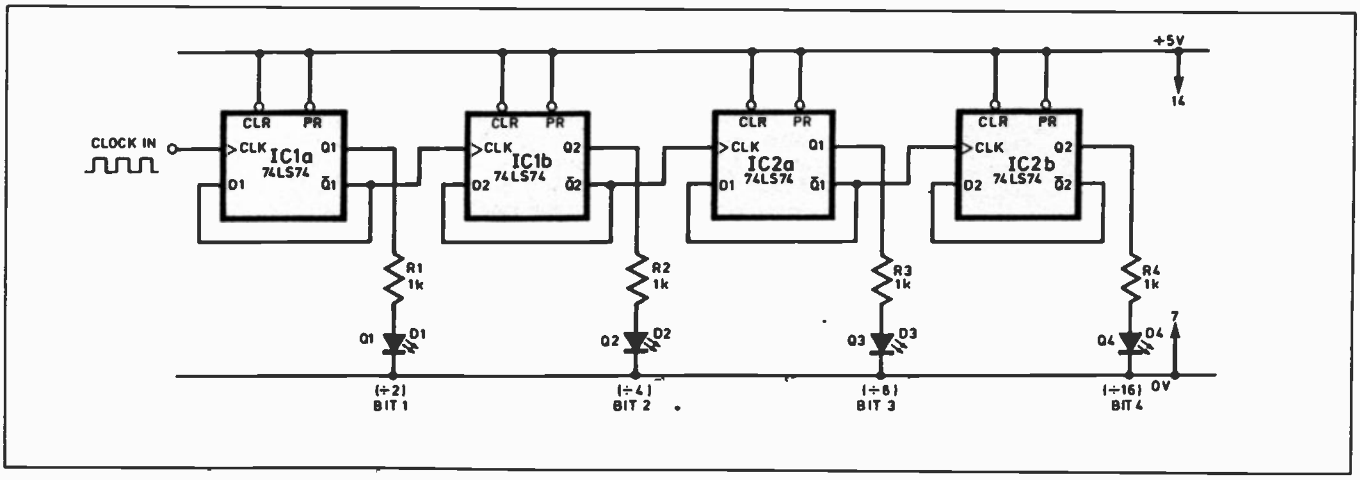



*Fig. 7.12. A complete 4-Bit binary counter.*

# TEACH-IN GCSE QUESTIONS

This month, a question posed by the Southern Examining Group in their GCSE Examination of Summer 1991 Paper 1 (1061-1063) and reproduced with their kind permission. It was designed to test your awareness of digital systems. The answers are the work of the Authors not the SEG and may not constitute the only possible solution.
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**SEG 1991**

3. A person who works at night and sleeps during the day has made a door buzzer which will only sound when it is dark. Fig. 1 shows its block diagram.

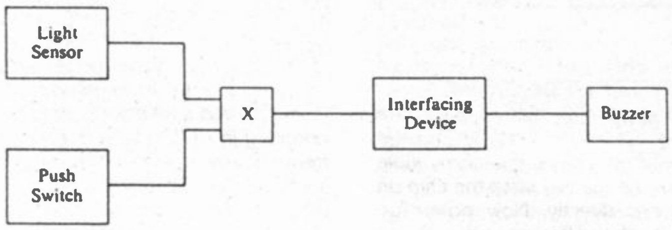



Fig. 1

(a) (i) Write down the names of the two input blocks.

Input 1 ..........................................................................

Input 2 ..........................................................................

(ii) Write down the name of the output block.

..........................................................................

*(3 marks)*

(b) (i) The output from the light sensor is high in the dark and low in the light.
The output from the push switch is high when pressed and low when not pressed.

Complete the truth table in Fig. 2 using 0's and 1's.

| Conditions | Light Sensor Output | Doorbell Switch Output | Output of Block X |
|---|---|---|---|
| Switch not pressed in the light | | | 0 |
| Switch not pressed in the dark | | | 0 |
| Switched pressed in the light | | | 0 |
| Switch pressed in the dark | | | 1 |

Fig. 2

(ii) Which logic gate has the same truth table as this?

## DECODER

The pattern of l.e.d.'s which you created with four binary digits in the last experiment shows how any decimal number between 0 to 15 can be represented by a logic system using a four bit counter. There are other forms of counter which will do the same job, often with an improved performance.

The previous circuit is ideal for our demonstration, but if it was used as part of a high-speed logic system then errors could occur in use. For instance, there is a tiny time lag which accumulates the further down the line of registers the clock data goes. This "propagation delay" becomes more noticeable with fast, sensitive circuits. However this system of ripple counting is perfectly acceptable in less demanding applications.

Logic systems are readily available which will help us out when it comes to making sense of counters. The *Mini Lab* Digital Display contains three seven-segment displays, each one driven by a simple decoding chip, the 74HCT4511. It's a **BCD-to-7 Segment Latch/Decoder Driver** (BCD means Binary Coded Decimal – see later). Note that this is a CMOS chip, not a TTL device, and requires anti-static and other usage precautions – see the separate panel *"TTL vs. CMOS"*. This chip automatically converts a four-bit number into its decimal equivalent, and shows it on the seven-segment display. So it becomes easy to decode that four-bit number generated by the preceding ripple counter, and display this in "English" on a digital display.

## DIGITAL DISPLAY

Having successfully constructed the four-bit register using two 74LS74 D-type flip-flops, SWITCH OFF and continue by connecting the Q1 to Q4 bits to the Digital Display terminals A-D respectively. Use the s.i.l. sockets in the Digital Display module marked "CONNECTOR 1" on the *Mini Lab*. This contains the pin-outs for digital display number one, marked on the right of the module as "DISP 1". Ensure that you do not allow the link wires to short to each other, as adjacent terminals in the socket strips are used.

The pin-out functions of the Digital Display are explained in the constructional article. The pin marked "LE" (Latch Enable) controls the 4-bit transparent latch of the decoder chip. A logic 1 on LE will freeze the display, showing the decoded (decimal) number present at the ABCD input of the module at that time. The decoding function still continues internally and "keeps up with" the input data, but the display is locked or "latched". However a logic 0 on LE permits the data on the input to be transmitted straight through the transparent latch after which it is viewed on the seven-segment display. Set LE to logic 0 therefore, for now. The other pins aren't used just yet.

When you are satisfied that the Digital display is correctly and soundly connected, switch on the 5V rail for the TTL logic and Digital Display, and the 12V rail for the 555 timer which provides the clock signal. With luck, DISP 1 of your Digital Display will be counting from zero upwards, and repeating. Adjust the clock frequency of the 555 timer as necessary. Compare the state of the four l.e.d.'s monitoring Q1 to Q4, against the decimal reading shown by the seven-segment l.e.d.

## BCD-DECIMAL

What is happening is that the ripple counter is generating a **Binary Coded Decimal** four bit number. This is shown in the table given earlier, where 0000 represents decimal zero, whilst 1111 represents decimal 15. The flip-flops generate the next number in the sequence every time a clock edge is received. So a four-bit number is created by looking at the Q1 to Q4 outputs.

The **BCD-Decimal Decoder Driver** within the *Mini Lab* Digital Display decodes this four-bit number, and translates it into a code which drives the seven segments of the l.e.d. display, in a suitable decimal format. The trouble is, the display can only show decimal 0 to decimal 9. The four-bit number counts all the way up to decimal *15*, as shown in the sequence of bits given earlier.

The decimal decoder/ driver can't cope with anything higher than 1001 (Decimal 9) so when the counter receives a BCD code representing 10 to 15 (1010 to 1111 inclusive – see table) – the display is blank. That's why the digital display seems to pause after counting up to 9: the next numbers in the input sequence cannot be *displayed* by the 4511 chip, though they will still be counted.

Don't worry unduly if the other two digits in your Digital Display are apparently doing their own thing: it's caused by noise and static charges accumulating on the other ABCD inputs, which fools the counters into thinking that it's reading a number. Simply connect all the other ABCD terminals to +5V to prevent it. This causes the displays to try to show 15, which is an "illegal" state – blank.

The system of Binary Coded Decimal is a method by which we can convert a decimal digit (0-9) into its equivalent four-bit number. Binary Coded Decimal differs from ordinary binary annotation in the way it represents decimal numbers greater than decimal 9. The decimal number 237 in decimal is 11101101 in true binary (according to the calculator Microsoft kindly included in our Windows software!), but in BCD format we have to consider each decimal digit *as a separate four-bit number*. So 237 becomes **0010 0011 0111** in BCD: nothing like the true binary conversion.

To actually represent this number using D-type latches (like the 74LS74) you would

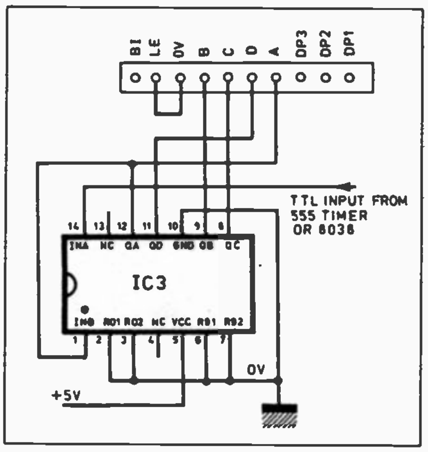



*Fig. 7.13. Decoding a 4-bit binary number into decimal, using the* Mini Lab *Digital Display. Use both the 74LS93 and 74LS90 decoder chips in turn.*

need no less than twelve flip-flops to generate the three 4-bit groups of BCD data, which could be decoded by the three decoder drivers of the *Mini Lab* Digital Display. Perish the thought... The next few experiments are somewhat more ambitious and will appeal to more advanced readers, as we investigate further logic functions which use the principles we have outlined so far.

## DECADE COUNTER

A complete BCD counter is available in the form of a 74LS93 chip. This contains four flip-flop circuits, all connected together to form a four-bit ripple counter just like the circuit we assembled earlier. Again it has a BCD output, consisting of a four-bit number which counts in binary from 0000 up to 1111.

Construct the suggested circuit of Fig. 7.13 using a 74LS93. **Important:** the +5V supply is connected to pin 5 whilst 0V goes to pin 10. If this circuit is working correctly, it will mimic the previous demonstration which used the 74LS74's, and will count from 0-9 with a blank when the values of 10-15 cannot be displayed. It's counting in binary.

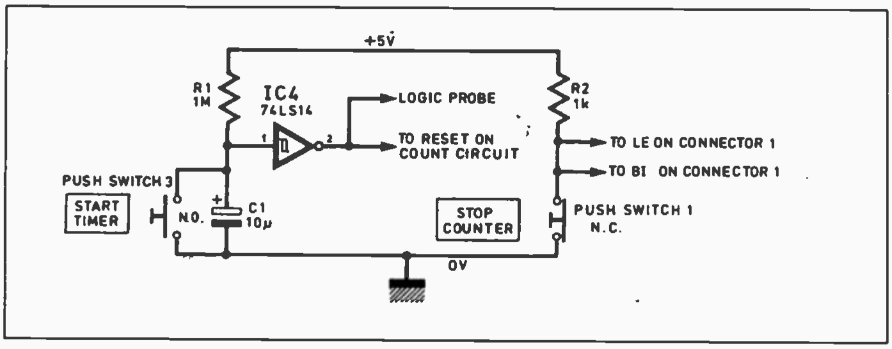



*Fig. 7.14. A complete 3-digit decimal counter module. This is used as the basis for the following experiments.*

The chip continues to count these forbidden numbers until decimal 0 is reached once more, when the display will light again.

To avoid counting numbers which we cannot display, the 74LS90 i.c. can be used instead of the '93: it is pin-for-pin compatible with the 74LS93, so simply swap the chip on your breadboard directly. Now power up again and see the difference: the digital display counts from 0-9 and immediately starts to count from 0 again. Internally, the 74LS90 has extra logic to reset the count after reaching decimal 9, not 15. It's a **decade counter**.

The circuit of Fig. 7.14 shows a complete three digit counter. This uses three 74LS90 decade counters. This can be built on one breadboard, trying to be as neat as possible because it will be useful for the next demonstrations. Try to leave the second breadboard free for the additional components we will add.

You can see that the output from the first counter feeds the input of the second, which in turn feeds the input of the third. Connect the binary-coded decimal outputs of all three decade counters to the appropriate ABCD terminals of the *Mini Lab* digital display. There are lots of wires between the breadboard and the display module, so take care not to rush the assembly. Use either the 8038 clock (easier) or the 555 Timer via the TTL interface shown earlier.

Also note the extra capacitors which can be wired across the 5V supplies for each chip. These reduce noise and prevent spurious signals from affecting operation. Apply 5V and if all is well, the display will be counting from 000 to 999. Adjust the clock frequency as required. Well done! Here are some interesting applications for this three-digit decade counter module.

## REACTION TIMER

This sophisticated circuit will test your reaction times and give a digital count of your performance. Fig. 7.15 shows the suggested circuit which uses the three-digit decade counter just constructed. Use a normally open (n.o.) switch across C1. The Logic Probe is used to monitor the output of IC1 which is connected to the reset inputs of all the counters.

When S3 is pressed and released, C1 charges through R1. After about five seconds the schmitt output goes low, which allows the counters to start counting up from zero. At this point, nothing is seen of the count because the BI (Blank Input) is grounded through the n.c. contacts of S1. When this switch is pushed and held open, the count in the 74LS90's is displayed on the Digital Display module. The count cannot change when the switch is held open as the LE (Latch Enable) is also connected to S3.

To play this game, press S3 and release. Wait for the Logic Probe to change from high to low. Then press S1 as fast as you can and hold down. The reading on the digital display is a measure of your reaction time. Vary the clock frequency until you get a count of over 100 for your best reaction. Now try to beat it! (Cheats may notice that the counter wraps around and starts again from 000 after reaching 999. If you delay your response you seem to get very low times once the timer starts from 000 again. *(So that's why I lost hands down! – A.W.)* Have fun. If youngsters use this module, ensure that the switches are treated with a little respect.

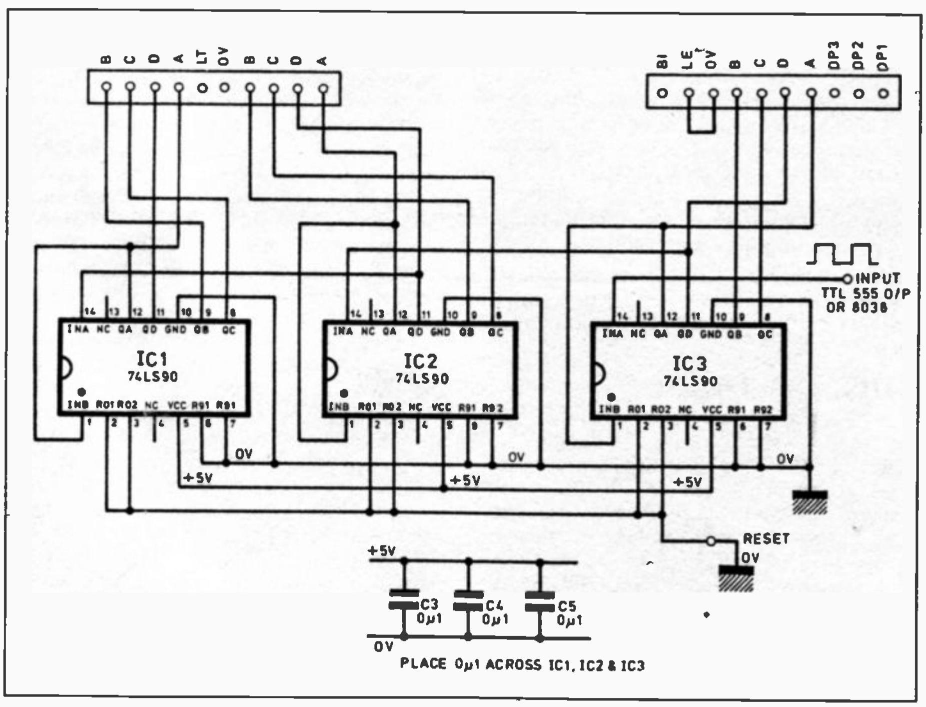
## DIGITAL FREQUENCY METER

By definition, frequency is the number of complete cycles which occur every second. So if we use our counter system to count the number of input pulses for precisely one second, we have a *Digital Frequency Meter* (D.F.M.). The result will be a digital reading in Hertz.

The signals are allowed through to the counter by a "time gate" which is made by taking the LE pin low for a period of one second. The '4511 chips in the Digital display module count up during this time, and capture the reading.

The counter must be reset to 0 *immediately* before the count is measured.

*Fig. 7.15. A digital frequency meter.*



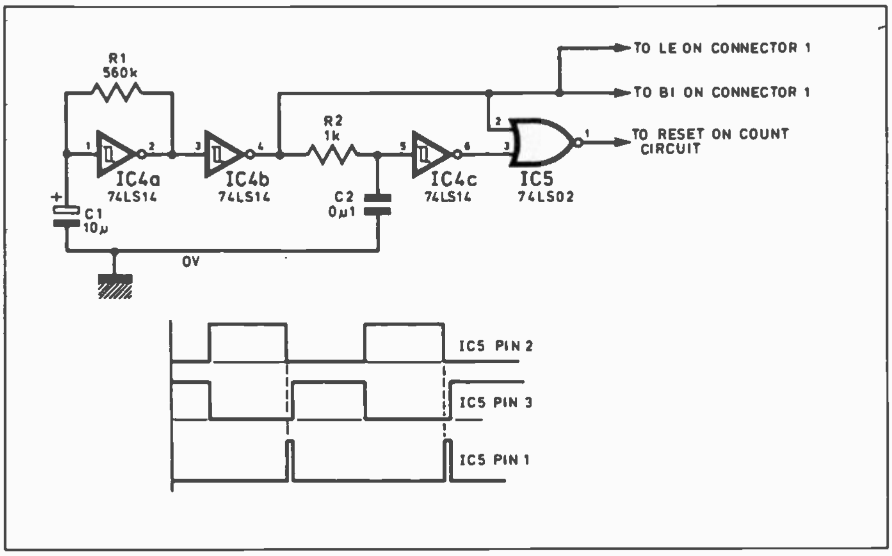



*Fig. 7.16. A suggested digital frequency meter.*

This is effected as follows. The 74LS90 can be reset to 0 using pins 2,3,6 and 7. Pins 6 and 7 are permanently connected in this circuit to 0V (logic 0) whilst 2,3, and 7 are all joined to form a reset circuit. When these pins are taken high, the decade counter is reset to zero.

In Fig. 7.16 the time base for the counter is made from three 74LS14 Schmitt inverters. IC4a forms an astable of about two seconds duration. IC4b inverts and buffers the clock whilst IC4c is fed via an RC network to delay the signal by about 40µS. The output of the second and third stage are fed to an OR gate IC5 to generate 40µS-wide reset pulses. Fig. 7.16(b) shows the timing waveforms of this pulse generator circuit, for the benefit of advanced readers.

Note that the output from the second stage of the 74LS14 is fed to the LE and BI pins of Connector 1, so amend the connection here after building the Reaction Timer. BI is used to suppress the displayed count which avoids confused readings. Now, use the 8038 square wave generator (500Hz range) and connect as shown, and turn on the 5V and 12V rails.

Hopefully, you will see the display turning on and off at about 1Hz. The count value should be stable when the display is on (the 4511 chips have latched the count to the display) as counting takes place when the display is blanked. Alter the 8038 frequency and see the reading alter. When we used a tantalum capacitor for C1, we managed to make the measured frequency to well within 10 per cent of its true value – the greater the oscillator error, the more inaccurate the circuit becomes.

As it stands, the circuit will measure frequencies from 1 to 999Hz. By changing the gate time, the range can be altered. Changing C1 to 1µ allows measurement to 9,990Hz (9.99kHz). 0µ1 allows readings up to 99.9kHz. Try this and use the 8038 accordingly. Utilise the decimal points by connecting the appropriate DP pin to 0V. Try removing the BI input, so the Digital display becomes "transparent" – see how confusing the display becomes. *Definitely* award yourself a prize for getting this far!

## LIGHT-FREQUENCY CONVERTER

Texas Instruments launched an interesting device in 1992: the TSL220 is a crystal-clear chip which combines a light-level detector with a pulse generator circuit. The result is a signal the frequency of which is dependent upon incidental light levels, refer to Fig. 7.17. If connected to the above DFM instead of the 8038, a digital count will be observed which is related to ambient light. Applications: a photographer's light meter, a smoke detector, a range finder (detect reflected light from an object). Can you think of more? Write and tell us.

In discussing digital systems (starting with the simplest of logic gates) we have tried to demonstrate how a simple "black box" approach is all that you need to construct even quite advanced circuits. None of it would be possible without integrated circuit technology, which allows for miniaturisation of logic functions, essential in today's technological world.

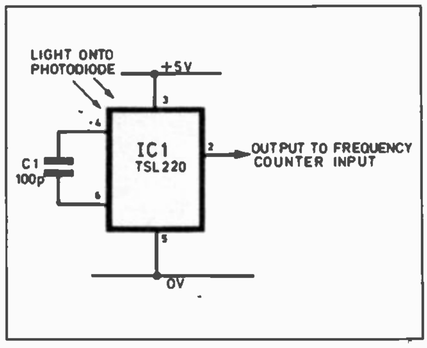



*Fig. 7.17. Texas Instruments' light-to-frequency chip TSL220. For experimenters this could form the basis of many light-sensitive projects.*

In Part Nine, we will introduce the **microprocessor** – the ultimate logic system, but really nothing more than a large "general purpose" black box that performs logic routines according to a program. Over three parts of *Teach-In* are devoted to this crucial application of micro-electronics. The optional **Micro Lab** is specially designed to run alongside the *Mini Lab* and using it we will take you step-by-step through the world of computerised logic systems to support those undertaking studies in GCE "A" Level Electronics.

**Next month:** Part Eight considers communications – a general outlook on this vital application of electronics. We experiment with the fascinating world of fibre optics, and your *Mini Lab* bursts into song with the addition of the Radio Tuner. Join us!

## GCSE QUESTION (see previous page)
## ANSWERS

(a) (i) Input 1: Either Light Sensor or Push switch
Input 2: Either Push switch or Light Sensor

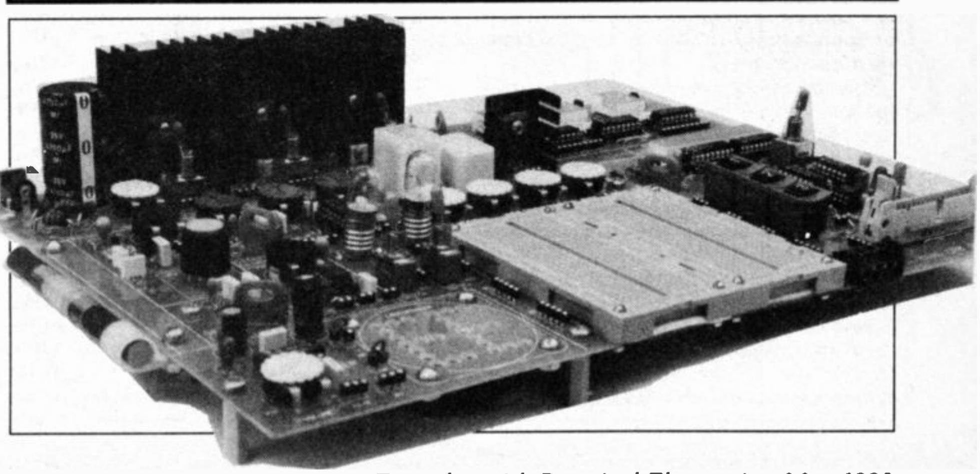
(ii) Buzzer

(b) (i)

| Light sensor Output | Doorbell Switch Output |
|---|---|
| 0 | 0 |
| 1 | 0 |
| 0 | 1 |
| 1 | 1 |

(ii) An AND gate.

(c) The interface provides the current needed to drive the buzzer without overloading the output of the AND gate.



# FOX REPORT

## by Barry Fox

### GAME PRICES

Everyone and their dog has now had something to say on the matter of video games, and the battle between Nintendo and Sega. The tabloid press has turned it into a circulation war.

Both Nintendo and Sega have played a clever game. They sell their console hardware cheap (around a third the price of a PC or CD-I player) and charge absurdly high prices for the software. Casual customers do not look at the software price before they buy the hardware.

Neither company shows the slightest interest in communicating with the technical press; I have never received a press release from either. There is precious little technology to report, except the bare fact that both companies can charge high prices because they release their software on memory cartridges, which cannot be easily copied, instead of floppy discs or tapes, which can.

All this talk about the Office of Fair Trading investigating the pricing rings hollow, because all the companies are doing is putting Lenny Bruce's old philosophy into practice. "If they give, I'll grab".

### PHOTOSENSITIVE

Most papers are now headlining the health scare over epilepsy. But the facts have been garbled. Here is a run down.

Of course children will turn nasty if their parents nag them to eat dinner just as they are notching up a record score.

The issue of epilepsy is old hat, too. We have been through this many times in the past, with disco strobe lights, faulty TV sets and fast-cut art movie sequences, for instance in pop videos. They have already had a game scare in the USA.

One in two hundred people suffer from epilepsy, but of these only 3 to 5 per cent are "photosensitive", that is to say their fits are triggered by flashing lights. Photosensitive epilepsy is most common below the age of 20 and females are more at risk than males. So although 0·3 million people suffer from epilepsy in the UK, only around 15,000, mostly children, are photosensitive.

Fits can be triggered in photosensitive epileptics by any light which flashes at a trigger frequency. This varies from individual to individual but is usually around 18Hz.

Remember that the human brain naturally produces low level electrical signals of varying frequency. When awake and active, there are Beta waves at between 13-30Hz. When relaxed but alert and creative, the frequency drops to the Alpha range (8-12Hz). Theta waves (4-7Hz) are associated with flashes of inspiration and Delta waves (1-3Hz) come with deep sleep.

The flashes caused by driving down a sunlit road, with trees by the side, can hit the trigger frequency for epilepsy. So can flashing lights at a disco. Some firms sell visor gadgets which deliberately flash lights into the wearer's eyes to alter consciousness. The flash rates include the risk frequencies of around 18 Hz.

Television screens can trigger a photosensitive fit, too. Confusion arises because there are several ways this can happen.

The brain needs to get a strong trigger. This happens when someone, whether service engineer or game-player, gets close to the screen and the retina of each eye gets a full dose of flash energy. The quick remedy is to cover one eye to halve the dose.

### TV FLICKER

Normal TV viewing puts the flash frequency above the danger trigger, because from a distance the two sets of interlaced lines which scan the picture blend into a 50Hz flicker. Going too close to the screen reveals the individual interlace scans, which are flickering at 25Hz, close to the trigger. And people who play video games peer close into the screen.

There is less risk when games are played on a personal computer, because the picture refresh rate used to be 60Hz and is now rising to 70, 72 or even 74 Hz. Also the image is not interlaced, it is made up from 480 horizontal rows or lines of 640 pixels each (for VGA, or Video Graphics Adaptor resolution), 600/800 for Super VGA or 768/1024 for Extended VGA. Also the screen phosphors may have a longer decay time, which smoothes the flicker. There is also less risk from an LCD screen because it is not bright and is too small to overdose the retina.

But Nintendo and Sega games hardware connects to a domestic TV set, and players sit close for hours on end, peering at the screen. There is more risk in Europe with 25/50Hz flicker than in the USA and Japan with 30/60Hz. There is no risk from the new 100Hz flicker-free TV sets, e.g. from Philips, but they are expensive.

Whatever the screen type, there may be a quite separate risk if the game itself generates flashes, for instance when the sprites and targets on screen flash.

It can be argued that it is better for parents to find out that their children are epileptic, in the safety of their own home, rather than out at a disco or games arcade. The British Epilepsy Association has a help line (0345 089 599) with all calls charged at local rate. It has kept a cool head on the current scare and produced an information leaflet on photosensitive epilepsy. Dealers might like to get a few copies to pass on to worried customers.

The Association says there is "dire need for more information". Here I am reminded of something which a video engineer said to me when we were discussing TV flicker. Try watching TV upside down. I did. If you are close and there is bright content, the picture flickers appallingly.

Why should this be?

### INVERTED VIEWING

When people who live in the USA or Canada come to Europe, they immediately complain about the flicker of our TV system. (Japanese people notice it too, but are usually too polite to complain). Americans have grown up with a 60Hz TV picture display rate and are offended by the 50Hz rate in Europe.

Europeans who have grown up with 50Hz, have grown not to notice the flicker.

But we have grown used to watching a TV image which is scanned from top to bottom, and the brain is thrown into confusion when confronted with an image that is scanned from bottom to top. And this is what you will see if you look at a TV upside down. It is comparable to the way dry land seems to pitch and roll after a rough sea journey, or walking onto a stationary escalator jolts and jars because the brain expects it to be moving.

Some years ago the BBC was testing loudspeakers and played a listening panel music with some frequencies sucked out. Once the panel had got used to the sucked out version, full-range music sounded wrong.

So be warned. If you are a photosensitive epileptic, do not be tempted to play Nintendo or Sega video games while standing on your head.

### BRAIN DAMAGE

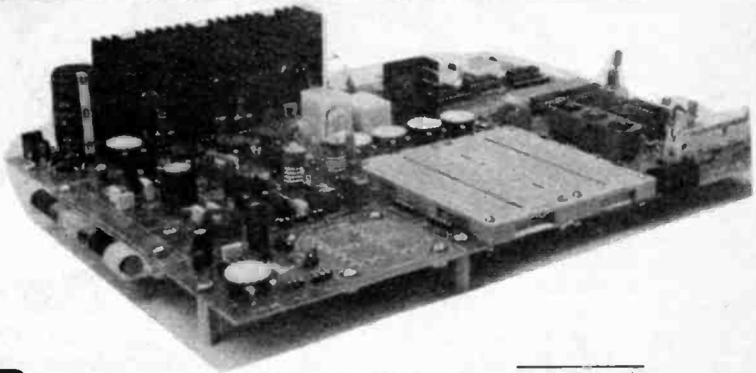
On a similarly light note, I loved the way one of the tabloids recently turned things round and used a video game analogy to explain other health matters.

"The brain is as fragile as a giant Nintendo computer game" explained the *Daily Star*. "If you bash it or knock it on the ground the wires of a Nintendo will come out and it stops working. If you bash your brain about you go into a coma".

"The brain then needs time to be repaired" continues the explanation. "New 'wires' need to grow".

This left me wondering how many people who had bashed their Nintendos around were waiting hopefully for them to repair themselves.

# MINI LAB



Alan Winstanley & Keith Dye B.Eng(Tech)AMIEE

***The Everyday with Practical Electronics Mini Lab has been created to accompany Teach-In '93, and enables the reader to assemble demonstration circuits by following the clear instructions and diagrams contained in the main text, with every chance of it working first time.***

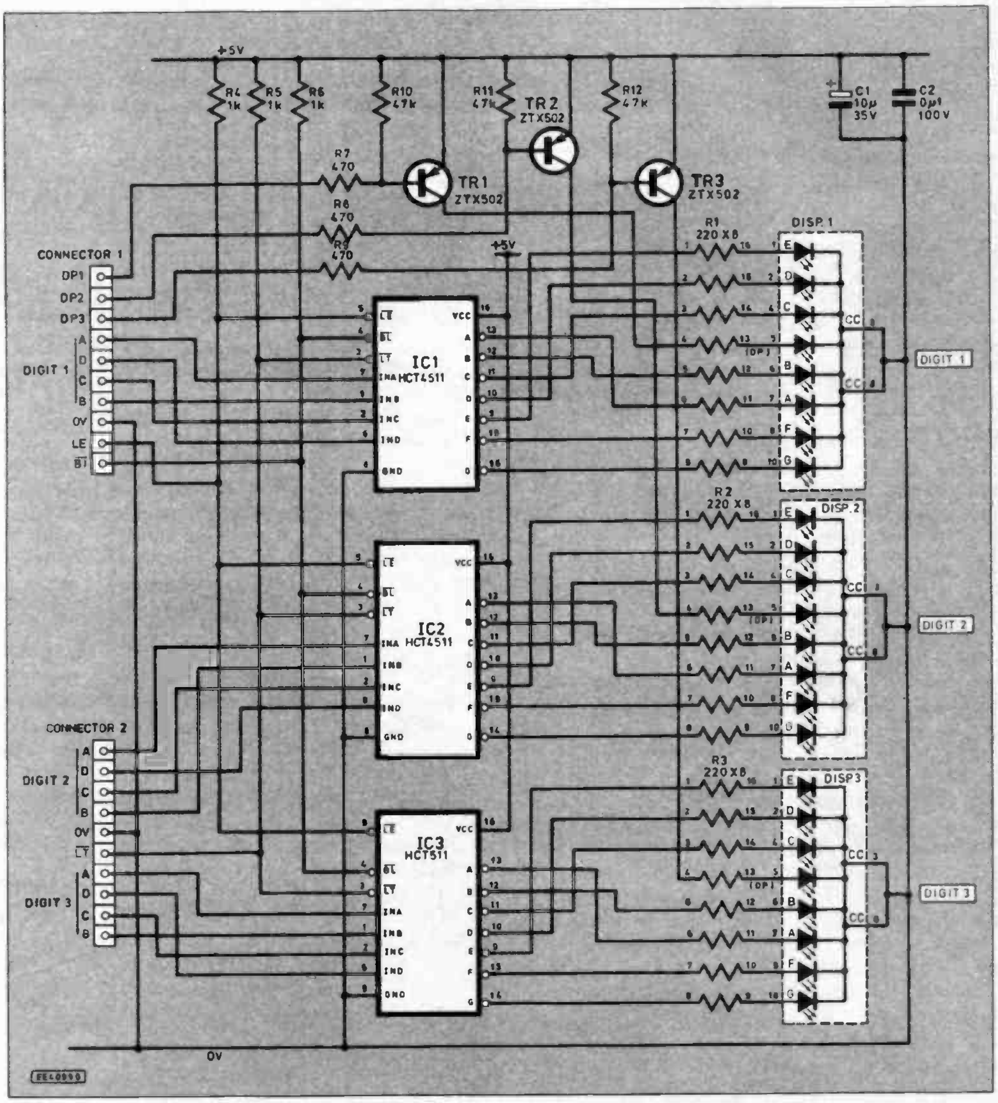



*Fig. 1. Complete circuit diagram of the Display module.*

THE "Display" module marked on your *Mini Lab* p.c.b. contains three BCD-to-decimal decoder drivers. These will read a 4-bit binary number, convert it into "English" (decimal) and then display it directly on a seven-segment l.e.d. display.

The circuit diagram is given in Fig. 1. This may look complex, but it is only the same basic module replicated three times. IC1 to IC3 are three 74HCT4511 BCD-decoder driver chips. A four bit number is presented to the binary-coded decimal inputs *ABCD* of each chip, where *A* is the least significant bit. (Refer to the tutorial for a further explanation).

Each chip decodes this into a decimal format which is then directly shown on a seven-segment display. As explained in this month's tutorial, it's not possible for the chips to *display* the decimal equivalent of a binary number greater than 1001 (decimal 9 or $9_{10}$) though it will *count* up to 1111 (decimal 15). Any "illegal states" result in a blank display.

## DISPLAYS

Three common-cathode displays are used, and the 4511 chip simply drives the segments *A-G* as needed to form a decimal number. Each segment of the display requires a current-limiting resistor just like any other l.e.d., and rather than use 24 individual resistors, we specified three dual-in-line 220 ohm thick-film resistor packages instead. Additionally, the decimal points in the seven segment displays are driven by external *pnp* transistors TR1 to TR3 which act like transistor buffers, (The 4511 cannot drive a decimal point itself).

We brought all the connections out to two ten-way single-in-line socket strips. *Connector 1* carries the BCD inputs for Digital Display No. 1 and all three decimal points whilst *Connector 2* carries the BCD inputs for both Display No. 2 and No. 3. Further input features are available as clearly marked on the silk-screen print, which makes your Digital Display a little more versatile.

The system operates from the 5V rail provided by the *Mini Lab* power supply. Whenever all three digits are lit, expect the 5V heatsink in the p.s.u. to become warm or hot. This is perfectly safe and there is no need to worry.

## CONSTRUCTION

The silk screen printing and solder-resist coating of the *Mini Lab* p.c.b. should ensure that this module can be assembled with the minimum of disappointment. However, a fine-tipped low-power (15W say) soldering iron is a *must*. Follow the diagram in Fig. 2 carefully. This is printed off directly from the CAD system which we used to design the p.c.b. artwork, and should be followed closely. It is essential that only the specified parts are used, to guarantee compatibility with the board.

Keep the 74HCT4511 chips in their anti-static packaging until it is time to insert them. Start by soldering in the solid tinned copper-wire jump leads. Note the connection over into the power supply section. Follow with the s.i.l. sockets – hold them down with sticky tape if needed – and the d.i.l. sockets for the three integrated circuits.

Add the discrete components, noting the polarity of the transistors and tantalum capacitor. Then solder in the digital displays (you could use further single-in-line sockets instead here, if you are worried about soldering them – six 5-way strips will be needed). Finally, take anti-static precautions as described in Part Six and swiftly locate the three decoder chips into their respective sockets, observing their orientation as always.

## MINI LAB COMPONENTS

**Resistors**

R1 to R3 220 x 8 dual in line resistor module. Represents 24 resistors.
R4 to R6 1k (3 off)
R7 to R9 470 (3 off)
R10 to R12 47k (3 off)
All ¼W ±5% carbon film except R1 to R3.

**Capacitors**

C1 10µ tantalum 35V
C2 100n polyester

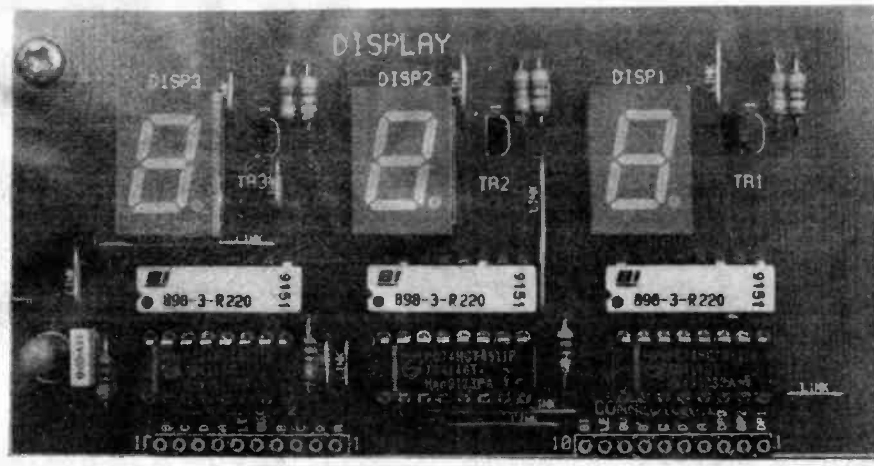
**Semiconductors**

IC1 to IC3 74HCT4511 BCD to seven-segment decoder/driver (3 off)
D1 to D3 7-segment 0·5in common cathode display
TR1 to TR3 ZTX502 *pnp* transistor

**Miscellaneous**

16-pin d.i.l. socket (3 off); s.i.l. turned pin sockets, 2 x 10; solder, tinned copper wire, etc.

**Price £11** Approx




## TESTING

After assembly, closely inspect your soldering, looking especially for solder bridges between adjacent solder pads, and dry or incomplete joints. Also check for any missing links. Then power up the module by switching on the 5V rail. The digital display may be showing a random number or nothing at all.

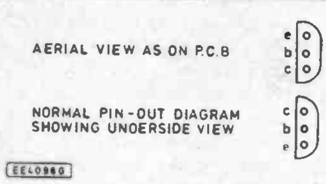
Connect the terminal **LT** (Lamp Test) to 0V (= Logic 0) and all seven segments should light. Connect the DP1 to DP3 (Decimal Point) pins to 0V to enable the appropriate decimal point l.e.d. A four-bit number presented on the *ABCD* inputs of each digit, should result in a decimal number being displayed, refer to the tutorial.

In use – the **BI** (Blank Input) pin is useful if you wish to blank the display for any reason, although counting continues internally. Shunt this pin to logic 0 to blank the display, and then just disconnect BI or send it to logic 1 to display the current counting operation. The seven-segment display will change as quickly as the BCD input code does – so some flickering will be evident when counting rapidly. Use this pin also if you are not using the Display module and find the digits distracting. A 0V terminal is nearby in Connector 1. Note that LT is the only input that takes precedence over BI.

A further pin, **LE** (Latch Enable) *must* be sent to Logic 0 if you are to display the current count. In this mode, the "transparent" latch decodes the input and displays it immediately. A logic 1 (or floating connection) on BI will freeze the display on the current count, although counting continues internally.

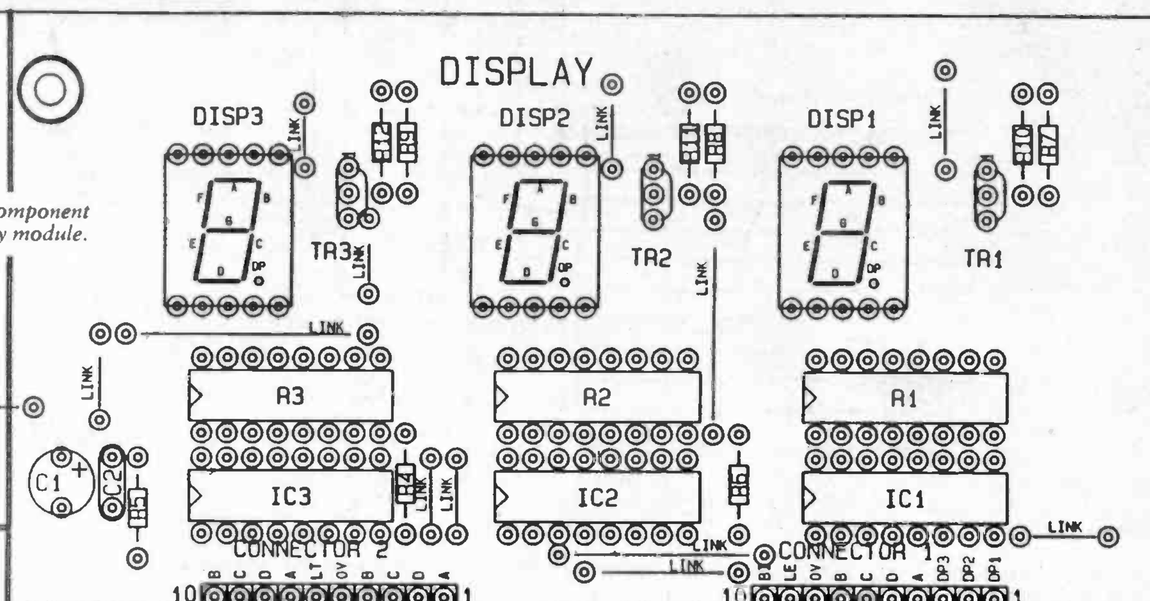
Use the LE terminal to "sample" and "freeze" the display at a particular interval, rather then let it free-run. The 8038 Signal Generator provides a suitable 5V square wave clock which is useful for sampling the display in this manner. Just try everything, and you will soon see how the module operates. For further information, we recommend ordering a copy of National Semiconductor's Data Sheet describing the (MM)74HC4511. This shows the decoder's truth table in detail.

**Next month:** The *Mini Lab* is finally completed with the addition of an a.m./m.w. radio. It receives Radio 1 clearly as well as local stations, not to mention a Swedish soap which we've listened to for the past six months, and we still don't understand a word! Tak Så Mycket! □




*Connections for TR1 to TR3.*

*Fig. 2. Mini Lab component layout for the Display module.*



# Techniques

## ACTUALLY DOING IT!

**by Robert Penfold**

STRIPBOARD is a form of general purpose printed circuit board that has been popular as the basis of electronic projects for what must be about 25 years. It is often sold under the proprietary name "Veroboard", and is probably better known by this name.

A normal (custom) printed circuit board (p.c.b.) is only suitable for one particular project, but stripboard can accommodate virtually any circuit. It is most commonly used for small to medium size projects, but it can be used successfully for quite large projects.

### STRAIGHT AND NARROW

Like most really good ideas, stripboard is basically very simple. It consists of a piece of thin board made from an insulating material which is drilled with a matrix of small holes.

The only stripboards that are readily available these days have the holes on a 0·1 inch (2·54 millimetre) matrix. This matches the pin spacing of d.i.l. integrated circuits and many other components. A few components have pins which do not match a 0·1 inch matrix, and the inability to accept such components is one of the few major limitation of stripboard.

Narrow copper strips run along rows of holes on one side of the board. Fig.1 shows this general scheme of things. Stripboard is used in standard printed circuit board fashion. The components are fitted on the plain (non-copper) side of the board with their leadout wires or pins threaded through the appropriate holes. The pins or leads are then soldered to the copper strips on the underside of the board. The copper strips carry the component interconnections.

A custom printed circuit has tracks which run horizontally, vertically, or at any angle in between. There are usually a number of tracks which intricately zig-zag their way around the board. Obviously this sort of thing is not possible with stripboard, which is limited to simple horizontal tracks running across the board. The board layout designer therefore has to accept some compromises.

One of these is that the component layout tends to be less neat than that of an equivalent custom printed circuit design. With the latter it is normal to have standard lead spacing for resistors, capacitors, diodes, etc. Also, the components normally run "north – south", with perhaps one or two components running "east – west".

These are luxuries which are not practical with stripboard layouts. Axial lead components are generally used with a variety of lead spacings, and in order to keep the layout reasonably compact it is often necessary to have a few components at odd angles.

### LINKS

Single-sided custom printed circuit boards often have a few link wires, but with stripboard layouts there is often a substantial number of links. These effectively take the place of the vertical and angled tracks on a custom p.c.b.

This may all seem to be of only academic importance, but there are practical consequences. A custom printed circuit board has one hole per leadout wire or pin. A stripboard has hundreds of unused holes. In fact the unused holes vastly outnumber the holes that are utilized.

This factor, together with the points mentioned previously, mean that great care has to be taken when building a stripboard project, as errors are relatively easy to make. You need to ensure that every component is fitted in exactly the right place.

### IDENTIFICATION

Stripboard component layouts in books and magazines are often marked with letters to identify the rows of copper strips, and numbers to identify the vertical rows of holes (Fig.2). Many constructors find it easier to quickly navigate their way around the board if it is marked in the same fashion using a fibre-tipped pen. A pen having a spirit based ink is needed for this. Water based inks will not mark the board very well in the first place, and will soon rub off.

Rather than adding a full set of numbers and letters, I usually just settle for marking every tenth column of holes, and every fifth row of copper strips. This enables any hole to be located quite quickly and reliably, and avoids any intricate labelling of the board.

The component-side view of the board normally includes a corner marker, and a matching marker on the copper side view makes the relative orientations of the two views perfectly clear. The identification numbers and letters might also be included on the underside view, particularly with large boards.

### BOARD BUILDING

When building a stripboard the first task is to cut out a board of the right size. Occasionally a project may use a standard size board, but in most cases a larger board must be trimmed down to the required size. I find that a full size hacksaw is the best tool to use for this job. Cut along rows of holes using a minimum amount of pressure.

Modern stripboard seems to be quite thin and brittle, so a "hammer and tongs" approach will almost certainly produce an end result that is only suitable for lots of very small projects! The cut edges of the board will probably be quite rough, but they are easily filed to a smooth finish using a small flat file.

Next any necessary breaks in the copper strips are made. Most stripboard projects require at least a few breaks in the strips, and these are represented in stripboard diagrams in the manner shown in Fig.3. The point of using breaks is that they enable each copper strip to carry several

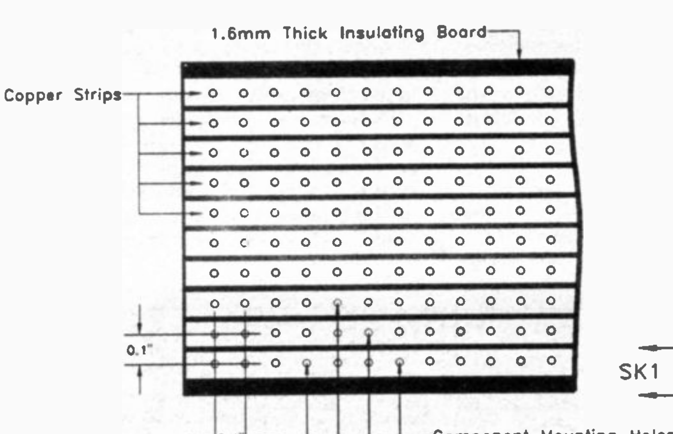



*Fig. 1. Stripboard is basically very simple, but is extremely effective.*

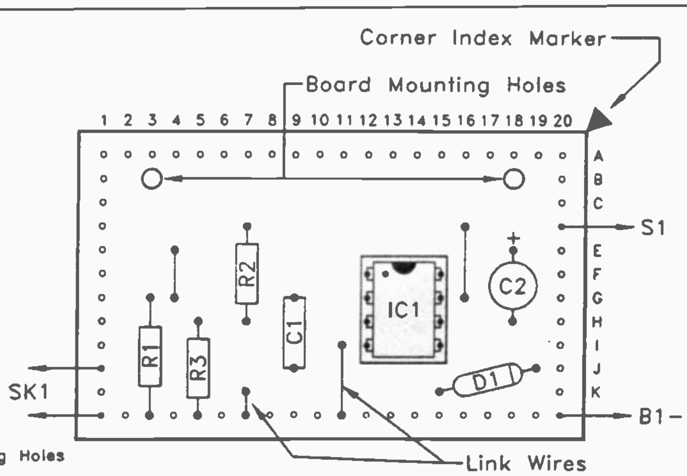



*Fig. 2. Stripboard top views are often marked with identification numbers/letters for the columns and rows of holes.*

interconnections, with each section of strip carrying a different set of connections.

A special tool (a spot face cutter) for making the breaks in strips is readily available, but it is by no means essential to use this. A hand-held twist drill of about 5 millimetres in diameter seems to do the job quite well. Either way, be sure to cut through the full width of the track. On the other hand, do not get carried away and cut deeply into the board. This could seriously weaken it, especially if there are a lot of breaks in the copper strips.

The board mounting holes should be drilled next. Again, go gently when drilling these holes, using no more pressure than is really necessary. Holes of 3·3 millimetres in diameter will accept 6BA or metric M3 mounting bolts. I could not recommend most types of plastic stand-off for use with stripboard, as they rarely hold the board securely in place. Mounting bolts plus spacers seem to give much more reliable results.

## COMPONENT FITTING

The board is then ready for the components and any link wires to be fitted. I generally start by putting in the integrated circuit holders, being very careful to get these in the right positions. These then act as guides which make it easier to fit the other components in the right places. It is generally easier if, as far as possible, components are placed relative to other components, rather than by their absolute positions.

For example, it might be easier to work on the basis of a resistor being two holes to the right of an existing component on the board, rather than bothering about its position in terms of coordinates. There is a slight drawback to this method in that a mistake in the positioning of one component can lead to a number of others being offset from their correct positions. Therefore, it is advisable to periodically double-check the absolute positioning. Probably the most important thing is to work your way methodically across the board, rather than fitting the components in a random fashion.

## LINK WIRES

The link wires can be made from 22 or 24 s.w.g. tinned copper wire. I find that the best wire to use is actually trimmings from resistor leadouts. It is worth keeping some lead trimmings for this purpose, but you will also need a small spool of 22 or 24 s.w.g. wire for the longer link-wires.

One way of adding the link wires is to preshape each wire using pliers, fit it in place, trim the ends so that about two millimetres of wire protrudes on the underside of the board, and then solder both ends of the wire to the copper strips. An alternative is to first fit one end of the wire and solder it in position. Then the other end is threaded through the appropriate hole, and the wire is then pulled tight using a pair of pliers. Pull the wire hard enough to straighten it out properly, but not so hard that it is seriously weakened or even snapped. The free end of the wire is then trimmed to length and soldered in place.

Whatever method you use, it is important that the link wires should run straight from one hole to the other. If they are allowed to meander from one hole to the other there is a danger of short circuits occurring. With long link wires you might like to play safe and fit them with pieces of p.v.c. insulating sleeving.

Be careful not to miss out any of the link wires, and be especially careful with boards that have large numbers of links. Missing link wires and breaks in the copper strips are common causes of failed stripboard projects.

Connections to off-board components should always be made via solder pins. Connecting these leads direct to the board can easily result in copper strips becoming torn away from the board, which will usually result in them breaking before too long. Normal 0·1 inch matrix stripboard takes one millimetre diameter pins.

## STRIP-SEARCH

The main cause of problems with stripboard construction is accidental short circuits between adjacent copper strips. The distance between strips is very small, and is actually well under one millimetre. If you tried to deliberately solder across such a gap it would probably prove to be extremely difficult. Accidentally bridging the gap is another matter though, and this inevitably occurs from time to time.

Often the offending solder will be clearly visible, but sometimes the problem is a very narrow trail of solder which is very difficult to see. In fact it might be hidden under some excess flux, leaving the constructor totally unaware of its presence.

If a stripboard project fails to work I always start by checking for accidental short circuits between the copper strips. If a visual search of the board is to be made, it is essential to clean the board first, to remove any excess flux. Special cleaning fluids and aerosols for this purpose are available from some of the larger component retailers.

It is also essential to use a fairly powerful magnifying glass, even if you have good short-distance eyesight. In fact something like an 8× eye-lupe (as sold by some camera shops) is the best tool for the job. Pay particular attention to areas of the board where there are large numbers of joints, and to the ends of the copper tracks.

## ONE HUNDRED PER CENT

I have never found a visual inspection to be a totally reliable method. Checks using a continuity tester are 100 per cent reliable, and will always reveal the presence of a solder trail, however well hidden it might be. Once you know that there is a short circuit between two strips it can usually be found quite quickly.

If you cannot find the cause of the short circuit, try carefully scoring between the two tracks using a modelling knife. If this is done a few times it should clear away any small pieces of solder, or make any larger pieces more obvious.

Small pieces of solder are easily cut away or removed with the hot bit of a soldering iron. With large blobs of solder across two tracks it is advisable to remove all the offending solder using desoldering equipment, and to then resolder the joint or joints.

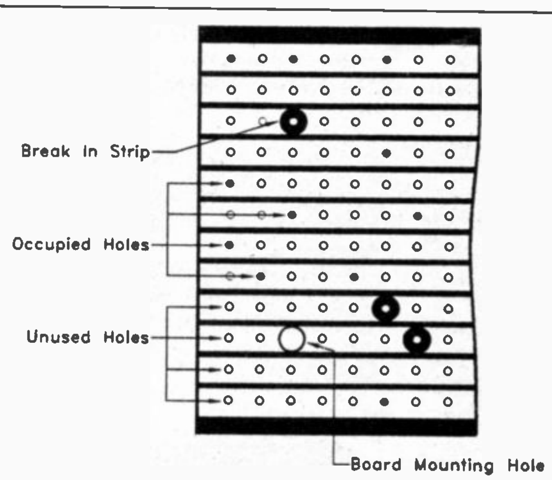
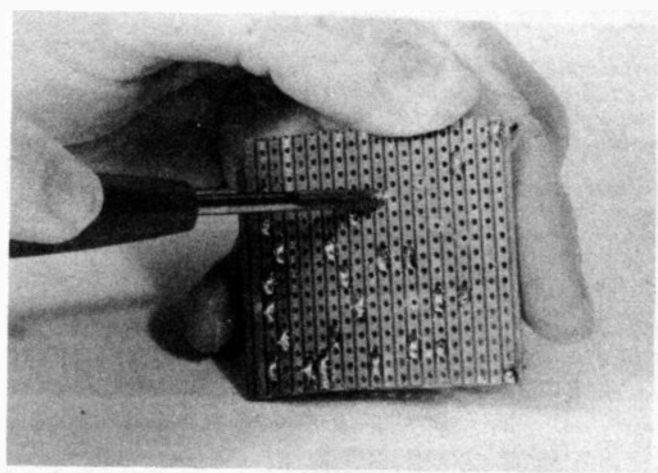
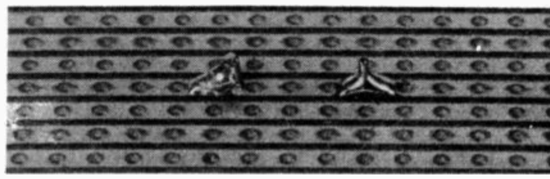



*Fig. 3. The normal method of representation in underside views.*



*Stripboard (or Veroboard) tracks can be cut using the special tool available or a small (7mm or 8mm) hand held drill bit.*



*The right hand joint is a good one, with the solder covering the wire and track nicely. The joint on the left looks suspect.*

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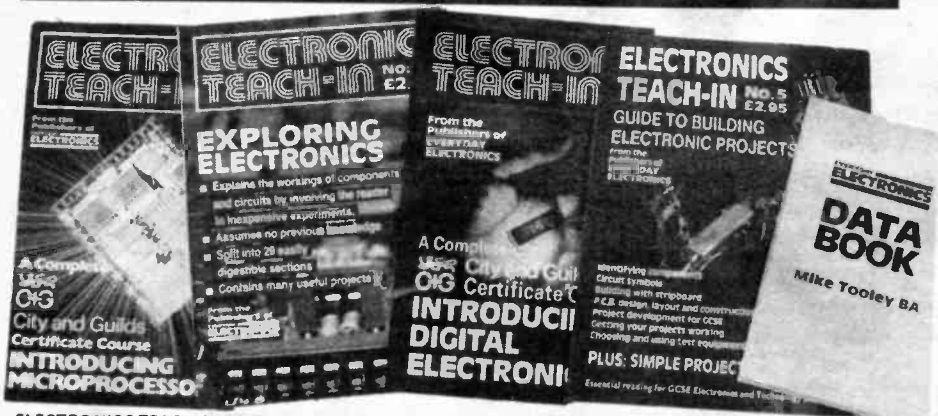


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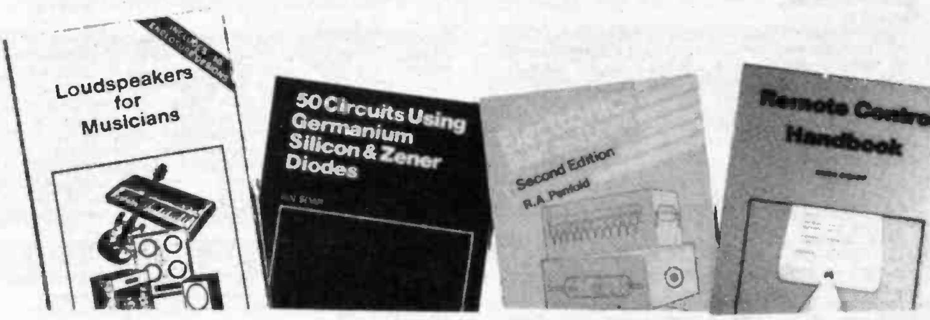


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# REPORTING AMATEUR RADIO

## Tony Smith G4FAI

### CODE-FREE LICENCE?

Many thanks to those readers who responded to my invitation to suggest why amateur radio might appear daunting to potential newcomers. Their letters, several of which were published last month, have been passed to the Radio Society of Great Britain whose response, when received, will also be published.

The question was asked "Why is it necessary to learn Morse to operate below 30MHz, when it need not be used once a licence is issued?" This is, in fact, the big debate inside amateur radio at present, so much so that the RSGB recently invited all UK amateurs and SWLs to express their views for or against the idea of a code-free licence for h.f. operation.

However, even if a vast majority voted in favour of a code-free licence, the RSGB is not, itself, able to change the rules. The Morse test is an international requirement and any change in the regulations needs to be made by an ITU World Administrative Radio Conference.

Radio amateurs are not represented at these conferences but representatives of their national societies do accompany national delegations to advise on matters affecting the amateur service. In this way, a society could arrange for proposals to abolish the Morse requirement to be put to a WARC. If other national societies persuaded their delegations to support such a proposal then the Morse test could well be abolished.

However, even assuming international agreement by national societies on this course of action, it could still be a long-term process. Each WARC, held every few years, defines the scope of its agenda in advance and proposals outside that agenda may have to wait for another conference.

### THE ARGUMENTS

The Morse test was originally introduced to make sure that amateurs interfering with official or emergency CW communications understood instructions to shift frequency or close down. The main argument against the test today is that its original purpose no longer exists and that its retention deters possible newcomers to the hobby who see it as irrelevant in modern communications.

Within the hobby, practitioners of newer modes, e.g., data, seeking more spectrum space, feel that if the test was abolished "old-fashioned" CW would die and more frequencies would become available for them.

Those who use CW argue that, with its great capability for communication in adverse conditions, it is too valuable a mode to be lost and that, for a variety of reasons, it is now in the interest of amateur radio itself to retain the test.

The RSGB is considering all these points and I will report back on their conclusions in due course. By coincidence, the matter was also discussed by the Board of Directors of the American national radio society, ARRL, earlier this year.

They reaffirmed their continued support for a Morse test as part of the amateur license requirements for operation below 30MHz; and instructed all ARRL representatives to continue to insist before all national and international bodies that there be no modification of the present requirements. *(W5YI Report)*.

### CLUB SYNDROME?

One correspondent, referred to hams "bubbling with self-righteousness on the virtues of Morse as a means to keep the 'Cowboy' element out", and to "the 'Club syndrome' where the established members ... proclaim the need for new members ... (and) deliberately obstruct this happening due to an overriding fear of diluting their elitism and status."

As a Morse enthusiast myself, I must take issue with that description! The Morse operators I know don't seem elitist or self-righteous at all!

In my experience, those who like and use Morse are more conscious of operating ethics, reasonably considerate of others, and represent the nicer end of the market. Of course that's a generalisation! I know some very nice people who use packet and there are some CW operators that I'd rather not work at all!

Some see advantages in retaining the Morse test, others accept that it has to go sometime. Those in favour genuinely see it as being in the best interest of the hobby, not as a means of self-aggrandizement, or foiling the legitimate aspirations of others.

### CLIQUEY?

Another correspondent describes radio amateurs as cliquey and unwelcoming. I thought they were too at first, but soon discovered that it had more to do with human nature than amateur radio. Its the same if you take up other activities. The old hands appear to know everything, and seem rather stand-offish.

Some radio clubs make a special effort to welcome beginners, but its really down to the newcomers to introduce themselves, explain that they are new to the game and in no time everyone is doing their best to be helpful.

On the air, there is a more instant camaradie. Answer a station's CQ call, explain that you are a beginner and usually the other operator will be very encouraging and welcoming. But *you* have to make the effort!

Public demonstrations don't always present the hobby at its best. How often do visitors find a few amateurs grouped round a display, talking to each other and ignoring those who want to know what's going on? This is usually because the demonstrators are ill at ease and unsure how to behave in public. The suggestion made that a properly organised advice desk be set up at such functions would surely make all the difference?

### NOVICE LICENCE IMPROVED

A review by the Radiocommunications Agency and interested parties has concluded that the radio amateur Novice licence has been a success in its first year.

Several minor changes have been made to the examination objectives and syllabus, effective from the June 1993 examination. The number of questions in each section of the syllabus will then be: Receivers and receiving techniques – 5; Components, applications and units – 3; Measurements – 4; Propagation and antennas – 5; Transmitters and transmitting techniques – 10; Operating techniques – 6; Station layout – 1; Construction – 1; Safety – 2; Licensing conditions – 8. Total questions, 45.

### MORE FREQUENCIES/MODES

Additionally, Novices have been given extra frequencies, plus additional modes in some bands, to give them better opportunities to contact other amateurs.

The present 3·565-3·585MHz Novice band now begins at 3·560MHz; and 28·100-28·190MHz now begins at 28·060MHz. Both these changes will enable Novices who have passed the 5 w.p.m. Novice Morse test to operate on the internationally recognised QRP (low power) frequencies.

The 50·620-50·760MHz band is extended to 50·000-51·000MHz with Morse and telephony added to data as permitted modes; and 51·250-51·750MHz is extended to 51·000-52·000MHz.

The 433·000-435·00MHz band now begins at 432·000MHz; and 435·000-440·000MHz is now available for operation with Morse, telephony, data, SSTV and FSTV.

The Novice licence is now an even better way to start in amateur radio, with limited study, inexpensive low power equipment, and a potential to make international contacts that was not available to full class B licensees a few years ago!

### YOUNG AMATEUR

The RA has also announced details of the Young Amateur of the Year Award 1993, for the most outstanding achievement by a young amateur radio enthusiast under 18. Entrants can enter themselves or be nominated by an adult sponsor, and there is no requirement to hold an amateur radio licence. Closing date for applications is 31st July and full details can be obtained from RSGB, Lambda House, Cranborne Road, Potters Bar, Herts EN6 3JE.

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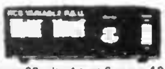

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| Sub C with solder tags | £2.50 |
| 1/3 AA with tags (Philips CTV) | £1.95 |

**Standard charger,** charges 4 AA cells in 5 hours or 4Cs or Ds in 12-14 hours + 1xPP3 (1, 2, 3 or 4 cells may be charged at a time) .......... £5.95
**High power charger,** as above but charges the Cs and Ds in 5 hours: AAs, Cs and Ds must be charged in 2s or 4s .......... £10.95

**Special offers – please check for availability**
F cells 32dia x 87mm .......... £3.95
F cell with solder tags, 1.2V .......... £4.30
42mm x 16mm dia. 1.2V .......... £1.45
Stick of 4 171mm x 16mm dia., with red & black leads 4.8V .......... £5.95
4 cell battery 94mm x 25mm dia. (1/2C cells) .......... £3.50
**Computer grade capacitors with screw terminals.** 38000µf 20V £2.50; 87000µf 10V £1.95; 68000µf 15V £2.95; 10000µf 16V £1.50
**7 segment common anode led display,** 12mm .......... £0.45
**LM2931AT 5.0 low drop out 5V regulator TO220 package** .......... £0.85
**7812 and 7912 12V 1A regulators** .. £20.00 per 100
**LM337k TO3 case variable regulator** .......... £1.60, 100+ £1.10
**BS250 P channel mosfet 45p, BC559 transistor** per 100 £3.95
**74LS05 hex invertor** .......... £10.00 per 100
**Used 8748 Microcontroller** .......... £3.50
**SL952 UHF Limiting amplifier LC 16 surface mounting package with data sheet** .......... £1.95
**AM27S02** .......... £1.25 each; 90p 100+
**CD4007UB** .......... 10p 100+, 6p 1000+
**TV Mains switch,** 4A double pole with momentry contacts for remote control, pack of 10 £3.95, box of 60 £19.95
**DC-DC convertor, Reliability model, V12P5,** 12V in 5V 200mA out, 300V input to output, Isolation with data, £4.95 each or pack of 10 – £39.50
**Hour counter** used 7 digit 240V ac 50Hz .......... £1.45
**Resistor pack** 2500 resistors 1/8-2W 50 different values .......... £8.95

**Resistor jumbo pack** 25000, 1/4 and 1/2W resistors our choice of values and size, will be mainly in boxes or rolls of 1000, 2000 and 5000 of one type .......... £25.00
**Qwerty keyboard,** 58 key good quality switches, new .......... £5.00
**Qwerty keyboard with serial output,** no data (used) .......... £6.00
**Polyester capacitors,** box type, 22.5mm lead pitch
1µf 250V dc 20p each, 15p 100+, 10p 1000+
2.2µf 250V dc 30p each, 20p 100+, 15p 1000+
3.3µf 100V dc 30p each, 20p 100+, 15p 1000+
**1µf 50V bipolar electrolytic axial leads,** 15p each, 7.5p 1000+
**0.22µf 250v polyester axial leads,** 15p each, 100+ 7.5p each
**Philips 123 series solid aluminium axial leads,** 33µf 10V & 2.2µf 40V 40p each, 25p 100+
**Multilayer AVX cerami capacitors,** all 5mm pitch, 100V 100pf, 150pf, 220pf, 10,000pf (10n) 10p each, 5p 100+, 3.5p 1000+
**Welwyn W23** 9W 120 ohm 35p each, 20p 100+
**680 ohm 2W metal film resistor,** 4p 100+, 2p 1000+
**Solid carbon resistors,** very low inductance, ideal for RF circuits, 27ohm 2W, 68ohm 2W 25p each, 15p each 100+, we have a range of 0.25W, 0.5w, 1w and 2w solid carbon resistors – please send SAE for list
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**AMD 27256-3 Eproms £2.00** each, **£1.25** 100+
**DIP switch 3PCO 12 pin (ERG SDC-3-023) 60p** each, **40p** 100+
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**Computer grade 58000µf 60V capacitors** with screw terminals .......... £4.95
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**A23** 12V car alarm remote control and lighter battery .......... 75p each, £50.00 100+
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Carbon Film resistors ¼W 5% E24 series 0.51 R to 10MO .......... 1p
100 off per value – 75p. even hundreds per value totalling 1000 .......... £6.00p
Metal Film resistors ¼W 10R to 1 MO 5% E12 series – 2p. 1% E24 series .......... 3p
Mixed metal/carbon film resistors ½W E24 series 1RO to 10MO .......... 1½p
1 watt mixed metal/Carbon Film 5% E12 series 4R7 to 10 Megohms .......... 5p
Linear Carbon pre-sets 100mW and ¼W 100R to 4M7 E6 series .......... 7p
**Miniature polyster capacitors 250V working for vertical mounting**
.015, .022, .033, .047, .068-4p. 0.1 - 5p. 0.12, 0.15, 0.22 - 6p. 0.47 - 8p. 0.68 - 8p. 1.0 - 12p
**Mylar (polyester) capacitors 100V working E12 series vertical mounting**
1000p to 8200p - 3p. .01 to .068 - 4p. 0.1 - 5p. 0.12, 0.15, 0.22 - 6p. 0.47/50V - 8p
**Submin ceramic plate capacitors 100V wkg vertical mountings. E12 series**
2% 1.8pf to 47pf - 3p. 2% 56pf to 330pf - 4p. 10% 390p-4700p .......... 4p
Disc/plate ceramics 50V E12 series 1 PO to 1000P, E6 Series 1500P to 47000P .......... 2p
**Polystyrene capacitors 63V working E12 series long axial wires**
10pf to 820pf - 5p. 1000pf to 10,000pf - 6p. 12,000pf .......... 7p
741 Op Amp - 20p. 555 Timer .......... 20p
cmos 4001 - 20p. 4011 - 22p. 4017 .......... 40p
**ALUMINIUM ELECTROLYTICS (Mfds/Volts)**
1/50, 2.2/50, 4.7/50, 10/25, 10/50 .......... 5p
22/16, 22/25, 22/50, 33/16, 47/16, 47/25, 47/50 .......... 6p
100/16, 100/25 7p; 100/50 .......... 12p
220/16 8p; 220/25, 220/50 10p; 470/16, 470/25 .......... 11p
1000/25 25p; 1000/35, 2200/25 35p; 4700/25 .......... 70p
**Submin, tantalum bead electrolyics (Mfds/Volts)**
0.1/35, 0.22/35, 0.47/35, 1.0/35, 3.3/16. 4.7/16 .......... 14p
2.2/35, 4.7/25, 4.7/35, 6.8/16 15p; 10/16, 22/6 .......... 20p
33/10, 47/6, 22/16 30p; 47/10 35p; 47/16 60p; 47/35 .......... 80p
**VOLTAGE REGULATORS**
1A + or – 5V, 8V, 12V, 15V, 18V & 24V - 55p. 100mA. 5.8, 12. 15, V + .......... 30p
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100/1A 1N4002 3½p. 1000/1A 1N4007 5p. 60/1.5A S1M1 5p. 100/1A bridge .......... 25p
400/1A 1N4004 4p. 1250/1A BY 127 10p. 30/15A OA47 .......... 10p
Zener diodes E24 series 3V3 to 33V 400mW - 8p. 1 watt .......... 12p
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BC327, 337, 337L - 12p. BC727, 737 - 12p. BD135/6/7/8/9 - 25p. BCY70 - 18p. BFY50/51/52 - 20p.
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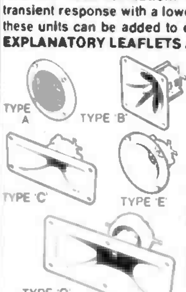


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**ALL POWERS INTO 4 OHMS**

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**PRICE £64.35 + £4.00 P&P**

**OMP/MF 300 Mos-Fet** Output power 300 watts R.M.S. into 4 ohms, frequency response 1Hz - 100KHz -3dB, Damping Factor >300, Slew Rate 60V/uS, T.H.D. typical 0.001%, Input Sensitivity 500mV, S.N.R. -110 dB. Size 330 x 175 x 100mm.
**PRICE £81.75 + £5.00 P&P**

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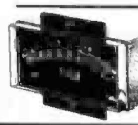
**NOTE: MOS-FET MODULES ARE AVAILABLE IN TWO VERSIONS: STANDARD - INPUT SENS 500mV, BAND WIDTH 100KHz. PEC (PROFESSIONAL EQUIPMENT COMPATIBLE) - INPUT SENS 775mV, BAND WIDTH 50KHz. ORDER STANDARD OR PEC.**



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